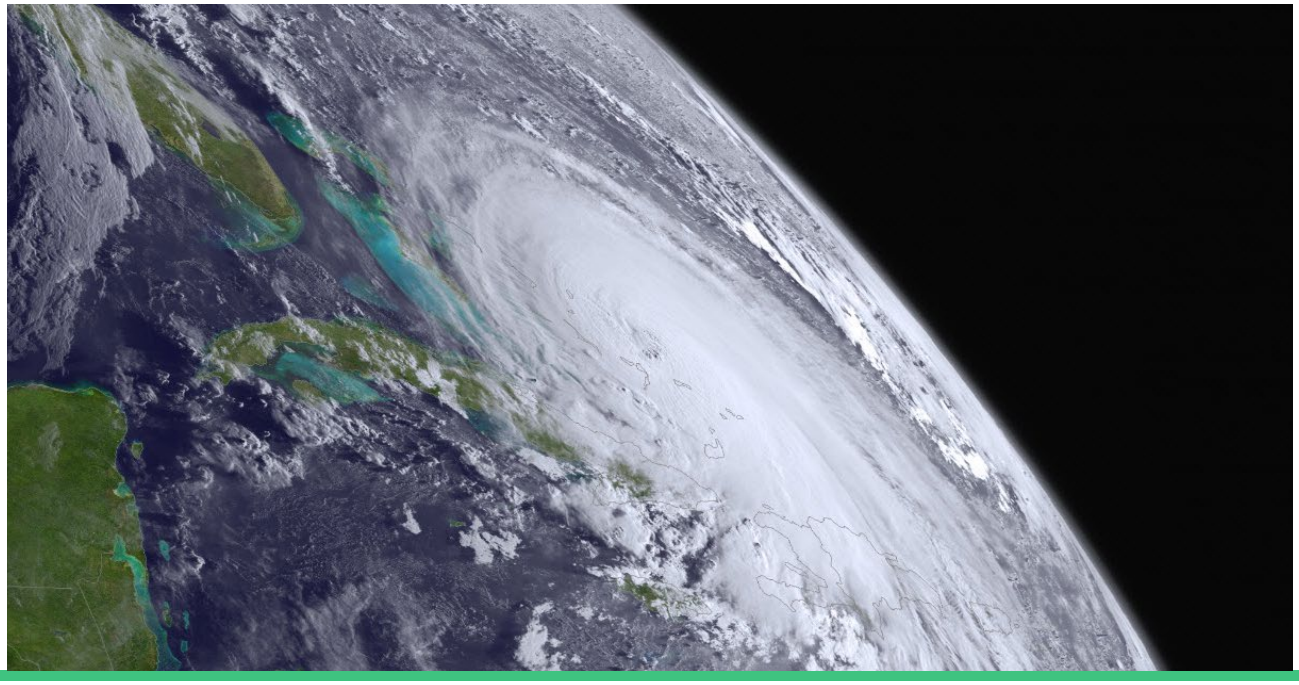

ANNUAL REPORT 2017

Ames Research Center: Cooperative Research in Earth Science and Technology

ARC-CREST

Bay Area Environmental Research Institute

www.baeri.org

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LETTER FROM **THE DIRECTOR**

I am pleased to present the annual report for the Ames Research Center Cooperative for Research in Earth Science and Technology (ARC-CREST). NASA awarded the ARC-CREST cooperative agreement to the Bay Area Environmental Research Institute (BAERI), the California State University at Monterey Bay (CSUMB) and the National Suborbital Education and Research Center at the University of North Dakota (NSERC/UND) in 2012. This report covers the performance period March 1, 2017 to February 28, 2018.

During the period of performance, ARC-CREST staff from the partner institutions worked side by side with their collaborators at NASA Ames Research Center on 37 separate Earth Science research, research support, and education or outreach projects. This report summarizes their accomplishments during that time. Through their hard work and commitment, the ARC-CREST team made many significant achievements to support NASA's Earth Science mission goals. In 2017, ARC-CREST researchers,engineers, staff, and students contributed to the success of over 10 airborne field campaigns, gave presentations to the White House Office and Science and Technology Policy and U.S. Global Change Research Program, conducted three large scale student outreach and education programs, were featured in the award-winning documentary Years of Living Dangerously, and provided key research to California officials dealing with the drought, to name just a few accomplishments.

Congratulations and thank you to the ARC-CREST team and our NASA partners for another great year in this exciting partnership!

Dr. Robert Bergstrom
Director

TABLE OF **CONTENTS**

Introduction 5

ARC-CREST Partners 7

ARC-CREST Staff 8

Earth Science Focus Areas

- Aerosol Modeling 10
- Agriculture, Health, and Marine Applied Sciences 12
- Alpha Jet Atmospheric Experiment (AJAX) 15
- Carbon Monitoring Systems (CMS) 17
- Coastal Ocean Biology 20
- Earth System Data Records (ESDR) 22
- 4STAR and Satellite Data Analysis 23
- Ground, Air, and Spaceborne Aerosol Typing 27
- Making Earth System Data Records for Use in Research Environments (MEaSUREs) 29
- NASA Earth Exchange (NEX) 31
- ORACLES Radiative Transfer ALgorithm Development 35
- Orbiting Carbon Observatory-2 Errors/Profiles (OCO-2 E/ OCO-2 P) 37
- Plant Physiology 38
- Pointing Schedules of Agile Aircraft 39
- Sentinel-2 40
- Total Carbon Column Observing Network (TCCON) 43
- Tropospheric Emission Spectrometer (TES) 44

TABLE OF **CONTENTS**

Earth Science Applied Sciences Program
- Disaster Management 46
- Ecological Forecasting 50
- Geostationary Coastal and Air Pollution Events Mission (GEO-CAPE) 51
- Indigenous Knowledge 52
- Water Resources Program 53

Heliophysics 55

Synthetic Biology 58

Airborne Science and Mission Support
- Airborne Science Support 61
- Airborne Science Advanced Planning 62
- Aircraft Remote Sensing 63
- Earth Science Project Office (ESPO) 64
- Meteorological Measurement Systems (MMS) 67
- Meteorological Support 69
- National Suborbital Education Research Center (NSRC) Mission Operations 71

Education and Outreach Activity
- Applied Remote Sensing Training (ARSET) 75
- CSUMB Educational Program 76
- DEVELOP 78
- Student Airborne Research Program (SARP) 79

Publications and Presentations 80

Glossary 87

INTRODUCTION

The Cooperative Agreement creating the Ames Research Center Cooperative for Research in Earth Science and Technology ("ARC-CREST") provides on page 16 (Required Publications and Reports) that a progress report is due annually, 60 days prior to the anniversary date of the grant/cooperative agreement. Accordingly, we present the following progress report for the sixth year of this Cooperative Agreement.

The primary task of ARC-CREST is to work cooperatively with NASA Ames Research Center's Earth Science Division and related groups to achieve NASA's strategic Earth Science objectives. These objectives include: (1) the conduct of research into fundamental questions related to the atmosphere, the oceans, the biosphere, and Earth's land masses; (2) the use of informational and computational sciences to visualize, analyze, and interpret Earth Science data; (3) the application of technology necessary for Earth Science research; and (4) the provision of outreach and education to the general public regarding Earth Science. In the sixth year of the ARC-CREST cooperative agreement, the current participants, Bay Area Environmental Research Institute ("BAERI") and California State University Monterey Bay ("CSUMB") worked to achieve each of these objectives.

The ARC-CREST scientific team, working closely with the Ames Earth Science Division, participated in over 36 different project areas covering the gamut of Earth Science research. One important theme was the measurement of atmospheric carbon dioxide, first by using the data from the Tropospheric Emission Spectrometer (TES), which is an infrared spectrometer flying aboard the Aura satellite and the Orbiting Carbon Observatory-2 (OCO-2). Closer to home, the Alpha Jet Atmospheric eXperiment (AJAX) continued flights over California and Nevada, measuring carbon dioxide and methane over multiple seasons to complement other data collection efforts. Other atmospheric carbon dioxide projects included the Earth Science Data Records (ESDR) project, and the Total Carbon Column Observing Network (TCCON) project.

ARC-CREST scientists also used NASA resources to study tropospheric ozone production, coastal ocean biology, space weather, solar physics, plant physiology, and synthetic biology. They also continued to develop and use cutting edge technology to advance Earth Science. The NASA Earth Exchange (NEX) project used NASA's supercomputing capability and different data layers (e.g. Landsat, PALSAR and NAIP 1-m) to generate space-derived metrics like forest/non-forest maps, canopy height and forest aboveground biomass across the continental U.S.

ARC-CREST scientists also worked with NASA to use data collected for Earth Science Research on a range of projects that have practical applications. For example, through the Ecological Forecasting project, there were important accomplishments in agricultural productivity, water management, earthquake response, and many other important areas. Our scientists also continued to adapt NASA unmanned aerial vehicles (UAVs) for use in fighting forest fires.

The ARC-CREST partners also provided support to critical Earth Science activities at NASA Ames Research Center, including the Earth Science Project Office; the Applied Sciences Program's Water Resources Program; the Meteorological Measurement System; and the Airborne Science Program (including payload integration engineering, data display and networking, and facility instrumentation for NASA's fleet of research aircraft). Development of NASA's capabilities in using Unmanned Aerial Vehicles for Earth Science projects continued to be a particular focus.

INTRODUCTION

Finally, through the Student Airborne Research Program (SARP) and the Digital Earth Virtual Environment and Learning Outreach Project (DEVELOP), ARC-CREST participants worked with the NASA Ames Research Center to provide extensive educational and public outreach opportunities related to Earth Science.

For more information please contact Dr. Robert Bergstrom, ARC-CREST Director (bergstrom@baeri.org), or Mark Sittloh, ARC-CREST Business Manager (msittloh@baeri.org).

ARC-CREST **PARTNERS**

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2. California State University at Monterey Bay
3. NASA Ames Research Center – Earth Sciences Division

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Votava, Petr
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Wang, Weile
Weinstock, Kenneth
Windell, Sean
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Bui, Thaopaul
Chin, Mian
Chirayath, Ved
Dungan, Jennifer
Fladeland, Matt
Flynn, Michael
Gentry, Diana
Gore, Warren
Guild, Liane
Hathaway, David
Hines, Kimberly
Iraci, Laura
Jensen, Eric
Johnson, Matthew
Kalmanje, Krishna
Kaye, Jack
Knobelspiesse, Kirk
Luna, Bernadette
Mansour, Nagi
Mehrotra, Piyush
Natraj, Vijay
Nemani, Ramakrishna
Pfister, Leonhard
Pierce, Brad
Podolske, Jim
Potter, Chris
Prados, Ana
Redemann, Jens
Rios, Joey
Shetye, Sandeep
Sullivan, Don
Vasques, Marilyn
Worden, John
Yu, Hongbin

EARTH SCIENCE FOCUS AREAS

Aerosol Modeling

NASA: Mian Chin, Hongbin Yu
BAERI: : Qian Tan

Atmospheric aerosols are a major air pollutant, and they can affect the climate in many ways. In 2017, our study of aerosols focused on two aspects:

First, the distribution of aerosols in the upper troposphere and lower stratosphere (UTLS). Once at UTLS, aerosols will have prolonged climatic impacts. They can come from both volcanic eruption and anthropogenic emissions. The quantification of those sources still has large uncertainty, as suggested by our analysis of the vertical profiles of aerosols and their precursors in the multi-model comparison.

Second, we analyzed the correlation between surface aerosol concentrations, PM2.5, and aerosol optical depth (AOD) on a fine temporal scale over polluted urban areas. PM2.5 is a primary air pollutant that affects public health. Currently, it is monitored at some ground stations by EPA. Column integrated AOD can be observed by satellite with global and continuous temporal coverage. Inferring surface PM2.5 from the AOD therefore has great potential to extend PM2.5 monitoring beyond the few ground stations and on a much broader spatial and temporal scale. Dr. Chin leads a working group studying this topic for a proposed geostationary satellite. We found that in urban areas, the PM2.5 vs. AOD correlation shows large variation from diurnal to seasonal and inter-annual scales.

.

Publications and Presentations

Rajapakshe, C., Z. Zhang, JE Yorks, H. Yu, Q. Tan, K Meyer, S. Platnick, D. Winker, Seasonally Transported Aerosol Layers over Southeast Atlantic are Closer to Underlying Clouds than Previously Reported, Geophysical Research Letters, 2017.

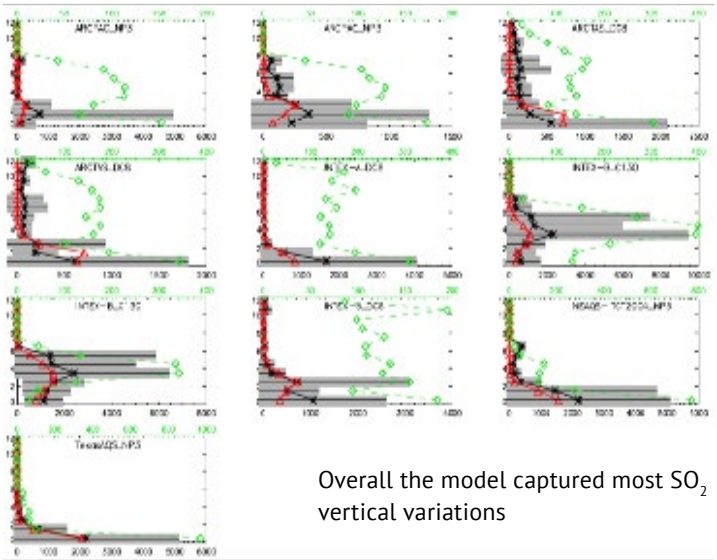
Tan, Q., M. Chin, V. Aquila, A. Rollins, M. Hoepfner, R. Gao, Vertical distribution of sulfur species (SO_2+Sulfate) seen in AEROCOM Models, POSIDON Science Meeting, Boulder, CO, June 2017

Tan, Q., M. Chin, V. Aquila, A. Rollins, M. Hoepfner, R. Gao, Diversity of vertical distribution of sulfur species (SO_2+Sulfate) in AEROCOM Models, AEROCOM Science Meeting, October 2017

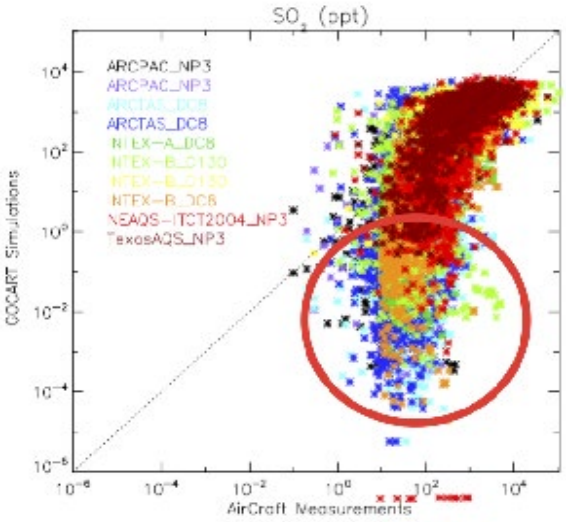
Tan, Q., M. Chin, H. Yu, A. G. Xia, PM2.5 variation related to AOD and meteorological conditions on diurnal scale in Beijing, China, AGU Fall Meeting, Dec 2017.

2017 Accomplishments

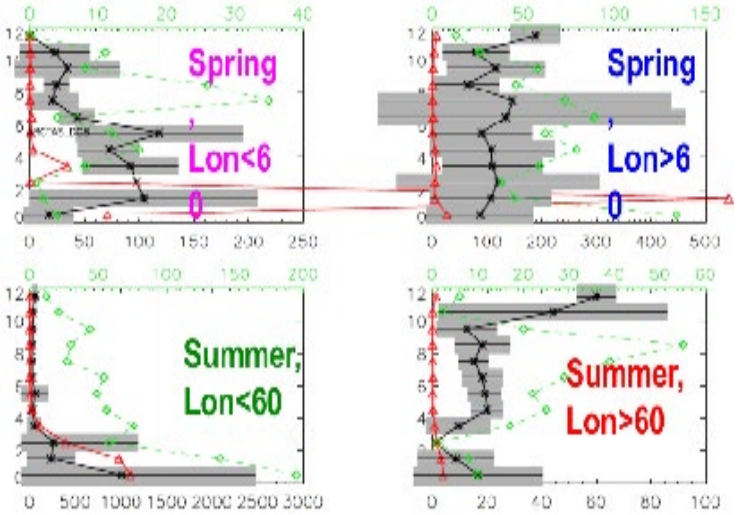
- Compared simulated sulfate aerosols and SO2 by Compared available aircraft observations and satellite retrievals of simulated sulfate aerosols and SO2 by models from the Aerosols Modeling Inter-Comparison project (AEROCOM);
- Compared vertical distribution of aerosols and tracked their transport from two space-borne LIDARs; and
- Analyzed the PM2.5 and AOD data in several paired sites in both the United States and China on fine temporal scales.



Overall the model captured most SO_2 vertical variations

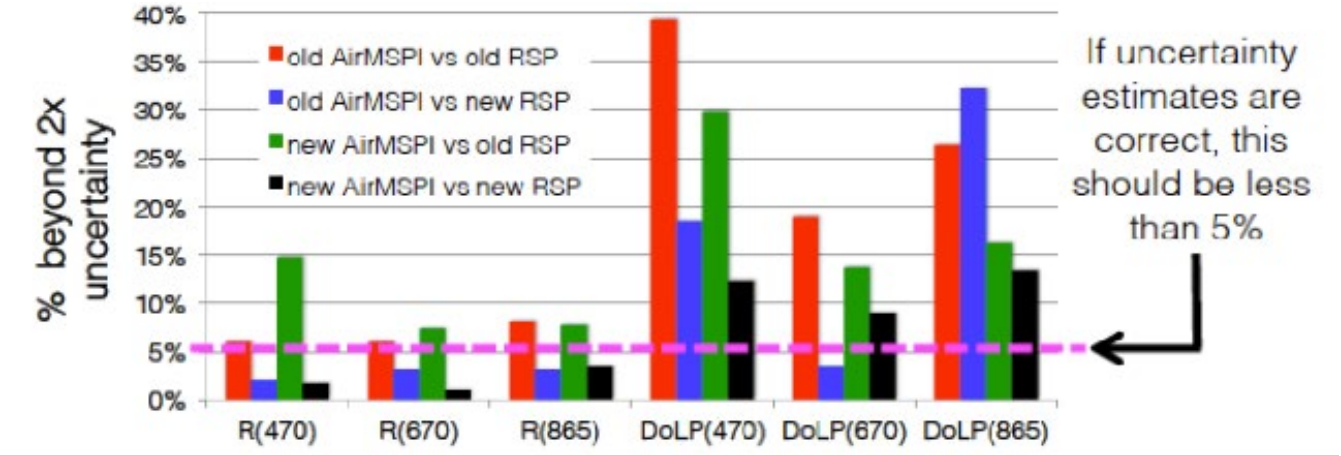


Low [SO_2]: instrument detection limit vs. small numerical value in model



Model underestimated SO_2 in high latitude in spring time.

Figure 1: Evaluation if modeled SO_2 vertical distributions



Agriculture, Health, and Marine Applied Sciences

NASA: Rama Nemani, Jennifer Dungan
CSUMB: Forrest Melton, Lee Johnson, Alberto Guzman, Jason Dexter, Carolyn Rosevelt, Isabel Zaragosa, Michael Hang, Kirk Post, Andrew Michaelis, Dan Muratore, Tian Xian Wang, Josue Duque, Kali Prescott, Elizabeth Patron

CSUMB personnel have a long history of participation and support of NASA research and applied science missions to apply satellite data to improve our understanding of environmental conditions and ecological processes that affect agriculture, public health and vector-borne disease, and coral reefs and other marine ecosystems. Under this task, CSUMB conducts research and applied science activities in these areas in collaboration with the Ames Earth Science Division (AESD) and numerous collaborators in government agencies, non-profits and NGOs, and the commercial sector. This task applies remote sensing data, ecological and weather models, agricultural models, and epidemiologic, vector, and pathogen models to advance the ability of U.S. and international institutions to understand and manage these processes. Activities under this task include analysis satellite data, management of airborne and field campaigns to collect data, and development of models and decision support systems.

The primary objectives of this task are to:

1) Apply satellite data, airborne data, and surface sensor networks to model and map agricultural productivity and crop water demand;

2) Apply satellite data, climate models, and ecological models to map habitat for disease vectors and model vector-borne disease transmission risk; and

3) Apply satellite multispectral and airborne hyperspectral data coupled with field measurements of biological data, to contribute to research on ecosystem health, ecological structure, and benthic habitat biodiversity of coral reefs and associated biotopes (seagrass).

2017 Accomplishments

• Mentor five CSUMB School of Natural Sciences (SNS) students who worked with the Satellite Irrigation Management Support (SIMS) and Fallowed Area Mapping projects in 2017 (Dan Muratore, Tian Xian Wang, Josue Duque, Kali Prescott, Elizabeth Patron). Additional research internships will be offered in 2018;

• Continued development of the SIMS data processing system on the NASA Earth Exchange (NEX), including prototype web and mobile interfaces (http://ecocast.arc.nasa.gov/sims). Delivered data during 2017 to partner with growers for evaluation and to support improvements in water use efficiency and irrigation optimization;

• Presented research results and shared data with the California Department of Water Resources (CDWR), partner growers, and at multiple industry and professional conferences;

• Received approval from CDWR for transition of SIMS to sustained operations at CDWR.

• Continued to work on transfer of the SIMS framework to Google Earth Engine and Amazon AWS for sustained operation by CDWR;

• Delivered data on land fallowing monthly from April - October to the CDWR and the California Department of Food and Agriculture (CDFA).

• Continued work on transition of the Fallowed Area Mapping algorithms to Google Earth Engine and development of training materials for CDWR.

• Initiated work to expand the Fallowed Area Mapping algorithms to Washington State and Nevada in partnership with the Washington State Depart of Agriculture and the Nevada State Engineer's Office;

• Continued field trials and research to quantify the value of SIMS and ET-based irrigation scheduling.

• Deployed and maintained instrumentation on three commercial farms in partnership with growers in the Salinas Valley.

• Collaborated with partner growers on data analysis and currently preparing manuscripts for publication. Results to date further confirm the value of SIMS for reducing applied water by 20-40% relative to standard practice, and also demonstrate the ability to reduce nitrate leaching by 50-75% or more;

• Collaborated with UC Davis and CA DWR on an comparison study of evapotranspiration models for the CA Delta. Initial report published and final report currently being prepared for publication;

• Initiated work on the OpenET project, a new ROSES supported project on evapotranspiration (ET) mapping in the western US in collaboration with DRI. Project Co-PI Johnson and Sr. Software Engineer Guzman are working with DRI on an effort to leverage SIMS and METRIC to map ET across four critically impacted basins spanning 6 western states. Johnson and Guzman worked with DRI to organize a training for water resource managers from six western states in October at DRI; and

• Secured additional funding related to this task, which was available only to non-federal, California institutions. Proposals led by Melton and Johnson were awarded from the CSU Agricultural Research Institute, CA DWR, and CDFA resulting in additional funding for the task

Publications and Presentations

JOURNAL ARTICLES:

Fisher, J.B., Melton, F.S., Middleton, E., Hain, C., Anderson, M., Allen, R., McCabe, M., Hook, S., et al., 2017. The future of evapotranspiration: Global requirements for ecosystem functioning, carbon and climate feedbacks, agricultural management, and water resources. Water Resources Research, 53(4), pp. 2618-2626.

Cahn, M.D. and Johnson, L.F., 2017. New approaches to irrigation scheduling of vegetables. Horticulturae, 3(2), pp. 28-47, doi:10.3390/horticulturae3020028.

Sun, L., Gao, Melton, F., K. Post et al (14 authors total). 2017. Daily Mapping of 30 m LAI and NDVI for Grape Yield Prediction in California Vineyards. Remote Sensing, 9(4), p.317.

Zhang, J., Campana, P.E., Yao, T., Zhang, Y., Lundblad, A., Melton, F. and Yan, J., 2017. The water-food-energy nexus optimization approach to combat agricultural drought: a case study in the United States. Applied Energy (in press).

PRESENTATIONS

Melton, F., L. Johnson, K. Post, A. Guzman, R. Spellenberg, I. Zaragoza, C. Rosevelt, A. Michaelis, R. Nemani, M. Cahn, K. Frame, B. Temesgen, S. Eching, 2016. Integrating Satellite and Surface Sensor Networks for Irrigation Management Decision Support in California. American Geophysical Union Fall Meeting, San Francisco, CA, Dec 12-16, 2016.

Johnson, L., M. Cahn, C. Rosevelt, A. Guzman, F. Melton, et al., 2016. Satellite estimation of fractional cover in California specialty crops. American Geophysical Union Fall Meeting, San Francisco, CA, Dec 12-16, 2016.

Donnelly, M., M. Marcontonio, F. Melton, and C. Barker, 2016. Mapping past, present, and future climatic suitability for invasive Aedes aegypti and Aedes albopictus in the United States: a process-based modeling approach using CMIP5 downscaled climate scenarios. American Geophysical Union Fall Meeting, San Francisco, CA, Dec 12-16, 2016.

Melton, F. et al., Advances in Mapping Evapotranspiration with Satellite Data, 2017. National Academy of Sciences, Fifth Arab American Frontiers Symposium, Rabat, Morocco, November 3, 2017 (National Academy of Sciences invited lecture).

Melton, F., L. Johnson, A. Guzman, C. Rosevelt, I. Zaragoza, J. Dexter, et al., 2017. Satellite Irrigation Management Support (SIMS): Integrating Satellite and Surface Sensor Networks for ET Mapping & Irrigation Management Decision Support in California. NASA ASP Water Resources Science Team Meeting, Pasadena, CA, July 18-19, 2017.

Melton, F., Haffa A., Aqueche K., Cahn M., Cassel-Sharma F., Dexter J., Duque J., Goorahoo D. 3, Hang M., Johnson L., Kortman S., Patron E., 1 Post K., Prescott K., Wang T., Zaragosa I., 2017. Quantifying the Benefits of On-farm BMPs for Irrigation and Nutrient Management, California State University Agricultural Research Institute Conference, Sacramento, CA, Sept 9-10, 2017.

Johnson, L., F. Melton, A. Guzman, C. Rosevelt, I. Zaragoza, J. Dexter, K. Post, A. Michaelis, R. Nemani, 2017. Satellite Irrigation Management Support (SIMS), Remote Sensing of ET Workshop, Reno, NV, Sept. 2017.

Melton, F., C. Rosevelt, A. Guzman and M. Hang, 2017. Mapping Drought Impacts on Land Fallowing. Google Earth Engine User Summit, Mountain View, CA, June 26, 2017.

Haffa A., W. Horwath, F. Melton, M. Cahn, R. Smith, 2017. Quantifying N2O Emissions under Different On-farm Irrigation and Nutrient Management BMPs that Reduce Groundwater Nitrate Loading and Applied Water. California Department of Food and Agriculture Conference, Sacramento, October, 2017.

Melton, F., I. Zaragosa, J. Dexter, K. Aqueche, B. Burgoa, M. Cahn, J. Duque, A. Haffa, M. Hang, L. Johnson, S. Kortman, E. Patron, S. Pheasant, K. Prescott, R. Smith, S. Triano, T. Wang, 2017. Capacity Building for Agricultural Sustainability on the California Central Coast through Research and Education. USDA NIFA Project Director's Meeting, Morro Bay, CA, Oct 3, 2017.

Cahn, M., L. Johnson, S. Benzen, L. Murphy, T. Lockhart, and I. Zaragoza, 2017. Optimizing Water Use of Romaine Lettuce Using an Evapotranspiration Based Method. ASHS Annual Conference, 19-22 Sept., Waikoloa HI.

Johnson, L., A. Fulton, R. Rosecrance, and M. Cahn, 2017. Satellite-informed modeling of almond and walnut evapotranspiration in California. ASABE Annual Int'l Meeting, 16-19 July, Spokane.

Johnson, L., A. Fulton, R. Rosecrance, and M. Cahn, 2017. Model comparison for ET estimation in walnut and almond. ASCE-EWRI World Environmental & Water Resource Congress, 21-25 May, Sacramento.

Cahn, M., L. Johnson, S. Benzen, L. Murphy, T. Lockhart, and I. Zaragoza, 2017. Optimizing water use of romaine lettuce using an evapotranspiration based method, ASCE-EWRI World Environmental & Water Resource Congress, 21-25 May, Sacramento.

Melton, F., L. Johnson, et al., 2017. Integrating Satellite and Surface Sensor Networks for Irrigation Management Decision Support in California. ASCE-EWRI World Environmental & Water Resource Congress, 21-25 May, Sacramento.

COMMITTEES AND PANELS
Forrest Melton participated on multiple ROSES peer review panels for the Applied Sciences Program.

Western Water Applications Office Capabilities Working Group (L. Johnson)

Western Water Applications Stakeholder Engagement Working Group (F. Melton)

Member of IGARSS17 Scientific Committee (L. Johnson)

Alpha Jet Atmospheric Experiment (AJAX)

NASA: Warren Gore, Laura Iraci
BAERI: Emma Yates, Ju-Mee Ryoo, Josette Marrero

AJAX is a public-private partnership between the aircraft owner (H211, LLC) and NASA Ames Research Center. The aircraft is based at and operated from Moffett Field, CA under a Space Act Agreement. It is a tactical strike fighter developed by Dassault-Breguet and Dornier. Carrying a crew of two, it has a ceiling of 51,000 ft, speed of 150 - 500 knots, and a range of approximately 1,200 miles (2.5-hours flight duration). Scientific instruments are housed in externally mounted wing pods. Current scientific payload consists of an ozone monitor, a greenhouse gas (carbon dioxide and methane) sensor, a meteorological measurement system (MMS), and a formaldehyde measuring instrument. In addition, plans are underway to install a nitrogen dioxide (NO_2) monitor.

In the past seven years, AJAX has flown over 200 science flights and participated in numerous field campaigns. The AJAX team researches many topics including 1) Satellite and remote sensing validation (OCO-2, GOSAT, TCCON), 2) investigating the transport of ozone from the free troposphere to the surface, impacting air quality, 3) identifying inaccuracies (under-estimations) in methane emission inventories for the State of California and 4) studying emissions from recent California wildfires.

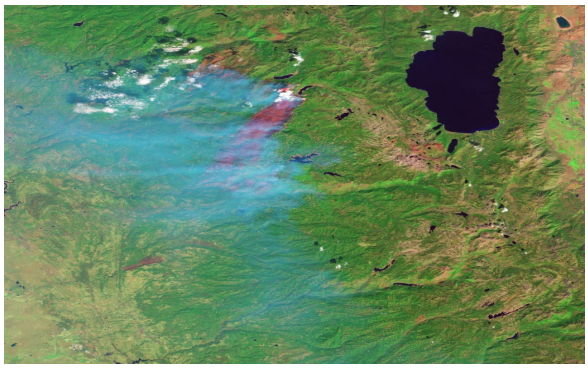


Figure 2: The King fire, burning in El Dorado National Forest as captured by Landsat-8 . ARC-CREST researchers measured CO_2 and CH_4 in the King fire plume from the Alpha Jet platform.

Figure 3: A view of the Alpha Jet research platform, based at NASA-ARC. Instruments are housed in specially designed wing pods.

2017 Accomplishments

• Completed 9 AJAX science flights. Targets have included Railroad Valley (RRV), Nevada for comparisons with the GOSAT and OCO-2 satellites; Sacramento and the San Francisco Bay Area for calculation of urban greenhouse gas emissions; and the Mojave Desert, CA for assessment of ozone transport from the LA Basin and CA Central Valley.

Publications and Presentations

St. Clair, JM; Swanson, AK; Bailer, SA; Wolfe, GM; Marrero, JE; Iraci, LT; Hagopian, JG; Hanisco, TF. "A new non-resonant laser-induced fluorescence instrument for the airborne in situ measurement of formaldehyde," Atmos. Meas. Tech. Discuss., 282, 2017. https://doi.org/10.5194/amt-2017-282.

Yates, EL; Johnson, MS; Iraci, LT; Ryoo, J-M; Pierce, RB; Cullis, PD; Gore, W; Ives, MA; Johnson, BJ;Leblanc, T; Marrero, JE; Sterling, CW; Tanaka, T. "An assessment of ground-level and freetropospheric ozone over California and Nevada." J Geophys Res Atmos, 122, 2017. doi: 10.1002/2016JD026266.

Kulawik, SS; O'Dell, C; Payne, VH; Kuai, L; Worden, HM; Biraud, SC; Sweeney, C; Stephens, B; Iraci, LT; Yates, EL; Tanaka, T. "Lower-tropospheric CO2 from near-infrared ACOS-GOSAT observations." Atmos. Chem. Phys., 17, 5407-5438, 2017.

Ryoo-JM; Johnson, MS; Iraci, LT; Yates, EL; Gore, W. "Investigating sources of ozone over California using AJAX airborne measurements and models: Assessing the contribution from long-range transport." Atmos. Eviron., 155, 53-67, 2017.

CONFERENCE POSTER
Marrero, JE, et al. "Airborne Measurements and Air Quality Impacts of the 2016 Soberanes California Wildfire." AGU Fall Meeting, New Orleans, LA, December 2017.

McNamara, M; Iraci, LT; Ryoo, JM; Marrero, JE, Yates, EL. "Identifying air parcel origins captured by AJAX for the 2016 California Baseline Ozone Transport Study (2016)." UC Davis Meteorology and Climate - Modeling for Air Quality Conference, Davis, CA, September 2017.

CONFERENCE ORAL
Ryoo, J-M, et al. "The impact of the Coastal Barrier Jet on precipitation over Northern California during atmospheric rivers using measurements and models." UC Davis Meteorology And Climate - Modeling for Air Quality Conference, Davis, CA, September 2017.

INVITED ORAL
Marrero, JE & AJAX team. "Airborne Measurements and Air Quality Impacts of California Wildfires." University of Cincinnati, Department of Geology colloquium, November 2017.

Marrero, JE & AJAX team. "Jet-Propelled Science! Using an Airplane to Sample the Atmosphere." Merritt College, October 2017.

Marrero, JE & AJAX team. "Alpha Jet Atmospheric eXperiment." NASA Student Airborne Research Program, June 2017.

AWARDS
Grant from the California Air Resources Board (CARB) to analyze data collected as part of the 2016 California Baseline Ozone Transport Study (CABOTS). operat

Carbon Monitoring Systems (CMS)

NASA: Rama Nemani
BAERI: Sangram Ganguly, Subodh Kalia, Logan Kilpatrick
CSUMB: Andrew Michaelis

The NASA CMS program is an initiative designed to make significant contributions in characterizing, quantifying, understanding, and predicting the evolution of global carbon sources and sinks through improved monitoring of carbon stocks and fluxes. Accurate monitoring of carbon sources and sinks from space-borne measurements and modeling techniques is key to controlling carbon pollution, reduce emission, and abating climate change due to carbon-induced warming of the atmosphere.

As part of the CMS multi-phase activities, a major effort was to quantify regional-to-continental forest Aboveground Biomass (AGB) and Forest canopy height using a host of satellite-derived data, ground data and physical models. Forest canopy height and AGB are key biophysical parameters needed to understand local, regional, and global carbon cycles and serve as an important input to a variety of climate and ecosystem models. Satellite-based observation and/or geospatial predictors (e.g., climate variables) that can alleviate the discontinuity of data in space and time are necessary because field measurement is labor-intensive and thus impractical for large-scale monitoring.

Through the CMS project, forest cover for the continental United States is being estimated at spatial resolution of 1-m in support of reducing uncertainties in the AGB estimation. The process involves the use of state-of-the art machine learning algorithms and segmentation algorithms to delineate tree cover from the USDA National Agricultural Imagery Program (NAIP) Imagery. The generated 1-m forest cover map will be aggregated to the Landsat spatial grid to demonstrate differences in AGB estimates (pixel-level AGB density, total AGB at aggregated scales like eco-regions and counties) when using a native 30-m forest cover map versus a 30-m map derived from a higher resolution dataset. The process will also be complemented with a LiDAR-derived AGB estimate at the 30-m scale to aid in true validation. This work will substantially contribute to filling gaps in ongoing NASA CMS research and help quantify errors and uncertainties in NASA CMS products. This work is an extension of previous CMS Phase II work which demonstrated the use of Landsat-based estimates of Leaf Area Index and ICESat Geoscience Laser Altimeter System (GLAS) derived canopy heights for estimating AGB at a 30-m spatial resolution, and which compared relatively well with inventory-based plot level estimates. The CMS work is data and compute intensive and has extensively used the NASA Pleiades supercomputing platform for doing the simulations and modeling.

In 2016 and 2017, three new CMS activities were funded. The 2016 CMS project with Sassan Saatchi as the Principal Investigator involves creating an annual GHG inventory and MRV system for the US forestlands. The BAER effort will be to create an annual tree/non-tree and disturbance maps from Landsat at 30-m that will serve as a key input towards the AGB estimation and carbon pool. The 2017 CMS project with Rodrigo Vargas as the Principal Investigator involves creating CMS across Mexico to support implementation of REDD+. The BAER team will build multi-scale resolution products of forest cover change, AGB, forest structural variables and GPP for Mexico. In addition, the current DeepSAT framework will be used to derive forest cover using commercial imagery (~50cm) available over Mexico. Another 2017 CMS funded project with George Hurtt as the Principal Investigator focuses on high resolution carbon monitoring and modeling and this is funded as a continuation study to prototype development and deployment of high resolution CMS capabilities to regional and national scales.

2017 Accomplishments

- Developed a robust scalable machine learning algorithm (SegNet) for performing classification/segmentation of 1-m NAIP imagery;
- Developed software for creating labeled training data (matlab module);
- Generated "region of interest" polygon tree mask data for 48 U.S. states;
- Built an automated parallel computing framework for deploying SegNet over Pleiades High Performance Computing cluster;
- Used the Allometric Scaling and Resource Limitations Model (ASRL) to model canopy heights using various geospatial predictors like elevation, long-term monthly precipitation, air temperature, solar radiation, vapor pressure and wind speed;

• Developed theoretical relationships between tree height and available, evaporative, and basal metabolic flow rates using the Allometric Scaling and Resource Limitations model;

• Generated predictions of maximum forest height for forested areas across the continental U.S. and compared these heights to actual reference height data (FIA) by region and accounting for forest age;

• Published in Global Ecology and Biogeography manuscript of ASRL. Manuscript figure also selected for journal cover page (December 2016, Issue 12, Volume 25);

• Worked on Segmentation Neural Network to train a binary classifier to predict forest and non-forest areas in a very high resolution 1-m NAIP imagery; and

• Achieved an accuracy of > 93% for the trained model (the model is scalable and can predict accurately for the areas where data is not available).

• Developed a robust scalable machine learning algorithm (UNet) for performing classification/segmentation of 1-m NAIP imagery;

• Developed an online web-based tool for creating labeled training data;

• Generated "region of interest" polygon tree mask data for 48 U.S. states;

• Built a automated parallel computing framework for deploying UNet over Pleiades High Performance Computing cluster and on AWS (Amazon Web Services);

• Generated the first Continental US NAIP 1-m tree cover map (map undergoing sanity check)

• Awarded two NASA Carbon Monitoring System (CMS) Awards - (1) Carbon monitoring systems across Mexico to support implementation of REDD+: maximizing benefits and knowledge (NNH16ZDA001N-CMS) and (2) High-Resolution Carbon Monitoring and Modeling: Continued Prototype Development and Deployment to Regional and National Scales (NNH16ZDA001N-CMS)

• Successfully completed the NASA Carbon Monitoring System (CMS) project titled "Reducing Uncertainties in Satellite-derived Forest Aboveground Biomass Estimates using a High Resolution Forest Cover Map".

• Continuing work on two NASA CMS projects

- "Annual GHG Inventory and MRV System for the US Forestlands" (collaboration with NASA JPL, Winrock International, USFS and Applied Geosolutions)

- "Tools to bridge the gap between static CMS maps, models, and stakeholders" (supporting Oregon State University with NEX compute, production pipeline and storage).

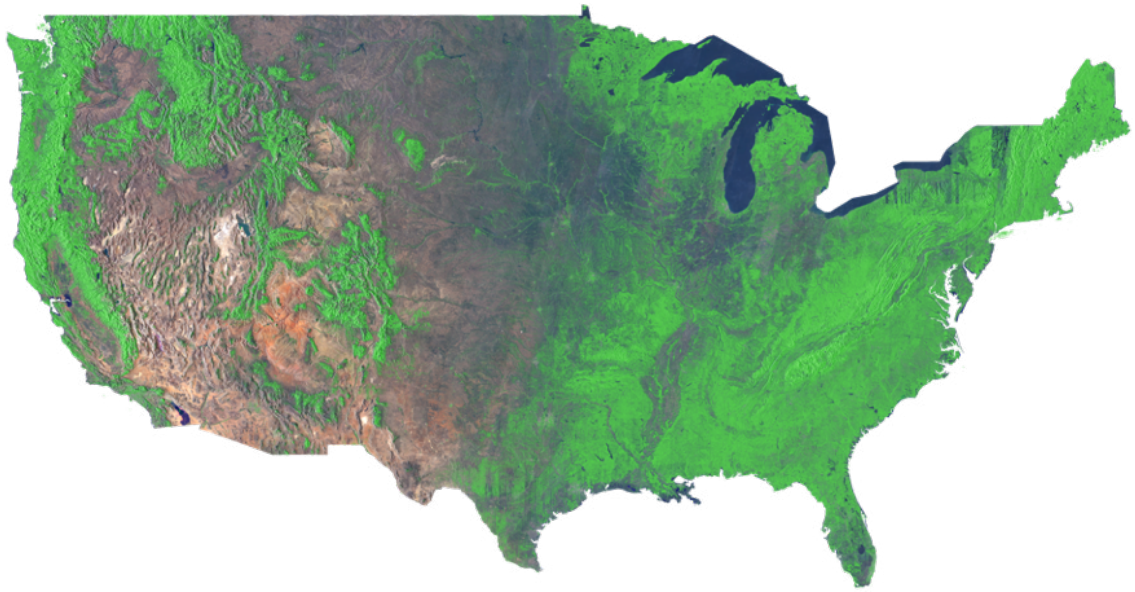


Figure 4: Continental US NAIP-derived 1-m tree cover map (in green overlay). Base map (RGB) is derived from Landsat 30-day composited product.

Publications and Presentations

Basu, S., Karki, M., Ganguly, S., DiBiano, R., Mukhopadhyay, S., Gayaka, S., Kannan, R., Nemani, R. R. (2017), Neural Processing Letters, 45 (3), 855-867.

Kumar, U., et al., (Ganguly, S., one of 13 authors) (2017), Exploring Subpixel Learning Algorithms for Estimating Global Land Cover Fractions from Satellite Data Using High Performance Computing, Remote Sensing, 9 (11), 1105.

Basu, S., Karki, M., Mukhopadhyay, S., Ganguly, S., Nemani, R. R., DiBiano, R., Gayaka, S. (2016), A theoretical analysis of deep neural networks for texture classification, IEEE Internation Joint Conference on Neural Networks, 992-999.

Boyda, E., Basu, S., Ganguly, S., Michaelis, A., Mukhopadhyay, S., Nemani, R. R. (2017), Deploying a Quantum Annealing Processor to detect tree cover in aerial imagery in California, PloS One, 12(2).

Basu, S., Sangram Ganguly, Supratik Mukhopadhyay, Robert Dibiano, Manohar Karki and Ramakrishna Nemani, DeepSat - A Learning framework for Satellite Imagery, ACM SIGSPATIAL 2015.

Ganguly, S. et al. Scaling Deep Learning Models to High Resolution Satellite Image Classification on the NASA Earth Exchange Platform. NASA Ames Machine Learning Workshop 2017. Moffett Field, California.

Ganguly,S. Scaling Deep Learning Models to High Resolution Satellite Image Classification on the NASA Earth Exchange Platform. Re-Work Deep Learning Summit (invited feature speaker), 2017. Boston.

Ganguly, S. et al. NEX-AI Presentation at the NASA Ames Radiation Workshop 2017. NASA Ames. California.

Ganguly, S. et al. Very High Resolution Tree Cover Mapping for Continental United States using Deep Convolutional Neural Networks. AGU Fall Meeting 2017. New Orleans.

Ganguly, S. et al. Scaling Deep Learning Models to High Resolution Satellite Image Classification on the NASA Earth Exchange Platform. NASA Ames Machine Learning Workshop 2017. Moffett Field, California.

Ganguly, S. , Scaling Deep Learning Models to High Resolution Satellite Image Classification on the NASA Earth Exchange Platform. Re-Work Deep Learning Summit (invited feature speaker), 2017. Boston.

Ganguly, S. et al. NEX-AI Presentation at the NASA Ames Radiation Workshop 2017. NASA Ames. California.

Ganguly, S. et al. Very High Resolution Tree Cover Mapping for Continental United States using Deep Convolutional Neural Networks. AGU Fall Meeting 2017. New Orleans.

PANELS AND COMMITTEES

Ganguly, S. Supercomputing (SC) 17 Panelist on Big Data and Machine Learning for Geospatial Sciences

Ganguly, S. Two NASA Panels for selecting grant awards (NASA Panel name undisclosed due to confidentiality clause)

Ganguly, S.NSF Panel for selecting grant awards (NSF Panel name undisclosed due to confidentiality clause)

Ganguly, S.Co-convening the AGU 2017 Session on “Machine Learning Applications in Earth Sciences and Remote Sensing” at New Orleans.

Ganguly, S.NASA Carbon Monitoring System (CMS) Working Group Lead on Algorithm Inter-comparison and Uncertainty Assessment and NASA CMS Science Team Member

Ganguly, S.Associate Editor Role for MDPI Remote Sensing Journal (2017 Started)

Ganguly, S. Review Editor for Environmental Informatics, Frontiers Journal

AWARDS

2017 Nvidia Success Story: http://images.nvidia.com/content/pdf/nasa-ames-success-story.pdf - An AI Monitor for Earth’s Vital featuring NEX’s AI capabilities for Earth Sciences.

Coastal Ocean Biology

NASA: Liane S. Guild, Kirk Knobelspiesse, Jens Redemann
BAERI: Juan L. Torres-Pérez, Sherry L. Palacios, Meloe Kacenelenbogen

This project aims to understand the effects of humans on the health and resilience of reefs, particularly those in the Caribbean. One of the current projects, Human Impacts to Coastal Ecosystems in Puerto Rico (HICE-PR) aims at studying how anthropogenic impacts to watersheds in Puerto Rico eventually cause detrimental effects on the shallow coastal reefs of the Island. This is a highly interdisciplinary project involving scientists from diverse disciplines such as remote sensing, hydrology, geography, coral reef biology and ecology, and sociology. Remotely sensed images are used to study land cover/land use changes in Puerto Rico along with extensive fieldwork to assess for changes in coral reef structure through time. Bio-optical techniques are used to study changes in the spectral shape of coral reef benthic components and beach sediments as a tool to validate satellite or airborne images.

The High-Quality Optical Observations (H-Q2O) project aims to improve Atmospheric Correction and Remote Sensing of Water Quality in the Coastal Zone. It combines the use of an airborne sensor suite to characterize coastal atmospheric and aquatic properties through an end-to-end assessment of image acquisition, atmospheric correction, and sea-truth observations.

The Hyperspectral Infrared Imager (HyspIRI) is being used to understand ocean biodiversity through the development of remote sensing algorithms that enable a synoptic view of phytoplankton community structure using airborne and satellite ocean color observations. Statistical and deterministic approaches are used to define and track water masses in river plume systems and to discriminate among algal taxa in phytoplankton blooms. The team contributed an optical proxy for low salinity water to identify the Columbia River plume on the coastal shelf using satellite imagery, a statistical model to identify and track the evolution of sub-mesoscale features within the larger river plume water mass, and a bio-optical algorithm based on first principles of aquatic optics to discriminate among major phytoplankton taxa within an algal bloom. The phytoplankton discriminator is an important tool for detecting harmful algal blooms and tracing pathways of carbon through different phytoplankton-dominated ecosystems.

2017 Accomplishments

CoralBASICS project

• Coordinated, prepared and conducted a series of workshops aimed at training local dive instructors on the collection of scientifically-valuable underwater data to characterize the present condition of coral reefs in PR. The divers were trained on Reef Check Protocols, the acquisition of data using video transects, water quality data acquisition with the smartphone application HydroColor, and data entry; and

• Made multiple field trips to the study sites to collect additional data and also to validate the efforts of the citizen scientists. The project was funded for its Prototype Phase and a final report will be submitted to the Program by January 26, 2018. Once reviewed, the team will compete for the approval of the Implementation Phase (3 years) to be conducted from 2018-2020.

HICE-PR project

• Coordinated the 4th Soil and Water Assessment Tool (SWAT) workshop where the team worked with hydrological data from both watersheds under study. They finished the underwater data collection on January 2017. The benthic data collected during the past 3 years in both watersheds sums to more than 12,000 photogrids. The data analysis will be submitted for a peer-review manuscript in 2018;

• Participated (Dr. Perez), in February 2017, in a field campaign in Hawaii for a NASA-funded project entitled "Using HyspIRI to identify benthic composition and bleaching in shallow coral reef ecosystems" (Kyle Cavanaugh, PI UCLA);

• Involved (Dr. Perez) in field campaigns in Monterey Bay related to the C-HARRIER project where he was in charge of collecting and analyzing field spectral information at Pinto Lake in Watsonville; and

• Invited (Dr. Perez), in September 2017, to participate in the NASA-funded project "The Neural Multi-modal Observation and Training Network for Global Coral Reef Assessment (NeMO-Net). He was in in charge of coordinating field efforts for data collection and participating in the training of the neural network particularly looking at areas with confusing benthic ID signatures (i.e. coral vs algae vs sponges, etc.).

Figure 5: ARC-CREST researcher Dr. Juan Torres-Perez takes measurements of corals off of Puerto Rico coast to better understand changes to this environment.

Figure 6: Coral reef off the coast of Puerto Rico

Publications and Presentations

Torres-Pérez, J.L., Armstrong, R., and Y. Detrés. 2017. Coral Bleaching Assessment through remote Sensing and Integrated Citizen Science (CoralBASICS). Biodiversity and Ecological Forecasting Meeting. Washington DC. May 2017. Also presented at the 38th US Coral Reef Task Force Meeting. Ft. Lauderdale, FL. August 2017.

Barreto-Orta, M., Torres-Pérez, J.L., Cabrera, N., Ortiz, J., Santiago, L., Setegn, S., Guild, L., Ramos-Scharrón, C., and R. Armstrong. 2017. Human Impacts to Coastal Ecosystems in Puerto Rico (HICE-PR): A remote sensing, hydrologic, ecologic, and socio-economic assessment with management implications. International Ocean Colour Science Meeting. Lisbon, Portugal. May 2017.

Torres-Pérez, J.L. 2017. Human impacts to coastal ecosystems in Puerto Rico (HICE-PR) and a new Citizen Science approach to assess the current condition of reefs in PR. Webinar presented at the US Coral Reef Task Force' Climate Change Working Group. September 2017.

Torres-Pérez, J.L., Armstrong, R.A., Detrés, Y., Aragonés-Fraud, C., and J. Meléndez. 2017. Coral Bleaching Assessment through remote Sensing and Integrated Citizen Science (CoralBASICS): Engaging dive instructors on reef characterization in Southwest, Puerto Rico coupled with the analysis of water quality using NASA Earth Observations. AGU Fall Meeting. December 2017. New Orleans, LA.

COMMITTEES AND PANELS

Dr. Pérez continues to be an invited reviewer in a number of peer-review journals. He is also part of two PhD graduate committees of two students from the University of Puerto Rico, one in the Department of Marine Sciences and the other in the Department of Environmental Sciences.

Earth Science Data Records (ESDR)

NASA: Matt Fladeland
BAERI: Susan Kulawik

The ESDR project supports the NASA Earth Science Data Systems Program. The Program's mission is to both manage and expand the many Earth science data records obtained from NASA satellites, airborne platforms, ground stations, and other sources. Management of these datasets includes archiving, algorithm development, calibration and validation, processing, quality control, and continued support to the user community. One component of the ESDR Program, the Earth System Data Records Uncertainty Analysis, seeks to extend and enhance Earth system data records used by NASA communities, including climate data records, through rigorous estimation of errors. Projects under the Earth System Data Records Uncertainty Analysis umbrella increase the scientific value of the measurements by identifying and validating systematic uncertainties in input data and physical models, and improving error estimations.

ARC-CREST scientists are working on developing and validating long-term records of atmospheric trace gases, including CO_2. They are using multiple remote sensing derived data products as well as airborne and ground-based data to create long-term, consistent data records of atmospheric CO_2 and other trace constituents. This data can be used for mitigation of natural hazards, K-12 science education, and other societal benefits.

Publications and Presentations

Kulawik, S. et al. Validation of OCO-2 v7 carbon dioxide. Presented results at IWGGMS meeting in June 2017. Ongoing work on the same analysis for OCO-2 v8 data for publication.

Kulawik, S. et al., Validation of OCO-2 and ACOS-GOSAT using HIPPO and TCCON, 13th International Workshop on Greenhouse Gas Measurements from Space, Helsinki, Finland, June 6-8, 2017.

2017 Accomplishments

- Compared measurements of carbon dioxide (CO_2) taken from satellites (TES, AIRS, GOSAT) and estimated from models (Carbon Tracker, and MACC) to aircraft data, starting with comparisons to the HIAPER Pole-to-Pole Observations (HIPPO);
- Updated comparisons between SCIAMACHY, GOSAT, MACC, and Carbon Tracker to TCCON, with a manuscript in preparation; and
- Focused on incorporating onto the analysis additional aircraft sets, sets co-located at TCCON sites and sets of OCO-2 data.

4STAR and Satellite Data Analysis

NASA: J. Redemann,
BAERI: Cecilia Chang, Meloe Kacenelenbogen, Yohei Shinozuka, Michal Segal-Rozenhaimer, Qin Zhang, Lauren Fahey, Samuel LeBlanc, Jordan Liss, Kristina Pistone

The Ames 4STAR (Spectrometer for Sky-scanning, Sun-tracking Atmospheric Research) Project uses ground and airborne sun-photometer instruments to study aerosol radiative properties and measure atmospheric trace gases. Instruments currently in use include: the recently developed 4STAR ground and air instruments and the Ames Airborne Tracking Sun-photometer (AATS-14). Scientists analyze measurements from these instruments to yield atmospheric aerosol optical depth and extinction spectra, aerosol size distributions, water vapor columns and profiles, and ozone columns. They also have used the sun-photometer instruments to validate measurements from 12 satellite instruments, two airborne simulators of satellite instruments, and several airborne and ground-based LIDARS. The AATS instrument has also been used in studies of aerosol radiative forcing of climate, aerosol light absorption spectra, and consistency (closure) between in situ and radiometric measurements. The 4STAR ground and air instruments broaden the types of usable aircraft and add the additional measurement capabilities of sky-scanning and improved wavelength resolution.

2017 Accomplishments

• Produced global seasonal clear-sky aerosol radiative forcing results based on multi-satellite sensor aerosol retrievals; those results were then compared to values derived from a subset of models that participated in the latest AeroCom initiative;

• Developed an alternate retrieval of aerosol above opaque water cloud using the CALIOP/ CALIPSO Depolarization Ratio Technique over the globe; and

• Used aerosol retrievals from a combination of MODIS, OMI and CALIOP satellite observations to infer aerosol types over the globe.

Instrument Development (AITT)

• Continued working on improving instrument reliability and accuracy through the AITT project. Specifically, we worked on instrument calibration stability via comparisons with newly developed ground based standard, and developing an active imager based sun-tracking system.

Data analysis (SEAC4RS NAAMES, KORUS-AQ)

• Generated, during the ORACLES mission. total AOD, columnar water vapor, O3 and NO2 as well as sky scans for all ORACLES flights. These will be inverted to get optical properties of the BB aerosols and other aerosols encountered during the campaign. 4STAR has measured Zenith cloud radiance as well, and data was processed to retrieve cloud optical depth and cloud droplet effective radii, which is scheduled to be archived soon;

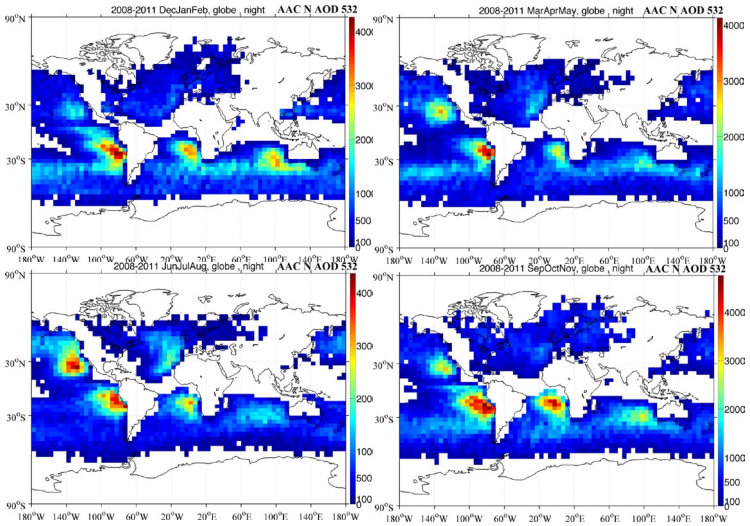


Figure 7: Global seasonal nighttime number of aerosol above cloud cases from 2008 to 2012 using CALIOP and the alternate depolarization ratio method

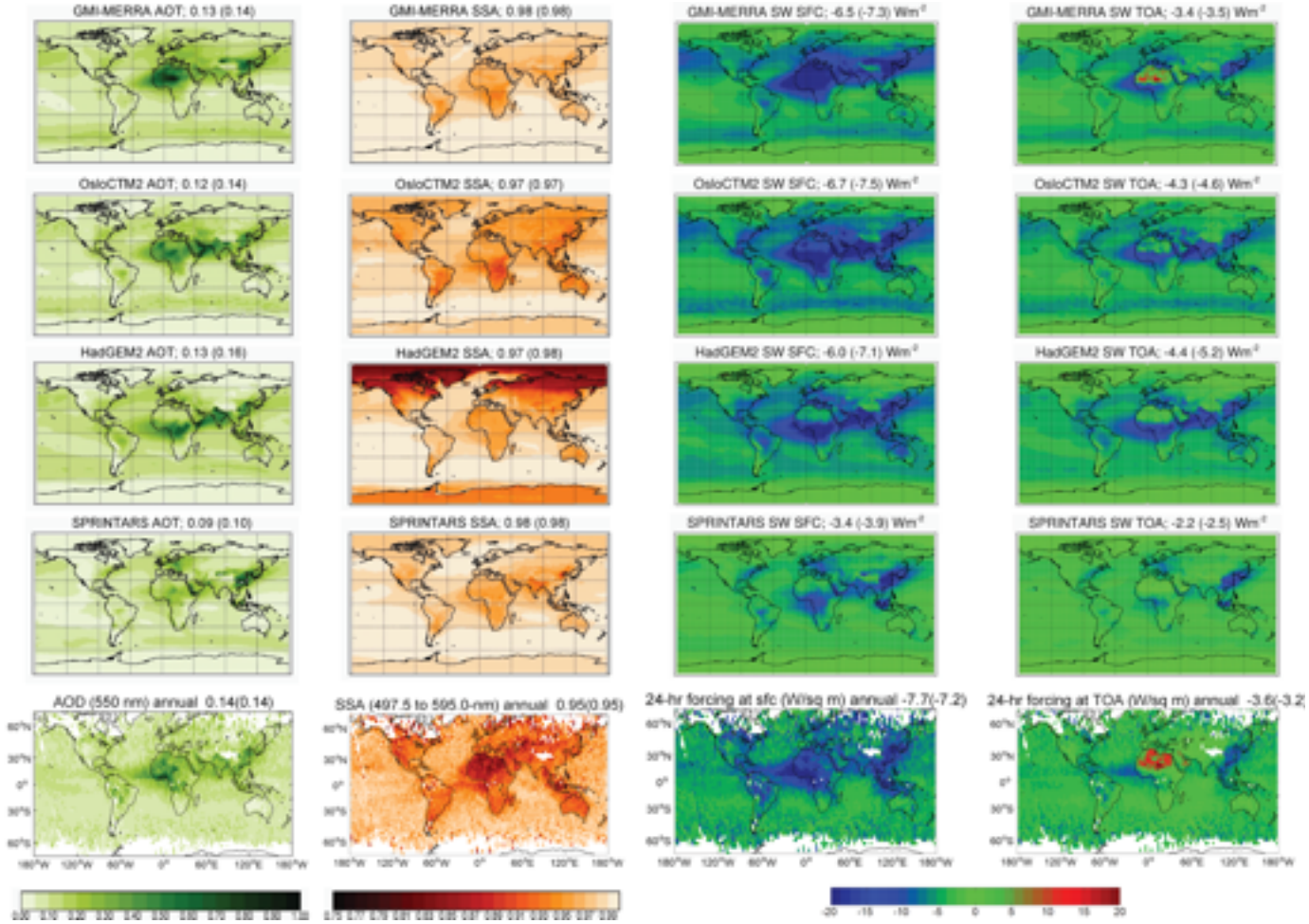


Figure 8: Annually averaged AOD, SSA, surface and TOA shortwave forcing from GMI-Merra, OSLO-CTM, HadGEM2, SPINTARS, compared to MODIS-OMI-CALIOP retrieval results (last row).

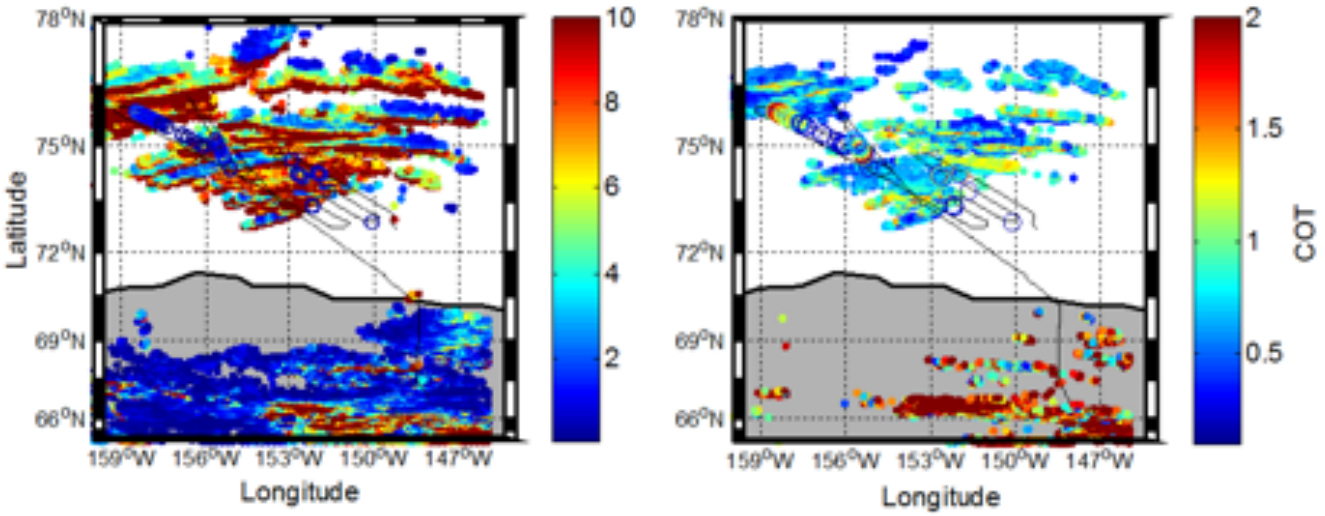


Figure 9: (adapted from Smith et al., 2015, submitted): (a) COT for all multi-layer ice clouds with top above 5 km height derived by CERES (solid circles),overlaid by direct sun cirrus retrievals (based on procedure developed in Segal-Rosenheimer et al., 2013) from the 4STAR instrument on-board C-130 (open circles), and (b) COT for only upper layer clouds, as derived by CERES, overlaid by direct sun cirrus retrievals from 4STAR (open circles) for September-15 flight. Note the different colorbar scales.

Publications and Presentations

Torres-Pérez, J.L., Armstrong, R., and Y. Detrés. 2017. Coral Bleaching Assessment through remote Sensing and Integrated Citizen SJethva, H., Torres, O., Remer, L., Redemann, J., Livingston, J., Dunagan, S., Shinozuka, Y., Kacenelenbogen, M., Segal Rosenheimer, M. Spurr, R. (2016). Validating MODIS Above-cloud Aerosol Optical Depth Retrieved from "Color Ratio " Algorithm using Direct Measurements made by NASA ' s Airborne AATS and 4STAR Sensors. AMT, (June), 1–16. http://doi.org/10.5194/amt-2016-178.

Redemann et al., Use of A-Train aerosol observations to constrain direct aerosol radiative effects (DARE) – comparisons with AeroCom models and uncertainty assessments, in preparation

Kacenelenbogen et al., CALIOP/ CALIPSO global seasonal nighttime aerosol extinction-to-backscatter (lidar) ratios and optical depths above low opaque water clouds, JGR, in preparation

Smith L. William Jr. et al.s, Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE): The Arctic radiant energy system during the critical seasonal ice transition. Bull. Amer. Meteor. Soc., Accepted.

LeBlanc et al., Changing arctic cloud properties near the sea-ice edge measured by transmitted light from an airborne platform during ARISE, in preparation for JGR

PRESENTATIONS

LeBlanc et al., Cloud Radiative effect and cloud property estimates from airborne measurements of transmitted light, IRS, Auckland, NZ, April 2016

LeBlanc et al., Changing Arctic cloud properties across the sea-ice edge measured by airborne measurements, Airborne radiometry workshop, Boulder, CO, March 2016

Redemann et al., Aerosol-radiation-cloud interactions in the South-East Atlantic: future suborbital activities to address knowledge gaps in satellite and model assessments, IRS, Auckland, NZ, April 2016

Kacenelenbogen et al., Global distribution of aerosols above low opaque water clouds and implications for all-sky Direct Aerosol Radiative Effect (DARE), Oral, Cloudsat/ Calipso meeting, Newport News, VA, USA, March 2016

Redemann et al., Use of A-Train aerosol observations to constrain direct aerosol radiative effects (DARE) – comparisons with AeroCom models and challenges in quantifying all-sky DARE, Cloudsat/ Calipo meeting, Newport News, VA, USA, March 2016

Redemann et al., Airborne hyperspectral observations of aerosols, clouds and radiation in the Southeast Atlantic – first results from NASA's ORACLES campaign, Hyperspectral Imaging and Sounding of the Environment (HISE), Leipzig, Germany, 14 - 17 November 2016.

Shinozuka et al., Aircraft- and ground-based assessment of the CCN-AOD relationship and implications on model analysis of ACI and underlying aerosol processes, AGU Fall Meeting, December 2016.

Shinozuka et al., NASA Ames Airborne Tracking Sunphotometers (AATS-6 & AATS-14) and 4STAR, Kaufman Symposium, NASA GSFC, June 2016.

Shinozuka et al., 4STAR and AATS, NAAMES Science Team, Corvallis, August 2016.

Kacenclenbogan et al, Spaceborne Remote sensing of aerosol type: glaobal distribution, model evaluation and translation into chemical speciation, AGU Fall Meeting, December 2016.

Kyle Dawson et al, Linking remotely sensed aerosol types to their chimcal composition. AGU Fall Meeting, December 2016

Pistone, K, J. Redemann and M Segal- Rosenhaimer, In-situ and remote-sensing observations of springtime clouds and aerosol loading over northern Alaska AGU Fall Meeting, December 2016

Shimozuka, et al, airborne measurements of multi-wavelength aerosol optical depth and cloud-transmitted radiances in the North Atlantic Aerosols and Marine eEcosysteems Study (NAAMES), AGU Fall Meeting, December 2016

Redemann J, and S. LeBlanc, The radiative effect of boundary layer clouds: Can aircraft measurements improve regional estimates? (Invited), AGU Fall Meeting, December 2016

Liss, J., et al, High Precision Sunphotometer using Wide Dynamic Range (WDR) Camera Tracking, AGU Fall Meeting, December 2016.

Ground, Air, and Spaceborne Aerosol Typing

NASA: Jens Redemann
BAERI: Meloe Kacenelenbogen (PI), Yohei Shinozuka, Michal Segal-Rozenhaimer, Qin Zhang, Qian Tan

To improve the predictions of aerosol composition in chemical transport models (CTMs) and global climate models (GCMs), a flexible aerosol classification algorithm (called Specified Clustering and Mahalanobis Classification), (SCMC) assigns an aerosol type to multi-parameter retrievals by spaceborne, airborne, or ground based passive remote sensing instruments [Russell et al., 2014]. SCMC uses Mahalanobis classification [Mahalanobis, 1936; Burton et al., 2012] with pre-specified clusters (or classes). The pre-specified classes were defined using parameters retrieved from AErosol RObotic NETwork (AERONET) stations where a single aerosol type tends to dominate in certain months. The aerosol types identified by this scheme are pure dust, polluted dust, urban-industrial/developed economy, urban-industrial/developing economy, dark biomass smoke, light biomass smoke and pure marine.

This project, begun in March 2015, is a three-year investigation with the following goals: (1) understand the limitations of the Specified Clustering and Mahalanobis Classification (SCMC) method applied to passive spaceborne polarimetry and ground-based sun and sky photometry, (2) improve this method through the addition of mixtures of aerosol types, (3) bridge the gap between remote sensing-inferred aerosol types and their corresponding chemical speciation, (4) use the SCMC method to evaluate aerosol type predictions from the GEOS-Chem CTM, (5) study long-term trends of aerosol types at a few key locations over the globe, (6) attribute various sources to those aerosol types using the GEOS-Chem CTM and (7) provide recommendations for future passive space-borne instrumentation that could yield an improved aerosol classification from space.

2017 Accomplishments

Task 1: Space-borne aerosol types and ground-based evaluation

- Applied the SCMC method to two different total-column datasets of aerosol optical properties: inversions from AERONET and retrievals from the space-borne POLDER (Polarization and Directionality of Earth's Reflectances) instrument. The POLDER retrievals used differ from standard POLDER retrievals [Deuzé et al., 2001] because they make full use of multi-angle, multispectral polarimetric data [Hasekamp et al., 2011]. Their classification algorithm uses three parameters, the Extinction Angstrom Exponent (EAE491,863), the Single Scattering Albedo (SSA670), and the difference between two SSA (dSSA863-491);

- Produced global monthly, seasonal and annual maps of POLDER-derived aerosol type probability of occurrence and most common aerosol type using POLDER or AERONET during the year 2006.

- Found reasonable aerosol features globally using POLDER observations (e.g. pure dust across the Atlantic Ocean or biomass burning dark smoke offshore from the Namibian coast in Jul-Aug-Sept) and POLDER-AERONET EAE, SSA, dSSA as well as SCMC-derived aerosol types compare reasonably well; and

- Recommended more accurate future passive space-borne satellite retrieval of RRI (and other parameters such as particle sphericity or volume concentration) for an improved space-borne aerosol classification over the globe.

Task 2: Bridge the gap between remote sensing-inferred aerosol types and corresponding chemical speciation

- With Dr Q. Tan's help, filtered, averaged, and collocated airborne measurements of EAE491-863, SSA491 and dSSA863-491 from the airborne NASA Langley Aerosol Research Group Experiment (LARGE) and RRI532 measurements from the Differential Aerosol Sizing and Hygroscopicity Spectrometer Probe (DASH-SP) during the SEAC4RS experiment;

- Inferred airborne SCMC aerosol types based on those optical measurements for every flight and compared those SCMC aerosol types to number fraction measurements of sulfate, organic, nitrate, biomass burning, soot, mineral and sea salt fractions from the Particle Analysis by Laser Mass Spectrometry (PALMS) instrument (present on the same aircraft during SEAC4RS); and

- Compared their airborne SCMC aerosol types to ambient mass concentration measurements of organic, sulfate, ammonium and nitrate from the High - Resolution Time - of - Flight Aerosol Mass Spectrometer (AMS) and mass concentration measurements of black carbon (BC) from the Single-Particle Soot Photometers (HD-SP2).

Publications and Presentations

Kacenelenbogen et al., 2016, "Spaceborne Remote Sensing of Aerosol Type: Global Distribution, Model Evaluation and Translation into Chemical Speciation", Oral, American Geophysical Union (AGU), 12/12-16 2016

Kacenelenbogen et al., 2016, "Spaceborne Remote Sensing of Aerosol Type: Global Distribution, Model Evaluation and Translation into Chemical Speciation", Oral, 97th

American Meteoorlogical Society (AMS) meeting, Conference on Atmospheric Chemistry, Seattle, WA, 01/ 22–26 2017.

COMMITTEES AND PANELS

M. Kacenelenbogen is serving on a NASA Panel review,.

Making Earth System Data Records for Use in Research Environments (MEaSUREs)

NASA: : Jennifer Dungan
BAERI: Pardha Teluguntla, Jun Xiong

The MEaSUREs project is part of NASA's Earth Science Data Systems Program, the mission of which is to both manage and expand the many Earth science data records obtained from NASA satellites, airborne platforms, ground stations, and other sources. The MEaSUREs project monitors global croplands to ensure sustainable water and food security. Development and maintenance of this data is important to climate scientists, agricultural scientists, farmers, natural resource managers, and national leaders.

Global Food Security-Support Analysis Data at 30 m (GFSAD30)
The goal of this research is to develop and implement spectral matching techniques (SMTs) and automated cropland classification algorithms (ACCA's) for production of multi-year cropland products that will help address food security issues using MODIS 250m time-series data for Australia.

Specific objectives include:
1. Development of reference cropland products for the year 2014 using novel spectral matching techniques based on ideal spectra of croplands generated using extensive field knowledge applied on MODIS time-series data;

2. Development of automated cropland classification algorithms using the reference data generated to train algorithms and then apply them to reference year 2014, as well as each year from 2000 to 2013;

3. Establish the accuracy of cropland products generated using spectral matching techniques and automated cropland classification algorithms, highlighting the ability of the algorithms to predict drought by applying them to data collected from 2000 to 2014.

2017 Accomplishments

- Production of 30m Cropland extent version 1.0 (GFSAD30CE) for Africa, Australia, New Zealand, and China;

- Products were released with web-access through www.croplands.org for visualization;

- Products & Documentation were submitted to Land Processes Distributed Active Archive Center (LP DAAC);

- Products are released through LPDAAC for download; and

- Development of Crop Intensity layer using MODIS Vegetation indices 16-day composite (MODIS/MOD13Q1) and Landsat 30m data. The proposed algorithm was deployed in Google Earth Engine to scale to large area.

Publications and Presentations

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Xiong, J. et al. 2017. Nominal 30-m Cropland Extent Map of Continental Africa by Integrating Pixel-Based and Object-Based Algorithms Using Sentinel-2 and Landsat-8 Data on Google Earth Engine. Remote Sensing. 2017, 9, 1065.

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Teluguntla, P. et al .Global Cropland Extent (GCE) 30m Products of Australia, New Zealand, and China using: (a) Random forest Algorithm and (b) Google Earth Engine Cloud Computing Presented during ,GFSAD30m August 2017 workshop conducted at U.S. Geological Survey , Reston, Virginia.

Xiong, J. et al. Global Cropland Mapping: Africa Crop Extent and Intensity. Presented during ,GFSAD30m Presented during GFSAD30m Fubruary 2017 workshop conducted at NASA ames research center, Moffet Field, CA

Xiong, J. et al. An Overview of Africa Croplands Products: Crop Extent Mapping using Google Earth Engine. Presented during ,GFSAD30m August 2017 workshop conducted at U.S. Geological Survey , Reston, Virginia.

NASA Earth Exchange (NEX)

NASA: Rama Nemani, Jennifer Dungan, Ved Chirayath, Piyush Mehrotra
BAERI: Sangram Ganguly, Govindasamy Bala, Ed Boyda, Anna Costanza, Ileen Dranchak, Ryan Eastman, Shreekant Gayaka, Subodh Kalia, Angela Hsueh, Shuang Li, Matthew Mage, Alvaro Ramirez-Hong, Jun Xiong,
CSUMB: Alberto Guzman, Hirofumi Hashimoto, Forrest Melton, Andrew Michaelis, Petr Votava, Weile Wang

Under this task, ARC-CREST scientists and software engineers collaborate with scientists and engineers in the NASA Ames Earth Science Division and the NASA Advanced Supercomputing (NAS) Division to develop and support the NEX collaborative supercomputing/cloud computing environment for large-scale Earth Science research.

Since its inception in 2009, the NEX project has evolved from having a sole focus on ecological forecasting to providing access to large Earth science datasets, supercomputing and cloud computing capabilities, and the development of an online collaborative research environment. The primary objective of the NEX project is to accelerate scientific discovery using data from NASA's satellite missions and climate models, and to facilitate scientific collaboration in a way that was not previously possible. NEX maintains a large set of satellite observations and climate model data for use by NASA-supported researchers who are tackling science questions that involve data and computing intensive analyses at regional to global scales. NEX provides the Earth science research community with a virtual collaborative, where scientists can process large data sets, run model codes, and share the results and knowledge. As the data products and models available within NEX and the community utilizing NEX grow, the support needed to maintain this unique collaborative environment also grows.

ARC-CREST researchers collaborate closely with scientists in NASA Ames Earth Science Division, as well as the broader NASA Earth science community to apply NEX capabilities to analyze long-term and emerging trends in ecosystem conditions, conduct simulations of climate and land use change impacts on terrestrial and aquatic ecosystems, map patterns in biodiversity, and monitor biomass at local to continental scales. The NEX team also supports applied science activities, such as the development of indicators of climate change impacts for Landscape Conservation Cooperatives and NASA Centers, and development of information products to support land managers, agricultural producers, and water managers throughout the U.S. NEX also supports monitoring and modeling of natural disasters and emerging public health threats. In addition, NEX supports production of global long-term data records for NASA's MEaSUREs program, as well as large-scale visualizations for data from NASA's Earth Observing System Data and Information System (EOSDIS).

The OpenNEX initiative, a collaboration between NASA and Amazon Web Services, develops cloud-hosted data, tools and solutions for working with satellite and climate data (e.g. virtual labs). Development of these tools and maintenance and administration of the OpenNEX platform are also are performed by ARC-CREST researchers. Additional information about NEX can be found at: https://nex.nasa.gov/nex/

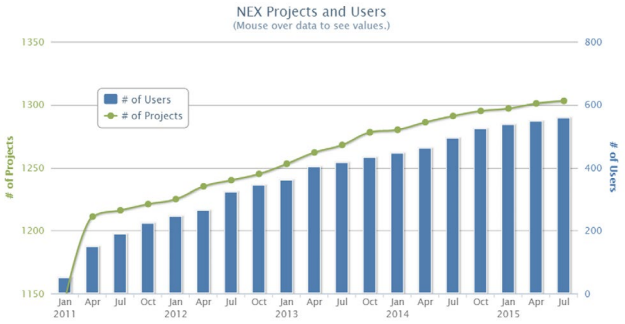

Figure 10: The NEX community of users has grown substantially over the past 3 years. ARC-CREST researchers now provide support for over 1300 projects and nearly 600 users. NEX is a one of its kind virtual platform for studying and collaborating on Earth science projects.

2017 Accomplishments

•Awarded NASA ESTO Advanced Information Systems Technology (AIST) Project - NeMO-Net - The Neural Multi-Modal Observation & Training Network for Coral Reef Assessment (NNH16ZDA001N-AIST): Using deep learning and convolutional neural networks to augment, fuse, and predict upon remote sensing coral data;

• Completed successfully the NASA ESTO Advanced Information Systems Technology (AIST) project titled "Prototyping agile production, analytics and visualization pipelines for big-data on the NASA Earth Exchange (NEX), NNH14ZDA001N-AIST". Collaborated with Kitware, Inc. to develop a new GeoNotebook technology that enables easy visualization and analysis of large-scale datasets on the Amazon cloud;

• Continued work on two NASA ACCESS projects:
o (Open)NEX: Enabling Code-to-Data Migration between High-Performance Computing, Cloud and Beyond

o Object Store-Based Data Service for Earth System Science (collaboration with the HDF Group);

• Making Earth System data records for Use in Research Environments (MEASURES) Project - Web-enabled Landsat Data (WELD), NNH06ZDA001N: Implemented major science improvements in the version 3.1 of the data release that is now available from the USGS EDC data center. Completed first large-scale true-resolution visualizations available through NASA EOSDIS GIBS system;

• Completed release of the Climate Explorer for the U.S. Climate Resilience Toolkit in collaboration with NOAA, Habitat Seven, USGS, EPA, and USBR. The Climate Explorer features multiple high resolution climate datasets generated on NEX, and was nominated for a Webby in 2017 in the category of "Best Visual Design – Functionality." Work is ongoing on version 2.0, which will feature the LOCA climate datasets generated using NEX. This work was conducted in support of the National Climate Assessment and USGCRP; and

• Developed a new high power MiDAR (Multispectral Detection and Active Reflectance) instrument.

• The team published 17 peer review publications in 2017, with additional publications in preparation.

• Awarded NASA ESTO Advanced Information Systems Technology (AIST) Project - Framework for Mining and Analysis of Petabyte-size Time-series on the NASA Earth Exchange (NEX) (NNH16ZDA001N-AIST)

• Awarded two NASA Carbon Monitoring System (CMS) Awards - (1) Carbon monitoring systems across Mexico to support implementation of REDD+ and (2) High-Resolution Carbon Monitoring and Modeling: Continued Prototype Development and Deployment to Regional and National Scales;

• Awarded NASA ESTO Advanced Information Systems Technology (AIST) Project - NeMO-Net - The Neural Multi-Modal Observation & Training Network for Coral Reef Assessment (NNH16ZDA001N-AIST): Using deep learning and convolutional neural networks to augment, fuse, and predict upon remote sensing coral data;

• Successfully completed the NASA ESTO Advanced Information Systems Technology (AIST) project titled "Prototyping agile production, analytics and visualization pipelines for big-data on the NASA Earth Exchange (NEX), NNH14ZDA001N-AIST". Collaborated with Kitware, Inc. to develop a new GeoNotebook technology that enables easy visualization and analysis of large-scale datasets on the Amazon cloud;

• Successfully completed the NASA Carbon Monitoring System (CMS) project titled "Reducing Uncertainties in Satellite-derived Forest Aboveground Biomass Estimates using a High Resolution Forest Cover Map";

• Successfully completed the NASA ESTO Advanced Information Systems Technology (AIST) project titled "Landcover Anomaly Detection through Data-driven Modeling of Satellite, Climate, and Topographical Variables";

• Continuing work on two NASA ACCESS projects: (Open)NEX: Enabling Code-to-Data Migration between High-Performance Computing, Cloud and Beyond Object Store-Based Data Service for Earth System Science (collaboration with the HDF Group);

• Continuing work on two NASA CMS projects :
o "Annual GHG Inventory and MRV System for the US Forestlands" (collaboration with NASA JPL, Winrock International, USFS and Applied Geosolutions)

o "Tools to bridge the gap between static CMS maps, models, and stakeholders" (supporting Oregon State University with NEX compute, production pipeline and storage)

• Making Earth System data records for Use in Research Environments (MEASURES) Project - Web-enabled Landsat Data (WELD), NNH06ZDA001N: Implemented major science improvements in the version 3.1 of the data release that is now available from the USGS EDC data center. Completed first large-scale true-resolution visualizations available through NASA EOSDIS GIBS system.

• Completed release of the Climate Explorer for the U.S. Climate Resilience Toolkit in collaboration with NOAA, Habitat Seven, USGS, EPA, and USBR. The Climate Explorer features multiple high resolution climate datasets generated on NEX, and was nominated for a Webby in 2017 in the category of "Best Visual Design -- Functionality". Work is ongoing on version 2.0, which will feature the LOCA climate datasets generated using NEX. This work was conducted in support of the National Climate Assessment and USGCRP.

• Developed a new high power MiDAR (Multispectral Detection and Active Reflectance) instrument.

Publications and Presentations

Fisher, J., et al. (W. Wang, of 24 co-authors). 2017. Missing pieces to modeling the Arctic-Boreal puzzle. Environmental Research Letters (in press).

Zhou, S., et al. (W. Wang, of 19 co-authors). 2017. Response of water use efficiency to global environmental change based on output from terrestrial biosphere models. Global Biogeochemical Cycles, DOI:10.1002/2017GB005733.

Tian, B., et al. (W. Wang, of 11 co-authors). 2017. Development of a model performance metric and its application to access summer precipitation over the U.S. Great Plains in downscaled climate simulations. Journal of Hydrometeorology, DOI:10.1175/JHM-D-17-0045.1.

Herring, J., VanDyke, M.S., Cummins, R.G. and Melton, F., 2017. Communicating local climate risks online through an interactive data visualization. Environmental Communication, 11(1), pp.90-105.

Iguchi, T., et al. (W. Wang, of 16 co-authors). 2017. Sensitivity of CONUS summer rainfall to the selection of cumulus parameterization schemes in NU-WRF seasonal simulations. Journal of Hydrometeorology. DOI: 10.1175/JHM-D-16-0120.1.

Kim, J. (W. Wang, of 11 co-authors). 2017. Winter precipitation characteristics in western US related to atmospheric river landfalls: observations and model evaluations. Climate Dynamics, doi:10.1007/s00382-017-3601-5.

Huntzinger, D.N., et a. (W. Wang, of 27 co-authors). 2017: Uncertainty in the response of terrestrial carbon sink to environmental drivers undermines carbon-climate feedback predictions. Scientific Reports.

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Li, S., S. Ganguly, J.L. Dungan, W.L. Wang, and R.R. Nemani, (2017). Sentinel-2 MSI Radiometric Characterization and Cross-Calibration with Landsat-8 OLI. Advances in Remote Sensing, 6, 147-159. doi:10.4236/ars.2017.62011

Li, S., J. Weigand, S. Ganguly (2017). The Potential for Climate Impacts from Widespread Deployment of Utility-Scale Solar Energy Installations: An Environmental Remote Sensing Perspective. J Remote Sensing & GIS. 6: 190. doi:10.4172/2469-4134.1000190

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Lang, M., et.al. (A. Moreno one of 6) (2017) Assessment of MODIS NPP algorithm-based estimates using soil fertility and forest inventory data in mixed hemiboreal forests. Forestry Studies. 66:49-64

Uttam, K., et al. (G. Sangram, A Michaelis, H Hashimoto, W. Wang, of 13 co-authors). 2017: Exploring subpixel learning algorithm for estimating global land cover franctions from satellite data using high performance computing). Remote Sensing, doi:10.3390/rs9111105

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Li, A. et al. NeMO-Net - The Neural Multi-Modal Observation & Training Network for Global Coral Reef Assessment. AGU Fall Meeting 2017. New Orleans.

Moreno, A. et al. Climate limits on forest structure across space and time. IUFRO Meeting 2017. Freiburg, Germany

Moreno, A. et al. Climate limits on forest structure across space and time. AGU Meeting 2017. New Orleans

Melton, F. et al. The U.S. Climate Explorer: Increasing Access to Climate Data for Climate Resilience Planning, Water Resources Policy Institute, San Jose, CA, 06 April 2017.

Wang, W. et al. Generating Land Surface Reflectance for the New Generation of Geostationary Satellite Sensors with the MAIAC Algorithm. AGU Fall Meeting 2017. New Orleans.

Ganguly, S. et al. Scaling Deep Learning Models to High Resolution Satellite Image Classification on the NASA Earth Exchange Platform. NASA Ames Machine Learning Workshop 2017. Moffett Field, California.

Ganguly, S. Scaling Deep Learning Models to High Resolution Satellite Image Classification on the NASA Earth Exchange Platform. Re-Work Deep Learning Summit (invited feature speaker), 2017. Boston.

Ganguly, S. et al. NEX-AI Presentation at the NASA Ames Radiation Workshop 2017. NASA Ames. California.

Ganguly, S. et al. Very High Resolution Tree Cover Mapping for Continental United States using Deep Convolutional Neural Networks. AGU Fall Meeting 2017. New Orleans.

Mr Prabhat, Biard J. Ganguly S., et al. ClimateNet: A Machine Learning dataset for Climate Science Research. AGU Fall Meeting 2017. New Orleans.

Kalia, S., Li, S., Ganguly, S., and Nemani R. R. DeepSAT's CloudCNN: A Deep Neural Network for Rapid Cloud Detection from Geostationary Satellites. AGU Fall Meeting 2017. New Orleans.

Li, A. et al. NeMO-Net - The Neural Multi-Modal Observation & Training Network for Global Coral Reef Assessment. AGU Fall Meeting 2017. New Orleans.

Moreno, A. et al. Climate limits on forest structure across space and time. IUFRO Meeting 2017. Freiburg, Germany

Moreno, A. et al. Climate limits on forest structure across space and time. AGU Meeting 2017. New Orleans

Melton, F. et al. The U.S. Climate Explorer: Increasing Access to Climate Data for Climate Resilience Planning, Water Resources Policy Institute, San Jose, CA, 06 April 2017.

COMMITTEES AND PANELS

Wang, W. Climate Scenario Task Force of US Global Change Research Program (USGCRP)

Melton, F. Climate Explorer for the U.S. Climate Resilience Toolkit Working Group, US Global Change Research Program (USGCRP)

AWARDS

2017 Webby Nomination, Best Visual Design - Functional, Climate Explorer for the U.S. Climate Resilience Toolkit (F. Melton, team member)

2017 Best Paper Runner Up Award & Best Paper Student at ACM SIGKDD Applied Data Science Track for the paper titled "DeepSD: Generating High Resolution Climate Change Projections through Single Image Super-Resolution" (S. Ganguly, co-author)

2017 Nvidia Success Story: http://images.nvidia.com/content/pdf/nasa-ames-success-story.pdf - An AI Monitor for Earth's Vital featuring NEX's AI capabilities for Earth Sciences.

ORACLES Radiative Transfer Algorithm Development

NASA: Kirk Knoblespeisse, Jens Redemann
BAERI: M. Segal-Rozenhaimer,

The primary goal of this research is to develop new algorithms to retrieve atmospheric aerosol and cloud optical properties from observations by polarimetrically sensitive instruments. These algorithms are intended for the analysis of aerosols lofted above clouds, the main target of ORACLES (ObseRvations of Aerosols Above CLouds and their IntEractionS). The ORACLES experiment will consist of 3 deployments in 2016, 2017, and 2018 offshore from Namibia involving 2 airplanes with numerous ground-based and airborne remote sensing and in-situ instruments. ORACLES provides multi-year airborne observations over the complete vertical column of the key parameters that drive aerosol-cloud interactions in the South-East Atlantic, an area with some of the largest inter-model differences in aerosol forcing assessments on the planet. Algorithms will be applied to observations by the Research Scanning Polarimeter (RSP) and the Airborne Multiangle SpectroPolarimetric Imager (AirMSPI).

An algorithm will be created to retrieve the optical properties of Aerosols Above Clouds (AAC), observed during ORACLES concurrently with some of the optical properties of the underlying clouds. The basis of this algorithm is the ability that multiviewing angle, polarimetrically sensitive instruments have to separate the effects of aerosols and (liquid phase) clouds. Since the polarimetric expression of the liquid phase cloudbow is very distinct, observations of the spectral and geometric expression of this cloudbow can be used to accurately determine the droplet effective radius and variance at the top of the cloud. Observations at scattering angles away from the cloudbow can then be used to determine aerosol characteristics because the underlying reflectance properties of the cloud have already been constrained (polarized reflectance is only sensitive to the top three cloud optical depths, so additional information such as overall cloud optical thickness and physical dimensionality are not needed).

Vertical distribution of the aerosols and clouds must either be assumed or specified by external data. Standard polarimetric retrievals are often performed using some version of optimal estimation, whereby a radiative transfer model representing the scene is tuned until its output matches observations. This can be very computationally expensive. The proposed algorithm uses a trained neural-network (NN) scheme that captures the various scenes expected to be observed during the campaign (with varying properties of both aerosol and cloud layers). NN allows the training (i.e., optimization) of a large dataset of options, using simulated inputs (i.e., polarimetric measurements of various scenes) that link (i.e., creates the best possible modeled coefficients) inputs (measurements) to outputs (retrieved properties of aerosol and clouds). After the training process is completed, retrievals are achieved by inputting sets of measurements, using the obtained coefficients from the training process.

2017 Accomplishments

- Completed the fine tuning of the cloud algorithm and archived ORACLES 2016 (ER-2 flights) and ORACLES 2017 (P-3) campaign data. Comparisons with the airborne RSP instrument standard cloud retrievals yielded good comparisons during the 2016 and 2017 campaigns; and

- Continued to assemble the aerosol above cloud algorithm and finalize the NN cloud retrieval method in a paper for the Journal of Remote Sensing.

Publications and Presentations

Knobelspiesse,K., Michal Segal-Rosenhaimer, Jens Redemann, Brian Cairns, Mikhail D. Alexandrov, Multi-angle, polarimetric cloud observations using a radiative transfer model trained Neural Network, The 16th Electromagnetic and Light Scattering Conference ELS-XVI, University of Maryland/College Park, MD, USA, 19-25 March 2017.

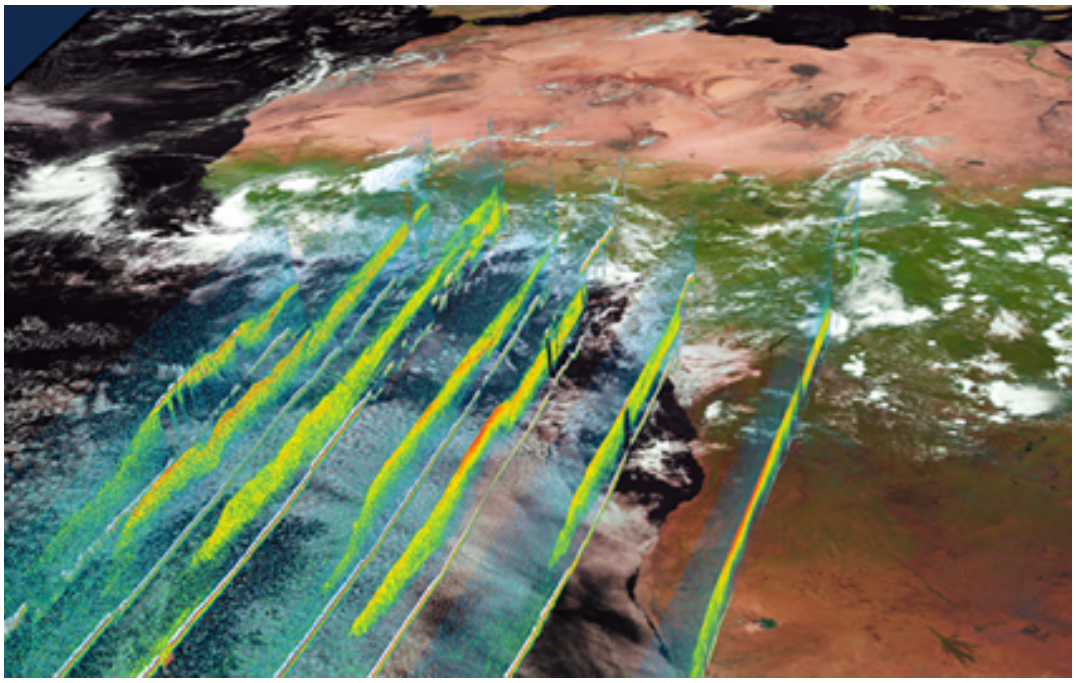


Figure 11: Composite CALIPSO lidar backscatter curtains show pervasive transport of BB aerosol transport during the first week of September 2008 as well as the underlying cloud tops over the South-East Atlantic (region of the ORACLES field campaign)

Orbiting Carbon Observatory – 2 Errors/Profiles (OCO-2 E/ OCO-2 P)

NASA: Matt Fladeland
BAERI: Susan Kulawik
Colorado State University: Chris O'Dell

The goal of this project is to develop vertically resolved GOSAT and OCO-2 products. Solving the carbon cycle to estimate locations and amounts of emitted carbon dioxide (e.g. from fires, combustion) and locations and amounts of carbon dioxide uptake (e.g. forests, oceans) is a complex problem utilizing satellite observations, ground based measurements, and transport modeling. Separation of satellite carbon dioxide measurements into lower and upper partial columns provides better constraint on model transport errors and uncertainties, and better information on whether variations in carbon dioxide result from nearby (lower partial column) versus transported (upper partial column) sources. Previous studies have shown that model transport error results in uncertainties in the carbon dioxide emissions and uptakes on continental scales and that vertically resolved observations can identify and constrain transport error.

Publications and Presentations

Kulawik,S., et al. Wednesday, 14 December 2016, 08:30 - 08:45. Moscone West – 3004. A31N-03 Lower-tropospheric CO2 from near-infrared ACOS-GOSAT observations

Kulawik, S. et al. Lower-tropospheric CO2 from near-infrared ACOS-GOSAT observations, Atmos. Chem. Phys., 17, 5407-5438, https://doi.org/10.5194/acp-17-5407-2017, 2017.

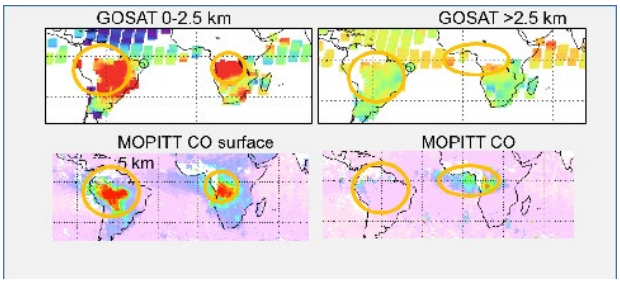


Figure 12: MOPITT multi-spectral CO is used to validate the partitioning between LMT-XCO_2 and U-XCO_2 in the tropics where the GOSAT prior is constant vertically. In the burning season, high values are seen at the surface in South America for GOSAT LMT-XCO_2 and MOPITT. Outflow shows up in the free troposphere in later months.

2017 Accomplishments

- Created vertically resolved products of carbon dioxide for the ACOS-GOSAT v3.5 dataset; and
- Validated the new products versus aircraft and surface observations and published in the ACPD paper, "Lower-tropospheric CO2 from near-infrared ACOS-GOSAT observations."

Plant Physiology

NASA: Dave Bubenheim
BAERI: Dave Wilson, Greg Schlick

ARC-CREST researchers on the Plant Physiology team are studying the ecophysiology of biological systems in both synthetic and natural environments. In natural environments, the team is investigating how plants respond to environmental toxicity, bioremediation, and adaptation to climate change, as well as how invasive plant species impact ecosystem functions. This investigation is especially important because the range of many plant species is expected to shift with changing climate and associated changes in resource availability. As the climate changes, different types of plants may be co-located that were not historically within the same ecosystem. This project is currently focused on the Yellowstar Thistle and Cheatgrass, invasive species to California.

The team uses a variety of techniques including: forward osmosis for determining toxicity thresholds; growth chambers, and experiments to induce phenology changes; soil water dynamic studies; and remote sensing techniques (e.g. hyper-spectral imaging to view accumulation of toxins). These techniques are also used to investigate carbon flux and plant physiology.

Finally, the Plant Physiology team is developing "Sustainable, Closed Ecology Systems" to provide life support for space travel and other planetary habitats. Using plants to produce food, oxygen, and water while removing CO_2 from the air and recovering nutrients from wastes is important to achieving sustainable, self-sufficient human settlements in space or on other planets.

2016 Accomplishments

Water Hyacinth (WH) Mapping

• Developed a new methodology for generating bi-weekly WH percent cover maps from (30 meter) Landsat satellite imagery for the SF Bay and Delta;

• Created and shared with CA-DBW a new SF Bay and Delta online map viewer for 30 meter WH percent cover layers from the past five years (http://cquest.arc.nasa.gov:8399/flexviewers/sf_wetlands/) ;

• Acquired and processed AVIRIS (15 meter) airborne hyperspectral imagery and classified pure stands of WH in the Delta for Landsat product verification; and

• Conducted on-water, field verification of mapping tool accuracy and relevance to directing field management practices such as herbicide application.

Submerged Aquatic Plant Mapping

• Acquired and processed AVIRIS (15 meter) airborne hyperspectral imagery and tested classification methods for Egaria densa; and

• Acquired and processed (2 meter) airborne hyperspectral imagery and tested classification methods for Egaria densa.

Delta Ecosystem Modeling

• Set-up successfully the USDA Soil and Water Assessment Tool (SWAT) for the Legal Delta area and tested agricultural drainage water quality simulations; and

• Overlaid actual agricultural drainage return pumping locations for Delta Island tracts.

Plant Environmental Response Testing

• Collected reviewed Water Hyacinth growth models;

• Developed environmental response input structure for model development; and

• Initiated controlled environment response studies with Water Hyacinth and Egaria densa.

Pointing Schedules of Agile Spacecraft

NASA: Kimberly Hines
BAERI: Sreeja Nag, Alan Li

Distributed Space Missions (DSMs) such as formation flight and constellations, are being recognized as important solutions to increase measurement samples over space and time. Given the increasingly accurate attitude control systems emerging in the commercial market, small spacecraft now can slew and point within few minutes of notice. In spite of hardware development in CubeSats at the payload (e.g. NASA InVEST) and subsystems (e.g. Blue Canyon Technologies), software development for tradespace analysis in constellation design (e.g. Goddard's TAT-C), planning and scheduling development in single spacecraft (e.g. GEO-CAPE) and aerial flight path optimizations for UAVs (e.g. NASA Sensor Web), there is a gap in open-source, open-access software tools for planning and scheduling distributed satellite operations in terms of pointing and observing targets. This project will demonstrate results from a tool being developed for scheduling pointing operations of narrow field-of-view (FOV) sensors over mission lifetime to maximize metrics such as global coverage and revisit statistics. Past research has shown the need for at least fourteen satellites to cover the Earth globally everyday using a Landsat-like sensor. Increasing the FOV three times reduces the need to four satellites, however adds image distortion and BRDF complexities to the observed reflectance. If narrow FOV sensors on a small satellite constellation were commanded using robust algorithms to slew their sensor dynamically, they would be able to coordinately cover the global landmass much faster without compensating for spatial resolution or BRDF effects. Our algorithm to optimize constellation satellite pointing is based on a dynamic programming approach under the constraints of orbital mechanics and existing attitude control systems for small satellites. As a case study for our algorithm, we minimize the time required to cover the ~17000 Landsat images with maximum signal to noise ratio fall-off and minimum image distortion among the satellites, using Landsat's specifications. Attitude-specific constraints such as power consumption, response time, and stability were factored into the optimality computations. The algorithm can integrate cloud cover predictions, specific ground and air assets and angular constraints.

Publications and Presentations

Nag, S., A.S. Li, J.H. Merrick "Scheduling Algorithms for Rapid Imaging using Agile Cubesat Constellations", COSPAR Advances in Space Research - Astrodynamics, November 2017, DOI:10.1016/j.asr.2017.11.010
Nag, S., T. Hewagama, G. Georgiev, B. Pasquale, S. Aslam, C. K. Gatebe, "Multispectral Snapshot Imagers onboard Small Satellite Formations for Multi-Angular Remote Sensing", IEEE Sensors Journal 17, no. 16 (2017), 5252-5268, DOI: 10.1109/JSEN.2017.2717384
Nag, S., C.K. Gatebe, T.Hilker, "Simulation of Multiangular Remote Sensing Products Using Small Satellite Formations", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 10, no. 2 (2017), 638-653, DOI: 10.1109/JSTARS.2016.2570683
Nag, S. J. Jung, K.S. Inamdar, "Communicating with Unmanned Aerial Swarms using Automatic Dependent Surveillance Transponders", IEEE Sensors Conference, November 2017
Nag, S., S.P. Hughes, J.J. Le Moigne "Navigating the Deployment and Downlink Tradespace for Earth Imaging Constellations", International Astronautical Congress, Adelaide, Australia, September 2017
Nag, S., Alan S. Li "Scheduling for Rapid Response Imaging using Agile, Small Satellite Constellations", 11th IAA Symposium on Small Satellites for Earth Observation, Berlin, Germany, April 2017
Nag, S.,"Sensor Webs of Agile, Small Satellite Constellations and Unmanned Aerial Vehicles with Satellite-to-Air Communication Links", 1st IAA Latin American Symposium on Small Satellites - Advanced Technologies and Distributed Systems, Buenos Aires, Argentina, March 2017.

2017 Accomplishments

- Published the following journal article on the pointing project - S. Nag, A.S. Li, J.H. Merrick "Scheduling Algorithms for Rapid Imaging using Agile Cubesat Constellations", COSPAR Advances in Space Research - Astrodynamics, November 2017, DOI:10.1016/j.asr.2017.11.010;

- Presented the following conference paper on the same project - S. Nag, Alan S. Li "Scheduling for Rapid Response Imaging using Agile, Small Satellite Constellations", 11th IAA Symposium on Small Satellites for Earth Observation, Berlin, Germany, April 2017; and

- Proposed a continuation for onboard scheduling for NASA NIP 2018 (pending results); and

- Began work adapting the algorithm for Distributed Spacecraft Autonomy).

Sentinel-2

NASA: Jennifer Dungan, Ramakrishna Nemani
BAERI: Sangram Ganguly, Shuang Li

Global climate change research suggests that extreme weather events are expected in higher frequency, intensity, and duration at global scales and these events will have drastic changes in both agricultural and forest landscapes. Higher temporal frequency moderate resolution data are required for monitoring agriculture production and forest status. To meet this need, multi-source (Landsat 8 and Sentinel-2) land imaging products have been proposed and prototyped by the NASA Earth Exchange (NEX, http://)nex.nasa.gov). In collaboration with the research scientists at NASA's Goddard Space Flight Center and NASA's Land-Cover/Land-Use Change Program, this project is integrating the 6S radiative transfer (RT) model, BRDF correction modules and spectral response function calibration modules to generate harmonized daily Surface Reflectance products from Landsat 8 OLI and Sentinel-2 MSI. During the evaluation period, the project focused on two points for the HLS project: 1) examine the radiometric characteristics of Landsat-8 OLI and Sentinle-2 MSI, and conduct cross-calibration to demonstrate how data from multiple moderate-resolution satellites can be harmonized together, and 2) Collaborate with the HLS project investigators to solve the version 1.3 issues.

Publications and Presentations

JOURNAL ARTICLE:

Li, S., S. Ganguly, J.L. Dungan, W.L. Wang, and R.R. Nemani, (2017). Sentinel-2 MSI Radiometric Characterization and Cross-Calibration with Landsat-8 OLI. Advances in Remote Sensing, 6, 147-159. doi:10.4236/ars.2017.62011

Li, S., J. Weigand, S. Ganguly (2017). The Potential for Climate Impacts from Widespread Deployment of Utility-Scale Solar Energy Installations: An Environmental Remote Sensing Perspective. J Remote Sensing & GIS. 6: 190. doi:10.4172/2469-4134.1000190

2017 Accomplishments

• HLS v1.3 release. The major progress of the HLS project 2017 is the release of HLS V1.3. However, the data format of current HLS V1.3 has readability issue by GDAL (Geospatial Data Abstraction Library), an important open source GIS library). Since GDAL is the backend of many popular GIS/RS software, the HLS could not be released as a formal NASA EOS product if it cannot be correctly recognized by GDAL. We identified this issue to the Multi-Source Land Imaging team and began the process to solve it. We worked closely with the NASA Goddard people to explore the technical solutions. Using NASA HDF4-EOS2 procedure, the HLS team finally correctly integrated coordinate reference information into the hdf files. The NASA NEX team reviewed/validated the latest HLS product and confirmed that the new HLS product fully complies with NASA HDF4-EOS2 procedure. This effort makes possible the next HLS V1.4 release by the end of 2017;

• Published paper of Landsat 8 OLI and Sentinel-2 MSI cross calibration; and

• Collaborate with the PIs of the Multi-source Land Imaging (MuSLI) project team for MuSLI supporting.

Improvement of HLS v1.3

• Expand the study area. There are 63 sub-regions in total, corresponding to 747 MGRS tiles (Sentinel-2) and 630 WRS2 scenes (Landsat 8);

• Fixed bug in spectral correction: Coefficients were not correctly calibrated. Updated coefficients are provided in the User Guide;

• Fixed bug in the BRDF normalization;

• Revised Quick-looks to now follow the "Full Resolution Browse" display algorithm used by USGS, relying on the red, NIR and SWIR 1.6 spectral bands; and

• Quality Assessment is now provided per-site in addition to per-tile.

Terrestrial Ecosystem and Carbon Simulation Modeling

NASA: Chris Potter
CSUMB: Steven Klooster; Vanessa Brooks Genovese

The ARC CREST Carbon research group utilizes the NASA-CASA (NASA-Carnegie-Ames-Stanford Approach) model, or the scaled-down version of the model called CASA Express, to model terrestrial trace gas fluxes (CO_2, CH_4, N_2O and NO) and plant production at global and regional scales. The model is one of a few satellite coupled global models that simulates controls over terrestrial production processes, interactions of trace gas flux components through nutrient substrate availability, soil moisture availability, temperature stress, soil texture and microbial activity. This model is a highly aggregated representation of major ecosystem carbon and nitrogen pools and associated transformation variables. NASA-CASA's modeling of biogeochemical cycles of carbon and nutrients provides a unique understanding of biosphere-atmosphere interactions. The carbon research team uses the NASA-CASA modeling results for predicting ecosystem responses to global climate warming and changes resulting from land use patterns, as well as for understanding influences on terrestrial net primary productivity, quantifying carbon pools, and estimating trace gas fluxes. This model has been used to generate maps of annual net primary production (NPP) and aboveground biomass carbon stocks in forests over various regions of the world. The Carbon team was primarily funded by the following projects this year: USDA-ARS California Delta Areawide Project for Integrated Resource Management, USDA/NASA Coffee mapping and BLM desert research project.

Publications and Presentations

Gaertner, J., V. B. Genovese, C. Potter, K. Sewake, and N. C. Manoukis. 2017. Vegetation Classification of Coffea on Hawaii Island using Worldview-2 Satellite Imagery. Journal of Applied Remote Sensing, 11(4), 046005. http://dx.doi.org/10.1117/1.JRS.11.046005.

2017 Accomplishments

USDA-ARS California Delta Area Wide Project for Integrated Resource Management

- Focused on using satellite and areal imagery to predict where water primrose and water hyacinth were growing across the delta. The goal of the Delta project is to reduce or eliminate the economic and environmental damage caused by large populations of water hyacinth and other invasive aquatic plants.

The Hawaii Coffee Berry Borer Modeling

- Tracked and predicted the spread of the coffee berry boring beetle which is causing widespread damage and destruction of coffee fields across the state of Hawaii; and

- Mapped coffee fields in the island of Maui.

BLM desert research project

- Worked on this multi-agency project designed to produce environmental data over the southern California desert landscape to assist in the decision-making concerning the development of utility-scale renewable energy installations in these areas;

- Mapped desert rocks and pavements using high resolution imagery to detect the extent and recent disturbances in landscapes.

Figure 13: The team provides support to users of SilvaCarbon, a technical assistance program sponsored by U.S. agencies and intended for forest managers around the world who use SilvaCarbon's models and outputs to understand changes in forest carbon.

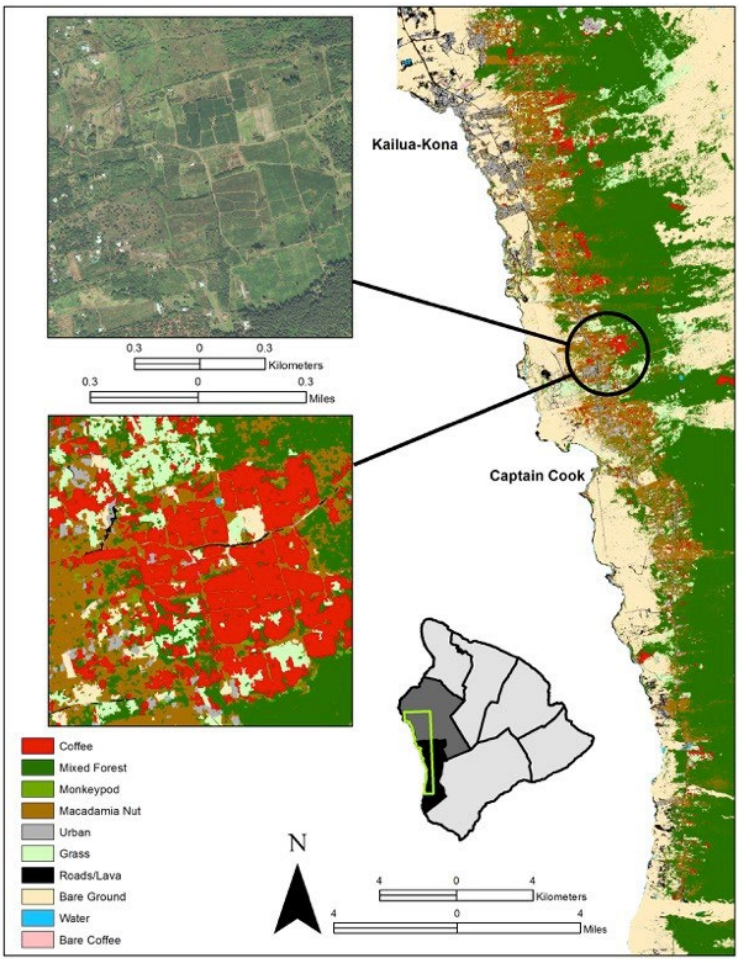


Figure 14: The Hawaii CBB project main objectives are to track and predict the spread of the coffee berry boring beatle which is causing widespread damage and destruction of coffee fields in the state of Hawaii. The Carbon team has been working with the USDA office in Hawaii to map coffee fields over the Big Island for several years to analyze the land cover change caused by the coffee berry borer

Total Carbon Column Observing Network (TCCON)

NASA: Laura Iraci, Jim Podolskie
BAERI: Patrick Hillyard

NASA Ames deployed a Fourier Transform Spectrometer (FTS) as part of the Total Carbon Column Observing Network (TCCON) to the Armstrong Flight Research Center (AFRC) in July 2013. The TCCON FTS is a solar-looking spectrometer that captures solar interferograms throughout the course of the day. After post-processing and converting the interferograms into spectra, fitting routines and further processing can be performed to obtain column-averaged dry-air mole fractions for gases of interest by looking at specific spectral regions. Currently, TCCON provides mole fractions for CO_2, CH_4, CO, N_2O, HF, H_2O, and HDO. The TCCON data can be used alone, as part of the international TCCON network, or in conjunction with other instrumetation to perform studies that relate to the above-mentioned gases.

Furthermore, the launch of the OCO-2 satellite has brought with it the need for highly accurate data with which calibrations can be performed. The NASA Ames TCCON has provided a great deal of data for the purpose of OCO-2 calibration. It has additionally been utilized for comparison with GOSAT data, in conjunction with aircraft in-situ measurements, and for comparision of data from the relatively new, portable Bruker EM27 solar spectrometer.

Publications and Presentations

M. Inoue, et al. (L. Iraci, J.R. Podolske and P. Hillyard are among 46 co-authors). Bias corrections of GOSAT SWIR XCO_2 and XCH_4 with TCCON data and their evaluation using aircraft measurement data, Atmospheric Chemistry and Physics.

2017 Accomplishments

- Maintained and managed the Linux workstation that is used for data processing and storage;
- Downloaded the data from the Armstrong Flight Research Facility (AFRC), and processed it according to the TCCON protocol in order to be comparable to other instruments in the network;
- Analyzed data including the processing of FTS interferograms as well as the fitting of the spectra in spectroscopic regions of interest for a given gas;
- Managed quality control, transferred the data to the California Institute of Technology, and safely archived the data at NASA Ames; and
- Used the FTS data in conjunction with GOSAT data and in-situ data taken at a network of sites around Indianapolis.

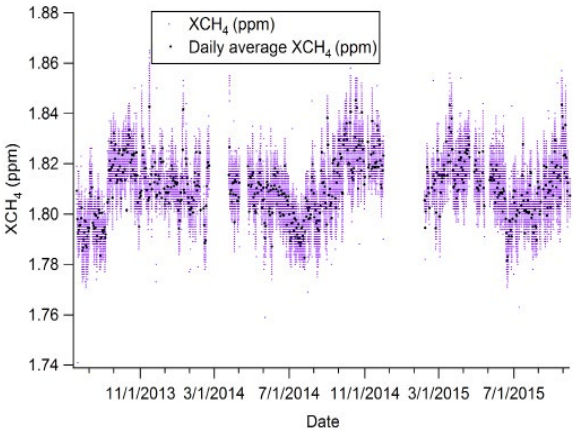


Figure 15: Column averaged, mole fractions of CH_4 in parts per million as measured by the TCCON instrument deployed at NASA-AFRC. Daily averages are shown in black.

Tropospheric Emission Spectrometer (TES)

NASA: John Worden
BAERI: Susan Kulawik

The Tropospheric Emission Spectrometer (TES) is an infrared spectrometer flying aboard the Aura satellite, currently in Earth orbit. Its high spectral resolution enables it to measure concentrations of many chemical constituents in our atmosphere including: ozone (O_3), carbon monoxide (CO), water vapor (H_2O), peroxyacetyl nitrate (PAN), formic acid (CH_2O_2), methanol (CH_3OH), methane (CH_4), and other gases. Measurements made by TES advance our understanding of the atmosphere's chemistry, knowledge that is a prerequisite to addressing air pollution and climate change. TES focuses on the troposphere, the layer of atmosphere that stretches from the ground to approximately 32,000 ft. TES can distinguish concentrations of gases at different altitudes, a key factor in understanding their behavior and impact. It is the first orbiting instrument able to measure ozone profiles, a very important chemical with regard to both global warming and air pollution.

ARC-CREST researchers and their partners at NASA-JPL are analyzing and interpreting TES data, making high quality TES data products available to the scientific community.

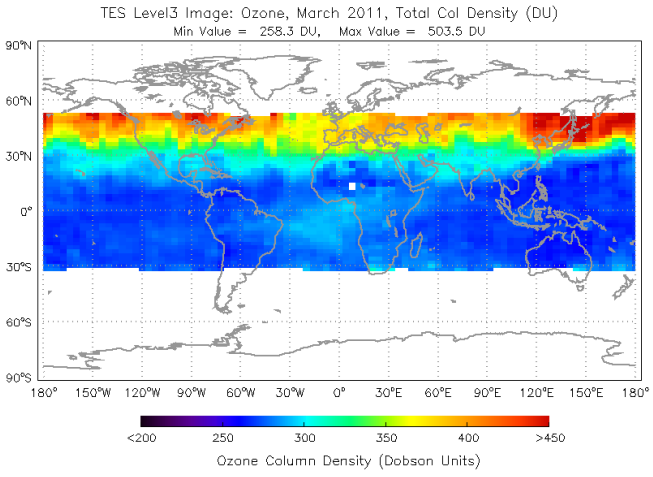


Figure 16: An example of data collected by the TES instrument. The figure is a global image of the total column density of ozone for the month of March in 2011. The ARC-CREST members of the TES team work to continually improve and expand the retrieval algorithms for TES data products.

Their work requires close coordination with the NASA Distributed Active Archive Center where these large datasets are hosted. Further, they work closely with the TES science team to expand the retrieval algorithms to capture additional atmospheric gas concentrations, to improve existing algorithms by reducing or better quantifying errors, and to conduct comparisons with other satellite or ground-based retrievals.

2017 Accomplishments

- Worked with the software team to transition the multi-satellite retrieval code to an operational code being run by the software team on OMI and AIRS data to continue the A-Train ozone record begun by TES;
- Developed TES ozone time series products for the Total Ozone Assessment Report (TOAR); and
- Continued to support TES "Lite" products which are easier for first time users, and continued development of the TES-heritage multi-satellite retrieval code.

Publications and Presentations

Kulawik, S., Vivienne Payne, Emily Fischer, Dejian Fu, "Acetone and Hydrogen Cyanide from Aura-TES", August 30-Sept 1, 2016, Rotterdam, The Netherlands.

Kulawik, S., Vivienne Payne, Emily Fischer, Dejian Fu, "Using TES retrievals of HCN to determine fire influence of Aura-TES footprints", AGU Fall Meeting, 12-16 December, 2016, San Francisco, CA

EARTH SCIENCE APPLIED SCIENCES PROGRAM

Disaster Management

NASA: Jim Brass
CSUMB: Vince Ambrosia, Robert Dahlgren

The The Disaster Task is composed of two principal elements: 1) Staffing to support the NASA Applied Science Program and 2) Supporting the development of airborne UAS and related sensor system technologies to enable improved science and applications data collection mission for NASA and partnering agencies and organizations. This element encompasses UAS systems development (and sensors) optimized for disaster support within the overall context of earth science mission support. The description of the two major components of the Disaster Task are presented below:

A. Disaster Task Element 1: Since 2013, Dr. Ambrosia has supported a portfolio of funded project efforts within the ASP-Wildfire Program. That responsibility includes scientific oversight of the project goals and objectives, budgetary management of the funded efforts of disparate organizations and investigators, metrics monitoring for the projects, interactions with partner agencies involved in the projects and serving as a representative on regional, national, and international wildfire science and applications panels and boards. Additional activities include organization and planning of national and international symposia and forums, as well as participating and collaborating in workshops and webinars, highlighting the ASP-Wildfire program and access and use of EO data to support wildfire science and applications by the community

B. Airborne systems (UAS for Environmental and Disaster Monitoring and Science Support)
(1) Research directed at lowering the cost of remote sensing using small unmanned aerial systems (sUAS), aka small drones, as stable low-altitude platforms to host payloads such as sensing instruments. What is unique about this research is the concept of modularity that allows UAS airframes that can be assembled Lego*-like and scaled such that they are holistically optimized to maximize performance for a given remote sensing mission. As a demonstration concept, components from surplus military sUAS are converted into modular aircraft capable of a variety of configurations, which are in development and scheduled for flight testing at the end of 2016. Some of the applications of these mass-customized aircraft will be volcanic plume observation, magnetometer surveys, wildlife census, marsh erosion, post-wildfire recovery, landslide hazard mapping, geological survey, inundation mapping, mudflat quality and quantity, and other data collection campaigns.

(2) Applied research and improvement of sensors and instruments for onboard manned and unmanned aircraft. This includes development and construction of specific instruments such as n-STAR, sun glint sensor, and polarimetric sensors. This work also includes the integration of payloads such as MicroDOAS and MFAM that often require significant effort for suspension system, aerodynamics, electromagnetic compatibility (EMC), and system engineering development.

(3) Electrical engineering of avionics and telemetry systems for commercial sUAS and larger military surplus unmanned aerial systems (UAS) at the NASA Ames Research Center. Subject matter expert in optical sensor physics, gyroscopes/accelerometers, lasers, and EMC testing.

(4) Education and outreach activities supporting several undergraduate and graduate interns at NASA Ames Research Center. Provide mentorship and focused sUAS projects for intern teams during the summer, and individuals throughout the school year, via a variety of programs.

*Lego is the trademark of the LEGO Group, Billund, Denmark.

Figure 17: Airborne systems (UAS for Environmental and Disaster Monitoring and Science Support)

2017 Accomplishments

Disaster Element Task 1 (Ambrosia)

• Organized a series of meetings and workshops in support of the NASA Applied Science Program- Wildfire Program. These workshops and meetings included planning agendas, budgetary control of the meeting expenses, contracting services, organizing speakers, development of breakout sessions, securing meeting facilities and securing A/V support to meetings;

• Managed a portfolio of 9 NASA ASP-funded Wildfire projects, including metrics tracking, budget maintenance and reporting, investigator interface, partnership / co-agency development and maturation and review / evaluations of work accomplished by those 9 teams;

• Represented NASA Applied Science Program on inter-agency, regional, national, and international science panels focused on wildfire assessment, including the USGEO / GEO Global Wildfire Information System (GWIS) Committee; Inter-agency Arctic Research Policy Committee (IARPC) - Wildfire Implementation Team (WIT); JFSP Fire and Smoke Model Evaluation Experiment (FASMEE) Team;

• Briefed NASA HQ management of programmatic goals and metrics of the Wildfire Program during quarterly ASP Programmatic Reviews;

• Sat on Technical and Scientific Panel of international remote sensing conferences, including the ISRSE 2017 meeting, the RSCy2017 meeting, and the 2017 Alaska Fire Science Consortium Workshop;

• Represented NASA Wildfire element by serving on Planning Committees for upcoming scientific symposia;

• Provided scientific peer review of 6 manuscripts submitted to journals in 2017;

• Wrote and managed the NASA ROSES16 A.50-Group on Earth Observations (GEO)Work Programme; 3.3.7 Global Wildfire Information System (GWIS) sub-element solicitation; lead the panel review selection and session, and serve as manager of the GWIS program projects (3) in that solicitation for 2017 through 2020;

• Reviewed one USDA SBIR submission for fire science support;

• Worked with NASA HQ Public Affairs on program descriptions and development of press releases and video of wildfire program project highlights

• Managed scientific content for the NASA Applied Science Program - Wildfire website; and

• Performed for an ASP-Wildfire Quarterly report video-blog on the NASA website.

Disaster Element Task 2 (Dahlgren):

FrankenRaven

• Oversaw, as Principal Investigator, demonstration vehicles developed by this project and flight tested during 2017. This ARMD funded LEARN-2 project "A Modular UAS Framework for Customizable Autonomy Research" has completed after a no-cost extension in June 2017 and final report was submitted.

Carp Tracking

• Managed a mission in Missouri with USGS personnel from the Columbia Environmental Research Center (CERC) to perform a feasibility demonstration of radio tracking of invasive carp. In this demonstration, a hexacopter UAS was used in combination with a direction-finding antenna to accurately locate a radio tag placed underwater in the Salt River at the Ted Shanks Wildlife Refuge.

Icing Testing of UAS

• Managed the characterization of three UAS in the Icing Research Tunnel (IRT) at the NASA Glenn Research Center. This involved coordination with multiple Federal agencies (USCG, NOAA, DOE) and test article suppliers (Navmar, Griffon, Pemdas, CU) and the IRT facility.

Education and Outreach

• Participated in the Naval Research Enterprise Internship Program (NREIP). Due to data-entry error by the Ames Education office there were an unusually large number of students for the summer. 2017 was the third year that the project, placing three ROTC interns during the summer. The 2016 NASA internship alumni are:

Ricky R. Palomares (Cal Poly Pomona)

Ravi Prathipati (Arizona State Univeristy)

Stanley V. Travers (university of DC)

Thomas H. S. Haig (Bowdoin College)

Hiram Gascot (NC State University)

Joseph S. Thurling (Cal Poly SLO)

Robert Comstock (Cal Poly SLO)

Matteo A. Clark (Virginia Tech)

Jared Sagaga (San Jose State University)

Sean Lam (University of Washington)

Cameron Hayes (San Jose State University)

SIERRA-B

• Provided general electrical engineering support for the Sierra-B project, and medium-class UAVs. A schematic review has been performed on a large drawing set for the Sierra-B aircraft, and a number of issues were addressed.

• Developed, inspected and redesigned the wiring for the sun photometer while keeping the previous wiring drawing standards and methods. Through this project, I evaluate opto-mechanical impairments in the 4STAR instrument and advise the science and engineering teams on photonics matters.

Publications and Presentations

CONFERENCE PRESENTATION:
Hadjmitsis, D.G et al (Ambrosia, V.G. among 17 authors). EXCELSIOR: a European Horizon 2020 Teaming project for the establishment of a Centre of Excellence in the Eastern Mediterranean for Earth surveillance and space-based monitoring of the Environment. From Imagery to Digital Reality: ERS & Photogrammetry: 17th International Scientific and Technical Conference, 16-19 October 2017, Hadera, Israel.

Ambrosia, V. G., 2017. Wildfire Applications at NASA and Extension of GEO-GWIS. Plenary Address at 11th European Remote Sensing Laboratories (EARSeL) - Forest Fire Special Interest Group Workshop, 26 September 2017, Chania, Crete, Greece.

Hadjmitsis, D.G et al (Ambrosia, V.G. among 18 authors). EXcellence Research Centre for Earth Surveillance and Space-Based Monitoring of the Environment (EXCELSIOR) for the Eastern Mediterranean Region: the Establishment of EO Hub for Data, Products and Services, 11th European Remote Sensing Laboratories (EARSeL) - Forest Fire Special Interent Group Workshop, 26 September 2017, Chania, Crete, Greece.

Ambrosia, V. G., L. Friedl and A. Soja, 2017. NASA Applied Science Program: Wildland Fire. Earth Observation Summit, The Role of Remote Sensing in Wildfire Management and Research, 20-22 June 2017, Montreal, Quebec, Canada.

Soja, A., V.G. Ambrosia and L. Friedl, 2017. NASA Fire Science and Applications: Technology, Satellites, Airborne Data and Models. 37th International Symposium of Remote Sensing of Environment (ISRSE), 8-12 May 2017, Tshwane, South Africa.

Ambrosia, V. G. and Friedl, L. 2017. Keynote Address: NASA Earth Science and Applications: New Perspective and Opportunities in a Changing World. Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20 March 2017, Paphos, Cyprus.

Bourgeois, J., Jonathan Stock, Matthew Fladeland, Robert Dahlgren, Laura Valoppi, Cheryl Strong, The Don Edwards San Francisco Bay National Wildlife Refuge: A Natural Laboratory for Federal Agencies and Partners , NASA/USGS Earth Science Poster Session, February 16th, 2017 (Moffett Field, CA)

Dahlgren,R. The Autonomous Systems Development Laboratory: Cultivating a Sustainable Summer Internship Opportunity in UAS at the NASA Ames Research Center, Federal UAS Workshop, February 17th, 2017 (Moffett Field, CA)

Dunagan, S.,Cecilia Chang, Robert Dahlgren, Lauren Fahey, Connor Flynn, Roy Johnson, Meloe Kacenelenbogen, Samuel LeBlanc, Jordan Liss, Jens Redemann, Beat Schmid, Michal Segal-Rosenhaimer, Yohei Shinozuka. Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR) Instrument Improvements, Earth Science Technology Forum 2017, June 13-15, 2017 (CalTech)

Vanderbilt, V., Craig Daughtry, Robert Dahlgren, Estimating leaf water status from Vis-NIR Reflectance and Transmittance, IGARSS (Dallas, TX), TH2.L10.5, July 27th, 2017

Vanderbilt,V., Craig Daughtry, Meridith Kupinski, Christine Bradley, Andrew French, Kevin Bronson, Russell Chipman, Robert Dahlgren Estimating the relative water content of leaves in a cotton canopy, SPIE Polarization (San Diego), 10407-34, September 7th, 2017

Dahlgren,R. Educational Projects in Unmanned Aerial Systems at the NASA Ames Research Center , Visiting Lecture ,October 9th, 2017, Blekinge, Sweden

Dahlgren,R., Matteo A. Clark, Robert J. Comstock, Matthew M. Fladeland, Hiram Gascot III, Thomas H. Haig, Sean J. Lam, Alex A. Mazhari, Ricky R. Palomares, Ethan A. Pinsker, Ravi T. Prathipati, Jared D. Sagaga, Joseph S. Thurling, Stanley V. Travers, Progress toward Modular UAS for Geoscience Applications, American Geophysical Union Fall Meeting, NH31C-08, December 13th, 2017

Dunagan,S., Roy R Johnson, Jens Redemann, Brent N Holben, Beat Schmid, Connor Joseph Flynn, Lauren Fahey, Samuel E LeBlanc, Jordan Liss, Meloe S Kacenelenbogen, Michal Segal-Rosenhaimer, Yohei Shinozuka, Robert P. Dahlgren, Kristina Pistone, Yana Karol, Ultra-Stable Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (5STAR), American Geophysical Union Fall Meeting, A13I-03, December 11th, 2017

Vanderbilt, V.C., Craig S.T. Daughtry, Robert P. Dahlgren, Estimates of Leaf Relative Water Content from Optical Polarization Measurements, American Geophysical Union Fall Meeting, A21B-2160, December 12th, 2017

Jake T Whinnery, Victoria T. Ly, Stanley V. Travers, Jared Sagaga, Robert P. Dahlgren, Diana Gentry, Coastal California's Fog Aerobiology and Ecology: Designing and Testing an Optimal Passive Impactor Collection Unit, American Geophysical Union Fall Meeting, A33I-2506, December 13th, 2017

Arismendi, D. (Robert P. Dahlgren, Diana Gentry among 13 authors), Coastal California's Fog Aerobiology and Ecology: A Local-Scale Survey on Atmospheric Microbial Life, American Geophysical Union Fall Meeting, A43B-2448, December 14th, 2017

Karl R. Anderson, Dave M. Witten II, Kevin O'Connor, Leanne Hanson, Robert P. Dahlgren, Duane C. Chapman, Jonas Jonsson, Ethan A. Pinsker. Radio Tracking Fish with Small Unmanned Aircraft Systems (sUAS), American Geophysical Union Fall Meeting, NH31A-0200 December 13th, 2017

Ecological Forecasting

NASA: Jim Brass
BAERI: Cindy Schmidt

The Ecological Forecasting program is a sub-program within NASA's Applied Science Program whose larger goal is to advance innovative and practical uses of Earth observations and modelling in order to enhance stewardship of natural resources and decision making of public and private organizations. ARC-CREST staff are part of the Program management team. In this capacity, they track the projects in the Ecological Forecasting portfolio, support strategic planning activities, help coordinate annual program review meetings and participate in interagency activities and meetings as required by the Program Manager for Ecological Forecasting. ARC-CREST staff help manage the following projects:

1. Projecting Effects of Climate Change on River Habitats and Salmonid Fishes, PI: Gordon Luikart, University of Montana

2. Bayesian Data-Model Synthesis for Biological Conservation and Management in Antarctica, PI: Heather Lynch, Stony Brook University

3. Bringing Wildlife Management into Focus: Integrating Camera Traps, Remote Sensing and Citizen Science to Improve Population Modeling, PI: Phil Townsend, University of Wisconsin

4. Using NASA resources to better inform wildlife conservation in the Anthropocene: Spatially predicting impacts of anthropogenic nightlight and noise on wildlife habitat integrity across the contiguous United States, PI: Neil Carter, Boise State University

5. Using earth observations and ecosystem modeling to improve the sustainability of agribusiness and extractive industries in working landscapes, PI: Gretchen Daily, Stanford University

6. Informing UN-assisted National Biodiversity Strategy Action Plans with Earth Observations: Application to forest integrity and connectivity, PI: Andrew Hansen, Montana State University

7. Harnessing NASA satellite remote sensing in support of large-scale conservation management on BLM lands, PI: Greg Okin, UCLA.

Publications and Presentations

"Using NASA data for Natural Resource Conservation", GeoLunch presentation, UC Berkeley, November 2017

"Using NASA satellites to monitor a changing Earth", Conservation Genetics workshop, Montana, September 2017

2017 Accomplishments

- Helped organize and attended NASA Ecological Forecasting PI meeting, Washington DC (May);
- Attended team meeting for Montana State project at the UN offices in New York (April);
- Attended team meeting for Montana State project at the University of Maryland and Arlington, VA, followed by a "Data for Sustainability Summit" organized by the United Nations Development Programme in Washington DC (October);
- Attended team meeting for Boise State project in Ft. Collins, CO (March);
- Attended team meeting for UCLA project in Denver, CO (September);
- Worked with PIs to ensure they comply with all Applied Science requirements; and
- Presented project summaries during bi-monthly Applied Sciences program reviews.

Geostationary Coastal and Air Pollution Events Mission (GEO-CAPE)

NASA: Laura Iraci, Vijay Natraj, Brad Pierce
BAERI: Susan Kulawik

The GEOstationary Coastal and Air Pollution Events (GEO-CAPE) mission was recommended by the National Research Council's Earth Science Decadal Survey to measure tropospheric trace gases and aerosols as well as coastal ocean phytoplankton, water quality and biogeochemistry from geostationary orbit. Multiple observations per day are required to determine tropospheric composition and air quality over spatial scales ranging from urban to continental, and over temporal scales ranging from diurnal to seasonal. High frequency satellite observations are also critical to studying and quantifying biological, chemical, and physical processes within the coastal ocean and beyond.

ARC-CREST researchers are involved in mission planning and the development of instrument concepts for this upcoming satellite mission. GEO-CAPE is planned to be in orbit in the 2020 time frame. At this preliminary stage, several instrument concepts are being studied to ensure that a range of potential instruments can meet GEO-CAPE requirements.

Publications and Presentations

Kulawik, S., Vijay Natraj, R. Bradley Pierce, Allen Lenzen, and Helen Marie Worden. A54B-08 O3 OSSEs on a Regional Scale for the GEO-CAPE Mission. Friday, 16 December 2016,17:45 - 18:00, Moscone West - 3010.

2017 Accomplishments

- Focused on real-time simulated retrievals; and
- Performed the first simulated NO_2 retrievals in November.

Figure 18: ARC-CREST researchers are contributing to the planning and development of the GEO-CAPE Mission. Planned to be in orbit ~ 2020, GEO-CAPE will measure tropospheric trace gases and aerosols and coastal ocean phytoplankton, water quality and biogeochemistry from geostationary orbit, providing multiple daily observations within the field of view.

Indigenous Knowledge

NASA: Jim Brass
BAERI: Cindy Schmidt, Amber McCullum, Sherry Palacios, Vickie Ly, Rachel Green

The NASA Applied Science Capacity Building program seeks to better understand the needs and data gaps in the use of geospatial data, particularly NASA Earth science data and products, within Indigenous communities in North America. With their strong links to the land and its ecosystems through indigenous knowledge, stewardship and subsistence practices, Native American tribes are likely to be disproportionately affected by changing climate conditions and other environmental change. Native Americans may be especially affected by changes in the timing and magnitude of water availably (i.e. droughts and floods), sea-level rise, and alterations to the location and health of culturally significant plants, which creates challenges in the preservation of natural and cultural resources.

Tribal members and other long-term residents of particular areas have developed extensive knowledge bases that include deep understanding of local environments and adaptive processes passed down through generations. That knowledge is referred to as "indigenous knowledge" or "Traditional Ecological Knowledge (TEK)" and is holistic in having cultural and spiritual components. TEK encompasses the relation of living beings with each other and the surrounding environment. Indigenous knowledge is based on observations of interrelations among humans, plant and animal species and their surrounding environment. It includes management practices that ensure sustainable use of resources and it strives to minimize ecosystem exploitation. Through treaties and historical precedence, tribes have sovereignty over their lands and rights and responsibilities regarding the protection of natural resources.

The NASA Capacity Building Program Indigenous People's (CBP IP) initiative seeks to determine the best approaches for building capacity for the use of geospatial data with Indigenous groups.

Publications and Presentations

Affiliated Tribes of Northwest Indians Annual Meeting, January 2017

Institute of Tribal Environmental Professionals Climate Change Adaptation workshop, February 2017

Alaska Forum on the Environment, February 2017

3-day remote sensing training: Bureau of Indian Affairs Geospatial Office, Denver, CO, June 2017

3-day remote sensing training: Southwest Indian Polytechnic Institute, Albuquerque, NM, August 2017

1-day remote sensing training: Tribal GIS conference, Albuquerque, NM, November 2017

Indigenous communities: Pathways to social-environmental sustainability workshop, Socio-Environmental Synthesis Center, Annapolis, MD, November 2017

2017 Accomplishments

- Collaborated with the BIA to incorporate remote sensing into their trainings offered to the US tribes. The NASA team completed two trainings and then turned the material over to the BIA. The BIA will be offering and giving the training themselves in the future, starting April 2018;

- Gave a full-day remote sensing training workshop at the 2017 Tribal GIS conference in Albuquerque, NM;

- Began coordinating with the NASA Applied Sciences Disaster program by attending the Disaster Reduction Across the Americas conference in Montreal in March, and organized a session on how indigenous communities across the Americas are developing successful disaster resilience strategies at the Regional Disaster Reduction Across the Americas conference in Buenos Aires, Argentina in September 2017. The session featured speakers from Bolivia, Colombia, Peru, Mexico, Canada and Argentina;

- Acquired funding from the Western Water Applications Office (WWAO, JPL) to develop a drought monitoring tool for the Navajo Nation; and

- Invited to participate in a 4-day workshop at the Socio-Environmental Synthesis Center in Annapolis, MD in November 2017. This workshop focused on developing strategies for climate change and disaster resilience for indigenous groups in Canada and the United States.

Water Resources Program

NASA: Jim Brass
CSUMB: Forrest Melton

The primary objectives of this task are to:

1) Support the NASA Applied Sciences Program, Water Resources application area by serving as an Associate Program Manager for Water Resources, and a Deputy Program Manager for the Suomi NPP satellite mission.

2) Monitor progress across the project portfolio, engage and support project teams in identifying and resolving project issues, and coordinate the ASP Water Resources science community.

3) Engage and support the NASA Applied Sciences stakeholder community.

Publications and Presentations

JOURNAL ARTICLES:

Fisher, J.B., Melton, F.S., Middleton, E., Hain, C., Anderson, M., Allen, R., Mcabe, M., Hook, S., et al., 2017. The future of evapotranspiration: Global requirements for ecosystem functioning, carbon and climate feedbacks, agricultural management, and water resources. Water Resources Research, 53(4), pp. 2618-2626.

BOOK CHAPTERS:

Lee, C.M., Serrat-Capdevila, A., Iqbal, N., Ashraf, M., Zaitchik, B., Bolten, J., Melton, F. and Doorn, B., 2017. Applying Earth Observations to Water Resources Challenges. In Earth Science Satellite Applications (pp. 147-171). Springer International Publishing.

PRESENTATIONS

Melton, F., Huntington, J., Grimm, R., et al. 2017. OpenET: Satellite Mapping of Evapotranspiration in the Western U.S. Water Funders Initiative Briefing, Mountain View, CA, September 18, 2017.

Melton, F., Doorn, B., Bolten, B., Lee, C., et al. Remote Sensing of Water Resources. Water and Long Term Value Conference, San Francisco, CA, Oct 26, 2017.

Melton, F., Doorn, B., Bolten, B., Lee, C., Brennan, S. Remote Sensing of Water Resources. Airborne Snow Observatory Workshop, Mammoth, CA, Sept 12 , 2017.

Melton, F., Doorn, B., Bolten, B., Lee, C., Brennan, S. Remote Sensing of Water Resources. Remote Sensing of ET Workshop, Reno, NV, Sept 14 , 2017.

Melton, F. Advances in Mapping Evapotranspiration with Satellite Data, 2017. National Academy of Sciences, Fifth Arab American Frontiers Symposium, Rabat, Morocco, November 3, 2017 (National Academy of Sciences invited lecture).

2017 Accomplishments

• Tracked and coordinated 9 ASP Water Resources projects. Monitored financial and technical progress and engagement with partners and stakeholders. Communicated regularly with project PIs to identify and resolve issues. Reported project progress to ASP PMs and Associates at 6 ASP Program Reviews;

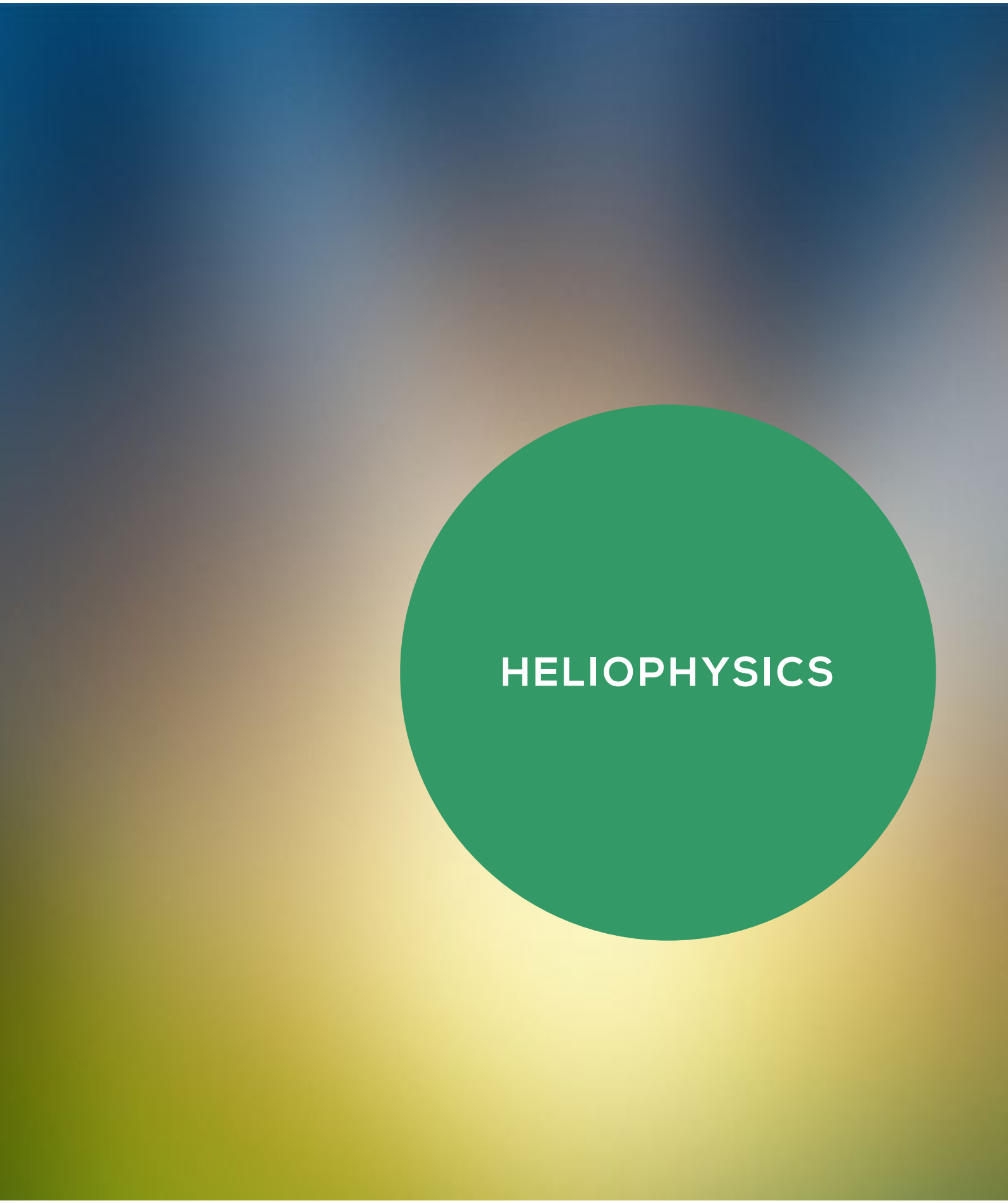
• Co-organized the annual NASA Applied Sciences Program (ASP) Water Resources PI Meeting held at the Jet Propulsion Laboratory, Pasadena, CA, July 18-19, 2017;

• Served as the NASA Representative to WESTFAST and the Climate Change and Water Working Group, which are federal interagency coordinating organizations;

• Maintained the ASP Water Resources website (http://c3.nasa.gov/water);

• Organized 4 hydrology sessions for the 2017 Fall AGU Meeting; and

• Led the organization of a program initiative with the Bechtel Foundation, Google, EDF and the Water Funders Initiative on remote sensing of evapotranspiration (ET). Coordinated 6 ET modeling teams, Google and EDF to prepare joint proposal to EDF. Working with EDF, secured $4.8 million in funding from multiple private foundations for the OpenET effort, which involves six PIs from the ASP Water Resources Community.



HELIOPHYSICS

Heliophysics Modeling and Simulation (HMS)

NASA: Nagi Mansour, David Hathaway
BAERI: Thomas Hartlep

In this project, we study the structure and evolution of the solar interior and surface using numerical simulations. One goal is the modeling of the magnetic field on the entire surface of the Sun. This is challenging because only part of the Sun is visible at any given time. However, knowledge of the entire surface is crucial for space weather modeling and forecasting. Using observational data and a surface flux transport model, we estimate the current state of the solar magnetic field on the entire solar surface and predict its state in the future.

The project also aims to improve our knowledge of the solar interior flows. Signatures of sound waves are visible on the solar surface and allow us to probe the interior similar to earth seismology. Using numerical simulations of wave propagation in the solar interior, we aim to improve helioseismic measurement and inversion techniques. In particular, we simulate how helioseismic waves travel inside the Sun in the presence of localized flow perturbations and measure the resulting changes in travel time of such waves from one point on the surface to another. The aim is to derive improved and realistic sensitivity kernels which relate the observed travel time shifts to the interior flow, and apply them to actual solar observations.

Also, at the present time, fast growing computational capabilities allow us to generate 3D radiative MHD simulations that are capable of reproducing the turbulent dynamics of solar magneto convection and atmosphere with a high degree of realism. Chromospheric processes involve complex non-linear multi-scale dynamics of magnetized and radiating plasma. Recent high-resolution observations from NASA space missions (IRIS, Hinode, and the Solar Dynamics Observatory) have revealed a tremendous complexity of chromospheric structures and dynamics. These include plasma jets, oscillations, waves, shocks, magnetic reconnection events, etc. Observations show that the chromospheric dynamics of the quiet Sun is dominated by spicules and spicule jet-like phenomena of various scales.

A complete physical understanding and quantitative modeling of high-resolution observations, as well as spectroscopic and spectro-polarimetric measurements, can be achieved only by developing time dependent 3D MHD models that take into account all essential mechanisms in the magnetized plasma, including turbulent transport, anisotropic heat and magnetic field diffusion, partial ionization, and radiative transfer. Such simulations have become achievable because of the development of fast supercomputer systems and efficient parallel computing algorithms and codes. Numerical simulations of this type have become increasingly important in the interpretation of observational data and for understanding basic physical mechanisms in the solar atmosphere. To investigate processes of the dynamical coupling and energy exchange between the subsurface layers and the chromosphere we perform 3D radiative MHD modeling for a computational domain that includes the upper convection zone and the chromosphere, and investigate the structure and dynamics solar turbulent magnetoconvection and atmosphere.

Publications and Presentations

Camacho, F. J.; Guerrero, G.; Smolarkiewicz, P. K.; Kosovichev, A. G. and Mansour, N. N. 2017. Exploring shallow sunspot formation by using Implicit Large-eddy simulations. Living Around Active Stars, Proc. of the IAU Symposium, Volume 328, pp. 117-119

Guerrero, G.; Smolarkiewicz, P. K.; de Gouveia Dal Pino, E. M.; Kosovichev, A. G.; Zaire, B. and Mansour, N. N. 2017. Are tachoclines important for solar and stellar dynamos? What can we learn from global simulations. Living Around Active Stars, Proc. of the IIAU Symposium, Volume 328, pp. 61-68

Kitiashvili, I.N. and Collins, N.S. Using Data Assimilation Methods of Prediction of Solar Activity. SHINE workshop, July 24-28, 2017, Saint-Sauveur, QC, Canada

Kitiashvili, I.N., Kosovichev A.G., Wray A.A. and Mansour, N.N. Realistic 3D Radiative Modeling of the Turbulent Structure of Moderate-Mass Stars and the Sun. SHINE workshop, July 24-28, 2017, Saint-Sauveur, QC, Canada

Kitiashvili, I.N., Kosovichev A.G., Mansour, N.N. and Wray A.A. 3D Realistic Modeling of Interaction of Quiet-Sun Magnetic Fields with the Chromosphere. "High-resolution Solar Physics: Past, Present, Future" National Solar Observatory Workshop #30, August 7-11, 2017, Sunspot, NM

Kitiashvili, I.N. and Collins, N.S. Early Estimation of Solar Activity Cycle:Potential Capability and Limits. "High-resolution Solar Physics: Past, Present, Future" National Solar Observatory Workshop #30, August 7-11, 2017, Sunspot, NM

2017 Accomplishments

Surface Flux Transport Effort

• Finalized the flux transport code 'SURF' and sent to the CCMC (Community Coordinated Modeling Center) at NASA/Goddard Space Flight Center to be released to the heliophysics community for Run-on-Request (RoR) calculations; and

• Estimated the effective diffusion coefficient caused by the random motion of supergranules.

Helioseismic Effort

• Completed simulations of wave propagation through 784 localized flow perturbations at different depths and locations inside the Sun (a total of 392 separate large simulations). From these time-dependent simulations, the travel time of helioseismic waves from one point on the surface to another are being computed (ongoing). The inversion code which derives sensitivity kernels given the mentioned travel times was extended from 2-D to 3-D;

• Developed a non-linear mean-field dynamo model, which can describe the essential general properties of solar cycles and the observed sunspot number series (such as Waldmeier's rule);

• Performed 3D radiative MHD simulations by employing sub-grid-scale turbulence models. The numerical simulations reproduce the local dynamo process that is responsible for the quiet-Sun magnetic field; and

• Examined four lines (5250A, 6173A, 6301A' and 15648A) for studying the temporal evolution of Stokes profiles during a small-scale flow eruption in a weak magnetic field region.

BIOLOGY

Synthetic Biology

NASA: Michael Flynn
BAERI: Rocco Mancinelli

This project aims to generate the knowledge required to engineer a potentially broad range of space biotechnology applications employing synthetic organisms and microbial bioreactors for in situ resource utilization and biological life support systems. The project focused on two missions this year: Euglena and Combined Regenerative Organic-food Production in Space (Eu:CROPIS) and Synthetic BioMembranes.

Eu:CROPIS: A significant part of using biological systems (synthetic or naturally occurring) in space is to understand the function of gravity from the gene level to the ecosystem level. Eu:CROPIS will elucidate the nitrogen cycle of an ecological system during srpaceflight. Because Earth has a 1 x g environment, understanding how the nitrogen cycle operates as a function of gravity is key to sustaining life off Earth. To change the gravity levels, the spacecraft will be maneuvered (by spinning) to produce three different gravity regimes during the mission. The three gravity regimes will be 0.01 x g - 0.1-x g (essentially microgravity); 0.16 x g (Moon gravity) and 0.38 x g (Mars gravity). Each gravity regime will last for six months. The Eu:CROPIS core element is a microbiological trickling filter of lava rock – the habitat of a multitude of microorganisms that purify and decontaminate water. It will be the first time nitrogen-transformation reactions will be measured as a function of gravity.

Synthetic BioMembranes: Membranes are a vital component of biological processes. Lipid-based membranes are also used commercially in separation and purification processes. Membranes are used extensively in modern spacecraft for separations, sensors, space suits, and structural components. Man-made membranes created using current technologies have short lifespans due to a susceptibility to chemical, physical, and radiation-exposure damage, resulting in a sizable resupply penalty for long-duration missions. The mission proposes to develop biomimicry capabilities critical for long-duration missions using principles of synthetic biology.

Publications and Presentations

Mancinelli, R.L, Hauslage J, Richter P, Strauch S, Lebert M. "Does gravity affect biogeochemical cycles? The Eu:CROPIS: Euglena: Combined Regenerative Organic-food Production In Space, satellite mission as an example." Presented at Astrobiology Science Conference (AbSciCon) 2017, Mesa, Arizona, April 23-28, 2017. Astrobiology Conference Proceedings, 2017, SESS. 501. (LPI Contrib. No. 1965) Abstract #3388, https://www.hou.usra.edu/meetings/abscicon2017/pdf/3388.pdf, Apr-2017

Mancinelli, R.L, Hauslage J, Richter P, Strauch S, Lebert M. "Using a spinning satellite to determine the effect of gravity on ecosystem N-cycling." Presented at The European Astrobiology Network Association (EANA) 2017, Aarhus, Denmark, August 14-17, 2017. EANA Abstracts. 2017 August. p. 42., Aug-2017

2017 Accomplishments

Eu:CROPIS

- Improved the lighting program so that 100 different intensities can be tested. This will be important, because the light intensity needs to be adjusted to match the increasing cell density (algal growth is the prerequisite of oxygen production);
- Completed construction of the flight unit; testing is ongoing in preparation for a January 2018 launch;
- Refined the computer simulation model by obtaining and incorporating more data from the laboratory studies of the CROP system;
- Better defined the relationship between and pH rates of N-transformation reactions and total amount of ammonium converted to nitrate. It was observed that the rate of nitrification is faster if the pH is not controlled, but the total yield of nitrate is less (i.e., nitrification ceased), whereas if the system is buffered the rate of nitrification is slower, but the total amount of nitrate produced is greater;
- Minimized gas leaks in the laboratory system and ground control; and
- Tested the integrated Eu:CROPIS flight system found that it is working properly.

Synthetic Biomembranes

• Evaluated the benefit if the SBM technology in comparison to the current state of the are as defined by the ISS UPA;

• Used the ESM metric to calculate a system mass for the base FO system, the FO system with the SBM modification and the ISS UPA. Results indicate that the FO with SBM modification reduces the equivalent mass of the FO technology about 80%. The FO technology alone reduces the ESM by 70%. The SBM technology reduces the FO ESM by about 50%. Analytical results show similar performance between the UPA and FO system, with the UPA having slightly better performance.

• Made comparison between regenerating the FA using a bioreactor and providing the FAs as a ground resupply item. The results showed that both options have the same ESM values;

• Evaluated the impact of the key assumption dealing with the FA bilayer replacement requirement. Analysis showed that the impact of going from a daily replacement to an hourly replacement doubled the ESM but was still significantly below the UPA ESM;

• Examined the feasibility of supplying the majority of nutrients required for cyanobacteria growth from the feed. It was shown by previous work growing E. coli that the majority of nutrients required could be provided by the feed; and

• Concluded that the SBM FO configuration has significant ESM benefits over the ISS UPA. These benefits are substantial enough that continued development is recommended. The next step in the development of the SBM is to develop a test system that can be used for long duration testing to demonstrate the SBM technology truly does extend the life of the FO membranes beyond the limits of a Mars or other long duration mission.

AIRBORNE SCIENCE AND MISSION SUPPORT

Airborne Science Support

NASA: Matt Fladeland
BAERI: Patrick Finch, Ron Instrella

The goal of this task is to provide software support to the NASA Airborne Science Program. There are currently three projects:

MTS (Mission Tools Software) Aircraft Tracking: The team has created and is maintaining and improving the software used as the back-end service to the Mission Tools Suite for tracking aircraft. The team makes use of multiple hardware devices, some portable, some less so, which leverage the Iridium network to pass data from a moving vehicle to our server. The team has written software for this data and have made it retrievable over the web for display in MTS. The software infrastructure will be built out to support a new handheld device (Iridium 9575 Extreme handset) offering not just tracking services, but also emergency communication services.

MTS Network Infrastructure: The team is building out a Virtual Private Network to communicate directly with the FAA to effect the tracking of all civilian aircraft over the United States. This effort supplements the individual tracking of specific NASA assets by allowing NASA to track aircraft near its specific assets in real-time. Storing this data will allow users to see how air traffic and weather affect data collection missions.

Airborne Science Data Repository: The team is building a software and storage system to automate the task of uploading data from NASA Airborne Science facilities instruments. At present, all data must be QC'd, uploaded, and made available by hand. This software and storage system will reduce the amount of time between data collection and dissemination.

2017 Accomplishments

- Deployed Iridium Extreme handsets for the MTS Aircraft Tracking project; thus, initial configurations are completed and any further development can be pushed to the platform remotely;

- Made the initial VPN connection for the MTS Network Infrastructure project, so the data machine behind the VPN is live and accessing data. We are in the process of moving out of R&D to the FAA staging network and are using FAA data to track aircraft; and

- Finished initial experimentation for the Airborne Science Data Repository, and a path forward has been identified to automate QC and file uploads.

Airborne Science Advanced Planning

NASA: Matt Fladeland
BAERI: Susan Schoenung, Patrick Finch, Randy Berthold

The Airborne Science Advanced Planning activity seeks to collect information on the needs of the NASA Earth Science community for support from NASA's Airborne Science Program (ASP). ASP provides flight services for Earth Science using NASA aircraft platforms, both manned and unmanned, operating out a several NASA Centers. ASP also provides payload integration services and mission assistance including flight planning, data management, and communications. To ensure that the right capabilities are available and will be available for future science activities, Advanced Planning maintains an out-year schedule of mission plans and the assets and services required. Information is gathered from NASA Earth Science program and from the science community through workshops, conferences, and ongoing interactions.

2017 Accomplishments

- Updated the ASP 5-year plan, monthly, for ASP management;
- Prepared a monthly map of all ESD airborne missions for ASP management;
- Completed preliminary briefing: "Airborne Science Support for NASA Earth Science Satellite and International Space Station Missions";
- Prepared the ASP 2016 Annual Report and two semi-annual newsletters; and
- Participated in various science team meetings related to NASA Earth Science missions to gather airborne requirements data.

Publications and Presentations

Fladeland, M., S. Schoenung, and M. Lord. (2017) "UAS Platforms: A White Paper," prepared for NCAR / EOL Workshop - Unmanned Aircraft Systems for Atmospheric Research, February 2017, Boulder, CO

Figure 19: Pre-flight checks are completed on UAS managed by the Airborne Science Advanced Planning team.

Aircraft Remote Sensing

NASA: Joey Rios
BAERI: Sreeja Nag

The Communications and Navigation (CN) Team of NASA's Unmanned Air Systems (UAS) manages a Traffic Management Project, also called UTM. UTM is a NASA effort, entirely in the public and open-source domain, to enable Civilian Low-Altitude Airspace and Unmanned Aircraft System Operations. These operations are very essential for high resolution airborne remote sensing. Alongside many committed government, industry and academic partners, NASA is leading the research, development and testing that is taking place in a series of activities called "Technology Capability Levels (TCL)," each increasing in complexity. Our role is to assist in research and development of TCL 2. We will identify commercially available technologies for UAS-to-UAS and UAS-to-ground communication, compare them to one another quantitatively, help the team procure select technologies for laboratory testing and assist in ground testing.

2017 Accomplishments

- Assisted the CN team in their holistic goal of setting CN requirements for UTM operations such that ground operators can monitor the state of their UAS and can be operated in a safe environment for remote sensing operations.

Earth Science Project Office (ESPO)

NASA: Marilyn Vasques, Bernadette Luna
BAERI: Erin Czech, Dan Chirica, Erin Justice, Quincy Allison, Sommer Beddingfield, Elizabeth Juvera, Brad Bulger, Ayuta Padhi, Brent Williams and Susan McFadden

The Ames Earth Science Project Office (ESPO) provides project management for NASA's Science Mission Directorate field research. ESPO provides planning, implementation, and post-mission support for large, complex, multi-agency, national and international field missions, especially airborne missions. ESPO has a long history of managing successful field missions, beginning in 1987 with the Stratosphere-Troposphere Exchange Project and the Airborne Antarctic O_3 Expedition experiments. More recently, ESPO's NASA customers have included the Atmospheric Chemistry and Modeling Analysis Program, the Tropospheric Chemistry Program, the Radiation Sciences Program, Atmospheric Dynamics and Remote Sensing, the Suborbital Science Program, and the EOS satellite validation program. Annually, the ESPO team manages the deployment of between six and ten major field missions and continues to provide support to the science team, airplane team, and the larger scientific community for previous years' missions. Finally, the ESPO team plays a critical role in planning for future missions, interfacing with NASA Headquarters, NASA and university scientists, crew members of airborne platforms, local support staff, and the larger scientific community. The unique work done by the ESPO team makes NASA Earth Science's core mission of collecting Earth Science data from airborne platforms with global coverage possible.

Figure 20: ATOM-3: DC-8 getting ready for the Polar Flight from Punta Arenas [10.14.2017]

Figure 21: Part of the ESPO team in São Tomé including BAERI Employees Dan Chirica and Susan McFadden August 2017

2017 Accomplishments

In 2017, the NASA-ARC-based ESPO team supported the following airborne missions under the ARC-CREST agreement:

• ATOM (Atmospheric Tomography Mission) is a five-year project using the NASA DC-8 to circumnavigate the globe four times throughout the project. ATom successfully completed deployments 2 and 3 and ESPO supported the project from the following locations: Palmdale, CA, Anchorage, AK, Kona, HI, Bangor, ME, Fiji, Ascension Island, Cape Verde, Azores, Chile, Greenland, New Zealand;

• ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) is a multi year multi aircraft, NASA Wallops P-3, campaign based out of São Tomé. This year ESPO supported the second deployment for ORACLES. A number of logistical challenges were endured due to working out of a different remote deployment location from last year and the sheer volume of equipment needed;

• KORUS-AQ (Korea United States Air Quality Study) was a multi aircraft campaign, AFRC DC-8 and LaRC B-200, conducted April through June at Osan Air Base in South Korea, with integration taking place at NASA AFRC and LaRC. We've continued to provide after mission support including planning for the science team meeting in 2018;

• EXPORTS (EXport Processes in the Ocean from RemoTe Sensing) is a five-year ocean biology project currently in planning stages. The two deployments are scheduled for summer of 2018 and spring of 2020, using one global class and one intermediate class research vessels. In 2018 Seattle will be the mobilization and demobilization location of the deployment, with approximately 60 scientists and support personnel performing research in the northern Pacific Ocean for 35 days. EXPORTS conducted its first science/planning meeting in September and will have a follow up planning meeting in February.

• CAMP2Ex (Cloud, Aerosol and Monsoon Processes Philippines Experiment). The CAMP2Ex is a response for the need to deconvolute the fields of tropical meteorology and aerosol science at the meso-b to cloud level. The operations will be based in Subic Bay (Philippines), nominally from late July through August 2018. ESPO is providing project management for this mission and BAERI employees helped with website support, mission planning, project coordination, and science team meeting planning.

Figure 22: Missions supported by the NASA-ARC based ESPO team

ESPO Activities:

• Deployed collectively deployed nationally and internationally for over 60 weeks;

• Provided, for all missions, logistical support for the deployment, including: management of deployment sites (facilities, lodging, transport, customs); interface between mission managers, instrument teams, NASA Program Managers and aircraft crew members; coordination of all shipping of equipment and materials (NASA-ARC shipping, university shipping, freight forwarding, customs, local transportation); and deployment setup and on-site support for the duration of mission;

• Managed, for all missions, the Science Operations Flight Request System (SOFRS). SOFRS manages and tracks the allocation of NASA's fleet of scientific aircraft and sensors, which includes over 300 instruments and 50 aircraft. In 2017, SOFRS reported over 4300 science flight hours were flown. ESPO team members continue to upgrade the system with its robust reporting capabilities that allow for comprehensive asset planning and usage analysis;

• Provided, for select missions, additional and specialized support related to instrument integration and operation, data systems support, and communications support for mission teams;

• Provided, for many missions, programming and IT support such as: in-field IT support for website, system and network setup, printer access, local ISPs, and user support for deployments; creation of new websites for missions beginning in 2017; improvement or additions to existing websites including ESPO, ESD, and ASP; maintenance of the ESPO Mission Database, ESPO Data Archive, and ESD Publications Database; maintenance of

archives of all older websites; monitoring of internet technologies and security options for deployment sites; improvement of file sharing options for mission participants;

• Provided, for many of missions, education, outreach, and communications support including: attendance at conferences, support for SAT communications between teachers and in-flight scientists; and support for open-house events at facilities hosting field deployments; and

• Provided, for Earth Science Directorate projects and missions, conference management including orientation, booking space, agenda facilitation, and various administrative tasks.

Conferences

BAERI employees planned and facilitated internationally attended conferences including the 3rd International A-Train Symposium in Pasadena, CA, and the Tenth Meeting of the Ozone Research Managers in Geneva, Switzerland.

Meteorological Measurement Systems (MMS)

NASA: Thaopaul Bui
BAERI: Jon Dean-Day, Cecilia Chang

The Meteorological Measurement System (MMS) provides in situ measurements of static pressure, static temperature, and 3-D winds on several NASA airborne research platforms, including the Global Hawk UAV, Sierra UAV, DC-8, ER-2, WB-57F, as well as the H211 Alpha Jet. These measurements are useful to chemistry studies which rely on our basic state measurements to compute reaction rates of atmospheric pollutants, to microphysical studies which focus on the formation and growth of ice crystals in cirrus clouds, and large scale transport studies which rely on our data to initialize back trajectories. The data are also useful for characterizing advection of pollutants in the planetary boundary layer and the structure and morphology of mesoscale waves which modulate the freeze-drying process of air rising through the tropical tropopause layer into the lower stratosphere.

The MMS is a fast-response (20Hz) system capable of measuring fine scales of turbulence, and thus is useful for computing fluxes of heat and momentum, as well as chemical contaminants when high-rate in situ chemistry instruments are also operating. It is also highly accurate (P, T, and 3-D winds are accurate to +/- 0.3 hPa, 0.3K, and 1 m/s), making it superior to the usual "facility" type navigation instruments which may provide some similar data, but with much degraded accuracy and reliability. Mr. Dean-Day's research focuses on maintaining the scientific validity of the MMS data and in performing some basic research with the measurements as time and opportunity allow.

2017 Accomplishments

- Calibrated and re-processed WB-57 MMS data from the NASA Pacific Oxidants, Sulfur, Ice, Dehydration and cONvection experiment (POSIDON). Utilized flush differential pressure measurements to compute attack and yaw angles. Identified and reconstructed sections of missing temperature data using redundant sensors. Optimized spectral content of winds using available flow angle data. Submit final 1Hz and 20Hz data files to project archive;

- Calibrated and re-processed DC-8 MMS data from the first two deployments of the Atmospheric Tomography project (ATom-1 and ATom-2). Merged LN-251 and LN-100 navigation data to estimate time delays of the aircraft measurements. On selected flights during which CMIGIT velocities were unavailable, LN251 navigation values were substituted to mitigate Shulering effects resulting from the disabled GPS receiver on the LN-100 INS. Submitted final 1 Hz and 20Hz data files to project archive;

- Provided remote data analysis and processing support during the second and third deployments of the Atmospheric Tomography project (ATom-2 and ATom-3). During the ongoing field campaign, evaluated performance of sensors and components using both time series and spectral analysis methods;

- Processed MMS pressure, temperature and wind data from Alpha Jet Atmospheric eXperiment (AJAX) research flights. Monitored and investigated instrument calibrations on an individual flight basis in order to maintain high quality of archived measurements; and

- Reviewed and improved scientific manuscripts which analyzed MMS data from prior field campaigns. Provided context and interpretation of MMS measurements to first authors, clarifying wording and logical presentation, as it relates to the study of turbulence and/or transport of water vapor within the Tropopause Transition Layer (TTL) or lower stratosphere.

Figure 23: An MMS payload is installed on the DC-8.

Publications and Presentations

Herman, R.L. et al. (J. Dean-Day, one of 12 co-authors), 2017. Enhanced stratospheric water vapor over the summertime continental United States and the role of overshooting convection. Atmos. Chem. Phys., 17, 6113-6124, https://doi.org/10.5194/acp-17-6113-2017.

Podglajen, A. et al. (J. Dean-Day, one of 9 co-authors), 2017. Small-scale wind fluctuations in the tropical tropopause layer from aircraft measurements: occurrence, nature, and impact on vertical mixing. J. Atmos. Sci., in press. https://doi.org/10.1175/JAS-D-17-0010.1

Smith, J.B. et al. (J. Dean-Day, one of 12 co-authors), 2017. A case study of convectively sourced water vapor observed in the overworld stratosphere over the United States. J. Geophys. Res., 122(17), 9529-9554. doi: 10.1002/2017JD026831

AWARDS

Group Achievement Award for POSIDON (Pacific Oxidants, Sulfur, Ice, Dehydration, and cONvection) Airborne Earth Science Mission Team.

Meteorological Support

NASA: Leonhard Pfister. Eric Jensen
BAERI: Rei Ueyama, Ju-Mee Ryoo

The NASA-ARC based Meteorological Support group provides meteorological and flight planning support in the planning, execution, and research phases of NASA airborne missions in both the troposphere and stratosphere.

Their work involves four tasks, which follow the time sequence of a typical field campaign from beginning to end: (i) campaign conception and planning, (ii) detailed campaign preparation, (iii) in-field support, and (iv) post-campaign analysis. During the campaign planning phase, they advise the science team on the meteorological conditions relevant for a given science question, which are key to identifying where and when the best measurements can be made. We also develop conceptual flight plans that, along with the specific measurements, are needed to answer the science questions. The second phase, detailed preparation, involves assembling the meteorological and flight planning team, ensuring the availability of meteorological data (e.g., model forecast products, contextual satellite data), designing a meteorological web site, and organizing forecasting and flight planning dry runs. For in-field support, we provide meteorological guidance to the science team in the field (usually in the form of daily weather briefings), provide the software infrastructure for systematic and efficient flight planning, and participate actively in-flight planning discussions. During the post-campaign analysis phase, we provide the science team with the foundational meteorological information needed to interpret their data.

This support requires forecasting knowledge and familiarity with forecasting tools such as atmospheric models and satellite measurements. It also requires continually interfacing and supporting scientists in the community and utilizing mission data in the years following the mission. The ability to provide these met-based mission tools in a timely manner is critical to mission success.

Their analysis of past campaign data has primarily focused on understanding the role of convection in driving tropical UTLS composition.

2017 Accomplishments

- Analyzed the convective influence of air parcels sampled during POSIDON mission and provided the trajectory-based data to the science team;
- Provided meteorological support for ORACLES mission;
- Provided plots of meteorological analysis and forecast fields from NCEP GFS, NASA GEOS-5 and ECMWF model products;
- Provided satellite (infrared, visible, water vapor channels) imagery animations with planned and real-time flight tracks;
- Managed the central meteorological support website with links to various sites useful for flight planning;
- Presented daily weather briefings during the mission;
- Participated in flight planning discussions; and
- Monitored the weather and cloud development during the flights.

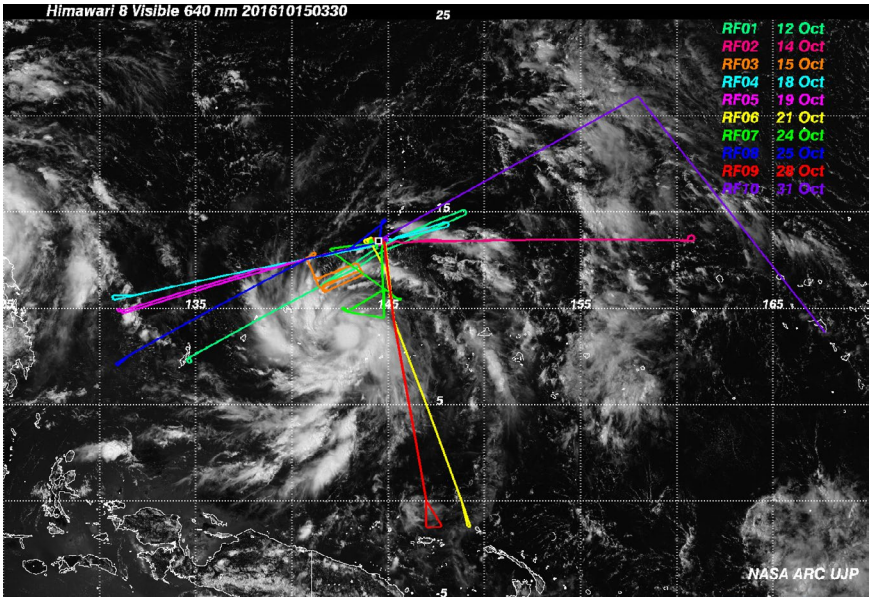


Figure 24: Himawari 8 Satellite Imagery to understand the role of convection in driving tropical UTLS composition.

Publications and Presentations

Jensen, E. J., R. Ueyama, L. Pfister, T. V. Bui, M. J. Alexander, A. Podglajen, A. Hertzog, S. Woods, R. P. Lawson, J.-E. Kim, and M. Schoeberl. Jensen, E. J., et al. (R. Ueyama, one of 35 authors). 2017. The NASA Airborne Tropical TRopopause EXperiment (ATTREX): High altitude aircraft measurements in the tropical western Pacific, Bull. Am. Meteor. Soc.; doi:10.1175/BAMS-D-14-00263.1.

Jensen, E. J., et al. (R. Ueyama, one of 13 authors). 2017. Physical processes controlling the vertical and longitudinal distributions of relative humidity in the tropical tropopause layer over the Pacific., J. Geophys. Res., accepted.

PRESENTATIONS

Ueyama, R. 2017. Recent progress in modeling of tropical tropopause layer water vapor and clouds, American Meteorological Society Annual Meeting 2017 (invited talk).

Ueyama, R., E. Jensen, L. Pfister, and M. Schoeberl. 2017. Convective influence on the lower stratospheric water vapor in the boreal summer monsoon region, NASA Ames Earth Science poster session.

Ueyama, R., M. Schoeberl, E. Jensen, and L. Pfister. 2017. Is convection important for controlling stratospheric humidity?, JpGU-AGU Joint Meeting 2017 (presenter and session co-convener).

Ueyama, R. 2017. Convective influence of air parcels sampled during POSIDON and ATTREX-3, POSIDON science team meeting.

Ueyama, R., E. Jensen, and L. Pfister. 2017. Convective influence on the lower stratospheric water vapor and TTL clouds during boreal summer, Jack Kaye visit to NASA Ames.

Ueyama, R., K. Kodera, L. Pfister, and N. Eguchi. 2017. Impact of tropical lower stratospheric cooling on tropical convection as observed by satellite-derived convective cloud top field, Joint SPARC Dynamics and Observations Workshop (presenter and session chair).

Ueyama, R., M. Schoeberl, E. Jensen, L. Pfister, and M. Avery. 2017. Impact of convection on stratospheric humidity and upper tropospheric clouds, American Geophysical Union Fall Meeting 2017 (presenter and session co-convener).

COMMITTEES AND PANELS

American Meteorological Society Middle Atmosphere Committee

AWARDS

NASA Group Achievement Award for POSIDON

Ames Contractor Council Certificate of Excellence (to the ORACLES Team)

National Suborbital Research Center (NSRC) Mission Operations

NASA: Matt Fladeland
UND/NSERC: Rick Shetter, Melissa Yang, Adam Webster, David Van Gilst, Eric Stith, Michael Delaney, Eric Buzay, Karen Katrinak, Emily Schaller, Jane Petersen

The National Suborbital Education and Research Center (NSRC) is responsible for two tasks for the Airborne Science Program:

Task 1: Science Mission Operations and

Task 2: Education and Training.

In support of Task 1, NSRC addresses all data, SATCOM, engineering and maintenance needs for the following manned NASA airborne science platforms: DC-8, C-130, and the ER-2. In addition, NSRC supports a number of field missions. Accomplishments related to specific airborne platforms are listed below. NSRC accomplishments specific to missions are discussed in their respective sections in this document. In support of Task 2, the NSRC team conducts education and training activities around select field missions. Separately, the NSERC team leads outreach program missions designed to build capacity with science students and teachers.

Figure 25 : DC-8

2017 Accomplishments

DC-8 Specific Engineering and Data and Satcom System Accomplishments

• Conducted extensive environmental testing of instrument components for the DC-8 aircraft as per Armstrong's new regulations;

• Began preliminary planning for the potential ECLIF mission;

• Looked at the details of an avionics tray to accommodate a new TCAS electronics box for the DC-8;

• Coordinated with Armstrong and QuickCrate to get some rack shipping crates made for the medium and low racks;

• Created a new design for a replacement for the original composite radar altimeter antenna panel (which was delaminating), created a detail/assembly drawing to send to the shop for fabrication, and performed a structural analysis of the design;

• Did a minor redesign of time server cooling fan installation to accommodate Meinberg time server;

• Began work on a facility improvement project:

• Installed new window clips for the DC-8 modified viewports that will seat the windows on the O-ring seals in the port;

• Rebuilt and installed FalconView VM on server; and

• Wired up the VectorNav and Serial Converter in the AIMMS-20 canister.

ER-2 Specific Engineering and Data and Satcom System Accomplishments

• Configured real-time data API for all ER-2 campaigns for use on MTS and the Airborne Science tracker;

• Designed a connector bracket for ER-2 Inmarsat router console connectors (VGA and USB), had them made, and reassembled the second canoe after successful electrical/operation checkout;

• Provided backup data systems support;

• Wrote software to facilitate HSRL using data from their instrument on the ER-2 and publishing it to MTS and for display on the P-3 for ORACLES;

• Trained mission managers in the use of the data download laptop; and

• Trained Caitlin Barnes (ASF) in the configuration of the data download laptop.

Specific Engineering and Data and Satcom System Accomplishments (P-3)

• Reintegrated P-3 data system in new rack;

• Reinstalled and verified facility instrumentation;

• Updated systems software and firmware to catch up from re-wing period;

• Installed new fast-syncing time server;

• Integrated 10 instrument teams with real-time data streams; and

• David Van Gilst traveled out to Waco, TX to check on housekeeping wiring in the P-3 to evaluate status of housekeeping wiring after re-wing. This allowed NSERC to be prepared for integration once the P-3 returned to WFF.

Specific Engineering and Data and Satcom System Accomplishments (C-130 (436))

• Designed and constructed new facility instrument suite to accommodate ACT-AMERICA Mission;

• Augmented the Air Data System to meet ACT-America Mission Requirements;

• Installed supplemental high precision transducers on copilot pitot-static system;

• Installed supplemental Rosemount TAT with high precision digital signal conditioner;

• Designed and processed calibration maneuvers;

• Installed 3-Stage Hygrometer (This will need to be moved due to contamination from other air sources);

• Sourced surplus APN-232 Radar Altimeter, allowing provision of radar altitude through the full range of aircraft altitudes at approximately 10% of new cost;

• Installed forward tracking camera;

• Completed design of port for Nadir tracking camera;

• Designed and constructed housekeeping data system, network, and Satcom facilities.

• Implemented gigabit network in cooperation with Pinnacle;

• Designed and constructed system patch panel for power control and signal concentration;

• Designed and constructed wiring harnesses for interface to aircraft avionics and facility instrumentation;

• Integrated NASDAT with aircraft systems and facility instrumentation;

Figure 26: ER-2

Figure 27: C-130

• Designed and implemented UPS backed DC power system allowing system to run on 400Hz power, stay up through power switch over and provide long-endurance support of aircraft GPS splitter;

• Designed and implemented filtered GPS Network for housekeeping system and experimenter use;

• Designed and implemented filtered Iridum antenna system for use with NASDAT.

• Assembled the cockpit Ethernet switch installation and shipped it out to Andalusia with the GPS splitter and WiFi access point assemblies for installation on the aircraft;

• Assembled the radar altimeter R/T adapter;

• Fabricated misc. components for the shelf assemblies and built up the main data system component shelves; and

David Van Gilst traveled out to Andulusia, AL, to install antenna and instrument wiring harnesses on the C130 (436);

• Integrated LN251 into N439NA Data System;

• Designed and constructed wiring harnesses, patch panel and system interfaces;

• Developed software to drive the LN251 startup sequence, diagnose faults and distribute data to the NASDAT and other data system components;

• Developed software to facilitate transfer of satellite data and quick look products without disrupting IRC/xChat communications;

• Mount permanently remaining data system components (UPS, AIS, Network Switch).

• Integrated NAAMES Payload with C-130 Data System; and

• Created a simple blank off plate design for the 102 TAT probes, so that the aircraft can fly without them, if needed.

Overall ASP Development Work (Total Air Temperature Measurement)

• Finalized the details for the pressure bulkhead connector pass-through for the new DC-8 TAT sensor wiring;

• Finalized the TAT sensor signal conditioner mechanical design assembly/installation, ordered parts, coordinated with the shop for fabrication, and assembled the box. The TAT sensor on the DC-8 worked well in KORUS-AQ. The design assembly/ installation was completed prior to deployment with the build-up of the new TAT sensor signal conditioner mechanical assembly;

• Continued work on TAT signal conditioner software;

• High-accuracy digital signal capture system based on Laurel Electronics resistance transmitter

  o Completed thermal stability testing at AFRC Environmental Lab;

  o Completed Packaging and Heating system design; and

  o Anticipated reduction of signal capture error by 50-60%;

• Reduced TAT error from ~ 1°C to .2 - .3 °C.

EDUCATION AND OUTREACH ACTIVITY

Applied Remote Sensing Training (ARSET)

NASA: Jim Brass, Ana Prados
BAERI: Cindy Schmidt, Amber McCullum, Vickie Ly, Sherry Palacios

NASA's Applied Remote Sensing Training (ARSET) Program offers satellite remote sensing training that builds the skills to integrate NASA Earth Science data into an agency's decision-making activities. The project's goal is to increase the utility of NASA Earth Science data for applied resource management professionals, policy makers, and regulatory agencies.

ARSET operates with a gradual learn approach, where they often conduct basic introductory webinars followed by more in-depth advanced webinars or in-person trainings. Their webinars consist of multi-week sessions about a specific topic and can be a combination of lectures, live demos of tool, and tutorials. Recordings of the live webinars are freely available. Most webinar materials are available in Spanish and English. Many courses need no previous experience with remote sensing, but there are prerequisites for advanced webinars. The ARSET program regularly partners with organizations to host two to four day in-person workshops with regionally specific curricula. Conducted in a computer lab, workshops provide a combination of lectures and hands-on activities and frequently feature guest speakers from NASA and other organizations. Attendees learn how to access, interpret and apply NASA data on local and global scales, with an emphasis on case studies.

ARSET conducts trainings in the focus areas of Health and Air Quality, Water Resources, Land Management, Wildfires, and Disasters. The ARSET team is located at multiple NASA centers and consists of scientists with backgrounds specific to the topic area they teach. The Ames team focuses on trainings in the Land Management and Wildfires areas. Since 2009, ARSET has had over 4,000 participants from more than 1,400 organizations and 130 countries. All ARSET materials are free and available for participants to access, use, and adapt.

Publications and Presentations

Wildfire PI meeting, Boise, ID, March

Hyperwall presentations on the use of NASA data for Wildfire applications, IUCN World Conservation Congress, Hawaii, September

From Remote Sensing Dud to Stud: NASA's ARSET Program, AGU Annual Fall Meeting, NASA Booth Presentation, December 2016

2017 Accomplishments

- Conducted advanced webinar: Creating and Using Normalized Difference Vegetation Index (NDVI) from Satellite Imagery (February-March);
- Conducted introductory webinar: Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring (June);
- Conducted introductory webinar: Introduction to Remote Sensing for Coastal and Ocean Applications (July);
- Conducted in-person workshop: From Earth Observations to Earth Applications: Satellite Applications for Biodiversity Conservation, IUCN World Conservation Congress, Hawaii, (September)
- Conducted in-person workshop: Application of Satellite Remote Sensing Data for Fire & Smoke Monitoring, International Smoke Symposium, Long Beach, CA (November);
- Organized and attended a best practice meeting with the USDA Forest Service Remote Sensing Applications Training Center, Salt Lake City, UT (March); and
- Participated in annual programmatic retreat to assess and refine the ARSET mission and vision, Goddard Space Flight Center (November).

California State University at Monterey Bay (CSUMB) Educational Program

NASA: James Brass
CSUMB: Susan Alexander, Kenneth Weinstock

The School of Natural Sciences at CSUMB offers a Bachelor of Science degree program in Environmental Science, Technology, and Policy (ESTP) and a Master of Science degree program in Applied Marine and Watershed Science (AMWS). These interdisciplinary programs emphasize the critical thinking and technical skills necessary to develop workable solutions to complex environmental problems. Our curriculum integrates training in science, technology, economics, and policy that focus on marine, coastal, and watershed systems.

Among its many components, the CSUMB mission emphasizes an educational approach that fosters in students distinctive technical and educational skills, the experience and abilities to start a successful career, the critical thinking abilities to be productive citizens, and the entrepreneurial spirit needed for innovation and success. Because the knowledge and understanding of the Earth system and its processes are increasingly dependent on advanced technologies for acquiring, analyzing and visualizing geospatial information about our planet, expertise in geospatial applications is one of the most sought after skill sets for students pursuing Earth system science careers.

The M.S. in AMWS offers two degree options: PSM and thesis. Within their chosen option, students elect an emphasis in marine or watershed science. Advanced technology training is integrated throughout the applied environmental science and policy curriculum.

Figure 28: CSUMB students in the Environmental Science, Technology and Policy Department survey wetlands in the Elkhorn Slough area, near Monterey California.

Photo credit: CSUMB Environmental Science, Technology and Policy Department

The PSM option within AMWS emphasizes professional skill sets that will distinguish students as they enter the workforce, including: advanced technologies for acquiring, analyzing, modeling and visualizing spatially explicit environmental data; professional and scientific communication; scientific ethics; and environmental economics and policy analysis. Within the PSM option, skills learned in the classroom are matured by students through professional internships. The program satisfies a demand for highly skilled professionals within environmental technology and applied science-based companies, governmental agencies, and non-profit organizations.

The team applies its educational, scientific, and technological expertise to train the next generation of Earth System scientists and to reach out to the public about the project. Specifically, we work to:

- Offer programs and career development opportunities within the Science, Technology, Engineering, or Mathematics (STEM) fields that specifically foster the identification, recruitment, and success of Hispanic, and other under-represented and low-income students;

- Provide hands-on training for undergraduate and graduate students in Earth Science research activities including participation in field campaigns, internships, apprenticeships, and other research experiences;

- Lead educational activities aimed at K-12 students, college and graduate students, and the general public utilizing NASA-developed technologies and results; and

- Communicate results of scientific activities through community outreach events, conferences, publications, and other venues.

2017 Accomplishments

The California State University at Monterey Bay (CSUMB) Educational Program continues to facilitate research collaborations between AMWS graduate students, ESTP senior undergraduate students, Cooperative Agreement Research Scientists, and NASA PIs at Ames Research Center on the following projects:

• ESTP and AMWS students and recent graduates Michael Hang, Dan Muratore, Rachel Spellenberg, Kali Prescott, Elizabeth Patron, Tian Xin Wang, and Josue Duque conducted research and assisted with field activities under the mentorship of ARC CREST Senior Scientist Forrest Melton, ARC CREST Research Scientists Kirk Post and Jason Dexter (within the Ecological Forecasting/NEX and Ag/Health/Marine tasks), and CSUMB Associate Professor Dr. Arlene Haffa;

• ARC CREST Research Scientist Robert Dahlgren worked with students from several universities (via the NASA Summer Internship Program) in support of the Disaster Management task; and

• We promoted student research opportunities at NASA Ames Research Center related to the Cooperative Agreement (e.g. DEVELOP) and will continue to facilitate student involvement in the Cooperative Agreement.

Education Support Products and Benefits:

• Provided hardware/software support and mentoring for 15+ students participating in the DEVELOP Summer 2017 session and year-round support for permanent DEVELOP staff and project teams during the spring and fall sessions. Installed a new IMAC system in DEVELOP to replace a failed system. DEVELOP support activities are expected to continue in 2018 at the same level;

• Provided mentoring and IT support to summer interns associated with the NASA/San Jose State University Center for Applied Atmospheric Research and Education program (CAARE) which is expected to continue in 2018;

• Provided year-round large-format poster graphics output support for scientific meetings with large effort prior to the AGU Fall Meeting for both the Earth Science and Space Science Divisions; and

• Replaced two aging desktop systems providing backup service with two Dell Poweredge C2100 servers acquired from another NASA Ames organization. Upgraded the Retrospect backup software on one system for improved compatibility with current operating systems;

Publications and Presentations

Melton, F., L. Johnson, K. Post, A. Guzman, R. Spellenberg, I. Zaragoza, C. Rosevelt, A. Michaelis, R. Nemani, M. Cahn, K. Frame, B. Temesgen, S. Eching, 2016. Integrating Satellite and Surface Sensor Networks for Irrigation Management Decision Support in California. American Geophysical Union Fall Meeting, San Francisco, CA, Dec 12-16, 2016.

Melton, F., Haffa A., Aqueche K., Cahn M., Cassel-Sharma F., Dexter J., Duque J., Goorahoo D. 3, Hang M., Johnson L., Kortman S., Patron E., 1 Post K., Prescott K., Wang T., Zaragosa I., 2017. Quantifying the Benefits of On-farm BMPs for Irrigation and Nutrient Management, California State University Agricultural Research Institute Conference, Sacramento, CA, Sept 9-10, 2017.

Melton, F., C. Rosevelt, A. Guzman and M. Hang, 2017. Mapping Drought Impacts on Land Fallowing. Google Earth Engine User Summit, Mountain View, CA, June 26, 2017.

Haffa A., W. Horwath, F. Melton, M. Cahn, R. Smith, 2017. Quantifying N2O Emissions under Different On-farm Irrigation and Nutrient Management BMPs that Reduce Groundwater Nitrate Loading and Applied Water. California Department of Food and Agriculture Conference, Sacramento, October, 2017.

Melton, F., I. Zaragosa, J. Dexter, K. Aqueche, B. Burgoa, M. Cahn, J. Duque, A. Haffa, M. Hang, L. Johnson, S. Kortman, E. Patron, S. Pheasant, K. Prescott, R. Smith, S. Triano, T. Wang, 2017. Capacity Building for Agricultural Sustainability on the California Central Coast through

DEVELOP

NASA: James Brass
BAERI: Juan L. Torres-Pérez

The Applied Sciences' DEVELOP National Program addresses environmental and policy issues through interdisciplinary research projects that apply NASA Earth Observations to community concerns around the globe. DEVELOP bridges the gap between NASA Earth Science and society, building capacity in both its participants and partner organizations to better prepare them to handle the challenges that face our society. DEVELOP creates capacity for young professional from diverse academic backgrounds (undergraduate, graduates and recent graduates) on the use of remote sensing and GIS to assess environmental problems. As such, the Ames projects during the past year have comprehended a wide range of themes such as drought, decision support systems for the Navajo Nation, impacts of methane concentrations on the air quality of the San Francisco Bay Area, assessment of the invasive seaweed Sargassum in the Caribbean and the Gulf of Mexico, and environmental factors that influence the presence/absence of disease vectors (e.g., mosquitoes) in tropical countries.

Dr. Juan L. Torres-Pérez began working with DEVELOP as the Center Mentor in 2014. Since then, he has mentored multiple teams of participants in about 20 different projects

2016 Accomplishments

• Provided advice on the use of different imagery available for analysis, methodologies, results, and comments/edits on the deliverables of each project (technical paper, poster presentations, oral presentations, lightning talks, Earthzine videos, etc.);

• Participated each week in staff meetings and seminars; and

• Conducted multiple interviews with the applicants. In total, they reviewed about 150 different applications for all three terms. Usually they expect to recruit six participants on each of the Fall and Spring terms and 12-15 for the Summer term to work on two-three different projects during each term. Throughout the year, they are continuously looking for project partners and ideas for new projects. They usually submit about 7-8 different project proposals per year to the National Program Office for their approval.

Figure 29: A Geospatial Evaluation of Drivers, Occurrences, and Distribution of Hypoxic Events within the Grijalva-Usumacinta River Delta System and the Southern Coast of the Gulf of Mexico

Student Airborne Research Program (SARP)

NASA: Jack Kaye
NSRC: Emily Schaller

The Student Airborne Research Program (SARP) is an eight-week summer program for junior and senior undergraduate and early graduate students to acquire hands-on research experience in all aspects of a scientific mission using NASA's DC-8 or P-3 airborne science laboratories. The DC-8 and P-3 are major NASA resources for studying Earth system processes, calibration/validation of space-borne observations, and prototyping instruments for possible satellite missions. Participants assist in the operation of instruments onboard the aircraft to sample atmospheric chemicals and to image land and water surfaces in multiple spectral bands.

Along with airborne data collection, students participate in taking measurements at field sites. The program culminates with formal presentations of research results and conclusions. Students participating in the program have a strong academic background in disciplines relevant to the Earth system including the physical, chemical or biological sciences, or engineering. Many have experience with image processing and GIS systems.

Figure 30: SARP students with the DC-8.

2017 Accomplishments

- Managed the 2017 Student Airborne Research Program including program design, faculty recruitment, participant recruitment, selection and logistics;
- Completed selection of 32 students from over 200 applications;
- Provided logistics for 32 students;
- Organized all science flights;
- Selected the top student presentations for participation at the AGU conference;
- Organized the conclusion of SARP 2017 with final student presentations, the final graduation meeting, collection of student evaluations and SARP laptops, and checkout from the UCI housing, return of the students for their flights home to the John Wayne airport, and return of SARP equipment and staff to Armstrong Building 703;
- Distributed flyers about SARP at the NASA Airborne Science table at AGU 2017;
- Assisted the 13 SARP 2017 students attending AGU with preparing their presentations; and
- Organized SARP alumni reunion dinner during AGU.

PUBLICATIONS AND PRESENTATIONS

Ambrosia, V. G. and L. Friedl, 2016. Keynote Address: NASA Applied Science Program: Building Capacity in the Community. Fourth International Conference on Remote Sensing and Geoinformation of Environment, Paphos, Cyprus, 4 April 2016.

Ambrosia, V. G., L. Friedl, and A. Soja, 2016. NASA Applied Science Program: Wildland Fire and Disasters. Fourth International Conference on Remote Sensing and Geoinformation of Environment, Paphos, Cyprus, 6 April 2016.

Ambrosia, V. G., L. Friedl, and A. Soja, 2016. NASA Applied Science Wildfire Program. IAWF Second International Smoke Symposium -- Workshop, Long Beach, CA, 14 November 2016.

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D'Orangeville, L., L. Duchesne, D. Houle, D. Kneeshaw, B. Côté, and N. Pederson, 2016: Northeastern North America as a potential refugium for boreal forests in a warming climate. Science, 352, 1452-1455.

Dahlgren, R., "The Value of Volunteering in Science & Engineering," UCSC Electrify Your Career: Get Involved! 9-1-2016.

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Egan, P.J. and M. Mullin, 2016: Recent improvement and projected worsening of weather in the United States. Nature, 532, 357-360.

Fisher, J., Middleton, E., Melton, F., Anderson, M., Hain, C., Allen, R. et al. 2016. The Future of Evapotranspiration: Global requirements for ecosystem functioning, carbon and climate feedbacks, agricultural management, and water resources. Nature (in review).

Flynn et al., 4STAR sky-scanning retrievals of aerosol intensive optical properties including size distribution, coarse mode fraction, complex index of refraction and single scattering albedo: comparisons to AERONET during TCAP I & II and SEAC4RS, American Geophysical Union (AGU).

Frankenberg, C., Kulawik, S. S., Wofsy, S. C., Chevallier, F., Daube, B., Kort, E. A., O'Dell, C., Olsen, E. T., and Osterman, G.: Using airborne HIAPER Pole-to-Pole Observations (HIPPO) to evaluate model and remote sensing estimates of atmospheric carbon dioxide, Atmos. Chem. Phys., 16, 7867-7878, doi:10.5194/acp-16-7867-2016, 2016.

PUBLICATIONS AND PRESENTATIONS

Gaertner, J., V. B. Genovese, C. Potter, K. Sewake, and N. C. Manoukis. 2016. Vegetation Classification of Coffea on Hawai'i Island using Worldview-2 Satellite Imagery. Journal of Applied Remote Sensing, In Press.

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GLOSSARY

ASPRS – American Society of Photogrammetry and Remote Sensing

ASRL– Allometric Scaling and Resource Limitations Model

ASTER – Advanced Spaceborne Thermal Emission and Reflection Radiometer

ATTREX – Airborne Tropical Tropopause Experiment

AATS – Ames Airborne Tracking Sunphotometer ATom – Atmospheric Tomography Mission

AVAPS – Advanced Vertical Atmospheric Profiling System

AVHRR – Advanced Very High Resolution Spectroradiometer

AVIRIS – Airborne Infrared Imaging Spectrometer

AWS – Amazon Web Services

BAER or BAERI – The Bay Area Environmental Research Institute

BCCA – Bias Correction/Constructed Analogs

BCSD – Bias Correction/Spatial Downscaling

BGAN – Broadband Global Area Network

CAAP – CELSS Antarctic Analog Project

CALIPSO – Cloud Aersol Lidar and Infrared Pathfinder Satellite Observations

CAN – Cooperative Agreement Notice

CARVE – Carbon in Arctic Reservoirs Vulnerability Experiment

CASA – Carnegie-Ames-Stanford Approach

CASI – Climate Adaptation Science Investigators

CDWR – California Department of Water Resources

CELSS – Controlled Ecological Life Support System

CERES – California Environmental Resources Evaluation System

CH_4 – Methane

CHAART – Center for Health Applications of Aerospace Related Technologies

CIMIS – California Irrigation Management Information System

CME – Coastal and Marine Ecosystems

CMIP5 – Coupled Model Intercomparison Project Phase 5

CMS – Carbon Monitoring Systems

CO – Carbon Monoxide

COAST – Coastal and Ocean Airborne Science Testbed

COMEX – Carbon Dioxide (CO_2) and MEthane eXperiment

COMPASS – Common Operations and Management Portal for Airborne Science Systems

CQUEST – Carbon Query and Evaluation Support Tools

CRUSH – Canopy Remotesensing for Uniformly Segmented Harvest

CSIRO – Commonwealth Scientific and Industrial Research Organisation

CSC – Climate Science Center

CSGC – California Space Grant Consortium

CSTARS – The Center for Spatial Technologies and Remote Sensing

CSUMB – California State University Monterey Bay

CWSP – Coastal and Watershed Science and Policy

DAAC – Distributed Active Archive Center

DAYMET – Daily Surface Weather and Climatological Summaries

DB AOD – Deep Blue Aerosol Optical Depth

DC3 – Deep Convective Clouds and Chemistry Experiment

DFRC – Dryden Flight Research Center (NASA)

DLR – Deutsches Zentrum für Luft- und Raumfahrt (the German Aerospace Center) DNS – Direct Numerical Simulation

DRI – Desert Research Institute

DRECP – Desert Renewable Energy Conservation Plan

DEVELOP – Digital Earth Virtual Environment and Learning Outreach Project

GLOSSARY

DISCOVER-AQ – Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality

DPM – Department of Payment Management

Dropsondes – Advanced Vertical Atmospheric Profiling System

DSEP – Division of Science and Environmental Policy

EARSeL – European Association of Remote Sensing Laboratories

EF – Ecological Forecasting

eMAS – Enhanced MODIS Airborne Simulator

EOS – Earth Observing System

EOS-PSO – EOS Project Science Office

ER-2 – Earth Resources 2 (Single-engine,high-altitude aircraft)

ESDR – Earth Science Data Record

ESTP – Environmental Science, Technology, and Policy

ETM – Enhanced Thematic Mapper

Eu:CROPIS – Euglena: Combined Regenerative Organic-food Production In Space

EVS-2 – Electronic Vibration Switch

FAI – Floating Algal Index

FCMC – Forest Carbon, Markets and Communities

FEL – Field Emission Lamp

FFSIG – Forest Fire Special Interest Group

FIA – Forest Inventory and Analysis

FOV – Field Of View

FPAR – Fraction of Photosynthetically Active Radiation

FRET – Forecast Reference Crop Evapotranspiration

FSun – Total Solar Flux

FTS – Fourier Transform Spectrometer

GCAD30 – Global Cropland Area Database at Nominal 30m

GCEV 1.0 – Global Cropland Extent Version 1.0

GEE – Google Earth Engine

GEO – Group on Earth Observations

GEO Ag. SBAs – Agriculture and Water Societal Beneficial Areas

GEO-CAPE – GEOstationary Coastal and Air Pollution Events

GEO GLAM – Global Agricultural Monitoring Initiative

GEOS-5 – Goddard Earth Observing System Model, Version 5

GEOSS – Global Earth Observation System of Systems

GeoTIFF – Public domain metadata standard which allows geo-referencing information to be embedded within a TIFF file.

GFS – Global Forecast Model

GH – Global Hawk

GHOC – Global Hawk Operations Center

GIS – Geographic Information System

GLAS – Geoscience Laser Altimeter System GOSAT – Green house gases Observing SATellite GPD – Generalized Pareto Distributions

GSFC – Goddard Space Flight Center

HAMSR – High Altitude MMIC Sounding Radiometer HICO - Hyperspectral Imager for the Coastal Ocean HDF – Hierachical Data

HIAPER – High-performance Instrumented Airborne Platform for Environmental Research

HIRAD – Hurricane Imaging Radiometer

HIWRAP – High-Altitude Imaging Wind and Rain Airborne Profiler

HS3 – Hurricane and Severe Storm Sentinel HYDRA – Hydrological Routing Algorithm HyspIRI – Hyperspectral Infrared Imager

IARPC – Interagency Arctic Research Policy Committee

ICCAGRA – Interagency Coordinating Committee for Airborne

GLOSSARY

Geoscience Research and Applications

ICESat – Ice, Cloud and Land Elevation Satellite

IGARRS – International Geoscience and Remote Sensing Symposium iGEM – International Genetically Engineered Machine

INMARSAT – International Maritime Satellite Organization

INPE – Instituto Nacional de Pesquisas Espaciais

INTEX – Intercontinental Chemical Transport ExperimenT

ISE – Information System for the Environment

ISPRS – International Society for Photogrammetry and Remote Sensing

ISRSE – International Symposium on Remote Sensing of Environment

IT – Information Technology

IUFRO – International Union of Forest Research Organizations

IWGADTS – Interagency Working Group for Airborne Data and Telecommunications Systems

KORUS-AQ – An International Cooperative Air Quality Field Study in KoreA LAI – Leaf Area Index (LAI)

LES – Large Eddy Simulation

Lidar – Light Detection and Ranging

LMSAL – Lockheed Martin Solar & Astrophysics Laboratory

LPDAAC – Land Processes Distributed Active Archive Center

LSAMP – Louis Stokes Alliance for Minority Participation program

MACC – Monitoring Atmospheric Composition & Climate

MAIAC – Multi-Angle Implementation of Atmospheric Correction

MASMODIS – Airborne Simulator

MASTER – MODIS/ASTER (airborne simulator)

MATLAB – Material Laboratory

MEaSUREs – Making Earth System Data Records for Use in Research Environments

MERIS – Medium Resolution Imaging Spectrometer (on Envisat satellite)

MHD – Magnetohydrodynamic

MILAGRO – Megacity Initiative: Local and Global Research Observations

MMS – Meteorological Measurement System

MODIS – Moderate Resolution Imaging Spectroradiometer

MTS – Mission Tools Suite

MWIR – Mid-wavelength infrared

NAIP – National Agricultural Imagery Program

NASA – National Aeronautics and Space Administration

N_2O – Nitrous Oxide

NACP -North American Carbon Program

NAFD – North American Forest Dynamics

NAS – NASA Advanced Supercomputing

NASDAT – NASA Airborne Science Data and Telemetry

NCAR – National Center for Atmospheric Research

NCEP – National Center for Environmental Prediction

NEX – NASA Earth Exchange

NGA - National Geospatial-Intelligence Agency

NGO – Non-Governmental Organization

NIDIS – The National Integrated Drought Information System

NIST – National Institute of Standards and Technology

NLFFF – Non-Linear Force Free Field

NOAA – National Oceanic and Atmospheric Administration

GLOSSARY

NOI – Northern Oscillation Index

NPP – NASA Postdoctoral Program

NPP – Net Primary Production

NPR – NASA Procedural Requirements

NSERC – National Suborbital Education and Research Center

NSF – National Science Foundation

NSSC – NASA Shared Services Center

NWS – National Weather Service

OCO-2 – Orbiting Carbon Observatory

OCS – Carbonyl Sulfide

OIB – Operation IceBridge

OLI – Operational Land Imager

ORACLES – Observations of Aerosols Above Clouds and their Interactions

OSTP – Office of Science and Technology Policy

PANAK – PAN/Aldehyde/Ketone (instrument)

P3 – Four-Engine Turboprop

PAO – Public Affairs Office

PBL – Planetary Boundary Layer

PM2.5 – Particulate Matter less than 2.5 Microns in Diameter

PMS – Particle Measuring System

RDAS – Rotating Disk Analytical System

REDD+ – Reducing Emissions from Deforestation and Forest Degradation

RESA – Renewable Energy Study Areas

RSAC – Remote Sensing Applications Center

SABOR – Ship-Aircraft Bio-Optical Research Experiment

SAFARI 2000 – Southern African Regional Science Initiative

SARP – Student Airborne Research Program

SCIAMACHY – Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY

SEAC4RS – Southeast Asia Composition, Cloud, Climate Coupling Regional Study

SEAGRASS – High Resolution Assessment of Carbon Dynamics in Seagrass and Coral Reef

SGS – Sub-Grid Scale

S-HIS or SHIS – Scanning High-resolution Interferometer Sounder

SIERRA – Sensor Integrated Environmental Remote Research Aircraft

SIMS – Satellite Irrigation Management Support

SIPS – Science Investigator-led Processing Systems

SOFRS – Science Operations Flight Request System

StareWAI – Staring Wide Area Imager

STEM – Science, Technology, Engineering, or Mathematics

STEP – Stratosphere-Troposphere Exchange Project

sUAS – small Unmanned Aerial Systems

SWIR – Short Wavelength Infrared

TARFOX – Tropospheric Aerosol Radiative Forcing Observational eXperiment

TCAP – Two Column Aerosol Project

TCCON – Total Carbon Column Observing Network

TES – Tropospheric Emission Spectrometer

TFRSAC – Tactical Fire Remote Sensing Advisory Committee

TMAS – Thermal Mapping Airborne Simulator

TOP – Terrestrial Observation and Prediction System

GLOSSARY

TOPS-SIMS – Terrestrial Observation and Prediction System-Satellite Irrigation Management

TPI – Task Principal Investigator

TTL – Tropical Tropopause Layer

TWiLiTE – Tropospheric Wind Lidar Technology Experiment

UAS – Unmanned Aerial Systems

UAV – Uninhabited Aerial Vehicles

UC-12B – Military Version of a Beechcraft B200 King Air.

UCD – University of California at Davis

UND – University of North Dakota

UROC – Undergraduate Research Opportunities Center

USAID -United States Agency for International Development

USCRTF – United States Coral Reef Task Force

USFS – United States Forest Service

USGS – United States Geological Survey UV – Ultraviolet

VIIRS – Visible Infrared Imaging Radiometer Suite

VINTAGE – Viticultural Integration of NASA Technologies for Assessment of the Grapevine Environment

VSIM – Vineyard Soil Irrigation Model

WAI -Wide Area Imager

WRAP – Wildfire Research and Applications Partnership