UNIVERSITY OF EXETER

SPACE WEATHER OF THE HELIOSPHERE

Processes and Forecasts

Abstracts

IAU Symposium 335 July 17-21, 2017

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Editorial Notes: The content of this conference abstract booklet was fixed on June 15th, 2017. It is designed as an electronic document and contains corrections to the printed conference program booklet. As usual, (minor) changes in the program may still occur.

MON 17 - am

08:00 *Registration opens – Northcott Theatre*

08:30 *Arrival Coffee/Tea*

Conference Introduction

Chair: Claire Foullon

09:00	Opening 1: Welcome by the Symposium Chair and Introduction by ***Mike Hapgood***

Session 1: Solar drivers and activity levels

Chair: Francesco Berrilli

09:15	**Mark Miesch** - *Modeling the Solar Cycle and Surface Flux Transport in 3D*
09:40	Jack Carlyle - The 2015 St Patrick's Day Storm: *Origins*
09:54	Valentin Martinez Pillet - *Vector magnetic fields of solar filaments and the prediction of Bz*
10:08	**Dibyendu Nandi** - *An Overview of Magnetic Activity in Solar-like Stars*

10:35 *Coffee Break*

11:00	Opening 2: Welcome from ***Nick Talbot***, Deputy Vice-Chancellor for Research and Impact
11:05	Garyfallia Kromyda - *Statistical Analysis of Individual Solar Active Regions*
11:19	Han He - *Magnetic activity discrepancies of solar-type stars revealed by Kepler light curves*
11:33	**Nicole Vilmer** - *How to anticipate flares and super flares?*
11:58	Navin Chandra Joshi - *Chain of Reconnections Observed During Sympathetic Eruptions*
12:12	Sophie Murray - *Connecting Coronal Mass Ejections to their Solar Active Region Sources: Combining Results from the HELCATS and FLARECAST Projects*

12:30 *Lunch – Reed Hall*

13:25 *School Prize Ceremony – Northcott Theatre*

Session 2: Solar wind and heliosphere

Chairs: David Webb, Sergio Dasso

13:35 **Alexei Struminsky** - *Gamma-ray Solar Flares and In-situ Particle Acceleration*

14:00 Hugh Hudson - *Solar Events with Extended Coronal Hard X-ray Emission*

14:14 Valentina Zharkova - *Effects of energetic particles of solar wind on Space Weather environment in the heliosphere*

14:28 **Hebe Cremades** - *Pursuing forecasts of the behaviour of solar disturbances through modeling and observations*

14:53 Vemareddy Panditi - *Comparison of Magnetic Properties in a Magnetic Cloud and Its Solar Source on 2013 April 11-14*

15:10 *Coffee Break*

15:35 Nandita Srivastava - *Interplanetary and Geomagnetic Consequences of Interacting CMEs of June 13-14- 2012*

15:49 Christina Kay - *The Effects of Deflection and Rotation on a CME's Near-Earth Magnetic Field Orientation*

16:03 Manuela Temmer - *Interplanetary space relaxation time from the impact of coronal mass ejections*

16:17 **Alisson Dal Lago** - *Effects of ICMEs on high energetic particles as observed by the Global Muon Detector Network (GMDN)*

16:42 Jinhye Park - *Dependence of the Peak Fluxes of Solar Energetic Particles on Coronal Mass Ejection Parameters from STEREO and SOHO*

16:56 Olga Khabarova - *Re-Acceleration of Energetic Particles In Large-Scale Heliospheric Magnetic Cavities–An Underestimated Factor Of The Space Radiation Environment*

17:10 *Welcome Reception - Reed Hall*

TUE 18 - am

08:30 *Arrival Coffee/Tea*

Session 2: Solar wind and heliosphere

Chairs: David Webb, Sergio Dasso

09:00	**Aline Vidotto** - *Winds of other Suns and their effects on exoplanetary systems*
09:25	Pauli Väisänen - *Long-term evolution of the power spectrum of galactic cosmic rays*
09:39	Jon Linker - *What Is The Best Use of Magnetic Maps for Coronal/Solar Wind Models?*
09:53	Rui Pinto - *New strategies for modelling and forecasting the background solar wind*

Session 3: Impact of solar wind, structures and radiation on magnetospheres

Chair: Patricia Reiff

10:07	**Stephen A. Fuselier** - *USA Solar Wind-Magnetosphere Coupling and the MMS Mission*

10:35 *Coffee Break*

11:00	Davide Rozza - *Comparison And Time Evolution Of The Geomagnetic Cutoff At The ISS Position: Internal Vs External Earth Magnetic Field Models*
11:14	Caitriona Jackman - *Large-Scale Structure of the Solar Wind Upstream Of Jupiter and Saturn with Implications for Solar Wind-Magnetosphere Coupling*
11:28	**David Brain** - *The Response of the Martian Atmosphere to the Solar Wind*
11:53	Rok-Soon Kim - *Different Responses of Solar Wind and Geomagnetism to Solar Activity during Quiet and Active Periods*
12:07	Dominique Fontaine - *Implications of the magnetic structure of magnetic clouds for their interaction with the terrestrial bow shock and magnetopause*

12:25 *Extended Lunch – Reed Hall*

TUE 18 - pm

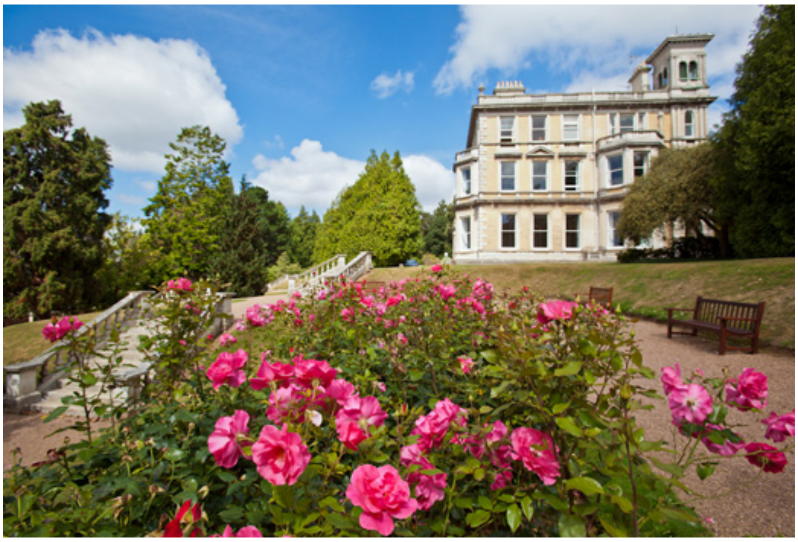
Session 3: Impact of solar wind, structures and radiation on magnetospheres

Chair: Patricia Reiff

14:00	Galina Kotova - *Geomagnetopause position and shape dependence on solar wind plasma and IMF parameters: analytic model comparison with observations and 3-D MHD runs*
14:14	**Ian R. Mann** - *On the Elegant Dynamics of the Ultra-relativistic Van Allen Radiation Belt: How ULF Wave Transport Explains an Apparently Diverse Response to Solar Wind Forcing*
14:39	Sarah Glauert - *Modelling Extreme Events In The Earth's Electron Radiation Belts*
14:53	**Mike Lockwood** - *Centennial Variability of Space Climate*
15:18	Ruth Bamford – EISCAT Space Weather Research - *Challenges And Strategic Research Plans For Earth And The Heliosphere*

Poster Session – Reed Hall

15:35	*Coffee Break and Poster Viewing*



Reed Hall, a majestic Italianate Mansion built in 1867 and set within beautifully landscaped gardens on the Streatham campus.

WED 19 - am

08:30 *Arrival Coffee/Tea*

Session 4: Impact of solar wind, structures and radiation on ionospheres, atmospheres

Chair: Olga Malandraki

09:00	**Aziza Bounhir** - *Thermospheric Dynamics in quiet and disturbed*
09:25	Victor U. J. Nwankwo - *Study of solar flare and storm-induced ionospheric changes in mid-latitude D-region using VLF signal propagation characteristics*
09:39	**Esa Turunen** - *Role of D-region Ion Chemistry in Atmospheric Forcing by Precipitating High-Energy Particles*
10:04	Delores Knipp - *Shock, Sheath And Ejecta Control Of Upper Atmosphere Heating And Cooling—When Nature Reigns In Storm Time Response Of The Thermosphere*
10:18	Tim Fuller-Rowell - *Modeling the thermosphere and ionosphere response to geomagnetic storms*

10:35 *Coffee Break*

11:00	Paulo Roberto Fagundes - *Ionosphere Space Weather Over The South America Region During The St. Patrick´s Geomagnetic Storm On March 2015*
11:14	**Heather Elliott** - *Solar Wind Interaction with Pluto*

Session 5: Long-term trends and predictions for space weather

Chair: Olga Malandraki

11:39	**Arnab Rai Choudhuri** - *Predicting A Solar Cycle Before Its Onset Using A Flux Transport Dynamo Model*

12:10 *Symposium Photograph – Reed Hall*

12:20 *Lunch – Reed Hall*

13:00 *Coaches departure – Excursion to Sidmouth*

THU 20 - am

08:30 *Arrival Coffee/Tea*

Session 5: Long-term trends and predictions for space weather

Chair: Olga Malandraki

09:00	Ching Pui Hung - *Estimating the Solar Meridional Flow and Predicting the 11-yr Cycle Using Advanced Variational Data Assimilation Techniques*
09:14	Kseniia Tlatova - *Reconstruction of the filaments properties- based on centenarians data daily observations of the Sun in H-alpha line*
09:28	Prantika Bhowmik - *Prediction of Solar Cycle 25 Using a Surface Flux Transport Model*
09:42	**Christopher T. Russell** - *The solar wind interaction with the solar system*
10:07	Kalevi Mursula - *Seasonal Solar Wind Speeds For The Last 100 Years: Unique Coronal Hole Structures During The Peak And Demise Of The Grand Modern Maximum*
10:21	Ralph Neuhaeuser - *Aurorae In The Deep Phase of the Maunder Minimum?*

10:35 *Coffee Break*

Session 6: Challenges and strategic plans for Earth and the heliosphere

Chair: Ian Mann

11:00	Richard Horne - *Electron Acceleration Due To Wave-Particle Interactions in the Outer Radiation Belt for a Severe Space Weather Event Driven by a Fast Solar Wind Stream*
11:14	**Mauro Messerotti** - *Defining and Characterising Heliospheric Weather and Climate*
11:39	Steven W. Clarke - *NASA Heliophysics Space Weather Research – Challenges and Strategic Plans for Earth and the Heliosphere*
11:53	**Arik Posner** - *Early Warning Of Solar Radiation Hazards – New Concepts, Capabilities, And Applications*

12:20 *Extended Lunch – Reed Hall*

THU 20 - pm

Session 6: Challenges and strategic plans for Earth and the heliosphere

Chair: Ian Mann

13:55	IAU TOWN HALL - *United Nations Expert Group on Space Weather: Strategy for Developing an International Framework for Space Weather Services (2018-2030)*
14:35	Irina Myagkova - *Control and Prediction of Radiation Environment in the Frame of Space Monitoring Data Center at Moscow State University*
14:49	Ralf Keil - *The SSA SWE Data Centre as a Tool Supporting the Space Weather Community*
15:03	Victor De la Luz - *The Mexican Space Weather Service – SCiESMEX*

Session 7: Forecasting models

Chair: Allan Sacha Brun

15:17	**Huaning Wang** - *Numerical Short-term Solar Activity Forecasting*
15:45	*Short Coffee Break*
16:00	Antoine Strugarek- *A Physically-Based Sandpile Model for the Prediction of Solar Flares Using Data Assimilation*
16:14	Mathew Owens - *Empirical solar-wind forecasts: Why they still matter in a world of advanced physics-based numerical models*
16:28	Nat Gopalswamy - *A New Technique to Provide Realistic Input to CME Forecasting Models*
16:42	Christine Verbeke - *Modeling Coronal Mass Ejections in the Inner Heliosphere using the Gibson-Low flux rope model with EUHFORIA: a parameter study* ***(cancelled)***
17:00	*Coaches departure – Conference Dinner in Torquay*

FRI 21 - am

08:30 *Arrival Coffee/Tea*

Session 7: Forecasting models

Chair: Allan Sacha Brun

09:00	**Maria Kuznetzova** - *Synergies in space weather modeling*
09:25	Janet Luhmann - *Prospects for Forecasting Solar Energetic Particle Events using ENLIL and SEPMOD*
09:39	**K.D. Leka** - *Forecasting Solar Flares: Present Status- Recent Advances- and Continued Challenges*
10:04	Marion Weinzierl - *Effect of non-potential coronal boundary conditions on solar wind prediction*
10:18	Silvia Dalla - *Application of Test Particle Simulations to Solar Energetic Particle Forecasting*

10:35 *Coffee Break*

11:00	**Daikou Shiota** - *Development of MHD simulation of interplanetary propagation of multiple coronal mass ejections with internal magnetic flux rope*
11:25	Mitsue Den - *High-Speed Solar Wind Forecast Model From The Solar Surface To 1AU Using Global 3D MHD Simulation*
11:39	Stefano Della Torre - *The HelMod Monte Carlo Model for the Propagation of Cosmic Rays in Heliosphere*

Session 8. Space weather monitoring, instrumentation, data and services

8a. Future Missions and Instrumentation

Chair: Zouhair Benkhaldoun

11:53	**Hector Socas-Navarro** - *Next Generation Solar Telescopes*
12:18	Roberta Forte - *The MOTH II Doppler-magnetographs and data calibration pipeline*

12:35 *Lunch – Reed Hall*

FRI 21 - pm

8a. Future Missions and Instrumentation

Chair: Zouhair Benkhaldoun

13:30	Mario Bisi - *The Worldwide Interplanetary Scintillation (IPS) Stations (WIPSS) Network in support of Space-Weather Science and Forecasting*
13:44	Sabrina Savage - *The Coronal Spectrographic Imager In The EUV (COSIE)*
13:58	Dipankar Banerjee - *The inner coronagraph on board Aditya L1 and automatic detection of CMEs*
14:12	Graziella Branduardi-Raymont - *SMILE: A Novel and Global Way to Explore Solar-Terrestrial Relationships*
14:26	*Junga Hwang - Small scale magNetospheric and Ionospheric Plasma Experiments; SNIPE*

8b. Data Handling and Assimilation & Relationships with the 'civil' society

Chairs: Norma B. Crosby, David Jackson

14:40	**Terrance Onsager** - *Data Utilization for Space Weather*
15:05	**Lee-Anne McKinnell** - *Operational Space Weather Practices as a service to society in South Africa*

15:35 Coffee Break

Round Tables

Table 1. Data Handling and Assimilation – Northcott Theatre

15:55	Petrus Martens - *Data Handling and Assimilation for Solar Flare Prediction*
	Sean Elvidge - *Using The Local Ensemble Transform Kalman Filter (LETKF) For Upper Atmosphere Modelling*
	Michael Sharpe - *Space – The Final Verification Frontier?*
	Xinghua Dai - *Reconstruction And Propagation Of Coronal Mass Ejections Based On Genetic Algorithm*

Table 2. Relationships with the 'Civil' Society - IAIS

15:55	Mike Hapgood - *Space Weather – What Is The Real Risk And How Do We Communicate That?*
	Suzy Bingham - *A citizen science magnetometer for measuring the effects of space weather*

16:55 ***Terrance Onsager & Lee-Anne McKinnell*** - Plenary Summaries of Round tables, Northcott Theatre

17:05 Final Words from ***Yihua Yan***, IAU Div E President

17:10 Conference Ends

Poster Program

Location of Posters in Reed Hall:

	Level	Room
Session 1	Ground Floor	Margaret Hewitt
Session 7		Ibrahim Ahmed
Sessions 2, 3 and 4	Upper floor	Upper Lounge
Session 5		Walter Dawn Room
Session 8		Upper Landing

Ref. **Presenting Author** **Poster Title**

Session 1. Solar drivers and activity levels

Ref.	Presenting Author	Poster Title
P1-01	Mahender Aroori	Quiet sun radiation during solar cycle 23 and 24
P1-02	Allan Sacha Brun	The Solar Dynamo and its Many Variabilities
P1-03	Jack Carlyle	Weighing Silhouettes: The Mass of Solar Filaments
P1-04	Nai-Hwa Chen	Temperature of source regions of 3He-rich impulsive solar energetic particles events
P1-05	Bernhard Fleck	First Results from the 2016-2017 MOTH-II South Pole Campaign
P1-06	Tadhg Garton	Multi-Thermal Segmentation And Identification of Coronal Holes
P1-07	Gareth Hawkes	Magnetic Helicity Flux As A Predictor Of The Solar Cycle
P1-08	Andrew Hillier	Observations of MHD Turbulence in Solar Prominences
P1-09	Petra Kohutova	Simulating The Dynamics Of Coronal Plasma Condensations
P1-10	Konstantina Loumou	Solar flare association with the Hale Sector Boundary
P1-11	Helen Mason	Spectroscopic Diagnostics of small flares and jets
P1-12	Daniel Miller	Alignment as an indicator of changes to modal structure within the Roberts flow
P1-13	Karin Muglach	Photospheric Magnetic Field Evolution And Flow Field Of Coronal Hole Jets
P1-14	Irina Myagkova	Hard X-Ray Emission of Solar Flares Measured by Lomonosov Space Mission
P1-15	Aleksandra Osipova	The Waldmeier Effect For Two Populations Of Sunspots
P1-16	Vemareddy Panditi	Research on solar drivers of space-weather: sun-earth connection of Magnetic Flux Ropes
P1-17	Nandita Srivastava	On the Dynamics of the Largest Active Region of the Solar Cycle 24
P1-18	Jianfei Tang	Propagation and Absorption of Electron Cyclotron Maser Emission Driven by Power-law Electrons
P1-19	Erwin Verwichte	Excitation and evolution of transverse loop oscillations by coronal rain
P1-20	Nicole Vilmer	Reliability of Photospheric Eruptive Proxies Using Parametric Flux Emergence Simulations
P1-21	Maria Weber	Simulations of Magnetic Flux Emergence in Cool Stars

P1-22	Matthew West	Further Exploration Of Post-Flare Giant Arches
P1-23	Yan Yan	Comparative study on the statistical characteristics between solar-type star flares and solar flares

Session 2. Solar wind and heliosphere

P2-01	Tanja Amerstorfer	Arrival Prediction of a Coronal Mass Ejection as observed from Heliospheric Imagers at L1
P2-02	Luke Barnard	Testing The Current Paradigm Of Space Weather Prediction With The Heliospheric Imagers
P2-03	Mario Bisi	The Worldwide Interplanetary Scintillation (IPS) Stations (WIPSS) Network October 2016 Campaign: LOFAR IPS Data Analyses
P2-04	Sergio Dasso	Superposed Epoch Study of Magnetic Clouds And Their Driven Shocks/Sheaths Near Earth
P2-05	Andrzej Fludra	Testing Models Of The Fast Solar Wind Using Spectroscopic And Heliospheric In Situ Observations
P2-06	Pavel Gritsyk	Electron acceleration in collapsing magnetic traps during the solar flare on July 19- 2012: observations and models
P2-07	Karine Issautier	Measuring the Solar Wind Electron Temperature Anisotropy using the Quasi-thermal Noise Spectroscopy method on WIND
P2-08	Daniel Johnson	Heliospheric Magnetic Field And Solar Wind Behaviour During Solar Cycle 23-24
P2-09	Olga Khabarova	Conic Current Sheets As Sources Of Energetic Particles In The High-Latitude Heliosphere In Solar Minima
P2-10	Olga Malandraki	Compositional Analysis Within The 'HESPERIA' HORIZON 2020 Project to Diagnose Large Solar Energetic Particle Events During Solar Cycle 23
P2-11	Pradiphat Muangha	Ground Level Enhancements in Solar Energetic Particles Observed by IceTop during 2011 to 2016
P2-12	Milton Munroe	A Behavioural Model Of The Solar Magnetic Cycle
P2-13	Nariaki Nitta	Earth-Affecting Coronal Mass Ejections Without Obvious Low Coronal Signatures
P2-14	Barbara Perri	Quasi-Static And Dynamical Simulations Of The Solar Wind Over An 11-Year Cycle
P2-15	Alexei Struminsky	Cosmic Rays near Proxima Centauri b
P2-16	Aline Vidotto	The Solar Wind Through Time
P2-17	David Webb	Understanding Problem Forecasts of ISEST Campaign Flare-CME Events

Session 3. Impact of solar wind structures and radiation on magnetospheres

P3-01	Franklin Aldás	Analysis Of Variations Of Earth´s Magnetic Field Produced By Equatorial Electro-Jets In Sudamerica
P3-02	Thamer Alrefay	Testing the Earth'S Bow Shock Models
P3-03	Sergio Dasso	Statistical Analysis of Extreme Electron Fluxes in the Radiation Belts: Observations from ICARE-NG/CARMEN-1- SAC-D

P3-04	Yongqiang Hao	Detection Of Plasmaspheric Compression By Interplanetary Shock Using GPS TEC Technique
P3-05	Rungployphan Kieokaew	Magnetic Curvature and Vorticity Four-Spacecraft Analyses on Kelvin-Helmholtz Waves: a MHD Simulation Study
P3-06	Galina Kotova	Physics-based modeling of the density distribution in the whole plasmasphere using measurements along a single pass of an orbiter
P3-07	Stefania Lepidi	Ground And Space Observations To Determine The Location Of Locally Vertical Geomagnetic Field
P3-08	Stefania Lepidi	Determining The Polar Cusp Longitudinal Location From Pc5 Geomagnetic Field Measurements At A Pair Of High Latitude Stations
P3-09	Nigel Meredith	Extreme Relativistic Electron Fluxes in the Earth's Outer Radiation Belt: Analysis of INTEGRAL IREM Data
P3-10	Gabrielle Provan	Planetary Period Oscillations In Saturn's Magnetosphere: Examining The Relationship Between Changes In Behavior And The Solar Wind.
P3-11	Pat Reiff	MHD Modeling of MMS Reconnection Sites
P3-12	Davide Rozza	GeoMagSphere Model Applied During Solar Events: A Study Of Cosmic Rays Detector From The International Space Station

Session 4. Impact of solar wind structures and radiation on ionospheres atmospheres

P4-01	Roshni Atulkar	Magnetic storm effects on the variation of TEC over low-mid and high latitude station
P4-02	Binod Bhattarai	Effect Of Geomagnetic Super Substorm At Low Latitude Stations
P4-03	Aziza Bounhir	Climatology of thermospheric neutral temperatures over Oukaïmeden Observatory in Morocco
P4-04	Rimpei Chiba	Sputtering Of Wollastonite By Solar Wind Ions
P4-05	Yongqiang Hao	Changes Of Solar Extreme Ultraviolet Irradiance In Solar Cycle 23 and 24
P4-06	Nadia Imtiaz	Particle-in-cell Modeling of CubeSat and Ionospheric Plasma Interaction
P4-07	Jung Hee Kim	Possible Influence Of The Solar Eclipse On The Global Geomagnetic Field
P4-08	Mai Mai Lam	The temperature signature of an IMF-driven change to the global atmospheric electric circuit (GEC) in the Antarctic troposphere
P4-09	Ayomide Olabode	An Investigation of Total Electron Content at Low and Mid Latitude Stations
P4-10	Ayomide Olabode	Geomagnetic Storm Main Phase Effect on the Equatorial Ionosphere over Ile-Ife as measured from GPS Observations
P4-11	Ayomide Olabode	Solar Activity effect on Ionospheric Total Electron Content (TEC) during Different Geomagnetic Activity in Low-Latitudes

P4-12	Pramod Kumar Purohit	Solar cycle variation and its impact on Critical Frequency of F2 layer
P4-13	Alexander Rakhlin	About Factors Of Solar Radiation Influenced On The Ionosphere
P4-14	Olga Sheiner	Effect Of Solar Coronal Mass Ejections On The Ionosphere
P4-15	Dadaso Shetti	Equatorial Plasma Bubbles observations during quit and disturb period over low Latitude region
P4-16	Manuela Temmer	Statistical analysis on how CME and SIR/CIR events effect the geomagnetic activity and the Earth's thermosphere
P4-17	Donghe Zhang	The Variability Of The Solar EUV Irradiance And Its Possible Contribution To The Ionospheric Variability During Solar Flare

Session 5. Long-term trends and predictions for space weather

P5-01	Melinda Dósa	Long-term longitudinal recurrences of the open magnetic flux density in the heliosphere
P5-02	Heather Elliott	Kp – Solar Wind Speed Relationship: Implications for Long-Term Forecasts
P5-03	Elijah Falayi	Study of geomagnetic induced current at high latitude during the storm- time variation
P5-04	Frederick Gent	Interpreting a millennium solar – like dynamo with the test – field method
P5-05	Romaric Gravet	Observed UV contrast of magnetic features and implications for solar irradiance modelling
P5-06	Norbert Gyenge	On Active Longitudes and their Relation to Loci of Coronal Mass Ejections
P5-07	Ching Pui Hung	Reconstructing the Solar Meridional Circulation from 1976 up to Now
P5-08	Mike Lockwood	Effects of Solar Variability on Global and Regional Climates
P5-09	Sushant Mahajan	Using Torsional Oscillations to Forecast Solar Activity
P5-10	Victor U. J. Nwankwo	Analysis of Long-term Trend of Space Weather-Induced Enhancement of Atmospheric Drag on LEO Satellites
P5-11	Vaibhav Pant	Kinematics of fast and slow CMEs in solar cycle 23 and 24
P5-12	Chris Russell	Long-term Observations of Solar Wind Using STEREO Data
P5-13	Mikhail Vokhmyanin	Sunspots areas and heliographic positions on the drawings made by Galileo Galilei in 1612
P5-14	Mikhail Vokhmyanin	Regularities of the IMF sector structure in the last 170 years
P5-15	Valentina Zharkova	Reinforcement of the double dynamo model of solar magnetic activity on a millennium timescale

Session 7. Forecasting models

P7-01	Jordan Guerra Aguilera	Modeling Ensemble Forecasts of Solar Flares
P7-02	Roxane Barnabé	Prediction Of Solar Flares Using Data Assimilation In A Sandpile Model ***(withdrawn)***

P7-03	Zouhair Benkhaldoun	The Space Weather through a multidisciplinary scientific approach.
P7-04	Mitsue Den	Physics-Based Modeling Activity From The Solar Surface To Atmosphere Including Magnetosphere And Ionosphere At NICT
P7-05	Mark Dierckxsens	Assessing Space Weather Applications and Understanding: SEP Working Team and SEP Scoreboard
P7-06	Mark Dierckxsens	The SEP Forecast Tool Within The COMESEP Alert System
P7-07	Sean Elvidge	International Community-Wide Ionosphere Model Validation Study: foF2/hmF2/TEC prediction
P7-08	Sarah Glauert	Validating the BAS Radiation Belt Model Forecasts of the Electron Flux at Medium Earth Orbit
P7-09	Daniel Griffin	Numerical Effects Of Vertical Wave Propagation In Atmospheric Models
P7-10	Richard Horne	Forecasting Risk Indicators for Satellites By Integrating The BAS Radiation Belt Model and Radiation Effects Models
P7-11	Xin Huang	A deep learning based solar flare forecasting model
P7-12	Irina Knyazeva	Comparison Of Predictive Efficiency of LOS Magnetograms Topological Descriptors and SHARP Parameters in the Solar Flares Forecasting Task
P7-13	Marianna Korsos	On the evolution of pre-flare patterns in 3-dimensional real and simulated Active Regions
P7-14	Timo Laitinen	Forecasting Solar Energetic Particle Fluence with Multi-Spacecraft Observations
P7-15	KD Leka	Predicting the Where and the How Big of Solar Flares
P7-16	Olga Malandraki	The real-time SEP prediction tools within the framework of the 'HESPERIA' HORIZON 2020 project
P7-17	Olga Malandraki	Prediction of GLE events
P7-18	Aoife Mccloskey	Flare Forecasting and Sunspot Group Evolution
P7-19	Gianluca Napoletano	A Probabilistic Approach To ICME Propagation
P7-20	Ljubomir Nikolic	PFSS-based Solar Wind Forecast and the Radius of the Source-Surface
P7-21	Naoto Nishizuka	Solar Flare Prediction with Vector Magnetogram and Chromospheric Brightening using Machine-learning
P7-22	Tomoya Ogawa	AMR-MHD Simulation of CME Propagation in Solar Wind generated on Split Dodecahedron Grid
P7-23	Rui Pinto	SWiFT-FORECAST: A physics-based realtime solar wind forecast pipeline
P7-24	Camilla Scolini	Study of the September 4- 2010 Coronal Mass Ejection: Comparison of the EUHFORIA and ENLIL Predictive Capabilities
P7-25	Olga Sheiner	Ground-based Observations of Powerful Solar Flares Precursors
P7-26	Olga Sheiner	Solar Radio Emission As A Prediction Technique For Coronal Mass Ejections' Registration

P7-27	Bill Swalwell	Solar Energetic Particle Event Forecasting Algorithms And Associated False Alarms
P7-28	Baolin Tan	Very Long-period Pulsations as a precursor of Solar Flares
P7-29	Yurdanur Tulunay	METU Data Driven Forecast Models: From the Window of Space Weather IAU Symposium 335
P7-30	Christine Verbeke	Assessing Space Weather Applications and Understanding: CME Arrival Time and Impact

Session 8. Space weather monitoring instrumentation data and services

P8-01	Ciaran Beggan	SWIGS: a new research consortium to study Space Weather Impacts on Ground-based Systems
P8-02	Francesco Berrilli	SWERTO: a regional Space Weather service
P8-03	Francesco Berrilli	The Ionosphere Prediction Service
P8-04	Norma B. Crosby	ESA SSA Space Radiation Expert Service Centre: Human Space Flight
P8-05	Erwin De Donder	End User Requirements For Space Weather Services.
P8-06	Victor De La Luz	The Early Warning Mexican Space Weather System
P8-07	Richard Harrison	European-led Visible-light Coronal And Heliospheric Imaging Endeavours For An Operational Space Weather Mission
P8-08	Neil Hurlburt	Corona and the solar magnetic field observations for space weather forecasting
P8-09	Karine Issautier	CIRCUS CubSa
P8-10	David Jackson	The Met Office Space Weather Operations Centre (MOSWOC)
P8-11	Sophie Murray	Verification of Flare Forecasts at the Met Office Space Weather Operations Centre
P8-12	Danislav Sapundjiev	Advanced observatory for space-weather research and forecast at the Geophysical Center in Dourbes – Belgium
P8-13	Mike Thompson	COSMO: the Coronal Solar Magnetism Observatory
P8-14	Andrei Tlatov	Modeling and forecast of parameters of space weather based on ground observations of solar activity
P8-15	Vincenzo Vitale	The High-Energy Particle Detector on board of the CSES mission
P8-16	Yihua Yan	On Mingantu Spectral Radioheliograph for Space Weather Observations

Abstracts for the Oral Program

Modeling the Solar Cycle and Surface Flux Transport in 3D

Mark S. Miesch
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The origins of solar magnetism lie deep below the solar surface, in the turbulent solar convection zone. However, recent evidence supports the idea that the magnetic field threading through the solar surface may play a disproportionate role in the magnetic self-organization that gives rise to the solar cycle. This bodes well from the standpoint of solar cycle prediction; if future magnetic activity is largely determined by magnetic fields and flows that we can measure now at the surface then we should be able to construct reliable forecast models. In this talk I will describe our ongoing efforts to construct such a model, namely the Surface flux Transport And Babcock-LEighton (STABLE) solar dynamo model. STABLE is fully 3D and can be regarded as a unification of surface flux transport models (2D in latitude and longitude) and flux-transport dynamo models (2D in latitude and radius). As such, it is capable of capturing the 11-year solar cycle as well as observed patterns of photospheric flux evolution. I will describe how STABLE is constructed and how we plan to develop it as a community tool for solar cycle forecasting, solar irradiance modeling, and coronal and heliospheric modeling (as a boundary condition). I will also highlight some early scientific results including solar cycle variability induced by random scatter in the tilt angles of sunspot pairs and modifications to the surface flux transport due to the 3D structure of magnetic fields and convective flows.

The 2015 St Patrick's Day Storm: Origins

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The magnetic storm experienced at Earth on St. Patrick's Day 2015 had been the strongest of cycle 24 (at that time) with a measured DST of -223 nT, though it was not expected to cause much of a disturbance. In this work we study the source region of several peculiar eruptions, leading to the formation and destruction of various structures, in the week leading up to the storm, and determine the true sequence of events.

By investigating the evolution of the source region's magnetic flux, this work points to explanations for the formation of a peculiar filament, as well as examining evidence for several trigger mechanisms for the main eruption. Not only does this give us a clearer understanding of the source region, but also identifies strengths and weaknesses of forecasting techniques. The mass involved in the eruptions is also analysed by measuring column density of various portions of filament material low down in the atmosphere using extreme ultraviolet images, and this is compared with mass estimates from white light coronograph data; these results are then used to investigate the general relationship between filament eruptions and CMEs, as well as comment on the energy budget of these specific eruptions.

Previous studies on the St. Patrick's Day Storm are also incorporated into this work, and an attempt is made to reconcile the disparate conclusions drawn by the scientific community as to why this storm was not only so effective, but also a major forecasting failure.

Vector Magnetic Fields of Solar Filaments and the Prediction of Bz

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With the progress occurred over the last decade, spectropolarimetric observations and analysis allow inferring the vector magnetic field in solar filaments. The HeI 1083nm spectral lines provide a rather complete description of the vector magnetic fields contained in these structures. The analysis techniques involve complex physics including the Zeeman effect, scattering polarization, and its modification via the Hanel effect. Inversion codes containing these physical ingredients are now publicly available. A synoptic program that maps regularly all on-disk filaments would allow feeding their magnetic configurations into CME propagation models once an eruption has been confirmed. Such a synoptic program could serve as the basis to systematically propagate magnetized CMEs and produce predictions of Bz near Earth. I will describe the initiatives the National Solar Observatory is undertaken to create such a synoptic program. In particular, these observations will be at the core of the new international synoptic network, SPRING, aimed at replacing GONG.

Session 1: **Invited**

An Overview of Magnetic Activity in Solar-like Stars

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The Sun is a typical G-type star with an outer convective envelope that supports the generation and maintenance of magnetic activity. A magnetohydrodynamic dynamo mechanism powers this magnetic activity, short- and long-term variations in which modulate the space environment and atmospheres of planets. Understanding stellar forcing of planetary environments therefore necessitates an appreciation of stellar magnetic variability across diverse timescales, stretching from dynamo cycle periods to stellar evolutionary timescales. In this talk I will review the magnetic activity of solar-type stars, identify important physical processes that generate variations over decadal to stellar evolutionary timescales, and provide a critical assessment of outstanding issues in solar-stellar magnetism.

Statistical Analysis of Individual Solar Active Regions

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The existence of single powerlaws in global solar flare statistics is a well established fact, inferred from numerous observational studies in the last decades. It was linked to the existence of Self-Organized Criticality (SOC) in the solar corona by Lu and Hamilton (1991). Lu et.al. (1993) also argued that individual active regions are in a SOC state, with flare distributions well-fitted by statistically indistinguishable, single powerlaws of a<2.

To test this, we identify and separately analyze the flares produced by ten individual active regions (2006-2016). The GOES soft X-ray flux time series of these regions are analyzed. A background subtraction algorithm is created to split the background coronal emission from the pure flare emission. Cumulative distributions of flare thermal energy, waiting time distributions and correlation functions are used in the analysis.

In five regions, a single powerlaw is seen with a slope of a<2, consistent with SOC. In the other five regions, a broken double powerlaw is seen with slopes a1<2 and a2>2, inconsistent with SOC. The existence of regions that are unable to reach a true SOC state has implications for flare prediction, since these regions produce favorably mid-sized flares and lack large-sized flares. The possibility that the single versus double powerlaw behavior is caused by differences in the strength of the driver of active regions is investigated.

Magnetic Activity Discrepancies of Solar-Type Stars Revealed by *Kepler* Light Curves

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Light curves of solar-type stars show gradual fluctuations due to rotational modulation by magnetic features (starspots & faculae) on star's surface. Two quantitative measures of modulated light curves are employed as the proxies of magnetic activity for solar-type stars. The first is autocorrelation index i_{AC}, which describes the degree of periodicity of light curve; the second is effective fluctuation range of light-curve R_{eff}, which reflects the depth of rotational modulation. The two measures are complementary and depict different aspects of magnetic activities on solar-type stars. By using the two proxies, we analyzed magnetic activity properties of two solar-type stars (KIC 9766237 & 10864581) observed with *Kepler* telescope, which have distinct rotation periods (14.7 vs. 6.0 days). We also applied the two proxies to the Sun. The results show that both the measures can reveal cyclic activity variations (referred to as i_{AC}-cycle & R_{eff}-cycle) on the two *Kepler* stars and the Sun. For the *Kepler* star with faster rotation rate, i_{AC}-cycle and R_{eff}-cycle are in the same phase; for the Sun (slower rotator), they in the opposite phase. By comparing the solar light curve with simultaneous photospheric magnetograms, it is identified that the magnetic feature that causes the periodic light curve during solar minima is the faculae of the enhanced network region, which can also be a candidate of magnetic features that dominate the periodic light curves on the two *Kepler* stars.

How To Anticipate Flares And Super Flares?

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X/ EUV and radio electromagnetic emissions from solar flares are among the first signatures of space-weather relevant disturbances originating from the solar atmosphere. These emissions may be shortly followed by the arrival of the first relativistic flare-accelerated particles (around 20 minutes after) and later by the arrival of CME-shock accelerated particles and ultimately by the CME shock itself. Therefore, being able to anticipate flares would also allow to anticipate energetic particles from flares and most of the fastest coronal mass ejections.

In this talk, I will present a general overview on solar flares, focusing on the characteristics of active regions leading to major solar flares, on the observations of the magnetic field in flaring active regions and on the observations in the X-ray and radio domains of solar flares. I will discuss the present capabilities in the predictability of solar flares and associated phenomena as well as the input of radio observations to help predicting the occurrence and importance of a flare associated solar energetic particle event as well as the arrival time of associated CMEs. I will finally discuss some observations of "extreme" events associated with very large flares and briefly review our knowledge on their occurrence and potential predictability.

Chain of Reconnections Observed During Sympathetic Eruptions

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In this work, we present multiwavelength observations and analysis of sympathetic eruptions, associated flares, and coronal mass ejections (CMEs) occurring on 2013 November 17. Two filaments, i.e., F1 and F2, are observed in between the two close active regions. Successive magnetic reconnections, caused by flux cancellation, shear, and expansion have been identified during the eruptions. The first reconnection occurred during the first eruption via flux cancellation between the sheared arcades overlying filament F2. This process creating a flux rope and leading to the first double ribbon solar flare. The eruptionof overlying arcades and coronal loops has been observed during this phase, which leads to the first CME. The second reconnection is believed to occur between the expanding flux rope of F2 and the overlying arcades of filament F1. We suggest that this reconnection destabilized the equilibrium of filament F1. which leads to its eruption. The third stage of reconnection occurred in the wake of the erupting filament F1 between the legs of the overlying arcades and create a flux rope as well as the second double-ribbon flare and a second CME. The fourth reconnection was between the expanding arcades of the erupting filament F1 and the ambient field. The bi-directional plasma flows both upward and downward have been observed in this stage. Observations and a nonlinear force-free field extrapolation provide evidence of the possibility of reconnection and the causal link between the filament systems. To investigate the onset of such sympathetic eruptions also provides important inputs for the space weather forecast.

Connecting Coronal Mass Ejections to their Solar Active Region Sources: Combining Results from the HELCATS and FLARECAST Projects

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Severe space weather events have the potential to significantly impact a range of vital technologies on Earth and in near-Earth space. Understanding the processes involved in the solar eruptions that cause these events is imperative to provide accurate space weather forecasts. Coronal mass ejections (CMEs) and other solar eruptive phenomena can be physically linked by combining data from a multitude of ground-based and space-based instruments as well as models, however this can be challenging for automated operational systems.

The EU Framework Package 7 HELCATS project provides data from heliospheric imaging onboard the two NASA/STEREO spacecraft in order to track the evolution of CMEs in the inner heliosphere. From a catalogue of nearly 2,000 CME events, an automated algorithm has been developed to connect the CMEs observed by STEREO to any corresponding solar flares and active region sources on the solar surface. CME kinematic properties, such as speed and angular width, are compared with active region magnetic field properties, such as magnetic flux, area, and polarity line characteristics.

The resulting HELCATS LOWCAT catalogue is also compared to the extensive active region property database created by the EU Horizon 2020 FLARECAST project. This analysis provides insight into the link between CME and flare events, as well as characteristics of eruptive active regions. The automated method may prove useful for future operational CME forecasting efforts.

Gamma-ray Solar Flares and In-situ Particle Acceleration

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At present two concurrent paradigms of solar energetic particle (SEP) origin exist - acceleration directly in the flare site or by shock wave of coronal mass ejection (CME). Active discussions on a relative role of flares and CME's for SEP acceleration and propagation are continuous till now. In my talk I will review solar gamma-ray observations and present arguments supporting in-situ particle acceleration.

Solar Events With Extended Coronal Hard X-ray Emission

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A characteristic pattern of solar hard X-ray emission, first identified in SOL1969-03-31 by Frost & Dennis (1971) now has been linked to prolonged high-energy gamma-ray emission detected by Fermi's LAT experiment, for example in SOL2014-09-01. The distinctive features of these events include flat hard X-ray spectra extending to well above 100 keV, a characteristic smooth and decaying pattern of time development, low-frequency gyrosynchrotron peak frequencies, a CME association, and gamma-rays identifiable with pion decay originating in GeV ions. The identification of these events with otherwise known solar structures nevertheless remains elusive, in spite of the wealth of imagery available from AIA and other sources. The quandary is that these events have a clear association with their CME in the high corona, and yet the gamma-ray production implicates the photosphere itself. We discuss the morphology and energetics of these phenomena and ask how they may be related to the flare/CMEprocess. We also ask how the characteristics of such events may help to identify potential terrestrial impacts.

Effects of energetic particles of solar wind on Space Weather environment in the heliosphere

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We review the characteristics of solar wind particles originating from the Sun, which undergo various re-acceleration significantly changing their energy and pitch angle distributions. By comparing the data from the WIND spacecraft with the advanced 3D Particle-In-Cell (PIC) simulations we find a constant energisation of electrons and ions occurring during their passes of the heliospheric current sheet (HCS) to much higher energies than those expected in the regular solar wind. The particle parameters (including energy distributions, their peak velocities, shear, beta parameters, pitch angle, and directivity) are shown to be highly dependent on the magnetic field topology of the HCS. Furthermore, particle and magnetic field characteristics are found affected by the HCS stability, formation of magnetic islands. This results in additional particle acceleration in these islands that can be the essential factor defining the Space Weather environment (Khabarova et al, 2015). In addition, further observations of accelerated solar wind particles associated with Interplanetary Coronal Mass Ejections (ICMEs) are also shown to be consistent with the interpretation of solar wind particles being accelerated in current sheets formed in the front of ICMEs. The observations show separation of ion and electron fluxes to the opposite sides from the ICME current sheet exhausts (Zharkova and Khabarova, 2015) and can account for electron fluxes called 'strahls'.

Pursuing forecasts of the behaviour of solar disturbances through modeling and observations

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Sophisticated instrumentation dedicated to studying and monitoring our Sun's activity has proliferated in the past few decades, together with the increasing demand of specialized space weather forecasts that address the needs of commercial and government systems. As a result, theoretical and empirical models and techniques of increasing complexity have been developed, aimed at forecasting the occurrence of solar disturbances, their evolution, and time of arrival to Earth. In this presentation we will review groundbreaking and recent methods to predict the propagation and evolution of solar disturbances such as coronal mass ejections and their driven shocks. The methods rely on a wealth of data sets provided by ground- and space-based observatories, involving remote-sensing observations of the corona and the heliosphere, as well as detections of radio waves.

Comparison of Magnetic Properties in a Magnetic Cloud and Its Solar Source on 2013 April 11-14

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In the context of the Sun–Earth connection of coronal mass ejections and magnetic flux ropes (MFRs), we studied the solar active region (AR) and the magnetic properties of magnetic cloud (MC) event during 2013 April 14–15. We use in situ observations from the *Advanced Composition Explorer* and source AR measurements from the *Solar Dynamics Observatory*. The MCs magnetic structure is reconstructed from the Grad–Shafranov method, which reveals a northern component of the axial field with left handed helicity. The MC invariant axis is highly inclined to the ecliptic plane pointing northward and is rotated by 117° with respect to the source region PIL. The net axial flux and current in the MC are comparatively higher than from the source region. Linear force-free alpha distribution at the sigmoid leg matches the range of twist number in the MC of 1–2 turns per AU. The MFR is nonlinear force-free with decreasing twist from the axis (9 turns/AU) toward the edge. Therefore, a Gold–Hoyle (GH) configuration, assuming a constant twist, is more consistent with the MC structure than the Lundquist configuration of increasing twist from the axis to boundary. As an indication of that, the GH configuration yields a better fitting to the global trend of in situ magnetic field components, in terms of rms, than the Lundquist model. These cylindrical configurations improved the MC fitting results when the effect of self-similar expansion of MFR was considered. For such twisting behavior, this study suggests an alternative fitting procedure to better characterize the MC magnetic structure and its source region links. We further show results from ten more such fitting cases to highlight the merits of GH over Lundquist model.

Interplanetary and Geomagnetic Consequences of Interacting CMEs of June 13-14, 2012

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We report on the kinematics of two interacting CMEs observed on June 13 and 14, 2012. Both CMEs originated from the same active region NOAA 11504. After their launch which is separated by several hrs, they were observed to interact at a distance of 100 solar radii from the Sun. Although the interacting CMEs of June 13-14, 2012 appear to be quite normal, in terms of speeds and associated flares and the resulting geomagnetic storm is also moderate with Dst attaining ≈ -71 nT value, the interaction event is very unique in terms of its geomagnetic consequence. Assuming a head-on collision scenario of the two CMEs, we find that their collision is inelastic in nature. The arrival of the CMEs is marked by an enhanced SSC which is 150 nT and is the the strongest of the present solar cycle 24. The role of interacting CMEs in enhancing the geoeffectiveness has also been examined.

The Effects of Deflection and Rotation on a CME's Near-Earth Magnetic Field Orientation

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Predicting the impact of coronal mass ejections (CMEs) and the southward component of their magnetic field is one of the key goals of space weather forecasting. We present a new model, the ForeCAT In situ Data Observer (FIDO), for predicting the in situ magnetic field of CMEs. We first simulate a CME using ForeCAT, a model for CME deflection and rotation resulting from the background solar magnetic forces (Kay et al. 2015). Using the CME position and orientation from ForeCAT, we then determine the passage of the CME over a simulated spacecraft. We model the CME's magnetic field using a force free flux rope and we determine the in situ magnetic profile at the synthetic spacecraft. We show that FIDO can reproduce the general behavior of several observed CMEs. FIDO results are very sensitive to the CME's latitude, longitude, and, especially, the tilt of the CME out of the equatorial plane, all of which are often difficult to precisely determine from coronagraph images. We show that the uncertainty in a CME's position and orientation from coronagraph images corresponds to a wide range of in situ magnitudes and even polarities. This small range of different positions and orientations often also includes CMEs that entirely miss the satellite. We show that a simple flux rope model could yield useful predictions of the magnetic field of Earth-impacting CMEs, particularly when driven by results from a simulation of the non-radial behavior of a CME, such as ForeCAT.

Interplanetary space relaxation time from the impact of coronal mass ejections

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While high-speed solar wind streams pose a continuous outflow from the Sun characteristically shaping interplanetary space, coronal mass ejections (CMEs) abruptly disrupt this rather steady structure. This causes a deviation from the quiet background solar wind conditions. We analyse how long interplanetary space needs to relax from such transient events and present a quantification of the duration of disturbed conditions (preconditioning), which has strong implications for studying CME propagation behavior and also for space weather forecasting. We investigate the plasma speed component of the solar wind during times of in-situ detected CMEs (ICMEs) and compare these measurements to different background solar wind models (ESWF, WSA, persistence model) for the time range 2011–2015. We obtain that ICMEs cause periods of disturbed solar wind speed ranging from about3 and up to 6 days after the ICME impacts the in-situ spacecraft. This is much longer than the average duration of an ICME disturbance itself (about 1.3 days), concluding that interplanetary space needs about 2–5 days to relax from the impact of ICMEs.

Effects of ICMEs on high energetic particles as observed by the Global Muon Detector Network (GMDN)

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The Global Muon Detector Network (GMDN) is composed by four ground cosmic ray detectors distributed around the earth: Nagoya (Japan), Hobart (Australia), Sao Martinho da Serra (Brazil) and Kuwait city (Kuwait). The network has operated since March 2006. It has been upgraded a few times, increasing its detection area. Each detector is sensitive to muons produced by the interactions of ~50 GeV Galactic Cosmic Rays (GCR) with the earth's atmosphere. At these energies, GCR are known to be affected by interplanetary disturbances in the vicinity of the earth. Of special interest are the interplanetary counterparts of coronal mass ejections (ICMEs) and their driven shocks because they are known to be the main origins of geomagnetic storms. It has been observed that these ICMEs produce changes in the cosmic ray gradient, which can be measured by GMDN observations.

In terms of applications for space weather, some attempts have been made to use GMDN for forecasting ICME arrival at the earth with lead times of the order of few hours. Scientific space weather studies, however, benefit the most from GMDN network. As an example, recent studies have been able to determine ICME orientation at the earth using cosmic ray gradient. Such determinations are of crussial importance for southward interplanetary magnetic field estimates, as well as ICME rotation.

In this work, we present some recent results obtained by the GMDN observations.

Session 2: **Oral**

Dependence of the Peak Fluxes of Solar Energetic Particles on Coronal Mass Ejection Parameters from STEREO and SOHO

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We investigate the relationships between the peak fluxes of 18 solar energetic particle (SEP) events and coronal mass ejection (CME) parameters (speed, angular width, and separation angle) obtained from multi-spacecraft (SOHO, STEREO-A and B) for the period from 2010 August to 2013 June. To obtain the radial speeds and the angular widths of CMEs, we apply STEREO CME Analysis Tool (StereoCAT) to the SEP-associated CMEs. The separation angles are determined as the longitudinal angle between flaring regions and magnetic footpoints of the spacecraft, which are calculated by the assumption of Parker spiral field. The main results are as follows. 1) We find that the dependence of the SEP peak fluxes on radial CME speed is similar to that on projected CME speed. 2) There is a positive correlation between SEP peak flux and angular width, which is more evident than the relationship between SEP peak flux and projected angular width. 3) There is a noticeable anti-correlation (r=-0.62) between SEP peak flux and separation angle. 4) Most of the strong SEP events are associated with very fast CMEs whose separation angles are closer to zero. 5) The multiple regression method between SEP peak fluxes and CME parameters shows that the longitudinal separation angle is the most important parameter, and the CME radial speed is secondary on SEP peak flux.

Re-Acceleration of Energetic Particles In Large-Scale Heliospheric Magnetic Cavities – An Underestimated Factor Of The Space Radiation Environment

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Case studies of particle acceleration up to several MeV/nuc throughout the heliosphere show that some energetic particle flux enhancements are not associated with standard mechanisms of particle acceleration. Atypical energetic particle events (AEPEs) represent increases in energetic particle flux observed at timescales from ~1/2 hour to several hours, sometimes, against the background of classical solar energetic particle events or before/after energetic particle enhancements associated with corotating interaction regions, but mostly in the relatively quiet solar wind (Khabarova et al. 2015, 2016). They are observed by different spacecraft with a time delay, corresponding to the propagation of the solar wind from one spacecraft to another, and therefore treated as local phenomena. AEPEs at 1 AU are associated with magnetic cavities formed by either the heliospheric current sheet or strong current sheets of various origins that magnetically confine small-scale magnetic islands (SMIs) with a typical width of ~0.01AU or less. The results are in a very good agreement with predictions based on a theory of stochastic particle energization in the supersonic solar wind via numerous dynamically interacting small-scale flux-ropes (Zank et al. 2014, 2015; le Roux et al. 2015, 2016). AEPEs associated with SMIs can be as dangerous to astronauts and spacecraft equipment as well-known SEP events, since AEPEs possess characteristics similar to and with energies that overlap SEP events.

Winds of other Suns and their effects on exoplanetary systems

Aline A. Vidotto
Trinity College Dublin

In this talk I will review some recent works on magnetised winds of Sun-like stars and discuss the impact stellar winds can have on surrounding exoplanets.

Compared to the physical interactions known to take place between the solar wind and the solar system planets, the interaction between stellar winds and exoplanets can be significantly stronger. This happens due to two main reasons: (1) the differences in the Physical properties of the host stars, such as magnetism, age and rotation, compared to the properties of our Sun; and (2) the extreme architecture of most of the known exoplanetary systems. I will also review the suggested relations between stellar activity and wind mass-loss rates, derived from astrospheric (Ly-alpha) measurements. I will discuss, in particular, the effects that the stellar magnetic field topology has on this relation.

Long-term evolution of the power spectrum of galactic cosmic rays

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University of Oulu, Oulu, Finland

Galactic cosmic rays are an important player in different phenomena inside the heliosphere and on Earth. The heliospheric modulation of cosmic rays cause their variability at different time scales.

Here we study the long-term evolution of the power spectrum of galactic cosmic rays in the frequency range $2.8 \cdot 10^{-7}$ – $2.8 \cdot 10^{-5}$ Hz (between 10 hours and 40 days). The analysis is based on 1-hour sampled data from 31 neutron monitors and several spacecraft instruments in 1954-2017, covering six solar cycles. We pay particular attention to the reliability of the datasets and the used methods.

Excluding periods of Forbush decreases and major solar particle events, we calculate the running power spectral density and the power-law slopes at different frequency bands, thus creating a multiple time-series of spectrum-related parameters. The analysed frequency range includes the time scales corresponding to the 27-day solar rotation, the diurnal variation of ground-based datasets, and the time scale of a few days where the spectrum exhibits a perfect power-law behaviour. We discuss the changes in the spectral properties of galactic cosmic rays over the solar cycle and longer time scales.

What Is The Best Use of Magnetic Maps for Coronal/Solar Wind Models?

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Predicting the evolution of Coronal Mass Ejections (CMEs) after their launch from the Sun, and their ultimate arrival time at Earth, is an important problem in space weather research. In physics-based models of this propagation, the state of the background solar wind is a key component of a successful prediction. Full-sun magnetic maps, utilized as boundary conditions, are, in turn, a crucial element of models of the corona and solar wind. This is true for empirically based models (such as the WSA model currently used at NOAA/SWPC) as well as more advanced MHD models. Magnetic maps from a range of sources (e.g., synoptic maps from ground and space-based observatories, flux transport models, etc.) typically agree qualitatively but not quantitatively. These quantitative discrepancies lead to important differences in the solutions. In this paper we describe these differences, how they affect the solutions, and how quantitative comparisons with coronal hole boundaries (observed in emission) may provide insights into the best use of magnetic maps. To accomplish the comparisons, we employ a recently developed database of synchronic EUV maps and coronal hole boundaries (Caplan, Downs, & Linker, ApJ, 823:53, 2016).

New strategies for modelling and forecasting the background solar wind

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I will present a new series of solar wind simulations of the background solar wind from the surface of the Sun to 1 AU. We used a new solar wind model, called MULTI-VP, which takes a coronal magnetic field map as input (past data or forecast) and calculates the dynamical and thermal properties of the solar wind from the chromosphere up to about 30 R_{sun} in quasi-real time (while keeping a good description the plasma heating and cooling mechanisms). MULTI-VP supplies the full set of physical inner boundary conditions required to initiate the model ENLIL, which was then used to calculate the properties of the wind flow in the heliosphere (from 21.5 Rsun to 1AU).

We have computed solar wind datacudes for several Carrington rotations both at solar minimum and at solar maximum (CRs 2055-2079 and 2130-2149; see link), which were calibrated against in-situ measurements of different spacecrafts, white-light J-Maps and coronal/heliospheric imagery in order to provide better predictions than the classical methods. These wind solutions will be available as HELCATS catalogues.

This combined modeling strategy does not rely on semi-empirical assumptions for the state of the solar wind at the high corona, and provides new estimates of the state of the background solar wind which are based only on physical principles. I will discuss the predictive capabilities of the model (synthetic imagery and in-situ time series) and its suitability to real-time space-weather applications.

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Solar Wind-Magnetosphere Coupling and the MMS Mission

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The MMS mission uses the near-Earth environment as a laboratory to explore the micro-physics of magnetic reconnection. This process takes place in the very small electron diffusion region, where electrons are demagnetized and magnetic fields reconnect. Although focused on micro-physics, most of the observations from this multi-spacecraft mission are made outside of this diffusion region. Observations both inside and outside the diffusion region have important implications on the overall coupling of the solar wind to the magnetosphere, especially when these observations are combined with results from other missions like Cluster, Polar, THEMIS, etc. In particular, these observations provide information on the length of the reconnection line, the reconnection rate, and the variability of this rate at the magnetopause. The combination of these three quantities provides a measure of the overall coupling between the shocked solar wind in the magnetosheath and the plasma and magnetic field in the magnetosphere. This talk explores this coupling at the magnetopause. Specific examples of the overall coupling from the MMS mission are discussed in detail.

Comparison And Time Evolution Of The Geomagnetic Cutoff At The ISS Position: Internal Vs External Earth Magnetic Field Models

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Our backtarcing code (GeoMagSphere code) is able to reconstruct the cosmic ray trajectories inside the Earth Magnetosphere. GeoMagSphere code is able to get the incoming directions of particles entering the magnetopause and to disentangle primaries from secondaries (produced in atmosphere) or trapped inside the Earth magnetic field. The separation of these particle families leads to evaluate the geomagnetic rigidity cutoff. The model can use only the internal symmetric (IGRF-12) magnetic field or can add the highly asymmetric external one (Tsyganenko models: T89, T96 or TS05). A comparison among these models will be presented especially in quite (solar pressure below 4 nPa) and disturbed (solar pressure above 4 nPa, as during solar events like flares, CME's) periods of solar activity. This analysis regards magnetic field data in magnetosphere, from CLUSTER, and simulated cosmic rays for a generic detector on the ISS as AMS-02. We found that high solar activity periods, like large fraction of the time during years 2011-2015, are better described using IGRF+TS05 model. The average vertical rigidity cutoff at ISS orbit will be shown in geographic maps with 2°x2° cells. A time evolution of this cutoff is also presented every 6 months giving us information regarding the solar - magnetosphere coupling.

Large-Scale Structure of the Solar Wind Upstream Of Jupiter and Saturn with Implications for Solar Wind-Magnetosphere Coupling

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The giant planetary magnetospheres surrounding Jupiter and Saturn respond in quite different ways, compared to Earth, to changes in upstream solar wind conditions. Spacecraft have visited Jupiter and Saturn during both solar cycle minima and maxima. We explore the large-scale structure of the interplanetary magnetic field (IMF) upstream of Saturn and Jupiter as a function of solar cycle, deduced from solar wind observations by spacecraft. We show the distributions of solar wind dynamic pressure and IMF angles over the changing solar cycle conditions, detailing how they compare to Parker predictions and to our general understanding of expected heliospheric structure at 5 and 9 AU. We explore how Jupiter's and Saturn's magnetospheric dynamics respond to varying solar wind driving over a solar cycle under varying Mach number regimes, and consider how changing dayside coupling can have a direct effect on the nightside magnetospheric response. We also address how solar UV flux variability over a solar cycle influences the plasma and neutral tori in the inner magnetospheres of Jupiter and Saturn, and estimate the solar cycle effects on internally driven magnetospheric dynamics.

The Response of the Martian Atmosphere to the Solar Wind

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The solar wind directly encounters the Martian upper atmosphere since the planet lacks a global magnetic field. This interaction influences the Martian environment in a variety of ways, with consequences for the energetics, chemistry, and dynamics in the upper atmosphere and exosphere. Of most significance for the planet as a whole, however, is the acceleration of particles away from the planet by electric fields near Mars and in the solar wind. Atmospheric ion escape may have contributed to the removal of a substantial fraction of the Martian atmosphere over time, transforming it from a planet with an atmosphere capable of supporting flowing liquid water at the surface to the relatively inhospitable atmosphere present today.

This presentation will review the current understanding of how the solar wind influences Mars, with a focus on results from the active Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft dedicated to observations of the upper atmosphere and solar wind interaction. We will present observations of the variety of ways in which the solar wind influences the Mars environment and describe how the solar wind influences atmospheric escape rates. Finally, we will summarize how observations by MAVEN can be placed in context to tell us how unmagnetized objects (e.g. comets, Pluto, Venus, exoplanets) interact with flowing plasma in general.

Different Responses of Solar Wind and Geomagnetism to Solar Activity during Quiet and Active Periods

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It is well known that there are good relations of coronal hole (CH) parameters such as the size, location, and magnetic field strength to the solar wind conditions and the geomagnetic storms. Especially in the minimum phase of solar cycle, CHs in mid- or low-latitude are one of major drivers for geomagnetic storms, since they form corotating interaction regions (CIRs). By adopting the method of Vrsnak et al. (2007), the Space Weather Research Center (SWRC) in Korea Astronomy and Space Science Institute (KASI) has done daily forecast of solar wind speed and Dst index from 2010. Through years of experience, we realize that the geomagnetic storms caused by CHs have different characteristics from those by CMEs. Thus, we statistically analyze the characteristics and causality of the geomagnetic storms by the CHs rather than the CMEs with dataset obtained during the solar activity was very low. For this, we examine the CH properties, solar wind parameters as well as geomagnetic storm indices. As the first result, we show the different trends of the solar wind parameters and geomagnetic indices depending on the degree of solar activity represented by CH (quiet) or sunspot number (SSN) in the active region (active) and then we evaluate our forecasts using CH information and suggest several ideas to improve forecasting capability.

Implications Of The Magnetic Structure Of Magnetic Clouds For Their Interaction With The Terrestrial Bow Shock And The Magnetopause

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Magnetic clouds are very geoeffective solar events capable to trigger strong magnetic storms in the terrestrial magnetosphere. However their interaction with the magnetosphere and their level of geoeffectivity are not yet fully understood. Some effects as the occurrence of other events (jets, shocks, other clouds, ...) in the immediate surroundings of the clouds are known to affects their geoeffectivity. We present here additional effects capable to modify their geoeffectivity which are directly related to the interaction of the clouds with the terrestrial environment. From observations and simulations, we have shown that the quasi-perpendicular or quasi-parallel configuration of the clouds at the bow shock preserves or changes the cloud's magnetic structure downstream of the bow shock. In order to estimate further the consequences of these effects for the clouds' interaction with the magnetophere, we run 3D hybrid simulations of the interaction of a magnetic cloud with the Earth's bow shock. We investigate the plasma and field distributions downstream of the bow shock and next to the magnetopause. We examine their role in triggering crucial processes for the magnetospheric activity as magnetic reconnection and surface instabilities. We compare the effects obtained for both quasi-perpendicular and quasi-parallel configurations at the bow shock.

Geomagnetopause position and shape dependence on solar wind plasma and IMF parameters: analytic model comparison with observations and 3-D MHD runs

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It is generally accepted to use solar wind ram pressure ρV^2 and IMF B_z component for empirical description of the geomagnetopause position and shape. Specific feature of the present talk is to use not solar wind ρV^2 but neighboring to magnetopause thermal P_{th}, and magnetic field P_{mag} pressures for proper modelling. These pressures are deduced basing on the results of 3-D MHD runs and analytic solutions for post bow shock MHD flow in Lagrangian variables. IMF B_y and B_z components influence the planetary magnetopause position and shape in two different ways: (i) $\sqrt{B_y^2 + B_z^2}$ component leads to increase P_{mag} close to magnetopause while (ii) B_z part of IMF leads additionally to variation of this boundary shape. The magnetopause shape variation in turn changes the so called 'doubling factor' f_d which indicates how much the internal magnetospheric field is increased due to Chapman-Ferraro currents. Doubling factor can be analytically related with magnetopause shape by Tsyganenko magnetospheric field ellipsoidal model. Incorporating all above effects in our analytical model leads to 'perfect' description of 'rapid' magnetopause approach to the Earth for southward IMF and to its 'stagnative' behavior with increase of northward IMF component. Our analytic model well describes additionally the magnetopause motion with variation of IMF cone angle.

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On the Elegant Dynamics of the Ultra-relativistic Van Allen Radiation Belt: How ULF Wave Transport Explains an Apparently Diverse Response to Solar Wind Forcing

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The NASA Van Allen Probes have opened a new window on the dynamics of ultra-relativistic electrons in the Van Allen radiation belts. Under different solar wind forcing the outer belt is seen to respond in a variety of apparently diverse and sometimes remarkable ways. For example, sometimes a third radiation belt is carved out (e.g., September 2012), or the belts can remain depleted for 10 days or more (September 2014). More usually there is a sequential response of a strong and sometimes rapid depletion followed by a re-energization, the latter increasing outer belt electron flux by orders of magnitude on hour timescales during some of the strongest storms of this solar cycle (e.g., March 2013, March 2015). Such dynamics also appear to be always bounded at low-L by an apparently impenetrable barrier below L~2.8 through which ultra-relativistic electrons do not penetrate. Many studies in the Van Allen Probes era have sought explanations for these apparently diverse features, often incorporating the effects from multiple plasma waves. In contrast, we show how this apparently diverse behaviour can instead be explained by one simple dominant process: ULF wave radial transport. Once ULF wave transport rates are accurately specified by observations, and coupled to the dynamical variation of the outer boundary condition at the edge of the outer belt, the observed diverse responses can all be explained. In order to get good agreement with observations, the modeling reveals the importance of still currently unexplained fast loss in the main phase which decouples pre- and post-storm ultra-relativistic electron flux on hour timescales. Similarly, varying plasmasheet source populations are seen to be of critical importance such that near-tail dynamics likely play a crucial role in Van Allen belt dynamics. Nonetheless, simple models incorporating accurate transport rates derived directly from ULF wave measurements are shown to provide a single natural, compelling, and at times elegant explanation for such previously unexplained and apparently diverse responses to solar wind forcing.

Modelling Extreme Events In The Earth's Electron Radiation Belts

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The high energy (> ~500 keV) electron flux in the Earth's radiation belts can be very dynamic and has been observed to change by orders of magnitude within a few hours. Since these electrons are responsible for internal charging, which can damage satellites, it is important to understand and quantify the likely worst case fluxes that satellites could encounter.

As part of the EU-FP7 project SPACESTORM, two different extreme events have been studied; a very large coronal mass ejection (CME) and a period of very high speed solar wind. The BAS Radiation Belt Model (BAS-RBM) has been adapted to model both types of extreme event. To validate the BAS-RBM results, a comparison between model and data for a large event of each type will be presented before the results for extreme events are shown.

The scenario for the extreme CME event is based on data from a CME that missed the Earth but was observed by the STEREO-A in July 2012. The simulations show that the magnetopause is likely to come inside of L*=5, the MeV electron belt is closer to the Earth than usual, and the >2 MeV flux at GEO is comparable to about a 1 in 10 year event. The extreme solar wind stream simulations are defined using a previously published super-posed epoch analysis of 40 high speed stream events. In this case the magnetopause remains at larger L* and the electron flux at MEO and GEO can reach higher levels than those seen with the extreme CME.

Centennial Variability of Space Climate

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Geomagnetic observations have been used to re-construct some of the conditions in the near-Earth solar wind back to about 1845. These variations can be extended back to the start of telescopic sunspot observations (1610) using models of the variation of the open solar flux, where flux emergence is quantified using sunspot number. By employing the results from runs of an MHD model of the solar corona, constrained by observed photospheric magnetic field, we can reconstruct all the near-Earth solar wind parameters that are relevant to space weather. However, the variability of the field orientation in the GSM frame means that these reconstructions are necessarily only of annual means which do not tell us directly about the occurrence of extreme space weather events. However, empirically, the shape of the distribution of solar-terrestrial variability indices is found to be remarkably fixed which means that, in practice, the mean values can be used to estimate the variation in the occurrence of space weather events. This paper will present the estimated variation of the occurrence frequency of most intense geomagnetic storms and substorms (defined by the largest 5% of events in the Ap, Dst and AE indices since 1966) for between 1610 and the present day

Session 3: **Oral**

Challenges And Strategic Research Plans For Earth And The Heliosphere

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Space weather motivates a broad range of research which includes understanding processes in the heliosphere and studies of its consequences in the Earth system. There is a wealth of existing diverse resources: the expertise in heliospheric, magnetospheric, and ionospheric research; the previous and existing ground-based and space-based instrumentation and their observational data; and space weather related data processing initiatives. Advanced tools within information and communication technology also offer new unprecedented opportunities for numerical simulation and data assimilation.

Using all these opportunities in an optimum way requires efficient networking among researchers, a common language and common standards for sharing data. EISCAT_3D will be an international research infrastructure using observations from an advanced radar located in northern Scandinavia for studies of the atmosphere and near-Earth space environment. The scientific data from EISCAT_3D will be an invaluable asset for space weather studies. EISCAT_3D is a project on the European Commission’s roadmap of research infrastructures and therefore participates in initiatives to improve data access, dissemination and work across disciplines. Motivated by, but not limited to this project we address the open issues in collaborative space weather research, how to make use of observations globally and how to link to theoretical and modelling work.

Thermospheric Dynamics in quiet and disturbed conditions

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By the end of 2013, the RENOIR (Remote Equatorial Nighttime Observatory of Ionospheric Region) experiment has been deployed at Oukaimeden observatory (31.206◦N, 7.866◦W, 22.84◦N magnetic) in Morocco under a collaboration between the University Cadi Ayyad at Marrakech and the University of Illinois at Urbana-Champaign. This experiment consists of a Fabry–Pérot interferometer (FPI) and a wide-angle imaging camera. The main goal of this experiment to characterize the coupling between the thermosphere and the ionosphere in the north African sector.

The climatology of the meridional and zonal winds and temperature has been established as well as their most probable departure from their quiet time climatology during geomagnetic storms.

In this paper, we want to analyze the behavior of the components of the winds; north and south for meridional wind, and east and west for the zonal one, as they are 500 km apart from one another. The idea behind the study is to see if there is a typical background for the quiet time pattern of the winds and how they depart from their quiet time behavior during geomagnetic storms. We also want to investigate the relationship between the components of the winds and the thermospheric temperature. Our first results show that for Kp<4, and when all the data are considered in the statistics there are only slight differences between the components of the winds. However, on night by night basis, some recurrences emerge. In some storm cases the temperature seem to react prior to the winds. The pattern of the component of the winds may have some explanations to that phenomenon.

Study of solar flare and storm-induced ionospheric changes in mid-latitude D-region using VLF signal propagation characteristics

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We analysed the trend in variations of characterised metrics of diurnal VLF signal amplitude during storm and flare conditions to understand signal propagation characteristics attributable to changes in the D-region ionosphere, driven by the events. Besides detectable flare-induced sudden change (fluctuation) in the amplitude and enhancement in phase of the signal we found that the mid-day signal amplitude peak (MDP) exhibited characteristic dipping in about 68% of the combined cases following 20 storm events. Some (but few) cases of propagation path-mismatched increase of MDP, as well as propagation path-matched increase of the signal were also observed during some events. The mean signal amplitude before sunrise (MBSR) and mean signal amplitude after sunset (MASS) also showed significant dipping (respective 66% and 64%). However, the signals (MBSR and MASS) appear to be influenced by the event occurrence time and intensity, and the highly variable conditions of dusk-to-dawn D-region ionosphere. The post-storm day signal (with significantly reduced geomagnetic activity) exhibited a tendency of recovery to pre-storm day level. Conversely, the sunrise terminator (SRT) and sunset terminator (SST) amplitude showed respective dipping of 46.5% and 32.5% of the combined cases, favouring storm-time rise or increase in the signals. Since the ionosphere can also be influenced by perturbations from sources other than solar origin we validate the finding by examining the state of the ionosphere (including the E and F region) between the signals transmitter and the receiver using appropriate ionospheric parameters. We also observed (in some cases) that the known X-ray flux induced daytime amplitude spike tend to diminished under concurrent geomagnetic storm condition when compared with quiet time scenario. We however recommend detailed modelling to better understand the dependence of this findings on signal propagation path and/or phenomena associated with time-variant conditions in the ionosphere.

Role of D-region Ion Chemistry in Atmospheric Forcing by Precipitating High-Energy Particles

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High-energy particle precipitation into the atmosphere is known to affect upper atmospheric composition by producing odd hydrogen and odd nitrogen, which in turn may decrease the concentration of ozone. We summarize here how ion chemistry couples to neutral chemistry during excess ionization events, the current experimental and model-based evidence on subsequent composition variations, as well as modeling efforts to understand the role of the energetic particle precipitation at high latitudes in causing natural variability of Earth's climate. Both large solar proton events and frequently occurring energetic electron precipitation cause significant variations in upper stratospheric and mesospheric ozone concentration, a result which needs further considerations for consequences.

Most studies so far on atmospheric effects of energetic particle precipitation concentrated on the indirect particle precipitation effect caused by the production of odd nitrogen (NOx) in the polar upper atmosphere, its subsequent transport to lower altitudes inside the wintertime polar vortex, depletion of ozone in the stratosphere, and effects on the radiative balance of the middle atmosphere, which may further couple to atmospheric dynamics and propagate downwards by changing polar winds and atmospheric wave propagation through wave–mean flow interaction. Solar proton events have been convincingly shown to produce major reduction of middle atmospheric ozone concentration. Recent results on energetic electron precipitation show long-term effects, as mapped by the MEPED detector onboard NOAA/POES satellites during 2002-2012. The events caused several long-lasting up to 90% destructions of mesospheric ozone at 60-80 km altitudes, as seen by 3 satellite instruments GOMOS, MLS and SABER. A single event study using data from the EISCAT VHF radar in Tromsø, Norway, and simultaneous observations by Van Allen probes satellite B, showed evidence of mesospheric ozone destruction up to tens of percent during the occurrence of pulsating aurora. The effect was notably maximized at the sunset time following the occurrence of the precipitation in the morning, due to the role of odd hydrogen chemistry. The magnitude of the effect depends on the precipitation characteristics used in modeling, which calls for more accurate measurements on the energy and flux, as well as spatial and temporal variations of the energetic electron precipitation.

Shock, Sheath And Ejecta Control Of Upper Atmosphere Heating And Cooling—When Nature Reigns In Storm Time Response Of The Thermosphere

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We present a multiyear superposed epoch study of the Sounding of the Atmosphere using Broadband Emission Radiometry nitric oxide (NO) emission data. We investigate the reason that some strongly driven storms exhibit a see-saw effect in thermospheric temperature response. NO is a trace constituent in the thermosphere that acts as cooling agent via infrared (IR) emissions. The NO cooling competes with storm time thermospheric heating, resulting in a thermostat effect. Our study of ~ 200 events reveals that shock-led interplanetary coronal mass ejections (ICMEs) are prone to early and excessive thermospheric NO production and IR emissions. Excess NO emissions can arrest thermospheric expansion by cooling the thermosphere during intense storms. The strongest events curtail the interval of neutral density increase and produce a phenomenon known as thermospheric "overcooling." We use low earth orbit particle precipitation data to show that interplanetary shocks and their ICME drivers can more than double the fluxes of precipitating particles known to trigger the production of thermospheric NO. Coincident increases in Joule heating likely amplify the effect. In turn, NO emissions are more than double. We discuss the roles and features of shock/sheath structures that allow the thermosphere to temper the effects of extreme storm time energy input. Shock-driven thermospheric NO IR cooling likely plays an important role in satellite drag forecasting challenges during extreme events.

Modeling the thermosphere and ionosphere response to geomagnetic storms

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The solar wind drivers of the ionosphere and thermosphere during geomagnetic storms include the expanded high latitude magnetospheric convection, auroral precipitation, and penetration of the high latitude electric fields to the equator. The increase in Joule heating at mid and high latitudes raises neutral temperature, drives thermal expansion and neutral density changes. The horizontal pressure gradients drive meridional wind surges and a change in the global circulation. The global circulation and vertical winds increase the ratio of molecular nitrogen to atomic oxygen at mid latitudes and are the primary cause of the negative phase ionospheric storm response. The positive phase is more complex and has been a modeling challenge for many years. The positive phase is manifest as storm enhanced densities, huge increases in total electron content at mid-latitude, and enhancement and poleward movement of the equatorial ionization anomaly, all with strong local time and longitude dependence. The positive phase is beginning to be understood and physical models are able to unravel some of the physical processes.

Ionosphere Space Weather Over The South America Region During The St. Patrick´s Geomagnetic Storm On March 2015

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Ionospheric storm is a term to describe global disturbances on ionosphere during geomagnetic disturbed periods. The tropical ionosphere is one of the most interesting regions of the Earth´s atmosphere to study the ionospheric disturbances during extreme space weather conditions. We investigated the response of the ionosphere in the South American sector during space weather event of 17 March 2015 (St. Patrick´s Day Storm) using a network of 102 GPS stations and 4 ionosondes. It is observed that the Vertical Total Electron Content (VTEC) was severely disturbed during the storm main and recovery phases. The VTEC shows a wavelike oscillation with 3 strong positive phase peaks and a negative phase during the main and recovery phases, respectively. This ionospheric negative phase was stronger at low-latitudes than in the equatorial region. In addition, there is ionospheric irregularity suppression during the storm main phase and a post-midnight irregularity during the first night of recovery phase. Also, two latitudinal chains of GPS stations from equatorial region to low latitudes in the east and west Brazilian sectors are used to investigate the storm time behavior of the Equatorial Ionization Anomaly (EIA) in the east and west Brazilian sectors. We observed an anomalous behavior in EIA caused by the wavelike oscillations during the storm main phase and reduced strength of the EIA, resulting from the negative phase in VTEC, during the storm recovery phase.

Solar Wind Interaction with Pluto

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The New Horizons taken during the July 2015 flyby of Pluto, and compare these observations to both predictions prior to the flyby and recent hybrid simulations of the flyby. We place these observations into the context of the overall heliosphere by showing how the solar wind varies with distance and describing how the specific solar wind conditions during the flyby compare to the solar wind conditions typical at this heliocentric distance (~33 AU). The SWAP instrument detected heavy Plutogenic ions distinct from the light solar wind. These observations were used to determine an upstream standoff distance of ~2.5 RP, a long heavy ion tail extending to at least 100 RP, and a downtail lost rate of ~ 5×1023 s-1. In addition to providing information about the Plutogenic ions, the SWAP observations provide limits on the orientation of the interplanetary magnetic field (outward), and upper limit of Pluto's surface field strength (<30 nT).

Predicting A Solar Cycle Before Its Onset Using A Flux Transport Dynamo Model

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We study the question whether we can use the flux transport dynamo model to predict the strength of a solar cycle before its onset. In order to make a prediction, we first need to understand the causes behind the irregularities of the solar cycle. We identify the fluctuations in the Babcock-Leighton mechanism for producing the poloidal field of the Sun and the fluctuations in the meridional circulation as the primary causes behind the irregularities of the solar cycle. Our dynamo calculations show that the strength of the meridional circulation a few years before the peak of the cycle affects the amplitude of the cycle rather than its strength around the peak and we can obtain information about this from the decay rate of the previous cycle. We start getting information about the Babcock-Leighton mechanism once we have sufficient data about the sizes and tilts of the bipolar sunspot pairs in the previous cycle. From such data, it is necessary to study realistically how the poloidal magnetic field of the Sun builds up. While this can be done by using surface flux transport models, there are certain limitations. We argue that 3D kinematic dynamo models are the most promising models for such studies. Given the many uncertainties in our understanding of the subject, we review our present ability in predicting solar cycles.

Estimating the Solar Meridional Flow and Predicting the 11-yr Cycle Using Advanced Variational Data Assimilation Techniques

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We present in this work the development of a solar data assimilation method based on an axisymmetric mean field dynamo model and magnetic surface data, our mid-term goal is to predict the solar quasi cyclic activity. Here we focus on the ability of our algorithm to constrain the deep meridional circulation of the Sun based on solar magnetic observations. To that end, we develop a variational data assimilation technique. Within a given assimilation window, the assimilation procedure minimizes the differences between data and the forecast from the model, by finding an optimal meridional circulation in the convection zone, and an optimal initial magnetic field, via a quasi-Newton algorithm. We demonstrate the capability of the technique to estimate the meridional flow by a closed-loop experiment involving 40 years of synthetic, solar-like data. By assimilating the synthetic magnetic proxies annually, we are able to reconstruct a (stochastic) time-varying meridional circulation which is also slightly equatorially asymmetric. We show that the method is robust in estimating a flow whose level of fluctuation can reach 30% about the average, and that the horizon of predictability of the method is of the order of 1 cycle length.

Reconstruction of the filaments properties, based on centenarians data daily observations of the Sun in H-alpha line

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The series of solar filaments characteristics is represented. This series is obtained by processing of daily observations in the H-alpha line according to the Kodaikanal observatory in Kodaikanal (India, 1912-2002). The series is complemented by database of filaments properties according to Kislovodsk for the period 1959-2016, Sacramento Peak (USA, 1962-2002) and Meudon (France, 1982-2015). These data are unique because they trace the polarity inversion line which helps to reveal the large-scale organization of the solar magnetic field. To select solar filaments boundaries, we have developed methods based on automatic processes like selection of low-contrast objects on the solar disk, and methods of editing the selected structures in semi-automatic mode. More than 24 thousand photographic plates were processed in total for Kodaikanal with more than 326 thousand filaments being detected.

Comparative analysis of solar filaments characteristics in 15-24 cycles of activity was carried out. The connection of solar filaments indices and long-term parameters of space weather is considered.

Prediction of Solar Cycle 25 Using a Surface Flux Transport Model

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The modulations in space weather are primarily governed by the variability in the solar activity. Adverse solar events like CMEs and solar flares originate mostly from sunspots, and the number of sunspots follows a cycle of decadal periodicity. Thus predicting the strength of future solar cycle has become an important scientific goal. The intrinsic stochastic nature of the Sun limits the predictability up to one cycle. Among a wide range of prediction methods, the polar field amplitude during a cycle minima has been proved to be one of the best precursors for estimating the amplitude of the succeeding cycle. Surface Flux Transport (SFT) models are quite successful in capturing the physics of generation of polar flux as well as their amplitudes. With our newly developed SFT model, we perform a continuous century scale simulation using observed sunspot data taken from RGO/NOAA database starting from the solar cycle 15 (the year 1913) to the current cycle 24 (the year 2016). We utilize our calibrated simulation to run the model forward to predict the polar flux during the cycle 24 minimum using a synthetic sunspot data profile (constructed depending on the statistical properties of sunspots) for the descending phase of the current cycle. Based on this estimated polar flux we present a predicted amplitude of the solar cycle 25 along with the probable occurrence time of cycle 25 maxima.

The Solar Wind Interaction with the Solar System

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The solar dynamo produces a magnetic field that reverses every sunspot cycle and has long term variations in strength. The solar energy flux produces a solar wind that is supersonic. As this solar wind expands outward, it interacts with the planets, and terminates at the point where it reaches pressure equilibrium with the local interstellar medium. The galactic magnetic field has a discernable effect on the heliosphere as the galactic cosmic ray access to the heliosphere is modulated by the strength and polarity of the solar wind magnetic field. Most of the planets in the solar system, if not all, have or once had an internal magnetic dynamo of their own. This magnetic field is often mistakenly taken to shield planetary atmospheres from the erosive power of the solar wind but, in fact, the magnetic field couples more momentum from the solar wind and hastens atmospheric loss than would occur in its absence. The Earth loses atmosphere much faster than its non-magnetic twin, Venus, while tiny Mars with its weak magnetic field matches Venus in atmospheric loss. Jupiter, alone, is little affected by its solar wind interaction. Its atmosphere is shielded in a deep gravitational potential well and its energetics dominated by its internal energy source. Its moons' though, do lose their atmospheres to the solar wind because the rapidly spinning magnetosphere and its population of charged particles ionizes the atmospheres of the Galilean moons and carries those ions out into the jovian magnetotail where they are efficiently accelerated outward towards the heliopause. A similar story holds for Saturn, a kinder gentler planet, whose symmetric rotationally aligned internal field suggests its dynamo is dying.

The Earth would have nothing to fear from the Sun had its inhabitants not chosen to develop a technological base on which they have become dependent. Since the interplanetary properties have been carefully monitored for less than a half-century and the Sun has much longer activity cycles, we may not know the extremes of space weather and must continue to monitor the Sun to determine those extremes.

A planet that is very much affected by the variations of solar activity is the dwarf planet Ceres. Ceres is an ice-bearing body whose exposed and near-surface ice sublimes to form a weak exosphere and ice layers are deposited in shadowed areas. When solar energetic particle events reach Ceres, this thin residual water-ice layer is sputtered and a temporary atmosphere, detectible from 1AU, is formed. The gravity of Ceres is too weak to retain this atmosphere and it is lost to space in about a week.

Seasonal Solar Wind Speeds For The Last 100 Years: Unique Coronal Hole Structures During The Peak And Demise Of The Grand Modern Maximum

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Solar coronal holes are sources of high-speed solar wind streams, which cause persistent geomagnetic activity especially at high latitudes. Here we estimate seasonal solar wind speeds at 1 AU for the last 100 years using high-latitude geomagnetic measurements, and show that they give information on the long-term evolution of important structures of the solar large-scale magnetic field, such as persistent coronal holes.

We find that the centennial evolution of solar wind speed at 1 AU is different for equinoxes and solstices, reflecting differences in the evolution of polar coronal hole extensions and isolated low-latitude coronal holes. Equinoctial solar wind speeds had their centennial maximum in 1952, during the declining phase of solar cycle 18, verifying that polar coronal holes had exceptionally persistent extensions just before the peak of the Grand Modern Maximum of solar activity.

On the other hand, solstice speeds had their centennial maximum during the declining phase of solar cycle 23 due to large low-latitude coronal holes. A similar configuration of seasonal speeds as in cycle 23 was not found earlier, not even during the less active cycles of early 20th century. Therefore the exceptional occurrence of persistent, isolated low-latitude coronal holes in cycle 23 is not related to the absolute level of sunspot activity but, most likely, to the demise of the Grand Modern Maximum.

Aurorae In The Deep Phase of the Maunder Minimum?

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Recently, several solar activity studies misinterpreted halo displays as aurorae, one of them even in the deep phase of the Maunder Minimum. Halos were very popular in the Early Modern Period with its apocalyptic zeitgeist during and following religious processes (reformation aftermath). 17th century reports on celestial observations (comets, aurorae, halos, etc.) by both laymen and scholars are phenomenological. They were often published on broadsheets with an eyewitness report and a figure on coloured woodcut from someone else. Even in the Hungarian collection of broadsheets and chronicle entries (Rethy & Berkes), considered the most homogeneous sample of aurorae in the Maunder Minimum, almost all reports are most certainly halo displays including elaborated narratives.

We set clear criteria for historical aurora borealis reports: night-time, non-southern direction, colour, dynamics, and repetition. Reports on, e.g., war armies or dragons on sky at night can refer to aurorae or lunar halos. One can distinguish them with astronomical, meteorological, and literary analyses: context, contemporary terminology and interpretation, current weather, direction, timing (twilight?), lunar phase, etc. We then review all European and East Asian reports so far interpreted as aurorae in and around the Maunder Minimum.

Only with a critically selected aurora catalogue (together with radioisotopes and sunspots), one can study the onset, depth, and duration of the Maunder Minimum.

Electron Acceleration Due To Wave-Particle Interactions in the Outer Radiation Belt for a Severe Space Weather Event Driven by a Fast Solar Wind Stream

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Satellite charging is one of the most important risks for satellites on orbit. Satellite charging can lead to an electrostatic discharge (ESD) resulting in component damage, phantom commands, loss of service and in exceptional cases total satellite loss. Here we show that a fast solar wind stream lasting 5 days or more can lead to very high electron flux and a severe risk of satellite charging. We use a physical model which takes into account substorms and electron acceleration and loss due to wave-particle interactions to calculate the maximum daily electron flux greater than 2 MeV. We find that the flux tends towards a limiting value after approximately 5 days of between 5 x 10^5 and 2 x 10^6 cm^{-2} s^{-1} sr^{-1} keV^{-1}. This exceeds the threshold for ESD problems as set out in the NASA handbook. The results are comparable to those found from a statistical analysis of electron data for a 1 in 150 year event, providing confidence in the method and the result. We conclude that a fast solar wind stream lasting 5 days or more can lead to ESD with a significant risk of component damage and disruption to satellite services. We suggest that since fast solar wind stream events have a very different nature to those driven by a coronal mass ejection they should be recognised as a different class of severe space weather event affecting satellites.

Defining and Characterising Heliospheric Weather and Climate

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At large distance scales, space exploration in the last decades has significantly helped in better locating the boundaries of the Heliosphere and outlining its shape as well as in probing the various plasma domains that separate the inner heliospheric region from the interstellar one. At shorter distance scales, a fleet of spacecraft has been probing the outer and inner Solar System plasma with a high level of detail.

This monitoring, complemented by space- and ground-based observations of processes relevant to the Heliosphere, has pointed out a series both of intrinsic and extrinsic perturbations that characterise the physical state of heliospheric plasmas both at small and large spatial scales and on short and long temporal scales, i.e., the Heliospheric Weather (HSWx) and Climate (HSC).

By means of concept maps that schematise the association among concepts, in this work we will present a new domain ontology for the definition and characterisation of HSWx and HSC as extensions of the terms Space Weather and Climate. In particular, we will concentrate on the basic definitions, phenomenology and workflows that lead to monitoring, modelling and predicting both HSWx and HSC by pointing out gaps and pitfalls that can affect the development of a robust operational machinery. This requires step forwards in understanding the physics of heliospheric phenomena via long-term, multi-wavelength, and multi-scale observations, still a chimera despite the social benefits it could provide.

NASA Heliophysics Space Weather Research: Challenges and Strategic Plans for Earth and the Heliosphere

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At the center of our solar system there is a magnetic variable star, our sun, that affects the planets, including the Earth, and sculptures the flows of interplanetary space itself. Heliophysics is the study of the sun's influence throughout the solar system and, in particular, its connection to the Earth and the Earth's extended space environment. Data from Heliophysics science missions are vital to the nation's space weather infrastructure. Specific to space weather, NASA formulates and implements a national research program for understanding the Sun and its interactions with the Earth and the Solar System and how these phenomena impact life and society. This program utilizes a fleet of space-based observing systems collectively called the Heliophysics System Observatory.

Early Warning Of Solar Radiation Hazards – New Concepts, Capabilities, And Applications

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In the past few years, there was significant progress in improving and testing of solar radiation hazard warning systems. Ion radiation beyond Earth's magnetosphere stems from the prompt occurrence of solar energetic particle events. Fast-rising ion intensities from solar particle events pose danger to astronauts venturing out beyond low-Earth orbit, in particular in low-shielding situations such as walking on the moon or during space walks. Early warning systems can avoid astronauts' exposure to significant dose rates over the first hours of the event, taking into account that by the time they reach a radiation shelter, the solar particle event could be in full swing. Also potentially affected are passengers on high-altitude polar routes, and sensitive systems in space, all of which would require earliest possible notification of radiation hazards, ideally before light-speed ions of high-intensity and/or ground level events leave the vicinity of the sun. We show for the first time that early warnings based on observations of an eruption – but before particles are released from the sun – are possible, issued with a coronagraph capable of early detection of CMEs. Moreover, we show how a planned integrated system of coronagraph-based warning with in-situ detection of initial solar energetic particle arrival can potentially lead to high-confidence alerts. Lastly, we show how such alerts from near Earth can be applied to astronauts' journeys to Mars on Hohmann trajectories.

IAU TOWN HALL. United Nations Expert Group on Space Weather: Strategy for Developing an International Framework for Space Weather Services (2018-2030)

The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS; hereafter the Committee) will commemorate the 50th Anniversary of the United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50) in 2018. These celebrations will also aim to define strategies and priorities for the COPUOS and which shape the global “Space 2030” agenda. The Committee has identified seven potential thematic priorities for UNISPACE+50 for future work in the period up to 2030. One of these is “Thematic Priority 4: International framework for space weather services”.

In 2015, the Committee under its permanent space weather agenda item established a Space Weather Expert Group. The Expert Group is now tasked by the Committee with seeking input towards the development of an international framework for space weather services under the UNISPACE+50 Thematic Priority 4. Specifically the draft focus for such a strategy is:

> ***Thematic Priority 4: International framework for space weather services***
> Objective: *Strengthen the reliability of space systems and their ability to respond to the impact of adverse space weather. Develop a space weather road map for international coordination and information exchange on space weather events and their mitigation, through risk analysis and assessment of user needs. Recognize space weather as a global challenge and the need to address the vulnerability of society as a whole. Increase awareness through developed communication, capacity-building and outreach. Identify governance and cooperation mechanisms to support this objective.*

Through this IAU Town Hall, the UN Space Weather Expert Group will seek to provide a forum to update scientists and researchers about the COPUOS activity. The Town Hall will also provide researchers with the opportunity to provide input into the development of this UN strategy. A significant focus for IAU scientists is expected to include the importance of developing and advancing the fundamental understanding of the underlying processes which cause severe space weather - consistent with the recently published COSPAR-ILWS Roadmap, “Understanding space weather to shield society: A global road map for 2015–2025 commissioned by COSPAR and ILWS” - see Schrijver et al., Adv. Space Res., 55(12), 2745-2807, (2015).

Prof. Ian R. Mann, University of Alberta (Canada).
Chair and Rapporteur for the UN COPUOS Expert Group on Space Weather.

Prof. Hermann Opgenoorth, Swedish Institute of Space Physics (Sweden).

Dr. Juha-Pekka.Luntama, Space Weather Program Manager, ESA SSA Program Office (ESOC, Germany)

Session 6: **IAU Town Hall**

Dr. Terrance Onsager, NOAA/NWS/Space Weather Prediction Center (USA)

Control and Prediction of Radiation Environment in the Frame of Space Monitoring Data Center at Moscow State University

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Radiation Environment of Near-Earth space is one of the most important factors of space weather. Space Monitoring Data Center of Moscow State University provides operational control and predict of radiation conditions both at Geostationary Orbits (GEO) and at Low Earth's Orbits (LEO) of the near-Earth space using data of recent (Vernov, CORONAS series) and current (Lomonosov, Meteor-M, Electro-L) space missions. Internet portal of Space Monitoring Data Center of Skobeltsyn Institute of Nuclear Physics of Lomonosov Moscow State University (SINP MSU) provides possibilities to control and analyze the space radiation conditions in the real time mode together with the geomagnetic and solar activity including hard X-ray and gamma-emission of solar flares. Operational data obtained from space missions at L1, GEO and LEO orbits and from the Earth's magnetic stations are used to represent radiation and geomagnetic state of near-Earth environment.

The SSA SWE Data Centre as a Tool Supporting the Space Weather Community

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The Space Weather (SWE) Network is a unique, distributed system established to provide tailored services to end users. The Data Centre is a facility made available for housing SWE data and products within the SWE network developed under the 'Space Situational Awareness' (SSA) Programme of the European Space Agency (ESA). It hosts the SWE Web Portal with its centralised interface to the current 20 distributed SWE services, the SWE database, which is based on a redeployment of the entire ESA SWENET data repository and a number of dedicated SWE applications.

Within the SSA Period 2 major software developments have been commenced focussing on developing the supporting infrastructure for the SWE network, which is expected to greatly facilitate user access to the wide range of data and products available. This includes

1. the upgrade of the existing SWE data systems hosed within the SWE Data Centre with the aim to harmonise different data systems and software components;
2. the implementation of improvements for the data model (e.g. OGC O&M) and the metadata model (the approach is a modified SPASE model), and
3. the extensions in the functionality of the SWE Web Portal with new and updated features and tools for data collection, discovery, visualisation and analysis.

Within the SSA Period 3, the SWE Data Centre will begin to host data from SSA hosted payload missions and will work with other federated data centres or systems enabling improved data discovery and visualisation, while maintaining the distributed network concept. This will require further developments in the interoperability capabilities of the SWE Data Centre facilities and technologies of data handling and tools in order to support maximum timely availability of these data together with their use in both SSA SWE services and exploitation by the wider scientific community.

This presentation will provide an overview of ongoing developments and will describe essential innovations which form an integral part of the coming upgrade to the SWE Data Centre in terms of data utilisation and dissemination. It will also highlight further upcoming opportunities for the European space weather community to access and work with SWE data and products.

The Mexican Space Weather Service - SCiESMEX

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In the last three years, Mexico as developed the infrastructure necessary to create a national service of space weather. In 2014, as part of a new policies in the mexican Civil Protection and the National Council of Science and Technology was created the Mexican Space Weather Service (SCiESMEX). In 2016 SCiESMEX becomes part of the new National Space Weather Laboratory (LANCE) and in the same year was created the Repository of Space Weather Data (RICE) and the Center of Supercomputing of Space Weather (SWESCOM) also part of LANCE.

CiESMEX integrated by researchers in ionosphere, cosmic rays, interplanetary medium, solar radio astronomy, theory of radiation, and supecomputing. The project is hosted in the Geophysics Institute campus Morelia of the National University of Mexico (UNAM) in the state of Michoacán, México.

SCiESMEX integrates the products and services related with the mexican space weather instrumentation and their scientific teams. We include equipment to monitor the geomagnetic field, cosmic ray fluxes, solar wind measurements using interplanetary scintillation, solar radio burst and interferences, and local networks of GPS station receivers. We are developing a new network of ionospheres, magnetometers, and radio spectrographs to warantee the covering of space weather monitoring in our territory.

Part of our duties includes be advisers of the National Center for Disaster Protection (CENAPRED) to create the first public policies for space weather events.

Numerical Short-term Solar Activity Forecasting

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It is well known that the energy for solar eruptions comes from magnetic fields in solar active regions. Magnetic energy storage and dissipation are regarded as important physical processes in the solar corona. With incomplete theoretical modelling for solar eruptions in the solar atmosphere, the solar activity forecasting is mainly supported with statistical models in which artificial intelligence technology has been employed in recent years. High temporal and spatial solar observations continuously from space well describes the evolution of activities in the solar atmosphere and progresses in three dimension reconstruction of solar magnetic fields makes numerical short-term solar activity forecasting possible. The observational data in time sequence are useful for data-driven numerical simulation in which some precursors of solar eruptions might be revealed. In the current report, we present prospects for numerical short-term solar activity forecasting based on our recent research results:

Observed vector magnetic fields on the solar surface are taken as the boundary condition for the data-driven simulation. With a special method to deal with the boundary condition, in which observed vector fields are incorporated as part of the bottom boundary conditions consistently, we are able to consider the nonlinear MHD interactions between the solar surface and the solar corona in a dynamic equilibrium state, and then reconstruct 3D magnetic fields in the corona as forced or force-free fields. The observational data drive the evolution of magnetic fields in an active region when a series of vector magnetograms in time sequences is employed. The evolution of dynamic equilibrium state in the active region might provide precursors of solar eruptions. An active region will be taken as an example to exhibit how the numerical forecasting model works.

A Physically-Based Sandpile Model for the Prediction of Solar Flares Using Data Assimilation

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The largest solar flares, of class X and above, are often associated with strong energetic particles acceleration. The acceleration process scenario based on multiple reconnection sites can be cheaply modelled with so-called *cellular automata* or *sandpile* models. These toy models have the advantage of reproducing many statistical features of solar flares, but generally lack a sound physical justification.
Building on the pioneering work of Lu and Hamilton, we develop a new class of sandpile models motivated by a physical interpretation of the three main ingredients (driver, instability criterion, relaxation path to a stable state) of *self-organized criticality* models. We furthermore benchmark the physical interpretation of our model with three-dimensional MHD simulations of an unstable, multiply- reconnecting coronal loop. We show that our sandpile model possesses very promising predictive capabilities for the largest events, in spite of its embedded stochastic process. Finally, we report on our recent efforts in coupling modern data assimilation techniques (4Dvar) to our model using the GOES X-ray flux and give preliminary estimates of its predictive performance using the past largest solar flares.

Empirical solar-wind forecasts: Why they still matter in a world of advanced physics-based numerical models.

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Space-weather forecasting with a lead-time longer than approximately 40 minutes, the nominal L1-to-Earth solar-wind propagation time, requires advanced prediction of near-Earth solar-wind conditions. This is provided by numerical magnetohydrodynamic models constrained, typically, by photospheric magnetic field observations. The accuracy of such forecasts is being continually improved through improved better numerics, better determination of the boundary conditions and better representation of the underlying physical processes.

Thus it is not unreasonable to conclude that simple empirical solar-wind forecasts, such as the 27-day persistence and analogue ensemble (AnEn) techniques discussed in this talk, have been rendered redundant. However, as numerical models are bringing space-weather forecasting into the realm of genuine operational “actionability,” empirical models arguably have more to contribute now than ever before:

- Through parts of the solar cycle, empirical models still outperform numerical models and thus are a valuable (and computationally cheap) forecast tool in their own right.
- Even when numerical models do outperform empirical techniques, the latter provide a useful sanity check and a qualitative estimate of forecast uncertainty.
- Persistence and AnEn forecasts do not require photospheric magnetic field observations, so provide some operational robustness to data availability.
- Empirical models also provide a useful benchmark in numerical model development, distinguishing between poor predictions and times of poor predictability
- The AnEn technique can directly add value to numerical forecasts, by correcting model bias and cheaply converting a deterministic forecast into a probabilistic one.
- Statistical techniques, such as the AnEn, provide a means to stochastically “downscale” numerical solar-wind predictions to the spatial/temporal scales required by magnetospheric models.

A New Technique to Provide Realistic Input to CME Forecasting Models

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Coronal mass ejections (CMEs) are the most important players in space weather because they cause the severest of geomagnetic storms and accelerate energetic particles to GeV energies. One of the vexing problems in space weather has been the prediction of the out-of-the-ecliptic (Bz) component of the CME magnetic field that reconnects with Earth's magnetic field. While there has been reasonable progress in the prediction of the arrival time of CMEs, predicting the Bz component has been a challenge. The limited progress can be attributed to the lack of realistic input to global MHD models that track CMEs into the heliosphere and provide asymptotic values of the CME parameters including the magnetic field. Investigations over the past decade have revealed that the fundamental magnetic structure of CMEs is a flux rope and hence it is inevitable that the models should have a flux rope input at the near-Sun boundary.

Here we report on a technique to construct a flux rope near the Sun using eruption data. The technique combines two key results: (i) the reconnected flux (RC) during an eruption approximately equals the poloidal flux of the ejected away from the Sun and (ii) all CMEs in the coronagraph field of view can be fit to obtain the geometrical properties of the flux rope. The RC is given by the area under post-eruption arcades and the underlying photospheric magnetic field strength, while the geometric properties are obtained by forward modeling white-light CMEs in the corona. By combining these two results, we can define a flux rope near the Sun (within the first few solar radii) under the force free approximation. We validate this technique by showing that (i) the RC flux is closely related to the flare fluence and CME kinetic energy, and (ii) the flux rope magnetic field strength in the corona derived from the RC flux and the 1-AU magnetic field strength obtained from spacecraft measurements are significantly correlated.

For a Lundquist flux rope, the poloidal flux and toroidal flux are related. Therefore, once the poloidal flux is known from the RC flux, we can get the axial field strength and the toroidal flux of the flux rope. The poloidal field strength is also related to the axial field strength via the helicity sign and the Bessel function. Thus we have a fully-defined flux rope, complete with geometric and magnetic parameters that can be input to global MHD models. The axial and poloidal fields essentially responsible for geoeffectiveness in high and low-inclination magnetic clouds at Earth, respectively and hence should lead to definite prediction schemes. For models that use a flux rope configuration, our results provide an important constraint on the input flux rope. For models that do not use a flux rope (e.g., ENLIL + cone), our results provide the critical next step in providing a self-consistent flux rope input at their inner boundary (~20 Rs).

Modeling Coronal Mass Ejections in the Inner Heliosphere using the Gibson-Low flux rope model with EUHFORIA: a parameter study

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The coronal and interplanetary dynamics are highly influenced by Coronal Mass Ejections (CMEs). One of the current key goals in space weather research and solar-terrestrial physics is the understanding of their origin and evolution from Sun to Earth. Especially the magnetic field configuration is of high importance as it is needed to determine the geo-effectiveness of the impinging structure. In this work, we present a detailed study where we focused on a change in the CME flux-rope input parameters and how this change influences the impact and effect of the CME at Earth.

Recently, the Gibson and Low flux rope model has been implemented into the inner heliosphere model EUHFORIA, a physics-based magnetohydrodynamics forecasting model of large-scale dynamics from 0.1 AU up to 2 AU. Coronagraph observations can be used to constrain the kinematics and morphology of the flux rope.

We have performed a parameter study focusing on the magnetized Gibson-Low flux rope model to determine the sensitivity of each model parameter and the corresponding impact of the CME at Earth. We focused on parameters corresponding to the cone model, as well as parameters specific to the Gibson and Low model, e.g. helicity, magnetic field strength. Finally, we discuss the forecasting capabilities of the modeling scheme.

Synergies in space weather modeling

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Space science research aiming to advance understanding of space weather processes in heliosphere and space weather forecasting are increasingly relying on powerful numerical simulations. Drastic diversity in spatial-temporal scales and underlying physics in the heliosphere system sets a grand challenge to develop sophisticated multi-scale models and coupled modeling systems. Specification and forecasting of space weather and its impact on human and technologies require coupled chains that incorporate (a) techniques for observational data ingestion, processing, and simulation input preparation; (b) space environment simulation models (empirical and first-principle); (c) tools for simulation output visualization and analysis, and algorithms that derive products and displays ready-to-be-used by forecasters and end-users; (d) models quantifying space environment impact. Gaps in observational data and uncertainties in simulation inputs require utilization of uncertainty assessment and uncertainty reduction techniques. Unprecedented web-based worldwide access to the largest collection of powerful space weather models and tools enabled by the Community Coordinated Modeling Center (CCMC, http://ccmc.gsfc.nasa.gov) revolutionized the way how state-of-the-art models are utilized in research and forecasting. The CCMC staff collaborates with model developers to modify and upgrade the model as necessary, and investigate opportunities for establishing patch-panel interfaces linking the model to others. Innovative software engineering solutions facilitate partnership and collaborative development between space weather research, educational and operational institutions worldwide and bring the exciting world of space weather forecasting to broader community. The presentation will discuss successes and challenges in development, implementation and evaluation of space weather forecasting systems and discuss ongoing international community-wide initiatives to address challenges in space weather forecasting.

Prospects for Forecasting Solar Energetic Particle Events Using ENLIL and SEPMOD

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Solar energetic particle (SEP) event modeling has gained renewed attention in part because of the availability of a decade of multipoint measurements from STEREO and L1 spacecraft at 1 AU. These observations are coupled with improving simulations of the geometry and strength of heliospheric shocks obtained by using coronagraph images to send erupted material into realistic solar wind backgrounds. The STEREO and ACE measurements in particular have highlighted the sometimes surprisingly widespread nature of SEP events. It is thus an opportune time for testing SEP models, which typically focus on protons ~1-100 MeV, toward both physical insight to these observations and potentially useful space radiation environment forecasting tools. Some approaches emphasize the concept of particle acceleration and propagation from close to the Sun, while others emphasize the local field line connection to a traveling, evolving shock source. Among the latter is the previously introduced SEPMOD treatment. Although SEPMOD can work with the results of any time-dependent heliospheric MHD simulation with interplanetary shocks, its development and current applications are based on the widely-accessible and well-exercised WSA-ENLIL-cone model. SEPMOD produces SEP proton time profiles at any location within the ENLIL domain, depending on the evolving shock properties and observer connected field line information to describe their source(s) and transport. Here we demonstrate a SEPMOD version that accommodates multiple, concurrent shock sources occurring over periods of several weeks duration. Such active intervals have been routine during the maximum of this recent solar cycle. The examples shown cover ~3 weeks in August 2010, July 2012, March 2013, April 2013, January 2014 and March 2015 that included widespread SEP activity and for which ENLIL results were optimized to match the available observed solar wind structure and shock arrivals. In addition to illustrating application of the 'multi-shock' source feature, the results illustrate the importance of considering longer-duration time periods and multiple CME contributions in analyzing and modeling SEP events.

Forecasting Solar Flares: Present Status, Recent Advances, and Continued Challenges

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Solar Energetic Events can encompass a variety of phenomena: the solar flare, particle acceleration to MeV and higher energies, and coronal mass ejections which send fast-moving plasma often on a collision course with the Earth. Some phenomena (e.g. associated CMEs) travel through the heliosphere with speeds such that modeling and now-casting are possible, while the impact from others (the sudden X-ray pulses of flares and the flux of energetic particles) propagate and impact the Earth environment at, or nearly at, the speed of light, and as such true forecasting is required. Over the last few decades, the availability of reliable, steady solar data, especially of the solar magnetic field has been complemented by significantly greater computing power and improvements to numerical classifier schemes. This combination has spawned numerous efforts around the world to improve the performance of solar flare forecasts. As we descend into the minimum of solar activity after two activity cycles' worth of these benefits, we ask: how well can we presently forecast solar flares? As with many such questions, the "devil is in the details". In many ways, predictions can be viewed as the ultimate test of our understanding of a physical process; with solar flares, however, the task is complicated by the reality of a remote-sensing science. In this talk I will present a brief summary of current forecasting approaches and performance, describe a few of those pesky devils, and present some prospects for improvement.

Effect of non-potential coronal boundary conditions on solar wind prediction

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We investigate the effect that non-potential simulations of the solar corona have on the predicted solar wind speed at Earth. Our coronal simulation is driven by Air Force Data Assimilative Photospheric Flux Transport (ADAPT) synoptic B r maps as input at the photosphere. The simulated magnetic field is extrapolated using the Schatten Current Sheet method from the outer boundary of the inner corona at 2.5 solar radii R_sun to 21.5 R_sun. Here, the boundary conditions for the solar wind software Enlil are computed using an empirical solar wind formula based on the distance from the coronal hole boundary.

We compare our results to observational OMNI data and results from WSA-Enlil. Additionally, we investigate the effect of only replacing the non-potential coronal conditions by potential ones, and and of replacing our wind speed formula by that of Riley et al. In addition to a visual comparison of the velocities and velocity distributions, the ability to predict high speed enhancements is considered as a quality criterion. The non-potential method accounts for more of the complex magnetic structure in the corona and therefore has a significant effect on the predicted wind speed. We are able to achieve reasonable prediction results with fewer free parameters than the WSA wind speed formula.

Application of Test Particle Simulations to Solar Energetic Particle Forecasting

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Modelling of Solar Energetic Particles (SEPs) is usually carried out by means of the 1D focused transport equation and the same approach is adopted within several SEP Space Weather forecasting frameworks. This presentation reviews an alternative approach, based on test particle simulations, which naturally describes 3D particle propagation.

The SPARX forecasting system (Marsh et al 2015) will be described as an example of how test particle simulations can be used in real time in a Space Weather context. The model is currently operational within the COMESEP alert system. The performance of the model, which is triggered by detection of a solar flare of class >M1.0, will be evaluated.

We will also discuss how the application of test particle models to SEP modelling and forecasting can be improved by including the effects of the heliospheric current sheet and more generally by taking into account more complex configurations of the heliospheric magnetic fields, such as those output of ENLIL simulations.

References:

Marsh M.S., et al., Space Wea., 13, 386, doi:10.1002/2014SW001120 (2015)

Development of MHD simulation of interplanetary propagation of multiple coronal mass ejections with internal magnetic flux rope

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Coronal mass ejections (CMEs) are the most important drivers of various types of space weather disturbance. We report a newly developed magnetohydrodynamic (MHD) simulation of the solar wind, including a series of multiple CMEs with internal spheromak-type magnetic fields (Shiota & Kataoka 2016), which is named as SUSANOO-CME. The MHD simulation solves the propagation of solar wind and CMEs in the whole inner heliosphere discretized with the Yin-Yang grid (Kageyama & Sato 2004) outer than 30 solar radii. The inner boundary conditions are given by a time series of solar wind maps inferred from a time series of the photospheric magnetic field synoptic maps (Shiota et al. 2014) and superposed modelled CMEs including internal magnetic flux ropes. The MHD simulation is therefore capable of predicting the time profile of the interplanetary magnetic field at the Earth, in relation to the passage of a magnetic cloud within a CME. This profile is the most important parameter for space weather forecasts of magnetic storms.

In order to evaluate the current ability of our simulation, we demonstrate two test cases: the propagation and interaction process of multiple CMEs during the periods of October to November 2003 and May to September of 2005. The former is associated with the highly complex active region NOAA 10486, which causes the 2003 Halloween storms. For several events, we succeeded in reproducing the arrival at the Earth's position of a large amount of southward magnetic flux following a shock, which is capable of causing an intense magnetic storm. It was found that the MHD simulation also is useful for understanding of the interaction between solar wind and a CME and the interaction between successive CMEs. We will discuss the current status and future directions of our developments for use in real time forecast.

High-Speed Solar Wind Forecast Model From The Solar Surface To 1AU Using Global 3D MHD Simulation

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High speed stream causes recurrent geomagnetic disturbances in the Earth's magnetosphere, so prediction of occurrence and timing of that high speed solar wind is one of the important issues in space weather forecasting. As is well known, that stream is emanating from coronal holes, however, it is still difficult to estimate the effect of a coronal hole in case that it extends from the high latitude to the low latitude. We develop three-dimensional MHD simulation code, REPPU (REProduce Plasma Universe) code driven by solar magnetic field from the solar surface to 1AU for monitoring of the global solar wind condition. One of the distinguishing features of the simulation model is the 3-D grid system, which has no polar singularity and no seam for covering the spherical structure. This leads to make it possible to set the inner boundary on the solar surface, thus our model is able to reproduce both coronal holes and global solar wind structure. We investigate connectivity of magnetic field from the solar surface to the Earth's orbit and correspondence of coronal holes and high speed stream region. It is expected that our results would be efficient to judge cautiousness of the coronal hole. Our model is now operating for solar wind forecasting at our institute. We present the simulation results and discuss usefulness of our model.

The HelMod Monte Carlo Model for the Propagation of Cosmic Rays in Heliosphere

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The heliospheric modulation model HelMod is a two dimensional treatment dealing with the helio-colatitude and radial distance from Sun and is employed to solve the transport-equation for the Galactic Cosmic Rays propagation through the heliosphere down to Earth. It is based on a 2-D Monte Carlo approach, involving the use of Stochastic Differential Equations, and includes a general description of the symmetric and antisymmetric parts of the diffusion tensor, thus, properly treating the particle drift effects as well as convection within the solar wind and adiabatic energy loss. The model has been tuned in order to fit 1) the data observed outside the ecliptic plane at several distances from the Earth and 2) the spectra observed near the Earth for both, high and low solar activity levels. Great importance was given to description of polar regions of the heliosphere. We present the flux for protons, antiprotons and helium nuclei computed along the solar cycle 23-24 in comparison with experimental observations and prediction for the solar maximum in solar cycle 24 covered by AMS-02 detector measurements. A stand-alone python module, fully compatible with GalProp, was developed for a comprehensive calculation of solar modulation effects, resulting in a newly suggested set of local interstellar spectra.

Next Generation Solar Telescopes

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This talk presents the current projects for next generation ground-based solar telescopes. The rationale for large-aperture telescope concepts will be discussed, focusing on the need for high-resolution observations at multiple atmospheric heights and with high polarimetric sensitivity and accuracy. I will give a status update on the construction of the Daniel K Inouye Solar Telescope (DKIST) and the design efforts for the European Solar Telescope (EST).

The MOTH II Doppler-magnetographs and data calibration pipeline

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The calibration pipeline of the level zero images obtained from the Magneto-Optical filters at Two Heights (MOTH II) instrument is presented. MOTH II consists of a dual channel telescope, each mounting a tandem of Magneto-Optical Filters (MOFs),at 5896 Å (NaD2-line) and 7700 Å (K I-line)respectively. MOTH II provides full disk line-of-sight Doppler velocity and magnetic field at two levels in the solar atmosphere. MOTH II run tests have been operated at the Mees Observatory (Maui, USA) and it has been deployed to the South Pole for observing campaigns in the last Antarctic summer (December 2016-January 2017).

The developed MOTH II pipeline comprehends the standard calibration corrections, the correction for the signal leakage, due to the non-ideal behaviour of the polarizers, and the geometrical registration between the eight images acquired by four CMOS cameras, relative to two components of the signal in two circular polarization states, in each of the two channels.

MOTH II data are used to investigate atmospheric dynamics (e.g., gravity waves and acoustic portals) and Space Weather phenomena. Particularly, flare forecasting algorithms, based on the detection of magnetic active regions and associated flare probability estimation, are currently under development. The possible matching of MOTH II data with HMI and AIA images into a flux rope model, developed in collaboration between Harvard-Smithsonian CfA and MIT Laboratory for Nuclear Science, is being tested.

The Worldwide Interplanetary Scintillation (IPS) Stations (WIPSS) Network In Support of Space-Weather Science And Forecasting

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Some of the key parameters for space-weather purposes at Earth include the velocity, density, magnetic field, high-energy particle fluxes, and radiation incident on the Earth. Interplanetary scintillation (IPS) can be used to provide a global measure of velocity and density as well as indications of changes in the plasma and magnetic-field rotations along each observational line of sight. If observations of IPS are formally inverted into a 3-D tomographic reconstruction (such as using the UCSD kinematic reconstruction technique), then source-surface magnetic fields can also be propagated out to the Earth (and beyond) as well as *in-situ* data being incorporated into the reconstruction. This has predominantly been done using IPS data only from ISEE in Japan. There is now a defined IPS Common Data Format (IPSCDFv1.1) which is being implemented by the majority of the IPS community. The Worldwide IPS Stations (WIPSS) Network aims to bring together, using IPSCDFv1.1, the worldwide real-time capable IPS observatories with well-developed and tested analyses techniques being unified across all single-site systems (such as MEXART, Pushchino, and Ooty) and cross-calibrated to the multi-site ISEE system (as well as learning from the scientific-based systems such as EISCAT, LOFAR, and the MWA), into the UCSD 3-D tomography to improve the accuracy, spatial and temporal data coverage, and both the spatial and temporal resolution for improved space-weather science and forecast capabilities.

The Coronal Spectrographic Imager In The EUV (COSIE)

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The Coronal Spectrographic Imager in the EUV (COSIE) combines a wide-field solar coronal EUV imager (EUVC) and an on-disk EUV imaging spectrometer (EUVS). This compact coronagraph makes use of a novel filter design allowing for observations from just above the solar disk out to 3 solar radii. Proposed for mounting onto the International Space Station (ISS) with an independent pointing platform, the goal of the mission is to enhance our understanding of the dynamics of the Transition Corona (the region in which the coronal magnetic field transitions from closed to open), and to provide improved detection and tracking of solar eruptive events for space weather research.

The inner coronagraph on board Aditya L1 and automatic detection of CMEs

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ADITYA-L1 is the first Indian mission that is dedicated to study solar atmosphere with unprecedented spatial and temporal resolution. Visible Emission Line Coronagraph (VELC) will be one of the payloads on-board ADITYA-L1 spacecraft dedicated to perform imaging and multi-slit spectroscopic and spectropolarimetric studies of solar corona (1.05 – $3R_0$) at high cadence, high spatial and spectral resolution. In this presentation I will give an overview on the payloads on Aditya L1, with particular emphasis on VELC. The spacecraft will be positioned at L1 and thus it poses a challenge for us to download high cadence data. We develop an automatic on-board CME detection method that will automatically segregate the images containing CMEs before the data is downloaded to ground station. The algorithm is tested on space based (LASCO/SOHO, COR1/STEREO) and ground based (KCOR) coronagraph images. Finally we simulate the CMEs as they will be seen in VELC/ADITYA-L1 field of view, and test the algorithm on simulated images. Preliminary results and performance of the algorithm will be presented.

SMILE: A Novel and Global Way to Explore Solar-Terrestrial Relationships

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SMILE (Solar wind Magnetosphere Ionosphere Link Explorer) aims to investigate the dynamic coupling of the solar wind with the Earth's magnetosphere in a novel and global manner. From a highly elliptical Earth polar orbit, SMILE will combine charge exchange soft X-ray imaging of the Earth's magnetic boundaries and polar cusps with simultaneous UV imaging of the northern aurora, while measuring solar wind/magnetosheath plasma and magnetic field conditions in situ.

SMILE is a scientific precursor of space weather operational satellites which are expected to forecast the arrival and impact of solar storms on the terrestrial environment. SMILE does not provide forecasting capabilities, rather its measurements will inform the science underpinning our still limited understanding of space weather and its fundamental drivers. For the first time we will be able to trace and link the processes of solar wind injection in the magnetosphere with those acting on the charged particles precipitating into the cusps and eventually the aurora.

SMILE is a joint mission between the European Space Agency and the Chinese Academy of Sciences, due for launch at the end of 2021. This presentation will cover the science that SMILE will deliver and its impact on our understanding of the way the solar wind interacts with the Earth's environment; it will provide an overview of SMILE's payload and mission and demonstrate the scientific potential of SMILE through simulations of the data that it will return.

Small scale magNetospheric and Ionospheric Plasma Experiments; SNIPE

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The observation of particles and waves using a single satellite inherently suffers from space-time ambiguity. Recently, such ambiguity has often been resolved by multi-satellite observations; however, the inter-satellite distances were generally larger than 100 km. Hence, the ambiguity could be resolved only for large-scale (> 100 km) structures while numerous microscale phenomena have been observed at low altitude satellite orbits. In order to resolve those spatial and temporal variations of the microscale plasma structures on the topside ionosphere, SNIPE mission consisted of four (TBD) nanosatellites (~10 kg) will be launched into a polar orbit at an altitude of 700 km (TBD). Two pairs of satellites will be deployed on orbit and the distances between each satellite will be from 10 to 100 km controlled by a formation flying algorithm. The SNIPE mission is equipped with scientific payloads which can measure the following geophysical parameters: density/temperature of cold ionospheric electrons, energetic (~100 keV) electron flux, and magnetic field vectors. All the payloads will have high temporal resolution (~ 16 Hz (TBD)). This mission is planned to launch in 2020.

The SNIPE mission aims to elucidate microscale (100 m-10 km) structures in the topside ionosphere (below altitude of 1,000 km), especially the fine-scale morphology of high-energy electron precipitation, cold plasma density/temperature, field-aligned currents, and electromagnetic waves. Hence, the mission will observe microscale structures of the following phenomena in geospace: high-latitude irregularities, such as polar-cap patches; field-aligned currents in the auroral oval; electro-magnetic ion cyclotron (EMIC) waves; hundreds keV electrons' precipitations, such as electron microbursts; subauroral plasma density troughs; and low-latitude plasma irregularities, such as ionospheric blobs and bubbles.

We have developed a 6U nanosatellite bus system as the basic platform for the SNIPE mission. Three basic plasma instruments shall be installed on all of each spacecraft, Particle Detector (PD), Langmuir Probe (LP), and Scientific MAGnetometer (SMAG). In addition we now discuss with NASA and JAXA to collaborate with the other payload opportunities into SNIPE mission.

Data Utilization for Space Weather

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The progress of technology and the global integration of our economic and security infrastructures have introduced vulnerabilities to space weather that demand a more comprehensive ability to predict accurately the dynamics of the space environment. Although there is broad recognition that solar-terrestrial physics research and applications are data starved, it is also the case that a large fraction of the available data are underutilized in our numerical prediction models. Not only do we need to ensure that essential observations are available in real time and with long-term continuity, we also face the challenge of improving predictive capabilities by using all of the available data effectively. This presentation will summarize national and international efforts to assess the value of data for operational applications and to prioritize the satellite missions and data needed in the future. Recent developments and challenges in utilizing data assimilation techniques in space weather models will be discussed.

Operational Space Weather Practices as a service to society in South Africa

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The South African National Space Agency (SANSA) operates the Regional Warning Center (RWC) for Space Weather in Africa. The RWC is operated from within the Space Science Directorate of SANSA in Hermanus, South Africa. The centre depends on ground based geophysical data from distributed networks across Southern Africa and the South Atlantic which complement available satellite based data to achieve an operational capability. Over the past 6 years SANSA has developed a regional capability to monitor and forecast space weather as well as prioritising research projects that enhance the modelling ability of the centre. SANSA has also partnered in a number of international space weather projects each of which has contributed towards enhancing the knowledge and expertise needed to provide these services.

A significant success of the SANSA space weather programme has been the relationships and engagement with affected industry partners in South Africa. These partners provide services to the nation, and are affected by adverse space weather. Engagement with the industry partners included creating awareness of space weather processes, the impacts, forecasting techniques, and mitigation efforts. The provision of useful information to these partners and their users was also a requirement.

This paper will discuss the significance of the current operational space weather practices of the SANSA RWC, and the role that industry play in ensuring that the right capability is developed for their needs. The importance and benefit of relationships with industry players within South Africa, the lessons learnt and the way forward in utilising this capability to protect the nation’s technology will be presented.

Data Handling and Assimilation for Solar Flare Prediction

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The solar-stellar informatics cluster at Georgia State University (GSU) is an interdisci-plinary effort between the departments of Physics & Astronomy and Computer Science. The first and major objective of this rapidly expanding group is the prediction of solar flares and closely related phenomena such as Solar Energetic Particles and Coronal Mass Ejections (CME's) using the methods of Data Analytics developed in the field of computer science in recent years.

The first requirement for such an undertaking is a clean and balanced database. We have analyzed all available data and metadata produced over the first three years of NASA's Solar Dynamics Observatory (SDO) mission and have presented comprehensive statistics and outliers while validating the cleanliness and usability of the data source for future research (Schuh et al. 2015). We are completing this effort for the rest of the SDO mission.

It is worth pointing out here that this undertaking is neither trivial nor effortless. SDO sends down of the order of 100,000 images per day, and from those images we produce metadata on various solar phenomena (e.g. sunspots, active regions, sigmoids, CME's) with automated feature recognition modules (Martens et al. 2012). One cannot review all these images and metadata by hand, so again automated methods had to be developed to accomplish this task. Examples of features that are not useful for flare prediction are sunspot or active region coordinates off the disk, image data gaps for various reasons (explained or unexplained), gaps in metadata caused for example by the relevant module being off-line, etc. It is obvious that any flare prediction algorithm would be greatly confused, say about the relation between flares and sigmoids, when there are undeclared gaps in either sigmoid or flare coverage.

Following the recommendation of the US National Science and Technology Council we are developing a publicly available flare forecasting data benchmark set that resolves the problems discussed above and that offers the data analytics community the opportunity for an unbiased comparison between the various flare prediction methods.

We will present the details of our methods and our results at the meeting.

Using The Local Ensemble Transform Kalman Filter (LETKF) For Upper Atmosphere Modelling

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This paper presents the initial results of the Advanced European electron density (Ne) Assimilation System (AENeAS) which is a new ionosphere/thermosphere model. AENeAS is a physics-based data assimilation model which uses a local ensemble transform Kalman filter (LETKF). The model assimilates electron density virtual height profiles from ionosondes and TEC measurements from GNSS receivers. The LETKF is an ensemble Kalman filter variant which combines the ensemble transform Kalman filter (ETKF) with the local ensemble Kalman filter (LEKF). The localization in the LETKF allows the analysis to be performed around each model grid point and completely in parallel. Ensemble perturbation matrices, where the ensemble mean is removed from each ensemble member, are used to estimate the model covariances. The LETKF results are equivalent to the LEKF results but are calculated in a more efficient manner, similar to the ETKF. Like any Kalman filter the LETKF requires a background model. AENeAS currently uses the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM).However, the maximum altitude modelled by TIE-GCM is between 500–700 km (depending on solar conditions). Since AENeAS is designed to provide ionospheric parameters such as the total electron content (TEC) an NeQuick topside is fitted above these heights.

Space – The Final Verification Frontier?

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The Met Office Space Weather Operations Centre was established to assist affected industries and infrastructure in the UK build resilience to space weather; one of its products is a twice daily, four day probabilistic forecast of: X-ray flares, high energy electrons, geo-magnetic storms and high energy protons. It is crucial for forecasters, forecast-users, modelers and stakeholders to understand the strengths and weaknesses of these forecast products. Therefore the Met Office are investing in the development of verification systems to evaluate the performance; to this end the X-ray flare and geo-magnetic storm components are already subject to real-time verification, the results of which are available to operational MOSWOC forecasters 24/7. This presentation outlines both the methodologies used to provide this service and verification results, evaluated over a 2-year period. To assess the skill associated with these forecasts it is helpful to compare against a reference; to this end, various rolling prediction periods have been analysed to identify the time-periods which minimise the Ranked Probability Score. Analysis suggests that forecasts tend to err on the side of caution by over-predicting events; statistically speaking, only the first day appears to provide a significantly better prediction than the reference.

Session 8: **Oral RT1**

Reconstruction And Propagation Of Coronal Mass Ejections Based On Genetic Algoritm

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Coronal mass ejections (CMEs) are the major driver of space weather. Three dimensional reconstruction of CMEs may largely improve the prediction of CME propagation. We develop a CME reconstruction method based on genetic algorithm that can provide the distribution of electrons inside the CME. Then we put the reconstructed CME into the Space Weather Modeling Framework (SWMF) which is developed by the Center for Space Environment Modeling (CSEM) at the University of Michigan to study the propagation of CME and the relative geo-effectiveness. We expect that our new method of CME reconstruction may advance the accuracy of space weather forecast.

Space Weather – What Is The Real Risk And How Do We Communicate That?

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One of the major challenges now facing the space weather community is to quantify the level of risk that space weather poses for societies around the world. It is broadly accepted that space weather is a risk, but is it really a major risk that warrants major investment in monitoring and forecast systems? e.g. as in the Lagrange mission studies being undertaken by ESA and the Space Weather Follow-On mission studies by NOAA. This talk will explore how the case for major risk and significant investment is developing. A key issue is how to use good science to steer between the twin obstacles of those who underestimate the risk (e.g. looking only at recent low activity) and those who exaggerate the risk (e.g. end-of-civilisation tales loved by many newspapers). We also need to recognise the high bar that our community faces in seeking investment – we have to demonstrate clear economic value from investment in space weather monitoring and forecasts – as done in recent studies funded by ESA, UK Space Agency and parts of the insurance industry. This all needs to be driven by the science, but requires strong engagement with the engineering communities who seek to mitigate space weather risks – so that space weather forecasting is synergistic with their efforts. It also requires strong engagement with economists, policy makers and, not least, the general public. The talk will present examples of relevant work and discuss how that work should be expanded in the coming years.

A citizen-science magnetometer for measuring the effects of space weather

Jennifer Haskell[1], Jacqueline Pitts[1], John Puddy[1], Callum Roberts[1], Sharon Strawbridge[1], Alma Rahat[1], Steve Marple[2], Ciaran Beggan[3], Suzy Bingham[4], Iain Grant[5], Alan Shuttleworth[5], Ken Bailey[5]

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[3]*British Geological Survey (BGS)*
[4]*Met Office*
[5]*Norman Lockyer Observatory.*

A citizen-science magnetometer has been installed at the Norman Lockyer Observatory (NLO), south-west UK, by a group of Natural Sciences students from the University of Exeter. Magnetometers can be used to measure the effect at Earth of geomagnetic storms. These storms are a result of variations in the solar wind; the largest storms are associated with coronal mass ejections (CMEs). Data from observatory and citizen-science magnetometers have been compared, including data from Raspberry Pi (RPi) magnetometers installed in schools. Such comparisons enable better understanding of the sensitivity of cheaper systems. Future work includes the development of the Met Office's Weather Observing Website (WOW) for ingestion of magnetometer data, currently used to display terrestrial weather observations.

Abstracts for the Poster Program

Variations of Quiet Sun Component of Solar Radio Emission during Solar cycle 23 and 24

Mahender Aroori[1], G Yellaiah[1], K Chennareddy[1]
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Radio observations are playing very important role for understanding the manner of solar atmosphere. The study of quiet sun radiation is also considerable importance since it helps to obtain the knowledge related to brightness temperature for different layers of the solar atmosphere. In this paper the quiet sun component of the solar radio emission has been investigated using the data obtained at different frequencies, 410, 610, 1415, 2695, 2800, 4995, 8800, 15400 MHz. Mean flux densities of three Carrington rotations at all frequencies were taken from the Monthly Bulletin on Solar Indices Bulletin, National Geophysical Data Centre, and Boulder, USA. Using a statistical method the quiet sun component was estimated for successive periods containing three solar rotations. The correlation coefficient between monthly mean sunspot numbers with monthly mean solar radio flux during solar cycle 23 and 24 is obtained.

P1-02

The solar dynamo and its many variabilities

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The Sun owes its magnetic field to a non linear dynamo within and at the base of its convective envelope. Such dynamo mechanism must explain why the Sun exhibits a quasi regular 11-yr cycle of magnetic activity. Simple mean field solar dynamo model possess a cyclic solution but it is too regular compared to the Sun. In this talk, we will discuss our current understanding on how solar dynamo works based on various numerical models, how non linear feedback can yield a modulation of the main activity cycle, how a lag of up to2 yr can exist between the southern and northern hemisphere and we will compare these results to a detailed analysis of the dynamo families in the Sun.

P1-03

Weighing Silhouettes: The Mass of Solar Filaments

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The solar atmosphere is dominated by magnetic fields, and the transient activity that propagates through the heliosphere is magnetic in nature. However, magnetic fields alone are not sufficient to describe many features and phenomena, particularly dynamic processes that fall under the umbrella of Space Weather.

This work outlines a quasi-spectroscopic technique to calculate the mass of plasma that is seen in absorption against the solar disc, as filaments are. This method utilises multi-wavelength observations from several different satellites to constrain not only the column density of the target, but the filling factor and foreground emission. The method has been extended to spatial-interpolative as well as temporal-interpolative approaches, and is currently being extended to model background radiation fields in the absence of sufficient observations.

The method is applied to a plethora of targets on the Sun in order to investigate the variety within and between different families of filaments. The method is also able to trace internal mass flows, which leads to clues not only regarding potential eruption, but also filament formation - a topic with many open questions remaining. The final goal of this project is to examine a statistically significant number of filaments in order to find characteristic masses of different classes of filaments, the implications this has on potential eruption, and how we can use this information to better predict Earth-threatening events.

Temperature of source regions of ^{3}He-rich impulsive solar energetic particles events

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Impulsive solar energetic particle (SEP) events have been understood to come from the energy dissipation process in small solar flares. The element abundance in impulsive SEP events varies from event to event and the associated acceleration mechanism is unclear. The energy spectra of different elements suggest some temperature-dependence of the source plasma as obtained from in-situ observations. It indicates that a subtle variation in the thermal emission of their associated solar source would play a key role in the properties of SEP events. We examine evolution of source regions of ^{3}He-rich SEPs using Solar Dynamics Observatory (SDO)/ Atmospheric Imaging Assembly (AIA) images and investigate their thermal variation. The selected ^{3}He-rich events are related to the recurrent coronal jets/small flares. The differential emission measure (DEM) analysis is applied to study the temperature evolution of the source regions. Preliminary results show the temperature of associated solar source is ranged between 6.2-6.6 K (log T).

First Results from the 2016-2017 MOTH-II South Pole Campaign

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We deployed and operated an advanced version of the Magneto-Optical Filters at Two Heights instrument (MOTH-II) at the South Pole during the austral summer of 2016/2017. MOTH-II provides full disk Dopplergrams and magnetograms taken simultaneously in K 7700 Å (formed in the middle photosphere) and Na D_2 5896 Å (formed in the lower chromosphere) at high spatial (1.7”) and high temporal (5 s) resolution. Each of the two channels is fed by a 20 cm aperture telescope. Two 3k × 3k CMOS cameras are used in each channel to record the left- and right-hand circularly polarized light in the blue and red wings of the lines. Together with data from SDO/HMI, MOTH-II yields detailed information about the velocity and magnetic field from the low photosphere up to the lower chromosphere, allowing novel investigations of the structure and dynamics of the Sun’s atmosphere and interior as well as to search for triggers of space weather events: How do emerging magnetic fields and flows interact to trigger flares and coronal mass ejections? What changes in the magnetic field configuration precede these eruptive events? What role do atmospheric gravity waves play in driving flows? We describe the instrument, give an overview of this year’s South Pole campaign, and present some initial results.

Multi-Thermal Segmentation And Identification of Coronal Holes

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Coronal holes are areas of open magnetic field in the solar corona which appear dark due to their low temperature and density relative to the surrounding quiet corona. Accurate extraction of coronal hole boundaries is important for the comparison of coronal properties with geomagnetic effects at 1AU. However, segmentation has been a challenging task due to the irregular morphologies and comparable intensities of coronal holes to the surrounding corona. Here, a new method of multi-thermal segmentation is described which accurately segments coronal holes using the thermal and emissive properties of coronal features across three passbands (171, 193 and 211 A) from the Atmospheric Image Assembly (AIA) onboard the Solar Dynamics Observatory (SDO). Using our segmentation method, it is possible to automatically and accurately extract the properties of coronal holes for comparison with *in-situ* observations of the solar wind at L1 and geomagnetic effects at 1AU.

Magnetic Helicity Flux As A Predictor Of The Solar Cycle

Gareth Hawkes, Mitchell A Berger
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It is known that the poloidal field is at its maximum during solar minima, and that the behavior during this time acts as a strong predictor of the strength of the following solar cycle. This relationship relies on the action of differential rotation (the Omega effect) on the poloidal field, which generates the toroidal flux observed in sunspots and active regions.
We measure the helicity flux into both the northern and southern hemispheres using a model that takes account of the omega effect, which we find offers a strong quantification of the above relationship. We find that said helicity flux offers a strong prediction of solar activity up to 5 years in advance of the next solar cycle.

Observations of MHD Turbulence in Solar Prominences

Andrew Hillier[1]
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Turbulence is believed to be a key dynamical process in in many astrophysical systems, playing a key role in many different aspects of solar activity from the dynamo to magnetic reconnection, and can play a key role in the inverse cascade of magnetic helicity, which is of great importance for understanding solar eruptions. The motions of plasma in quiescent prominences, as revealed by Hinode observations, display highly complex flows across a wide range of spatial and temporal scales, and with the small diffusivity and viscosity of the system, it is no surprise that prominences host turbulence. In this talk I will present my analysis of Hinode SOT dopplergrams of a quiescent prominence observed on the 2008-09-27. By investigating the spatial and temporal correlations between the line-of-sight velocity fluctuations, it was possible to determine the scaling of the power laws up to high-order in the velocity difference, with exponents that are at some scales consistent with weak MHD turbulence, and at others is consistent with strong MHD turbulence. I will present some interpretation of these results based on the current theoretical understanding of turbulence, but also highlight areas in which they do not match with theory, and hopefully provide satisfactory explanations as to why this is the case. From these results we will look at the energy cascade, determining if the net transfer of energy is from large to small or from small to large scales. We will discuss these results in the context of the large-scale energy build up required for eruptive solar phenomena.

P1-09

Simulating The Dynamics Of Coronal Plasma Condensations

Petra Kohutova, Erwin Verwichte
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Otherwise hot and diffuse solar corona contains numerous cool and dense plasma structures in the form of prominences and coronal rain. Coronal rain consisting of down-falling cool plasma condensations is a phenomenon occurring in footpoint-heated coronal loops as a result of thermal instability. Recent high resolution observations have shown that coronal rain is much more common than previously thought, suggesting its important role in the chromosphere-corona mass cycle. Due to its origin, coronal rain also provides us with physical insight into the atmospheric thermal cycle and into prominence formation and evolution. We present numerical MHD simulations of the dynamics of cool plasma condensations in a coronal loop. We address 2 mechanisms how coronal rain leads to the excitation of coronal loop oscillations. We find that the combined effect of pressure gradients in the coronal loop plasma and magnetic tension force resulting from changes in magnetic field geometry explains observed sub-ballistic motion of coronal rain and longitudinal oscillations of the individual condensations. We also find that the condensations can excite sustained, small amplitude, vertically polarised transverse loop oscillations.

Solar flare association with the Hale Sector Boundary

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We present work relating the occurrence of solar flares relative to the structures in the solar magnetic field called the Hale Sector Boundaries (HSBs). These are those parts of the boundary between the large-scale domains of different polarity of the interplanetary magnetic field, that have the same polarity change as sunspots back at the Sun. As the magnetic polarity of sunspots changes in each hemisphere and cycle (Hale et al. 1919), the HSB of a particular polarity change (i.e. positive leading negative) will only occur in one hemisphere per cycle, and then alternate for the next cycle. It has previously been found that these HSBs coincide stronger magnetic fields and more frequent flare occurrence (Dittmer 1975, Svalgaard & Wilcox 1976, Svalgaard et al. 2011). We extend this work by using the flare locations obtained from the RHESSI X-ray telescope, covering 2002 through to 2016, compared to the HSB obtained from two different methods. One uses the polarity change at the Earth to estimate when the HSB was at solar central meridian and the other uses Potential Field Source Surface (PFSS) extrapolations of photospheric magnetograms to obtain the HSB for all times. We find that for both Cycle 23 and 24 over 40% of flares occur within 30 degrees of the HSB, but that the correlation varies with cycle phase and hemisphere. We describe how this association evolves over time and the usefulness of both approaches for practical solar flare prediction.

Diagnostics of small flares and jets using SDO, Hinode and IRIS

Helen Mason
Department of Applied Mathematics and Theoretical Physics, University of Cambridge

Spectroscopic Observations with Hinode/EIS and IRIS provide us with the opportunity to measure plasma diagnostics (DEM, electron density and flows). These data can be used with imaging data (SDO, Hinode/XRT) to study the temperature distribution of small energetic solar features.

Such parameters are crucial for distinuishing between theoretical models.
Here we discuss blue-shifted emission seen during small flares by IRIS with the FeXXI (1354A) spectral line, together with electron densities measurements obtained using IRIS OIV and SIV spectral lines (Polito et al, 2016). We also investigate the relationship between cool and hot emission in solar jets (Mulay et al, 2016).

Alignment As An Indicator Of Changes To Modal Structure Within The Roberts Flow

Daniel Miller[1]
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Alignment of the velocity and magnetic fields has been examined in a number of different contexts within MHD some of which include turbulence, mean field theory, nonlinear dynamo theory and the solar wind. In particular it has been shown that nonlinear dynamos which saturate due to an alignment of velocity and magnetic field may do so at equipartition. In this poster I show how changes to the cross-helicity, a quantity measuring alignment, within kinematic dynamo theory can indicate a change in the magnetic field structure. I solve the induction equation at a large magnetic Reynolds number and show that large scale eddy like magnetic modes and magnetic field with a seperatrix like structure differ greatly in their value of cross-helicity.

Photospheric Magnetic Field Evolution And Flow Field Of Coronal Hole Jets

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Large scale eruptive phenomena like flares and CMEs are among the most studied topics in solar physics due to their role in the release of energy, mass and magnetic field which can impact the Earth environment. Among the small-scale types of eruptions coronal jets have received most of the attention in recent years. All of these phenomena provide strong evidence for magnetic reconnection occurring in the Sun's atmosphere. To understand them and constrain models it is critical to properly characterize them and to determine the magnetic evolution that leads to these phenomena. We use data from the Solar Dynamics Observatory (SDO) to measure the properties of coronal hole jets, in particular their relation to the magnetic field structure and the photospheric flow field which provide important constraints on eruptive event modelling.

P1-14

Hard X-Ray Emission of Solar Flares Measured by Lomonosov Space Mission

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Solar hard X-ray and gamma-emission was measured by BDRG instrument, the part of set of instruments operated onboard Russian satellite Lomonosov from April 2016 till now (solar-synchronous orbit with altitude 490 km, inclination of 97.6 degrees). Lomonosov measurements (14 flares with the X-ray energy > 10 keV, and more than half of them have class in Soft X-Rays less than C2) were compared to the data obtained with RHESSI, Konus-Wind, Fermi observatory, Radio Solar Telescope Net (RSTN) and with the Nobeyama Radioheliograph (NoRH) operating at the same time. The quasi-periodicities with different periods were found in some of them.

The Waldmeier Effect For Two Populations Of Sunspots

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Two distinct populations of sunspots have been identified by Nagovitsyn & Pevtsov (2016). We follow this survey by investigation of the global rules of solar activity such as Waldmeier effect (WE) using Royal Greenwich Sunspot group data from 1874 until 1976.

We investigate two forms of WE: original WE in the form of anticorrelation between rise times of sunspot cycle and its strength and modified version of WE in the form of the correlation between rise rates of sunspot cycle and its strength. We confirm that for the large sunspots both effects are significant, while for the small sunspots there is no evidence of correlation for original WE and for modified WE correlation rate is significantly smaller than for the large sunspots.

Our results lead us to the following conclusion: we suggest that when we study global rules of solar activity such as Waldmeier effect we obtain characteristics of large sunspots population, while information about small sunspots is lost behind. This is crucial for solar cycle prediction and for the solar dynamo theory.

P1-16

Research on solar drivers of space-weather: sun-earth connection of Magnetic Flux Ropes

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I present few representative results of the research on solar drivers, the flux ropes, of space weather carried out in the past two years. The objectives include how local plasma evolution leads to formation of magnetic flux ropes (MFRs), its eruption and heliospheric evolution. To show this scenario of Sun-earth connection of an MFR, we undertook an eruption event involving clear flux rope signatures on the Sun, and studied its formation, initiation, driving mechanisms. We also tracked its heliospheric evolution finally its interaction with Earth. Further, we extended our earlier studies on helicity flux transport in emerging ARs, sun-earth connections of MFR, and sunspot rotation as a driver of major solar eruptions. In an emerging AR, the helicity being pumped by flux emergence and plasma motions revealed that the flux tube is likely having opposite signs of helicity along its length. These results suggest that The ARs with a predominant sign of helicity flux launch CMEs at some point of time, however, the AR with successive injection of opposite helicity exhibits cancellation of coronal helicity leading to field reconfiguration and dissipation of energy heating the corona. The sun-earth connection of a CME is probed by in-situ observations, which delineates the source region magnetic signatures in the magnetic cloud. On the other hand, a rotating sunspot in AR 12158 is proved to have build flux rope like sigmoidal structure by injecting twist, which is apparently co-temporal with the occurrence of two major CMEs.

On the dynamics of the largest active region of the solar cycle 24

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We have studied the solar active region NOAA 12192 using the full-disc intensitygrams and the vector magnetograms observed by instruments onboard the Solar Dynamic Observatory (SDO). AR 12192 is the largest region since 1990, and it underwent a noticeable growth and produced 6 X-Class flares, 22 M-Class flares, and 53 C-Class flares in the course of its disc passage. But the most peculiar fact of this AR is that it was associated with only one small CME in spite of producing several X-Class flares. This AR was observed and tracked in the next two solar rotations. In this work, we have studied the evolution of the area of the AR along with the individual umbra and penumbral area of the sunspots during all the three disc passages and its relation to the associated flare activity.
For the AR11292, we also studied the evolution of various non-potential parameters viz. shear angle, vertical current etc, leading to the eruptions. Further, we attempted to examine the correlation between the changes in Lorentz force during the solar eruption and the initial momentum of the CME ejecta. This is expected to be useful to predict the initial CME trajectory and therefore will improve our understanding of the initiation and evolution of the ensuing CMEs from the source active regions.

Propagation and Absorption of Electron Cyclotron Maser Emission Driven by Power-law Electrons

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As the relatively simple and mild of the conditions for amplification, the electron cyclotron maser emission is believed to be the source of various short-time radio bursts often observed during solar and stellar flares. However, when the maser radiation propagates in the corona, it will encounters a series of optically thick regions because of the strong gyroresonance absorption by the thermal electrons of ambient cool plasma and this causes a serious problem in accounting for the radio bursts. In this work, we calculate the effective growth rates of maser emission driven by power-law energetic electrons with a steepness cutoff behavior and the optical depths of the absorption layers. The purpose of this investigation is to explore how and which harmonic emission can escape from the absorption layers to produce the observed radio bursts under typical conditions expected in the corona.

Excitation And Evolution Of Transverse Loop Oscillations By Coronal Rain

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We present first evidence of the excitation of vertically polarised transverse loop oscillations triggered by a catastrophic cooling at the loop top and consistent with two thirds of the loop mass comprising of cool rain mass. Coronal rain is composed of cool dense blobs that form in solar coronal loops and are a manifestation of catastrophic cooling linked to thermal instability. The nature and excitation of oscillations associated with coronal rain is not well understood. We consider observations of coronal rain using data from IRIS, SOT/Hinode and AIA/SDO in a bid to elucidate the excitation mechanism and evolution of wave characteristics. We also present an analytical model of wave-rain interaction that predicts the inertial excitation amplitude of transverse loop oscillations as a function of the rain mass. The seismological capability of the oscillation is exploited to deduce the relative rain mass. It is shown to be consistent with the evolution of the oscillation period showing the loop losing a third of its mass due to falling coronal rain in a 10-15 minute time period.

Reliability of Photospheric Eruptive Proxies Using Parametric Flux Emergence Simulations

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Flares and CMEs are among the most energetic events in the solar system, impacting the near-Earth environment and thus our technologies. The European H2020 research project Flarecast (Flare Likelihood and Region Eruption Forecasting) aims to develop a fully automated solar flare forecasting system with previous unmatched accuracy. Flarecast will automatically extract various active regions magnetic parameters from solar magnetogram and white-light images to produce accurate predictions using the current state-of-art forecasting techniques based on data-mining and machine learning.
Flare productivity is empirically known to be correlated with the size and the complexity of active regions. Several other parameters, based on magnetic field data from active regions have been tested in the recent years. Solely, none of these parameters have provided a clear eruptivity criterion yet. However, the predictability of these parameters has been only barely tested on numerical simulations.

In this context, we used the MHD numerical simulations of the formation of stable and unstable magnetic flux ropes of Leake et al. (2013) and Leake et al. (2014) to evaluate the predictive potential of the magnetic parameters. These eruptive / non-eruptive simulations only differs by the orientation of the overlying arcade. We used time series of magnetograms from the parametric simulations of stable and unstable flux emergence, in order to compute about 100 different parameters. This parameters list includes both new parameters, such as helicity, and parameters usually used as proxies in actual forecasting methods. Our results indicate that only parameters measuring the total non-potentiality of active regions associated with magnetic inversion line properties present significant preflare signatures, probably making them successful eruptive predictors.

Simulations of Magnetic Flux Emergence in Cool Stars

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Observations of magnetic spots on stellar surfaces encode information about the generation of fields and their rise to the surface. However, the manner by which bundles of magnetic field traverse the stellar interior is not especially well understood. In the solar context, some insight into this process has been obtained by assuming the magnetism consists partly of idealized thin flux tubes. We present two sets of thin flux tube simulations in rotating spherical shells of convection: one representative of the Sun, and the other of a 0.3 solar-mass, fully convective star. We comment on the ability of our solar simulations to reproduce sunspot latitudes, tilt angles following the Joy's Law trend, and a phenomenon akin to active longitudes. Although with far less precision than is possible for the Sun, starspots on fully convective M-dwarfs have been observed at all latitudes. In our simulations of such stars, the nature of the differential rotation and lack of a radiative interior has important consequences regarding the latitude of emergence and assumed flux tube initial conditions. In many cases, the rise of these flux tubes deviate from the solar trend, favoring significant poleward deflection unless the differential rotation is sufficiently prograde or the magnetic field is strongly super-equipartition. The results of these simulations aim to provide a link between dynamo-generated magnetic fields, fluid motions, and observations of starspots along the lower main sequence.

Further Exploration Of Post-Flare Giant Arches

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Recent observations from the SWAP EUV imager on-board PROBA2 and SXI X-ray observations from the GOES satellite have shown that post-flare giant arches and regular post-flare loops are one and the same thing. However, it is still not clear how certain loop systems are able to sustain prolonged growth to heights of approximately 400000 km (>0.5 solar-radii). In this presentation we further explore the energy deposition rate above post-flare loop systems through high-energy RHESSI observations. We also explore the difference between the loop systems through a multi-wavelength epoch analysis.

Comparative study on the statistical characteristics between solar-type star flares and solar flares

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Solar flares are the result of magnetic explosions in the solar atmosphere. Solar-type stars still show flares similar to solar flares. Using the short cadence data (1-min time resolution) of the Kepler space telescope, we have carried on the statistics to the characteristics of the flares of solar-type stars. The result agrees with the previous conclusion on solar flares. It suggests that they may follow the same physical process.

Arrival Prediction of a Coronal Mass Ejection as observed from Heliospheric Imagers at L1

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The Lagrangian point L5 is expected to be an ideal location for a future operational space weather mission, already indicated by The Solar TErrestrial RElations Observatory (STEREO). STEREO has provided us a deep insight into the interplanetary (IP) propagation of coronal mass ejections (CMEs). Especially the wide-angle heliospheric imagers (HI) enabled the development of a multitude of methods for analyzing the evolution of CMEs through IP space. In this study we present an ensemble forecast using an HI-based CME prediction tool and test if an HI observer located at L1 may be an appropriate alternative (or supplement) to an L5 HI observatory.

ElEvoHI, the Ellipse Evolution model (ElEvo) based on HI observations, is a prediction tool, which uses the benefits of different methods and observations. Including input from the graduated cylindrical shell model and assuming a drag-dominated IP motion, ElEvoHI forecasts arrival time and speed at any target in IP space.

Here, we present a test on a slow CME event of 3 November 2010, in situ detected by the lined-up spacecraft MESSENGER and STEREO Behind (B) and remotely observed by STEREO-B/HI, i.e. it was a halo CME for STEREO-B. These conditions simulate an Earth-directed CME observed by HI located at L1. Our study suggests that L1 may provide a sufficient vantage point for an Earth-directed CME, when observed by HI.

Testing the Current Paradigm of Space Weather Prediction with the Heliospheric Imagers

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Predictions of the arrival of four coronal mass ejections (CMEs) in geospace are produced through use of 3 CME geometric models combined with CME drag modelling, constraining these models with the available Coronagraph and Heliospheric Imager data. The efficacy of these predications is assessed by comparison with the SWPC numerical MHD forecasts of these same events. It is found that such a prediction technique cannot outperform the standard SWPC forecast at a statistically meaningful level. A citizen science approach is employed to track the CME fronts in the Heliospheric Imager field of view, and we demonstrate that this provides a more stable tracking of the CME feature than is achieved with a single expert tracking the same event. We test the Harmonic Mean, Self-Similar Expansion and Ellipse Evolution geometric models, and find that, for these events at least, the differences between the models are smaller than the observational errors. Comparison of the CME kinematics estimated independently from the STEREO-A and STEREO-B Heliospehric Imager data reveals inconsistencies that cannot be explained within the observational errors and model assumptions. We argue that these observations imply that the assumptions of the CME geometric models are routinely invalidated and question their utility in a space weather forecasting context. These results argue for the continuing development of more advanced techniques to best exploit the Heliospheric Imager observations for space weather forecasting.

The Worldwide Interplanetary Scintillation (IPS) Stations (WIPSS) Network October 2016 Campaign: LOFAR IPS Data Analyses

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The Low Frequency Array (LOFAR) is a next-generation low-frequency radio interferometer. It is capable of observing in the radio frequency range 10-250MHz, nominally with up to 80MHz bandwidth at a time. During October 2016, a unique opportunity arose whereby LOFAR was used to make nearly four weeks of continuous observations of interplanetary scintillation (IPS) as a heliospheric space-weather test campaign. This was expanded into a global effort to include observations of IPS with the Murchison Widefield Array (MWA) in Western Australia (capable of observing in the 80-300 MHz range nominally using up to 32 MHz of bandwidth), as well as many other Worldwide IPS Stations (WIPSS). IPS allows for the determination of solar wind plasma properties to be made throughout the corona/inner heliosphere. When there are sufficient observations, velocity and density-proxy results can be used as input to the UCSD 3-D time-dependent tomography suite to allow the full reconstruction of both velocity and density nominally out to around 3AU from the Sun. In this study, we undertake an initial analysis of the LOFAR IPS data October 2016, make some early comparisons to the results obtained from the MWA, and make a first attempt at the 3-D reconstruction of the LOFAR IPS results in the UCSD tomography. We also highlight some of the potential future tools that make LOFAR a very unique system to be able to test and validate a whole plethora of IPS analysis methods with the same set of IPS data.

Superposed Epoch Study of Magnetic Clouds And Their Driven Shocks/Sheaths Near Earth

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Magnetic Clouds (MCs) are huge interplanetary manifestations of solar eruptions. When MCs travel faster than the surrounding solar wind, the overtaken interplanetary plasma forms a sheath of heated and compressed plasma at their front. The main aim of this work is to find which are the common plasma and magnetic properties present in (and around) MCs observed near Earth. We apply a superposed epoch method to a large set of MCs observed in situ by the spacecraft ACE. We find that slow MCs at 1 AU have on average sheaths that are more massive, and we conclude that the low bulk speed of these events is mainly due to the drag (and consequent MCs slow down during their travel from the Sun)and not due to their initial conditions near the corona. Furthermore, we find that slow MCs also have a more symmetric magnetic field profile and that their sheaths are in a self-similar expansion as the associated MC. In contrast, fast MCs have an asymmetric magnetic profile and a sheath in compression. In all the types of MCs, we find that the proton density, the temperature, and the magnetic fluctuations can diffuse within the front of the MC; we propose that this s a consequence of magnetic reconnection. The obtained typical profiles of sheath and MC properties corresponding to slow, middle, and fast structures, can be used for forecasting or modelling these events. They are also useful for improving future operative space weather activities.

P2-05

Testing Models Of The Fast Solar Wind Using Spectroscopic And Heliospheric In Situ Observations

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Understanding the sources and acceleration mechanisms of the solar wind remains one of the major unsolved problems in solar physics. The fast solar wind originates in coronal holes and flows along open magnetic field lines. The increasing spatial resolution of remote sensing instruments allows us to probe the chromospheric and transition region sources of the solar wind in greater detail. Joint observations with high-resolution EUV spectrometers and in situ heavy ion sensors provide measurements of several ionization stages of heavy ions observed near the solar surface and in the heliosphere. In parallel, we solve the time-dependent equation for ionization and recombination for a chosen element and calculate the charge state evolution along the open magnetic fields for elements such as C, O, Mg, Si and Fe (Landi et al. 2012, 2014), for solar wind plasma leaving the Sun from the source region to the freeze-in point and beyond to 1 AU. Comparing charge states and spectral lines intensities above the limb predicted from this non-equilibrium ionization model to observations from SOHO/SUMER and Ulysses/SWICS, we test how well the assumed thermodynamic parameters of the solar wind reproduce observations. The electron temperature, density and velocity in these calculations are taken from several solar wind models (Cranmer et al. 2007; Oran et al. 2013). Our preferred 3D MHD solar wind model AWSoM, developed at the University of Michigan, is used to derive both a 3D distribution of the magnetic fields from the Sun's surface to the heliosphere, and the heating and acceleration of the solar wind through Alfven wave dissipation. Results of this work will be used to plan future solar wind studies with the Solar Orbiter mission.

P2-06

Electron acceleration in collapsing magnetic traps during the solar flare on July 19, 2012: observations and models

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Using the appropriate kinetic equation, we considered the problem of propagation of accelerated electrons into the solar corona and chromosphere. Its analytical solution was used for modeling the M7.7 class limb flare occurred on 19th July 2012. Coronal above-the-loop-top Hard X-Ray (HXR) source was interpreted in the thin-target approximation, the foot-point source – in the thick-target approximation with account of the reverse-current electric field. For the foot-point source we found a good accordance with the *RHESSI* observations. For the coronal source we also got very accurate estimate of the power-law spectral index, but significant differences between the modeled and observed HXR intensities were noticed. The last discrepancy was solved by adding the coronal magnetic trap model to the thin target model. The former one implies that the trap collapses in two dimensions, locks and accelerates particles inside itself. It this theoretically well-studied model, two acceleration mechanisms do work very well: the Fermi first-order acceleration and the betatron heating of fast electrons. In our report, we confirm an existence and high efficiency of the electron acceleration in collapsing magnetic traps during solar flares. Our new results represent (e.g. for *RHESSI* observations) the theoretical prediction of the two-step particle acceleration in solar flares, when the first step is the acceleration in reconnection area and the second one – the acceleration in coronal trap.

Measuring the Solar Wind Electron Temperature Anisotropy: Diagnostics using the Quasi-thermal Noise Spectroscopy method on WIND

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The transport of energy in space plasmas, especially in the solar wind, is far from being understood. Electrons are expected to play an important role for energy transport. Therefore, measuring accurately the temperature of the electrons and their non-thermal properties is essential to understand the transport properties of plasmas in non-local thermodynamic equilibrium.

Quasi-thermal noise spectroscopy is a reliable tool for measuring the electron temperature accurately since it is less sensitive to the spacecraft perturbations than particle detectors. This method gives an accurate diagnostics for in-situ electron parameters, mainly the density and the core temperature, as well as an estimation of suprathermal electron properties, and has been successfully implemented in various space media.

Here, we will focus on the electron temperature anisotropy determination using the quasi-thermal noise method. First, we will present analytical calculations implemented in the QTN theory, taking into account this anisotropy for the solar wind. We will show preliminary results on the diagnostics of the solar wind electron properties, using the radio and plasma wave experiment (WAVES) on WIND spacecraft. Finally, we will discuss implications of such extension on the electron distribution functions, in particular for future heliospheric missions such as Solar Orbiter, and Solar Probe Plus.

Heliospheric Magnetic Field And Solar Wind Behaviour During Solar Cycle 23-24

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Solar wind magnetic field, density, velocity and particle data from the ACE and WIND satellites are used to perform a spectral analysis of the solar wind parameters during cycles 23-24, particularly the unusual minimum between these cycles. These include charge state ratios, e.g. O7+/O6+ and C6+/C5+, as well as alpha to proton abundance ratios. Lomb-Scargle and wavelet spectral analysis are used to investigate the evolution of several periodicities of solar wind parameters. Results from the plasma parameters characterize the solar wind, which are compared with Carrington maps using SOHO/EIT 193 Å to identify salient features. The oxygen and carbon charge state ratios are a proxy for the electron temperature in the solar corona while the solar wind elemental composition abundances are related to processes in the source region of the solar wind. Solar wind composition observations and measurements by ACE at L1 therefore encapsulate imprints of the conditions under which the solar wind formed. Pearson correlation analysis between ACE magnetic field observations and solar spherical harmonic coefficients as a function of the 27-day Carrington rotation reveal that the sectorial solar magnetic field is dominant during the minimum 23-24, indicating an unusual configuration of the solar dynamo.

Conic Current Sheets As Sources Of Energetic Particles In The High-Latitude Heliosphere In Solar Minima

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Recently, evidence for long-lived conic (or cylindrical) current sheets (CCSs) in the polar solar wind has been found from Ulysses observations at high heliolatitudes at 2-3 AU (Khabarova et al., ApJ, 2017). CCSs are low-beta and low-speed structures with characteristic scales of several times lesser than the typical width of coronal holes. Their stability is supported by the tornado-like magnetic field. The occurrence of magnetic separators near the poles in solar minima is confirmed independently by reconstructions of the coronal magnetic field based on photospheric magnetic field charts. Additionally, solar wind speed IPS reconstructions show that long-lived low-speed regions are observed inside coronal holes during solar minima.

Energetic particle enhancements up to tens MeV were detected by Ulysses around CCSs both in 1994 and 2007. Therefore, CCSs might serve as channels for energetic particles accelerated in the solar corona by magnetic reconnection, which sheds light on the mystery of energetic particles observed at high heliolatitudes. The analysis of time-intensity profiles of energetic particle flux shows signatures of local magnetic reconnection in the solar wind as well.

Khabarova O.V. et al., High-latitude conic current sheets in the solar wind, The Astrophysical Journal, 836, 108, 1, 2017, https://doi.org/10.3847/1538-4357/836/1/108

Compositional Analysis Within The 'HESPERIA' HORIZON 2020 Project to Diagnose Large Solar Energetic Particle Events During Solar Cycle 23

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In this work we have examined 29 large SEP events with the peak proton intensity Jpp(>60MeV) >1 pfu during the solar cycle 23. The emphasis of our examination is put on a joint analysis of the Ne/O and Fe/O data in the3-40 MeV/nucleon energy range as covered by the Wind/LEMT and ACE/SIS sensors in order to differentiate between the Fe-poor and Fe-rich events emerged from the CME-driven shock acceleration process. Some of our main findings are: (1)An improved ion ratio calculation can be carried out by re-binning ion intensity data into the form of equal bin widths in the logarithmic energy scale, (2) through the analysis we find that the variability of Ne/O and Fe/O ratios can be used to investigate the accelerating shock properties, (3) in particular, we observe a good correlation of the high-energy Ne/O ratio with the source plasma temperature T recently reported by Reames (2016). Therefore, the (Ne/O) n value at high energies should be a proxy of the injection energy in the shock acceleration process, and hence the shock θ_{Bn} according to the models of Tylka & Lee (2006) and Schwadron et al. (2015).

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Ground Level Enhancements in Solar Energetic Particles Observed by IceTop during 2011 to 2016

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Ground level enhancements (GLEs) are sudden increases in cosmic ray intensity, due to relativistic (GeV-range) ions from solar storms, with such a strong flux that their atmospheric showers can be detected by ground-based detectors above the Galactic cosmic ray background. They are of practical interest because the strong relativistic ion flux can pose a space weather hazard to astronauts, air crews, and aircraft electronics, and provide the earliest direct indication of a space radiation storm. Here we survey GLEs during the present solar cycle, in particular during 2011-2016, as observed by the IceTop surface detectors in the IceCube Neutrino Observatory. Our search focused on 34 particle events selected to have significant enhancements in the >100 MeV proton channel of the GOES spacecraft. We find 3 GLEs that exhibit clear signals in IceTop of GeV-range solar ions. We discuss sensitivity limits, and provide a broader context in which these 3 GLEs are found to be much weaker than some GLEs in previous solar cycles. Partially supported by Thailand Research Fund grant RTA5980003 and US National Science Foundation awards PLR-1341562 and PHY-1505990.

A Behavioural Model of the Solar Magnetic Cycle

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This model is based on 3 assumptions: (1) the solar wind exits the sun radially and uniformly. (2) The solar wind is an electric current with positive charge carriers. Researchers report that heavy ions in the solar wind travel faster than electrons and protons. Heavy ions (He^{2+}, O^{6+}, etc) "dope" the solar wind with positive charge carriers, similar to how small concentrations of impurities "dope" semiconductors to produce negative or positive charge carriers. (3) The sun is located in an ambient magnetic field (the interstellar magnetic field). Results show that the "ion current" in the solar wind interacts with the magnetic field and Lorentz forces rotate the sun differentially, creating an opposing magnetic dipole in accordance with Lenz's law. The magnetic dipole traps the solar wind to form the corona and the solar wind exits the corona at lower speeds, losing kinetic energy in heating it up. The solar wind interacts with the combined ambient and dipole fields to produce new Lorentz forces. As the sun now rotates in its own magnetic field, feedback creates harmonic oscillations of both Lorentz forces and the dipole to produce the Hale Magnetic Cycle. Sunspots are the cross-sections of magnetic ropes tethering rotating parts to the Tachocline and only those rotating parts in direct contact with the Tachocline contain sunspots. Stages of the solar magnetic cycle where events like CMEs are more likely to occur are identified.

P2-13

Earth-Affecting Coronal Mass Ejections Without Obvious Low Coronal Signatures

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We present a study of the origins of coronal mass ejections (CMEs) that were not accompanied by obvious low coronal signatures (LCSs) and yet were responsible for appreciable disturbances at 1 AU. These CMEs characteristically start slowly. We show that EUV images taken by the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO) can reveal coronal dimming and a post-eruption arcade (compelling LCSs for CME), if we make difference images with long enough temporal separations that are commensurate with the slow initial development of the CME. By providing the limb views of Earth-bound CMEs, data from the EUV Imager and COR coronagraphs of the Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) on the Solar Terrestrial Relations Observatory (STEREO) turn out to be very useful as they help us limit the time interval in which the CME forms and undergoes initial acceleration. For other CMEs, we find similar but weaker LCSs, and only with lower confidence. It is noted that even these less clear events may result in unambiguous flux rope signatures in in situ data at 1 AU. There is a tendency that the CME source regions are located near coronal holes or open field regions. This may have implications for both the initiation of the stealthy CME in the corona and its outcome in the heliosphere. We discuss the possible interaction of stealthy CMEs with high speed streams from coronal holes and their frequency during cycle 24.

P2-14

Quasi-Static And Dynamical Simulations Of The Solar Wind Over An 11-YearCycle

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The solar photospheric magnetic field's structure changes over time scales ranging from a few minutes to 22 years –the duration of a solar cycle–and more. The steady solar wind is mostly influenced by the large scale magnetic field, that goes from dipolar and mostly symmetric during activity minimum to multipolar and mostly antisymmetric during maximum of activity. Making 3D models of the solar corona is necessary to recover the properties of the ecliptic plane, which concentrates the largest part of in-situ observations.

We first follow the evolution of the solar coronae and wind over the cycle 22 with 3D compressible MHD simulations. We constrain the photospheric magnetic field with synoptic magnetic maps. 12 different simulations are computed, corresponding to quasi-static solutions of the solar coronal structure every year between 1989 and 2000. They yield the expansion factor in a better fashion than the usual potential field source surface model and can be compared to remote and in-situ measurements of the solar wind. We also compare our results to emission measurements made by the SOHO/EIT instrument thanks to synthetic images post-processed from our simulations.

We then discuss a preliminary study of a non-linear dynamical coupling of an alpha-omega kinematic solar dynamo with the wind using 2.5D MHD numerical simulations. We consider numerical and physical aspects, and look at the validity of the quasi-static approach in simulating the global corona and solar wind.

P2-15

Cosmic Rays near Proxima Centauri b

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Cosmic rays are the important factor of space weather determining radiation conditions near planets. Last year a terrestrial planet candidate was discovered in an orbit around Proxima Centauri. Here we will present our estimates on parameters of stellar wind in the Parker model, possible fluxes and fluencies of galactic and stellar cosmic rays based on available data of the Proxima Centauri activity and its magnetic field. Galactic cosmic rays will be absent near Proxima bup to 1 TeV due to modulation by the stellar wind. Stellar cosmic rays may be accelerated in stellar flares and swept out from the astrosphere by the wind. Flares at Proxima Centauri are able to maintain constant density of stellar cosmic rays in the astrosphere. Maximal proton intensities in extreme Proxima events should by 3-4 orders more than in solar events.

The Solar Wind Through Time

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Winds of solar-like stars are very difficult to observe due to a combination of their low densities and limitations of current instrumentation. Here we perform 3D magnetohydrodynamical wind simulations to investigate the evolution of the solar wind from early to current epochs. For this, we use a sample of solar analogues ranging in age from 120 to 4700 Myr. Our models incorporate the magnetic field maps observationally derived for these stars. We further constrain our models by using X-ray observations. From these simulations we calculate mass loss rates and find a dependence in mass loss evolution with age and rotation for solar-like stars. Furthermore, this study examines the effect the aging wind has on the sizes of Earth-like magnetospheres, of which we also find a dependence on age and rotation of the host-star.

Understanding Problem Forecasts of ISEST Campaign Flare-CME Events

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The goal of the ISEST (International Study of Earth-affecting Solar Transients) VarSITI project is to understand the origin, evolution and propagation of solar transients through the space between the Sun and Earth, and to improve our prediction capability for space weather. A goal of ISEST Working Group 4 (Campaign Events) is to study a set of well-observed Sun-to-Earth events to better understand why some events are successfully forecast (textbook cases), whereas others become problem or failed forecasts. In this paper we study six cases during the rise of Solar Cycle 24 that highlight forecasting problems. These cases generally included major solar flares and CMEs, and the geoeffects ranged from none to the two Sun-Earth events in 2015 that caused "superstorms". These events were chosen to illustrate some key problems in understanding the chain from cause to geo-effect.

P3-01

Analysis Of Variations of Earth´s Magnetic Field Produced by Equatorial Electro-Jets In Sudamerica.

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Observations of the magnetic field in Huancayo in 1922 demonstrated the existence of the Equatorial electro jets, which is a narrow band of electrons traveling east to west 180 km above the Earth's surface by a belt along dip equator. Wind-driven currents, through the dynamo mechanism, produce an accumulation of positive charges at sunrise and negative at sunset, which translates into considerable variations in the geomagnetic field. In this study, we have used the Earth magnetic field (MG) data provided by Jerusalem station located in Ecuador, above the geographic equatorial line, in order to study its secular variation founding an strong correlation with sunspots number which indicates the influence of solar activity on the Earth’s ionosphere. We also have used the magnetic field data from others 5 magnetic stations in order to study for first time the latitudinal dependence of the EEJ current and its morphological features in Sud-America. We have found that the average electrojet current is symmetrically distributed along 25 degrees around the position of the peak of intensity, so that the jet extends from -10 To 15 degrees in magnetic latitude and the maximum intensity measured experimentally was in the station of Huancayo by its proximity with the dip equator.

P3-02

Investigates The Earth's bow shock Standoff distance models

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Space plasmas studies of bow shock dynamics and structure scales continues to attract intense theoretical and experimental investigations. A comparison of the empirical models is now plausible given the availability of multi-point measurements. For each of these empirical models, we compute the bow shock velocity, at the standoff distance. Then we compare these with the observed shock velocity as determined from a multipoint measurement provided by the Cluster quartet. The present study investigates the model's parameters and demonstrates which empirical models are more accurate than others are.

Statistical Analysis of Extreme Electron Fluxes in the Radiation Belts: Observations from ICARE-NG/CARMEN-1, SAC-D

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In this work we study the electron population of the outer radiation belt in an energy range from a few keV to tens of MeV. The flux of these particles increases significantly during a magnetospheric storm, induced by variable conditions of the solar wind. The expected extreme values for these particle fluxes are of great interest, mainly due to their impact on satellites and human activities in space. For example, detailed knowledge of the values and frequency of these extreme fluxes is essential for the specific design of satellites and for the development of satellite technologies. The purpose of this work is to study the extreme fluxes of electrons at the terrestrial radiation belts, for an specific energy range 0.249-1.192 MeV, at 660 km of altitude above the Earth surface, using measurements made by the detector ICARE-NG/Carmen-1 on board the polar Argentinean satellite SAC-D. A statistical analysis based on the peaks over threshold approach was implemented for the daily average electron flux. We find that the daily averaged electron flux measured at SAC-D is likely to have a finite upper limit in the (1) internal bound of the outer radiation belt for low energy channels and (2) in the external bound of the outer radiation belt for energies larger than 0.7keV.

Detection Of Plasmaspheric Compression By Interplanetary Shock Using GPS TEC Technique

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The ray paths between Global Navigation Satellite System (GNSS) satellites and receivers traverse the ionosphere and part of the plasmasphere. Total electron content (TEC) is thus derived from the phase delay of GNSS signals for the purpose of investigation on plasma variations in both the ionospheric and plasmasphere. On 17 March 2015 when an interplanetary shock (IS) impacted on the Earth's magnetosphere, unusual TEC variations were observed with hundreds of ground-based global positioning system (GPS) receivers. Instantaneous TEC impulses were detected in the signals of 4 GPS satellites which were cruising in the day side equatorial magnetosphere; they were synchronously registered by receivers spreading from low- to mid-latitudes and lasted for only several minutes, during which period the interplanetary magnetic field (IMF) kept northward. With the above characteristics, the TEC impulses discriminate themselves from usual traveling ionospheric disturbances (TIDs) and other known dynamics in association with magnetic storm following the shock. We suggest that the TEC variation is caused by shock-induced magnetospheric compression, which drives plasma to move earthward in the day side magnetosphere. As a result, some plasma moves from outside of GPS orbit (4.2 RE) to inside, contributes to the plasma content traversed by GPS ray path. The GPS TEC technique thus exhibits an unprecedented capability to capture small tremor of the magnetosphere.

P3-05

Magnetic Curvature and Vorticity Four-Spacecraft Analyses on Kelvin-Helmholtz Waves: a MHD Simulation Study

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Four-spacecraft missions are probing the Earth's magnetospheric environment with high potential for revealing spatial and temporal scales of a variety of in-situ phenomena. Magnetic curvatures are intrinsic to curved magnetic fields where the magnetic energy is stored in the form of magnetic tension. In-situ magnetic curvatures have been resolved by the four-spacecraft technique called "magnetic curvature analysis" (MCA). The MCA technique has been used in various plasma structures identified as current sheets, plasmoids, and magnetic reconnection diffusion regions. Vorticity is ubiquitous in flow systems which exbibit swirling patterns. Motivated by the curved magnetic field and vortical structures induced by Kelvin-Helmholtz (KH) waves, we investigate the robustness of the MCA and vorticity techniques to interpret applications in the real data. Here, for the first time, we test both techniques on a 2.5D MHD simulation of KH waves. Increasing (regular) tetrahedron sizes of virtual spacecraft are used to measure the curvature and vorticity of KH vortices. We investigate the magnetopause curvature and flow vorticity across KH vortex and we produce time series for static spacecraft in the boundary layers. We have found variations of the curvature vectors both in radii and orientations depending on the sizes of the tetrahedron. This is helpful to better understand the MCA measures when the technique is applied to in-situ data without knowing the scale sizes of plasma structures under consideration. The combined results of magnetic curvature and vorticity help us to understand the development of KH waves. This study lends support for cross-scale observations to better understand the nature of curvature and its role in plasma phenomena.

Keywords: magnetic curvature analysis (MCA), vorticity technique, in-situ plasma measurements, multi-spacecraft technique

Physics-based modeling of the density distribution in the whole plasmasphere using measurements along a single pass of an orbiter

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The data base of the Alpha-3/Interball-1 measurements was used for 3-D modeling of plasma distribution inside the wholeplasmasphere. The primary 2-D model describing the density distribution in the meridional plane is based on equations of the plasma distribution in the plasmasphere for the cases of thermal equilibrium and initial collisionless partial filling of plasmaspheric shells. This 2-D model is then expanded into a 3-D one using analytic equations for the shape of the plasmapause and density variations in the equatorial plane along the convection streamline. The final model contains six parameters with clear physical meaning.

This modeling approach can be applied for extrapolation of data from magnetospheric satellites with very different orbits into the entire plasmasphere. The derived plasmapause location is very important parameter in combined research of energetic particle distribution in the magnetosphere and their interaction with cold plasma. The study of solar wind influence on the parameters of our model will clarify the impact of solar wind and geomagnetic activity on the plasmasphere and plasmapause state.

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P3-07

Ground And Space Observations To Determine The Location Of Locally Vertical Geomagnetic Field

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The points where the horizontal component of the geomagnetic field vanishes are located in polar areas, far away from the geomagnetic poles and the poles of rotation of the Earth and, differently from the geomagnetic poles, can be found experimentally, conducting a magnetic survey to determine where the field is vertical. The experimental determination of the area where the total field is perfectly vertical, commonly known as dip pole, is not simple, due to the remoteness and harsh climatic conditions; another difficulty is related to the short term geomagnetic field variations, due to the interaction with the external solar wind, which causes the magnetospheric dynamics, particularly evident at high latitude, and as a consequence a displacement of the dip pole. Actually, the study of the dip pole displacements over short time scales can be considered an important tool for monitoring the magnetospheric dynamics at high latitude. In this study we present the updated location of the areas where the geomagnetic field is vertical, using data from the Swarm ESA's constellation of satellites along their almost polar orbits and tracking the path from past ground measurements of the geomagnetic field collected at remote and inaccessible areas of the planet. We also analyze the spatial local shift of these areas during different seasons and magnetospheric conditions.

Determining The Polar Cusp Longitudinal Location From Pc5 Geomagnetic Field Measurements At A Pair Of High Latitude Stations

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We use low frequency geomagnetic field measurements at two Antarctic stations to statistically investigate the longitudinal location of the polar cusp.

The two stations are Mario Zucchelli (geographic coordinates: 74.7°S, 164.1°E; corrected geomagnetic coordinates: 80.0°S, 307.7°E) and Scott Base (geographic coordinates: 77.8°S 166.8°E; corrected geomagnetic coordinates: 80.0°S 326.5° E), both located in the polar cap at a geomagnetic latitude close to the cusp latitude; they are separated by one hour in magnetic local time.

At each station the Pc5 power maximizes when the station approaches the cusp, i.e. around magnetic local noon. The statistical comparison between the Pc5 power at the two stations allows to determine the location of the cusp. Our analysis is conducted considering separately the different seasons, different magnetospheric activity levels as well as different values of the solar wind parameters.

The results, which indicate longitudinal shifts of the polar cusp depending on the selected conditions, are discussed in relation to previous studies of the polar cusp location based on polar magnetospheric satellite data.

Extreme Relativistic Electron Fluxes in the Earth's Outer Radiation Belt: Analysis of INTEGRAL IREM Data

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Relativistic electrons (E >500 keV) cause internal charging and are an important space weather hazard. To assess the vulnerability of the satellite fleet to these so-called “killer" electrons it is essential to estimate reasonable worst cases, and, in particular, to estimate the flux levels that may be reached once in 10 and once in 100 years. In this study we perform an extreme value analysis of the relativistic electron fluxes in the Earth's outer radiation belt as a function of energy L^*. We use data from the Radiation Environment Monitor (IREM) on board the International Gamma Ray Astrophysical Laboratory (INTEGRAL) spacecraft from 17 October 2002 to 31 December 2016. The 1 in 10 year flux at L^*=4.5, representative of equatorial medium Earth orbit, decreases with increasing energy ranging from 1.36x10^7 cm^{-2}s^{-1}sr^{-1}MeV^{-1} at E=0.69 MeV to 5.34x10^5 cm^{-2}s^{-1}sr^{-1}MeV^{-1} at E=2.05 MeV. The 1 in 100 year flux at L^*=4.5 is generally a factor of 1.1 to 1.2 larger than the corresponding 1 in 10 year flux. The 1 in 10 year flux at L^*=6.0, representative of geosynchronous orbit, decreases with increasing energy ranging from 4.35x10^6 cm^{-2}s^{-1}sr^{-1}MeV^{-1} at E=0.69 MeV to 1.16x10^5 cm^{-2}s^{-1}sr^{-1}MeV^{-1} at E=2.05 MeV. The 1 in 100 year flux at L^*=6.0 is generally a factor of 1.1 to 1.4 larger than the corresponding 1 in 10 year flux. The ratio of the 1 in 10 year flux at L^*=4.5 to that at L^*=6.0 increases with increasing energy ranging from 3.1 at E=0.69 MeV to 4.6 at E=2.05 MeV.

P3-10

Planetary Period Oscillations In Saturn's Magnetosphere: Examining The Relationship Between Changes In Behavior And The Solar Wind.

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We examine planetary period oscillations (PPOs) observed in Saturn's magnetospheric magnetic field data from the time of Saturn's equinox in 2009. In particular, we focus on the time period commencing February 2011, when the oscillations started to display sudden and unexpected changes in behaviour at ~100–200 day intervals. These were characterized by large simultaneous changes in the amplitude of the northern and southern PPO systems, together with small changes in period and jumps in phase. The abrupt changes commenced as the Sun started to emerge from a long extended solar minimum. We perform a statistical study to determine whether these modulations in PPO behaviour were associated with changes in the solar and/or upstream solar wind conditions. We report that the upstream solar wind conditions show elevated values of solar wind dynamic pressure and density around the time of PPO behavioural transitions, as opposed to before and after these times. We suggest that abrupt changes in PPO behaviour may be related to significant changes in the size of the Saturnian magnetosphere in response to varying solar wind conditions.

MHD Modeling of MMS Reconnection Sites

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The goal of the Magnetospheric Multiscale Mission is to understand the processes responsible for magnetic reconnection, to provide crucial inputs for space weather prediction sites such as our site.

One of us (Webster) has developed an algorithm to search the MMS burst data archive for reconnection sites, and have put together a comprehensive list of Electron Diffusion Regions (EDR's). We have run the SWMF-RCM model (via the CCMC) in highest spatial and temporal resolution mode for a selection of these EDR events.

For times where the MMS spacecraft data indicate passage through the EDR, the model predicts that the MMS is located near the 3D separator line. Tracing field lines near the separator, and allowing propagation based on the field line motion far from the Xline shows interesting features, such as field line stretching just as the open-closed boundary is approached. Both the inner and outer fields stretch and rotate, creating an enhanced guide field just at the boundary. The amount of time a given field line remains near the EDR is extremely fast, just a few seconds, consistent with the bursty characteristic of the electron anisotropies measured in the EDR.

GeoMagSphere Model Applied During Solar Events: A Study Of Cosmic Rays Detector From The International Space Station.

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Applying the backtracing procedure to cosmic ray particles arriving from the outer magnetosphere, we are able to distinguish among primary cosmic rays (particles coming from the outer magnetosphere), secondaries (produced inside the magnetosphere) and trapped (particles confined in "magnetic bottles" inside the magnetosphere). We found that the spectra of these three groups of particles are time dependent. It is relevant to monitor fluxes increases in particular during high solar activity periods, when solar events like flares, CME's, Forbush-decreases are more frequent, and in order to prevent radiation damage in space devices. In this work, we will show the behavior of magnetosphere during two solar events: March and May 2012, where two strong flares followed by CME's impacted on Earth. The backtracing applied to all particles detected demonstrated that only the Tsyganenko (TS05) model, coupled to IGRF-12, is able to correctly represent the magnetosphere in high solar activity periods.

Magnetic storm effects on the variation of TEC over low, mid and high latitude station

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The ionosphere is very important because of its influence on the passage of radio waves. Total electron content (TEC) is a key ionospheric parameter that describes the major impact of the ionosphere on the propagate on of radio waves which is crucial for terrestrial and space communication. The present investigation is dedicated to study the latitudinal variation of ionosphere. The study is carried out by taking three stations one each in low, mid and high latitude regions namely IISC, Bangalore, India (13.020 N, 77.570E), GUAO, Urumqi, China (43.820N, 87.600E) and NYAL, NY-Alesund, Norway (78.920N, 11.860E) respectively. To study the changes in the ionosphere at three selected station we have considered the GPS observations. The GPS derived TEC values have been collected from the SOPAC (Scripps Orbits and Permanent Array Center) data archive of the IGS (International GPS service). We studied the behaviour of ionospheric Total Electron Content (TEC) during the geomagnetic storms. We have selected 5 intense geomagnetic storms (Dst ≤ -100nT) that were observed during the year 2012. From our analysis we observed that the effect of geomagnetic storms on VTEC is highest at low latitude, moderate at mid latitude and low at high latitude.

P4-06

Effect of Geomagnetic Super Substorm at Low Latitude Stations

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Phenomena like solar energetic particles, geomagnetically induced currents and ionospheric disturbances are associated with and are caused by geomagnetic storms. They can cause frequent radio and radar scintillations, severe failure of power grids, disruption of navigation by magnetic compass and auroral displays at much lower latitudes than normal in earth. Substorm occurrence becomes more frequent during a geomagnetic storm and one substorm may start before the previous one has completed. So the high level of super substorm activity at low latitude is quite significant which makes the study of such events quite efficacious. The geomagnetic Northward component (X) field of the four stations in the equatorial and low latitude region were taken to study their variations during super substorm events of April 05 2010, August 24 2005 and November 24 2001. The location of the stations extends from Asia to South America across Africa. During a brief disturbance in the Earth's magnetosphere that causes energy to be released from the tail of the magnetosphere and injected into the ionosphere, we found that there was a peak decrease in the Northward component (X) field of all the low latitude stations across the globe. The storm time (D_{st}) variations in the Northward component (X) of geomagnetic field at low latitude stations during super substorm events was shown to be significant and to substantiate the results, wavelet transform and cross correlation techniques were used. We checked the correlation of Northward component of (X) with D_{st}, SYM-H, B_z, X, Y and E_y individually. Positive correlation of X with D_{st} and SYM-H shows that geomagnetic effect during the super substorm events at low latitude is significant. The power regions with the maximum fluctuation were analyzed using the continuous wavelet transform and was found to be uniformly distributed during the super substorm occurrences.

P4-03

Climatology of thermospheric neutral temperatures over Oukaïmeden observatory in Morocco.

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In this work we present the first multi-year results of the climatology of neutral temperatures measured using an imaging Fabry-Pérot interferometer which provide measurements of the 630.0 nm emissions caused by dissociative recombination of the O_2^+. These results are obtained during the period from January 2014 to January 2017 including observations from 966 nights. Looking at the results obtained, we find that the temperature is fixed at around 1000 K at the beginning of the night throughout the year, except in the case of the month of August where the temperature was constant and close to 800 K throughout the month. During the winter months the temperature gradually decreases to a temperature of 700 K just before sunrise. While during the summer months a slight increase in temperature is observed, the amplitude of which varies from 50 K to 200 K, the maximum is reached in the vicinity of 22:00 LT, and then continues to decrease until it reaches an almost temperature equal to 800 K at the end of the night. The comparison of these results with the predictions of the MSIS thermospheric model shows that the latter overestimates the value of the temperature during the whole year.

Sputtering Of Wollastonite By Solar Wind Ions

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Surface sputtering of Moon and Mercury by solar wind has been recognized as one of the key processes on the formation of the exosphere. In order to evaluate the contribution of solar-wind induced sputtering to the exosphere formation, experimental data for absolute sputtering yields of analog minerals bombarded by various solar wind ions are required.

Sputtering experiments have been performed at TU Wien during the past years using a quartz crystal microbalance (QCM) technique. In this method, the desired target material is predeposited on the quartz surface as a thin layer and the sputtering yields are determined by relating the quartz's resonance frequency shift to the mass loss during ion bombardment.

Wollastonite ($CaSiO_3$) was chosen as our first analog mineral and was deposited on the quartz crystal by pulsed laser deposition in an ambient oxygen gas. Surface analysis by XPS and TOF-SIMS indicates that the surface composition of the produced thin film corresponds well with that of the original stone.

Sputtering experiments with the wollastonite-coated QCM target were initially started with 2 keV Ar+ ions. The mass removal rate was precisely determined for different incident angles and the results were found to be in good agreement with SDTrimSP predictions. As a next step, sputtering experiments with ions with solar wind energies will be conducted and the respective roles of protons, alpha particles, and heavy multi-charged ions will be investigated.

Changes Of Solar Extreme Ultraviolet Irradiance In Solar Cycle 23 and 24

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Solar extreme ultraviolet (EUV) radiation is an important energy source for the terrestrial atmosphere and creation of the ionosphere. In recent solar cycles, continuous space-borne measurements of the solar EUV irradiance mainly come from three instruments: the Solar EUV Monitor (SEM) onboard the Solar and Heliospheric Observatory (SOHO), the Thermospheric Ionospheric Mesospheric Energy and Dynamics (TIMED) Solar EUV Experiment (SEE), and the Solar Dynamics Observatory (SDO) Extreme Ultraviolet Variability Experiment (EVE). The SEM data has been a critical data source for investigations on the interminima changes of solar EUV between the minima of 1996 and 2008, however, the result is still under debate due to possible influence from degradation of the SEM instrument. Upon examination of expected linear relation between SEE EUV and ionospheric peak electron density (NmF2), we use the SEE data as a calibration source to obtain an unbiased SEM data. As a result, a temporal sensor drift coefficient of ~-2%/yr is fitted, and a new estimation of the interminima change of EUV irradiance is ~10% reduction in 2008 compared to 1996. We also check the solar cycle changes of EUV spectrum using the SEE data, in terms of its dependence on the P and LASP Mg II indices. One result is that, three coronal emissions (Fe XV at 28.4 nm and 41.7 nm and Fe XVI at 33.5 nm) are found to brighten in SC24 relative to P, but not relative to the LASP Mg II index.

Particle-in-cell Modeling of CubeSat and Ionospheric Plasma Interaction

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We numerically investigate the interaction between the nano-satellite 'CubeSat' and surrounding plasma. The Dynamic Ionosphere CubeSat Experiment (DICE) is an exploratory space weather mission which aims to understand the impact of the solar flares on the Earth's environment. The DICE mission consists of the two identical 1.5 U CubeSats. Each CubeSat's payload carry multiple instruments including, a double probe electric field instrument, plasma and magnetic probes. The measurements made by these instruments provide deep insight into the way solar flare particles interact with the Earth's upper atmosphere. Therefore the purpose of the present study is to elucidate the particular issues related to the nanosatellite-plasma interaction which affect the on-board instruments.

The goal is achieved by simulating the interaction between CubeSat and ionospheric plasma with the three dimensional particle-in-cell code, PTetra. It is an electrostatic code which accounts for the presence of a static background magnetic field. The model also accounts for a number of physical processes which play important roles in the spacecraft charging. These include, the photo-emission and secondary electron emission. The study focuses on particular physical effects including, the presence of magnetic field, ionic composition and the photo-emission on the spacecraft charging and on the floating potential and plasma density spatial profiles in the vicinity of the CubeSat.

In the first part of this study, we investigate the effects of different physical conditions on the current collection of the spherical Langmuir probes mounted on the CubeSat. The computed current characteristics are then used to estimate the plasma parameters; i.e., the floating potential, the plasma density and temperature.

In the second part of our study, PTetra is used to model a double probe electric field (EFP) instrument. The sheath potential profiles obtained from PTetra simulations can be used to estimate the values of the electric field under specific conditions. These potential profiles are also used to compute the particle velocity distribution functions near the EFP instrument.

The simulation results illustrate the sensitivity of the current characteristics, electric field and the particle velocity distribution functions to certain physical effects.
This study will be helpful to understand the detailed interaction between the nanosatellites and the mesothermal plasma environment.

Possible Influence Of The Solar Eclipse On The Global Geomagnetic Field

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The solar eclipse affects terrestrial environments in various aspects. For instance, abrupt temperature decrease during the solar eclipse is well documented. The decreases in the electron concentration and current density decrease in the ionosphere during the solar eclipse are also well known. In this study, we attempt to search for any signatures of influence on geomagnetic field by the solar eclipse - especially the plasmasphere and the ground based geomagnetic measurements. We carry out the statistical analysis of H_P, H_E, H_N –components of magnetic field data and electron flux data(40~475keV) on the GOES satellites, x, y, z, H-components, and the intensity of the geomagnetic field(F) using the ground based geomagnetic data observed during the solar eclipses from 1991 to 2016. First, the solar eclipse seems that it doesn't have a significant effect on the magnetic field of the plasmasphere as compared to the ionoshpere. Second, we confirm that the characteristic decreases in the x, H-components and F and an increase in the y-component can be seen in the vicinity of the maximum eclipse time at the observing site. Third, we find that the variations are more conspicuous during the total solar eclipse rather than the annular eclipses. We also find that such a dip is likely to be noticed when the observing site locates in the second half compared to the first half of the eclipse path, as well as when the eclipse occurs in dusk side than in dawn side. Fourth, we find that reductions in the ground geomagnetic field by the solar eclipse are more evident in the ascending phase of the solar cycle than in the descending phase and solar minimum than solar maximum. We finally discuss implications of our findings.

P4-08

The temperature signature of an IMF-driven change to the global atmospheric electric circuit (GEC) in the Antarctic troposphere

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We use NCEP/NCAR reanalysis data to show that Antarctic surface air temperature anomalies result from differences in the duskward component B_y of the interplanetary magnetic field (IMF). We find the anomalies have strong geographical and seasonal variations. Regional anomalies are evident poleward of 60[Symbol]S and are of diminishing representative peak amplitude from autumn (3.2°C) to winter (2.4°C) to spring (1.6°C) to summer (0.9°C). We demonstrate that anomalies of statistically-significant amplitude are due to geostrophic wind anomalies, resulting from the same B_y changes, moving air across large meridional gradients in zonal mean air temperature between 60 - 80[Symbol]S. The mean tropospheric temperature anomaly for latitudes [Symbol] -70[Symbol] peaks at ~0.7 K and is statistically significant at the 1 - 5% level between air pressures of 1000 - 500 hPa (~0.1 - 5.6 km altitude above sea level) and for time lags with respect to the IMF of up to 7 days. The signature propagates vertically between air pressure p [Symbol] 850 hPa ([Symbol] 1.5 km) and p = 500 hPa (~5.6 km). The prompt tropospheric response and vertical propagation have previously been seen in the correlation between the IMF and high-latitude air pressure anomalies, known as the Mansurov effect. We conclude that we have identified the temperature signature of the Mansurov effect. These anomalies are associated with B_y-driven anomalies in the electric potential of the ionosphere, so we conclude that they are caused by IMF-induced changes to the GEC.

An Investigation of Total Electron Content at Low and Mid Latitude Stations

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The occurrence of unique Ionospheric phenomena such as prompt penetration electric field and equatorial ionization anomaly at both low and mid latitude regions has made total electron content measurements essential in such region. Using dual frequency GPS receiver at two low latitude and two mid latitude stations of Ile-Ife, Nigeria (Geomagnetic Lat. 9.47°N, Long. 78.66° E), Cotonou, Benin Republic (Geomagnetic Lat. 8.71°N, Long. 76.42° E) Marseille, France (Geomagnetic Lat. 44.32°N, Long. 87.25° E) and Titz, Germany (Geomagnetic Lat. 51.67°N, Long. 91.18° E), the measurement of ionospheric Total Electron Content for 2013, 2014 and 2015 has been carried out. The data from the four stations were used to study the seasonal variations of Total Electron Content. The seasonal variations maximize between 12:00 – 18:00UT (69TECu), 12:00 – 18:00UT (68TECu), 10:00 – 16:00UT (31TECu) and 10:00 – 16:00UT (28TECu) for Ile-Ife, Cotonou, Marseille and Titz stations correspondingly. Seasonal variations showed that Total Electron Content maximizes (69TECu, 68TECu, 31TECu and 28TECu) during the equinoctial months and least (44TECu, 46TECu, 16TECu and 15TECu) in summer, over the four stations during the three years considered in the study. Higher magnitude of Total Electron Content was observed at the low latitude (Cotonou and Ile Ife) stations while the magnitudes for mid latitude (Marseille and France) stations were lower comparatively throughout the study. The highest magnitude of Total Electron Content was experienced in 2014, followed by 2015 and the year 2013 experienced the least magnitude of Total Electron Content. The highest magnitude of Total Electron Content at the low latitude stations can be due to the occurrence of equatorial ionization anomaly. The study has revealed both seasonal and latitudinal variation in total electron content; the pre midnight magnitude of Total Electron Content is symmetrical to the post-midnight magnitude during winter season for mid latitude stations while asymmetrical Total Electron Content magnitudes were experienced during pre-midnight and post-midnight periods during equinox and solstice in the low latitude stations throughout the study. The existence of symmetrical peak values of Total Electron Content was noticed at about 08:00 - 13:00 UT and at about 16:00-20:00 UT during the summer period at the mid latitude stations while the Total Electron Content at both periods are asymmetrical during the equinoctial and winter season at low latitude stations throughout the study.

Keywords: GPS, Ionosphere, Low-latitude, Mid-latitude, Total Electron Content, Equatorial Ionization Anomaly.

Geomagnetic Storm Main Phase Effect on the Equatorial Ionosphere over Ile-Ife as measured from GPS Observations

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The effect of the main phase of two intense geomagnetic storm events which occurred on August 5 – 6 and September 26 – 27, 2011 on the equatorial ionosphere have been investigated using Global Positioning System (GPS) data obtained from an Ile-Ife station (geomagnetic lat. 9.84°N, long. 77.25°E, Dip 7.25°N). Total Electron Content (TEC) profiles during the main phase of the two geomagnetically disturbed days were compared with quiet time average profiles to examine the response of the equatorial ionosphere. International Reference Ionosphere (IRI) 2012 TEC model was also obtained from Virtual Ionosphere, Thermosphere, Mesosphere Observatory (VITMO) and the extents of deviation from measured GPS-derived TEC were examined for the main phase of the storm events. The results showed that the intensity of both storm events during the main phase which occurred at night-time correlated well with a strong southward direction of the z-component of the Interplanetary Magnetic Field (IMF-Bz) and Solar Wind Speed (Vsw), with the Disturbance storm time (Dst) profile showing multiple step development. TEC depletion was observed during the main phase of the August 5 – 6, 2011 storm event with TEC recording a maximum value of 9.31 TECU. A maximum TEC value of 55.8 TECU was recorded during the main phase of the September 26 – 27, 2011 storm event depicting TEC enhancement. Significant scintillation index value of 0.57 was observed when the main phase started on August 5 – 6, 2011 followed by a prolonged suppression while there was less significant scintillation impact on September 26 – 27, 2011 with a maximum value of 0.33. The present study show that rapid energy input from solar wind during geomagnetic storm events effect large variations in TEC and significant scintillation phenomenon in the equatorial ionosphere over Ile-Ife, Nigeria.

P4-11

Solar Activity effect on Ionospheric Total Electron Content (TEC) during Different Geomagnetic Activity in Low-Latitudes

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The dual frequency signals from the GPS satellites recorded at Ile-Ife, Nigeria (Geomagnetic cords: Lat 7.52°N and Long 4.28°E); Addis Ababa, Ethiopia (Geomagnetic cords: Lat 9.04°N, Long 38.77°E) and Bangalore, India (Geomagnetic cords: Lat13.03°E, Long 77.57°E) within the Equatorial Ionization Anomaly (EIA) zone for 2011 and 2012 have been analysed to study the effects of geomagnetic and solar activities on Total Electron Content (TEC). In this study, we described the diurnal and seasonal variations of TEC and the solar activity dependence of TEC. The diurnal variation of TEC shows pre-dawn minimum for a short period of time, followed by a steep early morning increase and then reaches maximum value during the daytime in the three stations. TEC shows a positive ionospheric storm effect, with increased geomagnetic activity corresponding to higher TEC values. The seasonal variation of TEC in the three stations showed that TEC maximizes during Equinoctial months (March, April, September, October), and records minimum values during Summer months (May, June, July, August), with intermediate values during the Winter months (November, December, January, February), showing a semi-annual variation. Winter anomaly was also observed. The variations of TEC at maximum and minimum solar radio flux (F10.7) and sunspot number (SSN) for the two years revealed that the magnitude and temporal fluctuation characteristics of TEC are influenced by solar activity and it is dependent on season and geographic location. From the analysis also, the best correlation was found between TEC and F10.7, wherein the largest value of coefficient occurs in Addis Ababa in 2011, with value of 0.851, while the minimum correlation of 0.227 was found at Bangalore in 2012.

P4-12

Solar cycle variation and its impact on Critical Frequency of F2 layer

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The period of an approximately 11-year cycle of solar activity is characterized by the rise and fall in the numbers and surface area of sunspots. We observed a number of other solar activity indices, including the 10.7 cm radio flux, solar Mg II core to wing ratio, relative sunspot number Rz and solar flare index and geomagnetic activity that vary in association with the sunspots for solar cycles 21,22 and 23 (1976–2008).This paper presents an analysis of the F-region variability of the ionospheric parameter foF2 at mid-latitude station Hobart (Australia Latitude:- 42.88° S and Longitude: 147.32° E) during the whole period (1976–2008) of solar cycle-21, 22 and 23. The diurnal, monthly, yearly and cycle to cycle characteristics of these ionospheric F-region parameter foF2 have been studied in detail. We also compared the dependence of foF2 on solar activity indices by using a correlation analysis and showed that a significant linear relationship between the foF2 values and Solar indices. The foF2 variation is strongly influenced by solar activity with about an 11-year solar cycle from the solar maximum to solar minimum.

About Factors Of Solar Radiation Influenced On The Ionosphere

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The study of nonstationary solar processes geoeffectiveness was based on influence exerted solar flares and the whole complex of phenomena associated with them. The response of midlatitude ionosphere to geomagnetic perturbation was considered as well. But in some cases the critical frequency f_0F2 of the reflection of radio signal during sounding of ionosphere does not respond to solar X-ray flares.

Method of using differential parameters of the upper ionosphere – temporal behaviour of f_0F2 deviation (Δf_0F2) is applied in the proposed study. We used the data of critical frequency f_0F2, determined from uniform ionograms obtained with the digital Ionosonde CADI, installed at the landfill NIRFI UNN “Vasilsursk” (near Nizhny Novgorod), and Ionospheric Station of Moscow.

It revealed that incoming streams of charged particles (solar electron flux, for example) play an important role in the temporal behaviour of f_0F2 deviation.

Effect Of Solar Coronal Mass Ejections On The Ionosphere

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The influence of solar processes on the state of near-earth space is constantly the object of serious study. First of all the solar radiation affects the parameters of the ionosphere and ionizing processes in it. The basic level indicator of the ionized particles is the critical frequency f_0F2 of the reflection of radio signal during sounding of ionosphere.

Understanding of the role of Coronal Mass Ejections (CME) in global solar-terrestrial processes allow us to put up the problem about their possible influence on near Earth' processes and ionosphere behavior.

Earlier the authors proposed the procedure of the detection the influence of CME on the differential parameters of the upper ionosphere [Symbol]f_0F2 as more sensitive in comparison with the traditional methods. First results were based on the data of regular observations f_0F2 during the cycle of solar activity (1975-1986). There is negative derivative in temporal behaviour of f_0F2 deviation after CME (Loop) onset and no changes after onset of other types of CME.

To verify the relationship discovered we used in the proposed study the data of critical frequency f_0F2, determined from uniform ionograms obtained with the digital Ionosonde CADI. It is installed at the landfill NIRFI UNN “Vasilsursk” (near Nizhny Novgorod), and program of regular observations allowed to obtain ionograms at least once in 1 min. There are many examples of time coincidence between the periods of CMEs existence and negative deflection in [Symbol]f_0F2 behaviour.

P4-15

Equatorial Plasma Bubbles observations during quit and disturb period over low Latitude region

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The Total Electron Content (TEC) is computed from Global Positing System (GPS) from Hyderabad (17.41^{0}N, 78.55^0 E) and Bangalore (13.02^{0}N, 77.57^{0}E) IGS station. In the present work we have discussed the possible mechanism of day-to-day variability in the occurrence of EPBs during quiet and disturb period and variation in the ionospheric TEC, % occurrence rate of Equatorial plasma bubble in a solar cycle and its comparison with solar flux in different geomagnetic conditions.

Key words: TEC, Low Latitude, EPBs

Statistical analysis on how CME and SIR/CIR events effect the geomagnetic activity and the Earth's thermosphere

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In order to estimate the impact of different types of solar wind on the geomagnetic activity and the neutral density in the Earth's thermosphere, we present a comprehensive statistical analysis based on interplanetary coronal mass ejections (ICME) covering the time range from July 2003 -2016 and stream interaction as well as corotating interaction regions (SIR/CIR)from July 2003 –December 2009.In general, geomagnetic storms induced by CIR are characterized by lower energy input compared to ICME induced storms but a significantly longer duration time due to a long-term negative Bz component in the magnetic cloud region.

Regarding the time of occurrence of ICME events, we rely on the catalogue maintained by Richardson and Cane. For the period of investigation more than 250Earth-directed CME events are listed. All of them have been measured in situ by plasma and field instruments on board the ACE spacecraft. The arrival times of SIRs/CIRs are taken from the catalogue maintained by Lan Jian based on ACE and Wind in-situ measurements. From this list, we extracted 98 SIR/CIR events, from which the minimum Bz component is determined within a time window of 36 hours starting at the arrival of the SIR/CIR(same procedure as for ICMEs). Accordingl y, the peak in Earth's neutral density is determined in the same time window. The densities itself are estimated by using accelerometer measurements collected by the Gravity Recovery And Climate Experiment (GRACE) satellites and subsequently related to various geomagnetic indices (e.g. SYM-H, Polar cap, a-indices, ...) as well as characteristic CME parameters like the impact speed, the southward magnetic field strength Bz and resultant derivatives.

We find high correlations (cc=0.9) between the CME characteristic (except the impact speed) and the thermospheric density enhancements as well as with most of the geomagnetic indices. However, considering only weaker ICME events (Bz up to -20nT) a lower correlation must be conceded. The same holds true for SIR/CIR events, as both cover compressed sheath regions with turbulent magnetic field. The absolute density increases for SIR/CIR induced storms is in the order of 1.7E-12kg/m3for Bz values ranging from -4 to -19nT, with a related correlation coefficient of -0.41.

The Variability Of The Solar EUV Irradiance And Its Possible Contribution To The Ionospheric Variability During Solar Flare

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The ionospheric electron density increases greatly during solar flare period due to the sudden increase of the solar irradiance in X-ray and EUV band. This sudden increase of the electron density causes many kinds of ionospheric effects that are named as sudden ionospheric disturbances (SIDs), for example, the sudden increase of total electron content (SITEC). Studies showed that although the value of ionospheric SITEC is roughly correlated with the flare level that is classified according to the soft X-ray peak flux from GOES satellite and the flare location in solar disc, the dispersion of the SITEC values during the solar flares with same level and location is also obvious. Here, using the GOES X-ray flux data, SOHO-SEM EUV data in the band of 0.1-50 nm and 26-34 nm, the variability of the solar EUV irradiance for solar flares from 1999 to 2007 is analyzed. Some statistical features for different irradiance band during solar flares are obtained. It is included the difference of the increase of the EUV irradiance in two bands (0.1-50 nm and 26-34 nm) and their ratio for the flare with the same class but different location. These results are helpful for the understanding of the variability of the ionospheric response to solar flare irradiance.

Long-Term Longitudinal Recurrences of the Open Magnetic Flux Density in the Heliosphere

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Open magnetic flux in the heliosphere is determined from the radial component of the magnetic field vector measured onboard interplanetary space probes. Earlier Ulysses research has shown remarkable independence of the flux density from heliographic latitude, explained by super-radial expansion of plasma.

Here we are investigating longitudinal variations in the 50 year long OMNI magnetic data set. The heliographic longitude of origin of the plasma package was determined by applying a correction according to the solar wind travel time. Significant long-term recurrent enhancements of the magnetic flux density, lasting for several years were observed during Cycle 23. Similar, long lasting recurring features were observed in the solar wind velocity, temperature and the deviation angle of the solar wind velocity vector from the radial direction. Examining the coronal temperature data of ACE leads to the explanation that these long-term structures are caused by slow - fast solar wind interaction regions and are the result of propagation.

Examining the magnetic polarity of these long-term modulations we found that there is an ambiguous relationship between magnetic flux density enhancements and magnetic sector boundaries. Rotation speed and a possible link to transient events were investigated to find out the nature of the relationship.

Kp – Solar Wind Speed Relationship: Implications for Long-Term Forecasts

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Many Kp forecasts rely on the upstream solar wind speed since the speed strongly correlates with the Kp index. However, the distribution of Kp and solar wind speed measurements is quite broad. To understand how common certain combinations of Kp and speed are, we plot the percentage of points in two-dimensional Kp and speed bins using a color scale. Using these color Kp-solar wind speed distributions for compressions, rarefactions, and Interplanetary Coronal Mass Ejections separately, we find that much of the variability in the Kp-solar wind speed distribution is attributable to the dynamic interaction between the fast and slow wind. We compare three different criteria for identifying compressions and rarefactions and find that density criteria provide greater separation between compressions and rarefactions than dynamic pressure or speed-time slope criteria. However, the speed-time slope provides enough separation to be useful given that the solar wind speed has a long autocorrelation time and can be predicted using solar observations (e.g., expansion factor models). To ensure our work can easily be incorporated into forecast models, we provide the Kp-speed distributions files for all three methods of identifying compressions and rarefactions. We perform several tests of a method to extend forecast lead times by estimating compression strength with a speed-time profile obtained from solar wind speed predictions based on solar wind and solar observations.

Study of geomagnetic induced current at high latitude during the storm-time variation.

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During the geomagnetic disturbances, the geomagnetically induced current (GIC) are influenced by the geoelectric field flowing in conductive Earth. In this paper, we studied the variability of GICs, the time derivatives of the geomagnetic field (dB/dt), geomagnetic indices: Symmetric disturbance field in H (SYH) index, AU (eastward electrojet) and AL (westward electrojet) indices, Interplanetary parameters such as solar wind speed (SW), and interplanetary magnetic field (Bz) during the geomagnetic storms on 31st March 2001, 21st October, 2001 and 9th November 2004 with high solar wind speed due to a coronal mass ejection. Wavelet spectrum based approach was employed to analyze the GIC time series in a sequence of time scales of one to twenty four hours. It was observed that there are more concentration of power between the 14–23 Hrs, 17-00 Hrs and 18-23 Hrs band on 31 March 2001, 21 October 2001 and 9 November 2004 respectively. Bootstrap method regression correlations between the time derivative of the geomagnetic field (dB/dt) and the observed values of the geomagnetic induced current which shows a distributed cluster of correlation coefficients at around r= -0.567, -0.717 and r= -0.488 respectively. We observed that the geomagnetic storm has a great effect on geomagnetically induced current (GIC) and geomagnetic field derivatives (dB/dt). The change might be ascribed to the coronal mass ejection with solar wind due to particle acceleration processes in the solar atmosphere.

P5-04

Interpreting a millennium solar-like dynamo with the test-field method

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Direct numerical simulations (DNS) of stellar dynamo have recently succeeded in emulating many key features of the magnetohydrodynamics (MHD) observed in stars, such as solar-like differential rotation profiles, cyclic variation in the magnetic field and field reversals, equatorward migration of the field, and episodic grand minima. The complexity of the processes in the models and stars themselves makes it difficult to interpret the results. Statistical analysis is useful to identify trends and describe patterns in the models and observations, but to understand the physics other analytical tools are required.

One such method is the mean-field approximation, by which the induction equation governing the evolution of the magnetic field is reduced to mean and fluctuation equations. The electromotive force (EMF), which controls the evolution of the mean-field, can then be expressed as a sum of tensors acting on the mean magnetic field or current, each representing identifiable physical processes. Investigation of these tensorial terms, if the mean-field approximation is valid, can help us to understand how the dynamo operates and how changes in parameters influence the dynamo. We must know the composition of these tensors, in order to use the mean-field method. Typically, for complex systems applying in stars, it is not possible to derive these tensors analytically, but we might obtain them numerically by applying the test-field method to DNS. We consider the application of the test-field method to a millennium dynamo simulation, exhibiting solar-like long term variability of the magnetic cycle.

P5-05

Observed UV contrast of magnetic features and implications for solar irradiance modelling

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The knowledge of solar irradiance and its temporal variations is essential for climate modelling and space weather. Measuring irradiance being difficult, one often relies on models and their different assumptions. This is in particular true in ultraviolet (UV) wavelengths where observations are highly fragmented in time and often lack sufficient long term stability. In this study, we aim at constraining UV irradiance models by characterizing the contrast of magnetic features at UV wavelengths. We analysed Solar Dynamics Observatory (SDO) magnetograms and visible and UV images (at 1600Å and 1700Å) from the HMI and AIA instruments on-board SDO from 2010 to the end of 2016, and used them to quantify and characterize the variability of the photometric contrast of magnetic structures versus the strength of the magnetic field, the positions on the solar disk, and in time. We found no significant variations of the contrast with the solar cycle. We found that magnetic features have a much stronger contrast in the UV than at visible wavelengths. Contrasts in UV also behave differently than in the visible, we found similar variability of the contrast at 1600Å than at 1700Å, although the contrast at 1600Å is generally higher and have a slower centre-to-limb variation than at 1700Å. Finally, we studied the contrast of magnetic structures as defined in irradiance models, such as quiet-Sun, sunspots and faculae, and analysed how this classification influence the models predictions.

On Active Longitudes and their Relation to Loci of Coronal Mass Ejections

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The spatial inhomogeneity of the distribution of coronal mass ejection (CME) loci in the solar atmosphere could provide a new tool to estimate the longitudinal position of the most probable CME-capable active regions in the Sun. The anomaly in the longitudinal distribution of active regions themselves is often referred to as active longitude (AL). In order to reveal the connection between the AL and CME loci, here, we investigate the morphological properties of active regions. The first morphological property studied is the separateness parameter, which is suitable to characterise the probability of the locus of an energetic event, such as solar flare or CME. The second morphological property we focus on is the tilt angle of sunspot groups. Analysis of tilt angle of sunspot groups allows us to estimate the helicity of active regions. An increased helicity leads to a more complex built-up of the magnetic structure and also can be the cause of CME eruption. We found that the most complex active regions appear statistically significantly near to the AL and that the AL itself is associated with the most tilted active regions. Therefore, the number of CME loci is higher around the enhanced longitudinal activity. Further, the origin of the fast CMEs is also found to be associated with the AL belt. We concluded that the source of the most probably CME-capable active regions is at the AL. Applying our method may allow us to predict the potential flare and CME sources several Carrington Rotation (CR) in advance, and, our further findings could provide new information for solar dynamo modelling.

Reconstructing the Solar Meridional Circulation from 1976 up to Now

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We present in this poster our study of the Sun's inner dynamics by means of a variational data assimilation method based on solar surface magnetic field observations. To do so we test our technique on 40 yr of Wilcox solar observatory data starting from 1976. Our method rests on an axisymmetric mean field flux transport dynamo model that is used to assimilate real solar data. The parameters of the model are carefully adjusted such that its statistics is a fair representation of the solar magnetic field. By minimising an objective function comparing our model output to solar data we are able to reconstruct the solar meridional circulation and initial magnetic configuration so that the model trajectory gives a minimal misfit to the data. By doing so we are able to determine in both hemisphere independently the solar meridional profile and evolution over the last 40 yr. Such a method can also be used to perform prediction and we test its ability to forecast cycle 25.

P5-08

Effects of Solar Variability on Global and Regional Climates

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A number of mechanisms have been proposed whereby variability in solar activity induces changes in either regional or the global mean climate of Earth. These can be divided into "bottom-up" mechanisms whereby changes influence the heating of Earth's surface which propagate up into the troposphere (such as through changes to the total solar irradiance or in externally-driven changes to Earth's albedo), or "top-down" where changes to the stratosphere percolate down into the lower troposphere (such as caused by changes in solar ultraviolet emissions or in the fluxes of energetic particles which can modulate stratospheric chemistry. Evidence for such effects is often inadequate and based on poor or inadequate statistical methods. All detection-attribution studies of global mean air surface temperature indicate a solar effect, but one that is small (relative to those associated with volcanoes, land use changes, anthropogenic aerosol and greenhouse gases, and internal climate variability). On regional scales, the situation is more interesting and more complex. There are indications that European winters may be influenced by increased occurrence of jet stream blocking events when solar activity is low. This effect has been simulated using numerical models that extend up into stratosphere. However, these simulations have required top-end (and probably amplified) estimates of the long-term variability of the solar UV flux. This may indicate an additional role of solar energetic particles in the modulation of polar stratospheric chemistry via the catalytic destruction of ozone which could mimic and/or amplify the effect of UV variations. This paper will review some of the evidence and some of the proposed mechanisms.

Using Torsional Oscillations To Forecast Solar Activity

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Perturbations in the differential rotation of the Sun called torsional oscillations have been noticed and recorded over the past four decades. Their origin, however, still remains a mystery. In this work, we propose that torsional oscillations are simply a consequence of magnetic field amplification coupled with the conservation of energy in the solar dynamo. This is a very simple and elegant way of explaining the observed torsional oscillation pro le. Applying this technique on the Helioseismic observations of torsional oscillations allows us to map the toroidal magnetic field inside the Sun which is of extreme importance as this magnetic field is a precursor to sunspots. We find that the active latitudes on the Sun's surface follow a region of high toroidal magnetic field (around 30;000 Gauss) deeper inside the solar convection zone (around 0:80$R_\odot$). We can also see the signatures of magnetic field of the next solar cycle about 5 years before the cycle actually begins.

Analysis of Long-term Trend of Space Weather-Induced Enhancement of Atmospheric Drag on LEO Satellites

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Solar and geomagnetic activity causes significant heating and expansion of the upper atmosphere, leading to an increase in atmospheric temperature (T) and density (ρ), and consequent increase in nominal LEO Satellites aerodynamic drag. Atmospheric drag effect on LEO satellites can be profound depending on the severity of both solar activity and cycle, and the satellite's orbital parameters. In this work, we present a model of atmospheric drag effects on the trajectory of two hypothetical LEO satellites with different ballistic coefficients, initially injected at h=450 km. We analysed the long-term trend in variation of the satellites orbital decay rate at different phases of the solar cycle, and during short intervals of strong geomagnetic disturbances or storm conditions. We found that the mean annual decay rate of the satellites during the peak of 23rd solar maximum was almost twice that of 24th maximum phase. The range in variation of thermospheric T and ρ is about 915-1470 K and 1.15E-12 - 14.70E-12 kg/sqm, respectively during the maxima, and about 756-1212 K and 0.31E-12 - 3.59E-12 kg/sqm during minimum phase. These define the condition in near-Earth space environment through which the satellites traversed. The result of the model compared well with observed decay profile of some LEO satellites.

Kinematics of fast and slow CMEs in solar cycle 23 and 24

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CMEs are episodic expulsion of plasma and magnetic fields from Sun into heliosphere. We study the kinematics of fast and slow CMEs in solar cycle 23 and 24. We find that the slow and fast CMEs behave differently in two cycles. We note that the slow and fast CMEs follow different power laws. While fast CMEs seem to follow a power law comparable with the power law of the energy distribution of flares, slow CMEs have much steeper distribution. Moreover, we find a double peak behaviour in the occurrences of fast CMEs in both cycles. It suggests that the fast CMEs originates from active regions and are associated with sunspots. We also find double peak behaviour in the occurrences of slow CMEs in cycle 24 but not in cycle 23. In addition to this, the number of slow CMEs are far more in solar cycle 24 than in cycle 23. These findings lead us to believe that the slow CMEs are associated with sunspots in solar cycle 24 and due to weak polar and heliospheric field, they could escape easily thus shows a double peak behaviour and more occurrence in cycle 24.

P5-12

Long-term Observations of Solar Wind Using STEREO Data

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Since the launch of twin STEREO spacecraft, we have been monitoring the solar wind and providing the Level 3 event lists to public. The interplanetary coronal mass ejections (ICMEs), stream interaction regions (SIRs), interplanetary shocks, and solar energetic particles (based on high energy telescope data) have been surveyed for 2007-2016 when the nominal scientific data are available. In combination with our previous observations of the same solar wind structures in 1995-2009 using Wind/ACE data and the same identification criteria, we study the solar cycle variations of these structures, and compare the same phase of solar cycles 23 and 24.

On the other hand, we study the variability of non-ICME solar wind using the long-term multiple-spacecraft observations from Wind/ACE and at least one STEREO spacecraft. We investigate the effect of the latitudinal difference and coronal hole evolution on such variability, and also assess the capability of capturing such variability using the coronal and solar wind modeling.

P5-13

Sunspots areas and heliographic positions on the drawings made by Galileo Galilei in 1612

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In 1612, Galileo Galilei made very accurate drawings of the solar disk. Currently, 39 of them are in the open access: one in May 3, 35 in June and July, and three in late August. Unfortunately, reports have not provided the clock time, which results in uncertainty of sunspots heliographic coordinates. In the present study, we determine the exact time of the drawings by comparing the positions of the same spots from day to day. The time of the observations, which varies from 12 to 16 UT, gives us the direction of the solar rotation axis and the position of the helioequator. Unlike the spots drawn by Christopher Scheiner in 1611–1612, none of the analyzed spots lies at the helioequator. This confirms the quality of the Galileo's drawings. We also measure areas of the spots and found that the largest sunspot group appears at the same ~85° longitude through the whole period of study – from May 3 to August 21.

Regularities of the IMF sector structure in the last 170 years

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The interplanetary magnetic field (IMF) controls magnetospheric currents which cause variations of the ground-based magnetic field. Regular magnetic observations made in the 19th century allow us to infer daily IMF polarities back to 1844. The results coincide with satellite data in about 79% days. Moreover, for the most part of the 19th and 20th centuries, proxies obtained from different geomagnetic data (Helsinki, Saint-Petersburg, Potsdam, and Ekaterinburg) show the same patterns. This assumes that the reliability of the proxies is sufficient to study the IMF in the past. The large-scale organization of the IMF polarities, the so-called sector structure, reveals semi-centennial north-south displacements of the heliospheric current sheet (HCS).

P5-15

Reinforcement of the double dynamo model of solar magnetic activity on a millennium timescale

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We reinforce our previous prediction of the upcoming solar grand minimum (Modern minimum) to occur in cycles 25-27, or in 2020-2055, as derived from the synoptic maps for solar cycles 21-24 from with Principal Components Analysis (PCA) (Zharkova et al, 2015). Eigen values and eigen vectors are derived for the first pair of solar dynamo waves generated in two cells of the solar interior associated with dipole magnetic sources. The solar magnetic eigen vectors and their summary curve are classified with symbolic regression analysis for oscillatory function using Hamiltonian approach. The classified curve was utilized to extrapolate solar activity backwards to the three millennia and to compare it with relevant historic and Holocene data down to 1000BC. The extrapolation of the summary curve confirms the eight grand cycles of~350-400-years superimposed on 22 year-cycles caused by beating effect of the two dynamo waves generated in the two (deep and shallow) layers of the solar interior. Furthermore, the summary curve reproduces a remarkable resemblance to the sunspot and terrestrial activity reported in the past: the recent Maunder Minimum, Wolf minimum, Homer minimum , the Medieval Warmth Period, the Roman Warmth Period and so on. We show that consideration in dynamo model of the next pair of dynamo waves associated with quadruple magnetic sources helps to account for the Dalton minimum and other centennial minima associated with Gleissberg cycle.

P7-01

Modeling Ensemble Forecasts of Solar Flares

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In the past decade several new methods for forecasting solar flares have been developed. Different methods often produce different forecasts for the same event because they are based on different empirical relations or models, use different input data, and/or they are trained with different datasets. In addition, some of these methods might depend partially or entirely on human decisions and expertise. Therefore, direct comparison between the performances of different methods has proven to be a difficult task thus far. In this work we investigate the use of numerical weather prediction methods as an alternative to historical flare forecasting techniques. Ensemble forecasting has been used in terrestrial weather forecasting for many years as a way to combine different predictions in order to obtain a more accurate result. Here we construct ensemble forecasts for major solar flares (M and X classes) by linearly combining the full-disk probabilistic forecasts from a group of operational forecasting methods (ASSA, ASAP, NOAA, MAG4, MOSWOC, and Solar Monitor). Forecasts from each method are weighted by a factor that accounts for the method's ability to predict previous events. These combination weights are then calculated in several ways: 1) by metric optimization using probabilistic forecasts, 2) by metric optimization using categorical forecasts, and 3) by estimation of the cumulative partial quadratic errors. Several performance metrics (probabilistic and categorical) were considered in this analysis. The results provide space weather forecasters with a set of parameters (combination weights, thresholds) that allow them to select the most appropriate values for constructing the ensemble value, according to the performance metric of their choice. In this way different forecasts can be made to fit different end-users needs.

Prediction Of Solar Flares Using Data Assimilation In A Sandpile Model

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Solar flares result from impulsive and localized energy bursts in the solar corona. Their energy is distributed as a power-law over many orders of magnitude. The strongest flares (X-class) are the rarest and the most difficult to predict. Based on the work of Lu & Hamilton, Strugarek & Charbonneau (2014) developed a deterministically driven sandpile model reproducing many statistical aspects of the solar flares.

We couple the model to solar observations trough data assimilation of the GOES X-ray flux. A 4DVar approach using a simulated annealing method is used to match the data and the output of the model. We further decompose the model on its eigen-vectors using its covariance matrix to reduce the number of degree of freedom of the model and speed up the assimilation process. We give the range of energies over which the model is able to robustly assimilate the GOES X-ray flux. Assimilation of previous epochs of strong flaring activity on the Sun shows promising predictive skills.

P7-03

The Space Weather through a multidisciplinary scientific approach.

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Space weather encompasses understanding how the near-space environment responds to forces from lower-atmosphere weather systems as well as conditions on the sun. Although the specific effects of space weather (including power grid failures, communication outages, and navigation errors when using space-based navigation systems such as GPS) are local in nature, understanding and predicting their occurrence requires a global view of the environment.

For this reason, we adopted a multidisciplinary approach at the Cadi Ayyad University in Morocco to better understand the sun-earth interaction. Our ambition is to identify the various correlations, which may exist between the phenomena observed by various instruments. For this we have deployed an experiment dedicated to the study of the Ionosphere - RENOIR - with the cooperation of the University of Illinois, USA, we have installed a GPS station in cooperation with MIT and we have started cooperation with the LESIA of Paris Observatory for the study of solar eruptions through the RHESSI satellite in particular.

We suggest to present here a first attempt to combine the observations from these various facilities on the context of an event occurred on 2014 February 27, in order to draw conclusions about the possibility of finding a causal relationship between the Solar activity and the disturbances of the upper layer of the terrestrial atmosphere.

P7-04

Physics-Based Modeling Activity From The Solar Surface To Atmosphere Including Magnetosphere And Ionosphere At NICT

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We present the development of theoretical models which cover from the solar surface to the atmospheres at NICT. Our models consist of three regions: (1) the solar surface and the solar wind, (2) Earth's magnetosphere-ionosphere, and (3) a whole atmospheric model from the troposphere to the ionosphere, called GAIA (Ground-to-Topside Model of Atmosphere and Ionosphere for Aeronomy)

The former two models are developed using the same MHD simulation code called REPPU (REProduce Plasma Universe) code. One of the features of REPPU code is that there is no singular point in the unstructured grid system, which is able to simulate global solar wind structure from about 1 solar radius to 1AU (detail in Den's another presentation) and to calculate in the uniform accuracy over not only the magnetosphere but also the ionosphere for strong solar wind case such as Bastille event. We compare the simulation results with observations such as AE index.

GAIA consists of atmosphere, ionosphere, and electrodynamics models, which are coupled with each other. The atmosphere model covers the whole region from the ground to the exobase and treats a full set of physical processes. The ionospheric model solves equations of mass, momentum, and energy for major ion species and electrons. The electrodynamics model treats the closure of global ionospheric currents induced both by the neutral wind dynamo.

We describe our simulation models and present typical simulation results obtained by each model.

Assessing Space Weather Applications and Understanding: SEP Working Team and SEP Scoreboard

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CCMC - International (CCMC-I) is a self-organizing informal forum for facilitating novel global initiatives on space weather research, development, forecasting and education. One of the CCMC-I initiatives is the International Forum for Space Weather Capabilities Assessment. We present the current status of the SEP Scoreboard and SEP Working Teams and the progress made during and after the International CCMC-LWS working meeting in April 2017. The goal of the SEP working team is to evaluate how well different models/techniques can predict historical SEP events throughout the heliosphere; establish metrics agreed upon by the community; and to provide a benchmark against which future models can be assessed against.

Through open communication with the scientific and user community, we discussed the following questions: Using case studies of selected events, can we assess where we stand with SEP prediction? How well can the success of SEP models be compared? Is it possible to identify a uniform metric? How do we move beyond using case studies for model/data comparisons? The team also considers the requirements from different users, such as satellite operators, aviation, and ground-based services. Initially a short event period at Earth was selected to test the proposed metrics, and this will be expanded to more event periods and to multi-spacecraft events.

P7-06

The SEP Forecast Tool Within The COMESEP Alert System

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The SEP Forecast Tool was developed as part of the COMESEP project to provide alerts for proton events with energies >10 MeV and >60 MeV following the near real-time observation of an X-ray flare. The alerts are provided in terms of a risk level by combining the likelihood for SEP occurrence with the expected SEP event strength. The predictions are mainly based on a statistical analysis of solar cycle 23 events, but also include results from a relativistic full-orbit test particle model. Information on detected flares and coronal mass ejections used as input for the forecasts are received through the COMESEP Alert System. The tool has been operational as part of this system since November 2013. Evaluations have been performed using events from solar cycles 22 and 24, and the effect of including different input parameters has been studied. The overall performance within the COMESEP Alert System will also be shown, as well as detailed forecasts during selected time periods. This work has received funding from the European Commission FP7 Project COMESEP (263252).

International Community-Wide Ionosphere Model Validation Study: foF2/hmF2/TEC prediction

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To assess the current state of space weather modeling capabilities and to develop a process to capture science progress in first principles models that feed into operations, the CCMC (Community Coordinated Modeling Center) has initiated the "International Forum for Space Weather Capabilities Assessment". The International Forum also aims to establish internationally recognized metrics and benchmarks that are meaningful and informative to end-users, developers, and decision makers. Focused topics of this International Forum related to the ionospheric phenomena include storm impacts on global/regional TEC, plasma density, and scintillation. In this paper, we will present preliminary results, obtained through the International Forum, of validation of ionosphere models for reproducing storm impacts on foF2/hmF2/TEC using GPS TEC, ISR and ionosonde observations. This study has been supported by CCMC at the Goddard Space Flight Center. The model outputs and observational data used for the study will be permanently posted at the CCMC website and made available for use by the wider space science community.

Validating The BAS Radiation Belt Model Forecasts Of The Electron Flux at Medium Earth Orbit

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Understanding, and ultimately predicting, the electron radiation environment at medium Earth orbit (MEO) is becoming increasingly important. Global navigation satellites operate in MEO and satellites that use electric orbit raising to reach geostationary orbit (GEO) can spend hundreds of days here. Satellite designers need information on the likely conditions that spacecraft will encounter and current and forecast conditions are useful for satellite operators.

There is limited data (both historic and real-time) available on the high-energy electron flux at MEO but models can be used to recreate and forecast the environment. The BAS Radiation Belt Model (BAS-RBM) is a physics-based model that includes the effects of wave-particle interactions, radial transport and losses to the magnetopause and atmosphere. In the EU-FP7 SPACESTORM project, it has been developed to forecast the high-energy (>~500 keV) electron flux from GEO to the outer edge of the inner belt.

The Standard Radiation Environment Monitor (SREM) on the Galileo In-Orbit Validation Element-B (GIOVE-B) spacecraft provides an independent validation of the BAS-RBM results. The fluxes from the BAS-RBM can be compared to the measured count rates using the SREM response functions. We will present a comparison between the simulations and the GIOVE-B data, including the calculation of skill scores.

P7-09

Numerical Effects Of Vertical Wave Propagation In Atmospheric Models

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Numerical methods can affect waves in various ways. Here, ray tracing techniques have been used to investigate numerical effects of wave propagation of acoustic and gravity waves in the non-hydrostatic dynamical core ENDGame. The aim is to demonstrate the extent to which numerical wave propagation causes instabilities at high altitudes in atmosphere models, and how processes that damp the waves may help to improve these model's stability. An important application of this study is to the vertical extension of ENDGame into a whole-atmosphere model that can be used for simulating space weather and its interactions with all levels of the atmosphere.

The main results include the effects of the space discretisation causing waves to be less well-resolved in the horizontal direction, preventing waves from propagating as far horizontally, and channelling excessive amounts of wave energy upwards into the thermosphere. However, the introduction of molecular viscosity, a physical process that has a significant damping effect in the thermosphere, should have the effect of keeping wave amplitudes from getting too large in the upper atmosphere.

Forecasting Risk Indicators for Satellites By Integrating The BAS Radiation Belt Model and Radiation Effects Models

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The Space Weather Prediction Center makes a number of forecasts and nowcasts that are relevant to satellites. These include a forecast of the daily electron flux greater than 2 MeV at geosynchronous orbit, and a nowcast of solar energetic particles greater than 10 MeV. While these environmental forecasts are very important they do not take into account the radiation effects on satellites which depend on the material used, nor do they cover lower orbits. In the SPACESTORM project we have integrated the BAS radiation belt model with data from the SWPC and radiation effects models. We have identified four risk indicators covering internal charging, surface charging, total electron dose and solar array damage. We use data where possible and the BAS forecasting model to forecast risk indicators for 4 representative orbits where most commercial and GNSS satellites operate. These include GOES East, GOES West, Galileo and the slot region. We present examples of our forecasting system for different types of magnetic storms and fast solar wind stream events. We present examples of periods where the risk indicators exceed risk levels as defined by the NASA handbook. The system is available on line 24/7.

A deep learning based solar flare forecasting model

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The electromagnetic storm from the Sun is the source of the space weather. Solar flare is one of the most powerful eruptive events from the Sun, and it's threaten can arrive to the Earth within about 8 minutes. So it is important to forecast the occurrence of the solar flare. Many machine learning methods have been used to build the solar flare forecasting models. In these methods, the physical parameters are constructed from the observational data of active regions by the solar physicists, and then the relationships between these parameters and the solar flares are discovered by the machine leaning algorithm. Instead of these traditional methods, we automatically learn the forecasting patterns from the observational data of active regions by using the deep learning method. We test the performances of the deep learning based solar flare forecasting model for different forecasting periods (48 hours, 24 hours and 12 hours). The performance of the deep learning based solar flare forecasting model is almost stable for the different forecasting periods, while the performance of the traditional forecasting model is worse with the smaller forecasting period. Because of the adaptive learning ability of the deep learning method, the proposed deep learning based solar flare forecasting model can obtain the good forecasting ability for the different forecasting periods. It is valuable to meet the needs in the different space weather tasks.

Comparison Of Predictive Efficiency of LOS Magnetograms Topological Descriptors and SHARP Parameters in the Solar Flares Forecasting Task

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The growth of the quantity and quality of the Solar magnetic field observational data and development of machine learning methods stimulate improved forecasting techniques in the Solar flares forecasting task. Most of them based on complexity of the photospheric magnetic field of the Sun active regions. There are big numbers of different characteristics for magnetic field complexity description. Due to many empirical assumptions during the calculation there are hardly reproducible. For HMI/SDO vector magnetograms there are automated active region tracking system exist. For each active region key features called SHARP parameters is calculated and available online in open access. We propose to use topological features for active regions complexity description based on topological data analysis approach. Using topological invariants as complexity description (in terms of critical points) confirmed be researches in random field analysis. Furthermore, they computed directly from the data without any empirical suggestion and scale invariance. We compared efficiency of these features computed only by the LOS magnetograms with the SHARP parameters in Solar flares forecasting model. The topological features model slightly superior the SHARP features model by the main quality metrics, so they could be useful in forecasting systems.

On the evolution of pre-flare patterns in 3-dimensional real and simulated Active Regions

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In this presentation, we address newly discovered pre-flare behavioral patterns in typical sunspot groups by focusing on their evolution as a function of height above the solar surface in a 3-dimensional solar AR. Here, we further probe and apply the concept of the pre-flare behavioral patterns using a magneto-hydrodynamic (MHD) simulation generating solar-like flares.

We introduce and discuss the relevant properties and the capability of pre-flare tracking of ARs to improve Space Weather forecasting by focusing on the evolution from the photosphere towards the chromosphere, Transition Region and low corona. The basis of a proxy measure of our approach is the so-called weighted horizontal gradient of magnetic field (W_GM) defined between spots of opposite polarities closer to the polarity inversion line(s) of an AR. The value and the temporal variation of W_GM is found to possess novel and potentially important diagnostic information about (i) the intensity of expected flares and (ii) the accuracy of onset time prediction.

Next, we will demonstrate how, by tracking the temporal evolution of W_GM, distance between opposite polarity spots and the associated net flux at various heights in the lower solar atmosphere evolves as function of height. We show that this latter temporal behavior across the chromosphere-low corona has fundamentally new forecast capabilities. We found, that at a certain height the converging of opposite polarities begins much earlier than at the photosphere or at other heights. The gained time of forecast capability could be as high as 24 hrs. Therefore we present a tool to identify the optimum height in the solar atmosphere for flare forecasting that may considerably increase the flare prediction.

P7-14

Forecasting Solar Energetic Particle Fluence with Multi-Spacecraft Observations

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Forecasting Solar Energetic Particle (SEP) fluence, as integrated over an SEP event, is an important element when estimating the effect of solar eruptions on humans and technology in space. Current real-time estimates are based on SEP measurements at a single location in space: corotation of the interplanetary magnetic field that guides the particles is usually neglected. However, the interplanetary magnetic field corotates with the Sun approximately 15 degrees each day with respect to Earth, thus in 4 days the near-Earth spacecraft will have changed their connection already 60 degrees from the original SEP source. We estimate the effect of the corotation on particle fluence using a simple particle transport model, and show that ignoring corotation can cause up to an order of magnitude error in fluence estimations, depending on the interplanetary particle transport conditions. We compare the model predictions with STEREO observations of SEP events, and study how interplanetary shocks affect the fluences at different heliospheric locations and SEP energies, as compared to the model predictions. We will evaluate the ability of the recently proposed L5/L1 combined space weather mission to improve the fluence forecast with use of simple particle propagation models, and discuss the insights that more recent particle transport models, with more advanced physical descriptions, can provide for analyzing the effect of corotation of SEP fluences.

Predicting the Where and the How Big of Solar Flares

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The approach to predicting solar flares generally characterizes global properties of a solar active region, for example the total magnetic flux or the total length of a sheared magnetic neutral line, and compares new data (from which to make a prediction) to similar observations of active regions and their associated propensity for flare production. We take here a different tack, examining solar active regions in the context of their energy storage capacity. Specifically, we characterize not the region as a whole, but summarize the energy-release prospects of different sub-regions within, using a sub-area analysis of the photospheric boundary, the CFIT non-linear force-free extrapolation code, and the "Minimum Current Corona" model. We present here early results from this approach whose objective is to understand the different pathways available for regions to release stored energy, thus eventually providing better estimates of the "where" (what sub-areas are storing how much energy) and the "how big" (how much energy is stored, and how much is available for release) of solar flares.

The real-time SEP prediction tools within the framework of the 'HESPERIA' HORIZON 2020 project

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The continuous measurement of electron and proton fluxes in the near-earth environment has proved to be very valuable for predicting SEP and GLE events. On the one hand, near-relativistic (NR) electrons (1 MeV electrons have 0.95c) travelling faster than ions (30 MeV protons have 0.25c) are used to forecast the arrival of 30-50 MeV Solar energetic Particle (SEP) events with real-time measurements of NR electrons. The faster electrons arrive at L1 30 to 90 minutes before the slower protons. The REleASE scheme (Posner, 2007) uses this effect to predict the proton flux using the actual electron flux and the increase of the electron flux in the last 60 minutes. In HESPERIA the same forecasting matrices were adapted in addition to real-time NR flux measurements from the ACE/EPAM experiment. On the other hand, we showed that the correlation of X-ray flux with differential proton fluxes measured by the GOES satellites, using the UMASEP scheme (Núñez 2011, 2015), may be applied to predict >500 MeV SEP and GLE events. These findings suggest that a synthesis of the various approaches may improve over the status quo. Both forecasting tools are operational under the HESPERIA server at the National Observatory of Athens. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 637324.

Prediction of GLE events

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Timely notifications on Ground Level Enhancement (GLE) events are of great significance, because they offer the unique advantage of valuable added minutes to space weather users. Pilots, for example, can re-route their planes at lower latitudes to be better protected by the Earth's shielding. Within the Horizon 2020 HESPERIA project, a new system for the prediction of GLE events, called UMASEP-500, was developed. This application uses the UMASEP scheme (Núñez, 2011; 2015), which correlates X-ray flux with each of the differential proton fluxes measured by the GOES satellites. When the correlation estimation exceeds a threshold, and the associated flare is larger than a specific X-ray peak flux, a GLE forecast is issued. We assume that a GLE prediction is successful when it is triggered before the first GLE alert is issued by any neutron monitor (NM) station. Considering data taken from January 2000 to December 2016, the HESPERIA UMASEP-500 tool had a POD of 53.8%, and a FAR of 30.0%. For this period, the tool obtained an AWT of 8 min taking as reference the alert time from the first NM station. Taking as reference the time of the warnings issued by the GLE Alert Plus (Souvatzoglou et al., 2014) for the aforementioned period, the aforementioned tool obtained an AWT of 15 min. This project has received funding from the European Union's Horizon 2020 research and innovation programme under agreement No 637324.

Flare Forecasting and Sunspot Group Evolution

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Previously, McIntosh white-light classifications of sunspot groups and their historical flare rates have been used to calculate Poisson probabilities for flare forecasting. Here, we examine the temporal evolution of McIntosh classifications and calculate average flare rates for the following 24-hour periods. The impact that these evolution-dependent flare rates have on the performance of flare forecasts will be presented via the application of standard forecast verification measures. Finally, potential corrective techniques for improving the forecasting performance will be explored and results presented.

A Probabilistic Approach To ICME Propagation

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Interplanetary Coronal Mass Ejections (ICMEs) are violent phenomena of solar activity with repercussions throughout the entire heliosphere. They are among the major cause of geomagnetic disturbances, with enormous economic consequences on our hi-tech society, including severe risks for space missions and telecommunication disturbances.

Therefore, the techniques for monitoring, tracking and predicting the arrival of ICMEs at Earth are one of the primary tasks in space-weather research.

At present, a detailed description of the whole dynamics of an ICME by means of a magnetohydrodynamical model of the heliosphere is in general not affordable, since numerical simulations involve a large amount of data, time and computational power.
In this work, we evolve the well known Drag Based Model of ICME propagation, by incorporating the uncertainties on the model parameters and the limited measurements accuracy of initial conditions by means of probability distributions.

The new model performs an uncertainty-comprehensive evaluation of the ICMEs trajectory, using minimal computational resources and can be employed to forecast the time of arrival at 1 AU and the associated velocity.

Comparison of model forecasts with ICME events registered in the past, suggests that this approach is an effective tool for the purpose of forecasting and deserves further attention and studies.

PFSS-based Solar Wind Forecast and the Radius of the Source-Surface

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The potential-field source-surface (PFSS) model of the solar corona is an important tool used in space weather (SW) research and operations. The PFSS model is based on a current-free approximation and uses solar magnetograms to derive the coronal magnetic field between the surface of the Sun and the so-called “source-surface”. At the source-surface, which is typically placed at 2.5 solar radii (R_0), the coronal magnetic field is purely radial, i.e. “open”. An important application of the PFSS model is for solar wind forecasting. In the PFSS-based solar wind models, solar wind properties are empirically associated with the coronal magnetic field. These models can be used as stand-alone solar wind forecast models, or to provide boundary conditions to heliospheric MHD codes. In these implementations of the PFSS model, the source-surface is typically fixed at 2.5 R_0 as well. For example, this is also the case in the Wang-Sheeley-Arge (WSA) solar wind and ENLIL MHD model configuration, which is used for operational forecasting of coronal mass ejection (CME) arrivals. However, there is a question on how well the PFSS-based solar wind models with the fixed source-surface perform as the solar activity changes. This question is particularly important since the current solar cycle (cycle 24) is relatively weak in comparison with previous solar cycles. Here, the PFSS model and solar wind forecast performances are discussed for 2007-2016. Global Oscillation Network Group (GONG) magnetograms are used in the PFSS model to derive the coronal magnetic field for various radii of the source-surface. These results are compared with observed magnetic flux and coronal holes. The results show that the model with the customary location of the source-surface at 2.5 R_0 significantly underestimates the open magnetic flux and area of the coronal holes. For example, in many cases, especially around the solar cycle 24 maximum, instead of 2.5 R_0 the source-surface with a radius of ≈ 1.5 R_0 provides better agreement between the model and observations. The fact that the location of the source-surface depends on solar activity has implications on the PFSS-based solar wind models. To examine this, the WSA model is used to forecast the solar wind speed. The obtained results suggest that changing the source-surface location and re-tuning the empirical solar wind relation could improve the solar wind speed forecast. These results also imply that the PFSS-based solar wind models with the solar activity dependent source-surface could provide better background solar wind conditions to the CME propagation models.

Solar Flare Prediction with Vector Magnetogram and Chromospheric Brightening using Machine-learning

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Solar flares have been empirically predicted using solar observation data. Experts have engaged in predicting solar flares in the daily forecast meeting in NICT, but the prediction score has not been improved for a long time. Since the huge amount of observation data is now available in the near-real time, we developed a model of flare prediction using machine-learning techniques and the huge numbers of solar images.

We used observation data taken by SDO and GOES during 2010-2015, such as both line-of-sight and vector magnetograms, 1600A UV brightening, and soft X-ray activities. We detected active regions and extracted 60 features for each region. We randomly divided the dataset into two for training and test, and we applied three machine-learning algorithms to predict flares: the support vector machine (SVM), the k-nearest neighbor (k-NN) and the extremely randomized trees (ERT).

As a result, we succeeded in improving our prediction score, the True Skill Statistic (TSS), from 0.5 to 0.8, and we found that the kNN shows the best performance. We investigated the importance ranking of 60 features, and we found that the high-ranking features, e.g., flare histories, the number of magnetic neutral lines, chromospheric brightening area, the total flux, features from vector magnetogram, indicate the flare triggers or the stored energy. We also discuss a standard evaluation method of flare prediction models in an operational setting.

Reference: Nishizuka et al. 2017, ApJ, 835, 156

AMR-MHD Simulation of CME Propagation in Solar Wind generated on Split Dodecahedron Grid

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We performed a 3-dimensional magnetohydrodynamics (MHD) simulation of propagation of a shock wave generated by a coronal mass ejection (CME). Hierarchical Cartesian meshes are employed, which are controlled by adaptive mesh refinement (AMR) technique. It is important for space weather forecast to predict arrival time of CME shock waves. A CME shock wave runs interplanetary space, where high and low velocities of background solar wind affect propagation speed of the shock wave. Thus a realistic solar wind structure needs to be used for precise predictions. We input solar wind generated by another 3-D MHD calculation, in which a triangular grid derived by splitting a regular dodecahedron is used. In the split dodecahedron grid, triangles cover spheres homogeneously and there are no singularities differently from spherical coordinates. This is a suitable feature to deal with the solar corona.

First, we run a MHD calculation on the dodecahedron grid with the initial solar magnet field constructed from an observed synoptic map and a coronal heating model. It comes to a steady-state solar wind. Then we input the solar wind onto the inner boundary of an AMR-MHD simulation having a computational box larger than one of the first calculation. It also comes to a steady-state, then a CME model input the inner boundary. A shock wave arises from the CME and propagates interplanetary space. By the AMR technique, fine grids catches the shock front through its propagation from near the sun to and beyond the Earth's orbit.

We will show details of our method, results compared with observations, and a computational performance in our poster.

SWiFT-FORECAST: A physics-based realtime solar wind forecast pipeline

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We present an ongoing effort to build a real-time solar wind forecasting pipeline named SWiFT (Solar Wind Flux-Tube)-FORECAST developed at IRAP. SWiFT couples together a series of modules: determination of the background coronal magnetic field, calculation of the properties of many individual solar wind streams from ~1 to 30 solar radii, propagation across the heliosphere and formation of CIRs, estimation of synthetic diagnostics (white-light COR/HI and EUV imaging, in-situ time-series) and comparison to observations and spacecraft measurements. The multiple flux-tube approach allows for very significant gains in computation time in respect to the full 3D MHD problem. The goal is provide continuously a full set of bulk physical parameters of the solar wind based solely on physical principles (wind speed, density, temperature, magnetic field, phase speeds) up ti 6-7 days in advance, and at a time cadence and a forecast compatible with space weather applications.

SWiFT was design to be modular. It currently uses a combination of existing surface magnetograms and PFSS extrapolations but the interface is ready to include different combinations of magnotograms sources (WSO, SOLIS, GONG, ADAPT), coronal field reconstruction methods (NLFFF, Solar Models), wind models (MULTI-VP), heliospheric propagation models (CDPP/AMDA 1D MHD, ENLIL, EUHFORIA).

SWiFT's setup is flexible and can be adapted to different applications focusing either on forecasting or past-event analysis, and either on global-scale or localised structures (e.g, ecliptic plane, orbit of a spacecraft).

This is work is supported by the CNES.

Study of the September 4, 2010 Coronal Mass Ejection: Comparison of the EUHFORIA and ENLIL Predictive Capabilities

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Coronal Mass Ejections (CMEs) and their interplanetary counterparts are considered to be the major space weather drivers, and an accurate modelling of their onset and propagation up to 1 AU represents a key issue for more reliable space weather forecasts.

In this work we test the predictive capabilities of the newly developed EUHFORIA heliospheric model by comparing simulation results with that from ENLIL (developed at NASA/CCMC) and in-situ measurements of plasma and magnetic fields.

In particular, we present an analysis of the September 4, 2010 CME observed by the SOHO and STEREO missions in coronagraphic and interplanetary images. We perform a parameter study testing the effect of different input parameters, namely the CME source location, speed, angular width and shape, on simulation outputs at different locations, with the final aim of studying the sensitivity of EUHFORIA to input parameters' variations compared to that of ENLIL, and of identifying a set of parameters that best reproduce observations.

We first simulate the event using the EUHFORIA+Cone and ENLIL+Cone models, performing several simulations varying the CME input parameters. We then study the propagation and global evolution of the CME up to its arrival at 1 AU, where we compare STEREO-A and Wind in-situ measurements of the Interplanetary CME, with the parameters derived by simulations using the EUHFORIA and ENLIL models.

Ground-based Observations of Powerful Solar Flares Precursors

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The importance problem of Solar-terrestrial physics is regular forecasting of solar activity phenomena, which negatively influence the human's health, operating safety, communication, radar sets and others. The opportunity of development of short-term forecasting technique of geoeffective solar flares is presented in this study. This technique is based on the effect of growth the fluctuations of horizontal component of geomagnetic field before the solar proton flares, that is considered as a prognostic parameter of solar proton flares.

Previously carried out data analysis of H-component of geomagnetic field values (obtained from 100 geomagnetic stations) demonstrated the increase in the amplitude of the fluctuations with periods of 30-60 minutes for 2-3 days before the solar proton flare.

In this report, we present a predictive algorithm and short-term forecasting scheme, developed on the basis of solitary solar proton events (observed in 1991, 2001, 2005, and 2006) and geomagnetic data (Patent RU 2491583 C1). Proposed method for predicting solar proton flares has been checked for solitary events in 2011, 2012. It improves the reliability of solar proton flares forecasting and reduces the cost of implementation the short-term forecasting technique of powerful solar flares.

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Solar Radio Emission As A Prediction Technique For Coronal Mass Ejections' Registration

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The concept of solar Coronal Mass Ejections (CMEs) as global phenomenon of solar activity caused by the global magneto hydrodynamic processes is considered commonly accepted. These processes occur in different ranges of emission, primarily in the optical and the microwave emission being generated near the surface of the sun from a total of several thousand kilometers. The usage of radio-astronomical data for CMEs prediction is convenient and promising. Actually, spectral measurements of solar radio emission cover all heights of solar atmosphere; sensitivity and accuracy of measurements make it possible to record even small energy changes. Registration of the radio emission is provided by virtually all-weather ground-based observations, and there is the relative cheapness to obtain the corresponding information due to a developed system of monitoring observations. On the large statistical material there are established regularities of the existence of sporadic radio emission at the initial stage of CMEs' formation and propagation in the lower layers of the solar atmosphere during the time interval from 2-3 days to 2 hours before registration of CMEs on coronagraph. In this report we present the prediction algorithm and scheme of short-term forecasting developed on the base of statistical analysis regularities of solar radio emission data prior to "isolated" solar Coronal Mass Ejections registered in 1998, 2003, 2009-2013.

Solar Energetic Particle Event Forecasting Algorithms And Associated False Alarms

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Solar energetic particles (SEPs) are a significant component of space weather. It is believed that they are accelerated by intense solar flares, or by shocks caused by fast coronal mass ejections (CMEs), or by a combination of the two. Yet SEPs are not seen at Earth following all such large solar events, and it is these which may be termed “false alarms”.

We defined 2 simple SEP forecasting algorithms, the first based upon the occurrence of well magnetically-connected CMEs with a reported speed in excess of 1,500 km/s, and the second upon X class flares. We assessed the performance of the algorithms in predicting >40 MeV proton events at Earth against data sets for the period 1996 to 2013, and identified the false alarms.

We found that the two algorithms correctly forecast almost the same proportion of SEP events (47.8% and 49.4% respectively), but that the algorithm based upon fast CMEs had a significantly lower false alarm rate (28.8% as opposed to 50.6%). X class flares without any associated CME, or which were associated with a CME slower than 500 km/s, did not produce SEPs.

We discuss how it is possible to define an improved forecasting algorithm (based upon information gathered from the data) taking into account parameters pertaining to both flares and CMEs.

Very Long-period Pulsations as a precursor of Solar Flares

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Solar flares are the most powerful explosions occurring in the solar system, which may lead to disastrous space weather events and impact various aspects of our Earth. So far, it is still a big challenge in modern astrophysics to understand the origin of solar flares and predict their onset.

Recently, from the analysis of soft X-ray emission observed by the GOES, we reported a new discovery of very long-periodic pulsations occurred in the preflare phase before the onset of solar flares (preflare-VLPs). These pulsations are typically with period of 8 - 30 min and last for about 1 - 2 hours, which can be regarded as a precursor of solar flares. Theoretical analysis indicates that such preflare-VLP is possibly generated from LRC oscillations of plasma loops where electric current dominates the physical process during magnetic energy accumulation in the source region. The preflare-VLP provides an essential information for understanding the triggering mechanism and origin of solar flares, and may help us to response to solar explosions and the corresponding disastrous space weather events as a convenient precursory indicator.

METU Data Driven Forecast Models: From the Window of Space Weather IAU Symposium 335

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ODTÜ-METU, Ankara, Turkey

Space weather processes, in general, are non-linear and time-varying. In such cases "data driven models" such as Neural Network, Fuzzy Logic and Genetic Algorithm based models were proved promising to be used in parallel with the mathematical models based on first physical principles. In particular, with the recent developments in "big data" systems, one of the urgent issues is the development of new signal processing techniques to extract manageable, representative data out of the "relevant big data" to be employed in "training", "testing" and validation phases of model construction.

Since 1990, under the EU Frame Work Program Actions, we have developed such models for nowcasting, forecasting, warning and also for filling the data gaps on space weather cases including prediction of orbital spacecraft parameters. In particular, some typical, illustrative examples include the forecasting the ionospheric critical frequencies foF2, during disturbed conditions, such as solar storms and extreme events; GPS total electron content(TEC); solar flare index during solar maximum and the construction of solar EUV flux variations

To conclude briefly, the structures of our data based models and the associated ınput data organisation and typical errors in terms of absolute values, percent are summarised. (%), and RMS which have been within the acceptable operational expectations.

Assessing Space Weather Applications and Understanding: CME Arrival Time and Impact

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CCMC - International (CCMC-I) is a self-organizing informal forum for facilitating novel global initiatives on space weather research, development, forecasting and education. One of the CCMC-I initiatives is the International Forum for Space Weather Capabilities Assessment. We present the current status of the CME arrival time and impact team and the progress made during and after the International CCMC-LWS working meeting in April 2017. Over the past years, considerable effort has been made to decide upon a set of metrics for each of the solar physics domains in order to quantify and to track the progresses made. Our team focusses on the assessment of how successfully different models and techniques can predict CME arrival time and impact. After open communication with the scientific and user community, preliminary metrics for the quantification of the model performance have been established.

Initially a small core set of events were selected to test the metrics, and will be expanded to a large representative set of events covering realistic events in the full domain of observable CMEs. Current and future models have and will be tested for their CME arrival time and impact forecasting capabilities, based on these metrics and the selected set of events.

SWIGS: a new research consortium to study Space Weather Impacts on Ground-based Systems

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Space weather is a hazard to national strategic infrastructures, particularly the National Grid and the UK pipeline and railway networks. Its impact at the Earth's surface is a consequence of processes that connect geomagnetic and geoelectric activity on the ground with ionospheric and magnetospheric current systems, all subject to solar wind and hence solar activity control. Fundamentally, there are critical gaps in our current understanding of all of these scientific processes and linkages. This crucially impacts on our ability to construct adequate models that now- and fore-cast the damaging geomagnetically induced currents (GIC) that flow in grounded strategic infrastructures during geomagnetic storms.

For this newly-funded NERC Highlight Topic, a consortium of ten UK universities and research centres (called SWIGS) has been established with links to over a dozen UK and international industrial and scientific project partners. We plan to develop a dramatically improved physical understanding of electromagnetic fields and currents in near-Earth space and in the upper atmosphere, by focussing on the couplings between the solar wind and geo-electromagnetic processes on the ground, in the ionosphere and in the magnetosphere. This will lead to a new generation of solid Earth and space environment models that quantify how space weather, surface-level rapid magnetic variations and electric fields impact models of surface conducting infrastructures such as the National Grid.

SWERTO: a Regional Space Weather Service

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SWERTO service, located at Physics Department of UTOV (University of Rome Tor Vergata, Italy), is a Space Weather service mainly based on data obtained from satellite-borne (e.g., PAMELA, ALTEA) and ground-based (e.g., IBIS, MOTH II) instruments in which UTOV Space Weather team is involved.

The service will allow the registered user to access scientific data from instrumentation available to the Physics Department researchers through national and international collaborations, and will provide fluent software for the selection and visualization of such data, promoting the access to technical and scientific information from the industries which employ technologies vulnerable to Space-Weather effects. Basically, SWERTO aims to: i) design and realize a data-base with the particle fluxes recorded by the space missions: PAMELA, ALTEA, Alteino, SilEye, NINA, and with the spectro-polarimetric measurement of the solar photosphere from the IBIS instrument, currently at NSO/Sacramento Peak Observatory, and MOTH II multi-height observations; ii) allow an "Open Access" to the data-base to regional industries involved and exposed to Space-Weather effects; iii) implement a tutorial and a FAQ section to help decision makers to realize and evaluate the risks from Space-Weather events; iv) dissemination and Outreach.

SWERTO has been financed by the "Regione Lazio FILAS-RU-2014-1028" grant for the period November 2015 – October 2017.

The Ionosphere Prediction Service

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Space weather events related to solar activity can affect both ground and space-based infrastructures, potentially resulting in failures or service disruptions across the globe and causing damage to equipment and systems.

The Ionospheric perturbation can origin from the above events and its prediction and forecasting can contribute to the understanding and mitigation of the impact of significant ionospheric events on several applications, spanning from telecommunication up to distribution of energy infrastructures.

Global Navigation Satellite Systems (GNSS) represent one of such infrastructures that can suffer from atmospheric phenomena, in particular due to the interaction of the RF signals with the ionosphere.

The Ionosphere Prediction Service (IPS) project funded by European Commission and currently ongoing, will provide a prototype of a monitoring and prediction service to GNSS user communities to help them to cope with the effects of the ionosphere and mitigate the related effects for the specific GNSS-based application/services.

The aim of the IPS project is then to design and develop a platform (prototype) able to translate the prediction and forecast of the ionosphere into a service customized for specific GNSS user communities.

This objective will be achieved by means of the utilization of observational networks and the development of ionospheric models, which can help limiting their disruptive effects with early warning alerts.

It is foreseen a period of experimentation of the offered services with the involvement of the user communities to evaluate the forecast capabilities and to get feedbacks for further service developments and exploitation.

P8-04

ESA SSA Space Radiation Expert Service Centre: Human Space Flight

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Space weather affects end-users in a wide range of sectors applicable to Earth and the heliosphere. In the frame of its Space Situational Awareness (SSA) programme (http://swe.ssa.esa.int/) the European Space Agency (ESA) is establishing a Space Weather (SWE) Service Network to support end-users in three ways: mitigate the effects of space weather on their systems, reduce costs and improve reliability. Several European expert groups contribute to this Network organised in five Expert Service Centres (ESCs): Solar Weather, Heliospheric Weather, Space Radiation, Ionospheric Weather and Geomagnetic Conditions. In understanding the end-user needs, the ESCs are supported by the SSA Space Weather Coordination Centre (SSCC) that offers first line support to the end users. Here we present the Space Radiation ESC (R-ESC) including the service domains it supports, specifically the Human Space Flight domain. Future robotic and human solar system exploration is an emerging topic of this domain that will need products and tools specifically designed for the mitigation of space weather effects. For this purpose, inter-disciplinary communication/collaboration between different communities ranging from scientists, engineers, medical doctors to end-users is essential and must be encouraged. It will allow basic space science to be used in the most optimal way for the development of these products and tools.

End User Requirements For Space Weather Services.

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In the frame of its Space Situational Awareness (SSA) programme, the European Space Agency (ESA) is establishing a Space Weather Service Network to support end-users, in a wide range of affected sectors, in mitigating the effects of space weather on their systems, reducing costs and improving reliability. In building this network space weather products/tools are developed and federated in services, that are suitable for operational implementation and importantly that meet the end users' needs. For the latter, the SSA Space Weather Coordination Centre (SSCC) which provides user helpdesk and first line user support for the SWE Network, follows an end user strategy to establish a close relationship with the end users of space weather services in order to better understand their needs. In this presentation we outline the SSCC end user strategy and give an overview of end user requirements that have been synthesized from interactions with various user communities through dedicated user support campaigns and meetings.

The Early Warning Mexican Space Weather System

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In the last two years, Mexico as working in the implementation of public policies to create the first protocol of civil protection for space weather events.

The National Center for Disaster Protection (CENAPRED), the National Laboratory of Space Weather (LANCE), and a set of federal institutions concerned in the topic are working together in four groups of discussion to create i) the public policies, ii) the early warning system, iii) science recommendations, iv) and instrumentation developing recommendation for space weather.

In this work, we present the improves in the law of Civil Protection to include the Space Weather in the Mexican agenda and the progress in the protocols developed by the CENAPRED commissions for space weather events.

European-led Visible-light Coronal And Heliospheric Imaging Endeavours For An Operational Space Weather Mission

Jackie Davies, Richard Harrison And The SCOPE And STEREO/HI Teams
STFC-RAL Space, Didcot, UK

The most destructive space weather effects are associated with coronal mass ejections (CMEs) ─ in particular, as is increasingly becoming realized, when they act in concert with other CMEs or background solar wind structures such as stream interaction regions. As has been demonstrated, not least over the last decade since the launch of the STEREO mission, CMEs can be tracked in broad-band, visible light from the lower corona all the way out to 1 AU and beyond.

Visible-light imaging of CMEs in the corona underpins current operational CME arrival predictions; equivalent imaging of the heliosphere ─ although not yet fully exploited in an operational sense ─ shows potential for improving those predictions. Such visible-light imaging, particularly in the context of operational space weather services, are best undertaken from space, ideally beyond the confines of Earth-orbit.

Analysis of such imagery from STEREO has demonstrated ─ although arguably it is not yet rigorously quantified ─ the value of an off-the-Sun-Earth line perspective for viewing Earth-directed CMEs in visible-light, particularly in addition to such observations taken from a near-Earth vantage point. In this presentation, we review the visible-light coronal and heliospheric imaging endeavours that are currently being undertaken within Europe, more specifically those targeted towards operational space weather opportunities.

P8-08

Corona and the solar magnetic field observations for space weather forecasting

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Understanding the magnetic field emerging from the solar surface and its interaction with the solar corona is essential for developing methods to forecast space weather. Accurate forecasts require a full knowledge of the global distribution of the magnetic field. STEREO EUVI observations have demonstrated the value of multiple views of the corona to assess trigger conditions for flares and CMEs, but to date, magnetograph observations are only available from instruments located on the Sun-Earth line. We discuss a concept for a next generation compact, space-based magnetograph that can be deployed at geocentric orbit, or at the L1 or L5 Lagrange points to enable greater observational coverage of the solar surface. We also consider EUVI coronal observations, and in particular, we present data acquired with the SUVI instrument on the recently launched GOES-16 satellite. Comparing the results from SUVI, SDO AIA, and STEREO EUVI informs the derivation of the coronal observational requirements for future space weather monitoring systems.

CIRCUS CubSat

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LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, Univ. Paris Diderot, Sorbonne Paris Cité, Meudon, France

CIRCUS (Characterizing the Ionosphere with a Radio receiver on a CUbe Sat) is a three-unit cubsat project. It is designed to study in situ the ionospheric plasma of the Earth with a high temporal resolution (< 1ms), using the quasi-thermal noise spectroscopy method. This technique is based on the measurement of the electrostatic fluctuations of the ambient plasma using electric antennas connected to a sensitive radio receiver. The method, which provides accurate measurements of the local electron density and temperature, has been successfully implemented on various space plasmas.

We will present the main scientific goals of the CIRCUS project, such as the ionospheric turbulence, non-thermal electromagnetic activity, and space weather aspects. We will also review technical constraints including the telemetry rate and discuss in particular the orbit opportunities and the observation modes.

P8-10

The Met Office Space Weather Operations Centre (MOSWOC)

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The Met Office Space Weather Operations Centre (MOSWOC) monitors space weather 24/7, providing twice daily forecasts and timely alerts and warnings. MOSWOC was officially opened in 2014 and disseminates forecasts to customers in areas such as government departments, the energy sector and satellite operations. Forecasts include four-day probabilistic forecasts of geomagnetic storms, X-ray flares, high energy proton events and high energy electron events, along with CME arrival time predictions. To ensure consistency in forecasting space weather MOSWOC forecasters communicate daily with other organizations such as Space Weather Prediction Centre (SWPC) and British Geological Survey (BGS). A space weather research group supports forecasters through implementation of research models to the operational environment. Models currently running at MOSWOC include WSA-Enlil, Relativistic Electron Forecast model (REFM), D-Region Absorption Prediction Model (D-RAP) and a 27-day solar wind parameter persistence model. Future models to be implemented include the SWPC aurora model, OVATION-PRIME 2013. Verification of the geomagnetic storm and X-ray flare forecasts is available to forecasters in near real-time.

Verification of Flare Forecasts at the Met Office Space Weather Operations Centre

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One essential component of operational space weather forecasting is prediction of solar flares. The Met Office Space Weather Operations Centre (MOSWOC) produces a Sunspot Region Summary every six hours, including flare predictions for numbered active regions, as well as a full-disk four-day Radio Blackout Forecast twice daily. Verification of these predictions provides an understanding of the strengths and weaknesses of the flare forecasting process.

Here we present verification of M-class flare probability forecasts since data archiving began in 2014 (with X-class events too rare to verify). To evaluate forecast resolution, Relative Operating Characteristic curves are calculated to show the ability of a forecast to discriminate between events and non-events. To understand forecast bias, reliability diagrams are plotted to show how well forecast probabilities of an event correspond to observed frequencies. The Ranked Probability Skill Score is also calculated to quantify the extent to which the forecast improves predictions with respect to the flare climatological benchmark forecast.

The flare verification process is implemented automatically in near-real-time at MOSWOC, which enables forecasters to improve subsequent predictions. The results of this verification study highlight the value of forecaster experience, as well as the difficulty forecasting beyond 24-hour forecast lead times.

The Belgian space weather observatory in Dourbes

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The Geophysical Centre of the Royal Meteorological Institute (RMI) was established in the late 1940s in Dourbes (50.1ºN, 4.6ºE), in the south Belgian region of Wallonia (site). The location, deliberately chosen to be away from cities, industrial sites, and major transportation routes, provides a suitable environment for accurate space weather observations of the geomagnetic field, the ionosphere, and the cosmic ray activity.
The geomagnetic observatory (IAGA code: DOU), in operation since 1953 and following on the previous century-old tradition of magnetic observations in the Brussels area, consists of variometers for measuring the variation of the field components about the baseline values and magnetometers for the absolute measurements needed to establish the baseline values. The current measurement cadence is 1 s for time, with a precision of 0.1 nT for the induction and 0.001° for both, the declination and the inclination. The lower-side of the ionosphere is constantly monitored with a Lowell Digisonde-4D® (URSI code: DB049), a state-of-the-art equipment ***using*** high-frequency (HF) radar principles of remote sensing, to evaluate with high accuracy and precision the conditions of the ionospheric plasma above the station. The Global Navigation Satellite System (GNSS) signal receivers provide high-quality information with a high time resolution on the total electron content (TEC) and the small-scale variability of the ionosphere. This information can be used for development of user oriented services and warning procedures as well as for fundamental research on a variety of topics including upper-side ionosphere and plasmasphere processes. For cosmic ray observations, a standard 9-NM64 neutron monitor (3 units of 3 counters) is in operation since 1965 (NMDB code: DRBS), providing measurements of the secondary neutron component of the cosmic rays on the ground. The data acquisition unit was upgraded in September 2003 and since then the data is recorded at 1-minute rate.
Utilising the entire set of instrumentation available at the Centre, as a real-time finely tuned observatory, allows for multi-instrument high-resolution concurrent and collocated observations of key characteristics of the space weather and its effects. Several services (http://ionosphere.meteo.be) have been developed during the years that were used in international projects and are now available to interested users. The Local Ionospheric Electron Density profile Reconstruction (LIEDR) system acquires and processes data from the simultaneous ground-based GNSS TEC and digital ionosonde measurements, and deduces the vertical electron density distribution in the local ionosphere. LIEDR can be used for validation purposes in ionospheric models, maps, and other monitoring services. Also, a nowcast system for operational estimation of a proxy K-type geomagnetic index (K-LOGIC) has been developed. K-LOGIC is based on a fully automated computer procedure for real-time digital magnetogram data acquisition, data screening and removing outliers, estimating the solar regular variation of the geomagnetic field, calculating the index, and issuing an alert if storm-level activity is indicated. In addition, an

automatic data quality control (ADQC) for correction of data from the Dourbes Neutron Monitor was developed and implemented in real-time.
The presentation will report on our current and planned work related to monitoring and investigating various space weather effects and the services we offer to help mitigating these effects.

P8-13

COSMO: the Coronal Solar Magnetism Observatory

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The Coronal Solar Magnetism Observatory is a proposed new facility led by the High Altitude Observatory and a consortium of partners to observe measure magnetic field and plasma properties in a large (one degree) field of view extending down to the inner parts of the solar corona. COSMO is intended as a research facility that will advance understanding and prediction of space weather. The instrumentation elements of COSMO are: a white-light coronagraph (K-Cor), already operational at the Mauna Loa Solar Observatory (MLSO); the Chromosphere and Prominence Magnetometer (ChroMag), due for deployment to MLSO later this year; and the COSMO Large Coronagraph which has completed Preliminary Design phase and review.

Modeling and forecast of parameters of space weather based on ground observations of solar activity

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We present the prospect of creating space weather forecasting service based on terrestrial solar activity observations in Russia. The forecast space weather can be divided into three components: 1) forecast recurrent, slowly changing, events related to the topology of the large-scale magnetic field; 2) evaluation of UV fluxes and hard radiation, and 3) the observation fast phenomena such as solar flares and eruptive processes and forecast the effects of the Earth's orbit.

The forecast of recurrent events is based on daily observations of large-scale magnetic field telescope STOP. To estimate EUV flux, as well as for registration of eruptive events we use the data of automatic patrol telescopes. Such telescopes, spectrographs operate in H-alpha and CaIIK lines, providing a registration process with an exposition time of about 1 minute. To detect eruptive emissions we use the difference between the intensities in the wings of the spectral lines. This method also allows us to determine the full vector of coronal ejection speed. In this presentation, we consider the results of observation Complex Kislovodsk Mountain Astronomical Station Space weather forecast.

P8-15

The High-Energy Particle Detector on board of the CSES Mission

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Measurements of electrons (between 3 and 100 MeV), protons (between 30 and 300 MeV) and light nuclei (up to few hundreds of MeV) fluxes, in low Earth orbit, will be performed with the High-Energy Particle Detector (HEPD). This detector consists of a high precision silicon tracker, a versatile trigger system, a range-calorimeter and an anti-coincidence system. It is one of the instruments on board of the China Seismo-Electromagnetic Satellite (CSES), which will have a circular orbit, with an altitude of 500 km and 98 degrees of inclination. The satellite launch is scheduled for summer 2017 and the expected lifetime is of 5 years. HEPD measurements of multi-MeV particle fluxes in the inner magnetosphere will be complementary to those performed along higher orbits and in different energy bands by other missions. When operated at polar latitudes HEPD might also access to solar particles and low energy cosmic rays. A detailed description of the HEPD will be given.

On Mingantu Spectral Radioheliograph for Space Weather Observations

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To address fundamental processes in the solar eruptive phenomena, it is important to have imaging - spectroscopy over centimetric - decimetric wave range. The Chinese Spectral Radioheliograph (CSRH) is a solar-dedicated interferometric array with a frequency range from 400MHz to 15 GHz. There are two arrays of 40 4.5m antennas covering 400MHz -2 GHz, and 60 2m antennas covering 2 - 15 GHz including antennas, receivers, and correlators which have already been established recently in Mingantu Town, Innermongolia of China. CSRH is renamed as Mingantu Spectral Radioheliograph (MUSER) after its accomplishment. We introduce the perspectives of MUSER with high spatial resolution, high time resolution, and high frequency resolution for solar eruptive events observations that have great impact in space weather. Some initial results are presented.

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SPACE WEATHER

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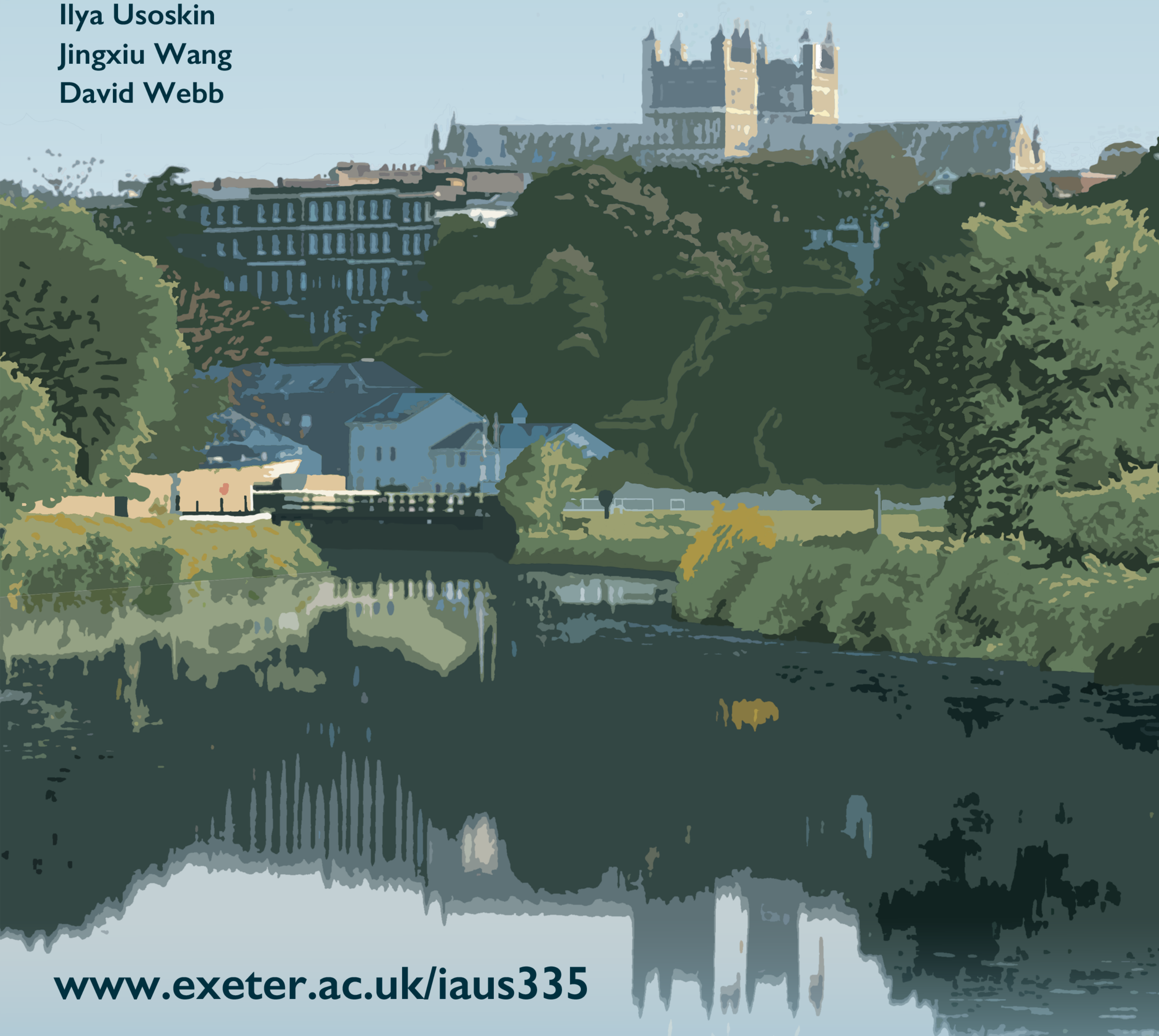

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