COOPERATIVE INSTITUTE
FOR
CLIMATE and SATELLITES (CICS)

Scientific Report

For the period:

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1 INTRODUCTION

1.1 Background

The Cooperative Institute for Climate and Satellites (CICS) is a national consortium of academic, non-profit and community organizations with leadership from the University of Maryland, College Park (UMCP) and the University of North Carolina (UNC) System through North Carolina State University (NCSU). This partnership includes Minority Serving Institutions as well as others with strong faculties that enhance CICS' capability to contribute to NOAA's mission and goals.

CICS has two principal locations, one on the M-Square Research Park campus of UMCP adjacent to the NOAA Center for Weather and Climate Prediction, and the other within the National Climatic Data Center. The two locations are referred to as CICS-MD, located in College Park MD, and CICS-NC, located in Asheville NC.

CICS scientific vision centers on the observation, using instruments on Earth-orbiting satellites and in situ networks, and prediction using realistic mathematical models of the present and future behavior of the Earth System. In this context, observations include the development of new ways to use existing observations, the invention of new methods of observation, and the creation and application of ways to synthesize observations from many sources into a complete and coherent depiction of the full system. Prediction requires the development and application of coupled models of the complete climate system, including atmosphere, oceans, land surface, cryosphere and ecosystems. Underpinning all of these activities is the fundamental goal of enhancing our collective interdisciplinary understanding of the state and evolution of the full Earth System. This vision is consistent with and supportive of NOAA's Strategic Goals, and CICS tasks comprise research projects that advance NOAA objectives.

1.2 CICS Vision and Mission

CICS' Vision and Mission derive from the historical expertise of the lead institutions and partners that comprise the CICS Consortium, together with NOAA's requirements. The CICS vision and mission are closely tied to the NOAA Strategic Goals.

VISION
CICS performs collaborative research aimed at enhancing NOAA's ability to use satellite and in situ observations and Earth System models to advance the national climate mission, including monitoring, understanding, predicting and communicating information on climate variability and change.

MISSION
CICS conducts research, education and outreach programs in collaboration with NOAA to:

- Develop innovative applications of national and international satellite observations and advance transfer of such applications to enhance NOAA operational activities;

- Investigate observations and design information products and applications to detect, monitor and understand the impact of climate variability and change on coastal and oceanic ecosystems;
- Identify and satisfy the climate needs of users of NOAA climate information products, including atmospheric and oceanic reanalysis efforts;
- Improve climate forecasts on scales from regional to global through the use of observation-derived information products, particularly through participation in the NOAA/NWS/NCEP Climate Test Bed;
- Develop and advance regional ecosystem models, particularly aimed at the Mid-Atlantic region, to predict the impact of climate variability and change on such ecosystems; and
- Establish and deliver effective and innovative strategies for articulating, communicating and evaluating research results and reliable climate change information to targeted public audiences.

The Research Themes for CICS are:

- **Theme 1: Climate and Satellite Research and Applications** incorporates the development of new observing systems, or new climate observables from current systems.
- **Theme 2: Climate and Satellite Observations and Monitoring,** focuses on: (a) development and improvement of climate observables from current systems, and (b) development of all continental and global fields of climate parameters that can be used for climate analysis and climate model initialization.
- **Theme 3: Climate Research and Modeling is** the research component that brings together (a) climate observables, modeling and validation in a comprehensive integrated whole, and (b) observational products with model development efforts to enable research into the improvement of forecasts of climate system variability on space scales ranging from regional to global, and time scales from a week or two to centuries.

1.3 CICS MD

CICS-MD is based upon the model and experience gained by UMCP through the leadership of the Cooperative Institute for Climate Studies in collaboration with NOAA beginning in 1983. The Earth Systems Science Interdisciplinary Center (ESSIC) managed the earlier Cooperative Institute beginning in 2002, successfully shepherding it through a period of dramatic growth in both funding and activity levels. ***CICS-MD focuses on the collaborative research in satellite observations and Earth System modeling conducted by the Center for Satellite Applications and Research (STAR) of NOAA/NESDIS and the National Centers for Environmental Prediction (NCEP) of NOAA/NWS.*** CICS-MD has initiated collaborations with other NOAA elements in the Washington, DC area, including the National Oceanographic Data Center (NODC) and the Air Resources Laboratory (ARL).

Dr. Phil Arkin (Director) and Dr. E. Hugo Berbery (Associate Director) of ESSIC lead CICS-MD. This collaboration also includes strong participation from the UMCP Departments of Atmospheric and Oceanic Science (AOSC), Geographical Sciences (GEOG) and Geology (GEOL), the University of Maryland Institute for Advanced Computer Studies (UMIACS), and the Joint

Global Change Research Institute (JGCRI), a collaboration between UMCP and the Department of Energy (DoE) Pacific Northwest National Laboratory.

1.4 CICS NC

CICS-NC is an Inter-Institutional Research Center (IRC) of the UNC System, referred to as North Carolina Institute for Climate Studies (NCICS). It is administered by North Carolina State University (NCSU) and affiliated with all of the UNC academic institutions as well as a number of other academic and community partners. ***CICS-NC focuses primarily on the collaborative research into the use of satellite observations in climate research and applications that is led by the National Climatic Data Center (NCDC) of NOAA/NESDIS.*** CICS-NC also is engaged in productive collaborative research with other NOAA elements, including the ARL Atmospheric Turbulence and Diffusion Division.

CICS-NC is led by Dr. Otis Brown and includes numerous partners from academic institutions with specific expertise in utilizing satellite observations in climate research, applications and models.

1.5 CICS Consortium

The CICS Consortium includes a wide range of research universities, non-profit organizations and community groups. Its role is to augment the capabilities of CICS and to extend its ability to conduct innovative and original collaborative research with NOAA. The CICS Consortium includes CICS-MD and CICS-NC, and is led by Dr. Arkin as Executive Director.

1.6 Governance

As specified in the Memorandum of Agreement (MOA) between NOAA and the University of Maryland, scientific and executive guidance for CICS is provided by the Executive Board, which represents NOAA, UMCP and NCSU senior management and guides and directs Institute operations. The Council of Fellows provides overall advice to the CICS Executive Director and the Directors of CICS-MD and CICS-NC.

During the past year, a meeting of the Executive Board was held at UMCP in College Park, MD on 1 August 2011, chaired by Dr. Steve Halperin, Dean of the College of Computer, Mathematical, and Natural Sciences. With the signing of the MOA, new members of the Executive Board have been selected. They are:

For UMCP

- Dr. Patrick O'Shea - Vice President for Research
- Dr. Jayanth Banavar - Dean, College of Computational, Mathematical and Natural Sciences
- Prof. Antonio Busalacchi - Director, Earth System Science Interdisciplinary Center

For NCSU/UNC System

- Dr. Terri Lomax - Vice Chancellor, Research and Graduate Studies, NCSU
- Prof. Ray Fornes - Professor of Physics, College of Physical and Mathematical Sciences, NCSU
- Dr. Suzanne Ortega - Senior Vice President for Academic Affairs, University of North Carolina System

For NOAA

- Dr. Al Powell, Director, NESDIS Center for Satellite Research and Applications
- Dr. Wayne Higgins, Director, NWS/NCEP Climate Prediction Center
- Dr. Michael Tanner, Deputy Director, NESDIS National Climatic Data Center
- Dr. Richard Artz, OAR Air Resources Laboratory

The next meeting of the Executive Board will be held at CICS-NC in Asheville, NC, on April 17, 2012.

The CICS Council of Fellows, in accordance with the MOA, advises the CICS leadership on research needs and opportunities related to CICS research themes, including but not limited to those at NOAA, CICS-MD, CICS-NC, and consortium academic institutions. The membership of the permanent Council is currently being determined.

A second meeting of CICS scientists and NOAA collaborators was held at NCDC in Asheville, NC on November 2-3, 2011. CICS-NC scientific projects were described and research needs and opportunities were discussed at the meeting, which constituted an ad-hoc Council meeting.

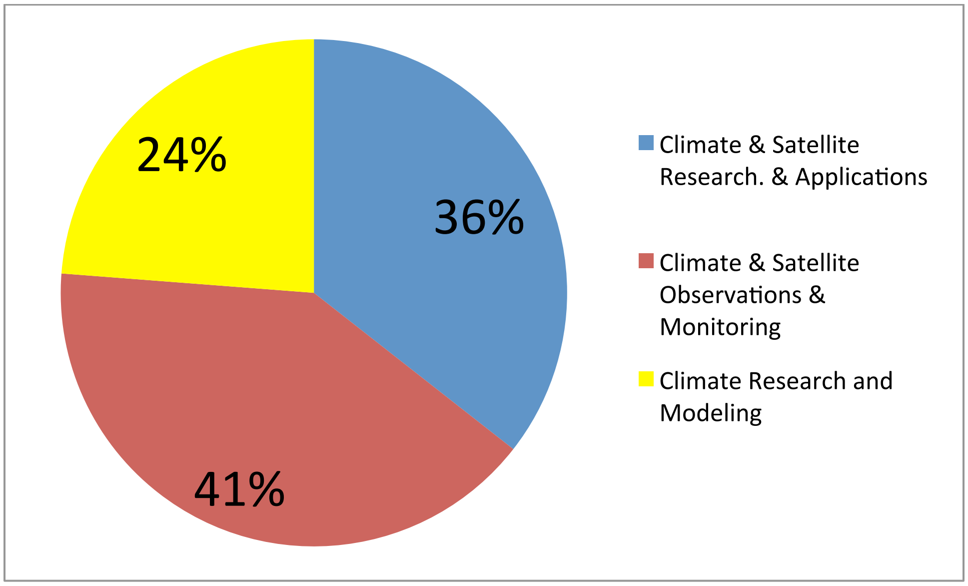
CICS thematic research is organized through Tasks, led by the CICS and NOAA scientists leading the research. Specific reports on research accomplishments by each Task are included in Section 4 of this report.

2 HIGHLIGHTS OF THIS YEAR'S RESEARCH

2.1 *Summary of achievements*

The total task funding for CICS research now stands at approximately $32 Million, an increase of more than $14 Million during the past year. In Figure 1 we summarize graphically the stratification of active task funding by CICS Research Theme and by NOAA Strategic Goal.

CICS Research Themes



NOAA Goals

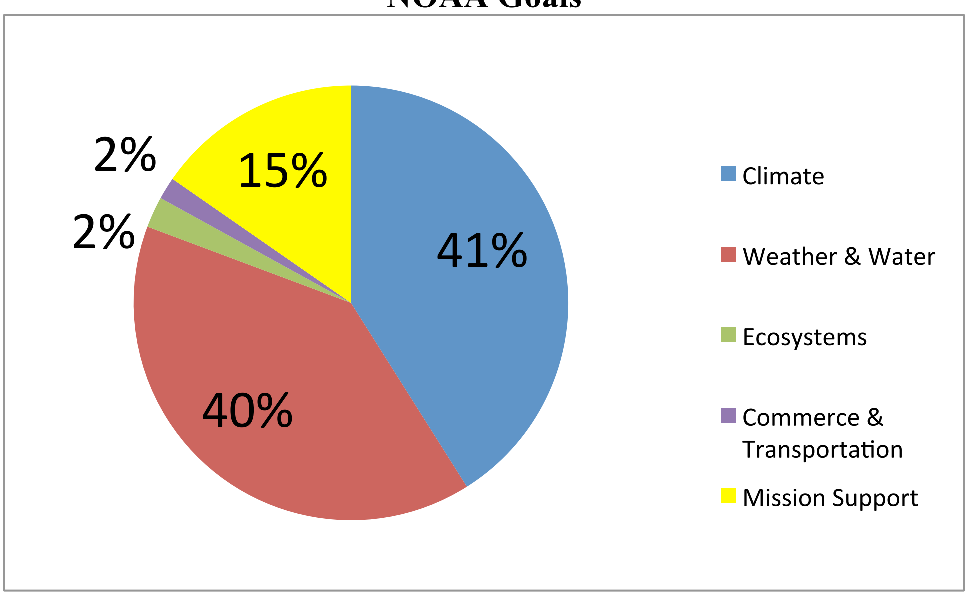


Figure 1: Funding (%) by CICS research theme (top) and by NOAA goals (bottom).

In Table 1 we present statistics for peer reviewed papers, and for presentations and non-peer reviewed papers, with subtotals for those with CICS and NOAA lead authors; note that the total includes a few instances in which the lead author was from a different organization. Table 2 provides the categorization of CICS staff and investigators, with supplementary tables breaking out the three major components of CICS.

Table 1: CICS Publication Statistics

Publications	Total	Institute Lead Author	NOAA Lead Author
Peer Reviewed	110	75	17
Non-Peer Reviewed (includes videos and formal presentations)	205	183	10

Table 2: CICS-TOTAL Personnel Statistics

Category	Total	BS	MS	PhD
Research Scientist	26	-	-	26
Visiting Scientist	1	-	-	1
Postdoctoral Fellow	16	-	-	16
Research Support Staff	14	1	13	-
Administrative	5	3	2	-
Total (> 50% support)	62	4	15	43
Undergraduate Students	2	-	-	-
Graduate Students	12	-	-	-
Employees that receive < 50% NOAA funding (not including students)	10	-	-	10
Located at NOAA facility (Camp Springs, Silver Spring or NCDC)	38	1	9	28
Obtained NOAA employment within the last year	2	-	-	2

Table 2a: CICS-MD Personnel Statistics

Category	Total	BS	MS	PhD
Research Scientist	14	-	-	14
Visiting Scientist	1	-	-	1
Postdoctoral Fellow	13	-	-	13
Research Support Staff	8	-	8	-
Administrative	2	2	-	-
Total (> 50% support)	38	2	8	28
Undergraduate Students	1	-	-	-
Graduate Students	12	-	-	-
Employees that receive < 50% NOAA funding (not including students)	9	-	-	9
Located at NOAA facility (Camp Springs or Silver Spring)	15	-	2	13
Obtained NOAA employment within the last year	2	-	-	2

**Note: These numbers include CICS-MD sub-award (3) personnel, but exclude CUNY, listed in a companion table.*

Table 2b: CICS-NC Personnel Statistics

Category	Total	BS	MS	PhD
Research Scientist	12	-	-	12
Visiting Scientist	-	-	-	-
Postdoctoral Fellow	3	-	-	3
Research Support Staff	6	1	5	-
Administrative	3	1	2	-
Total (> 50% support)	24	2	7	15
Undergraduate Students	1	-	-	1
Graduate Students	-	-	-	-
Employees that receive < 50% NOAA funding (not including students)	1	-	-	1
Located at NOAA facility (National Climatic Data Center)	24	1	7	15
Obtained NOAA employment within the last year	-	-	-	-

** Undergraduate student is located at NOAA facility, but has not earned her BS yet, therefore the total located is 24.*

Assume each subcontractor (9 projects) has a PI employed at less than 50% except for Gallupi.
Subcontractor Input:

- Allen – PI <50%, 1 MS <50%, 1 Grad Student < 50%
- Boyles – PI <50%, 1 MS >50%
- Burrell Montz Covey – 2 PhD <50%, 1 Grad Student >50%
- Colleton – 1 BS < 50%, 1 MS < 50%
- Evans – 1 MS <50%
- Galluppi – 2 MS >50%, 2 BS <50%
- Hall – PI <50%, 1 MS <50%, 4 BS <50%, 1 GS <50%, 1 UG <50%
- Wentz – 1 MS <50%
- Yuter – 2 UG > 50%

Table 2c: CUNY/CREST Personnel Statistics

Category	Total	BS	MS	PhD
Research Scientist	9	-	-	9
Visiting Scientist	1	-	-	1
Postdoctoral Fellow	-	-	-	-
Research Support Staff	-	-	-	-
Administrative	1	-	-	1
Total (> 50% support)	4	-	-	4
Undergraduate Students	2	2	-	-
Graduate Students	3	-	-	3
Employees that receive < 50% NOAA funding (not including students)	6	-	-	6
Located at NOAA facility (Camp Springs or Silver Spring)	-	-	-	-
Obtained NOAA employment within the last year	-	-	-	-

In Section 4, CICS-MD and CICS-NC personnel describe the research activities and results from the ongoing projects for the period of April 1, 2011 – March 31, 2012.

2.2 Research highlights

In the following sections we summarize the research highlights from the past twelve months of this agreement.

a. CICS-MD

These highlights for CICS-MD are segmented according to NOAA partner.

i. STAR

CICS-MD started to publish a twice yearly ***CICS-MD Circular*** with the institute's background and science highlights. The design for its new web site is being completed and will soon be developed. As a part of the CICS-MD commitment to outreach and education seven graduate students from around the country were supported to attend the NOAA-sponsored Climate Diagnostics and Prediction Workshop.

GOES-R ABI Longwave Radiation Budget products (OLR, DLW and ULW) are being developed on schedule, including the deliveries of the Routine and Deep-dive Validation Tool packages with continued support for AWG Framework and Algorithm Verification and Validation activities.

The first version of an algorithm for **angular correction of GOES-R observed clear sky land surface temperature (LST) for angular anisotropy has been developed.** This empirical model of angular anisotropy of satellite observed LST uses available simultaneous GOES-E and GOES-W observations from five SURFRAD stations.

GOES-15 is the latest operational geostationary satellite and has now been **included in the Geo-SST processing suite and is generating products.** Other work on the GOES-13+ family of sensors shows that **where solar scattered light is contaminating the Imager, the SST is biased and will not be used.**

A **statistically based quality control (QC) procedure** was developed and applied on the 1/3 degree daily antenna temperature files to remove spurious values not detected in the original database, enabling the rainfall product to be reprocessed using the current version of the algorithm for the period 1987-2009.

The radiometric response of the VIIRS reflective solar bands has been closely monitored using both on-board calibrator solar diffuser measurements and data acquired over the Antarctic Dome C calibration site. We also evaluated the image quality of the VIIRS Sensor Data Records and confirmed that the images display high dynamic range and low noise level and are free of spatial and radiometric artifacts.

CICS scientists continue to assess the quality of and develop further improvements in remote sensing observations of snow and sea-ice thickness from airborne and satellite platforms in order to monitor the recent significant **decline in the sea-ice cover of the Arctic Ocean** and to support efforts to improve the ability to forecast future changes to the sea ice pack.

CICS scientists have demonstrated that diagnostic soil moisture information from microwave and **thermal infrared retrieval methods can add skill to land surface model predictions of soil moisture** in a dual data assimilation framework.

The GOES-R ABI **active fire detection** and characterization product will provide continuity with the current GOES Imager Wildfire Automated Biomass Burning (WF_ABBA) fire data set for the Western Hemisphere into the next decade. CICS scientists are developing, testing, and implementing the "deep-dive" validation tool for ABI's active fire product using higher resolution spaceborne (Landsat-class) and airborne reference data.
The **Active Fire team** tested the VIIRS data processing and data dissemination system, finalized the simulated data (proxy generator) code, completed the MODIS Collection 6 fire code, and begun the process of adapting this code for the VIIRS sensor and IDPS processing chain. Since the VIIRS thermal cooler doors opened on January 18th, 2012, the fire team has been downloading, processing, and inspecting the active fire detections.

While seasonal patterns of **phytoplankton blooms** are well known, long-term patterns are not as well understood due to the limited spatial or temporal extent of available data. CICS scientists have developed a **new statistical reconstruction method was developed to extend ocean color surface chlorophyll concentrations over the past 50 years** in order to analyze the low frequency response by phytoplankton biomass to climatic signals.

CICS scientists are developing a first-of-its kind high resolution Northern Hemisphere **snow depth analysis** product for integration into an enhanced version of the NOAA Interactive Multisensor Snow and Ice Mapping System (IMS). The processing algorithm blends in-situ, satellite and analyst snow depth estimates in an optimal fashion for producing snow depth along with snow cover extent once daily over the Northern Hemisphere and twice daily over US.

Remotely sensed land surface temperature from geostationary and polar-orbiting satellite imagery can be assimilated into climate, mesoscale atmospheric and land surface models to enable improved estimates of land surface conditions or as input to land surface models for estimating sensible and latent heat fluxes. This approach is being used by CICS scientists to improve the GOES-R land surface temperature algorithm over snow for a new snowmelt mapping application and for use in land surface modeling schemes for the monitoring of surface fluxes all-year round.

CICS scientists provided leadership, satellite expertise, and meteorological support for the **GOES-R Proving Ground** efforts based at NOAA/NWS HPC, OPC, TAFB, and NOAA/NESDIS/SAB by interacting with NWS operational forecasters and NESDIS satellite analysts to prepare them for new satellite products that will become operationally available after the launch of the GOES-R satellite series and to foster research opportunities to find operationally specific weather events that highlight these products.

CICS scientists investigated various options of multi-channel combinations for improving the **shortwave radiative flux** product from the ABI sensor on GOES-R and made recommendations to the program managers.

CICS scientists developed a **new 5-km global SST analysis** based on data from geostationary and polar satellites that provides improved resolution of mesoscale and coastal oceanographic features whilst avoiding excessive noise. This new analysis is expected to benefit applications that require accurate daily gap-free estimates of sea surface temperature, such as NOAA's Coral Reef Watch program.

CICS scientists developed and implemented a **new physical SST retrieval methodology** for all geostationary imagers. The new products demonstrate significantly reduced biases and uncertainties compared to the previous generation of operational products.

Support has continued for the **risk reduction and algorithm development** activities for the upcoming GOES-R GLM. The CICS research group played a critical role in the CHUVA field campaign (Brazilian contribution to GPM), and through participation in the GOES-R Visiting Scientist program, will continue to evaluate the extensive datasets that were gathered during CHUVA.

CICS continues to **support GOES-R GLM proxy data and science needs through operation, maintenance and analysis of total lightning data from their regional network of Lightning Mapping Arrays** in collaboration with scientists at Texas Tech University and the University of Oklahoma. Science studies have focused on relating flash size and rate to thunderstorm kinematic structure, lightning in the anvils of supercells, winter storms, and LMA performance characterization.

ii. CPC

CICS scientists continue to collaboration with CPC staff in a number of monitoring and diagnostic roles, particularly involving precipitation estimation, analysis, and validation. In particular, large volumes of native resolution satellite-derived precipitation estimates from NESDIS algorithms that are stored on CICS/ESSIC computers were transferred to CPC to assist in **the backward extension of CPC's "CMORPH" precipitation analysis.**

CICS scientists examined **oceanic net freshwater flux (E-P) products** including two based on observations (GPCP/OAFlux and CMAP/OAFlux) and four from reanalyses (CFSR, MERRA, ERA-Interim, JRA25) to determine suitability for the **validation of climate models.**

CICS scientists continued the evaluation of the performance of the **MiRS, MSPPS, Hydroestimator, and SCaMPR** precipitation products through the CICS validation website, which was enhanced to include new statistical information requested by NOAA collaborators.

CICS scientists are developing a **drought early warning system** for the United States based on drought indices derived from seasonal climate forecasts. The predictive skill of drought indices and seasonal forecasts of precipitation, soil moisture, and runoff from the Climate Forecast System version 2 is evaluated and their potential use for drought prediction examined.

CICS scientists collaborated with PIs of the observational component of the **DYNAMO** campaign (aircrafts, ground radars, radiosondes, ships, ocean moorings) for **defining a series of monitoring and forecast products in order to help decision making** during the campaign.

iii. NODC

In 2011 CICS played a significant role in the development of improved satellite data products, working with the ocean science community to provide global and regional ocean data, and by validating new space-based ocean observing technologies. CICS enhanced NOAA's ability to understand, predict and communicate climate variability by data distribution and education through web based satellite data, detailed descriptions of these data and the World Ocean Database.

iv. CPO

CICS scientists provided **programmatic support** to the NOAA Climate Program Office (CPO) by supporting Director Chet Koblinsky in coordinating an interagency working group of the USGRCP; co-managing the CPO Modeling, Analysis, Predictions, and Projections competitive grants program, and serving as the climate representative on the NOAA Energy Team.

v. NCDC

The HIRS OLR CDR product, one of the pioneer Operational **Climate Data Record** products, has entered Initial Operational Capacity in September 2011, with all the production software and document package released to the public through the NCDC CDR program.

The **AVHRR operational calibration** has large (up to 0.5K) biases that are both scene and time dependent. CICS scientists are deriving a new AVHRR calibration that can significantly reduce these biases with the aim of producing an accurate **fundamental climate data record.**

b. CUNY Highlights

PSDI: Development of an Upgraded Southern Hemisphere Automated Snow/Ice Product – the new upgraded Snow and Ice Mapping System for Southern Hemisphere has been developed and is being implemented. The system is based on observations from METOP AVHRR at 1 km spatial resolution.

JPSS: Development of Operational Algorithm & Software to Validate Snow Cover Product from VIIRS NPP – validation of the VIIRS snow cover product has started. Qualitative examination of images received during the first two months of satellite operation has shown that the product does not fully satisfy the requirements and needs improvement

Development of Operational Algorithms & Software to Derive and Validate Snow Depth Product from GOES-R – development of the operational algorithm and software to generate the Snow Depth product for GOES-R ABI has completed. The code and all support documents have been delivered to the program management. The estimated accuracy of the product satisfies the requirements.

Development of Operational Algorithms & Software to Derive and Validate NDVI and Green Vegetation Fraction (GVF) Product from GOES-R – development of the operational algorithm and software to generate the NDVI and GVF products for GOES-R ABI has completed. The code and all support documents for the products have been delivered to the program management. The estimated accuracy of the products satisfies the requirements.

Improving Monitoring of Tropical Forests and their Characterization in NCEP Models Using GOES-R ABI Land Products – collection of observation data from MSG SEVIRI instrument in support of the study has continued. The archive contains more than 5 years worth of observations. The data archive is routinely updated and maintained.

Improvement of Snow Water Equivalent Estimation from Microwave Remote Sensing Data – the CREST-Snow Analysis and Field Experiment (CREST-SAFE) has been designed and being carried out to advance our understanding on microwave emission from intra-seasonal changes in snow condition.

Cloud-top Relief Spatial Displacement Adjustments for GOES-R Images – this project focuses on estimating and adjusting cloud-top relief spatial displacement CTD) from GOES-R IR observations utilizing a 3-D principle for simultaneous/corresponding GOES-East and -West IR. To meet these goals two major tasks: (1) relationship between cloud-top height (CTH), and (2) relationship between CTH and cloud-top IR, are required.

Development of validation tools and proxy data for GOES-R ABI Air Quality Proving Ground for the Northeast (NY Metro Region) – we have developed multiple approaches to construct suitable TOA Proxy data for GOES-R ABI sensor over complex urban surfaces to test current Aerosol Algorithms. Testing the surface reflectances show significant dispersion and biases however and a direct assessment using the AQPG GOER-R ABI aerosol algorithm is needed to assess the operational biases.

Storm Initiation 0 to 6 hours prior to Convection – the CREST role in this multi-institutional effort is to provide validation fields via back trajectories from radar observed initiation. Code has been written to produce these fields and is currently being tested.

Incorporating Cooling Rates into GOESR Precipitation Retrieval – cloud top cooling rates based on cloud tracking were calculated for several months of data over the north Atlantic. These will be ingested into the GOESR SCaMPR algorithm and the results studied for improvement.

Coastal Site Data Uncertainties – the CCNY group provided consistent stream of data from SeaPRISM instrument on Long Island Sound Coastal Observatory (LISCO) to NASA – AERONET and NRL SSC and from hyperspectral HyperSAS for the validation of NPP-VIIRS sensor and other Ocean Color satellites. A novel BRDF model for coastal waters was developed based on extensive radiative transfer simulations and validated on the LISCO site and satellite data.

CUNY CREST Weather Camp – the CREST Weather Camp has been organized each summer since 2009 to inculcate knowledge and interest among HS students in Atmospheric and Meteorological related STEM fields. This also serves as a "Pre-college prep".

Annual Colloquium and Early Career Summer Exchange Program – the Annual Colloquium early career summer exchange program has been organized each summer since 2006 to strengthen scientific and educational collaborations between CIs and CREST and to help improve professional skillsets among graduate students to help prepare them for professional careers.

Quantitative Image Restoration - we have adapted our current band 6 MODIS restoration algorithm to work with visible bands of the ABI simulated data. The broken detectors to be restored in our implementation are fully configurable.

c. CICS-NC Highlights

Development of a re-analyzed, homogenous precipitation record for the continental United States was done using radar, surface gauge, and satellite platforms and methods developed at the National Severe Storms Laboratory in Norman, OK.

Problems in the Version I NCDC Aerosol Climate Data Record (CDR) were addressed and corrected, and, the Version II NCDC Aerosol CDR was generated. The dependence of aerosol optical thickness (AOT) retrieval on the clear sky threshold in the AVHRR cloud mask was studied.

Assembled Advanced Very High Resolution Radiometer (AVHRR) Sea Surface Temperature (SST) retrieval algorithms into a robust code package to produce a Climate Data Record (CDR) for the AVHRR SST time series, NOAA-7 (1981) through NOAA-18 (2010) and deliver the package to NODC to support on-going production of the AVHRR Pathfinder SST time series.

This task focuses on the development and use of a new validation methodology to estimate the quantitative uncertainty in the Land Surface Temperature (LST) Environmental Data Record (EDR) derived from Suomi NPP/VIIRS, and contribute to improving the retrieval algorithm. It employs a land surface model to scaling up point LST measurements currently made operationally at NOAA's Climate Reference Network.

Calibration of the geostationary imager visible channel in the ISCCP B1 data is almost complete for the GOES, Meteosat, MSG, GMS and MTSAT series for the time period 1979-2009. Gaps in calibration and existing discrepancies in some of ISCCP calibration have been addressed, and the present calibration conforms to the MODIS standard.

Develop and provide documentation for the Pathfinder Sea Surface Temperature (PFSST) program as a component of transitioning this 20+ year dataset from a Research Climate Data Record (CDR) to an Operational CDR at NOAA/NCDC.

We are implementing the Geostationary Surface Albedo (GSA) algorithm for GOES data on behalf of NOAA to contribute to an international effort in collaboration with EUMETSAT and JMA in support of the Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM),. This effort signifies the first such attempt to use the same core algorithm across internationally operated geostationary satellites to produce albedo products to produce a climate data record for this variable.

Uncertainty quantification in climate research is a multidisciplinary area of increasing importance. Approximately 60 statisticians, mathematicians, and climate scientists from academia and governmental institutions met in Asheville, NC, USA in January 2012 to discuss the issues surrounding uncertainty quantification in the context of climate observations. This workshop was an opportunity to engage with and understand the different concerns and perspectives from the largely academic mathematical and statistical communities and climate data product scientists and providers.

A two-stage SST analysis is being developed to best utilize the improved coverage of low-resolution microwave satellite data along with the restricted coverage and high resolution of infrared satellite data. Also an objective method is being designed to improve the signal-to-noise ratio of the final product.

Extreme precipitation events have direct impacts to many aspects of our society. Satellite-based precipitation estimation provides a unique way to monitor large precipitation systems with high spatial and temporal resolutions. Our research over the reporting period has contributed to the understanding of precipitation variability at various spatial and temporal scales. Long-term (more than 30 years) satellite-based high-resolution precipitation data is under development. Extreme events relevant to floods and droughts will be processed. The developed high-resolution precipitation measurement can be used for improving our understanding of spatial and temporal variability of precipitation distribution and for documenting the recent trends in extreme precipitation events.

Tasks in this report period are focused on (1) developing a climate data record of high-resolution precipitation estimation, (2) processing a 4-D database of heavy precipitation events from historical precipitation measurement, and (3) evaluating high-resolution precipitation data for hydrologic applications. The work accomplished for the high-resolution data processing, evaluation, and application of the project are discussed.

This project involves the development of a re-analyzed, homogenous precipitation record for the continental United States, using radar-based software developed at the National Severe Storms Laboratory in Norman, OK.

We perform inter-satellite calibrations to the High-Resolution Infrared Radiation Sounder (HIRS) observations. Based on the inter-satellite calibrated HIRS observations, upper-tropospheric water vapor climate data record and vertical profiles of temperature and specific humidity are derived.

This research is a comparison of satellite-derived phenology with ground-based temperature metrics. The goal of this task is to determine which air or soil temperatures are better indicators for estimating the timing of growing season at 39 stations located within the contiguous U.S.
The focus of this modeling based investigation was to analyze the sensitivity of ensemble spread to hurricane track (direct and indirect hits and near-misses) and data assimilation (data type and techniques).

We use a multi-sensor approach to characterize precipitation features at high spatial and temporal resolution. Focused over the Southeastern United States, this work aims at representing a proof of concept and a first step toward the development of rainfall climatologies at high spatial and temporal resolution. More broadly, this work is part of an on-going effort at NCDC to provide high-resolution precipitation estimates for hydrological applications and to derive trends in the evolution of precipitation patterns over time.

This research uses novel satellite datasets to investigate tropical intra-seasonal variability, including the Madden–Julian Oscillation (MJO) and equatorial waves. Particular emphasis is placed on the relationship between the MJO and tropical cyclone activity in the Western Hemisphere. Daily monitoring of satellite-derived MJO signals provides a valuable tool for predicting tropical variability in the 5–30 day range.

The goal of this task is to improve the USCRN soil observations and research ways to use the soil data. Currently, we have developed multiple ways to improve the quality assurance procedure. Research has also been conducted on understanding the spatial relationship of USCRN soil data and approaches to develop drought-monitoring products.

This research tested various precipitation quality assurance (QA) algorithms in both artificial and field scenarios with the intent of identifying a QA variant with a greater level of skill detecting precipitation signals.

The purpose of this comparisons study was to identify the added value of USCRN station architecture/infrastructure (observational redundancy, sensor shielding, automation, etc.) on the observation of precipitation.

Continuously monitoring operations of GHCN-M version 3. Using the International Surface Temperature Initiative, new stations will be available for observing global climate variability and change. This will lead to the development of GHCN-M version 4.

Significant progress has been made on creation of a new surface temperature databank resource with over 40 contributions from the international community that will yield an initial release consisting of the order of 40,000 stations – a marked improvement over GHCN. A substantial reassessment of US surface temperature records reinforced our understanding of this record and pointed to an asymmetrical error with far greater probability that we underestimate than overestimate the real trend. The GCOS Reference Upper Air Network continues to grow and we have received applications from several new sites.

ORAU will assist NOAA/ATDD in the installation of new USCRN and USRCRN stations based on each program's performance measures and will perform routine annual maintenance visits to the existing USCRN and USRCRN sites. ORAU will also assist with the regular calibration of various sensors deployed at the monitoring sites.

The overall goal of this project is to provide information and practical tools to draw upon prior NOAA-funded ecological research on sea-level rise in NC in order to enhance coastal management and decision-making for ecological restoration, shoreline erosion abatement (e.g., living shoreline site suitability), and planning for sustainability of wetlands undergoing sea-level transgression. Accomplishments in this early phase of the project include organizing a stakeholder advisory group, completing a data and project tool inventory, needs and capability assessment for web map applications, and hosting a workshop for interested partners in the digital online atlas component.

The TSU provided scientific, graphical, coordination, technical and strategic support for the National Climate Assessment (NCA), yielding many critical products and contributions. These contributions included the production of regional climatologies and outlooks for all eight regions of the NCA, developing data management, strategic interagency planning, workshop support, Federal Advisory Committee meeting support and web system development, as well as many other contributions.

An analysis of the physical climate of the National Climate Assessment (NCA) regions was completed, including historical trends based on NOAA climate observations and 21st Century projections based on CMIP3 and NARCCAP climate models, for use by the authors of the 2013 NCA report. Research on extreme precipitation trends identified the major meteorological phenomena responsible for observed upward trends and examined the potential effects of climate change on estimates of probable maximum precipitation.

This project is investigating the nature of changes in extratropical cyclone (ETC) occurrence using a new reanalysis data set that extends back into the late 19th Century. Preliminary results point to some significant shifts in the spatial distribution and frequency of ETCs from the late 19th to the early 21st Century in the Northern Hemisphere. Most importantly, trends in ETC activity computed over more than 100 years are in some cases *opposite* in sign to those computed since 1950. The ratio of the number of high latitude to mid latitude ETCs was higher in the late 19th/early 20th Centuries; on the surface, this implies a shift in the mean track of ETCs to the south during the latter two-thirds of the 20th Century. Indeed, the mid-latitudes of North America and the Atlantic became more active after the 1930s. At the same time, at high latitudes there was a change to higher activity in the eastern Hemisphere and lesser activity in the western Hemisphere. These shifts indicate a need to rethink probable weather patterns in climate change scenarios.

This activity provides data coordination support to the National Climate Assessment (NCA). Design data management strategy and create the necessary infrastructure for managing inputs and outputs, of data and information, for the NCA process. Ensure NCA compliance to the Information Quality Act. Provide transparency and traceability to all data and information associated with the 2013 NCA report.

Providing primary science and technical support to NOAA and the NOAA Technical Support Unit of the National Climate Assessment (NCA), including: the processing and analysis of observational and climate model data, the production of documents for the NCA, and research on Assessment-relevant topics.

Climate model and observational data is becoming too large to continually transfer products to end-users. We have developed tools to help scientists perform calculations and off load smaller more meaningful data sets for direct examination.

The Science House of NCSU provides K-12 educational outreach for climate and Earth system science in partnership with NOAA's NCDC and CICS-NC. Educational support materials will be created for a museum exhibit called: "Highlighting 150 Years of Weather Observations in Asheville".

The ultimate goal of this program is to establish the routine relevancy of climate science information and provide the climate context to extreme weather events. Climate Central also seeks to raise climate literacy by showcasing the findings of the upcoming National Assessment report. We do this by highlighting NCDC products and showcasing the expertise of NOAA scientists.

This research examines challenges and opportunities associated with the delivery and use of climate information. Specifically, this research a) examines mechanisms and models for private sector engagement; b) assesses various business and economic strategic forecasting needs; and c) further examines the specific climate information needs and potential economic impacts of climate change on plant-based businesses.

There is a need to advance climate science and climate change literacy of decision makers as they explore practical and cost-effective approaches to leverage available resources. Provision of climate data for applications and decision capabilities, which can factor into strategic, planning and operational decisions, requires partnerships across public, private and academic organization. This research focuses on identifying challenges of and opportunities with advancing the application of climate data, on gathering the needs and demands of various select industries for climate information, and determining an approach to address the gaps through beginning with climate literacy

This task examines challenges and opportunities associated with the delivery and use of climate information, primarily targeted for the plant-based economic sector. Specific targets are the climate information needs and potential economic impacts of climate change on plant-based businesses through two key activities: the Executive Roundtable and the Plant Sector Working Group.

This year's objectives focuses on prototyping products and services for improving the communications of weather and climate information to emergency managers application in critical decision-making. The project infuses social sciences with technology into a guidance that can be applied to for understanding customer needs for information. The methods have been applied to various weather events and the utility of current and future products and services.

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The predictability of flooding associated with atmospheric river storms in California is dependent on the repeatability of the spatial pattern of precipitation as a function of environmental characteristics that can be reliably forecast. Initial work indicates considerable variability in the spatial distribution of precipitation frequency among similar atmospheric river storms. One area of consistent frequent rainfall is the Plumas National Forest in the Feather River Basin.

3 NOAA/CICS CORE ACTIVITIES

CICS core activities include education, coordination, scientific computing, outreach, management and administration related to CICS-MD, CICS-NC and Consortium efforts. During the past 12 months, CICS leaders have continued to establish the essential administrative and management activities required to support the collaborative science and research. In addition, further progress has been achieved on the full suite of core activities, as described below. The primary mechanisms that will support the Executive Director in ensuring coherent collaboration across the entire Consortium will include the Council Fellows, the Science Meeting, and the personal efforts of the CICS-MD and CICS-NC Directors.

3.1 Management and Administration

Dr. Phil Arkin as Executive Director leads the CICS Consortium. He also serves as Director of CICS-MD, with Dr. E. Hugo Berbery as Associate Director. Teresa Ferrete is the administrative assistant. CICS-MD is housed administratively within ESSIC at UMCP. Infrastructure support is provided by ESSIC management and staff, including Andy Negri, Assistant Director, the ESSIC Business Office, led by Jean LaFonta, assisted by Iris Harrigan (Business Manager) and Cheryl Sliter (Business Services Specialist).

Dr. Otis Brown is Director of CICS-NC, located within the NCDC facilities in Asheville, NC. Administrative support at CICS-NC has been provided by Ms. Janice Mills (Business Manager) and Ms. Jennifer Roshaven (University Program Specialist).

3.2 Coordination

A major challenge for CICS is to ensure that collaboration and communication across the entire Consortium contributes effectively to advancing NOAA's research mission. Several mechanisms are utilized to this end, ranging from direct discussions among the Directors to participation in the annual CoRP Symposium to facilitating visits among students and scientists associated with CICS and other Cooperative Institutes.

The 2011 CoRP Symposium was held at NCDC, Asheville, NC, hosted by CICS-NC. Scientists from all the NESDIS Cooperative Institutes and CREST attended, with a strong student contingent. The Director of CICS-NC played a prominent role, and the CICS-MD Associate Director attended as well. The 2011 CICS Science meeting was also held NCDC, Asheville, NC, with more than 20 presentations by scientists from CICS-NC, CICS-MD and other Consortium members.

3.3 Web Sites, banners and logos

CICS web sites continue to be developed and refurbished to enhance CICS outreach to all interested sectors. An independent site, climateandsatellites.org, intended to provide a comprehensive description of the CICS Consortium has been established and is in the process of being enhanced. This site provides the background, mission and vision statements for CICS, as well as links to Consortium participants. Both CICS-MD and CICS-NC maintain dedicated sites for their own activities that also include cross-links with others CICS sites using a consistent "look and feel. CICS-MD is redesigning its web site. The final version is expected to be in place in the coming months.

A set of consistent banners has been developed to represent CICS, CICS-NC and CICS-MD:

And the corresponding logos for CICS-MD and CICS-NC are:

3.4 Education

Young scientists, including students and post-doctoral researchers, play an important role in the conduct of research at CICS-MD and CICS-NC. Both CICS-MD and CICS-NC strive for close integration with the graduate programs at the respective host institutions of UMCP and NCSU. CICS scientists participate in courses by serving as guest lecturers and by helping to mentor graduate and undergraduate students. In addition, extensive series of seminars on a variety of topics are organized by CICS. See Table 3 for a list of such seminars conducted at CICS-MD. These include presentations by senior faculty from UMCP and from other institutions as well as informal seminars by junior CICS-MD scientists intended to foster discussion and provide opportunities for interaction among the staff. Finally, CICS-MD has an ongoing program that provides support for 1-2 Graduate Research Assistantships (GRA) in the Department of Atmospheric and Oceanic Science or associated Departments at UMCP. The first student under this program was Ross Fessenden, who enrolled in the Fall Semester of 2010. Unfortunately, Mr. Fessenden decided to transfer for personal reasons to an institution closer to his home at the end of the fall semester. Beginning with the Fall 2011 semester, incoming student Ni Dai is progressing well as a CICS graduate research assistant. An offer has been made to a new student who will begin in Fall 2012 if she accepts.

Another UMCP PhD student, Manisha Ganeshan, visited CIMSS with support from the STAR Cooperative Research Exchange Program to learn how to use and apply a clear-sky regression retrieval algorithm on AIRS satellite Level 1B infrared radiances. The algorithm is used in retrieving temperature and moisture profiles at 101 atmospheric levels. This observational data were used in combination with modeling results to investigate the role of convective inhibition in initiating deep convection over the Chesapeake Bay watershed. In addition, through this visit the PhD student also learnt how to retrieve high resolution land surface temperature (LST) using MODIS Level 1B calibrated radiances.

Finally, an outstanding student, Daniel Kendix, from the Montgomery County (Maryland) science magnet Blair High School, was employed during summer 2011 as an intern with support from CICS-MD. He studied the variability in precipitation and circulation as depicted by atmospheric reanalyses.

CICS-NC hired five post-doctoral fellows who are working on topics of interest to NCDC scientists (documented under Workforce Development). On the local level CICS-NC is working with The Science House, the NC Arboretum, and the Asheville and Buncombe County School systems to develop curricula which will integrate climate change into the K-8 grades.

3.5 Outreach

Outreach to the scientific community and the general public is a high priority for CICS. The great complexity and diversity of the CICS mission and composition makes this a challenging endeavor, requiring multiple approaches. CICS-MD, as the most mature component of the Consortium, had several ongoing activities.

CICS-MD has prepared its first *Circular*, and intends to continue publishing it twice a year. The first issue reports on CICS-MD vision and mission, its research themes and brief descriptions of research being done at the institute. The titles of these contributions are: (a) A CICS Partner – NOAA/ NESDIS/Satellite Climate Studies Branch; (b) Improving Satellite Heavy Rain Estimates Using Lightning Information; and (c) Seasonal Drought Prediction over the United States. A view of the CICS-MD Circular is presented in an Appendix.

Supported by CICS-MD, an undergraduate student did a summer internship to examine the land surface fluxes over different climate regions of the US.

3.6 Seminars

CICS conducts a series of informal seminars and participates in the ESSIC seminar series at College Park and Asheville to communicate scientific results to the broader community (see Education and Table 3). In addition, CICS scientists make both oral and poster presentations at technical meetings, and frequently visit other institutions to present seminars describing their work. Scientists at other Consortium members expect to contribute to this method for outreach as their projects mature and begin to produce more results. Table 3 provides a list of CICS-related seminars.

3.7 Public Events

Maryland Day, an annual event that attracts more than 70,000 visitors to the UMCP campus, provides CICS-MD with an exceptional opportunity to reach out to the public to illustrate our important research results regarding climate and satellites. See Figure 2 below. Maryland Day 2011 was held on April 30, 2011, and CICS scientists are contributed significantly to the Earth Science tent, where exhibits were displayed related to the theme “Exploring Extraordinary Earth: Explore our ever-changing planet with Earth system scientists from UM, NASA, and NOAA! Build your own instruments to measure winds and rain fall amounts. Harvest water and learn about the water cycle. Participate in these and other Earth science-themed activities!”

Preparations are now underway for Maryland Day 2012, which will be held in College Park, MD on April 28, 2012.

Figure 2: University of Maryland President Wallace Loh (center) with ESSIC Director Prof. Antonio Busalacchi (right) and Assistant Director Andrew Negri view NOAA's Magic Planet at the Maryland Day Open House, April 30, 2011

3.8 Private Enterprise Interactions

Jenny Dissen leads a robust program of informal and more formal outreach activities with the private sector for CICS-NC. A Summer Institute focused on Adaptation to Climate Change is planned for 2012 (planning was done in 2010/2011). A series of interactions with the private energy sector is underway in order to improve understanding of this sector's interests and needs on sub-decadal time scales.

4 CICS-MD PROJECT REPORTS

4.1 GOES-R Projects

Risk Reduction Research for GOES-R Geostationary Lighting Mapper

Task Leader Scott Rudlosky and Rachael Albrecht
Task Code EBRAGOESR11
Contribution to CICS Themes Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals Goal 2: 40%; Goal 4: 30%; Goal 5: 30%

BACKGROUND
The instrument complement on the planned Geostationary Operational Environmental Satellite-R (GOES-R) will include the Geostationary Lightning Mapper (GLM). This instrument will provide regular and frequent depictions of lightning occurrence from geostationary orbit for the first time, offering a significant advance in the ability of scientists to observe and understand the role of lightning in severe weather, tropical storms, and climate.

Drs. R. Albrecht and S. Rudlosky of the Cooperative Institute for Climate Studies (CICS) will participate in risk reduction and algorithm development activities in support of the GOES-R GLM. They will serve as NESDIS/STAR subject matter experts supporting GLM science and applications development, and will serve as members of the GLM Risk Reduction Team. They will initially develop methods to ensure user readiness for GLM data by working with proxy data from other observing programs, including the Tropical Rainfall Measuring Mission (TRMM) Lightning Imaging Sensor (LIS), Lightning Mapping Arrays (LMA), and models. These algorithms will utilize data from the GLM in a variety of nowcasting, severe storm identification, aviation weather, wildfire, and precipitation applications.

ACCOMPLISHMENTS
Dr. Albrecht conducted statistical analyses of individual TRMM/LIS events, groups, and flashes combined with TRMM/TMI and TRMM/PR observations. This research aims to better understand lightning behavior under convective and stratiform areas in order to develop/improve QPE algorithms (in collaboration with Dr. Nai-Yu Wang and Dr. Kaushik Gopalan of CICS/UMD). A manuscript describing this research has been submitted to JGR.

Dr. Albrecht coordinated the deployment of 4 lighting location systems (LLS) in Sao Paulo, Brazil, for the fourth CHUVA field campaign. These LLS are the 12 sensor Sao Paulo Lightning Mapping Array (SPLMA), a 7 sensor LINET network, a shorter baseline EarthNetworks Total Lightning Network (ENTLN) with 7 WeatherBug sensors, and the new Vaisala Total Lightning Sensor 200 (TLS200) with 5 sensors (Figure 1). The other 6 operational LLS (RINDAT, STARNET, GLD360, WWLLN, GLN and ATDnet) also agreed to share data during the IOP (i.e., from 1 November 2011 to 31 March 2012). In addition to the CHUVA Project objectives, this project has two additional major objectives: 1) to collect total lightning data (GLM proxy) under the Meteosat SEVIRI (ABI proxy) and 2) to perform the first intensive LLS intercomparison, which will improve our knowledge of lightning emissions and our ability to monitor lighting discharges.

As part of the CHUVA campaign, the GLM Science Team deployed the Sao Paulo Lightning Mapping Array (SPLMA) to the metropolitan area of Sao Paulo, Brazil, as part of the proxy data acquisition under Meteosat-SEVIRI coverage. Dr. Rudlosky spent 5 weeks in Sao Paulo assisting with the SPLMA deployment.

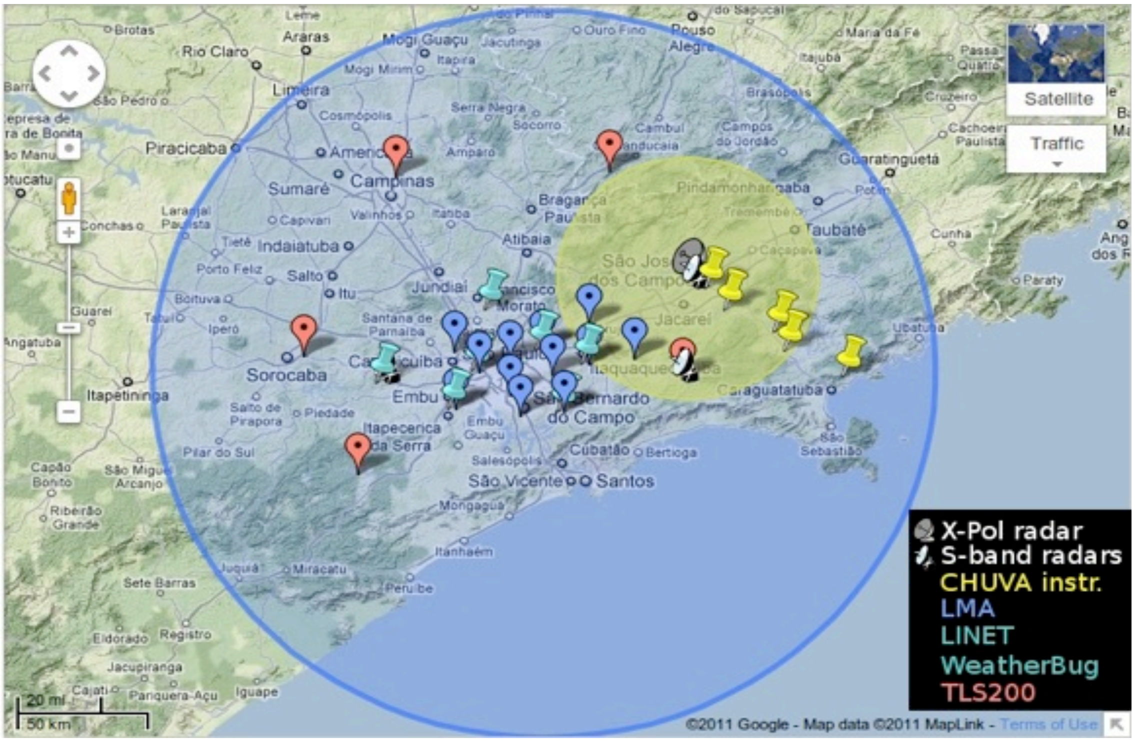


Figure 1: CHUVA-GLM Vale do Paraiba instrumentation.

Dr. Rudlosky recently moved to a physical scientist position with NESDIS/STAR (Dec. 2011), but remains collocated with CICS, and continues to contribute to the GLM Risk Reduction activities. For example, he recently completed an evaluation of the World Wide Lightning Location Network (WWLLN) and Vaisala's Global Lightning Dataset (GLD-360) relative to TRMM/LIS observations (Figure 2). Specifically, he determined the fraction of TRMM/LIS flashes that are observed by the various ground-based networks. This study also documented spatial variability in the various performance metrics, and provided performance statistics to Proving Ground partners that currently use these data.

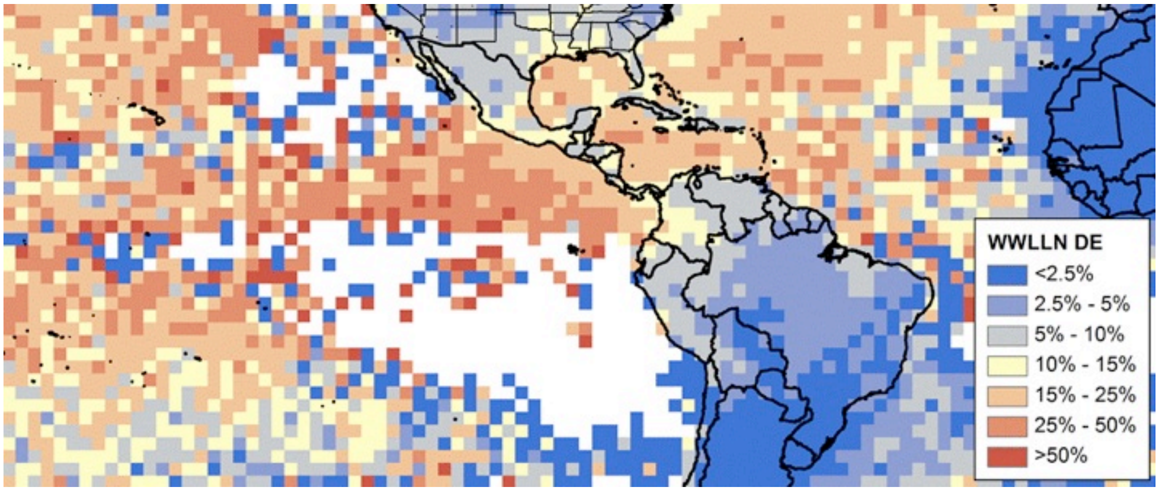


Figure 2: WWLLN Detection Efficiency relative to TRMM/LIS.

Professional service was provided by Dr. Albrecht through peer review of manuscripts submitted to Theoretical and Applied Climatology, *Revista Brasileira de Meteorologia*, Journal of Applied Meteorology and Climatology and International Journal of Climatology.

Dr. Rudlosky reviewed manuscripts submitted to the Bulletin of the American Meteorological Society and Geophysical Research Letters, and also participated in a 3-day panel review of proposals to NASA's New Investigator Program (NIP). He also conducted two internal reviews of manuscripts comparing lightning and precipitation measurements, which have subsequently been submitted to the Journal of Geophysical Research.

PLANNED WORK

During the upcoming year, Dr. Albrecht will continue her work on the TRMM/LIS dataset, providing a foundation for GLM Risk Reduction activities. For example, Dr. Albrecht is using the CHUVA-GLM data to intercompare LLS observations, focusing on TRMM LIS overpasses and a variety of case studies. She will be visiting NASA NSSTC (Huntsville, AL) and CICS-MD (College Park, MD) during May 2012 to collaborate with Dr. Richard Blakeslee and Dr. Rudlosky as part of the GOES-R Visiting Scientist (VS) Program. The intercomparison study also will benefit from the participation of two additional Brazilian scientists who assisted the deployment of the SPLMA. The Brazilian scientists will also travel to Huntsville and College Park as part of the GOES-R VS program.

Dr. Albrecht also continues her work on potential nowcasting algorithms for severe weather (hail, damaging winds, and flash flooding) in Sao Paulo city based on total lightning, multi-sensor, and multi-platform data (ground-based radar and satellites). Additionally, Dr. Rudlosky continues his investigation of relationships between severe weather and lightning in the Mid-Atlantic region. GOES-R funds have been used to hire a part-time graduate student (Dustin Shea) to continue this analysis of severe and non-severe storms in the Mid-Atlantic. More recently, CICS director Dr. Phillip Arkin has agreed to hire Dustin as a half-time GRA, which will allow him to continue his research under the supervision of Dr. Rudlosky.

Dr. Rudlosky next will apply the findings from part one of his investigation of long-range lightning detection networks to develop a GLM-proxy dataset at an improved temporal resolution and larger spatial scale than is currently available to the GLM Science Team. The new GLM proxy dataset will be provided to members of the Algorithm Working Group (AWG) as well as GOES-R Proving Ground partners. This research will greatly expand both the number and variety of users and will help to better prepare the various users to implement the upcoming GLM data into their operations.

Planned travel for Dr. Albrecht includes: i) a visit to NSSTC/UAH for 3 weeks and CICS for one week in May 2012, ii) a second visit to both locations during Spring 2013 to continue our collaborative research on LLS intercomparisons, nowcasting algorithms, and lighting-precipitation estimation in collaboration with Dr. Nai-Yu Wang and Dr. Bob Adler; and iii) attend the Fall AGU Meeting (December 2012) and/or AMS Annual Meeting (January 2013) to present the results of these ongoing studies.

Planned travel for Dr. Rudlosky includes visits to the International Conference on Lightning Detection/Meteorology (ILDC/ILMC, Boulder, CO), and the NOAA Satellite Science Week (Kansas City, MO). Additional trips may be scheduled as funding sources are better defined. The CICS GRA (Dustin Shea) will present results of his ongoing work at the AMS Annual Meeting (January 2013).

PUBLICATIONS

Gonçalves, F. L. T., J. A. Martins, R. I. Albrecht, C. A. Morales, M. A. Silva Dias, and C. E. Morris (2012): Effect of bacterial ice nuclei on the frequency and intensity of lightning activity inferred by the BRAMS model. Atmos. Chem. Phys. Discuss., 11, 26143-26171, 2011, doi:10.5194/acpd-11-26143-2011.

Naccarato, K. P., and R. I. Albrecht (2012): On the relationship between total lightning and precipitation over Brazil and North Argentina. *J. Geophys. Res*., Submitted.

Rudlosky S. D., and H. E. Fuelberg, 2011: Determining relationships between lightning and radar parameters in the Mid-Atlantic Region. *Wea. Forecasting*, Submitted.

Wang, N.-Y., K. Gopalan, and R. Albrecht, 2012: Lightning, radar reflectivity and passive microwave observations over land from TRMM: Characteristics and applications in rainfall retrievals. *J. Geophys. Res*., Submitted.

PRESENTATIONS

Albrecht, R. i. et al. (2011): The 13 years of TRMM Lightning Imaging Sensor: From individual flash characteristics to decadal tendencies. XIV International Conference on Atmospheric Electricity, 8-12 August, Rio de Janeiro, Brazil.

Albrecht, R. I. et al. (2012): The CHUVA-GLM field campaign. Convection Working Group Workshop, 27-30 March, Prague, Czech Republic.

Naccarato, K., R. I. Albrecht, O. Pinto Jr. (2011): Monthly variations of cloud-to-ground lighting activity in Brazil based on high-resolution lightning image sensor (LIS) data. XIV International Conference on Atmospheric Electricity, 8-12 August, Rio de Janeiro, Brazil.

Naccarato, K. P., R. I. Albrecht, O. Pinto Jr. (2011): Cloud-to-ground lightning density over Brazil based on high-resolution lightning imaging sensor (LIS) data. XIV International Conference on Atmospheric Electricity, 8-12 August, Rio de Janeiro, Brazil.

Rudlosky, S. D. and H. E. Fuelberg, 2011: Relationships between lightning and radar in the Mid-Atlantic Region. *Southern Thunder Workshop*, Norman, OK, July 11-14.

Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates

Task Leader Robert F. Adler (Weixin Xu, collaborator)
Task Code RARAGL_R311
Contribution to CICS Themes Theme 1: 20%; Theme 2: 80%
Contribution to NOAA Goals Goal 2: 100%

BACKGROUND
This work is part of the ongoing NOAA GOES-R Risk Reduction (GOES-R3) program. The research of this project seeks to enhance precipitation estimates from the future GOES-R by combining information from the Geostationary Lightning Mapper (GLM) with the Advanced Baseline Imager (ABI) to produce a superior combined instrument product. This effort will make the GOES-R precipitation information uniquely important and provide a large step forward in improving satellite rain estimates in the coming decades.

Geostationary IR precipitation estimation techniques (Adler and Negri, 1998) and lightning-rainfall relationships have been extensively investigated. The current work examine lightning-convection-rainfall relations using TRMM data to build on information already in the literature, and develop an approach to integrate the lightning information into geostationary IR rain algorithms, including the ABI rainfall algorithm based on SCaMPR (Kuligowski, 2002). The resulting test product will then analyzed to determine the benefit of the lightning data and the usefulness of the enhanced product. The last part of the project will be to finalize and test the code for the enhanced rainfall product for the use at GOES-R launch, or shortly thereafter. This work will also be combined with Nai-Yu Wang's project (coupling lightning information in microwave rainfall estimate) in the second and third years to take advantage of the synergism between two efforts.

ACCOMPLISHMENTS
The year-1 efforts focus on examining lightning-convection relationships using TRMM measurements. Results provide insights and lightning-rainfall quantities in using lightning information to aid identify convective cores in thick anvils missed by the IR technique, eliminate misidentified convective cores, and correctly define convective rainfall volume. Initial tests are underdoing to apply these results to improve the representation of convective cores compared to the Convective/Stratiform technique proposed by Adler and Negri (1988).

Specifically, stage 1 studies quantify the relationships between lightning activity, convective rainfall and associated cloud properties on both convective system scale (or storm scale) and satellite pixel scale (~ 5 km) based on 13 years of TRMM measurements of rainfall, lightning and clouds. Results show that lightning frequency is a good proxy to separate storms of different intensity, identify convective cores (Figure 1), and screen out false convective core signatures in areas of thick anvil debris. Significant correlations are found between storm-scale lightning parameters and convective rainfall for systems over the southern USA, the focus area of the study. Storm-scale convective rainfall or heavy precipitation area has the best positive correlation with lightning flash area. Correlations between convective/heavy rainfall and lightning flash rate are somewhat weaker. Statistics further show that active lightning and intense precipitation are not well collocated on the pixel scale (5 km). Simple positive correlations between lightning flash rate and precipitation intensity are weak on pixel scale. However, lightning frequency and rain intensity have probabilistic relationships: the probability of heavy precipitation, especially on a coarser pixel scale (~ 20 km), increases with increasing lightning flash density. Therefore, discrete thresholds of lightning density could be applied in a rainfall estimation scheme to assign precipitation in specific rate categories.

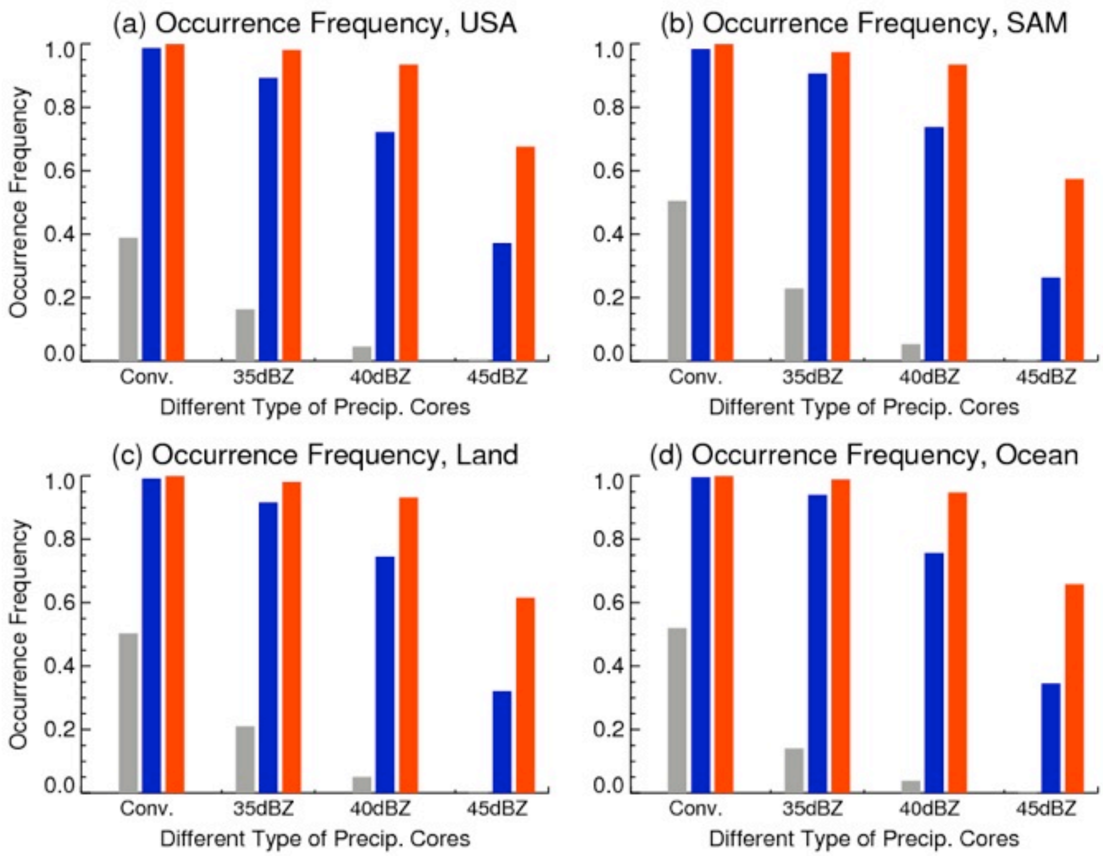


Figure 1: Occurrence frequency of storms with different precipitation cores (at least 100 km^2) over (a) southern USA, (b) South America, (c) Tropical land, (d) Tropical ocean; gray, blue, and red histograms represent storms without any lightning, storms have 1 flash per min, and storms produce 5 flashes per min, respectively.

PLANNED WORK

- Develop an initial IR-lightning rain estimation scheme using the VIRS and LIS data from TRMM based on year-1 studies;
- Test and adjust the lightning-enhanced rainfall algorithm through current geostationary IR data, ground-based lightning measurements, and in-situ observations;
- Develop and test a modified GOES-R Baseline/Lightning rain algorithm using Testbed and other data.
- Statistically evaluate the GOES-R pre-launched lightning-IR rainfall technique using long-term TRMM measurements.

PUBLICATIONS

Xu, W., R. F. Adler, and N.-Y. Wang, (under review): Improving Geostationary Satellite Rainfall Estimates Using Lightning Observations, I: Underlying Lightning-Rainfall-Cloud Relationships. *J. Appl. Meteor. Climatol*.

PRESENTATIONS

Xu, W., R. F. Adler, and N.-Y. Wang: Improving Geostationary Satellite Rainfall Estimates Using Lightning Observations: Underlying Lightning-Rainfall Relationships. Amer. Meteor. Soc., 92nd Annual Meeting, Jan 2012, New Orleans, LA.

REFERENCES

Adler, R. F., and A. J. Negri, 1998: A satellite infrared technique to estimate tropical convective and stratiform rainfall. *J. Appl. Meteor.*, **27**, 30-51.

Kuligowski, R. J., 2002: A self-calibrating real-time GOES rainfall algorithm for short-term rainfall estimates. *J. Hydrometeor*, **3**, 112–130.

Development of Longwave Radiation Budget Products for GOES-R ABI Instrument

Task Leader Hai-Tien Lee
Task Code HLHLGOESR11
Contribution to CICS Themes Theme 1: 10%; Theme 2: 70%; Theme 3: 20%.
Contribution to NOAA Goals Goal 2: 100%

- **BACKGROUND**

This work supports the GOES-R Algorithm Working Group tasks for the development and validation of three longwave radiation budget (LWRB) products for the Advanced Baseline Imager (ABI) instrument.

The GOES-R LWRB products include the outgoing longwave radiation flux density (OLR) at the top of the atmosphere and the downward and upward longwave radiation flux density (DLR and ULR) at the Earth's surface. FY10 activities include algorithm development, validation, and documentation activity leading up to delivery of an Algorithm Package (AP) to the GOES-R Ground Segment Project (GSP) on September 30, 2010; and Development of product validation "tools" that include those targeted for use in operations (routine tools) and in STAR (deep dive tools.

- **ACCOMPLISHMENTS**

The LW ERB products are the Option 2 products whose schedules are initially one year behind the Baseline products. Since the early start of the OLR algorithm development, we have moved forward and aligned the LW ERB schedule to the Baseline shortwave ERB products. The LWERB algorithms have been developed, validated, coded in Fortran, and implemented into the framework for system integration testing. All three algorithms have met the 100% F&PS requirements.

- The 100% code package and ATBD documents are completed and delivered.
- The validations of four-month framework test run for OLR, DLR and ULR have been performed.
- Extended OLR validation has been performed with four months of data that complement the framework tests. The extended OLR validation results are consistent with earlier findings.
- The ADEB review of LWRB products have been completed.
- The Ver.1 LWRB Routine and Deep-dive Validation Tool packages were delivered in November 2010 and the Version 2 packages are under development (scheduled to deliver in December 2011).
- Continue to provide the LWRB Algorithm Verification and Validation (V&V) support.

PLANNED WORK

- The Ver.2 LWRB Routine and Deep-dive Validation Tool packages are scheduled for delivery in December 2011 (with the Version 3 packages to be delivered in later 2012).
- Continue to provide Framework and LWRB Algorithm Verification and Validation (V&V) support.

PUBLICATIONS

Lee, H.-T., I. Laszlo, and A. Gruber, 2010: ABI Earth Radiation Budget - Outgoing Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (submitted)

Lee, H.-T., I. Laszlo, and A. Gruber, 2010: ABI Earth Radiation Budget – Surface Downward Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (submitted)

Lee, H.-T., I. Laszlo, and A. Gruber, 2010: ABI Earth Radiation Budget – Surface Upward Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (submitted)

PRESENTATIONS

Lee, H.-T., et al., 2011: GOES-R AWG Product Validation Tool Development for LW ERB Products. GOES-R AWG Annual Meeting, Fort Collins, CO., June 14-16, 2011.

DELIVERABLES

Routine and Deep-Dive Validation Tools Ver.1 packages for LW ERB products (OLR, DLW and ULW).

Combining GOES-R and GPM to improve GOES-R rainrate product

Task Leader	Nai-Yu Wang
Task Code	NWNWGOESR11
Contribution to CICS Themes	Theme 1: 70%; Theme 2: 30%
Contribution to NOAA Goals	Goal 1: 30%; Goal 2: 70%

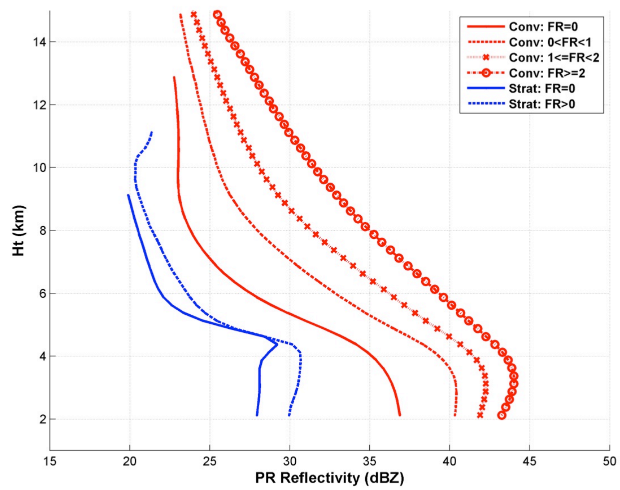
BACKGROUND

This project focuses on the multi-instrument and multi-platform synergy of combining GOES-R and NASA GPM to improve precipitation products. The proposed project has two objectives: 1) to improve microwave-based precipitation by connecting the ice-phased microphysics commonly observed by GOES-R GLM and GPM microwave instruments 2) to provide GOES-R rain-rate (QPE) algorithm a better microwave rain-rate calibration. Innovative strategy to make use of lighting and microwave data in identifying the convective and stratiform rain types will be developed, which will improve microwave-based rain rate estimates. Because GOES-R ABI rainfall rate (QPE) algorithm requires the microwave-based rain rates as a calibration target (Kuligowski, 2009), the better microwave rain rates will improve the accuracy of GOES-R rainfall rate retrievals.

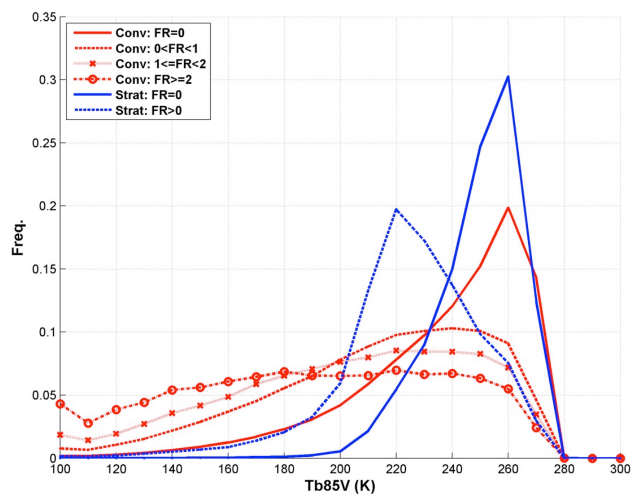
Passive microwave precipitation algorithms generally employ a convective and stratiform partitioning scheme to identify convective fraction for each pixel. Methods used to calculate the areal convection fraction typically draw upon measures of 37 and 85 GHz rainfall signal from a single pixel, as well as spatial variability of rainfall such as the minimum 85 GHz Tb, the gradient and standard deviation of 85 GHz Tb from adjacent neighboring pixels centered around the pixel to be classified [*Kummerow et al.*, 2001; *Grecu and Anagnostou*, 2001; *Olson*, 2001; *McCollum and Ferraro*, 2003; *Dinku and Anagnostou*, 2005, *Gopalan, et al.*, 2010]. In this study, we investigate the viability of using lightning in conjunction with passive microwave to maximize the correlation between convective precipitation and PM measurements. The goal here is to use lightning information to improve PM's ability to discriminate convective and stratiform precipitation.

ACCOMPLISHMENTS

This study addresses the hypothesis that lightning can be used to help PM better delineate convective and stratiform precipitation. Four years (2002-2005) of TRMM Microwave Imager (TMI), Lightning Imaging Sensor (LIS), and Precipitation Radar (PR) data are co-located for analysis and derivation of a robust and physically based convective and stratiform separation. The relationships between flash rates, PR reflectivity and 85 GHz TBs are illustrated in Figure 1. Convective pixels are divided into the four flash rate (FR) categories of Table 1: FR=0, 0<FR<=1 fl/min, 1<FR<=2 fl/min and FR>2 fl/min; while stratiform pixels (where high flash rates are rare) are divided into 2 flash rate bins: FR=0 and FR>0. Figure 1a shows the median PR reflectivity profiles for each of these 6 categories. For convective pixels, the categories with higher lightning activity tend to have higher peak reflectivity (i.e., large size ice particles, Figure 1a), cooler Tb_{85V} (i.e., large IWP, Figure 1b), and higher surface reflectivity (i.e., heavy surface precipitation, not shown here). The convective categories also tend to have deeper storm structures; i.e. the high reflectivity values (>40 dBZ) extend to greater heights, indicating strong up-draft and convective activity. For example, the median reflectivity profile of convective pixels with 0<FR<=1, shows the reflectivity peak of 40 dBZ at 3.5 km, where above this height the reflectivity decreases gradually to 30 dBZ at ~7km. Profiles of more electrical active convective pixel ,i.e. FR>2, exhibit reflectivity greater than 30 dBZ extent up to 11 km, and the reflectivity peak of 44 dBZ at 3.5 km. These same profiles show a broad range of Tb_{85V}, but the relative frequency of colder values increases with increasing lightning activity (Figure 1b).



(a)



(b)

Figure 1a: (Top) Median reflectivity profiles for convective and stratiform rain types separated by lightning activity, and Figure 1b: (bottom) Tb_{85V} histograms for each subset in part a), from Jan 2002 –Dec 2002.

Based on the distribution of lightning flash rates in the four years of TRMM TMI/PR/LIS data discussed in the previous paragraph, we stratify the data into 4 categories with increasing lightning activity (see Table 1); this is equivalent to classify the data into categories with increasing convective activity. The convective fraction relationships for the 4 convective categories are trained using TRMM data from January 2002- December 2005. Figure 2 shows the frequency distribution of TMI and TMI-LIS convective fraction estimates for the convective and stratiform as referenced by TRMM PR. For pixels tagged by PR as convective (P(C) = 1), the TMI-LIS algorithm detects higher convective fractions than TMI. TMI-LIS jointly identify ~10% more pixels as completely convective (convective fraction=1) compared to TMI; and these pixels have TMI convective fractions in the 0.4 – 0.6 range. For stratiform pixels, the TMI-LIS algorithm estimates marginally lower convective fractions.

The impact of using LIS information along with TMI is summarized in Table 2, which contains the mean biases and root-mean-square (RMS) errors of the TMI and TMI-LIS estimates compared to PR. The improvement in the TMI retrievals upon incorporating LIS information is most clearly observed in deep convective systems. For convective pixels (PR P(C) = 1), the mean bias in the convective ratio for TMI-LIS compared to PR is ~8% lower than the corresponding value for the TMI algorithm. Consequently, the mean rainrate bias relative to PR is reduced from ~17% to ~12% by adding LIS information to TMI. However, the RMS error in the TMI-LIS rainrate estimates is ~4.5% higher compared to the TMI estimates. This indicates that even though the TMI-LIS algorithm improves the mean biases (both in CSI and RR estimates), it appears to increase the variance of rainrate errors relative to PR. This may be due to the original RR_{conv} and RR_{stra} regressions. These $Tb_{85V} – RR$ relationships were not stratified by lightning categories. For future algorithm development, calculating $Tb_{85V} – RR$ convective and stratiform relationships based on Table 1 that incorporates lightning might be the next step to better improve the impact of lightning on PM rain-rate algorithms. The overall rainrate improvement is 6%.

Table 1: *Categories with increasing lightning activity.*

Category	Criterion	Number of pixels (Percentage)	Rain Type Distribution Convective/Stratiform/Other (%)
Category 0 (CAT0)	Pixels where LIS detects no flashes	~13 million (94%)	6% / 61% / 33%
Category 1 (CAT1)	Pixels where LIS detects 0-1 flashes/min	~470,000 (3.4%)	34% / 21% / 45%
Category 2 (CAT2)	Pixels where LIS detects 1-2 flashes/min	~221,000 (1.6%)	47% / 11% / 42%
Category 3 (CAT3)	Pixels where LIS detects > 2 flashes/min	~89,000 (0.6%)	99.7% / 0.25% / 0%

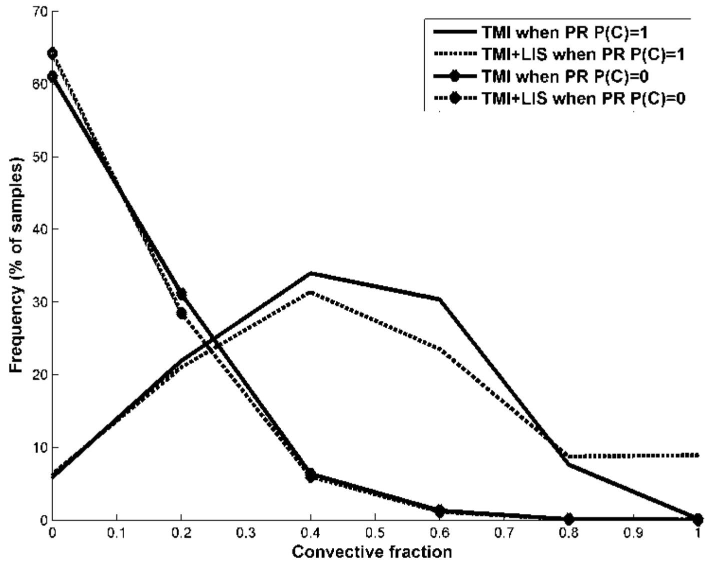


Figure 2: Frequency distributions of TMI and TMI-LIS convective fractions for convective pixels and stratiform pixels (as defined by PR) from Jan 2006 –Dec 2009.

Table 2: *Mean biases and RMS errors between TMI & TMI-LIS conv. fractions and RRs compared to PR*

	Conv. fraction				**RR (mm/hr)**			
	TMI – PR		**TMI-LIS – PR**		**TMI – PR**		**TMI-LIS – PR**	
	Bias	**RMSE**	**Bias**	**RMSE**	**Bias**	**RMSE**	**Bias**	**MSE**
All pixels	-0.02	0.26	-0.02	0.26	0.8	4.8	0.8	4.9
Convective: PR P(C)=1	-0.55	0.58	-0.51	0.57	-2.1	9.0	-1.5	9.4
Stratiform: PR P(C)=0	0.10	0.15	0.09	0.15	0.9	3.2	0.9	3.1

PLANNED WORK

- A manuscript entitled “Lightning, radar reflectivity and passive microwave observations over land from TRMM: Characteristics and applications in rainfall retrievals” is in the development and will be submitted to Journal of Geophysical Research shortly.
- We’re at the end of 2 year project and this report is considered the final report. The database established for this project is currently being utilized by a separate GOES-R3 project entitled “Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates” lead by Robert Adler and Nai-Yu Wang.

PUBLICATIONS

Wang, N.-Y., Gopalan, K., and Albrect, R., Lightning, radar reflectivity and passive microwave observations over land from TRMM: Characteristics and applications in rainfall retrievals, *Journal of Geophysical Research*. To be submitted.

PRESENTATIONS

Wang, N.-Y., Gopalan, K., and Albrect, R., Improving precipitation retrieval using total lightning data: a multi-sensor, multi-platform synergy between GOES-R and GPM, 2012 AMS Annul Meeting

18^{th} Conference on Satellite Meteorology, oceanography, and climatology, January 25, 2012

Wang, N.-Y., Gopalan, K., and Albrect, R., Combing GOES-R and GPM to improve GOES-R rainrate product, 2011 GOES-R Science Week, Huntsville, Alabama

Application of the GOES-R Land Surface Temperature Product for snowmelt mapping

Task Leader Cezar Kongoli

Task Code CKCKLS_R311

Contribution to CICS Themes Theme 1: 40%; Theme 2: 30%; Theme 3: 30%

Contribution to NOAA Goals Goal 1: 10%; Goal 2: 80%; Goal 5: 10%.

BACKGROUND

Land surface temperature (LST) lies at the heart of the surface energy balance and is a key variable in weather and climate models. Satellite LST produced routinely from the imagery data of geostationary (GOES) and polar-orbiting (POES) satellites can be assimilated into climate, mesoscale atmospheric and land surface models for improved estimates of land surface conditions or as input to land surface models for estimating sensible and latent heat fluxes in agricultural and natural landscapes.

LST is one of the baseline products in the GOES-R ABI processing system and on the priority development list of the GOES-R Algorithm Working Group. The main goal of this project is to improve the GOES-R LST algorithm over snow for use in a new snowmelt mapping application. This new application would offer the capability to detect melt on-set and monitor rapidly evolving synoptic weather events conducive to solar-radiation driven snowmelt. Another goal of this project is to use the remotely sensed LST in surface energy balance modeling and land data assimilation schemes all-year round Note that GOES LST applications for land surface modeling are restricted to snow-free landscapes. It is anticipated that the improved LST product be used by the NOAA's NCEP/EMC land surface team during demonstration phase for validation of model-derived LST and LST data assimilation for melting and patchy snow conditions. This proposal is for the first year support of the GOES-R Land Surface Temperature Product for snowmelt mapping

ACCOMPLISHEMENTS

Since the start of this project in January, 2012, a snow dataset has been compiled at selected sites in continental US for assessment of the GOES-derived LST. This dataset includes standard meteorological observations, surface snow measurements of depth and snow fraction, and surface temperature and energy fluxes of radiation and turbulent heat. The snow fraction observations are needed for assessment of fractional snow cover on retrieved surface temperature. Surface temperature measurements are needed for algorithm validation and improvements, and standard meteorological observations along with surface energy fluxes are needed for land surface model simulations using remotely sensed LST. GOES sensor data are being collected and combined with the snow dataset.

In synergy with a USDA project that is being leveraged for the GOES-LST, a remote sensing-based land surface modeling scheme called the Two-Source Energy Balance (TSEB) model has been extended over snow-covered landscapes for estimating surface energy fluxes and temperature over composite snow-vegetation surfaces.

PLANNED WORK

- Apply the GOES LST algorithm to snow data at the selected sites
- Assess the impact of fractional snow cover parameter on the retrieval of LST
- Based on assessment results, make adjustments to the algorithm to account for patchy snow cover

Land Surface Temperature Diurnal Analysis (Diurnal) to Validate the Performance of GOES-R Advance Baseline Imager

Task Leader Konstantin Vinnikov
Task Code KVKVLSAWG11
Contribution to CICS Themes Theme 1: 75%; Theme 2: 25%
Contribution to NOAA Goals Goal 1: 30%; Goal 2: 70%

BACKGROUND
The goals of this Task are: to statistically evaluate angular anisotropy of LST (Land Surface Temperature) using available simultaneous land based and satellite, GOES-E and GOES-W, observations at locations of SURFRAD stations; to develop algorithm for correcting GOES-R retrieved clear sky LST for angular anisotropy of LST field; to take into account angular anisotropy of LST in validation of GOES-R observed LST.

There are only a few modeling and case study type previous investigations on this subject, which includes empirical evaluation of "Anisotropy in the land surface temperature as observed with two geostationary satellites" by Peter Romanov and Dan Tarpley. They concluded that "at least 2-3 K temperature change may be caused by changing the relative solar-satellite azimuth from backscatter to approximately 90º. The difference between temperatures observed in the backscatter and forward scatter may be higher. The major reason for the temperature differences is the effect of shadows".

The climatological approach is applied here. The main requirements to the angular correction algorithm is to convert satellite observed directional LST, *T(z,zs,az)*, that depends on satellite viewing angle *z*, sun zenith angle *zs*, and azimuth *az* into the scalar, unbiased, energy effective value of LST, θ, that can be used in land surface energy balance computation.

ACCOMPLISHMENTS
Two-kernel approach
The proposed statistical model to approximate angular dependence of satellite observed LST can be expressed by the next simple equation:

$$T(z,zs,az)/T(0) = 1+A\cdot\varphi(z)+D\cdot\psi(z,zs\leq 90^{o},az), \qquad (1)$$

where: T(0) is LST in the nadir direction at z=0; φ(z) is "infrared kernel" (related to angular anisotropy of infrared radiation near land surface); ·ψ(z,zs≤90º,az) is "solar kernel" (related to angular anisotropy in solar radiation near land surface), ψ(z,zs≥90º,az)≡0; A and D are the coefficients that should be estimated from observations. These coefficients depend on land cover structure. Such a model follows traditional structure of the BRDF semi-empirical models based on linear combination of "kernels" as it is generalized by David L. B. Jupp in "A compendium of kernel & other (semi-) empirical BRDF Models," available from http://www.eoc.csiro.au/tasks/brdf/k_summ.pdf.

Statistical empirical models $\varphi(z)$ and $\psi(z,zs\leq 90^{o},az)$ are developed using available simultaneous clear sky LST observations of two satellites, GOES-8 and GOES-10, at five representative SURFRAD station locations during one full year 2001. Small, about 15 minute, difference in observation time of the satellites has been taken into account using analytical approximations of seasonal and diurnal variations of LST at each of station as it has been demonstrated in (Vinnikov et. al., 2008, 2011). At this stage, dependence of the A and D coefficients on land cover structure has been ignored.

Infrared kernel

Nighttime observations, $z>90^{o}$ only, have been used to find the best expression for "infrared kernel" $\varphi(z)$ and to estimate A value. Using LST T_E and T_W, observed by GOES-E and GOES-W satellites, respectively , we have to assume that one of them, arbitrary chosen, is unbiased and the other one has constant bias in the observed LST. Let us assume that GOES-W observed LST, T_W , is biased compared to GOES-E and T_W value should be substituted by T_W+B_w, were B_W is an unknown constant bias, to be determined. Using expression (1) for observations at $z>90^{o}$ we can write:

$$T(0)\approx T_E /[1+A\cdot\varphi(Z_E)]\approx[T_W+B_W]/ [1+A\cdot\varphi(Z_W)]. \quad (2)$$

This equation in the next form can be used for testing different approximations of $\varphi(z)$ and least square estimation of the unknowns B_W and A:

$$T_E-T_W \approx B_W+A*(T_W+B_W)\cdot\varphi(Z_E)-T_E\cdot\varphi(Z_W). \quad (3)$$

The equation has been written for each pair of simultaneous observations of the satellites at locations of five SURFRAD stations. Total number of equations is equal to N=1619. Not more than three iterations are needed to resolve rather weak nonlinearity in (3). Correlation coefficient between left and right parts of (3) has been used as measure of quality of selected approximation of $\varphi(z)$ kernel. The best results have been obtained with next approximations:

$$\varphi(z)=A\cdot[1-\cos(z)],\ B_W=0.57\text{ K},\ A=-0.0138. \quad (4)$$

Solar kernel

Following to the same procedure as for infrared kernel, we selected the next simple analytical expression to approximate solar kernel:

$$\psi(z,zs,az)=[1-\cos(z)]\cdot\sin(zs)\cdot\cos(zs)\cdot\cos(zs-z)\cdot\cos(az). \quad (5)$$

The analogues to the equations (2) and (3) are:

$$T(0)\approx T_E /[1+A\cdot\varphi(Z_E)+D\cdot\psi(Z_E,ZS,AZ_E)]\approx[T_W+B_W]/ [1+A\cdot\varphi(Z_W))+D\cdot\psi(Z_W,ZS,AZ_W)], \quad (6)$$

$$T_E\cdot[1+A\cdot\varphi(Z_W)]-(T_W+B_W)\cdot[1+A\cdot\varphi(Z_E)]\approx D\cdot[(T_W+B_W)\cdot\psi(Z_E,ZS,AZ_E)-T_E\cdot\psi(Z_W,ZS,AZ_W)]. \quad (7)$$

Assuming A and B_W are known, equation (7), written for each pair of observations, has been used to obtain the least square estimate of amplitude D in (1):

$$D=0.0313. \tag{8}$$

The correlation coefficient between left and right sides of equation (7) is equal to 0.62.

Algorithm for angular correction of satellite observed LST.
Satellite observed angular dependent LST should be converted into the temperature θ that can be used in land surface energy balance computations. Let us define such land surface temperature as the next:

$$\theta^4 = \pi^{-1} \int_0^{2\pi} \int_0^{\frac{\pi}{2}} T(z',\beta)^4 \sin(z') \cos(z')\, dz' d\beta \tag{9}$$

T(z,β) in (9) can be obtained from the observed T(Z,ZS,AZ) at satellite zenith viewing angle Z , solar zenith angle ZS, and relative azimuth AZ, using model (1).

$$T(z,\beta)=T(Z,ZS,AZ)\cdot[1+\varphi(z)+\psi(z,zs,az)]/[1+\varphi(Z)+\psi(Z,ZS,AZ)]. \tag{10}$$

$$\theta = \frac{T(Z,ZS,AZ)}{1+\varphi(Z)+\psi(Z,ZS,AZ)} \left(\pi^{-1} \int_0^{2\pi} \int_0^{\frac{\pi}{2}} [1+\varphi(z')+\psi(z',sz,\beta)]^4 \sin(z')\cos(z')\, dz' d\beta\right)^{0.25}. \tag{11}$$

$$\theta = T(Z,ZS,AZ) \cdot C/[1+\varphi(Z)+\psi(Z,ZS,AZ)]. \tag{12}$$

$$C = \left(\pi^{-1} \int_0^{2\pi} \int_0^{\pi/2} [1+\varphi(z')+\psi(z',sz,\beta)]^4 \sin(z')\cos(z')\, dz' d\beta\right)^{0.25} \tag{13}$$

$$C=0.9954. \tag{14}$$

In such a way we can estimate unbiased annular corrected effective values of LSTs

$$\theta_E=T_E\,(Z_E)\cdot C/[1+\varphi(Z_E)+\psi(Z_E,ZS,AZ_E)]. \tag{15}$$

$$\theta_W= (T_W(Z_W)+B_W)\cdot C/[1+\varphi(Z_W)+ \psi(Z_E,ZS,AZ_E)]. \tag{16}$$

Equations (15-16) give the first version of the algorithm for angular correction of GOES-R observed LST. The function T(z,zs,az)/T(0) for different sun zenith angles is shown in Figure 1.

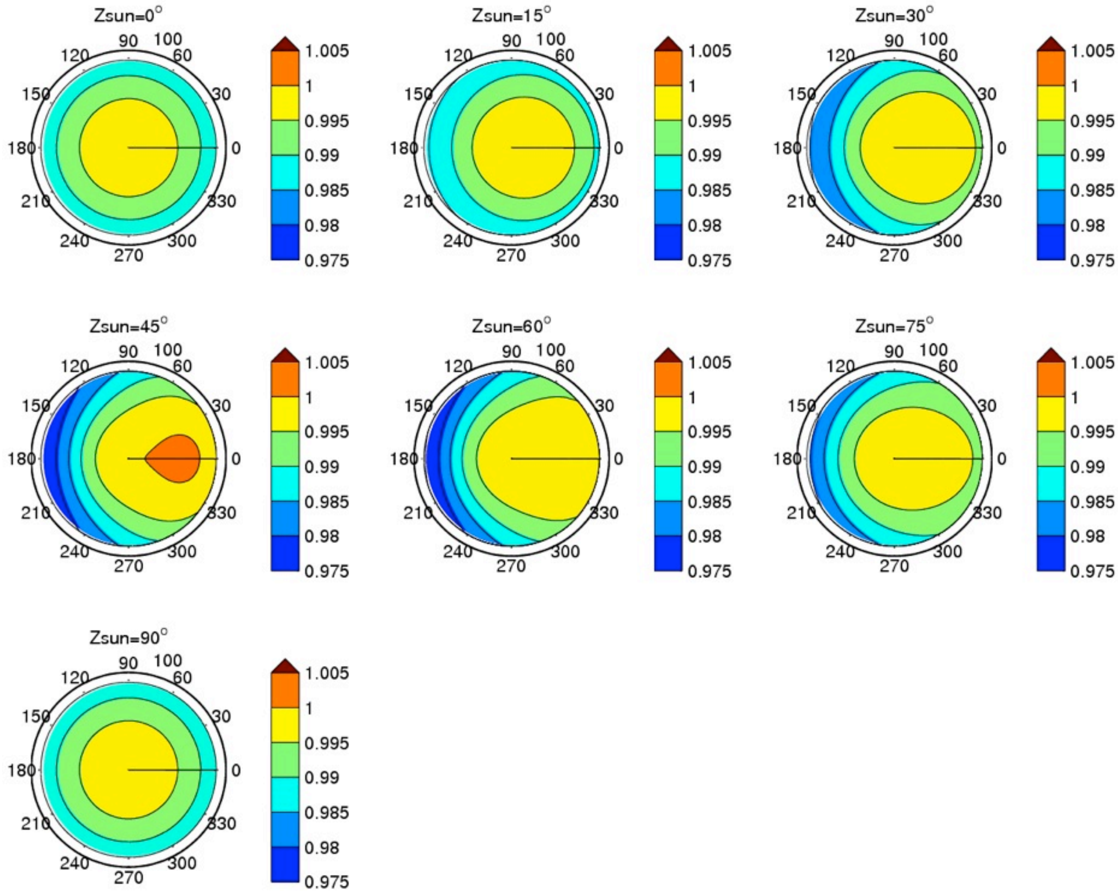


Figure 1: Estimated angular dependence of satellite observed LST for different solar zenith angles, T(z,zs,az)/T(0)=1+A·φ(z)+D·ψ(z,zs,az), is displayed in polar coordinate system (viewing zenith angle – radial coordinate 0-90º, relative azimuth-angular coordinate 0-360º)

PLANNED WORK

The first version of the algorithm for angular correction of GOES observed LST will be assessed and improved using LST data retrieved from observations of upward and downward infrared fluxes at the SURFRAD stations. Work on improving the approximating expressions for infrared and solar kernels will be continued. Work on taking into account anisotropy of LST in validation of GOES-R observed LST will be continued.

GOES-R Proving Ground

Task Leader Michael Folmer
Task Code PASRPG_R311
Contribution to CICS Themes Theme 1: 20%; Theme 2: 80%
Contribution to NOAA Goals Goal 2: 50%; Goal 5: 50%

BACKGROUND

The Geostationary Operational Environmental Satellite R-Series (GOES-R) Proving Ground is a collaborative effort between the GOES-R program office, cooperative institutes, weather forecast offices, National Centers for Environmental Prediction (NCEP) National Centers, and National Oceanic and Atmospheric Administration (NOAA) Testbeds across the country. The Proving Ground is a project in which simulated GOES-R products can be tested and evaluated before the GOES-R series of satellites are launched into space. The simulated GOES-R products are generated using combinations of currently available GOES data, along with higher-resolution data provided by instruments on polar-orbiting satellites such as the Moderate Resolution Imaging Spectroradiometer (MODIS) on National Aeronautic and Space Administration's (NASA) Aqua and Terra satellites as well as model synthetic satellite data.

The GOES-R Proving Ground efforts based at the NOAA National Weather Service (NWS) Hydrometeorological Prediction Center (HPC), Ocean Prediction Center (OPC), National Hurricane Center (NHC) Tropical Analysis and Forecast Branch (TAFB), and National Environmental Satellite, Data, and Information Service (NESDIS) Satellite Analysis Branch (SAB) in Camp Springs, Maryland requires a full-time visiting scientist to coordinate the evaluation effort, help facilitate product availability, generate combined reports in a timely manner, interact with forecasters directly to help train them on the application of products, and provide feedback to product developers.

ACCOMPLISHMENTS AND PLANNED WORK

A Research Associate (RA) was hired by the Cooperative Institute for Climate and Satellites (CICS) on 15 May 2011 to provide leadership, satellite expertise, and meteorological support for the GOES-R Proving Ground efforts based at HPC, OPC, TAFB, and SAB. This project is focused on maximizing the forecast value of geostationary satellite data and products. The CICS RA interacts with NWS operational forecasters and NESDIS satellite analysts to prepare them for new satellite products that will become operationally available after the launch of the GOES-R satellite series.

Products have been ingested using a Local Data Manager (LDM) and FTP scripts. The first product to be introduced was the Red, Green, Blue (RGB) Airmass product, which aids in the identification of various airmasses. Collaborations have begun between the CICS RA and NASA SPoRT (RGB product developer) to quantify the RGB product performance, potentially providing additional tools to increase forecaster confidence in the identification of stratospheric intrusions as seen in the Airmass products. Approximately 25-30 forecasters and analysts have been trained on the product and feedback has been gathered to report back to the developers and the GOES-R Program Office. Additional research collaboration has begun with Saint Louis

University and the NASA DEVELOP program to further investigate the use of this product for explosive extratropical cyclogenesis and associated high wind events. The researcher also is involved in meetings to discuss the future direction of NESDIS satellites, training with VISIT/SHyMET, and various other research groups.

Additional products are currently being ingested at the Proving Grounds, which will be introduced to forecasters in the next month. These products include the WRF-simulated Advanced Baseline Imager (ABI) radiances for bands 8 through 16, and the Enhanced-V / Overshooting Top Detection Algorithm. Looking forward, products to be introduced and tested include Convective Initiation, Lightning Detection, Cloud Top Phase, Cloud Top Height, Cloud Top Temperature, Volcanic Ash, Quantitative Precipitation Estimate (QPE) / Rainfall Rate, and Derived Motion Winds.

PUBLICATIONS

Folmer, M., R. Pasken, T. Eichler, G. Chen, J. Dunion, and J. Halverson, 2011: The Impact of the Saharan Air Layer on the Development of Eastern Atlantic Tropical Cyclones. *PhD Dissertation*, Saint Louis University, ProQuest.

PRESENTATIONS

Fuell, K., A. Molthan, M. Folmer, and M. DeMaria, 2011: Demonstration of RGB Composite Imagery at NOAA National Centers in Preparation of GOES-R. *7th GOES User's Conference*, Birmingham, AL, October 15-21.

Folmer, M.J., B. Reed, S. Goodman, J. M. Sienkiewicz, E. Danaher, J. Kibler, and D. R. Novak, 2012: The 2011 HPC/OPC/SAB GOES-R Proving Ground Demonstration. *Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 92nd American Meteorological Society Annual Meeting*, New Orleans, LA, January 22-26 .

Folmer, M.J., R. W. Pasken, T. Eichler, G. Chen, J. Dunion, and J. Halverson, 2012: The Impact of the Saharan Air Layer on the Development of Eastern Atlantic Tropical Cyclones. *Fourth Symposium on Aerosol-Cloud-Climate Interactions, 92nd American Meteorological Society Annual Meeting*, New Orleans, LA, January 22-26.

PROPOSALS SUBMITTED

- GOES-R Risk Reduction Visiting Scientist Proposal - Awarded $2890 for travel on 12/14/11
- NASA DEVELOP proposal with Saint Louis University and NASA SPoRT
- 2012 JPSS Proving Ground and Risk Reduction Proposal

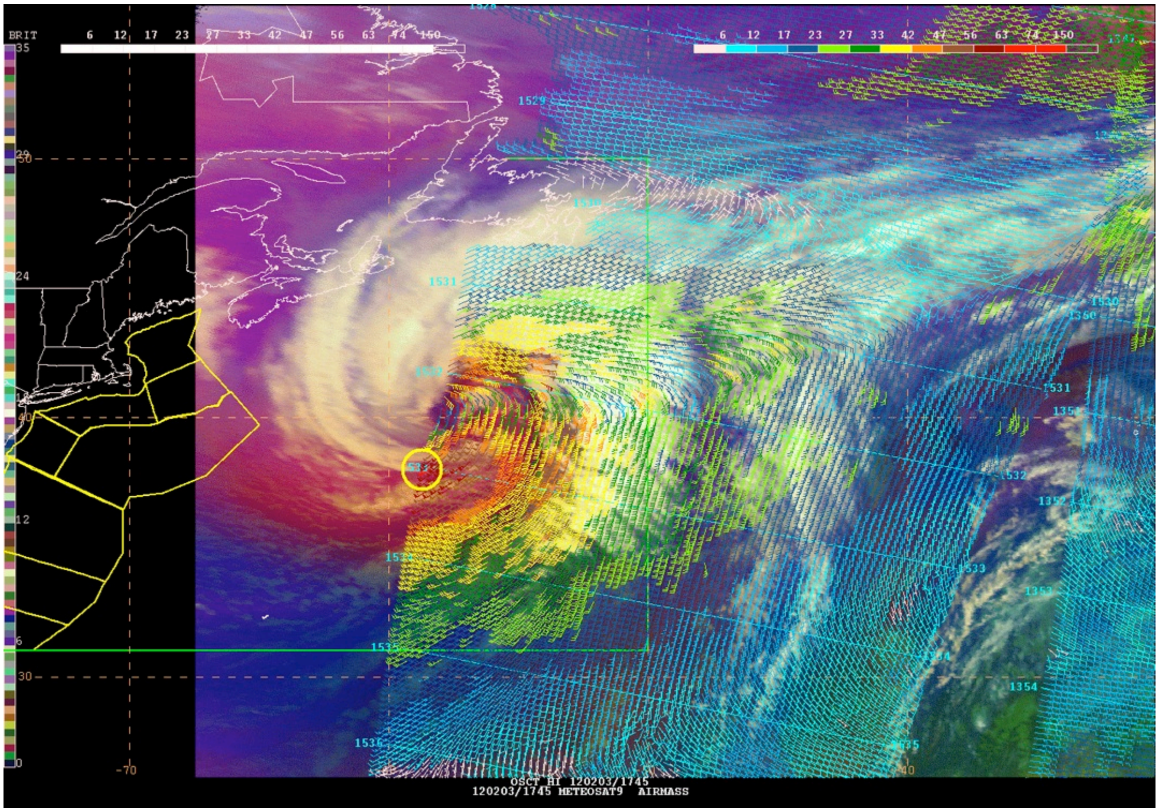


Figure 1: The Spinning Enhanced Visible Infra-Red Imager (SEVIRI) RGB Airmass product above shows a rapidly deepening extratropical cyclone southeast of Nova Scotia. An Ocean-sat-2 Scatterometer (OSCAT) high resolution wind plot is overlaid to show the high wind associated with a stratospheric intrusion. The pink coloring is the dry, stratospheric air advecting into the PV anomaly at storm center with a red flag (yellow circle) highlighting a 65 knot wind observation.

Validation and Refinement of GOES-R Fire Detection Capabilities

Task Leader Dr. Wilfrid Schroeder

Task Code WSWSABAWG1 and WSWSGOESR11

Contribution to CICS Themes Theme 1: 100%

Contribution to NOAA Goals Goal 1: 50%; Goal 5: 50%

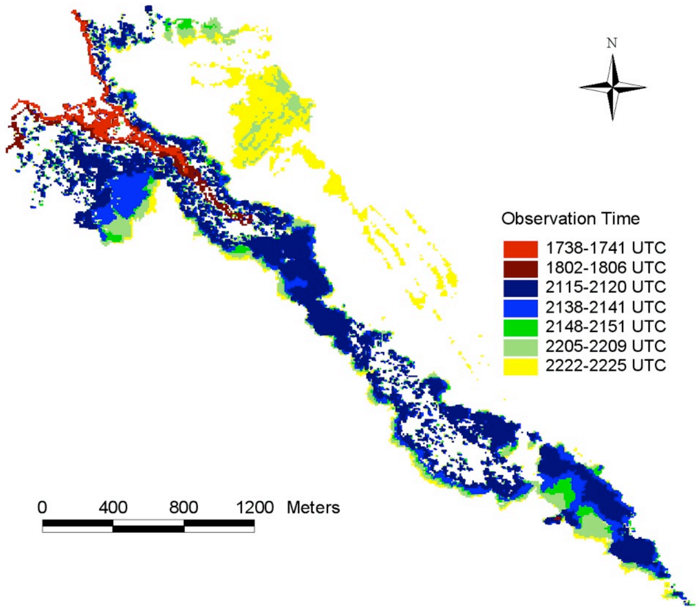
BACKGROUND

This task relates to the development of the *deep-dive* validation for the GOES-R ABI active fire detection and characterization algorithm using higher spatial resolution reference data. The methodology has been previously applied to moderate-to-coarse spatial resolution data, including the global validation of the Terra MODIS *Fire and Thermal Anomalies* product (MOD14)[URL1], and the regional validation of the GOES Imager Wildfire Automated Biomass Burning Algorithm (WF_ABBA) [Schroeder *et al*. 2008a] and NOAA/NESDIS's Hazard Mapping System (HMS)[Schroeder *et al*., 2008b]. The fire detection probabilities and false alarm rates are calculated from the summary fire statistics derived from binary fire masks (fire – no fire) produced by near-coincident higher spatial resolution Landsat-class data [Giglio *et al*., 2008; Schroeder *et al*., 2008a].

ACCOMPLISHMENTS

The first main module of the *deep-dive* validation tool designed to assess the binary (fire – no fire) GOES-R ABI active fire detection product was completed in 2011. Algorithm refinements were introduced to allow use of a wide variety of future reference data. Algorithm documentation was started in 2011, including preparation of an Algorithm Theoretical Basis Document (ATBD) describing the methodology used in the development of the GOES-R *deep-dive* active fire detection validation.

Development of the second main module of the *deep-dive* tool focusing on the validation of GOES-R ABI active fire retrievals (Fire Radiative Power [FRP], fire size and temperature) involved extensive testing of retrieval methods applied to fine spatial resolution airborne data. Most of the work was concentrated on the NASA Ames Research Center Autonomous Modular Sensor – Wildfire (AMS) airborne instrument. That system was deployed over numerous wildfires in the western U.S., including a 450ha prescribed fire at Henry Coe State Park near San Jose, CA on October 2011. The Henry Coe airborne fire data were collected coincidently with GOES (11 and 13) Imager, MODIS (Terra and Aqua), and AVHRR (NOAA-15, 16, 18, 19 and METOP) sensor data, complemented by ground stations to support detailed fire retrieval calibration and assessment. The development of the *deep-dive* fire retrieval validation component is using these assorted data sets for testing and refinement of the methodology. Additional data from AMS shall become available during 2012 and will be incorporated to the analyses.



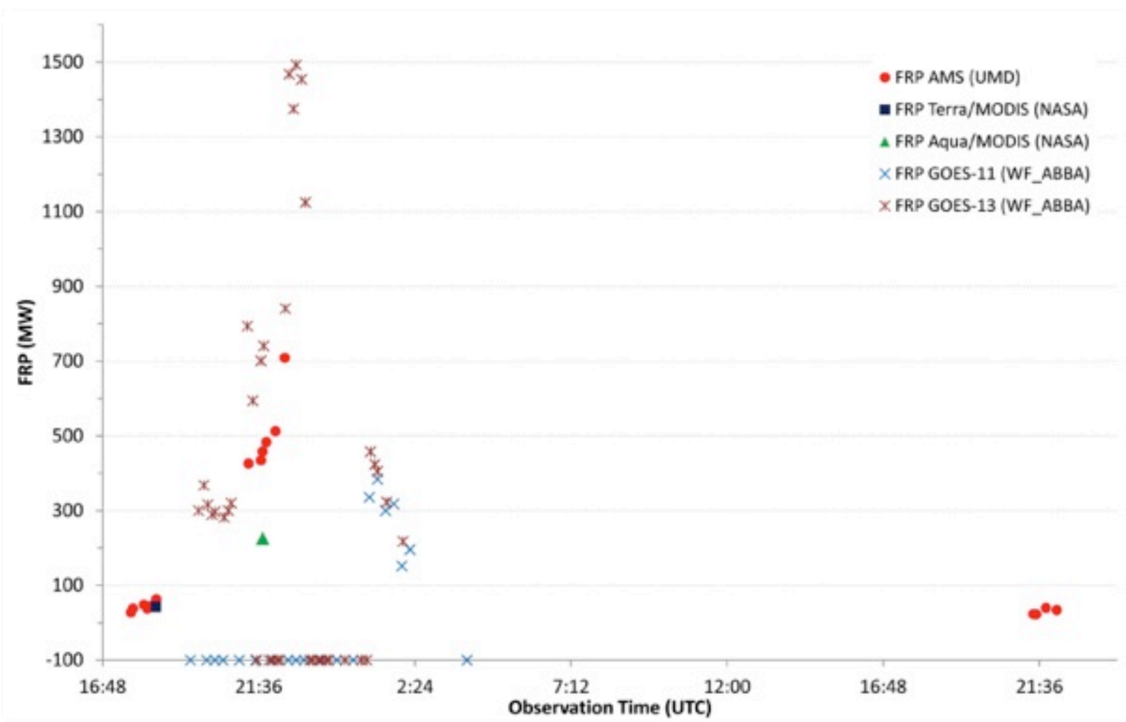


Figure 1: Progression of prescribed burn at Henry Coe State Park, CA as mapped by NASA/Ames Autonomous Modular Sensor-Wildfire (AMS) airborne instrument on Oct 18th 2011 (left) and the available fire retrievals (Fire Radiative Power [FRP]) derived from AMS, MODIS (Terra & Aqua) and GOES (11 & 13) imager data acquired starting ~1650UTC on Oct 18th and ending ~2200UTC on Oct 19th 2011.

OUTREACH

The GOES-R ABI active fire validation results described above were presented at the GOES-R AWG Annual Review meeting which took place in Fort Collins, CO June 14-16.

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Schroeder, W., Prins, E., Giglio, L., *et al*. (2008a), Validation of GOES and MODIS ac tive fire detection products using ASTER and ETM+ data. Remote Sensing of Environment, 112, 2711-2726.

Schroeder, W., Ruminski, M., Csiszar, I., *et al*. (2008b), Validation analyses of an opera tional fire monitoring product: The Hazard Mapping System. *International Jour nal of Remote Sensing*, 29(20), 6059-6066.

URL1: http://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD14

Development of Algorithms for Shortwave Radiation Budget from GOES-R

Task Leader Rachel Pinker
Task Code RPRPGOES11
Contribution to CICS Themes Theme 2: 100%
Contribution to NOAA Goals Goal 1: 100%

BACKGROUND
Under the GOES-R activity, new algorithms are being developed to derive surface and Top of the Atmosphere (TOA) shortwave (SW) radiative fluxes from the ABI sensor. This project supports the development and testing of the STAR effort. Specifically, scene dependent narrow-to-broadband (NTB) transformations and angular distribution models (ADMs) are developed to facilitate the use of observations from ABI. The NTB transformations are based on theoretical radiative transfer simulations with MODTRAN-3.7 using 14 land use classifications based on the International Geosphere-Biosphere Programme (IGBP). This represents an improvement over currently available NTB transformations that consider only 4 land use categories. The ADMs are a combination of MODTRAN-3.7 simulations and the Clouds and the Earth's Radiant Energy System (CERES) observed ADMs. The radiative transfer simulations provide information that fills in gaps in the CERES ADMs. The NTB transformations and ADMs have been tested using proxy data from multiple satellites to simulate ABI observations. Initial algorithms were delivered in 2010. The current focus is on validation and improvement.

ACCOMPLISHMENTS
Two major issues have been addressed:
- Determining the feasibility of developing alternative sets of NTB transformation coefficients based on different inputs that can be used as back-ups when the primary input observations from ABI are missing,
- Evaluating the quality of our algorithms by comparing the TOA SW upward fluxes we produced using MODIS proxy data against fluxes observed by the Geostationary Earth Radiation Budget (GERB) sensor aboard Meteosat-9.

Back-up NTB transformation coefficients
The NTB transformation coefficients and algorithms delivered in June 2010 were based on 3 channels of MODIS proxy data: 0.65 micron, 0.86 micron, and 0.47 micron. Extensive testing showed that NTB transformations derived with this channel combination produced the most accurate TOA SW upward fluxes. However, since ABI will provide radiance observations in 16 spectral intervals, it is also desirable to see if satisfactory results can be achieved using other channel combinations. This would allow flexibility if primary inputs are unavailable. We identified 12 possible combinations of channels in the visible and near-IR (NIR) portions of the spectrum for testing. Immediately we saw that combinations containing the NIR channels produced TOA SW upward fluxes with extremely high biases when compared to fluxes observed from CERES observations. We pinpointed the cause of the problem to be unrealistically high NTB coefficients in the NIR channels for ice clouds. The NTB coefficients are calculated by doing multiple linear regressions of the broadband albedo and the narrowband albedo for each MODIS channel. We found that for NIR channels, a non-linear relationship existed between the two al-

bedo types for ice clouds, particularly those with low values of cloud optical depth. The use of non-linear regression techniques did not seem to improve the results.

The table below summarizes our evaluation of TOA SW upward fluxes produced with 8 of the channel combinations in comparison to CERES fluxes. Combination 1 uses only two of the available visible channels (0.65 mm and 0.86 mm), and it compares reasonably well to the CERES TOA fluxes, although the bias is significantly higher than Combination 2, which was used for the initial delivery. Combinations 3 – 8 include at least one NIR channel, and they produce fluxes that are virtually unusable. Based on these results, we determined that the NIR channels are not suitable for use in the NTB transformations. The conclusion of our analysis is that it is only advisable to use Combination 1 as a back-up. This will be useful in cases where the 0.47 mm channel is not available. This analysis can be repeated with data from the various ABI channels once GOES-R becomes operational.

Table 1: *Evaluation of MODIS-derived vs. CERES-derived top of the atmosphere shortwave upward fluxes using all data available during the hours of 0 – 23 UTC on July 8, 2006 (873,032 observations). The highlighted combination was used for the original NTB coefficient delivery.*

Combo #	Channels (mm)						Bias (Wm^{-2})	SD (Wm^{-2})	Corr
	0.65	0.86	0.47	1.38	1.64	2.13			
1	X	X					12.0	37.7	0.97
2	**X**	**X**	**X**				**2.4**	**28.1**	**0.99**
3	X	X		X			51.9	102.8	0.92
4	X	X			X		80.3	162.6	0.91
5	X	X				X	-2.9	93.7	0.81
6	X	X	X	X			46.6	124.3	0.90
7	X	X	X		X		66.0	175.6	0.91
8	X	X	X			X	-34.4	83.1	0.87

Evaluation against GERB

We have made significant progress in our comparison of GERB observations and ABI fluxes simulated with MODIS proxy data. We have developed the software required for the following procedures: (1) read the GERB TOA SW upward fluxes and geo-locate the data, (2) visualize MODIS and GERB data for quality control, (3) collocate the MODIS pixels within the GERB grid boxes and average the MODIS-based TOA SW upward fluxes within each grid box (example is shown in figure below), (4) statistically compare the fluxes from each source. Preliminary evaluation with a sample size of 9248 GERB grid boxes shows a substantial negative bias of -37.5 Wm^{-2} in the MODIS-based fluxes. The underestimate of the MODIS-derived fluxes in comparison to GERB is not surprising. An in-depth evaluation of CERES vs. GERB SW TOA upward fluxes (Clerbeaux et al. 2009) found that GERB fluxes were 7.5% higher than CERES values. They attribute this mainly to absolute calibration differences between the GERB and CERES instruments. Previous comparisons of MODIS-derived SW TOA upward fluxes against CERES showed that globally the MODIS fluxes were about 1% higher than CERES. We are continuing to investigate this large negative bias in comparison to GERB by processing more swaths, comparing absolute radiances in addition to fluxes, and developing code to break down the analysis by surface type and cloud conditions.

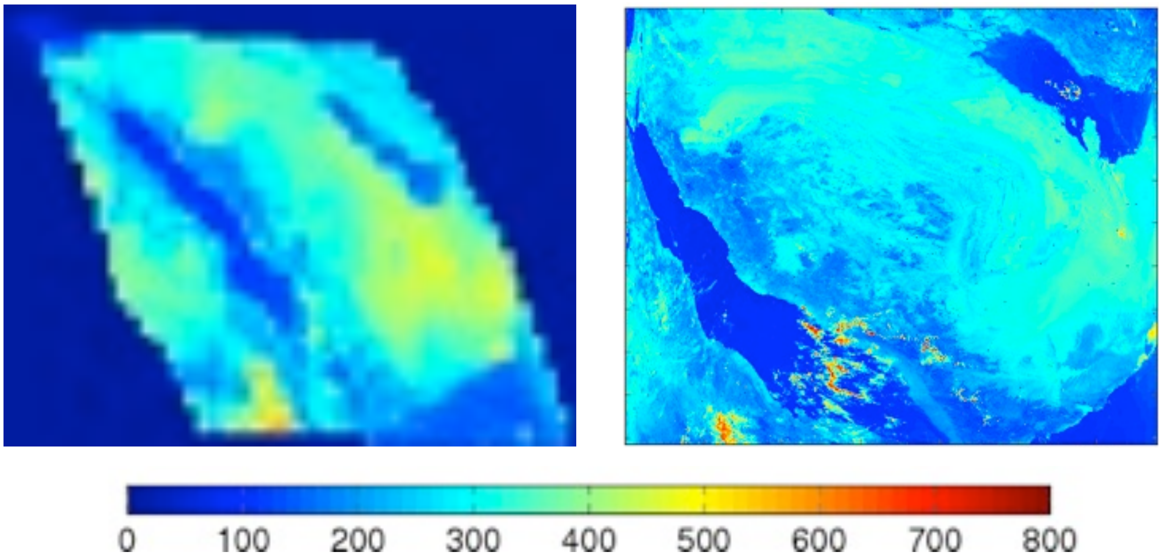

Figure 1: TOA SW upward flux (Wm^{-2}) from 8 Jul 2006 at 0745 UTC from GERB (left) and MODIS (right).

PLANNED WORK

- Improve and augment the NTB transformations for water and ice clouds. Additional simulations are needed to more accurately model radiative transfer in atmospheres where water and ice clouds are present.
- Perform additional testing to incorporate view zenith and azimuth angle dependence in the NTB transformations by augmenting the scope of the data base for more robust regression coefficients
- Routine Validation
    - Produce an extended collocation database that matches CERES and GERB reference observations with the algorithm products derived from MODIS and SEVIRI, addressing issues of angular and temporal matching as well as spatial resolution
    - Develop more visualization tools for algorithm products and reference data
    - Generate and visualize comparison statistics with emphasis on stratification for the following categories: clear-sky, cloudy-sky, all-sky, land, water, high elevation, low elevation
- "Deep Dive" validation tool for detailed product analysis
    - Extract all of the information that is pertinent for computing the TOA flux at a point, including: NTB coefficients and ADM correction used, solar and satellite geometry, reflectance in each channel used, surface type, snow cover, cloud amount, cloud type, COD
    - Correlate errors with individual input sources
    - Reprocess fluxes with the ability to change NTB and ADM input values and determine if a better result can be obtained

PUBLICATIONS

Niu, X. and R. T. Pinker (2011): Revisiting satellite radiative flux computations at the top of the atmosphere, International Journal of Remote Sensing, DOI:10.1080/01431161.2011.571298 **To link to this article:** http://dx.doi.org/10.1080/01431161.2011.571298

Wonsick, M., X. Niu and R. T. Pinker, 2012. A new technique to calculate shortwave radiative fluxes from SEVIRI. In preparation.

REFERENCES

Clerbaux, N., J. E. Russell, S. Dewitte, C. Bertrand, D. Caprion, B. De Paepe, L. Gonzalez Sotelino, A. Ipe, R. Bantges, and H. E. Brindley, 2009: Comparison of GERB instantaneous radiance and flux products with CERES Edition-2 data. *Rem. Sens. of Environ.*, **113**, 102-114. doi:10.1016/j.rse.2008.08.016

Implementation of the Geostationary SST algorithm for the GOES-15 satellite

Task Leader Jonathan Mittaz
Task Code JMJM_SST_11
Contribution to CICS Themes Theme 2: 100%
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

BACKGROUND

This proposal has two parts with the first relating directly to GOES-15 and the second relating to the impact of scattered light on the GOES-13+ set of sensors.
GOES-15 is the latest GOES satellite to go operational and covers the GOES-West (Western US and Pacific Ocean) sector and went operational in December 2011. To maintain the complete set of sensors currently processed under the Geostationary SST project (GOES-E/GOES-W, MTSAT and MSG), GOES-15 needs to be incorporated into the Geostationary Sea Surface Temperature processing system. The required changes and the result of the operational GOES-15 processing are detailed below.

Along with GOES-15 going operational, the GOES-13+ (GOES-N-GOES-P) series of satellites have issues with scattered light that biases the Geo-SST products. The scattered light problem arises because the GOES-13+ satellites were designed to operate through the complete eclipse season where previous GOES sensors were turned off. Now that the sensors remain on through eclipse a significant scattered light problem has been seen around local midnight where solar radiation is being scattered into the field of view and biasing the observed radiances. ITT has developed an algorithm to try and remove the scattered light from the data but the effectiveness of this model needs to be assessed as regards its impact on SST retrieval during times when the scattered light is a problem.

ACCOMPLISHMENTS

GOES-15

In order to get GOES-15 running as part of the operational Geostationary SST product suite significant changes needed to be made to the operational code, primarily related to the implementation of the fast radiative transfer model (RTM) used as part of the processing. Previously, the RTM used was NOAAs Community Radiative Transfer Model (CRTM) Version 1. Unfortunately, the required GOES-15 coefficients for the CRTM (the Spc and Tau coefficients) were not generated using CRTM Version 1 but only existed for CRTM version 2. This meant that the CRTM interfaces in the operational Geo-SST code had to be rewritten to use CRTM Version 2. The operational code also had to be updated to deal with GOES-15 data including updates to the Group for High Resolution SST (GHRSST) L2P code. All the code changes were successfully implemented before GOES-15 went operational (Figure 1). The GHRSST L2P datasets came one month after the satellite went operational due to the need to generate coefficients for the Single Sensor Error Statistics (SSES) required by the GHRSST L2P format, but these are now also being generated.

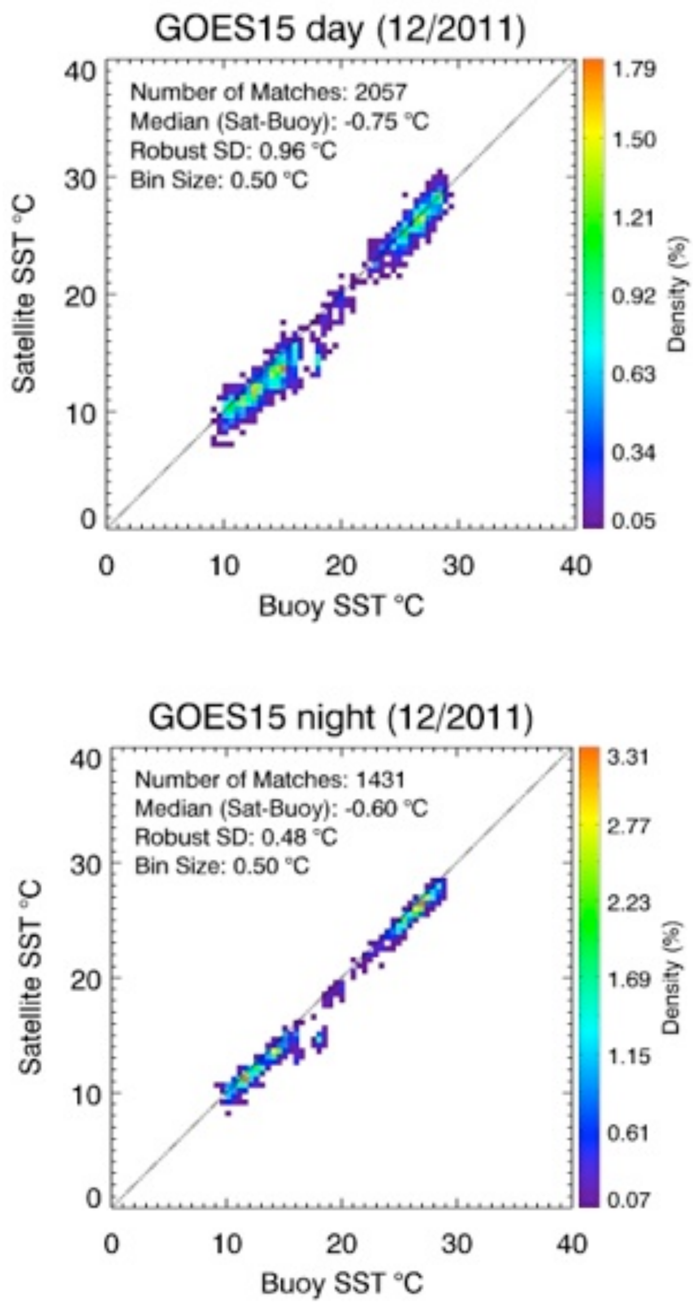

Figure 1: Validation plots for GOES-15 for December 2011 (when the satellite went operational). The data used in the validation was taken from the operational system. The statistics are comparable to those seen for GOES-13.
http://www.star.nesdis.noaa.gov/sod/mecb/goes_validation/test/sst_region.php.
Assessment of scattered light in GOES-13

GOES-13

As mentioned above, from GOES-13 onwards the GOES sensors are capable of observing throughout the eclipse season which leads to images which are contaminated with scattered solar radiation. Test data were provided by ITT to assess the impact of both the uncorrected and corrected scattered light on the Geo-SST retrievals. Figure 2 shows an example of one set of test images that have been analyzed by running the data through the Geo-SST processing chain. The four images show (from left to right and top to bottom) top-left: an uncorrected image, top-right: an image corrected with ITTs algorithm, lower-left: an image taken just before the time of the contaminated image and lower-right: the image taken directly after the contaminated image. The images show both the impact of the scattered light on the cloud mask as well as the difference between the Geo-SST derived SST and the OSTIA 0.05x0.05 analysis which has been used as a reference. Also shown are the histograms for the Geo-SST – OSTIA temperature differences.

Figure 2 clearly shows the impact of the uncorrected scattered light on the Geo-SST retrievals. Looking at the uncorrected image, because of the extra non-geophysical signal caused by the scattered light the Geo-SST cloud detection algorithm erroneously sets large regions to cloud, thereby losing valuable data. As one might hope, the ITT corrected image has much better coverage than the uncorrected image and probably recovers most of the good pixels. However, as is apparent in the histogram plot, while the coverage is improved the ITT corrected data is adding a bias to the retrieved SST which is of the order of 0.5K. While only one set of data is shown here, in total 9 images were analyzed and a similar conclusion was found in at least half of the images provided, namely that the coverage was improved by the ITT algorithm but an SST bias was also added. The Geo-SST team decided that because of this bias we would exclude corrected pixels from the Geo-SST analysis to ensure that no spurious biases were added to the Geo-SST products.

PLANNED WORK

When the McIDAS AREA files contain the line prefix information enabling the Geo-SST code to know which scan lines have been corrected for scattered light the Geo-SST code will then be updated to exclude those scan lines from further processing.

PUBLICATIONS

None

PRESENTATIONS

None

OTHER

- For the GOES-15 portion of the project updated Bayesian cloud/SST generation code and CRTM coefficients were provided to NOAA OSPO. Updated GHRSST L2P code was also given to NOAA OSPO.
- For the stray light portion of the project a presentation was given to the Geo-SST team which was then passed onto NOAA OSPO.

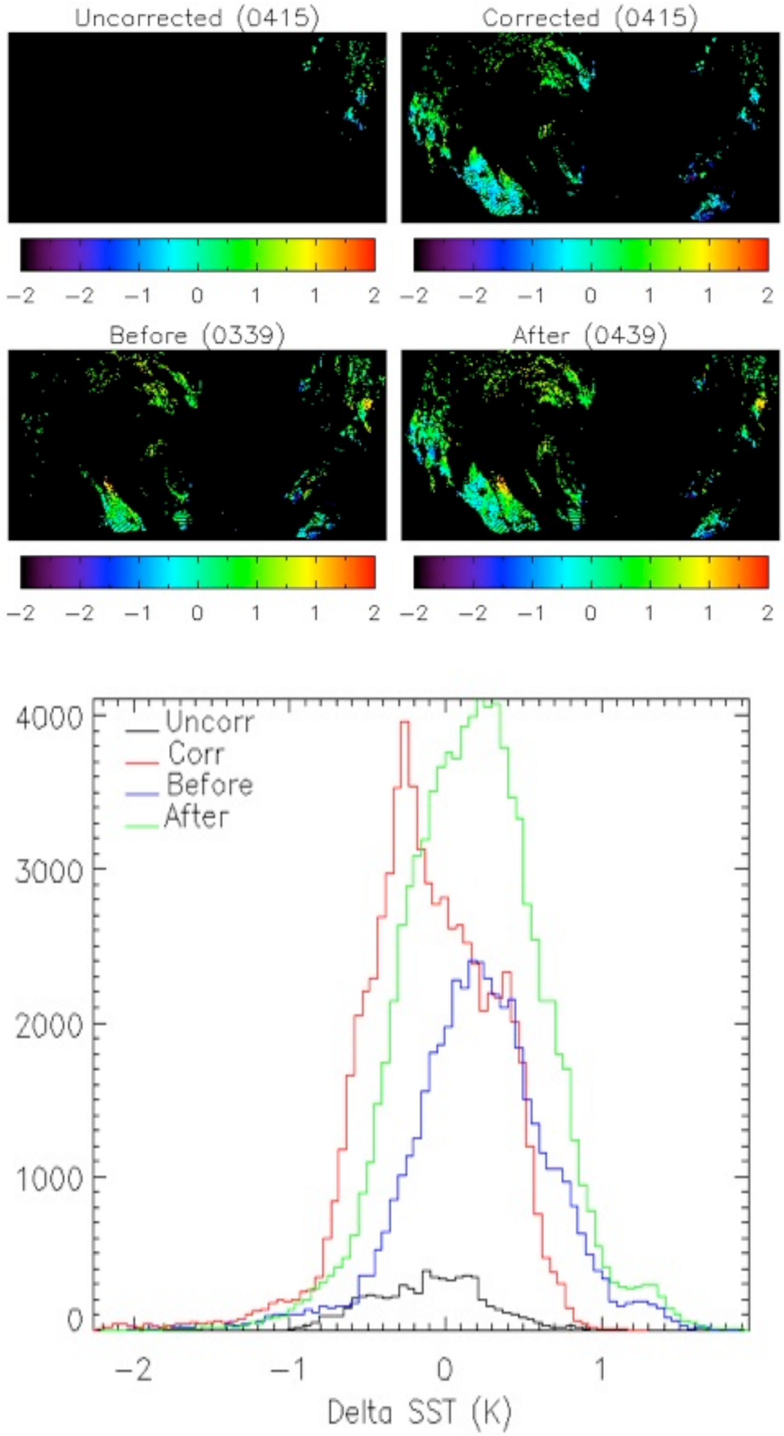

Figure 2: The images show (from top-left to lower-right) the SST difference images for the southern hemisphere sector which have been derived from a) the uncorrected image b) the ITT corrected image c) the image taken just before the onset of scattered light contamination and d) the image taken just after. The data shown is the difference between the Geo-SST and OSTIA. Image b) shows that the ITT algorithm manages to recover most of the data missed in the uncorrected image but as can be seen from the histograms shown on the right, the corrected image also introduces a bias to the SST.

Evapotranspiration and Drought Monitoring Using GOES-R Products for NIDIS

Task Leader Christopher Hain

Task Code XZCHDM_R311

Contribution to CICS Themes Task 1: 50%; Task 2: 50%

Contribution to NOAA Goals Task 1: 10%; Task 2: 90%

BACKGROUND

Monitoring evapotranspiration (ET) and the extent and severity of agricultural drought is an important component of food and water security and world crop market assessment. Agricultural systems are climate-sensitive, and conventional surface instrument networks are sparse and report with delays, therefore, satellite remote sensing and modeling play a vital role in monitoring regional water use and providing early warning of impending moisture deficits, and can be used to supplement coarser resolution data from weather and precipitation networks to assess drought conditions. Because land-surface temperature (LST) is strongly modulated by evaporation, thermal infrared (TIR) remote sensing data carry valuable information regarding surface moisture availability and therefore have been widely used to map ET, drought, and vegetation stress. Signatures of vegetation stress are manifested in the LST signal before any deterioration of vegetation cover occurs, for example as indicated in the Normalized Difference Vegetation Index (NDVI), so TIR-based drought indices can provide an effective early warning of impending agricultural drought. Evapotranspiration deficits in comparison with potential ET (PET) rates provide proxy information regarding soil moisture availability, without any need for knowledge of antecedent precipitation. In regions of dense vegetation, ET probes moisture conditions in the plant root zone, down to meter depths. Our group has spearheaded use of anomalies in the remotely sensed ET/PET fraction (f_{PET}) generated with ALEXI as a drought monitoring tool that samples variability in water use, and demonstrating complementary value in combination with standard drought indices that reflect water supply.

Fully automated ALEXI ET and drought monitoring systems have been implemented at 10-km resolution over the continental U.S. using TIR and shortwave information from current GOES instruments. With the launch of GOES-R, our capabilities for ET and drought monitoring will be significantly enhanced due to substantial improvements in spatiotemporal resolution, radiometric accuracy, and cloud-clearing capabilities. With GOES-R, the resolution of ALEXI ESI and ET products can be improved to 2-km. This will significantly improve utility to the drought community and action agencies served by NIDIS, who are demanding drought information at increasingly higher spatial resolution to support decision making at the sub-county scale.

ACCOMPLISHMENTS

During the past year, our research group has collected and archived all necessary MSG-SEVIRI (a GOES-R proxy) input products (e.g., land surface temperature; incoming shortwave radiation; surface albedo; leaf area index) from the Land Surface Analysis Satellite Applications Facility (LSA-SAF) for the period of 2007 to 2011. This time period will provide the initial 5-year climatology for the computation of ALEXI ESI products over Europe. All necessary meteorological inputs for ALEXI have also been processed and archived, mainly in the form of daily WRF simulations for each day during the study period. The ALEXI evapotranspiration climatological database (2007-2011) is currently be processed and archived at 3 km over Europe using the afore-mentioned input fields. Initial results for ALEXI evapotranspiration show good agreement with expected patterns during the year of 2008 (Fig. 1).

Additionally, in response to the development of a significant drought and famine event over the Horn of Africa, ALEXI evapotranspiration and ESI drought maps are being generated at 3-km over the region using the same MSG-SEVIRI inputs (Figure 2). Initial results over this region show significant dry ESI anomalies over most of Somalia and eastern Ethiopia. These dry anomalies agree well with famine assessments from the Famine Early Warning Systems Network (FEWS NET; Fig. 2) and with precipitation anomalies over the region (not shown).

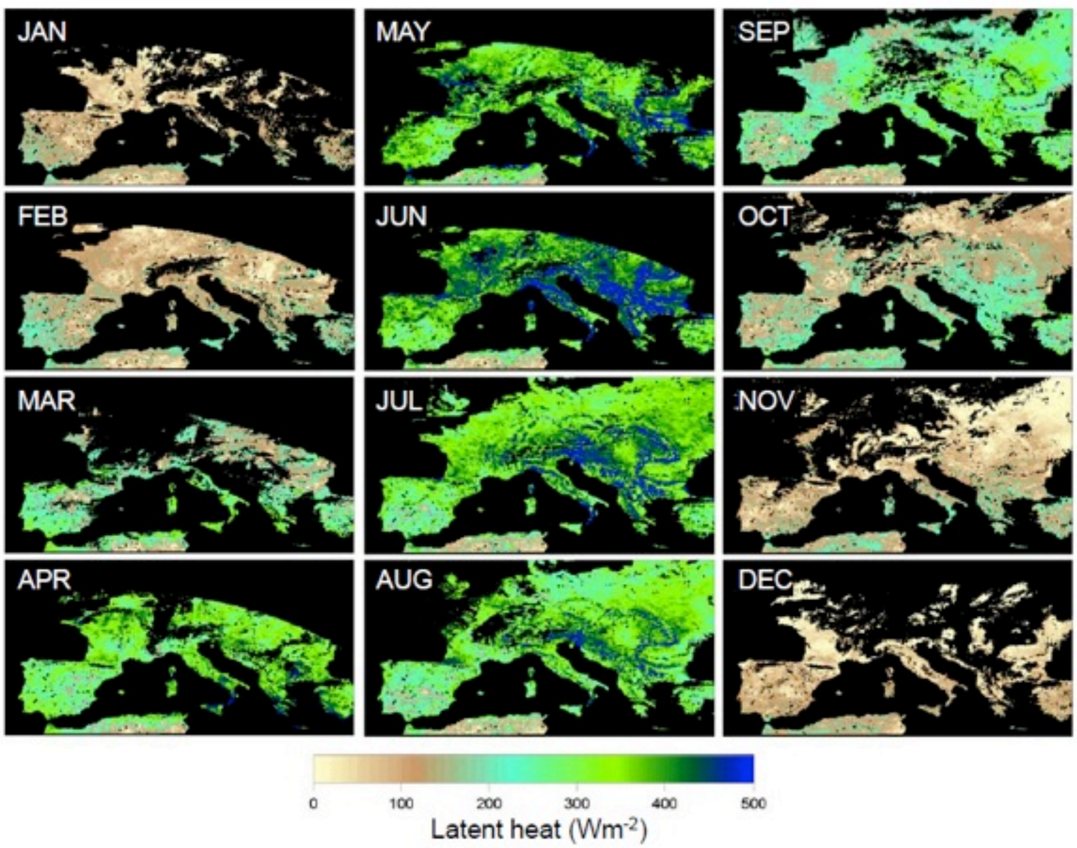

Figure 1: Monthly composites of ALEXI clear-sky evapotranspiration for 2008.

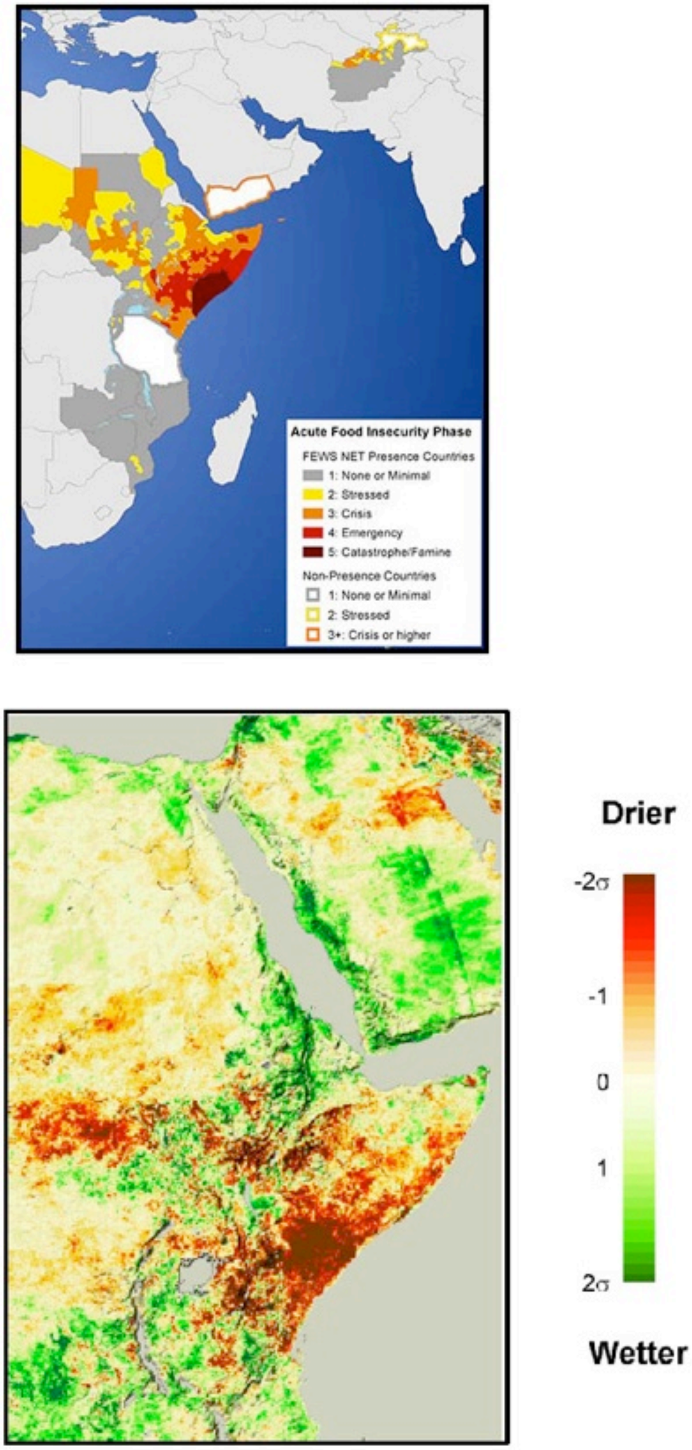

Figure 2: Active Food Security Phase from the Famine Early Warning Systems Network (FEWS NET; top) and ALEXI Evaporative Stress Index(ESI; bottom) for May 2011.

PLANNED WORK

Ongoing and future work will focus on:

- Generation of ESI maps over Europe for 2007-present based on the climatological data-base of ALEXI ET estimates.
- A quantitative evaluation of 3-km evapotranspiration and drought products over Europe for 2007-present using ground-based flux observations, other satellite and model-based ET estimates and all available standard drought metrics.
- An automated ALEXI processing system connected to GOES-R products over the U.S.
- Demonstration of 2-km flux and drought products over NIDIS U.S. pilot study areas.
- Dissemination of GOES-R drought products through the NIDIS Drought Portal.

Developing GOES-R land surface albedo product

Task Leader Shunlin Liang
Task Code SLSLGOESR11
Contribution to CICS Themes Theme 1: 40%; Theme 2: 40%; Theme 3: 20%.
Contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

BACKGROUND
Surface albedo is defined as the ratio between incoming and outgoing irradiance at the earth surface, which is a key component of surface energy budget. Surface albedo is used to drive climate, mesoscale, atmospheric, hydrological, and land surface models. The accuracy of surface albedo also affects the reliability of weather prediction. The frequent temporal refreshment, fine spectral resolution and large spatial coverage make GOES-R/ABI a unique data source for mapping surface albedo.

The goal of this task is to develop algorithms to generate GOES-R land surface albedo (LSA) product. In the previous report, we mentioned some major activities including: 1) we designed a framework that incorporates the atmospheric radiative transfer with surface Bidirectional Reflectance Distribution Function (BRDF) modeling to simultaneously estimate surface albedo and instantaneous aerosol optical depth (AOD); 2) we applied the algorithm using MODerate resolution Imaging Spectroradiometer (MODIS) observations as proxy data and made extensive validations on surface albedo and reflectance retrievals; 3) we provided some preliminary science codes to the algorithm integration team (AIT) for software implementation and process demonstration.

To demonstrate the accuracy of our LSA algorithm, data from both polar-orbiting and geostationary satellites will be used based on the similar characteristics to that of GOES-R sensor in terms of temporal, spatial, spectral, and angular information. Based on the previous activities, we will evaluate the LSA algorithm over different surfaces, analyze the error sources, and apply the algorithm using geostationary satellite data which has similar data structure to the GOES-R data. This report summarizes our main accomplishments in algorithm development and products validation during the past year.

ACCOMPLISHMENTS
In the previous report, we introduced the basic principles and the major procedure of the GOES-R LSA algorithm. To evaluate the performance of the LSA algorithm, we made extensive validations on both surface albedo and directional reflectance products derived from MODIS observations. Ground shortwave albedo measurements are obtained from the Surface Radiation (SURFRAD) Network and the Greenland Climate Network (GC-Net). Good agreement was found between our estimated albedo values and ground measurements.

To further examine the accuracy of the atmospheric correction in the LSA algorithm, both AOD and surface reflectance by-product were validated using data from AErosol RObotic NETwork (AERONET) and the MODIS AERONET-based Surface Reflectance Validation Network (MODASRVN) surface reflectance data. Validation results show that the LSA algorithm can generate AOD estimations with similar accuracy as that of MODIS AOD products. Our simultaneous surface reflectance retrievals agree with the MODASRVN data very well. Error analysis has been done to explore the relationship of solar zenith and the estimation accuracy of AOD and reflectance.

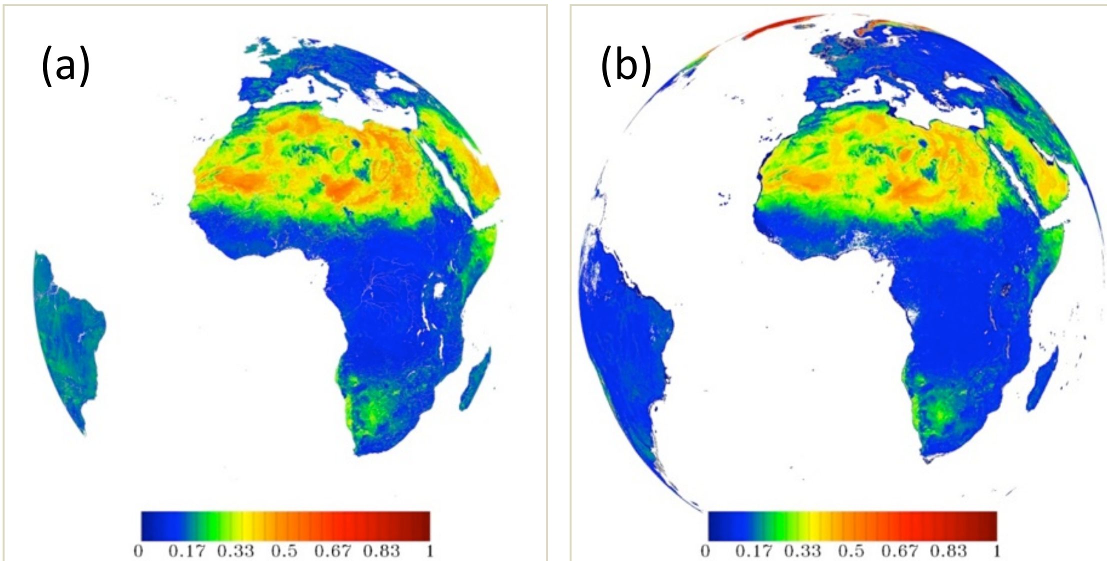

Figure 1: Comparison of shortwave albedo in MSG2/SEVIRI projection on DOY 121, 2005: (a) black-sky albedo estimations from SEVIRI proxy data; (b) reprojected MODIS black-sky albedo products. (white color means no data or water).

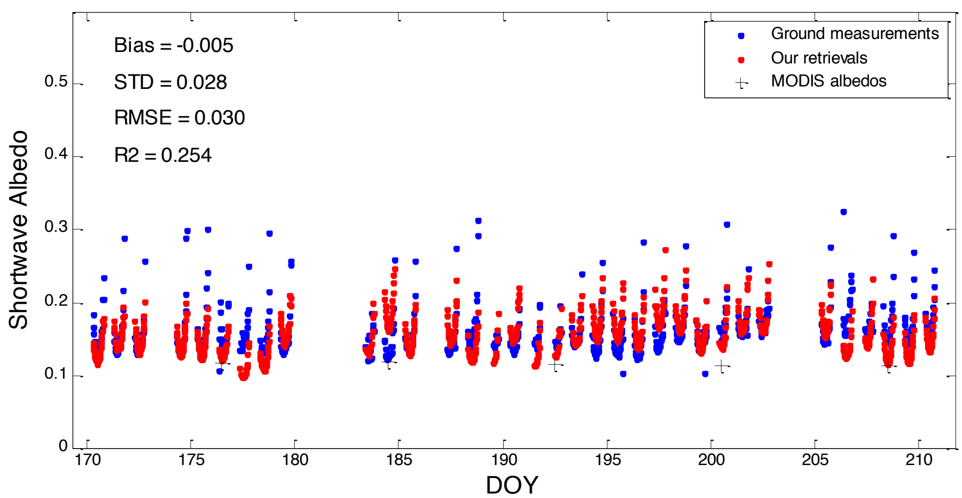

Figure 2: Time-series comparisons of our retrievals from SEVIRI data, ground measurements and MODIS albedo products at the site (49.025N, 14.772E) for the year of 2005.

Based on the findings of the prototype algorithm using MODIS data and the data structure geostationary structure, we then designed the LSA algorithm using MSG/SEVIRI observations as proxy data. There are two major assumptions for the albedo estimation from SEVIRI data: 1) surface albedo does not change within one day, all observations are used to estimate daily albedo; 2) aerosol type and properties do not change within one day, but AOD varies from time to time. By using the albedo climatology data generated from multi-year MODIS albedo products, the LSA algorithm can successfully retrieve the surface albedo from SEVIRI observations on a daily basis.

To maintain the data completeness and to better serve the land surface modeling studies, we revised the algorithm by adding two major improvements: 1) a data file has been built up storing the most recent clear sky observations; this file is updated once a day replacing old data with the clear sky data observed in the current day; 2) a direct estimation algorithm is added to estimate the shortwave albedo in the online mode when there are not enough clear sky observations available.

The albedo retrievals were validated using both ground measurements and other satellite products. The overall accuracy of 0.01 in bias and 0.03 in root mean squared error (RMSE) was found compared to MODIS albedo products (Fig. 1). In the time-series comparison with ground measurements (Fig. 2), the LSA algorithm is proved to be capable of monitoring the diurnal changes as well as the day-to-day variations in surface albedo.

With regard to the algorithm software development, we delivered the Version 5 codes and passed Test Readiness Review and Unit Test Review during the past year. We also completed writing the final version of LSA Algorithm Theoretical Basis Document (ATBD). We then successfully delivered our 100% ATBD and algorithm package to AIT. Extended testing activities have been accomplished with the cooperation of AIT to verify the LSA algorithm software performance under different scenarios. We also designed some routine validation tools to collate our LSA products with ground measurements and other satellite albedo products to demonstrate the accuracy of our estimations.

PUBLICATIONS

He, T., Liang, S., Wang, D., Wu, H., Yu, Y., & Wang, J. (2012). Estimation of surface albedo and directional reflectance from Moderate Resolution Imaging Spectroradiometer (MODIS) observations. *Remote Sensing of Environment, 119*, 286-300

He, T., Liang, S., Wu, H., & Wang, D. (2011). Prototyping GOES-R albedo algorithm based on MODIS data. In, *Geoscience and Remote Sensing Symposium (IGARSS), 2011 IEEE International* (pp. 4261-4264)

PRESENTATIONS

He, T. et al. GOES-R AWG Land Team: ABI Land Surface Albedo (LSA) and Surface Reflectance Algorithm. June 14th, 2011. Fort Collins, CO, USA.

A GOES thermal-based drought early warning index for NIDIS and dual assimilation of microwave and thermal infrared satellite observations of soil moisture into NLDAS for improved drought monitoring

Task Leader	Christopher Hain, Shunlin Liang
Task Code	PASL_GTBD11
Contribution to CICS Themes	Task 1: 33%; Task 2: 33%; Task 3: 33%.
Contribution to NOAA Goals	Task 1: 10%; Task 2: 90%

BACKGROUND

Evapotranspiration deficits in comparison with potential ET (PET) rates provide proxy information regarding soil moisture availability. In regions of dense vegetation, ET probes moisture conditions in the plant root zone, down to meter depths. Our group has spearheaded use of anomalies in the remotely sensed ET/PET fraction (f_{PET}) generated with ALEXI as a drought monitoring tool that samples variability in water use, and demonstrating complementary value in combination with standard drought indices that reflect water supply. Additionally, our research group has demonstrated that diagnostic information about SM and evapotranspiration (ET) from microwave (MW) and thermal infrared (TIR) remote sensing can significantly reduce soil moisture (SM) drifts in LSMs such as Noah.

The two retrievals have been shown to be quite complementary: TIR provides relatively high spatial resolution (down to 100 m) and low temporal resolution (due to cloud cover) retrievals over a wide range of vegetation cover, while MW provides relatively low spatial (25 to 60 km) and high temporal resolution (can retrieve through cloud cover), but only over areas with low vegetation cover. Furthermore, MW retrievals are sensitive to SM only in the first few centimeters of the soil profile, while in vegetated areas TIR provides information about SM conditions integrated over the full root-zone, reflected in the observed canopy temperature. The added value of TIR over MW alone is most significant in areas of moderate to dense vegetation cover where MW retrievals have very little sensitivity to SM at any depth. This synergy between the two different retrieval techniques should provide a unique opportunity for the development of a dual assimilation system with the potential to improve drought assessments from the NLDAS suite of land surface models.

ACCOMPLISHMENTS

During the past year, our research group has developed all necessary routines to automatically download and process all necessary inputs needed for the generation of ALEXI ESI maps over the CONUS. The real-time system is currently running in a beta-mode at NOAA-NESDIS-STAR and is preparing to begin delivery of weekly ALEXI ESI maps to end-users at the Climate Prediction Center and the National Drought Mitigation Center at the beginning of April 2012. Real-time and retrospective (back to 2000) ALEXI ESI maps will also be made available to the user community at the following website which was developed in the past year and is shown in Fig. 1: http://hrsl.arsusda.gov/drought.

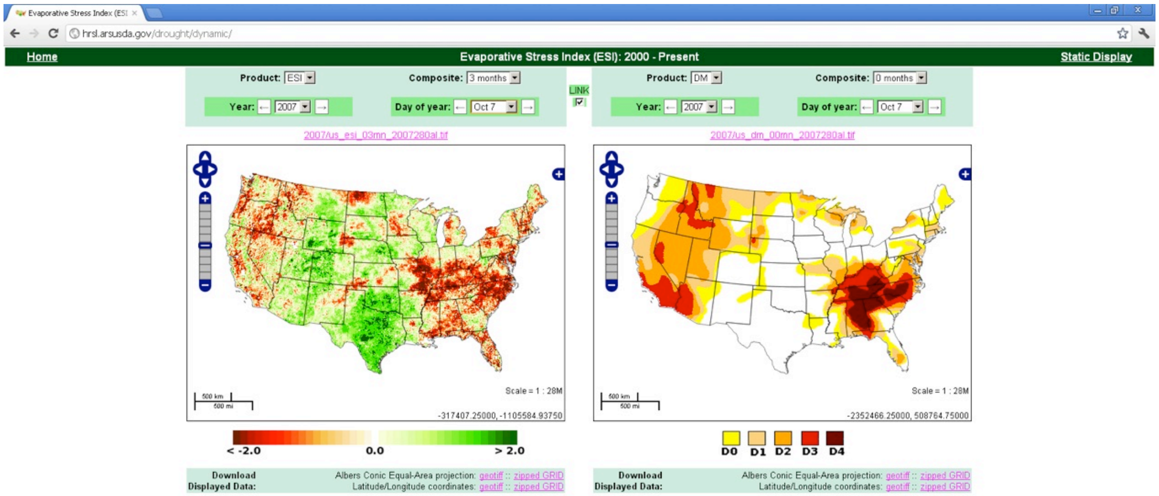

Figure 1: Screenshot of the ALEXI ESI website (http://hrsl.arsusda.gov/drought).

Additionally, during the past year our research group has begun the initial steps towards the implementation of TIR (ALEXI) and MW SM in a dual assimilation framework within the Noah LSM. All necessary inputs have been downloaded and archived needed for the assimilation simulations and include AMSR-E LPRM surface SM retrievals and TRMM 3B42RT 3-hour precipitation for the 2003 to 2011 study period. An initial set of assimilation experiments have been completed during an initial period of 2005-2008 to assess assimilation performance, using a retrieval error representation based on the fraction of green vegetation cover. Initial results show that each TIR and MW SM, in isolation, has the ability to correct precipitation errors from the TRMM 3B42RT forcing, as compared to an open-loop simulation (see Fig 2). However, when both SM products are assimilated, little additional improvement is noted (relative to each in isolation; see Fig. 2), the cause of this result is currently being investigated and may be related to the current retrieval/model error covariance presentation.

PLANNED WORK

Ongoing and future work will focus on:

- Continued implementation and refinement of ALEXI ESI real-time routines, post-processing tools and product website.
- Real-time product delivery of ALEXI ESI maps to NIDIS-USDP, CPC, and NDMC.
- Optimization of ALEXI SM data assimilation strategy.
- Continued assessment of data assimilation performance.
- Quantitative assessment of data assimilation SM results with in-situ soil moisture observations, NLDAS products and CFSRR forecasts.
- Comparison of data assimilation SM anomalies with the United States Drought Monitors and anomalies in all available standard drought metrics.
- Real-time product delivery of ALEXI SM assimilation drought maps to NIDIS-USDP, CPC and NDMC.

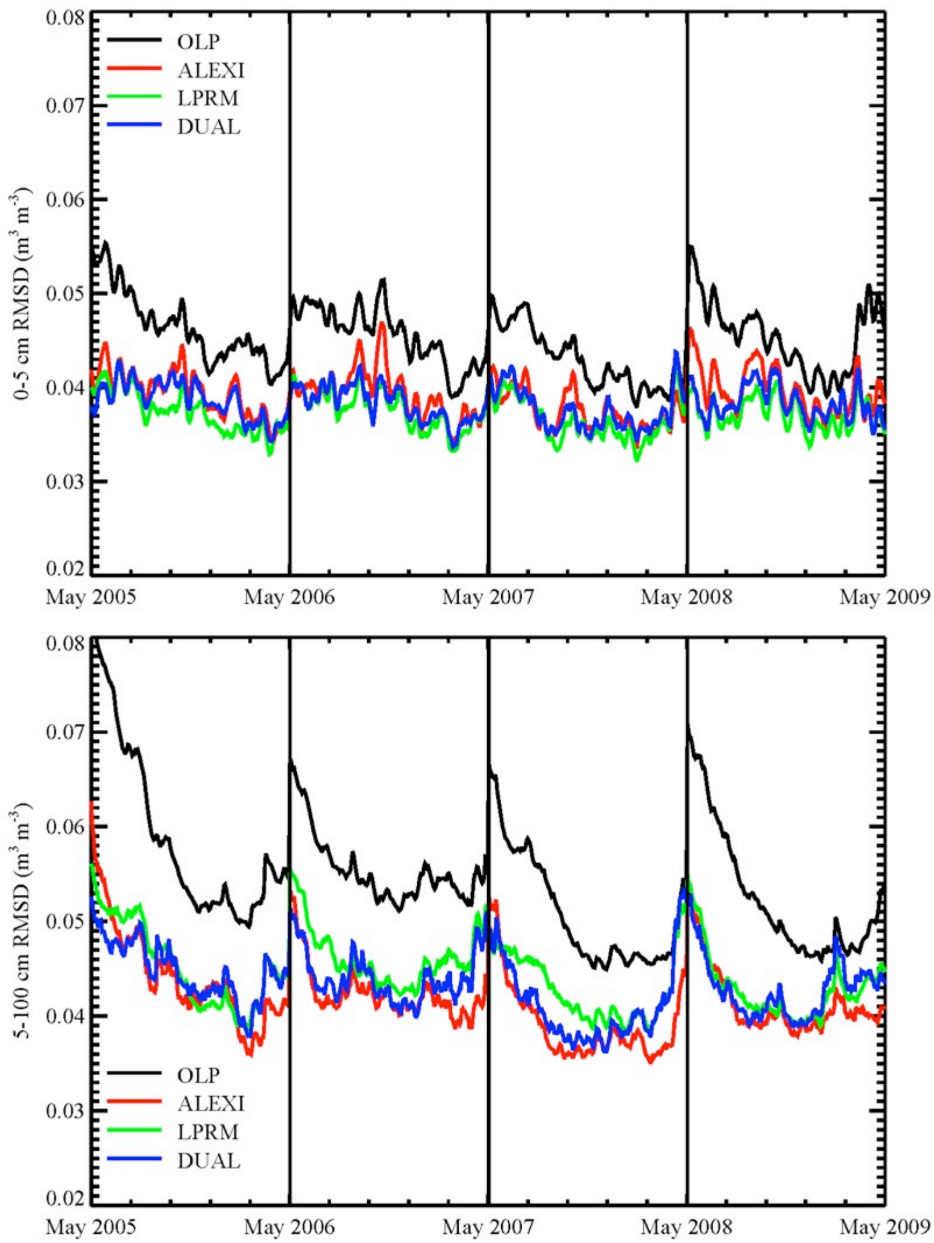

Figure 2: CONUS domain averaged time series of 0-5 cm SM RMSD (top) and 5-100 cm SM RMSD (bottom) for the open-loop simulation [black], ALEXI only simulation [red], LPRM only simulation [green] and DUAL (ALEXI+LPRM) [blue].

PUBLICATIONS

Hain, C. R., W. T. Crow, J. R. Mecikalski, M. C. Anderson, and T. Holmes, 2011: An intercomparison of available soil moisture estimates from thermal infrared and passive microwave remote sensing and land surface modeling, *J. Geophys. Res.*, *116*, D15107, doi:10.1029/2011JD015633.

Hain, C. R. and Coauthors, 2011: A GOES Thermal-Based Drought Early Warning Index for NIDIS, *Extended Summary, 36th NOAA Annual Climate Diagnostics and Prediction Workshop*, Fort Worth, TX, NOAA's National Weather Service, 215-221. [Available online at http://www.nws.noaa.gov/ost/climate/STIP/36CDPW/Digest-36CDPW.pdf]

Anderson, M. C., C. R. Hain, B. Wardlow, J. R. Mecikalski, and W. P. Kustas, 2011: Evaluation of a drought index based on thermal remote sensing of evapotranspiration over the continental U.S., *J. Climate*, *24*, 2025-2044.

Anderson, M. C., C. R. Hain, B. Wardlow, A. Pimstein, J. R. Mecikalski, and W. P. Kustas, 2012: A drought index based on thermal remote sensing of evapotranspiration. In *Remote Sensing of Drought*, B. Wardlow, M. C. Anderson, and J. Verdin, Eds., Taylor and Francis. In press.

PRESENTATIONS

Hain, C. R., W. T. Crow, M. C. Anderson, and J. R. Mecikalski. "*An EnKF Dual Assimilation of Thermal-Infrared and Microwave Satellite Observations of Soil Moisture Into the Noah Land Surface Model*", 92nd Annual Meeting of the American Meteorological Society in New Orleans, LA 22-26 January 2012 (invited).

Hain, C. R., M. C. Anderson, and X. Zhan. "*An Intercomparison of Remote Sensing and Model-Based Estimates of Evapotranspiration over the CONUS*", 92nd Annual Meeting of the American Meteorology Society in New Orleans, LA 22-26 January 2012 (invited).

Hain, C. R., M. C. Anderson, and X. Zhan. "A GOES Thermal-Based Drought Early Warning System", American Geophysical Union Fall Meeting in San Francisco, CA 5-9 December 2011 (invited).

Hain, C. R., W. T. Crow, M. C. Anderson, X. Zhan, B. Wardlow, M. Svoboda, and J. R. Mecikalski", "*Dual Assimilation of Microwave and Thermal-Infrared Satellite Observations of Soil Moisture into NLDAS for Improved Drought Monitoring*", American Geophysical Union Fall Meeting in San Francisco, CA 5-9 December 2011.

Hain, C. R., W. T. Crow, M. C. Anderson, J. R. Mecikalski, and T. Holmes, "*Developing a Dual Assimilation Approach for Thermal Infrared and Passive Microwave Soil Moisture Retrievals*", European Geophysical Union General Assembly in Vienna, Austria 3-8 April 2011.

Hain, C. R., M. C. Anderson, X. Zhan and J. R. Mecikalski, "*Intercomparison of an ET-based Drought Index Derived from Geostationary Satellite Data with Standard Drought Indicators*", European Geophysical Union General Assembly in Vienna, Austria 3-8 April 2011.

An Evapotranspiration Data Product Based on GOES Thermal Observations

Task Leader **Zhanqing Li and Rongjun Wu**
Task Code **ZLZLGIMPAP11**
Contribution to CICS Themes
Contribution to NOAA Goals

BACKGROUND

We propose to produce satellite-based maps of evapotranspiration (ET) over North America in direct support of numerical weather and seasonal climate modeling at the Environmental Modeling Center (EMC) of the National Centers for Environmental Predictions (NCEP). The product will be delivered to EMC for the cross-validation of their ET simulations from the Noah land surface model (LSM). The product may be assimilated into the Noah LSM to improve their ET estimates and in turn to improve the numerical weather or seasonal climate predictions.

In this task, we apply the Atmosphere-Land Exchange Inverse (ALEXI) model with the NESDIS GOES Surface and Insolation Products (GSIP) to estimate land surface evapotranspiration using the GOES satellite thermal observations on a $1/8^{\circ}$ grid over the contiguous U.S. (CONUS). First, the ALEXI preprocessing system will be restructured to ingest standard operational NESDIS GSIP products, including skin temperature, solar insolation, and surface and upper air meteorological data. Maps of ET from ALEXI will be compared with AmeriFlux observations of ET. Comparison of the ALEXI ET estimates with the NCEP Noah LSM simulations will also be carried out.

ACCOMPLISHMENTS

Collaborating with Drs. X. Zhan and Chris Hain of NOAA-NESDIS-STAR, we have ported the computer code of ALEXI model to NESDIS using the following input from NOAA operations: 1) meteorological forcing from North America Regional Reanalysis (NARR) of NCEP; and 2) downward solar radiation (DSWR) and land surface temperature (LST) from the GOES Surface and Insolation Products (GSIP) of NESDIS.

We have executed the ALEXI model on NESDIS computing facility using the above NOAA operational inputs. Figure 1 is an comparison of the NESDIS-ALEXI run to the ALEXI model run previously at University of Alabama Huntsville. From the figure, we can see the NESDIS-ALEXI output is very close to the UAH-ALEXI run.

We have also collected and processed ET observational data from the stations of AmeriFlux for validating the ET estimates from ALEXI-NESDIS. Results will be presented in a short paper that is currently in preparation.

PUBLICATION

Hain, Chris, Rongjun Wu, Xiwu Zhan and Martha Anderson. 2012. Validation of evapotranspiration estimates from ALEXI using NOAA GSIP and NARR data as input. *Geophysical Research Letters*. (In preparation)

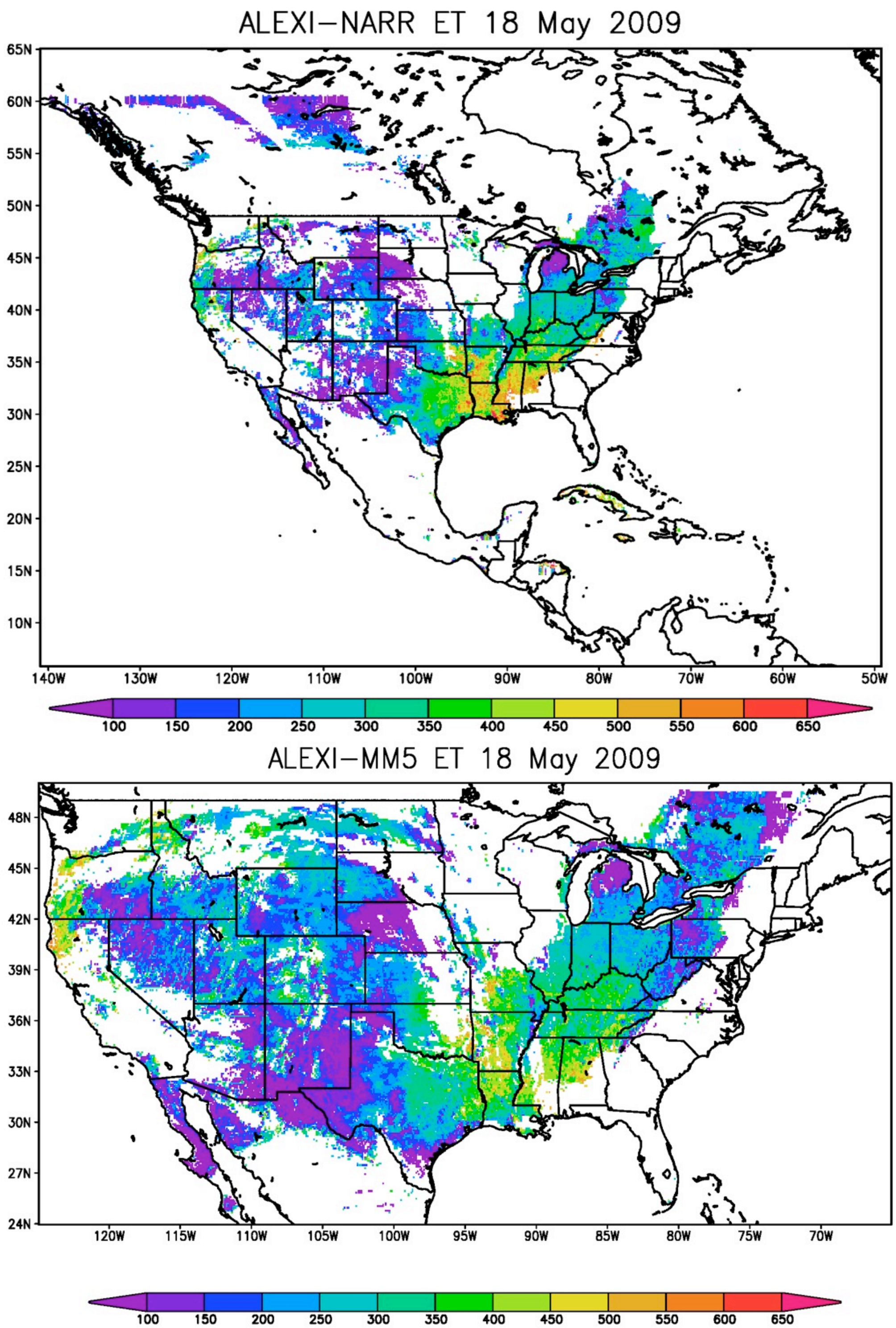

Figure 1: Estimates of evapotranspiration (ET) from the Atmosphere-Land Exchange Inversion (ALEXI) model implemented at NESDIS-STAR with inputs from NOAA operational data sets (ALEXI-NESDIS) and the version of ALEXI model developed at University of Alabama Huntsville (ALEXI-UAH) for May 18, 2009.

Diel Cycles in Aerosol Optical Properties: Aircraft Profiles in Support of the GOES-R Mission

Task Leader R.R. Dickerson and J.W. Stehr
Task Code RDRDGOESR11
Contribution to CICS Themes Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals Goal 5: 100%

BACKGROUND
The composition of the atmosphere (trace gases and aerosols) has a profound effect on human health, visibility, and the Earth's radiative properties. Aerosol optical depth (AOD) observed from satellites can provide a view broad in space and time, but the accuracy of retrievals for varying surface properties, and varying aerosol optical properties, as well as the relationship between remotely sensed AOD and surface concentration of PM2.5 (in mass per unit volume, called suspended matter in GOES-R F&PS requirements document) remain as major unanswered questions in atmospheric science (EPA, 2009).

ACCOMPLISHMENTS
Our primary mission this summer was to fly in conjunction with the NASA DISCOVER-AQ campaign. New aircraft measurements and tests over the Mid-Atlantic region included:

- Supported the DISCOVER-AQ campaign in the Baltimore-Washington, D.C. area in July 2011.
- Improved scattering measurements using our TSI nephelometer by incorporating corrections for angular truncation and relative humidity effects as a direct result of participation in DISCOVER-AQ.
- Aerosol absorption at 7 wavelengths (borrowed Aethalometer) and later 2 wavelengths (purchased Aethalometer) incorporated as a standard product
- Demonstrated pressure-independence of CRDS measurements of NO_2, improved performance and further modified the instrument
- Successful testing and improvement of the aerosol inlet and filter system.
- Conducted preliminary comparisons of proxy GOES-R ABI retrievals with UMD aircraft profile data.

The new isokinetic inlet allows the detection of aerosols up to 5 mm in diameter, and the new Aethalometer provide information on the vertical distribution of light absorption due to aerosols over a broad spectral range. With separate funds we purchased, tested and successfully flew a new Aethalometer during NASA's DISCOVER–AQ this summer. We have incorporated the Aethalometer, Particle Soot Absorption Photometer, and Nephelometer into the aircraft package to better determine particle optical properties

The bulk of this research was performed in July of 2012 in conjunction with NASA P-3 and UC-12 aircraft as they flew over the Mid Atlantic region to evaluate satellite measurements of trace gases and aerosols (Figure 1). These combined with the historical data set of aircraft profiles provide for *a priori* estimates of aerosols for retrievals from satellite measurements. The altitude integral of aerosol extinction provides the aerosol optical depth (AOD). A total of 23 flights were flown, all but four in conjunction with DISCOVER-AQ activities.

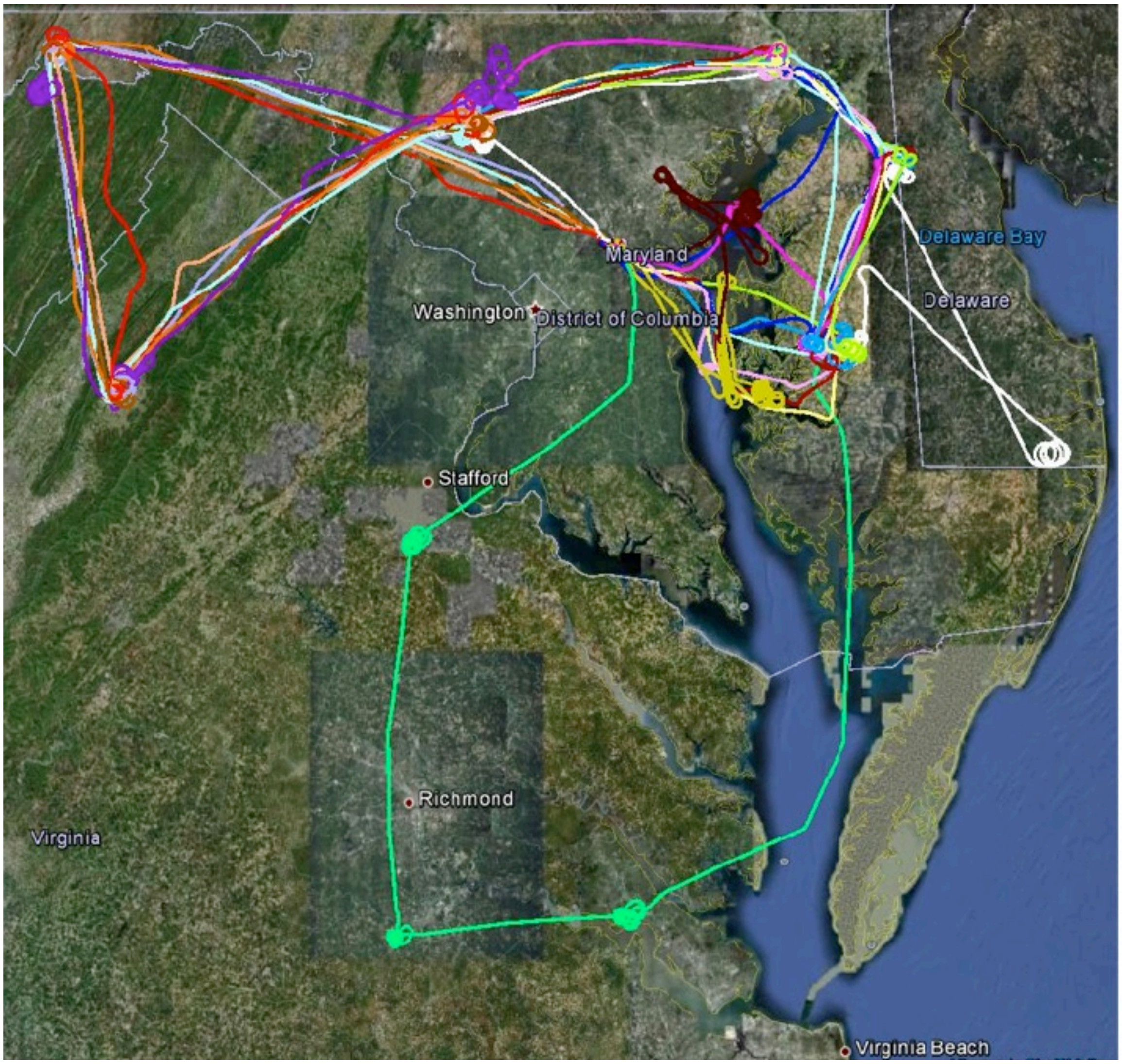

Figure 1: The flight tracks of the UMD Cessna 402B during DISCOVER-AQ.

With our NOAA colleagues, we have taken initial steps toward validation and improvement of GOES-R ABI AOD/Suspended Matter retrievals. The aircraft data extant and to be collected during the proposed field campaigns will be used to validate the GOES-R ABI aerosol products using the approach shown in Figure 2. Aircraft profiles of aerosol extinction should ideally be matched with GOES-R ABI AOD within a window of five to fifteen minutes to obtain a clear view (a composite can be created using multiple snapshots of ABI) co-located with aircraft profile and integrated to compare AODs. Because MODIS is being used as a proxy for ABI, we have limited matchups. For example, for the seven aircraft flight profiles available on June 10, 2010 only two matchups were obtained for ABI retrievals whereas for GOES we obtained 6 matchups. The example profile shown in Figure 2 uses GOES-12 AODs (a composite over 3-hr temporal window to obtain clear views) with an aircraft aerosol extinction profile overlaid. The aircraft extinction profile is integrated to obtain AOD and compared to GOES AODs and ABI AOD/suspended matter generated using MODIS radiances as proxy for ABI.

Initial results were presented at the Fall AGU meeting in a session convened by the PI entitled: REMOTE SENSING OF TRACE GASES AND AEROSOLS: AIR QUALITY APPLICATIONS.

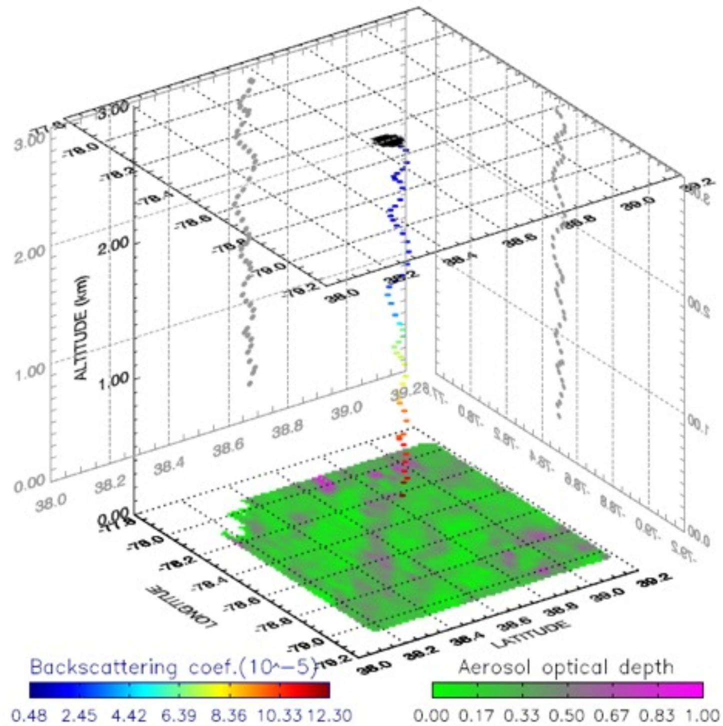

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Figure 2: Sample aircraft profile of aerosol extinction obtained by UMD aircraft measurements on June 9, 2010 superimposed on the 2D Field of GOES AOD. The GOES AOD composite was created for a 3-hr time hour window around the aircraft profile measurement time.

Improving GOES-R Cloud and Precipitation Products Associated with Deep Convective Systems by using NEXRAD Radar Network over the Continental U.S.

Task Leader Zhanqing Li

Task Code ZLZL_NX311

Contribution to CICS Themes

Contribution to NOAA Goals

BACKGROUND

One of the GOES-R goals is to improve operational satellite-based cloud and precipitation products to enhance short-term heavy rainfall and flood forecast, as well as long-term assessments concerning agriculture and water resources management. Most of heavy precipitation are associated with deep convective systems (DCSs) whose large-scale morphologic feature of cold cloud shield at the tropopause-level and cloud microphysical properties (phase, size, LWP, etc.) near cloud top can be monitored by the GOES-R.

It is difficult, however, to separate precipitating portions of DCS from non-precipitating anvils from the GOES-R observations, which leads to large uncertainties in satellite IR-based precipitation retrievals. This key limitation can be improved by using a newly developed automatic 3-D radar (NEXRAD) classification technique to identify the convective and stratiform rain region (precipitation) and cirrus anvil region (non-precipitating) from midlatitude DCSs [Feng et al. 2011]. By integrating the radar classification technique with satellite cloud property retrievals, we are developing a satellite-microphysics-based cloud classification to improve the current IR-based precipitation retrieval algorithm, and then evaluating its improvement against ground-based radar observations and aircraft in situ data.

Proposed research objectives:

- To use the newly developed classification technique to identify DCSs and classify them into convective core, stratiform rain region, mixed and ice anvils, and then to obtain their corresponding statistics of the GOES-R cloud and precipitation over the continental U.S., and
- To use the multi-scale, multi-sensor ground-based radars and other observations, and aircraft in situ measurements to validate satellite retrieved cloud and precipitation properties from the Mid-latitude Convective Clouds Experiment (MC3E) during the late spring/early summer of 2011 within the ARM SGP site.

Responsible persons in this proposed research:

- Dr. Dong's group at UND will develop the hybrid classification algorithm using current GOES and NMQ data and generate the statistical results. Dr. Dong's group is also responsible for collecting surface, satellite and aircraft data during the MC3E field IOP over the SGP region during May-June 2011.
- Co-PI, Dr. Zhanqing Li's group at UMD will provide MODIS or GOES-R proxy dataset that are both taken from the GOES-R cloud team, and generated by applying their own algorithms and to work with Dr. Dong's group to develop and test cloud classification algorithms.

- Our NOAA Collaborator, Dr. Bob Kuligowski, will provide the GOES-R precipitation product (SCaNPR) for Dr. Dong's group for evaluation.

ACCOMPLISHMENTS

Dr. Dong and his graduate student, Mr. Zhe Feng, attended the GOES-R3 science meeting and presented an oral presentation and poster at Huntsville, Alabama during 21-23 September 2011. Here is the brief summary of our research results from our poster.

- The new hybrid classification algorithm has been developed using both NEXRAD and GOES observations.
- Applying the new classification to classify precipitating clouds and anvil clouds, and then compare with SCaMPR rainfall against Q2 radar rainfall in different cloud types.

Here are some comparison results between SCaMPR and NEXRAD Q2 products:

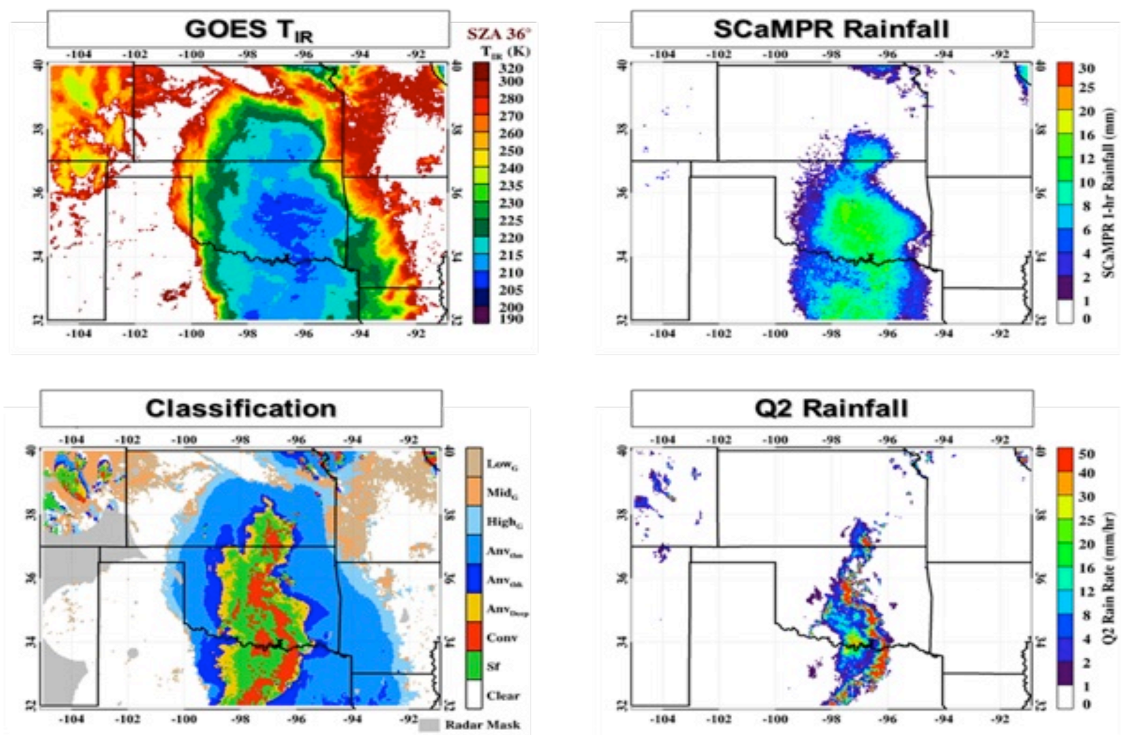


Figure 1: Comparison between SCaMPR rainfall and NEXRAD Q2 product over the domain: Oklahoma area (14° × 8°) during May 2011 (hourly rainfall).

Finding: SCaMPR cannot differentiate CC/SR/DeepCloud, simply define these classification and group as Rain Core.

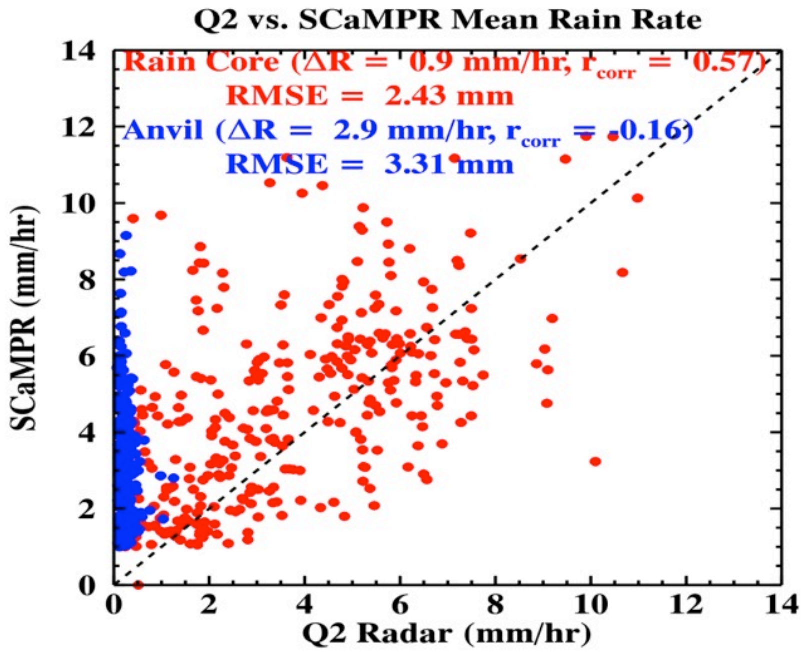


Figure 2: Hourly total rainfall comparison result: SCaMPR has slight positive bias in rain in Rain Core: ~1mm/ hr; But significantly overestimate rainfall in Anvil Clouds: +2.9mm/hr.

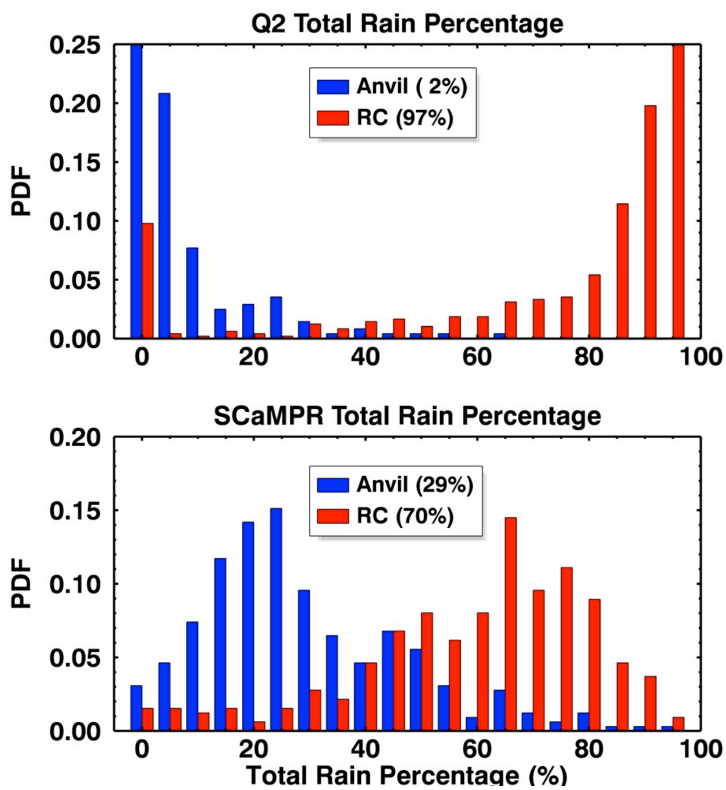


Figure 3: Comparison summary: SCaMPR overestimated precipitation in anvil clouds but underestimated precipitation in raincore region (This finding has been sent to our NOAA collaborator, Bob).

In progress during the period 08/01/2011-01/31/2012 and update

- Dr. Dong's Ph.D student, Ms. Ning Zhou, has been collecting the surface, satellite and aircraft data for MC3E IOP, and will compare the MODIS/GOES/GOES-R proxy cloud properties those have been used in NOAA GOES-R SCaMPR precipitation product.
- Dr. Dong's Ph.D student, Dr. Zhe Feng, is writing a paper related to continental DCS lifecycle, which will help us to understand the precipitation lifecycle.

Dr. Li and his Ph.D student, Mr. Jie Peng, attended the AMS 92nd Annual Meeting at New Orleans Louisiana. They collected and analyzed four years A-Train satellite datasets to identify the DCSs and their convective cores globally using their own algorithms, which will be verified by Dr. Dong's classification algorithm in the future. The following is the brief summary of the research results.

- Using CloudSat and CALIPSO datasets, DCS has been identified globally, Figure 4 shows a typical DCS and its convective core.
- DCS occurrence frequency averaged in grids (5° × 5°) and geographical distribution of DCS sorted by the averaged cloud top height of its convective core are showed in Figure 5 and Figure 6, respectively.

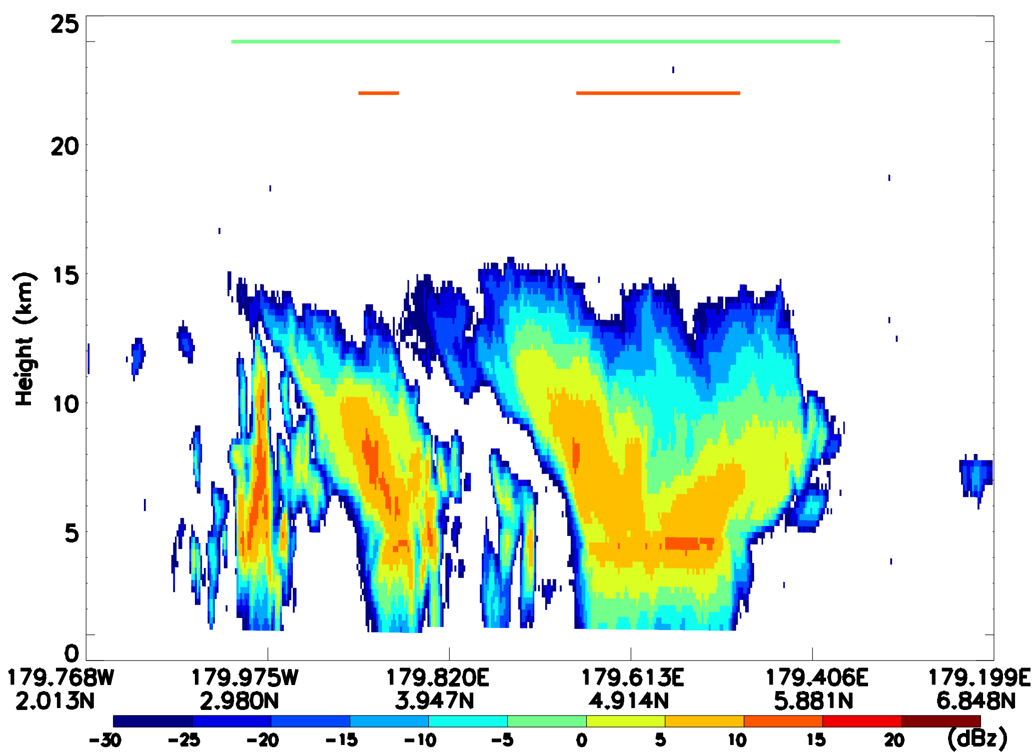
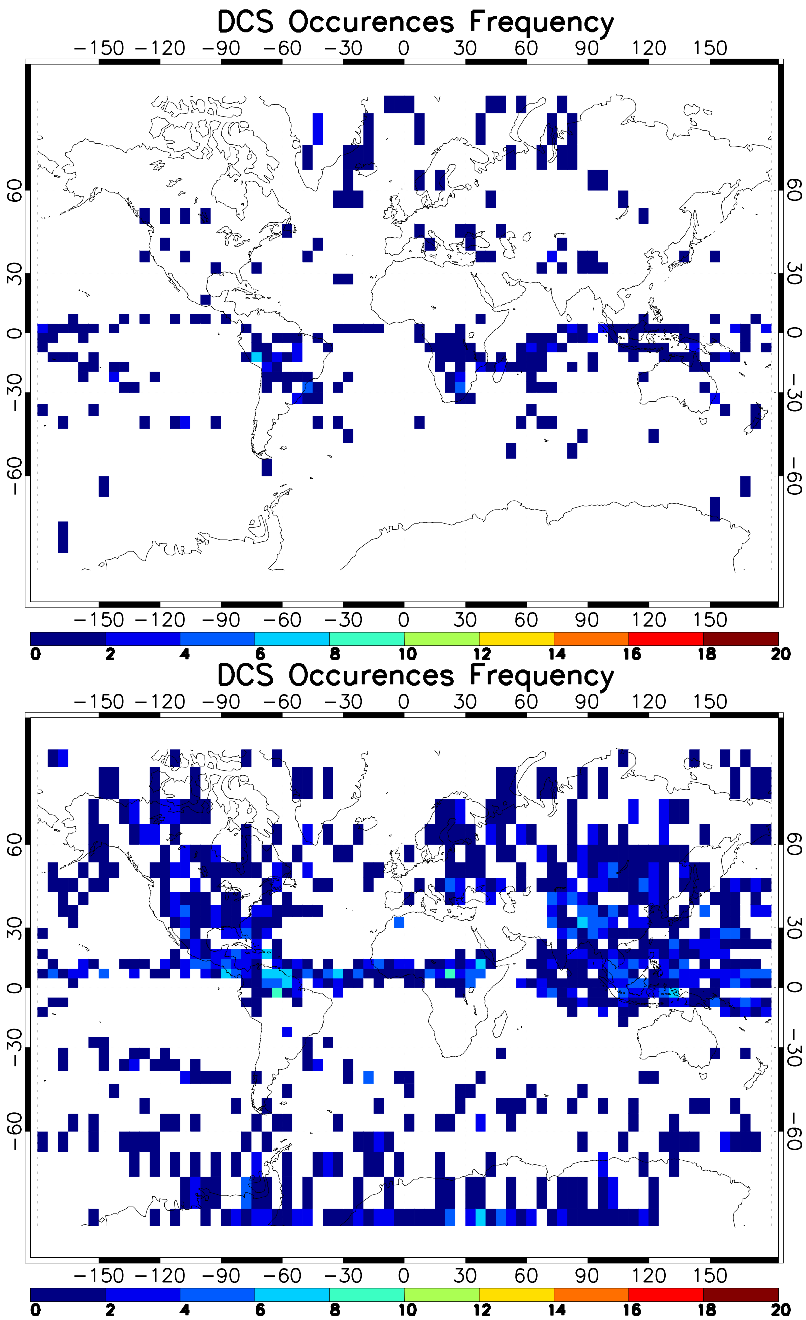


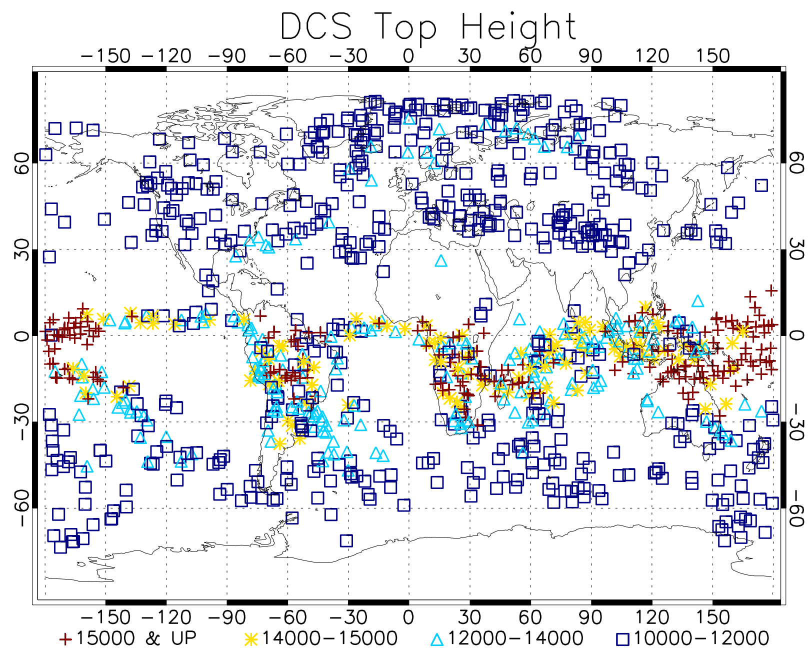
Figure 4: Vertical cross sections of radar reflectivity (color shading) detected by the CloudSat CPR over the Pacific during the nighttime overpass on 1 Jan 2007 and red lines and green dots near the top of each panel represent horizontal locations of deep convective cores and DCS, respectively.



- (b)

Figure 5: DCS frequency Occurrences globally averaged in grids (5° × 5°) during (a) Jan 2010; (b) July 2010

(a)



(b)

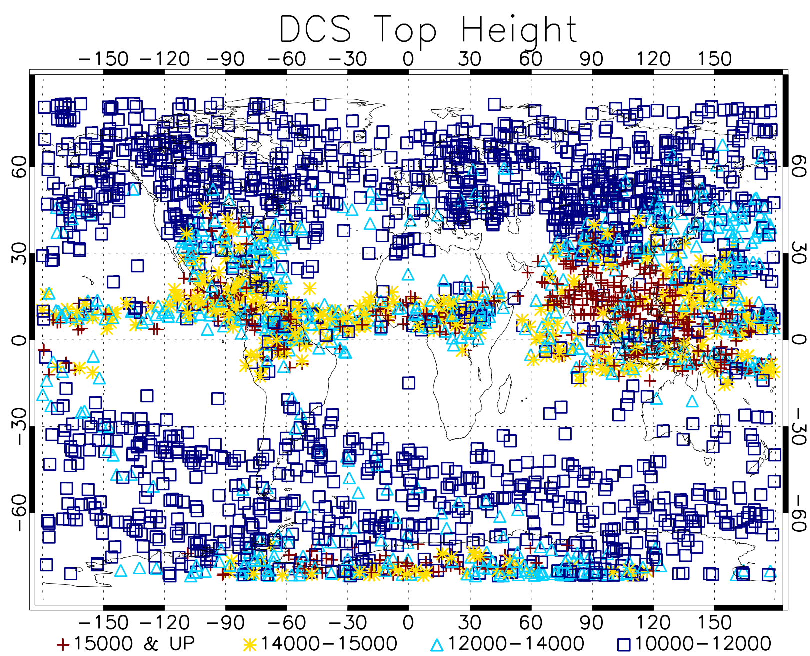


Figure 6: Geographical distribution of DCS sorted by the averaged cloud-top height (m) of its convective core during (a) Jan 2010; (b) July 2010.

4.2 JPSS Projects

Use of LETKF sensitivity to detect the origin of the NCEP '5-day forecast dropouts' and improve QC of JPSS polar orbiting instruments

Task Leader	Eugenia Kalnay
Task Code	PAEK_LETK11
Contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals	Goal 5: 100%

ACCOMPLISHMENTS

During the first year, we carried out the following tasks:

- We developed a simplified formulation of the ensemble forecast sensitivity to the observations, and tested it on the Lorenz 40 variable model (see attached draft of a paper in preparation).
- This formulation has been shown to be simpler, more computationally efficient and slightly more accurate than the original one of Liu and Kalnay (2008) with the slight correction of Li, Liu and Kalnay (2010).
- This new formulation also has the advantage that, unlike the original formulation, it can be applied directly onto the Ensemble Square Root Filter (ESRF) type of Ensemble Kalman Filter now being tested at NCEP for the operational hybrid system.
- We pointed out that for longer forecasts, the adjoint sensitivity of Langland and Baker (2004) becomes noisy because the model perturbations are assumed to be linear. The ensemble sensitivity, on the other hand, also worsens with the length of the forecast because of the use of observation localization, which is fixed on the analysis observations, whereas their impact moves with time.
- In the attached paper we introduce and test two approaches that can be used to ameliorate the problem of localization in the ensemble sensitivity for longer forecasts.

Based on this research, Collaborator Y. Ota has already tested the method developed in the attached paper on the new ESRF that will become operational at NCEP. This allows already estimating the impact of observations on the NCEP forecasts, as done with the adjoint sensitivity approach at NRL and GMAO. In addition, our paper of Kunii et al. (2012) demonstrating the utility of ensemble sensitivity is in press.

References

Kunii, M., T. Miyoshi, and E. Kalnay, 2012: Estimating impact of real observations in regional numerical weather prediction using an ensemble Kalman filter. MWR, http://dx.doi.org/10.1175/MWR-D-11-00205.1

Langland R. H., and N. L. Baker, 2004: Estimation of observation impact using the NRL atmospheric variational data assimilation adjoint system. Tellus, 56A, 189-201.

Li H., J. Liu, and E. Kalnay, 2010: Correction of 'Estimating observation impact without adjoint model in an ensemble Kalman filter'., Quart. J. Roy. Meteor. Soc., 136, 1652-1654.

Liu J., and E. Kalnay, 2008: Estimating observation impact without adjoint model in an ensemble Kalman filter. Quart. J. Roy. Meteor. Soc., 134, 1327-1335.

Research for Advanced Calibration of Joint Polar Satellite System (JPSS) Instrument

Task Leader Slawomir Blonski
Task Code ZLZL_RFAC11
Contribution to CICS Themes Theme 1: 100%
Contribution to NOAA Goals Goal 5: 100%

BACKGROUND
The Joint Polar Satellite System (JPSS) is the next generation of the U.S. polar-orbiting satellites that will provide continuity of observations for the existing NOAA Polar-orbiting Operational Environmental Satellites (POES) and for the new Suomi National Polar-orbiting Partnership (NPP) mission. The Suomi NPP satellite was launched on October 28, 2011, and the first JPSS spacecraft, scheduled for launch in 2016, will take advantage of technologies developed for the NPP satellite and its scientific instruments. Calibration methods developed for NPP will both improve the current operational data products and apply to the future JPSS measurements.

The Visible Infrared Imager Radiometer Suite (VIIRS) is one of five instruments onboard the NPP satellite. It is a 22-band multispectral imaging radiometer with a spectral range from 400 nm to 12 µm that includes both reflective solar bands and thermal emissive bands. VIIRS uses a unique spatial sampling aggregation scheme that reduces changes in the pixel ground footprint size along the Earth surface scan. Several of the spectral channels also use a dual-gain setup that dynamically adjusts to the imaged scene brightness. These novel characteristics necessitate more consideration of image quality issues during on-orbit calibration and validation of the VIIRS instrument.

ACCOMPLISHMENTS
Shortly after VIIRS acquired first imagery on November 21, 2011, image quality of the new datasets was evaluated, and it was confirmed that the images display high dynamic range and low noise level, and are free of any spatial and radiometric artifacts from the applied sample aggregation (see an example in Figure 1). A further, more quantitative evaluation of image quality included "striping" caused by non-uniformity of detector arrays. Differences of radiometric response among detectors were measured and used to initiate an update of calibration coefficients that reduce striping when applied to the imagery.

Since it was observed that VIIRS sensor sensitivity in the near infrared and adjacent bands decreases with time more quickly than anticipated, radiometric response of the reflective solar bands has been closely monitored using both on-board calibrator solar diffuser measurements and data acquired over the Antarctic Dome C calibration site. Monitoring of VIIRS radiometric gains, i.e., ratios of digital counts to radiance, was implemented based on on-board calibrator data provided in intermediate product files and on such known sensor characteristics as spectral response functions, solar diffuser bidirectional reflectance distribution functions, and transmittance of the solar attenuation screen. Time series of the radiometric gains produced from the VIIRS sensor measurements of light reflected by the solar diffuser were then used to predict rate of future changes in VIIRS sensitivity and to estimate that the radiometric response degradation will level off within few months. VIIRS measurements of Earth surface reflectance at the Dome C site in Antarctica have shown that the observed degradation of radiometric response is not an artifact caused by the solar diffuser. Dome C is a CEOS-recommended standard site for satellite radiometric calibration and validation that is characterized by stable snow cover and reduced atmospheric effects. Temporal dependence of the Dome C data agrees well with the SD measurements (Figure 2) and supports the use of Dome C in validation of radiometric calibration updates that correct degradation of VIIRS radiometric sensitivity.

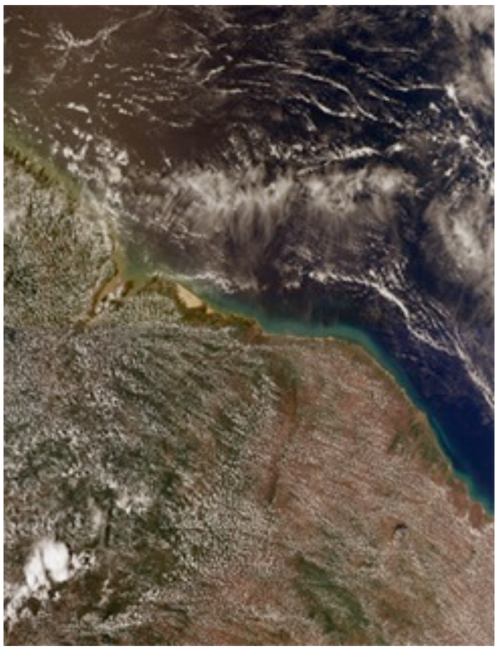


Figure 1: One of the first images acquired by the VIIRS instrument onboard the Suomi NPP satellite on November 21, 2012.

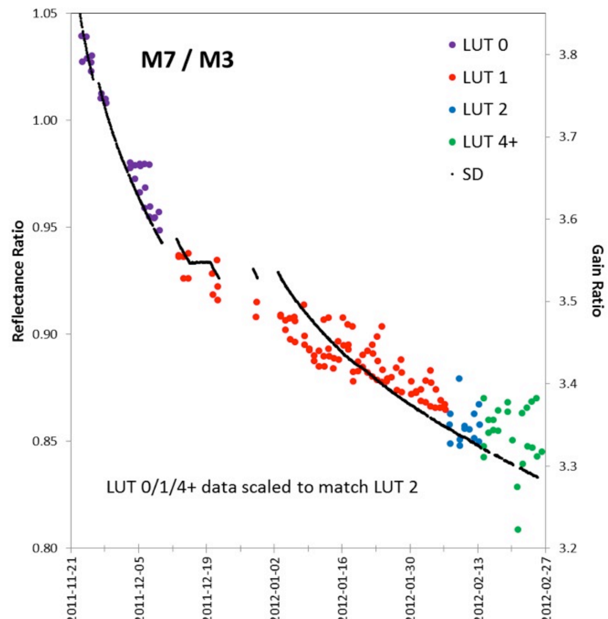


Figure 2: VIIRS Top-of-Atmosphere reflectance ratio for the Dome C site compared with on-board solar diffuser (SD) gain ratio for two bands: M7 (865 nm) and M3 (488 nm).

PLANNED WORK

- Continue monitoring VIIRS radiometric performance and calibration uncertainty using both onboard solar diffuser and standard calibration sites
- Further evaluate VIIRS image quality including striping artifacts, band-to-band registration, and spatial resolution measures
- Use simultaneous nadir overpass data to compare VIIRS radiometric calibration and geolocation accuracy with MODIS and other sensors
- Investigate potential for on-orbit characterization of VIIRS spectral response

PRESENTATIONS

Blonski, S., and C. Cao. *NOAA Calibration/Validation Update*. CEOS Working Group on Calibration and Validation Plenary Meeting, Brisbane, Australia, 6-10 February 2012.

Blonski, S., C. Cao, S. Uprety, and X. Shao. *Using Antarctic Dome C Site and Simultaneous Nadir Overpass Observations for Monitoring Radiometric Performance of NPP VIIRS In-*

strument. IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Munich, Germany, 22-27 July 2012, submitted.

Development of JPSS AMSR-2 Hydrology Products

Task Leader Patrick Meyers
Task Code RFRF_JPAM11
Contribution to CICS Themes Theme 1: 20%; Theme 2: 80%
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

BACKGROUND

The hydrological cycle of the Earth is one of the most complex global feedback mechanisms that impact all living forms on the planet. An accurate description of the global precipitation patterns over an extended period of time is critical to determining any changes in the hydrological cycle. These pattern changes include the frequency, areal extent and duration of extreme weather events (e.g., flash floods, drought, extreme events, etc.) as well as long term shifts of the global rainfall distribution.

Measurements from polar orbiting satellites, particularly from microwave sensors, offer perhaps the most viable means to develop algorithms for global retrievals of hydrological parameters. This project focuses on the development of algorithms related to the hydrological cycle for the forthcoming AMSR-2 sensor that will be flown on the GCOM-W satellite that will be launched and operated by JAXA in early 2012.

AMSR-2 will provide a suite of products similar to the EOS Aqua AMSR-E sensor which stopped functioning in October 2011. Retrievals of rainfall rate, total precipitable water, cloud liquid water, and soil moisture

ACCOMPLISHMENTS

The Goddard profiling algorithm (GPROF) for hydrological retrievals has been updated for use with TRMM brightness temperatures in an effort led by Dr. Chris Kummerow (CIRA/Colorado State). AMSR-E and AMSR-2 brightness temperatures cannot be directly input into GPROF because of frequency differences with TRMM, particularly the 85/89 GHz channels. A linear regression technique was applied to adjust AMSR-E brightness temperatures to TRMM frequencies for clear and rain-likely conditions using collocated brightness temperatures to account for sensor differences (Figure 1). This correction dramatically decreased the frequency of rainfall observed at high mid-latitude elevations where snow was likely contaminating retrievals (Figure 2).

Rainfall retrievals over land are susceptible to contamination from surface conditions such that a comprehensive screening procedure is needed to reduce erroneous retrievals of rainfall. Several potential screening techniques are being developed to flag regions of likely snow cover and arid lands where microwave rainfall retrievals are inaccurate. The proposed snow screen incorporates monthly averages of snow cover to provide users with a meaningful climatological estimate of confidence in the retrieval.

PLANNED WORK

- Continue development of the GPROF rainfall algorithm for retrievals over land, particularly removing contamination effects from surface ice and snow
- Calculate and apply brightness temperature correction to SSM/I data for application of the GPROF algorithm
- Coordinate implementation of algorithm suite with NASA and NOAA/NESDIS for transition to the AMSR-2 sensor.

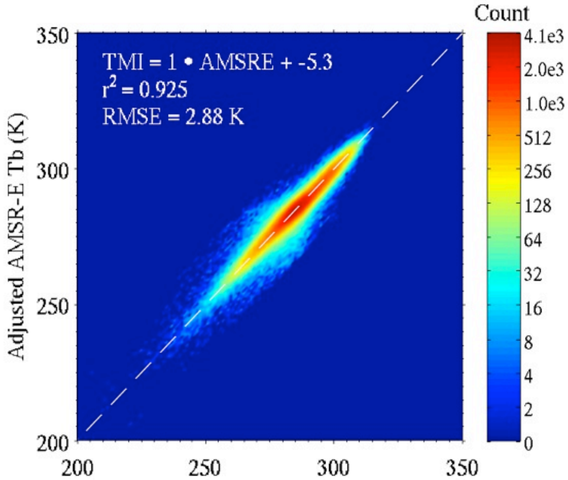


Figure 1: Adjusted AMSR-E 89V brightness temperature using linear regression correction. Shading represents the density of observations in 1°x1° bins

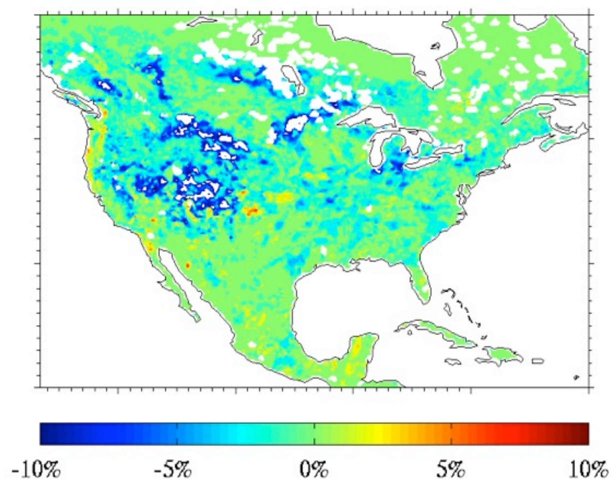


Figure 2: Change in frequency of observation of precipitation by applying adjusted AMSR-E brightness temperatures for January 2010. The adjustment greatly reduced false alarms in the Rocky Mountains.

Research for the Advanced Calibration of the Joint Polar Satellite System (JPSS) Instrument

Task Leader Chunhui Pan
Task Code ZLZL_RFAC11
Contribution to CICS Themes Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals Goal 5: 100%

BACKGROUND
This work is part of NOAA/STAR ongoing Research for Advanced Calibration of Joint Polar Satellite System (JPSS) Instrument Ozone Mapper Suites (OMPS) Calibration and Validation and represents a continuation and enhancement of NPP/JPSS activities. The research and development in this work supports the long-term data quality monitoring from OMPS, which would from the baseline of sensor parameters to the delivery of the reliable Sensor Data Records (SDRs).

Launched on October 28, 2011, OMPS has acquired various types of calibrations images through both the nominal and special calibration activates, these images allows us to gauge the sensor performance through the sensor activation from the initial launch & activation to the nominal routine operation. Strategy for incorporating ground performance into post-launch anomalies focus on the data product quality performance as well as the long-term monitoring of satellite health and status, including establish sensor initial settings and parameters**,** monitoring and trending of satellite telemetry, tracking of sensor characteristics on orbit, updating of sensor parameters and algorithms when needed, provision of overlapping operations for periods up to one year and comparisons of the performance of selected products against TOMS and SBUV, and/or through high quality ground truth measurements. In this report we present the work accomplished from the Early Observation and Activation (LEO&A) to the Early Orbit Checkout (EOC).

ACCOMPLISHMENTS

- Developed sensor data analysis algorithms and software tools for Raw Data Records (RDRs) and Sensor Data Records (SDRs) to perform data analyses, image visualization and sensor performance evaluation and monitoring, includes Nadir TC dark, bias linearity and solar flux calval.
- Performed internal consistency checks of sensor parameters and instrument behavior to identify sensor anomalies, optimize sensor and algorithm settings, as well as test Ops tools and alternate algorithms with real data through checkout activities. Evaluated and assessed sensor performance as a result of early orbit calibration, as well as the sensor performance transition from ground to real flight conditions. Based on my analysis, it is concluded that OMPS made a smooth transition from ground to orbit. Sensor on-orbital linearity, dark, and bias performance meet the system requirements and agrees with the prelaunch results. Sensor EOC engineering reports have been completed and submitted. Analyses also indicate that in the flight condition, the settings of sensor parameters related to the system linearity, dark and bias are appropriate and flight software is functional well during OMPS activation and outgassing phase. On-orbit trending shows that sensor

lamp signal; linearity, dark and bias vary with sensor orbital thermal loadings and are correlated with CCD window and telescope temperatures. However, such thermal impact, so far, is negligible. The solar calibration shows that there is discrepancy in spectrum between the reference and orbital results; optimization of sensor solar parameter is recommended.

- Performed Satellite Telemetry Monitoring and Trending, monitoring spacecraft and sensor operational status, maintain long-term histories of key parameters, analyzing trends in spacecraft and sensor telemetry, and sensor engineering data, to determine if any potential issues present. Two examples are linearity performance traending (figure 4) and dark current trending (figure 5) over time.
- Actively participated all work related regular routine meetings, such as OMPS implementation meeting, SDR team meeting, cal/val leads tag up meeting, OMPS science meeting and JPSS Data Analysis Working Group (JDAWG), etc.

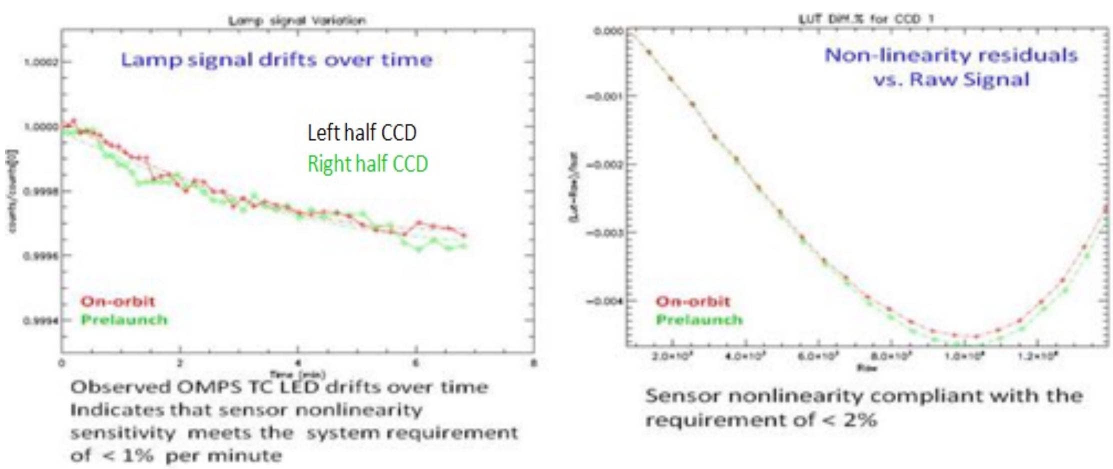


Figure 1: OMPS Total Column Linearity performance transition from ground to orbit. The LED lamp stability and system non-linearity agree with pre-launch results and meet the system requirements

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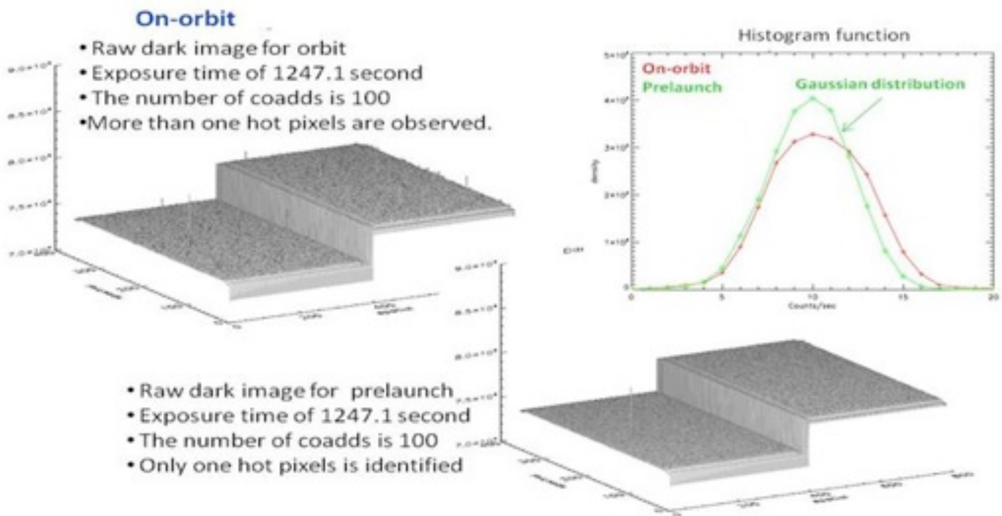


Figure 2: OMPS Total Column Dark performance transition from ground to orbit. As expected, on orbit dark current has slight higher dark signals and noise.

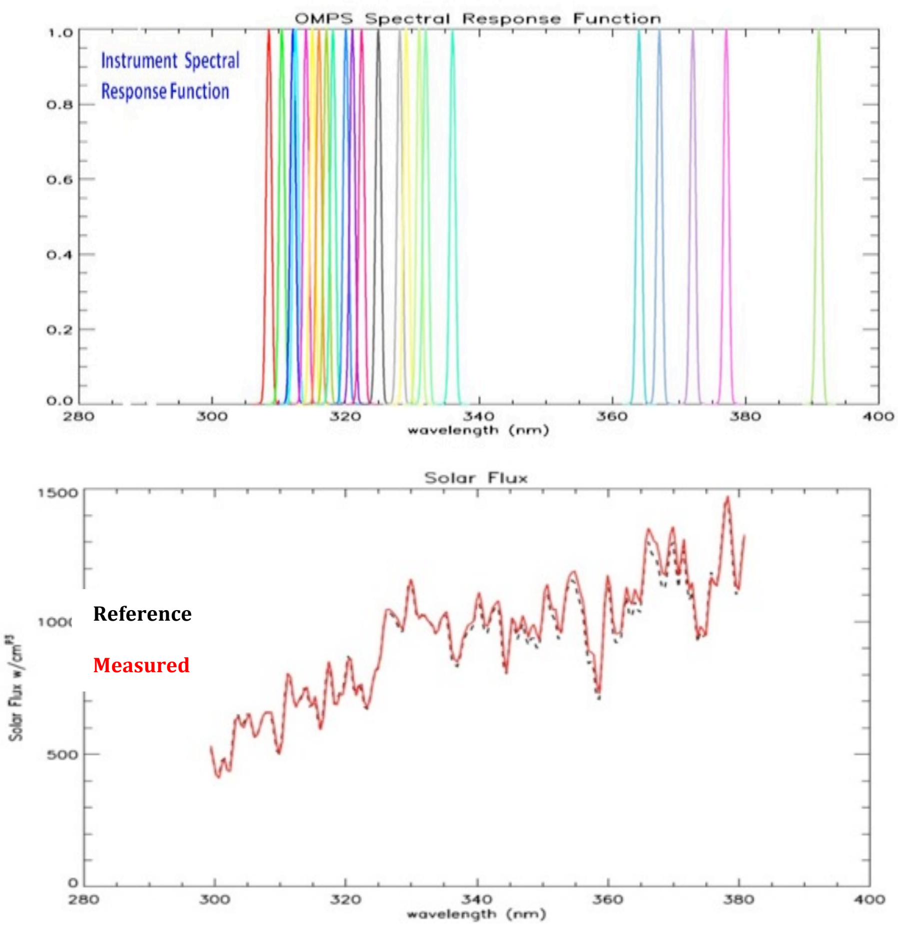


Figure 3: OMPS Total Column spectral performance transition from ground to orbit. On-orbit spectral shows slightly shifts in spatial and spectral scales, indicating a possible change in solar diffuser position, as well as thermal optic impacts.

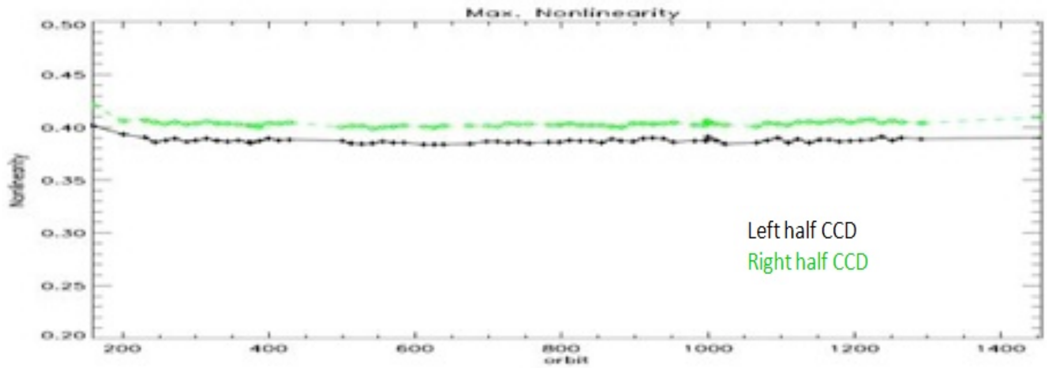


Figure 4: Sensor TC system linearity trending from Nov 11, 2011 to Feb 12, 2012.

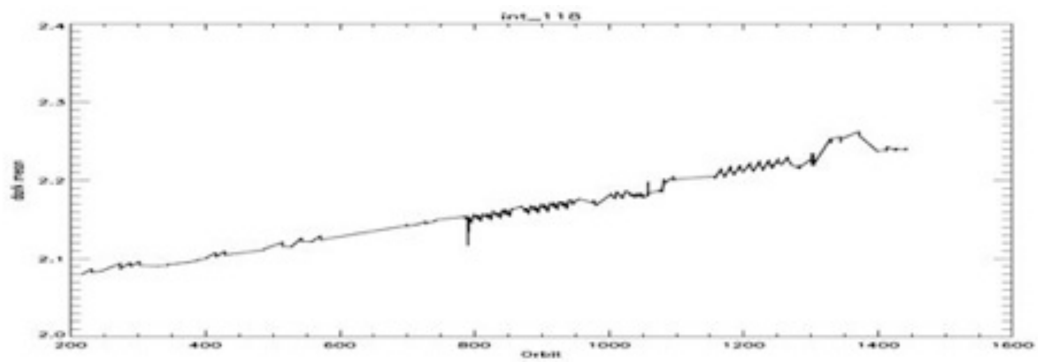


Figure 5: Sensor TC dark current trending from Nov 11, 2011 to Feb 12, 2012

PLANNED WORK

Continue work on OMPS calibration and validation (calval.) and evaluate sensor performance in insensitive Calval. and Operation phases. Calval tools will be cover radiometric and SDR earth view calibration.

PUBLICATIONS

C. Pan, L. Flynn, X. WU, G. Jaross, S. Janz, W. Yu, C. Seftor, R. Buss, OMPS Early Orbit Performance Evaluation and Calibration, AMS 92nd Annual Meeting, New Orleans, LA. Jan. 22-26, 2012

C. Pan, F. Weng, X. Wu, Janz, L. Flynn, R. Buss, E. Beach, OMPS Early Orbit Linearity Evaluation and Calibration, IGARSS 2012. Submitted and is in review

C. Pan, F. Weng, X. Wu, Janz, L. Flynn, R. Buss, E. Beach, OMPS Early Orbit Dark and Bias Evaluation and Calibration, IGARSS 2012. Submitted and is in review

Scientific Support for Joint Polar Satellite System (JPSS) Instrument Calibration, and Community Radiative Transfer Model (CRTM)

Task Leader **Zhanqing Li**

Task Code **ZLZL_CRTM10**

Contribution to CICS Themes

Contribution to NOAA Goals

BACKGROUND

NOAA is now taking the full responsibility for operational calibrations for all instruments onboard Suomi NPP and JPSS satellites. The Cross-track Infrared Sounder (CrIS) on board NPP/JPSS is an infrared interferometer and provides atmospheric sounding for both weather and climate applications. The Advanced Technology Microwave Sounder (ATMS) is a new generation of total-power microwave radiometers with twenty-two channels and it will provide sounding for both atmospheric vertical temperature and humidity profiles. Under all the weather conditions Well-calibrated Sensor Data Record (SDR) radiances from CrIS and ATMS are crucial to NWP applications and provide critical atmospheric correction estimates for many surface Environmental Data Record (EDR) algorithms.

The Visible/Infrared Imager/Radiometer Suite (VIIRS) provides satellite measured radiance/reflectance data for both weather and climate applications. Well-calibrated Sensor Data Records (SDRs) from VIIRS are crucial to numerical weather prediction (NWP) and Environmental Data Record (EDR) algorithms and products. The Ozone Mapping and Profiler Suite (OMPS) monitors the global distribution of ozone in three-dimension on daily basis. This is crucial for climate studies and fulfils the U. S. treaty obligation. Calibration of the OMPS Sensor Data Record (SDR) is a key component for the success of OMPS mission that requires detailed scientific studies and engineering work.

This task will be focusing on NOAA operational calibration support for JPSS instruments (e.g. CrIS, VIIRS, ATMS and OMPS) and development of innovative techniques to improve the calibration of JPSS instruments for advanced applications. The task will also provide support for improvement in radiative transfer science used in the US Joint Center for Satellite Data Assimilation (JCSDA) community radiative transfer model.

Progress and dissemination of CICS-MD research for the JPSS/NPP mission

Task Leader	Hugo Berbery
Task Code	PAPA_PDCICS
Contribution to CICS Themes	Theme 1: 40%; Theme 2: 40%; Theme 3: 20%
Contribution to NOAA Goals	Goal 1: 40%, Goal 5: 60%

BACKGROUND

The Cooperative Institute for Climate and Satellites (CICS) is formed through a consortium of academic, non-profit and community organizations provide foci for collaborative research and associated activities in support of NOAA mission goals related to meteorological satellite and climate data and information research and development. **This task is designed to contribute to the dissemination and promotion of preliminary NPP activities carried out at CICS and NESDIS**. NPP is the next generation polar-orbiting satellite that will act as the bridge between NOAA's current satellites and the Joint Polar Satellite System (JPSS), expected to launch in 2017. NPP will provide information such as atmospheric profiles of temperature, moisture, and pressure for weather forecasting, sea surface temperature, ocean color, and vegetation indices for drought monitoring and forecasting (NESDIS; http://www.nesdis.noaa.gov/news_archives/npp_packed.html). The project will help ensure the climate community is informed about and prepared to use NPP and JPSS instruments.

ACCOMPLISHMENTS

The dissemination of CICS-MD activities is being carried out following different approaches:

1. First, in order to disseminate the research being done in CICS-MD, a new web site is being designed and is expected to go live during the summer. This web site will include the research activities in CICS, information on CICS-MD outreach, simple ways of searching the contribution to different CICS-MD Themes as well as the contributions to NOAA Goals.
2. Second, CICS-MD has prepared its first *Circular*, and intends to continue publishing it twice a year. The first issue reports on CICS-MD vision and mission, its research themes and brief descriptions of research being done at the institute. The titles of these contributions are: (a) A CICS Partner – NOAA/ NESDIS/Satellite Climate Studies Branch; (b) Improving Satellite Heavy Rain Estimates Using Lightning Information; and (c) Seasonal Drought Prediction over the United States.
3. Lastly, a presentation at the CICS Science meeting was done outlining the research approach and achievements in CICS-MD.

PLANNED WORK

- Continue preparation of material for the upcoming CICS-MD web site;
- Work closely with the web site designers and developers to ensure a timely delivery of the web site.
- Prepare a new issue of the CICS-MD Circular, which will include ongoing research towards JPSS and NPP missions.

PRESENTATIONS

Berbery, E. H., 2011: "Cooperative Institute for Climate and Satellites-Maryland" presented at the *Second Annual CICS Science Meeting*, Asheville, North Carolina, 2-3 November 2011

OTHER

Outreach

CICS-MD supported seven graduate students to attend the 36^{th} Annual Climate Diagnostics and Prediction Workshop in Fort Worth, Texas, 3-6 Oct 2011.

NPP/JPSS Global Space based Inter-Calibration System (GSICS)

Task Leader	Likun Wang
Task Code	PAPA_GSIC11
Contribution to CICS Themes	Theme 1: 70%; Theme 2: 30%
Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

BACKGROUND

This task will be focusing cross-calibration support for Suomi National Polar-Orbiting Partnership (NPP) and Joint Polar Satellite System (JPSS) instruments, including Visible/Infrared Imager/Radiometer Suite (VIIRS), Cross-track Infrared Sounder (CrIS), and Advanced Technology Microwave Sounder (ATMS). The proposed work will use inter-calibration techniques to access the spectral and radiometric calibration accuracy, *preciseness, and stability* of NPP and JPSS instruments. The scientists under this task will work closely with the international community through WMO GSICS and CEOS Working Group CalVal (WGCV) and develop the best practices for inter-calibration. The work will deliver a comprehensive evaluation report on NPP instrument calibration to the NOAA/NESDIS JPSS program office.

The major method will use the observations from multiple instruments to compare with simultaneously collocated NPP and JPSS observations. Other methodologies that exist to determine the absolute calibration of a satellite sensor include using 1) well-characterized measurements of celestial targets, such as the moon, sun, and stars, 2) vicarious calibration using ground-based and airborne instrument measurements taken at earth-reference and field experiment sites, and 3) global and regional radiative transfer model simulations of satellite data based respectively on NWP model output and earth-reference and field experiment sites.

ACCOMPLISHMENTS

The work of Year 2012 focuses on validation of the Cross-track Infrared Sounder (CrIS) Sensor Data Records (SDR) on the newly-launched Suomi NPP by comparing it with other two on-orbit infrared (IR) hyperspectral instruments, including the Atmospheric Infrared Sounder (AIRS) on NASA Earth Observing System (EOS) *Aqua* and Infrared Atmospheric Sounding Interferometer (IASI) on *Metop-A* and –B. Since the GSICS community has extensively used the observations from these hyperspectral IR instruments to independently assess the radiance measurements of broad- or narrow-band instruments that share the same spectral region. Therefore, it is urgent to establish a common standard for these instruments.

An inter-calibration system has been implemented to directly compare temporarily coincident CrIS and IASI and CrIS and AIRS at orbital crossing points of satellites occurring at high latitudes, the so-called simultaneous nadir overpasses (SNO). The system can automatically extract the SNO spectra from two compared instruments and resample the spectra at the common spectral grids. Figure 1 gives an example for the CrIS and IASI SNO case on March 30 2012 at the Southern Polar region. Although the CrIS spectrum agrees well with IASI overall, the CrIS is around 0.2K warmer than IASI at the spectral range from 640 to 800 cm-1. The above case clearly shows the ability to identify the NPP instrument calibration bias from the inter-calibration study.

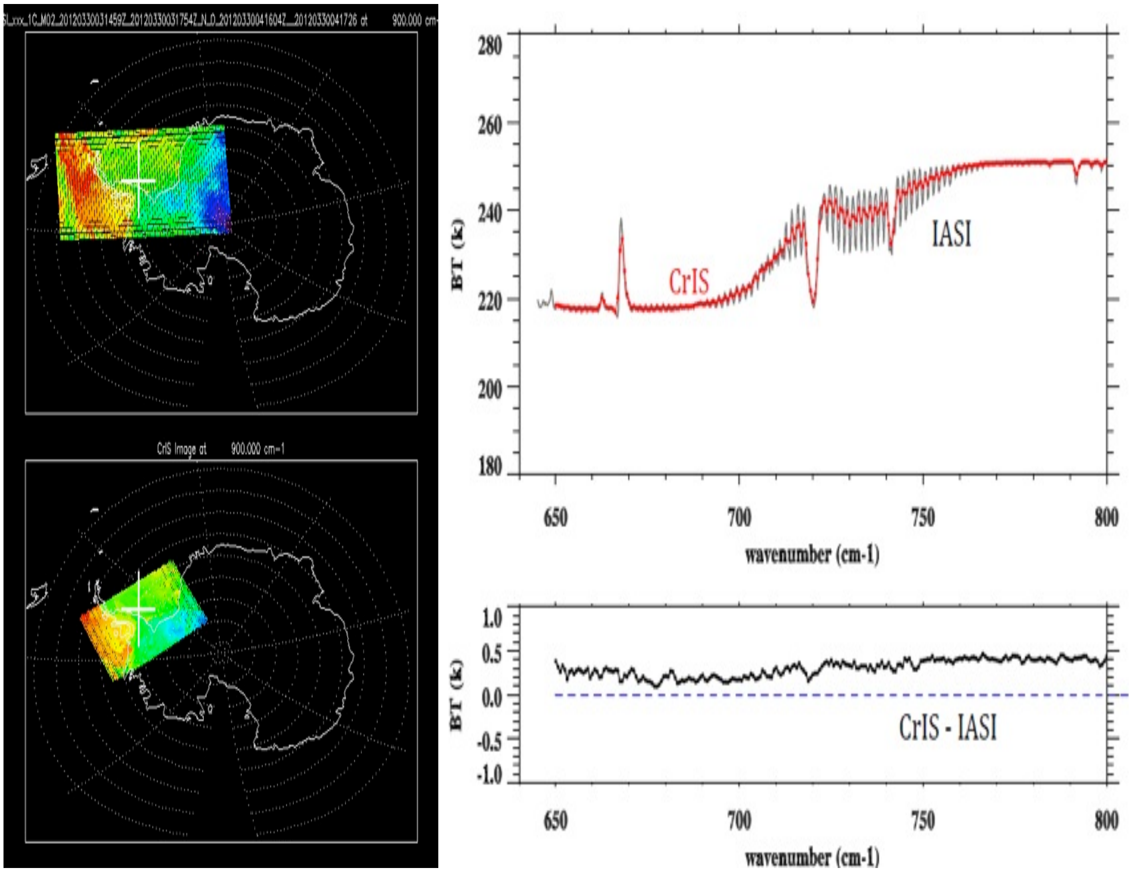


Figure 1: (Left) Simultaneous nadir overpass observations for IASI (top) and CrIS (bottom) indicated by the white plus symbols as well as (Right) the SNO spectra from IASI (black) and CrIS (red) and their BT differences (bottom).

PLANNED WORK

- Develop cross calibration algorithm using NWP model-based double difference
- Evaluate long-term radiometric and spectral consistency among AIRS, IASI, and CrIS using the SNO and double difference methods at both relatively large wavelength intervals and the finest spectral scale.
- Enhance the GSICS inter-calibration for geostationary instruments by introducing CrIS

PUBLICATIONS

Wang, L., X. Wu, M. Goldberg, and F. Weng, 2012: Effects of Ice Decontamination on GOES-12 Imager Calibration, *IEEE Transactions on Geoscience and Remote Sensing (Under review).*

Yu F., X. Wu, M.K. Rama Varma Raja, Y. Li, L. Wang, and M. Goldberg, 2012: Evaluations of Diurnal Calibration Variation and Scan Angle Emissivity Calibration for GOES Imager Infrared Channels. ***IEEE T****ransactions on Geoscience and Remote Sensing. (Accepted upon revision).*

PRESENTATIONS

Wang, L.**,** Y. Han, F. Weng, and M. Goldberg : Inter-calibration of NPP CrIS with AIRS and IASI, NPP CrIS SDR Product Review meeting. 4 April 2012.

4.3 *Other STAR or Satellite Projects*

The Development of AMSU Climate Data Records (CDR's)

Task Leader Wenze Yang; Chabitha Devaraj; Isaac Moradi

Task Code RFWYAMSU_11

Contribution to CICS Themes Theme 1: 100%

Contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

BACKGROUND

Current passive microwave sounder data, used in hydrological applications, are derived from POES satellites for which the primary mission is operational weather prediction. These data are not calibrated with sufficient stability for climate applications. A properly calibrated FCDR needs to be developed to enable the utilization of these data for TCDR and Climate Information Records and to extend their application into the JPSS era (e.g., POES/AMSU to NPP/ATMS to JPSS/ATMS). Once developed, TCDR's for water cycle applications (precipitation, water vapor, clouds, etc.) will be developed for use as key components in international programs such as GEWEX, CEOS and GPM.

Passive microwave sounder data have proven their worth in more than just tropospheric temperature and moisture monitoring. NOAA/NESDIS generates operational products from the Advanced Microwave Sounding Unit (AMSU) focused on the hydrological cycle (e.g., rainfall, precipitable water, cloud water, ice water, etc.) through two product systems known as the Microwave Surface and Precipitation Products Systems (MSPPS) and the Microwave Integrated Retrieval System (MIRS) since the launch of NOAA-15 in 1998. These data offer the unique opportunity to develop CDR's that can contribute to other satellite time series with similar capabilities such as the DMSP SSM/I and SSMIS, the TRMM TMI, and Aqua AMSR-E. This project will focus on the development of AMSU FCDR's for the AMSU-A window channels (e.g., 23, 31, 50 and 89 GHz) and the AMSU-B/MHS sensor.

ACCOMPLISHMENTS

Our accomplishments during the second year of the three-year project are as follow: 1. successfully hosted a workshop in March, 2011, as summarized in Ferraro et al. 2011; 2. finished geolocation correction using coastal brightness temperature comparison approach, as summarized in Moradi et al. 2012 and below; 3. finished cross scan asymmetry characterization, correction and verification for AMSU-A window channels, as summarized in Yang et al. 2012 and below; 4. obtained some results on cross scan asymmetry characterization for AMSU-B/MHS window channels, as summarized below.

Geolocation Correction

One of the most important preprocessing practices for the satellite data is geolocation. The accuracy of geolocation is affected by different errors including satellite attitude errors, i.e. pitch, roll, and yaw offsets, sensor mounting error, satellite clock offset, and errors in ephemeris data. Microwave satellite data do not have fine spatial resolution, therefore their geolocation accuracy can not be identified using simple methods like superimposing coastlines on the satellite data. In this study, we used the difference between ascending and descending brightness temperatures (ΔTb) along the shorelines to quantify the geolocation error. If geolocation is perfect then ΔTb will be very small that is related to the diurnal variation of surface emissivity, surface physical temperature, and environmental effects. In case of geolocation error, along the shorelines ΔTb becomes the difference between land and Ocean Tb's. The differences between land and ocean Tb's are very large that is related to the large difference between land and water emissivity in microwave frequencies, land emissivity is very close to one but ocean emissivity is about 0.5. For example lets assume 300 K for the surface temperature over both land and ocean; corresponding Tb is 300 x 0.9 = 270 K over land and 300 x 0.5 = 150 over ocean.

We counted number of pixels along the coastlines where $\Delta Tb > T_{thr}$ (T threshold) as an index for the geolocation accuracy and tried to minimize it by tuning satellite attitudes, pitch, roll, and yaw. The method is not sensitive to the T_{thr} but T_{thr} has to be greater than diurnal ranges of physical temperature. We used 30 K for our computations but larger values can be adopted as well. We first tuned pitch, then roll and finally yaw to minimize number of pixels where $\Delta Tb > T_{thr}$.

After finding the best match for the satellite attitudes, we calculated new geolocation data for AMSU-A Channels 1, 3, and 15, and AMSU-B/MHS Channel 1. AMSU-A Channel 2 has the same geolocation error as AMSU-A Channel 1 as they are on the same unit. All AMSU-B/MHS channels have the same geolocation error as they are on the same unit.

Our study shows that NOAA-15 AMSU-A2-1 (Channels 1 and 2) has the largest geolocation error, see Figure 1. In fact, AMSU-A2-1 onboard NOAA-15 is mounted about 1.2 degrees negative cross-track, so that the instrument does not point to the satellite subpoint when the scan angle is zero. Other problems that we found in NOAA level 1b data and were corrected are as follows:

- MHS step angle is about 1+1/9 but NOAA has initially used 1+1/10 until 2005 day number 217. The difference can be up to 30 km for off-nadir pixels.
- The clock offset correction for NOAA-17 both AMSU-A and -B sensors was turned off. The clock offset has a large impact on geolocation accuracy so that 1 second clock offset is roughly equal to 6 km geolocation error.
- NOAA 15 clock offset is not included in level 1b geolocation at the beginning while NOAA-15 clock offset is sometimes more than 2 seconds. This time offset can shift the data about 12 km along track.
- NOAA geolocation package failed to calculate GHA (Greenwich Hour Angle) at the beginning of 2004 for about 5 days. Those data have a very large geolocation error. The longitude is about 1 degree wrong.
- Level geolocation data are in geocentric coordinates before 2007.

In this study we corrected all these errors and calculated new values for latitude, longitude and satellite zenith angle. The latter is very important for radiative transfer calculations as the outgoing radiance is a function of the zenith angle.

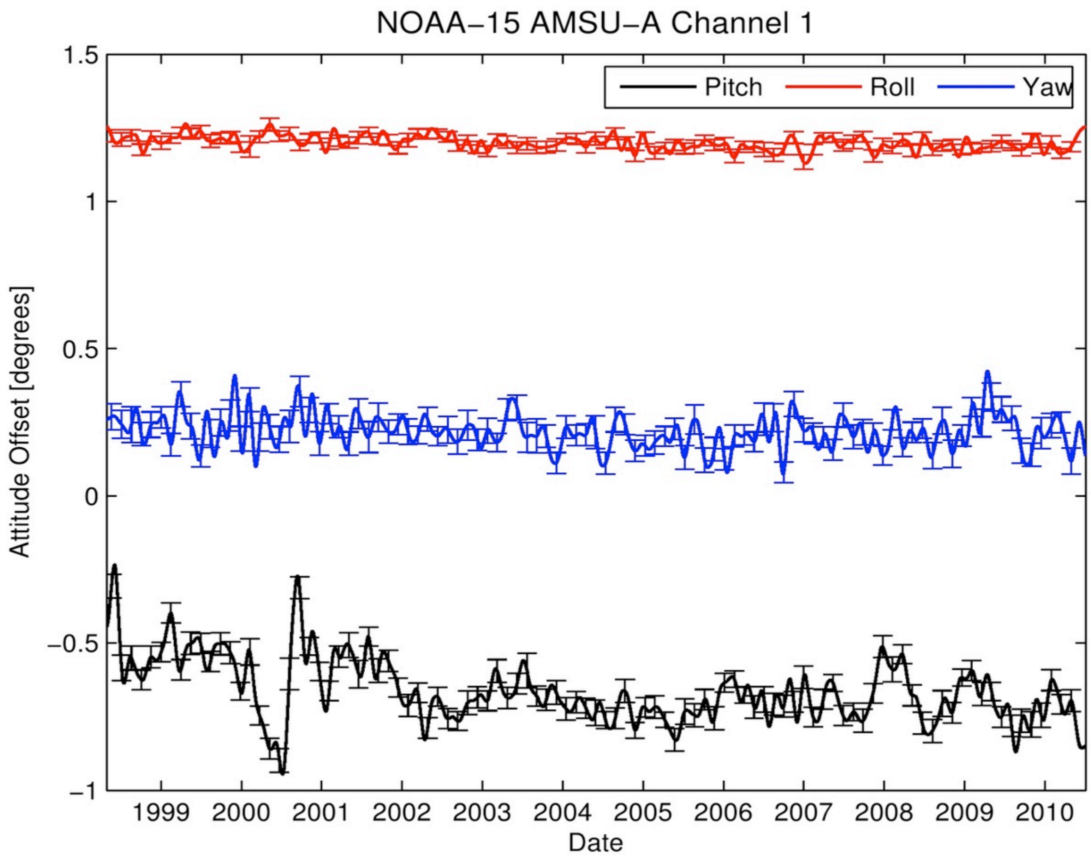


Figure 1: Time series of the satellite attitudes for NOAA-15 AMSU-A Channel 1. AMSU-A2 instrument is mounted about 1.2 degrees negative cross-track. So that the sensor does not point to the nadir when then scan angle is zero. The sensor has a small alongtrack offset as well, about 0.5 degree.

Cross Scan Asymmetry of AMSU-A Window Channels: Characterization, Correction and Verification

Following the path set in the first year, we finished AMSU-A scan bias characterization and investigation of possible reasons and corrections, and the result is summarized in Yang et al., 2012. AMSU-A scan bias is characterized by referencing to simulated brightness temperature (TB) and taking the difference between observations and simulations over low and mid-latitude oceans (60°S-60°N) under clear sky. The difference is adjusted across scan line by its nadir value so there is no systematic difference at nadir. The bias is asymmetric relative to the nadir, and there is little difference between ascending and descending cases. The asymmetry pattern appears to be stable through several years of data examined, but is quite different for each satellite. The asymmetry might be due to both sensor errors and asymmetric environmental conditions. By introducing the vicarious cold reference (VCR) approach and stratifying at the most probable value (MPV) level, the sample cross-scan asymmetry of AMSU-A window channels is illustrated in Figure 2.

The correction approach is based on the characterization of the cross-scan asymmetry at cold end (Figure 2) and warm end. By applying the asymmetry correction in MSPPS, the improvement is evident, as shown in Figure 2. Before correction, the asymmetry effect is clearly seen in the CLW image (Figure 3a) with drier atmosphere at the left edge of the swath and wetter at the opposite edge, which makes the cloud system unrealistic. For instance, compared to the uncorrected CLW image, the corrected version has a much more coherent cloud structure above the vast ocean area at mid- and high-latitudes of Southern Hemisphere (Figure 3b). The corrected 31.4 GHz emissivity (Figure 3d) also exhibits much improvement in its cross-scan symmetry than the original (Figure 3c). This is most noticeable in the 15°N to about 37°N latitude bands where the lower emissivity is asymmetric at the two limbs in the original image but becomes comparable after correction. In summary, asymmetry correction makes the angular distribution much more symmetric and realistic. It is worth noting that the CDR asymmetry cross-scan approach outperforms the current operational correction approach, which is essentially a one-point correction.

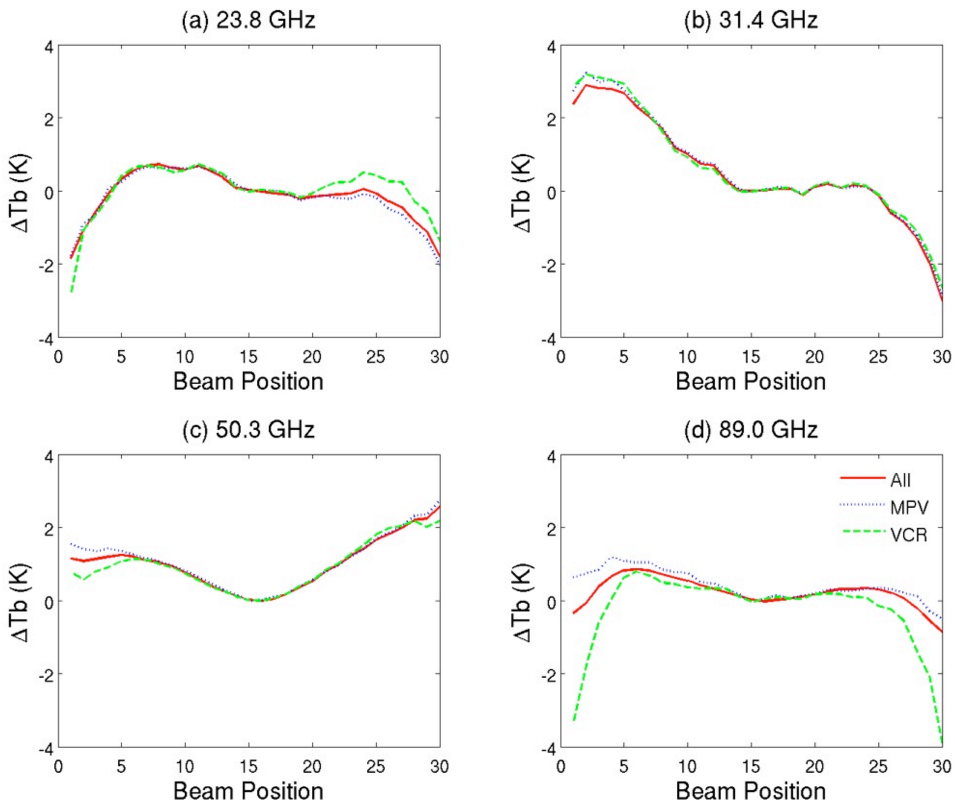


Figure 2: Mean bias of simulated brightness temperature from the observed under clear-sky over ocean in mid- and low-latitude for NOAA-15 AMSU-A (a) 23.8, (b) 31.4, (c) 50.3 and (d) 89 GHz. Results are for all observation (All), most probable value stratification (MPV), and vicarious cold reference (VCR). The mean bias is relative to nadir.

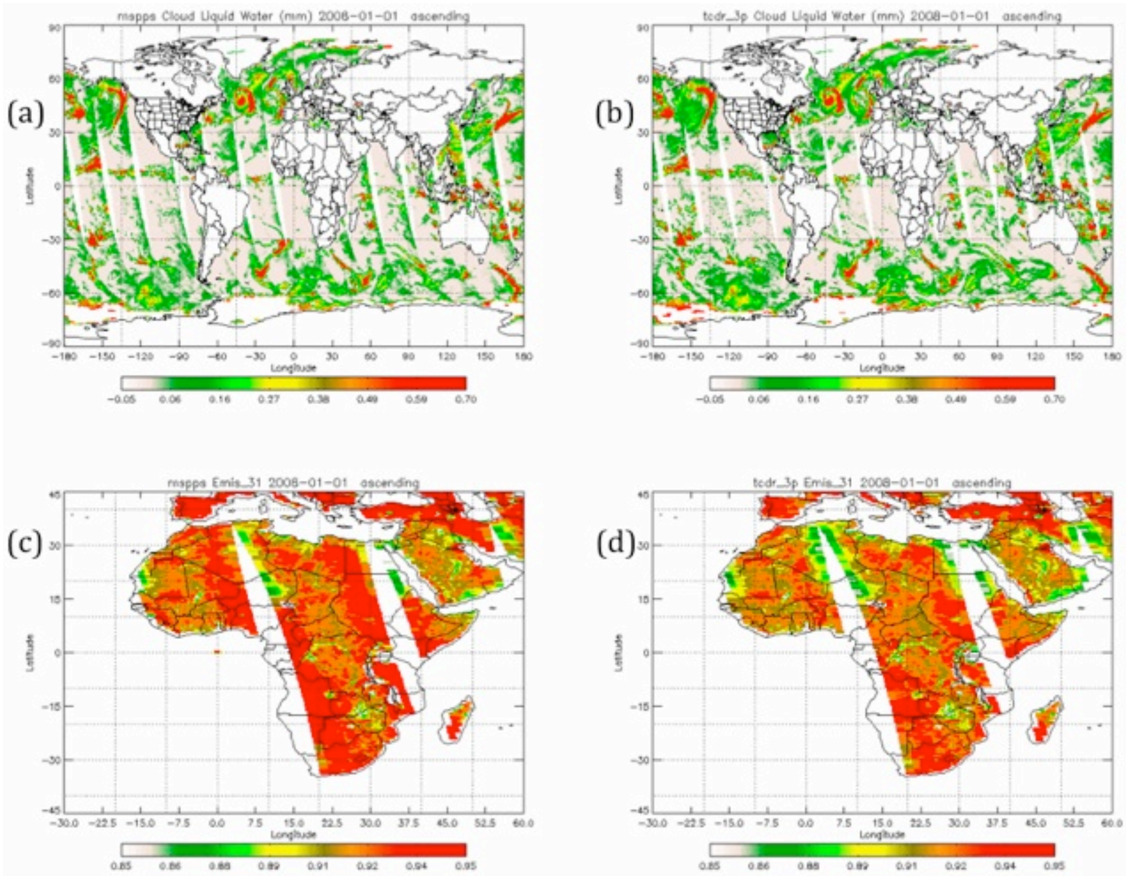


Figure 3: Geographical distribution of cloud liquid water (upper panels) and land surface emissivity at 31.4 GHz (lower panels), derived through MSPPS. Images (a) and (c) are the original products; and (b) and (d) are with asymmetry correction. For clarity, the 31.4 GHz emissivity is shown over the continent of Africa instead of the entire globe.

AMSU-B/MHS Cross-track Asymmetry for the Window Channels

We are also working on characterizing the AMSU-B/MHS cross-track asymmetry for the window channels. The across-scan bias and asymmetry in AMSU-B/MHS was analyzed using a similar method that was adopted for AMSU-A. Using the Community Radiative Transfer Model (CRTM), the AMSU-B/MHS channel brightness temperature (TB's) over tropical ocean under clear sky conditions (determined using PATMOS-x) were compared with CRTM simulated TB's for AMSU-B/MHS channels. The antenna pattern correction for AMSU-B/MHS channels for conversion of antenna temperature to brightness temperature was done based on the method and the coefficients provided by AAPP (ATOVS and AVHRR Pre-processing Package).

We investigated the asymmetry pattern for NOAA-18 satellite for the year 2008 using stratification of different environmental conditions. We identified that while 89 GHz channel was highly sensitive to surface related parameters, 157 GHz channel was mostly sensitive to atmospheric humidity. We then inspected the pattern and magnitude of the asymmetry for low wind speed and low humidity stratification case (Figure. 4) and for low wind speed and high humidity stratification case (Figure. 5). The stratification results indicate that in order to better correct for the across scan asymmetry, we need to develop different approaches to characterize these two channels.

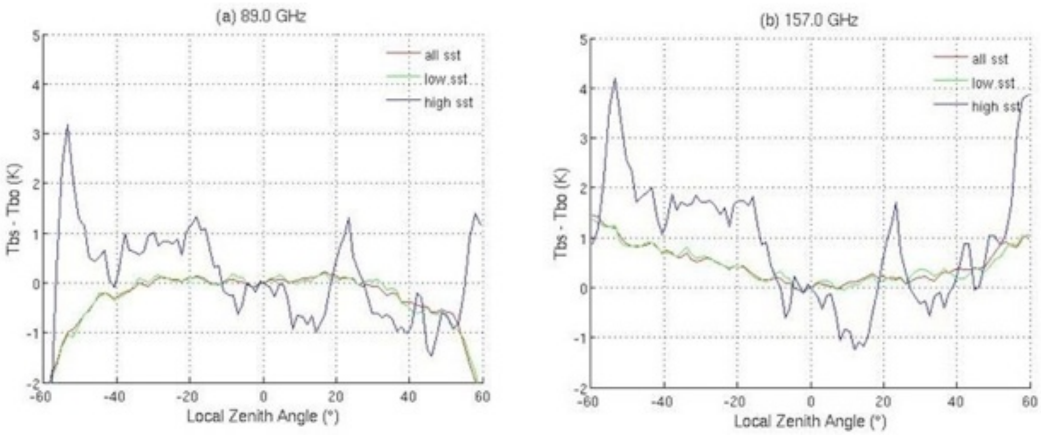


Figure 4: Mean bias observed in 2008 NOAA-18 MHS channels for low wind speed and low humidity stratification case for different ranges of sea surface temperature (sst).

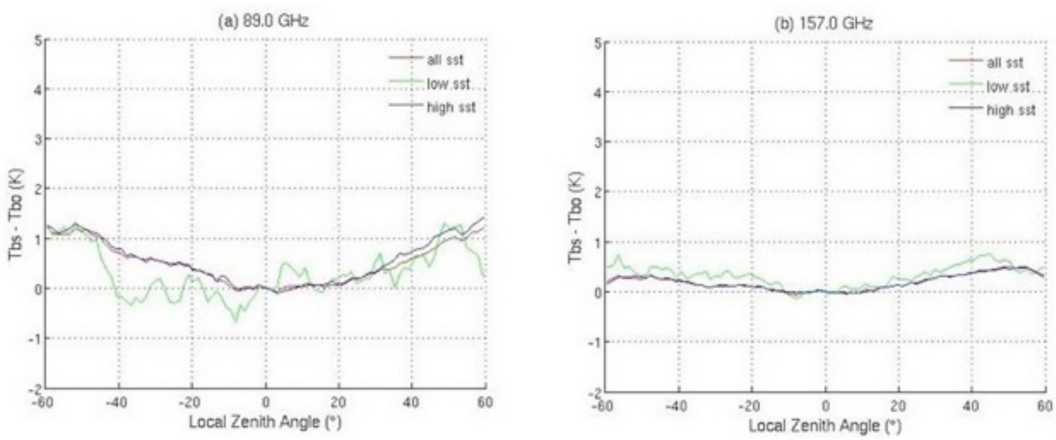


Figure 5: Mean bias observed in 2008 NOAA-18 MHS channels for low wind speed and high humidity stratification case for different ranges of sea surface temperature (sst).

PLANNED WORK

The ongoing and future work is scheduled in three lines:

- For AMSU-A window channels, we will carry out inter-satellite calibration to correct systematic biases. There are three potential inter-satellite calibration approaches for window and water vapor channels: simultaneous nadir overpass (SNO), vicarious reference, and double differencing technique. We will explore the most suitable approach(es) for our application as the project progresses.
- For AMSU-B/MHS window channels, we are now investigating the causes of AMSU-B/MHS scan bias, such as sensor RFI, warm target contamination, orbital decay, and sensor/satellite degradations, etc. Then single-satellite and inter-satellite calibration will be explored and performed.

- We just started our work on AMSU-B/MHS water vapor channels, which would include single-satellite bias characterization and correction, as well as inter-satellite calibration. Different techniques including simulations using radiative transfer models, and inter-comparing satellite data will be used to quantify and correct different biases. The inter-satellite calibration will highly depend on SNO and double differences method but other possible methods will also be investigated.

PUBLICATIONS

R. Ferraro, H. Meng, Z. J. Luo, "Using satellite microwave sensors to develop climate data records," EOS, Transactions American Geophysical Union, vol. 92, no. 32, pp. 268, doi:10.1029/2011EO320005, 2011.

W. Yang, H. Meng, R. Ferraro, I. Moradi, and C. Devaraj, "Cross scan asymmetry of AMSU-A window channels: Characterization, correction and verification," IEEE Trans. Geosci. Remote Sens., 2012, submitted.

I. Moradi, H. Meng, R. R. Ferraro, and S. Bilanow, "Correcting geolocation errors for microwave instruments aboard NOAA POES satellites," IEEE Trans. Geosci. Remote Sens., 2012, to be submitted.

PRESENTATIONS

H. Meng, R. Ferraro, C. Devaraj, I. Moradi, and W. Yang, 2011: Project overview – The development of AMSU FCDR's and TCDR's for hydrological applications. Talk presented at NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders – AMSU/MHS/SSMT2, Earth System Science Interdisciplinary Center (ESSIC), College Park, MD, USA, March 2-3.

W. Yang, H. Meng, and R. Ferraro, 2011: AMSU-A asymmetry for window channels. Talk presented at NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders – AMSU/MHS/SSMT2, Earth System Science Interdisciplinary Center (ESSIC), College Park, MD, USA, March 2-3.

C. Devaraj, 2011: AMSU-B/MHS asymmetry. Talk presented at NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders – AMSU/MHS/SSMT2, Earth System Science Interdisciplinary Center (ESSIC), College Park, MD, USA, March 2-3.

I. Moradi, H. Meng, and R. Ferraro, 2011. AMSU navigation and geolocation errors. Talk presented at NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders – AMSU/MHS/SSMT2, Earth System Science Interdisciplinary Center (ESSIC), College Park, MD, USA, March 2-3.

C. Devaraj, H. Meng, R. Ferraro, W. Yang and I. Moradi, 2011: The Development of AMSU-B/MHS Fundamental CDR's. Talk presented at CALCON meeting in Logan, UT in August 29-September 1.

C. Devaraj, H. Meng, R. Ferraro, W. Yang and I. Moradi, 2011: The Development of AMSU-B/MHS Fundamental CDR's. Poster presented at AGU Fall Meeting in San Francisco, CA in December 5-9.

W. Yang, I. Moradi, C. Devaraj, H. Meng, and R. Ferraro, 2011: Development of AMSU Fundamental CDR. Talk presented at X-Cal meeting in Fort Collins, CO in July 13-14.

W. Yang, I. Moradi, C. Devaraj, H. Meng, and R. Ferraro, 2011: The Development of AMSU-A Fundamental CDR's. Poster presented at EUMETSAT/GSICS in Oslo, Norway in September 5-9.

I. Moradi, H. Meng, and R. Ferraro, 2012: Geolocation and scan asymmetry correction for the passive microwave instruments. Talk presented in 18th Conference on Satellite Meteorology, Oceanography and Climatology / First Joint AMS-Asia Satellite Meteorology Conference, New Orleans, Louisiana, USA, January.

I. Moradi, H. Meng, and R. Ferraro, 2011: Geolocation and scan asymmetry correction for NOAA POES passive microwave instruments. Poster presented in AGU Fall Meeting, San Francisco, CA, USA, December.

I. Moradi, H. Meng, and R. Ferraro, 2011: Geolocation correction for NOAA POES passive microwave instruments. Talk presented in GPM Intersatellite Calibration Working Group, Denver, CO, USA, November.

I. Moradi, H. Meng, and R. Ferraro, 2011: Geolocation correction for NOAA POES passive microwave instruments. Talk presented in CICS Science Meeting, NCDC/NOAA, Asheville, NC, USA, November.

I. Moradi, H. Meng, and R. Ferraro, 2011: Geolocation correction for NOAA POES passive microwave instruments. Talk presented in CALCON Technical Conference: Conference on Characterization and Radiometric Calibration for Remote Sensing, Utah State University, Logan, UT, USA, August.

I. Moradi, H. Meng, and R. Ferraro, 2011. Geolocation Correction for Microwave Instruments (AMSU-A, AMSU-B and MHS) Onboard NOAA POES Satellite, NESDIS/STAR/NOAA, World Weather Building, Camp Springs, MD, USA. Invited Talk.

I. Moradi, H. Meng, and R. Ferraro, 2011. Geolocation Correction for NOAA POES Passive Microwave Instruments, ESSIC, University of Maryland, College Park, MD, USA. Invited Talk.

Operational AMSR-E SSTs

Task Leader	Andrew Harris
Task Code	AHAHAMSRE11
Contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals	Goal 2: 25%; Goal 3: 25%; Goal 4: 25%; Goal 5: 25%

BACKGROUND

The ability to retrieve SSTs even with 100% cloud cover is an invaluable asset for ocean forecasting and numerical weather prediction, especially during winter months. For example, the ability to observe rapidly varying SSTs due to strong mixing during the passage of hurricanes is especially useful during the high activity phases of the hurricane season. The AMSR-E microwave imaging instrument can retrieve SSTs through clouds, and product is impervious to aerosol contamination. It is for these reasons that the timely provision of microwave SST observations is a highly desirable goal for a number of oceanographic, climate and weather applications.

Project goals

Although the capabilities have been amply demonstrated in the research community, the calibration and SST retrieval approach employed in NOAA operational centers is significantly sub-optimal. Adaptation of research methodologies to the near-real-time environment requires a "transfer of technology" effort:

- The method must be "understood" by those receiving the technology
- Adaptations to the near-real-time environment must be made, based on operational constraints and understanding of where compromises can be made, if required
- Validation of the end-product and further adjustment and improvement, as required

Much of the technology transfer work has been performed by Remote Sensing Systems (RSS), who developed the AMSR-E calibration and retrieval methodology. The PI has overall technical oversight and has worked closely with both RSS and NOAA staff in order to ensure that the transfer of technology is successful.

ACCOMPLISHMENTS

The RSS calibration and SST retrieval algorithm has been adapted to near-real-time operation and transferred to NOAA Office of Satellite Product and Operations (OSPO). The OSPO contractor has successfully implemented the code on the backup server and run test cases. Ancillary data required for processing include an ice mask and surface wind fields. The former is required in order to screen for the presence of ice (emissivity ~1) within the AMSR-E footprint (including the side-lobe) since ocean emissivity is ~0.5. Combined with the linear Planck function, unmasked ice can produce errors of tens of Kelvin in retrieved SST even in the sidelobe. Wind direction is used to improve surface emissivity estimates.

In this processing, ancillary fields of wind and sea ice are obtained from the NCEP operational server. The algorithm was tested with both analysis and forecast winds. The benefits of the latter are twofold. Firstly, reliance on analysis wind introduces an inevitable latency in the processing which is ameliorated by using a predictive forecast from a previous analysis time. Secondly, the use of forecast data gives the model dynamics recover from any assimilation shock issues that can arise in 3d-var systems. We have noted before that this can be an issue in certain assimilation systems, at least for low windspeeds due to lack of sensitivity in much of the scatterometer data. The main potential disadvantage is, of course, that forecast fields may be less accurate.

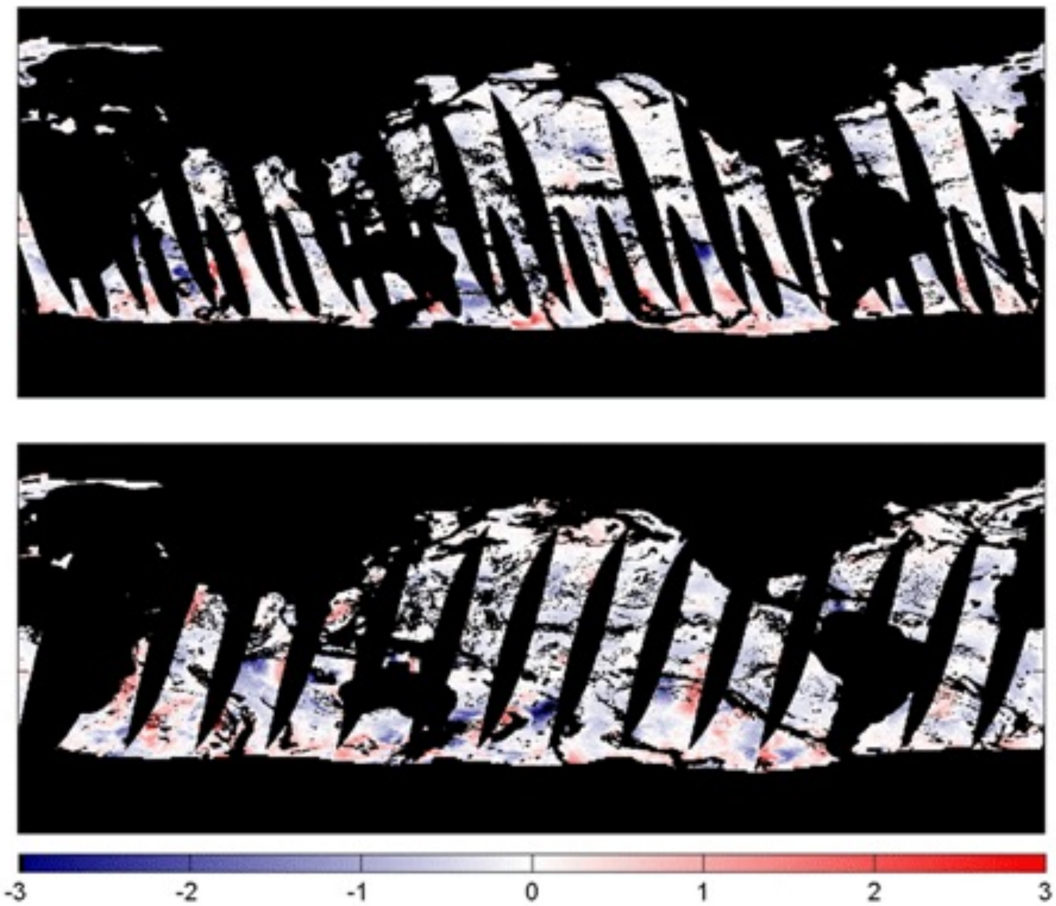


Figure 1: Differences between AMSR-E near-real-time and RSS SST retrievals for daytime (top) and nighttime (bottom). The gaps in the ascending swaths are due to masking of sunglint.

Figure 1 shows the differences between the new pre-operational AMSR-E SST product and the reference RSS product. While there are some discrepancies, the majority of differences are <0.2 K. Most of the difference is due to the limitations of a near-real-time calibration which does not have the benefit of forward and backward differencing to constrain small pointing and antenna temperature cycling errors. These are evident as cross-track dipoles and along-track dipoles respectively.

PLANNED WORK

- The abrupt failure of AMSR-E on October 4, 2011, essentially puts the project on hold. While NASA are attempting to restart the antenna, it has become increasingly clear that the quality and quantity of science data required from the instrument will not be forthcoming. However, valuable lessons have been learned about the process of porting a non-operational microwave SST to the NOAA operational environment. The links formed with RSS, especially with respect to research-to-operations transition, are valuable for NOAA.
- The PI has directed remaining effort towards assisting in NOAA's preparations for the validation and utilization of data from the AMSR-2 instrument, which is currently due for launch on the Japanese GCOM-W1 platform on May 18, 2012.

OTHER

Operational AMSR-E processing system delivered to OSPO

Improvements to the AMSR-E Rain over Land Algorithm

Task Leader **Arief Sudradjat**
Task Code **PAASAMSRE10**
Contribution to CICS Themes
Contribution to NOAA Goals

Last year's report was the final one on work performed under this award, due to the departure of Dr. Sudradjat.

NPOESS data exploitation (nde)- MIRS precipitation RETRIVAL

Task Leader **Nai-Yu Wang**

Task Code **NWAHAPSDI11**

Contribution to CICS Themes

Contribution to NOAA Goals

Last year's report was the final one on work performed under this award. All funds have been expended.

Addition of MiRS Precipitation Products from the ATMS Instrument to the STAR Precipitation Cal/Val Activity

Task Leader John Janowiak
Task Code JJJJAMIRS11
Contribution to CICS Themes Theme 1: 90%; Theme 2: 10%; Theme 3: 0%.
Contribution to NOAA Goals Goal 2: 75%; Goal 3: 15%; Goal 4: 10%

BACKGROUND

A Precipitation Product Cal/Val task has been implemented to evaluate satellite-derived precipitation estimates that are produced by NESDIS/STAR. This task was initiated to provide support to incorporate MiRS precipitation products from the ATMS instrument into the CVal/Val activity.

ACCOMPLISHMENTS

As of early 2012, only a few samples of MiRS precipitation products that were derived from the ATMS instrument aboard the NPP satellite were available. We downloaded all of the MiRS granules for a sample day, gridded the precipitation estimates to a 0.25^{o} degree latitude/longitude grid that matches the "Stage IV" radar reference data, plotted the individual swaths and compared them to an independent precipitation analysis (CMORPH) to ensure that we processed the data properly. We then modified the product evaluation software to incorporate the MiRS/ATMS estimates so that when the estimates become available on a routine basis, the evaluation process will be ready to accept them.

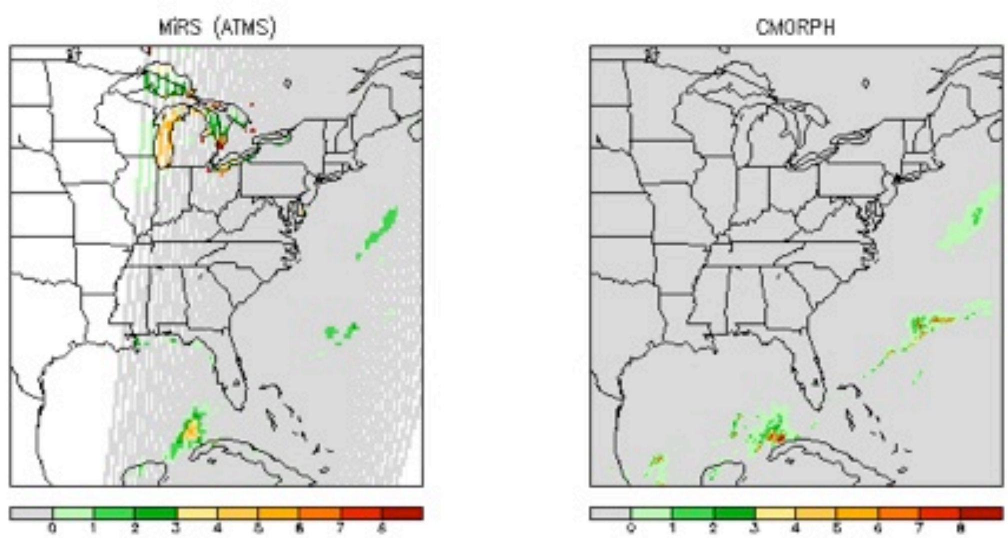


Figure 1: Plot of precipitation (mm/hr) for MiRS (from ATMS instrument; left) and CMORPH (right) for 8 U.T.C. on January 29, 2012.

PLANNED WORK

We await the routine production of MirS precipitation products from ATMS.

A Prototype STAR Precipitation Product Validation Center

Task Leader John Janowiak

Task Code Prototype STAR Precipitation Product Validation Center

Contribution to CICS Themes Theme 1: 90%; Theme 2: 10%; Theme 3: 0%.

Contribution to NOAA Goals Goal 2: 75%; Goal 3: 15%; Goal 4: 10%

BACKGROUND

A system has been developed and implemented, with input from STAR scientists, to evaluate operational NESDIS precipitation and to analyze the results of these evaluations. This effort is conducted by comparing instantaneous precipitation estimates from individual satellite swaths with hourly radar data (NCEP "Stage IV" mosaic) over the US. We also evaluate NESDIS precipitation products over South America, where daily rain gauge data re used as the reference standard. These evaluations are done within two weeks after the end of each meteorological season (Dec-Feb, Mar-May, etc.) and the results are disseminated via a web page: http://cics.umd.edu/~johnj/STAR/html/MAIN_page.html. In addition, we perform evaluations to assess the performance of new or updated algorithms, as requested to do so by the NESDIS PREcipitation Product Oversight Panel (PREPOP)

ACCOMPLISHMENTS

Evaluations for the MAM 2011, JJA 2011, and SON 2011, and DJF 2011-2012 seasons of the performance of the MiRS, MSPPS, Hydroestimator, and SCaMPR precipitation products were performed. The web pages were updated to include the statistical information that was generated by the evaluation process, and the appropriate STAR scientists were notified when the seasonal evaluations were completed.

Now that this process has matured, much effort was expended to streamline and to document the various processes to ensure that continuance of this task will be assured in the event of changes in the personnel who conduct this task. The entire process was also ported from the aging "CICS" SGI server at ESSIC to the new, linux-based "CICS2" server.

PLANNED WORK

- Continue to produce the seasonal evaluation of existing NESDIS/STAR precipitation products.
- Incorporate new precipitation products into the evaluation process as requested by the NESDIS PREPOP.
- Add new or modified statistics or the displays of them as directed by the PREPOP.

PRESENTATIONS

Arkin, P. A., J. E. Janowiak, D. Vila: (2011): Evaluation of Satellite-derived Precipitation Estimates over the Americas. American Geophysical Union. Session H93. Evaluation of Precipitation Retrievals. San Francisco, CA. Dec. 5-9, 2011.

Preparation for Assimilation of CrIS Cloud-Cleared Radiances Using IASI Proxy Data

Task Leader Sean Casey

Task Code PALRCRAJC11

Contribution to CICS Themes Theme 3: 100%.

Contribution to NOAA Goals Goal 2: 100%

BACKGROUND

The initial research plan involved impact assessments of Atmospheric Infrared Sounder (AIRS) cloud-cleared radiances (CCRs) compared with standard clear-sky radiances. At the moment, only clear-sky radiances from AIRS are being assimilated into the operational model. By including CCRs, information content ingested from AIRS could be increased by an order of magnitude.

Initial study by Jim Jung, however, yielded mixed results, with positive impact with data near the beginning of the AIRS dataset and negative impact at later dates. While no channel degradation was noted from the AIRS instrument over this time, channels 4 and 5 from Advanced Microwave Sounding Instrument-A (AMSU-A) have degraded in the past three years. These two channels have been used as an important quality-control tool both at the operational and research level; small differences between the AMSU-A all-sky radiance and the AIRS CCR suggest that the cloudy-sky signal within the field-of-regard is small, increasing the likelihood of an accurate CCR retrieval. Channel degradation on AMSU-A leads to inaccurate all-sky measurements, thus rendering this important quality-control step useless.

In addition, the AIRS instrument is nearing the end of its orbital life, with no follow-on mission of the same instrument planned. While the Cross-track Infrared Sounder (CrIS) will be operational within the year, the instrument specifications between CrIS and AIRS differ enough to suggest that impact studies using AIRS may have little to no predictive value of doing similar studies with CrIS. With these issues in mind, the decision was made to use data from the Infrared Atmospheric Sounding Interferometer (IASI) instead; no channel degradation of the accompanying microwave instrument has yet been noted, and there are currently two follow-on missions using the same instrument in the works to launch within the next four years.

ACCOMPLISHMENTS

The time period of study for this experiment will be August and September 2011. These months were chosen so that the impacts on tropical cyclone forecasts can be analyzed as well as other important metrics. July 2011 will be used for “spin-up” purposes in order for the model to reach equilibrium using CCRs. An initial run using archived bufr files from this time period is carried out first using the Global Forecast System (GFS) model. Then, using code developed by Chris Barnet & Jim Jung, and modified by Sean Casey to use IASI CCR and Level-2 ncdf files, another run will be carried out using the same specifications as the control run, changing only the type of IASI radiances assimilated into the community Gridpoint Statistical Interpolation (GSI) system.

Initial analyses using the IASI CCRs suggested that the "cloud-cleared" radiances were not fully "cloud-cleared;" that is, vertical temperature discontinuities from measured radiances still suggested a cloud signal was present in most vertical profiles. In his work using AIRS CCRs, however, Jim Jung also included CCR profiles with a low noise amplification factor (less than 2, which corresponds to a 100% increase in signal used when calculating CCR values). Doing this yielded the expected increase in observations for

given channels, as shown in Figure 1. All channels greater than channel 150 (which corresponds to a wavelength of 14.65 μm) show an increase in observations while using CCRs. These channels all have weighting functions which peak below the tropopause (i.e., in areas where clouds could be expected), and the CCR data (again, with low noise amplification factor data included) increases the number of observations below a potential cloud layer. The decrease in observations for upper-atmosphere channels (wavelengths greater than 14.65 μm) are due to the decreased swath width for the CCR data; the CCR algorithm does not work properly for the two outermost AMSU-A fields-of-regard, so this data is discarded in the CCR runs.

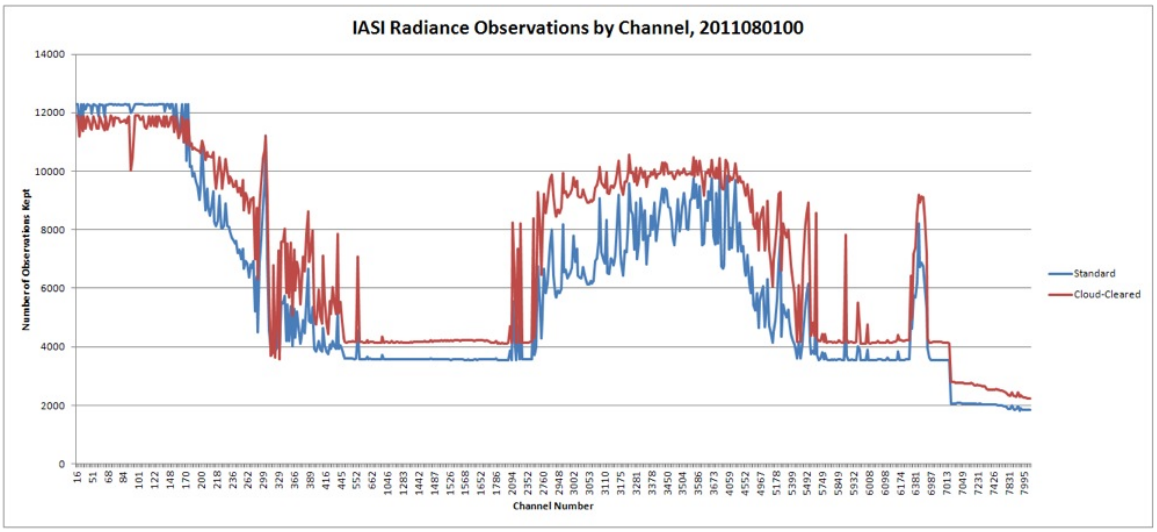


Figure 1: Number of observations at a given IASI channel for GSI analysis centered at August 1, 2011 at 0Z. Blue line shows values for standard radiances, and red line for CCRs.

The increase in observations, however, does not mean an increase in accuracy. Figure 2 shows that the observation-analysis (O-A) distribution for CCRs (red line) may be broader than that for standard radiances (blue line). Using a different threshold for noise amplification factor yields a different distribution, as well as adding in rejection criteria based on cloud fraction (not shown). The amplification factor of 2, with no set limit on cloud fraction, may not be the optimum criteria for rejection of IASI CCRs as they were for AIRS CCRs. The objective will be to find the combination of amplification factor and/or cloud fraction criteria that yields the best impact on the forecast in comparison with standard radiances.

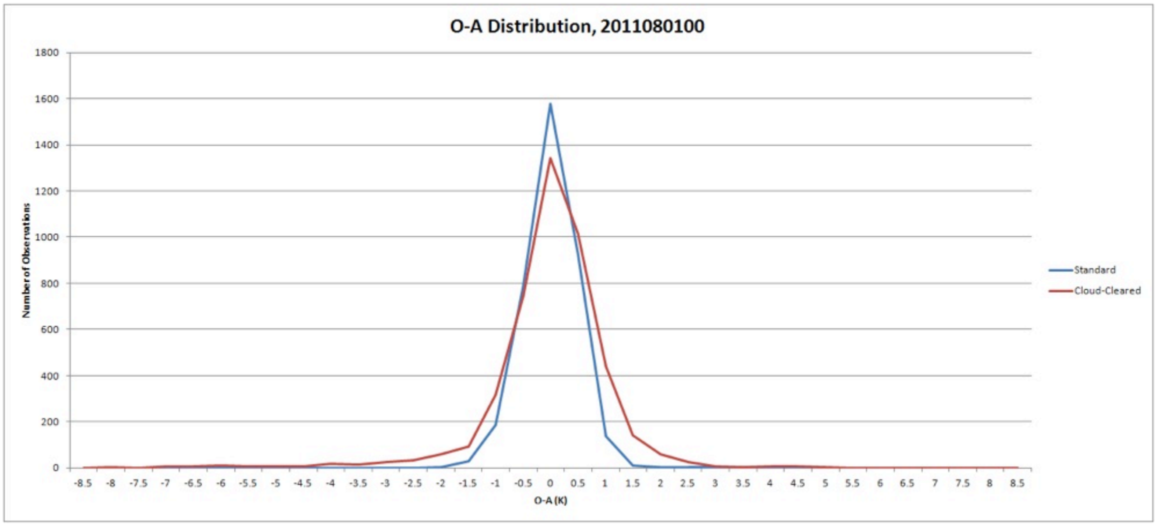


Figure 2: Observation-Analysis (O-A) distribution for channel 1652 (9.45 μm) for August 1, 2011 0Z. Blue line shows values for standard radiances, and red line for CCRs.

This work is well on its way to being completed in a few months' time. While funding for this particular project runs out in May 2012, results obtained in the next few months could have important implications for other projects. If a positive impact is observed, IASI CCRs may be assimilated into the operational model of National Center for Environmental Prediction (NCEP) forecasts in the near future. The experimental plan used in this study can easily be adapted for assimilation of CrIS and AIRS CCRs. While IASI CCR assimilation is currently the most promising of the three hyperspectral infrared sounders, assessment of AIRS CCRs could be done using other quality control metrics, and CrIS CCRs (once a few months of data are available) could theoretically be assimilated into operational models throughout the instrument's operational lifetime. Instrument differences could also compared with an eye towards what instrument type yields more positive CCR impacts. For example, differences in impact between IASI (four infrared fields-of-view (FOV) for one microwave field-of-regard (FOR)) and AIRS/CrIS (nine FOVs for one FOR) could influence FOV-per-FOR specifications for future hyperspectral infrared sounders.

PLANNED WORK

- Finish control and experimental runs, with an eye for optimal utilization of IASI CCRs.
- As funding for this project expires in May 2012, with no renewal probable, work will cease on this project following the IASI CCR assimilation experiment.

Investigations over Arctic Sea Ice using Satellite and Aircraft Altimetry

Task Leader Sinéad L. FARREL
Task Code SFSFFIOASI11
Contribution to CICS Themes Theme 1: 30%; Theme 2: 70%
Contribution to NOAA Goals Goal 1: 25%; Goal 2: 70%; Goal 4: 5%.

BACKGROUND
Sea ice mass balance and thickness are leading indicators of the state of the climate system. The ongoing loss of Arctic sea ice has serious implications for the polar environment and climate. Recent studies indicate that the observed decline in sea ice extent, now receding at a rate of -11% per decade, may contribute to colder, snowier winters in Europe, North America, and East Asia. Moreover satellite altimeter observations of sea ice thickness indicate a decrease in the overall volume of the ice pack during the last decade, indicating the loss of the thickest, multiyear ice in particular. Continuous monitoring of Arctic sea ice using satellite and airborne altimetry is necessary to determine whether these observations are part of a sustained negative trend, or a reflection of natural, inter-annual variability.

Furthermore it is essential to validate the measurement capabilities of satellite altimeters via assessments using independent aircraft and field data. The goal of this investigation is to quantify the ability of satellite altimeters on board ICESat, Envisat, CryoSat-2, and ICESat-2 to map the elevation and thickness of Arctic sea ice. Central to this goal is the utilization and analysis of data gathered by the NASA IceBridge airborne mission, which provides a yearly, multi-instrumented survey of key, rapidly changing regions of the Arctic sea-ice pack.

ACCOMPLISHMENTS
The 2011 field season was highly successful with three aircraft flights beneath satellite-borne radar altimeters, as well as overflights of direct sea ice field measurements in the Beaufort and Lincoln Seas. The major accomplishments during this reporting period were the analyses of various airborne datasets collected via the NASA IceBridge mission and comparison with complimentary satellite radar altimetry and in situ measurements.

The team conducted a detailed inter-comparison of IceBridge airborne data collected in April 2009 during the joint NOAA/NASA Canada Basin Sea Ice Thickness (CBSIT) experiment, with in situ field measurements of sea ice and snow thickness that were acquired at the Danish GreenArc Ice Camp north of Greenland. Snow depth estimates from the Kansas University snow radar system were validated via comparison with the in situ measurements, with a demonstrated agreement between the datasets to better than 3 cm. Following the publication of these results (*Farrell et al.*, 2011a), a basin-scale analysis of snow thickness on Arctic sea ice, using measurements from the IceBridge snow radar system, was completed. Results from the 2009 Arctic campaign were used to derive trans-Arctic profiles of snow depth (Figure 1). This experiment demonstrated the first, routine measurement of snow thickness on sea ice from an airborne system (*Kurtz and Farrell*, 2011). Comparisons with a climatology of snow depth, compiled from over 40 years of in situ measurements (*Warren et al.*, 1999), revealed that snow on multiyear sea ice was consistent with historical values, while snow thickness on first year ice was ~50% lower than the climatology.

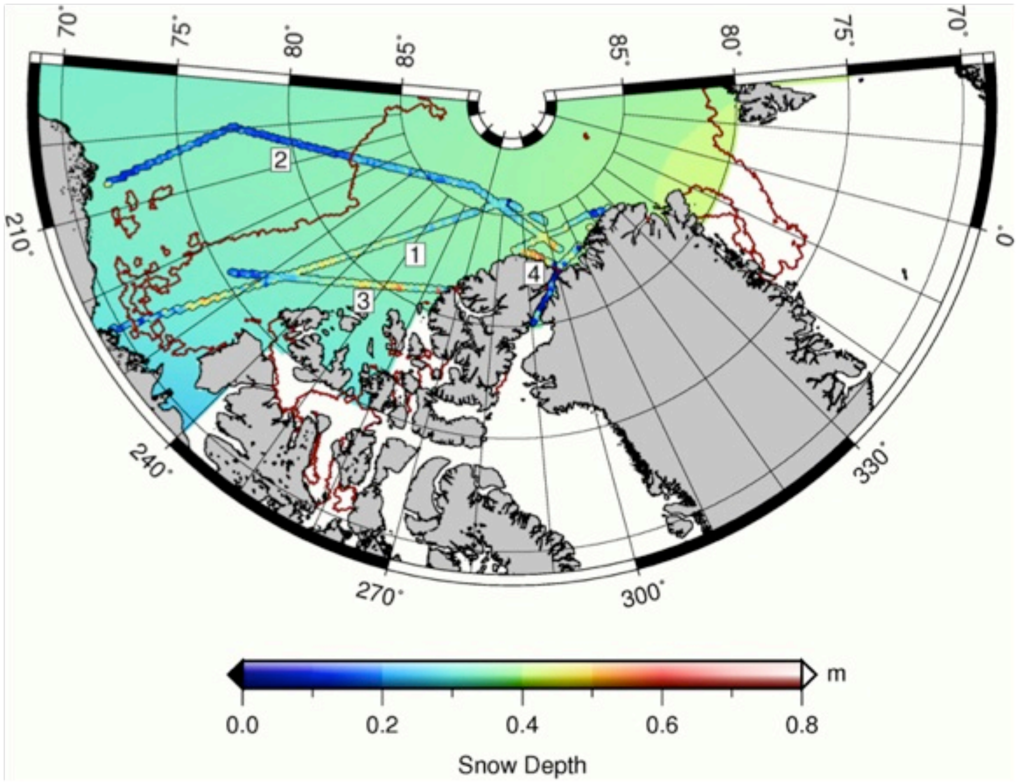


Figure 3: Trans-Arctic profiles of snow depth derived along 2009 IceBridge flight-lines, overlaid on a snow depth climatology from Warren et al., 1999.

During the March 2011 IceBridge campaign, a coordinated multiscale, nested approach to mapping snow depth and ice thickness distribution in the Arctic was taken (Gardner et al., 2012). In situ information for calibration and validation of airborne and CryoSat-2 satellite data was collected across a range of sea ice types at the "ICEX" ice camp approximately 350 km north of Alaska, at the edge of the multiyear ice zone. A second set of on-ice measurements were collected north of Alert, Canada during the ESA "CryoVex" campaign. The analysis of these coincident measurements will enable an assessment of the true uncertainty in the estimates of snow depth and sea ice thickness derived from remote-sensing platforms, as a function of ice type (Richter-Menge et al., 2011). Further presentations of our analyses of airborne and satellite measurements of Arctic sea ice were given at the American Geophysical Union Fall Meeting 2011 (Farrell et al., 2011b, Connor et al., 2011, Kurtz et al., 2011), and prepared for publication (Connor et al., 2012).

PLANNED WORK

In November 2011, the team expanded to include a postdoctoral Research Associate, Dr. Thomas Newman. Ongoing work will be to continue analysis of data collected during the 2011 Arctic sea ice campaign. We will also assist with conducting the 2012 campaign, and processing the data in conjunction with the acquisition, analysis, and synthesis of the complimentary satellite and in situ field datasets. Specifically we will:

- Integrate the measurements and results from the focused Spring 2011 in situ and airborne data collection campaign in the vicinity of the "ICEX" and "CryoVex" sea ice field camps, with coincident IceBridge data gathered in the Canada Basin in March-April 2011, to assess the accuracy of the airborne data with respect to sea ice type.
- Develop algorithms to exploit CryoSat-2 Level 1b waveforms, and perform an initial assessment of the accuracy and precision of CryoSat-2 Level 2 elevation retrievals for lead detection and sea ice freeboard estimation.
- Process airborne IceBridge Ku-band and snow radar altimetry, in concert with coincident CryoSat-2 data, for investigation of radar snow/ice penetration characteristics, ice type identification, floe/lead transitions, and lead detection.

PUBLICATIONS

Connor, L. C., S. L. Farrell, D. C. McAdoo, W. B. Krabill, and S. Manizade (2012),Vaidating ICESat over thick sea ice in the northern Canada Basin, *IEEE Transactions on Geoscience & Remote Sensing*, accepted with minor revisions.

Gardner, J., J. Richter-Menge, S. Farrell, and J. M. Brozena (2012), Coincident multiscale estimates of Arctic sea ice thickness, *EOS Trans. AGU*, 93(6), 57, DOI:10.1029/2012EO060001.

Kurtz, N. T. and S. L. Farrell (2011), Large-scale surveys of snow depth on Arctic sea ice from Operation IceBridge, *Geophys. Res. Lett.*, 38, L20505, DOI:10.1029/2011GL049216.

Farrell, S. L., N. Kurtz, L. Connor, B. Elder, C. Leuschen, T. Markus, D. C. McAdoo, B. Panzer, J. Richter-Menge, and J. Sonntag (2011a), A First Assessment of Ice Bridge Snow and Ice Thickness Data over Arctic Sea Ice, *IEEE Transactions on Geoscience & Remote Sensing*, PP (99), pp.1-14, DOI:10.1109/TGRS.2011.2170843.

PRESENTATIONS

Farrell, S. L., N. T. Kurtz, V. Onana, J. P. Harbeck, and K. Duncan (2011b), Sea Ice Lead Distribution from High Resolution Airborne Imagery, *Abstract C52B-03 present\ed at 2011 Fall Meeting*, AGU, San Francisco, Calif., 5-9 Dec. 2011.

Richter-Menge, J., S. Farrell, B. C. Elder, J. M. Gardner, and J. M. Brozena (2011), A Coordinated Ice-based and Airborne Snow and Ice Thickness Measurement Campaign on Arctic Sea Ice, *Abstract C41E-0454 presented at 2011 Fall Meeting*, AGU, San Francisco, Calif., 5-9 Dec. 2011.

Kurtz, N. T., S. L. Farrell, J. P. Harbeck, L. Koenig, V. Onana, J. G. Sonntag, and M. Studinger (2011), State of the Arctic and Antarctic sea ice covers from Operation IceBridge snow and ice thickness observations (Invited), *Absrtact C52B-02 presented at 2011 Fall Meeting*, AGU, San Francisco, Calif., 5-9 Dec. 2011.

Connor, L. N., S. W. Laxon, D. C. McAdoo, A. Ridout, R. Cullen, S. Farrell, R. Francis (2011), Arctic sea ice freeboard from CryoSat-2: Validation using data from the first IceBridge underflight, *Abstract C53F-04 presented at 2011 Fall Meeting*, AGU, San Francisco, Calif., 5-9 Dec. 2011.

OTHER

- Dr. Farrell visited the Francis Scott Key Elementary School, 2300 Key Blvd, Arlington, Virginia in June 2011. Working with Specialist Teachers, Caitlin Fine (science) and Kerensa McConnell (art), Dr. Farrell delivered a presentation to 2nd graders on the Polar Regions, snow, ice, and the polar environment.
- Dr. Farrell currently serves as a member of the NASA Operation IceBridge Science Team, and was recently selected to serve on the ICESat-2 Science Definition Team.
- Dr. Farrell was acknowledged for her participation on the IceBridge Science Team when NASA presented the 2011 Group Achievement Award to the Team for exceptional achievement in support of NASA's IceBridge campaign.

LINK TO RESEARCH WEBPAGE:
http://ibis.grdl.noaa.gov/SAT/SeaIce/index.php

Development of a 4-km Snow Depth Product for the Version 3 Interactive Multi-Sensor Snow and Ice System (IMS-V3)

Task Leader Cezar Kongoli

Task Code CKCKIMSS-12

Contribution to CICS Themes Theme 1: 20%; Theme 2: 70%; Theme 3: 10%.

Contribution to NOAA Goals Goal 1: 20%; Goal 2: 70%; Goal 5: 10%.

BACKGROUND

The Interactive Multisensor Snow and Ice Mapping System (IMS) is an operational software package for monitoring snow and ice coverage. This software enables qualified OSPO analysts to tag locations as snow covered or ice covered over the entire Northern Hemisphere. The National Centers for Environmental Prediction (NCEP) relies on IMS for snow cover and lake cover initialization for the Global Forecast System (GFS), Climate Forecast System (CFS), North American Mesoscale Model (NAM) and Rapid Update Cycle (RUC) models. The RUC model also applies ice cover fields from the IMS for ice initialization. NCEP requires improvements to the IMS products which include adding Snow Depth (SD), a date of last observation, two observations per day, GRIB2 format, and global coverage. To address these needs, a third version of the IMS (hereafter referred to as IMS V3) is under development. IMS V3 will also upgrade the data available to analysts, provide improved production flow that hampers the current system, and prepare the IMS for data pulling from future imagery sources such as those that will be on NPP and GOES-R. The addition of a 4-km SD field to IMS will allow the capability of delivering a consistent and optimal suite of IMS snow products to the NCEP community. Currently, NCEP uses the Air Force SD product as input and merges it with IMS snow. This proposal is for the continued support of the daily 4-km SD product and its integration into IMS V3 until delivery to operations.

ACCOMPLISHEMENTS

The design phase of the SD processing algorithm has been completed. Figures 1 depicts the algorithm flow diagram. The Optimal Interpolation (OI) scheme has been developed including the spatial correlation functions used to compute weighted SD output. The scheme is being tested to generate 4-km SD from in-situ and microwave data on a regional basis. Figure 2 shows interpolated SD output over Eurasia.

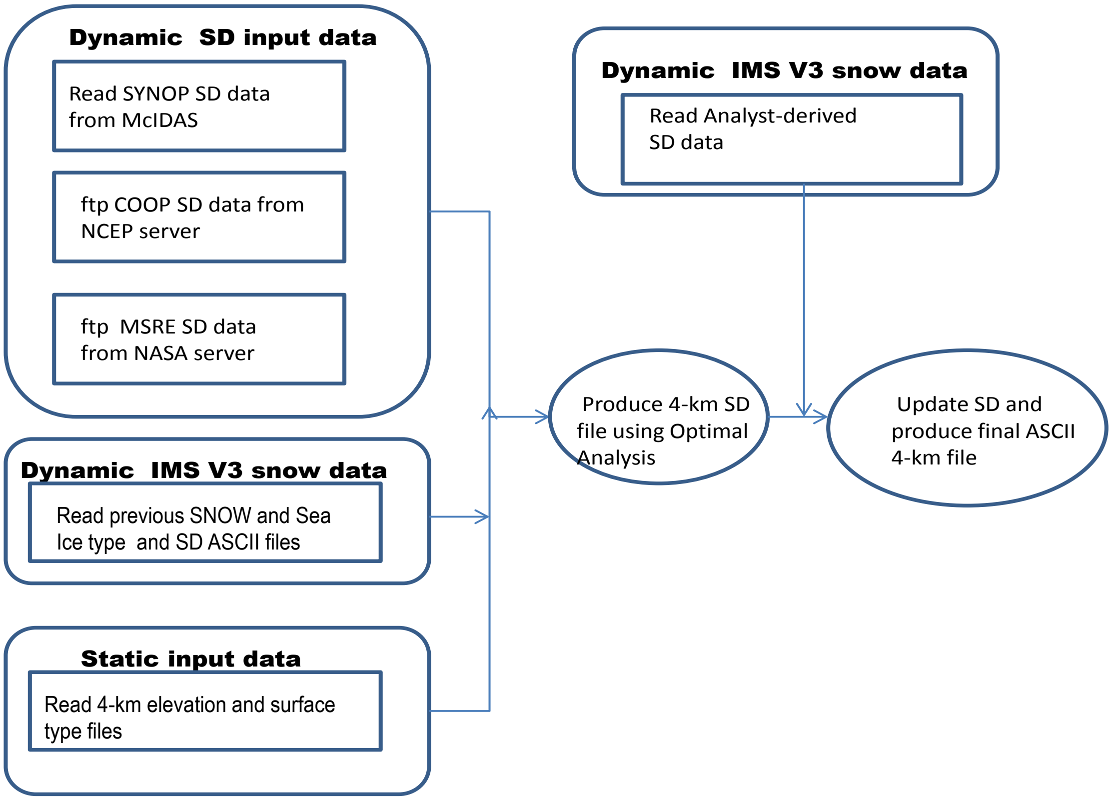


Figure 1: Data flow for the generation of the IMS Snow Depth.

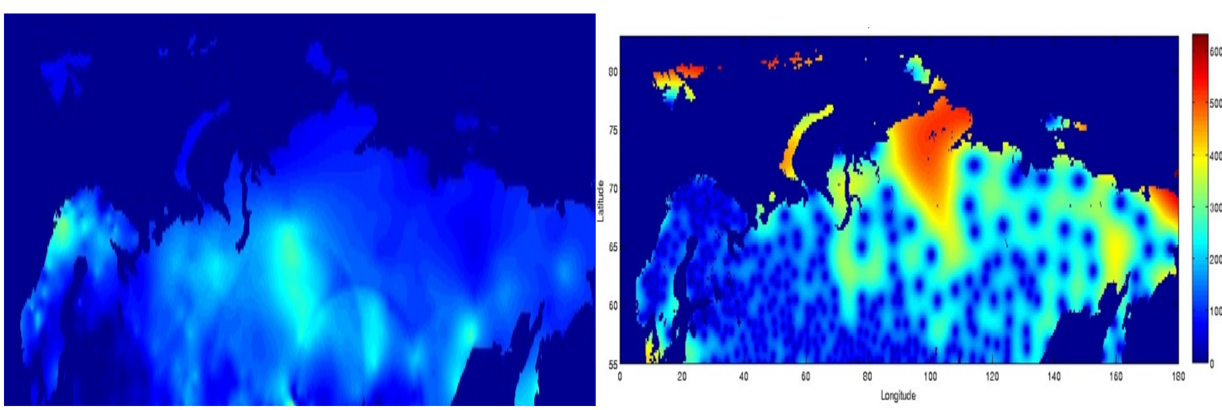


Figure 2: A snapshot of spatial interpolation of in-situ SD stations (top) and corresponding errors (bottom) generated by the optimal interpolation method.

Routines for the processing of daily in-situ and microwave data have been developed. In-situ data being processed include SYNOP, METAR and US COOP reports. SYNOP and METAR data are being obtained from McIDAS, and US COOP Reports from the NOAA NCEP Server. Algorithm is being tested using historical AMSR-E data since the AMSR-E sensor stopped operations. As a back-up for AMSR-E data, routines are being developed for the processing of high-resolution data from the Microwave Integrated retrieval System (MIRS). Further design details can be found on the documents provided in the Critical Design Review (CDR) on February 2, 2012.

PLANNED WORK

- Continue testing of preliminary algorithm
- Integrate SD processing algorithm into IMS V3 system
- Perform SD system testing in development environment
- Perform preoperational testing and provide required documentation

PRESENTATIONS

S. Helfrich and C. Kongoli, “Improved monitoring of snow depth combining surface observations from existing stations and newly developed acoustic sensors", International Symposium on Cryosphere and Climate Change (ISCCC) 2012, Manali India, 2-4 April, 2012.

Microwave and Diurnal Corrected Blended SST

Task Leader Andrew Harris
Task Code AHAH_MICR11
Contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: 0%.
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 70%; Goal 5: 10%.

BACKGROUND

NESDIS have been in the process of developing a new high-resolution (0.1°×0.1° and 0.05°×0.05°) global SST analyses to replace the previous 100-km, 50-km and 14-km (regional) products. The new scheme, which uses a recursive estimator to emulate the Kalman filter, also provides continuously updated uncertainty estimates for each analysis grid point. Since the analysis is entirely satellite-based, there is no explicit attempt to correct regional biases to an *in situ* standard. However, biases between individual datasets are corrected in a statistical manner, with certain assumptions of persistence and correlation length scale.

Improvements have been made to the analysis by assimilating a thinned version of the RTG_HR as the bias-free dataset to which others are adjusted. The impact of the RTG data is negligible where there is adequate density of other observation. The analysis is performing well with the addition of new geostationary SST data and the recent improvement in resolution from 0.1°×0.1° to 0.05°×0.05° (see Figure 1), particularly with respect to the definition of high-resolution features of oceanographic importance, such as mesoscale and coastal eddies.

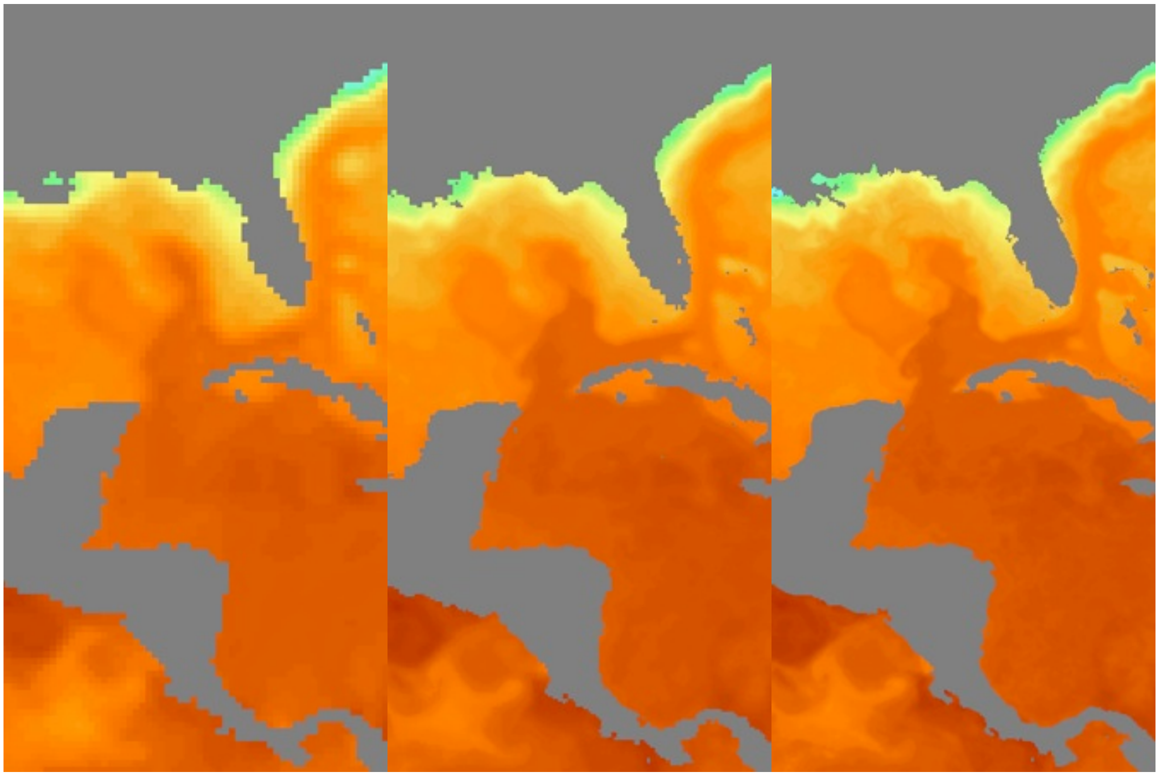


Figure 1: Comparison of Reynolds Daily OI ¼°×¼° SST analysis (left panel), POES-GOES Blended 0.1°×0.1° SST analysis (middle panel) and POES-GOES Blended 0.05°×0.05° SST analysis (right panel). Improved definition of shallow water regions in the vicinity of Abaco and other Caribbean islands, as well as coastal eddies in the Gulf Stream and Loop Current, is evident, particularly in the 1/20 degree product.

Project goals

Despite the substantial coverage gains afforded by utilizing carefully bias-corrected geostationary data, there remain significant regions of the world's oceans for which few infrared observations are available. Primarily these are regions of heavy cloud cover which may persist for several weeks or even months. These regions of persistent cloud cover are usually off the west coast of large continental land masses, and are seasonal in nature. Eastern basin currents return cooler water to the Equator and thus are locations for the formation of seasonal marine stratiform cloud as warm continental air passes over the cool water. Classic locations for such persistent cloud cover include off the coasts of California, Peru and Namibia. In such circumstances, the current analysis falls back on the thinned RTG data. However, the RTG analysis itself has to rely on sparse *in situ* data if no cloud-free infrared satellite SST data are available. Thus, despite the fine analysis grid resolution, the actual resolution of SST features may be very coarse indeed. It is to this end that we propose to add microwave SST retrievals from the AMSR-2 instrument to the input datastream for the analysis. This represents a substantial departure, not least because the native resolution of the data is significantly coarser than the grid resolution, and will therefore require different treatment. Secondly, the causes of bias in microwave SST retrievals are rather different from those encountered in infrared SST data and their time-and-space scales will need to be determined. The project originally planned to utilize data from AMSR-E but that instrument's failure in October 2011 prompted a reprioritization of project tasks and this task was originally intended to be tackled in the first year.

ACCOMPLISHMENTS

The experimental version of the 0.05°×0.05° resolution version of the analysis has been successfully transferred to operations. We have also adopted the GHRSST standard 1/20 degree land mask, combined with a refined version of the ocean basins which now includes the Black Sea and Caspian Sea. Various issues with the CoastWatch header information have been resolved. These were primarily due to the legacy nature of the CoastWatch georeferencing system, which was originally intended to map small AVHRR scenes rather than global equal-angle fields.

Additionally, work has been done to improve the algorithm preprocessing and analysis. The ingest routines are being converted from Matlab to C to improve speed, which will prove invaluable when full-resolution 1-km AVHRR data are included in the analysis. The latter will give us the opportunity to apply more sophisticated quality control techniques during the super-ob preprocessing stage. Work has also been done to optimize the quad-tree tile sizes and overlap used in the multi-scale analysis.

Some work has also been directed towards identifying possible improvements to the diurnal correction aspect of the processing. Although this is not due for another year, the demise of AMSR-E necessitated significant restructuring of the project plan. We now plan to take advantage of the NCEP wave model forecast fields to incorporate into the vertical turbulent mixing scheme (see Figure 2).

PLANNED WORK

- The abrupt failure of AMSR-E on October 4, 2011, necessitated substantial revision of the project schedule. The first phase now incorporates the conversion of I/O intensive ingest routines from Matlab to C, and the production of a nighttime-only SST analysis in support of the NOAA Coral Reef Watch mission. Stage 1 of the project is scheduled to be complete in August 2012.
- Next year's work includes the incorporation of microwave SSTs from the Japanese AMSR-2 instrument (when they become available), and the inclusion of AATSR data as a bias correction reference. The diurnal correction will be added in the final phase.

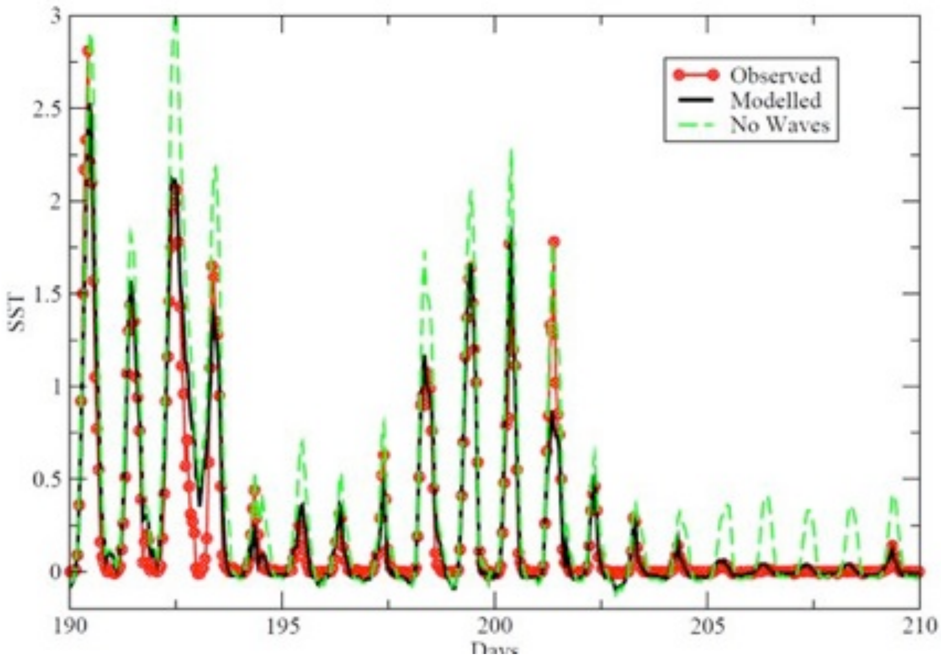


Figure 2: Comparison of observed and modeled diurnal warming results for Arabian Sea mooring. The tendency of the model to over-predict when wave-mixing is not included is evident for both high and low warming cases. (Taken from Janssen, GHRSST, 2011)

Geo-SST Phase II	
Task Leader	Andrew Harris
Task Code	AHAH_GSST11
Contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%; Theme 3: 0%
Contribution to NOAA Goals	Goal 2: 25%; Goal 3: 25%; Goal 4: 25%; Goal 5: 25%

BACKGROUND

In the sea surface temperature (SST) operational processing methodology used to date, the confidence in SST retrieval algorithms (developed by direct regression of satellite-measured radiances against *in situ* observations) is highest where the satellite data have least impact, and lowest where their potential is greatest. During the course of the satellite record, there have been significant changes in the density and spatial distribution of the *in situ* data. These changes may have affected the accuracy of algorithms for different satellites. The effect of aerosols, particularly from the major eruptions of El Chichon (1982) and Mount Pinatubo (1991) have caused significant biases and trends in retrieved SST that far exceed the stringent 0.1 degK.decade^{-1} requirement of climate monitoring. While reprocessing efforts such as AVHRR Oceans Pathfinder have succeeded in removing much of the bias present in operational satellite SST data, they still fall short of requirements in a number of areas; *e.g.*, cloud elimination.

Two issues that go hand-in-hand with the estimation of SST from satellite radiances are those of cloud detection and surface effects. In cloud detection, the use of predetermined thresholds threatens the prospect of the detection/false alarm ratio being influenced by changing cloud regimes, impacting the spatial and temporal retrieval errors. A better approach is to input the level of certainty for each observation into the analysis step, as part of the error limit description for each observation. In this regard, cloud detection errors are generally non-Gaussian and asymmetric and a revised method of analysis is needed in order to produce an optimal result. Surface effects (skin effect and diurnal thermocline) are also asymmetric in their behavior. This asymmetric behavior can be modeled given adequate forcing fluxes.

Another key issue that has arisen is that of radiance bias correction. Any physical retrieval methodology is reliant on accurate forward modeling of satellite-observed radiances. This problem has been known about in the satellite soundings discipline for many years and empirical predictors are generally used to ensure that there are no fundamental discrepancies between forward-modeled and satellite-observed radiances. There are some differences between the correction of sounding channel radiances and window channel radiances, especially when the latter are to be used for sea surface temperature retrieval. Firstly, as is to be expected, the radiance biases are generally quite weak functions of model state vector. This may lead to quite poorly-optimized functions for radiance bias correction when purely empirical methods are used. Secondly, the accuracy requirement for sea surface temperature retrieval is much greater than for sounding. Systematic brightness temperature errors need to be «0.1 degK in order to avoid contributing >0.1 degK to the final retrieval error.

ACCOMPLISHMENTS

A new form of physical retrieval retrieval has been developed which is specifically designed to account for situations when the gain matrix tends to higher condition numbers, *i.e.* where the amplification of "noise" increases. This is known to be a significant problem for non-linear retrievals where many channels may be used to estimate a detailed state vector, or the observation operator is not well-represented by a jacobian of partial derivatives. However, its importance for seemingly simple near-linear retrieval problems with reduced state vectors has not hitherto been recognized. Our solution is to calculate a regularization matrix $\mathbf{R_m}$ by using a modified estimate of total least squares to be included in the usual normal equation of minimum least squares, *i.e.*:

$$x = x_a + [\mathbf{K}^T\mathbf{K} + \mathbf{R_m}]^{-1}\mathbf{K}^T[y_o - F(x_a)] \quad (1)$$

We are also employing a larger observation operator, which uses (in the case of the GOES Imager) the 13.3 micron channel (itself with little sensitivity to SST) and two "synthetic" channels, comprising the sum and difference of the 3.9 and 11 micron channels. The latter aid in stabilizing the solution, while the former provides an extra degree of freedom for the calculation of total least squares (*i.e.* 2 channels and 2 unknowns always provides a perfect fit).

The algorithm has been implemented and tested for GOES day & night (see Figure 1), MTSAT-2 day & night and Meteosat-9 day & night. In each case, the error characteristics have improved with respect to the current operational processing.

Additionally, work has been done to develop a new uncertainty estimate for each pixel based on a total error calculation using the departure of the actual retrieval increment from a value based on the averaging kernel. This has turned out to be a reliable way of providing a secular mapping of calculated uncertainty estimate to observed error. The new metric will be employed in the generation of our Geo-SST GHRSST products.

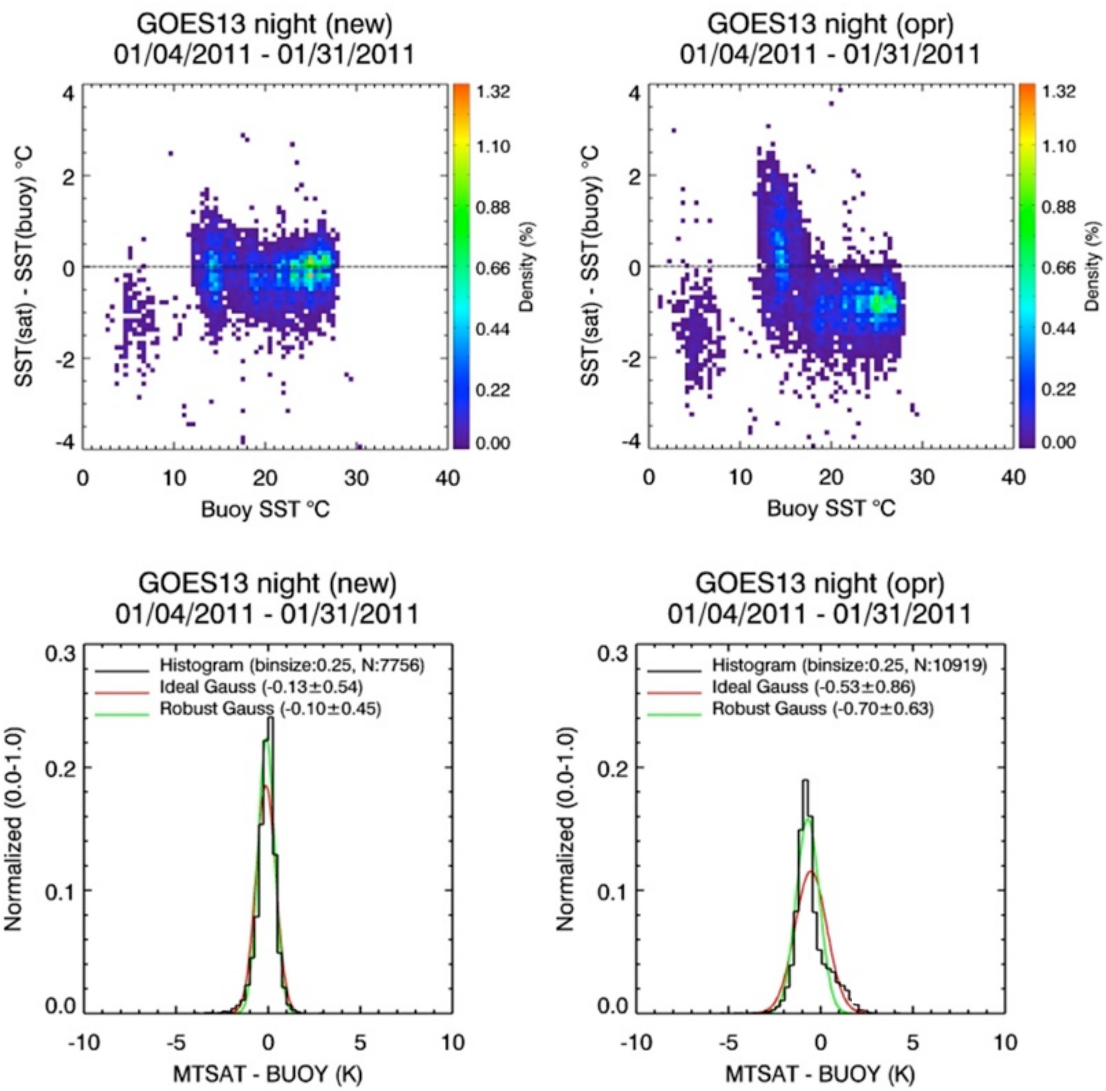


Figure 1: Nighttime validation results for new physical retrieval methodology (left-hand column) and current operational GOES-SST retrieval (right-hand column). Both scatter and bias trends are reduced.

PLANNED WORK

- The work in this project is due to finish end-June 2012. We are hopeful that version 1 of the NCEP aerosol product will be incorporated to improve biases due to desert dust (the only aerosol type to be included in their version 1 release).
- Additionally, we will produce a single global geostationary gridded SST product from the four sensors that we currently process

OTHER

Physical SST retrieval processing code (with other updates) delivered to OSPO

Integration soil moisture satellite observations and model simulations into the global crop assessment decision support system of USDA Foreign Agricultural Service

Task Leader Zhanqing Li

Task Code ZLZLLISMO11

Contribution to CICS Themes

Contribution to NOAA Goals

BACKGROUND

The proposed project aims at enhancing the U. S. Department of Agriculture (USDA) Foreign Agricultural Service (FAS) global crop assessment decision support system via the integration of NASA soil moisture data products and adoption of NASA land surface modeling and data assimilation tools. USDA FAS crop yield forecasts affect decisions made by farmers, businesses, and governments by predicting fundamental conditions in global commodity markets. Regional and national crop yield forecasts are made by crop analysts based on the Crop Condition Data Retrieval and Evaluation (CADRE) Data Base Management System (DBMS). Soil moisture availability is a major factor impacting these forecasts and the CADRE DBMS system currently estimates soil moisture from a simple water balance model (the Palmer model) based on precipitation and temperature datasets operationally obtained from the World Meteorological Organization and U.S. Air Force Weather Agency.

An on-going NASA Applied Sciences project has successfully assimilated NASA Advanced Microwave Scanning Radiometer (AMSRE) soil moisture retrievals into the existing USDA FAS Palmer model to create a global soil moisture analysis product. However, this existing product could be further enhanced in several aspects. First, its reliability is currently limited by the simplicity of the Palmer model. Recent software advances at NASA have led to the development of the Land Information System (LIS) data assimilation system. The modular nature of LIS enables the use of multiple (more physically complex) land surface models and contains an imbedded Ensemble Kalman filter data assimilation capability. As such, LIS provides an optimal framework for the integration of soil moisture products into the USDA CADRE system. Second, concerns over the future availability of AMSRE observations are hindering complete adoption of the approach. To address this need, new satellite sources of soil moisture retrieval products can be exploited to ensure the future continuity of soil moisture to USDA FAS.

The specific objectives of the proposed project will be 1) maintaining the continuity of AMSRE soil moisture to the USDA FAS CADRE system, 2) developing contingency plans for a possible disruption in the availability of AMSRE data during the proposed project period, 3 designing a prototype of the CADRE DBMS system centered around NASA LIS, and 4) developing a LIS-compliant data assimilation system to integrate future soil moisture products from the upcoming NASA Soil Moisture Active/Passive mission into the CADRE DBMS system.

In this task, as a part of the project team, we will be responsible for the number 2) of the above objectives: Develop a contingency capacity for the generation and (near real-time) delivery of surface soil moisture retrieval products from alternative satellites data sources. We will also assist PI from USDA-ARS and other Co-Investigators form USDA-FAS, NASA-GSFC) on assimilating the alternative soil moisture data into NASA LIS to routinely provide USDA-FAS with global soil moisture analysis data products.

ACCOMPLISHMENTS

1. Collaborating with Drs. X. Zhan and J. Liu of NOAA-NESDIS-STAR, we have evaluated different parameterizations of land surface vegetation optical depth (VOD) and their impact on microwave soil moisture retrievals. A combined method uses the LPRM VOD retrievals to feed the single channel algorithm. The result shown below is presented to the McroRad 2012 meeting held in Frascati, Italy in early March, 2012.
2. Evaluating soil moisture retrievals with in situ soil moisture measurements. We have collected and processed in situ soil moisture measurements for dozens of sites in US, Australia and China to validate the soil moisture retrieval algorithms. The results are being summarized for Wang Xin's Ph.D. thesis.
3. Xin Wang has started to implement the Land Information System (LIS) for assimilating satellite soil moisture data product in Noah land surface model for better simulation results of the LSM. Results will be part of Wang Xin's Ph.D. thesis too.

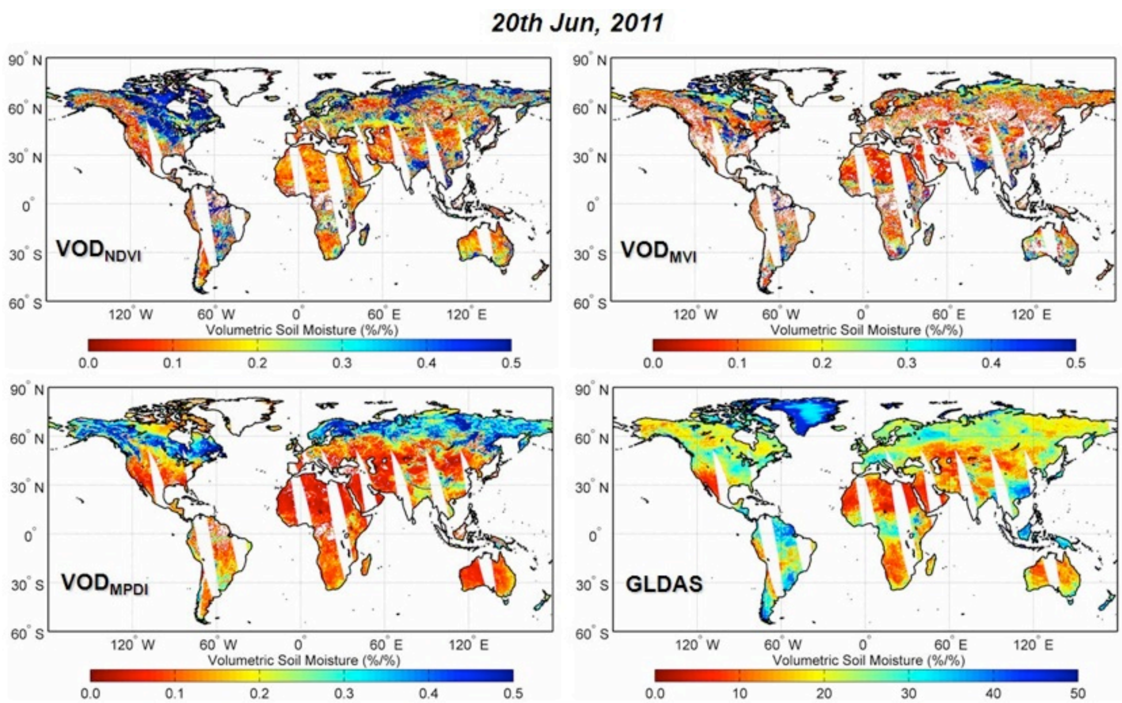


Figure 1: Soil moisture retrievals from AMSR-E observations using three different VOD parameterization schemes.

PUBLICATIONS

Two journal papers are planned from the results of the above stated accomplishments. Based on these results, Mr. Wang will complete his Ph.D. degree dissertation.

Reconstruction of Global Phytoplankton Biomass

Task Leader Stephanie Uz
Task Code ABSURGPB_11
Contribution to CICS Themes Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals Goal 1: 80%, Goal 3: 20%

BACKGROUND

This work is part of the NOAA CICS-MD project "Reconstruction of global phytoplankton biomass". The research and development in this project includes creating a statistical reconstruction of ocean color surface chlorophyll concentrations in order to characterize low frequency patterns in phytoplankton biomass over the past 50 years. While seasonal patterns of phytoplankton blooms are well known, long term patterns are not as well understood. Documenting low frequency changes requires long time-series of phytoplankton biomass measurements, yet the best-resolved, large-scale, continuous biological variable (satellite-derived surface chlorophyll concentration) is only 14 years long. Transparency data have been used to infer declining phytoplankton biomass abundance during the past century, but in situ data sets have limited spatial extent and have yielded conflicting results.

Canonical correlation analysis (CCA) has successfully reconstructed physical variables, including sea surface temperature and meteorological fields. Because ocean physics controls nutrient availability through upwelling, or horizontal advection, to the first order ocean physics controls ocean biology. Multi-decadal data sets of physical variables exist. Sea surface temperature, mixed layer depth, sea surface height, and wind stress curl are variables which reflect vertical exchange processes. Of these, sea surface temperature and mixed layer depth have been found to correlate best to ocean color chlorophyll. Simple Ocean Data Assimilation (SODA) mixed layer depths and sea surface temperatures are available between 1958-2008. Now CCA is applied to a biological data set to extend ocean color chlorophyll concentration back to 1958 using a longer record of physical proxy data because phytoplankton abundance is primarily controlled and predicted by physical forcing. After validation, chlorophyll reconstructions will be analyzed in relation to climatic signals to test the hypothesis that low frequency oscillations are reflected in phytoplankton biomass patterns over the past 50 years.

ACCOMPLISHMENTS

Based upon the optimal spatial and temporal decorrelation scales in the ocean color chlorophyll record, the monthly SeaWiFS chlorophyll concentrations were binned to 5o and temporally smoothed at monthly resolution. SeaWiFS chlorophyll data are available September, 1997 through December, 2010 with gaps toward the end of the record filled with MODIS Aqua. Simple Ocean Data Assimilation (SODA) 2.1.6 data are available 1958-2008. Extension of the SODA record is contingent upon availability of winds from the NOAA-CIRES 20th Century Reanalysis (20CR) which are currently available through 2008. The SODA data were binned the same as the chlorophyll; the land mask was expanded to exclude pixels within 5o of the coast; the annual cycles were removed; the anomalies were demeaned and normalized by their standard deviations.

Normalized data were decomposed using Empirical Orthogonal Functions (EOF) that represent the major variations in the data while filtering out noise. The first nine modes account for about 50% of the variability in global CHL and combined SST and MLD. CCA was first tried at global scale, but the large El Niño signal in the Tropical Pacific clearly dominates, with other regions appearing weak and noisy. Since physical dynamics and bloom mechanisms have regional dependencies, conduction CCA over various regimes or biomes makes more sense. Once the Tropical Pacific between 20oN-20oS was isolated, the first nine EOF modes account for 73% of the variability in CHL and combined SST and MLD (Figure 1).

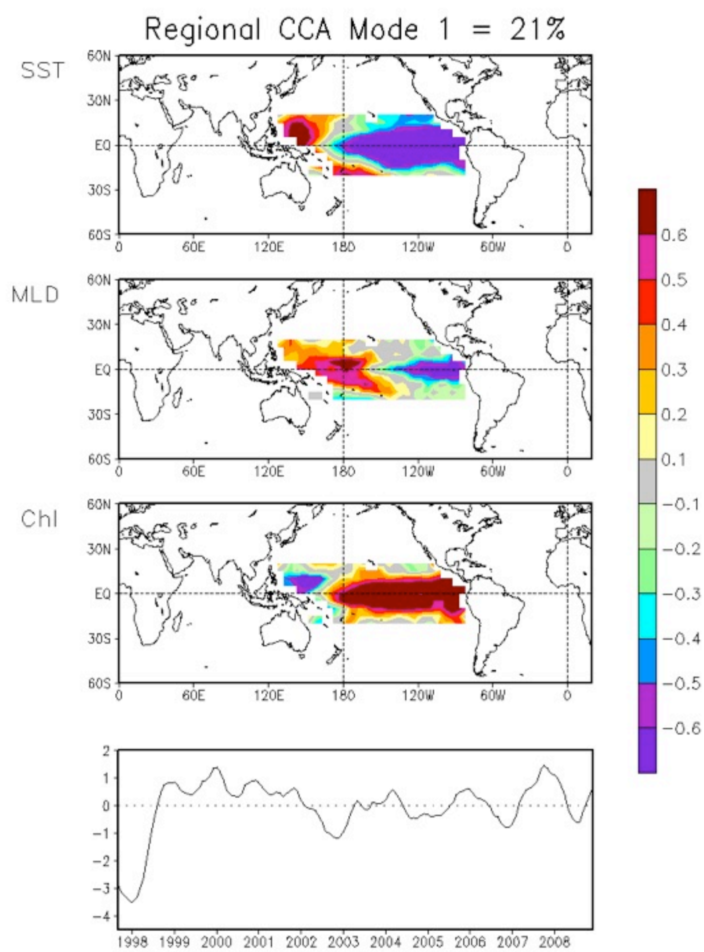


Figure 1: Tropical Pacific Canonical Correlation Analysis Mode 1 for monthly, 5o sea-surface temperature (top map), mixed layer depth (middle map), chlorophyll (bottom map), and time-varying amplitudes (bottom panel) for 136 months between September, 1997 and December, 2008. This mode explains 21% of the total cross-correlation in the 9 mode CCA.

CCA mode 1 is dominated by the 1997/1998 El Niño/Southern Oscillation (ENSO) and demonstrates the strong and primarily inverse relationship between CHL and SST. By contrast, CHL and MLD have a variable relationship: inverse in upwelling regions (e.g. eastern equatorial Pacific) and direct in the mid Tropical Pacific warm pool, but inverse in the vicinity of western Tropical Pacific coral atolls.

The maximum correlations between linear combinations of the predictors (SST and MLD) and predictor (CHL) during the training period were used to generate the reconstruction.

The Tropical Pacific regional chlorophyll reconstructions validate well against the training data (R > 0.9 away from land). During strong El Nino years, negative chlorophyll anomalies are observed in the reconstructions while strong La Nina years correspond to positive chlorophyll anomalies (Figure 2). These observations are consistent with previous studies on the climatic influence of ENSO upon ocean surface chlorophyll.

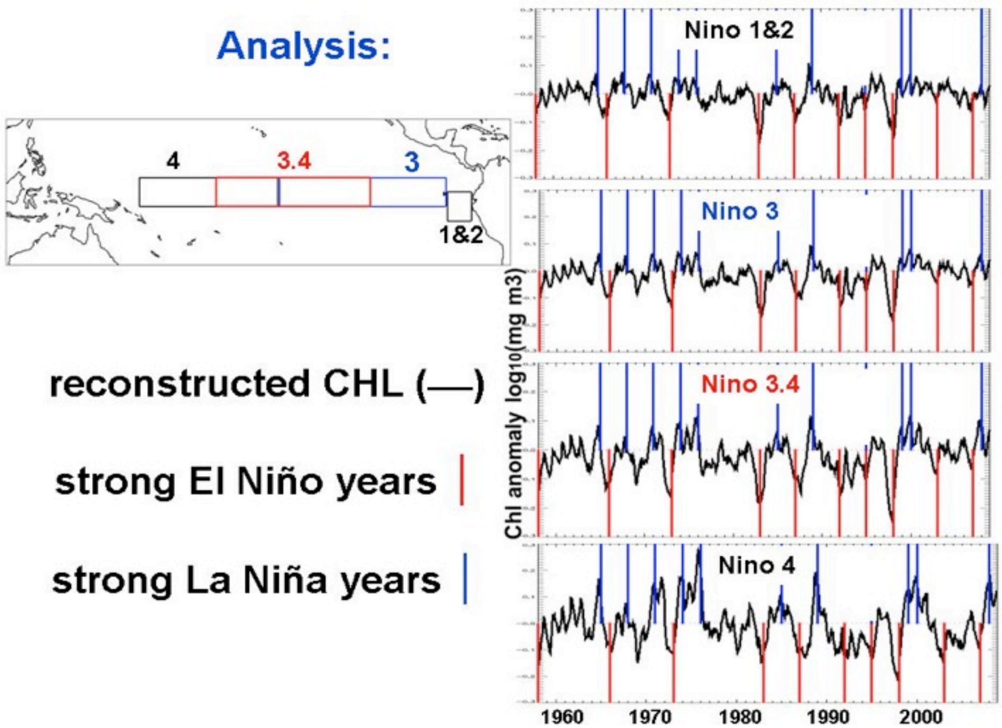


Figure 2: Tropical Pacific Nino regions shown in map on left. On right panels: reconstructed chlorophyll anomalies averaged over each Nino region (black line), with strong El Nino years (red lines) and strong La Nina years (blue lines) superimposed.

PLANNED WORK

- Validate with other ocean color data sets (e.g. CZCS) and in situ observations
- Continue reconstructions for other regions
- Analyze low frequency phytoplankton spatial patterns

PUBLICATIONS

Schollaert Uz, S., A. J. Busalacchi, C.W. Brown, T. Smith, J.A. Carton, M.N. Evans, K. Ide (in prep.) Statistical reconstruction and analysis of global chlorophyll concentrations using proxy data. University of Maryland Dissertation.

PRESENTATIONS

Talk given by S. Schollaert Uz on February 24, 2012 in 'Advancing Satellite Ocean Color Science for Global and Coastal Research' session during Ocean Sciences Meeting 2012, Salt Lake City

LINK TO RESEARCH WEBPAGE:

http://www.atmos.umd.edu/~ses/

4.4 Projects from other NOAA Organizations

Participation in Climate Research Activities at the Air Resources Laboratory

Task Leader Russ Dickerson
Task Code PAPA_ARL11
Contribution to CICS Themes
Contribution to NOAA Goals

BACKGROUND
Most major cities in the US suffer days of poor air quality, and these days are related to weather as well as emissions of pollutant precursors. The ability to forecast pollution levels provides a public service to affected vulnerable groups and helps State agencies with the responsibility and authority to control emissions to take actions to avoid pollution events. The major pollution problems in the US are fine particulate matter (PM2.5) and ground level ozone, or photochemical smog. This project involves making and improving emissions and forecasts for applications including climate effects on air quality, ecosystem applications, as well as for the protection of human health due to poor air quality.

ACCOMPLISHMENTS
We are working with NOAA's Air Resources Laboratory (ARL) to hire a mid-level faculty member (Research Associate Professor) to lead this effort. We have identified an excellent, experienced candidate and are in the process of getting the necessary letters of reference to make this appointment. Dr. Daniel Q. Tong, an air quality forecaster with experience working with ARL has agreed to lead the project. Dr. Tong has a Ph.D. in Atmospheric Sciences from North Carolina State University, Raleigh (2003) and 24 publications in the reviewed scientific literature. After he is hired, and assuming adequate budget, we will pursue postdoctoral scholars to assist with this effort.

Hydrological Support for the Climate Prediction Center

Task Leader	J. Janowiak and L.-C. Chen
Task Code	JJJJHYDRO10
Contribution to CICS Themes	Theme 1: 25%; Theme 2: 25%; Theme 3: 50%
Contribution to NOAA Goals	Goal 1: 50%; Goal 2: 50%

BACKGROUND

This work is to support NOAA/NCEP Climate Prediction Center's (CPC's) efforts on drought monitoring and prediction. Tasks include monitoring the production of operational data such as North American Regional Reanalysis (NARR) and North American Land Data Assimilation System (NLDAS) to support U.S. Drought Monitor and Outlook, and developing algorithms and techniques for drought prediction. Seasonal hindcasts of drought indices over the United States are made for the period from 1982 to 2009 based on the NCEP Climate Forecast System Reanalysis and Reforecasts (CFSRR).

Three indices: standardized precipitation index (SPI), soil moisture percentile (SMP), and standardized runoff index (SRI), and their potential use for drought prediction are explored. SPI, which measures precipitation deficits, is used to identify meteorological drought. SMP, computed based on probability distributions, is used to classify agricultural drought. SRI, similar to SPI and measuring runoff deficits, represents hydrological drought. Before predicting drought indices, monthly-mean precipitation, soil moisture, and runoff forecasts from Climate Forecast System version 2 (CFSv2) are bias-corrected and downscaled to regional grids of 0.5° resolution based on the probability distribution functions from hindcasts.

ACCOMPLISHMENTS

Uncertainties in drought indices derived from the North American Land Data Assimilation Systems operated by NCEP Environmental Modeling Center and the University of Washington (UW) were assessed for the monitoring period of 1979 to 2008. For SMP and SRI, differences are relatively small among different land surface models (LSMs) within the same system; however, the differences of ensemble mean between the two systems are large over the western United States ─ in some areas exceeding 20% for SMP. The differences are most apparent after 2002 when the NCEP system transitioned to use the real-time NARR data and CPC/Office of Hydrologic Development daily precipitation gauge data as input forcing. Numerical experiments were performed to address the sources of uncertainties. Comparison of simulations using a common LSM (i.e., the Variable Infiltration Capacity (VIC) model) with input forcing of the two systems indicates that the differences in precipitation forcing are the primary source of the uncertainties in SMP and SRI. While forcing differences of temperature, short-wave and long-wave radiation, and wind speed are also large after 2002, their contributions to the differences in SMP and SRI are much smaller than precipitation. Results of this investigation have been summarized into a research paper, which has been accepted to be published in Journal of Hydrometeorology.

Work on SPI prediction based on CFSv2 precipitation forecasts has been completed. Operational SPI products including recent observations and three-month and six-month outlooks are available at CPC's Drought Assessment website. The drought webpages have been redesigned to provide interactive functions for users to easily compare drought indices computed from different options (e.g., durations or models). The new webpages also provide data of drought indices in GeoTIFF format for users to download for their analysis. The new webpages will become operational in March 2012. Prediction skill of SPI forecasts has been evaluated and presented in the World Climate Research Programme (WCRP) Open Science Conference in Denver, Colorado on October 27, 2011. Generally, prediction skill is seasonally and regionally dependent and the six-month SPI forecasts are skillful out to 3-4 months.

A climatological analysis also has been conducted to evaluate monthly-mean runoff and soil moisture reforecasts from CFSv2 against those from NLDAS. Generally, monthly-mean runoff estimates from CFSv2 and Climate Forecast System Reanalysis (CFSR) are smaller than those from NLDAS. When comparing CFSv2 soil moisture hindcasts with NLDAS four-model ensemble, the differences are larger than those with NLDAS Noah model, suggesting that Noah model tends to produce more soil moisture and less runoff than the other three LSMs in NLDAS. Therefore, the partition between runoff, soil moisture, and evaporation in Noah model needs improvement. Work is currently underway to investigate the causes for the underestimation of runoff outputs from CFSv2.

In addition, forecast skill of soil moisture (SM) anomaly from direct CFSv2 forecasts (CFSRR) and those obtained from a LSM (i.e., VIC model) driven by daily precipitation (P), temperature (T), and wind forecasts from CFSv2 (i.e., hydroclimate forecast) are compared with forecasts based on persistence of NLDAS and the ensemble streamflow prediction (ESP) technique. Figure 1 shows the root-mean-square errors of SM anomalies/standard deviation for month-1 forecasts from four forecast methods (persistence, ESP, CFSRR, and hydroclimate forecast) for February, May, August, and November. Forecasts are verified against historical VIC simulations produced by the UW system. All forecasts are bias-corrected and downscaled to grids of 0.5° resolution. Generally, forecast skill of SM anomalies is seasonally and regionally dependent. In wintertime, SM forecasts over the western region are skillful out to three months for all methods. For all lead months, forecast skill from CFSRR is lower than that based on persistence, suggesting that direct SM forecasts from CFSv2 may have limited use for drought prediction. For hydroclimate forecasts, the differences between the forecasts with and without P, T corrections in the input forcing are small. P, T corrections only improve the forecasts slightly. The skill of hydroclimate forecasts depends on the skill of CFSv2 forecasts. In winter season when P forecast skill from CFSv2 is high, hydroclimate forecasts outperform the other three forecast methods and can be used as a tool for drought prediction.

PLANNED WORK

- Continue work on evaluation of the prediction skill of runoff forecasts from direct CFSv2 forecasts and hydroclimate forecasts.
- Develop operational SMP forecast system and products.
- Continue work on SRI prediction. Regional characteristics of seasonal hydrologic prediction will be examined.
- Develop a drought early warning system for the U.S. based on CFSv2 forecasts and assess their prediction skill.

- Design products to provide regional water supply information to the user communities, such as the National Integrated Drought Information System community and NWS River Forecast Centers.

PUBLICATIONS

Mo, K. C., L.-C. Chen, S. Shukla, T. Bohn, and D. P. Lettenmaier, 2012: Uncertainties in North American Land Data Assimilation Systems over the Contiguous United States. Accepted by Journal of Hydrometeorology.

PRESENTATIONS

Chen, L.-C., K. C. Mo, and M.-Y. Lee, 2012: Soil Moisture and Runoff Forecasts from the Climate Forecast System Version 2, Abstract of the 92nd AMS Annual Meeting, the 26th Conference on Hydrology, New Orleans, Louisiana. (http://ams.confex.com/ams/92Annual/webprogram/Paper197651.html)

Mo, K. C., L.-C. Chen, S. Shukla, T. Bohn, and D. P. Lettenmaier, 2012: Uncertainties in North American Land Data Assimilation Systems over the Contiguous United States, Abstract of the 92nd AMS Annual Meeting, the 26th Conference on Hydrology, New Orleans, Louisiana. (http://ams.confex.com/ams/92Annual/webprogram/Paper194324.html)

Chen, L.-C., and K. C. Mo, 2011: Seasonal Drought Prediction over the United States, WCRP Open Science Conference, World Meteorological Organization, Denver, Colorado.

Shukla, S., K. C. Mo, L.-C. Chen, and D. P. Lettenmaier, 2011: Uncertainties in the North American Land Data Assimilation Systems, WCRP Open Science Conference, World Meteorological Organization, Denver, Colorado.

OTHER

Travel support for early career scientists to participate in WCRP Open Science Conference: Climate Research in Service to Society, World Meteorological Organization, 2011.

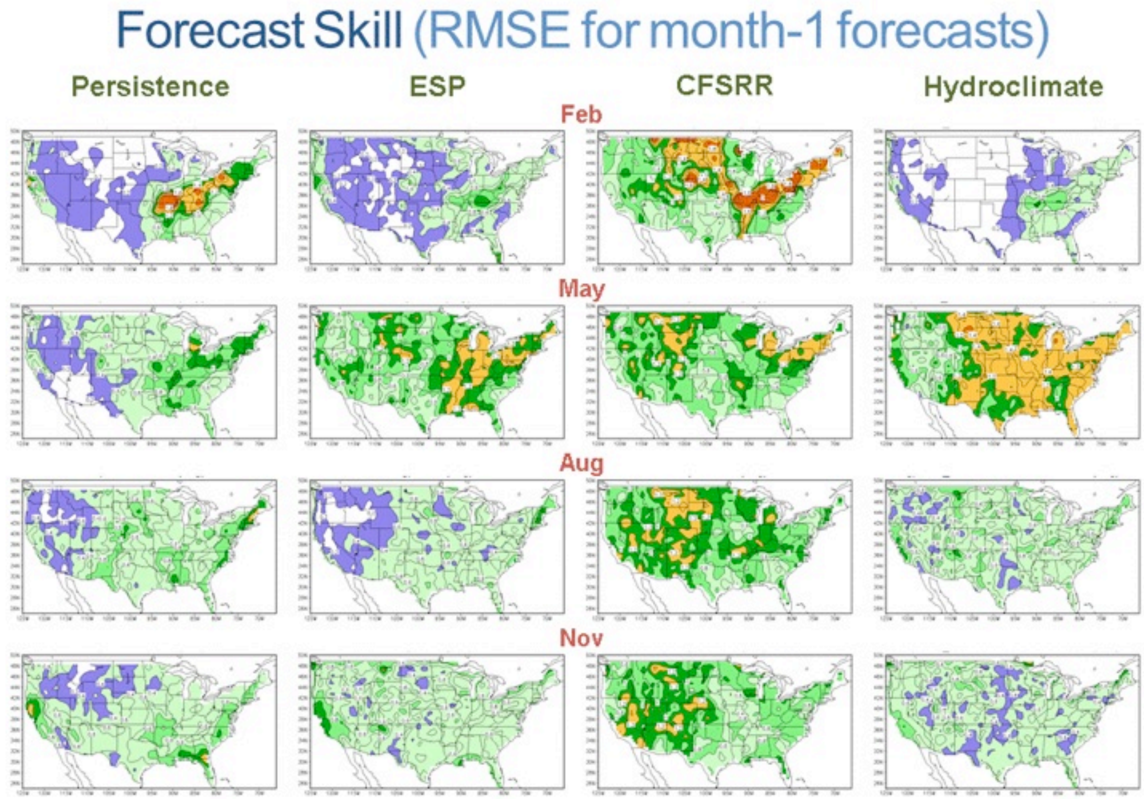


Figure 1: Root-mean-square errors of soil moisture anomalies/standard deviation for month-1 forecasts from four forecast methods (persistence, ensemble streamflow prediction (ESP), direct CFSv2 forecasts (CFSRR), and hydroclimate forecast) for February, May, August, and November. Forecasts are verified against historical simulations by the Variable Infiltration Capacity model over the period of 1982 to 2009.

CICS Support of CPC's Climate Monitoring and Prediction Activities

Task Leader	Augustin Vintzileos
Task Code	JJJJ_CMPA11
Contribution to CICS Themes	Theme 2: 30%; Theme 3: 70%.
Contribution to NOAA Goals	Goal 1: 100%

BACKGROUND

The Climate Prediction Center (CPC) of NCEP/NWS/NOAA assesses and predicts short-term climate variability and its impact for both the Tropics and the U.S.. The complex nature of the global climate system, and the requirement for continuous improvement in CPC capabilities, makes conducting ongoing collaborative developmental research imperative. This task includes activities of the PI that range from providing improved monitoring products, validation of model forecasts of the Madden-Julian Oscillation (MJO) and subseasonal variability in general and the development of key forecast products to support CPC's operational product suite. Along with the above items, work also includes investigation of the reasons for model forecast successes and failures. The above tasks are directly supporting the operational Global Tropics Hazards and Benefits Assessment (GTH) and the DYNAMO field campaign during 2011-2012.

ACCOMPLISHMENTS

During the past year, the PI has continued to collaborate with CPC staff in a number of monitoring, forecasting and diagnostic roles, particularly involving the Madden-Julian Oscillation (MJO) and its impacts on global and U.S. weather statistics at forecast lead times of Week-1 and Week-2. A major event regarding the understanding of the MJO and consequently the improvement of its prediction during 2011/2012 was the DYNAMO observational campaign. This campaign proved to be very successful as three major MJO events occurred during its duration. The PI was involved with DYNAMO from its earliest stages as a member of the DYNAMO Science Steering Committee as well as a co-PI of a proposal funded by NOAA to provide operational real-time monitoring and forecast support to DYNAMO. He collaborated with PI's from all observational components of DYNAMO (aircraft, oceanography, radar and radiosondes) to define a set of variables to forecast/monitor for facilitating decision making by PIs in the field as well as aiding updates on the current status of the MJO to the field on a regular basis.

He used his extensive knowledge of the NCEP IT infrastructure to design, develop, implement and transition to operations the algorithms that were able to provide a suite of monitoring/forecasting products to the campaign operations with a success rate of at least 99%. The remaining less than 1% was due to failed infrastructure on various days and the PI volunteered for over-night, holiday and weekend work to restore the flow of information towards the Indian Ocean. He also maintained the algorithms that he designed through infrastructure evolutions (migration to new computers systems). Examples of products can be found at: http://catalog1.eol.ucar.edu/cgi-bin/dynamo/model/index He participated in the weekly conference calls for the consolidated MJO forecasts and the weekly calls with the PIs at the Maldives, an example of the consolidated forecasts can be found at:
http://catalog1.eol.ucar.edu/dynamo/report/ncep_mjo_discussion/20120228/report.NCEP_MJO_Discussion.201202280000.Summary.pdf

The tools developed for the DYNAMO campaign are already being generalized and transitioned to benefit the CPC operational GTH forecast product. Examples of operational monitoring and forecast products are provided in Figure 1 in which the observed weekly mean OLR is compared to its climatological distribution and Figure 2 in which the GFS weekly forecast is compared to the observed climatological distribution. Further, an interface for clearly and succinctly displaying forecast tools being generated in realtime to support the CPC MJO assessment and GTH is under development and nearing completion. This interface allows quick and meaningful viewing of the many operational products, substantially benefiting the forecasters.

The PI led the effort for a team at NCEP (CPC, EMC and NCO) to draft and submit a follow-on proposal to make use of the obtained DYNAMO field data during 2011-2012 for future data denial experiments and in which the goal is to better understand the physical mechanisms for MJO onset and decay.

PLANNED WORK

The work to follow will evolve along two axes:

1. The tools developed for the DYNAMO campaign will be transitioned to operations to support the GTH forecast. These tools will be enhanced with probabilistic forecast information and objective verification of previous forecasts. The target of this axis of work is to provide an automatic first guess forecast based on dynamical models. This tool which is designed to require minimal maintenance and human intervention will be a valuable asset to the GTH forecasters. He plans to provide continuous improvements to this tool by incorporating bias corrections and multi-model capacity initially based on the GFS, GEFS and CFS with a vision of using the NMME and by incorporating more products as they are requested by and discussed with stakeholders. In parallel, the PI, plans to develop a new graphical interface. This is necessary due to the significant amount of information that will be generated and will optimize access to the information required for issuing the forecast.
2. During the second part of the DYNAMO work he will verify model forecasts during the campaign and beyond and investigate reasons for the sometimes erratic behavior that the model demonstrated. The targets of this axis of work is:
    a. To pinpoint processes that are not well represented in the models,
    b. To provide the forecasters with a protocol for when to (or not to) have confidence in the model forecast as a function of geography, season, model type, regime, etc.

Both targets of axis B will be significantly facilitated if the proposal concerning the DYNAMO data denial experiment will get funded.

PUBLICATIONS

Wen, M., Yang, S., Vintzileos, A., Higgins, W., and Zhang, R., 2012: Impacts of model resolutions and initial conditions on predictions of the Asian summer monsoon by the NCEP Climate Forecast System. *Weather and Forecasting. In press.*

Chattopadhyay, R., A.Vintzileos, and C. Zhang, 2012: A Description of the Madden Julian Oscillation Based on Self Organizing Map. *J. Climate*, Submitted.

OTHER

The PI is a member of (1) the DYNAMO Science Steering Committee, (2) the US-THORPEX Science Steering Committee and (3) the WCRP/CLIVAR MJO-Task Force. Previous work of the PI related to the MJO was used in the "Assessment of Intraseasonal to Interannual Climate Prediction and Predictability" of the National Research Council of the National Academies.

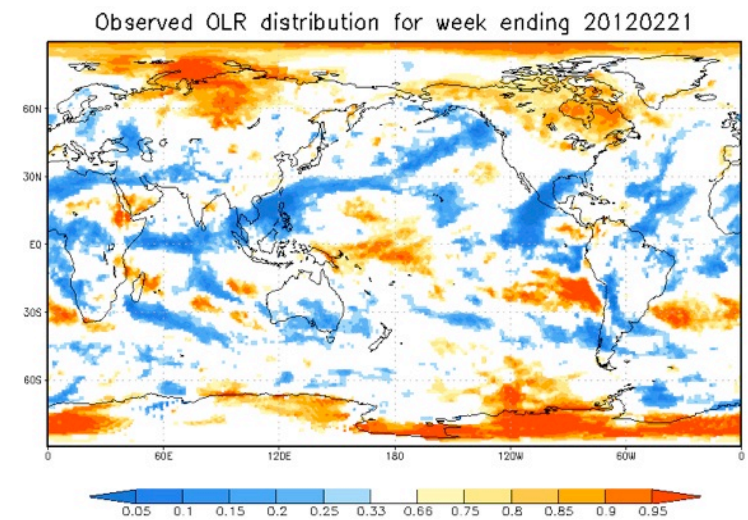


Figure 1: Percentiles of weekly observed OLR for the lowest 33% of the climatological distribution (blue colors) and for the upper 33% (red colors). In this particular example, the combined influence of the ongoing La Nina event and MJO activity are evident and are used as data for quantitative verification for the GTH product.

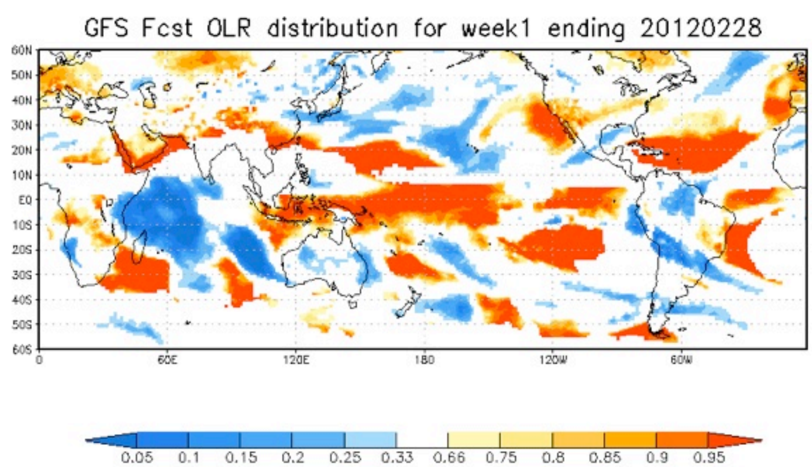


Figure 2: As in Figure 1, except for a weekly forecast from the GFS. In this example, a strong MJO signal dominates the Indian Ocean. At this stage of tool development, no bias correction is yet applied.

University of Maryland Center of Excellence in Data Assimilation

Task Leader J.A. Carton
Task Code JCJCUMCED11
Contribution to CICS Themes Task 1: 70%; Task 2: 30%
Contribution to NOAA Goals Goal 1: 20%, Goal 2: 60%, Goal 5: 20%

BACKGROUND

This is a proposal to continue development of a world class center of excellence in data assimilation education/research at the University of Maryland by expanding our academic capabilities through the hire of a faculty member in this critical area. The demand for students with scientific training in atmospheric and oceanic science is high due to the increasing recognition of the impacts that weather, climate, and the environment have on our lives. Within atmospheric and oceanic science data assimilation is a key area of technology which combines information obtained from environmental sensors with that obtained from numerical simulation to provide a 'best estimate' of the evolving earth system – North American weather, or Gulf of Mexico currents, for example. Data assimilation thus links together expertise in the fields of applied mathematics and numerical analysis with such earth science disciplines as meteorology, physical oceanography, and hydrology.

ACCOMPLISHMENTS

A search committee was formed consisting of three University of Maryland faculty and two NOAA scientists (Sid-Ahmed Boukabara and Stephen Lord). The top candidate, Takemasa Miyoshi, has been hired. Since arriving Assistant Professor Miyoshi has begun a very active research initiative focused on development of Ensemble Kalman Filters (see publication list below). He has started advising two graduate students, Daisuke Hotta, and Guo-Yuan Lien. This grant also supported preparations for the JCSDA 9th Workshop on Satellite Data Assimilation which was held in College Park, MD - May 24-25, 2011.

PLANNED WORK

- Further development of localization in the LETKF data assimilation
- Further development of covariance inflation in LETKF
- Maintaining balance in an ensemble filter
- LETKF application to ozone monitoring.

Refereed Publications

Miyoshi, T., E. Kalnay, and H. Li, 2012: Estimating and including observation error correlations in data assimilation. Inv. Prob. Sci. Eng., in press.

Kunii, M., T. Miyoshi, and E. Kalnay, 2011: Estimating impact of real observations in regional numerical weather prediction using an ensemble Kalman filter. Mon. Wea. Rev., in press. doi:10.1175/MWR-D-11-00205.1

Miyoshi, T. and M. Kunii, 2012: The Local Ensemble Transform Kalman Filter with the Weather Research and Forecasting Model: Experiments with Real Observations.

Pure and Appl. Geophys., 169, 321-333. doi:10.1007/s00024-011-0373-4

Saito, K., H. Seko, M. Kunii, and T. Miyoshi, 2012: Effect of lateral boundary perturbations on the breeding method and the local ensemble transform Kalman filter for mesoscale ensemble prediction. Tellus, 64A, 11594. DOI:10.3402/tellusa.v64i0.11594

Kang, J.-S., E. Kalnay, J. Liu, I. Fung, T. Miyoshi, and K. Ide, 2011: "Variable localization" in an Ensemble Kalman Filter: application to the carbon cycle data assimilation. J. Geophys. Res., 116, D09110. doi:10.1029/2010JD014673

Miyoshi, T., 2011: The Gaussian Approach to Adaptive Covariance Inflation and Its Implementation with the Local Ensemble Transform Kalman Filter. Mon. Wea. Rev., 139, 1519-1535. doi:10.1175/2010MWR3570.1

Moteki, Q., K. Yoneyama, R. Shirooka, H. Kubota, K. Yasunaga, J. Suzuki, A. Seiki, N. Sato, T. Enomoto, T. Miyoshi, S. Yamane, 2011: The influence of observations propagated by convectively coupled equatorial waves. Quart. J. Roy. Meteor. Soc., 137, 641-655. doi:10.1002/qj.779

Seko, H., T. Miyoshi, Y. Shoji, and K. Saito, 2011: Data Assimilation Experiments of Precipitable Water Vapor using the LETKF System: Intense Rainfall Event over Japan 28 July 2008. Tellus, 63A, 402-414. DOI:10.1111/j.1600-0870.2010.00508.x

Greybush, S. J., E. Kalnay, T. Miyoshi, K. Ide, and B. R. Hunt, 2011: Balance and Ensemble Kalman Filter Localization Techniques. Mon. Wea. Rev., 139, 511-522. doi:10.1175/2010MWR3328.1

Sekiyama, T. T., M. Deushi, and T. Miyoshi, 2011: Operation-Oriented Ensemble Data Assimilation of Total Column Ozone. SOLA, 7, 41-44. DOI:10.2151/sola.2011-011

WEBSITE
http://www.atmos.umd.edu/~miyoshi/

Exploration of an advanced ocean data assimilation scheme at NCEP

Task Leader J.A. Carton and E. Kalnay
Task Code PAJCEAODA11
Contribution to CICS Themes Task 1: 70%; Task 2: 30%
Contribution to NOAA Goals Goal 1: 20%, Goal 2: 60%, Goal 5: 20%

BACKGROUND

This is a proposal to explore improvements to the 3DVar filter used in the Global Ocean Data Assimilation System by development of a hybrid filter through a UMD/NCEP collaboration. The hybrid approach we propose is that of *Wang et al.* (2007a,b; 2008a,b) in which the error co-variance matrix is determined as a weighted average of the original 3DVar and the flow-dependent error covariance determined by a set of ensembles.

In designing the hybrid filter we are guided by several principles. The first is that the new filter should build on the current 3DVar with minor software extensions. The second is that the results of the new filter must be at least as good as the 3DVar, even before any tuning. The third is that while the new filter will require additional computer time, the time required should be significantly less than for a full ensemble Kalman Filter or 4DVar.

ACCOMPLISHMENTS

First, Steve carried out a series of intercomparison studies between LETKF and SODA indicating significant improvement of LETKF. For example, **Fig. 1** shows the impact of using LETKF relative to a more conventional optimal interpolation data assimilation scheme in analyzing heat storage in the upper 500m. Fig. 2 shows the temperature observation minus forecast differences and observation minus analysis differences for several experiments indicating that the error levels are substantially reduced when LETKF is used. The manuscript describing this work has been completed and is under submission (*Penny et al., 2012*).

Most recently Steve has implemented LETKF in the same ocean model as GODAS and has carried out a series of intercomparison studies between NCEP's GODAS and the same model with LETKF and a hybrid system using LETKF implemented. Preliminary results are encouraging for improvement in the operational system.

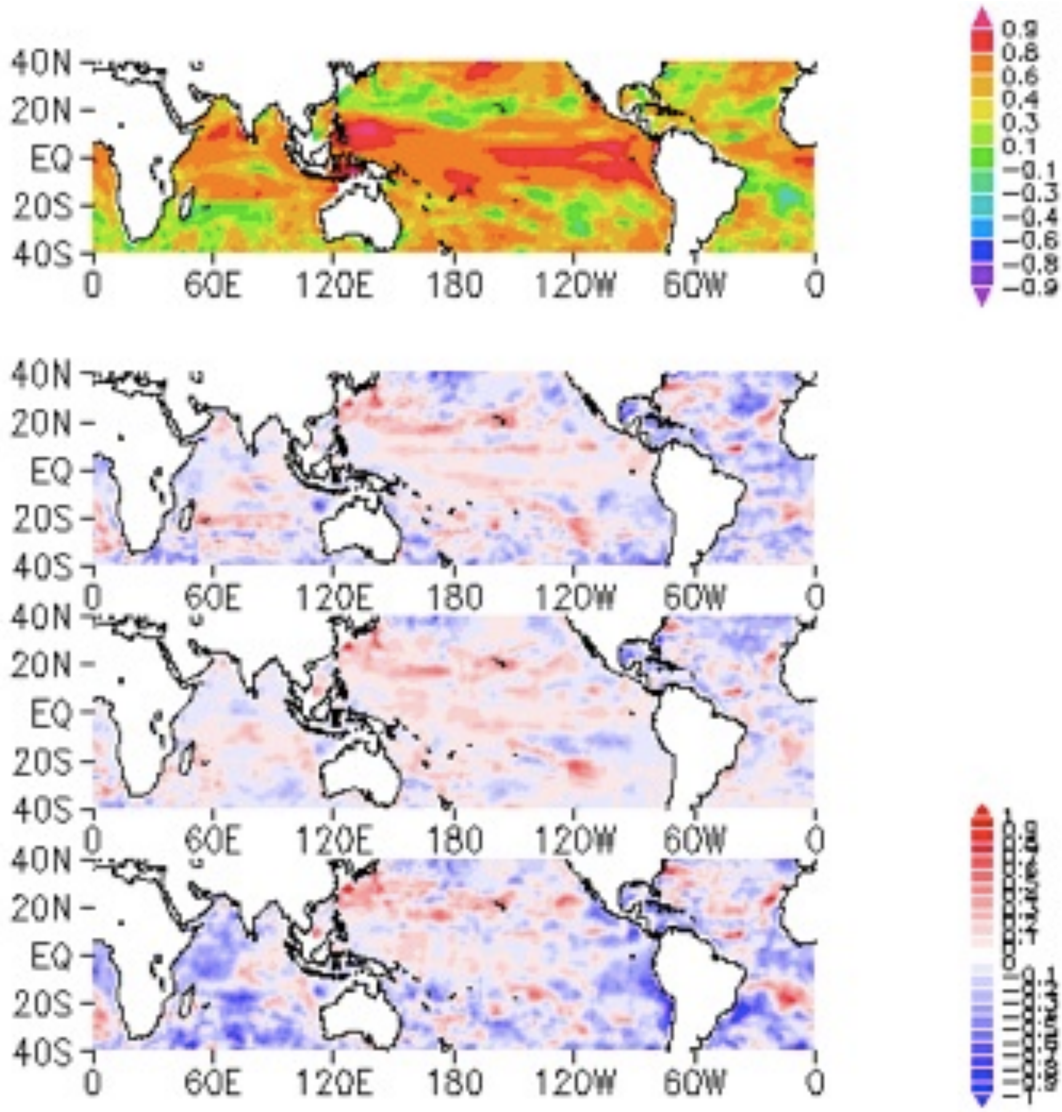


Figure 1: Improvement in correlation between monthly average top 500 m heat content and altimetry sea surface height from 1997-2003 versus nature run (a simulation with no data assimilation) for: SODA (second panel), LETKF-IAU (third panel)and LETKF-RIP (fourth panel). Seasonal cycle is included.

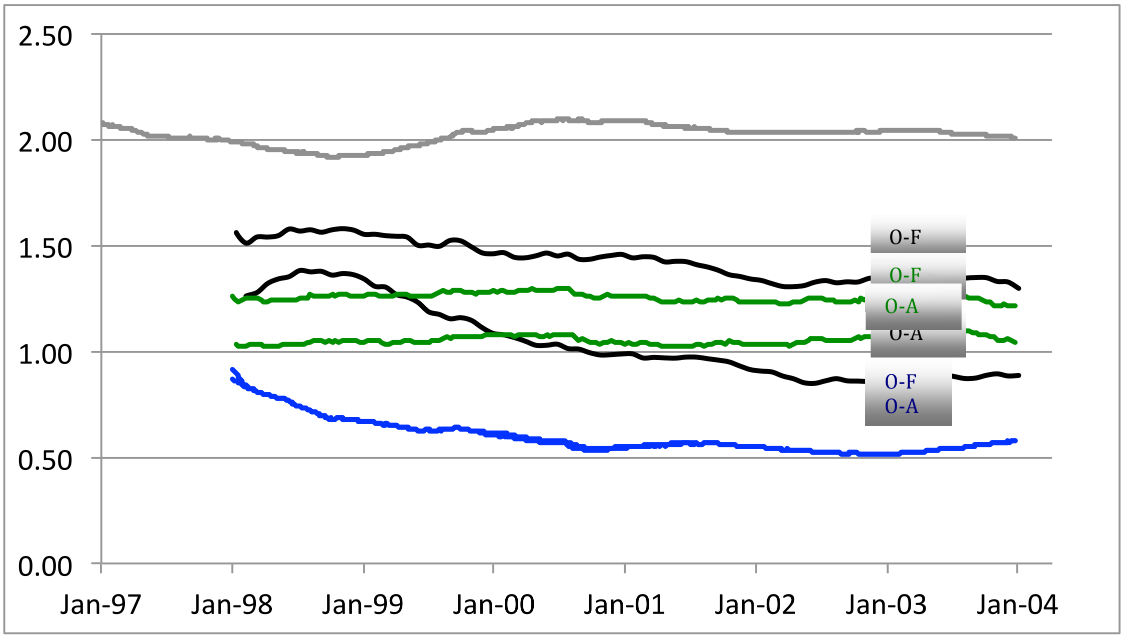


Figure 2: Comparison of RMS observation-minus-forecast and observation-minus analysis differences for global data assimilation experiments using Optimal Interpolation (similar to 3DVar, green) and the Local Ensemble Transform Kalman Filter (black, IAU; blue, running in place) for the seven year period 1997-2003. Grey line shows results from simulation. Vertical axis is temperature (^{o}C). Here differences are summed over all depths.

PUBLICATIONS

Penny, S.G., E. Kalnay, J.A. Carton, B. Hunt, K. Ide, T. Miyoshi, and G. Chepurin, 2012: Comparison of the 4D Local Ensemble Transform Kalman Filter and the Simple Ocean Data Assimilation in a Global Ocean, *Mon. Wea. Rev.*, submitted.

CICS Support for the National Oceanographic Data Center

Task Leader	Gregg Foti and James Reagan
Task Code	PAPASNODC11
Contribution to CICS Themes	Theme 1: 45%; Theme 2: 55%
Contribution to NOAA Goals	Goal 1: 55%; Goal 2: 30%; Goal 5: 15%

BACKGROUND

NOAA's National Oceanographic Data Center (NODC) is an organization (http://www.nodc.noaa.gov/) that provides scientific and public stewardship for national and international marine, environmental, and ecosystem data and information. With its regional branch assets and divisions (http://www.nodc.noaa.gov/General/NODC-About/orgchart.html), NODC is integrated to provide access to the world's most comprehensive sources of marine environmental data and information. NODC maintains and updates a national ocean archive with environmental data acquired from domestic and foreign activities and produces products and research from these data which help monitor global environmental changes. NODC manages and operates the World Data Center (WDC) for Oceanography (http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-wdca.html) in Silver Spring.

The satellite team is responsible for the archiving and delivery of ocean data products that are derived from sensors operating in space. These include sea surface temperature, ocean altimetry, ocean vector winds and other products derived from these measurements. The satellite team adds value by providing metadata, making the data discoverable, performing quality assurance and providing scientific and technical support to users of these data (http://www.nodc.noaa.gov/SatelliteData/).

The Coral Reef Temperature Anomaly Database (CoRTAD) product is designed to quantify global-scale stressors that are widely deemed responsible for the decline of coral reefs. A likely candidate is rising sea surface temperature (SST) in much of the tropics. CoRTAD, funded by the NOAA Coral Reef Conservation Program uses SST from NOAA's Pathfinder program to develop weekly SST averages, thermal stress metrics, SST anomalies (SSTA), SSTA frequencies, SST Degree heating weeks and climatologies (http://www.nodc.noaa.gov/SatelliteData/Cortad/).

One of the most requested products from the NODC is the World Ocean Database (WOD) (http://www.nodc.noaa.gov/OC5/WOD/pr_wod.html). The WOD is a vast database of hydrographic data. There contains over 12 million observations dating back to the early 19th century in the WOD. In order for the WOD to keep growing, and to keep being used by the public for a multitude of different ocean studies, data from the NODC archive must be continually processed and merged into the WOD. This requires that the data be converted into a common format, checked for uniqueness and quality, and merged into the WOD.

The WOD also is used to create gridded climatologies (e.g. World Ocean Atlas) and a multitude of other gridded products. More recently, since the introduction of Argo profiling floats, salinity and salinity anomaly gridded products have been calculated through the WOD. These products require a great deal of quality control checking to ensure accuracy of the product. With high quality gridded salinity products, research efforts are now underway to compare and analyze these products with the Aquarius Sea Surface Salinity mission as well as the GRACE twin satellites mission.

ACCOMPLISHMENTS

The Coral Reef Temperature Anomaly Database (CoRTAD) version 4 beta (see example in Figure 1) has been completed. Improvements over previous versions of CoRTAD include:

- CoRTAD 4 is now in NetCDF format, which is preferred by ocean modelers and much of the oceanographic community.
- CoRTAD 4 contains vastly enriched metadata.
- CoRTAD 4 uses the latest Pathfinder data, version 5.2.
- CoRTAD 4 now goes back to the last 2 months of 1981 and now contains 2010 data.
- CoRTAD 4 has slightly higher spatial resolution at 8192 x 4096 global pixels.
- CoRTAD 4 uses an improved land mask.

The Satellite team has been working with various agencies to evaluate new data products including geostationary and polar satellite SST, Ocean wind and Coastal Ocean Dynamics Applications Radar (CODAR) coastal current with the purpose of reaching agreements to distribute and archive these data.

The CLIVAR & Carbon Hydrographic Data Office (CCHDO) CTD data was processed and merged into the World Ocean Database (WOD). Of the 4,786 CTD profiles from CCHDO, 3,042 were either new or updated profiles (as compared to data already in WOD) and were merged into the WOD. The International Council for the Exploration of the Seas (ICES) OSD data was processed and merged into the WOD. Of the 5,501 OSD profiles from ICES, 5,435 were either new or updated profiles (as compared to data already in WOD) and were merged into the WOD. Thus, a total of 8,477 profiles were added or updated in WOD. Figure 2 depicts the geographic distribution of these 8,477 profiles that were added or updated in WOD.

The first complete run of quality control for the WOD calculated 2011 global monthly salinity anomaly fields was completed. This run captured and masked out all profiles that were creating "bullseyes" in the anomaly fields. There are 26 standard depth levels from 0m to 2000m for each monthly salinity anomaly field. Further quality control was also performed on the seasonal salinity anomalies from 2005-2011. All these products can now be seen and used at http://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/.

Preliminary comparisons between the Aquarius Sea Surface Salinity (SSS) v1.2DR monthly fields and the WOD calculated monthly salinity fields show some weaknesses and strengths in both products. It is important to note that the Aquarius product is still only to be used for evaluation purposes. As expected, Aquarius SSS has difficulty in coastal regions as well as the higher latitudes. It does seem to pick up river outflow regions rather well which appears to be a limitation of the WOD derived monthly salinity fields. Figure 3 shows September-December 2011 differences between the WOD SSS field and the Aquarius SSS field. The limitations stated earlier for both products can be clearly seen, along with strong differences in the Equatorial Pacific. All these observations are preliminary and still require much more work and investigating.

PLANNED WORK

- Continue working with partners to provide global and regional products and climatologies identified as high priority by users, particularly users within NOAA.
- Begin the integration of Quality Monitoring for ocean surface salinity. This endeavor will use data from new salinity sensing satellites as well as in-situ ocean surface salinity products.
- Maintain leading role in world's SST community by operating the Group for High Resolution SST (GHRSST) Long Term Stewardship and Reanalysis Facility (LTSRF). The NODC LTSRF archives over 30GB of SST data each day. These data are created in the US, Europe, Australia and Japan.
- Develop the next version of Pathfinder as a SST Climate Data Record (CDR)
- Continue operational efforts by conducting scientific records (archive) appraisals for ocean satellite products and accessioning those products assessed as suitable for long-term archive. Products currently undergoing assessment include:
    - Geostationary Operational Environmental Satellites (GOES) SST
    - Polar Operational Environmental Satellites (GOES) SST with AVHRR Clear-Sky Processor over Oceans (ACSPO) processing
    - Merged GOES with Polar orbiting satellite SST products
    - Ocean wind products derived from synthetic aperture radar (SAR) instruments.
    - Near shore ocean current products derived from land based High frequency (HF) radar
- Continue to discover, assess, acquire and archive the wide array of new ocean data as they become available.
- Improve NODC's profile/participation in satellite mission stewardship and satellite data exploitation. Achieve an increased role in defining archive requirements for mission data and routine inclusion of NODC in budget for stewardship of large ocean datasets to be created or acquired by NOAA.
- Perform final quality control testing of the data and metadata CoRTAD 4 product.
- Archive CoRTAD and provide support for discovery, outreach, data usage and comprehension.
- Continue to process and merge in hydrographic data for the World Ocean Database. Including large datasets from the International Council for the Exploration of the Seas, Northeast Fisheries Science Center, and CLIVAR & Carbon Hydrographic Data Office.
- Continue to perform quality control to the WOD calculated monthly and seasonal global salinity anomaly fields for 2011 and 2012.
- Continue to compare and analyze the Aquarius Sea Surface Salinity fields to the WOD calculated SSS fields. Will continue to look at trends in sea surface salinity and its relation to the global hydrological cycle over the oceans. This also may lay the groundwork to create a merged product to more accurately represent SSS.
- Resume work on the comparison and analysis between the WOD-derived freshwater volumes in the ocean (as calculated from the salinity anomaly products) and the freshwater volumes as observed through the GRACE twin satellite mission.

PUBLICATIONS

Boyer, T., S. Levitus, J. Antonov, J. Reagan, C. Schmid, R. Locarnini (in review) Subsurface salinity, Global Oceans (in State of the Climate in 2011). *Bull. Amer. Meteor. Soc.*

Levitus, S., J. I. Antonov, T. P. Boyer, O. K. Baranova, H. E. Garcia, R. A. Locarnini, A. V. Mishonov, J. Reagan, D. Seidov, E. S. Yarosh, and M. M. Zweng (in review) World ocean heat content and thermosteric sea level change (0-2000), 1955-2010. *Geophysical Research Letters.*

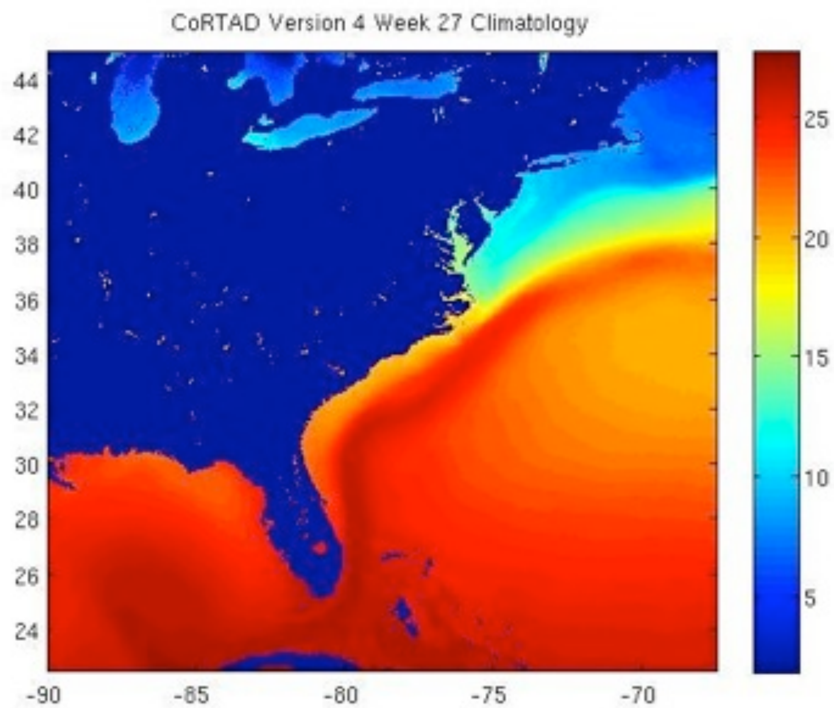


Figure 1: CoRTAD version 4 sea surface temperature climatology for Eastern North America. Week 27 for years 1982 through 2010 using Advanced Very High Resolution Radiometer (AVHRR).

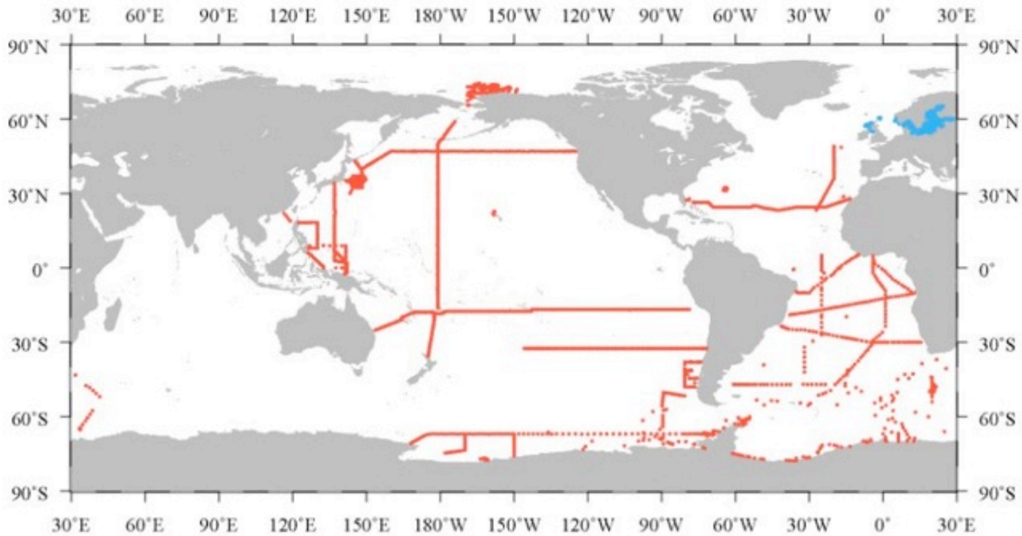


Figure 2: CTD and OSD data processed and added to the World Ocean Database from 9/19/2011 -3/1/2012. Data comes from the CLIVAR & Carbon Hydrographic Data Office (red) and the International Council for the Exploration of the Seas (blue). There were a total of 8,477 profiles added or updated in the WOD.

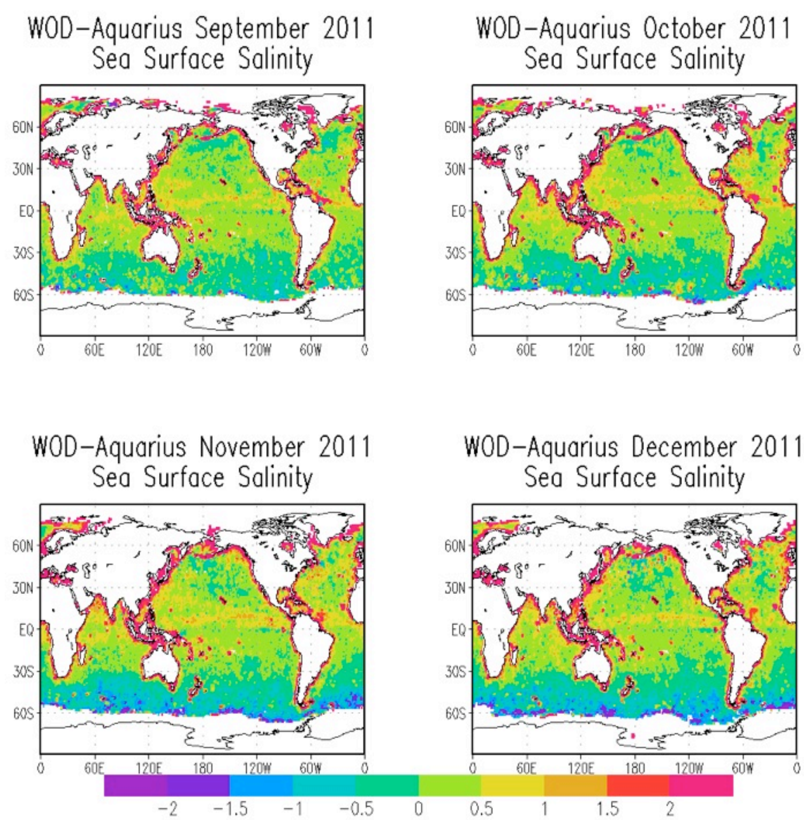


Figure 3: Difference between WOD calculated sea surface salinity fields and Aquarius (v1.2DR) sea surface salinity fields for 9/2011 through 12/2011.

Global Precipitation Analysis Development and Climate Diagnostic Research

Task Leader John Janowiak
Task Code JJJJ_PREC10
Contribution to CICS Themes Theme 1: 90%; Theme 2: 10%
Contribution to NOAA Goals Goal 2: 75%; Goal 3: 15%; Goal 4: 10%

BACKGROUND
The Climate Prediction Center (CPC) of NCEP/NWS/NOAA assesses and predicts short-term climate variability and its impact on the U.S. The complex nature of the global climate system, and the requirement for continuous improvement in CPC capabilities, makes the conduct of on-going collaborative developmental research imperative. This task includes activities of the PI and his colleagues at CICS that range from providing validation information about satellite-derived and model forecasts of precipitation to streamlining CPC's operational processes, and which contribute to the advancement of the goals of CPC.

ACCOMPLISHMENTS
During the past year, collaboration has continued with CPC staff in a number of monitoring and diagnostic roles, particularly involving precipitation estimation, analysis, and validation. In particular, large volumes of native resolution satellite-derived precipitation estimates from NESDIS algorithms that are stored on CICS/ESSIC computers were transported to CPC to assist in the backward extension of CPC's "CMORPH" precipitation analysis.

PLANNED WORK
- Work with CPC personnel on the development and application of satellite-based precipitation analyses will continue.
- The satellite-derived precipitation validation activities over the US in support of the International Precipitation Working Group (IPWG) will be maintained and improved.

Program Management at the Climate Program Office

Task Leader Dan Barrie
Task Code PADBPMCPO11
Contribution to CICS Themes Theme 2: 20%; Theme 3: 80%
Contribution to NOAA Goals Goal 1: 60%; Goal 2: 10%; Goal 5: 30%

BACKGROUND

This task was initiated in the Fall of 2010 principally to provide Chet Koblinsky, director of the Climate Program Office, with support in his role as chair of a newly formed modeling working group (WG) within the United States Global Change Research Program (USGCRP). The task leader was hired in this support role based upon his previous experience with a broad array of modeling systems, including General Circulation Models (at both regional and global scales), Integrated Assessment Models, and other modeling systems. In addition, the task leader's experience with utilizing modeling systems to examine problems at the intersection of physical and socioeconomic systems (wind energy-environmental interactions) was deemed relevant to the newly integrative and highly interdisciplinary thrust of the modeling WG.

The task leader's activities within the Climate Program Office, and more broadly within NOAA have expanded to include program management duties in the Modeling, Analysis, Predictions, and Projections (MAPP) competitive grants program, where the task manager works alongside Don Anderson and Annarita Mariotti to manage the program's activities, including yearly requests for proposals, grants processing, and other programmatic activities. The task leader is also serving as the climate representative to the NOAA Energy Team, a cross-NOAA effort too coordinate and advance NOAA's contribution to the stability and development of the Nation's electricity capacity.

In addition to the programmatic efforts described above, the task leader continues to engage in research activities, including preparing journal articles based upon his thesis research, and securing new computing resources for data analysis and model runs. The task leader's research interests continue to be focused on wind energy-environmental interactions, and he has developed a number of new research focuses in collaboration with NOAA staff, including staff from the Office of Atmospheric Research, and various staff at the Earth System Research Laboratory.

ACCOMPLISHMENTS

In collaboration with Chet Koblinsky, a new working group, the Interagency Group on Integrative Modeling (IGIM) has been developed at the USGCRP. Membership in this group was solicited from each of the 13 USGCRP agencies, and the group has received active participation from 20 individuals representing 10 agencies. Critically, this group entrains expertise from a diverse array of modeling disciplines, including Climate and Earth System Modeling (ESM); Integrated Assessment Modeling (IAM); and Impacts, Adaptation, and Vulnerability Modeling (IAV). This diverse membership is emblematic of the new "end to end" focus of the USGCRP, in other words, connecting the raw science with the end users in a two-way manner. The various modeling communities described above have not historically been well-linked; data is shared in more of a one-way direction, with physical modelers providing output to the end user community without a robust system of two-way communication to adapt modeling efforts to user needs. In addition, the ESM and IAM communities are only now being directly linked, especially with the inclusion of the carbon cycle in ESMs, which inherently captures human activities. ESMs and IAMs are also being explicitly linked in the form of integrated Earth System Models. The IGIM serves these communities effectively by coordinating, at the federal agency level, a diverse array of program management so as to provide a clear, coordinated direction for the federal modeling effort.

In his duties as a coordinator of the IGIM, the task leader has organized and coordinated day-to-day activities of the group, including monthly meetings, requests for information from the USGCRP, and internal group discussions. The task leader also effectively acts as the NOAA modeling representative in situations where the USGCRP has requested information about agency modeling activates; this requires coordination with the various labs and operational centers at NOAA, including GFDL, ESRL, CPC, etc. A number of reports and documents have been contributed to by the task leader, including both the Fiscal Year (FY) 12 and FY13 Our Changing Planet documents, and a wide variety of FY12 and FY13 budgetary briefing documents.

As a program manager in the MAPP competitive grants program, located in the CPO, the task leader has provided significant support to the program management team in its yearly competitive grant cycle. This includes interacting with and providing guidance to funded and prospective investigators; reviewing project reports, letters of intent, and proposals for relevance and scientific merit; completing programmatic tasks associated with grant processing, running and documenting scientific panel reviews of received proposals; and reviewing and coordinating the review of non-competitive proposals received either by the MAPP program or by other programs in the CPO.

In 2011-2012, the task leader has developed a monthly, eight-part Webinar series. Each Webinar highlights a different area of MAPP research (e.g. model development, intraseasonal prediction, reanalysis, etc.) with three to five talks given by MAPP-supported Principal Investigators (PIs). These Webinars are intended to highlight the success of the MAPP program for NOAA management and the external community, and to connect PIs with each other to advance scientific understanding in a particular research area. The webinar series has been attended by approximately 175 unique individuals, some of whom have attended multiple webinars. A website for the webinar series has been created, where slides and recordings of the proceedings are posted (http://www.climate.noaa.gov/index.jsp?pg=./cpo_pa/mapp/webinars.html). This activity has provided greater exposure to the MAPP program.

PLANNED WORK

- Continue coordination of the USGCRP IGIM group as described above.
- Continue management of MAPP competitive grants program as described above.
- Continue to represent the climate goal in the NOAA Energy Team.
- Publish journal articles associated with doctoral research.
- Initiate new research activities.

PUBLICATIONS

Karl et al., Our Changing Planet, The U.S. Global Change Research Program for Fiscal

Year 2012

Karl et. Al, Our Changing Planet, 2013

PRESENTATIONS

"The impact of anthropogenic global warming on the United States wind resource," American Meteorological Society Annual Meeting, Oral Presentation, Seattle, Washington, 2011,

"The impact of wind energy on weather: studies with a simplified model," American Meteorological Society Annual Meeting, Poster Presentation, Seattle, Washington, 2011

4.5 Climate Projects

Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record

Task Leader	Hai-Tien Lee
Task Code	HLHL_HIRS10
Contribution to CICS Themes	Theme 1: 10%; Theme 2: 70%; Theme 3: 20%.
Contribution to NOAA Goals	Goal 1: 100%

BACKGROUND

The primary goals of this project are to prototype an operational production system for the outgoing longwave radiation climate data record while continue the improvements and validation efforts for the existing product and algorithms. An end-to-end system has been proposed to produce OLR CDR product using HIRS level-1b data input. The derivation of climate data record involves several careful procedures with OLR retrieval performed for each HIRS pixel, including: applying inter-satellite calibration to maintain continuity; use of diurnal models to minimize orbital drift effects in temporal integral; and consistent radiance calibration. We are also developing OLR algorithms for the operational sounders following the HIRS, including the IASI and CrIS, such that the OLR CDR time series can be extended into the foreseeable future (~2040) without data gaps.

ACCOMPLISHMENTS

HIRS OLR CDR Quality Assurance

The HIRS OLR CDR product and its software and documentation package have all been delivered to NCDC and are now posted on the NCDC CDR web site for public access (http://www.ncdc.noaa.gov/cdr/operationalcdrs.html).

The HIRS OLR CDR has entered the Initial Operational Capacity (IOC) starting September 2011 at NCDC, with CICS continues on the maintenance and improvement works (funding pending). The HIRS OLR Climate Data Record Ed2.2 is extended up to date with more than 33 years, from 1979 to 2012 (see Fig. 1).

The HIRS OLR CDR is compared well to the CERES Ed2 and Ed2.5 products. The slight trend (~1-2 Wm^{-2} per decade) in the OLR differences between HIRS and CERES Ed2 after year 2000 (i.e., w.r.t. Terra and Aqua data) is the focus of the validation studies. We are verifying if this trend is caused by the Ed2 CERES OLR biases related to the spectral response function degradation in SW and Total channels. The new calibration method CERES devised is expected to fix this problem and a Ed2.5 product was generated for early phase assessment (the Ed.3 product that would be available at least in another 6 months will include the new calibration method as well as other improvements). Preliminary comparisons of HIRS OLR and CERES Ed2.5-Lite products showed consistent results traceable to the past HIRS/ERBS validation studies. However, it seems that there remains to have trending differences whose existence and causes are yet to be confirmed. We continue to collaborate with NASA colleagues to understand these results.

Transition from Research to Operation

The HIRS OLR CDR Processing System Diagram is shown in Figure 2. This diagram shows that the system is consisted of three components: the Online Processing, the Offline Processing, and the Science Maintenance. The Online Processing column depicts the flow chart of the HIRS OLR CDR derivation sequence; while the Offline Processing column contains the corresponding development works that provide the necessary static inputs, e.g., OLR regression coefficients. The Science Maintenance column shows examples of works for future improvements. The system uses Subversion for version control.

The complete computation source code package for HIRS OLR CDR Production system has been delivered on April 1st, 2011. The system integrity test for the NOAA-16, 17, 18, 19 and MetOp-2 has been performed and it has passed the verification check. Similar integrity tests will also be conducted for the rest satellites to ensure correct processing at any given month within the time series.

The Operator's manual and code documentations have been delivered along with the source code package. The "Submission of Agreement" form has been submitted and is under processing. The HIRS Outgoing Longwave Radiation Climate Data Record Algorithm and Theoretical Base Document (C-ATBD) has been submitted and accepted in July 2011.

The HIRS OLR CDR production system is operational in September 2011.

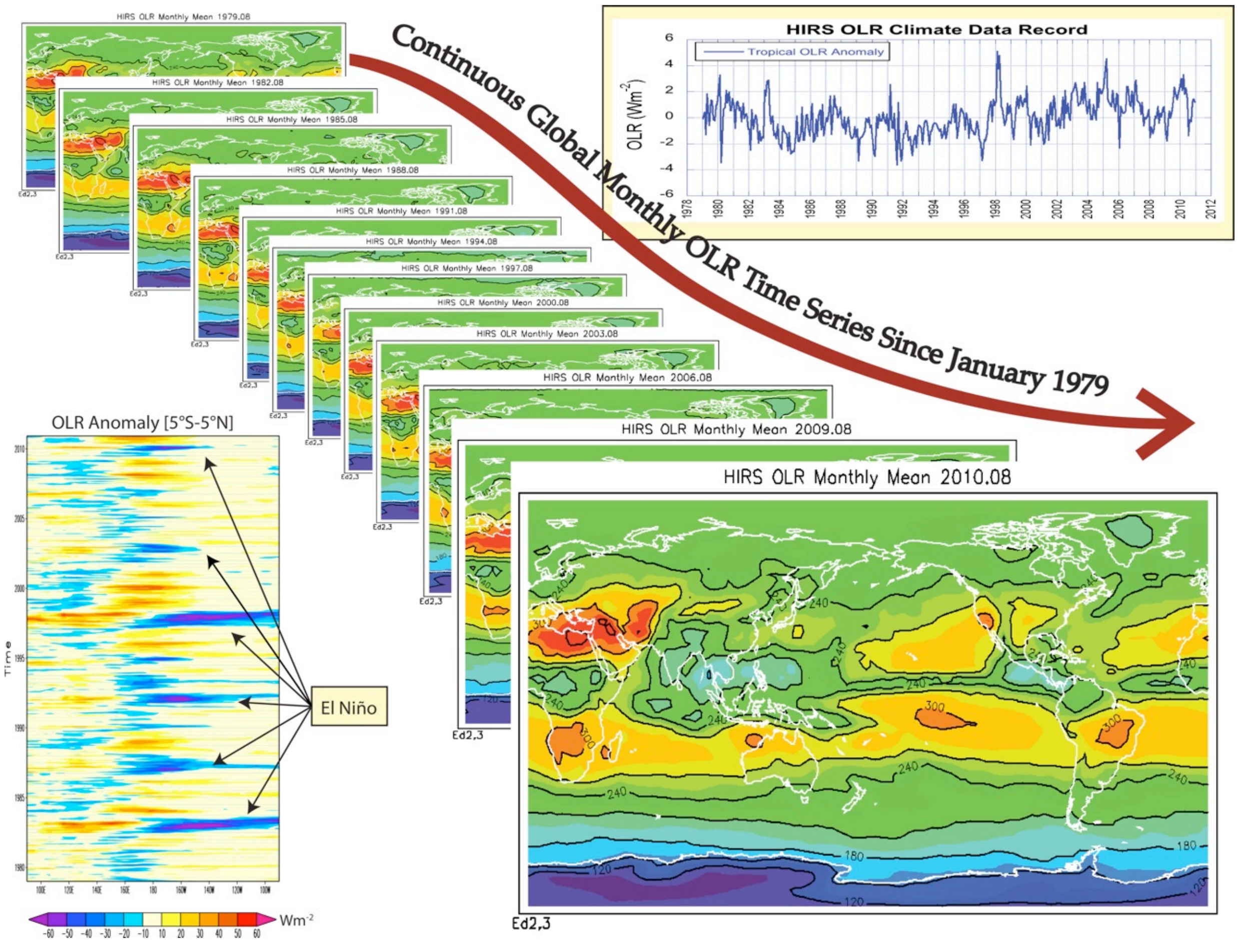


Figure 4: The HIRS OLR Climate Data Record is a continuous time series of the outgoing longwave radiation at the top of the atmosphere from 1979 to the present. It is a 2.5° by 2.5°gridded monthly mean product in full global coverage. The HIRS OLR CDR product can be used in the studies of earth radiation budget, evaluation of radiative flux parameters of the numerical weather prediction models, climate sensitivity analysis, and climate monitoring, etc.

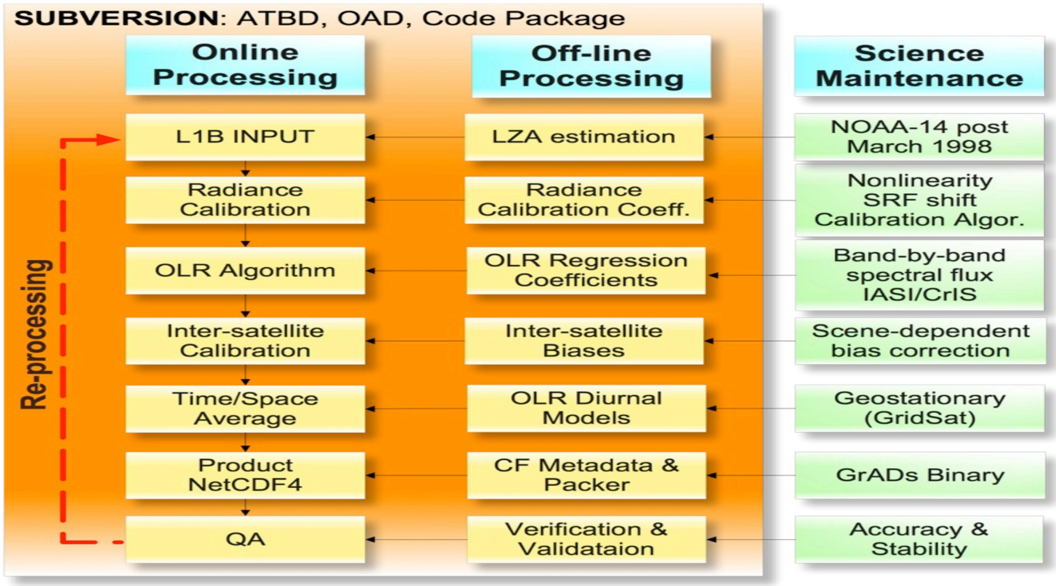


Figure 5: The HIRS OLR CDR Processing System Diagram. This diagram shows that the system is consisted of three components: the Online Processing, the Offline Processing, and the Science Maintenance. The Online Processing column depicts the flow chart of the HIRS OLR CDR derivation sequence; while the Offline Processing column contains the corresponding development works that provide the necessary static inputs, e.g., OLR regression coefficients. The Science Maintenance column shows examples of works for future improvements. The system uses Subversion for version control.

PLANNED WORK

Tasks (July 1 2012 – June 30 2013)[(1)]:

- Verification of HIRS OLR CDR Operational Production at NCDC
- Maintain parallel production of HIRS OLR CDR at CICS
- Maintenance of NCDC HIRS OLR CDR Operational Production System
- Address the possible intersatellite calibration error due to OLR algorithm channel switch
- Continue HIRS OLR algorithm improvements following the nonlinear multi-band regression experiments reported in Lee et al. (2009).
- Prepare journal articles and conference presentations

[(1)] *Under negotiation*

PUBLICATIONS

Lee, H.-T., 2011: HIRS Outgoing Longwave Radiation Climate Data Record Algorithm Theoretical Basis Document (C-ATBD) (ftp://ftp.ncdc.noaa.gov/pub/data/sds/cdr/docs/ hirs-olr-catbd.pdf)

PRESENTATIONS

Lee, H.-T., 2011: Sustainability of HIRS OLR Climate Data Record – *From Research to Operation.* First Conference on Transition of Research to Operations: Successes,

Plans and Challenges / 91st AMS Annual Meeting, Seattle, WA, January 23-27, 2011.

Lee, H.-T., 2011: HIRS OLR Climate Data Record – Production and Future Plans. NASA Sounder Science Team Meeting. Greenbelt, Maryland, Nov 8-10, 2011. (Oral)

DELIVERABLES

- HIRS OLR CDR product in NetCDF format, spanning from January 1979 to December 2010.
- HIRS OLR CDR Production System software and document package.

CIRUN: Climate Information Responding to User Needs

Task Leader	Antonio Busalacchi (Steve Halperin, CIRUN Director)
Task Code	PAPACIRUN10
Contribution to CICS Themes	Theme 3: 100%.
Contribution to NOAA Goals	Goal 1: 100%

BACKGROUND

Major climate change is upon us, and the next 50 years will see dramatic and rapid changes in our environment. The impact will be international, where population migrations in the many tens of millions are a real possibility, and on almost every sector of our economy. Through CIRUN the University of Maryland is working with partners to mobilize a national effort to build the capacity to predict these changes in advance on time scales of seasons to decades, and to convert these predictions into information that government and industry can use to plan and adapt. This will open many new opportunities, as the effort will require significant new research in computation, visualization, modeling and earth science.

ACCOMPLISHMENTS

- A CIRUN workshop, jointly sponsored by the NOAA Oceans and Human Health Initiative (OHHI), was held at ESSIC on Feb. 21/22. It brought together 40 participants from three communities: (1) State and local departments of public health and the environment from Maryland, Delaware, Virginia and Washington, (2) FDA, NIH, NOAA and university health and microbiology scientists, and (3) NOAA and university modeling and forecast scientists. The objective of the workshop was to identify actions that would improve the information provided to the public health sector about the current and future status of harmful alga blooms and those vibrio that are dangerous to humans, with a particular focus on the Chesapeake Bay.
    - Recommendations for actions were made by three breakout groups, which met after an initial context-setting plenary session. Each breakout group was composed of a mix of participants from all three communities, each of which brought a distinct perspective to the workshop. This made for lively discussions in the breakout groups. Remarkably, however, when the conclusions of the three breakout groups were summarized in a final plenary session all three identified the same principal themes. These conclusions will be integrated into a single final report to be posted on the CIRUN website (www.climateneeds.umd.edu).
- Prof. Steve Halperin was appointed CIRUN Director 9/1/11. The CIRUN mission is to promote and support measures that will enable policy makers in the public and private sectors to use reliable information about climate and environmental change in their decision processes. He is a member of the steering committee to plan two Forums on Climate Change and Coastal Communities.
- Created CIRUN brochure, including a weekly posting of climate adaptation news articles
- Complete revamping of CIRUN website
- Organized a CIRUN workshop (2/21-2/22, '12) with 45 attendees, at ESSIC, jointly with the NOAA Oceans and Human Health Initiative and the Public Health Departments of

the State of Maryland and Washington State, focused on Vibrio and HABs in the Chesapeake Bay.

PLANNED WORK

- Began planning for two more workshops:
- Impact of climate change on wildlife
- The current state and reliability of actionable information on climate change
- Organizing a public panel on population growth and the implications for adaptation to climate change, tentatively planned for spring 2012.

A Special Sensor Microwave Imager/Sounder (SSMI/S) Application for Hydrological Products Retrieval

Task Leader **Daniel Vila (Arief Sudradjat, collaborator)**

Task Code **DVDV_SSMI10**

Contribution to CICS Themes

Contribution to NOAA Goals

Last year's report was the final one on work performed under this award, due to the departures of Dr. Vila and Dr. Sudradjat.

Assessment of Oceanic Freshwater Flux Using Salinity Observations

Task Leader Li Ren
Task Code None
Contribution to CICS Themes Theme 2: 30%; Theme 3: 70%.
Contribution to NOAA Goals Goal 1: 100%

BACKGROUND

It has long been difficult to validate oceanic evaporation and precipitation due to the relative lack of in-situ data, although oceanic evaporation and precipitation are major components of the global hydrological cycle as well as among the most important components of the climate system, with 86% of global evaporation and 78% of global precipitation occurring over the oceans. With the rapidly growing number of ocean salinity measurements in recent years, the concept of "ocean rain gauge" has gained increasing attention. This task is focused on using the ocean salinity observation from Argo to validate the freshwater flux products, and is part of a larger research project with additional support from NSF and NASA.

ACCOMPLISHMENTS

Six E-P sets including two observations (GPCP/OAFlux and CMAP/OAFlux) and four reanalyses (CFSR, MERRA, ERA-Interim, JRA25) were validated by employing the ocean rain gauge (salinity changes) as a validating reference. On a global average, the E-P anomalies after removing the seasonal cycle from OAFlux/GPCP has the best agreement with the indirect E-P anomalies estimate from the salinity changes according to their temporal correlations and the RMSD (Table 1). Thus, we recommend the E-P of OAFlux and GPCP for global ocean modeling studies, particularly for inter-annual variation. Among the four reanalyses, CSFR has the highest temporal correlation and ERA-Interim has the lowest RMSD to the E-P anomalies estimate from the salinity changes (Table 1).

Table 1: *Monthly-Temporal correlation (r), the critical r-value (r_c) corresponding to z-test with 95% confidence level and RMSD of the differences between the direct and the indirect method.*

E-P	GPCP	CMAP	MERRA	CFSR	JRA25	ERA-I
R	0.49	0.33	0.21	0.25	-0.41	-0.14
r_c	0.30	0.28	0.49	0.53	0.47	0.48
RMSD (m $year^{-1}$)	0.031	0.031	0.049	0.038	0.073	0.035

PLANNED WORK

- Examine the spatial patterns of the upper ocean salinity variation.
- Validate the spatial skill of the E-P products according to the ocean salinity observations.

PUBLICATIONS

Ren, L., E. Hackert, P. Arkin and A.J. Busalacchi, Assessment of Global Oceanic Net Freshwater Flux Products Using Argo Salinity Observations, *submitted to GRL.*

PRESENTATIONS

Ren, L., E. Hackert, A. J. Busalacchi, P.A. Arkin, Oceanic Net Freshwater Flux Anomalies Inferred from Upper Ocean Salinity (2006 to 2010), AGU Fall Meeting 2011, San Francisco, 12/2011, oral.

A Recalibration of the AVHRR data record to provide an accurate and well parameterized FCDR

Task Leader Jonathan Mittaz

Task Code Shadow award

Contribution to CICS Themes Theme 2: 100%;

Contribution to NOAA Goals Goal 1: 70%; Goal 2: 30%

BACKGROUND

The Advanced Very High Resolution Radiometer (AVHRR) is a critical instrument for climate change studies because different versions of the AVHRR sensors have been available continuously for over 30 years and continue to be used to the present day. To use the AVHRR for climate change studies, however, accurate and stable radiances are required, or at the very least the biases and trends have to be well understood. Unfortunately these are not available with the current operational calibration, and work done by us and others has already shown significant biases and errors of up to > 0.5K. Further, analysis done by the University of Miami as part of the Pathfinder project shows that for at least one AVHRR (NOAA-16) significant time varying calibration problems are producing large time variable SST biases (see Figure 2). These issues of both large biases and time variable calibration problems will severely limit the use of the AVHRR for climate change studies if left uncorrected.

In order to address the problems with the current AVHRR calibration we have developed a completely new physically based calibration methodology which has been able to find and highlight the complex sources of bias and error in both the pre-launch and in-orbit data for the AVHRR. By including effects such as stray light and instrument temperature drifts we have shown that it is possible to remove much of the source of error seen in AVHRR radiances and under certain circumstances provide a nearly zero bias pre-launch calibration. We have also shown that the new calibration also has the capability of predicting instrument gain during times when the onboard calibration data are affected by solar and/or Earthshine contamination - solar contamination has been a significant problem for many NOAA platforms as their equator crossing times drift. The baseline for this new calibration are matches with the (A)ATSR series and we have developed new match code which deals with variations in observed instrument footprints. We have also derived a correction for the biased 12μm channel on the AATSR. We are currently in the process of moving through the AVHRR series starting with the more modern AVHRRs to derive a new calibration scheme to the complete historic AVHRR data record to fix calibration biases and contamination effects and therefore provide an accurate and clean AVHRR FCDR.

ACCOMPLISHMENTS

This year a significant amount of time has been spent setting up software to accurately match different satellites together such as the AVHRR and (A)ATSR making sure that the different footprints/point spread functions of the different instruments have been taken into account. Much of this work has been done by a new hire, Manik Bali. Now that this software is in place we have begun systematically analyzing data from different AVHRRs to derive new calibrations to create a database of AVHRR/ATSR matched data to be used in determining the new AVHRR calibration.

As a necessary sub-project (which was not part of the original proposal) we have also used the matching software to match IASI with the AATSR so we can estimate and diagnose the known issues with the AATSR 12µm channel. To do this we have matched one months worth of IASI data with the AATSR, convolving the IASI spectrum with the AATSR 11 and 12µm channels spectral response functions to derive equivalent brightness temperatures. Figure 1 shows preliminary results from this analysis and shows that while the 11µm channel has a simple and small (0.06K) bias between IASI and the AATSR, the 12µm channel shows a strong and large (>0.2K) trend as a function of scene temperature. Note that this trend must be due to errors in the AATSR since both the 11 and 12µm channels are covered by a single IASI band and if IASI were at fault a trend would have been seen in both the 11 and 12µm channels. This is the first time to our knowledge that such a trend in the bias has been reported in the AATSR and we are in the process of contacting the AATSR calibration team to work on a solution. While more work (and more data) needs to be analyzed, we have used this result to correct the 12µm AATSR data when doing our AVHRR recalibration.

Using the correction to the AATSR 12µm channel defined above we have currently derived new calibrations for three AVHRRs, NOAA-16, NOAA-17 and NOAA-18. For NOAA-16 we have had to do extra work involving a significant amount of research and data analysis due to large time dependent biases. Figure 2 shows examples of the correlation between the radiance bias and the blackbody temperature for NOAA-16 and shows that the bias is, to first order, linearly correlated with the BB temperature. However the plot also shows that the radiance bias is not a simple function of temperature – the red data points are for the period 2004 – 2007 and the black points are for the period 2008- 2011. These two periods correspond to different behaviors in the thermal state of the instrument and show that the radiance bias behavior seen in NOAA-16 is complex.

At the moment the full solution to the behavior of the radiance bias with respect to the thermal state has not been completed. However, as the lower plot of Figure 2 shows, even a simple correction can significantly help in the retrieval of geophysical parameters from NOAA-16 and we are close to arriving at a solution to the problem.

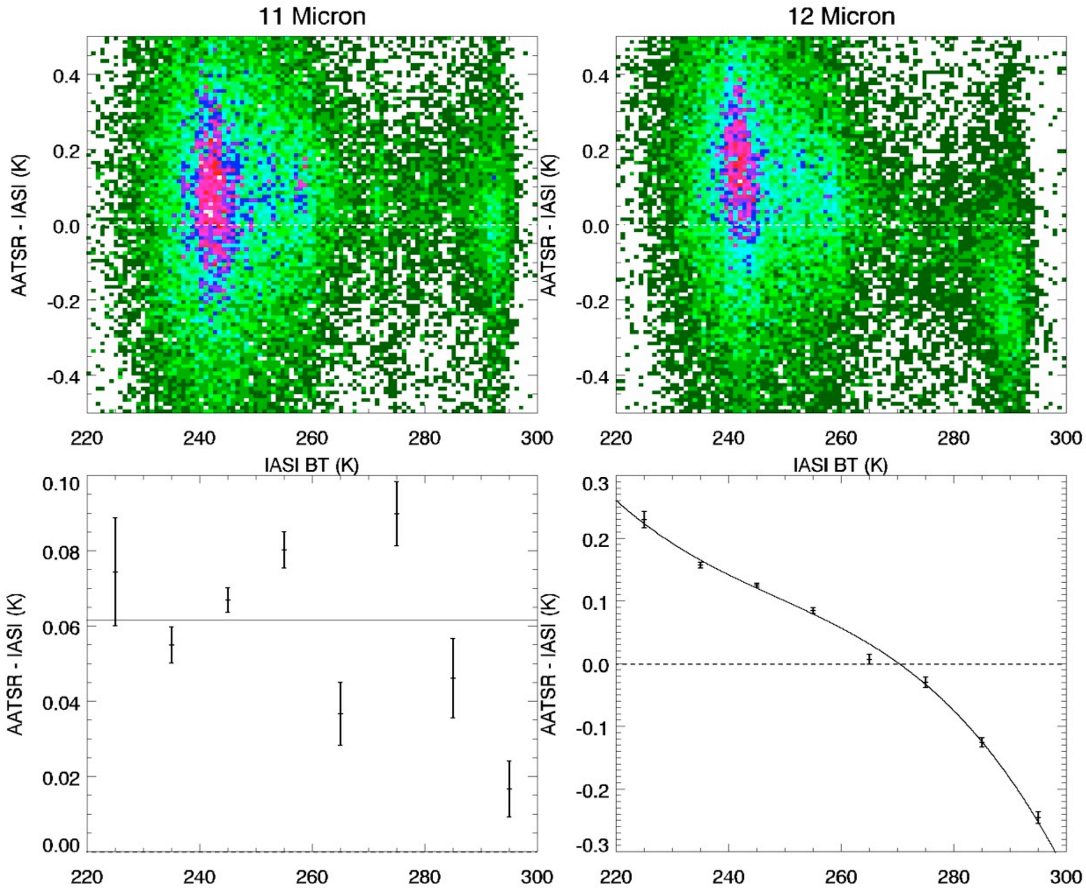


Figure 1: Comparison between the AATSR and IASI where the IASI spectrum has been integrated over the 11 and 12 µm AATSR spectral response functions. The 11µm bias can be characterized as a simple offset of 0.062K with no obvious trend and may be due to either an offset in IASI or in the AATSR or both. The 12 micron channel, however, shows a significant trend as a function of the observed scene temperature which must be due to biases in the AATSR data since a single IASI band covers both the 11 and 12µm channels. The solid line is a cubic model fitted to the data and can be used to removed the 12µm bias from the AVHRR/AATSR matches.

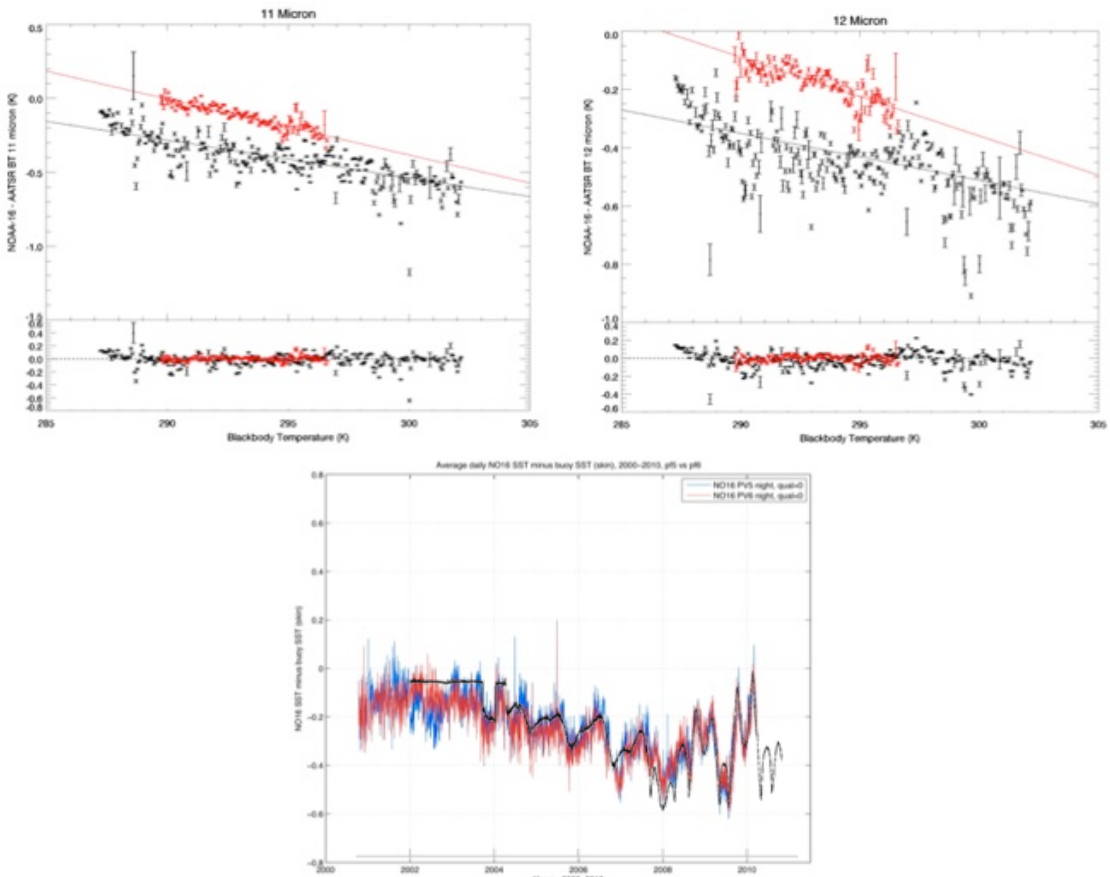


Figure 2: Top two panels show the correlation between instrument temperature and radiance bias (relative to the AATSR) for the AVHRR on-board NOAA-16 for the 11 and 12μm channels. The red data points correspond to data over the time period 2004-2007 and the black data points correspond to the time period 2008-2011 and show that the bias time dependence changed in 2008. The lower panel shows and example of the SST bias caused by not correcting for the time dependent bias (based on Pathfinder V6.0 data, Evans (private communication)) together with an estimate of the expected SST bias based on a simple time dependent radiance bias model. The agreement shows that the radiance bias for NOAA-16 is indeed related to the instrument temperature.

PLANNED WORK

Now that we have matchup software that is fully tested and verified we will continue to generate new calibrations not just for the AVHRR/3 sensors but for earlier sensors as well. We will use the (A)ATSR series to go back to 1991 (to NOAA-11) and will start working on even earlier satellites. As part of this we will redo the pre-launch calibration for the AVHRR/2 sensors and will also start using RTM radiances as well as HIRS radiances to redo the calibration of the AVHRR sensors pre-1991. Finally we will begin using SST as a reference to validate the new calibration. Work has already begun on this (e.g. “Calibration of NOAA satellites and its impact on SST retrievals”, a talk given at the GHRSST Workshop on Tropical Warm Pool and High Latitude SST Issues held in Melbourne, Australia 2012). We also intend to provide public access to the new calibration for the AVHRR/3 sensors by the summer of 2012.

PUBLICATIONS

Mittaz, J.P.D. & A.R. Harris, A Physical Calibration of the AVHRR/3 Part II: An in-orbit comparison of the AVHRR longwave thermal IR channels on-board MetOp-A with the IASI instrument. *Journal of Oceanic and Atmospheric Technology*, 28, 1072-1087, 2011

Mittaz, J.P.D. & A.R. Harris, The Calibration of the Broadband Infrared Sensors Onboard NOAA Satellites, GHRSST XII Science Team Meeting, Edinburgh, UK, 27th June-1st July, 2011, Ed. A. Kaiser-Weiss, 270-276, 2011

PRESENTATIONS

Mittaz, J.P.D., 'Instrument Calibration and its Impact on SST Retrieval', US SST Science Team meeting, Miami, Fl, Nov 2011, 2011

A Retrospective Analysis of IPCC TAR & FAR Model Projections of Sea Level Rise

Task Leader J.A. Carton
Task Code JCJCSIPCC11
Contribution to CICS Themes Task 1: 70%; Task 2: 30%
Contribution to NOAA Goals Goal 1: 20%, Goal 2: 60%, Goal 5: 20%

BACKGROUND

Observations of global sea level, available since 1991, have shown a rise of over 3mm/yr, significantly in excess of the 100yr average rise of under 2mm/yr. IPCC projections are quite uncertain, but suggest that these numbers may grow alarmingly in the next century. Part of the concern has to do with the possibility of local regions such as the eastern United States, where sea level rise may substantially exceed the global average due to a combination of post glacial rebound, changing currents, and warming of the mid-depth ocean associated with changes in the meridional overturning circulation (*Yin et al., 2010*). Within NOAA GFDL has extensive commitment to producing coupled climate model projections and are adding physical processes such as those controlling continental ice melt and the ocean freshwater budget for the purpose of providing more accurate sea level projections. Observational data related to sea level is maintained at NOAA's Laboratory for Satellite Altimetry (satellite altimetry), National Ocean Survey (tide gauges), and National Ocean Data Center (subsurface temperature). The purpose of this work is to bring together the model projections and the observations to learn about the processes regulating sea level rise and thus the accuracy of future projections.

ACCOMPLISHMENTS

An initial study of sea level rise in the Southern Ocean, as it appears in the IPCC AR4 projections and in observations has been carried out and is being prepared for publication. The Southern Ocean is of particular interest because sea level has risen by as much as 6mm/yr in the past fifteen years, well above the global average (**Fig. 1**).

In a growth of this activity, a student, Ben Johnson, working with Eric Leuliette of NOAA, has developed a suite of software to compare satellite altimeter sea level and tide gauge sea level, accounting for such effects as tides, geographic and temporal interpolation. This software will allow a continual 'sanity check' on satellite altimetry and thus represents a critical activity associated with monitoring sea level rise.

FUTURE PLANS

- Examine the spatial structure of relationship between gauge sea level and altimetry.
- Complete a publication on the altimeter-tide gauge work.
- Explore predictions of regional sea level rise in AR5 coupled general circulation models. In particular we are interested in the impact of circulation changes, AMOC, and clouds and aerosols.

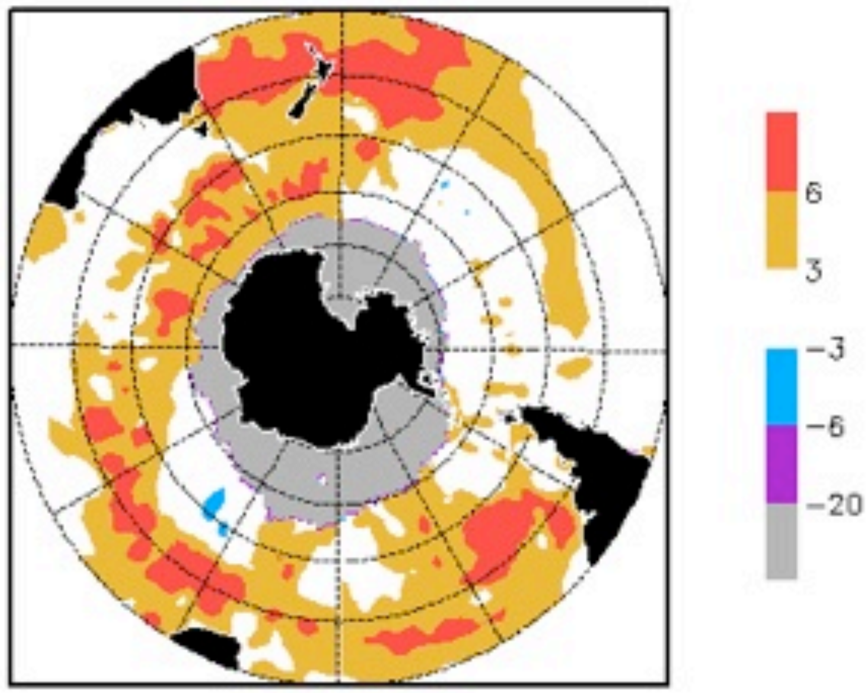


Figure 1: Observed sea level rise (mm/yr) based on combined monthly altimetry 1993-2007. Seasonal maximum ice distribution is shown in grey. The effects of post-glacial rebound have not been included.

REFERENCES

Yin, Jianjun, Stephen M. Griffies, Ronald J. Stouffer, 2010: Spatial Variability of Sea Level Rise in Twenty-First Century Projections. *J. Climate*, **23**, 4585–4607. doi: 10.1175/2010JCLI3533.1

4.6 Land Surface Projects

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Surface Reflectance

Task Leader Chris Justice, Eric Vermote
Task Code GEOG-01 Surface Reflectance
Contribution to CICS Themes Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals Goal 1: 50%; Goal 5: 50%

BACKGROUND
The goal was to provide early evaluation of the surface reflectance product from VIIRS, most of the reporting report was devoted to the development of tools for data analysis.

- developing the visualization and analysis tools for VIIRS based on the tools created for MODIS
- initial evaluation of the L1 data from VIIRS during the commissioning phase – in close cooperation with the NPP Science Calibration Team and the land lead at NOAA STAR
- download and evaluation of IDPS-generated products
- initial preparation of surface reflectance data code for VIIRS building on the most recent MODIS surface reflectance product working with the NASA Land PEATE and proposed alterations to the IDPS Code

ACCOMPLISHMENTS
VIIRS SR and VCM CAL/VAL Tools development

1. **HDF5 visualization/analysis tools development.** The objective of this task was to develop tools that directly handle hd5 format (without conversion). The tool developed at the SCF for MODIS were adapted for HDF5 and successfully read and display several hdf5 products from the IDPS system.
2. **APU tool for CMG analysis.** The Climate Modeling Grid was used for preliminary evaluation of the global data quality. The objective is to compare the "science quality" portion of the NCT4 SR IP (2010-09-06 from 12:26Z to 22:18Z) dataset to the MODIS Aqua Climate Modeling Grid (CMG) Surface Reflectance product. A zone was selected and pixels flagged as cloud-free in both datasets were selected for comparison. The APU tool was run on the dataset to provide a better estimate of instrument performance.

VIIRS first light activities and early SDR's assessment

1. **Download of VIIRS's SDR data after door opening and process corrected reflectance.** The goal of this activity was to be able to download and apply a first level atmospheric correction to the data and generate first light images (figure 1). VIIRS SDR data for band M3, M4 and M5 as well as geo-location data were downloaded from both GRAVITE and Land PEATE, they were processed to corrected reflectance and re-projected (see figure 3 and 4). All data acquired up to November 28th were downloaded

and processed globally and re-projected in the Climate Modeling Grid (at 0.05 deg) enabling quick evaluation.

2. **Assessment of the at-launch calibration.** The VIIRS data were formed into the climate modeling grid format and compared to the equivalent MODIS product. We were able to successfully use both Aqua data (for cloud masking VIIRS) and Terra data (to get coincident geometry), and perform an early assessment of the calibration in band M5 (see figure 2). The VIIRS reflectance in M5 were overestimated by 15% as it turns out that the wrong calibration LUT (SN-000 test values) was used in the IDPS processing instead of the at-launch version (SN-001 at launch). The next step is to re-evaluate the calibration by using the at-launch calibration (SN-001) but also the post launch calibration based on on-board calibrators (SN-002).

VIIRS first light activities and early SDR's assessment

1. The goal of this sub-task was to be able to propose and test algorithm changes in an ADL like environment. All the code needed as input to the agricultural monitoring system: Aerosol, VIIRS Cloud Mask, Surface Reflectance and the Climate Modeling Grid generator are running at the SCF. We are now starting to test some necessary code changes ready for PDR submission (i.e. to enable process SR over clouds masked areas). A PDR will be submitted through the LAND PEATE.
2. **Cloud Mask Activity.** Working with the VIIRS Cloud Mask (VCM) lead (Tom Kopf) we accessed CASANOSA and downloaded the latest version of the cloud mask LUT. The VCM LUT is a very large xml file (~25,000 lines. The conversion to an ASCII format was achieved with SAFARI, most xml editors cannot handle such a large file. The next step is to test the LUT and update on the VCM code by running it at the SCF (equivalent to ADL test).

PLANNED WORK

Continue the Calibration monitoring and validation of the reflectance product and cloud mask over land surfaces.

PRESENTATIONS

Informal presentations at various VIIRS Telecons/Meetings

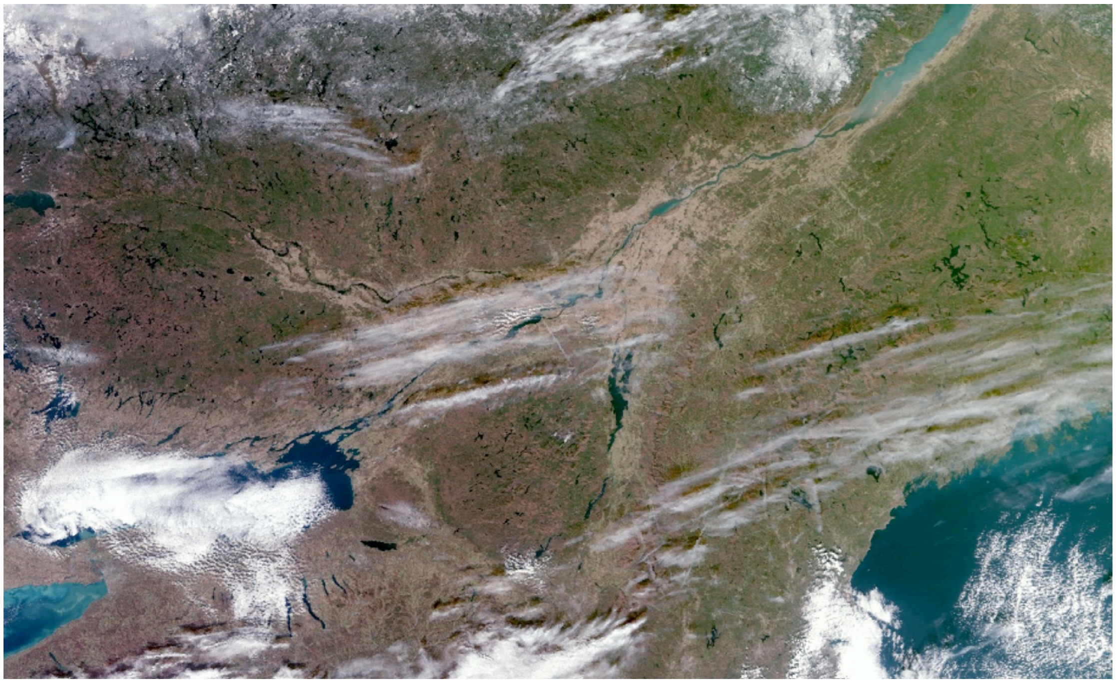


Figure 1: VIIRS First Light Image generated at the SCF

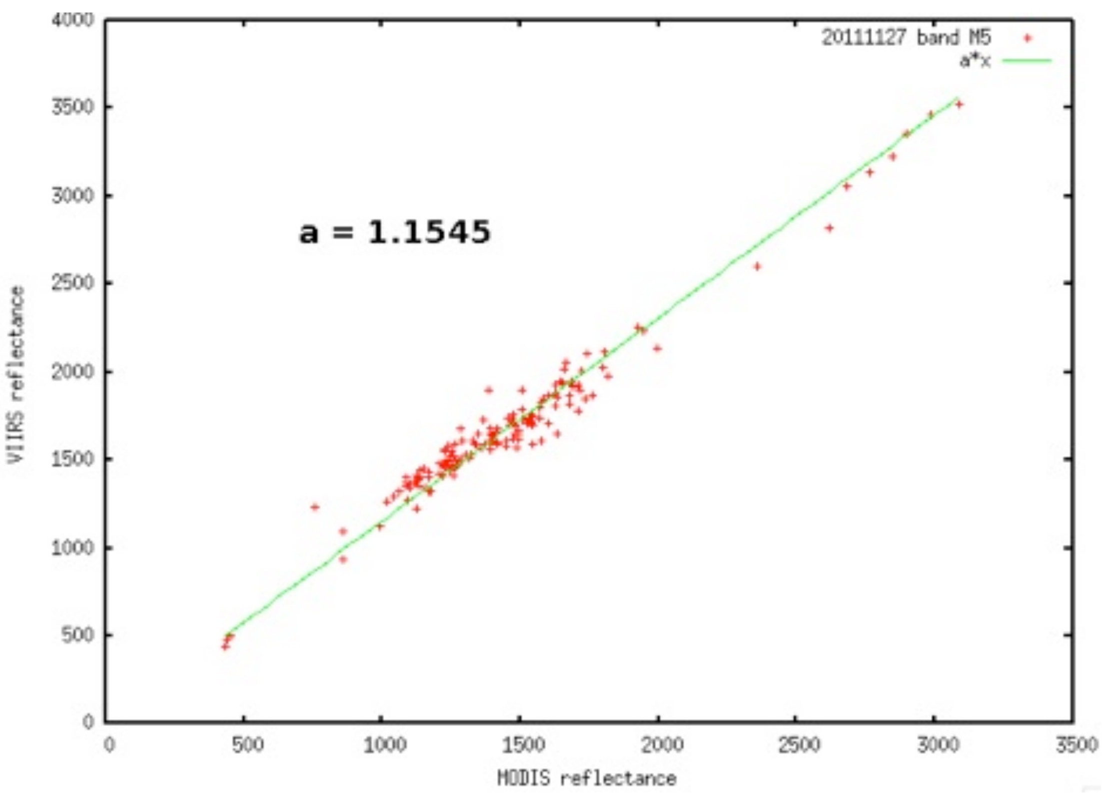


Figure 2: VIIRS early assessment inter-calibration results for band M5

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Land Surface Albedo

Task Leader Chris Justice, Shunlin Liang
Task Code GEOG-02 Land Surface Albedo
Contribution to CICS Themes Theme 1: 40%; Theme 2: 40%; Theme 3: 20%
Contribution to NOAA Goals Goal 1: 60%; Goal 2: 40%

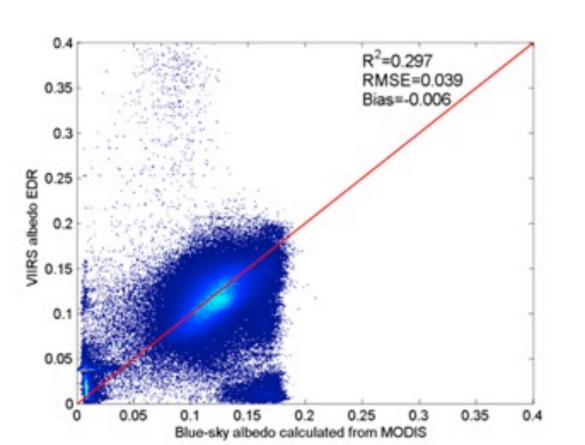
BACKGROUND

This work is part of the project "NPP/VIIRS Land Product Validation Research and Algorithm Refinement" and particularly focused on the validation and refinement of the NPP/VIIRS land surface albedo algorithm. Land surface albedo (LSA), together with ice surface albedo and ocean surface albedo, are combined into one final product --VIIRS surface albedo EDR. LSA is generated from two types of algorithms: Dark Pixel Sub Algorithm (DPSA) and Bright Pixel Sub Algorithm (BPSA). DPSA uses the Bi-directional Reflectance Distribution Function (BRDF) information from the 16-day gridded albedo IP to first calculate spectral albedo and then convert spectral albedo to broadband albedo using empirical models. BPSA directly estimate broadband albedo from VIIRS TOA radiance. In addition to land pixels, surface albedo over sea ice pixels is also calculated from a similar direct estimation approach.

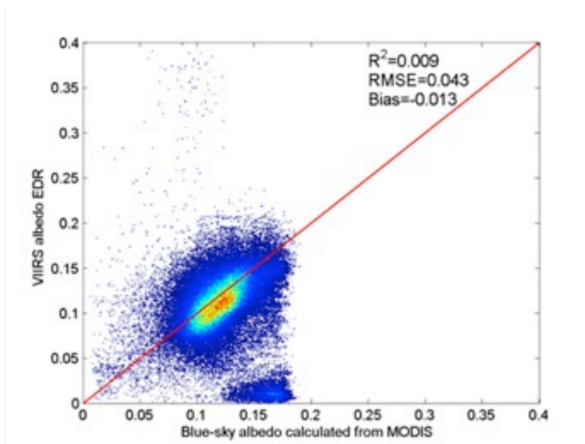
ACCOMPLISHMENTS

Pre-launch evaluation and validation work.

We participated the cal/val rehearsal before the launch of NPP. During the rehearsal, we tested the data delivery system and evaluated the proxy data using the MODIS albedo products. The following figures show some results from the evaluation work.



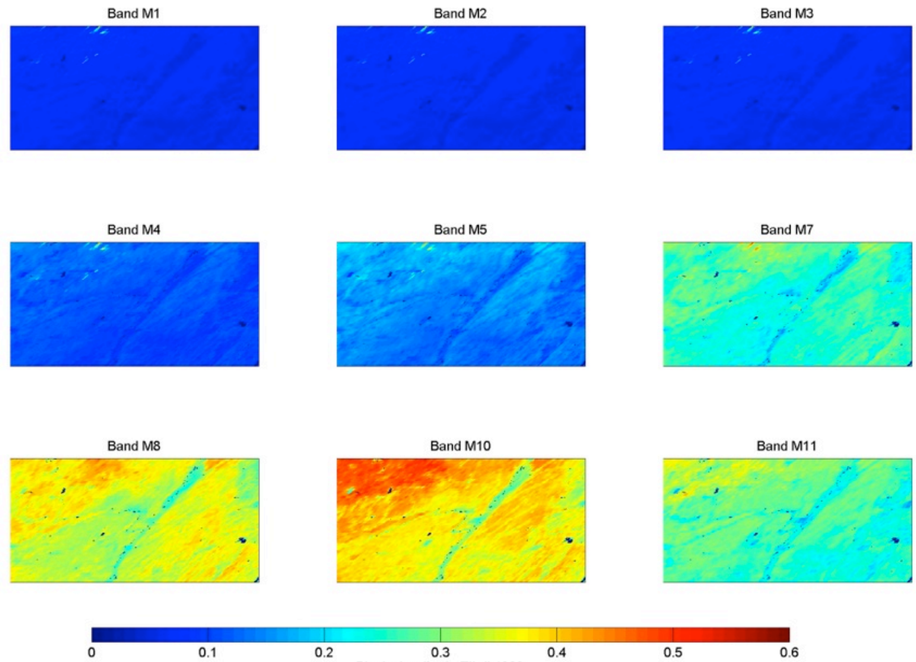
Scatterplot of all collocated pixels



Scatterplot of pixels with good quality and with MODIS AOD available

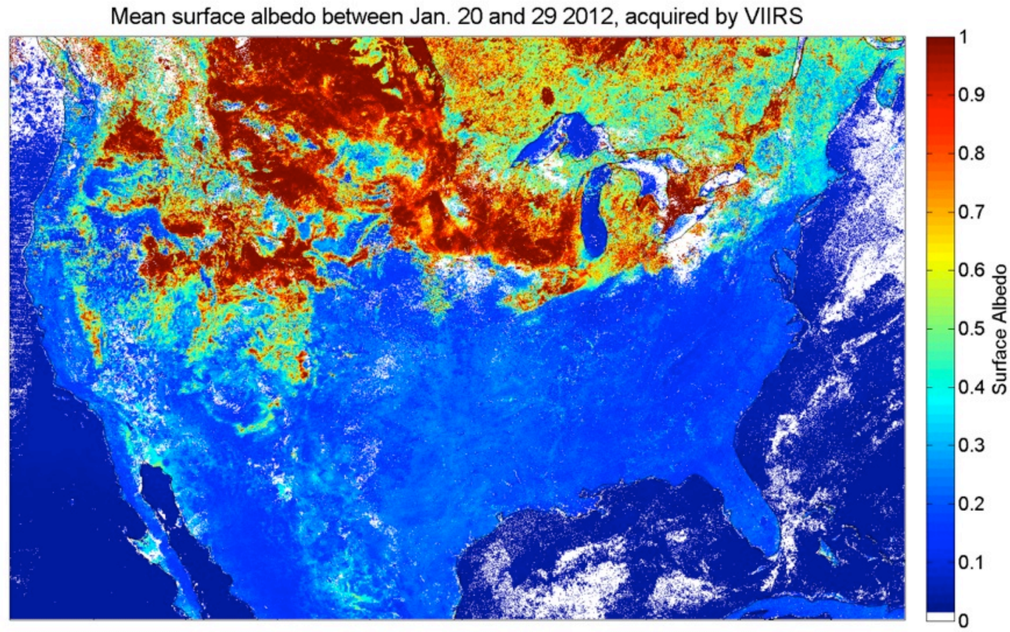
Verifying VIIRS albedo codes

The VIIRS albedo EDR codes have been included in the latest release of ADL (Version 3.1). We tested the codes on our local computational environments and programed to handle the input and output of the albedo codes. The intermediate products of DPSA are stored in a special format called GIP. In GIP files, 2-D images are stored in 1-D land-pixel-only arrays to save storage. The following figure is an example of one black-sky albedo file (Tile ID: 1389):



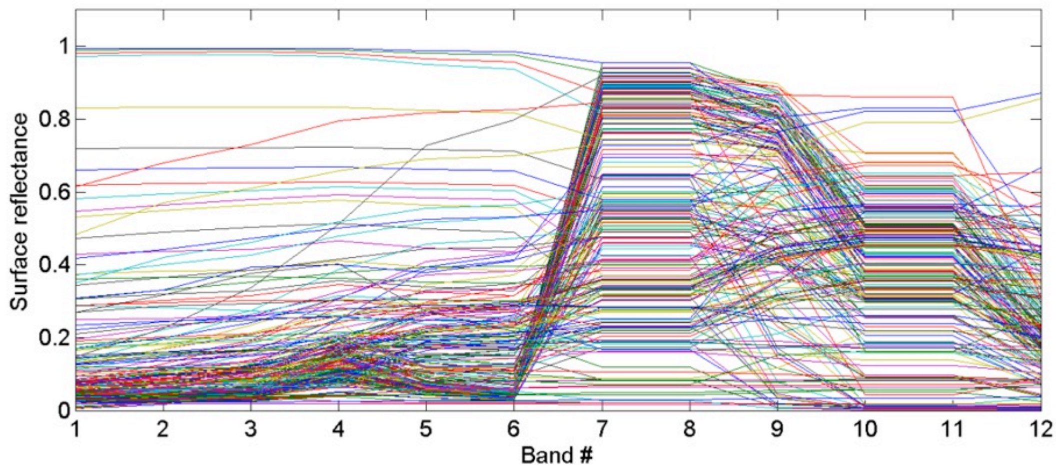
Evaluating the actual NPP/VIIRS albedo EDR

After the launch, we started evaluating the actual VIIRS albedo products. Once the albedo EDR is available, multiple days' data covering the continental US are downloaded and evaluated. Data from different paths are first re-projected and mosaiced to one daily map. The overlapping region has the values of the mean of the multiple scenes. The following figure shows a composite map by averaging the albedo EDR of the ten days.



Based on the evaluation, we found: 1) surface albedo EDR products have values over both ocean and land; 2) the seasonal snow is captured in the albedo map; 3) albedo from the different paths are relatively consistent, so the mosaiced image has no unnatural boundary; 4) "Data gap" is a problem, since albedo is produced for cloud-free pixels; 5) missing strips exist; 6) some values without physical meaning (<0 or >1) are produced.
Due to the special sampling design, the albedo EDR has some missing values at the edge of scanning lines, called "bow-tie" effects. We developed codes of interpolation to mitigate the effects.

Analyzing the sensitivity of retrieved albedo to the input errors
MODTRAN5simulation is used to generate datasets of TOA reflectance for evaluation of the sensitivity of retrieved albedo to the various errors of input data. A lab-measured database of surface reflectance, containing 245 records, is used as the input of surface boundary. The following figure shows the spectral reflectance of the database at twelve VIIRS bands. Together with the atmospheric parameters from the MODTRAN simulation, the surface information of the database is used to generate the TOA signals at VIIRS bands. The simulated TOA signals are used to test the algorithm and evaluate its sensitivity.



PLANNED WORK

- Updating BPSA coefficients
- BPSA directly estimates surface albedo from the top of atmosphere (TOA) spectral reflectance through a regression formulation. We propose to update the regression coefficients by incorporating the latest spectral response function of VIIRS and considering surface BRDF. Radiative simulation will be run on the BRDF dataset for generating the VIIRS TOA radiances by fully incorporating the interaction between atmosphere and non-Lambertian surfaces. The updated regression coefficients will be generated using the improved simulation data.
- Further evaluating VIIRS albedo EDR products
- We will continue working on the evaluation of the data, by examining the spatial and temporal characteristics of the VIIRS albedo product over some regions or some specific cover types.
- Validating VIIRS albedo EDR products
- The further quantitative validation will generate detailed information on the precision and accuracy of surface albedo EDR products. We plan to compare VIIRS surface albedo products against other satellite data (e.g. MODIS albedo products) and field measurements (e.g. SURFRAD, FLUXNET).

PUBLICATIONS

Wang,D., Liang, S., He, T., Yu, Y., Schaaf, C. 2012, Estimating daily land surface albedo from MODIS BRDF and surface reflectance products, In preparation.

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Land Surface Type

Task Leader	Chris Justice, Chengquan Huang
Task Code	GEOG-03 Land Surface Type
Contribution to CICS Themes	Theme 1: 30%; Theme 2: 40%; Theme3: 30%
Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 20%; Goal 3: 20%; Goal 5: 40%

BACKGROUND

The surface type Environmental Data Records (EDR) is an important data product from the Suomi NPP satellite. Using the IGBP land cover classification scheme, it labels the land cover types around the world on a daily basis. It is created from the Quarterly Surface Type (QST) Intermediate Product (IP) and other VIIRS EDR products such as ice/snow EDR and fire EDR.
The QST IP will be created every three months after a full year of VIIRS data has been gathered and calibrated. Before that, the MODIS land cover classification product derived by the Boston University (BU) in 2001 is used as a seed QST IP for the surface type EDR and other NPP EDR algorithms that require QST IP as an input. Development of the MODIS land cover classification has been detailed by Friedl et al. (2002).

The goals of our project are:

- Use existing training data collected through previous VIIRS surface type efforts (namely, training data collected by BU and UMD) to generate a QST IP using the current VIIRS QST IP algorithm (i.e., C5.0) and recent MODIS data.
- Examine possible problems in the existing QST IP seed product.
- Collect and replenish the training datasets. Examine and refine the classification metrics/ algorithm
- Support VIIRS cal/val activities

The time frame of this project is Aug 2011 to Apr 2012.

ACCOMPLISHMENTS

We have imported the training data that were obtained from BU and UMD through previous VIIRS surface type work. These were part of the training data used to produce global land cover classifications using MODIS (Friedl et al., 2002) and AVHRR data (Hansen et al., 2000). As provided, the UMD training data did not have a metadata file. No information was provided regarding data dimension and georeferencing. We successfully reconstructed a metadata file based on our knowledge of the AVHRR global land cover classification developed by Hansen et al. (2000). The UMD training set has 3 times the amount of pixels compared to the BU training set, and thus would have more weight than the BU training dataset when the two datasets are used together. What we found was that, large amount of training data was the result of highly concentrated training polygons in limited regions of the world. As a result, the characterization of land cover classes is uneven. Currently we are collecting new training data to address this issue.

Currently there is no fully functional compositing process on the VIIRS. We have built compositing tools both for the MODIS data and the VIIRS data. We have also found that, the VIIRS compositing process requires one more step when compared to that of MODIS. The oversaturation pixels are somewhat common and have to be filled first before the Max-NDVI compositing. We have produced 32-day MODIS composites for both 2001 and 2009.

Apart from the ice/snow cover and burn scars, the future VIIRS ST EDR might also include flooding. During the first weeks of NPP launch, Thailand suffered a severe flooding. We have used VIIRS imagery to create the during/after flooding map around Bangkok area to support the VIIRS scientific activities.

The VIIRS ST EDR is automatically created in IDPS by combining the QST IP and the snow/ice EDR and burn scar EDR. We have examined many surface type EDR products and found that many of the products in northern Siberia in the winter months did not have snow. We then searched for snow/ice EDR products for the same area and time periods but could not find those products. We are further investigating on this issue.

PLANNED WORK

In the next two months our main goal is to produce a new QST IP using recent MODIS data. The new product will be evaluated against the seed product. If it is deemed sufficiently better than the existing seed QST IP, it will be used to replace the existing seed product.

PUBLICATIONS

In the next two months our main goal is to produce a new QST IP using recent MODIS data. The new product will be evaluated against the seed product. If it is deemed sufficiently better than the existing seed QST IP, it will be used to replace the existing seed product.

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Active Fire Application Related Product

Task Leader Dr. Wilfrid Schroeder, Dr Evan Ellicott, Dr. Louis Giglio
Task Code GEOG-04 Active Fire Application Related Product (ARP)
Contribution to CICS Themes Theme 1: 100%
Contribution to NOAA Goals Goal 3: 50%; Goal 5: 50%

BACKGROUND

This task is a follow-on to the earlier project *Development of an enhanced active fire product from VIIRS*, which ended last year. The goal of this project is to assist the JPSS in the development, evaluation, validation, and implementation of an improved VIIRS active fire code in the early post-launch period. Development of an active fire product from VIIRS that would more closely resemble the MODIS product will provide continuity of data with intrinsic scientific merit.

ACCOMPLISHMENTS

At this early stage of the first funding cycle we have just begun to implement the MODIS Collection 6 detection and fire radiative power (FRP) retrieval algorithms (code version 6.1.5) in our prototype VIIRS fire code. The Collection 6 MODIS algorithm offers improvements over the current VIIRS algorithm, which is simply a straightforward "port" of the MODIS Collection 4 algorithm with no specific changes made for VIIRS. Among other improvements, the Collection 6 algorithm employs dynamic potential fire thresholds to better capture small, cool fires, an additional rejection test to help eliminate commission errors in small forest clearings in the Amazon, and expands processing over the open ocean and other large water bodies to permit the detection of offshore gas flaring.

We began a preliminary evaluation of the VIIRS fire ARP with the onset of valid thermal data in late January 2012. This process has been greatly expedited using the pre-launch software we developed under the earlier project for searching, downloading, and intercomparing (both qualitatively and quantitatively) VIIRS and coincident Aqua MODIS fire pixels. One preliminary finding is that VIIRS seems to under-detect large fires compared to MODIS. This is not surprising since the current VIIRS algorithm was at no point tuned specifically for VIIRS during the prelaunch development cycle. We stress that at this stage all findings are preliminary given the extremely short time period for which calibrated VIIRS thermal data have been available.

PLANNED WORK

- Complete testing of prototype VIIRS code using Collection 6 MODIS algorithm as a baseline.
- Complete preliminary tuning of algorithm parameters to account for the different radiometric characteristics and spatial resolution of the VIIRS sensor.
- Begin testing specific algorithm enhancements to exploit the unique (and sometimes superior) characteristics of the VIIRS sensor.
- Complete a preliminary validation of the VIIRS active fire product using data acquired with airborne sensors.

- Verify code performance across transition zones separating the three main regions of the image, each formed by unique pixel aggregation schemes.
- Perform a statistical analysis of the detection performance of the current and improved VIIRS fire detection algorithms.
- Monitor product performance under different fire pixel scenarios involving the saturation-prone M15 thermal band used by the detection algorithm.
- Continue to evaluate the VIIRS ARP generated within the IDPS and by the Land PEATE.

PRESENTATIONS

Csiszar, I., Schroeder, W., Giglio, L., Justice, C. O., and Ellicott, E., "Establishing active fire data continuity between Aqua MODIS and NPP VIIRS", 92nd Annual Meeting of the American Meteorological Society in New Orleans, LA, 22-26 January 2012.

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Land EDR Coordination with NASA Science Team

Task Leader Chris Justice
Task Code GEOG-05 Land EDR Coordination with NASA Science Team
Contribution to CICS Themes Theme 1: 40%; Theme 2: 60%
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 10%; Goal 3: 20%; Goal 5: 50%

BACKGROUND

NOAA STAR has taken on the responsibility for VIIRS algorithm development and validation following the restructuring of the VIIRS contract. The NASA Science Team is in parallel undertaking research to evaluate the EDRs and develop science quality products from NPP VIIRS as necessary. This will involve evaluating the EDR's generated by the IDPS and suggesting and demonstrating improvements to the algorithms. This will be undertaken primarily on the NASA Land PEATE. With the overlap in the STAR and NASA activities, a close working relationship between STAR Scientists and Algorithm Support Team, Cal/Validation scientists and the NASA Land Science Team will be highly desirable. As the NASA Land Discipline lead for VIIRS Dr. Justice will provide liaison between the teams working closely with Dr Ivan Csiszar NOAA land lead for VIIRS. Tasks involves: participation in land telecons, coordinating joint team workshops and meetings, outreach and presentations on VIRS Land capabilities. The goal is for a well coordinated land program for VIIRS.

ACCOMPLISHMENTS

The land team meets together weekly through coordinated telecons to discuss developments and identify issues. This is organized by the Land PEATE and the NCDC group (Privette et al.) and provides an excellent mechanism for discussing immediate findings, tracking progress on issues and coordinated responses to the Project.
The land groups are developing capability to evaluate the EDRs, and the team as a whole is exploring the process of how changes will be made to the IDPS code.
The first light image was well coordinated by the land group but could have been better handled by the NASA PR machine. Initial evaluations of VIIRS EDR data products are underway.

The land teams are working well together ensuring a linkage between upstream and downstream products.

PLANNED WORK

- In addition to the regular ongoing weekly telecons, the next phase of the cooperation between STAR and NASA Land efforts will be developed at the upcoming NASA NPP Science Team meeting. Justice will develop the land agenda working with the NASA Program Management and coordinate with Csiszar. The possibility of a land coordination workshop will be discussed.
- Greater emphasis is needed on program outreach.
- Science products generated by the NASA Science Team will be entrained into the Land Peate system and used for comparison with the EDRs.

PRESENTATIONS

Privette headed up a community presentation for the AMS – selected individual product presentations were given

OTHER

During the reporting period concerns were raised about DRL distribution of immature land products.

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Support for NOAA Operational Land Products Using AERONET-based Surface Reflectance Validation Network

Task Leader	Yujie Wang
Task Code	GEOG-06 Support for NOAA Operational Land Products Using
Contribution to CICS Themes	Theme 1: 20%; Theme2: 80%
Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

BACKGROUND

The land surface reflectance, albedo and vegetative index (derivative from surface reflectance) are important parameters of the weather and climate models defining the Earth radiative budget, complex land-water-air interactions and the boundary mass and heat transfer. The goal of this project is developing a validation (accuracy assessment) system for these products from different operational satellites, such as AVHRR series, NPP/NPOESS VIIRS and GOES-R to help the agency's multiple interests.

This task is focused on enhancement of AERONET-based Surface Reflectance Validation Network (ASRVN) and validation of the NOAA's surface reflectance and albedo operational products. The ASRVN approach uses accurate AERONET measurements of atmospheric aerosol and water vapor to perform an accurate atmospheric correction of satellite measurements and compare derived reflectance, albedo and vegetation indices with respective satellite products.

The basic functionality of the ASRVN has been under development since 2009 for MODIS. The ASRVN currently receives 50x50 km^2 subsets of MODIS L1B data from MODIS adaptive processing system (MODAPS) and Aerosol Robotic Network (AERONET) aerosol and water vapor information. It performs an atmospheric correction for about 100 AERONET sites globally based on accurate radiative transfer theory with complex quality control of input data. In this report, we present the work accomplished for the ASRVN system enhancement (i.e., evaluate ASRVN products by comparing with ground measurements, development of analysis tools for Accuracy, Precision and Uncertainty (APU) assessment).

ACCOMPLISHMENTS

The ASRVN products were originally delivered in gridded format at 1 km resolution. To facilitate comparisons with operational satellite products, we added the ASRVN processing for the swath data. Produced ASRVN NDVI may be used by the research community for a detailed independent VI validation and science analysis. An additional product, Hemispherical-Directional Reflectance Factor (HDRF), which is an at-surface reflected radiance normalized to the reflectance units, was also derived to directly compare with the ground-based measurements.

The ASRVN HDRF was verified against ground-based HDRF measurements collected during 2001-2008 over a bright calibration site Railroad Valley, Nevada. The ground measurements were conducted by the Remote Sensing Group (RSG) at the University of Arizona using an ASD spectrometer. The study showed a good agreement between ASRVN and RSG HDRF for both MODIS Terra and Aqua with *rmse*~ 0.01-0.025 in the 500m MODIS land bands B1-B7. Obtained *rmse* is below uncertainties due to the internal and seasonal variability of the 1 km^2 bright calibration area. Figure 1 shows the comparison results of ground measured HDRF vs. ASRVN HDRF using all MODIS solar reflective bands B1-B7 for both Terra and Aqua.

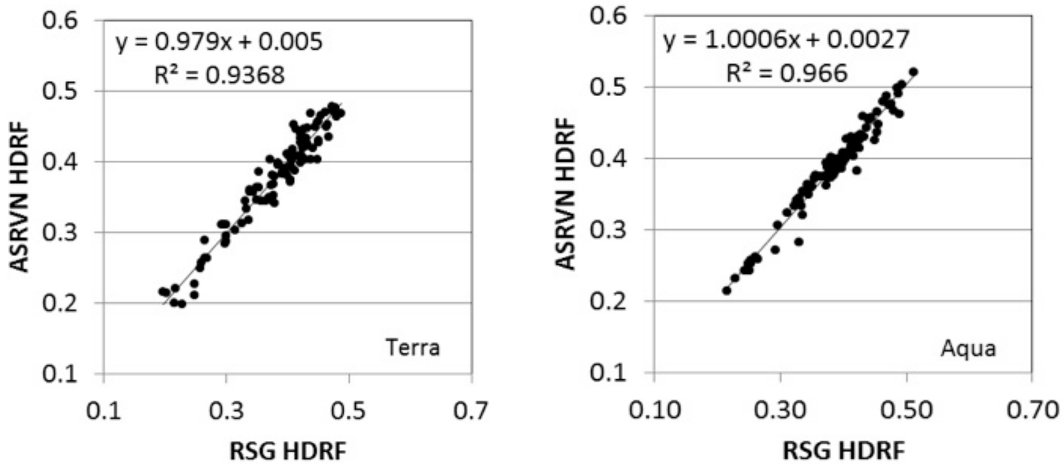


Figure 1: Overall comparison of measured HDRF and ASRVN HDRF for all 7 MODIS solar reflective bands.

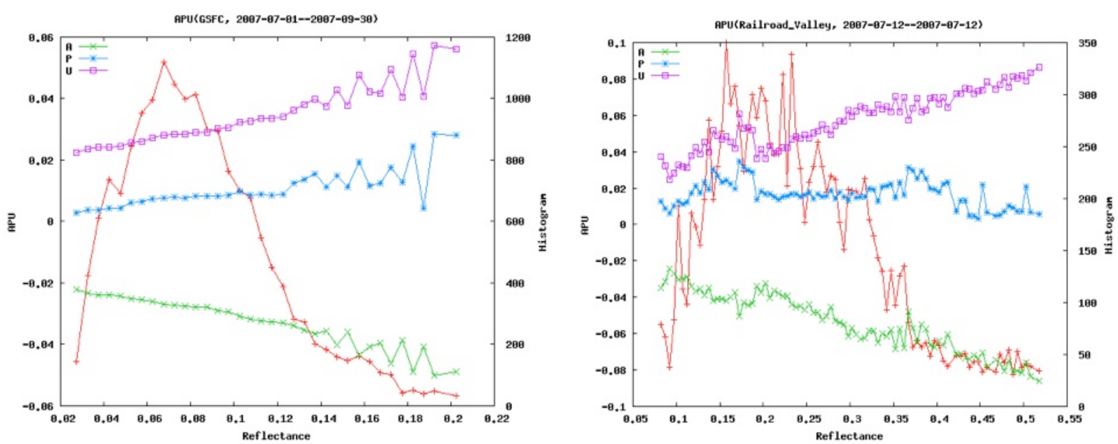


Figure 2: APU plot of simulated VIIRS surface reflectance for GSFC (left panel) and Railroad Valley (right panel) sites.

The prototyping of ASRVN validation methodology for the VIIRS has been accomplished using MODIS data as a proxy of VIIRS measurements. The analysis is based on the Accuracy-Precision-Uncertainty (APU) values and includes angular, spectral, spatial and temporal domains. The software has been developed to perform stratified analysis at both regional/global and a single site scale over a range of conditions (i.e. different surface brightness, aerosol loading, sun-view geometry, cloudiness). A graphic component to automatically create report plots has also been developed. Figure 2 gives an example of APU analysis results for the surface reflectance over two AERONET sites (GSFC and Railroad Valley) from MODIS data.

PLANNED WORK

- Continue the ASRVN validation analysis using VIIRS operational measurements and products.
- Develop the ASRVN approach for instrument cross-calibration, prototype with MODIS Terra/Aqua data.

PUBLICATIONS

Wang, J. Czapla-Myers, A. Lyapustin, K. Thome, E. G. Dutton (2011), AERONET-based Surface Reflectance Validation Network (ASRVN) Data Evaluation: Case Study for Railroad Valley Calibration Site, Remote Sensing of Environment, 115(10), 2710-2717, DOI:10.1016/j.rse.2011.06.011.

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: New Approaches for Vegetation Index Time Series Evaluation

Task Leader Alfredo Huete
Task Code GEOG-07 New Approaches for Vegetation Index Time Series Evaluation
Contribution to CICS Themes Theme 1: 30%; Theme2: 60%; Theme 3: 10%
Contribution to NOAA Goals Goal 1: 80%; Goal 2: 20%

BACKGROUND

We are evaluating *in-situ* observation networks for their potential utility in validating long-term VI time series across multiple sensor systems (AVHRR- MODIS- VIIRS). These networks provide independent, *in-situ* measurements of surface VI values and vegetation canopy states, and are evolving into highly calibrated and traceable systems such as (1) AERONET sites, (2) baseline surface radiation network (BSRN), and (3) FLUXNET. These *in-situ* measurements are derived at higher quality (finer spatial and temporal resolution) than the satellite measurement, can be applied and cross-calibrated to multiple satellites, and facilitate various methods of quality, uncertainty, and cross-sensor continuity assessments.

ACCOMPLISHMENTS

- Continued VI validation and uncertainty assessments work from the ASRVN data set and product derived by Alexei Lyapustin using the Aerosol Robotic Network (AERONET) sites.
- Expanded the ASRVN analyses to include the influences of 8-day vs 16-day compositing influences on VI uncertainties associated with less optimal atmosphere corrections and increased BRDF uncertainties.
- Continued analyses in using the Flux Tower network (Fluxnet) for assessments of VI quality and uncertainties across broad range of biomes and vegetation functional types.
- We made some preliminary attempts in coupling both AERONET and FLUXNET into a combined analyses on VI data quality and uncertainties.
- We derived some ET- VI and GPP-VI assessments from the tower sites as functions of MODIS footprint size. Further work in this area involves derivation of flux tower footprints for optimal matching with the satellite data.
- Lastly we made limited progress in use of the BSRN network for comparisons of broadband/ hemispherical NDVI and 2-band EVI with prototyped VIIRS VIs.

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PLANNED WORK

Evaluation of Vegetation Index uncertainties methods developed will be tested with actual NPP-VIIRS data.

PUBLICATIONS

- Manuscript entitled “Evaluation of MODIS VI products using the AERONET-based Surface Reflectance Validation Network dataset”, by Zhangyan Jiang, Alfredo, R. Huete, Yujie Wang, Alexei Lyapustin, and Tomoaki Miura is ready for submission.
- Contributed to a manuscript on VI - Evapotranspiration relationships, Glenn, E. P., Doody, T. M., Guerschman, J. P., Huete, A. R., King, E. a., McVicar, T. R., Van Dijk, A. I. J.

M., et al. (2011). Actual evapotranspiration estimation by ground and remote sensing methods: the Australian experience. Hydrological Processes, 25(December), 4103-4116.
- Contributed to Manuscript, "Spectral Compatibility Analysis of the NDVI across VIIRS, MODIS, and AVHRR Using EO-1 Hyperion: An Evaluation of Atmospheric Effects", by Tomoaki Miura, Joshua P. Turner, Alfredo R. Huete (submitted to IEEE-TGARSS)
- Completed a chapter on VIs and new methods of validation. Huete, A.R. and Glenn, E.P., 2011, "Recent advances in remote sensing of ecosystem structure and function"**, In**: Advances in Environmental Remote Sensing: Sensors, Algorithms, and Applications (Weng, Q., Ed.), CRC Press, Taylor and Francis Group, pp.553.
- Preparation of manuscripts from PhD student, Ramon Solano on the following topics (1) Effects of a Minimum-angle compositing on Vegetation Indices; (2) Evaluation of 8-day vs 16-day compositing on NDVI and EVI; (3) Analysis of Bidirectional Reflectance Distribution Function effects on Vegetation Index time series; and (4) Performance analysis of a 16-day MODIS Vegetation Index algorithm based on the 8-day MODIS Surface Reflectance: effects for climate signal anomalies detection in long-term time series

PRESENTATIONS

Presentation of ASRVN analyses at the International Symposium on Remote Sensing of Environment (ISRSE) in Sydney, April 2011.

Participation in a Fluxnet- Specnet workshop organized by Dennis Baldocchi in Berkeley, CA in June 2011.

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Assessments of Albedo and Surface Type

Task Leader Crystal Schaaf and Mark Friedl
Task Code GEOG-08 Assessments of Albedo and Surface Type
Contribution to CICS Themes Theme 2: 100%
Contribution to NOAA Goals Goal 2: 25%; Goal 5: 75%

BACKGROUND

Albedo

One goal of this effort is focused on preparing a validation framework for satellite derived albedo products and identifying the validation field sites that are most appropriate for each season. The difference in spatial scale between what can be measured at the surface and what can be retrieved by satellite sensors is very difficult problem to reconcile and it is crucial to understand the limitations of the ground data. However, once spatially representative sites have been identified, then albedo data from tower sites can be directly compared to satellite product pixels and evaluations can be made.

Surface Type

In addition, another goal of this effort is to develop and implement the datasets and tools required to validate the VIIRS surface type EDR. Our strategy for accomplishing this goal focuses on developing sample, response, and analysis designs that will allow statistically defensible validation of the surface type EDR. The sample design is based on a stratified random sample of validation sites, the response design is based on classifications of high resolution imagery, and the analysis design is based on techniques we are developing to aggregate high resolution classifications to the 1 km spatial resolution of the surface type EDR (described in a number of papers in press). In parallel with these products, we are developing statistical software tools to estimate confusion matrices and accuracy statistics, including overall and class-specific accuracies and standard errors.

ACCOMPLISHMENTS

Albedo

A geostatistical framework that relies on high resolution satellite imagery (primarily Landsat ETM+) is being used to assess the representativeness of a variety of sites for the NPP/VIIRS Albedo EDR (Román et al., 2009). To date, over 120 sites have been assessed for representativeness under both leaf-on and leaf-off conditions. The evaluation of the Fluxnet La Thuile sites has been incorporated into a recently accepted paper (Cescatti et al., 2012). An assessment of ideal tower height to achieve representativeness has also been performed (to identify those sites where a modest increase in tower height would be sufficient to change a site from being spatially unrepresentative to one that would be of use for validation of satellite albedo products.

Daily albedos (similar to the VIIRS DPSA algorithm and using MODIS data as proxy) were run in the prelaunch period to assess the ability of the algorithm to capture albedo in times of rapid change (since as spring greenup and snow melt) at some of the sites that appear to be spatially representative. A paper describing the albedo variation during snow melt at high latitude tundra sites at Barrow Alaska and near the Anaktuvuk River appeared in print during the period (Wang et al., 2012). Additional daily data were developed for comparision at sites in Greenland (pure snow at the Summit station) and in deciduous forests in Wisconsin (near the Park Falls/CHEAS site) and are being evaluated.

With the successful launch of Suomi NPP, some very initial comparisons have been carried out at several spatially representative New England sites. Unfortunately, access to the underlying BRDF IP and DPSA results has not yet materialized so comparisons are still being limited to the final daily broadband albedos. The data are still variable at this point.

PLANNED WORK.
Final refinement of algorithms and preparation of documentation is underway

PUBLICATIONS
Albedo
Wang, Z., C. B. Schaaf, M. J. Chopping, A. H. Strahler, J. Wang, M. O.Román, A. V. Rocha, C. E. Woodcock,Y. Shuai, Evaluation of Moderate-resolution Imaging Spectroradiometer (MODIS) snow albedo product (MCD43A) over tundra, Remote Sensing of Environment, 117, 264-280, 2012.

Cescatti, A., B. Marcolla, S. K. Santhana Vannan, J. Y. Pan, P. Ciais, R. B. Cook; B. E. Law; G. Matteucci, M. Migliavacca, E. Moors, A. D. Richardson, G. Seufert and C. B. Schaaf, Intercomparison of MODIS albedo retrievals and in situ measurements across the global FLUXNET network, Remote Sensing of the Environment, in press, 2012.

Surface Type
Olofsson, P., Stehman, S.V., Woodcock, C.E., Friedl, M.A. Sulla-Menashe, D., Sibley, A.M., Newell, J.D. and M. Herold 2011. A global land cover validation data set, I: Fundamental Design principles, in press, *International Journal of Remote Sensing*.

Stehman, S.V., Olofsson, P., Woodcock, C.E., M. Herold , and M.A. Friedl, 2011. A global land cover validation data set, II: Augmenting a stratified sampling design to estimate accuracy by region and land-cover class, in press, *International Journal of Remote Sensing*.

Sulla-Menashe, D.J., Olofsson, P., Stehman, S.V., Woodcock, C.E., Herold, M., Newell, J., Sibley, A.M. and Friedl, M.A. 2010, A global land cover site database in support of global land cover validation. Abstract B41C-0313, presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Herold, M., Woodcock, C.E., Stehman, S., Nightingale, J., Friedl, M. and C. Schmullius 2010. The GOFC-GOLD/CEOS Land cover harmonization and validation initiative: Technical design and implementation. *Proceedings of the 2010 European Space Agency Living Planet Symposium*, Bergen Norway, June 28-July 2, 2010

Implementation and support of a VIIRS Near-Real Time Rapid Fire System for Fire Monitoring at the US Forest Service

Task Leader Evan Ellicott

Task Code EOG-09: Implementation and support of a VIIRS Near-Real Time Rapid Fire System for Fire Monitoring at the US Forest Service

Contribution to CICS Themes Theme 1: 25%; Theme 2: 75%

Contribution to NOAA Goals Goal 3: 50%; Goal 5: 50%

BACKGROUND

The objective of the proposed work is the development of a near-real-time VIIRS active fire product delivery system for implementation, testing, and application at the US Forest Service (USFS) Remote Sensing Applications Center (RSAC) to support operational fire management. Building on the MODIS heritage of data use by the USFS, guidance in the use of the standard VIIRS active fire EDR, as well as an enhanced product offering better continuity with the MODIS fire product will be provided.

ACCOMPLISHMENTS

- Coordination with the USFS RSAC to being ingesting and visualizing the VIIRS active fire product for end-user evaluation.
- Partial implementation of code in the NASA LandPEATE environment to execute the MODIS version 6 algorithm improvements.
- Software was also developed to ingest and display VIIRS AF detections from the standard IDPS product. A prototype website providing background information as well as imagery of AF detections was also developed. This tool was also used to display and evaluate the first active fire science data following the activation of the thermal VIIRS bands on January 18, 2012.
- The VIIRS active fire team has created a website to highlight the product's detection capabilities and provide a mechanism for users of MODIS, GOES, and other active fire products to stay up to date with VIIRS' progress. The site has been populated with recent detections and continues to be updated. We foresee this site eventually offering data dissemination capabilities for selected test users (e.g. U.S. Forest Service, NOAA fire weather applications, etc.). Figure 3 offers a recent screen capture.

Figure 3: VIIRS Active Fire website (viirsfire.geog.umd.edu) screen capture.

PLANNED WORK

- Develop and implement web-based user interface to provide selected data testers access to value-added mapping/visualization products that display the IDPS-generated VIIRS fire detection data
- Finalize background material and tutorial on VIIRS fire detection (including appropriate use and data considerations/limitations).
- Initial collection and processing of user feedback on comparison of algorithm output/mapping products with reference (validation) data/information
- Implement necessary adjustments into the IDPS operational algorithm based on evaluation results
- Work with GOFC-GOLD Regional fire networks to identify end users and establish feedback mechanisms

PRESENTATIONS

E. Ellicott , Csiszar, I., W. Schroeder, L. Giglio, and C. Justice, "The NPP VIIRS active fire product", Tactical Fire Remote Sensing Advisory Committee (TFRSAC) meeting, Boise, ID, October 27, 2011.

A Terrestrial Surface Climate Data Record for Global Change Studies

Task Leader	Eric Vermote
Task Code	GEOG-10
Contribution to CICS Themes	Theme 1: 50%; Theme2: 50%
Contribution to NOAA Goals	Goal 1: 100%

BACKGROUND

The overall objective of this project is to produce, validate and distribute a global land surface climate data record (CDR) using a combination of mature and tested algorithms and the best available land imaging polar orbiting satellite data from the past to the present (1981-2011), and which will be extendable into the JPSS era. The data record consists of one fundamental climate data record (FCDR), the surface reflectance product. Two Thematic CDRs (TCDRs) are also be derived from the FCDR, the normalized difference vegetation index (NDVI) and LAI/fAPAR. These two products are used extensively for climate change research and are listed as Essential Climate Variables (ECVs) by the Global Climate Observing System (GCOS). In addition, these products are used in a number of applications of long-term societal benefit. The two TCDRs are used to assess the performance of the FCDR through a rigorous validation program and will provide feedback on the requirements for the Surface Reflectance FCDR.

ACCOMPLISHMENTS

Several improvements have been applied to the dataset, improved geolocation, calibration, cloud mask, and aggregation scheme. The AVHRR data record compared favorably to the MODIS coincident data record (used a reference) as it has been verified for NOAA16 during the 2003-2004 period (figure 1). We have also started the generation of the LAI/fAPAR product and the product compared well to the climatology developed by Frederic Baret at INRA (see Figure 2), the Boston University algorithm for LAI/fAPAR have also been implemented and is under testing. We have developed the code for the processing of the 1km AVHRR data that will be used to process the 1992-1998 AVHRR HRPT record. We have used the Climate Data Record in application of societal benefit (Yield prediction for agriculture). We have started transitioning the code and dataset to NOAA NCDC in Asheville.

PLANNED WORK

We are planning to make final improvements to the AVHRR atmospheric correction (water vapor and aerosol) that will be possible when the updated calibration of the longwave bands on AVHRR (4,11 and 12 microns) is available. Processing of the 1km AVHRR data, The VEGETATION data record (in collaboration with INRA), and the use of the full record (MODIS, AVHRR and VEGETATION) in drought monitoring/impact applications.

PRESENTATIONS

A Terrestrial Surface Climate Data Record for Global Change studies, Vermote et al., 2nd Annual CICS Science Meeting, National Climatic Data Center in Asheville, North Carolina on November 2-3, 2011.

A Terrestrial Surface Climate Data Record for Global Change studies, Vermote et al., AGU Falls Meeting, San Francisco, 5-9 December 2011 (Poster).

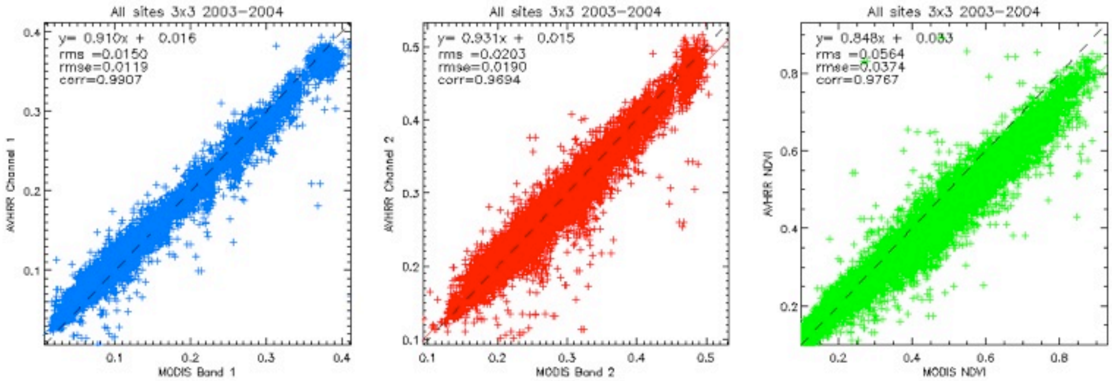

Figure 1: Comparison of MODIS (x axis) with AVHRR (y axis) for 2003-2004 for 150 sites, Left panel with the blue crosses is channel 1, center panel with red crosses is channel 2, right panel with green crosses is NDVI.

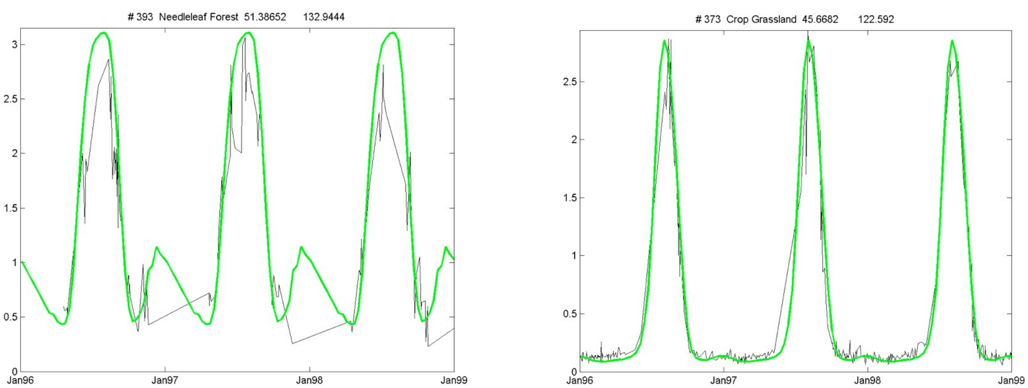

Figure 2: Two sites extracted from the comparison of the LAI product generated by this project for NOAA14 (black line) over 420 sites with the INRA LAI climatology (1999-2007)

Development of an enhanced active fire product from VIIRS

Task Leader E. Ellicott
Task Code EEEEDEAFP11
Contribution to CICS Themes Theme 1: 100%
Contribution to NOAA Goals Goal 3: 50%; Goal 5: 50%

BACKGROUND

The work performed in this task is for year 3 of the project "Development of an enhanced active fire product from VIIRS". The goal of this project is to assist the JPSS in the development, evaluation, validation and implementation of the VIIRS Fire Code in the pre-launch period. Development of an active fire product from VIIRS which would closely resemble the MODIS product provides continuity of data with intrinsic scientific merit.

In year 3 the VIIRS active fire team was focused on development of the enhanced "yes/no" fire detection algorithm for VIIRS. This algorithm is based on the contextual principles of MODIS (Giglio et al., 2003) and with the proper adjustments for the different spatial resolution and radiometric characteristics of the VIIRS sensor accounted for. The MODIS C6 algorithm has been completed and is undergoing evaluation. The enhanced algorithm for VIIRS will follow suite once the MODIS C6 testing is complete. It will then undergo additional evaluation and testing once it has been implemented into the data processing chain. Before implementation of the enhanced fire code can occur though, it must first follow the project protocol which includes vetting and testing in the Algorithm Data Library (ADL). With this in mind the fire team has gained access to the necessary systems and familiarized itself with the code, processing chain, and data structure.

The fire team was also actively engaged in the preparations for post-launch data production. Critical to this phase of product evaluation and validation were several meetings and data "dress rehearsals" designed to simulate data dissemination and access by the science teams. Codes were developed to search, download, and evaluate (both qualitatively and quantitatively) VIIRS and coincident MODIS fire detections. The VIIRS fire detections in this pre-launch period, were created from MODIS, but designed by the satellite platform contractor (Northop Grumman) to best simulate real VIIRS data.

The active fire science team has since developed a robust catalog of codes and analysis tools to evaluate the VIIRS fire product post launch, as well as capabilities to validate the product against MODIS. In addition, we have refined the simulated radiance data generator (proxy generator) for examining product performance in the absence of additional coincident observations from other platforms, as well as to test implementation of the enhanced fire code, and potential future changes in the sensor performance.

ACCOMPLISHMENTS

Enhanced fire detection algorithm

- The AF team completed production of the MODIS collection (C6), and is preparing to develop an implement a VIIRS-equivalent algorithm. The C6 algorithm offers improvements over the current VIIRS algorithm, which is based on the MODIS C4, through an adaptive assignment of potential fire thresholds to better capture small, cool fires and reduce false alarms occurring in hot, arid environments. In addition, improvements to the internal cloud mask to eliminate occasional misclassification of snow and desert as cloud were incorporated to minimize false alarm detections, cloud obscuration, and ambiguities in water masking.

- Partial implementation of code in the NASA LandPEATE environment to execute the MODIS version 6 algorithm improvements was accomplished.

EDR CAL/VAL Dress Rehearsal – Phases I & II

- The AF team delivered the validation operations concept (OPSCON) document as preparation for the cal/val rehearsal scheduled for June (Phase I) and August (Phase II).
- An automated search tool was developed to find near-coincident MODIS and VIIRS fire detections. The IDL code searches fire pixel coordinates and temporal separation (<15minutes) between data sets to produce evaluation data sets.
- An ftp script was established enabling automated data download of NPP/VIIRS and Aqua/MODIS data. Transfer of NPP/VIIRS data was performed by running the GRAVITE Transfer Protocol (GTP) tool using the team's local computer facility (LCF) located at the University of Maryland (UMD). Transfer of Aqua/MODIS data was performed via standard ftp connection established between UMD and the MODIS Level 1 and Atmosphere Archive and Distribution System (LAADS). Transfer code used the user's input (temporal window) to find and download pertinent files.

Proxy data generation

- Simulated data evaluation completed to address bias in simulated (ASTER-MODIS) and real (MODIS) radiances.

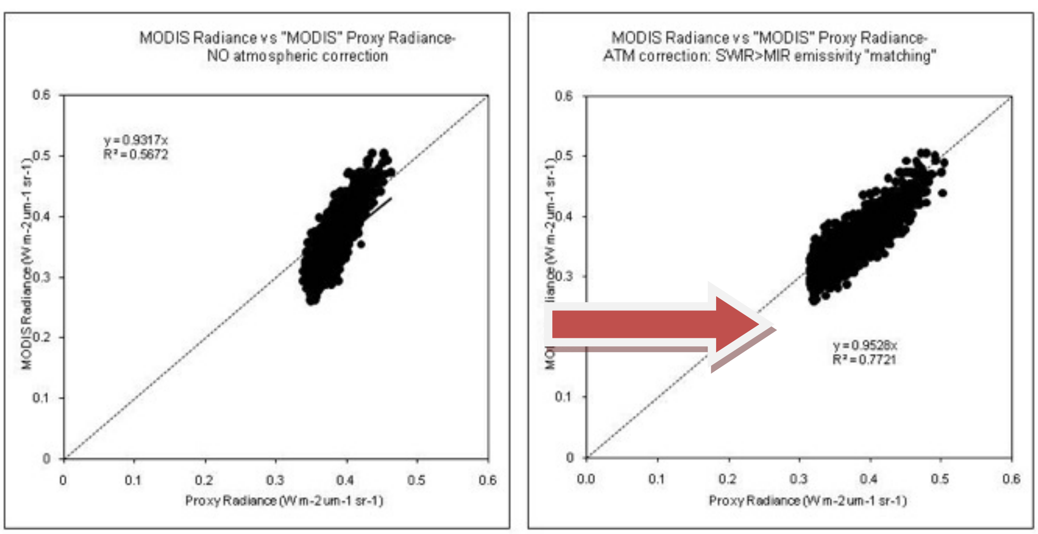

Figure 3: Proxy data MIR radiances evaluation against MODIS radiances for scence from North Carolina (2005049.1600). Left plot shows proxy radiances without atmospheric perturbation correction while the right is after atmospheric effects are accounted for. Data generated using ASTER kinetic temperature (AST08) and surface reflectance (AST07_XT) products along with MODTRAN and NCEP/radiosonde profile data

PRESENTATIONS

Csiszar, I., W. Schroeder, L. Giglio, C. Justice, E. Ellicott. "Establishing active fire data continuity between Aqua MODIS and NPP VIIRS", 92nd Annual Meeting of the American Meteorological Society in New Orleans, LA, Seattle, 22-26 January 2012.

Csiszar, I., W. Schroeder, L. Giglio, E. Ellicott, C. Justice. Validation of the NPP VIIRS active fire product, IGARSS Annual Meeting in Vancouver, Canada, 24-29, July 2011.

WEBSITE

www.viirsfire.geog.umd.edu

Development of Land Surface Characterization for GPM-era Precipitation Measurement

Task Leader Nai-Yu Wang
Task Code NWNWGPMER11
Contribution to CICS Themes Theme 1: 70%; Theme 2: 30%
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

BACKGROUND

If the Global Precipitation Measurement Mission (GPM) is to meet its requirement of global 3-hourly precipitation, the use of sounders such as AMSU will likely be needed. This project utilizes the "traditional" imager channels in conjunction with high frequency observations from AMSU and SSMIS, cloud resolving models and advanced radiative transfer models to:

- Study the effects of hydrometeors on the 10-183 GHz radiances and utilize them to improve the current Bayesian precipitation retrieval scheme (e.g., GPROF). Focus will be on cold season precipitation systems (e.g., stratiform rain and snowfall) since the present scheme has focused only on tropical rainfall systems.
- Investigate the potential of incorporating microwave sounding channels (50-60 GHz and 183 GHz) to the hydrometeor profile retrieval.
- Improve the current GPROF "surface screening" to remove ambiguity between precipitation and other surface signatures that resemble precipitation through the use of innovative methods such as dynamic land surface data sets available from ancillary data sets (i.e., NWP assimilation fields, emerging emissivity products, etc.).

ACCOMPLISHMENTS

In this study, a database of Integrated Water Path (IWP) values from the WRF database and simulated brightness temperatures at 89GHz, 160 GHz, 183±3 GHz and 183±9 GHz vertical polarizations (the high-frequency GMI channels). The IWP values are used as a proxy for the snowfall rates, which are not available to us at this time. The database is created using a training set of WRF profiles over a 456 km x 456 km area around the CARE site at a 1 km horizontal resolution for January 21st, 2007 and January 22nd, 2007 at 1 hour intervals. This set of approximately 10 million input profiles was then clustered into 32 classes using the k-means algorithm (see MacQueen [1967]). The resulting class centroids were used to retrieve IWP from Tb vectors using a Bayesian form similar to the one described in Grecu and Olson [2006]:

$$E(IWP\,|\,TB) = \sum_{i=1}^{N} IWP_i \frac{\exp[-0.5(TB_{obs} - TB_i)^T S_i^{-1} (TB_{obs} - TB_i)]}{\sqrt{(2\pi)^4 |S_i|}} \qquad (1)$$

where E(IWP|TB) is the retrieved IWP for the observed Tb vector TBobs, TBi are the Tb vector centroids for each class i, IWPi is the mean IWP for the corresponding class and Si is the covariance matrix for the class i. The retrieved values were found to closely resemble the training values. However, the retrievals grossly underestimated high IWP values in some regions with high surface temperatures and therefore correspondingly high surface emissions (the relevant region is highlighted with a black circle). In order to compensate for the differences in the surface emissions by location, the input vector TB_{in} was modified as follows:

$$TB'_{in} = \varepsilon T_{surf} - TB_{in} \quad (2)$$

where TB'_{in} is the modified input vector, ε is the estimated emissivity vector corresponding to the channel frequencies and viewing angles (assumed to be 0.9 in this study) and T_{surf} is the mean surface temperature for a given location. Figure 1 shows the modification to the input vector results in a significantly improved match between the training and retrieved IWP values.

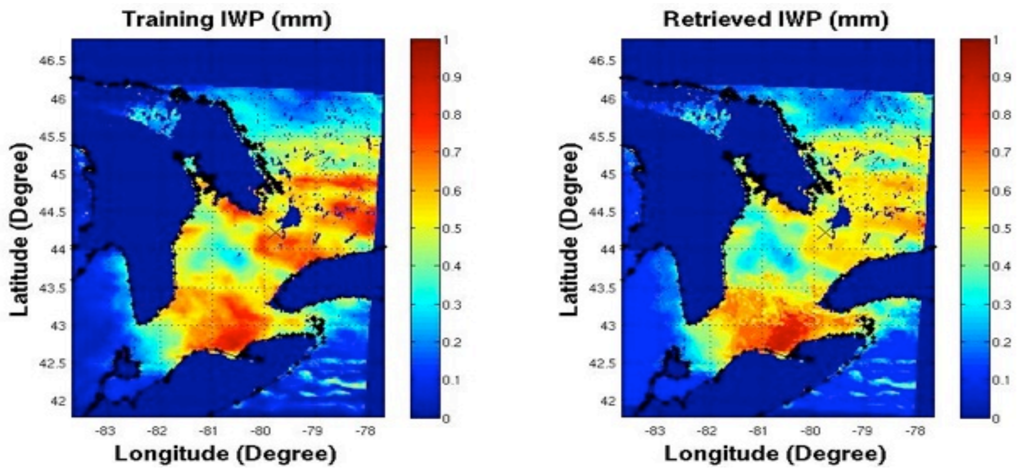

Figure 1:

PLANNED WORK

- Continue work on the Bayesian algorithm of retrieving ice water content near the surface.
- Work on the manuscript for publication.

PRESENTATIONS

Wang, N.-Y., Gopalan K., and R. Ferraro, Developing Winter Precipitation Algorithm over C3VP

2012 AMS Annual Meeting, January 23, 2012.

Satellite Land Surface Temperature and Albedo

Task Leader	Yuling Liu
Task Code	YUYU_JU11
Contribution to CICS Themes	Theme 1: 70%; Theme 2: 30%
Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

BACKGROUND

This work is part of the ongoing Joint Polar-Orbiting Satellite System (JPSS) project "Satellite Land Surface Temperature (LST) and Albedo". This particular task is focused on the scientific support of LST retrieval from Visible Infrared Imaging Radiometer Suite (VIIRS) NPP satellite before and after launch.

A second component includes the evaluation and validation of LST derived from U.S. Geostationary Operational Environmental Satellite (GOES) Series 13, 14 and 15. In this report we present the work accomplished for the first component of the project (i.e., the validation of the VIIRS LST product).

ACCOMPLISHMENTS

The LST analysis of first month of NPP land product has been implemented. The cross-satellite comparison with MODIS Aqua LST product has been conducted. Using the swath matchup tool, we collected the data covering continental U. S. (25◦N ~ 50◦N, 125◦W ~ 65◦W) from Jan. 22, 2012 and Jan. 30, 2012 for nighttime comparison, Jan.24, 2120 and Feb.1, 2012 for daytime comparison. The overall result is shown below.

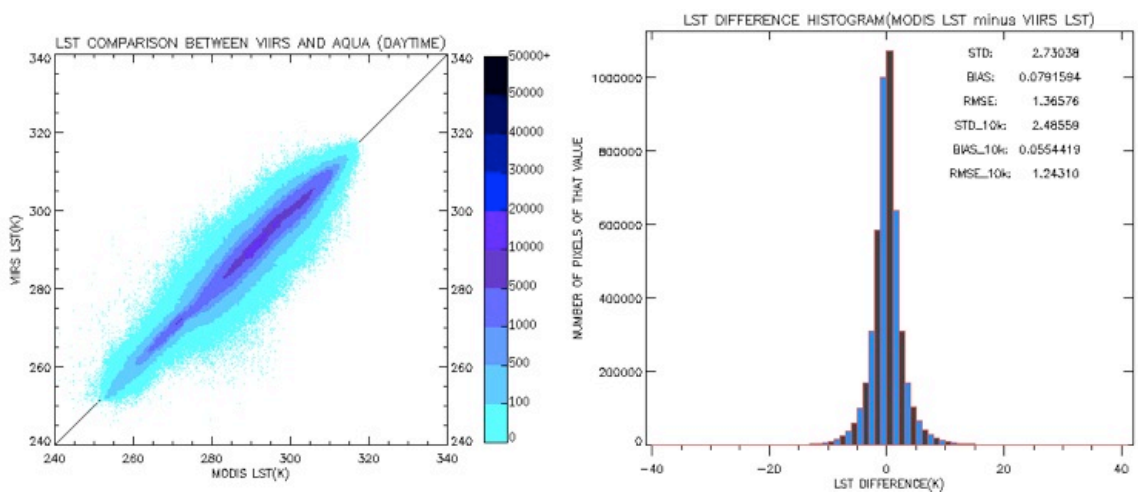

Figure 1: Daytime comparison between VIIRS LST and AQUA LST

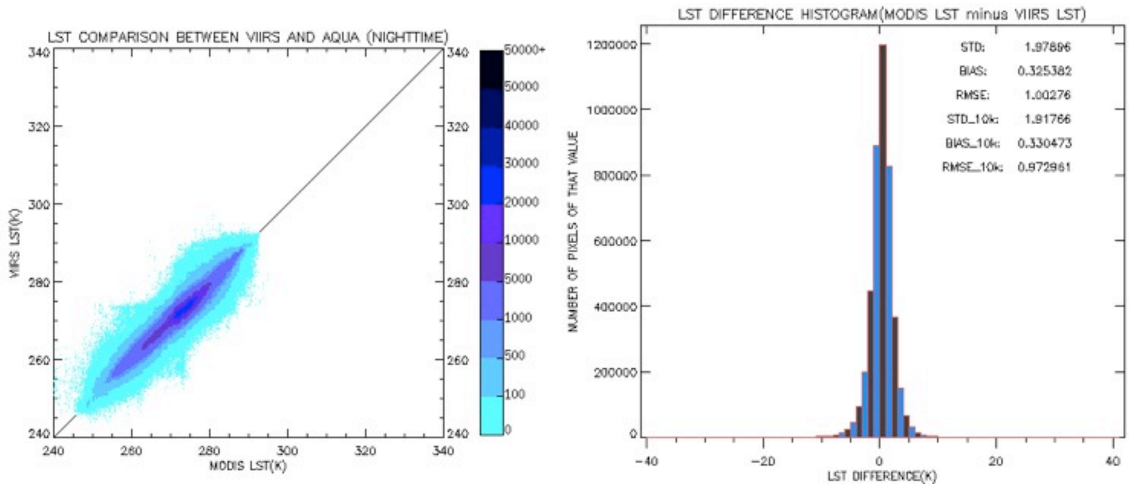

Figure 2: Nighttime comparison between VIIRS LST and AQUA LST

In addition we compared the performance of VIIRS LST and MODIS LST over surface type and the result shows that VIIRS and MODIS generate closer LSTs over surface types of deciduous broadleaf forests and Croplands/Natural Vegetation Mosaics. But there is a big difference over surface types of permanent wetlands, barren, water bodies, evergreen needle leaf forests and closed shrub lands, in which the overall STD is over 3K. Among them, the biggest difference is found for preferment wetlands type with STD as 3.56K.

For GOESLST, we investigated the effect of emissivity data source on LST retrieval. The alternative emissivity datasets include the 10-year monthly average emissivity, last month emissivity, and the same month emissivity of last year were investigated. We also tested current monthly emissivity and current weekly emissivity for comparison and evaluation. The results show that the 10-year monthly average emissivity performs the best by retrieving stable and accurate land surface temperature. A publication summarizing this work has been submitted to IEEE Geoscience and Remote Sensing Letters and is currently under review.

PLANNED WORK

- Support the LST validation during post launch
- Continue the cross comparison of the LST data from NPP and from other satellites, e.g. MODIS LST, SEVIRI LST, etc.
- Continue to support the tuning of the LST algorithms and coefficients.
- Continue to collect ground truth data for validation
- Evaluate LST EDR output against existing ground measurements, e.g. SURFRAD, CRN, etc.
- Continue the development of validation tools
- Continue the ground site characterization analysis for validation uncertainty and quality control.
- Scientific support of LST algorithm refinement
- Evaluate the algorithm switch from the 4-bands dual split window process to 2-bands split-window process.

- Investigate possibility of replacing current surface type dependent algorithm using emissivity explicit algorithm
- Investigate spatial discontinuity in the sun glint area

PUBLICATIONS

Dayong Shen, Yuling Liu, Shengli Huang. Annual Accumulation over the Greenland Ice Sheet Interpolated from Historical and Newly Compiled Observation Data. Geografiska Annaler: Series A, Physical Geography, 2012, 3 (In press)

Yuling Liu, Yunyue Yun, Donglian Sun, Dan Tarpley and Li Fang, Effect of Emissivity Data Sources on Land Surface Temperature Retrieval, IEEE Geoscience and Remote Sensing Letters(Under Review)

5 CICS-NC PROJECT REPORTS

5.1 Development of Climate Data and Information Records and Scientific Data Stewardship

Precipitation Re-analysis using Q2

Task Leader	Ryan Boyles
Task Code	
Date Awarded	03/08/2010
Contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%;
Contribution to NOAA Goals	Goal 1: 10%; Goal 2: 90%

EXECUTIVE SUMMARY

This project involves the development of a re-analyzed, homogenous precipitation record for the continental United States using radar, surface gauge, and satellite platforms and methods developed at the National Severe Storms Laboratory in Norman, OK.

BACKGROUND

This work is part of an effort to create a high resolution, spatially and temporally homogenous precipitation record based on existing data collected from NOAA's array of NEXRAD radars and surface precipitation gauges distributed throughout the United States. With large coverage over the United States and very high temporal frequency (<10 minutes), radar offers the ability to see at a much higher spatial and temporal resolution than gauge networks or satellites alone.

NSSL has developed and is testing a 2nd generation Quantitative Precipitation Estimate (QPE) (called Q2) that provides 1KM spatial resolution with 5minute temporal resolution. NSSL uses Q2 to provide experimental flash flood guidance in near real time, but Q2 could also serve as a climate data record for the continental US (CONUS). NOAA needs a central archive for accurate, high-quality, precipitation information at high temporal and spatial resolutions to support local-scale climate analysis and climate monitoring. NSSL is working with NCDC through this CICS-NC project to develop a Q2 re-analysis to provide a 14-year period of record of precipitation for the CONUS.

The development of a high-resolution precipitation dataset will allow those in both research and operations to have access to information which can increase our understanding of the role of environment on rain and snowfall, allow for small-scale studies of land surface relationships (e.g. topography, land use) on precipitation producing systems, and provide localized estimates of precipitation for hydrology need and drought monitoring.

ACCOMPLISHMENTS

Using the NMQ/Q2 software from Norman, OK, the reanalysis has been completed over a pilot domain covering nine radars in North and South Carolina. This has resulted in the process being adapted from its current real-time use at NSSL to a re-analysis mode that can be run in parallel supercomputing systems, using archived NEXRAD data as input. The process has been repeated for a second test domain in the upper Midwest.

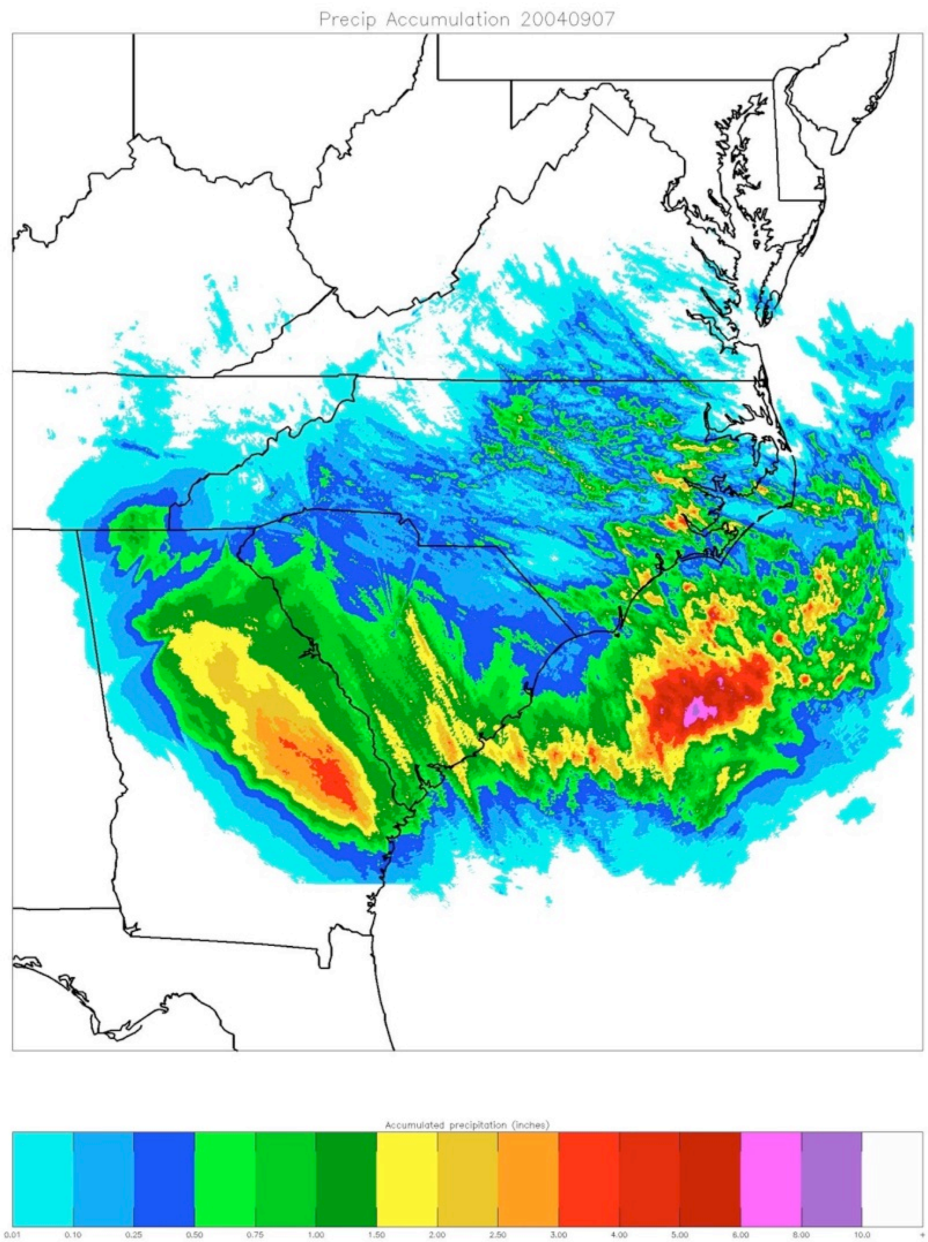

Figure 1: 24-hour precipitation accumulation over the Carolinas region for September 7, 2004, during the rainfall associated with Hurricane Frances

The resulting five-minute, 1 KM resolution precipitation estimate obtained from this process can be quickly accumulated into precipitation totals over any desirable time period. Figure 1 shows the radar-only precipitation estimate for September 7, 2004, over the Carolinas region, as the remnants of Hurricane Frances inundated the area. While this image shows estimates using radar alone, the process, in its full capacity, will allow for the integration of gauge networks, lightning data, and eventually satellite based estimates of precipitation.

This work has been presented in an invited talk to the NC State Climate Office (Jun 2011), at the AMS Conference on Applied Climatology (Jul 2011, Asheville, NC), and at the Fall Meeting of the American Geophysical Union (Dec 2011, San Francisco, CA).

PLANNED WORK

- Expand reanalysis to cover first an expanded pilot domain, spanning 30 radars throughout the SE United States, and then further expand to cover all of the continental United States.
- Incorporate rain gauge networks for calibration and correction in poorly covered areas, especially those in high terrain and sparsely covered regions.
- Provide output to a network of established users for preliminary external assessment and evaluation.
- Once community evaluation is complete for the pilot domains, preliminary calculations of Standardized Precipitation Index will be made and evaluated for drought monitoring potential, which is provided under support to NCSU from USDA.

PUBLICATIONS

None

PRESENTATIONS

Stevens, S. “NMQ/Q2 Reanalysis in the Southeastern United States”. Invited talk for Dr. Ryan Boyles, NC State Climate Office, Raleigh, NC. Jun 2011

Stevens, S., B. Nelson, C. Langston. “National Mosaic and Multi-Sensor QPE (NMQ) reanalysis in the southeastern United States” 19th AMS Conference on Applied Climatology, Asheville, NC. Jul 2011.

Stevens, S., B. Nelson, C. Langston, and R. Boyles. “National Mosaic and Multi-sensor QPE (NMQ/Q2) reanalysis in the Carolinas region and directions toward a ConUS-wide implementation” 2011 American Geophysical Union Fall Meeting, San Francisco, CA. Dec 2011.

AVHRR Aerosol Retrieval		
Task Leader	Pui Chan	
Task Code		
Date Awarded	01/03/2011	
Contribution to CICS Themes		Theme 1: 70%; Theme 2: 30%;
Contribution to NOAA Goals		Goal 1: 100%

EXECUTIVE SUMMARY

Problems in the Version I NCDC Aerosol Climate Data Record (CDR) were addressed and corrected, and, the Version II NCDC Aerosol CDR was generated. The dependence of aerosol optical thickness (AOT) retrieval on the clear sky threshold in the AVHRR cloud mask was studied.

BACKGROUND

Aerosols affect the climate through direct and indirect effects. Uncertainty in aerosol effects on climate is one of the largest uncertainties in climate forcing (IPCC, 2007). A long-term aerosol climate data set is essential in studying climate change. The AVHRR aerosol data set provides AOT retrieval over global oceans from 1981 to 2009 and it is the longest aerosol record currently available.

In the NCDC Aerosol CDR, AOT is retrieved from AVHRR PATMOS-X level-2b radiances using an "independent" two-channel algorithm (Zhao, X., 2011: "Aerosol Climate Algorithm Theoretical Basis Document"). The look up table used in the retrieval is based on top of atmosphere reflectance computed using the 6S radiative transfer model (Vermote et al., 1997) with a weakly absorbing aerosol model and a bimodal lognormal size distribution. AOT retrieval is made during daytime, over ice-free ocean and under clear sky condition.

Cloud screening is the largest source of uncertainty in AOT retrieval (Ignatov and Nalli, 2002). If cloud screening is insufficient, cloud contamination will cause retrieved AOT to be too high. If cloud screening is too stringent, strong aerosol signals will be discarded and the retrieved AOT will be too low. Sensitivity studies of aerosol products to the different cloud screening methods are lacking in all satellite aerosol products (Li et al., 2009). In this study the clear sky threshold in the AVHRR cloud mask was varied and its effect on AOT retrieval studied.

ACCOMPLISHMENTS

The aerosol retrieval code was modified to address and correct some of the problems found in the version I NCDC Aerosol CDR. The code was modified to make it more efficient and minimize execution time. The aerosol retrieval procedure was automated to make it run fast and require minimal monitoring. Errors encountered during retrieval are now recorded in error log files and alert emails are sent to monitoring personnel. The version II NCDC Aerosol CDR was generated using the new aerosol code.

The clear sky threshold in the AVHRR cloud mask was varied and its effect on AOT retrieval was studied. Three cases of clear sky threshold were considered: with Patmos-x cloud probability of less than 0.5%, 1% and 5% regarded as clear sky (cases 1, 2, 3 respectively). Time series analysis of monthly average AOT over the 29-years period was applied to specific areas where specific problems may be pertinent to the cloud mask.

Examples include areas of abundant cirrus, smoke and dust. Some of the findings are:

- In areas of abundant cirrus, the shapes of AOT time series are similar for the 3 cases; with AOT shifted upward for progressively less stringent clear sky threshold (Fig. 1). This suggests that cirrus contamination probably will not affect long-term AOT trend significantly. This result is not surprising as cirrus contamination affects AOT retrieval ‘equally’ when AOT is large or small.
- However, in areas of heavy dust, differences in AOT between case 3 and case 1 is much larger (~0.08) for large AOT and smaller (~0.04) for small AOT. This is not surprising as miss-classification of dust /cloud is likely to affect AOT retrieval much more when pixel is heavy dust (where AOT is large) than when pixel AOT is small. The very strict spatial and thermal uniformity tests in AVHRR cloud mask can be a large source of error in not correctly classifying dust-laden pixels (Evan, et al., 2006).
- For ‘global’ average (40S-40N), AOT time series / long-term trend are similar for the 3 cases in general.
- The minimum AOT in the seasonal cycle decreases after year 2000, especially in the pristine atmosphere over the southern hemisphere ocean. This is probably due to the refined sensitivity of AVHRR/3, which was introduced after year 1998.

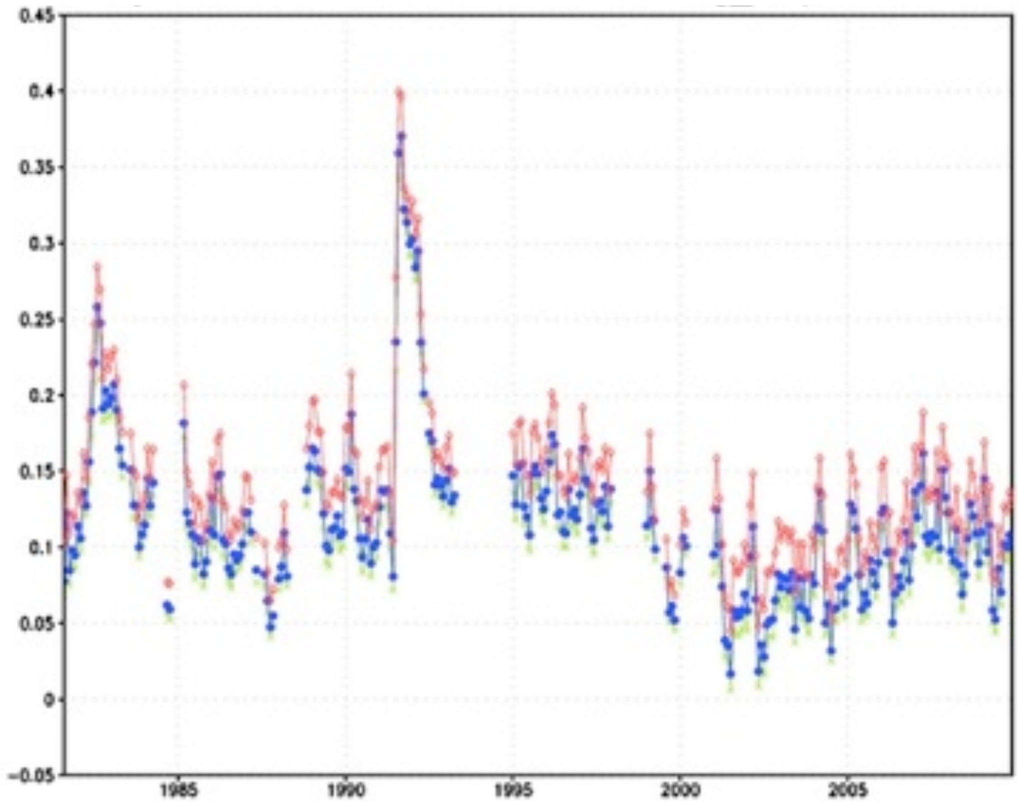

Figure 1: Time series of monthly average AOT at 0.63 µm in area of abundant cirrus over the central Pacific. The green, blue and red lines represent the 3 cases of clear sky thresholds with cloud probabilities less than 0.5%, 1% and 5% regarded as clear sky. The period of data is 1981-2009.

PLANNED WORK

- Additional validation of NCDC AVHRR AOT retrieval with AERONET measurements
- AOT trend compared to trends in cloud amount, cloud albedo and cloud optical depth
- AOT trend compared to trend in clear sky shortwave surface radiative flux
- Familiarization with the multi-channel aerosol retrieval algorithm. Run the multi-channel algorithm with real-time VIIRS data. Validate the VIIRS AOT retrieval with AERONET measurements.

OTHER

Deliverables include the updated aerosol retrieval code that was used in generating the Version II NCDC Aerosol CDR, the scripts used to automate the aerosol retrieval process, as well as the Version II NCDC Aerosol CDR in HDF format.

Transfer NOAA/NASA AVHRR Pathfinder SST Processing to NODC

Task Leader Robert Evans; (NOAA Collaborator: Kenneth Casey)
Task Code
Date Awarded 04/2/2011
Contribution to CICS Themes Theme 2: 100%
Contribution to NOAA Goals Goal 1: 100%

EXECUTIVESUMMARY

The primary goal of this work is to assemble Advanced Very High Resolution Radiometer (AVHRR) Sea Surface Temperature (SST) retrieval algorithms into a robust code package to produce a Climate Data Record (CDR) for the AVHRR SST time series, NOAA-7 (1981) through NOAA-18 (2010) and deliver the package to NODC to support on-going production of the AVHRR Pathfinder SST time series. All goals for this year were accomplished.

BACKGROUND

The primary goal of this work is to assemble AVHRR SST retrieval algorithms into a robust code package to produce a CDR for the AVHRR SST time series for the satellites NOAA-7 (1981) through NOAA-18 (2010), and, deliver the package to NODC to support on-going production of the AVHRR Pathfinder SST time series.

This work is based on the Pathfinder 5.2 approach, originally published in Kilpatrick et. al, 1999 (Pathfinder 5.0) and updated to 5.2 with the inclusion of an updated land mask, use of the Reynolds ¼ degree, daily OI analysis enhanced with rivers and lakes and inclusion of ancillary fields required by the GHRSST Version 2.0 file specification and formatted in the GHRSST netCDF4 files format.

ACCOMPLISHMENTS

Accomplishments during the period April 1, 2011 to March 31, 2012 include:

- Delivery of updated AVHRR SeaDAS 6.1 documentation to NODC and NCDC including an ATBD and process flow charts,
- Production of Pathfinder 5.2 SST fields for NOAA-7 beginning with observations from November, 1981 through NOAA-18, December 2010,
- Transfer of the SeaDAS format HDF4 fields to Ken Casey's group at NODC to convert to NetCDF4 GHRSST format and add ancillary data fields required by the GHRSST format,
- The NODC group performed extensive checking of the Pathfinder data products and delivered the entire time series to NCDC for archive,
- Transfer of SeaDAS 6.1 based AVHRR processing codes to NODC to install in the NODC processing cluster and transfer to NCDC for archive in the CDR archive.

The release of the Pathfinder 5.2 data set has resulted in a good reception of the data set by the user community as evidenced by the following use statistics of Pathfinder 5.2 data delivery from the NODC repository, Figure 1. The order of 500 to 700 users has been downloading ~300-400 Gigabytes/month utilizing a variety of on-line data delivery options.

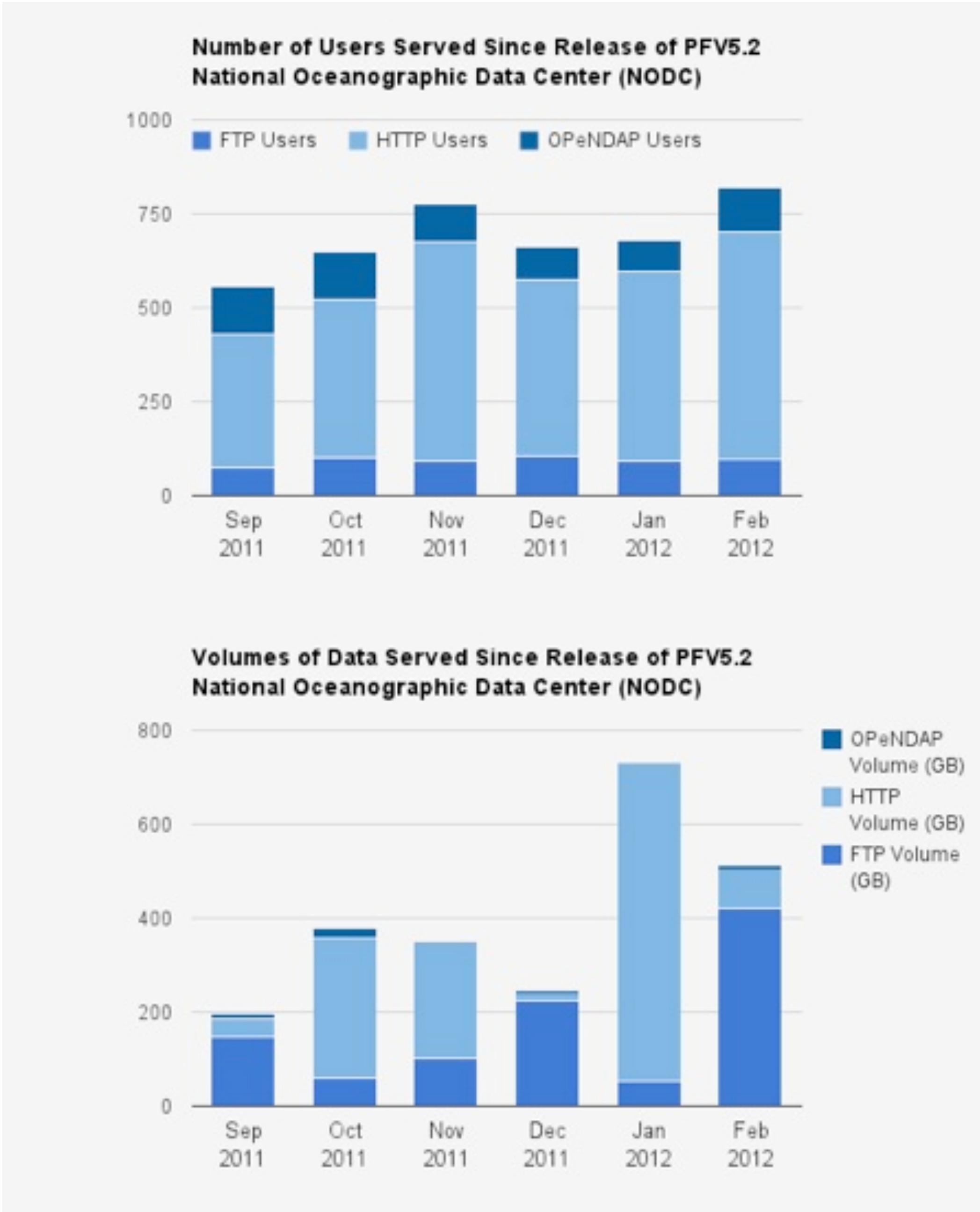

Figure 1: Number of users and data volume delivered by month of the Version 5.2 AVHRR Pathfinder 5.2 data set served for the NODC repository.

PLANNED WORK

Planned work for the next year includes extending the record by adding September and October 1981 to the NOAA-7 time series. These months were not part of the submission during the current year due to missing SST reference fields. NCDC (Banzon & Reynolds) working in conjunction with NODC (Casey) will generate the missing fields and subsequently augment them with the Pathfinder Version 5.0 rivers and lakes. UMiami will produce the HDF4 Level 3 files and delivery to NODC for conversion to NetCDF4.

In addition, the remainder of the NOAA-18 data record, the first 6 months of 2011 will be processed and delivered to NODC for NetCDF4 conversion. The final netCDF4 fields will be sent from NODC to NCDC for archive.

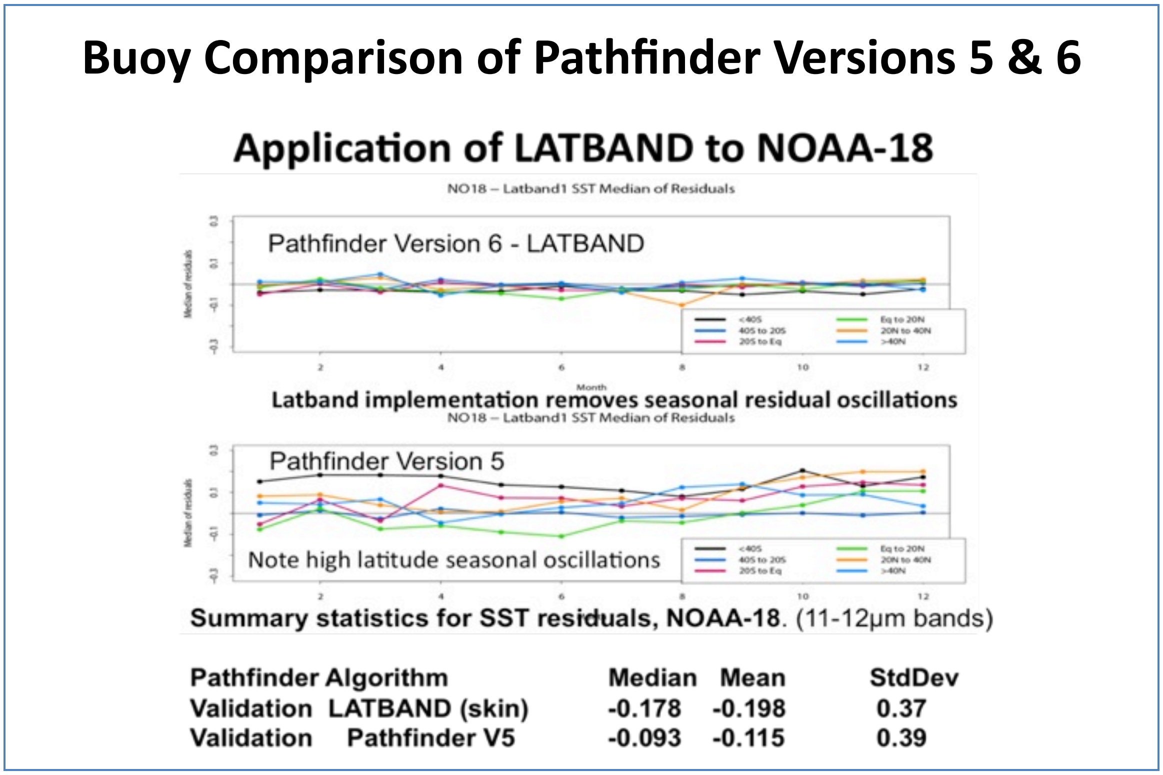

Figure 2: Comparison of Pathfinder Version 5.2 and Pathfinder Version 6 algorithms referenced to co-located, contemporaneous drifting buoys. The seasonal and latitude dependent anomalies seen in Pathfinder 5.2 are significantly reduced when compared to Version 6, which uses the 6 sets of latitude specific SST retrieval coefficients.

The initial Pathfinder 5.2 SST retrieval algorithm used two sets of coefficients, one for low water vapor concentration regimes and a second set for high water vapor regimes. The differentiation between the two regimes is accomplished by using the difference in brightness temperature between the 10 and 11 um channels as a proxy of water vapor concentration. This is the same term that is the basis of the SST retrieval algorithm atmospheric correction. Since the Pathfinder 5.2 algorithm utilized the same coefficients for both the northern and southern hemispheres, no adjustment was provided for the seasonal and latitudinal change in the vertical profiles of atmospheric temperature and water vapor. The use of 6 sets of coefficients for Pathfinder Version 6 does a more complete job of addressing this hemispheric asymmetry.

The following activities will be undertaken by University of Miami and NODC to initiate the transition to Pathfinder Version 6 and provision of NOAA-19 SST fields in the Pathfinder data set, dependent on funding availability. Version 6 improves on the Pathfinder 5.2 algorithm by minimizing residual seasonal, latitude dependent anomalies seen in latitude, time series through use of a set of 6 latitude specific SST retrieval coefficient sets, introducing the Version 6 algorithm into the Pathfinder processing will result in the Pathfinder AVHRR data set utilizing the same algorithm as is used in the MODIS and VIIRS observations resulting in a seamless algorithm application across the 3 sensors. The processing will follow the same path as was successfully implemented for Pathfinder 5.2 processing and data delivery to the NCDC CDR program.

Work Tasks

- Develop and validate NOAA-19 Pathfinder Version 6 SST retrieval coefficients and uncertainty hypercube.
- Resolve navigation issue with Pathfinder processing utilizing SeaDAS 6.3 and deliver the entire 64-bit processing code suite to NODC and NCDC.
- Process and compare a reference data set, NOAA-19 at both Miami and NODC to validate NODC processing. This activity includes updating the SST retrieval codes to Pathfinder Version 6 (monthly zonal latitude band coefficients), generating the per retrieval uncertainty estimates (uncertainty hypercubes), selecting the SST reference field and generating the daily, global SST fields for validation and distribution of Pathfinder fields at NODC.
- NODC will deliver NOAA-19 netCDF4 data fields to NCDC.
- Initiate discussions with the CDR program to extend the Pathfinder Version 6 data set to NOAA-7 to NOAA-18 satellites. This activity would take place during a subsequent funding cycle and would require additional funding.
- Miami will develop Pathfinder Version 6 coefficients and hypercubes tables for NOAA-7 through NOAA-18.
- NODC will develop a Level 2 to Level2P converter and validate.
- NODC will develop a Level 3 to Level3U converter and validate.
  - Miami will process NOAA-7 through NOAA-18 Level 3 Pathfinder Version 6 data set and deliver to NODC. This will serve as an initial delivery of Pathfinder 6 and as a reference data set for validation of NODC processing.
  - NODC will initiate full Level 2 and Level 3 Version 6 processing.
  - NODC will convert HDF4 Pathfinder 6 files to NetCDF4 format and deliver to NCDC. At this point NODC will have a complete processing capability to process and sustain AVHRR L1b to Pathfinder NetCDF4 format and maintain the data set as new L1b files are acquired.
  - NODC continues on-going production of Pathfinder 6 fields as new NOAA-19 L1b observations are acquired.

PUBLICATIONS

Kilpatrick, K. A., G. P. Podesta and R. Evans, JGR, Vol 106, NO. C5, Pg 9179-9197, May 15, 2001

PRESENTATIONS

Evans, R. and G. Podesta, Characterizing and comparison of uncertainty in the AVHRR Pathfinder Versions 5 & 6 SST field to various reference fields, Boulder

GHRSST meeting, March, 2011

Casey, K., and R. Evans, The AVHRR Pathfinder Sea Surface Temperature Climate Data Record, 2012 Ocean Sciences, February, 2012

Casey, K., and R. Evans, Pathfinder, GHRSST and the SST Essential Climate Variable Framework, WCRP Open Science Conference, October, 2011

Casey, K., and C. Donlon, Pathfinder, GHRSST, CEOS and the SST Essential Climate Variable Framework, NASA SST Science Team, November, 2011

OTHER
None

Suomi NPP VIIRS Land Surface Temperature EDR Validation

Task Leader	Pierre Guillevic
Task Code	
Date Awarded	07/01/2012
Contribution to CICS Themes	Theme 1: 10%; Theme 2: 80%; Theme 3: 10%.
Contribution to NOAA Goals	Goal 2: 20%; Goal 5: 80%

EXECUTIVE SUMMARY

This task focuses on the development and use of a new validation methodology to estimate the quantitative uncertainty in the Land Surface Temperature (LST) Environmental Data Record (EDR(derived from Suomi NPP/VIIRS, and contribute to improving the retrieval algorithm. It employs a land surface model to scaling up point LST measurements currently made operationally at NOAA's Climate Reference Network.

BACKGROUND

This task is part of the ongoing NPP/JPSS VIIRS Land Product Validation Plan (v. 1.0; 16 January 2009) for validation of the Land Environmental Data Records (EDRs) produced from the Visible Infrared Imager Radiometer Suite (VIIRS) of the Suomi National Polar-orbiting Partnership (NPP) and/or the Joint Polar Satellite System (JPSS). Suomi NPP/JPSS is a satellite system used to monitor global environmental conditions, and collect and disseminate data related to the atmosphere, oceans, land and the near-space environment.

NOAA will soon transition VIIRS on JPSS as its primary polar-orbiting satellite imager. Employing a near real-time processing system, NOAA will generate a series of EDRs from VIIRS data. For example, the VIIRS Land Surface Temperature (LST) EDR will estimate the surface skin temperature over all global land areas and provide key information for monitoring Earth surface energy and water fluxes. Since both VIIRS and its processing algorithms are new, NOAA is conducting a rigorous calibration and validation program to understand and improve product quality. This task represents a new validation methodology to estimate the quantitative uncertainty in the LST EDR, and contribute to improving the retrieval algorithm. It employs the SETHYS land surface model to scaling up point LST measurements currently made operationally at many field and weather stations around the world, e.g. NOAA's Climate Reference Network (CRN). The scaling method consists of the merging information collected at different spatial resolutions within a land surface model to fully characterize large area (km x km scale) satellite products. The approach is used to explore scaling issues over terrestrial surfaces spanning a large range of climate regimes and land cover types, including forests and mixed vegetated areas.

This work represents a continuation and enhancement of previous activities.

ACCOMPLISHMENTS

Model calibration

The parameterizations of energy and water transfers used in the SEtHyS land surface model (Coudert *et al.*, 2006[1]) are conceptual and involve a set of parameters that cannot be routinely measured at ground level. For a given application, several parameters and initial conditions need to be estimated in order to obtain reliable simulated LST.

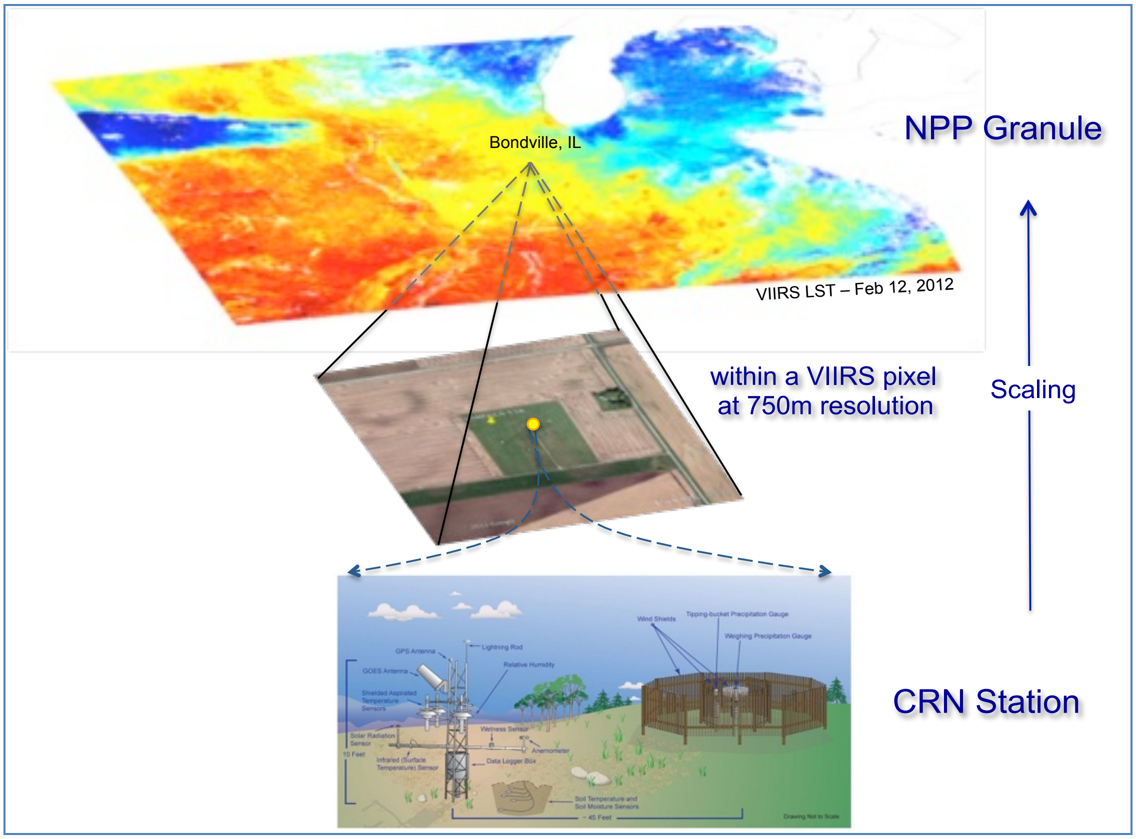

Figure 1: Suomi NPP VIIRS Land Surface Temperature (LST) and Climate Reference Network (CRN). Representation of the scaling issue when using the NOAA's Climate Reference Network (CRN) to validate LST EDR from Suomi NPP VIIRS. The approach combines point field data and fine resolution imagery in the SETHYS land surface model to characterize the LST over moderate resolution scales (750 meters).

Here, model calibration and data assimilation scheme consist of the minimization of a cost function expressing the divergence between model outputs and observations. To achieve a robust

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[1] Coudert B., C. Ottlé, B. Boudevillain, J. Demarty, and P. Guillevic (2006), Contribution of thermal infrared remote sensing data in multiobjective calibration of a dual-source SVAT model. *Journal of Hydrometeorology*, 7, 404-420.

[2] Demarty J., Ottlé, C., Braud, I., Olioso, A., Gupta, H. V., & Bastidas, L. A. (2005). Constraining a physically based Soil–

model calibration, we use the multi-objective calibration iterative process (MCIP; Demarty et al., 2005[2]). Based on a stochastic Monte Carlo approach, MCIP represents the reduction of an initial parameter space by the optimization of one or several model outputs against observations, here LST. We fully implemented and tested the MCIP algorithm that is now integrated in the LST EDR validation scheme.

First, the validation methodology was tested successfully with NASA/MODIS data as proxy for NPP/VIIRS, at a mixed agricultural site located near Bondville, IL. Results indicate an absolute error for MODIS LST products of 2.0 K when accounting for scaling, and higher than 3 K without scaling. The VIIRS LST EDR requires a 1.5 K measurement accuracy and 2.5 K measurement precision. Ultimately, this validation approach should lead to an accurate and continuously assessed VIIRS LST products suitable to support weather forecast, hydrological applications, or climate studies. It is readily adaptable to other moderate resolution satellite systems.

Preliminary validation results indicate a bias of -0.3K and precision of 1.9K of the VIIRS LST EDR when using 13 clear-sky VIIRS granules over Bondville, IL (Fig. 1).

Characterization of LST spatial variability using airborne satellite and ground based data
NOAA/NCDC and CICS-NC are collaborating with the NOAA/ATDD and the University of Tennessee Space Institute's (UTSI) Aviation Systems and Flight Research Department in Tullahoma, TN, to utilize aircraft for performing measurements of LST over selected U.S. Climate Reference Network (USCRN) sites in the continental U.S. The goal is to provide data to quantify the spatial variability and representativeness of the single-point skin temperature measurement being recorded at USCRN sites. A secondary goal is to provide additional ground-truth data to validate scaling methodology used to validate VIIRS LST EDR over mixed vegetated areas.

PLANNED WORK

- Assess uncertainties associated with ground measurements, model parameterizations, and the scaling methodology.
- Develop a routine validation platform based on 25 CRN stations.
- Evaluate VIIRS LST EDR validation scheme using data from EUMETSAT stations over Namibia, Senegal and Portugal, developed and maintained for MSG/SEVIRI LST product validation.

PUBLICATIONS

Guillevic P., Privette J., Coudert B., Palecki M. A., Demarty J., Ottlé C. and Augustine J. (2012). Land Surface Temperature product validation using NOAA’s surface climate observation networks – Scaling methodology for the Visible Infrared Imager Radiometer Suite (VIIRS). Submitted to Remote Sensing of Environment.

[2] Demarty J., Ottlé, C., Braud, I., Olioso, A., Gupta, H. V., & Bastidas, L. A. (2005). Constraining a physically based Soil–Vegetation–Atmosphere Transfer model with surface water content and thermal infrared brightness temperature measurements using a multiobjective approach. Water Resources Research, 41.

PRESENTATIONS

Guillevic P., J. L. Privette, B. Coudert, E. Davis, T. Meyers, M. A. Palecki, J. A. Augustine and C. Ottlé (2012). A Scaling Methodology to Compare Land Surface Temperature Products Derived from the Visible Infrared Imager Radiometer Suite (VIIRS) and Measured by NOAA's observational networks. American Meteorological Society (AMS) annual meeting. New Orleans, LA. 22-26 February.

Guillevic P., J. L. Privette, B. Coudert, E. Davis, T. Meyers, M. A. Palecki, J. A. Augustine and C. Ottlé (2011). Land Surface Temperature product validation using NOAA's surface climate observation networks – Scaling methodology for the Visible Infrared Imager Radiometer Suite (VIIRS). American Geophysical Union (AGU) meeting. San Francisco, CA, USA. 5-9 December.

OTHER

None

Improvements to the Calibration of the Geostationary Satellite Imager Visible Channel in the ISCCP B1 Data

Task Leader	Anand K. Inamdar (NOAA Collaborator: Ken Knapp)
Task Code	
Date Awarded	07/01/2011
Contribution to CICS Themes	Theme 1: 15%; Theme 2: 80%; Theme 3: 5%.
Contribution to NOAA Goals	Goal 1: 30%; Goal 2: 30%; Goal 5: 40%

EXECUTIVE SUMMARY

Calibration of the geostationary imager visible channel in the ISCCP B1 data is almost complete for the GOES, Meteosat, MSG, GMS and MTSAT series for the time period 1979-2009. Gaps in calibration and existing discrepancies in some of ISCCP calibration have been addressed, and the present calibration conforms to the MODIS standard.

BACKGROUND

The task is the assessment of the current Visible channel calibration of the International Satellite Cloud Climatology Project (ISCCP) B1 geostationary satellite data. The ISCCP B1 data represents geostationary imagery at 3 hourly and 10 km spatial resolution retrieved from the global suite of geostationary meteorological satellites (GOES over the US, Meteosat over Europe, GMS over Japan, INSAT over Indian sub-continent) covering the period 1983 until present. There are three main channels in the ISCCP B1, consisting of the visible, infrared window and water vapor. While the latter two have been already calibrated, the focus of this task is visible channel calibration.

Visible channel calibration is currently managed by the Meteorological Center in France through normalization with the concurrent Advanced Very High Resolution Radiometer (AVHRR) solar channel on the afternoon NOAA polar-orbiting satellite at the same viewing geometry. However, certain discrepancies have been discovered in the calibration of some of the GOES, Meteosat and MTSAT series satellites and there is also an absence of any calibration prior to 1983. The main objective of the present work is to fill in these calibration gaps and perform a uniform calibration for all the geostationary satellite visible channels from 1979 until present, through cross-calibration with the MODIS-quality AVHRR visible channel Climate Data Record (CDR) product recently made available by NOAA. This will enhance the quality of the recently rescued ISCCP B1 data, especially since it will be employed in a future reprocessing of the ISCCP cloud climatology resulting in a higher spatial resolution of the cloud properties and surface radiation budget. The ISCCP B1 data has been successfully employed in hurricane research and is currently being used in the evaluation of the global geostationary surface albedo project.

ACCOMPLISHMENTS

The processing of the calibration for all geostationary meteorological satellites through match-up with the AVHRR solar channel reflectance in the PATMOS-x data (CDR) is almost complete for the period 1979 – 2009 for the GOES, Meteosat, MSG, GMS and MTS series. The previously reported cumulative histogram matching technique has been implemented through deriving an optimized set of matching criteria. The time series of calibration slopes for selected GOES, MET and GMS series are shown in Figs. 1-3. The slope of the calibration slope time series is a measure of the degradation of the visible sensor during its lifetime. While the slopes of calibration curves follow the ISCCP calibration closely for the most part, there are individual differences, such as that for GOES – 7 (Fig. 1) during the post-Pinatubo eruption period (after 1992). Also the calibration for GOES-11 (not shown) reveals a big offset, as also that for the MTS-1 (Fig. 3) in addition to the excessive noise characterizing the ISCCP calibration.

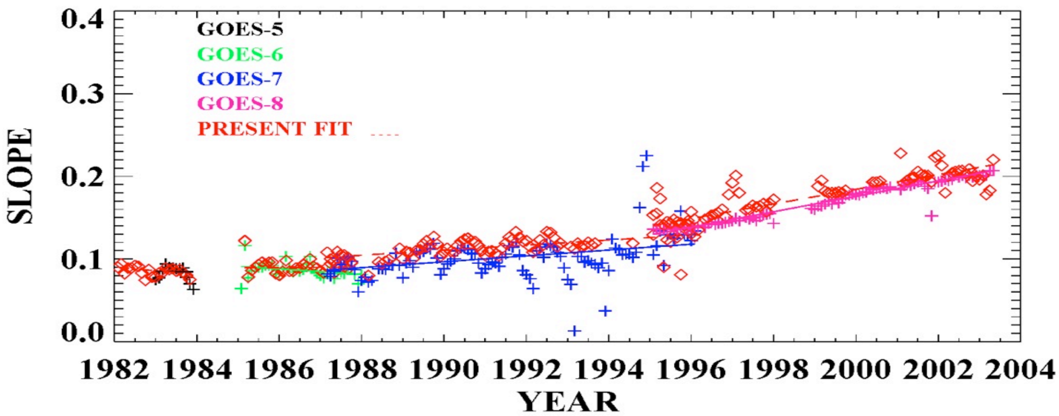

Figure 1: Time series of calibration slope for GOES-5 to GOES-8 (1982 – 2004). The '+' symbols and the solid lines refer to the ISCCP and the diamond symbols and the associated regression fit line (dashed) are from the present calibration approach.

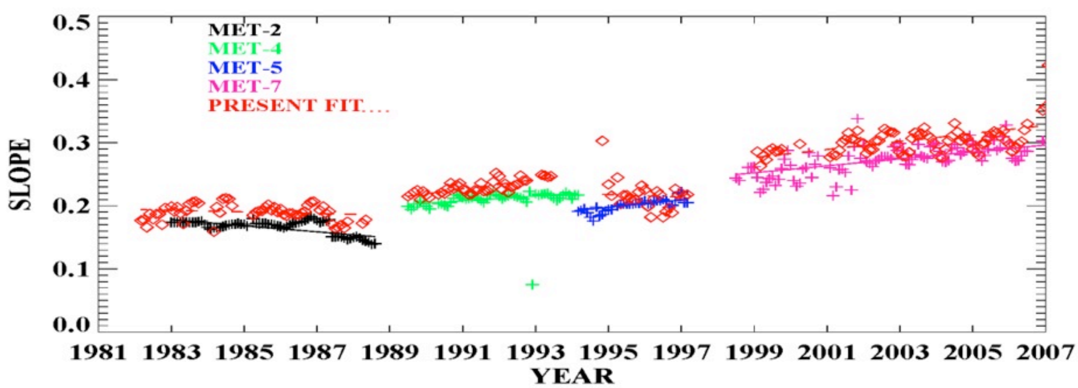

Figure 2: Same as Fig. 1, but for the Meteosat series (MET-2, MET-4, MET-5 and MET-7).

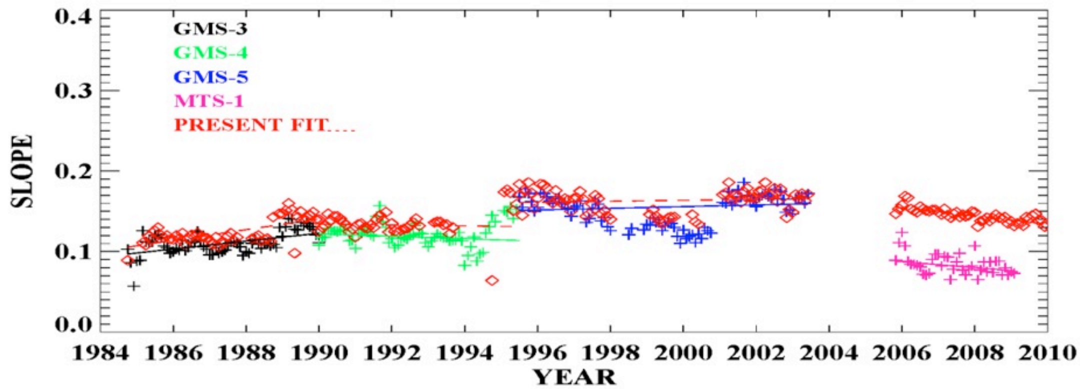

Figure 3: Same as Fig. 2, but for the GMS series GMS-3, GMS-4, GMS-5 and MTSAT (MTS-1) satellite.

PLANNED WORK

- Reprocessing of GOES raw data from 1979 to address inhomogeneities in the record and obtain a more uniform B1U data.
- Extraction of aerosol signals from ISCCP B1 and ISCCP Gridsat data.

PUBLICATIONS (Non-peer reviewed)

Anand Inamdar, and Ken Knapp, 2012: Assessment of Calibration Performance of the Geostationary Satellite Image Visible Channel in the ISCCP B1 Data, Proceedings of the 92nd annual meeting of the American Meteorological Society, New Orleans, Jan 22-26, 2012.

PRESENTATIONS

"Assessment of Calibration Performance of the Geostationary Satellite Image Visible Channel in the ISCCP B1 Data", presented at the 18th Conference on Satellite Meteorology, Oceanography and Climatology/ First Joint AMS-Asia Satellite Meteorology Conference, New Orleans, Jan 25, 2012.

OTHER

None

Pathfinder Sea Surface Temperature (PFSST) Climate Data Record (CDR) Transition from Research to Operations Documentation

Task Leader Katherine Kilpatrick
Task Code
Date Awarded 06/01/2011
Contribution to CICS Themes Theme 2: 100%
Contribution to NOAA Goals Goal 1: 80%; Goal 2: 20%

EXECUTIVE SUMMARY

Develop and provide documentation for the Pathfinder Sea Surface Temperature (PFSST) program as a component of transitioning this 20+ year dataset from a Research Climate Data Record (CDR) to an Operational CDR at NOAA/NCDC.

BACKGROUND

The Pathfinder Sea Surface Temperature (PFSST) program was originally initiated as a cooperative research project in 1991 between the University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS) and the NASA Jet Propulsion Laboratory (JPL) Physical Oceanography Distributed Active Archive Center (PO.DAAC). Beginning in 2002, the NOAA National Oceanographic Data Center (NODC) began partnering with RSMAS to improve the Pathfinder Climate Data Record (CDR), improve its long-term stewardship, and broaden its usage. The PFSST products have been reprocessed several times over the years, as the scientific understanding of the AVHRR instruments, algorithms and in situ matchup calibration data improved, and now provide a mature archive record of over two decades of global satellite measurements of sea surface temperature from multiple generations of AVHRR sensors. Processing of the PFSST is now being transferred to NODC to ensure their long-term availability, survivability, and provenance.

This task supports the documentation requirements to transition the AVHRR Pathfinder sea surface temperature climate data record (PFSST CDR) from research to operations (R2O). An overview of the PFSST processing is shown in Figure 1.

ACCOMPLISHMENTS

The documentation was submitted to NCDC on a schedule that facilitated transition of the FSST CDR to operations in FY2011.

- Specific subtasks completed included provision of:
- Documentation for all Header elements
- Provided documentation in the *ROBODoc* format for 5 main modules and 565 individual code files.
- Documentation for Data and Process Flow
- Provided a top tier flow chart of data flows and processing sequence.
- Provided detailed information on the names and sequences of calling scripts and data staging needed for each element of the PFSST processing.
- Operational Algorithm Description (OAD) Documentation

- A draft version of the Operational Algorithm Description (OAD) conforming to the Research to Operations (R2O) guidelines was provided based on extant Univ. of Miami, NASA JPL-PODAAC and NOAA/NODC source and ancillary information.

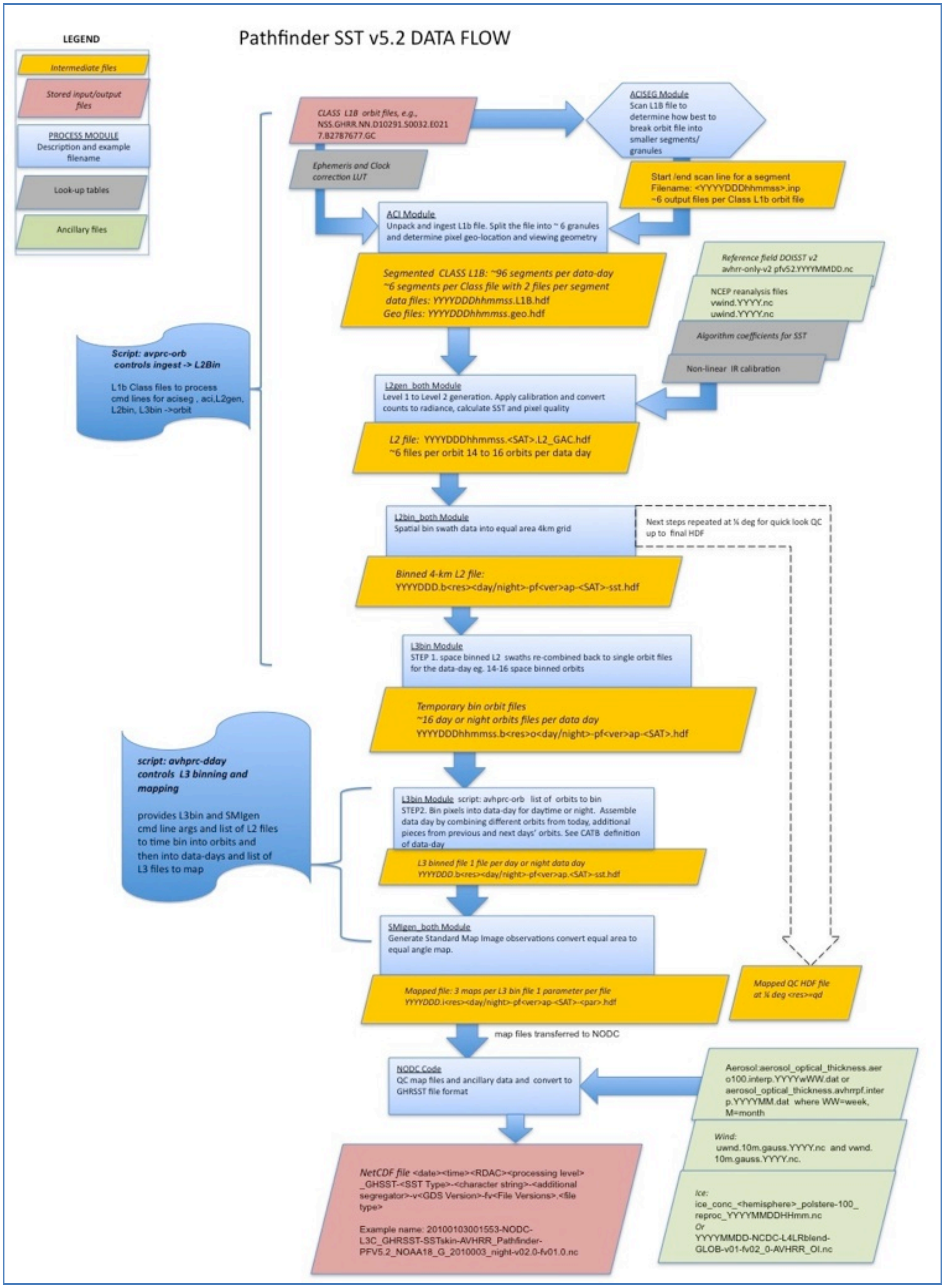

Figure 1: Overview of the PFSST processing.

PLANNED WORK
Continue to update OAD, Code Headers, and Flow Charts with any required changes, and complete Final Report .

PUBLICATIONS
None

PRESENTATIONS
None

OTHER
None

Implementation of Geostationary Surface Albedo (GSA) Algorithm with GOES data

Task Leader Jessica Matthews
Task Code
Date Awarded 06/01/2011
Contribution to CICS Themes Theme 2: 100%
Contribution to NOAA Goals Goal 1: 100%

EXECUTIVE SUMMARY

We are implementing the Geostationary Surface Albedo (GSA) algorithm for GOES data on behalf of NOAA to contribute to an international effort in collaboration with EUMETSAT and JMA in support of the Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM),. This effort signifies the first such attempt to use the same core algorithm across internationally operated geostationary satellites to produce albedo products to produce a climate data record for this variable.

BACKGROUND

Surface albedo is the fraction of incoming solar radiation reflected by the land surface, and therefore is a sensitive indicator of environmental changes. To this end, surface albedo is identified as an Essential Climate Variable (ECV) by the Global Climate Observing System (GCOS). In support of the Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM), NCDC is implementing the GSA algorithm for GOES data to contribute to an international effort in collaboration with EUMETSAT and JMA. Currently, the GSA algorithm generates products operationally at EUMETSAT using geostationary data from satellites at 0° and 63°E and at JMA using 140°E geostationary data. To create the stitched global Level 3 product as illustrated in Figure 1, NCDC is tasked with implementing the algorithm for GOES-E (75°W) and GOES-W (135°W).

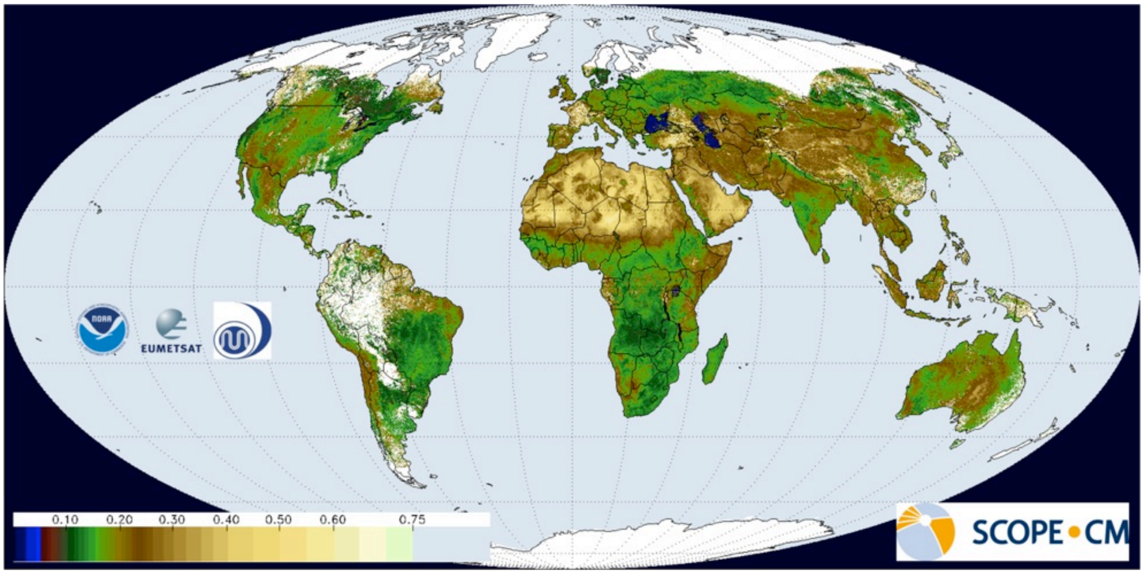

Figure 1: This figure illustrates the Level 3 global broadband surface albedo product proof of concept for the period of May 1-10, 2001. (Figure care of A. Lattanzio)

Previously the GSA algorithm was run with GOES data only for viability studies with 10 days of data. To effectively and efficiently generate products with this algorithm over large time periods, much effort must be extended to understand the application to GOES data specifically. The effort may be divided into two general categories: Operations and Science. Examples of Operations tasks include: porting code developed in the EUMETSAT computing environment to be functional in the NCDC computing environment, code development to work with GOES data format imagery, code development for ancillary NWP input data, etc. Examples of Science tasks include: calibration of GOES data, evaluation of the effect of different spatial and temporal resolutions of GOES as compared to the resolutions of EUMETSAT and JMA satellites, validation of the algorithm as applied to GOES data with external data sets, development of uncertainty bounds for the product, etc.

ACCOMPLISHMENTS

To date, much of the effort for this project has been directed towards implementation of an operational algorithm at NCDC. The 32-bit core algorithm has been successfully ported to the 64-bit computing environment at NCDC. We have developed a code package to convert GOES formatted imagery into the required binary input for the core algorithm. And, we have developed a preliminary code package to convert the binary product output into netCDF4 format for archival.

In August 2011 NCDC hosted a weeklong visit by the team of collaborators from EUMETSAT. During this productive visit a number of tasks were accomplished. Most notably the first successful test runs of the algorithm were completed with GOES imagery at NCDC, signifying a major milestone for the project. Figure 2 illustrates the results of these first successful tests. Other issues addressed during this visit include discussions on: GOES scene selection choices, calibration techniques, current error estimation routines, conversion of outputs to netCDF format, inclusion of ancillary inputs, and generation of globally stitched and gridded Level 3 products.

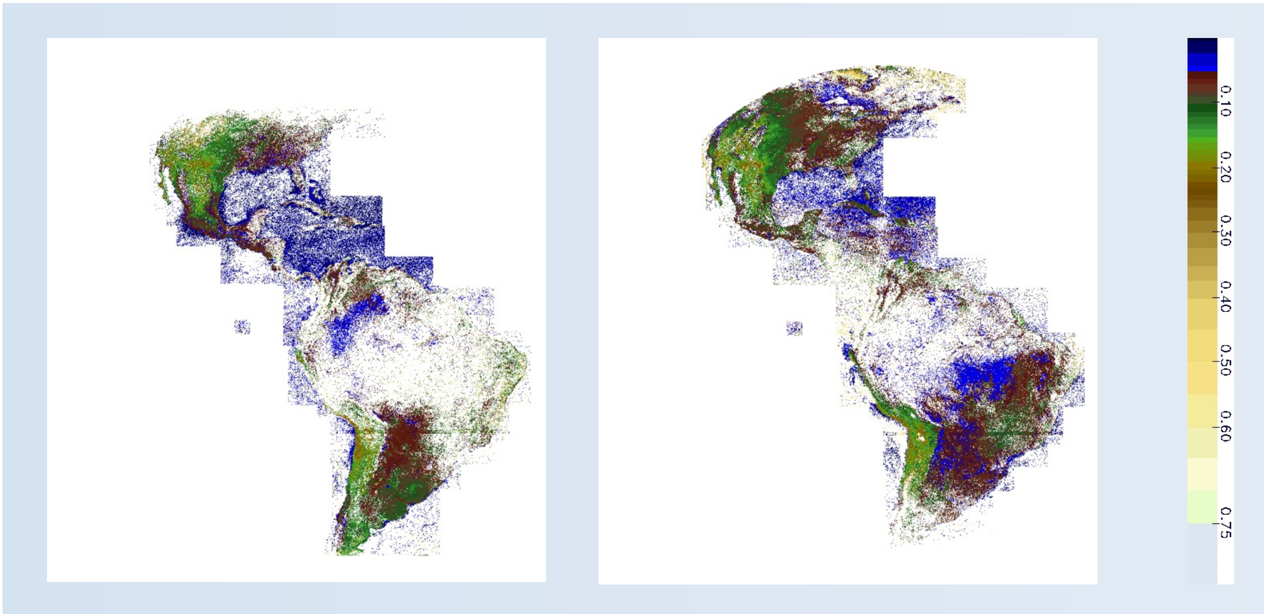

Figure 2: Directional hemispherical reflectance (DHR) for a solar angle of 30°, also called the black sky albedo. Both panels used GOES-E (GOES-8) data as input. The left and right panels are for January 1-10, 2000 and June 29-July 8, 2000, respectively.

PLANNED WORK

Operations

- Complete development for GOES-specific application including incorporation of total column ozone and water vapor ancillary inputs.
- Generate products with GSA for GOES-E and GOES-W for the SCOPE-CM requested period of 2000-2003.
- Pending validation, implement algorithm for entire historical record of GOES data (1979-present).

Science

- Algorithm validation for GOES data using MODIS and in situ data.
- Development of uncertainty analysis technique for GSA products.
- Sensitivity analyses on the impact of scene selection and calibration methodology on final albedo products.
- Investigate possible angular and seasonal patterns in RPV parameters.

PUBLICATIONS

In development

PRESENTATIONS

Matthews, J.L., Lattanzio, A., Hankins, B., Inamdar, A., Knapp, K., and Privette, J. 2011. Surface albedo based on geostationary observations. Poster presented at AGU Annual Meeting, December 6-10, 2011, San Francisco, CA.

Uncertainty Quantification for Climate Data Records

Task Leader Jessica Matthews
Task Code
Date Awarded 08/15/2011
Contribution to CICS Themes Theme 3: 100%
Contribution to NOAA Goals Goal 1: 100%

EXECUTIVE SUMMARY

Uncertainty quantification in climate research is a multidisciplinary area of increasing importance. Approximately 60 statisticians, mathematicians, and climate scientists from academia and governmental institutions met in Asheville, NC, USA in January 2012 to discuss the issues surrounding uncertainty quantification in the context of climate observations. This workshop was an opportunity to engage with and understand the different concerns and perspectives from the largely academic mathematical and statistical communities and climate data product scientists and providers.

BACKGROUND

Observations are key to uncertainty quantification in climate research because they form the basis for any evidence of climate change and provide a corroborating source of information about the way in which physical processes are modeled and understood. However, observations themselves possess uncertainties originating from many sources including measurement error and errors imposed by the algorithms generating derived products (see Figure 1). Over time global observing systems have undergone transformations on pace with technological advances and these changes require adequate quantification of resultant imposed biases to determine the impact upon long term trends. The uncertainties in climate observations pose a set of methodological and practical challenges for both the analysis of long-term trends and the comparison between data and model simulations.

ACCOMPLISHMENTS

In January 2012, a workshop was held to discuss the issues surrounding uncertainty quantification in the context of climate observations. The National Oceanic and Atmospheric Administration (NOAA)'s National Climatic Data Center (NCDC) hosted the event. This workshop was co-sponsored by the Cooperative Institute for Climate and Satellites (CICS-NC) (http://www.cicsnc.org) and by the Statistical and Applied Mathematical Sciences Institute (SAMSI) (http://www.samsi.info). It was organized in cooperation with the Program in Spatial Statistics and Environmental Statistics (SSES) at The Ohio State University (OSU) (http://www.stat.osu.edu/~sses).

Workshop events included fourteen invited speakers over five oral sessions, multiple panel discussions, and a poster session addressing the themes: remote sensing issues, spatial scaling, Bayesian techniques for coupling data to models, data fusion and assimilation, and climate measurement networks. The detailed conference schedule, along with links to the presentations, may be found at http://www.samsi.info/uq-observations.

This workshop was an opportunity to engage with and understand the different concerns and perspectives from the largely academic mathematical and statistical communities and climate data product scientists and providers. Major outcomes of the workshop include:

- The relationship between the mathematical, statistical, climate science, and data provider communities is ideally synergistic, and there is a mutual interest in joining together in collaboration.
- Raw measurements of remotely sensed data appear to be well archived and stewarded by U.S. government agencies. Ground-based measurement records still face significant challenges with digitization, archival, and retention.
- Homogenization techniques require reliability and transparency.
- Choosing an appropriate statistical methodology and inter-comparing the options is a challenge for climate scientists and data providers.
- Complete transparency requires auditability, reproducibility, and replication, which cannot all be accomplished merely via code provision

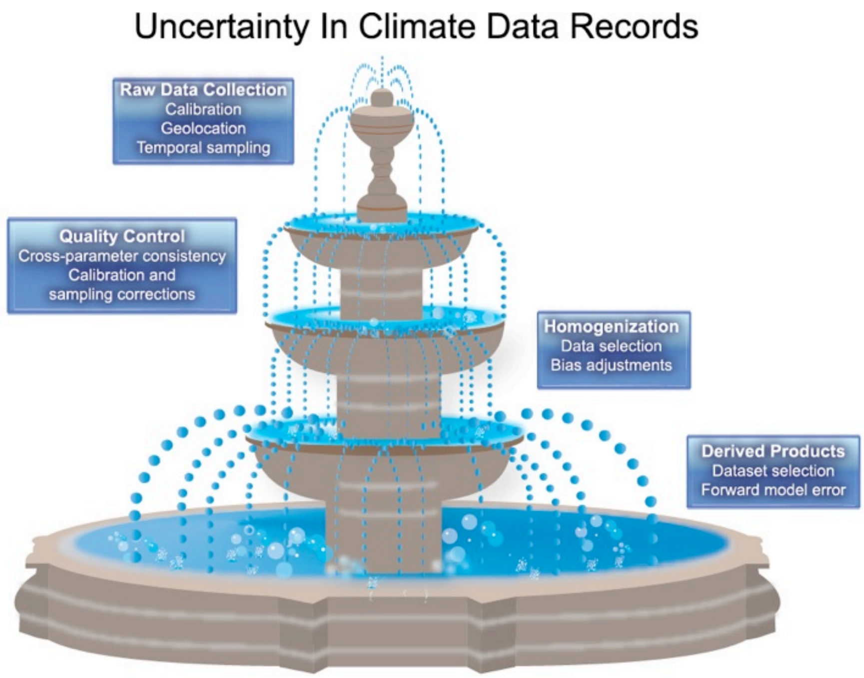

Figure 1: Illustrated as a "fountain", at each level of climate data manipulation, additional uncertainties are introduced. At the premier level, raw data is affected by measurement errors. During the quality control procedures of the next level, uncertainty may be introduced when correcting the geolocation of measurements and identifying inconsistent measurements. The homogenization methods used to remove systematic bias and data artifacts at the next level may introduce additional uncertainty. Finally, both the choice of dataset to use as input and the forward model algorithms applied to generate derived products may introduce another layer of uncertainty. The typical climate data user gathers records from the "pool" at the bottom of this "fountain", thereby realizing the total sum of uncertainties from all the preceding levels.

PLANNED WORK

- Continue to bridge between NCDC and the largely academic mathematical and statistical communities.
- Evolve this workshop into an annual event to facilitate continued cooperation and communication within the science.

PUBLICATIONS

Matthews, J.L., Mannshardt, E., Gremaud, P. (in review) Uncertainty quantification for climate observations. Submitted to *Bulletin of the American Meteorological Society*

PRESENTATIONS

Matthews, J.L. (2011) A model quantifying the effect of soil moisture and plant development on leaf conductance: Confidence interval estimation. Poster presented at SAMSI Program in Uncertainty Quantification: Climate Change Workshop, Pleasanton, CA, August 29-31, 2011.

OTHER

None

High Resolution SST Analysis

Task Leader Richard W. Reynolds (NOAA collaborator: Viva Banzon)
Task Code
Date Awarded 07/01/2011
Contribution to CICS Themes Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals Goal 1: 100%

EXECUTIVE SUMMARY

A two-stage SST analysis is being developed to best utilize the improved coverage of low-resolution microwave satellite data along with the restricted coverage and high resolution of infrared satellite data. Also an objective method is being designed to improve the signal-to-noise ratio of the final product.

BACKGROUND

In the last progress report, work had begun on a two-stage analysis optimum interpolation (OI) procedure with a high-resolution step built on top of a low-resolution step. For this effort microwave satellite data were used in the low-resolution analysis on a 28 km grid. The high-resolution analysis used infrared data on a 4.8 km grid. Comparisons of six analyses including the two-stage OI showed that there was no clear correlation between feature resolution and grid resolution in SST analyses. Furthermore, when the analysis procedures push the feature resolution beyond the spatial and temporal resolution limitations of the input data, the apparent small-scale features in the SST analysis are very likely noise.

ACCOMPLISHMENTS

During the past year a new effort has been undertaken to demonstrate how space-time distributions of satellite SST data impact high-resolution analyses. The procedure used to show this impact began with daily complete SST fields from a high-resolution global model, which were considered to be the "true" SST. Both low resolution and high-resolution "pseudo" data were derived from the model to represent microwave and infrared satellite data, respectively. These fields were then treated as data and subsampled based on actual satellite SST data distributions from microwave and infrared instruments. The full and subsampled SST data fields were then analyzed to determine the influence of missing low-resolution and high-resolution data.

The results showed that the spectral variance of a high-resolution analysis using the reduced or subsampled data at high wavenumbers were often larger than the original input data. This result suggests that the analyses added high-resolution noise when filling in missing data. Cross-spectral analysis with respect to the input data confirmed this result showing that the high-resolution analysis produced increasing noise as the coverage decreased. These results also showed that high-resolution coverage in the Gulf Stream was unlikely in January and only possible about half the time in July. The Sargasso Sea had high-resolution coverage during much of January and most of July due to reduced cloud coverage compared to the Gulf Stream.

Many users expect that when high-resolution data are not available that analyses will not show high-resolution features. Unfortunately, this assumption is wrong. High-resolution analyses show high-resolution features with and without high-resolution data. In the latter case, unfortunately the high-resolution features are just noise, that is, artifacts of the analysis process.

PLANNED WORK

During the coming year work on the objective determination of feature resolution will be continued using the two-stage OI procedure. To insure that the results are not dependent on only one analysis, the analysis procedure is being repeated using the UK Met Office Operational SST and Sea Ice Analysis. A final paper on the results will be prepared for publication.

The SST ocean model data from the objective determination study will be used to lower the high-resolution analysis noise in the two-stage OI. This will be done using the high and low-resolution pseudo data as input to the two-stage OI and comparing the analysis output to the full pseudo data set. Once this tuning has been completed, the two-stage analysis will be produced from 2003 through 2009. The codes and scripts will be documented and the analysis will be made operational at National Climatic Data Center.

PUBLICATIONS

Reynolds, R.W. and D.B. Chelton, 2011, "Objective determination of feature resolution in an SST analysis" available at: https://www.ghrsst.org/documents/q/category/proceedings-of-the-ghrsst-science- team-meetings/ (The paper is contained in page 294-297 in the document labeled "2011, GHRSST XII, Edinburgh, UK")

PRESENTATIONS

"Objective Determination of Feature Resolution in an SST Analysis." was presented at two meetings: the GHRSST Science Team meeting, Edinburgh, UK, 21-25 June 2011 and the Uncertainty Quantification for Climate Observations Workshop, Asheville, NC, January 17-19, 2012.

Extended results with preliminary OSTIA results were presented at the Ocean Science Meeting in Salt Lake, UT, 20-24 February 2012. The presentation was entitled "Objective Determination of Feature Resolution in SST Analyses by R. W. Reynolds, D. B. Chelton, D. Menemenlis, M. Martin and J. Roberts-Jones.

OTHER

None

Satellite Data Support for Hydrologic and Water Resources Planning and Management

Task Leader Soroosh Sorooshian
Task Code
Date Awarded 07/01/2011
Contribution to CICS Themes Theme 1: 75%; Theme 2: 25%
Contribution to NOAA Goals Goal 1: 25%; Goal 2: 75%

EXECUTIVE SUMMARY

Extreme precipitation events have direct impacts to many aspects of our society. Satellite-based precipitation estimation provides a unique way to monitor large precipitation systems with high spatial and temporal resolutions. Our research over the reporting period has contributed to the understanding of precipitation variability at various spatial and temporal scales. Long-term (more than 30 years) satellite-based high-resolution precipitation data is under development. Extreme events relevant to floods and droughts will be processed. The developed high-resolution precipitation measurement can be used for improving our understanding of spatial and temporal variability of precipitation distribution and for documenting the recent trends in extreme precipitation events.

Tasks in this report period are focused on (1) developing a climate data record of high-resolution precipitation estimation, (2) processing a 4-D database of heavy precipitation events from historical precipitation measurement, and (3) evaluating high-resolution precipitation data for hydrologic applications. The work accomplished for the high-resolution data processing, evaluation, and application of the project are discussed.

BACKGROUND

Satellite-based precipitation products provide an excellent data source for hydrometeorological applications and climate studies. One of the main objectives of the project is the development of long-term high-resolution precipitation measurement for extreme event (floods and droughts) studies. Specific tasks are focused on developing of climate data record of high-resolution precipitation estimation and evaluating high-resolution precipitation data for hydrologic applications. Two peer review papers were published and four presentations were presented at AGU and AMS annual meetings.

ACCOMPLISHMENTS

Develop Climate Data Record of High Resolution Precipitation Estimation

The ISCCP (International Satellite Cloud Climatology Project) B1 data are evaluated and used for PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) rainfall estimation. The PERSIANN precipitation dataset will cover more than 30 years when it is fully processed and completed. PERSIANN precipitation bias is adjusted by GPCP (Global Precipitation Climatology Project) monthly precipitation estimates. The adjusted dataset has monthly rainfall consistent to GPCP estimation while retaining the spatial and temporal features of precipitation estimates from PERSIANN estimation at 0.25^o spatial and 3-hourly temporal resolution. This bias adjusted dataset is further up-scaled to 0.5^o daily for extreme event analysis. Figure 1 shows the adjustment of PERSIANN bias using GPCP monthly rainfall for Jan 2007. Currently, more than 10 years of GPCP adjusted PERSIANN data are generated. We plan to process more than 30 years of historical data for extreme event analysis.

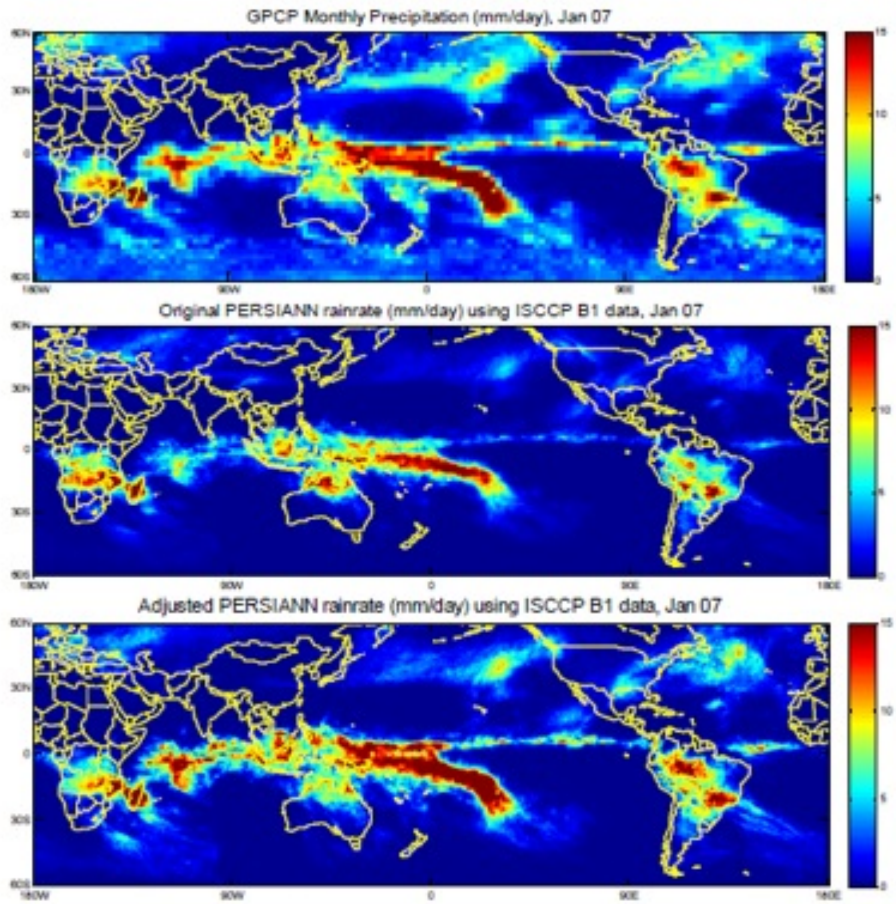

Figure 1: Monthly Bias Correction Method (Top: GPCP Monthly, 2.5°, Middle: Original PERSIANN Aggregated Monthly 0.25°, Bottom: Adjusted PERSIANN Monthly 0.25°)

Process 4-D Database of Heavy Precipitation Events

A fast connected components labeling (CCL) algorithm for extracting large precipitation systems from a consequence of satellite precipitation images has been developed. The CCL algorithm was applied to a 10-year (2000-2009) and global (60^o to 60^o) PERSIANN dataset, which has the resolution of 0.25^o and 3-hours. To enable easy storing and sharing, a MySQL database was set up to archive all the heavy precipitation events extracted. By implementing a relational database, researchers can obtain a particular set of events based on the temporal and geographical preferences in the studies. Figure 2 illustrates a continuous precipitation event that can be viewed as an object of connecting precipitating pixels in a sequence of continuous satellite images. The CCL algorithm scans over satellite images and extracts the objects based on a user-specified threshold of storm duration and intensity.

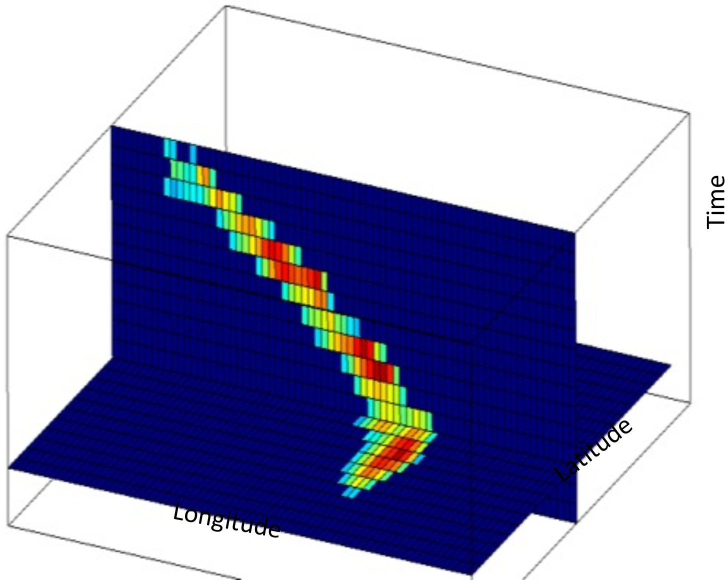

Figure 2: A heavy precipitation event is represented as an object in a 3-D (longitude, latitude, and time) hyper-space from a sequence of continuous satellite precipitation images.

Evaluate and Utilize High Resolution precipitation Data for Hydrologic Applications

The effectiveness of using satellite-based precipitation products for streamflow simulation at catchment scale is evaluated. Satellite-based PERSIANN precipitation products are used as forcing data for streamflow simulations at 6-h time scales during the period of 2003–2008. SACramento Soil Moisture Accounting (SACSMA) model is used for streamflow simulation over the mid-size Illinois River basin (1498 km^2). The results show that by employing the satellite-based precipitation forcing the general streamflow pattern is well captured at both 6-h and monthly time scales. Adding PERSIANN bias-adjustment, satellites products can improve estimation of both precipitation inputs and simulated streamflows substantially (Behrangi et al., 2011). Verification analyses show that, comparing with unadjusted PERSIANN estimation, the GPCP adjusted PERSIANN estimation has improved streamflow simulation.

Figure 3 presents time series of monthly averaged precipitation rates over the Illinois River basin: (a) PERSIANN (unadjusted); and (b) PERSIANN-adj (adjusted version). The grey lines show the monthly averaged multi-sensor radar/gauge-adjusted baseline data. It shows that the PERSIANN algorithm can capture the precipitation pattern and the bias-adjusted version consists of a better agreement with the reference of gauge-adjusted radar multi-sensor data. PERSIANN estimates tend to overestimate the amount of precipitation, particularly during the spring and summer months. The bias-adjusted PERSIANN data shows improvement in capturing both the variation and the total amount of precipitation.

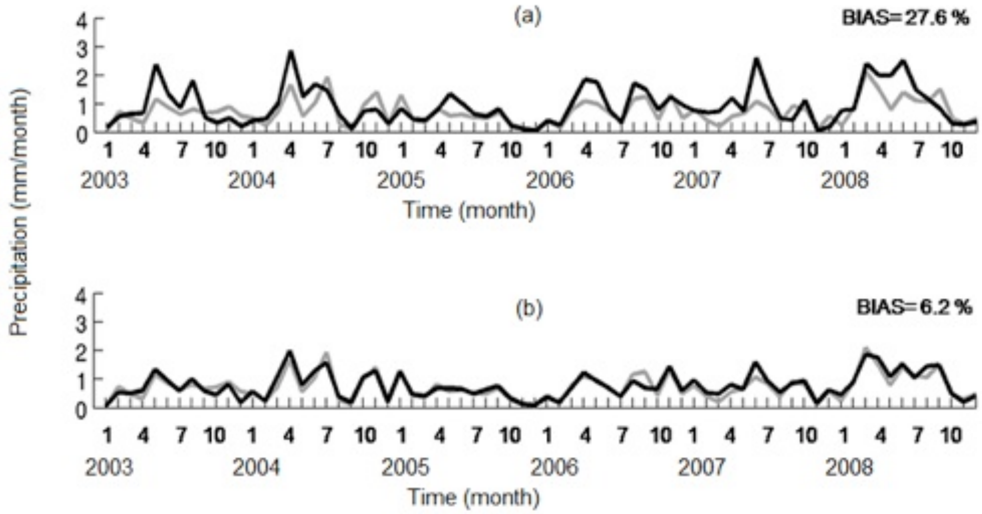

Figure 3: Time series of monthly precipitation estimates over the Illinois River basin based on (a) PERSIANN estimation; and (b) GPCP adjusted PERSIANN estimation. The grey lines show the monthly averaged multi-sensor radar reference data.

PLANNED WORK

- Continue processing high resolution precipitation data and 4-D database of heavy events (location, incremental depth/intensity, and time period)
- Utilize the developed database to conduct seasonal and regional analysis of heavy precipitation events.
- Analyze the pattern and trend of large storm events, including frequency, intensity, duration, coverage, and path.
- Evaluate the satellite data product over effective radar coverage and high-density gauge sites. Storm events from satellite, radar, and gauge observations will be extracted and evaluated.
- Develop a process to steward the framework such that the database can be implemented an operational setting to deliver the processed data to data archive centers.

PUBLICATIONS

Peer Reviewed

AghaKouchak, A., A. Behrangi, S. Sorooshian, K. Hsu, and E. Amitai, 2011, Evaluation of satellite-retrieved extreme precipitation rates across the central United States, *Journal of Geophysical Research*, 116, D02115, doi:10.1029/2010JD014741.

Non-Peer Reviewed

Ali Behrangi, Behnaz Khakbaz, Tsou Chun Jaw, Amir AghaKouchak, Kuolin Hsu, and Soroosh Sorooshian, 2011, Hydrologic Evaluation of Satellite Precipitation Products Over a Mid-size Basin, *Journal of Hydrology*, 397, 225–237.

PRESENTATIONS

Li, J., K. Hsu, A. AghaKouchak, and S. Sorooshian, A Hybrid Framework for Verifica tion of Satellite Precipitation Products, AGU Fall Meeting, 5-9 December, 2011, San Francisco, CA, 2011.

Nasrollahi, N., K. Hsu, S. Sorooshian, Application of CloudSat Cloud Classification Maps and MODIS Multi-spectral Satellite Imagery in Identifying False Rain from Satellite Images, AGU Fall Meeting, 5-9 December, 2011, San Francisco, CA, 2011

Ashouri, H., K. Hsu, and S. Sorooshian, Reconstruction of Daily Precipitation for Climate Trend Detection and Extreme Precipitation Analysis, AMS Meeting, 22-26 January, 2012. New Orleans, LA. 2012.

Hsu, K. (Invited), A Machine Learning Approach for Precipitation Estimation from Multiple Satellite Information. American Meteorological Society Annual Meeting, 22-26 January, 2012. New Orleans, LA. 2012.

OTHER

None

Precipitation Re-analysis using NMQ/Q2

Task Leader	Scott Stevens
Task Code	
Date Awarded	03/08/2010
Contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals	Goal 1: 10%; Goal 2: 90%

EXECUTIVE SUMMARY

This project involves the development of a re-analyzed, homogenous precipitation record for the continental United States, using radar-based software developed at the National Severe Storms Laboratory in Norman, OK.

BACKGROUND

This task is part of an effort to create a homogenous precipitation record based on existing data collected from NOAA's array of NEXRAD radars, distributed throughout the United States. With nearly universal coverage over the United States and very high temporal frequency (5-10 minutes), radar offers the ability to see at a much higher resolution than gauge networks or satellites alone.

The development of a high-resolution precipitation dataset will allow those in both research and operations to have access to information which can increase our understanding of the role of environment on rain and snowfall, allow for small-scale studies of topographical effects on storm systems, as well as provide for more precise hydrological warnings in advance of flooding events.

ACCOMPLISHMENTS

Using the NMQ/Q2 software from Norman, OK, the reanalysis has been completed over a pilot domain covering nine radars in North and South Carolina. This has resulted in the process being adapted from its current real-time use at NSSL to a re-analysis mode that can be run in parallel supercomputing systems, using archived NEXRAD data as input.

The resulting five-minute rainrates obtained from this process can be quickly accumulated into precipitation totals over any desirable time period. Figure 1 shows the radar-only precipitation estimate for September 7, 2004, over the Carolinas region, as the remnants of Hurricane Frances inundated the area. While this image shows estimates using radar alone, the process, in its full capacity, allows for the integration of gauge networks, lightning data, and eventually satellite overpasses.

This work has been presented in an invited talk to the NC State Climate Office (Jun 2011), at the AMS Conference on Applied Climatology (Jul 2011, Asheville, NC), and at the Fall Meeting of the American Geophysical Union (Dec 2011, San Francisco, CA).

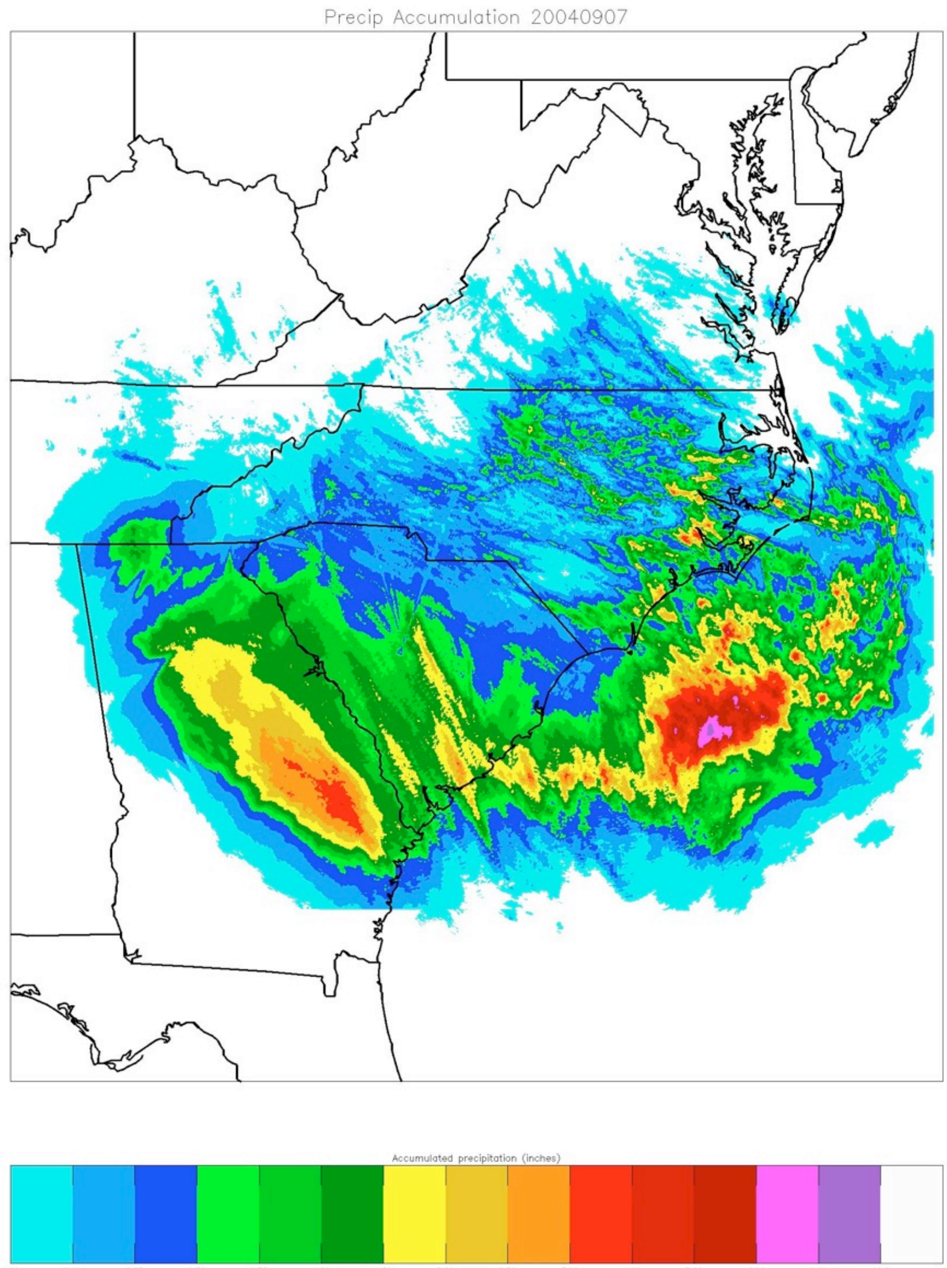

Figure 1: 24-hour precipitation accumulation over the Carolinas region for September 7, 2004, during the rainfall associated with Hurricane Frances

PLANNED WORK

- Expand reanalysis to cover first an expanded pilot domain, spanning 30 radars throughout the SE United States, then further expand to cover all of the continental United States.
- Incorporate rain gauge networks for calibration and correction in poorly covered areas, especially those in high terrain and sparsely covered regions
- Provide output to outside users for assessment and evaluation

PUBLICATIONS

None

PRESENTATIONS

Stevens, S. "NMQ/Q2 Reanalysis in the Southeastern United States". Invited talk for Dr. Ryan Boyles, NC State Climate Office, Raleigh, NC. Jun 2011

Stevens, S., B. Nelson, C. Langston. "National Mosaic and Multi-Sensor QPE (NMQ) reanalysis in the southeastern United States" 19th AMS Conference on Applied Climatology, Asheville, NC. Jul 2011.

Stevens, S., B. Nelson, C. Langston, and R. Boyles. "National Mosaic and Multi-sensor QPE (NMQ/Q2) reanalysis in the Carolinas region and directions toward a ConUS-wide implementation" 2011 American Geophysical Union Fall Meeting, San Francisco, CA. Dec 2011.

OTHER

None

Providing SSM/I Fundamental Climate Data Records to NOAA

Task Leader	Frank Wentz
Task Code	
Date Awarded	08/2010
Contribution to CICS Themes	Theme 2: 100%
Contribution to NOAA Goals	Goal 1: 100%

BACKGROUND

The Special Sensor Microwave Imagers (SSM/I) are a series of 6 satellite radiometers that have been in operation since 1987. These satellite sensors measure the natural microwave emission coming from the Earth's surface. These emission measurements contain valuable information on many important climate variables including winds over the ocean, the moisture and rain in the atmosphere, sea ice, and snow cover. However, the extraction of this information from the raw satellite measurements is a complicated process requiring considerable care and diligence. The first step in the process is the generation of Fundamental Climate Data Records (FCDR) of the sensor measurements in term of antenna temperatures and brightness temperatures. Since the first SSM/I was launched in 1987, Remote Sensing Systems (RSS) has been providing SSM/I data to the research and climate communities. The RSS SSM/I datasets are generally recognized as the most complete and accurate SSM/I FCDR available.

ACCOMPLISHMENTS

The primary objective of this investigation is to make a high-quality SSM/I FCDR with supporting documentation more widely and easily available to the User Community. This is being accomplished by converting the RSS data to a netCDF4 format and then providing it to NCDC/NOAA for archiving and distribution.

The bulk of this investigation was the Year-1 work described in our previous Progress Report. In Years 2 and 3, we are providing User support for the SSM/I FCDR. This support includes: (1) the continue processing of the F15 SSM/I, (2) a complete reprocessing of all SSM/I data when Version 7 is finalized, (3) converting the RSS binary format into the netCDF4 format, and (4) supporting Users inquiries and feedback and attending meetings and conferences.

Whereas the generation of the V6 FCDR was part of RSS's commercialization program, the development and generation of the V7 FCDR was mostly paid for by NASA. This NASA support is acknowledged here and will be acknowledged on the NCDC/NOAA web site hosting the V7 FCDR.

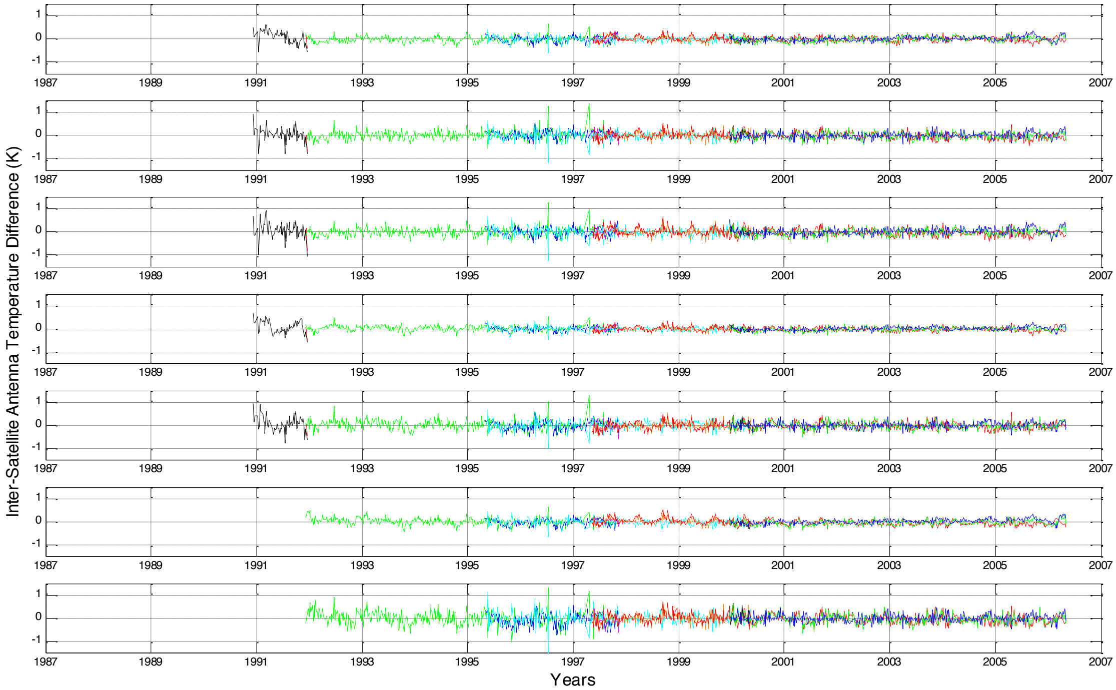

Figure 6: T_A differences for 11 overlap periods after applying all the corrections. Each overlap period is shown in a different color with the color-coding. The 7 frames show the 7 channels going from 19V at the top to 85H at the bottom in the order indicated. These results are for the evening portion of the orbit. (This is Figure 8 in the Technical Report: The Version-6 Calibration of SSM/I, October 2010 – see link below.)

Table 1. Color-coding for figures displaying the 11 inter-satellite overlap periods.

black	red	green	blue	magenta	cyan	orange	black	red	green	blue
F08	F08	F10	F10	F10	F11	F11	F11	F13	F13	F14
F10	F11	F11	F13	F14	F13	F14	F15	F14	F15	F15

We originally intended to deliver the V7 SSM/I data in Year 2. However, we encountered some unexpected complications in calibrating the SSM/Is. These complications have been resolved, and the result is a significantly improved product as compared to V6.

The primary improvements include:

- The inter-calibration of the 6 SSM/Is is now accomplished by adjusting the antenna pattern correction (i.e., the coefficients that convert antenna temperature to brightness temperature) rather than simply adding offsets. This is a more physical way of doing de-biasing and should provide a consistent calibration over both ocean and land.
- The new V7 radiative transfer model (RTM) eliminated the need to adjust the SSM/I earth incidence angles to achieve proper calibration, particular for the F10 SSM/I. The incidence angle dependence of the V7 RTM precisely matches that exhibited by the observations, thereby eliminating any need to adjust the incidence angle.
- Corrections are made for solar radiation intrusion into the SSM/I hot load
- Geolocation of the 6 SSM/Is was verified and in some cases fine-tuned.

- The overall calibration is now consistent with other microwave imagers such as WindSat, AMSR-E and SSM/IS.

PLANNED WORK

The V7 calibration for the 6 SSM/I was completed in March 2012 and the V7 FCDR will be converted to netCDF and delivered to NCDC/NOAA in April/May 2012. A technical report describing the V7 calibration method will be also provided. This will complete this investigation.

PUBLICATIONS

To download the 5 Technical Reports, please visit the following website:
ftp://eclipse.ncdc.noaa.gov/pub/ssmi/rss_v6_ssmi/doc/

PRESENTATIONS

None

OTHER

None

Inter-satellite Calibrations for the High Resolution Infrared Radiation Sounders

Task Leader Qiong Yang
Task Code
Date Awarded 1/13/2010
Contribution to CICS Themes Theme 1: 70%; Theme 2: 30%
Contribution to NOAA Goals Goal 1: 80%; Goal 5: 20%

EXECUTIVE SUMMARY

We perform inter-satellite calibrations to the High-Resolution Infrared Radiation Sounder (HIRS) observations. Based on the inter-satellite calibrated HIRS observations, upper-tropospheric water vapor climate data record and vertical profiles of temperature and specific humidity are derived.

BACKGROUND

HIRS has been on board the NOAA polar orbiting satellites for more than 30 years. It provides global observations from the surface to the stratosphere, and has been used for a number of climate change studies. For example, HIRS data were used to study trends in upper tropospheric water vapor, outgoing long-wave radiation and global cloud cover. However, there are significant challenges in producing a consistent, climate quality time series of the HIRS observations from different satellites. HIRS observations from each satellite were calibrated independently. Inter-satellite biases exist due to the independent calibration that is based on each individual HIRS channel spectral response function along with other factors. These inter-satellite biases are a common source of uncertainty for long-term climate studies. Thus, the goal of this task is to perform inter-satellite calibrations to HIRS measurements and produce a statistically homogeneous HIRS dataset. The, based on the inter-satellite calibrated HIRS channels 01-12, we derive vertical profiles of temperature and humidity.

ACCOMPLISHMENTS

HIRS clear-sky channels 01-12 have been calibrated to the MetOp2 satellite using temperature dependent step functions between two sequential satellites. Figure 1 shows the time series of the inter-satellite calibrated channel 12 brightness temperatures.

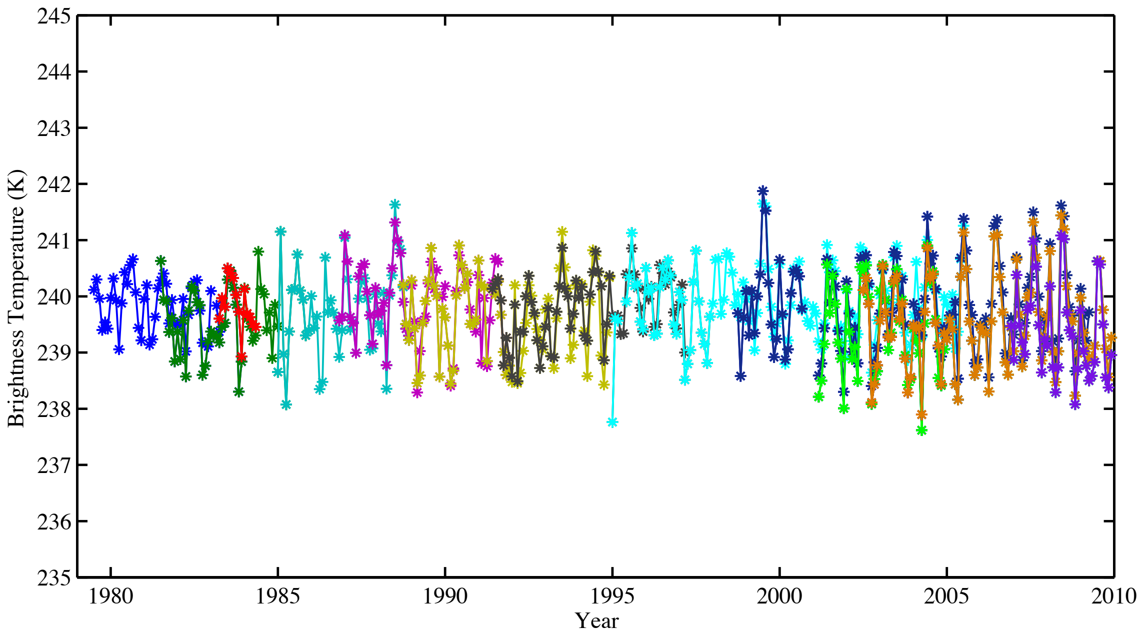

Figure 1: Time series of calibrated channel 12 brightness temperatures. Different color represents different satellite.

Based on the inter-satellite calibrated HIRS channels 01-12 observations, vertical profiles of temperature and humidity have been derived using neural network functions. Figure 2 shows an example of temperature and specific humidity profiles over the Western Pacific.

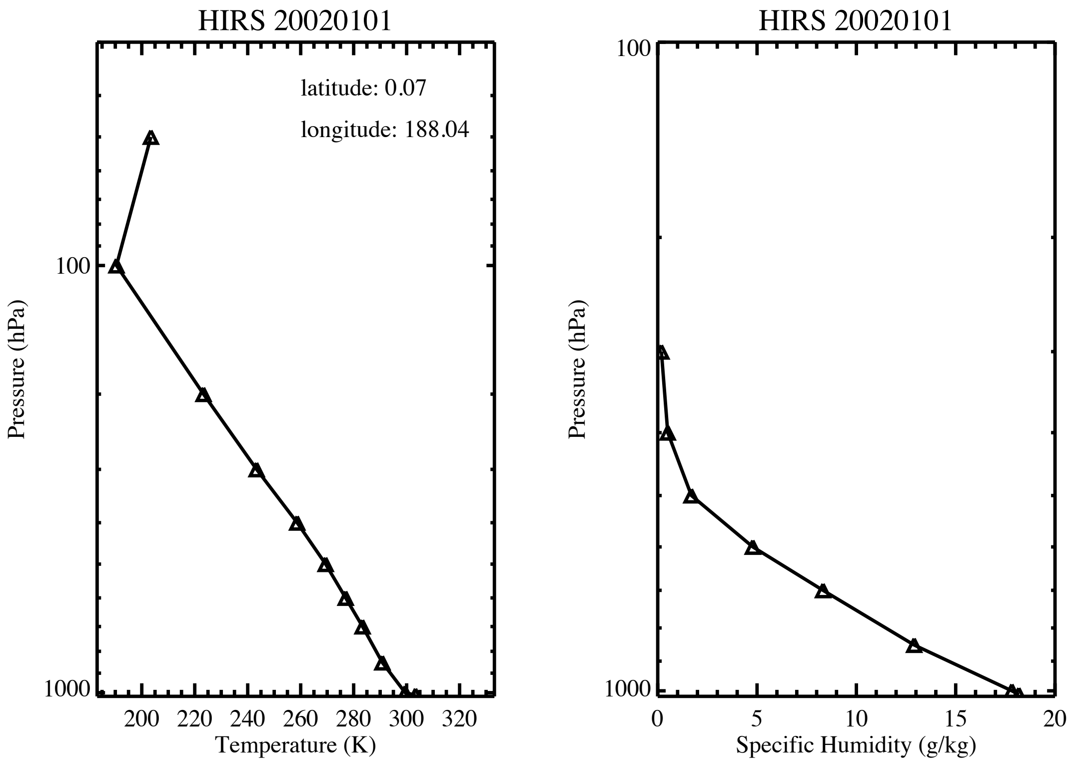

Figure 2: An example of retrieved temperature and specific humidity profiles in Western Pacific (latitude: 0.07° and longitude: 188.04°).

PLANNED WORK

- Validate retrieved temperature and humidity profiles using Constellation Observing System for Meteorology Ionosphere & Climate (COSMIC) observations
- Derive upper-tropospheric humidity dataset
- Perform inter-satellite calibrations for full-sky

PUBLICATIONS

None

PRESENTATIONS

None

OTHER

None

5.2 Workforce Developments

Comparison of ground based temperature measurements with satellite-derived phenology

Task Leader	Jesse E. Bell and Jessica Matthews
Task Code	
Date Awarded	10/30/2010
Contribution to CICS Themes	Theme 1: 70%; Theme 2: 30%
Contribution to NOAA Goals	Goal 1: 60%; Goal 5: 40%

EXECUTIVE SUMMARY
This research is a comparison of satellite-derived phenology with ground-based temperature metrics. The goal of this task is to determine which air or soil temperatures are better indicators for estimating the timing of growing season at 39 stations located within the contiguous U.S.

BACKGROUND
Climate observations of growing season are essential for understanding plant phenology and physiological development. Consequently, the most accurate definition of growing season is important for understanding ecosystem processes, agricultural development, and drought status. Air temperature, as it is one of the most commonly recorded climate variables, is traditionally used to define the onset and end of the growing season when phenology measurements are not available. Because below ground activity has been shown to be a predominant indicator of vegetative growth, research is being conducted to determine if soil temperature is a better metric for calculating plant phenology than air temperature. Using air and soil temperature measurements from the U.S. Climate Reference Network (USCRN), we are comparing the remotely-sensed MODIS normalized difference vegetation index (NDVI) derived growing season measurement with different ground-based temperature thresholds to determine which *in situ* temperature variable provides the most accurate estimation of growing season.

The goal of this task is to determine the *in situ* temperature measurement(s) that best relate to the onset and end of satellite-derived growing season. The approach includes an investigation of 39 USCRN stations that have two complete years (2010-2011) of air and soil temperature data. MODIS NDVI data, from AQUA and TERRA, are used to calculate start of season (SOS) for each USCRN station in the study. Four satellite images geo-located nearest to each station were extracted for all of 2010 and 2011. Three different methods for calculating SOS were used on this imagery: a local threshold based on yearly minimum and maximum NDVI values (ratio), slope based estimates from polynomial fits to NDVI data (polynomial), and slope based estimates from exponential functional fits to NDVI data (exponential). The NDVI SOS estimates were then compared to the air and soil temperature thresholds (0^oC, 5^oC and 10^oC) derived from the ground based measurements. We hypothesize that the use of remotely-sensed data will help to determine the most accurate method for calculating growing season and assist in developing plant-based indices for each USCRN station.

ACCOMPLISHMENTS

The USCRN calculations of growing season, based on the three temperature thresholds, have been completed with available 2010 and 2011 data. Calculations of growing degree days were also performed for each station in the study. Air and surface temperatures were found to estimate significantly shorter growing season lengths than soil temperatures. As expected, the estimate of growing season length progressively increased with increasing depth (5cm 10cm, 20cm, and 50cm) of soil temperature measurements. Initial analysis for the estimated SOS in 2011 appears earlier than the 2010 season.

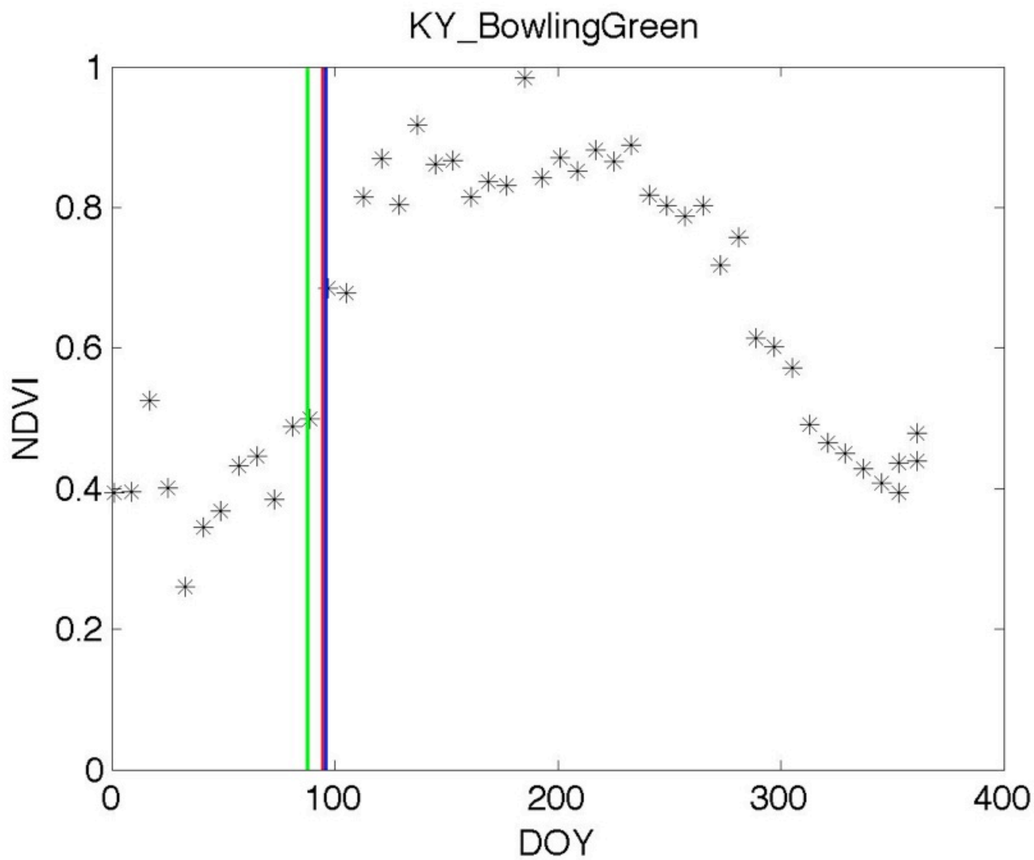

Figure 1: MODIS NDVI data for the pixel containing the Bowling Green, Kentucky USCRN station in 2010. The three vertical lines are an indication of the SOS estimate from NDVI data using the ratio (red line), polynomial (green line), and exponential (blue line) methods.

MODIS NDVI data were analyzed for four pixels surrounding each of the 39 USCRN stations in the study. Three methods to calculate SOS from NDVI data are currently being evaluated for each station. Figure 1 illustrates an example comparison of the results of the three methods at the Bowling Green, Kentucky USCRN station. The first method (ratio) translates NDVI into a ratio based on the annual minimum and maximum NDVI measurement. An arbitrary threshold (0.5) was then used to establish the SOS. The remaining two methods used polynomial and exponential curve fitting, respectively. After the curves were fitted to the NDVI time series, SOS was determined to be the time-point associated with the maximum slope in the time series. These three procedures are currently being evaluated to determine which of these is the most accurate method to estimate SOS from NDVI data for each of the 39 locations during the 2010 and 2011 growing seasons, and also how these SOS estimates compare to the SOS estimates from ground-based temperature methods (see Figure 2).

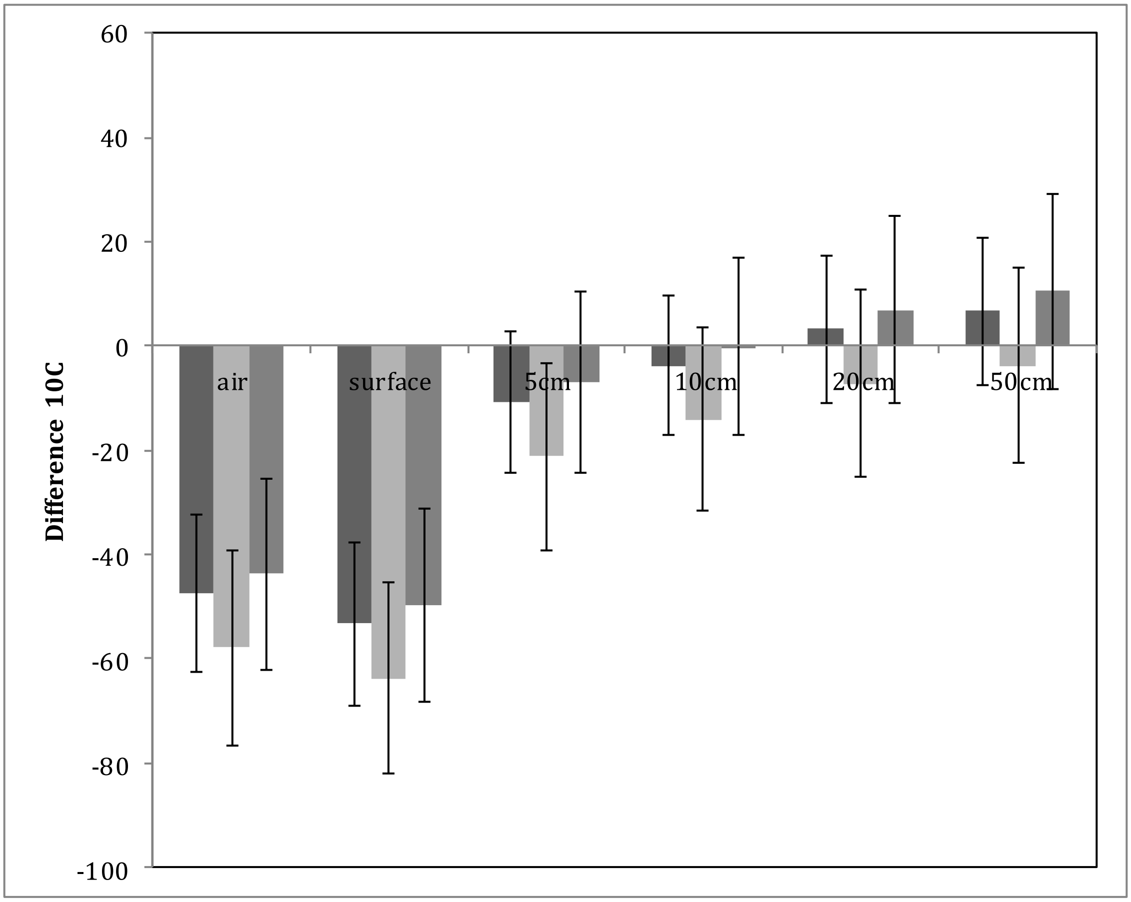

Figure 2: Calculated RMSE differences between estimates of SOS based on remotely-sensed NDVI and the 10^{o}C threshold for air, surface, and soil temperatures at 39 USCRN locations during 2010. Each bar indicates the difference between the SOS using the ratio method (very dark gray bar), polynomial method (light gray bar), and exponential method (medium gray bar) compared to the 10^{o}C threshold. Error bars indicate the standard deviation.

PLANNED WORK

- Complete comparison of the three NDVI-based SOS estimates and quantitatively determine the best method for each station. This may include analysis of station geographical location, general climatology, and land cover to ascertain the effects of these variables on method success.
- Compare NDVI-based SOS estimates with estimates from ground-based temperature thresholds to determine which of air or soil temperatures are better for estimating the timing of growing season at 39 USCRN stations located within the contiguous U.S.

PUBLICATIONS

In preparation

PRESENTATIONS

Bell, J.E. (Poster Presentation). Air and soil temperatures for estimating growing season and growing degree days. NOAA/NESDIS Cooperative Research Program Symposium, Asheville, North Carolina. 18 August 2011.

OTHER

Second place poster presentation at NOAA/NESDIS Cooperative Research Program Symposium.

Investigation of Hurricane based Precipitation over North Carolina, using the Weather Research and Forecasting Model (WRF)

Task Leader Ronald D. Leeper
Task Code
Date Awarded 07/01/2011
Contribution to CICS Themes Theme 2: 25%; Theme 3: 75%
Contribution to NOAA Goals Goal 2: 80% Goal 3: 10%; Goal 4: 10%

EXECUTIVE SUMMARY

The focus of this modeling based investigation was to analyze the sensitivity of ensemble spread to hurricane track (direct and indirect hits and near-misses) and data assimilation (data type and techniques).

BACKGROUND

The weather research and forecasting (WRF) model is the latest mesoscale numerical weather predication system supporting two dynamic cores dedicated to research and operational demands, within a portable, efficient, and parallel framework. In addition, the modeling system was designed to serve a host of roles from operational forecasting, 1 and 2D idealized simulations, to hurricane, air-quality, wild fire, and ocean coupling research. The WRF modeling system was brought online to support/facilitate the Cooperative Institute for Climate and Satellites (CICS-NC) climate research and modeling theme.

The WRF model was integrated into a hurricane simulation study, investigating the impact of modeling physics on storm track, intensity, and precipitation. A variety of hurricanes that have impacted the Carolinas were considered within the context of direct and indirect hits and near-misses. Simulations were conducted using three nested domains at 18, 6, and 2 km resolutions (figure 1a) with the inner-two most meshes allowed to move. This research will compare simulation ensembles of Hurricane tracks, maximum wind speed, and center pressure against the National Hurricane Center's Hurricane Database (HURDAT) data set (figure 1b). In addition, ensemble precipitation forecasts will be evaluated relative to satellite, rain gauge, and ground based Q2 quantitative precipitation estimates.

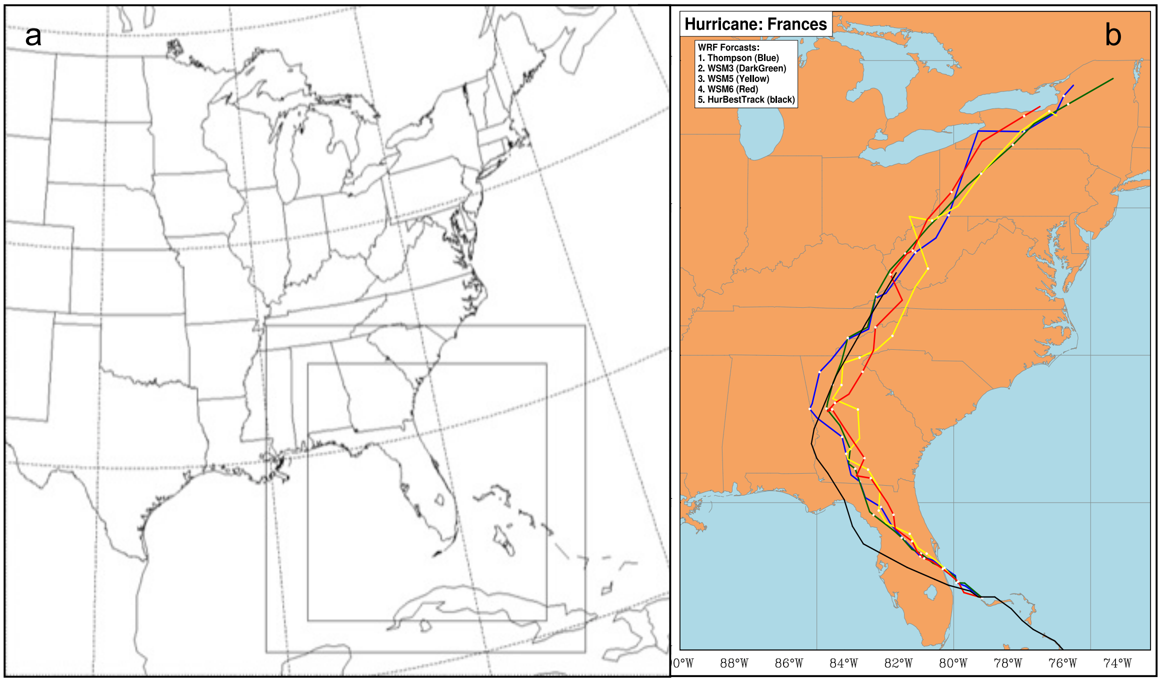

Figure 1: Plot (a) of modeled Hurricane Frances three nested domains at 18, 6, and 2 km resolution. The inner two most domains were allowed to follow the storm as moving meshes. Preliminary plot (b) of individual ensemble member (mulit-colored) with HURDAT (black) tracks for Hurricane Frances that made an indirect hit on the Carolinas in 2004.

PLANNED WORK

- Expand the study to include a total of 5 to 6 hurricanes
- Identify possible combinations of modeling physics options that generally yield improved model performance
- Monitor the sensitivity of model performance with the inclusion of assimilated ground and satellite based data sets into model simulations.

PUBLICATIONS

None

PRESENTATIONS

None

OTHER

None

Characterization of Precipitation Features in the Southeastern United States Using a Multi-sensor Approach: Quantitative Precipitation Estimates

Task Leader Olivier P. Prat (NOAA Collaborator Brian R. Nelson)
Task Code
Date Awarded 08/16/2010
Contribution to CICS Themes Theme 1: 20%; Theme 2: 75%; Theme 3: 5%
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

EXECUTIVE SUMMARY

We use a multi-sensor approach to characterize precipitation features at high spatial and temporal resolution. Focused over the Southeastern United States, this work aims at representing a proof of concept and a first step toward the development of rainfall climatologies at high spatial and temporal resolution. More broadly, this work is part of an on-going effort at NCDC to provide high-resolution precipitation estimates for hydrological applications and to derive trends in the evolution of precipitation patterns over time.

BACKGROUND

The primary goal of this project is to investigate long-term precipitation characteristics in the Southeastern United States at fine spatial and temporal resolution using a multi-sensor approach. The frequency and spatial distribution of precipitation extremes are evaluated using an ensemble of satellite and radar rainfall estimates. We use the precipitation reanalysis from the National Mosaic and Multi-Sensor Quantitative precipitation Estimates (NMQ/Q2), in order to derive yearly, seasonal, and sub-daily precipitation trends at high resolution (1-KM/5-minute) for the period 1998-2010 with an attention to intense precipitation events.

This particular task is focused on the inter-comparison of satellite observations from the Tropical Rainfall Measurement Mission (TRMM) and ground based (Q2) precipitation estimates in terms of precipitation intensity, accumulation, diurnal cycle, event duration, precipitation type (stratiform/convective), and precipitation systems (localized thunderstorms, mesoscale convective systems, tropical storms). In addition we investigate the impact of the spatial and temporal resolutions on each of these quantities, as well as the ability of satellite products to capture extreme precipitation events.

ACCOMPLISHMENTS

- Developed precipitation climatology at fine scale using satellite datasets TRMM Precipitation Radar (TPR 2A25: 5km/daily) and TRMM Multisatellite Precipitation Analysis (TMPA 3B42: 25KM/3HR) for the period 1998-2010. Subtasks included: (A) The derivation of yearly, seasonal, and diurnal precipitation trends from both datasets (TPR 2A25 and TMPA 3B42) (Prat and Nelson 2012); and (B) the quantification of the rainfall contribution originating from tropical cyclones (Prat and Nelson 2011).
- Initiated the inter-comparison TRMM satellite data versus NMQ/Q2 (National Mosaic and Multi-Sensor QPE) data (1km/5min) for the Carolinas. Current work consists intending the domain of study to the Southeastern United States (Prat et al. 2012).

Figure 1 displays a comparison of the instantaneous rain-rate and the 3-hourly rain accumulation derived from the different sensors (Q2, TMPA, TPR) in the case of the tropical cyclone Frances (2004). We note comparable patterns between satellite (TMPA, TPR) and ground based Q2 estimates for the rainfall distribution and the rain bands. As expected we have a much higher resolution with estimates derived from Q2. We also note important local differences due to beam blocking effect (Q2) and to different rain rates estimation algorithms, sensor sensitivity, characteristics and technical limitation, or the number of NEXRAD sites processed (9 in the figure).

Figure 2a displays the average daily precipitation for summertime at 1km resolution derived from NMQ/Q2 from 1998 to 2010. We note higher rainfall along the coast (sea breeze effects) and over ocean (Gulf Stream). We also note over the mountains the beam blocking effect with those characteristics lines starting from the radar site location. In western North Carolina, we observe a very low daily accumulation because neither of the two radars located in TN and SC is able to fully capture rainfall events. Figure 2b presents the differences between the satellite estimates TMPA 3B42 and Q2 re-gridded at 25-km. Larger differences are observed in Western North-Carolina and upstate South Carolina with a lower daily rain rate on the order of 75% for the radar based product Q2 as the result of the beam blocking effect. Over the coastal Carolinas, we note a higher daily accumulation on the order of 75% observed by Q2 that corresponds to sea breeze effects captured by Q2 due to a higher spatial resolution than TMPA 3B42 for which those localized events are harder to capture.

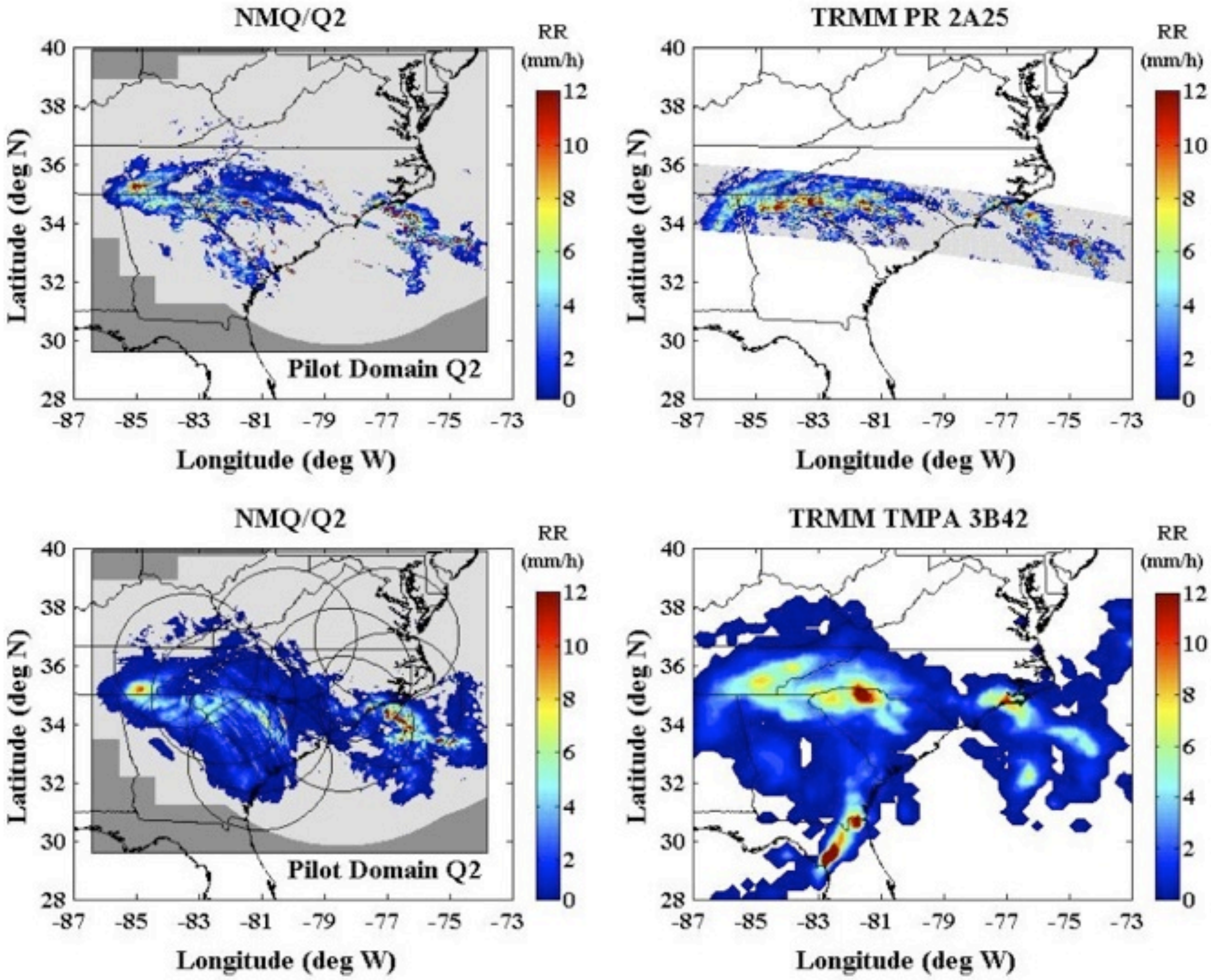

Figure 1: Hurricane Frances on 09/07/2004. Instantaneous rain-rate at 1235UTC for: a) NMQ/Q2 (1km), and b) TPR 2A25 (5km). Three-hourly averaged rain-rate c) NMQ/Q2(1km) and d)TMPA 3B42 (25km)

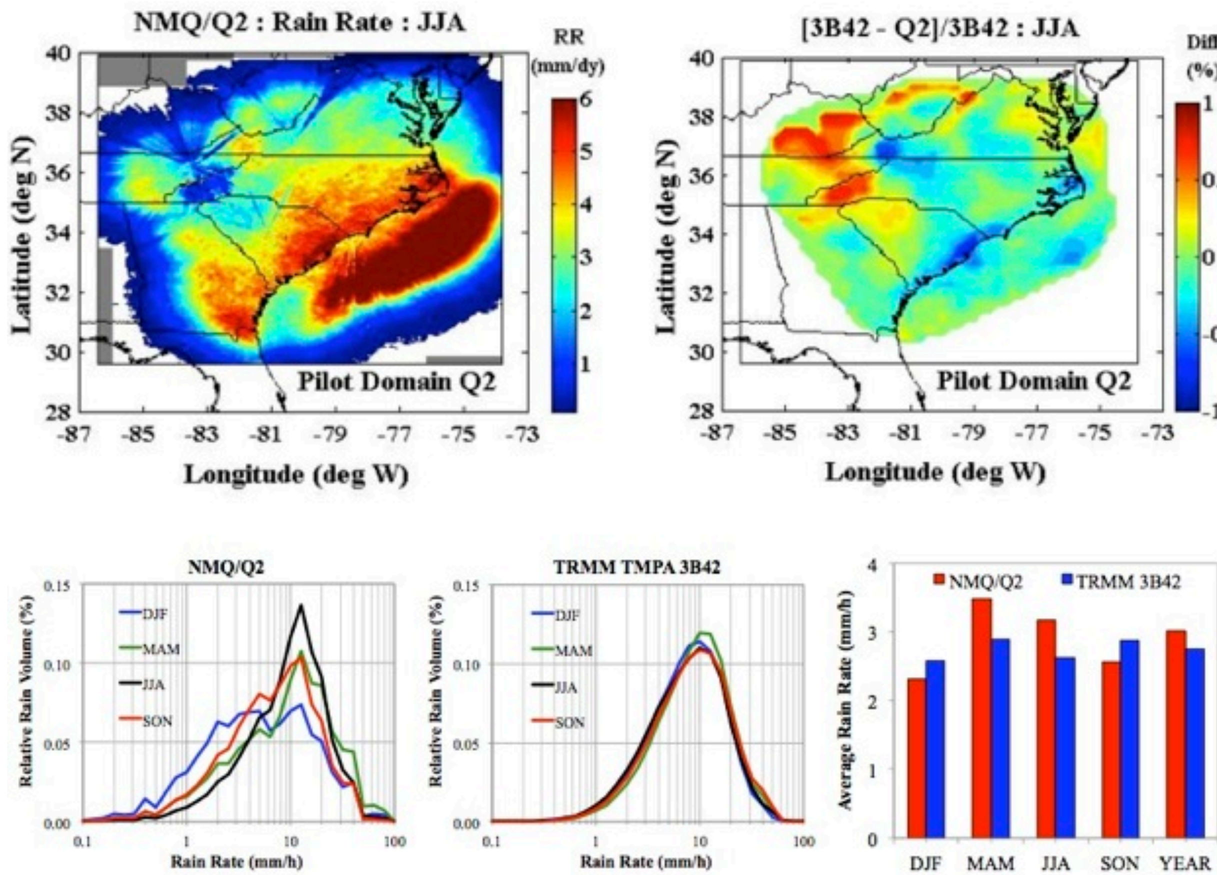

Figure 2: a) Mean precipitation derived from NMQ/Q2 (1km), and b) differences between NMQ/Q2 and TMPA 3B42 (25km) for summer (JJA). Seasonal PDFs derived from: c) NMQ/Q2, and d) TMPA 3B42. e) Seasonal and annual average rain-rate for NMQ/Q2 and TMPA 3B42.

Figures 2c and 2d display the seasonal PDFs for the relative rain volume derived from Q2 (Fig. 2c) and TMPA 3B42 (Fig. 2d) respectively over the same area corresponding to the actual footprint of the nine radars. In both cases we note that a rain rate around 10mm/h hour contributes the most to the rain volume. We observe a higher seasonal variability for Q2 than for TMPA 3B42, which displays very similar PDFs throughout the year regardless of the seasonal characteristic of precipitation. Furthermore, the PDF for summer derived from Q2 is shifted towards higher rain intensity, mainly due to the presence of summertime convection activity over the area. In addition, we note that winter PDF derived from Q2, indicates a more widespread rain rate contribution from 2mm/h to 10mm/h, when compared to 3B42, and that is due to cold precipitation such as snow or mixed phase.

Finally, Figure 2e displays the seasonal average rain rate (i.e. integration of the area under the curves). We observe a lower rain intensity of about 11% between Q2 and TMPA 3B42 during the cold season (winter and fall), and a higher rain intensity of about 17% between Q2 and TMPA 3B42 during the warm season (summer and spring) with globally a higher annual rain rate of about 8% for Q2 (radar only) when compared to satellite estimates TMPA 3B42.

PLANNED WORK

- Continue work on the characterization of precipitation features for the period 1998-present. Extend the current domain of study to 36 radars to cover the domain [86°W-74°W, 24°N-40°N].
- Examine differences in precipitation estimates between satellites (TMPA 3B42, TPR 2A25, and others) and Q2. Differences observed will be discussed as a function of the geographical location, precipitation type (stratiform, convective), and events characteristics (MCS, Tropical Cyclones). Local characteristics of the diurnal cycle of precipitation will be investigated.
- Assess the effects of local artifacts including beam blocking effects on precipitation estimates over mountainous areas. Focus will be on areas where precipitation estimates are the less reliable (for example coasts and mountains).

PUBLICATIONS

Prat, O.P., and B.R. Nelson, 2011: Precipitation contribution of tropical cyclones in the Southeastern United States from 1998 to 2009 using TRMM satellite data. *J. Climate*. Submitted.

Prat, O.P., and B.R. Nelson, 2012: Yearly, seasonal, and diurnal precipitation trends in the Southeastern United States derived from long-term remotely sensed data. *Atm. Res*. Submitted.

Prat, O.P., B.R. Nelson, and S.E. Stevens, 2012: Characterization of precipitation features in the Southeastern United States using high spatial and temporal resolution quantitative precipitation estimates derived from the National Mosaic and Multi-sensor QPE (NMQ/Q2). *J. Hydrometeorol*. In preparation.

PRESENTATIONS

Prat, O.P., and B.R. Nelson, 2011. Characterization of precipitation extremes at high spatial and temporal resolution in the Southeastern United States derived from long-term satellite and radar rainfall estimates. 2011 AGU fall meeting, December 5-9 2011, San Francisco, CA, USA.

Nelson, B.R., O.P. Prat, and E.H. Habib, 2011. Diurnal cycle of precipitation in the Southeast U.S. using high spatial and temporal resolution quantitative precipitation estimates and radar-reflectivity products derived from National Mosaic and Multi-sensor QPE (NMQ/Q2). 2011 AGU fall meeting, December 5-9 2011, San Francisco, CA, USA.

Wilson, A., J. Tao, K. Olson, A.P. Barros, O.P. Prat, and D. Miller, 2011. From fog to tropical cyclones: Challenges to comprehensive ground validation in the Southern Appalachians. 2011 NASA Precipitation Measurement Missions (PMM) science team meeting, November 7-10 2011, Denver, CO, USA.

Prat, O.P., and B.R. Nelson, 2011. Characterization of precipitation extremes for the continental United States derived from long-term satellite records. 2nd annual CICS science meeting, November 2-3 2011, Asheville, NC, USA.

Prat, O.P., and B.R. Nelson, 2011. Deriving precipitation features in the Southeastern United States from long-term remotely sensed data. 8th annual science symposium NOAA/NESDIS Cooperative Research Program (CoRP), August 17-18 2011, Asheville, NC, USA.

Prat, O.P., and B.R. Nelson, 2011. Characterization of precipitation features in the Southeastern United States using a multi-sensor approach – milestones for a longer-term assessment of climate change impacts. 19th AMS conference on applied climatology, July 18-20 2011, Asheville, NC, USA.

Prat, O.P., and B.R. Nelson, 2011. Yearly, seasonal, and diurnal precipitations trends in the Southeastern United States derived from long-term remotely sensed data and quantification of hydro-climatic extremes. 2011 EGU general assembly, April 4-8 2011, Vienna, Austria.

OTHER

None

5.3 Surface Observing Networks

The Madden-Julian Oscillation and Tropical Cyclones in the Western Hemisphere

Task Leader Carl Schreck (NOAA Collaborators James Kossin and Lei Shi)
Task Code
Date Awarded 08/19/2010
Contribution to CICS Themes Theme 1: 30%; Theme 2: 70%
Contribution to NOAA Goals Goal 1: 60%; Goal 2: 40%

EXECUTIVE SUMMARY

This research uses novel satellite datasets to investigate tropical intra-seasonal variability, including the Madden–Julian Oscillation (MJO) and equatorial waves. Particular emphasis is placed on the relationship between the MJO and tropical cyclone activity in the Western Hemisphere. Daily monitoring of satellite-derived MJO signals provides a valuable tool for predicting tropical variability in the 5–30 day range.

BACKGROUND

The MJO has frequently been identified with proxies for convection such as outgoing longwave radiation (OLR). These data are suitable for the Eastern Hemisphere where deep tropical convection is commonplace. However, the convective signal becomes weaker in the Western Hemisphere, even as the signal persists in the upper troposphere. Inter-satellite calibration techniques have recently produced a homogeneous 32-year dataset of upper tropospheric water vapor (UTWV) from the high-resolution infrared radiation sounder (HIRS). These data are being used to develop a global view of the MJO.

The MJO significantly affects tropical cyclone activity around the globe. This project uses the UTWV data to identify how the MJO influences tropical cyclogenesis over the eastern North Pacific and the North Atlantic. Possible mechanisms include the local enhancement of convection and low-level vorticity, amplification of easterly waves, remote impacts on the vertical wind shear, and baroclinic effects. These issues are being explored through a case study of the record breaking Atlantic hurricane season in 2005.

Tropical cyclone activity is diagnosed using the International Best Track Archive for Climate Stewardship (IBTrACS) from NOAA's National Climatic Data Center. IBTrACS combines tropical cyclone data from numerous international agencies. Operational procedures have evolved through time, and they vary greatly between agencies. Research is ongoing to document and mitigate these heterogeneities in the record.

ACCOMPLISHMENTS

A climatology of the MJO and equatorial waves in UTWV has been submitted to the *Journal of Climate*. Spectral analysis shows that the MJO and equatorial waves stand out above the low-frequency background in UTWV, similar to previous findings with OLR. The MJO and equatorial Rossby waves are associated with a greater fraction of the total variance in UTWV than in OLR. In the subtropics, UTWV identifies the subsidence drying that occurs poleward of the MJO's convection. These signals are absent from OLR. For equatorial Rossby waves, the variance is more equatorially symmetric and less seasonally dependent in UTWV than in OLR. Kelvin waves, on the other hand, are overshadowed in UTWV by the extratropical Rossby waves that share similar propagation characteristics. These results demonstrate the utility of UTWV, in concert with OLR, for identifying tropical intra-seasonal variability.

A new website (http://monitor.cicsnc.org/mjo/) was developed and implemented for daily monitoring of the MJO and equatorial waves. This website applies established diagnostics to both UTWV and OLR. It has been tailored to meet the needs of forecasters at NOAA's Climate Prediction Center (CPC). Special diagnostics have also been developed to support forecasts for the DYNAMO (Dynamics of the MJO) field campaign that was conducted over the Indian Ocean from October 2011 to March 2012.

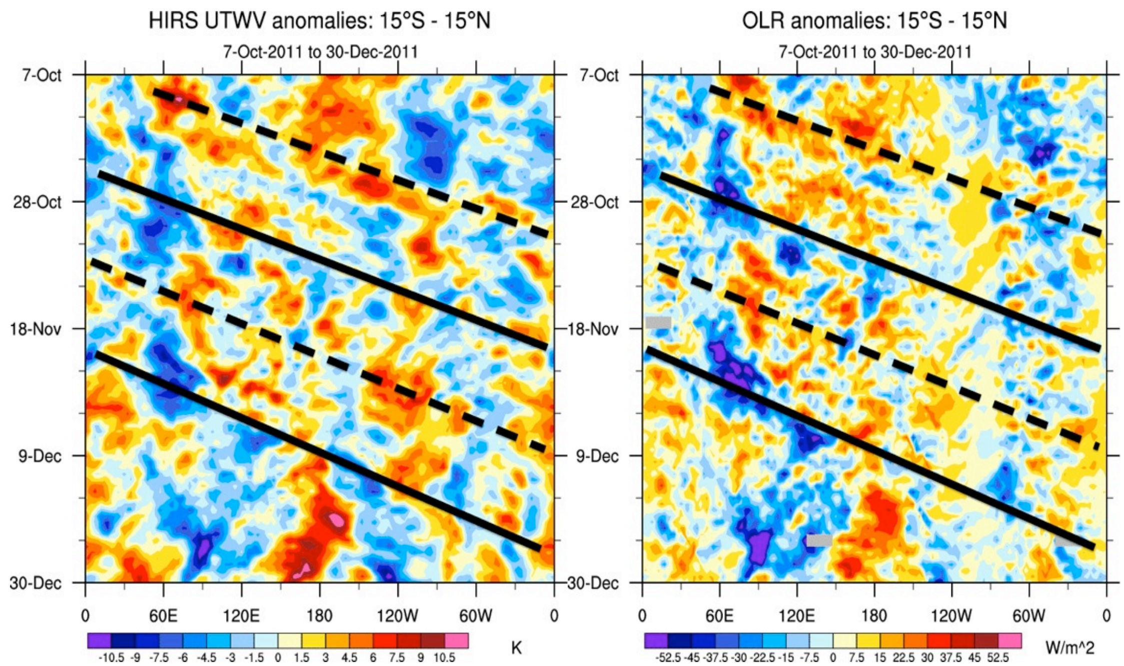

Figure 1: Longitude–time Hovmöller diagrams of OLR (left) and UTWV (right) anomalies relative to their respective 1979–2011 daily climatologies. Both variables are averaged 15°S–15°N. Heavy black lines identify the convective (solid) and suppressed (dashed) phases of the MJO.

Figure 1 illustrates two longitude–time Hovmöller diagrams from the monitoring website. The left panel shows OLR, while the right panel presents UTWV brightness temperatures. In both cases, the shading indicates anomalies relative to their respective 32-year daily climatologies. Negative anomalies (cool shading) correspond to cold cloud tops in OLR and enhanced upper-level moisture in UTWV. In both cases, these negative values are generally associated with ascent.

Fortunately for the DYNAMO field campaign, the MJO was particularly active during October–December 2011. Tropical convection varies on a variety of time scales, but the heavy black lines in Fig. 1 roughly identify the convective (solid) and subsiding (dashed) phases of the MJO. The DYNAMO campaign was centered near 60°E where MJO's convection initiates before it moves eastward. In OLR (left panel), the MJO signals weaken as they traverse the eastern Pacific (150°W–60°W). UTWV (right panel), on the other hand, tracks the signals more continuously around the globe. The positive and negative UTWV anomalies also have similar magnitudes, unlike OLR. UTWV is more sensitive to the subsiding branches of the tropical circulation, as demonstrated by the large positive (warm colors) anomalies near the dateline in December. These diagnostics provided a valuable forecasting tool during the field campaign.

The record-breaking 2005 Atlantic hurricane season provided an ideal testbed to examine the relationship between the MJO and tropical cyclones in the Western Hemisphere. During August, tropical cyclone development gradually shifted eastward from the eastern Pacific to the western Atlantic with the passage of the MJO's convective envelope. This envelope circumnavigated the globe, and the pattern repeated in September–October. Ongoing research is examining the modulation of convection, low-level vorticity, and vertical wind shear by this MJO event. UTWV also indicates a connection between the MJO signals in the Northern Hemisphere and extratropical systems in the Southern Hemisphere. These relationships and their impacts on tropical cyclone activity will be explored further.

Research is also underway to produce a global climatology of tropical cyclones using IBTrACS. IBTrACS comprises historical tropical cyclone best-track data from numerous sources around the globe, including all of the Regional Specialized Meteorological Centers (RSMCs). It represents the most complete amalgamation of tropical cyclone data compiled to date. IBTrACS offers a unique opportunity to revisit the global climatology of tropical cyclones. This research is exploring the mean annual global tropical cyclone activity as well as interannual variability within each basin. Discrepancies between sources in IBTrACS are being identified in order to motivate future reanalysis efforts.

PLANNED WORK

- Complete the case study of the MJO during the 2005 Atlantic Hurricane season and submit it for publication.
- Use estimates of total precipitable water from the Special Sensor Microwave Imager/Sounder (SMMIS) to investigate the evolution of low-level moisture during MJO onset.
- Use IBTrACS to produce a global climatology of tropical cyclones for the period 1981–2010. Particular emphasis will be placed on uncertainties between data sources and heterogeneities in time.

PUBLICATIONS

Schreck, C. J., L. Shi, J. P. Kossin, and J. J. Bates, 2011: Tropical intraseasonal variability in outgoing longwave radiation and upper tropospheric water vapor. *J. Climate*, Submitted.

Ventrice, M. J., C. D. Thorncroft, and C. J. Schreck, 2011: Impacts of convectively coupled Kelvin waves on environmental conditions for Atlantic tropical cyclogenesis. *Mon. Wea. Rev.*, In Press.

Aiyyer, A., A. Mekonnen, and C. J. Schreck, 2012: Projection of tropical cyclones on wavenumber-frequency filtered equatorial waves. *J. Climate*, In Press.

Schreck, C. J., J. Molinari, and A. Aiyyer, 2012: A global view of equatorial waves and tropical cyclogenesis. *Mon. Wea. Rev.*, **140**, 774-788.

PRESENTATIONS

Schreck, C. J., 2011: The Madden–Julian Oscillation and Equatorial Waves in Upper Tropospheric Water Vapor. Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC, September 2011.

Schreck, C. J., 2011: Upper Tropospheric Water Vapor: A New Dataset for Monitoring the Madden–Julian Oscillation. NOAA's Climate Prediction Center, Camp Springs, MD, August 2011.

Schreck, C. J., J. Kossin, K. Knapp, and L. Shi, 2011: Continuing development of climate information records at NOAA's National Climatic Data Center. *World Climate Research Programme Open Science Conference*, 24–28 October 2011, Denver, CO.

Schreck, C. J., J. Kossin, and L. Shi, 2011: The Madden–Julian Oscillation and equatorial waves in upper tropospheric water vapor. *8th Annual Cooperative Research (CoRP) Science Symposium*, 17-18 August 2011, Asheville, NC.

Schreck, C. J., 2011: Best track continuity. *2nd IBTrACS Workshop*, 11-13 April 2011, Honolulu, HI.

Schreck, C. J., 2011: Best track data in synoptic studies: What is a tropical cyclone? *2nd IBTrACS Workshop*, 11-13 April 2011, Honolulu, HI.

OTHER

- Developed monitoring website (http://monitor.cicsnc.org/mjo/) to increase user engagement
- Contributed to NOAA/CPC's weekly Madden–Julian Oscillation and Global Tropical Hazards Assessment
- Provided additional forecasting support to NOAA/CPC for the DYNAMO field campaign

Validation of US Climate Reference Network (USCRN) Soil Moisture and Temperature

Task Leader	Jesse E. Bell
Task Code	
Date Awarded	10/30/2010
Contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

EXECUTIVE SUMMARY

The goal of this task is to improve the USCRN soil observations and research ways to use the soil data. Currently, we have developed multiple ways to improve the quality assurance procedure. Research has also been conducted on understanding the spatial relationship of USCRN soil data and approaches to develop drought-monitoring products.

BACKGROUND

The US Climate Reference Network is a series of climate monitoring stations maintained and operated by NOAA. To increase the network's capability of monitoring soil processes and accurately estimating drought, it was decided to add soil observations to the list of USCRN instrumentation. In the summer of 2011, the USCRN team completed the installation of all soil observational probes in the contiguous US. Each station, along with traditional measurements of surface air temperature, precipitation, infrared ground surface temperature, wind speed, and solar radiation, now also transmits relative humidity, soil temperature, and soil moisture measurements every hour. The data is maintained and stored at NOAA's National Climatic Data Center, while installation and maintenance is performed by NOAA's Atmospheric Turbulence and Diffusion Division (ATDD).

The task of this project is to produce high-quality soil datasets and use these data to research the relationship of soil observations to spatial change and develop drought-monitoring products. To ensure the network is providing quality data, there are a series of quality checks that must be performed before the data are made available to end-users. One task of this project is to improve the current quality assurance method to accurately determine faulty sensors for removal from the final soil products. Exploring the data record and researching ways to identify erroneous changes in the time series is the best way of improving the quality assurance procedure. In this report we will explore ways that we have improved the soil observations' quality assurance and promoted the networks abilities to potential users.

ACCOMPLISHMENTS

The completion of the network in 2011 has required implementation of improved soil quality assurance. As the soil observations are transmitted hourly from 114 stations on a near real time basis via the GOES satellite, there are large amounts of data to observe for occurrences of faulty periods. The first step was to automate the quality assurance process and decide the proper checks to determine sensor health. After a thorough investigation, the decision was to proceed with certain checks to ensure the automatic ingest could instantaneously flag and remove faulty time periods.

We investigated the appropriate range boundaries for determining when sensors are recording values that exceed sensor limits. Initial boundaries were determined by the largest physical limits of the sensor. We then examined the possibility of using specific soil conditions as a determinant of boundary limits. The results of this study were mixed. We were able to determine that specific boundaries can be produced, but some of the boundaries may unexpectedly remove actual measurements. Further investigation will be needed in understanding this phenomenon.

The next stage of development included incorporating a "bad sensor list" to the quality assurance process. The bad sensor list is a list of sensor time periods that are removed from the final products because these periods are not reliable. On a semi-regular basis, there is an evaluation of the data series to determine bad periods in the data record. These periods are then added to the bad sensor list for removal. Currently, we are evaluating a way to automate the post-ingest quality control.

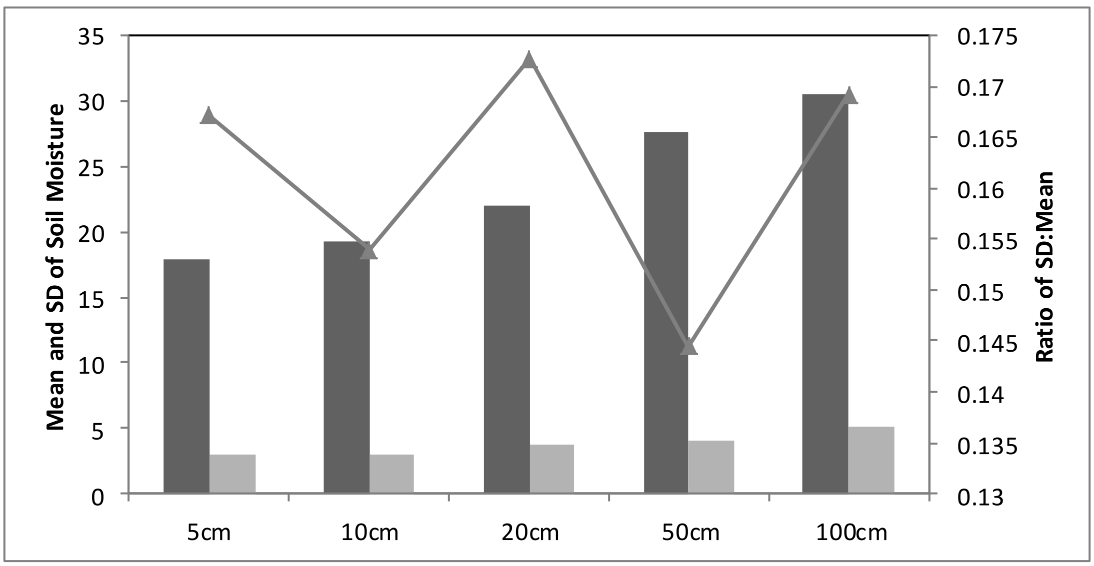

Figure 1: Soil moisture means (dark bars) and standard deviations (lighter bars) were produced from five soil depths across all stations recording measurements during the month of June 2011. Line graph (y-axis) was produced from ratios of standard deviations to means.

In addition to improving the quality assurance of these data, we are examining spatial relationships that may assist in understanding the changes that occur between sensors (fig. 1). These relationships will not only help improve quality assurance, but also assist the scientific community in understanding spatial relationships of soil moisture and temperature (fig. 2). We are also developing drought-monitoring products to improve the usability of the data (e.g. plant available water).

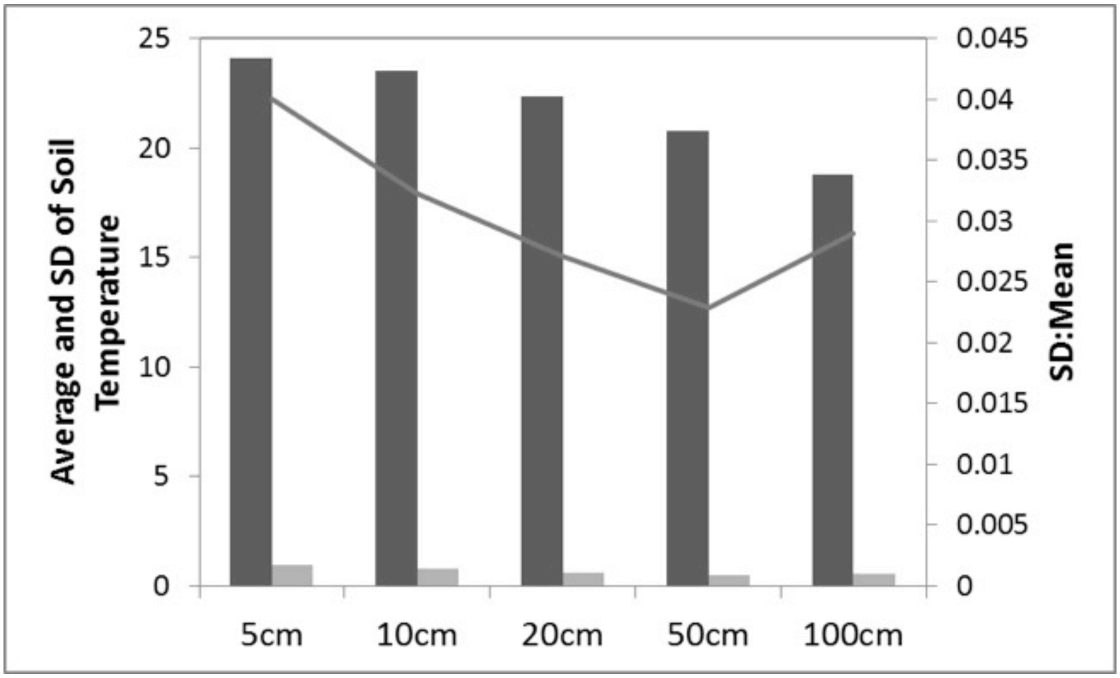

Figure 2: Soil temperature means (dark bars) and standard deviations (lighter bars) were produced from five soil depths across all stations recording measurements during the month of June 2011. Line graph (y-axis) was produced from ratios of standard deviations to means.

PLANNED WORK

- Continue work on soil observation quality assurance.
- Automate the post-ingest quality control procedure.
- Research the variability of soil data.
- Continued development of drought-monitoring products to increase data use.

PUBLICATIONS

Bell J.E., B. Baker, H. Diamond, M. Hall, J. Kochendorfer, J Lawrimore, R.D. Leeper, T Meyers, M.A. Palecki, and T Wilson. US Climate Reference Network: recently added soil observations. *In preparation*

PRESENTATIONS

Bell, J.E. and M.A. Palecki. USCRN soil temperature and moisture observations. Ameri can Meteorological Society. New Orleans. January 2012

Bell, J.E. US Climate Reference Network. NCSU Mountain Horticultural Crops Research and Extension Center. Mills River, North Carolina. 22 September 2011

Bell, J.E. US Climate Reference Network Overview and Soil Moisture/Temperature Monitoring. Soil Science Department. Raleigh, North Carolina. 25 August 2011

Bell, J.E. US Climate Reference Network: Soil Moisture/Temperature. NOAA/NESDIS Cooperative Research Program Symposium. Asheville, North Carolina. 18 August 2011

OTHER

First Place Oral Presentation at the NOAA/NESDIS Cooperative Research Program Symposium.

Development and Testing of a Next Generation US Climate Reference Network (USCRN) Quality Assurance Methodology for Precipitation

Task Leader Ronald D. Leeper
Task Code
Date Awarded 07/01/2011
Contribution to CICS Themes Theme 1: 10%; Theme 2: 90%
Contribution to NOAA Goals Goal 1: 10%; Goal 2: 90%

EXECUTIVE SUMMARY

This research tested various precipitation quality assurance (QA) algorithms in both artificial and field scenarios with the intent of identifying a QA variant with a greater level of skill detecting precipitation signals.

BACKGROUND

This task is part of an ongoing effort by the USCRN team to review current quality assurance (QA) procedures and make recommendations when needed as outlined in the USCRN Program Development Plan. Evaluation of current USCRN QA strategy for precipitation has revealed several non-precipitation processes that can limit current QA (currentQA) performance. In this research, two separate QA methodologies were proposed and evaluated against the current procedure.

ACCOMPLISHMENTS

Two separate QA procedures were developed to ensure a broad range of possible solutions were considered to address current QA (currentQA) sensitivities. An incremental approach (incrementQA), which consisted of modest changes to the original algorithm, was developed as the evolution of the currentQA methodology. The second method (weightedAvgQA), by including past wire performance in the generation of weights applied to calculation of precipitation, significantly differed from both current and increment QA variants.

Preliminary findings support the adoption of a newer precipitation QA algorithm that has been found to be both more skillful in artificial testing and have reduced sensitive to non-precipitation processes observed in the field (figure 1). Annual precipitation calculations from weightedAvgQA on average exceeded currentQA estimates by 2.0%.

A precipitation generator was designed to evaluate QA performance with respect to the detection of an artificial signal. The precipitation generator takes a user defined precipitation event, and produces an artificial output signal that represents the event. Users can additionally embed various levels of randomly generated gauge noise and evaporation components onto the artificial signal. Generated gauge output can then be processed through each of the variants to quantify QA performance with regard to signal detection. Table 1 shows ensemble mean absolute errors (MAE) for each of the QA variants at various levels of embedded gauge noise and evaporation for an artificial heavy precipitation event.

PLANNED WORK

- Additional field comparisons specifically targeting periods in the network history and stations that have had different network architecture (i.e. periods with and without wetness sensors, five minute versus fifteen minute data streams, stations with known communication issues and those exposed to nature, etc.).
- Evaluation of QA variant change on station calculated precipitation pseudo-normals.

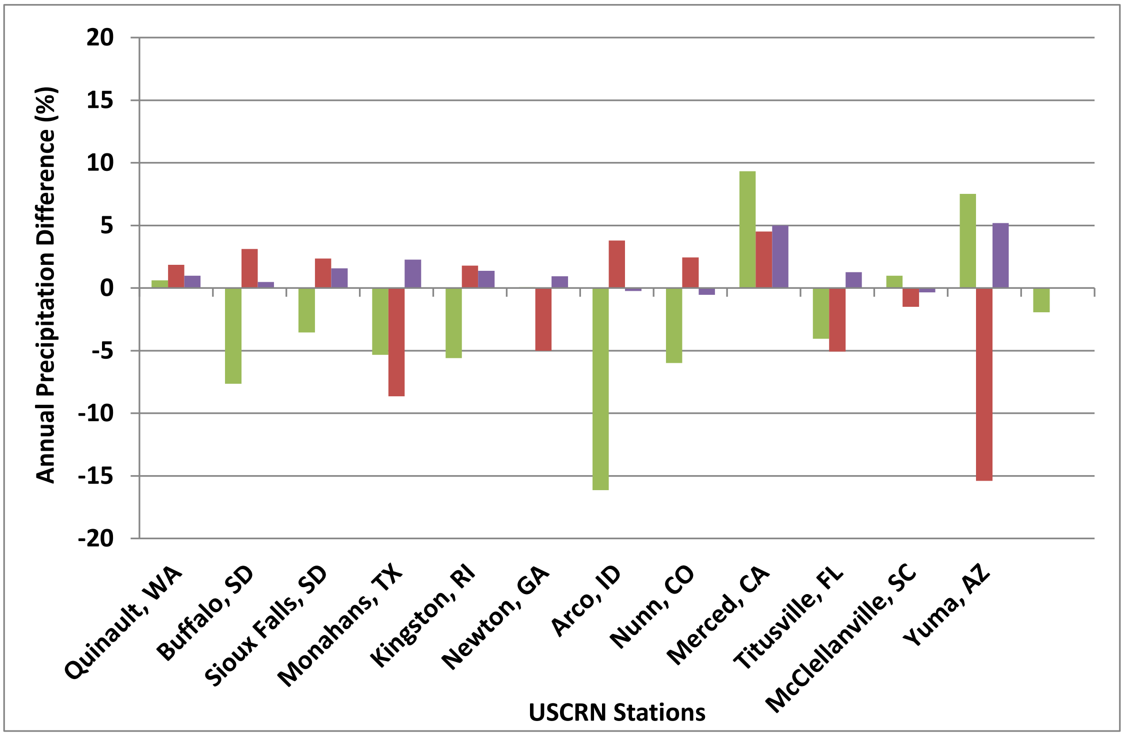

Figure 1:Annual precipitation differences for 2010 calculated as (QA-variant minus currentQA) for (green) tipping bucket, (red) incrementQA, and (purple) weightedAvgQA for a series of USCRN stations.

Table 1: *CurrentQA, incrementQA, and weightedAvgQA one-hundred member ensemble MAE for an artificial heavy precipitation event at various levels of gauge evaporation (0.00 – 0.02) and wire noise (000,111,113,133,and 333).*

QA Variants	Gauge Evaporation	Noise Level Per Wire				
		000	**111**	**113**	**133**	**333**
CurrentQA	0	0.27	0.21	0.34	0.61	0.75
	0.01	0.17	0.20	0.31	0.48	0.52
	0.02	0.09	0.21	0.30	0.44	0.45
IncrementQA	0	0.17	0.12	0.14	0.22	0.56
	0.01	0.07	0.10	0.14	0.21	0.40
	0.02	0.07	0.12	0.15	0.19	0.33
weightedAvgQA	0	0.03	0.07	0.08	0.13	0.22
	0.01	0.03	0.07	0.08	0.12	0.21
	0.02	0.04	0.07	0.08	0.13	0.21

PUBLICATIONS

Leeper, R. D., Davis, J., and Palecki, M. A. (Internal Review) Precipitation Quality Assurance Methods for Weighting Bucket Precipitation Gauges Producing Three Redundant Measurements.

PRESENTATIONS

Leeper, R. D. (Oral Presentation) Precipitation Quality Assurance Methods for Weighting Bucket Precipitation Gauges Having Three Redundant Measurements. AMS Joint Conference on Climate Variations and Change and the Symposium on Meteorological Observations and Instrumentation. New Orleans, LA January, 2012.

OTHER

None

Collocated US Climate Reference Network (USCRN) and Cooperative Observer Network (COOP) Precipitation Comparisons

Task Leader Ronald D. Leeper
Task Code
Date Awarded 07/01/2011
Contribution to CICS Themes Theme 2: 100%
Contribution to NOAA Goals Goal 1: 10%; Goal 2: 90%

EXECUTIVE SUMMARY

The purpose of this comparisons study was to identify the added value of USCRN station architecture/infrastructure (observational redundancy, sensor shielding, automation, etc.) on the observation of precipitation.

BACKGROUND

USCRN was specifically engineered to detect and monitor US temperature and precipitation climate signals. Special consideration to the design and sensor selection makes the USCRN one of the first networks in the world in host both temperature and precipitation observations in triplicate form. In addition, USCRN is one of the first networks to fully shield rain gauges in both a small-double-fence inter-comparison reference (SDFIR) and double-alter shields (figure 2) in addition to heating the gauge orifice to with stand all types of atmospheric conditions. The purpose of this investigation was to evaluate the impact of station design on the observation of precipitation.

This study primarily focused on collocated comparisons between COOP and USCRN stations. Additionally, other observational networks within a mile of the collocated pair were also considered. Comparisons were made at annual, monthly, and event-wise (multiday sum) time scales with days having missing data from either network excluded.

ACCOMPLISHMENTS

USCRN observed precipitation comparisons helped identify multiple erroneous COOP observations that were often un-flagged by quality control procedures. Quires concerning these erroneous observations have been submitted to the National Weather Service for review. At present, over 70 mm of false precipitation has been removed from NCDC data records. These examples showcase the value of using the USCRN as a “reference” network.

Despite the presence of potentially errant COOP observations and USCRN sensitivity to non-precipitation processes, collocated USCRN and COOP data were very similar with r^2 typically greater than 0.9. Nonetheless, COOP tended to slightly over-catch USCRN observations. This was the case regardless of 1.5 meter wind speeds (light or strong). However, under frozen conditions (maximum temperature less than -5 °C) USCRN persistently over caught COOP stations (figure 3). The added value of station infrastructure, in this case gauge shielding and heated orifice, improved the capture of frozen hydrometers.

Figure 2: Photograph of well-shielded Geonor rain gauge showing both wooded SDFIR and metal double alter shields at the USCRN station in Torrey, Utah.

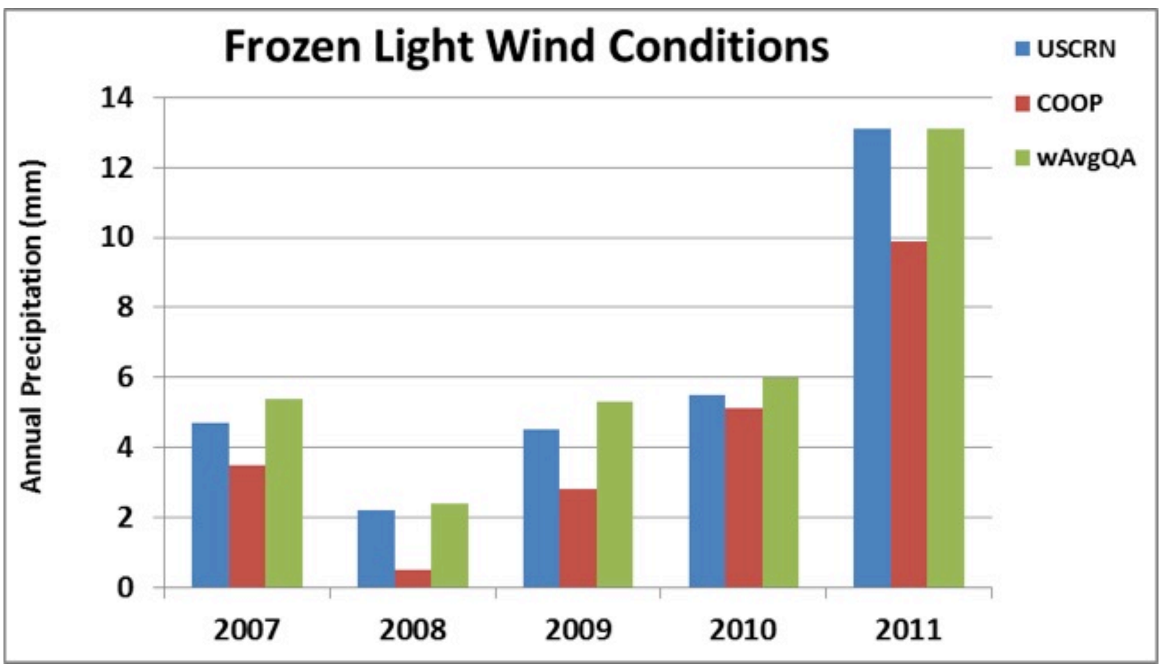

Figure 3: Annual precipitation estimates for (blue) USCRN, (red) COOP, and (Green) USCRN-weightedAvgQA variant under light wind (speeds < 4 ms^{-1}), frozen (maximum daily temperature less than -5 °C) conditions for the collocated station pair in Harrison, NE.

A rain gauge noise index was developed to assess the overall level of noisiness at any given moment in time. The gauge index is a composite of each of the three wire noise levels where wire noise is a metric of hourly first order difference ranges. The noise index will be incorporated in this study to determine if precipitation discrepancies could be partially attributed to USCRN gauge noise.

PLANNED WORK

- Include maximum and minimum temperature comparisons to evaluate the importance of network design on temperature records relative to COOP stations
- Write an initial draft that introduces the USCRN, outlining the mission, purpose, station design, climate observables, and incorporate a portion of these station comparisons.
- Fine tune the noise index so a near-real time monitor of USCRN gauge noise levels can be developed.

PUBLICATIONS

None

PRESENTATIONS

Leeper, R. D (Oral Presentation) Role of Network Architecture in Surface-Based in-situ climate observations. AMS Conference on Applied Climatology. Asheville, NC 18th July 2011

OTHER

None

Maintenance and Streamlining of the Global Historical Climatology Network Monthly (GHCN-M) Dataset

Task Leader	Jared Rennie
Task Code	
Date Awarded	7/30/2010
Contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals	Goal 1: 90%; Goal 2: 10%

EXECUTIVE SUMMARY
Continuously monitoring operations of GHCN-M version 3. Using the International Surface Temperature Initiative, new stations will be available for observing global climate variability and change. This will lead to the development of GHCN-M version 4.

BACKGROUND
Since the early 1990s the Global Historical Climatology Network-Monthly (GHCN-M) dataset has been an internationally recognized source of information for the study of observed variability and change in land surface temperature. Version 3, which marks the first major revision to this dataset in over a decade, became operational in May 2011 and provides monthly mean temperature data for 7280 stations from 226 countries and territories. This version introduces a number of improvements and changes that include consolidating "duplicate" series, updating records from recent decades, and the use of new approaches to homogenization and quality assurance. Since its initial release, GHCN-M version 3 has undergone minor updates to incorporate monthly maximum and minimum temperature, as well as improve processing run time.

Efforts are underway to upgrade GHCN-M and release version 4. One of the major priorities of this update is to add more stations to improve spatial and temporal scales. The International Surface Temperature Initiative (ISTI), a working group of climate scientists, meteorologists, and statisticians, consists of an effort to create an end-to-end process for land surface air temperature analyses. The goal is to create a single, comprehensive global databank of surface meteorological observations. The databank will be version controlled and seek to ascertain data provenance. There are multiple stages of the databank, including the original paper record, keyed data in its native format, and a merged dataset with duplicate source data reconciled. All data, along with its underlying code, will be made public free of charge, in order to be open and transparent.

Once the databank is released, more stations with better provenance will be added into current GHCN-M processing to create a more robust dataset. Other goals of GHCN-M v4 include improving quality assurance, as well as addressing uncertainties within the surface temperature record.

ACCOMPLISHMENTS
Multiple sources of data, on monthly and daily timescales, have been submitted to NCDC and uploaded to the Databank FTP site. Some sources contain digital images of the origi-

nal paper copy (known as Stage 0), while all should contain keyed data in its native format (Stage 1). Data is then converted into a common format and data provenance flags are added to every single observation (Stage 2). These flags are determined based upon information provided by the data sender. Some examples include whether an original paper copy is available, and if any quality control or homogenization was applied to the dataset prior to submission. Currently, there are 20 daily sources and 18 monthly sources that have been converted to Stage 2. In addition, all daily sources were converted into monthly averages, in order to make the monthly version of the databank more robust.

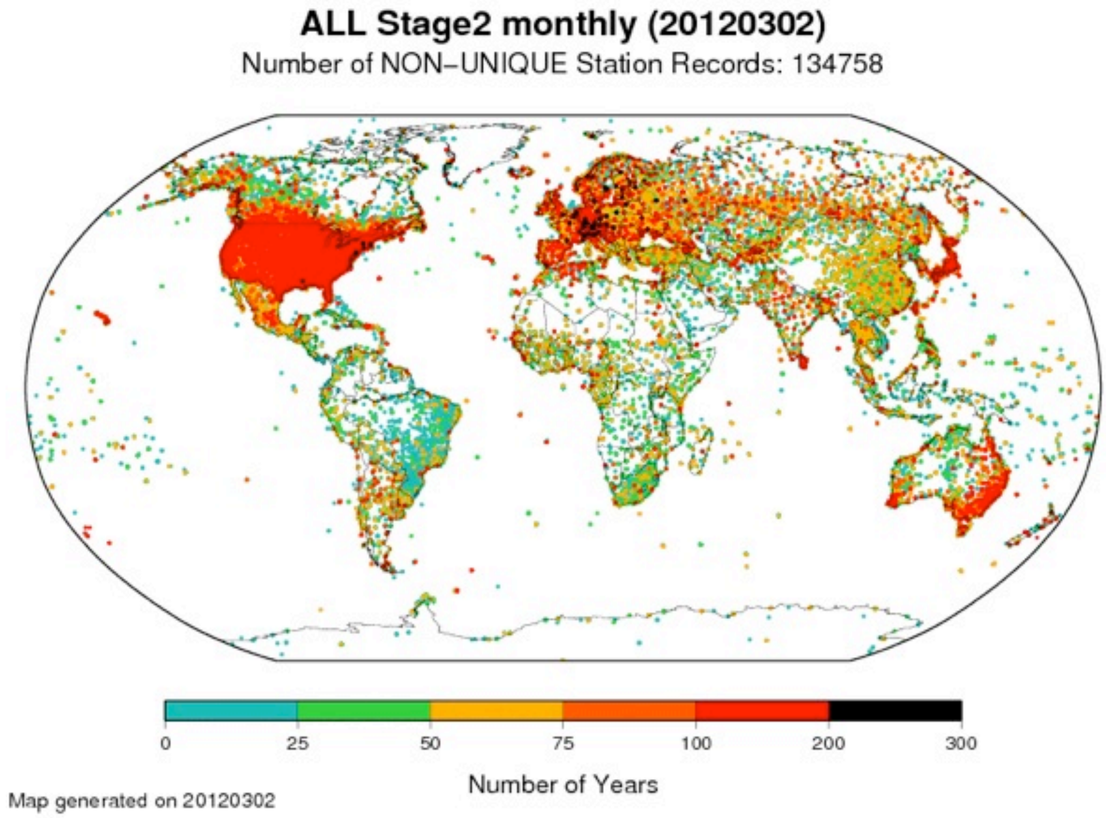

Figure 1: Location of Stage 2 monthly station records in the databank, along with their period of record.

Currently there are 134,758 station records in Stage 2, which include the monthly sources, as well as the "monthly averaged" daily sources (see Figure 1). The algorithm to merge these sources into a single merged Stage 3 dataset with duplicates removed is currently under development. The process occurs in an iterative fashion through all the sources, and comparisons are made to determine if a station match exists and a merge should occur. This process is designed to be Bayesian in approach and based upon metadata matching and data equivalence criteria. Metadata comparisons include the geographic distance between the stations, elevation difference, and an algorithm for station name similarity. Data comparisons include "goodness-of-fit" measures for overlapping data, and neighbor comparisons for non-overlapping data. Weighted priors are formed based upon bootstrapping techniques, and are then recombined to form a posterior probability of station match. Validation of each technique is being applied using stations with known bias and noise and comparing output.

The algorithm is being designed to be modular, and easy to read by researchers. If an analyst determines that certain techniques are inadequate, or if they wish to apply their own techniques, the modularity of the algorithm should facilitate this with minimal effort.

PLANNED WORK

- Continue work on merge program, and release version 1.0 of merged Stage 3 dataset, along with code.
- Receive feedback from public, and provide updates as needed.
- Using Stage 3 dataset, apply quality control and bias corrections, and evaluate performance.
- Establish end-to-end process for GHCN-M version 4.0 production
- Release GHCN-M version 4.0 to the public

PUBLICATIONS

Lawrimore, J.H. et al (2011) The International Surface Temperature Initiative's Global Land Surface Databank. *Submitted to the 9th International Temperature Symposium*

PRESENTATIONS

Rennie, J.J. (2011), The International Surface Temperature Initiative: Global Land Surface Databank Development, CICS Science Meeting, National Climatic Data Center, Asheville, NC, 3 Nov 2011.

OTHER / LINKS

Location of latest GHCN-M version 3 dataset: http://www.ncdc.noaa.gov/ghcnm/v3.php

The International Surface Temperature Initiative: www.surfacetemperatures.org

FTP site of the Global Databank:
http://www.gosic.org/GLOBAL_SURFACE_DATABANK/GBD.html

Assessments, improving understanding of historical observations and instigation of future reference observations

Task Leader	Peter Thorne
Task Code	
Date Awarded	7/01/2010
Contribution to CICS Themes	Theme 1: 30%; Theme 2: 60%; Theme 3: 10%
Contribution to NOAA Goals	Goal 1: 90%; Goal 2: 10%

EXECUTIVE SUMMARY

Significant progress has been made on creation of a new surface temperature databank resource with over 40 contributions from the international community that will yield an initial release consisting of the order of 40,000 stations – a marked improvement over GHCN. A substantial reassessment of US surface temperature records reinforced our understanding of this record and pointed to an asymmetrical error with far greater probability that we underestimate than overestimate the real trend. The GCOS Reference Upper Air Network continues to grow and we have received applications from several new sites.

BACKGROUND

In situ climate records represent a substantial challenge both historically and into the future. These measurements were never made in a metrologically traceable fashion and change has been ubiquitous. These projects aim to address both the backward looking problem and propose solutions moving forwards.

The International Surface Temperature Initiative aims to improve our fundamental understanding of historical land surface records through a renewed effort to gain better 'raw' data holdings and improved provenance thereof, look at the homogenization problem anew and undertake benchmarking (software testing) in a rigorous fashion.

The GCOS Reference Upper Air Network aims to create a network of global reference quality measurements with robust uncertainty estimates derived through an unbroken chain to absolute standards. Within year representation was made to GCOS to instigate a similar global surface network along the lines of USCRN. Within a system of systems approach such networks form the top tier and will be instrumental in insuring the quality of the future climate record for future generations of researchers.

ACCOMPLISHMENTS

Significant advances have been made in the efforts to create a first version release of a monthly land surface temperature databank. Over 40 data sources have been accrued from national and international partners. Work has then been undertaken by CICS and NCDC staff to create a merging procedure that is automatic, modular, and tunable. Efforts are ongoing in this regard and a first release is envisaged in summer 2012. This release is likely to consist of the order 40,000 unique stations. Figure 1 shows the map of station availability in the 40 sources prior to attempting to merge.

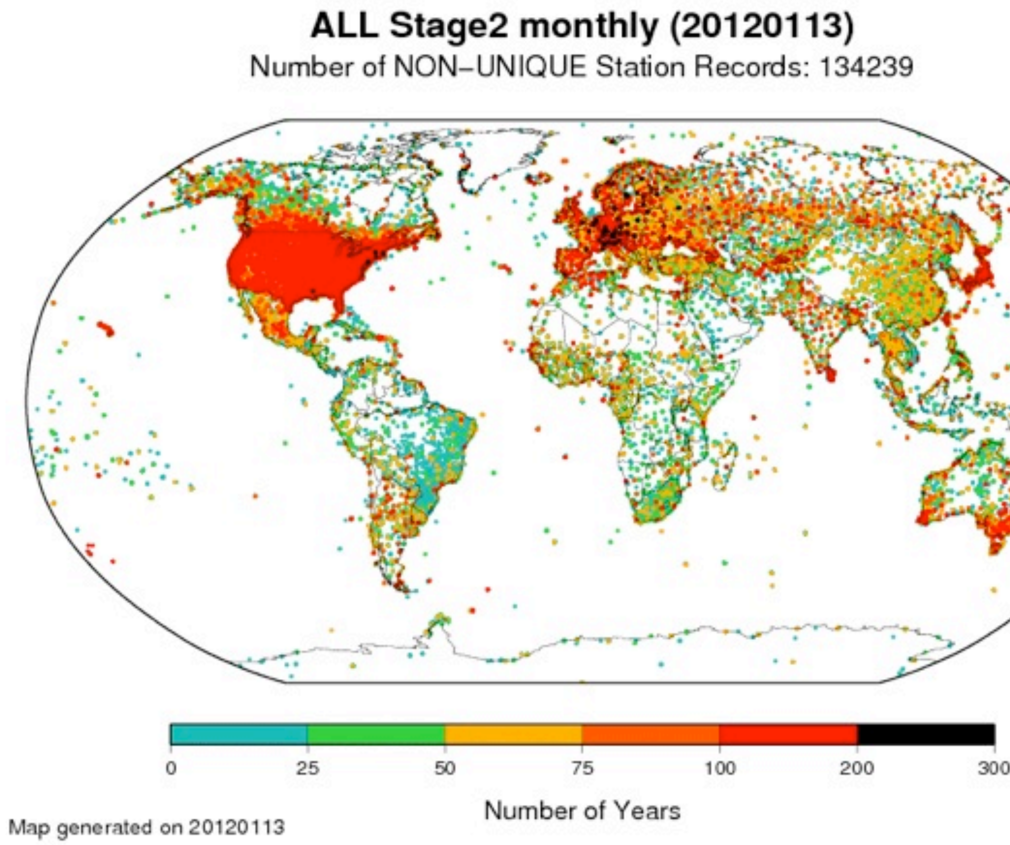

Figure 1: Map of station coverage as at 1/13/12 in the databank. Source: Jared Rennie

Significant efforts have also accrued on other aspects of the surface temperature initiative. An example of benchmarking approaches has been published in JGR considering the US land surface data record USHCN. The use of benchmarks, and an ensemble of plausible realizations of the pairwise homogenization algorithm yielded additional insights into the likely uncertainties in this record. The algorithm was shown to be reasonable but have a propensity to under-estimate the trend adjustment required in the presence of an overall systematically biased input data stream with a propensity for breaks of one sign. This is similar to known facets of the US surface raw data yielding a conclusion that we are far more likely to be underestimating than overestimating CONUS warming trends.

Efforts continue to build up the GCOS Reference Upper Air Network. Regulatory materials have been prepared and vetted. Data has started flowing for the first product – radiosonde profiles – through NOAA NCDC. Significant progress has been made towards bringing additional measurements into the data stream including lidars, radiometers and GPS precipitable water. Three new sites have applied or are in the process of applying to join the network.

Work has continued on the IPCC WG1 AR5 drafting process. The First Order Draft was prepared and submitted to review. These reviews art now in the process of being considered. Authorship on the climate chapter team for the National Climate Assessment has started.

PLANNED WORK

- Continued work on IPCC and NCA assessment activities
- Continued oversight of the development of the GCOS Reference Upper Air Network
- Continued oversight of the International Surface Temperature Initiative
- Data bank release and publications
- GHCNMv4 product release support
- Efforts to assess sensitivity of diurnal temperature range trends to inhomogeneities

PUBLICATIONS (4/1-3/31 published only)

Williams, C. N., M. J. Menne, and P. W. Thorne, Benchmarking the performance of pairwise homogenization of surface temperatures in the United States. J. Geophys. Res., 117, D05116, doi:10.1029/2011JD016761

Thorne, P. W., K. M. Willett et al. Guiding the Creation of a Comprehensive Surface Temperature Resource for 21st Century Climate Science. *Bull. Am. Met. Soc.*, DOI: 10.1175/2011BAMS3124.1

Santer, B. D., C.A. Mears, C. Doutriaux, P.M. Caldwell, P.J. Gleckler, T.M.L. Wigley, S. Solomon, N. Gillett, D.P. Ivanova, T.R. Karl, J.R. Lanzante, G.A. Meehl, P.A. Stott, K.E. Taylor, P. Thorne, M.F. Wehner, and F.J. Wentz. Separating Signal and Noise in Atmospheric Temperature Changes: The Importance of Timescale. *J. Geophys. Res.*, doi:10.1029/2011JD016263,

Peterson, T. C., K. M. Willett et al. Observed changes in surface atmospheric energy over land. *Geophys. Res. Lett.*, **38**: L16707, doi:10.1029/2011GL048442

Thorne, P. W., et al. A quantification of uncertainties in historical tropical tropospheric temperature trends from radiosondes. *J. Geophys. Res. - Atmos.*, **116**, D12116, DOI: 10.1029/2010JD015487.

Seidel, D. J., N. P. Gillett et al. Stratospheric temperature trends: Our evolving understanding. *WIRES: Climate Change*, **2**(4): 592-616 DOI: 10.1002/wcc.125

Blunden, J., D. S. Arndt et al. State of the climate in 2010. *Bull. Amer. Met. Soc.*, **92**(6), S1-S266

Dai, A. G., J. H. Wang, et al. A New Approach to Homogenize Daily Radiosonde Humidity Data. *J. Clim.*, **24**(4): 965-991.

Mears, C. A., F. J. Wentz, et al. Assessing uncertainty in estimates of atmospheric temperature changes from MSU and AMSU using a Monte-Carlo estimation technique. *J. Geophys. Res. - Atmos.*, **116**, D08112 doi:10.1029/2010JD014954.

PRESENTATIONS

Thorne, P. W. An overview of the International Surface Temperature Initiative, NIST, MD, June 2011

Thorne, P. W. International Surface Temperature Initiative overview, WCRP Open Science Conference, Denver, 2011

Thorne, P. W. GCOS Reference Upper Air Network, at CICS/SAMSI workshop Jan 2012

Thorne, P. W., What is the GCOS Reference Upper Air Network?, CBS Expert Team meeting on regulatory materials, Geneva, Switzerland, Jan 2012.

Thorne, P. W. International surface temperature initiative overview, International Temperature Symposium 9 (ITS9), CA, March 2012 (invited plenary talk)

Thorne, P. W. GCOS Reference Upper Air Network: An introduction, ITS9, CA, March 2012

Voemel, H, Thorne P. W., GCOS Reference Upper Air Network: uncertainty estimation, ITS9, CA March 2012

Lawrimore, J., Thorne P., ISTI: Surface databank progress. ITS9, CA, March 2012

Presentation for NCDC's Thirsty Thursday Seminars: *How Do We Know the World is Warming?*

OTHER

- Visit to NIST to discuss collaboration, June 2011
- Principal organizer 4th Implementation and Coordination meeting of GCOS Reference Upper Air Network, Tokyo, Japan, March 2012
- BAMS state of the climate 2011 global chapter co-editor
- Hosted visits by UK Met Office staff and climate code foundation
- Helped in instigation of citizen science alliance tropical cyclone classification crowd-sourcing project.
- Member of science advisory panel to climate code foundation
- Member of steering committee of Earthtemp initiative
- Signed letters of intent with meteomet initiative to enable collaboration with European NMIs for GRUAN and ISTI.
- Closing Plenary Remarks at ITS9 (only 4 selected out of 600)

WEBPAGE LINKS

http://www.surfacetemperatures.org
http://www.gruan.org

Climate Monitoring and Research Support to the Atmospheric Turbulence and Diffusion Division of NOAA's Air Resources Laboratory

Task Leader Mark E. Hall
Task Code
Date Awarded 7/01/2011
Contribution to CICS Themes Theme 2: 100%
Contribution to NOAA Goals Goal 1: 100%

EXECUTIVE SUMMARY
ORAU will assist NOAA/ATDD in the installation of new USCRN and USRCRN stations based on each program's performance measures and will perform routine annual maintenance visits to the existing USCRN and USRCRN sites. ORAU will also assist with the regular calibration of various sensors deployed at the monitoring sites.

BACKGROUND
ATDD is one of three field divisions of the NOAA's ARL. Through ATDD, ORAU works closely with NOAA to perform lower atmosphere research in the areas of air quality, contaminant dispersion, and climate.

ATDD's objectives are to:
- Develop better methods for predicting transport and dispersion of air pollutants
- Improve modeling of air-surface exchange of water, energy, and carbon so that their effect(s) on the earth's climate may be better understood
- Make high-quality measurements in support of these efforts toward increased understanding
- Install and maintain a long-term, self-consistent system to monitor climate across the United States.
- ATDD's staff has historically consisted of Federal civil servants from NOAA and personnel from ORAU /Oak Ridge Institute for Science and Education (ORISE). These personnel contribute 100% of their time in support of ATDD's mission, work toward goals set by the ATDD Director, and are co-located with the NOAA personnel.

One of the primary *foci* for the ATDD/ORAU partnership has been sustaining NOAA's climate observing systems and developing research efforts that will enhance our understanding of a changing environment in the different ecosystems within the United States.

ACCOMPLISHMENTS
NOAA designated the USRCRN for modernization to better meet its mission of providing the nation with data regarding the state of a region's climate quality. To ensure the most accurate data are collected throughout the network, ATDD/ORAU completed the installation of 74 new USRCRN stations in the southwest climate region. The pilot project is part of NOAA's goal to install ~500 USRCRN stations.

ATDD/ORAU is leading the installation, calibration, and maintenance of the new, automated stations that will collect temperature and precipitation data every 5 minutes. Each new station includes triple redundant temperature and precipitation sensors for reliability. Additionally, the station is expandable to allow for any future interest in measuring soil temperature, soil moisture, snowfall, and snow depth. The first stations were installed in early October 2010, with an additional 50 stations added in FY2011. The ultimate goal is for both the USRCRN and the USCRN to work together to deliver accurate, high-quality data to users studying climate trends.

In FY2011 ATDD/ORAU was selected to expand the USCRN into Alaska. ORAU personnel are involved in site surveys, Arctic capable equipment, calibration and installation, operational test and evaluation, station commissioning, and life cycle operations and maintenance (O&M). The establishment of at least 29 Alaskan climate reference observing stations will enable the United States to have the same level of climate monitoring capability in Alaska compared to the national monitoring of temperature and precipitation trends in the lower 48 states (e.g., ability to track with at least 99% temperature and 98% precipitation accuracy for decadal trends). The Alaskan CRN is a NOAA legacy contribution to the International Polar Year (IPY) and the nation. The AKCRN is a most important part of the integrated national and global climate-observing system. AKCRN monitoring will significantly improve the understanding and knowledge of climate variability and change, which can often be more pronounced and detected earlier in high latitudes.

The Alaska CRN station near Tok, Alaska was installed in August 2011, which brought the total number of completed stations to 9. An additional 5 locations were surveyed for future installations.

PLANNED WORK

- ORAU will assist NOAA/ATDD in the installation of new USCRN and USRCRN stations for each fiscal year based on each program's performance measures and will perform routine annual maintenance visits to the existing USCRN and USRCRN sites. ORAU will also assist with the regular calibration of various sensors deployed at the monitoring sites.
- ORAU will provide design and measurement capabilities for the USCRN stations to include development of alternative power systems for use in harsh arctic environments.
- ORAU will calibrate instruments, train site operators, and test each system to reduce instrument failures. ORAU will also maintain a comprehensive inventory of equipment ready for deployment as either new stations or as replacement parts.
- ORAU will assist NOAA/ATDD in the operation, evaluation, and maintenance of the climate observing testbeds to evaluate new measurement technologies, including dataloggers, sensors, precipitation gauges, and communication systems.
- ORAU will provide engineering capability to provide alternative installation strategies in non-ideal locations, which could include solid rock foundations, arctic permafrost locations, extreme climates (e.g., arctic, Siberian, or desert) locations, and remote wild locations.

- ORAU will contribute to the metadata for the climate-observing systems to ensure continuity of data and data confidence.
- ORAU will research the climate trends and variability utilizing NOAA's monitoring networks. Peer-reviewed papers will be published as journal articles, symposium presentations, Technical memorandums, and trade articles.

PUBLICATIONS

Rasmussen, R., Baker C.B., J. Kochendorfer, T. Meyers, S. Landolt, A. Fisher, J. Black, J. Theriault., P. Kucera, D. Gochis, C. Smith, R. Nitu, M. Hall, S. Cristanelli, E. Gutmann (2012). The NOAA/FAA/NCAR Winter Precipitation Test Bed: How Well Are We Measuring Snow? Bulletin of American Meteorological Society. *Published online February 2012, will be in print June 2012.*

PRESENTATIONS

2 presentations at the annual American Meteorological Society meeting.

OTHER

None

5.4 National Climate Assessments

Maps, Marshes and Management: Ecological Effects of Sea Level Rise in NC	
Task Leader	Thomas R. Allen
Task Code	
Date Awarded	10/19/2011
Contribution to CICS Themes	Theme 1: 70%; Theme 2: 20%; Theme 3: 10%.
Contribution to NOAA Goals	Goal 1: 0%; Goal 2: 100%

EXECUTIVE SUMMARY

The overall goal of this project is to provide information and practical tools to draw upon prior NOAA-funded ecological research on sea-level rise in NC in order to enhance coastal management and decision-making for ecological restoration, shoreline erosion abatement (e.g., living shoreline site suitability), and planning for sustainability of wetlands undergoing sea-level transgression. Accomplishments in this early phase of the project include organizing a stakeholder advisory group, completing a data and project tool inventory, needs and capability assessment for web map applications, and hosting a workshop for interested partners in the digital online atlas component.

BACKGROUND

The NOAA Ecological Effects of Sea-Level Rise project funded by NOAA CSCOR Sea-Level Rise Program launched multiple basic and applied science investigations of wetland responses to sea-level rise, sedimentation rate measurement, and landscape simulation modeling. This follow-on synthesizes and expands selected results of this research in conjunction with collaborating managers (Albemarle-Pamlico National Estuary Program/APNEP, NC Division of Coastal Management, and The Nature Conservancy.)

ACCOMPLISHMENTS

A volunteer advisory committee was established prior to the proposed work and confirmed once the project funding was announced, including Dr. Brian Boutin (*The Nature Conservancy*, NC Coastal Climate Change Adaptation Program), APNEP staff (Director Dr. Bill Crowell, Dean Carpenter, and Bill Hawhee) and Tancred Miller (Policy Analyst, NC DCM.)

A geospatial analyst was hired and has conducted a review of alterative available web map portals and compiled the templates and software installation. Hardware for long-term and high-bandwidth operational use is currently being assessed. New software pending release in summer 2012 will also be evaluated for enhanced functionality.

Initial prototype maps have been installed on a test server with a website (not disclosed to the public while under development; http://www.ecu.edu/renci/coastalatlas/).
The preliminary maps compile shoreline and sea-level rise inundation products from the prior EESLR project and ongoing work at ECU.

A workshop was held on February 13 at ECU to solicit feedback on the plans and broader coastal atlas initiatives that might be pursued. Fourteen representatives attended from outside ECU from cooperating institutions and the advisory committee. A recent outcome of this meeting is the leveraging forthcoming from NC DCM in its NOAA and Governor's South Atlantic Alliance initiatives. In addition, the group identified the ECU Joyner Library as a prospective partner. An initial meeting between library staff and the ECU team has prompted additional meetings and closer involvement so that research and discovery could be enhanced in a coastal atlas project.

In compiling geospatial data content for the atlas, the team has obtained all available NC ocean shorelines, access to estuarine shoreline GIS data under development, seamless LiDAR DEMs, and a map of vulnerable low-lying lands produced in-house. The latter layer has already been shared with our APNEP management partner for evaluation of human and environmental health vulnerabilities, and a presentation and publication are in review.

A presentation on the project was given to the NOAA-in-the-Carolinas annual meeting, held in Charleston, SC, on March 15-16th. The map produced as a baseline for sea-level rise was also accepted for publication in the forthcoming annual *ESRI Map Book* (Fig. 1) due out this summer.

PLANNED WORK

- Draft web map portals are now being refined for shoreline erosion and sea-level rise and will require iterative review and editing with our partners.
- Development of decision-support tools, interactive capability, and computationally feasibility are in initial phase of development.
- Toward the end of this fiscal year, the focus will turn to the higher order analysis of model incorporation via the online GIS (e.g., MEMII or similar spatially enabled marsh response modeling, currently restricted to site-based modeling), requiring a higher degree of coding and scientific evaluation.

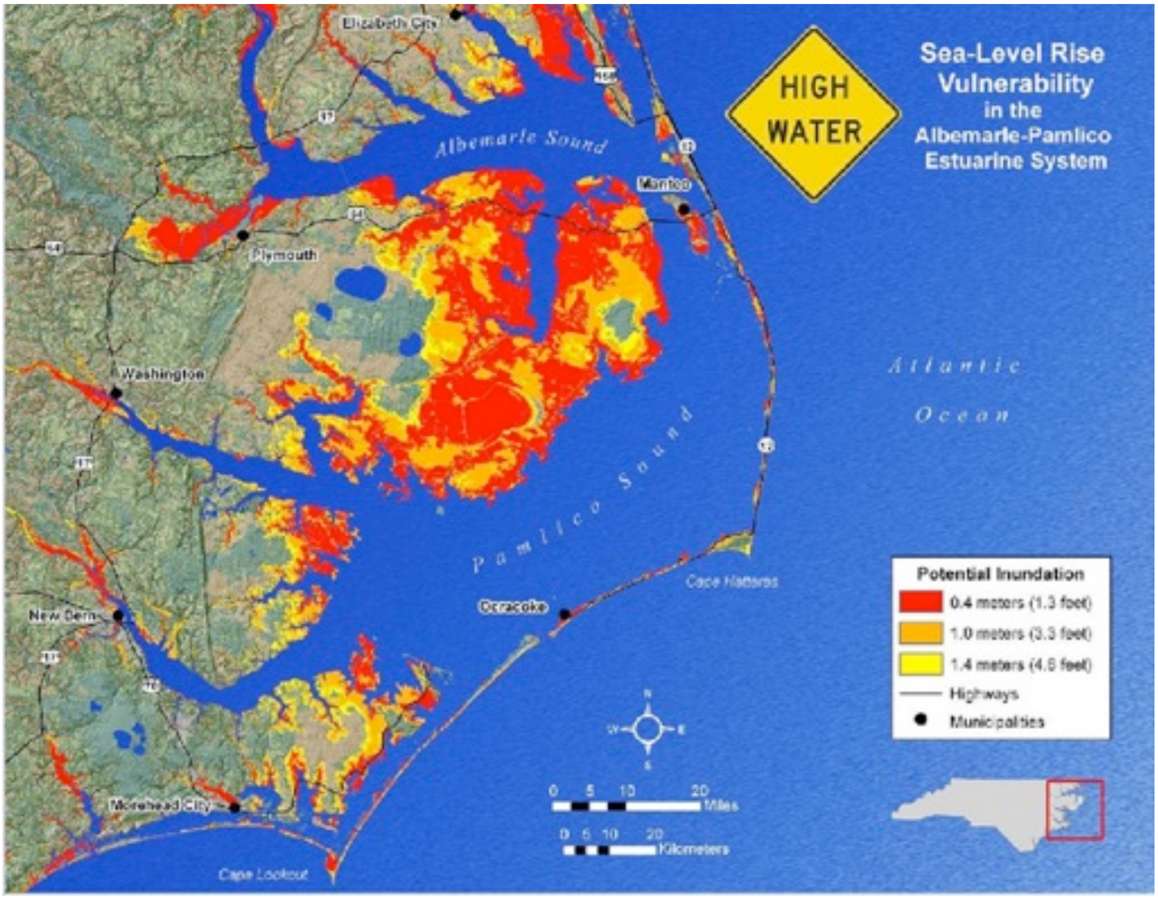

Figure 7 Sea-Level Rise Vulnerability Map to be published in ESRI Annual Map Book (2012).

PUBLICATIONS

Carey, M., B. Gore, T. Hill, M. Covi, and T. Allen. 2012. Sea-Level Rise Vulnerability in the Albemarle-Pamlico Estuarine System. *ESRI Map Book* XX (forthcoming.)

PRESENTATIONS

Allen, T.R. Visualization and Decision-Support Tool Developments. NOAA-in-the-Carolinas, Charleston, SC, March 15-16, 2012.

OTHER

None

Technical Support Unit (TSU) for the National Climate Assessment

Task Leader	Paula Hennon
Task Code	
Date Awarded	11/11/2011
Contribution to CICS Themes	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Contribution to NOAA Goals	Goal 1: 100%

EXECUTIVE SUMMARY

The TSU provided scientific, graphical, coordination, technical and strategic support for the National Climate Assessment (NCA), yielding many critical products and contributions. These contributions included the production of regional climatologies and outlooks for all eight regions of the NCA, developing data management, strategic interagency planning, workshop support, Federal Advisory Committee meeting support and web system development, as well as many other contributions.

BACKGROUND

NOAA is participating in the high-level, visible, and legally mandated National Climate Assessment (NCA) process, which will be responsive to greater emphasis on user-driven science needs under the auspices of the US Global Change Research Program (USGCRP). National climate assessments are intended to advance the understanding of climate science in the larger social, ecological, and policy systems to provide integrated analyses of impacts and vulnerability. NOAA's National Climatic Data Center (NCDC) and many parts of NOAA have provided leadership on climate assessment activities for over a decade. A renewed focus on national and regional climate assessments to support improved decision-making across the country continues to emerge. Decisions related to adaptation at all scales as well as mitigation and other climate-sensitive decisions will be supported through an assessment design that is collaborative, authoritative, responsive and transparent. NOAA is working through an interagency process and investing in partnerships across many scales to support this comprehensive assessment activity.

ACCOMPLISHMENTS

In its second year at NCDC, NOAA’s Assessment Technical Support Unit (TSU) continued to provide critical input and support to the National Climate Assessment (NCA) being run by the U.S. Global Change Research Program. The NCA is being conducted under the auspices of the Global Change Research Act of 1990, which calls for a report to the President and Congress that evaluates, integrates, and interprets the findings of the federal research program on global change (USGCRP) every four years.

As the agencies comprising USGCRP seek to establish an ongoing, sustainable assessment process, as well as deliver a timely report in 2013, NCDC’s TSU and the staff at USGCRP work in concert to provide coordination and technical support to a wide network of interagency and external groups and individuals. The TSU has coordinated and facilitated several meetings of the National Climate Assessment Development and Advisory Committee – the federal advisory committee for the NCA – as well as a series of workshops held to develop technical input to the NCA.

Scientific support staff at the TSU had a busy year producing regional climatologies and projected, high-resolution outlooks for each of the eight NCA geographic regions. Additionally, they fulfilled several requests for new scientific analyses from various regional and sectoral teams working to provide technical input to the NCA. Other functions of the TSU include data management for the NCA, coordinating regional engagement for the NCA and strategic planning for the NOAA Assessment Services Program as a whole.

A final significant focus of the TSU is the development of an interagency "Global Change Information System" initially focused on providing web access to the NCA, but also ensuring robust traceability of sources, connection to other climate and environmental information across the Government and elsewhere, and using cutting edge data access methods. This web-focused activity of the NCA will serve as a key component of the ongoing, sustainable process. Early progress has included redeploying the 2009 "Global Climate Change in the United States" report to test some principles of traceability and searchability, developing collaborative work spaces for the approximately 250 authors and more than two dozen technical input teams, and facilitating upload of over 120 technical inputs to the process.

PLANNED WORK

- Build and manage the editorial team, which will translate the scientific text and assessment information into a non-scientific, public facing document readable by the Congress and the general public
- Identify, onboard, and manage the core National Climate Assessments web development team, who will build the website for the National Climate Assessments and provide enhanced text and data visualization capabilities
- Develop a proposal for various publishing company that are targeted to publish the final National Climate Assessments reports
- Develop process and methodology for tabloid and on-line magazine so that final report can be viewable in multiple formats
- Conduct content review of the information in the National Climate Assessments
- Continue to manage the overall team, their activities and milestones, and provide general management oversight of the report completion process
- Develop the technical and process interface and interaction between CICS-NC and NCA

PUBLICATIONS

None

PRESENTATIONS

Scheduled to deliver NCDC center-wide overview of the National Climate Assessments activities

OTHER

Supported the upload of technical and scientific input that allowed 113 users, through secure access, to submit 211 technical inputs directly to the NCA author-collaboration website. An additional 321 submissions were made through email and were subsequently uploaded into the system. A total of 532 technical inputs were submitted by the deadline of March 1st 2012.

National Climate Assessment Scientific Support Activities

Task Leader Kenneth E. Kunkel
Task Code
Date Awarded 09/15/2010
Contribution to CICS Themes Theme 3: 100%
Contribution to NOAA Goals Goal 1: 100%

EXECUTIVE SUMMARY

An analysis of the physical climate of the National Climate Assessment (NCA) regions was completed, including historical trends based on NOAA climate observations and 21st Century projections based on CMIP3 and NARCCAP climate models, for use by the authors of the 2013 NCA report. Research on extreme precipitation trends identified the major meteorological phenomena responsible for observed upward trends and examined the potential effects of climate change on estimates of probable maximum precipitation.

BACKGROUND

NOAA is participating in the high-level, visible, and legally mandated National Climate Assessment (NCA) process, which will be responsive to greater emphasis on user-driven science needs under the auspices of the US Global Change Research Program (USGCRP). National climate assessments are intended to advance the understanding of climate science in the larger social, ecological, and policy systems to provide integrated analyses of impacts and vulnerability. NOAA's National Climatic Data Center (NCDC) and many parts of NOAA have provided leadership on climate assessment activities for over a decade. A renewed focus on national and regional climate assessments to support improved decision-making across the country continues to emerge. Decisions related to adaptation at all scales as well as mitigation and other climate-sensitive decisions will be supported through an assessment design that is collaborative, authoritative, responsive and transparent. NOAA is working through an interagency process and investing in partnerships across many scales to support this comprehensive assessment activity. To support these activities, CICS-NC has instituted a task group of a senior scientist, a deputy focused on coordination, an attribution support member and a DC-based staff support member. The Lead Senior Scientist provides scientific oversight for the development of NOAA's assessment services, focusing on a contribution to the National Climate Assessment and, in support of the National Climate Assessment and in conjunction with NOAA and other agency expertise, providing scientific oversight and guidance to coordinate and implement distributed and centralized high-resolution modeling capabilities.

ACCOMPLISHMENTS

An analysis of historical climate variations and trends was completed, focused around eight U.S. regions defined for the 2013 National Climate Assessment report. This analysis examined trends in mean temperature and precipitation, metrics of extreme temperature and precipitation, freeze-free season length, and variables of more regional interest, such as lake ice in northern regions. For example, a set of very long-term precipitation-observing COOP stations was used to examine the temporal and spatial variations in number of extreme precipitation totals of 2-day duration. Time series of spatially averaged indices (Fig. 3) indicate that since 1991, all regions have experienced a greater than normal occurrence of extreme events. In the eastern regions, the recent numbers are the largest since reliable records begin (1895). In addition to the historical analysis, climate model simulations of the 21st Century for the A2 and B1 scenarios were analyzed and summarized for use by the authors of the 2013 report. The analysis examined the CMIP3 suite of global climate models, statistically downscaled versions of the CMIP3 models, and regional climate model simulations from the North American Regional Climate Change Assessment Project. Nine documents were prepared, summarizing the historical data analysis and the analysis of the climate models.

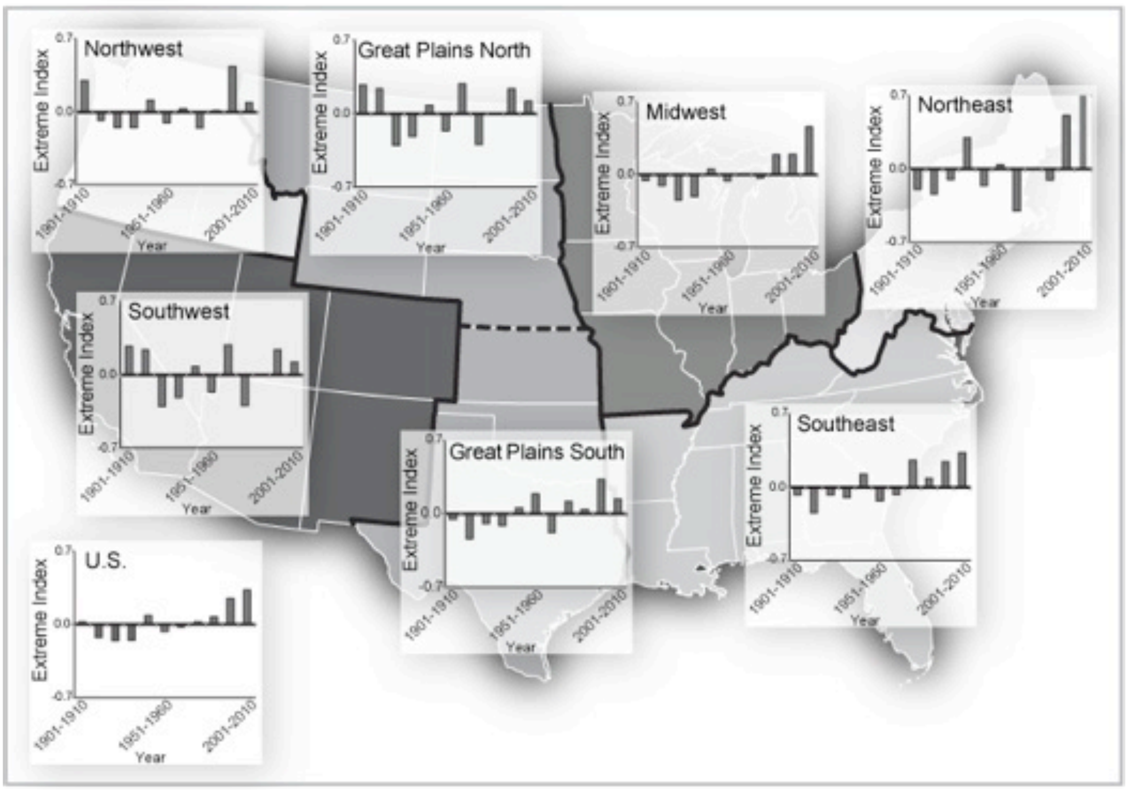

Figure 1: Time series of decadal values of an index (standardized to 1) of the number of 2-day precipitation totals exceeding a threshold for a 1 in 5-yr occurrence for 7 regions and the U.S. as a whole. This was based on an individual analysis of 930 long-term stations. Station time series of the annual number of events were gridded and then regional annual values were determined by averaging grid points within the region. Finally, the results were averaged over decadal periods.

Research on extreme precipitation examined the potential influence of water vapor changes on the observed increase in extreme precipitation. This was done by examining precipitable water values associated with extreme precipitation events for the period of 1971-2009. These precipitable water values were compared for two periods: 1971-1989 and 1990-2009. The results in Table 2 depict significant increases in the water vapor associated with extreme precipitation events in the latter period, particularly east of the Rockies.

Table 2: *Differences between two periods (1990-2009 minus 1971-1989) for daily, 1-in-5yr extreme events and coincident (spatial and temporal) precipitable water values.*

Region	Extreme Precipitation Frequency index Difference (%)	Precipitable Water Difference (%)
Northeast	+55**	+2
Southeast	+11*	+9***
Midwest	+21**	+6**
North Great Plains	+18*	+16***
South Great Plains	+15	+8***
Northwest	+36*	+4
Southwest	+36*	-4

**Significant at 0.10 level*
***Significant at 0.05 level*
****Significant at 0.01 level*

The potential effect of climate change on future values of probable maximum precipitation was examined by looking at simulated future changes in maximum precipitation water. Climate model simulations indicate a substantial increase in water vapor concentrations during the 21st Century. There is high confidence in this model outcome because the imbalance in the radiative energy budget arising from an increase in greenhouse gases will almost surely be manifested in an increase in ocean heat content. This in turn will lead to an increase in near-surface atmospheric water vapor concentrations over the oceans. The model simulations indicate that the changes in maximum water vapor concentrations, which are a principal input to Potential Maximum Precipitation (PMP) estimation techniques, will change by an amount similar to mean water vapor changes, and ultimately to an accelerated water cycle with heavier extreme rains. Changes in other factors used as inputs to PMP are not clear, neither from theoretical considerations nor from analyses of climate model simulations. In the absence of any basis for adjusting these factors, the best assumption is that these will not change in the future. This leads to the conclusion that the most scientifically sound projection is that probable maximum precipitation values will increase in the future.

Research was conducted to determine the meteorological phenomena associated with the increase in extreme precipitation events. Daily extreme precipitation events, exceeding a threshold for a 1 in 5 yr occurrence, were identified from a network of 935 cooperative observer stations for the period of 1908-2009. Each event was assigned a meteorological cause, categorized as extratropical cyclone near a front (FRT), extratropical cyclone near center of low (ETC), tropical cyclone (TC), mesoscale convective system (MCS), air mass (isolated) convection (AMC), North American Monsoon (NAM), and upslope flow (USF). The percentage of events ascribed to each cause were 54% for FRT, 24% for ETC, 13% for TC, 5% for MCS, 3% for NAM, 1% for AMC, and 0.1% for USF. On a national scale, there are upward trends in events associated with fronts and tropical cyclones, but no trends for other meteorological causes. On a regional scale, statistically significant upward trends in the frontal category are found in five of the nine regions.

PLANNED WORK

- Contribute to the writing of the 2013 National Climate Assessment Report.
- Revised regional climate descriptions in response to review comments
- Conduct an analysis of CMIP5 climate model simulations based on needs of the national climate assessment
- Complete journal article on effects of climate change on probable maximum precipitation
- Complete analysis of the atmospheric water vapor environment associated with the upward trend in extreme precipitation events and submit journal article on results

PUBLICATIONS

Kunkel, K.E., T.R. Karl, H. Brooks, J. Kossin, J. Lawrimore, D. Arndt, L. Bosart, D. Changnon, S.L. Cutter, N. Doesken, K. Emanuel, P.Ya. Groisman, R.W. Katz, T. Knutson, J. O'Brien, C. J. Paciorek, T. Peterson, K. Redmond, D. Robinson, J. Trapp, R. Vose, S. Weaver, M. Wehner, K. Wolter, D. Wuebbles, (in review) Monitoring and understanding changes in extreme storm statistics: state of knowledge. *Bull. Amer. Meteor. Soc*.

Liang, X.-Z., M. Xu, X. Yuan, T. Ling, H.I. Choi, F. Zhang, L. Chen, S. Liu, S. Su, F. Qiao, Y. He, J.X.L. Wang, K.E. Kunkel, W.Gao, E. Joseph, V. Morris, T.-W. Yu, J. Dudhia, and J. Michalakes, 2012: Regional Climate-Weather Research and Forecasting Model (CWRF). *Bull. Amer. Meteor. Soc.* (accepted)

Liang, X.-Z., M. Xu, W. Gao, K.R. Reddy, K.E. Kunkel, D.L. Schmoldt, and A.N. Samel (in press) Development of a distributed cotton growth model and its parameter determination over the United States. *Agronomy Journal*.

Liang, X.-Z., M. Xu, W. Gao, K.R. Reddy, K.E. Kunkel, D.L. Schmoldt, and A.N. Samel (in press) Physical modeling of U.S. cotton yields and climate stresses during 1979-2005. *Agronomy Journal*.

Kunkel, K.E., D.R. Easterling, D.A.R. Kristovich, B. Gleason, L. Stoecker, and R. Smith (in press) Meteorological causes of the secular variations in observed extreme precipitation events for the conterminous United States. *J. Hydromet*.

Westcott, N.E., S.D. Hilberg, R.L. Lampman, B.W. Alto, A. Bedel, E.J. Muturi, H. Glahn, M. Baker, K.E. Kunkel, and R.J. Novak, 2011: Predicting the seasonal shift in mosquito populations preceding the onset of the West Nile Virus in central Illinois. *Bull. Amer. Meteor. Soc.*, **92**, 1173-1180.

Non-peer reviewed

Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, and K.T. Redmond (in review)

Climate of the Northwest U.S., prepared for the National Climate Assessment Development and Advisory Committee.

Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, and K.T. Redmond (in review) Climate of the Southwest U.S., prepared for the National Climate Assessment Development and Advisory Committee.

Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, C.E. Konrad II, C.M. Fuhrmann, B.D. Keim, M.C. Kruk, A. Billot, H. Needham, and M. Shafer (in review) Climate of the Southeast U.S., prepared for the National Climate Assessment Development and Advisory Committee.

Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, S. Hilberg, M. Timlin, L. Stoecker, and N. Westcott (in review) Climate of the Midwest U.S., prepared for the National Climate Assessment Development and Advisory Committee.

Kunkel, K.E., L. Stevens, S.E. Stevens, M.C. Kruk, D.P. Thomas, E. Janssen, K.G. Hubbard, M.D. Shulski, N.A. Umphlett, K. Robbins, L. Romolo, A. Akyuz, T.B. Pathak, and T.R. Bergantino (in review) Climate of the U.S. Great Plains, prepared for the National Climate Assessment Development and Advisory Committee.

Kunkel, K.E., L. Stevens, S.E. Stevens, and E. Janssen (in review) Climate of the Contiguous United States, prepared for the National Climate Assessment Development and Advisory Committee.

Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, J. Rennells and A. DeGaetano (in review) Climate of the Northeast U.S., prepared for the National Climate Assessment Development and Advisory Committee.

Stewart, B.C., and J.E. Walsh, K.E. Kunkel, and L.E. Stevens (in review) Climate of Alaska, prepared for the National Climate Assessment Development and Advisory Committee.

Victoria W. Keener, V.W. and K. Hamilton, and S.K. Izuka, K.E. Kunkel, K.E., and L. Stevens (in review) Climate of the Pacific Islands, prepared for the National Climate Assessment Development and Advisory Committee.

PRESENTATIONS

Farrell, S.L. (2011b), AOSC 401: Global Environment, Aspects of the Cryosphere: Sea Ice and Snow, Guest Lecture for Prof. Zhanqing Li, Dept. of Atmospheric and Oceanic Science, University of Maryland, College Park, MD, 1 April 2011.

Kunkel, K.E. (2012), Recent Weather in the United States: Are Extremes Becoming More Prevalent?, invited talk, Monsanto Corp., St. Louis, MO, 13 February, 2012.

Kunkel, K.E. (2012), Climate Change Impacts on Probable Maximum Precipitation, 2012 Annual Meeting of the American Meteorological Society, New Orleans, LA, 25 January, 2012.

Kunkel, K.E. (2012), Overview of previous work (SAP 3.3), and workshop challenge, invited talk, Forum on Trends in Extreme Winds, Waves, and Extratropical Storms along the Coasts, Asheville, NC, 11 January, 2012

Kunkel, K.E. (2011), Observed Trends in Temperature and Precipitation Extremes, invited talk, 2011 Fall AGU Meeting, San Francisco, CA, 6 December, 2011.

Kunkel, K.E. (2011), Climate Change Impacts on Probable Maximum Precipitation, invited talk, 2011 Fall AGU Meeting, San Francisco, CA, 5 December, 2011.

Kunkel, K.E. (2011), Climate Scenarios Update, invited talk, meeting of the National Climate Assessment Development and Advisory Committee, Boulder, CO, 15 November, 2011.

Kunkel, K.E. (2011), Northeast Regional Climatology and Outlook, invited talk, Northeast Regional Assessment Workshop, New York City, NY, 17 November, 2011.

Kunkel, K.E. (2011), Temperature Extremes, invited talk, Workshop: Trends and Causes of Observed Changes in Heat and Cold Waves as well as Drought, Asheville, NC, 8 November, 2011.

Kunkel, K.E. (2011), Past Assessment, invited talk, Workshop: Trends and Causes of Observed Changes in Heat and Cold Waves as well as Drought, Asheville, NC, 8 November, 2011.

Kunkel, K.E. (2011), Meteorological Causes of Extreme Precipitation Trends in the U.S., World Climate Research Programme Open Science Conference, Denver, CO, 24 October, 2011.

Kunkel, K.E. (2011), Extreme Precipitation, NCDC Seminar, Asheville, 17 October, 2011.

Kunkel, K.E. (2011), Extreme Precipitation, invited talk, NOAA Climate Board, Washington, DC, 14 October, 2011.

Kunkel, K.E. (2011), Southeast Regional Outlook, invited talk, Southeast Regional Assessment Workshop, Atlanta, GA, 26 September, 2011.

Kunkel, K.E. (2011), Southwest Regional Climatology and Outlook, invited talk, Southwest Regional Assessment Workshop, Boulder, CO, 1 August, 2011.

Kunkel, K.E. (2011), Workshop Challenge and Background, Workshop on Monitoring

Changes in Extreme Storms Statistics: State of Knowledge, Asheville, NC, 25 July, 2011.

Kunkel, K.E. (2011), Precipitation Extremes-Mechanistic Perspective, Workshop on Monitoring Changes in Extreme Storms Statistics: State of Knowledge, Asheville, NC, 25 July, 2011.

Kunkel, K.E. (2011), State Climatologist Contributions to the National Climate Assessment, invited talk, Annual Meeting of the American Association of State Climatologists, Asheville, NC, 21 July, 2011.

Kunkel, K.E. (2011), Potential Impacts of Climate Changes on Estimates of Probable Maximum Precipitation, Practical Solutions for a Warming World: *AMS Conference* on Climate Adaptation, Asheville, NC, 19 July, 2011.

Kunkel, K.E. (2011), "Trends in Extreme Snowfall Seasons", invited talk, NOAA/FEMA Snow Workshop, Estes Park, CO, May 26, 2011.

Kunkel, K.E. (2011), National Climate Assessment and NARCCAP, invited talk, NARCCAP Users Workshop, Boulder, CO, 7 April, 2011.

Kunkel, K.E. (2011), Development of Regional Climate Information for the National Climate Assessment, invited talk, inaugural meeting of the National Climate Assessment Development and Advisory Committee, Washington, DC, 5 April, 2011.

OTHER
None

Trends in Extratropical Cyclone Occurrence

Task Leader Kenneth E. Kunkel
Task Code
Date Awarded 07/01/2011
Contribution to CICS Themes Theme 3: 100%
Contribution to NOAA Goals Goal 1: 100%

EXECUTIVE SUMMARY
This project is investigating the nature of changes in extratropical cyclone (ETC) occurrence using a new reanalysis data set that extends back into the late 19th Century. Preliminary results point to some significant shifts in the spatial distribution and frequency of ETCs from the late 19th to the early 21st Century in the Northern Hemisphere. Most importantly, trends in ETC activity computed over more than 100 years are in some cases *opposite* in sign to those computed since 1950. The ratio of the number of high latitude to mid latitude ETCs was higher in the late 19th/early 20th Centuries; on the surface, this implies a shift in the mean track of ETCs to the south during the latter two-thirds of the 20th Century. Indeed, the mid-latitudes of North America and the Atlantic became more active after the 1930s. At the same time, at high latitudes there was a change to higher activity in the eastern Hemisphere and lesser activity in the western Hemisphere. These shifts indicate a need to rethink probable weather patterns in climate change scenarios.

BACKGROUND
ETCs are large-scale, non-tropical low pressure storm systems that typically develop along a frontal boundary between air masses of contrasting temperature. The ETC is the principal atmospheric phenomenon through which sensible and latent heat fluxes are exchanged between the subtropical and polar regions. These large-scale cyclonic storms are the major feature of mid-latitude weather during the colder times of the year and often have severe weather associated with them. These storms can produce large snowfall amounts that, together with high winds, result in blizzard conditions, large waves leading to coastal erosion, and severe convective events with lightning and tornadoes. In fact, these storms (or their absence in the case of drought) are responsible for many of the extreme weather types experienced at mid- and high-latitudes. ETCs are ubiquitous throughout the year, but tend to be stronger and located more equatorward in the cold season. Future changes in extreme weather in mid to high latitudes will likely involve changes in the frequency, intensity, and tracks of ETCs.

A number of recent studies focused on the Northern Hemisphere have documented a significant poleward shift of the storm track in both the Pacific and Atlantic ocean basins, a decrease in ETC frequency in mid-latitudes, and a corresponding increase in ETC activity at higher latitudes for the latter half of the 20th century. Future climate warming may lead to a decrease in polar low activity. A new analysis of surface pressure data has extended the availability of pressure field data from the mid-20th century as used in previous studies, back to the late 19th Century. We have used this new 20th Century Reanalysis (20CR) data set to extend the analysis of ETC occurrence in the Northern Hemisphere to the period 1871-2007.

We examined the 20CR record (Fig. 1), restricting the analysis to significant long-lived ETCs (storms lasting at least 72h and travelling at least 1000 km), and found that a different picture emerges. There is an overall upward trend in ETC occurrence in mid latitudes (30°-60°N), but no trend for high latitude (60°-90°N) ETCs. Further examination of the ETC counts over time reveals that in the late 19th and early 20th Century, high latitude ETC occurrence was similar to the latter part of the 20th Century (Fig. 1). In contrast, mid-latitude ETC activity in the late 19th/early 20th Century was considerably lower than in the recent period.

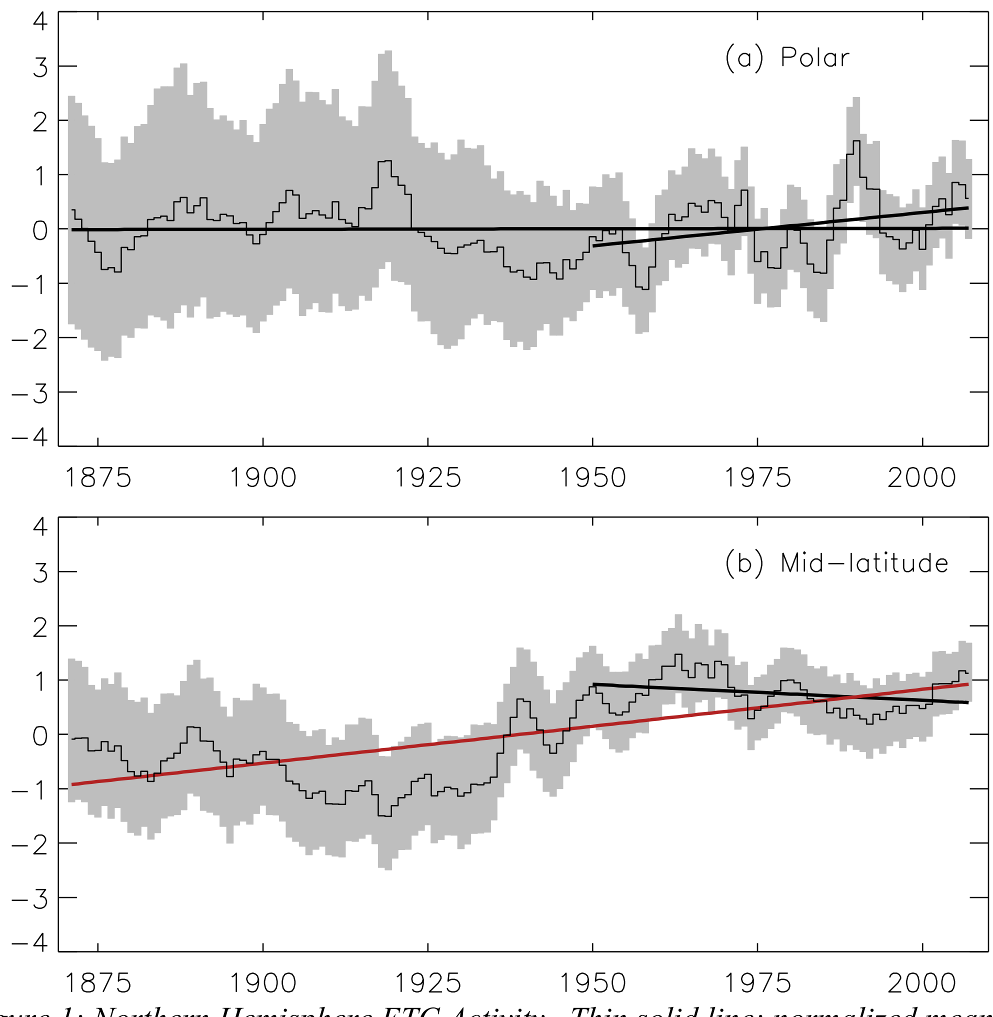

Figure 1: Northern Hemisphere ETC Activity. Thin solid line: normalized mean ETC activity for polar (60-90°) and mid-latitude (30-60°) bands, upper and lower plots respectively. Shaded bars indicate the ETC activity for the second smallest and second largest of the 56 ensemble members. Heavy straight lines indicate the least squares fit from 1871-2007 and 1950-2007, respectively. Statistically significant slopes (95% confidence interval) are plotted with a red line

ACCOMPLISHMENTS

We examined the 20CR record (Fig. 1), restricting the analysis to significant long-lived ETCs (storms lasting at least 72h and travelling at least 1000 km), and found that a different picture emerges. There is an overall upward trend in ETC occurrence in mid latitudes (30°-60°N), but no trend for high latitude (60°-90°N) ETCs. Further examination of the ETC counts over time reveals that in the late 19th and early 20th Century, high latitude ETC occurrence was similar to the latter part of the 20th Century (Fig. 1). In contrast, mid-latitude ETC activity in the late 19th/early 20th Century was considerably lower than in the recent period

PLANNED WORK

Perform sensitivity analyses to determine the extent to which the changing spatial density of surface pressure data affects the trend results. Of particular interest is whether the sparse density of observations in the late 19th and early 20th Centuries in the North Pacific result in high or low biases in the number of ETCs in that region.

PUBLICATIONS

None

PRESENTATIONS

"20th Century Trends in Northern Hemisphere Extratropical Cyclone Occurrence", World Climate Research Programme Open Science Conference, Denver, CO, October 2011.

OTHER

None

National Climate Assessment Data Coordination Activities

Task Leader Ana Pinheiro Privette
Task Code
Date Awarded 01/03/2012
Contribution to CICS Themes Theme 3: 100%
Contribution to NOAA Goals Goal 1: 50%; Goal 5: 50%

EXECUTIVE SUMMARY

This activity provides data coordination support to the National Climate Assessment (NCA). Design data management strategy and create the necessary infrastructure for managing inputs and outputs, of data and information, for the NCA process. Ensure NCA compliance to the Information Quality Act. Provide transparency and traceability to all data and information associated with the 2013 NCA report.

BACKGROUND

The National Climate Assessment (NCA) is being conducted under the auspices of the Global Change Research Act (GCRA) of 1990. The GCRA requires a report to the President and the Congress every four years that integrates, evaluates, and interprets the findings of the U.S. Global Change Research Program (USGCRP). National climate assessments act as status reports about climate change science and impacts, and incorporate advances in the understanding of climate science into larger social, ecological, and policy systems, and with this provide integrated analyses of impacts and vulnerability. The NCA aims to help the federal government prioritize climate science investments, and in doing so will help to provide the science that can be used by communities around the country to plan more sustainably for our future.

NCA is classified as *A Highly Influential Scientific Assessment* (HISA): (1) has a potential impact of more than $500 million in any one year on either the public or private sector (the economic test); or (2) is novel, controversial, or precedent-setting, or of significant interagency interest (the narrative test). Consequently, the NCA reports are required to meet the highest level of quality in the Information Quality Act (NOAA IQA), by ensuring and maximizing the quality, objectivity, utility and integrity of information disseminated by the agency.

The NCA team is currently working on the 2013 NCA report. To improve upon the NCA existing process, several changes are being implemented for the upcoming report. For the first time, the NCA will accept external inputs to the NCA report (requested via a Federal Register). Another change includes the creation of a designated collaborative workspace for the authors of the 2013 report that will work as a "one-stop-shop" for data and information relevant to the process of writing the 2013 report. In addition, the NCA 2013 report aims to have a strong web presence, to facilitate the dissemination of its results. This will be accomplished through its publication on the Global Change Information System (GCIS), a web based source of authoritative, accessible, usable, and timely information about climate and global change for use by scientists, decision makers, and the public, currently under development.

NOAA NCDC is providing leadership and support roles to the National Climate Assessment program. In its COOP agreement with NCDC, CICS NC is supporting the data related aspects of the NCA through the NCA Data Coordinator role. It is the Data Coordinator's (DC) responsibility to ensure NCA compliance to the Information Quality Act and provide transparency, and traceability, to the data and information associated with the 2013 NCA report. In addition, the NCA Data Coordinator will define the data management strategy for the NCA, including definition of data policies, data archiving criteria and procedures, and will oversee the overall management of all inputs and outputs of data into/from the NCA process. The DC will work closely with the Global CCIS system's architect to optimize the process of creating a web presence for the NCA 2013 report. The DC will coordinate her activities with the NCA Program Manager, the NCA TSU and the USCGRP Team (DC based) to ensure a long-term sustainable National Climate Assessment process.

ACCOMPLISHMENTS

- Defined NCA data management strategy (tasks, milestones, timelines)
- Defined NCA Data Archiving strategy (flowchart).
- Supervised, co-designed and guided implementation to the Technical Input upload system, which allows, for the first time, public participation into the NCA report. Through a contract to UNCA-RENCI, the NCA TSU created the NCA Resources Website (DRUPAL based) that allowed 113 users, through secure access, to submit 211 technical inputs directly to the site. An additional 321 submissions were made through email and were subsequently uploaded into the system. A total of 532 technical inputs were submitted by the deadline of March 1st 2012.
- Documented NCA Technical Input request and submission process (required for traceability purposes)
- Supervised, co-designed and guided implementation to the Collaborative Workspace. This secure web space provides over 200 NCA authors a space for accessing relevant support information and sharing chapter drafts.
- Reviewed two Climate Trends and Outlooks documents.
- Additional roles and responsibilities include:
- Member of the Core Integration Team for the GCIS Interagency Working Group (IWG)
- Member of the NCDC Interagency Metadata Tiger Team to define federal interagency metadata standards

PLANNED WORK

- Continue to provide leadership and support for data management to the NCA program.
- Design and implement a system to manage the review process and public comments to the 2013 NCA report.
- Define NCA data policy.
- Investigate and document Provenance for all data used in the 2013 NCA report

- Continue to manage the NCA Resources page.

PUBLICATIONS
None

PRESENTATIONS
None

OTHER
None

Assessment Science Support: Analysis of Climate Model Data

Task Leader Laura Stevens
Task Code
Date Awarded 06/16/2011
Contribution to CICS Themes Theme 3: 100%
Contribution to NOAA Goals Goal 1: 50%; Goal 5: 50%

EXECUTIVE SUMMARY

Providing primary science and technical support to NOAA and the NOAA Technical Support Unit of the National Climate Assessment (NCA), including: the processing and analysis of observational and climate model data, the production of documents for the NCA, and research on Assessment-relevant topics.

BACKGROUND

The National Climate Assessment (NCA) is an important resource for understanding and communicating climate change science and impacts in the United States. It informs the nation about already observed changes, the current status of the climate, and anticipated trends for the future. The Global Research Act of 1990 mandates that a national climate assessment be conducted every four years, resulting in a report to the President and Congress. The next report is due in 2013 and is currently in preparation, with a draft report to be completed in 2012.

Primary science and technical support is being provided to NOAA and the NOAA Technical Support Unit (TSU) of the National Climate Assessment. This includes the analysis of observational and climate model data, the development of climate data analysis products, and research on assessment-relevant topics.

Research is being conducted, in collaboration with the lead scientist for Assessments, Kenneth Kunkel, using several climate model datasets. This includes the processing and analysis of CMIP3 (Coupled Model Intercomparison Phase 3) daily statistically downscaled climate data (Daily_CMIP3) for the North American region, in preparation of national and regional outlooks for the NCA.

ACCOMPLISHMENTS

The calculation, analysis and visualization of a suite of derived climate variables has been performed for the North American region using daily data downscaled to 1/8° resolution from 16 different CMIP3 climate models (see figure for example). This includes the simulation of two IPCC emissions scenarios (A2 and B1), for four different time periods. Calculations of regionally averaged values have been made for six U.S. regions, and compared to those from NARCCAP (North American Regional Climate Change Assessment Program) dynamically downscaled climate simulations. These results are included in documents prepared as technical input for the 2013 National Climate Assessment report (see below).

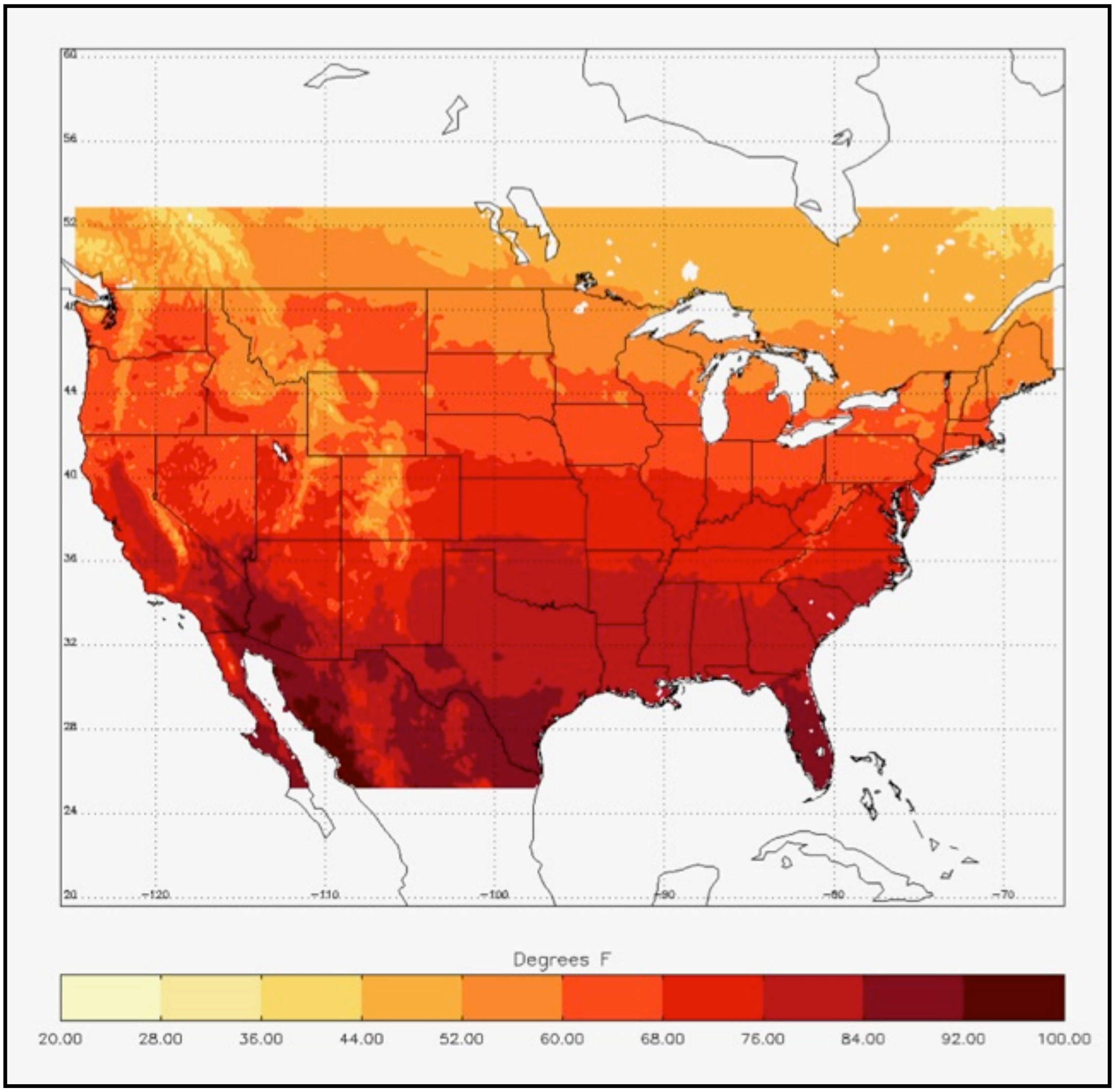

Figure 1: Projected annual mean daily maximum temperature for 2041-2070, simulating the IPCC A2 emissions scenario. This is a multi-model mean from 16 CMIP3 daily statistically downscaled simulations.

Research has been conducted to address specific scientific questions of direct relevance to the 2013 NCA report and the ongoing climate assessment regarding Daily_CMIP3, as well as additional non-downscaled climate model datasets.

Requests for tailored physical climate information from the NCA Development and Advisory Committee (NCADAC), the NCA office, and the NCA regional teams have been fulfilled, including the provision of mathematical analyses and graphical products.

One national and eight regional "Climate Trends and Outlooks" documents have been produced for the NCADAC, as technical input for the National Climate Assessment. Contributions to these documents include: data analysis, visualization of data, and scientific writing. An overview of these documents was presented at the NCA Technical Workshop on Rural Communities, Charleston, SC, in February 2012.

PLANNED WORK

- Perform additional analyses on Daily_CMIP3 and other datasets (including CMIP5), comparing climate model simulations to observations of the present climate;
- Analyze climate model simulations of the future to better understand the model characteristics leading to changes in impacts-related variables;
- Produce various time series and climatological datasets using Daily_CMIP3 and other data;
- Cooperate with other TSU members in documenting all mathematical procedures and algorithms used to create such datasets.

PUBLICATIONS

Kunkel, K., L. Stevens, and E. Janssen (in review), Climate of the Contiguous United States, *prepared for the National Climate Assessment Development and Advisory Committee*.

Kunkel, K., L. Stevens, S. Stevens, E. Janssen, and K. Redmond (in review), Climate of the Northwest U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

Kunkel, K., L. Stevens, S. Stevens, E. Janssen, and K. Redmond (in review), Climate of the Southwest U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

Kunkel, K., L. Stevens, S. Stevens, E. Janssen, J. Rennells, and A. DeGaetano (in review), Climate of the Northeast U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

Kunkel, K., L. Stevens, S. Stevens, E. Janssen, S. Hilberg, M. Timlin, L. Stoecker, and N. Westcott (in review), Climate of the Midwest U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

Kunkel, K., L. Stevens, S. Stevens, E. Janssen, C. Konrad, C. Fuhrman, B. Keim, M. Kruk, A. Billet, H. Needham, and M. Schafer (in review), Climate of the Southeast U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

Kunkel, K., L. Stevens, S. Stevens, E. Janssen, M. Kruk, D. Thomas, K. Hubbard, M. Shulski, N. Umphlett, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, and T. Bergantino (in review), Climate of the U.S. Great Plains, *prepared for the National Climate Assessment Development and Advisory Committee*.

Stewart, B., J. Walsh, K. Kunkel, and L. Stevens (in review), Climate of Alaska, *prepared for the National Climate Assessment Development and Advisory Committee*.

Keener, V., K. Hamilton, S. Izuka, K. Kunkel, and L. Stevens (in review), Climate of the Pacific Islands, *prepared for the National Climate Assessment Development and Advisory Committee*.

PRESENTATIONS

- Stevens, L. and K. Kunkel (2012), Climate Trends and Outlooks for the United States, Plenary talk at the NCA Technical Workshop on Rural Communities, Charleston, SC, 13 February 2012.
- Stevens, L., K. Kunkel, and S. Stevens (2011), Analysis of CMIP3 Daily Statistically-Downscaled Data, Presentation at the CICS Science Meeting 2011, Asheville, NC, 2 November 2011.

OTHER

None

5.5 National Climate Model Portal

NOAA's National Climate Model Portal (NCMP)

Task Leader Justin Jay Hnilo
Task Code
Date Awarded 10/2010
Contribution to CICS Themes Theme 3: 100%
Contribution to NOAA Goals Goal 1: 33%; Goal 2: 33%; Goal 3: 34%

EXECUTIVE SUMMARY

Climate model and observational data is becoming too large to continually transfer products to end-users. We have developed tools to help scientists perform calculations and off load smaller more meaningful data sets for direct examination.

BACKGROUND

The National Operational Model Archive and Distribution System (NOMADS) is a web-services based project providing both real-time and retrospective format independent access to climate and weather model data. NOMADS was established to specifically address the growing need for this remote access to high volume numerical weather prediction and global climate models and data and to facilitate climate model and observational data inter-comparison issues. The National Climate Model Portal (NCMP) continues to be developed to extend the technologies and capabilities currently operational in NOMADS. NCMP, in close coordination with the NOAA Climate Service Portal (NCSP) will serve as an on-line resource to both improve models for modelers, and to convey key aspects of complex scientific data in a manner accessible to both climate and weather modelers and to non-specialists or other particular user communities.

NCMP activities in the coming contract year will include: 1) continuing development of a requirements specification process, functional requirements, and preliminary design document; 2) additional proof of concept model-to observational capability using existing but enhanced tools and applications; 3) a downscaling proof-of-concept capability; 4) a user interface portal and community workspace into NOAA's suite of Climate and Weather Models; and (5) the development of on-line climate model diagnostic tools and resources.

Initial work emphasizes the development of diagnostic tools. In this initial phase we have developed tools that re-grid, extract average annual, seasonal, diurnal cycles from data as well various statistical measures and the extraction of station data equivalents from gridded data. Other capabilities being developed are the examination of anomalies, measures of extreme events, climate sensitivity, decadal trends and ratios of variances.

ACCOMPLISHMENTS

We have implemented a set of first look diagnostics that allow one for example to simply run a python script and extract station data equivalents from large gridded data (e.g., CFSR). As the website continues to evolve we will be serving such scripts and showing small plots of the output. These tools can be readily applied to both observational estimates (e.g., re-analyses) as well as model data. From models we have started to calculate derived values and diagnostics from the large IPCC (e.g., AR4) data holdings and will eventually serve these calculated values on the website. We have used these tools to support both the US National Assessment and continuing sectoral engagements at NCDC. We support via generation of plots submitted to the projections tab off the climate dashboard.

Annually averaged global surface temperature for all participant AR4 models:

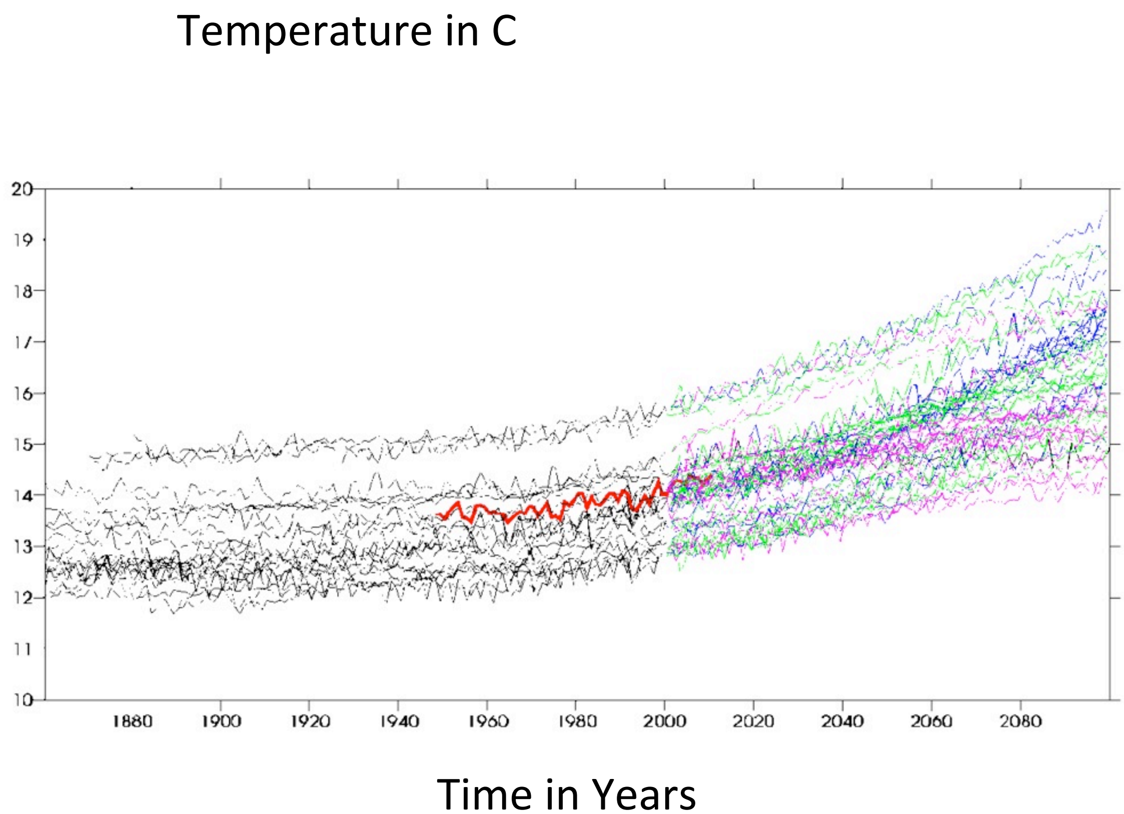

Figure 1: Globally averaged surface temperature (C) for all participant models and scenarios for the IPCC AR4. The climate of the 20th century run is in black, the SRESA2 scenario in blue, The SRESA1B in green and the SRESB1 in purple. An observational estimate the NCEP/NCAR reanalysis is in thicker red.

Out tool development and implementation will allow one to dynamically generate figures and offload processed data files when complete. Shown in Figure 2, is an example of these tools. The seasonal values of all participant models that submitted surface temperature for the AR4 models are shown. We re-grid all output to the same spatial grid, extract the seasons June-July-August (JJA) and December-January-February (DJF) for each model, average all participant runs for two time periods 1970-2000, for the climate of the 20th century (20c3m), and the period 2050-2059, for the high emission scenario (SRE-

SA2). Also, the entire globe differences for SRESA2 – 20c3m are shown for these two seasons below. The chosen color scale is the same in each, showing the preferential warming (by a factor of two) in the projected winter season. Our expectation is that these calculations and capability will be of interest to continuing adaption and mitigation work within NOAA as well as external users.

Seasonally Averaged Surface Temperature Output Differences for JJA and DJF.

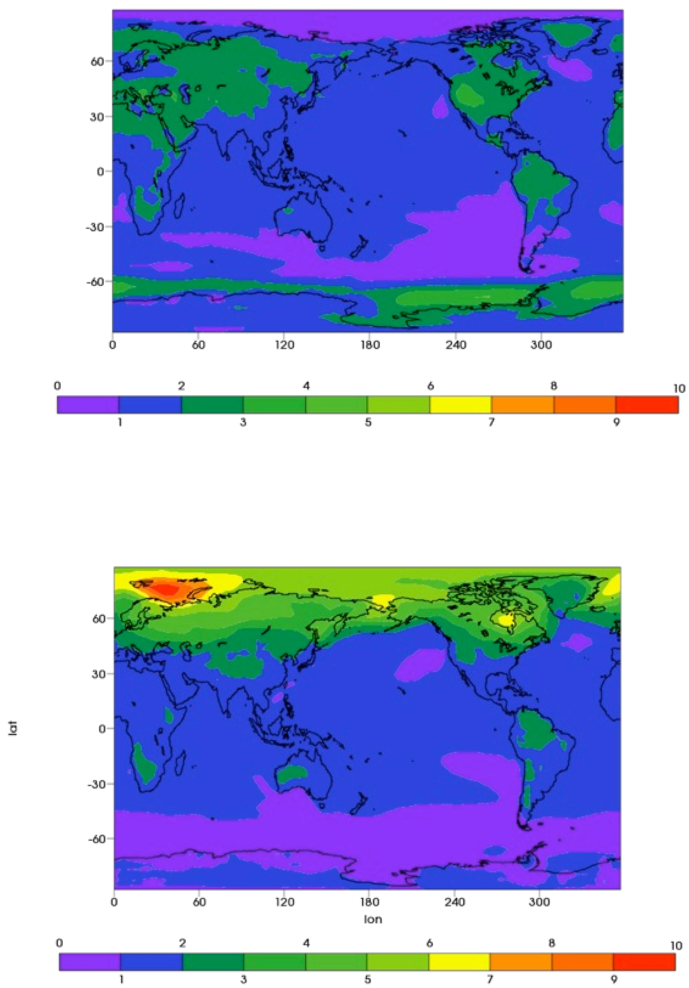

Figure 2: Seasonally Averaged Participant Member Surface Temperature Output Differences for the high emission scenario (SRESA2), and the climate of the 20th century run (20c3m) calculated as (SRESA2 – 203cm) for JJA(left) and DJF(right), in degrees C. Participant members in SRESA2 scenario are 19, and for the 20c3m are 24.

PLANNED WORK

- Post diagnostic routines on our website for each of use
- Implement new ability to extract shapefile regions from the gridded data
- Continue to expand data holdings and apply above calculations to AR5 data

PUBLICATIONS
None

PRESENTATIONS
None

OTHER
None

5.5 *Climate Literacy*

Highlighting 150 Years of Weather Observations in Asheville

Task Leader Michelle Benigno
Task Code
Date Awarded 4/22/11
Contribution to CICS Themes
Contribution to NOAA Goals Goal 2: 100%

EXECUTIVE SUMMARY

The Science House of NCSU provides K-12 educational outreach for climate and Earth system science in partnership with NOAA's NCDC and CICS-NC. Educational support materials will be created for a museum exhibit called: "Highlighting 150 Years of Weather Observations in Asheville."

BACKGROUND

The Science House is an educational outreach arm of NC State University that serves over 5,000 teachers and over 36,000 students annually from six offices spread across the state of North Carolina. The mission of The Science House is to:

- Cultivate and diversify the pool of students pursuing degrees and careers in STEM (Science, Technology, Engineering and Math) fields.
- Improve the quality of teaching and learning in STEM education.
- Communicate innovative scientific and educational research to the public.

The Science House programs are guided by the best research and practices in STEM education. In addition, they lead the K-12 outreach projects for several multi-university STEM research centers that are at the cutting edge of their disciplines.

ACCOMPLISHMENTS

Climate science education is a crucial part of the work of The Science House. The Science House leads teacher professional development sessions that focus on understanding the Earth system, the changing nature of the climate and its impacts, resource management and sustainability. The Science House supports students and teachers by providing climate materials, teaching techniques, and sharing cutting edge research from climate scientists. Laboratory equipment is loaned out to participating teachers at no cost. Students can use this equipment to collect local data, which can then be compared with various data from the National Climatic Data Center.

The Mountain Office of The Science House increased the number of students served during the 2010-11 school year by 57% and increased the number of teachers and administrators reached by 70%. The Science House partners with CICS-NC and collaborates with NOAA's NCDC to outreach to K-12 students and teachers which now includes instruction with The Magic Planet. Part of this outreach also includes collaboration on an exhibit that will be erected at Asheville's Colburn Earth Science Museum showcasing the history of the people who supported the weather and climate community since 1857. Michelle Benigno leads this effort in Western North Carolina.

PLANNED WORK

- Supporting educational materials will be developed by The Science House to enhance the exhibit, “Highlighting 150 Years of Weather Observations in Asheville” once the exhibit is installed at Asheville's Colburn Earth Science Museum.
- Continue climate education outreach to k-12 population and continue collaborations on various Earth system educational opportunities.

PUBLICATIONS

None

PRESENTATIONS

None

OTHER

Michelle Benigno was awarded the Outstanding Extension Service Award for 2010 by NC State University.

Year 2 CICS Support of the Development of Climate Data and Information Records and Scientific Data Stewardship Program

Task Leader Heidi Cullen
Task Code
Date Awarded 6/30/2010
Contribution to CICS Themes Theme 3: 100%.
Contribution to NOAA Goals Goal 4: 100%

EXECUTIVE SUMMARY

The ultimate goal of this program is to establish the routine relevancy of climate science information and provide the climate context to extreme weather events. Climate Central also seeks to raise climate literacy by showcasing the findings of the upcoming National Assessment report. We do this by highlighting NCDC products and showcasing the expertise of NOAA scientists.

BACKGROUND

In Year 2, we focused on extreme weather, adaptation strategies, and media training for select NCDC scientists. Climate Central highlights how NCDC data and tools can be used to better understand and manage climate and weather-related risks on seasonal to decadal and longer timescales through two video series. Our content routinely utilizes the data, maps and forecast products produced by NCDC scientists.

Figure 1: Extreme Weather 101 is a 4-part series of roughly 2-minute video segments. They are video explainers featuring NCDC scientists and local TV meteorologists.

The first is a 5-part series of roughly 2-minute video segments called *Extreme Weather 101*. These are video explainers featuring NCDC scientists and local TV meteorologists (Figure 1).

Extreme Weather 101 Topics:

- Drought
- Extreme Heat
- Snowstorms
- Tornadoes and Climate
- Precipitation and Floods

The second is a 4-part series of 2-minute video segments called *Tell Me Why* with interviews featuring NCDC scientists answering key climate science questions.

Tell Me Why Topics:

- *Tell Me Why*... The Climate Extremes Index Matters
- *Tell Me Why*...We Need Normals
- *Tell Me Why*...Questions Swirl Around Tornadoes and Climate
- *Tell Me Why*...Satellite Climate Data Matters

Drawing upon research efforts across NOAA and within CICS-NC, as well as studies like the 2009 USGCRP Global Climate Change Impacts in the United States report these videos are being distributed to a variety of media partners at both the local and national level, and on the Climate Central and NOAA-related websites. Climate Central works with partners at the local and national level to distribute our content widely across different media platforms. Climate Central is currently working in partnership with 12 local TV stations in markets totaling 25 million households to deliver newsworthy climate science information to local TV meteorologists on a weekly basis. Local broadcast meteorologists nationwide are among the most trusted and familiar sources of informal science education for most Americans.

A large majority of adults watch local TV news, especially the weather, and they look to weathercasters as a trusted source of information about climate. Through this network, Climate Central has the potential to reach more than three million Americans each month. We plan to have at least 50 markets in place and a greatly expanded national reach within five years. This project is an offshoot of a larger NSF-funded Climate Change Education Partnership [NSF award number 1043235 (Maibach)].

ACCOMPLISHMENTS

During the period April 1, 2011 to March 31, 2012, Climate Central completed four *Tell Me Why* videos. The *Tell Me Why* videos have been approved by NCDC leadership and are being closed captioned and prepared for release. We are currently finalizing the *Extreme Weather 101* series. Interviews with local TV meteorologists will be completed in late March.

In addition, Cullen and Bell visited NCDC in Asheville, NC on January 9th and 10th. During the visit we held a Media 101 Lunch-and-Learn with selected NCDC staff. We also interviewed several scientists featured in the videos. Those scientists are Deke Arndt (Extreme Weather 101: Heat, Tornado; Tell Me Why: Climate Extremes Index), Jay Lawrimore (Extreme Weather 101: Snowstorms), Anthony Arguez (Tell Me Why: New Normals), Mike Brewer (Extreme Weather 101: Drought), Jeff Privette (Tell Me Why: Satellite and Climate Data) and Tom Peterson (Extreme Weather 101: Precipitation and Floods).

PLANNED WORK

We are currently drafting a new work plan in coordination with Katy Vincent and Jenny Dissen to reflect our reduced budget in Year 3. The overall objective of our work remains unchanged.

PUBLICATIONS

None

PRESENTATIONS

None

OTHER

None

Stakeholder Engagement to Better Understand Climate Information Needs

Task Leader Nancy Colleton
Task Code
Date Awarded 3/1/2011
Contribution to CICS Themes Theme 3: 100%.
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 20%, Goal 5: 60%

EXECUTIVE SUMMARY

This research examines challenges and opportunities associated with the delivery and use of climate information. Specifically, this research a) examines mechanisms and models for private sector engagement; b) assesses various business and economic strategic forecasting needs; and c) further examines the specific climate information needs and potential economic impacts of climate change on plant-based businesses.

BACKGROUND

The U.S. Government has invested greatly in the science and technologies that enable us to view the Earth. This project attempts to leverage US investment on weather and climate information through engagement of new and emerging users for the benefit of environmental, economic, and national security.

Improved weather and, more recently, climate data and information are becoming essential to managing communities as well as businesses. Since 2007, NOAA/NCDC, the Institute for Global Environmental Strategies, and the North Carolina Arboretum have worked together to engage stakeholders to better understand climate information needs. In 2007, the NOAA Data Users Conference examined the information needs of the energy, insurance, and transportation sectors. In 2008, the A Growing Interest meeting brought together experts in the green or plant-based sector for the first time to better understand climate science ,discuss potential climate impacts on the plant sector, and examine what data sets might better help this sector manage risk and adapt to climate change.

ACCOMPLISHMENTS

To date, this project has reached three key milestones:
The preliminary review of mechanisms and models for private sector engagement;
The convening of *A Growing Interest 2* workshop on 21-22 March 2012; and
The preliminary organization of the upcoming *Executive Roundtable*, which is scheduled for 25-26 April 2012.

The preliminary review of the mechanisms and models for private sector engagement examines common trends and pending issues with regard to the NOAA Partnership Policy, the Climate Partnership Task Force (CPTF) results, and the Open Weather and Climate Services (OWCS) concept. The CPTF and OWCS activities are recent efforts facilitated by the NOAA Science Advisory Board (SAB), its Climate Working Group and Environmental Information Services Working Group. Both reports, which include specific recommendations, have been transmitted by the SAB to NOAA for consideration and response.

Representatives of public gardens and arboreta, the nursery and landscape sector, botanical and natural products sector, forest service, and horticulture society joined NOAA scientists in *A Growing Interest 2* workshop to examine the latest climate science, the current state of the plant-based sector, and how NOAA data and information might help this sector better manage the risks posed by climate change.

Some of the key observations of this workshop include:

- To facilitate the delivery and use of NOAA data and information, a sustained dialogue between NOAA and the plant sector is essential to better understand sector trends and concerns and where NOAA data and information products can be most useful.
- A need exists to better communicate and describe climate data and information to the plant sector. While a user may not readily recognize how climate data and information may be useful to their operations when described as such, if this information is communicated in terms of long-term forecasting for weather and water its value may be more easily identified.
- Climate data and information is still relatively unknown and, as a result, not easily accessible to most users.

These observations along with identified possible actions will be included in a final report, which will be delivered in the June 2012 time period.

An Executive Roundtable focusing on long-term, strategic environmental forecasting will be convened on April 25-26, 2012 in conjunction with the Climate Normals Workshop, organized by NCDC.

PLANNED WORK

- Complete assessment of mechanisms for private sector engagement;
- Produce final report;
- Develop final report on *A Growing Interest workshop*;
- Convene an *Executive Roundtable* on April 25-26, 2012; and
- Produce final report.

OTHER

Nancy Colleton co-organized (with Antonio Busalacchi, Chair, WCRP Joint Scientific Committee), the Climate Science in the Service of Society: Private Sector Needs and Opportunities, the Open Science Conference, October 25, 2011, Denver, Colorado.

Research Activities in Advancing Climate Literacy and Outreach across Public, Private and Academic Institutions

Task Leader Jenny Dissen
Task Code
Date Awarded 10/12/2010
Contribution to CICS Themes Theme 1: 20%; Theme 2: 40%; Theme 3: 40%
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 30 %; Goal 4: 30%; Goal 5: 20%

EXECUTIVE SUMMARY
There is a need to advance climate science and climate change literacy of decision makers as they explore practical and cost-effective approaches to leverage available resources. Provision of climate data for applications and decision capabilities, which can factor into strategic, planning and operational decisions, requires partnerships across public, private and academic organization. This research focuses on identifying challenges and opportunities with advancing the application of climate data, on gathering the needs and demands of various select industries for climate information, and determining an approach to address the gaps through beginning with climate literacy.

BACKGROUND
Understanding changes in our climate has emerged as an important area of scientific endeavor over the last 3 decades. There is a rapidly increasing realization that profound changes in the Earth climate system are occurring and will impact most everyone either directly or indirectly. The International Scientific Congress on Climate Change (March 2009, Copenhagen) indicated that we are already following the path of the worst-case IPCC emissions scenario trajectories. Our society will need to adapt to the historic greenhouse gas emissions already injected into the Earth system. The magnitude and scale of climate change and its impacts are yet unpredictable, arguably under-estimated, and certain to intensify as past emission levels impact weather. As the discussion on reducing emissions shifts into mainstream awareness and is considered as a climate mitigation pathway, the question still remains on understanding the inevitable impacts that are already occurring and how we can strategically adapt to increases in severe weather conditions and trends in temperature, precipitation, etc.

Adaptation to climate variability can be considered in the following context: 1) reducing the exposure to the risk of damage, 2) building resiliency capacity to cope with the unavoidable damage, and 3) taking advantage of opportunities to avoid or reduce the damage. Adaptation should be an on-going fluid and flexible effort; there is no end-point nor is there a one-size fits all solution. Although there has been tremendous progress and advancement in our understanding and modeling of the earth system, there are a lot of unknown factors still being examined. This uncertainty creates further complications relative to investment planning and deliberate policy decision making today.

To develop effective and strategic adaptation opportunities and to meet future demands of climate information, stakeholder engagement, literacy and outreach activities need to take place to establish better collaborations between federal, contractor and academic partners. The overall NOAA strategy for climate information products assumes that the private sector will provide most derived climate products (also termed climate analyses, decision support information and/or climate information records). At the moment private investment in such activities is in its infancy and needs significant nurturing to flourish at the levels needed for the national climate enterprise. CICS-NC works with NCDC to assist in the incubation of such activities.

ACCOMPLISHMENTS

To advance climate literacy activities across public, private and academic partners on climate data, information and application opportunities, there were several activities accomplished during April 2011 to end of March 2012. These include developing frameworks, delivering presentations, engaging in relationship building and capacity- building activities, enabling catalytic support of innovation in uses of climate data, and ongoing operational support to NCDC.

Key highlights of accomplishments in literacy and outreach are framed under these key themes:

- Advancing climate literacy for private sector partnerships through interdisciplinary activities
- Growing climate literacy with and for education/academic purposes and partners
- Providing operational support to NCDC's activities in advancing their outreach with the Sectoral Engagement Team, communication with the Communications Officer and literacy with the Education Lead

Advancing climate literacy for private sector partnerships through interdisciplinary activities

- As part of the AMS's 1st Conference on Climate Adaptation, CICS-NC developed and executed a special forum and seminar activity called "Value Added Opportunities," where leaders of NOAA's National Climatic Data Center and CICS-NC showcased examples of scientific data simulations, visualizations, and artistic rendering to highlight collaborative efforts of artists, scientists and educations working together for value added opportunities of climate data. Private sector entrepreneurs, scientists and NOAA leadership including Dr. Kathryn Sullivan and Dr. Tom Karl attended this event.
- CICS-NC functioned as a lead for the *Job Accelerator Grant* that laid the groundwork in the Western North Carolina region for establishing partnerships regionally and across the state. The grant request was issued by The Commerce Department's Economic Development Administration (EDA), Department of Commerce and Department of Labor's Employment and Training Administration as a coordinated initiative to advance regional competitiveness and regional innovation. The grant was created to support innovation, commercialization, business formation and expansion, development of a skilled workforce, job creation, exports, sustainable economic development and global competitiveness in approxi-

mately 20 industry clusters that exhibit high- growth development potential. The proposal drafted by CICS-NC and the broader team used NCDC's climate data and application opportunities as the innovative capability to drive new commercial opportunities. The grant was not selected.

- CICS-NC Director, Otis Brown, and Jenny Dissen presented at NC State's Forum on Entrepreneurial Opportunities Associated with Climate Change Informatics, as part of their Office of Research, Innovation and Economic Development. This forum was designed to create a structured and informal discussion about the intersection between Climate Change and the need for new types of businesses built around informatics that address a one month to 10 year time scale.
- This engagement has lead the creation of a new venture start-up called *Global Climate Analytics* where NC State professors/entrepreneurs have teamed with venture capitalists and NC State's ORIED to create a tool and service to make global climate data and analytical tools about global climate data readily accessible to consumer and business users, through a consumer cloud-based search engine. Activities are in development stages.
- The interaction and engagement also spurred a meeting at NCDC, creating a need for NCDC to develop a methodical framework for private-sector engagement.
- Supported and led the development of an ongoing framework and approach for advancing the knowledge on climate data applications through a new activity called *Dataset Discovery Day*. This one-day workshop allows NCDC to discuss their data products and CICS-NC to discuss application opportunities in various sectors. CICS-NC and NCDC Sectoral Engagement Team have partnered to conduct this workshop on a bi-monthly basis.
- CICS-NC has established a relationship with Duke Energy to understand the impacts of changing climate normals on their energy load forecast. This spurred a research activity in developing profiles of optimal climate normals for each climate division in North Carolina. This research was shared with Duke Energy as an example of displaying secular trends in temperature, Heating Degree Days (HDD) and Cooling Degree Days (CDD) as a starting point to engage in further dialogue on impacts to their operational activities.
- By way of this engagement and research with Duke Energy, CICS-NC has lead the development of an upcoming workshop on *Alternative Climate Normals*, where regulatory agencies, science community and business leaders will discuss the impacts of changing normals on business and opportunities in potentially enabling change in current regulations to allow flexibility for businesses to apply alternative normals.
- CICS-NC has lead and supported the development of the *U.S. Disaster Reanalysis Workshop* where NCDC is investigating new econometric principles to apply in their current operational product called the US Weather/Climate Billion Dollar Disaster analysis.

Climate literacy for education/academic partners

- Supported the successful world-premiere launch of the video game *Fate of the World* and the corresponding film *Gaming the Future,* which demonstrates global strategy games as an effective educational and scenario-building tool to discuss impacts of climate change. The film can be viewed here: http://www.cicsnc.org/people/jenny-dissen/progress-update/

- As part of AMS 1st conference on Climate Adaptation, CICS-NC supported the display of art called *Pillars of Climate* (Steve McIntyre, June 30, 2011) to advance interdisciplinary connections between climate science and communications. Created through an art competition at the University of North Carolina Asheville (UNCA) through the Climate Change and Society course of study within the Master of Liberal Arts program at the University of North Carolina Asheville (UNCA), two young artists, created *"Pillars of Climate"* as an installation that investigates the issues of perception and dissemination of data in climate change. The art display is one example of blending science, communication, and outreach, highlighting the shift towards making science data visible, accessible and meaningful.
- Supported NCDC's scientist and meteorologist Marjorie McGuirk to collaborate with UNC Asheville's program *Climate Change and Society* to include a professional certification program
- CICS-NC, working with NCDC's Education Lead, established a partnership with *The Science House* of North Carolina State University for K-12 education outreach related to climate science and climate data to this audience group. *The Science House* has expanded their physical space to include more communications and display materials related to NCDC's activities and climate science. This partnership has enabled NOAA's NCDC to share the *Magic Planet* with *The Science House* to bring greater visibility to more K-12 students. Through this partnership, CICS-NC was asked to provide advisory and board support to a new pioneering STEM-focused high school in the Buncombe County of Western North Carolina.
- Reviewed and supported the publication of "Monitoring the Climate System with Satellites," a 2-hour module, jointly funded by NOAA/NESDIS and EUMETSAT, that describes the unique role that environmental satellites play in monitoring the Essential Climate Variables (ECVs) that are key for measuring the climate system. Module was distributed to over 50,000 K-12 teachers.

Providing operational support to NCDC's activities in Communications, Remote-Sensing, Sector Engagement and Education

- Supported NCDC's Communications Officer on numerous activities related to NCDC's operational and strategic activities:
- Provided review of the Communications Strategy Plan
- As part of the NCDC/CICS-NC partnership with *Climate Central*, provided advisory and review support for NCDC and Climate Central on creating videos talking about extreme events and what the science says as it relates to climate change. The following videos are currently in the process of being developed: Extremes 101 videos on snowstorms, heavy precipitation, tornadoes, drought, extreme heat events, and Tell Me Why videos on new climate normals, satellite and climate data, and climate extremes index. Videos are available on climate.gov website.
- Supported NCDC's Remote-Sensing Application Division on outreach activities related to satellite observations

- Developed a work plan and approach to identify users and applications of satellite climate data records
- Collaborating with the climate modeling community to advance the use of 30-year historical satellite-derived climate data record for both use in models and for model inter-comparisons
- CICS-NC lead NCDC's activities in celebrating the SUOMI-NPP Launch Celebration, which is one of the first intersections of the in-situ and satellite-based observing platforms. Activities included poster sessions, presentations and expertise provided by the remote-sensing team on new data and research capabilities enabled through the SUOMI-NPP sensors.
- Supported NCDC's Sector Engagement Team
- Developed an analysis that provided a perspective on NCDC's volume of requests for information and NCDC's customer profile. The analysis is now part of the NCDC Overview and Briefing Discussion, and demonstrates that businesses, consultants and legal industry are the largest customer group of NCDC's data.
- Developed an approach for NCDC's Sectoral Engagement team, where the leads were asked to summarize their understanding of how climate data was used by various sectors based on institutional knowledge and participation in various workshops and meetings

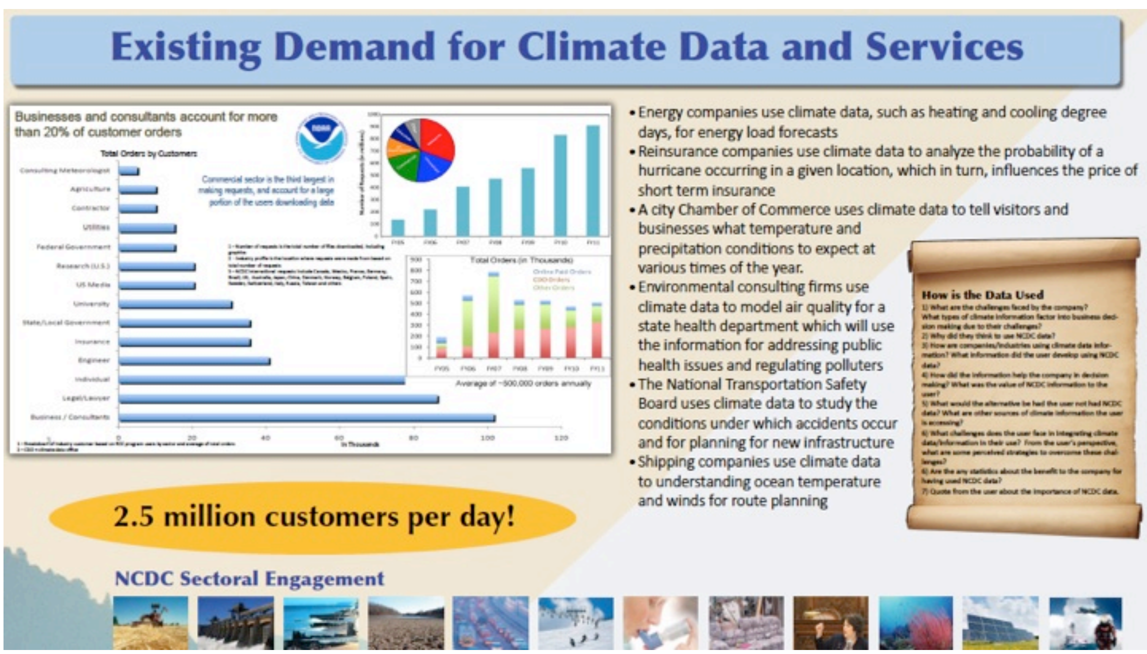

Figure 1: NCDC climate data volume (estimated), profile of customers (proxy), and example of climate data applications. Image taken from AMS 92nd Annual Conference poster presentation Investigating Methods for Advancing Climate Literacy for Private Sector.

PLANNED WORK

- Execute workshops on *Alternative Climate Normals* and *U.S. Disaster Reanalysis,* and utilize comments and outcomes from the discussions to research agenda and capturing needs for growing climate literacy
- Execute one-day workshops as outlined in the schedule for *Dataset Discovery Day*; this includes pilot and potential operational implementation of Dataset Discovery Days as a private sector engagement framework
- Support review of videos produced by Climate Central to build them as operational educational products for climate.gov
- Grow and advance research activities in partnership with Duke Energy, or extend the application for other utilities companies interested in understanding impacts of changing climate normals on their business; this supports CICS-NC ability to provide in-depth insights in sector-specific information needs through research
- Identify collaborative opportunities between CICS-NC and The Science House to grow literacy in K-12 related to climate data products, available from NCDC
- Determine application examples and opportunities in satellite CDR's and modeling community user group; identify needs of the modeling community to enable greater use of satellite CDRs
- Continue supporting and partnering with the NCDC Sectoral engagement teams and activities, Communications Officer and Remote Sensing and Applications Division on various outreach activities

PUBLICATIONS

None

PRESENTATIONS

Dissen, J. (2012), Advancing Climate Literacy, Presentation at the Climate Prediction Applications Science Workshop 2012, Miami, FL, 16-18 Miami 2012.

Dissen, J. (2012), CICS-NC and Approach Towards Climate Literacy and Climate Adaptation, Presentation for Asheville-Buncombe County Economic Development Coalition/Asheville Area Chamber of Commerce and the Caldwell Community College and Technical Institute International Brazil Visit, Asheville, NC, 29 January 2012.

Dissen, J., T. Houston, and K. Vincent. (2011), Investigating Methods for Advancing Climate Literacy for Private Sector. Poster presented at AMS 92 Annual Meeting, New Orleans, LA, 22-26 January 2012.

Dissen, J., O. Brown and M. McGuirk. (2011), An Approach Towards Literacy and Climate Adaptation, Presentation at the CICS Science Meeting 2011, Asheville, NC, 2 November 2011.

Dissen, J. (2011), Climate Change: Impacts to Opportunities, Presentation at the NCSU ORI Forum on Entrepreneurial Opportunities Associated with Climate Change Informatics, Raleigh, NC, 18 August, 2011.

OTHERS

- Selected by Management and Program Analyst of NOAA Climate Program Office to be reviewer of 2012 SBIR competition proposal 8.3.3C The Local Three Month Temperature and Precipitation Outlooks (L3MTO and L3MPO) (March, 2012)
- Joined leaders from business, government, academia, and the non-profit for the first annual Climate Leadership Conference (http://www.climateleadershipconference.org), in Fort Lauderdale, Florida; discussions included the importance of understanding the regional implications of climate change, activities in local adaptation planning efforts in South Florida and how private sector leaders are leading activities in energy efficiency and reduction in GHG emissions (March, 2012)
- Engaged in knowledge exchange half-day discussion and meeting with the IFC (commercial bank of the World Bank) Climate Change Unit (February, 2012)
- Selected as an advisor to provide input to Canada's National Roundtable on Environment and Energy on a two-part webinar series on *Leveraging investments in climate science and impacts and adaptation research to support business responses to climate change today* (January, 2012)
- Selected as a voting member of AMS Energy Committee, a sub-committee of Board on Enterprise Economic Development (BEED) (January, 2012)
- Participant in CSC and SAP's Sustainability Executive Forum for Process Industries and Utilities (September, 2011)
- Participant in the American Society of Civil Engineers' (ASCE) Committee on Adaptation to a Changing Climate Workshop entitled "Observational and Analytical Climate Modeling for Engineering Applications," (November 2011)
- Completed Global Energy Seminar at Harvard Business School Executive Education (received scholarship stipend) (November 2011)
- Participant in NC State College of Management Center for Innovation Management Studies (CIMS) workshop on "Situational Awareness: Becoming a Decision-Ready Organization," (October 2011)

Stakeholder Engagement to Better Understand Climate Information Needs

Task Leader George Briggs, The North Carolina Arboretum Society
Task Code
Date Awarded 3/1/2011
Contribution to CICS Themes Theme 3: 100%.
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 20%, Goal 5: 60%

EXECUTIVE SUMMARY

This task examines challenges and opportunities associated with the delivery and use of climate information, primarily targeted for the plant-based economic sector. Specific targets are the climate information needs and potential economic impacts of climate change on plant-based businesses through two key activities: the Executive Roundtable and the Plant Sector Working Group.

BACKGROUND

The US Government has invested greatly in the science and technologies that enable us to observe the Earth. This project attempts to leverage the investment of weather and climate information for new and emerging users for the benefit of environmental, economic, and national security.

Improved weather and now climate data and information are becoming essential to managing communities as well as businesses. Since 2007, NOAA/NCDC, the Institute for Global Environmental Strategies, and The North Carolina Arboretum have worked together to engage stakeholders to better understand climate information needs. In 2007, the NOAA Data Users Conference examined the information needs of the energy, insurance, and transportation sectors. In 2008, the *A Growing Interest* meeting brought together experts in the plant-based sector or green sector for the first time to better understand climate science, discuss potential impacts to the plant sector, and examine what data sets might better help this sector manage risk and adapt to climate change.

The North Carolina Arboretum is tasked with providing technical and professional expertise in support of the Executive Roundtable and the Plant Sector Working Group, to further define the information needs of the plant sector, as a follow up action to the 2008 *A Growing Interest* workshop. The Arboretum focuses on providing horticultural, landscape architectural and botanical insight, as well as selection and engagement of Roundtable leadership. In collaboration with IGES, this activity is to assess and examine the models for public-partnerships in support of providing climate services on a national basis to various private sectors.

The Plant Sector Working Group addresses important plant-related industry sectors, e.g. horticulture and gardening, nursery, landscape architecture and contracting, golf, arboreta and botanical gardens, recreation etc. In collaboration with IGES, a Plant Sector Workshop was held to improve the delivery of climate services to plant-based businesses nationally.

ACCOMPLISHMENTS

To date, The North Carolina Arboretum activity has reached two key milestones:
Supporting IGES planning, participant recruitment, and convening of *A Growing Interest 2* workshop on 21-22 March 2012 hosted by The North Carolina Arboretum; and
Supporting the preliminary planning and organization of the upcoming *Business Roundtable* that is scheduled for 25-26 April 2012.

The Arboretum assisted in the identification, participant recruitment, communications and hosting of a composition of national participants representing various sectors of plant-based industry – national representatives of public gardens and arboreta, the nursery and landscape sector, botanical and natural products sector, forest service, and horticulture society. These professionals joined NOAA scientists in *A Growing Interest 2* workshop to examine the latest climate science, the current state of the diverse, plant-based sector, and how NOAA data and information might help to better manage risk as related to climate change. The Arboretum, represented by George Briggs, led several important activities prior to the workshop, which greatly expands potential audience engagement resulting from the workshop.

During the spring of 2011, the Arboretum partnered with NCDC Director Tom Karl in leading negotiations resulting in the signing of a formal agreement between NOAA and the American Public Gardens Association (APGA). Executed June 2011 at the APGA Annual Meeting in Philadelphia, the agreement supports NOAA's fostering of public, community and industry understanding of climate issues and assists public gardens in creating education and community engagement strategies, training staff in climate sciences, and adapting to climate impacts within their institutions. This constituency represents 500 public gardens serving 60 million visitors annually.

During a change in APGA leadership occurring Fall 2011, the Arboretum integrated the interim director to the terms of the agreement and into relationships with NOAA, and orchestrated the introduction of APGA to EcoAmerica leadership at the request of NCDC. The APGA/EcoAmerica partnership adds zoo and nature center audiences, creating potential total audience engagement exceeding 200 million visitors annually. The APGA Interim Director participated in the workshop.

Observations from the workshop, along with identified possible actions, will be included in a final report, which will be delivered in the June 2012 time period.

A Business Roundtable focusing on long-term, strategic environmental forecasting will be convened on April 25-26, 2012 in conjunction with the Climate Normals Workshop, organized by NCDC. The Arboretum has provided counsel to IGES in the planning of the Business Roundtable, assisted in recruiting the chair, met with NCDC & IGES leadership and the chair for agenda development, and will participate representing plant-based industry sectors. The Arboretum is also assisting with the logistics of hosting the conference in Asheville, NC.

PLANNED WORK

- Develop and complete final report on *A Growing Interest workshop*;
- Convene an *Executive Roundtable* on April 25-26, 2012; and
- Produce a final report.

PRESENTATIONS

George Briggs the Keynote Address, which included emphasis on the APGA/NOAA agreement and the need for the green industry to engage with climate issues, at the Central Kentucky Ornamental and Turfgrass Conference on 9 February 2012.

OTHER

Participated on 23 August 2011 in an APGA workshop of 8 major US public gardens held in Richmond, Virginia featuring The North Carolina Arboretum's outreach programs related to climate sciences, work with NCDC and NOAA, and economic development.

5.6 Consortium Projects

Prototypes of Weather Information Impacts on Emergency Management Decision Processes

Task Leader	Burrell Montz Covey
Task Code	
Date Awarded	7/1/2010
Contribution to CICS Themes	Theme 1: 100%.
Contribution to NOAA Goals	Goal 2: 90%; Goal 5: 10%

EXECUTIVE SUMMARY

This year's objectives focuses on prototyping products and services for improving the communications of weather and climate information to emergency managers application in critical decision-making. The project infuses social sciences with technology into a guidance that can be applied to for understanding customer needs for information. The methods have been applied to various weather events and the utility of current and future products and services.

BACKGROUND

This work results from collaboration between University of North Carolina at Chapel Hill, Institute for the Environment and the Renaissance Computing Institute, the HQ of the National Weather Service Office of Science and Technology, and East Carolina University Department of Geography. This portion of the report focuses on the East Carolina University (ECU) component, but in the context of the overall goal of the research, which is to understand how to improve NWS weather and climate decision support to the emergency management (EM) community to save lives and protect property. ECU served as the social science lead institution for the project with primary responsibility for developing the means to infuse social science research into NWS operations to 1) to understand the EM decision processes for risk and crisis management, 2) to understand what is effective translation of scientific information into knowledge for decision making, 3) to understand how collaborative technologies can facilitate knowledge exchange and situational understanding, and 4) to demonstrate prototyping methods fusing together social sciences, physical sciences, and technological advances to advance decision support. To accomplish our work, we employed an incremental and iterative research and development process with EM decision-makers guiding the process.

The work of the second year focused on the Risk Paradigm as the linking mechanism between the National Weather Service and emergency management. The paradigm is a process oriented structure so the year's objectives concentrated on infusing social science into operations by 1) prototyping products and services that improve the communication and utility of weather and climate information in EM processes, 2) developing guidance for National Weather Service field personnel to understand EM requirements and to develop improved products and services using the 4-Step Method, and 3) exploring improved approaches to communicating weather and climate knowledge to emergency managers. We applied the 4-Step Methodology developed during year one to understanding NWS-EM processes for a tropical weather event to validate its utility. The method uses social sciences to understand decision making contexts, identify gaps and needs in current practices, explores improvements to product and services through prototyping, and validates findings to make recommendations for operational changes. Documenting the methodology is on going and being tested with forecast offices to transfer the method to weather personnel for operational utility, and to explore the methodology application to a range of event types, geographic areas, and customer needs.

ACCOMPLISHMENTS

To identify critical needs of emergency managers in the risk paradigm to make decisions, a 4-Step method was developed in year 1. The steps include 1) identify the context and timelines of critical decision making, 2) identify current practices of preparing and gathering critical knowledge to make decisions, and identify gaps of needs, 3) prototype approaches and products that improve knowledge transfer between the NWS and EM communities, and 4) validate new products and services in operations. The method was applied in year one to winter weather, and in year two the method was applied to a second use case for tropical weather. In Year 2, we undertook focus groups, surveys of representatives of various Emergency Support Functions, and interviews. After Hurricane Irene, we were able to talk to emergency managers and to carry out surveys of local decision-makers about the products they used. Some of the findings from these efforts include:

- Tropical storm force winds arrival time in a jurisdiction was the most critical parameter needed but does not readily exist in a product.
- Products with least reported use and confidence are Slosh MEOW and MOM and Storm Surge Forecasts
- Issues with communication effectiveness are in need of exploration
- Network and flow of information
- Differences in knowledge and needs
- Differences in definitions (impact, hazard, risk)
- Even within EM Community, one size does not fit all. For example, some prefer text and others graphics.
- Understanding of decisions made and timing of those decisions is critical to developing the most useful products and services (Figure 1)
- Web pages are heavily used so context, timing, and consistency are important

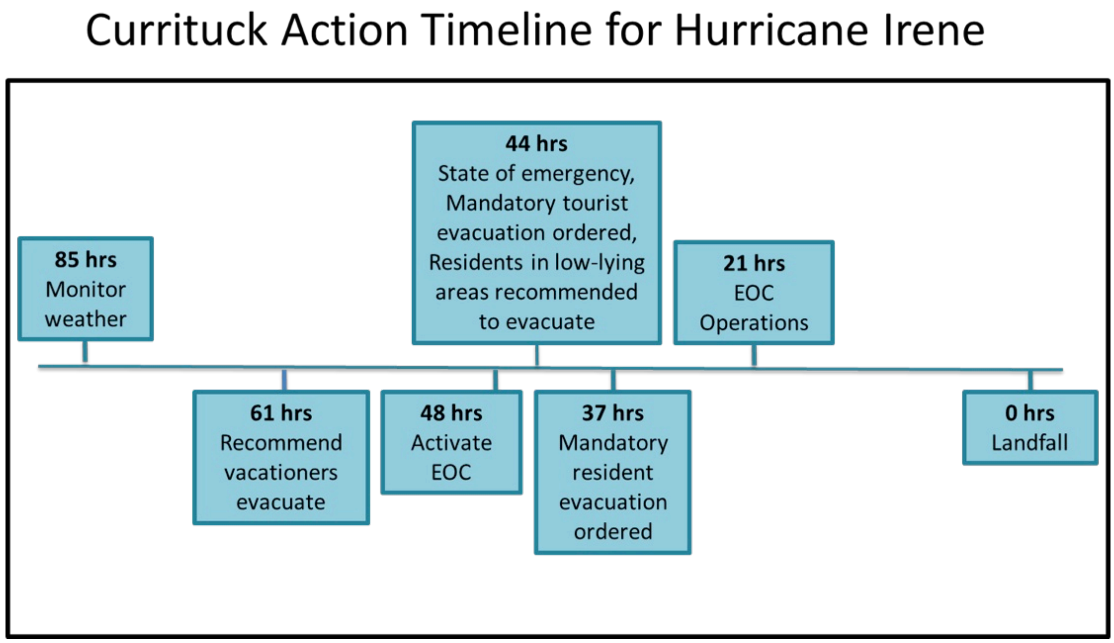

Figure 1: Critical Decision Timeline During Hurricane Irene

We have also worked with NWS personnel in Montana as they prepared for and held focus groups with school officials regarding winter weather school closings. Documenting the 4-Step methodology for use by Weather Service personnel is on-going. The method is being applied by test WFOs to applications in other regions of the country in Montana and the Midwest. Refinements to the guidance document are being made as needs to clarify the approach are uncovered.

PLANNED WORK

The current phase of the work is to conclude in June 2012. The work will conclude with the following outputs (ECU working in conjunction with the Institute for the Environment):

- A documented 4-Step methodology that can be applied by any WFO, region, or national center to better identify and understand the needs of emergency management for weather and climate information in their decision making. The guidance can be developed into a training program by the NWS or allow individual groups to apply as they see fit to improve their operations.
- The method is being applied to help evaluate a change in the Impact-Based Warning for tornadoes and severe weather in the Central Region. The project will set up the context for identifying how high-impact information can be produced and used more effectively. Surveys and other methods of collecting baseline and post-event effectiveness information will be developed. This work will serve as a case study for applying the results of this project to other issues of climate and weather information exchange.

PUBLICATIONS

None

PRESENTATIONS

"North Carolina School Closings in the Winter of 2010-2011: Decision-makers and Decision-making." Burrell Montz with Ken Galluppi, Jessica Losego, Kelsey Mulder and Catherine Smith. Annual Meeting of the Southeast Division of the Association of American Geographers, November 2011. Savannah, GA.

"WxEM – Weather for Emergency Management: Briefing to NWS Corporate Board." Ken Galluppi, Jessica Losego, and Burrell Montz. National Weather Service Corporate Board Meeting, December 2011.

"Weather for Emergency Management: Implications for NWS Tropical Weather Products and Services." Jessica Losego, Ken Galluppi, Burrell Montz, Catherine Smith, and Steve Schotz. American Meteorological Society, January 2012. New Orleans, LA.

"Weather Service and Emergency Management Collaboration Through An Interactive Web-Based Map Conferencing Infrastructure." Ken Galluppi, Jeff Heard, Jessica Losego, Burrell Montz, Catherine Smith, and Steve Schotz. American Meteorological Society, January 2012. New Orleans, LA.

"Needs and Use of Tropical Weather Information by the Emergency Management Community in North Carolina." Burrell Montz, Ken Galluppi, Jessica Losego, Catherine Smith, Darin Figurskey, and Richard Bandy. American Meteorological Society, January 2012. New Orleans, LA.

"Making Decisions when a Hurricane Threatens: Product Preferences for Emergency Management in North Carolina" Kelsey Mulder, Burrell Montz, Jessica Losego, and Ken Galluppi. Association of American Geographers Annual Meeting, February 2012. New York, NY

"Community Sense-Making for Coordinated Action: How Do Emergency Managers use the Cone of Uncertainty?" Catherine F. Smith with Jessica Losego, Ken Galluppi, and Burrell Montz. Symposium on Usability, Information Design, and Information Interaction to Communicate Complex Information, January, 2012. Seattle, WA

"Weather for Emergency Management: How to Bridge the Gap." Burrell Montz with Ken Galluppi, and Jessica Losego. National Hurricane Conference, March, 2012. Orlando, FL

OTHER

None

Prototypes of Weather Information Impacts on Emergency Management Decision Processes

Task Leader Kenneth Galluppi
Task Code
Date Awarded 7/1/2010
Contribution to CICS Themes Theme 1: 100%.
Contribution to NOAA Goals Goal 2: 90%; Goal 5: 10%

EXECUTIVE SUMMARY

This year's objectives focus on prototyping products and services for improving the communications of weather and climate information to emergency managers application in critical decision-making. The project infuses social sciences with technology into a guidance that can be applied to for understanding customer needs for information. The methods have been applied to various weather events and the utility of current and future products and services.

BACKGROUND

This work results from collaboration between University of North Carolina at Chapel Hill, Institute for the Environment and the Renaissance Computing Institute, the HQ of the National Weather Service Office of Science and Technology, and East Carolina University Department of Geography. The goal of the research is to understand how to improve NWS weather and climate decision support to the emergency management (EM) community to save lives and protect property. This project has goals to infuse social science research into NWS operations to 1) to understand the EM decision processes for risk and crisis management, 2) to understand what is effective translation of scientific information into knowledge for decision making, 3) to understand how collaborative technologies can facilitate knowledge exchange and situational understanding, and 4) to demonstrate prototyping methods fusing together social sciences, physical sciences, and technological advances to advance decision support. To accomplish our work, we employed an incremental and iterative research and development process with EM decision-makers guiding the process.

The work of the second year focused on the Risk Paradigm as the linking mechanism between the National Weather Service and emergency management. The paradigm is a process oriented structure so the year's objectives concentrated on infusing social science into operations by 1) prototyping products and services that improve the communication and utility of weather and climate information in EM processes, 2) developing guidance for National Weather Service field personnel to understand EM requirements and to develop improved products and services using the 4-Step Method, and 3) exploring improved approaches to communicating weather and climate knowledge to emergency managers. We applied the 4-Step Methodology developed during year one to understanding NWS-EM processes for a tropical weather event to validate its utility. The method uses social sciences to understand decision making contexts, identify gaps and needs in current practices, explores improvements to product and services through prototyping, and validates findings to make recommendations for operational changes. Documenting the methodology is on going and being tested with forecast offices to transfer the method to weather personnel for operational utility, and to explore the methodology application to a range of event types, geographic areas, and customer needs.

ACCOMPLISHMENTS

The project introduced the National Academy of Sciences Risk Paradigm as an organization by which the National Weather Service and emergency management work towards a common goal. To identify critical needs of emergency managers in the risk paradigm to make decisions, a 4-Step method was developed in year 1. The steps include 1) identify the context and timelines of critical decision making, 2) identify current practices of preparing and gathering critical knowledge to make decisions, and identify gaps of needs, 3) prototype approaches and products that improve knowledge transfer between the NWS and EM communities, and 4) validate new products and services in operations. The method was applied in year one to winter weather, and in year two the method was applied to a second use case for tropical weather. Though the focus was on validating the method, eleven priority findings for tropical decision-making resulted.

From the EM point of view, findings included such issues as:

- Tropical storm force winds arrival time in a jurisdiction was the most critical parameter needed but does not readily exist in a product.
- EMs are most focused on resulting impacts from storms, and less understanding is needed about the science understanding of the causes. Impact information is needed to localize information in time and space.
- EMs require best guess answers as to what will happen and when first, then can deal with the uncertainty of the forecasts through probabilities.
- Surge products are needed that improve understanding of the event in terms of timing and localized depth.

Figure 8: Prototype of Emergency Management needs for areal impacts connected to hurricane tracks.

Documenting the 4-Step methodology for use by Weather Service personnel is on-going. The method is being applied by test WFOs to applications in other regions of the country in Montana and the Midwest. Refinements to the guidance document are being made as needs to clarify the approach are uncovered.

PLANNED WORK

The current phase of the work is to conclude in June 2012. The work will conclude with the following outputs:

- A documented 4-Step methodology that can be applied by any WFO, region, or national center to better identify and understand the needs of emergency management for weather and climate information in their decision making. The guidance can be developed into a training program by the NWS or allow individual groups to apply as they see fit to improve their operations.
- The method is being applied to help evaluate a change in the Impact-Based Warning for tornadoes and severe weather in the Midwest region. The project will set up the context for identifying how high-impact information can be produced and used more effectively. This work will serve as a case study for applying the results of this project to other issues of climate and weather information exchange.

PUBLICATIONS

None

PRESENTATIONS

"North Carolina School Closings in the Winter of 2010-2011: Decision-makers and Deci sion-making." Burrell Montz with Ken Galluppi, Jessica Losego, Kelsey Mulder and Catherine Smith. Annual Meeting of the Southeast Division of the Association of American Geographers, November 2011. Savannah, GA.

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"Weather for Emergency Management: How to Bridge the Gap." Burrell Montz with Ken Galluppi, and Jessica Losego. National Hurricane Conference, March, 2012. Orlando, FL

OTHER

None

Spatio-temporal patterns of precipitation and winds in California

Task Leader	Sandra Yuter
Task Code	
Date Awarded	08/01/2011
Contribution to CICS Themes	Theme 1: 100%.
Contribution to NOAA Goals	Goal 2: 100%

EXECUTIVE SUMMARY

The predictability of flooding associated with atmospheric river storms in California is dependent on the repeatability of the spatial pattern of precipitation as a function of environmental characteristics that can be reliably forecast. Initial work indicates considerable variability in the spatial distribution of precipitation frequency among similar atmospheric river storms. One area of consistent frequent rainfall is the Plumas National Forest in the Feather River Basin.

BACKGROUND

Atmospheric rivers (ARs) are narrow corridors of enhanced water vapor transport within extratropical cyclones. When they arrive in California, ARs contribute significantly to the water supply and flood generation in the State. Although focused research during the last few years has yielded quantitative linkages between ARs and both regional water supply and extreme precipitation events, questions remain regarding the modification and redistribution of water vapor and precipitation in ARs by California's coastal mountains and Sierra Nevada. Previous work indicates that all recent flooding events on the US west coast were associated with an AR but not all ARs yielded flooding. Several factors can potentially turn an AR event into a flooding event. There is limited understanding of the relative roles of atmospheric stability, barrier jets, and small-scale ridges along the windward slope on watershed precipitation totals.

A key missing piece on the role of ARs in flooding events is knowledge of the detailed spatial distribution of precipitation over the windward slopes of the Sierra Nevada for each AR event and for groupings of AR events with similar environmental variables. The proposed work will utilize operational radar data from six National Weather Service WSR-88D radars (KBHX, KBBX, KRGX, KDAX, KMUX and KHNK) to construct a radar echo precipitation climatology of AR events for a 10 year period. A long-term radar echo climatology is needed since existing rain gauges provide only incomplete information on precipitation in this region, particularly over rugged mountainous terrain.

ACCOMPLISHMENTS

Upper air soundings were analyzed from two California sites to characterize the range of environments of AR events; 439 soundings from KDAK (Oakland, CA; soundings every 12 hours during AR events from Oct 1997 – Apr. 2011) and 68 soundings from KLHM (Lincoln, CA; soundings ~4-6 hours during events from Dec. 2010 – Mar 2011). Typical AR storms, (between the 25th and 75th percentiles) are stable, have cross-barrier wind speeds of 0 to 7 m/s and freezing level heights between 2.5 and 4 km. Higher freezing levels > 4 km are associated with higher stability and higher cross-barrier wind speeds.

A methodology was developed to "stitch" together precipitation frequency maps from the six radars to obtain a regional map. This method was applied to several test case storms. The Plumas National Forest in the Feather River Basin is a location of frequent rainfall during many AR storms, which is consistent with previous work that showed localized wind convergence in this area.

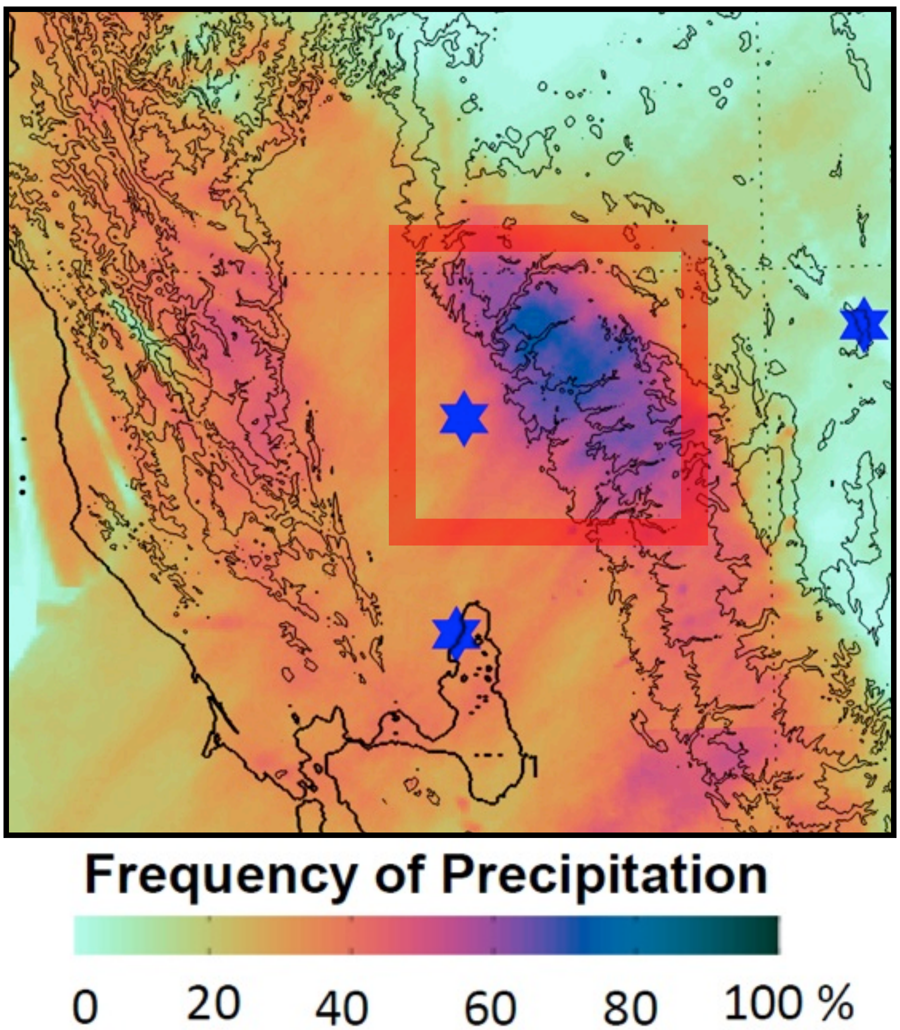


Figure 1: Detail from precipitation frequency map from 8 Feb 2007 AR storm showing region of higher frequency in the Plumas National Forest. Stars indicate locations of National Weather Service WSR-88D radars.

PLANNED WORK

- Complete radar data quality control to remove the remaining non-meteorological echo in the domains of each of the six radars.
- Radar data and composite processing for AR storms over 10 years that represent the range of environmental conditions (~40-50 storms)
- Empirical analysis of the spatial variations of atmospheric river storm precipitation relative to a variety of environmental conditions in order to address the following questions: To what degree is the spatial distribution of precipitation from AR storms in CA predictable? Which of the AR storm environmental variables which include water vapor flux, wind direction, stability and strength of the barrier jet are most valuable in predicting the locations of heavy precipitation.
- If time and resources allow:
- Radar data and composite processing of remaining AR storms over 10 year period (~40-50 storms).
- Finalize empirical analysis and radar climatology with larger sample size.

PUBLICATIONS

None

PRESENTATIONS

Yuter, S. E., D. Kingsmill, C. White, M. Wilbanks, N. Hardin, and J. Cunningham, 2011: The spatial distribution of precipitation frequency for atmospheric river storms in Northern California. *Abstracts, AGU Fall Meeting*, Dec 2011.

OTHER

None

6 CUNY TASKS

Development of Operational Algorithms & Software to Derive and Validate NDVI and Green Vegetation Fraction (GVF) Product from GOES-R

Task Leader	Peter Romanov
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 1: 100%.
Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

BACKGROUND

The final objective of this project consists in the development of algorithms and software to routinely produce and validate two land surface products, the Normalized Differential Vegetation Index (NDVI) and the Green Vegetation Fraction (GVF) from GOES-R Advanced Baseline Imager (ABI) instrument data. The primary NDVI product is an image-based map of the top of the atmosphere NDVI generated on an hourly basis. The external cloud mask will be used to limit NDVI estimates to cloud-clear pixels only. The GVF product presents the fraction of green vegetation with every land pixel of GOES-R ABI. It is derived from the observed NDVI using a linear mixture approach. Product validation systems assume consistency checks applied to both NDVI and GVF products.

The goal of this work is to perform the tasks as defined in the Algorithm Working Group (AWG) Land Team NDVI and GVF schedule and validation plan. During the current year we have prepared and delivered to AIT the final version of the software to generate NDVI and GVF products, the first version of the validation systems for both products and conducted a number of reviews for the products.

ACCOMPLISHMENTS

During the previous year we have finalized the development and testing of both the GOES-R GVF and NDVI algorithms at 100% readiness. The new GVF algorithm has been delivered to the Algorithm Implementation Team (AIT) along with all required documentation. The work on the GVF algorithm for GOES-R and its testing was conducted using Meteosat Second Generation (MSG) SEVIRI data as proxy to GOES-R ABI. The archive of SEVIRI data is routinely collected and maintained. At this time we have more than four years time series of half-hourly images from SEVIRI, which is sufficient for the algorithm development and testing purposes. The work on the GVF product towards 100% readiness included the testing and review process of the corresponding algorithm and processing as well as update of the ATBD to meet 100% readiness requirements. Both NDVI and GVF algorithms for GOES-R were also tested with the GOES-R proxy dataset developed by the GOES-R AIT. The accuracy of estimated GVF and NDVI was within specifications for these products formulated in the GOES-R project documents.

Comprehensive routine and dive-in validation tools for the NVDI product have been designed. The routine validation system estimates day-to-day temporal variations of the derived NDVI. Estimates of day-to-day temporal variations are made for each half-hourly NDVI product by comparing it with the NDVI product obtained at the same time of the day one day earlier. Only pixels that were cloud-clear on both days are accounted for in calculations. The product precision is estimated as the root mean square (RMS) daily change of NDVI calculated across all cloud clear retrievals. Cases with NDVI daily change exceeding 0.05 are identified and labeled as "questionable NDVI estimate". Figure 1 presents an example of NDVI product precision estimates for the day 2006219. Estimates are given for all land pixels as well as for several individual land surface cover categories. AIT-generated GOES-R proxy data were used for these estimates.

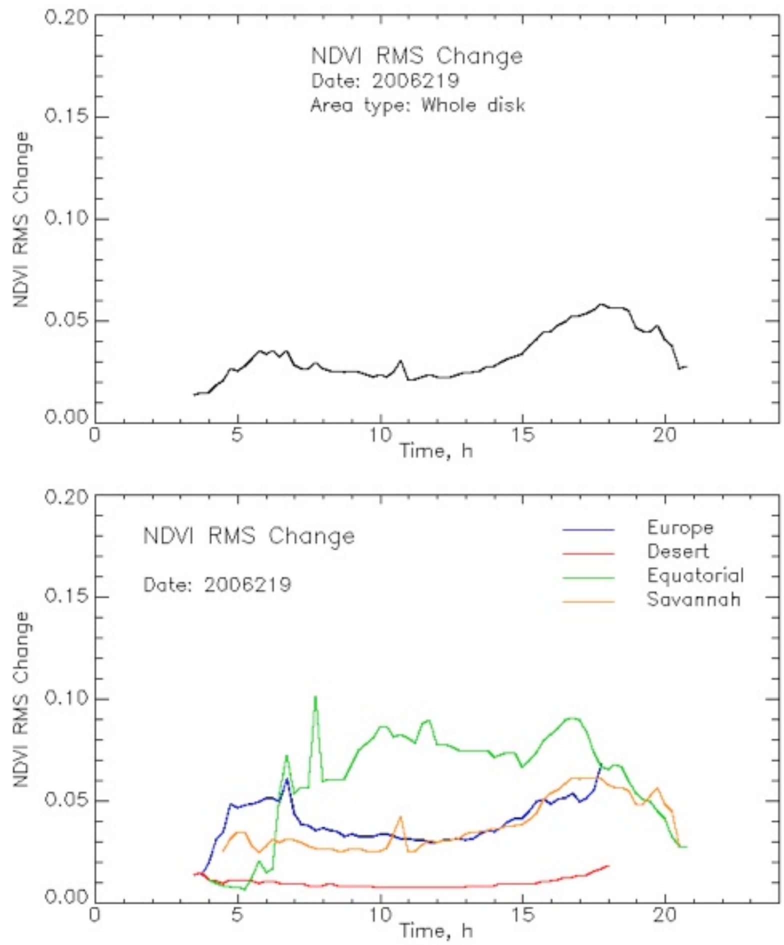


Figure 1: Diurnal change of estimated NDVI precision. Precision is expressed as RMS of the daily change of NDVI values. The RMS should generally be below 0.05 to satisfy accuracy requirements.

A similar system has been designed to validate the GOES-R GVF product. The system checks both day-to-day and intraday variations of estimated GVF in order to assess the precision of GVF estimates. Validation studies have shown that NDVI and GVF products generated with the developed algorithm satisfy the requirements specify in the Mission Requirement Document (MRD).

PLANNED WORK

The future work on the GVF and NDVI product will focus on the development and improvement of the routine and dive-in validation tools. The dive-in validation tool will include codes and scripts to compare NDVI and GVF derived from GOES-R with NDVI derived from polar orbiting satellites. The tool will be tested with MSG SEVIRI data as proxy for GOES-R ABI. The next version of validation tools will be delivered to AIT according to the schedule that will be finalized later this year.

PRESENTATIONS

Romanov P. , H. Xu NDVI product for GOES-R ABI: Current Status. 2011 NOAA STAR GOES-R AWG Review. Fort Collins, CO 14-16 June 2011.

Romanov P. , Y. Tian GVF product for GOES-R ABI: Current Status. 2011 NOAA STARGOES-R AWG Review. Fort Collins, CO, 14-16 June 2011.

Development of Operational Algorithms & Software to Derive and Validate Snow Depth Product from GOES-R

Task Leader Peter Romanov
Task Code CUNY
Date Awarded
Contribution to CICS Themes Theme 1: 100%.
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

BACKGROUND

The final objective of this project consists in the development of algorithms and software to routinely produce and validate the Snow Depth (SD) product from GOES-R Advanced Baseline Imager (ABI) instrument data. The SD is estimated from the snow fraction (which is another GOES-R ABI product) only over plain non-forested areas. The external cloud mask is used to limit SD estimates to cloud-clear pixels only. The validation system for this product should provide routine estimates of the product accuracy. The validation approach consists in a direct comparison of derived snow depth with synchronous collocated observations of snow depth at ground-based meteorological stations.

The goal of this work is to perform the tasks as defined in the Algorithm Working Group (AWG) Cryosphere Team SD schedule and validation plan. During the current year we have prepared and delivered to AIT the final versions of the software for the SD product, developed a system to conduct routine validation of the product and conducted a number of reviews for the SD product.

ACCOMPLISHMENTS

During the previous year the fifth (and the final) version of the operational algorithm to estimate snow depth from GOES-R ABI was developed, tested and transferred to GOES-R Algorithm Implementation Team (AIT). To estimate the snow depth the algorithm uses an empirical relationship between the snow depth and the snow fraction. The fractional snow cover is estimated with a separate algorithm by another group within the GOES-R Cryosphere Team. As compared to the fourth version of the algorithm, the fifth version accounts for the seasonal change in the relationship between the snow depth and the snow fraction. The fifth version of the algorithm incorporates quality flags and quality control information as it was requested by AIT. The algorithm performance was tested with both current GOES-Imager data and with GOES-R proxy data that were generated by AIT from observations of Moderate Resolution Spectroradiometer (MODIS) onboard EOS satellites Terra and Aqua. As an example, Figure 1 presents a sequence of daily snow depth maps over US Great Plains and Canadian Prairies generated with GOES Imager data during the period of about two weeks.

The progress on the development of the Snow Depth product was reported at the annual GOES-R ABI Algorithm Working Group meeting in Fort Collins, CO in June 2011. In July 2011 we have received reviews of the Snow Depth ATBD. In August 2011 the algorithm was presented at the ADEB review. Recommendations with respect to the algorithm improvement and modifications to the ATBD document were taken into account in preparation of the 100% readiness software and documents. The final version of the code and support documentation were delivered to AIT in September 2011.

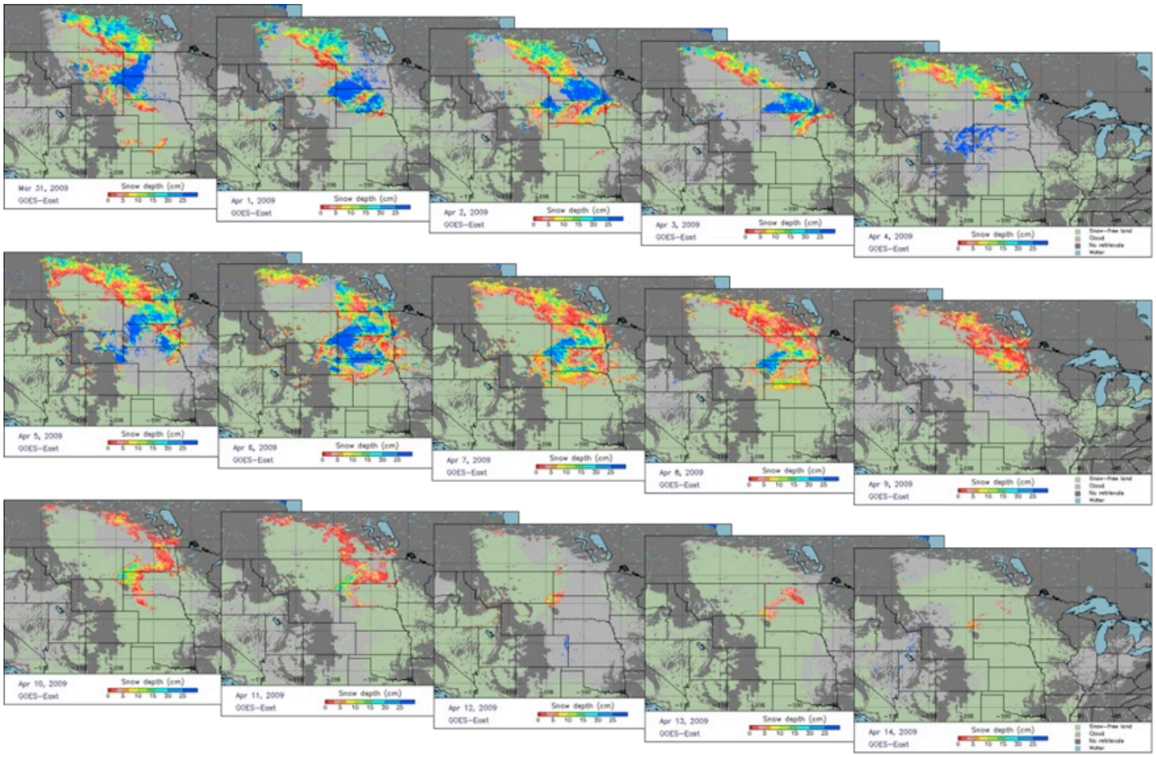


Figure 1: Example of the snow depth retrieval with the GOES-R ABI SD algorithm. The SD algorithm has been applied to the snow fraction derived from MODIS Terra with GOES-R fractional snow cover algorithm.

PLANNED WORK

The future work on the Snow Depth product will mostly focus on the development and improvement of the tool to validate operational retrievals of snow depth with GOES-R ABI data. The approach to validate GOES-R-based maps of snow depth distribution is straight-forward and includes a direct comparison of the derived snow depth with matched snow depth observations at ground-based stations.

PUBLICATIONS

Romanov P. (2011) Satellite-Derived Information on Snow Cover for Agriculture Applications in Ukraine. In F.Kogan et al. (eds.) Use of Satellite and In-Situ Data to Improve Sustainability. NATO Science for Peace and Security Series C: Environmental Security, Part 2, 81-91, Springer Science Business Media B.V.

PRESENTATIONS

Romanov P. , C. Kongoli Snow Depth product for GOES-R ABI. 2011 NOAA STAR GOES-R AWG Review Fort Collins, CO, 14-16 June 2011.

Development of Operational Algorithm & Software to Validate Snow Cover Product from VIIRS NPP

Task Leader	Peter Romanov
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 1: 100%.
Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

BACKGROUND

The Binary Snow Cover and the Snow Cover Fraction are among the suite of land surface products which will be derived from observations of the 22-band Visible/Infrared Imager/Radiometer Suite (VIIRS). VIIRS instrument onboard the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) was launched in October 2011. Other VIIRS instruments onboard the JPSS (Joint Polar satellite System) platform will be launched in 2014 and 2021.

The objective of this project consists in the development of algorithms and software to assess the quality of snow cover retrievals from VIIRS and to quantitatively evaluate the accuracy of the product. The work on the project during the last year period was concentrated on the following two tasks: (1) Development of tools to compare and validate snow retrievals from VIIRS with surface observation data and (2) Evaluation of the accuracy of the VIIRS operational snow mapping algorithm as implemented in NASA's Product Evaluation and Analysis Tool Element (PEATE) and (3) First tests of the VIIRS snow cover product from NPP generated with NPP satellite data.

ACCOMPLISHMENTS

During the past year we continued development of the VIIRS snow cover validation tool. The tool incorporates scripts and codes that (1)regrid daily global VIIRS data to the Climate Modeling Grid (CMG) at 5km spatial resolution, (2) acquire in situ observations of snow depth observation data from NOAA NCDC and CPC archives and (3) compare VIIRS snow cover maps with in situ observations. We also tested VIIRS snow maps generated by NOAA and NASA from VIIRS proxy data. In the end of the year we have examined the first snow retrievals made from NPP VIIRS data launched in October 2011.

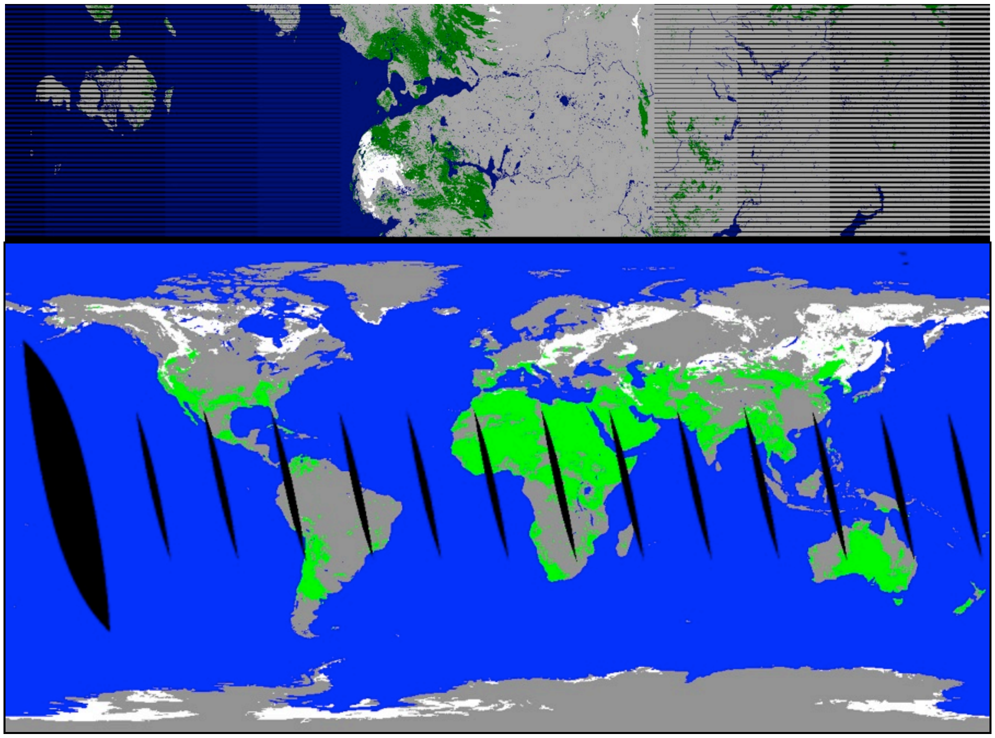
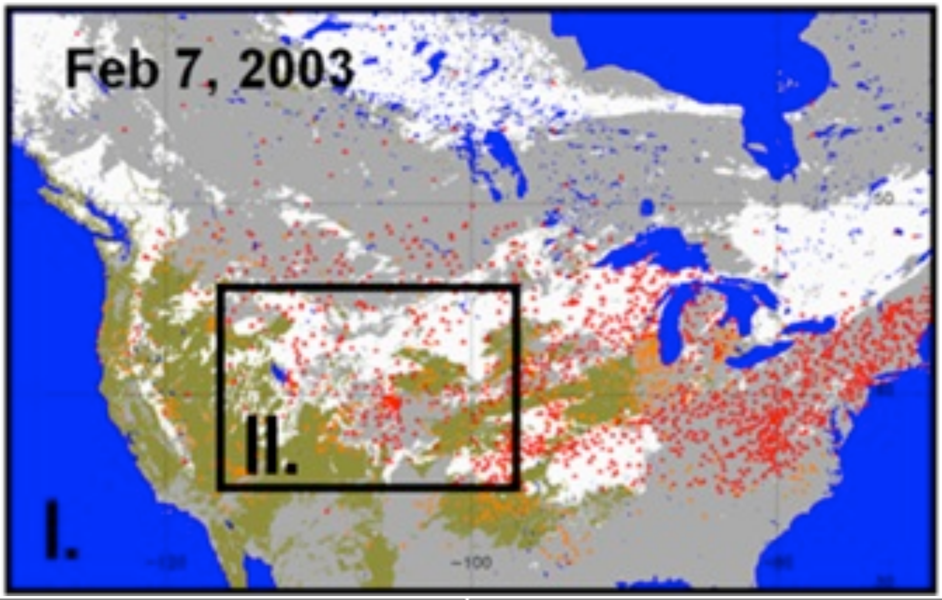


Figure 1: Left: Image of VIIRS proxy snow granule at 375 m spatial resolution. Right: VIIRS snow granules regridded to global latitude-longitude projection at 5 km resolution.

Figure 1 presents an example of a VIIRS snow granule at 375 m spatial resolution and a global daily snow cover map produced by combining and regridding all daily snow cover granules. As it seen from Fig. 1 the global snow cover map provides a reasonable overall representation of the snow cover distribution. However a closer examination of the map reveals a large number of snow cover misses mostly in the dense forested areas in Canada and Russia as well as frequent misclassifications of clouds as snow cover in tropical areas of Africa and South America.

Quantitative validation of the proxy VIIRS product has shown that its accuracy was somewhat below the required 90% level (see the example in Fig.2). Omission errors are more likely to occur in the sno maps than commission errors.



Area I.

		Station data: Snow	Station data: No Snow
VIIRS	Snow	487	50
	No Snow	67	292

Total: 896 Accuracy: 86.9%

Area II.

		Station data: Snow	Station data: No Snow
VIIRS	Snow	157	14
	No Snow	42	123

Total: 336 Accuracy: 83.3%

Figure 2: Example of validation of VIIRS snow product derived from proxy data using surface observations of snow cover. Left: location of stations in North America used in the comparison, Center and Right: Statistics of correspondence between satellite-based snow retrievals and surface observations for two areas.

PLANNED WORK

The future work will be focused primarily on the assessment of the quality and accuracy of the snow product generated with VIIRS data from board NPP satellite. We will implement a routine validation system that provides comparison of VIIRS snow maps with surface observation data and with NOAA IMS interactive snow cover charts for the Northern Hemisphere. The analysis of errors in the VIIRS snow product will help to identify improvements to be introduced to the VIIRS snow identification algorithm.

PRESENTATIONS

Romanov P. , I. Appel (2011) Validating Snow cover Product from NPP VIIRS. IGARSS 2011, Vancouver, Canada.

Development of an Upgraded Southern Hemisphere Automated Snow/Ice Product

Task Leader	Peter Romanov
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 1: 100%.
Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

BACKGROUND

This work is part of the ongoing NESDIS efforts to upgrade the Global Automated Snow and Ice Mapping System. The previous version of the system used data from older generation visible/infrared and microwave satellite sensors (NOAA AVHRR, DMSP SSMI). The primary objective of these efforts consist in incorporating in the system observations from newer generation satellite sensors (METOP AVHRR, DMSP SSMIS, MSG SEVIRI) along with upgrading the snow detection and mapping algorithm. The new system will provide global snow and ice cover maps at the nominal spatial resolution of 2 km, which is 2 times higher than the resolution of the older automated snow/ice product.

This particular task is focused on the upgrading of the Southern Hemisphere portion of the Automated Snow/Ice Product. The planned completion of the task is in December 2012. During the first year and a half of the project implementation the primary objective was to develop an operational algorithm to generate maps of snow cover distribution in the Southern Hemisphere. Maps of snow cover are generated solely with METOP AVHRR data at 2 km nominal spatial resolution. The approach we implemented in the algorithm consists in mapping snow cover only over areas affected by seasonal snow cover. These areas include South America west of 60°W, South Africa south of 24°S, New Zealand and Australia south of 25°S and east of 140°E.

In this report we present the work accomplished during the first year and a half of the project execution.

ACCOMPLISHMENTS

During the first year and a half of the project execution we have upgraded the older snow mapping system developed for NOAA-17 AVHRR data to operate with METOP AVHRR data. A number of substantial modifications to the old system were done to accommodate a substantially larger volume of data provided by METOP. The original snow mapping algorithm was also modified to account for the parallax effect in the mountainous areas. During February-May 2011 we have introduced the first portion of the upgrades to the current operational snow mapping system. This included the replacement of NOAA-17 that failed in the end of 2010 with the data from METOP AVHRR. We also replaced SSMI with the newer SSMIS instruments onboard DMSP F-16 and F-17 satellites. Still at that stage the spatial resolution of the map was left unchanged at 4 km.

The upgraded software for the new 2 km resolution snow mapping system based on METOP AVHRR data has been developed and implemented in a quasi-operational mode on local servers. The system has been generating daily snow cover maps at 2 km spatial resolution over South America, South Africa, Australia and New Zealand since November 2010. The main products generated by the system include (1) the daily snow cover map, where all satellite observations over land surface are classified into three categories, snow, snow-free land and clouds/undetermined (2) Daily blended snow cover map, where each pixel characterizes the state of the land surface when it was last observed cloud-clear, (3) The date of last update for each pixel of the map and (4) support information that includes quality control flags and quality control information.

Figure 1 presents an example of the daily snow cover, blended snow cover map and the map of cover temperature for South Africa.

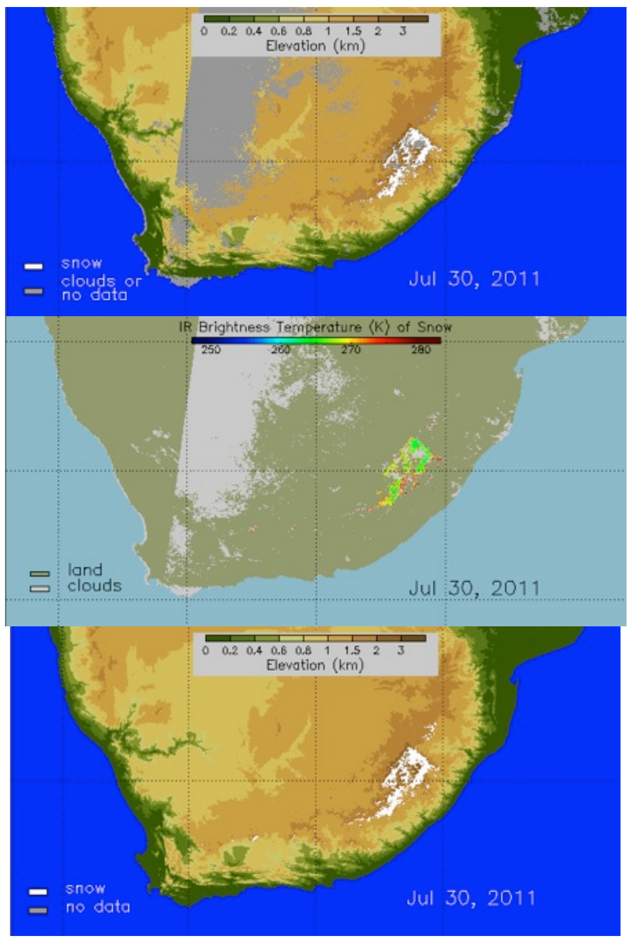


Figure 1: (Top) Daily map of snow cover in Southern Africa. Center: maps of snow cover temperature. Right: Blended snow cover map of Southern Africa. All products have been generated on a daily basis since November 2010.

PLANNED WORK

METOP-AVHRR-based snow mapping system will be finalized, delivered to NOAA OSO and implemented operationally in summer 2012. Prior to the final delivery the system will be discusses at the Test Readiness Review (TRR) in March 1012, and System Readiness Review (SRR) in April 2012. By the time of the final delivery we will prepare and provide all necessary documentation for the system that includes in particular, the Algorithm Theoretical Basis Document (ATBD) and Software Architecture Document (SWA). This will complete the first stage of the project implementation. At the next stage we will complement the system with DMSP SSMIS data that will be used to map ice cover in the Southern Ocean. Besides that we will add a separate algorithm for mapping snow cover over South Africa with MSG SEVIRI instrument data. Preliminary studies have shown, that availability of frequent views from SEVIRI allows for more reliable and robust snow identification from this instrument than from METOP AVHRR. The delivery of the stage 2 algorithm and code of the Automated SH Snow and Ice Mapping System to NOAA OSO is expected in December 2012.

PUBLICATIONS

Romanov P. (2011) Southern Hemisphere Automated Snow/Ice (METOP-AVHRR) Algorithm Theoretical Basis Document. V. 1.0

Improving Monitoring of Tropical Forests and their Characterization in NCEP Models Using GOES-R ABI Land Products

Task Leader Peter Romanov (Co-I), PI: Y.Tian, IMSG Inc.
Task Code CUNY
Date Awarded
Contribution to CICS Themes Theme 1: 100%.
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

BACKGROUND

This is a small task in support of Dr.Tian's investigation on the potential use of GOES-R ABI data to improve characterization of tropical forests. Responsibilities of P. Romanov (who is the Co-I in this project) consist in collecting and maintaining a set of Meteosat Second Generation (MSG) SEVIRI data for use in the study. The task assumes the total effort of about one week per year.

ACCOMPLISHMENTS

During this year the collection of data for Dr.Tian's research has continued. The dataset includes MSG SEVIRI images at 30 minute interval in several selected bands needed for land surface characterization. These bands are visible (ch.1 at 0.6 µm), near infrared (ch. 2 at 0.9 µm), shortwave infrared (ch.3 at 1.6 µm), middle infrared (ch.4 at 3.9 µm) and far infrared split-window bands (ch.9 at 10.8 µm and ch.10 at 12.0 µm). The data collection is performed automatically. We conduct routine checks on the quality of the data and make sure that the dataset is complete.

During the previous year we upgraded the storage system by adding one 8Tb hard drive.

PLANNED WORK

The collection of MSG SEVIRI data will continue during the whole 3-year period of the project implementation. By the end of the period we will have about 10 years' worth of data accumulated in the dataset.

Quantitative Image Restoration

Task Leader	Irina Gladkova
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 1: 70%; Theme 2: 30%
Contribution to NOAA Goals	Goal 1: 20%; Goal 5: 80%

BACKGROUND

One of the NOAA's mission support goal is to "Provide a Continuous Stream of Satellite Data and Information with the Quality and Accuracy to Meet Users Requirements for Spatial and Temporal Sampling and Timeliness of Delivery". The intrinsic risks of damaged to sensors associated to launching and operating satellites in the hostile environment of space continuously threaten NOAAs critical priority of maintaining a continuous stream of accurate and high quality satellite data and information. Such risks are not specific to GOES-R, but given the essential role GOES-R will play for NOAA, it is critical that techniques be in place and ready to mitigate any potential risk from temporary or permanent non-functional detectors. Even when the detectors are partially function, artifacts such as stripes can present severe problems.

The real possibility of such problems is clear as seen in SEVERI striping abnormalities on the MSG, or the large number of damaged detectors in band 6 of Aqua (MODIS). Fortunately there are powerful statistically sound methods of estimating the missing data. While none would suggest such estimations can completely replace the missing data, they can mitigate the risk by using all available data to provide the a high quality estimation of the missing data. This threat can be mitigated through development of the statistically sound and high performance quantitative image restoration algorithm we have propose.

ACCOMPLISHMENTS

We have adapted our current band 6 MODIS restoration algorithm to work with visible bands of the ABI simulated data. The broken detectors to be restored in our implementation are fully configurable. In addition we adapted our current algorithm to also operate on infra-red and near infrared bands. We have evaluated the restoration with simulated damage to band 0.47 micron visible and 2.1 micron infrared band. Figure 1 shows an example of performed evaluations where we first simulate a possible damage on Terra's Band 3 (proxy for 0.47 micron ABI) and comparing the column-interpolated (current NASA band6 scenario) as well as QIR restored values with original. The original appears nearly identical to that of our restoration.

We have also created a database of restored Aqua band 6 over the Yellowstone region for the 2010-2011 snow season to evaluate the benefit of band 6 restoration for snow products. Along with the restored radiances, we are providing NDVI, thermal image and NDSI inputs along with a band 6 based snow map product. In addition, we have regridded the restored Aqua based on restored band 6, and combined Terra data to produce a

Terra-Aqua combined Cloud-Gap-Filled (CGF) snow cover map product over the snow season.

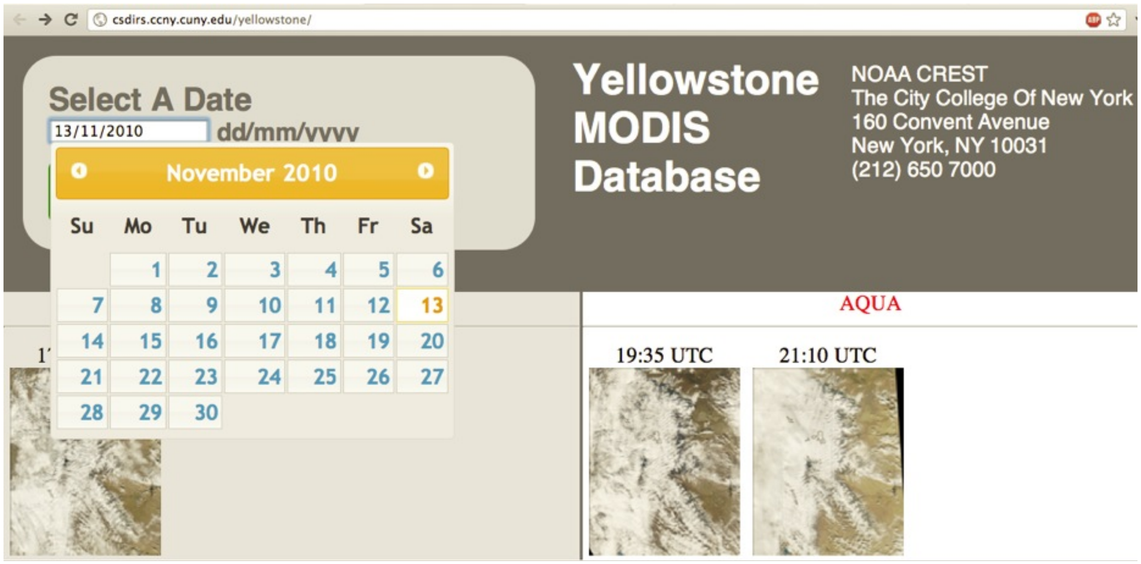


Figure 1: Screenshot of the data base (available from http://csdirs.ccny.cuny.edu/yellowstone/)

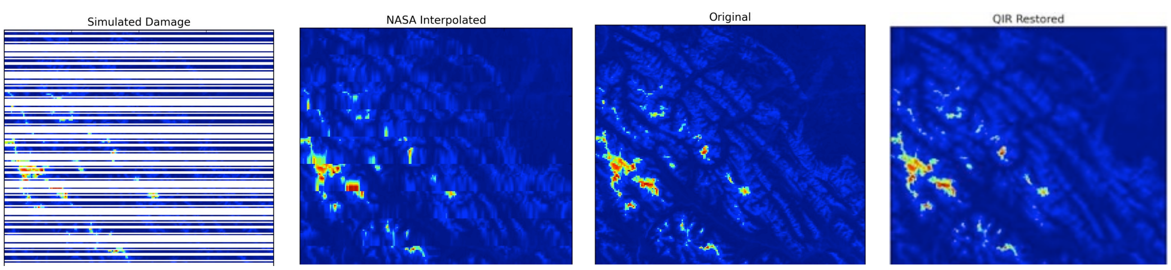


Figure 2: Simulation of possible damage and restoration using Terra granule at 500m resolution acquired on day 273 of 2010 19:05 UTC.

PLANNED WORK

- Investigate improvements by integrating spatial interpolation within the damaged channel with cross band interpolation.
- Investigate fusing information from full disk and CONUS high resolution for restoration.

PUBLICATIONS

I. Gladkova, M. Grossberg, F. Shahriar, G. Bonev, P. Romanov, Quantitative Restoration for MODIS Band 6 on Aqua, IEEE Transactions on Geoscience and Remote Sensing, vol.50, no. 6, Jun. 2012. To be published. [Online]. Available: doi:10.1109/TGRS.2011.2173499.

Gladkova, M. Grossberg, G. Bonev, P. Romanov, F. Shahriar, Increasing the Accuracy of MODIS/Aqua Snow Product Using Quantitative Image Restoration Technique, IEEE Geoscience and Remote Sensing Letters, to be published

PRESENTATIONS

I. Gladkova, M. Grossberg, G. Bonev, P. Romanov, Seasonal snow cover of Yellowstone estimated with restored MODIS Aqua, and MODIS Terra snow cover maps, AGU Chapman Conference on Remote Sensing of the Terrestrial Water Cycle in Kona, Hawaii

Cloud-top Relief Spatial Displacement Adjustments for GOES-R Images

Task Leader	Mahani
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 1: 90%; Theme 2: 10%
Contribution to NOAA Goals	Goal 1: 50%; Goal 2: 50%

BACKGROUND

The proposed project is an effort to develop a technique based on stereoscopic principles to estimate and adjust cloud-top relief spatial displacements from high-resolution GOES-R InfraRed (IR) observation data. This algorithm will use IR observations from two GOES-R east and west satellites to derive/update the IR-Could-Top Height (CTH) relationship for estimating CTH and its associated Could-Top spatial Displacement (CTD). Cloud-top spatial error is associated with cloud top height and satellite viewing angle for each cloud cell. CTH is one of the current GOES-R Algorithm Theoretical Basis Document (ATBD) products. ATBD is a physical and IR-based approach. But, the accuracy of CTH estimates by ATBD for multi-layer and for thin cirrus clouds is low. The proposed approach is expected to increase the accuracy of CTH estimates because of using 3-D principals, which is based on geometry of clouds in addition to physics of satellite imagery. Hence the GOES-R ATBD outputs, particularly CTH estimates, are expected to be improved by incorporating the proposed algorithm with ATBD.

Utilizing simultaneous corresponding cloud images from two geostationary satellites located at two different locations (e.g., GOES-East and GOES-West) will help to meet the requirements for using stereographical principal to derive the relationship between CTH and IR. The derived the CTH-IR relationship needs to be updated and modified gradually for various cloud types, locations, and seasons. There is no need for availability of simultaneous corresponding GOES- east and -west IR images to implement the algorithm for estimating and adjusting CTD. The cloud-top IR-CTH relationship is a piecewise linear approximation in the proposed approach. The derived relationship will be tested and improved using multi IR frequency to be able to use it for CTD adjustment of GOES-IR observations of multi-channels. CALIPSO-CTH is used to validate and to compare the CTH estimates by the developed and ATBD algorithms.

ACCOMPLISHMENTS

In this project the focus is to estimate CTD only associated with CTH due to the assumption that CTD related to other sources such as satellite navigation have been already adjusted from GOES IR observations because of using the geographically registered images. Earth curvature is another source of creating CTD that will be considered for areas with latitude greater than 45°North or South. To estimate CTH, two relationships are considered, the relationship between CTD and CTH and the relationship between CTH and cloud-top IR brightness temperature.

CTH-CSD Relationship using 3-D Principle:
The CTD-CTH relationship has been studied for GOES-11 and GOES-13 channel-4 infrared, as proxy for GOES-R data, and accomplished by deriving the associated equations and diagram. This relationship is a stereoscopic based geometrical relationship using using corresponding pixels from GOES_E and -W IR image. The assumptions in this study are: 1) the component of CTD, along latitude direction, dLy, is the same for each corresponding cloud cells on two GOES-E and -W satellite images, because both satellites locate at latitude = 0, Eq. 1; and 2) the difference between the longitude direction (the direction of two GOES satellites) components for each corresponding cloud cell on GOES-E, $dLx_{G\text{-}E}$, and GOES-W, $dLx_{G\text{-}W}$, images is proportional to CTH and cloud cell-satellite view angle along satellite orbit, γ_λ, Eq. 2, as Fig. 1 shows, then:

$$dLy_{G\text{-}E} = dLy_{G\text{-}W}, \quad \& \quad \Delta dLx = dLx_{G\text{-}E} - dLx_{G\text{-}W} = f(CTH, \gamma_\lambda^{(rd)}) \quad (1)$$

The two corresponding isotherm contours of cloud-top temperature for two corresponding IR images from GOES-E and –W are compared in Figure 1. As Fig. 1 illustrates, each two corresponding temperature contours are apart only in X-direction and not in Y-direction. Fig. 1 also demonstrates that the X-displacement between corresponding contours for colder temperature (higher altitude), 210K (blue contours), is greater than the X-displacement between corresponding contours for warmer temperature (lower altitude), 250K (red contours), so ($\Delta dLx_{210K} > \Delta dLx_{250K}$).

The simplified derived equations for estimating dLx and dLy for any given cloud cell located at altitude (h) and the angular geographic longitude and latitude coordinates of (λ_p , φ_p) and for each GOES satellite located at (λ_s , φ_s), are:

$$dLy_p = h\, H'\, Sin(d\varphi_{s\text{-}p}) \,/\, [H'\, Cos(d\varphi_{s\text{-}p}) - 1 \quad (2)$$
$$dLx_p = h\, H'\, Sin(d\lambda_{s\text{-}p}) \,/\, [H'\, Cos(d\lambda_{s\text{-}p}) - 1] \quad (3)$$

where H' is the satellite distance from the center of the earth, $d\varphi = \varphi_p - \varphi_s$, and $d\lambda = \lambda_p - \lambda_s$ with the assumption that CTH (h) is small enough that can be equal to zero in comparison with radius of earth and the components of angular displacement in longitude and latitude directions are small enough that can use the angles instead of sin of them. Eq. 2 was used to create Figure-2 that represents the relationships between CTH-CTD in terms of angular distance between cloud cells and satellite, for GOES satellites.

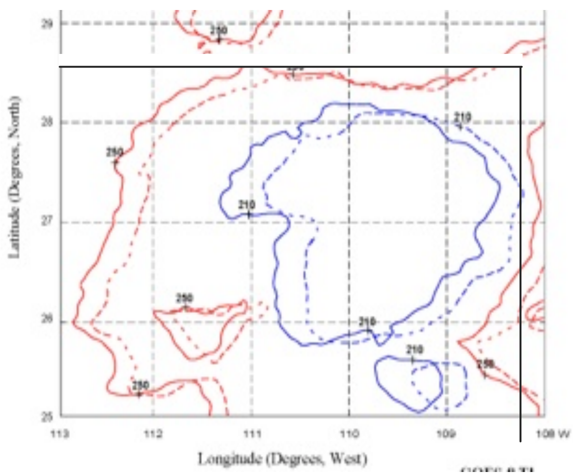


Figure 1: Comparison of two isotherms from two simultaneous and corresponding GORS-11 & 13 IR images for cloud-top temperatures of 210K & 250K.

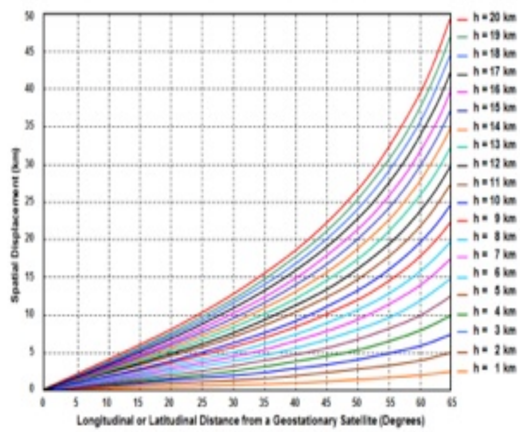


Figure 2: Cloud-top relief spatial displacement (CTD) as a function of cloud-top height (CTH) and cloud top distance from satellite for GOES IR imagery.

Deriving IR-CTH or IR-CTD relationships:

X-parallaxes (ΔdLx) are proportional to cloud-top heights or their corresponding cloud-top IR-temperatures (Fig. 1). By understanding the IR-CTH or IR- ΔdLx relationship, CTH or its corresponding CTD can be estimated for any cloud-cell with known cloud-top IR-temperature. Deriving the IR-CTH relationship using lag-correlation for detecting corresponding pixels and a piecewise linear relationship with three pieces, has been studied. The basic idea of using a piecewise linear approach is to simplify the image-processing requirements so that it can be automated. IR-CTH relationship for winter clouds will be studied also. Three hours of corresponding IR images from GOES-11 and -13, for the northeastern study area for convective clouds, in July 2011, have been used to derive the 3-piece piecewise linear IR-CTH relation with 6-parameters. The 6-parameters are h_0, T_1, T_2, l_1, l_2, and l_3, (shown in Fig. 3).

Parameter h_0 (height for pixels at a selected IR-temperature in the range of 270K-285K) is bounded by the range [0-5km]; T_1 and T_2 are two brightness-temperature thresholds in the ranges of [230K-280K] and [200K-250K] respectively and $T_2 < T_1$; and l_1, l_2, and l_3 are the gradients (lapse-rates) of the 3-pieces with the ranges of [5-15K/km], [4-12K/km], and [3-10K/km] for $1/l_1$, $1/l_2$, and $1/l_3$ respectively. The Shuffled Complex Evolution (SCE) method, a global optimization program with RMSE response function was used to optimize the piecewise line parameters. The optimized parameters, out of SCE, for selected study case are listed in table-1 and shown in Figure-3.

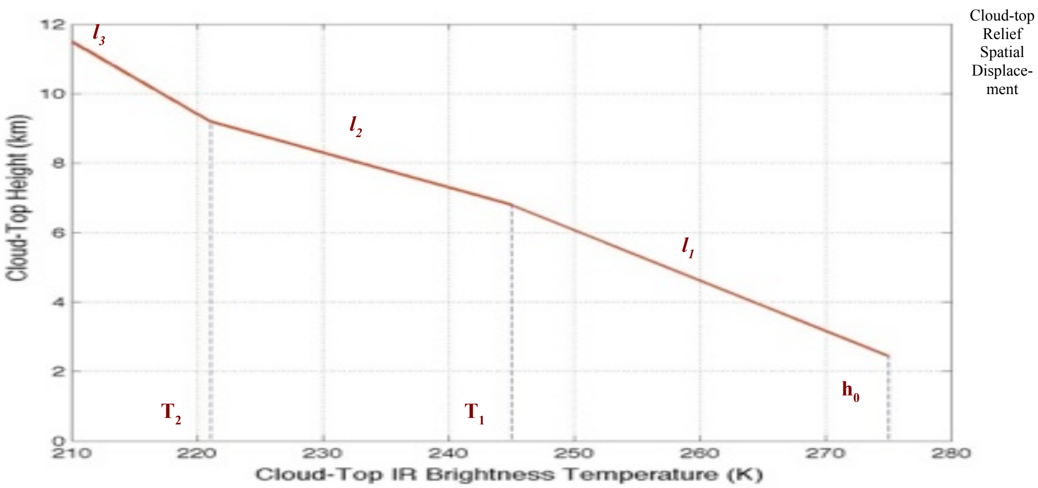


Figure 3: 6-parameters of a 3-piece piecewise linear CTH-IR relationship.

Table-1: *optimized parameters for a 3-piece relationship line for a convective cloud,*

Parameters	Optimized Values
h_0	2.45 (km)
T_1	240 (K)
T_2	221 (K)
l_1	0.145 (km/K)
l_2	0.101 (km/K)
l_3	0.209 (km/K)

PLANNED WORK

- Continuation of investigating the IR – CTH piecewise linear relationships with different number parameters and evaluation of the piecewise relationship lines, using GOES Channel-4, to select the most appropriate parameters for various cloud types, regions, and seasons.
- Evaluate estimated CTH by comparing with existing CTH products from ATBD and CALIPSO cloud-top height;
- Compute cloud-top relief spatial displacement and adjust GOES images for cloud cells using multi-channel-based relationships;
- Incorporate/combine the proposed technique into/with the GOES-R ACHA algorithm to examine if the CTH and associated CTD can be improved for GOES images;
- Adapt CTH – CTD and CTH – IR relationships for other GOES IR-channel data to enhance the proposed methodology for GOES IR images from different IR channels;
- Update/Modify the optimized model parameters based on variability of cloud type, land type, season, and topography for different GOES-IR channels.

- Assess the enhanced CTH and adjusted GOES-E and -W images to examine if the developed technology needs to be improved.
- Submit an article to a peer reviewed journal for publication, on CTH and adjustment of associated spatial displacement from GOES-R IR images.

PUBLICATIONS

Tesfagiorgis, K., S.E. Mahani, N. Krakauer, and R. Khanbilvardi; *2011; "Bias Adjust ment of Satellite Precipitation Estimates using a Radar-Gauge Product"; HESS Journal*; V(15), pp. 2631-2647.

Tesfagiorgis, K., S.E. Mahani, and R. Khanbilvardi; 2011; "Multi-Sources Precipitation Estimation: Mitigating Gaps Over Radar Network Coverage"; Conference Proceeding, IGARSS 2011; July 24-29, 2011; Vancouver/Canada; pp: 3054-3057.

PRESENTATIONS

Mahani, S.E., B. Vant-Hull, R. Khanbilvardi, and R. Rabin; "*Convective Cloud Towers and Precipitation Initiation, Frequency and Intensity"*; Annual AGU Fall Meeting; San Francisco/CA; Dec. 5-9, 2011.

Mahani, S. E.; *"Cloud-top Relief Spatial Adjustment of GOES-R Images"*; Annual GOES-R3 review meeting by NASA/NOAA; Huntsville/AL; Sep. 21-23. 2011.

Mahani, S., K. Tesfagiorgis, R. Khanbilvardi, and D. Kitzmiller; *"Multi-Sources Precipitation Estimation: Mitigating Gaps over Radar Network Coverage"*; Annual IEEE International Geosciences & Remote Sensing Society American Geographical Union (IGARSS); Vancouver/Canada, July 24-29. 2011.

Convective Storm Forecasting 1-6 hours into the Future

Task Leader	Vant-Hull
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 1: 70%; Theme 2: 30%
Contribution to NOAA Goals	Goal 2: 50%; Goal 4: 50%

BACKGROUND

This is a new collaborative effort between CIMMS, NSSL, U. Alabama Huntsville, and CREST. The other institutions have various approaches to predicting convective initiation, the CREST component is to supply validation based on radar data. Back trajectories from points of convective initiation will be used to produce grids of times to initiation from every location in time and space.

ACCOMPLISHMENTS

Weather model data and radar data for a test case over Oklahoma has been reduced to the proper geographic range and relevant variables subsetted. A framework code has been written that associates wind files to the proper radar files and interpolates between them.

PLANNED WORK

- Points of convective initiation will be found based on advecting all precipitation locations back one time step and seeing if all the precipitation disappears within a given radius.
- From points of convective initiation, back trajectories will be followed for 6 hours, creating grids of times to initiation.

French Visiting Scientist Nowcasting Task

Task Leader	Vant-Hull
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 2: 100%
Contribution to NOAA Goals	Goal 1: 50%; Goal 2: 50%

BACKGROUND

This work focuses on the upgrade of the EUMETSAT thunderstorm identification and tracking algorithm (RDT) that was adapted to work with GOES data and installed at CREST in 2007. The new version uses multiple satellite channels and numerical weather model input as a convective mask. The algorithm would need to be tuned on North American data including lightning flash data.

In order to install the new algorithm adapted to use GOES data as input, the French programmer of the code (Frederic Autones) was invited to spend a week at CREST. He would install the algorithm and provide training in its use. MDL was also interested in having him install the full SAFNWC package on their system, for use with SEVIRI data.

ACCOMPLISHMENTS

The 2012 version of RDT was installed, modified to ingest GOES data the IR window channel (11 μm) and two water vapor channels (6.7 and 13.3 μm). Code was written to automatically download NWP data and convert to the proper form for RDT. Code was also written to group lightning, satellite and NWP data together for case study operation. The SAFNWC code was installed at MDL.

The project lead (Brian Vant-Hull) was trained in the use of the new software. Members of MDL received basic training on the use of the SAFNWC package.

PLANNED WORK

- The updated version of RDT will be tuned to North America by running on at least 4 months of satellite, lightning and NWP data. The algorithm will be run at CREST, and the results passed on to Meteo-France for tuning.
- The operational area will be extended into the Atlantic for use by aviation, where no radar data is available.

PUBLICATIONS

Vant-Hull, B., F. Autones, S. Mahani, J. Mecikalski, R. Rabin, R. Khanbilvardi, 2012: Convective Cloud Towers: Precipitation and Lightning Frequency versus Intensity. *Submitted to J. Appl. Met.*

PRESENTATIONS

Autones, Frederic, 2011: An overview of Meteo France Nowcasting Tools and Products. NOAA-CREST, City College of New York, New York, Nov 17, 2011.

Development of validation tools and proxy data for GOES-R ABI Air Quality Proving Ground for the Northeast (NY Metro Region)

Task Leader Barry Gross
Task Code CUNY
Date Awarded
Contribution to CICS Themes Theme 1: 50%; Theme 2: 50%
Contribution to NOAA Goals Goal 2: 100%

BACKGROUND

The AQPG has been developed as a means to test current ABI aerosol algorithms and to demonstrate performance based on realistic proxy datasets. It is also the case that aerosol retrievals are most complex over brighter surfaces and in particular urban centers. This difficulty is particularly a concern due to population impacts and local sources making monitoring more critical. In particular, the aerosol retrieval product for GOES-R ABI builds on the heritage of the MODIS algorithm and therefore suffers some of the difficulties that MODIS has in retrieving aerosols over urban areas. In particular, the current surface parameterizations cannot be considered optimal and more regional algorithms are needed to assess the GOES-R ABI algorithm. The purpose is therefore to create the most realistic proxy datasets on the ABI channels that can provide robust tests of the algorithm ion the NYC area.

ACCOMPLISHMENTS

The current approach of the AQPG team is to extrapolate the MODIS MOD09 surface spectral BRDF to the ABI geometry which is not always a realistic approach especially in urban areas. To date, we have tested the spectral reconstruction of the surface reflection using the MODIS BRDF against an approach where the spectral BRDF function is constructed by first using the GASP derived MOSAIC on the VIS channel to estimate the BRDF kernel functions and only using the MODIS channel ratios to modify the magnitudes of the BRDF functions in the appropriate land channels. The results for the blue channel (figure 1a) tend to show a bias with the GASP overestimating the surface reflection model. Part of the problem tends to be the use of the MOD09 surface product in comparison to MODASRVN where the surface retrievals is made based on data from the AERONET retrievals.

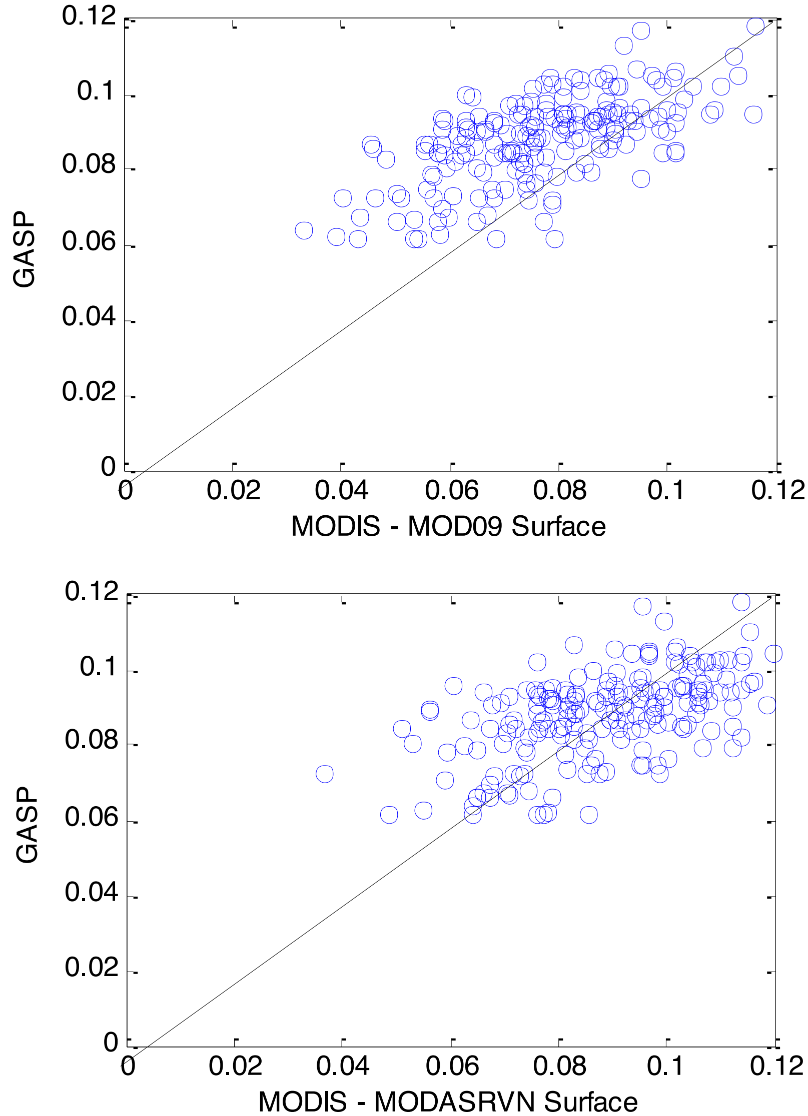


Figure 1: Comparison of different surface models in the blue channel: a. MOD09 – GASP, b. MODASRVN – GASP

The comparison seems to indicate the MODIS ARRVN approach against the GASP approach seems to be in better agreement with less bias and somewhat less spread with MODASRVN. This result holds in general for the red channel as well but the differences are less pronounced. This illustrates that the issues with the surface representation using MOD09 does not seem to be optimal and that the GASP approach seems to hold some promise in better estimating brighter surfaces.

PLANNED WORK

Test the MODIS Aerosol Algorithm using the MODASRVN and the MOD009 surface models in lambertian mode to see how much bias exists between the methods

PRESENTATIONS

J. He, A. Picon, L. Cordero, B. Madhavan, B. Gross, F. Moshary, S. Ahmed , "Potential Difficulties for GOES-R to Extract Aerosol Optical Depth and Surface PM2.5 in An Urban Environment", Eighth Annual Symposium on Future Operational Environmental Satellite Systems, AMS Annual Meeting Jan 2012.

Improvement of Snow Water Equivalent Estimation from Microwave Remote Sensing Data

Task Leader	Reza Khanbilvardi and Tarendra Lakhankar
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 1: 10%; Theme 2: 20%; Theme 3: 70%.
Contribution to NOAA Goals	Goal 2: 100%

BACKGROUND

The objective of research project is to improve estimation of snow water equivalent from microwave remote sensing data. The effect of seasonal behavior of change in snowpack properties such as snow depth, density, and grain size on microwave brightness temperature will be investigated using in-situ high frequency microwave radiometer.

The CREST-Snow Analysis and Field Experiment (CREST-SAFE) is being carried out to use multi-sensor microwave instrument observation to characterize seasonal snow condition. CREST-SAFE is setup at the research site of the National Weather Service office in Caribou, ME. The primary objective of the experiment is to collect the long term microwave and snow observations to understand snow metamorphism process from dry, wet, and melting conditions. Microwave observations were acquired by dual-polarization radiometers at the frequencies of 37 GHz and 89 GHz. To support interpretation of microwave observations and support microwave radiative transfer modeling, we have also routinely collected information on the temperature profile in the snow pack, snow cover skin temperature, air temperature and the snow depth.

ACCOMPLISHMENTS

- New instruments were installed at CREST-SAFE site, including: snow-pillow to measure the snow water content, ultrasonic snow depth sensor to measure snow depth, and rain/snow station to measure snowfall rate, radiation sensor, air temperature and humidity probe. Microwave radiometers were calibrated for low temperature using liquid Nitrogen.
- During the current (2011-2012) winter season, the CREST-SAFE experiment is being carried out at Caribou ME. We are collecting the microwave brightness temperature from 37 and 89 GHz radiometer. The snowpack properties including temperature profile, snow grain size, snow density are being measured on site. The meteorological data including incoming and outgoing radiation, air temperature, humidity, wind speed are being recorded on site.
- Additional airborne radiometric data is being collected through NASA's DC-8 flights, flown over CREST-SAFE site. The airborne data was collected as a part of NASA's Global Precipitation Measurement Cold-season Precipitation Experiment (GCPEx).
- During this period, we investigated the observations made through 2010-2011 winter season by microwave radiometer along with support observations of the snow pack properties.

- A manuscript is under preparation to be submitted to a peer reviewed journal.

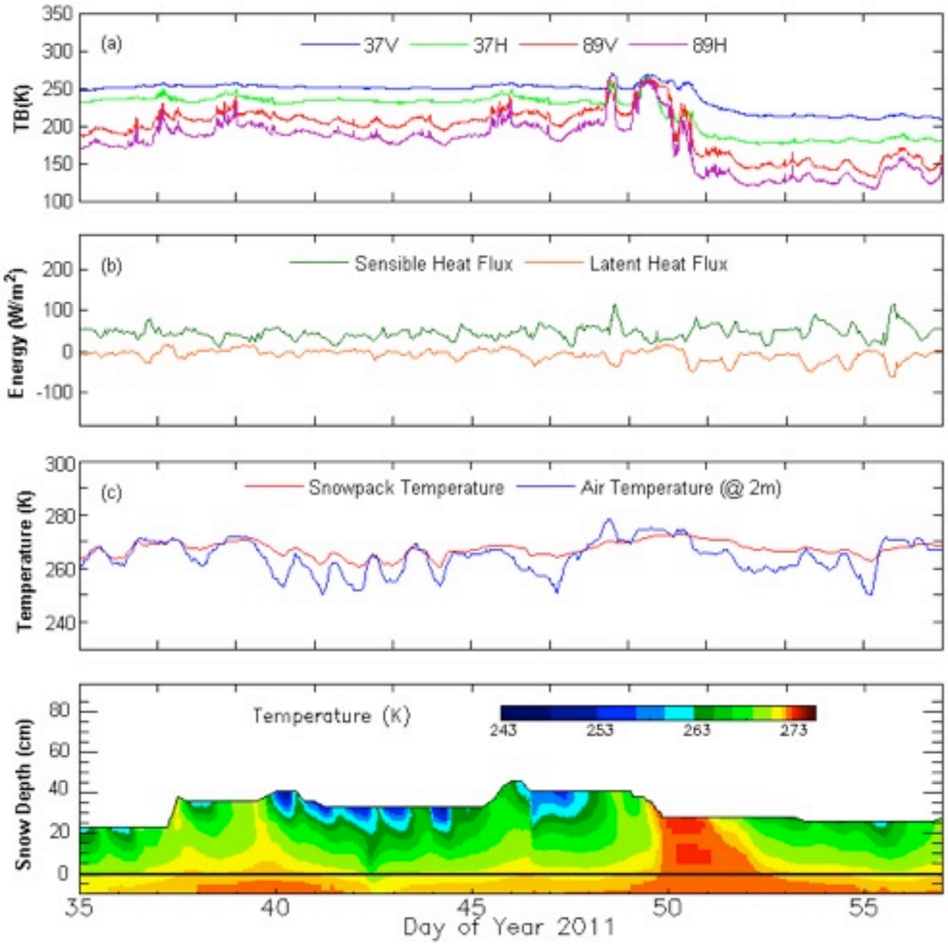


Figure 9: Time series of accumulating snow phase during mid-winter (2010-2011) with slow snow metamorphism due to below freezing temperature shows (a) radiometric observations using 37 and 89 GHz radiometer, (b) Solar radiation measurements in terms of sensible heat flux and latent heat flux, (c) Snow depth, air temperature, and average snowpack temperature measured by temperature profiler, and (d) temperature measured at different depth below and above the ground surface using temperature profiler shows diurnal variation.

PLANNED WORK

- Compare and investigate the brightness temperature measured on site with AMSR-E and SSM/I brightness temperature.
- Analyze the microwave observations for time categories includes: early, mid-winter, spring (melt-freeze period), and melting period.
- Investigate impact of seasonal behavior of snow grain size on brightness temperature through fresh and aged snow.

PUBLICATIONS

Lakhankar T., Munoz J., Powell A., Romanov P., Rossow W., and R. Khanbilvardi (2012) CREST-Snow Field Experiment: Analysis of Snowpack Properties using Multi-Frequency Microwave Remote Sensing Data, Manuscript under review, to be submitted to Peer reviewed Journal.

PRESENTATIONS

Lakhankar T., Munoz J., Romanov P., and R. Khanbilvardi (2012) NOAA-CREST Field Experiment: Remote Sensing of Snow Properties Using Microwave Radiometry, presented at 26th Conference on Hydrology, 92nd American Meteorological Society Annual Meeting, January 22-26, 2012.

Munoz J., Lakhankar T., Romanov P., and R. Khanbilvardi (2011) Estimation of surface snowpack properties using multi-frequency microwave remote sensing data, presented at Eastern Snow Conference Meeting, hosted by McGill University, Montreal, Canada

CUNY/CREST Weather Camp

Task Leader	Brian Vant-Hull and Shakila Merchant
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 2: 100%
Contribution to NOAA Goals	Goal 1: 25%; Goal 2: 25%; Goal 3: 25%; Goal 4: 25%

BACKGROUND

This high school summer weather camp has been running since 2009 in partnership with the local National Weather Service office on Long Island. The goal is to provide in depth exposure to meteorology/climatology to between 6 and 15 students a year, selected by application. The first week is a day camp on the campus of the City College of New York featuring discussions, hands-on demonstrations, and presentations by specialists in various fields. The second week moves to Long Island to be near the NWS office at Brookhaven. Camping in the local state park gets the largely city raised teenagers directly into the environment they are studying, with daily visits to the NWS office for lectures, demonstrations, and field observations. A night is spent in a hotel for access to a conference room with a career seminar.

Figure 2: Place-based learning experience for the High School students at the Weather Forecast Office in NWS/WFO, Long Island, NY, Summer 2011.

Seven Campers were involved this year, coming from as far as Arizona and Florida. These already motivated high school students exhibited a 40% increase in their weather knowledge over the two week period.

ACCOMPLISHMENTS

The camp was visited by a Channel One news team, who conducted interviews and made a 5 minute informational video about the camp that is available online (see publications).

Activities from the camp were presented to a group of 20 science teachers at the National Science Teacher's Convention in Hartford CN, October 2011.

PLANNED WORK

Publicity has begun earlier this year than in the past, including planned visits to high schools. The goal is to have a full complement of 12 campers this year.

Figure 3: Weather Campers at the Camp Site near NWS/Weather Forecast Office, Brookhaven, National Lab region, Long Island, NY – July 2011.

PUBLICATIONS

http://www.channelone.com/video/weather-camp/

PRESENTATIONS

Vant-Hull, Brian: "Lessons from Weather Camp", National Science Teachers' Association Annual Meeting, Hartford, CN, October 28, 2011.

Annual Colloquium – Early Career Summer Exchange Program

Task Leader	Shakila Merchant and Reza Khanbilvardi
Task Code	CUNY
Date Awarded	
Contribution to CICS Themes	Theme 2: 100%
Contribution to NOAA Goals	Goal 1: 25%; Goal 2: 25%; Goal 3: 25%; Goal 4: 25%

BACKGROUND

The progress report has two elements (1) The Annual CoRP Symposium and (2) The Early Scientist Career Exchange Program for graduate and post doc scientists. Within the NOAA/NESDIS/STAR Cooperative Research Program (CoRP), several activities are supported that address two goals: (1) Increased visibility and employment opportunities for students and early career scientists (and provide the best candidates for open positions in NOAA and the CI's); and (2) Strengthened collaborations between CI personnel at all levels.

To accomplish these goals, CoRP supports:

- The STAR/CoRP Science Symposium, held each summer at one CI. Travel funds are available for students and early career scientists to attend.
- Scientific exchanges for students and early career scientists, for visits to other CI's during which the student will give a seminar and interact with research scientists located at other CI's.
- Scientific exchanges for established CI research scientists to visit other CI's present their most exciting research results and develop or strengthen scientific partnerships.

The four NESDIS/CoRP CIs and one CSC are: the Cooperative Institute for Meteorological Satellite Studies (**CIMSS**); Cooperative Institute for Research in Atmosphere (**CIRA**), Cooperative Institute for Oceanographic Satellite Studies (**CIOSS**); Cooperative Institute for Research in Atmosphere (**CIRA**) and Cooperative Remote Sensing Science and Technology (**CREST**) Center.

Annual Colloquium

Cooperative Research Program (CoRP) Annual Colloquium/Symposium help students (1) understand the importance of Satellites and Remote Sensing Sciences; (2) help them advance their knowledge in data processing and analysis, modeling and forecasting, satellite algorithm and development, and calibration and validation of satellite products.

The broad goals of the CoRP symposiums in the past and the current are:

- Foster student/young scientist interaction between CIs and CREST
- Comparing Physical and Statistical Approaches to Satellite Retrievals
- Discuss current and future Satellite Calibration and Validation activities
- Educate students regarding Satellite Data Assimilation and Analysis

- Educate students on Satellite Data and Model Fusion Approach
- Search for synergy between on-going activities at the cooperative institutes and CREST and develop new collaborations

Early Career Exchange Program:
Early Career Development Programs in the past years has helped CREST graduate students visit various NESDIS Cooperative Institutes like CIRA, CIMSS, CIOSS and CICS during Summer (August-September) to obtain hands-on experience on useful software and techniques relevant to their research projects such as (1) Man Computer Interactive Access System (McIDAS) software training at CIMSS (2) application of advanced techniques in using remote sensing data for tracking public health risks (like West Nile Virus) (3) work on Advanced Microwave Sounding Unit (AMSU) data and Snowfall Rate Estimation Using Satellite Data and (4) Nowcasting of Thunderstorms. More than 30 CREST graduate students have benefited through these early career exchange program since 2006.

Figure 1: Pictures from the two-day CoRP Symposim.

ACCOMPLISHMENTS
15 CREST students and postdoctoral scientists attended the two-day CoRP symposium held at NCDC, Asheville, NC on August 17-18. 2011. Ana Picon and Ousmane gave oral presentations while other students made poster presentations.

Two of CREST Graduate students – Hamidreza Nourozi and Marzieh Azarderakhsh visited CIMSS in summer 2011 and worked with several CIMSS and NOAA scientists on the research satellite data for forecasting models and estimation of microwave land surface emissivity.

PLANNED WORK
Continue collaborative research and education interactions with NESDIS CIs (CIMSS; CIRA; CICS and CIOSS).

OTHER

- Graduate student Roza Nazari received a first prize for her poster presentation during the Annual CoRP symposium held at NCDC, Asheville, NC – August 17-18, 2011.
- Hamidreza Nourozi finished his PhD and is currently working as Assistant Professor at New York City College of Technology, and is affiliated to CREST as research scientist and mentoring CREST students.
- Marzieh Azaderaksh also defended her thesis fall 2011 and is currently working with Dr. Kyle McDonald, Senior Scientist/Faculty (CCNY) at NOAA-CREST and JPL/visiting scientist as Postdoctoral Scientist and mentoring two graduate students on NOAA related Sciences.

Incorporating Cooling Rates into GOESR Precipitation Retrieval

Task Leader Vant-Hull
Task Code PAPANCREP11
Date Awarded
Contribution to CICS Themes Theme 1: 100%
Contribution to NOAA Goals Goal 2: 100%

BACKGROUND

The precipitation retrieval algorithm selected by the GOESR AWG is Self Calibrating Multi-spectral Precipitation Retrieval (SCaMPR) package originally developed by Robert Kuligowski of NESDIS/STAR. The current version performs multivariable regression of channel radiances against recent microwave retrievals in the region, thereby using information from a single image for each retrieval. It has been hypothesized that a regression that included cooling rates in all channels would improve the retrieval skill, since precipitation is often associated with the growing phase of cumulus clouds.

The WDSS-II segmotion tracking algorithm was selected by the AWG for extrapolation of the SCaMPR estimated precipitation rates into the near future. It was sensible to use this same algorithm to calculate cooling rates by subtracting extrapolated IR fields from the previous image (with no growth rates) from the current IR fields. The cooling rate field can then be incorporated into the SCaMPR algorithm and the results compared to ground truth to see if the new variable indeed improves precipitation estimation.

ACCOMPLISHMENTS

THE CREST COMPONENT OF THIS WORK WAS COMPLETED AS OF MARCH 2012.

PLANNED WORK

The STAR researcher (Kuligowski) work to compare the results with and without the cooling rate data is pending.

7 OTHER CONSORTIUM TASKS

Implementation of the GCOS Reference Upper Air Network at Howard University: Monthly Cryogenic Frost-point Hygrometer Launches

Task Leader	Belay Demoz
Task Code	BDBDHUGC011
Date Awarded	
Contribution to CICS Themes	Task 1: 20%; Task 2: 60%; Task 3: 20%.
Contribution to NOAA Goals	Goal 1: 100%

BACKGROUND

The reliable detection of climatic change in the entire atmospheric column requires very high quality atmospheric observations of state variables using well characterized measurement uncertainties. While the Global Climate Observation Systems (GCOS) Upper Air Network (GUAN) provides upper air measurements over large regions of the globe, its goal and thus its instruments are primarily designed for operational weather forecasting. The data from the GUAN sites (and instruments), although often used for climate study purposes, are not of the highest instrument quality and may not guarantee that the data are suitable for long-term trend detection. Efforts to improve quality in the acquisition of climate-quality data resulted in the initiation of a reference upper-air network sites to better meet the needs of the international climate research community. This discussion, held under the auspices of the World Meteorological Organization (WMO), was formalized between 2005 and 2007 and has led to the GCOS Reference Upper-Air Network (GRUAN; GCOS-112, GCOS-134). Howard University Beltsville Campus, in collaboration with NASA/GSFC and NOAA/NWS is among the original sites selected as a GRUAN site. As a GRUAN site, Beltsville is required to launch high quality radiosoundings at least once per week and reference quality sonds at least once per month. The funding under this task covers part of the resources needed for the once per month launches.

ACCOMPLISHMENTS

The project was awarded (to Howard University) on December 2011. Since the award date, we have made the necessary financial procedures to enable us to purchase the Cryogenic-Frost point Hygrometer (CFH). The goal of this one-year project is to enable The Howard University site to provide vertical profiles of reference measurements using the Cryogenic-Frost point Hygrometer (CFH). Initial arrangements for shipment of the expendable materials from the manufacturer have been made. The necessary arrangements are being developed for the purchase the CFH's and associated consumables to establish the necessary dataflow protocols and submit the data with associated metadata to the GRUAN Lead center in Lindenberg, Germany.

PLANNED WORK

Launch of the CFH sondes starting summer of 2012 from the Howard University Beltville research site.

PRESENTATIONS

Demoz, et al. (2012): The Howard University Beltsville GRUAN site Update. Presented at the 4th GRUAN Implementation-Coordination Meeting (ICM-4); Tokyo, Japan. 4-9 March 2012. See www.gruan.org

CIMMS and Texan Tech University Support to GOES-R Risk Reduction

Task Leader Eric Bruning
Task Code EBEBGOESR11
Date Awarded
Contribution to CICS Themes Theme 1: 90%; Theme 2: 10%
Contribution to NOAA Goals Goal 2: 10%; Goal 3: 75%; Goal 4: 15%

BACKGROUND

This task supports GOES-R GLM needs for proxy data, validation datasets, and operational demonstrations of total lightning data (in the GOES-R Proving Ground) thorough sustaining support for the Oklahoma and West Texas Lightning Mapping Array (OKLMA and WTLMA, respectively). Detection of total lightning in the new WTLMA will complement the OKLMA, creating a unique regional-scale domain where total flash rates can be retrieved for larger mesoscale storm complexes and other severe weather outbreaks that are frequent producers of damaging wind and tornadoes. The continued operation of this network will allow for the determination of instantaneous local flash rates and a regional total lightning climatology that will serve as validation datasets for the GOES-R GLM.

ACCOMPLISHMENTS

Funding was received by the Cooperative Institute for Mesoscale Meterological Studies at the University of Oklahoma around 1 January 2011, with a portion subcontracted thereafter to TTU. Since then, it has provided funding for operating and maintaining the OKLMA and spinup costs for the WTLMA. TTU and OU personnel traveled to Huntsville, AL to participate in the GOES-R GLM science meeting and Risk Reduction Review in October, 2011.

Since the last report, the WTLMA has been deployed and installation of the SW extension of the OKLMA is nearly complete. First thunderstorm data were taken on 21 Nov 2011 (Fig. 1), and those results were reported at the AGU 2011 Fall meeting (Fig. 1, Bruning 2011b). In support of R3 activities at OU and with other national partners, TTU has implemented an LDM feed of 1-min lightning source and gridded flash data and derived products to OU. The Lubbock National Weather Service office will also get these data, an activity supported by other work through the COMET program.

At OU, funds have supported a part-time research scientist to complete an analysis of the conditions under which lightning occurs far downstream in thunderstorm anvils (Weiss et al. 2012) and to analyze the range dependence of the Lightning Mapping Array for use in GOES-R proxy data sets and for climatological studies. The latter work is ongoing. TTU has continued work have focused on explaining fundamental flash properties observed by VHF total lightning mapping systems. Bruning (2011b) used dimensional arguments to develop an energy-based scaling relationship combining flash rate and extent that exhibited a (–5/3) power-law slope at the same length scales within the inertial subrange for which that slope is observed in thunderstorm kinetic energy spectra. These results strongly suggest a link between thunderstorm eddy structure and flash size and rate. A manuscript based on this result is in preparation. TTU continues to pursue studies of electrified winter storms with collaborators at U.A. Huntsville (Schultz et al. 2011a,b,c).

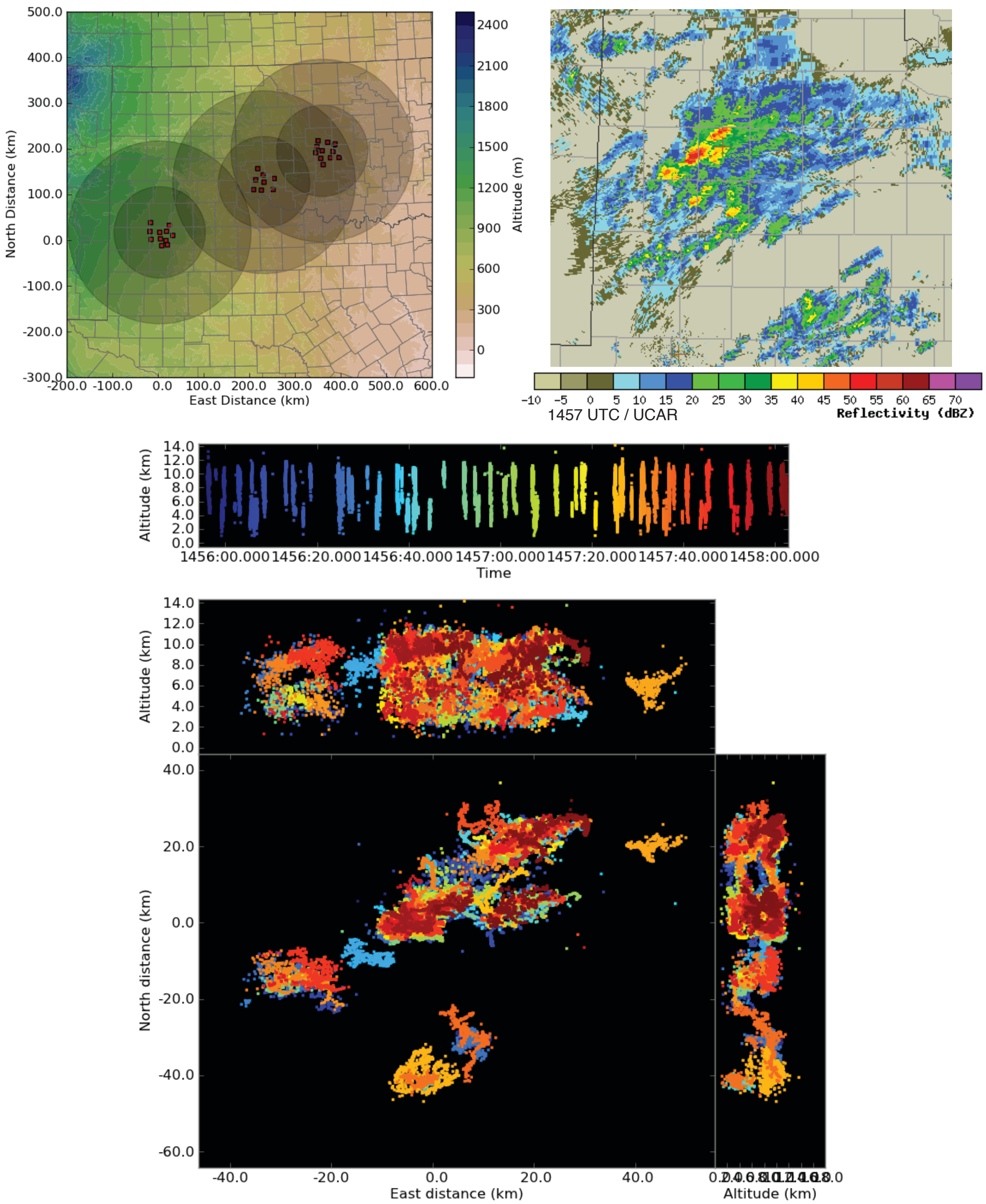


Figure 10: (top left) West Texas and Oklahoma Lightning Mapping Array site locations and 2D coverage domain. The WTLMA captured first lightning data in storms on 21 Nov 2012, as seen in (top right) a WSR-88D radar mosaic at 1457 UTC and (bottom) data from the WTLMA from 1456-1458 UTC. The lightning coordinate center is about 10 km west of Lubbock, TX at Reese Center.

PUBLICATIONS

Weiss, S. A., D. R. MacGorman, and K. M. Calhoun, 2012: Lightning in the anvils of supercell thunderstorms. *Mon. Wea. Rev.*, in press, 10.1175/MWR-D-11-00312.1

Bruning, E. C., S. A. Weiss, and K. M. Calhoun, 2012: An evaluation of inverted polarity terminology and electrification mechanisms. *Atmos. Res.*, submitted.

Schultz, C. J., W. A. Petersen, E. C. Bruning, L. D. Carey, and R. J. Blakeslee, 2011a: Three dimensional mapping of lightning and associated cloud properties during two thundersnow events. *Mon. Weather Rev.*; withdrawn for revision.

PRESENTATIONS

Bruning, E. C., 2011b: Lightning flash size spectra: Observations and theory. *Eos Trans. AGU, Fall Meet. Suppl.*, AE31A-0266.

Schultz, C. J., E. C. Bruning, L. D. Carey, W. A. Petersen, and S. Heckman, 2011c: Total lightning within electrified snowfall using LMA, NLDN and WTLN measurements. *Eos Trans. AGU, Fall Meet. Suppl.*, AE12A-03.

Schultz, C. J., W. A. Petersen, L. D. Carey, and E. C. Bruning, 2011b: C-band dual-polarimetric observations of snowfall in a southeastern thundersnow event. *Preprints, 35th Conference on Radar Meteorology, Pittsburgh, PA, USA*, American Meteorological Society, Paper 209.

MacGorman, D. R., et al., 2011: Lightning and electrical structure of severe storms. *Intl. Conf. Atmos. Elec., Rio de Janeiro, Brazil*.

Bruning, E. C., 2011a: West Texas LMA: Deployment and operations update. *GOES-R Geostationary Lightning Mapper Science Meeting*, Huntsville, AL.

Prototype development of a microwave radiometer simulator for land surface and precipitation characterization

Task Leader Eric Wood
Task Code EWPRINC11
Date Awarded
Contribution to CICS Themes Task 1: 25%; Task 2: 75%
Contribution to NOAA Goals Goal 1: 20%, Goal 2: 80%

BACKGROUND

The poor progress in developing algorithms to characterize land emissivity has limited the assimilation by weather forecast models of space-borne microwave radiometers and sounders over land, especially at lower microwave frequencies. This has also impacted the development of advanced satellite precipitation retrieval algorithms. The project brings together an inter-disciplinary team for an exploratory effort in developing a land-to-space microwave emission forward modeling capability. The goals of the project are (i) to evaluate the Community Radiative Transfer Model (CRTM) ability to characterize surface emissivity, clouds and precipitation when compared to satellite-based observations and retrieved microwave products from selected case studies, and (ii) to assess the feasibility of developing a microwave radiometer forward model based on a coupled modeling package (e.g. WRF-CRM/Noah/CRTM). In the exploratory project, an uncoupled analysis will be done where Noah LSM will be run off-line using NLDAS forcings with the atmospheric variables based on either satellite retrievals (e.g. AIRS) or NWP models (e.g. NARR).

The project will utilize the extensive data base at CREST/CUNY of satellite observations of surface emissivity, surface temperature, cloud and atmospheric water and temperature profiles. This data base will be used to select case studies that span conditions that will include clear sky, non-precipitating clouds, precipitating warm clouds and precipitating cold clouds. Snow covered conditions aren't included at this stage. The surface hydrologic conditions will utilize NCEP's Noah LSM, which solved the surface energy and water budgets and provides surface temperature and soil moisture as prognostic variables. These can be used in the CRTM to predict surface emissivity, which will be compared to observed values from CUNY's data base.

ACCOMPLISHMENTS

During the last year, we used our Land Surface Microwave Emission Model (LSMEM) with atmospheric profiles obtained from CUNY (temperature, water vapor, ozone and cloud water content) that were used by CUNY to retrieve on a daily basis SSM/I surface emissivities. The land surface inputs (soil moisture and surface temperatures) came from out land surface model simulations.

Additionally, we obtained CUNY's daily SSM/I retrievals that we divided into clear and cloudy conditions (pixel-by-pixel) based on NLDAS data (essentially by calculating the cloud albedo from the NLDAS GOES radiation retrievals.) Previously CUNY released clear sky, monthly averaged emissivities but our project wishes to compute a daily emissivity using LSMEM (or eventually CRTM) linked to a land surface model. Our analysis was carried out over North America. Results show that the clear and cloudy average SSM/I emissivities as retrieved by CUNY are very similar, but with slightly lower standard deviations for the cloudy case, which we attribute to more uniform atmospheric conditions.

The retrieved LSMEM clear-sky surface emissivities show higher values over northern Canada and lower temporal variability most every where. We attribute the higher emissivities in Northern Canada to the lack of an accurate water mask in LSMEM for that region. Results are shown in Figure 1.

The project has installed the Joint Center for Satellite Data Assimilation, JCSDA microwave emission and radiative transfer model, CRTM at Princeton.

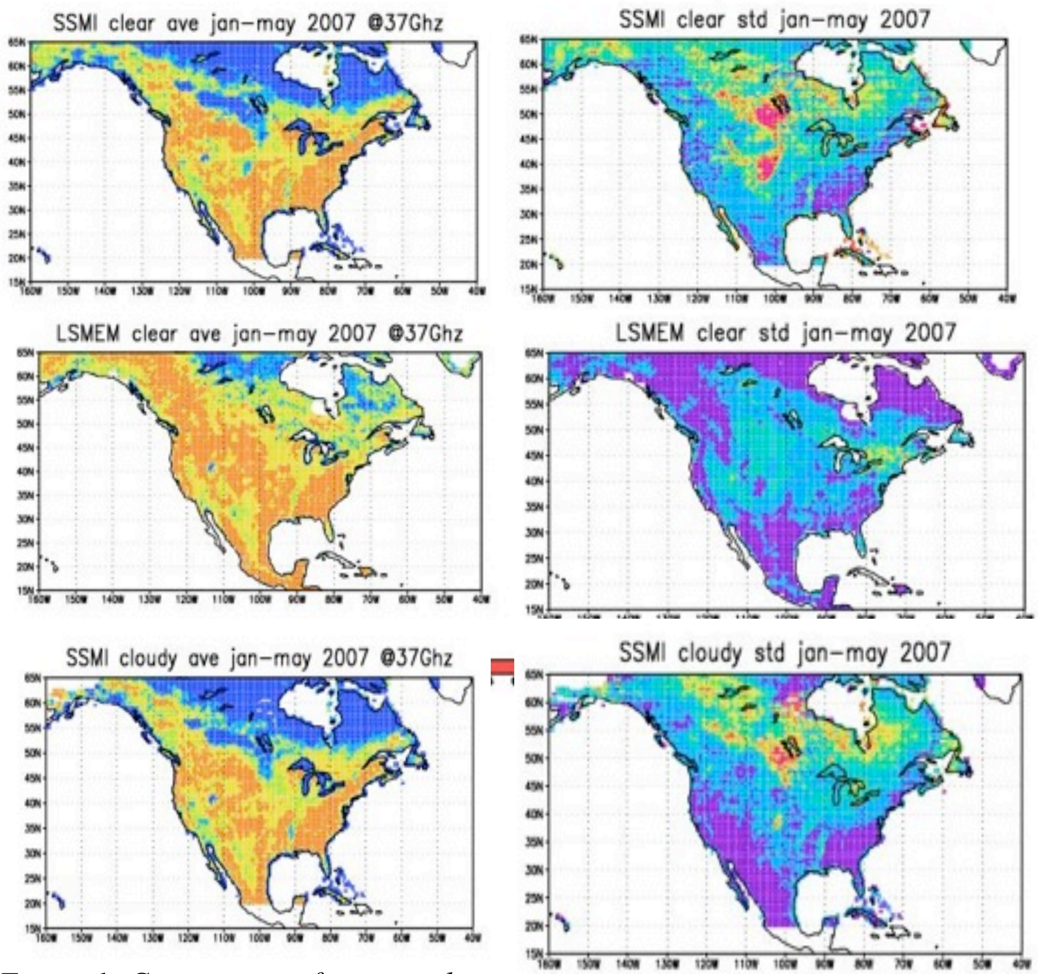


Figure 1: Comparison of mean and standard variation in surface emissivity from CUNY (labeled SMM/I) and Princeton LSMEM retrieved emissivities..

PLANNED WORK

- Carry out additional retrievals if we are able to obtain additional atmospheric data from CUNY.
- Use the Joint Center for Satellite Data Assimilation, JCSDA microwave emission and radiative transfer model, CRTM, to retrieve surface emissivities using soil moisture and surface temperature from our land surface model as inputs to CRTM.

Appendix 1: Arrivals and Departures

This year CICS welcomed many new members. They are:

Hugo Berbery joined CICS-MD in July 2011 as Associate Director and ESSIC Research Professor. Previously he was a Research Professor at the Department of Atmospheric and Oceanic Science also of the University of Maryland. Dr. Berbery received his Lic. Degree (1976) and Ph. D. (1987) from the University of Buenos Aires. In 2011 he was elected Fellow of the American Meteorological Society. His research interests cover different areas of climate variability and dynamics. He uses regional models and diagnostic approaches to investigate the regional mechanisms of the American monsoon systems, and the effects of land-cover changes and land surface-atmosphere feedbacks on the hydroclimate and extremes of the Americas. Dr. Berbery has recently examined the modulation of daily U.S. precipitation by lower frequency modes and the combined effect of El Niño and Tropical Atlantic in favoring droughts.

Slawomir Blonski began working as a Visiting Associate Research Engineer for CICS/NOAA STAR on October 17, 2011. He collaborates with Dr. Changyong Cao on calibration and validation of sensor data records from the VIIRS instruments on the current Suomi NPP satellite and the future JPSS satellites. Dr. Blonski received his MS degree in Applied Physics from the Gdansk University of Technology in 1985 and his PhD degree in Physics from the University of North Texas in 1991. Before joining CICS, he conducted research at Rutgers University, Aberdeen Proving Ground, and NASA Stennis Space Center, participating among others in verification and validation of science data products from the first commercial remote sensing satellites. His current research interests include advanced methods for characterizing spatial, spectral, and radiometric responses of satellite and aerial electro-optical instruments such as VIIRS.

Dr. Sean Casey joined the Joint Center for Satellite Data Assimilation (JCSDA) as an ESSIC Visiting Scientist in May 2011. His primary goals are to investigate the effectiveness of assimilating cloud-cleared radiances from hyperspectral satellite instruments into the NOAA operational model. Before joining JCSDA, Sean worked as a Postdoctoral Research Associate at the Jet Propulsion Laboratory, Pasadena, CA, where he worked with the Atmospheric Infrared Sounder (AIRS) science team. His interests included analysis of AIRS/CloudSat coincident scans over the tropical ocean to investigate cloud/environment interactions, quantitative identification of midlevel cumulus congestus clouds [paper published February 2012 in Atmospheric Chemistry and Physics (ACP)], relation of cumulus congestus to the Madden-Julian Oscillation (MJO), and determining convective buoyancy from CloudSat overpasses. Sean earned a Bachelor of Science Degree from the University of Washington, Seattle, WA, in June 2005. He then went to Texas A&M University, College Station, TX, where he earned his M.S. degree in August 2007 and Ph.D. in December 2009.

Teresa Ferrete joined CICS-MD as an administrative assistant on February 15, 2012 and has been providing critical support to the Directors.

Gregg Foti joined CICS-MD in August of 2011. Mr. Foti earned his MS in Physical Oceanography at The Rutgers Institute of Marine and Coastal Sciences in 2007. Prior to that he worked as a software engineer for the Navy, AT&T and IBM in New Jersey. After graduating Mr. Foti joined NASA's Physical Oceanography Distributed Active Archive Center at the Jet Propulsion Laboratory in Pasadena California. There he served as the Scientific Data Engineer for Satellite Sea Surface Temperature and Salinity. Mr. Foti's research has included remote sensing of the oceans, detecting salinity from space, ocean modeling and fresh water budgeting of coastal systems.

Christopher Hain began as a Research Associate for ESSIC/NOAA on August 14, 2011, working with Dr. Phil Arkin of ESSIC and Dr. Xiwu Zhan of NOAA/NESDIS on developing evapotranspiration and drought monitoring tools using GOES-R products for the National Integrated Drought Information System (NIDIS) and developing a satellite-based drought early-warning system over the continental United States based on the dual assimilation of thermal infrared and microwave soil moisture retrievals. Dr. Christopher Hain received his MS degree in Atmospheric Science and PhD degree in Atmospheric Science from the University of Alabama in Huntsville in 2007 and 2010. His research interests are mainly focused on the development of the satellite-based Atmosphere-Land Exchange Inverse (ALEXI) model, a thermal infrared-based surface energy balance modeling system, which provides applications for drought monitoring, soil moisture monitoring and land surface assimilation, and regional and global evapotranspiration estimates. Building on a current NOAA-funded research supporting GOES-based drought index development over the continental United States, Hain is developing/implementing a system which will demonstrate the utility of future GOES-R product for the routine mapping of evapotranspiration and drought conditions.

Quanhua (Mark) Liu has worked as a Visiting Senior Scientist at ESSIC/CICS since October 15th , 2011. He works on the VIIRS sensor data record calibration in supporting of the NPP/JPSS program. He serves as co-chair of the community radiative transfer model (CRTM) working group for coordinating contributions to the CRTM development and implementation from multi-agencies, universities, and companies. The CRTM is the key component in the data assimilation system for weather forecasting. Dr. Quanhua (Mark) Liu received his MS degree in Physics from Chinese Academy of Science and PhD degree in remote sensing and meteorology from the University of Kiel in Germany. His research interests are mainly focused on radiative transfer model development, sensor data calibration, data assimilation for weather and air quality forecasting. He and his team have conducted global solar and wind energy forecasting at the first time.

Patrick Meyers came to CICS/ESSIC in the fall of 2011 to work with Ralph Ferraro (STAR/NESDIS/NOAA) on improving satellite rainfall retrievals for GPM in advance of the deployment of the AMSR2 sensor. Patrick received his B.S. in Atmospheric Science from Cornell University in 2008 and his M.S. in Meteorology and Physical Oceanography from the University of Miami in 2011 improving a satellite altimetry technique for estimating ocean thermal structure for hurricane intensity forecasting. At ESSIC, Patrick evaluates and develops algorithms for passive microwave retrievals of geophysical parameters, particularly precipitation rates over land.

Thomas Newman recently joined the Cooperative Institute for Climate and Satellites (CICS) at the University of Maryland as a Research Associate, working with Dr. Sinead Farrell on the use of satellite and airborne data for cryospheric investigations. Dr. Newman studied at University College London in the United Kingdom and received his M.Sci degree in Earth and Space Science in 2006, and a Ph.D. degree in 2011, for a dissertation on the application of synthetic aperture techniques to radar echo soundings of the Pine Island Glacier, Antarctica. His research interests are mainly focused on remote sensing of the cryosphere to better understand changes in the ice cover of the Arctic and Southern Oceans, and the factors behind the acceleration and thinning of glaciers draining the large ice sheets of Antarctica and Greenland. Dr. Newman collaborates with the NOAA/NESDIS/STAR Laboratory for Satellite Altimetry and is currently assessing the ability of satellite altimeters to map the thickness of polar ice via intercomparisons with in-situ and airborne datasets, including data gathered by NASA's Operation IceBridge Mission.

Chunhui (Sherry) Pan began as a Visiting Research Associate for ESSIC/NOAA STAR on Oct 31, 2011, working with Dr. Fuzhong Weng on NPP/JPSS Ozone Mapper Profiler Suite (OMPS) instrument calibration and validation. Dr. Chunhui Pan received her MS. and PhD. degrees in Mechanical Engineering from University of Maryland at College Park in 2000 and 2002. Her research interests include remote sensing instrument calibration and characterization, inter-comparison and validation of Earth-observing sensors. Her previous research experience at SSAI/NASA includes MODIS and VIIRS calibration and Characterization.

James Reagan began as a Research Assistant for ESSIC/CICS/NOAA NODC on September 19th, 2011 working under the supervision of Sydney Levitus (NODC) James Reagan received his BS degree in Atmospheric Science from Cornell University in 2008 and his MS degree in Atmospheric and Oceanic Sciences from the University of Maryland in 2010. His current work focuses on data archiving and processing for the World Ocean Database (WOD) and quality control of WOD-derived global scale salinity products. His current research is focused on attaining a better understanding of salinity/freshwater variability in the global ocean which in turn will hopefully shed new light on the global hydrological cycle over the global ocean. This research utilizes the Aquarius Sea Surface Salinity (SSS) data products, the Gravity Recovery and Climate Experiment (GRACE) twin satellites freshwater volume products, and the WOD-derived global salinity and salinity anomaly products. These studies are being conducted under the supervision of Tim Boyer (NODC) and Sydney Levitus (NODC).

Likun Wang received the B.S. degree in atmospheric sciences and the M.S. degree in meteorology from Peking University, Beijing, China, in 1996 and 1999, respectively, and the Ph.D. degree in atmospheric sciences from University of Alaska Fairbanks, in 2004. He currently is a assistant research scientist with ESSIC/CICS in support of satellite sensor calibration and validation program for NOAA/NESDIS. Before that, he worked on lidar/radar remote sensing of clouds as a postdoctoral research associate with University of Maryland from 2004 to 2005. His current principal areas of interest include: 1) improving accuracy and preciseness of satellite measurements and products through calibration and validation efforts; and 2) recalibrating NOAA's historic satellite data records to create consistent, homogeneous long-term satellite measurements for climate studies.

Departures from CICS include:

Naomi Johnson for the University of Maryland System Chancellor's Office.

Dr. Kaushik Gopalan for the Space Applications Center, Ahmedabad India.

Eric Hughes for UMD Atmospheric and Oceanographic Sciences PhD program.

Dr. Scott Rudlosky for NOAA/NESDIS/STAR Satellite Climate Studies Branch.

Appendix 2: CICS-MD related seminars

April 1, 2011
Prof. John Kutzbach, Atmospheric and Oceanic Sciences, UW-Madison
Examining the Possible Influence of Climate on Human Evolution

April 18, 2011
Zhanqing Li, ESSIC
Aerosol Remote Sensing: A Review of Critical Issues

April 25, 2011
Hamid Norouzi, CUNY CREST
A Method To Improve Land Emissivity Retrieval Over Land From AMSR-E Observations

April 27, 2011 at 10:30 am
Weixin Xu, Univ. Utah
Relationships Among Lightning Activity, Rainfall, and Convective Properties in Different Convective Regimes

June 1, 2011
Dr. Philip Bogden
The Data Deluge: Driving Change in the Conduct of Science

June 6, 2011
Dan Pisut, Phil Arkin, Ralph Ferraro
The Earth Now: A Joint Weather and Climate Information Project Between CICS, SSEC and STAR

August 29, 2011
Jingjing Li, UC Irvine
A Hybrid Framework for Verification of High Resolution Satellite Precipitation

September 12, 2011
Dr. Ling Tang, ESSIC
Transfer of Satellite Rainfall Error from Gauged to Ungauged Regions

Thursday, September 15, 2011
Dr. Brent Lofgren, NOAA/Great Lakes Environmental Research Laboratory
Hydrometeorological Modeling in the Great Lakes Region

September 16, 2011
Prof. Sam Shen, San Diego State Univ.
Spectral Methods for Quantifying Uncertainties in Climate Change Assessment

September 26, 2011
Dr. Raghu Murtugudde, ESSIC
Title: Big History: Earth, Life, and Sustainability

October 3, 2011
Isaac Moradi, ESSIC/CICS
Geolocation Correction for NOAA POES Passive Microwave Instruments

October 7, 2011
Dr. Matt Sapiano, Colorado State University
Constructing a Fundamental Climate Data Record for SSM/I and SSMIS

October 10, 2011
Dr. Jia Wang, NOAA Great Lakes Environmental Research
Leading Arctic climate patterns and sea ice variability: Diagnosis and modeling.

January 20, 2012
Dr. Kazumasa Aonashi, Meteorological Research Institute, Tsukuba, Japan
"New GSMaP over-land precipitation retrieval algorithm"

February 06, 2012
Dr. Chris Kidd, ESSIC
Global Precipitation Measurement: Past, present, and future challenges

February 15, 2012
Viviana Maggioni, UCONN
The impact of satellite-rainfall error modeling on the estimation of soil moisture fields

Appendix 3: CICS-NC Related Seminars

a. Seminar Presentations at North Carolina State University

US Climate Reference Network Overview and Soil Moisture/Temperature Monitoring

Presenter:	Dr. Jesse E. Bell
Date:	25 August 2011
College/Dept.	College of Agriculture and Life Sciences; Department of Soil Science

Abstract:
During summer 2011, installation of probes to observe soil moisture and temperature was completed at 114 US Climate Reference Network (USCRN) stations across the conterminous states. At each site, three sets of probes were placed in three directions about three meters from the instrument tower base. At most sites, the probes were installed at depths of 5, 10, 20, 50, and 100 cm; sites with shallow soils were installed at the 5 and 10 cm depths only. The continuity of the record is enhanced by triplicate observations at each depth, allowing valid observations to continue even if an instrument fails underground. The redundancy of measurements at each depth also creates a unique opportunity to understand the spatial representativeness of individual soil probe measurements, and the nature of local soil moisture/temperature variance.

Climate Change: Global Climate Impacts in the United States – A Primer

Presenter:	Dr. Otis Brown
Date:	August, 11 2011
College/Dept:	Office of Research, Innovation and Economic Development

Abstract:
Most research on climate change looks out 50 to 100 years, with a geographic focus on areas the size of continents. These time and geographic scales don't address businesses' more immediate needs, create a sense of urgency, or impact their decision-making in terms of climate change response. Instead, businesses need climate change information that focuses on impacts in the one-month to 10-year range, allowing them to integrate this information into their business planning to minimize risk and maximize opportunities. This presentation was to provide an overview of the current science, current climatic trends, impacts, and determine options for private sector opportunities.

Climate Change: Impacts to Opportunities

Presenter:	Jenny Dissen
Date:	August, 11 2011
College/Dept:	Office of Research, Innovation and Economic Development

Abstract:
As businesses and industries determine pathways for climate adaptation, there are two

dimensions to examine: impacts of climate change, opportunities to capitalize on options, and information gaps that can be addressed by new ventures and research. This presentation discusses the impacts of changing climate on the energy industry, an overview of the current market, and information gaps for products and services that can lead to innovative solution development from entrepreneurial thinking.

A model quantifying the effect of soil moisture and plant development on leaf conductance: Confidence interval estimation

Presenter:	Dr. Jessica Matthews
Date:	August 30, 2011
College/Dept:	SAMSI

Abstract:
Global climate models are complex compilations of a number of inter-related submodels. Our focus is on the coupled conductance-photosynthesis submodel component, which is either omitted or oversimplified in many climate models, substantially reducing the relevance of the model to changing atmospheric composition and changing precipitation patterns. We consider a data set produced from two different genotypes of soybeans grown in a controlled soil moisture field under four different watering regimes over the course of the 2008 and 2009 growing seasons. We then develop a new model to characterize total leaf conductance as a function of plant development and soil moisture conditions. To establish confidence intervals for the estimated parameters and model predictions, we compare: traditional asymptotic theory, Monte Carlo simulations, and bootstrap methods.

High-resolution observations and modeling of precipitation processes in the Southeastern United States - A Journey through Precipitation at all Scales

Presenter:	Olivier Prat
Date:	October 24, 2011
College/Dept:	Civil, Construction and Environmental Engineering

Abstract:
The objective of this presentation is to provide an overview of the challenges associated with the measurement and modeling of precipitation processes from the raindrop scale to the continental scale. The presentation examined successively (1) the development of a physical parameterization of drop-drop interaction at the millimetric scale, and (2) how this physical parameterization combined with surface and remotely sensed observations helped improving surface rainfall estimates at the basin scale in the Southeastern United States particularly in case of extreme events such as thunderstorms and tropical cyclones. Finally (3), this presentation wrapped up with a practical aspect of rainfall measurements by investigating the tropical cyclone contribution in term of water resources and extreme rainfall events around the world.

The Madden-Julian Oscillation and Equatorial Waves in Upper Tropospheric Water Vapor

Presenter: Dr. Carl Schreck
Date: September 26, 2011
College/Dept: Department of Marine, Earth, and Atmospheric Sciences

Abstract:
The Madden–Julian oscillation (MJO) and convectively coupled equatorial waves have frequently been identified with proxies for convection such as outgoing longwave radiation. This method is well suited to the Indo–Pacific region where deep convection is abundant. However, tracking becomes more difficult in the Western Hemisphere. The convection dissipates, even as the signals persist in the upper troposphere. Inter-satellite calibration techniques have recently produced a homogeneous 31-year dataset of upper tropospheric water vapor (UTWV). These data will be used to revisit the climatologies of the MJO and equatorial waves with the goal of developing a more global view. The utility of UTWV for operational monitoring of these systems will also be explored.

National Mosaic and Multi-Sensor QPE (NMQ) reanalysis in the southeastern United States

Presenter: Scott Stevens
Date: June 13, 2011
College/Dept State Climate Office

Abstract:
This presentation summarizes the ongoing efforts at CICS-NC to perform a reanalysis of NEXRAD data using the NMQ/Q2 algorithms, developed at the National Severe Storms Laboratory in Norman, OK. Potential applications are discussed, both for operations and research, and plans are presented for immediate next steps.

How Can We Be Sure the World is Warming?

Presenter: Dr. Peter Thorne
Date: March 21, 2011
College/Dept Marine, Earth and Atmospheric Sciences Department, North Carolina State University

Abstract:
This presentation examines the evidence basis for global warming by looking at ten distinct indications of changing climate, with a single casual change. This discussion includes estimated changes in trends of indicators across the various spheres on a global scale. Indicators examined include: ice, humidity, sea level, ocean heat content, cryospheric indicators, including sea ice and glaciers, surface temperature including marine air temperature, land surface and sea surface temperature and upper air temperatures.

b. Collaborative Research Projects

Warming holes: Can CMIP5 climate models represent the variability and sources of regional temperature trends in the Continental United States?

Co Principal Investigators:	Dr. Kenneth Kunkel and Dr. Walter Robinson
Funding:	National Science Foundation (Funded, work in progress)
College/Dept	Marine, Earth and Atmospheric Sciences Department, North Carolina State University

A Partnership For Data-driven Climate Education

Co Principal investigators:	Dr. Peter Thorne and Dr. Walter Robinson
Funding:	National Science Foundation (pending)
College/Dept	Marine, Earth and Atmospheric Sciences Department, North Carolina State University

Developing and Serving Daily Surficial Soil Moisture Products at Multiple Scales using Microwave Radiometry, Vegetation Corrections, and Other Ancillary Data

Co Principal Investigators:	Dr. Jeffrey G. White Dr. Josh Heitman, Dr. Ryan Boyles, Dr. Jesse.Bell, Dr. Tyson Ochsner (OSU)
Funding:	National Aeronautics and Space Administration (pending)
College/Dept:	North Carolina State University and Oklahoma State University

Appendix 4: CICS Circulars

a. CICS-MD Circular

CICS-MD

Cooperative Institute for Climate and Satellites

BACKGROUND

The Cooperative Institute for Climate and Satellites (CICS) is a multi-institution partnership led by the University of Maryland at College Park (UMCP) and engaged in collaborative research with several Centers and Laboratories of the National Oceanic and Atmospheric Administration (NOAA). CICS comprises two main research centers, one at the University of Maryland (CICS-MD) and the other in Asheville, NC which is administered by North Carolina State University (CICS-NC). Phil Arkin is the Executive Director of CICS and Director of CICS-MD, with Hugo Berbery as the CICS-MD Associate Director. CICS-NC is in the able hands of its Director, Otis Brown.

VISION

CICS performs collaborative research aimed at enhancing NOAA's ability to use satellite observations and Earth System Models to advance the national climate mission, including monitoring, understanding, predicting and communicating information on climate variability and change.

MISSION

CICS conducts research, education and outreach programs in collaboration with NOAA to:

- Develop innovative applications of national and international satellite observations and advance transfer of such applications to enhance NOAA operational activities;
- Investigate satellite observations and design information products and applications to detect, monitor and understand the impact of climate variability and change on coastal and oceanic ecosystems;
- Identify and satisfy the satellite climate needs of users of NOAA climate information products, including atmospheric and oceanic reanalysis efforts;
- Improve climate forecasts on scales from regional to global through the use of satellite derived information products, particularly through participation in the NOAA/NWS/NCEP Climate Test Bed;
- Develop and advance regional ecosystem models, particularly aimed at the Mid-Atlantic region, to predict the impact of climate variability and change on such ecosystems; and
- Establish and deliver effective and innovative strategies for articulating, communicating and evaluating research results and reliable climate change information to targeted public audiences.

DIRECTORS' MESSAGE

It is our pleasure to introduce the first issue of the CICS-MD Circular. We hope to inform interested scientists, managers and decision makers about significant events, while providing a glimpse into current research projects. We plan semiannual updates that will present new research activities in CICS-MD and relevant information for our partners.

CICS-MD has been actively promoting its research through presentations at many specialized science meetings and performing outreach activities like supporting students participating in the Climate Diagnostics and Prediction Workshop. The recent CICS Science Meeting held in Asheville, NC, was an opportunity to share our science with our colleagues at CICS-NC and to help coordinate and plan further collaborations.

The Memorandum of Agreement between NOAA and UMCP has been signed and formalizes the mechanisms that will govern CICS. A new Executive Board is being formed with the mission of providing oversight and direction to CICS. The community of CICS scientists is coming together and developing new research links and collaborations among members of the CICS consortium and NOAA Laboratories and Centers.

CICS-MD administers and processes all of the funding actions for the entire Consortium and handles the reporting as well: we are very grateful to the ESSIC Business Office, headed by Joan La Fonta, and Andy Negri, ESSIC Assistant Director, for their help in those areas. We welcome comments and suggestions for this Circular, and look forward to a continued communication.

Best wishes,
Phil Arkin and Hugo Berbery

PARTNERS

CICS-MD is hosted and administered by the University of Maryland's Earth System Science Interdisciplinary Center (ESSIC) and includes participants from the Departments of Atmospheric and Oceanic Science and Geography, and the Joint Global Change Research Institute. CICS-MD is the keystone of the CICS Consortium, which includes CICS-NC and other organizations.

CICS-NC, located in Asheville, is part of the North Carolina Institute for Climate Studies (NCICS) administered by North Carolina State University, and incorporates partners across institutions that make up the University of North Carolina System.

The CICS Consortium includes another 15 institutions as partners, including academic, non-governmental, and private research enterprises. Active members of the Consortium at present include Princeton University, Howard University, University of California at Irvine, City University of New York, University of Miami, Oregon State University, South Carolina, Climate Central, Remote Sensing Systems, the Institute for Global Environmental Strategies, and the Oak Ridge Associated Universities.

cics-md

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UNIVERSITY OF MARYLAND

RESEARCH THEMES

Theme 1: Climate and Satellite Research and Applications incorporates the development of new observing systems, or new climate observables from current systems.

Theme 2: Climate and Satellite Observations and Monitoring focuses on: (a) development and improvement of climate observables from current systems, and (b) development of all continental and global fields of climate parameters that can be used for climate analysis and climate model initialization.

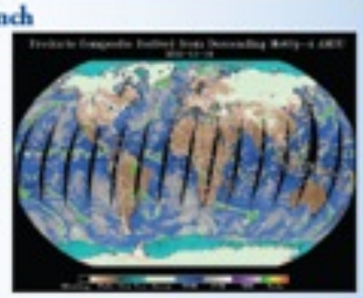
Theme 3: Climate Research and Modeling is the research component that brings together (a) climate observables, modeling and validation in a comprehensive integrated whole, and (b) observational products with model development efforts to enable research into the improvement of forecasts of climate system variability on space scales ranging from regional to global, and time scales from a week or two to centuries.

NOAA SPONSORS

- Center for Satellite Applications and Research (STAR)/National Environmental Satellite, Data and Information Service (NESDIS)
- Climate Prediction Center/National Centers for Environmental Prediction/ National Weather Service
- National Climatic Data Center/NESDIS
- National Oceanographic Data Center/ NESDIS
- Air Resources Laboratory/ Office of Oceanic and Atmospheric

A CICS Partner – NOAA/NESDIS/Satellite Climate Studies Branch

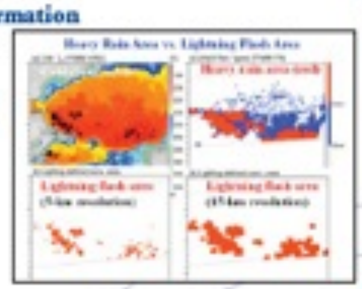
Since 2005, CICS-MD has developed a strong partnership with the Satellite Climate Studies Branch (SCSB), part of NOAA/NESDIS/Center for Satellite Applications and Research (STAR), to exploit the capabilities of Earth-observing satellites to study the climate variations of the atmosphere, the land and the oceans. SCSB and CICS-MD researchers work on a host of topics the focus that range from high priority topics related to NESDIS' operational satellite programs to cutting edge research focused on ecosystems and climate. The effort uses remote satellite observations as well as model simulations to detect, monitor and forecast the effects of climate change on the environment, including effects on its ecosystems.



The figure on the right shows a composite product of hydrological variables derived from one of the operational polar orbiting satellite – MetOp-A – that are derived from a microwave sensor package known as "AMSU." These products, generated since 2000, are useful for weather forecasters and climate scientists.

Improving Satellite Heavy Rain Estimates Using Lightning Information

Researchers (Robert Adler, Nai-Yu Wang, and Weixin Xu) in CICS are funded by the National Oceanic and Atmospheric Administration (NOAA) to develop techniques to incorporate lightning information to improve satellite rainfall estimates. NOAA's Geostationary Operational Environmental Satellite (GOES-R; to be launched in 2016) will have the first ever Geosynchronous Lightning Mapper (GLM). Tropical Rainfall Measuring Mission (TRMM) data are being used to develop the basis and eventually the algorithms to combine GOES-R Infrared (IR) and GLM data to provide high resolution rainfall information, especially with regard to convective cores and heavy rain areas. This algorithm would be helpful in earlier warnings of heavy rain or flooding events, especially over remote area not covered by rain gauges or radars.



Seasonal Drought Prediction over the United States

CICS Research Associate Li-Chuan Chen and Physical Scientist Kingtse Mo at NOAA/ NCEP/Climate Prediction Center (CPC) have developed a new tool to predict meteorological drought over the contiguous United States using standardized precipitation index (SPI) based on precipitation forecasts from NCEP Climate Forecast System version 2 (CFSv2). The methodology and forecast skill were presented in the WCRP Open Science Conference in Denver, Colorado on October 27, 2011. Generally, prediction skill is seasonally and regionally dependent and the six-month SPI forecasts are skillful out to 3-4 months. The products (available at http://www.cpc.ncep.noaa.gov/products/Drought/Figures/index/spi.fcst.gif) became operational in April 2011 and have been used to assist in CPC's drought monitoring and assessment activities.

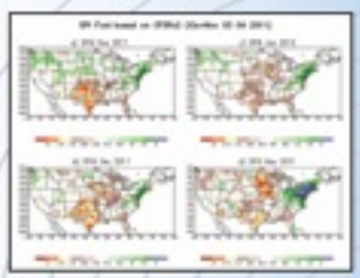


Figure shows the six-month SPI (SPI6) forecasts for (a) November 2011, (b) December 2011, (c) January 2012, and (d) three-month SPI (SPI3) for November 2011 based on the CFSv2 November 3-4 initial conditions.

Dr. Phil Arkin, CICS-MD Director
Dr. R. Hugo Berbery, CICS-MD Associate Director

December 2011

b. CICS-NC Circular

CICS-NC
Cooperative Institute for Climate and Satellites

CICS-NC Background

The Cooperative Institute for Climate and Satellites North Carolina (CICS-NC) was inaugurated July 1, 2009, hosted by NC State University for the University of North Carolina General Administration. The UNC General Administration in January 2010 formally approved the establishment of the NC Institute for Climate Studies (NCICS) that formally links CICS-NC/NCICS with all the UNC System campuses and provides an inter-institutional mechanism for collaborative research activities and governance.

CICS-NC Research with NCDC

CICS-NC conducts collaborative research with NOAA's National Climatic Data Center, whose needs span from basic and applied science research, social science research, policy research and development and outreach to the public.

CICS-NC scientific vision centers on observation from Earth orbiting satellites and prediction using realistic mathematical models of the present and future behavior of the Earth System.

Observations include:

- development of new ways to use existing observations,
- invention of new methods of observation, and
- creation and application of ways to synthesize observations from many sources into a complete and coherent depiction of the full system.

Prediction requires the development and application of coupled models of the complete climate system, including atmosphere, oceans, land surface, cryosphere and ecosystems.

Main collaborative activities are currently organized into 8 streams of activity:

- Climate Data Records,
- Climate Literary,
- Surface Observing Networks,
- National Climate Model Portal,
- National Climate Assessment,
- Workforce Development,
- Consortium Projects, and
- Administrative Support.

These streams are supported by the different divisions in NCDC, NOAA Line Offices such as the National Environmental Satellite, Data and Information Service (NESDIS), Oceanic and Atmospheric Research (OAR), and the National Weather Service (NWS), the US Global Change Research Program (USGCRP), and North Carolina State University.

Today, the CICS-NC team consists of nearly 25 researchers that support the NOAA mission with a focus on enhancing the collective interdisciplinary understanding of the state and evolution of the full Earth System.

Over the past year, these researchers have published nearly 20 peer reviewed papers with 10 more under revision. Members of the CICS-NC scientists' team are leading contributors to the IPCC Fifth Assessment Report, one of whom is the Editor of the Global Chapter of the State of the Climate Report. They also engage in international program management, specifically the GCOS Reference Upper Air Network and the recently instigated International Surface Temperatures Initiative. CICS-NC scientists have been principal organizers of two international workshops, have presented at over 10 conferences with nearly 20 presentations on the topics of climate research and applications, satellite and observation monitoring and climate modeling.

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The UNIVERSITY of NORTH CAROLINA
A Multi-Campus University
NC State University

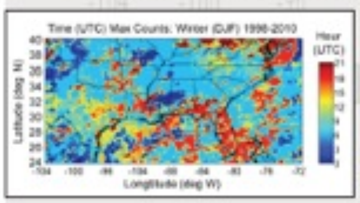
CICS-NC Recent Updates

In January 2011, UNC General Administration formally approved the establishment of the NC Institute for Climate Sciences (NCICS), which formalizes the CICS-NC linkage with all the UNC System campuses and provides an inter-institutional mechanism for collaborative activities and governance. CICS consortium partners at NC State, RENCI, East Carolina University, University of Miami, University of California – Irvine, Climate Central and Remote Sensing Systems are engaged in NOAA supported collaborative projects.

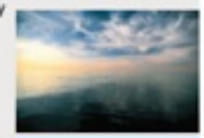
CICS installed and brought into operation a 340-node high performance computing cluster to assist with climate data record development and validation in Asheville. A first of its kind, high-resolution precipitation (5 minute/1 Km) is being processed and should be available for the southeastern US later this year.

Research Updates

- CICS-NC research associate, Scott Stevens, is currently working with the State of North Carolina Climate Office to support the development of the Q2 product that provides quantitative precipitation information at 1-km resolution at a five-minute interval. This product is generated in real-time at NSSL, but only archived for a limited period of time. Using the NCDC archive of NEXRAD observations, NCDC, in partnership with NSSL and CICS, is creating a 13 year reanalysis using the Q2 algorithms, beginning with a pilot domain centered over Virginia and the Carolinas.
- CICS-NC post-doc, Dr. Jessica Matthews is working with NCDC, EUMETSAT and JMA in implementing the Geostationary Surface Albedo (GSA) for GOES data to create a global stitched product. Surface albedo is the fraction of incoming solar radiation reflected by the land surface, and is a sensitive indicator of environmental changes. To this end, surface albedo is identified as an Essential Climate Variable (ECV) by the Global Climate Observing System (GCOS). The significant milestone of the first successful test run processing GOES data, GOES-E (75°W) and GOES-W (135°W), with the GSA algorithm at NCDC was recently achieved.
- CICS-NC post-doc, Dr. Carl Schreck is investigating the Madden-Julian Oscillation (MJO) using upper tropospheric water vapor. Previous datasets focused on the MJO in Eastern Hemisphere, but upper tropospheric water vapor is useful for identifying and predicting the MJO globally. By processing this dataset in near real-time, he provides NOAA's Climate Prediction Center with a valuable new forecasting tool.



- CICS-NC research associate, Dr. Anand Inamdar, is working with NCDC's Dr. Ken Knapp in updating calibration for GOES Visible channel (0.67 micron) from 1990 – 2009. The International Satellite Cloud Climatology Project (ISCCP), established in 1982 as part of the World Climate Research Program (WCRP), has been collecting and processing data from the polar orbiting and geostationary satellites (GEOs) globally since 1983. The goal is to collect and analyze satellite radiance measurements to infer the global distribution of clouds, their properties, and their diurnal, seasonal, and interannual variations. Recently, Dr. Ken Knapp (NOAA's National Climatic Data Center) led the rescue of the archived data to produce ISCCP B1 data, which represents geostationary imagery from satellites worldwide that are sub-sampled to 10 km and 3 hour-resolution.



- Dr. Ken Kunkel, a CICS scientist and NC State Research Professor, is the lead scientist for the National Climate Assessment.
- Dr. Peter Thorne, a CICS scientist and NC State Res. Associate Professor, has been selected as a lead author for the IPCC 5th Assessment Review.

Outreach Updates

In February 2011, CICS scientists engaged and participated at a local interactive science exhibit and the world press release of a strategy climate change game called 'Fate of the World' that celebrated the successes of collaborative partnerships and how science data played a key role in cutting-edge games, technology, art and design. The event promoted the value of science, innovation, research and value of partnerships. CICS-NC has initiated the planning for the "Summer Institute on Climate Adaptation" to be held in Asheville in June 2012. As an effort to enable literacy and education, CICS-NC has engaged with North Carolina based private electric energy utility company for a collaborative project on the opportunities of advanced planning to address impacts of climate variability.

Underpinning CICS-NC activities is the importance of partnerships and collaborations across private, public and academic entities. CICS-NC partners with other institutions like the Joint Global Change Research Institute at the University of Maryland – College Park, The Land Surface Hydrology Group at Princeton University, Renaisssance Computing Institute (RENCI), Oak Ridge National Laboratory, NC Arboretum, UNC System, regional economic development partners and many other public and private enterprises to develop projects to advance climate change research.

Dr. Otis Brown, CICS-NC Director
www.cicsnc.org

August 2011

Appendix 5: List of Publications

	# Publications
CICS-MD	59
CICS-NC	40
CUNY	9
Other Consortium Members	2

CICS-MD Publications: 59

1. Gonçalves, F. L. T., J. A. Martins, R. I. Albrecht, C. A. Morales, M. A. Silva Dias, and C. E. Morris (2012): Effect of bacterial ice nuclei on the frequency and intensity of lightning activity inferred by the BRAMS model. Atmos. Chem. Phys. Discuss., 11, 26143-26171, 2011, doi:10.5194/acpd-11-26143-2011.

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4. Wang, N.-Y., K. Gopalan, and R. Albrecht, 2012: Lightning, radar reflectivity and passive microwave observations over land from TRMM: Characteristics and applications in rainfall retrievals. *J. Geophys. Res*., Submitted.

5. Xu, W., R. F. Adler, and N.-Y. Wang, (under review): Improving Geostationary Satellite Rainfall Estimates Using Lightning Observations, I: Underlying Lightning-Rainfall-Cloud Relationships. *J. Appl. Meteor. Climatol*.

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7. Lee, H.-T., I. Laszlo, and A. Gruber, 2010: ABI Earth Radiation Budget – Surface Downward Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (submitted)

8. Lee, H.-T., I. Laszlo, and A. Gruber, 2010: ABI Earth Radiation Budget – Surface Upward Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (submitted)

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19. *C. Pan, F. Weng, X. Wu, Janz, L. Flynn, R. Buss, E. Beach,* OMPS Early Orbit Dark and Bias Evaluation and Calibration, IGARSS 2012. Submitted and is in review

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27. Liang, X.-Z., M. Xu, W. Gao, K.R. Reddy, K.E. Kunkel, D.L. Schmoldt, and A.N. Samel (in press) Physical modeling of U.S. cotton yields and climate stresses during 1979-2005. *Agronomy Journal*.

28. Kunkel, K.E., D.R. Easterling, D.A.R. Kristovich, B. Gleason, L. Stoecker, and R. Smith (in press) Meteorological causes of the secular variations in observed extreme precipitation events for the conterminous United States. *J. Hydromet*.

29. Westcott, N.E., S.D. Hilberg, R.L. Lampman, B.W. Alto, A. Bedel, E.J. Muturi, H. Glahn, M. Baker, K.E. Kunkel, and R.J. Novak, 2011: Predicting the seasonal shift in mosquito populations preceding the onset of the West Nile Virus in central Illinois. *Bull. Amer. Meteor. Soc.*, 92, 1173-1180.

30. Kunkel, K., L. Stevens, and E. Janssen (in review), Climate of the Contiguous United States, *prepared for the National Climate Assessment Development and Advisory Committee*.

31. Kunkel, K., L. Stevens, S. Stevens, E. Janssen, and K. Redmond (in review), Climate of the Northwest U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

32. Kunkel, K., L. Stevens, S. Stevens, E. Janssen, and K. Redmond (in review), Climate of the Southwest U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

33. Kunkel, K., L. Stevens, S. Stevens, E. Janssen, J. Rennells, and A. DeGaetano (in review), Climate of the Northeast U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

34. Kunkel, K., L. Stevens, S. Stevens, E. Janssen, S. Hilberg, M. Timlin, L. Stoecker, and N. Westcott (in review), Climate of the Midwest U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

35. Kunkel, K., L. Stevens, S. Stevens, E. Janssen, C. Konrad, C. Fuhrman, B. Keim, M. Kruk, A. Billet, H. Needham, and M. Schafer (in review), Climate of the Southeast U.S., *prepared for the National Climate Assessment Development and Advisory Committee*.

36. Kunkel, K., L. Stevens, S. Stevens, E. Janssen, M. Kruk, D. Thomas, K. Hubbard, Shulski, N. Umphlett, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, and T. Bergantino (in review), Climate of the U.S. Great Plains, *prepared for the National Climate Assessment Development and Advisory Committee*.

37. Stewart, B., J. Walsh, K. Kunkel, and L. Stevens (in review), Climate of Alaska, *prepared for the National Climate Assessment Development and Advisory Committee*.

38. Keener, V., K. Hamilton, S. Izuka, K. Kunkel, and L. Stevens (in review), Climate of the Pacific Islands, *prepared for the National Climate Assessment Development and Advisory Committee*.

39. Ali Behrangi, Behnaz Khakbaz, Tsou Chun Jaw, Amir AghaKouchak, Kuolin Hsu, and Soroosh Sorooshian, 2011, Hydrologic Evaluation of Satellite Precipitation Products Over a Mid-size Basin, *Journal of Hydrology*, 397, 225–237.

40. Carey, M., B. Gore, T. Hill, M. Covi, and T. Allen. 2012. Sea-Level Rise Vulnerability in the Albemarle-Pamlico Estuarine System. *ESRI Map Book* XX (forthcoming.)

CUNY Publications: 9

1. Romanov P. (2011) Satellite-Derived Information on Snow Cover for Agriculture Applications in Ukraine. In F.Kogan et al. (eds.) Use of Satellite and In-Situ Data to Improve Sustainability. NATO Science for Peace and Security Series C: Environmental Security, Part 2, 81-91, Springer Science Business Media B.V.

2. Romanov P. (2011) Southern Hemisphere Automated Snow/Ice (METOP-AVHRR) Algorithm Theoretical Basis Document. V. 1.0

3. Gladkova, M. Grossberg, F. Shahriar, G. Bonev, P. Romanov, Quantitative Restoration for MODIS Band 6 on Aqua, IEEE Transactions on Geoscience and Remote Sensing, vol.50, no. 6, Jun. 2012. To be published. [Online]. Available: doi:10.1109/TGRS.2011.2173499.

4. Gladkova, M. Grossberg, G. Bonev, P. Romanov, F. Shahriar, Increasing the Accuracy of MODIS/Aqua Snow Product Using Quantitative Image Restoration Technique, IEEE Geoscience and Remote Sensing Letters, to be published

5. Gladkova, M. Grossberg, G. Bonev, P. Romanov, Seasonal snow cover of Yellowstone estimated with restored MODIS Aqua, and MODIS Terra snow cover maps, AGU Chapman Conference on Remote Sensing of the Terrestrial Water Cycle in Kona, Hawaii

6. Tesfagiorgis, K., S.E. Mahani, N. Krakauer, and R. Khanbilvardi; *2011; "Bias Adjustment of Satellite Precipitation Estimates using a Radar-Gauge Product"; HESS Journal*; V(15), pp. 2631-2647.

7. Tesfagiorgis, K., S.E. Mahani, and R. Khanbilvardi; 2011; "Multi-Sources Precipitation Estimation: Mitigating Gaps Over Radar Network Coverage"; Conference Proceeding, IGARSS 2011; July 24-29, 2011; Vancouver/Canada; pp: 3054-3057.

8. Vant-Hull, B., F. Autones, S. Mahani, J. Mecikalski, R. Rabin, R. Khanbilvardi, 2012: Convective Cloud Towers: Precipitation and Lightning Frequency versus Intensity. *Submitted to J. Appl. Met.*

9. Lakhankar T., Munoz J., Powell A., Romanov P., Rossow W., and R. Khanbilvardi (2012) CREST-Snow Field Experiment: Analysis of Snowpack Properties using Multi-Frequency Microwave Remote Sensing Data, Manuscript under review, to be submitted to Peer reviewed Journal.

Other Consortium Members' Publications: 2

1. Weiss, S. A., D. R. MacGorman, and K. M. Calhoun, 2012: Lightning in the anvils of supercell thunderstorms. *Mon. Wea. Rev.*, in press, 10.1175/MWR-D-11-00312.1

2. Bruning, E. C., S. A. Weiss, and K. M. Calhoun, 2012: An evaluation of inverted polarity terminology and electrification mechanisms. *Atmos. Res.*, submitted.

Appendix 6: List of Presentations

	# Presentations	# Non- Peer Reviewed Publications	Total
CICS-MD	63	9	72
CICS-NC	102	12	114
CUNY	13	-	13
Other Consortium Members	6	-	6

CICS-MD Total Presentations: 63

1. Albrecht, R. i. et al. (2011): The 13 years of TRMM Lightning Imaging Sensor: From individual flash characteristics to decadal tendencies. XIV International Conference on Atmospheric Electricity, 8-12 August, Rio de Janeiro, Brazil.

2. Albrecht, R. I. et al. (2012): The CHUVA-GLM field campaign. Convection Working Group Workshop, 27-30 March, Prague, Czech Republic.

3. Naccarato, K., R. I. Albrecht, O. Pinto Jr. (2011): Monthly variations of cloud-to-ground lighting activity in Brazil based on high-resolution lightning image sensor (LIS) data. XIV International Conference on Atmospheric Electricity, 8-12 August, Rio de Janeiro, Brazil.

4. Naccarato, K. P., R. I. Albrecht, O. Pinto Jr. (2011): Cloud-to-ground lightning density over Brazil based on high-resolution lightning imaging sensor (LIS) data. XIV International Conference on Atmospheric Electricity, 8-12 August, Rio de Janeiro, Brazil.

5. Rudlosky, S. D. and H. E. Fuelberg, 2011: Relationships between lightning and radar in the Mid-Atlantic Region. *Southern Thunder Workshop*, Norman, OK, July 11-14.

6. Xu, W., R. F. Adler, and N.-Y. Wang: Improving Geostationary Satellite Rainfall Estimates Using Lightning Observations: Underlying Lightning-Rainfall Relationships. Amer. Meteor. Soc., 92nd Annual Meeting, Jan 2012, New Orleans, LA.

7. Lee, H.-T., et al., 2011: GOES-R AWG Product Validation Tool Development for LW ERB Products. GOES-R AWG Annual Meeting, Fort Collins, CO., June 14-16, 2011.

8. Wang, N.-Y., Gopalan, K., and Albrect, R., Improving precipitation retrieval using total lightning data: a multi-sensor, multi-platform synergy between GOES-R

and GPM, 2012 AMS Annual Meeting18th Conference on Satellite Meteorology, oceanography, and climatology, January 25, 2012

9. Wang, N.-Y., Gopalan, K., and Albrect, R., Combing GOES-R and GPM to improve GOES-R rainrate product, 2011 GOES-R Science Week, Huntsville, Alabama Fuell, K., A. Molthan, M. Folmer, and M. DeMaria, 2011: Demonstration of RGB Composite Imagery at NOAA National Centers in Preparation of GOES-R. *7th GOES User's Conference*, Birmingham, AL, October 15-21.

10. Folmer, M.J., B. Reed, S. Goodman, J. M. Sienkiewicz, E. Danaher, J. Kibler, and D. R. Novak, 2012: The 2011 HPC/OPC/SAB GOES-R Proving Ground Demonstration. *Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 92nd American Meteorological Society Annual Meeting*, New Orleans, LA, January 22-26 .

11. Folmer, M.J., R. W. Pasken, T. Eichler, G. Chen, J. Dunion, and J. Halverson, 2012: The Impact of the Saharan Air Layer on the Development of Eastern Atlantic Tropical Cyclones. *Fourth Symposium on Aerosol-Cloud-Climate Interactions, 92nd American Meteorological Society Annual Meeting*, New Orleans, LA, January 22-26.

12. He, T. et al. GOES-R AWG Land Team: ABI Land Surface Albedo (LSA) and Surface Reflectance Algorithm. June 14th, 2011. Fort Collins, CO, USA.

13. Hain, C. R., W. T. Crow, M. C. Anderson, and J. R. Mecikalski. "*An EnKF Dual Assimilation of Thermal-Infrared and Microwave Satellite Observations of Soil Moisture Into the Noah Land Surface Model*", 92nd Annual Meeting of the American Meteorological Society in New Orleans, LA 22-26 January 2012 (invited).

14. Hain, C. R., M. C. Anderson, and X. Zhan. "*An Intercomparison of Remote Sensing and Model- Based Estimates of Evapotranspiration over the CONUS*", 92nd Annual Meeting of the American Meteorology Society in New Orleans, LA 22-26 January 2012 (invited).

15. Hain, C. R., M. C. Anderson, and X. Zhan. "A GOES Thermal-Based Drought Early Warning System", American Geophysical Union Fall Meeting in San Francisco, CA 5-9 December 2011 (invited).

16. Hain, C. R., W. T. Crow, M. C. Anderson, X. Zhan, B. Wardlow, M. Svoboda, and J. R. Mecikalski", "*Dual Assimilation of Microwave and Thermal-Infrared Satellite Observations of Soil Moisture into NLDAS for Improved Drought Monitoring*", American Geophysical Union Fall Meeting in San Francisco, CA 5-9 December 2011.

17. Hain, C. R., W. T. Crow, M. C. Anderson, J. R. Mecikalski, and T. Holmes, "*Developing a Dual Assimilation Approach for Thermal Infrared and Passive Micro-*

wave Soil Moisture Retrievals", European Geophysical Union General Assembly in Vienna, Austria 3-8 April 2011.

18. Hain, C. R., M. C. Anderson, X. Zhan and J. R. Mecikalski, "*Intercomparison of an ET-based Drought Index Derived from Geostationary Satellite Data with Standard Drought Indicators*", European Geophysical Union General Assembly in Vienna, Austria 3-8 April 2011.

19. Blonski, S., and C. Cao. *NOAA Calibration/Validation Update*. CEOS Working Group on Calibration and Validation Plenary Meeting, Brisbane, Australia, 6-10 February 2012.

20. Blonski, S., C. Cao, S. Uprety, and X. Shao. *Using Antarctic Dome C Site and Simultaneous Nadir Overpass Observations for Monitoring Radiometric Performance of NPP VIIRS Instrument*. IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Munich, Germany, 22-27 July 2012, submitted.

21. Berbery, E. H., 2011: "Cooperative Institute for Climate and Satellites-Maryland" presented at the *Second Annual CICS Science Meeting*, Asheville, North Carolina, 2-3 November 2011

22. Wang, L., Y. Han, F. Weng, and M. Goldberg : Inter-calibration of NPP CrIS with AIRS and IASI, NPP CrIS SDR Product Review meeting. 4 April 2012.

23. H. Meng, R. Ferraro, C. Devaraj, I. Moradi, and W. Yang, 2011: Project overview – The development of AMSU FCDR's and TCDR's for hydrological applications. Talk presented at NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders – AMSU/MHS/SSMT2, Earth System Science Interdisciplinary Center (ESSIC), College Park, MD, USA, March 2-3.

24. W. Yang, H. Meng, and R. Ferraro, 2011: AMSU-A asymmetry for window channels. Talk presented at NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders – AMSU/MHS/SSMT2, Earth System Science Interdisciplinary Center (ESSIC), College Park, MD, USA, March 2-3.

25. C. Devaraj, 2011: AMSU-B/MHS asymmetry. Talk presented at NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders – AMSU/MHS/SSMT2, Earth System Science Interdisciplinary Center (ESSIC), College Park, MD, USA, March 2-3.

26. Moradi, H. Meng, and R. Ferraro, 2011. AMSU navigation and geolocation errors. Talk presented at NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders – AMSU/MHS/SSMT2, Earth System Science Interdisciplinary Center (ESSIC), College Park, MD, USA, March 2-3.

27. C. Devaraj, H. Meng, R. Ferraro, W. Yang and I. Moradi, 2011: The Development of AMSU-B/MHS Fundamental CDR's. Talk presented at CALCON meeting in Logan, UT in August 29-September 1.

28. C. Devaraj, H. Meng, R. Ferraro, W. Yang and I. Moradi, 2011: The Development of AMSU-B/MHS Fundamental CDR's. Poster presented at AGU Fall Meeting in San Francisco, CA in December 5-9.

29. W. Yang, I. Moradi, C. Devaraj, H. Meng, and R. Ferraro, 2011: Development of AMSU Fundamental CDR. Talk presented at X-Cal meeting in Fort Collins, CO in July 13-14.

30. W. Yang, I. Moradi, C. Devaraj, H. Meng, and R. Ferraro, 2011: The Development of AMSU-A Fundamental CDR's. Poster presented at EUMETSAT/GSICS in Oslo, Norway in September 5-9.

31. Moradi, H. Meng, and R. Ferraro, 2012: Geolocation and scan asymmetry correction for the passive microwave instruments. Talk presented in 18th Conference on Satellite Meteorology, Oceanography and Climatology / First Joint AMS-Asia Satellite Meteorology Conference, New Orleans, Louisiana, USA, January.

32. Moradi, H. Meng, and R. Ferraro, 2011: Geolocation and scan asymmetry correction for NOAA POES passive microwave instruments. Poster presented in AGU Fall Meeting, San Francisco, CA, USA, December.

33. Moradi, H. Meng, and R. Ferraro, 2011: Geolocation correction for NOAA POES passive microwave instruments. Talk presented in GPM Intersatellite Calibration Working Group, Denver, CO, USA, November.

34. Moradi, H. Meng, and R. Ferraro, 2011: Geolocation correction for NOAA POES passive microwave instruments. Talk presented in CICS Science Meeting, NCDC/NOAA, Asheville, NC, USA, November.

35. Moradi, H. Meng, and R. Ferraro, 2011: Geolocation correction for NOAA POES passive microwave instruments. Talk presented in CALCON Technical Conference: Conference on Characterization and Radiometric Calibration for Remote Sensing, Utah State University, Logan, UT, USA, August.

36. Moradi, H. Meng, and R. Ferraro, 2011. Geolocation Correction for Microwave Instruments (AMSU-A, AMSU-B and MHS) Onboard NOAA POES Satellite, NESDIS/STAR/NOAA, World Weather Building, Camp Springs, MD, USA. Invited Talk.

37. Moradi, H. Meng, and R. Ferraro, 2011. Geolocation Correction for NOAA POES Passive Microwave Instruments, ESSIC, University of Maryland, College Park, MD, USA. Invited Talk.

38. Arkin, P. A., J. E. Janowiak, D. Vila: (2011): Evaluation of Satellite-derived Precipitation Estimates over the Americas. American Geophysical Union. Session H93: Evaluation of Precipitation Retrievals. San Francisco, CA. Dec. 5-9, 2011.

39. Farrell, S. L., N. T. Kurtz, V. Onana, J. P. Harbeck, and K. Duncan (2011b), Sea Ice Lead Distribution from High Resolution Airborne Imagery, *Abstract C52B-03 present\ed at 2011 Fall Meeting*, AGU, San Francisco, Calif., 5-9 Dec. 2011.

40. Richter-Menge, J., S. Farrell, B. C. Elder, J. M. Gardner, and J. M. Brozena (2011), A Coordinated Ice-based and Airborne Snow and Ice Thickness Measurement Campaign on Arctic Sea Ice, *Abstract C41E-0454 presented at 2011 Fall Meeting*, AGU, San Francisco, Calif., 5-9 Dec. 2011.

41. Kurtz, N. T., S. L. Farrell, J. P. Harbeck, L. Koenig, V. Onana, J. G. Sonntag, and M. Studinger (2011), State of the Arctic and Antarctic sea ice covers from Operation IceBridge snow and ice thickness observations (Invited), *Absrtact C52B-02 presented at 2011 Fall Meeting*, AGU, San Francisco, Calif., 5-9 Dec. 2011.

42. Connor, L. N., S. W. Laxon, D. C. McAdoo, A. Ridout, R. Cullen, S. Farrell, R. Francis (2011), Arctic sea ice freeboard from CryoSat-2: Validation using data from thefirst IceBridge underflight, *Abstract C53F-04 presented at 2011 Fall Meeting*, AGU, San Francisco, Calif., 5-9 Dec. 2011.

43. S. Helfrich and C. Kongoli, "Improved monitoring of snow depth combining surface observations from existing stations and newly developed acoustic sensors", International Symposium on Cryosphere and Climate Change (ISCCC) 2012, Manali India, 2-4 April, 2012.

44. Talk given by S. Schollaert Uz on February 24, 2012 in 'Advancing Satellite Ocean Color Science for Global and Coastal Research' session during Ocean Sciences Meeting 2012, Salt Lake City

45. Chen, L.-C., K. C. Mo, and M.-Y. Lee, 2012: Soil Moisture and Runoff Forecasts from the Climate Forecast System Version 2, Abstract of the 92nd AMS Annual Meeting, the 26th Conference on Hydrology, New Orleans, Louisiana. (http://ams.confex.com/ams/92Annual/webprogram/Paper197651.html)

46. Mo, K. C., L.-C. Chen, S. Shukla, T. Bohn, and D. P. Lettenmaier, 2012: Uncertainties in North American Land Data Assimilation Systems over the Contiguous United States, Abstract of the 92nd AMS Annual Meeting, the 26th Conference on Hydrology, New Orleans, Louisiana. (http://ams.confex.com/ams/92Annual/webprogram/Paper194324.html)

47. Chen, L.-C., and K. C. Mo, 2011: Seasonal Drought Prediction over the United States, WCRP Open Science Conference, World Meteorological Organization, Denver, Colorado.

48. Shukla, S., K. C. Mo, L.-C. Chen, and D. P. Lettenmaier, 2011: Uncertainties in the North American Land Data Assimilation Systems, WCRP Open Science Conference, World Meteorological Organization, Denver, Colorado.

49. "The impact of anthropogenic global warming on the United States wind resource," American Meteorological Society Annual Meeting, Oral Presentation, Seattle, Washington, 2011,

50. "The impact of wind energy on weather: studies with a simplified model," American Meteorological Society Annual Meeting, Poster Presentation, Seattle, Washington, 2011

51. Lee, H.-T., 2011: Sustainability of HIRS OLR Climate Data Record – *From Research to Operation.* First Conference on Transition of Research to Operations: Successes, Plans and Challenges / 91st AMS Annual Meeting, Seattle, WA, January 23-27, 2011.

52. Lee, H.-T., 2011: HIRS OLR Climate Data Record – Production and Future Plans. NASA Sounder Science Team Meeting. Greenbelt, Maryland, Nov 8-10, 2011. (Oral)

53. Ren, L., E. Hackert, A. J. Busalacchi, P.A. Arkin, Oceanic Net Freshwater Flux Anomalies Inferred from Upper Ocean Salinity (2006 to 2010), AGU Fall Meeting 2011, San Francisco, 12/2011, oral.

54. Mittaz, J.P.D., 'Instrument Calibration and its Impact on SST Retrieval', US SST Science Team meeting, Miami, Fl, Nov 2011, 2011

55. Csiszar, I., Schroeder, W., Giglio, L., Justice, C. O., and Ellicott, E., "Establishing active fire data continuity between Aqua MODIS and NPP VIIRS", 92nd Annual Meeting of the American Meteorological Society in New Orleans, LA, 22-26 January 2012.

56. Privette headed up a community presentation for the AMS – selected individual product presentations were given

57. Presentation of ASRVN analyses at the International Symposium on Remote Sensing of Environment (ISRSE) in Sydney, April 2011.

58. E. Ellicott , Csiszar, I., W. Schroeder, L. Giglio, and C. Justice, "The NPP VIIRS active fire product", Tactical Fire Remote Sensing Advisory Committee (TFRSAC) meeting, Boise, ID, October 27, 2011.

59. A Terrestrial Surface Climate Data Record for Global Change studies, Vermote et al., 2nd Annual CICS Science Meeting, National Climatic Data Center in Asheville, North Carolina on November 2-3, 2011.

60. A Terrestrial Surface Climate Data Record for Global Change studies, Vermote et al., AGU Falls Meeting, San Francisco, 5-9 December 2011 (Poster).

61. Csiszar, I., W. Schroeder, L. Giglio, C. Justice, E. Ellicott. "Establishing active fire data continuity between Aqua MODIS and NPP VIIRS", 92nd Annual Meeting of the American Meteorological Society in New Orleans, LA, Seattle, 22-26 January 2012.

62. Csiszar, I., W. Schroeder, L. Giglio, E. Ellicott, C. Justice. Validation of the NPP VIIRS active fire product, IGARSS Annual Meeting in Vancouver, Canada, 24-29, July 2011.

63. Wang, N.-Y., Gopalan K., and R. Ferraro, Developing Winter Precipitation Algorithm over C3VP. 2012 AMS Annual Meeting, January 23, 2012.

CICS-MD Non-Peer Reviewed Publications: 9

1. Wonsick, M., X. Niu and R. T. Pinker, 2012. A new technique to calculate shortwave radiative fluxes from SEVIRI. In preparation.

2. Hain, Chris, Rongjun Wu, Xiwu Zhan and Martha Anderson. 2012. Validation of evapotranspiration estimates from ALEXI using NOAA GSIP and NARR data as input. *Geophysical Research Letters*. (In preparation)

3. Wang,D., Liang, S., He, T., Yu, Y., Schaaf, C. 2012, Estimating daily land surface albedo from MODIS BRDF and surface reflectance products, In preparation.

4. Wang, N.-Y., Gopalan, K., and Albrect, R., Lightning, radar reflectivity and passive microwave observations over land from TRMM: Characteristics and applications in rainfall retrievals, *Journal of Geophysical Research*. To be submitted.

5. Jiang, Z., Alfredo, Huete, R., Wang, Y., Lyapustin, A., Miura, T. "Evaluation of MODIS VI products using the AERONET-based Surface Reflectance Validation Network dataset"

6. Glenn, E. P., Doody, T. M., Guerschman, J. P., Huete, A. R., King, E. a., McVicar, T. R., Van Dijk, A. I. J. M., et al. (2011). Actual evapotranspiration estimation by ground and remote sensing methods: the Australian experience. Hydrological Processes, 25(December), 4103-4116.

7. Miura, T., Turner, J., Huete, A. "Spectral Compatibility Analysis of the NDVI across VIIRS, MODIS, and AVHRR Using EO-1 Hyperion: An Evaluation of Atmospheric Effects." (submitted to IEEE-TGARSS)

8. Huete, A.R. and Glenn, E.P., 2011, "Recent advances in remote sensing of ecosystem structure and function"**, In**: Advances in Environmental Remote Sensing: Sensors, Algorithms, and Applications (Weng, Q., Ed.), CRC Press, Taylor and Francis Group, pp.553.

9. Moradi, H. Meng, R. R. Ferraro, and S. Bilanow, "Correcting geolocation errors for microwave instruments aboard NOAA POES satellites," IEEE Trans. Geosci. Remote Sens., 2012, to be submitted.

CICS-NC Total Presentations: <u>102</u>

1. Stevens, S. "NMQ/Q2 Reanalysis in the Southeastern United States". Invited talk for Dr. Ryan Boyles, NC State Climate Office, Raleigh, NC. Jun 2011

2. Stevens, S., B. Nelson, C. Langston. "National Mosaic and Multi-Sensor QPE (NMQ) reanalysis in the southeastern United States" 19th AMS Conference on Applied Climatology, Asheville, NC. Jul 2011.

3. Stevens, S., B. Nelson, C. Langston, and R. Boyles. "National Mosaic and Multi-sensor QPE (NMQ/Q2) reanalysis in the Carolinas region and directions toward a ConUS-wide implementation" 2011 American Geophysical Union Fall Meeting, San Francisco, CA. Dec 2011.

4. Evans, R. and G. Podesta, Characterizing and comparison of uncertainty in the AVHRR Pathfinder Versions 5 & 6 SST field to various reference fields, Boulder GHRSST meeting, March, 2011

5. Casey, K., and R. Evans, The AVHRR Pathfinder Sea Surface Temperature Climate Data Record, 2012 Ocean Sciences, February, 2012

6. Casey, K., and R. Evans, Pathfinder, GHRSST and the SST Essential Climate Variable Framework, WCRP Open Science Conference, October, 2011

7. Casey, K., and C. Donlon, Pathfinder, GHRSST, CEOS and the SST Essential Climate Variable Framework, NASA SST Science Team, November, 2011

8. Guillevic P., J. L. Privette, B. Coudert, E. Davis, T. Meyers, M. A. Palecki, J. A. Augustine and C. Ottlé (2012). A Scaling Methodology to Compare Land Surface Temperature Products Derived from the Visible Infrared Imager Radiometer Suite (VIIRS) and Measured by NOAA's observational networks. American Meteorological Society (AMS) annual meeting. New Orleans, LA. 22-26 February.

9. Guillevic P., J. L. Privette, B. Coudert, E. Davis, T. Meyers, M. A. Palecki, J. A. Augustine and C. Ottlé (2011). Land Surface Temperature product validation using NOAA's surface climate observation networks – Scaling methodology for the Visible Infrared Imager Radiometer Suite (VIIRS). American Geophysical Union (AGU) meeting. San Francisco, CA, USA. 5-9 December.

10. "Assessment of Calibration Performance of the Geostationary Satellite Image Visible Channel in the ISCCP B1 Data", presented at the 18th Conference on Satellite Meteorology, Oceanography and Climatology/ First Joint AMS-Asia Satellite Meteorology Conference, New Orleans, Jan 25, 2012.

11. Matthews, J.L., Lattanzio, A., Hankins, B., Inamdar, A., Knapp, K., and Privette, J. 2011. Surface albedo based on geostationary observations. Poster presented at AGU Annual Meeting, December 6-10, 2011, San Francisco, CA.

12. Matthews, J.L. (2011) A model quantifying the effect of soil moisture and plant development on leaf conductance: Confidence interval estimation. Poster presented at SAMSI Program in Uncertainty Quantification: Climate Change Workshop, Pleasanton, CA, August 29-31, 2011.

13. "Objective Determination of Feature Resolution in an SST Analysis." was presented at two meetings: the GHRSST Science Team meeting, Edinburgh, UK, 21-25 June 2011 and the Uncertainty Quantification for Climate Observations Workshop, Asheville, NC, January 17-19, 2012.

14. Extended results with preliminary OSTIA results were presented at the Ocean Science Meeting in Salt Lake, UT, 20-24 February 2012. The presentation was entitled "Objective Determination of Feature Resolution in SST Analyses by R. W. Reynolds, D. B. Chelton, D. Menemenlis, M. Martin and J. Roberts-Jones.

15. Li, J., K. Hsu, A. AghaKouchak, and S. Sorooshian, A Hybrid Framework for Verification of Satellite Precipitation Products, AGU Fall Meeting, 5-9 December, 2011, San Francisco, CA, 2011.

16. Nasrollahi, N., K. Hsu, S. Sorooshian, Application of CloudSat Cloud Classification Maps and MODIS Multi-spectral Satellite Imagery in Identifying False Rain from Satellite Images, AGU Fall Meeting, 5-9 December, 2011, San Francisco, CA, 2011

17. Ashouri, H., K. Hsu, and S. Sorooshian, Reconstruction of Daily Precipitation for Climate Trend Detection and Extreme Precipitation Analysis, AMS Meeting, 22-26 January, 2012. New Orleans, LA. 2012.

18. Hsu, K. (Invited), A Machine Learning Approach for Precipitation Estimation from Multiple Satellite Information. American Meteorological Society Annual Meeting, 22-26 January, 2012. New Orleans, LA. 2012.

19. Stevens, S. "NMQ/Q2 Reanalysis in the Southeastern United States". Invited talk for Dr. Ryan Boyles, NC State Climate Office, Raleigh, NC. Jun 2011

20. Stevens, S., B. Nelson, C. Langston. "National Mosaic and Multi-Sensor QPE (NMQ) reanalysis in the southeastern United States" 19th AMS Conference on Applied Climatology, Asheville, NC. Jul 2011.

21. Stevens, S., B. Nelson, C. Langston, and R. Boyles. "National Mosaic and Multi-sensor QPE (NMQ/Q2) reanalysis in the Carolinas region and directions toward a ConUS-wide implementation" 2011 American Geophysical Union Fall Meeting, San Francisco, CA. Dec 2011.

22. Bell, J.E. (Poster Presentation). Air and soil temperatures for estimating growing season and growing degree days. NOAA/NESDIS Cooperative Research Program Symposium, Asheville, North Carolina. 18 August 2011.

23. Prat, O.P., and B.R. Nelson, 2011. Characterization of precipitation extremes at high spatial and temporal resolution in the Southeastern United States derived from long-term satellite and radar rainfall estimates. 2011 AGU fall meeting, December 5-9 2011, San Francisco, CA, USA.

24. Nelson, B.R., O.P. Prat, and E.H. Habib, 2011. Diurnal cycle of precipitation in the Southeast U.S. using high spatial and temporal resolution quantitative precipitation estimates and radar-reflectivity products derived from National Mosaic and Multi-sensor QPE (NMQ/Q2). 2011 AGU fall meeting, December 5-9 2011, San Francisco, CA, USA.

25. Wilson, A., J. Tao, K. Olson, A.P. Barros, O.P. Prat, and D. Miller, 2011. From fog to tropical cyclones: Challenges to comprehensive ground validation in the Southern Appalachians. 2011 NASA Precipitation Measurement Missions (PMM) science team meeting, November 7-10 2011, Denver, CO, USA.

26. Prat, O.P., and B.R. Nelson, 2011. Characterization of precipitation extremes for the continental United States derived from long-term satellite records. 2nd annual CICS science meeting, November 2-3 2011, Asheville, NC, USA.

27. Prat, O.P., and B.R. Nelson, 2011. Deriving precipitation features in the Southeastern United States from long-term remotely sensed data. 8th annual science symposium NOAA/NESDIS Cooperative Research Program (CoRP), August 17-18 2011, Asheville, NC, USA.

28. Prat, O.P., and B.R. Nelson, 2011. Characterization of precipitation features in the Southeastern United States using a multi-sensor approach – milestones for a long-

er-term assessment of climate change impacts. 19th AMS conference on applied climatology, July 18-20 2011, Asheville, NC, USA.

29. Prat, O.P., and B.R. Nelson, 2011. Yearly, seasonal, and diurnal precipitations trends in the Southeastern United States derived from long-term remotely sensed data and quantification of hydro-climatic extremes. 2011 EGU general assembly, April 4-8 2011, Vienna, Austria.

30. Schreck, C. J., 2011: The Madden–Julian Oscillation and Equatorial Waves in Upper Tropospheric Water Vapor. Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC, September 2011.

31. Schreck, C. J., 2011: Upper Tropospheric Water Vapor: A New Dataset for Monitoring the Madden–Julian Oscillation. NOAA's Climate Prediction Center, Camp Springs, MD, August 2011.

32. Schreck, C. J., J. Kossin, K. Knapp, and L. Shi, 2011: Continuing development of climate information records at NOAA's National Climatic Data Center. *World Climate Research Programme Open Science Conference*, 24–28 October 2011, Denver, CO.

33. Schreck, C. J., J. Kossin, and L. Shi, 2011: The Madden–Julian Oscillation and equatorial waves in upper tropospheric water vapor. *8th Annual Cooperative Research (CoRP) Science Symposium*, 17-18 August 2011, Asheville, NC.

34. Schreck, C. J., 2011: Best track continuity. *2nd IBTrACS Workshop*, 11-13 April 2011, Honolulu, HI.

35. Schreck, C. J., 2011: Best track data in synoptic studies: What is a tropical cyclone? *2nd IBTrACS Workshop*, 11-13 April 2011, Honolulu, HI.

36. Bell, J.E. and M.A. Palecki. USCRN soil temperature and moisture observations. American Meteorological Society. New Orleans. January 2012

37. Bell, J.E. US Climate Reference Network. NCSU Mountain Horticultural Crops Research and Extension Center. Mills River, North Carolina. 22 September 2011

38. Bell, J.E. US Climate Reference Network Overview and Soil Moisture/Temperature Monitoring. Soil Science Department. Raleigh, North Carolina. 25 August 2011

39. Bell, J.E. US Climate Reference Network: Soil Moisture/Temperature. NOAA/NESDIS Cooperative Research Program Symposium. Asheville, North Carolina. 18 August 2011

40. Leeper, R. D. (Oral Presentation) Precipitation Quality Assurance Methods for Weighting Bucket Precipitation Gauges Having Three Redundant Measurements. AMS Joint Conference on Climate Variations and Change and the Symposium on Meteorological Observations and Instrumentation. New Orleans, LA January, 2012.

41. Leeper, R. D (Oral Presentation) Role of Network Architecture in Surface-Based in-situ climate observations. AMS Conference on Applied Climatology. Asheville, NC 18th July 2011

42. Rennie, J.J. (2011), The International Surface Temperature Initiative: Global Land Surface Databank Development, CICS Science Meeting, National Climatic Data Center, Asheville, NC, 3 Nov 2011.

43. Thorne, P. W. An overview of the International Surface Temperature Initiative, NIST, MD, June 2011

44. Thorne, P. W. International Surface Temperature Initiative overview, WCRP Open Science Conference, Denver, 2011

45. Thorne, P. W. GCOS Reference Upper Air Network, at CICS/SAMSI workshop Jan 2012

46. Thorne, P. W., What is the GCOS Reference Upper Air Network?, CBS Expert Team meeting on regulatory materials, Geneva, Switzerland, Jan 2012.

47. Thorne, P. W. International surface temperature initiative overview, International Temperature Symposium 9 (ITS9), CA, March 2012 (invited plenary talk)

48. Thorne, P. W. GCOS Reference Upper Air Network: An introduction, ITS9, CA, March 2012

49. Voemel, H, Thorne P. W., GCOS Reference Upper Air Network: uncertainty estimation, ITS9, CA March 2012

50. Lawrimore, J., Thorne P., ISTI: Surface databank progress. ITS9, CA, March 2012

51. Presentation for NCDC's Thirsty Thursday Seminars: *How Do We Know the World is Warming?*

52. 2 presentations at the annual American Meteorological Society meeting.

53. Allen, T.R. Visualization and Decision-Support Tool Developments. NOAA-in-the Carolinas, Charleston, SC, March 15-16, 2012.

54. Scheduled to deliver NCDC center-wide overview of the National Climate Assessments activities

55. Farrell, S.L. (2011b), AOSC 401: Global Environment, Aspects of the Cryosphere: Sea Ice and Snow, Guest Lecture for Prof. Zhanqing Li, Dept. of Atmospheric and Oceanic Science, University of Maryland, College Park, MD, 1 April 2011.

56. Kunkel, K.E. (2012), Recent Weather in the United States: Are Extremes Becoming More Prevalent?, invited talk, Monsanto Corp., St. Louis, MO, 13 February, 2012.

57. Kunkel, K.E. (2012), Climate Change Impacts on Probable Maximum Precipitation, 2012 Annual Meeting of the American Meteorological Society, New Orleans, LA, 25 January, 2012.

58. Kunkel, K.E. (2012), Overview of previous work (SAP 3.3), and workshop challenge, invited talk, Forum on Trends in Extreme Winds, Waves, and Extratropical Storms along the Coasts, Asheville, NC, 11 January, 2012

59. Kunkel, K.E. (2011), Observed Trends in Temperature and Precipitation Extremes, invited talk, 2011 Fall AGU Meeting, San Francisco, CA, 6 December, 2011.

60. Kunkel, K.E. (2011), Climate Change Impacts on Probable Maximum Precipitation, invited talk, 2011 Fall AGU Meeting, San Francisco, CA, 5 December, 2011.

61. Kunkel, K.E. (2011), Climate Scenarios Update, invited talk, meeting of the National Climate Assessment Development and Advisory Committee, Boulder, CO, 15 November, 2011.

62. Kunkel, K.E. (2011), Northeast Regional Climatology and Outlook, invited talk, Northeast Regional Assessment Workshop, New York City, NY, 17 November, 2011.

63. Kunkel, K.E. (2011), Temperature Extremes, invited talk, Workshop: Trends and Causes of Observed Changes in Heat and Cold Waves as well as Drought, Asheville, NC, 8 November, 2011.

64. Kunkel, K.E. (2011), Past Assessment, invited talk, Workshop: Trends and Causes of Observed Changes in Heat and Cold Waves as well as Drought, Asheville, NC, 8 November, 2011.

65. Kunkel, K.E. (2011), Meteorological Causes of Extreme Precipitation Trends in the U.S., World Climate Research Programme Open Science Conference, Denver, CO, 24 October, 2011.

66. Kunkel, K.E. (2011), Extreme Precipitation, NCDC Seminar, Asheville, 17 October, 2011.

67. Kunkel, K.E. (2011), Extreme Precipitation, invited talk, NOAA Climate Board, Washington, DC, 14 October, 2011.

68. Kunkel, K.E. (2011), Southeast Regional Outlook, invited talk, Southeast Regional Assessment Workshop, Atlanta, GA, 26 September, 2011.

69. Kunkel, K.E. (2011), Southwest Regional Climatology and Outlook, invited talk, Southwest Regional Assessment Workshop, Boulder, CO, 1 August, 2011.

70. Kunkel, K.E. (2011), Workshop Challenge and Background, Workshop on Monitoring Changes in Extreme Storms Statistics: State of Knowledge, Asheville, NC, 25 July, 2011.

71. Kunkel, K.E. (2011), Precipitation Extremes-Mechanistic Perspective, Workshop on Monitoring Changes in Extreme Storms Statistics: State of Knowledge, Asheville, NC, 25 July, 2011.

72. Kunkel, K.E. (2011), State Climatologist Contributions to the National Climate Assessment, invited talk, Annual Meeting of the American Association of State Climatologists, Asheville, NC, 21 July, 2011.

73. Kunkel, K.E. (2011), Potential Impacts of Climate Changes on Estimates of Probable Maximum Precipitation, Practical Solutions for a Warming World: *AMS Conference* on Climate Adaptation, Asheville, NC, 19 July, 2011.

74. Kunkel, K.E. (2011), "Trends in Extreme Snowfall Seasons", invited talk, NOAA/FEMA Snow Workshop, Estes Park, CO, May 26, 2011.

75. Kunkel, K.E. (2011), National Climate Assessment and NARCCAP, invited talk, NARCCAP Users Workshop, Boulder, CO, 7 April, 2011.

76. Kunkel, K.E. (2011), Development of Regional Climate Information for the National Climate Assessment, invited talk, inaugural meeting of the National Climate Assessment Development and Advisory Committee, Washington, DC, 5 April, 2011.

77. "20th Century Trends in Northern Hemisphere Extratropical Cyclone Occurrence", World Climate Research Programme Open Science Conference, Denver, CO, October 2011.

78. Stevens, L. and K. Kunkel (2012), Climate Trends and Outlooks for the United States, Plenary talk at the NCA Technical Workshop on Rural Communities, Charleston, SC, 13 February 2012.

79. Stevens, L., K. Kunkel, and S. Stevens (2011), Analysis of CMIP3 Daily Statistically-Downscaled Data, Presentation at the CICS Science Meeting 2011, Asheville, NC, 2 November 2011.

80. Dissen, J. (2012), Advancing Climate Literacy, Presentation at the Climate Prediction Applications Science Workshop 2012, Miami, FL, 16-18 Miami 2012.

81. Dissen, J. (2012), CICS-NC and Approach Towards Climate Literacy and Climate Adaptation, Presentation for Asheville-Buncombe County Economic Development Coalition/Asheville Area Chamber of Commerce and the Caldwell Community College and Technical Institute International Brazil Visit, Asheville, NC, 29 January 2012.

82. Dissen, J., T. Houston, and K. Vincent. (2011), Investigating Methods for Advancing Climate Literacy for Private Sector. Poster presented at AMS 92 Annual Meeting, New Orleans, LA, 22-26 January 2012.

83. Dissen, J., O. Brown and M. McGuirk. (2011), An Approach Towards Literacy and Climate Adaptation, Presentation at the CICS Science Meeting 2011, Asheville, NC, 2 November 2011.

84. Dissen, J. (2011), Climate Change: Impacts to Opportunities, Presentation at the NCSU ORI Forum on Entrepreneurial Opportunities Associated with Climate Change Informatics, Raleigh, NC, 18 August, 2011.

85. George Briggs the Keynote Address, which included emphasis on the APGA/NOAA agreement and the need for the green industry to engage with climate issues, at the Central Kentucky Ornamental and Turfgrass Conference on 9 February 2012.

86. "North Carolina School Closings in the Winter of 2010-2011: Decision-makers and Decision-making." Burrell Montz with Ken Galluppi, Jessica Losego, Kelsey Mulder and Catherine Smith. Annual Meeting of the Southeast Division of the Association of American Geographers, November 2011. Savannah, GA.

87. "WxEM – Weather for Emergency Management: Briefing to NWS Corporate Board." Ken Galluppi, Jessica Losego, and Burrell Montz. National Weather Service Corporate Board Meeting, December 2011.

88. "Weather for Emergency Management: Implications for NWS Tropical Weather Products and Services." Jessica Losego, Ken Galluppi, Burrell Montz, Catherine

Smith, and Steve Schotz. American Meteorological Society, January 2012. New Orleans, LA.

89. "Weather Service and Emergency Management Collaboration Through An Interactive Web-Based Map Conferencing Infrastructure." Ken Galluppi, Jeff Heard, Jessica Losego, Burrell Montz, Catherine Smith, and Steve Schotz. American Meteorological Society, January 2012. New Orleans, LA.

90. "Needs and Use of Tropical Weather Information by the Emergency Management Community in North Carolina." Burrell Montz, Ken Galluppi, Jessica Losego, Catherine Smith, Darin Figurskey, and Richard Bandy. American Meteorological Society, January 2012. New Orleans, LA.

91. "Making Decisions when a Hurricane Threatens: Product Preferences for Emergency Management in North Carolina" Kelsey Mulder, Burrell Montz, Jessica Losego, and Ken Galluppi. Association of American Geographers Annual Meeting, February 2012. New York, NY

92. "Community Sense-Making for Coordinated Action: How Do Emergency Managers use the Cone of Uncertainty?" Catherine F. Smith with Jessica Losego, Ken Galluppi, and Burrell Montz. Symposium on Usability, Information Design, and Information Interaction to Communicate Complex Information, January, 2012. Seattle, WA

93. "Weather for Emergency Management: How to Bridge the Gap." Burrell Montz with Ken Galluppi, and Jessica Losego. National Hurricane Conference, March, 2012. Orlando, FL

94. "North Carolina School Closings in the Winter of 2010-2011: Decision-makers and Decision-making." Burrell Montz with Ken Galluppi, Jessica Losego, Kelsey Mulder and Catherine Smith. Annual Meeting of the Southeast Division of the Association of American Geographers, November 2011. Savannah, GA.

95. "WxEM – Weather for Emergency Management: Briefing to NWS Corporate Board." Ken Galluppi, Jessica Losego, and Burrell Montz. National Weather Service Corporate Board Meeting, December 2011.

96. "Weather for Emergency Management: Implications for NWS Tropical Weather Products and Services." Jessica Losego, Ken Galluppi, Burrell Montz, Catherine Smith, and Steve Schotz. American Meteorological Society, January 2012. New Orleans, LA.

97. "Weather Service and Emergency Management Collaboration Through An Interactive Web-Based Map Conferencing Infrastructure." Ken Galluppi, Jeff Heard,

Jessica Losego, Burrell Montz, Catherine Smith, and Steve Schotz. American Meteorological Society, January 2012. New Orleans, LA.

98. "Needs and Use of Tropical Weather Information by the Emergency Management Community in North Carolina." Burrell Montz, Ken Galluppi, Jessica Losego, Catherine Smith, Darin Figurskey, and Richard Bandy. American Meteorological Society, January 2012. New Orleans, LA.

99. "Making Decisions when a Hurricane Threatens: Product Preferences for Emergency Management in North Carolina" Kelsey Mulder, Burrell Montz, Jessica Losego, and Ken Galluppi. Association of American Geographers Annual Meeting, February 2012. New York, NY

100. "Community Sense-Making for Coordinated Action: How Do Emergency Managers use the Cone of Uncertainty?" Catherine F. Smith with Jessica Losego, Ken Galluppi, and Burrell Montz. Symposium on Usability, Information Design, and Information Interaction to Communicate Complex Information, January, 2012. Seattle, WA

101. "Weather for Emergency Management: How to Bridge the Gap." Burrell Montz with Ken Galluppi, and Jessica Losego. National Hurricane Conference, March, 2012. Orlando, FL

102. Yuter, S. E., D. Kingsmill, C. White, M. Wilbanks, N. Hardin, and J. Cunningham, 2011: The spatial distribution of precipitation frequency for atmospheric river storms in Northern California. *Abstracts, AGU Fall Meeting*, Dec 2011.

CICS-NC Non-peer Reviewed Publications: 12

1. Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, and K.T. Redmond (in review) Climate of the Northwest U.S., prepared for the National Climate Assessment Development and Advisory Committee.

2. Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, and K.T. Redmond (in review) Climate of the Southwest U.S., prepared for the National Climate Assessment Development and Advisory Committee.

3. Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, C.E. Konrad II, C.M. Fuhrmann, B.D. Keim, M.C. Kruk, A. Billot, H. Needham, and M. Shafer (in review) Climate of the Southeast U.S., prepared for the National Climate Assessment Development and Advisory Committee.

4. Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, S. Hilberg, M. Timlin, L. Stoecker, and N. Westcott (in review) Climate of the Midwest U.S., prepared for the National Climate Assessment Development and Advisory Committee.

5. Kunkel, K.E., L. Stevens, S.E. Stevens, M.C. Kruk, D.P. Thomas, E. Janssen, K.G. Hubbard, M.D. Shulski, N.A. Umphlett, K. Robbins, L. Romolo, A. Akyuz, T.B. Pathak, and T.R. Bergantino (in review) Climate of the U.S. Great Plains, prepared for the National Climate Assessment Development and Advisory Committee.

6. Kunkel, K.E., L. Stevens, S.E. Stevens, and E. Janssen (in review) Climate of the Contiguous United States, prepared for the National Climate Assessment Development and Advisory Committee.

7. Kunkel, K.E., L. Stevens, S.E. Stevens, E. Janssen, J. Rennells and A. DeGaetano (in review) Climate of the Northeast U.S., prepared for the National Climate Assessment Development and Advisory Committee.

8. Stewart, B.C., and J.E. Walsh, K.E. Kunkel, and L.E. Stevens (in review) Climate of Alaska, prepared for the National Climate Assessment Development and Advisory Committee.

9. Victoria W. Keener, V.W. and K. Hamilton, and S.K. Izuka, K.E. Kunkel, K.E., and L. Stevens (in review) Climate of the Pacific Islands, prepared for the National Climate Assessment Development and Advisory Committee.

10. Anand Inamdar, and Ken Knapp, 2012: Assessment of Calibration Performance of the Geostationary Satellite Image Visible Channel in the ISCCP B1 Data, Proceedings of the 92nd annual meeting of the American Meteorological Society, New Orleans, Jan 22-26, 2012.

11. Bell J.E., B. Baker, H. Diamond, M. Hall, J. Kochendorfer, J Lawrimore, R.D. Leeper, T Meyers, M.A. Palecki, and T Wilson. US Climate Reference Network: recently added soil observations. *In preparation*

12. Prat, O.P., B.R. Nelson, and S.E. Stevens, 2012: Characterization of precipitation features in the Southeastern United States using high spatial and temporal resolution quantitative precipitation estimates derived from the National Mosaic and Multi-sensor QPE (NMQ/Q2). *J. Hydrometeorol*. In preparation.

CUNY Presentations: 13

1. Romanov P. , H. Xu NDVI product for GOES-R ABI: Current Status. 2011 NOAA STAR GOES-R AWG Review. Fort Collins, CO 14-16 June 2011.

2. Romanov P. , Y. Tian GVF product for GOES-R ABI: Current Status. 2011 NOAA STARGOES-R AWG Review. Fort Collins, CO, 14-16 June 2011.

3. Romanov P. , C. Kongoli Snow Depth product for GOES-R ABI. 2011 NOAA STAR GOES-R AWG Review Fort Collins, CO, 14-16 June 2011.

4. Romanov P. , I. Appel (2011) Validating Snow cover Product from NPP VIIRS. IGARSS 2011, Vancouver, Canada.

5. Gladkova, M. Grossberg, G. Bonev, P. Romanov, Seasonal snow cover of Yellowstone estimated with restored MODIS Aqua, and MODIS Terra snow cover maps, AGU Chapman Conference on Remote Sensing of the Terrestrial Water Cycle in Kona, Hawaii

6. Mahani, S.E., B. Vant-Hull, R. Khanbilvardi, and R. Rabin; "*Convective Cloud Towers and Precipitation Initiation, Frequency and Intensity"*; Annual AGU Fall Meeting; San Francisco/CA; Dec. 5-9, 2011.

7. Mahani, S. E.; *"Cloud-top Relief Spatial Adjustment of GOES-R Images"*; Annual GOES-R3 review meeting by NASA/NOAA; Huntsville/AL; Sep. 21-23. 2011.

8. Mahani, S., K. Tesfagiorgis, R. Khanbilvardi, and D. Kitzmiller; *"Multi-Sources Precipitation Estimation: Mitigating Gaps over Radar Network Coverage"*; Annual IEEE International Geosciences & Remote Sensing Society American Geographical Union (IGARSS); Vancouver/Canada, July 24-29. 2011.

9. Autones, Frederic, 2011: An overview of Meteo France Nowcasting Tools and Products. NOAA-CREST, City College of New York, New York, Nov 17, 2011.

10. J. He, A. Picon, L. Cordero, B. Madhavan, B. Gross, F. Moshary, S. Ahmed , "Potential Difficulties for GOES-R to Extract Aerosol Optical Depth and Surface PM2.5 in An Urban Environment", Eighth Annual Symposium on Future Operational Environmental Satellite Systems, AMS Annual Meeting Jan 2012.

11. Lakhankar T., Munoz J., Romanov P., and R. Khanbilvardi (2012) NOAA-CREST Field Experiment: Remote Sensing of Snow Properties Using Microwave Radiometry, presented at 26th Conference on Hydrology, 92nd American Meteorological Society Annual Meeting, January 22-26, 2012.

12. Munoz J., Lakhankar T., Romanov P., and R. Khanbilvardi (2011) Estimation of surface snowpack properties using multi-frequency microwave remote sensing data, presented at Eastern Snow Conference Meeting, hosted by McGill University, Montreal, Canada

13. Vant-Hull, Brian: "Lessons from Weather Camp", National Science Teachers' Association Annual Meeting, Hartford, CN, October 28, 2011.

Other Consortium Members' Presentations: 6

1. Demoz, et al. (2012): The Howard University Beltsville GRUAN site Update. Presented at the 4th GRUAN Implementation-Coordination Meeting (ICM-4); Tokyo, Japan. 4-9 March 2012. See www.gruan.org

2. Bruning, E. C., 2011b: Lightning flash size spectra: Observations and theory. *Eos Trans. AGU, Fall Meet. Suppl.*, AE31A-0266.

3. Schultz, C. J., E. C. Bruning, L. D. Carey, W. A. Petersen, and S. Heckman, 2011c: Total lightning within electrified snowfall using LMA, NLDN and WTLN measurements. *Eos Trans. AGU, Fall Meet. Suppl.*, AE12A-03.

4. Schultz, C. J., W. A. Petersen, L. D. Carey, and E. C. Bruning, 2011b: C-band dual-polarimetric observations of snowfall in a southeastern thundersnow event. *Preprints, 35th Conference on Radar Meteorology, Pittsburgh, PA, USA*, American Meteorological Society, Paper 209.

5. MacGorman, D. R., et al., 2011: Lightning and electrical structure of severe storms. *Intl. Conf. Atmos. Elec., Rio de Janeiro, Brazil*.

6. Bruning, E. C., 2011a: West Texas LMA: Deployment and operations update. *GOES-R Geostationary Lightning Mapper Science Meeting*, Huntsville, AL.