10TH EUROPEAN SPACE WEATHER WEEK

November 18 - 22, 2013
Antwerp, BELGIUM

10TH ANNIVERSARY

EXTREME EVENTS - STRATEGIC DATA - E-INFRASTRUCTURE - MODELLING - SPACECRAFT OPERATIONS - RADIO WAVE PROPAGATION - SOLAR FLARE PREDICTION - FORECAST VERIFICATION - AVIATION - SOCIETAL RESILIENCE - PLANETARY SYSTEMS - SPACE EXPLORATION - COSMIC RAY DETECTORS

Final Programme & Abstract Book

STCE esa belspo KU LEUVEN FWO VLAANDEREN

SWSC Journal of Space Weather and Space Climate

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Table of Contents

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Tenth European Space Weather Week

Programme

Monday, 18 November 2013

09:00 Registration desk open

10.00 Start Tutorial

11.00 Coffee break

11:30 Continue Tutorial

12:30 Lunch break

13:30 Welcome & Opening

Session 1: Extreme Space Weather Events and their Impact
Chairs: Matthew Angling, Keith Ryden

14:00 Solar Superstorms - A Natural Hazard with Wide Ranging Impacts **- *Invited***
Cannon, Paul
University of Birmingham, (UNITED KINGDOM) *37*

14:35 Rates of Large Flares in One Gigayear Old Solar-like Stars With Implications for the Sun
Saar, Steven ; Meibom, Soeren ; Kashyap, Vinay ; Drake, Jeremy
Smithsonian Astrophysical Obs., (UNITED STATES) *37*

14:52 Further Investigations of the July 23, 2012 Extremely Rare CME: What if this CME was Earth-Directed?
Ngwira, Chigomezyo [1]; Pulkkinen, Antti [2]; Wintoft, Peter [3]; Viljanen, Ari [4]
[1]Catholic University of America/NASA-GSFC, (UNITED STATES); [2]NASA Goddard Space Flight Center, Space Weather Laboratory, Greenbelt, MD 20771, (UNITED STATES); [3]Swedish Institute of Space Physics, Lund, (SWEDEN); [4]Finnish Meteorological Institute, Helsinki, (FINLAND) *38*

15:09 The 100 Largest Geomagnetic Storms in the Last 150 Years
Vennerstrom, Susanne [1]; Lefevre, Laure [2]; Dumbovic, Mateja [3]; Crosby, Norma [4]; Clette, Frederic [2]; Veronig, Astrid [5]; Vrsnak, Bojan [3]; Leer, Kristoffer [1]
[1]DTU Space, (DENMARK); [2]Royal Observatory of Belgium, (BELGIUM); [3]University of Zagreb, (CROATIA); [4]Belgian Institute for Space Aeronomy, (BELGIUM); [5]University of Graz, (AUSTRIA) *38*

15:26 Russian Geomagnetic Recordings in the 19th Century compared to Modern Observations
Myllys, Minna ; Viljanen, Ari ; Nevanlinna, Heikki
Finnish Meteorological Institute, (FINLAND) *38*

15:43 Modeling the Recovery Phase of Extreme Geomagnetic Storms
Cid, Consuelo ; Palacios, Judith ; Saiz, Elena ; Cerrato, Yolanda ; Aguado, Jesus ; Guerrero, Antonio
University of Alcala, (SPAIN) *39*

16:00 *Coffee break and Poster Session 1*

Session 2: Developing Societal Resilience Against Space Weather

Chairs: Mike Hapgood, Terry Onsager

16:30 The Dutch National Safety & Security Strategy: Consequences of Satellite disruption due to solar storm

16:48 Risk Preparedness and Operational Mitigation in the UK
Felton, C. [1]; Gibbs, Mark [2]
[1]UK Cabinet Office, (UNITED KINGDOM); [2]UK MET Office, (UNITED KINGDOM) *39*

17:06 Resilience in Basic Functions when Disaster Hits Risk Governance in Norway **- *Invited***
Thomassen, Erik
Directorate for Civil Protection, (NORWAY) *39*

17:24 Building Capacity for Preparedness
Andersson, E.
Swedish Civil Contingencies Agency, (SWEDEN) *40*

17:42 International Space Weather Service Coordination during Extreme Events
Sharma, M. [1]; Onsager, T. [2]; Lafeuille, J. [2]
[1]US Department of State, (UNITED STATES); [2](- Not specified -) *41*

18:00 End of Plenary session

18:15 Arrival of the guests at ZOO Antwerp
Koningin Astridplein, 20-26 at 2018 Antwerp

18:30-19:30 **Keynote lecture** in the Darwin Room

19:35-21:35 **Reception** in the Marbel Room

21-35:22:35 Evening stroll in the ZOO

Tuesday, 19 November 2013

Session 3 Strategic Data Sets Supporting Awareness of the Solar Source of Space Weather
Chairs: David Berghmans, Mathieu Kretzschmar

Session 4 Space Weather Effects on HF and Trans-Ionospheric Radio Wave Propagation
Chairs: Ioanna Tsagouri, David Altadill, Nicolas Bergeot, Michael Pezzopane

Session 5 The Impact of Space Weather on Space Exploration
Chairs: Giovanni Lapenta

09:30 Space Weather in the Problem of Providing Radiation Safety of the Crews of the Manned Spacecraft **- *Invited***
Petrov, Vladislav ; Benghin, Viktor ; Mitrikas, Viktor
Institute of biomedical problems, (RUSSIAN FEDERATION) *49*

09:45 Updates to the ESA Interplanetary and Planetary Radiation Model for Human Spaceflight
Heynderickx, Daniel [1]; Aran, A. [2]; Daly, E.J. [3]; Jiggens, P. [3]; Lei, F. [4]; Sanahuja, B. [2]; Truscott, P.R. [5]; Tylka, A. [6]; Vainio, R.
[1]DH Consultancy BVBA, (BELGIUM); [2]Universitat de Barcelona, (SPAIN); [3]ESA/ESTEC, (NETHERLANDS); [4]RadMod Research Ltd., (UNITED KINGDOM); [5]Kallisto Consultancy Limited, (UNITED KINGDOM); [6]NASA/GSFC, (UNITED STATES); [7]University of Helsinki, (FINLAND) *50*

10:00 Modelling Satellite Interaction with Space Weather and Environment **- *Invited***
Marchand, Richard ; ur Rehman, Saeed ; Hussain, Nadia
University of Alberta, (CANADA) *50*

10:15 ***TBD***

10:30 ***Coffee break & Poster Session 5***

11:00 Space Weather During the Two Recent Solar Activity Minima. **- *Invited***
Gburek, Szymon
Space Research Centre Polish Academy of Sciences, (POLAND) *51*

11:15 CMEs in the Inner Heliosphere - Propagation and Interaction with the Solar Wind **- *Invited***
Temmer, Manuela [1]; Rollett, Tanja [1]; Möstl, Christian [1]; Gressl, Corinna [1]; Veronig, Astrid [1]; Vrsnak, Bojan [2]
[1]Institute of Physics, University of Graz, (AUSTRIA); [2]Hvar Observatory, University of Zagreb, (CROATIA) *51*

11:30 The Role of Drifts in the Propagation of Solar Energetic Particles
Marsh, Mike ; Dalla, Silvia ; Laitinen, Timo ; Kelly, James
University of Central Lancashire, (UNITED KINGDOM) *51*

11:45 Monte Carlo and Non-Monte-Carlo Techniques for SEP Statistical Model Generation and Assessment of Uncertainties
Truscott, Pete [1]; Heynderickx, Daniel [2]; Lei, Fan [3]; Varotsou, Athina [4]; Jiggens, Piers [5]; Hilgers, Alain [5]
[1]Kallisto Consultancy, (UNITED KINGDOM); [2]DH Consultancy, (BELGIUM); [3]RadMod Research, (UNITED KINGDOM); [4]TRAD, (FRANCE); [5]ESA/ESTEC, (NETHERLANDS) *52*

12:00 Study of the Solar wind Effects on the Magnetosphere using Fully Kinetic Simulations
Amaya, Jorge [1]; Deca, Jan [1]; Markidis, Stefano [2]; Divin, Andrey [3]; Lembège, Bertrand [4]; Cazzola, Emanuelle [1]; Lapenta, Giovanni [1]
[1]KULeuven, (BELGIUM); [2]KTH Royal Institute of Technology, (SWEDEN); [3]Institutet för rymdfysik, Uppsala universitet, (SWEDEN); [4]LATMOS, CNRS, (FRANCE) *52*

12:15 Space Debris in the Near-Earth Space: Impact on Space Missions Coronas-F and Coronas-Photon.
Kuzin, Sergey ; Shestov, Sergey ; Ulyanov, Artem
Lebedev Physical Institute, (RUSSIAN FEDERATION) *53*

12:30 ***Lunch break***

13:30-15:00 Splinter Session

Scala 2	**Scala 3**	**Scala 4**
Ionospheric Effects on Radio Systems Topical Working Group *M. Angling -QinetiQ, UK*	Next generation SPENVIS *M. Kruglandski - BIRA-IASB, BELGIUM*	Cospar Initiative for a Roadmap for Space Weather activities *K. Kauristie - Finnish Meteorological Institute, FINLAND* *K. Schrijver - Lockheed Martin Advanced Technology Center, UNITED STATES* *A. Glover - ESA/ESAC, SPAIN*

15:15-16:45 Splinter Session

Scala 2	**Scala 3**	**Scala 4**
The DIAS system: status, future developments and sustainability plan *A. Belehaki - National Observatory of Athens, GREECE*	Space Weather Research and Operations: The Added Value of FP7 Projects *M. Messerotti - INAF, ITALY*	Towards automatic detection of solar radio bursts for space weather applications *C. Marqué- STCE, BELGIUM* *X. Bonnin - LESIA, Observatoire de Paris, FRANCE*

16:45 Coffee break

17:15-18:45 Splinter Session

Scala 2	**Scala 3**	**Scala 4**
SSA Space Weather Service Network *Kruglanski, Michel - BIRA-IASB, BELGIUM* *A. Glover - ESA, SPAIN*	SEP Server Release *Vainio, Rami - University of Helsinki, FINLAND* *D. Heynderickx - DH Consultancy, Leuven, BELGIUM*	Open Discussion of Solar Spectral Variability as Product for any Space Weather and Space Climate User Communities *M. Haverreiter - PMOD/RWC, SWITSERLAND* *V. Delouille - ROB, BELGIUM*

Wednesday, 20 November 2013

Session 6 Space Weather Impacts on Aviation
Chairs: Daniel Matthiae, Emilien Robert

10:30 Coffee break & Poster Session 6

Session 7 Data and Model Infrastructures for the Advancement of Space Weather Science and Services
Chairs: Andre Csillaghy - Daniel Heynderickx - Bogdan Nicula

Session 8 Space Weather in Planetary Systems
Chairs: Gaël Cessateur, Alexander Shapiro, Mathieu Barthélémy

12:30 Lunch break

13:30-16:00

Scala

Space Weather Working Team Plenary Meeting

Chair: Stefaan Poedts, KULeuven

16:00 Coffee break

16:30 Space Weather Fair

17:30 Start Beer tasting

Thursday, 21 November 2013

Session 9 Spacecraft Operations and Space Weather
Chairs: Dave Pitchford, Richard Horne, Hugh Evans

09:00 Space Weather Warnings: When Should Operators Really Be Worried? **- *Invited***
Monham, Andrew
EUMETSAT, (GERMANY) *66*

09:20 Space Environment Impacts on Geostationary Communications Satellites: Amplifier Anomalies and Solar Array Degradation **- *Invited***
Lohmeyer, Whitney ; Cahoy, Kerri
MIT, (UNITED STATES)..... *66*

09:40 ***TBD***

10:00 A Case for Miniature Targeted Space Weather Sensors **- *Invited***
Likar, Justin ; Bogorad, Alexander ; Lombardi, Robert ; Herschitz, Roman
Lockheed Martin Space Systems Company, (UNITED STATES)..... *67*

10:30 Coffee break & Poster Session 9

11:00 The COMESEP Space Weather Alert System
Rodriguez, Luciano [1]; Devos, Andy [1]; Bourgoignie, Bram [1]; Kraaikamp, Emil [1]; Nicula, Bogdan [1]; Bonte, Katrien [2]; Verbeeck, Cis [1]; Crosby, Norma [3]; Dierckxsens, Mark [3]; Calders, Stijn [3]; Kruglanski, Michel [3]; Veronig, Astrid [4]; Rotter, Thomas [4]; Temmer, Manuela [4]; Vrsnak, Bojan [5]; Dumbovic, Mateja [5]; Zic, Tomislav [5]; Calogovic, Jasa [5]; Vennerstrom, Susanne [6]; Kristoffer, Leer [6]; Malandraki, Olga [7]; Tziotziou, Kostas [7]; Patsou, Ioanna [7]; Lygeros, Nikos [7]; Dalla, Silvia [8]; Marsh, Mike [8]; Robbrecht, Eva [1]
[1]Royal Observatory of Belgium, (BELGIUM); [2]Centre for mathematical Plasma-Astrophysics, KU Leuven, (BELGIUM); [3]Belgian Institue for Space Aeronomy, (BELGIUM); [4]University of Graz, (AUSTRIA); [5]Hvar Observatory, (CROATIA); [6]Technical University of Denmark, (DENMARK); [7]National Observatory of Athens, (GREECE); [8]University of Central Lancashire, (UNITED KINGDOM)..... *68*

11:15 Potential Operational uses for Directional Observations of Solar Proton Fluxes at Geostationary Orbit
Rodriguez, Juan [1]; Mazur, Joseph [2]; Green, Janet [3]; Kress, Brian [4]
[1]University of Colorado, (UNITED STATES); [2]The Aerospace Corporation, (UNITED STATES); [3]National Oceanic and Atmospheric Administration, (UNITED STATES); [4]Dartmouth College, (UNITED STATES).. *68*

11:30 Low Energy Electrons (5-50 keV) in the Inner Magnetosphere
Ganushkina, Natalia [1]; Amariutei, Olga [1]; Pitchford, David [2]; Liemohn, Michael [3]
[1]Finnish Meteorological Institute, (FINLAND); [2]Power/Thermal Subsystems \& Spacecraft Survivability, SES ENGINEERING, (LUXEMBOURG); [3]University of Michigan, Ann Arbor, MI, (UNITED STATES) *69*

11:45 Impact of Space Weather on Spacecraft Operations at ESA/ESOC
Reid, Simon [1]; Kirsch, Marcus [2]; Pantaleoni, Mauro [3]
[1]RHEA System S.A., (BELGIUM); [2]ESA, (GERMANY); [3]RHEA System S.A., (GERMANY) *70*

12:00 An Evaluation of the AP9/AE9 Radiation Belt Models for Application in an ESA Context
Heynderickx, Daniel [1]; Truscott, P.R. [2]; Evans, H. [3]; Daly, E.J. [3]
[1]DH Consultancy BVBA, (BELGIUM); [2]Kallisto Consultancy Limited, (UNITED KINGDOM); [3]ESA/ESTEC, (NETHERLANDS)..... *70*

12:15 Modelling the High-Energy Electron Flux throughout the Radiation Belts using the BAS Radiation Belt Model
Glauert, Sarah A. ; Horne, Richard B. ; Meredith, Nigel P.
British Antarctic Survey, (UNITED KINGDOM)..... *70*

Session 10 Solar Flare Prediction: Progress and Challenges
Chairs: Manolis K. Georgoulis, D. Shaun Bloomfield, Peter T. Gallagher

10:30 Coffee break & Poster Session 10

12:30 Lunch break

13:30 Splinter session

Scala 2	**Scala 3**	**Scala 4**
Education, Outreach and Emerging Markets: Worldwide Efforts *N. Crosby - Belgian Institute for Space Aeronomy, BELGIUM*	Forecaster Forum *L. Trichtchenko - Natural Resources Canada, CANADA*	European Space Weather Business Group *D. Heynderickx - DH Consultancy BVBA, BELGIUM* *M. Wik, - NeuroSpace, SWEDEN*

15:15 Splinter session

Scala 2	**Scala 3**	**Scala 4**
Space weather event analysis *D. Pitchford - SES, LUXEMBOURG* *H. Evans - ESA ESTEC, NETHERLANDS* *R. Horne - British Antarctic Survey, UNITED KINGDOM*	Role and legal responsibility of Space Weather forecasters *M. Messerotti - INAF, Astronomical Observatory of Trieste, ITALY* *T. Onsager - NOAA/Space Weather Prediction Center, UNITED STATES* *R. Van der Linden - STCE, BELGIUM* *M. Hapgood - STFC, RAL, UNITED KINGDOM*	Solar Storms: Flares, CMEs and Solar Energetic Particle (SEP) events *N. Vilmer - LESIA Observatoire de Paris, FRANCE* *O. Malandraki - NOA, GREECE* *N. Crosby - BIRA-IASB, BELGIUM*

16:45 Coffee break

17:15 Splinter session

Scala 2	**Scala 3**	**Scala 4**
Spacecraft, Aircraft and Launcher Environments *S. McKenna-Lawlor - Space Technology Ireland, IRELAND*	AFFECTS space weather tools and services provided *V. Bothmer - University of Goettingen, GERMANY* *the affects team*	PROBA2 Splinter: status and direction of the instruments and scientific achievements after four years in orbit *M. West - ROB, BELGIUM*

19:30 Conference Dinner

Address:

Hilton Antwerp
Groenplaats, 32
2000 Antwerp

The dinner will be held in the Belle-époque Ballroom

Friday, 22 November 2013

Session 11 Modelling the Plasmasphere for Space Weather Purposes

Chairs: *Janos Lichtenberger, Anders Jorgensen, Mark Clilverd*

09:00 The Role of the Cold Plasma Density in Radiation Belt Dynamics: New Measurements from the Van Allen Mission - ***Invited***

Friedel, Reinhard [1]; Jorgensen, Anders [2]; Skoug, Ruth [3]; Kletzing, Craig [4]

[1]Los Alamos National Laboratory, (UNITED STATES); [2]New Mexico Tech, (UNITED STATES); [3]LANL, (UNITED STATES); [4]University of Iowa, (UNITED STATES) *75*

09:25 Ground-Based Remote Sensing of the Plasmasphere and Space Weather Applications - ***Invited***

Menk, Frederick

University of Newcastle, (AUSTRALIA) *75*

09:50 Plasmaspheric Electron Densities and Plasmashere-Ionosphere Coupling Fluxes - ***Invited***

Lichtenberger, János [1]; Ferencz, Csaba [1]; Hamar, Dániel [1]; Steinbach, Péter [1]; Rodger, Craig [2]; Clilverd, Mark [3]; Collier, Andrew [4]

[1]Eötvös University, (HUNGARY); [2]Unversity of Otago, (NEW ZEALAND); [3]British Antarctic Survey, (UNITED KINGDOM); [4]SANSA Space Science, (SOUTH AFRICA) *75*

10:10 Magnetospheric Plasma Density inferred from Field Line Resonances: Effects of using Different Magnetic Field Models - ***Invited***

Vellante, Massimo [1]; Piersanti, Mirko [1]; Heilig, Balazs [2]; Reda, Jan [3]

[1]University of L'Aquila, (ITALY); [2]Geological and Geophysical Institute of Hungary, (HUNGARY); [3]Geophysical Institute of Polish Academy of Sciences, (POLAND) *76*

10:30 Coffee break & Poster Session 11

11:00 A 3D Model of the Plasmasphere to Study its Links with the other Regions of the Magnetosphere - ***Invited***

Pierrard, Viviane [1]; Borremans, Kris [2]; Darrouzet, Fabien [2]; Lemaire, Joseph [2]

[1]Belgian Institute for Space Aeronomy, (BELGIUM); [2]BISA, (BELGIUM) *76*

11:25 Data Assimilation Results from PLASMON - ***Invited***

Jorgensen, Anders [1]; Lichtenberger, Janos [2]; Duffy, Jared [1]; Friedel, Reiner [3]; Clilverd, Mark [4]; Heilig, Balazs [5]; Vellante, Massimo [6]; Raita, Tero [7]; Manninen, Jyrki [7]; Rodger, Craig [8]; Collier, Andrew [9]; Reda, Jan [10]; Holzworth, Robert [11]; Ober, Daniel [12]; Boudouridis, Athanasios [13]; Zesta, Eftyhia [14]; Chi, Peter [15]

[1]New Mexico Tech, (UNITED STATES); [2]Eotvos University, (HUNGARY); [3]Los Alamos National Laboratory, (UNITED STATES); [4]British Antarctic Survey, (UNITED KINGDOM); [5]MFGI, (HUNGARY); [6]University of L'Aquila, (ITALY); [7]Sodankylä Geophysical Observatory, (FINLAND); [8]University of Otago, (NEW ZEALAND); [9]SANSA Space Science, (SOUTH AFRICA); [10]Institute of Geophysics, Polish Academy of Sciences, (POLAND); [11]University of Washington, (UNITED STATES); [12]Air Force Research Laboratory, (UNITED STATES); [13]Space Science Institute, (UNITED STATES); [14]NASA, (UNITED STATES); [15]University of California Los Angeles, (UNITED STATES) *77*

11:50 A Model of Energetic Electron Precipitation Fluxes inside and outside of the Plasmasphere during Space Weather Events - ***Invited***

Clilverd, Mark [1]; Rodger, Craig [2]; Lichtenberger, Janos [3]; Jorgensen, Anders [4]

[1]British Antarctic Survey, (UNITED KINGDOM); [2]University of Otago, (NEW ZEALAND); [3]Eötvös University, (HUNGARY); [4]New Mexico Institute of Mining and Technology, (UNITED STATES) *77*

12:10 ***TBD***

Session 12 Space Weather Forecast Verification
Chairs: *Peter Wintoft, Ioanna Tsagouri, Alan Thomson, Andrew Bushell*

10:30 Coffee break & Poster Session 12

Session 13 Use of Ground-Based Cosmic Ray Detectors for Space Weather Monitoring and Forecasting
Chairs: *Ashot Chilingarian, Karel Kudela*

10:00 NMDB - the Database of Real-Time Neutron Monitor Measurements: An Excellent Cornerstone for Space Weather Applications
Bütikofer, Rolf [1]; Flückiger, Erwin O. [1]; Fuller, Nicolas [2]; Steigies, Christian T. [3]
[1]University of Bern / HFSJG, (SWITZERLAND); [2]Observatoire de Paris, (FRANCE); [3]Christian-Albrechts Universität, Kiel, (GERMANY) *82*

10:15 Operation of the Space Environmental viewing and Analysis Network (Sevan) in 24-th Solar Activity Cycle
Chilingarian, Ashot ; Arakelyan, Karen ; Bostanjyan, Nikolai ; Daryan, Ara ; Reymers, Artur ; Pokhsraryan, David
Yerevan Physics Institute, (ARMENIA) *83*

10:30 Coffee break & Poster Session 13

11:00 Establishing a Space Weather Service based upon Neutron Monitors for the ESA SSA Program **- *Invited***
Mavromichalaki, Helen [1]; Papaioannou, Athanasios [1]; Souvatzoglou, George [2]; Dimitroulakos, John [2]; Paschalis, Pavlos [1]; Gerontidou, Maria [1]; Sarlanis, Christos [2]
[1]National and Kapodistrian University of Athens, (GREECE);
[2]ISNet Company, (GREECE) *83*

11:30 Neutron Monitor: New Life and Potential
Balabin, Yury ; Gvozdevsky, Boris ; Germanenko, Alexey ; Vashenyuk, Eduard
Polar Geophysical Institute, (RUSSIAN FEDERATION) *84*

11:45 Atmospheric Electric Field Effect for total NM Intensity and Different Multiplicities
Dorman, Lev [1]; Applbaum, David Shai [2]; Ben Israel , Itzik [2]; Dai , Uri [2]; Kozliner , Lev [1]; Pustil'nik , Lev [1]; Sternlieb , Abraham [3]; Zukerman , Igor [1]; Kazantsev, Vasilii [1]
[1]Israel Cosmic Ray Center of Tel Aviv University, Golan Research Institute and Israel Space Agency, (ISRAEL);
[2]Tel Aviv University, (ISRAEL); [3]Tel Aviv University & Ariel University, (ISRAEL) *84*

12:00 The First Ground Level Event of Solar Cycle 24 and its Longitudinal Distribution in the Inner Heliosphere
Heber, B. [1]; Dresing, N. [1]; Röntgen, M. [1]; Herbst, K. [1]; Klassen, A. [1]; Kühl, P. [1]; Labrenz, J. [1]; Terasa, C. [1]; Dröge, W. [2]; Kartavykh, Y. [3]; Gomez-Herero, R. [4]; Valtonen, E. [5]; Kocharov, L. [6]; Malandraki, O. [7]
[1]Christian-Albrechts-Universität zu Kiel, (GERMANY); [2]Julius-Maximilians Universität Würrzburg, (GERMANY);
[3]Ioffe Physico-Technical Institute, Russian Academy of Sciences, St-Petersburg, (RUSSIAN FEDERATION);
[4]Universidad de Alcala, (SPAIN); [5]University of Turku, (FINLAND); [6]Sodankylä Geophysical Observatory, (FINLAND);
[7]National Observatory of Athens, (GREECE) *84*

12:15 Cosmic Ray Variations caused by Magnetic Clouds in the Interplanetary Disturbances
Abunin, Artem [1]; Abunina, Maria [1]; Belov, Anatoly [1]; Eroshenko, Eugenia [1]; Oleneva, Victoria [1]; Yanke, Victor [1]; Papaioannou, Athanasis [2]; Mavromichalaki, Helen [2]; Eroshenko, Eugenia [1]
[1]IZMIRAN, (RUSSIAN FEDERATION); [2]University of Athens, (GREECE) *85*

12:30 Lunch break

13:30 Splinter session

Scala 2	**Scala 3**	**Scala 4**
Ground effects topical group / eurisgic *M. Wik - NeuroSpace, SWEDEN*	A dialogue for the establishment of a sustainable network for space weather in Europe *J. Lilensten - IPAG, CNRS, FRANCE* *A. Belehaki - NOA, GREECE* *R. Van der Linden - STCE, BELGIUM*	Advanced Thermosphere Modelling for Orbit Prediction (ATMOP) *N. Sanchez Ortiz - DEIMOS Space, SPAIN*

15:15 Splinter session

Scala 2	**Scala 3**
Promoting Citizen Science for Space Weather Research and Applications *R. Qahwaji - University of Bradford, UNITED KINGDOM* *P. Vanlommel - STCE, BELGIUM* *J. Lilensten - Institut de Planetologie et d'Astrophysique de Grenoble (IPAG), FRANCE*	Neutron Monitor Data and the ESA SSA Program *H. Mavromichalaki and A. Papaioannou* *National and Kapodistrian University of Athens, GREECE*

16:45 End of conference

Poster sessions

Owing to the large number of posters, it will unfortunately not be possible to put all the posters on display all week.

The posters contributions to plenaries 1 - 8 will be on display from Monday Nov 18 until Wednesday Nov 20, 16:00u the latest.
The poster contributions to plenaries 9 - 13 are put on display from Wednesday Nov 20, 16:00u until the end of the conference.
We therefore kindly ask the authors of the poster contributions to plenaries 1 - 8 to free the poster boards by Wednesday Nov 20, 16:00 the latest.

Monday 18 November 2013, 16:00 - 16:30

Poster session 1 Extreme Space Weather Events and their Impact

Poster session 2 Developing Societal Resilience Against Space Weather

Tuesday 19 November 19 2013
10:30 - 11:00

Poster session 3 Strategic Data Sets Supporting Awareness of the Solar Source of Space Weather

Session 4 Space Weather Effects on HF and Trans-Ionospheric Radio Wave Propagation

Session 5 The Impact of Space Weather on Space Exploration

Wednesday 20 November 2013
10:30 - 11:00

Session 6 Space Weather Impacts on Aviation

Session 7 Data and Model Infrastructures for the Advancement of Space Weather Science and Services

Thursday 21 November 2013
10:30-11:00

Session 9 Spacecraft Operations and Space Weather

Session 10 Solar Flare Prediction: Progress and Challenges

Friday 22 November 2013
10:30-11:00

Session 11 Modelling the Plasmasphere for Space Weather Purposes

Session 12 Space Weather Forecast Verification

Session 13 Use of Ground-Based Cosmic Ray Detectors for Space Weather Monitoring and Forecasting

ABSTRACTS

Solar Superstorms - A Natural Hazard with Wide Ranging Impacts

Cannon, Paul
University of Birmingham

Rarely occurring solar superstorms generate X-rays and solar radio bursts, accelerate solar particles to relativistic velocities and cause major perturbations to the solar wind. These environmental changes can cause detrimental effects to the electricity grid, satellites, avionics, air passengers, signals from satellite navigation systems, mobile telephones and more. They have consequently been identified as a risk to the world economy and society. This paper will review their impact on a variety of engineered systems and will identify ways to prepare for these low-probability but randomly occurring events. The paper has an emphasis on the UK, but many of the conclusions also apply to other countries.

Explosive eruptions of energy from the Sun that cause minor solar storms on Earth are relatively common events. In contrast, extremely large events (superstorms) occur very occasionally - perhaps once every century or two. Most superstorms miss the Earth, travelling harmlessly into space. Of those that do travel towards the Earth, only half interact with the Earth's environment and cause damage. Since the start of the space age, there has been no true solar superstorm and consequently our understanding is limited. There have, however, been a number of near misses and these have caused major technological damage, for example the 1989 collapse of part of the Canadian electricity grid. A superstorm which occurred in 1859, now referred to as the 'Carrington event' is the largest for which we have measurements; and even in this case the measurements are limited to perturbations of the geomagnetic field.

An event in 1956 is the highest recorded for atmospheric radiation with August 1972, October 1989 and October 2003 the highest recorded radiation events measured on spacecraft. How often superstorms occur and whether the above are representative of the long term risk is not known and is the subject of important current research. The general consensus is that a solar superstorm is inevitable, a matter not of 'if' but 'when?'. One contemporary view is that a Carrington-level event will occur within a period of 250 years with a confidence of ~95% and within a period of 50 years with a confidence of ~50%, but these figures should be interpreted with considerable care.

Mitigation of solar superstorms necessitates a number of technology-specific approaches which boil down to engineering out as much risk as is reasonably possible, and then adopting operational strategies to deal with the residual risk. In order to achieve the latter, space and terrestrial sensors are required to monitor the storm progress from its early stages as enhanced activity on the Sun through to its impact on Earth. Forecasting a solar storm is a challenge, and contemporary techniques are unlikely to deliver actionable advice, but there are growing efforts to improve those techniques and test them against appropriate metrics. Irrespective of forecasting ability, space and terrestrial sensors of the Sun and the near space environment provide critical space situational awareness, an ability to undertake post-event analysis, and the infrastructure to improve our understanding of this environmnet.

The paper will explores a number of technologies and demonstrates that the UK is indeed vulnerable to a solar superstorm. In a 'perfect storm' a number of technologies will be simultaneously affected which will substantially exacerbate the risk. Mitigating and maintaining an awareness of the individual and linked risks over the long term is a challenge for government, for asset owners and for managers.

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Rates of Large Flares in One Gigayear Old Solar-like Stars With Implications for the Sun

Saar, Steven; Meibom, Soeren; Kashyap, Vinay; Drake, Jeremy
Smithsonian Astrophysical Obs.

We hope to better estimate the rate of very strong (Carrington event-type) flares in the Sun by studying flares of stars in several open clusters with well determined ages using Kepler data. Here we derive white light flare distributions for a sample of near-solar-mass (G0-G5) dwarfs in NGC 6811 (age ~ 1 Gyr). We compare these with solar white light flare rates and, by estimating X-ray emission from the same flares using a solar-based relationship, we compare the Kepler results to other solar and stellar X-ray flare data. We explore implications of our results for the rates of large solar flares.

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Further Investigations of the July 23, 2012 Extremely Rare CME: What if this CME was Earth-Directed?

Ngwira, Chigomezyo[1]; Pulkkinen, Antti[2]; Wintoft, Peter[3]; Viljanen, Ari[4]

[1]Catholic University of America/NASA-GSFC; [2]NASA Goddard Space Flight Center, Space Weather Laboratory, Greenbelt, MD 20771; [3]Swedish Institute of Space Physics, Lund; [4]Finnish Meteorological Institute, Helsinki

On 23 July 2012, NASA's Solar TErrestrial RElations Observatory - Ahead (STEREO-A) spacecraft observed in-situ an extremely fast coronal mass ejection (CME) that traveled one astronomical unit (1 AU) in about 17-hours. The July 23 event also had very strong interplanetary magnetic field components. In this case study, we use the Space Weather Modeling Framework (SWMF) to carry out simulations of this Extremely Rare (ER) type CME event. We consider STEREO-A in-situ observations to represent the upstream L1 solar wind boundary conditions. By varying various solar wind input parameters, we examine what would have happened if this ER-type CME were Earth-directed. We analyze the solar wind-magnetosphere-ionosphere coupling and the subsequent geomagnetic ground response. Our initial results of this ER-type CME show that the ground response would have been comparable, though slight higher, to the March 1989 storm event and the Halloween storm event of October 2003. This has important practical applications for hazard management of electrical power grids.

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The 100 Largest Geomagnetic Storms in the Last 150 Years

Vennerstrom, Susanne[1]; Lefevre, Laure[2]; Dumbovic, Mateja[3]; Crosby, Norma[4]; Clette, Frederic[2]; Veronig, Astrid[5]; Vrsnak, Bojan[3]; Leer, Kristoffer[1]

[1]DTU Space; [2]Royal Observatory of Belgium; [3]University of Zagreb; [4]Belgian Institute for Space Aeronomy; [5]University of Graz

In an effort to understand the chain of events - at the Sun, in interplanetary space and at Earth - which lead to extreme geomagnetic storms, we have created a ranked list of the 100 largest geomagnetic storms in the period 1868-present. The selection and ranking is based on the aa-index and a set of single geomagnetic observatory data with long records. For these events, available historical data such as sunspot records, flare observations, neutron monitor data, in situ solar wind data and various geomagnetic measures, has been collected and analyzed. For a very large majority of the events, the erupting active region at the Sun has been identified, as well as the time of the major eruption associated with the storm. The characteristics of geomagnetic records and solar wind in situ measurements have been compared statistically to less intense storms, and it is found that the extreme storms are in general more complex, displaying several storm peaks. The large majority (>90%) of the extreme storms are further associated with one or several shocks as indicated in the geomagnetic records by observed storm sudden commencements. Most of the events occur in spring or fall season. For all events in the time period where neutron monitor data is available they display Forbush decreases, mostly complex with several substructures. Ground Level Enhancements (GLEs) indicating intense Solar Energetic Particle (SEP) events are, on the other hand, only present in ~20% of the events. The presented work has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no 263252 [COMESEP] .

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Russian Geomagnetic Recordings in the 19th Century compared to Modern Observations

Myllys, Minna; Viljanen, Ari; Nevanlinna, Heikki

Finnish Meteorological Institute

We analyse the magnetic results of four Russian observatories in 1850-1862 located at geomagnetic latitudes of 46-56 N. During this period, the recordings were performed on a regular basis saving a 1-min spot reading once per hour. The data set contains the Carrington storm in Sep 1859 with nearly a complete temporal coverage. To quantify the activity level indicated by the old sparsely saved values, we reduce modern continuous 1-min magnetometer recordings at corresponding geomagnetic latitudes to the same format as the old Russian ones. By varying the hourly saving time of the 1-min spot value in the modern data, we can especially assess how accurately the old recordings reveal information of the extreme Carrington event.

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Modeling the Recovery Phase of Extreme Geomagnetic Storms

Cid, Consuelo; Palacios, Judith; Saiz, Elena; Cerrato, Yolanda; Aguado, Jesus; Guerrero, Antonio
University of Alcala

The recovery phase of the largest storms ever recorded has been studied. These events provide an extraordinary opportunity for two goals: (1) to validate the hyperbolic model by Aguado et al. [2010] for the recovery phase after disturbances as severe as the Carrington event, or that related to the Hydro-Quebec blackout in March 1989, and (2) to check whether the linear relationship between the recovery time and the intensity of the storm still complies. Our results reveal the high accuracy of the hyperbolic decay function to reproduce the recovery phase of the magnetosphere after an extreme storm. Moreover, the characteristic time that takes the magnetosphere to recover depends in an exponential way on the intensity of the storm, as indicated by the relationship between the two parameters involved in the hyperbolic decay. This exponential function can be approached by a linear function when the severity of the storm diminishes.

This work analyzes also the severity of the 1989 storm responsible for the Hydro-Quebec power blackout, providing an estimation of the peak value for this storm. The comparison of this value with historical records indicates that, although the Carrington storm is the most intense geomagnetic storm ever recorded, it is not as extreme as usually is stated.

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Risk Preparedness and Operational Mitigation in the UK

Felton, C.[1]; Gibbs, Mark[2]
[1]UK Cabinet Office; [2]UK MET Office

The UK presentation will discuss how the risk presented by severe space weather was first recognised in the UK and how it fits with the UK's overall approach to risk assessment. This will focus on how the UK's existing risk identification system, the National Risk Assessment, has been used to assess the UK's vulnerability and instigate the necessary preparedness planning and how preparation for a severe space weather incident is consistent with the way in which we prepare for other high impact natural hazards. The presentation will also set out how the UK's work has been discussed and compared with that of other countries' and how we are seeking to design an international approach to planning for this risk. Next, it will describe how a space weather warning service has been implemented within the Met Office's existing operational forecast centre, how warnings of severe space weather have been integrated within Government's existing warning systems and how the UK is working with international partners (especially the US) to develop our warning systems. There will be a description of how the process has already and will in the future be exercised within the UK to ensure effectiveness of the planning and preparedness and also exercised with key international partners. Finally, we will highlight the gaps in our current emergency planning knowledge and the ways in which the scientific community can help us to fill these gaps.

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Resilience in Basic Functions when Disaster Hits Risk Governance in Norway

Thomassen, Erik
Directorate for Civil Protection

The presentation focuses on the Norwegian approach to Risk Governance, focusing on the annual National Risk Assessment which includes a Space Weather scenario and identification of deliveries and services basic to society.

From a Government perspective resilience in infrastructures and basic functions can only be achieved through others. Hence governance is the key issue, and systemizing the use of standard government tools the only applicable strategy.

The presentation will focus on governance and on processes, regulations and designations needed to establish a risk management system for critical infrastructures and basic societal functions on a strategic level. The system is in progress, but it will still be a few years before it is implemented on a broad scale.

The Norwegian approach is based on recognizing the fact that what really matters is the functionality of the society; maintaining services which are crucial in everyday life or basic for the security of the society as a whole. Such functions must plan to be operational no matter what might occur.

The value of infrastructures lies in their functionality. Infrastructures are in many cases important as carriers of input factors for services vital to the population and the society, but intact infrastructures don`t necessarily guarantee that the services they should be carrying may be delivered. There might be other problems, such as lack of staff, competence or important inputs to the production. And the other way around: a breakdown in one important infrastructure service doesn't necessarily mean that other services vital to the society need to go down with it. Building resilience is in many cases building redundancy.

The approach is focusing on resilience in enterprises responsible for the deliveries of vital importance to the society. The authorities´ role is to clarify responsibility and ensure that owners and operators of critical infrastructures and basic societal functions take their responsibility seriously. From a Government point of view identifying and designating the vital deliveries in the society will be of crucial importance. To put governance into practice you need to know who to address and more or less precisely what you want them to follow up.

However, nobody can guarantee full functionality of infrastructures or services at all times. Enterprises must take into account the possibility of deficiencies in deliveries from sub-contractors and infrastructure services they are critically dependent of and plan for continuity in their vital services no matter what happens.

The National Risk Assessment (NRA), a public document published annually, offers authorities and enterprises a backdrop for planning. The NRA of 2013 gives an overview of disaster risk in Norway and analyzes 17 specific scenarios ranging from diseases and landslides to terrorism and war-like situations. A severe Solar Storm is one of the scenarios analyzed.

Authorities and enterprises are expected to take these 17 scenarios into consideration when they are planning for continuity in their basic services. In addition to this they should analyze other unlikely but still possible scenarios of importance for their sector or industry. The point is to identify and reduce vulnerabilities.

A third pillar in this system of Risk Governance is audits and reviews. Norway is the only country in Europe where ministries and subordinated agencies are subject to audits from the contingency authorities. The audits focus on resilience in basic societal functions, business continuity and contingency planning, exercises etc.

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Building Capacity for Preparedness

Andersson, E.
Swedish Civil Contingencies Agency

The Swedish emergency preparedness system is primarily built on the principle of responsibility, which means that whoever is responsible for an activity under normal conditions should maintain that corresponding responsibility, as well as initiating cross-sectoral cooperation, during major emergencies. Our system is therefore based on a close cooperation between sectors and the continuous building of networks with relevant public and private stakeholders, and with scientists and experts. MSB's work to improve the management of space weather impacts, involves a continuing communication with the stakeholders about the risk and about response and recovery efforts. It is through exchange of knowledge and trust that we further enhance cross-sectoral coordination, which is an important tool when dealing with the cascading effects of a space weather event. Sweden is, as many other countries, in the process of improving our preparedness in regards of space weather events by integrating the risk into an all-hazards approach. But it is still a fragile system that is dependent on a few people's expertise. Preparedness requires a common purpose and a common capacity, which can be achieved by synchronizing with our international partners for cooperation, networking and exchange of information. There are existing networks of scientists, but how can we build a working level network of stakeholder organizations?

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International Space Weather Service Coordination during Extreme Events

Sharma, M.[1]; Onsager, T.[2]; Lafeuille, J.[2]
[1]US Department of State; [2]

Societal resilience against space weather requires a close collaboration among emergency managers and space weather service providers. Effective planning and response to extreme space weather will rely on accurate and coordinated information provided by the forecast centers and a close relationship with emergency managers. This presentation will describe efforts underway to identify the actions that must be taken by the space weather service providers to ensure that coordinated information is available to support the actions of emergency managers. This could include establishing criteria for joint procedures based on disturbance level, defining a standard set of actions, and ensuring effective coordination. As this effort among the service providers is progressing, ongoing interactions with research activities to improve services and emergency managers to define targeted services will be required.

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The 'ideal' Collection of Data Sets for Space Weather Forecasting

Devos, Andy; Stegen, Koen; Vansintjan, Robbe; West, Matthew J; Mampaey, Benjamin; Delouille, Véronique
Royal Observatory of Belgium

Several important data sets are currently collected via different methods, ranging from remote to in-situ spacecraft and ground observations. These are made available for space weather purposes through various channels. The most commonly used data sets will be described, including their advantages and drawbacks. There exists a misalignment between the currently provided data sets and the requirements requested by forecasters and other users of space weather data. Inaccuracies, errors and delays in space weather forecasting could often be reduced with better data-set management, especially in terms of latency, accessibility and multi-point measurements. An 'ideal' collection of space weather data sets will be discussed.

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Mission Concepts and Measurement Needs at the L4/L5 Points

Lavraud, Benoit[1]; and, INSTANT team[2]
[1]IRAP/CNRS/Université de Toulouse; [2]All

We will present both scientific and space weather objectives, and the related measurements needs, of potential future missions to the L4 and L5 Lagrangian points. We will present past and current concept, which vary largely by objective from primarily science-driven to purely space weather-driven. An intermediate concept, which we shall call INSTANT (INvestigations of Solar Transient Associated Natural Threats), will be discussed.

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PROBA2 a Space Weather Monitor

West, Matthew[1]; Seaton, Dan[1]; Dominique, Marie[1]; Berghmans, David[1]; Zender, Joe[2]; Stegen, Koen[1]; Pylyser, Erik[1]
[1]Royal Observatory Belgium; [2]ESA

PROBA2 is a European Space Agency space weather mission, comprised of two Sun monitoring instruments, "The Sun Watcher using APS and Image Processing" (SWAP, an EUV imager) and the "Large Yield Radiometer" (LYRA), a solar UV radiometer. PROBA2 is used for both science and space weather forecasting, and has provided a continual data set since late 2009.

In this talk we will discuss the data-sets provided by PROBA2, the operational constraints and difficulties of the mission as well as the advantages and flexibility of being a small mission. In particular we will look at PROBA2's unique pipeline for data delivery and some of the challenges and opportunities PROBA2 presents as a result of the spacecraft orbit and processing requirements. We will also discuss the variable conditions to which the spacecraft is exposed in orbit and our efforts to track and correct for degradation of the instruments throughout the course of the mission.

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Monitoring Ionospheric Plasmas in Space Weather Context via DSLP/Proba-2 Data Archive

Travnicek, Pavel[1]; Stverak, Stepan[2]; Pavelka, Roman[2]; Hercik, David[3]; Zender, Joe[4]
[1]Space Sciences Laboratory, University California, Berkeley, US; [2]AsI & IAP, Academy of Sciences of the Czech Republic;
[3]Technical University Braunschweig; [4]ESTEC, ESA

The experiment Dual Segmented Langmuir Probe (DSLP) on board Proba-2 spacecraft (ESA) provides a long-term continual survey of basic plasma properties measured in situ in the dawn and dusk sectors of the upper terrestrial ionosphere. DSLP observations are acquired by two identical segmented spherical Langmuir probes representing a novel approach to a well developed plasma diagnostic technique. Starting its nominal operations in May 2010, more than 3 years of regular observations are currently being available providing a substantial data set for monitoring observed ionospheric disturbances and irregularities e.g. in view of potential space weather drivers. We show some of the DSLP data scientific applications like seasonal or immediate variations of derived plasma properties in comparison with possible effects of sudden solar events or overall solar activity. In order to facilitate the scientific analysis of the large DSLP data set, all raw measurements are routinely being processed into calibrated higher level data products and made available throughout an online accessible data archive derived from the PDS and CDF standards. Here we present the complete structure of the archive with individual data products, and show available tools to access, handle and analyse individual DSLP samples.

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BASS2000 and HELIO: Dataset and Added-Values

Aboudarham, Jean[1]; Bonnin, Xavier[2]; Renie, Christian[2]; Fuller, Nicolas[2]; Cecconi, Baptiste[2]; Bentley, Robert D.[3]; Csillagy, André[4]
[1]Paris Observatory; [2]Paris Observatory, LESIA; [3]MSSL/UCL; [4]FHNW

Full Sun observations from ground or space provide important information on the background of the Sun when important events occur. Simultaneous and complementary data are necessary to have both time continuity and spatial information. BASS2000 Meudon provides context information from several instruments: Meudon and Coimbra spectroheliographs, Brussels USET refractor, Pic du Midi coronograph and Nançay solar radio observations. Some of these data are used to populate the Heliophysics Feature Catalogue (HFC) developed in the frame of the European project HELIO. HFC provide around one solar cycle of descriptions for filament, prominences, coronal and photospheric active regions, sunspots, coronal holes, radio sources at metric wavelength and radio type III bursts. The time tracking of the behavior of solar features requires continuity in observations and the best time resolution possible. Space probes are submitted to lifetime constraints while ground-based observations have to deal with many defaults (clouds, sky transparency, parasites, ...) that have to be taken into account before being able to extract added-values from them.

We'll describe here what has been done, and the needs for standardization of data description in order to develop generic tools compliant with Virtual Observatory.

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UV/EUV Solar Spectral Imaging Data for Space Weather

Buchlin, Eric; Baudin, Frédéric
IAS (CNRS/U. Paris-Sud)

The upper solar atmosphere (chromosphere and corona), emitting mainly in the ultraviolet, plays a crucial role as a source of space weather events. It is continuously observed by imagers and spectro-imagers such as those from SoHO, STEREO, and SDO, and their data is of interest for the space weather community. The MEDOC centre at IAS includes such large data sets, and provides added-value products such as differential emission measure maps and tools such as the FESTIVAL multi-instrument visualization software. Images allow us for instance to detect filaments / prominences automatically, potentially giving an early warning for an eruption.

We will present the data sets presently available as well as the ones that future space missions will provide. We will describe the issues related to extremely large data sets. We will finally show some example of analysis of these data sets.

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Ground-Based H-Alpha Imaging of the Solar Sources of Space Weather

Veronig, Astrid[1]; Pötzi, Werner[1]; Temmer, Manuela[1]; Riegler, Gernot[2]; Pock, Thomas[2]; Hirtenfellner-Polanec, Wolfgang[1]; Möstl, Ute[1]; Baumgartner, Dietmar[1]

[1]University of Graz, Kanzelhöhe Observatory - Institute of Physics; [2]Graz University of Technology, Institute for Computer Graphics and Vision

We review the availability and use of ground-based H-alpha observations for the study of the solar sources of space weather. High-cadence full-disk imaging in the H-alpha spectral line provides us with a valuable means to identify erupting filaments - potentially associated with Earth-directed coronal mass ejections - and the onset and peak of intense solar flares in quasi real-time. We present first results of the automatic detection of solar flares and erupting filaments implemented at the Kanzelhoehe Observatory H-alpha observing system in the frame of ESA's Space Situational Awareness (SSA) Program. Specific problems related to the ground-based H-alpha observations and potential solutions will be discussed.

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A New Solar Observing Network for Space Weather Operations and Solar Physics Research

Hill, Frank[1]; Roth, Markus[2]; Thompson, Michael[3]

[1]National Solar Observatory; [2]Kiepenheuer-Institut für Sonnenphysik; [3]High Altitude Observatory

Since all space weather originates in and on the Sun, forecasters need continuous, long-term, consistent, and reliable solar data as a foundation for useful predictions. It has long been recognized that an effective strategy to obtain nearly continuous solar data is to set up a ground-based network of identical observing instruments geographically distributed so that gaps from night time, weather and instrumental problems are reduced. While space platforms can provide nearly-continual solar observations that are also free of terrestrial atmospheric limitations, networks have five distinct advantages: the costs of developing and maintaining a network are roughly a factor of 10 to 15 lower; the network instrumentation can be upgraded, and repaired when it fails; the network lifetime is in principle unlimited; there are less stringent telemetry restrictions than for satellite-borne platforms; and networks are not very vulnerable to space weather events. In addition, there are a number of new scientific research directions in solar physics that motivate the desire for a new ground-based network, particularly one that is capable of multi-wavelength measurements that provide data at different heights in the solar atmosphere. Such observations would provide information on wave propagation and the vector magnetic field as a function of height in the solar atmosphere. In turn, these data would provide greatly improved inferences of the structure and dynamics below active regions via helioseismology, as well as more accurate extrapolations of the magnetic field in the corona. This presentation will outline the scientific and operational requirements, and describe some instrumental concepts for a new network.

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The Strategic Opportunities for Space Weather from Synoptic Full-Disk Vector Magnetogram Data

Leka, K.D.

NorthWest Research Associates

Systematic observations of the photospheric magnetic field provide guidance and challenges for understanding the solar cycle and space weather, by allowing study of solar surface magnetic features and their behavior over days, weeks, and solar cycles. Routine continuous observations of the line-of-sight component have proven crucial for advances in many topics of solar and space-weather research, and are now being routinely used in real-time forecasting of space-weather events. Observations of the full vector of the photospheric field have historically been more sparse; they are more difficult. Yet from even the earliest routine observations of the photospheric vector field came crucial insights into the magnetic morphology and energy storage of the active regions responsible for space weather events such as solar flares and coronal mass ejections. Vector solar magnetic field data -- specifically when routine, sufficiently-well sampled (temporally, spatially, spectrally) and uninterrupted over a sufficiently long time period, such as are now beginning to be available -- allow for investigations (a) statistical in nature, which can (b) avoid some of the very limiting assumptions required when using solely the line-of-sight magnetic component, i.e. (c) having those two additional components of information to provide the full physical magnetic vector at the surface, provides information on the plasma physics, available energy, and dynamic behavior of solar

phenomena simply not available otherwise. I highlight future promises (based on current research) that are available from routine, continuous (synoptic) photospheric vector magnetic field observations, especially in the context of space-weather-related research and improvements to operations for topics such as early detection of emerging active regions, forecasting solar flares, and improvements to global-field models.

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Space Weather Monitoring; Benefits and Needs of the e-Callisto Network.

Zucca, Pietro[1]; Monstein, Christian[2]; Gallagher, Peter T.[3]; Marqué, Christophe[4]; Carley, Eoin P.[3]; Morosan, Diana E.[3]; McCauley, Joe[3]

[1]Trinity College Dublin; [2]Institute for Astronomy, ETH-Zentrum, Zurich, CH-8093; [3]School of Physics, Trinity College Dublin, Dublin 2; [4]Royal Observatory of Belgium Avenue Circulaire 3 B1180 Brussels

Extreme space-weather events are natural phenomena caused by solar activity that can have a serious impact on modern technological infrastructures. Monitoring near real time the solar activity is crucial to predict the arrival time of such events on Earth.

The e-Callisto network, initiated through IHY2007 and ISWI, is a worldwide-distributed set of radio spectrometers designed to monitor solar radio emission in the metre and decametre bands. Here we describe the network characteristics and we present the important contribution of the e-Callisto network as a 24-hour monitor of the solar eruptive activity.

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Solar Radio Monitoring at Nançay Observatory - Spectrography and Imaging

Klein, Karl-Ludwig; Kerdraon, Alain; Lecacheux, Alain

Observatoire de Paris, CNRS

Radio emission of the active Sun at decimetre to decametre wavelengths (frequencies below 1 GHz) reveals electron beams, shock waves and confined energetic electron populations during flares and coronal mass ejections. The information gained is relevant to astrophysical research on solar eruptive activity, particle acceleration and propagation, as well as to space weather issues such as early signatures of coronal mass ejections and particle acceleration that may affect the Earth.

The Nançay radio observatory has a worldwide unique set of complementary instruments that monitor the Sun : imaging with the Radioheliograph (150-450 MHz) and spectrography with the Decameter Array (10-80 MHz) have been carried out since several years. Since September 2012 a new spectrograph (140-1000 MHz) is being operated. Furthermore a new low-frequency receiver has been installed at the Decameter Array, opening the window between 30 and 10 MHz, which is heavily contaminated by terrestrial emitters. This set of instruments presents a coverage of eruptive activity in the low and middle corona (up to about a solar radius above the photosphere) which goes as far down in frequency as possible from ground, and is complemented by space borne spectrographic observations on the Wind and STEREO missions, which will continue with Solar Orbiter in the future. This contribution will present the instruments and data sets provided, and illustrate their diagnostic capabilities with recent observations.

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Real Time Assimilative Global IRI Electron Density Model using GIRO Measurements to Assess Space Weather Events

Reinisch, Bodo[1]; Galkin, Ivan[2]; Huang, Xueqin[1]; Nsumei, Patrick[3]; Bilitza, Dieter[4]

[1]Lowell Digisonde International; [2]University of Massachusetts; [3]University of Massachusetts Lowell; [4]George Mason University

Ionospheric models are mostly unable to correctly predict the effects of space weather events on the ionosphere. This is especially true for the International Reference Ionosphere (IRI) which by design is a monthly median climatology model [Bilitza et al., 2011]. The IRI electron density profile critically depends on the correct values of the F2 layer peak height and density, hmF2 and NmF2 (or foF2) which are directly affected by most space weather events. Real time data from the global ionosonde network GIRO [Reinisch and Galkin, 2011] are assimilated in the IRI electron density model in an effort to create the IRI Real Time Assimilative Model IRTAM. First results for the foF2 assimilation are available at http://giro.uml.edu/RTAM

[Galkin et al., 2012]. New GIRO data arrive nominally every 15 min –possibly faster during campaigns- and new electron density profiles are generated. Using the new Vary-Chap profile model [Nsumei et al., 2012] for the topside profiles leads to more realistic total electron content estimates.

Refernces
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Galkin, I. A., B. W. Reinisch, X. Huang, and D. Bilitza (2012), Assimilation of GIRO Data into a Real-Time IRI, Radio Sci., 47, RS0L07, doi:10.1029/2011RS004952.
Nsumei, P., B. W. Reinisch, X. Huang, and D. Bilitza (2012), New Vary-Chap profile of the topside ionosphere electron density distribution for use with the IRI Model and the GIRO real time data, Radio Sci., doi:10.1029/2012RS004989.
Real time assimilative foF2 maps for IRI

Reinisch, B. W. and I. A. Galkin (2011), Global Ionospheric Radio Observatory (GIRO), Earth, Planets and Space, 63(4), 377-381.

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The Upgraded DIAS System: New Products for the TopsideIonosphere and Plasmasphere and for the high Latitude Ionosphere

Belehaki, Anna[1]; Kutiev, I.[2]; Zolesi, B.[3]; Tsagouri, I.[1]; Marinov, Pencho[2]; Pietrella, Marco[3]; Elias, Panagiotis[1]; Tziotziou, K.[1]; Themelis, K.[1]
[1]National Observatory of Athens; [2]Bulgarian Academy of Sciences; [3]INGV

Knowledge of the state of the upper atmosphere, and in particular its ionized part, is very important in several applications affected by space weather, especially the communications and navigation systems that rely on radio transmission. To better classify the ionosphere and forecast its disturbances over Europe, a data and model infrastructure platform called the European Digital Upper Atmosphere Server (DIAS) has been established in the National Observatory of Athens by a European consortium formed around eight ionospheric stations, and funded by the European Commission.

The DIAS system operates since 2006 and the basic products that are delivered are real-time and historical ionograms, frequency plots and maps of the ionosphere on the foF2, M(3000)F2, MUF and bottomside electron density, as well as long term and short term forecasting up to 24 hour ahead. The DIAS system supports more than 500 subscribed users, including telecommunication companies, satellite operators, space agencies, radio amateurs, research organizations and the space weather scientific community. In 2012 the system has been upgraded, in close collaboration between NOA, INGV and BAS, with funding from the ESA/SSA Programme.

The first group of new products results from the implementation of the TaD model (Topside Sounder Model assisted by Digisonde) that makes possible the generation of maps of the electron density at heights up to GNSS orbits, and of TEC and partial TEC maps (topside and plasmaspheric) over Europe. The TaD is based on the simple empirical functions for the transition height, the topside electron density scale height and their ratio, based on the Alouette/ISIS database, and models separately the oxygen, hydrogen and helium ions density profiles. The model takes as input the plasma characteristics at the height of maximum electron concentration that are provided in real-time by the DIAS Digisondes. To further improve its accuracy, we adjust the modeled TEC parameter with the GNSS-TEC parameter calculated at the Digisondes location. This adjustment forces the model to correctly reproduce the topside scale height, even in cases when the scale height at hmF2 is not available. This adjustment is very important for the application of TaD in an operational environment.
The second group of new products consists of long term prediction and of nowcasting maps of the foF2 parameter that cover the whole European region - including Scandinavia. Long term prediction maps have been extended to 80 deg N applying the CCIR coefficients for the region above 65 deg N, while from 32 to 60 deg N we continue to apply SIRM (Simplified Ionospheric Regional Model), as in the case of middle latitude maps that are released routinely by the DIAS system. Between 60 and 65 deg N there is a buffer zone where an interpolation routine is applied. Nowcasting maps are based on the SIRMUP (SIRM updated in real-time) concept, however, a different effective sunspot number (Reff) is estimated for each latitudinal zone, from which a synthetic Reff is calculated.

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Report on Establishing a- 'Global Ionospheric Flare Detection System' (GIFDS)

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German Aerospace Center (DLR)

Solar flares influence the Earth's space up to its surface for several minutes and are often precursors of space weather storms. These phenomena are often related to coronal mass ejections (CMEs) and gain more and more interest. Hence, the DLR Neustrelitz started recently the project 'Global Ionospheric Flare Detection System - GIFDS' to establish an operational near real time ground based warning system.

If a solar flare hits the Earth, the ionization of the bottomside ionosphere increases which impacts the propagation of VLF waves during daytime by a sudden significant change in signal strength and phase. In order to receive permanent information from the dayside sector the warning system requires a network of VLF receivers around the globe. DLR is just establishing the first two receivers at DLR Neustrelitz and in US at the University of Alabama Huntsville.

Operational measurements are realized by Perseus SDR (Software Defined Radio) receivers enabling the reception of multiple frequency channels in a range of 10 to 60 kHz. As simultaneous measurements at different channels show the same characteristic variation, the impact of a solar flare is assumed and a warning message will be automatically generated and distributed. In comparison to X ray data of GOES satellite, further analyses are accomplished concerning the reliability, strength and time resolution of derived warnings. Preliminary results are reported.

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The Ability to Forecast Sporadic E Layer Appearance

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SRC PAS

The forecast of sporadic E layer occurring locally and sometimes nontransparent is the crucial topic for radiocommunication. We propose the method of forecasting sporadic E layer appearance. The method is based on magnetic data and the changes of magnetic Eta parameter defined as the square root of a ratio of the energy of the external part of the vertical component to that of the horizontal components. We present the correlation of sporadic E layer appearance 1-2 hours after the increase of Eta value. The correlation between data from different European ionosondes and data from magnetic observatories lying close to the selected ionosonde was taking into account. We apply autocovariance method for prediction of the Eta index variations and in this connection the sporadic E layer appearance. Forecasting method and statistics for Warsaw ionosonde and data from Belsk Magnetic Observatory placed 50 km South-West from Warsaw are presented. Near real time magnetic data from Belsk (every 30 minutes) give the possibility to predict the Eta index variations and the sporadic E layer appearance 2 hours after the increase of the eta value.

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GINESTRA, MImOSA and MEDSTEC: Competence Surveys within the ESA ALCANTARA Initiatives

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On October 2012 ESA funded the competence surveys titled GINESTRA (Ground-based Ionosphere monitoring Networks in SoutheasTeRn Asia: a survey), MEDSTEC (Towards Mapping of Electron Density, Scintillation and Total Electron Content) and MImOSA (Monitoring the Ionosphere over South America) in the frame of the ALCANTARA initiatives (http://www.esa.int/SPECIALS/GSP/SEMDZ9NLM5H_0.html). The three projects started between October and November 2012 and ended on May-June 2013.

The competence surveys were addressed to the assessment of the current capabilities on ionospheric monitoring in the areas of interest (South-eastern Asia, Africa and South America, respectively), in order to understand how the existing facilities can be integrated with new installations, to effectively support and/or improve space weather activities oriented to assist GNSS

operations. Over the considered regions, the presence of the Equatorial Ionospheric Anomaly and of the South Atlantic Magnetic Anomaly produces important peculiarities in the distribution of the plasma irregularities. Consolidating the operational monitoring of these irregularities, by taking also into account possible improvement on existing monitoring networks, can positively impact models and space weather activities. The surveys were made through: a careful analysis of the existing literature, a close interaction with public and private local entities and a dissemination activity. The paper presents the results of the three surveys and the possible follow-up actions in the field.

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Recent Developments in the Understanding of Space Weather Effects on Satellite Navigation Systems

Forte, Biagio
University of Bath

Space weather may cause disruptions to satellite-based telecommunication and navigation services owing to degradation of radio signals when propagating through the ionised portion of the Earth's atmosphere. Trans-ionospheric radio waves may be scattered when propagating through large-to-small scale plasma density inhomogeneities. The net result of this scattering process is to disperse the energy carried by the signal and manifest as random fluctuations in amplitude and phase (i.e. scintillation), associated with lower tracking C/N0 conditions. The appearance of plasma density inhomogeneities varies with solar and magnetic activities, local time, latitude and season, in response to space weather conditions. The impact of adverse space weather conditions on satellite navigation systems and services include accuracy degradation in code and carrier measurements as well as in differential positioning, losses of lock and cycle slips, unavailability of SBAS messages. Recent developments are presented on the following aspects: (1) further understanding of the scattering mechanisms leading to radio wave scintillation, (2) space weather impact on different GNSS frequencies and corresponding signal tracking, (3) occurrences of losses of lock at both high and low equatorial latitudes.

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Observed High-Latitude GNSS Disturbances during a Less-Than-Minor Geomagnetic Storm

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Norwegian Mapping Authority

Ionospheric disturbances at high latitudes can affect modern satellite based navigation and positioning systems. These effects can be complex and has not been studied as extensively as the effects at lower latitudes. The Norwegian Mapping Authority (NMA) monitors ionospheric activity trough our Real Time Ionospheric Monitor (RTIM) and are establishing a network of scintillation receivers for a real-time monitoring of scintillations in this area.

We present the ionospheric observations from a recent geomagnetic storm, and the observed consequences for a network RTK positioning service. Using data from monitor stations, we show the positioning errors that a user would experience during such an event. Although the storm in question only reached a Kp index of 4, which is below the NOAA scale for geomagnetic storms, it caused serious disturbances of the network RTK positioning at high latitudes (65-70 degrees N).

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Spline Model for high- Latitude Ionospheric Scintillation using In Situ Data

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[1]Space Research Centre; [2]Space Research Center

Dynamics Explorer 2 retarding potential analyzer (RPA) plasma density data is used as input to de Boor B-spline function. The satellite was on a nearly polar orbit. Various parameters derived from DE 2 satellite data needed for the scintillation index calculation have been modeled. Results are presented in the form of maps, of those parameters and scintillation index S4 in the geographic coordinates for various geophysical conditions.

Key words: scintillation index, spline model, high latitude etc.

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Ionospheric Irregularities Morphology as Derived by GNSS Scintillation Monitors

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Ionospheric influence on GNSS satellite signals delay, phase and amplitude changes can be deduced from information about various drifting ionospheric density structures. Large and small scale structures behaviour in the ionosphere can describe changes of the signal propagating in ionospheric plasma. This is the main source of problems for satellite positioning systems that has not been satisfactory solved yet.

We present a case study of ionospheric irregular structures patterns during geomagnetic storm event occured on 5th and 6th April 2010, measured by GPS monitors set on Svalbard and other diagnostic tools. In purpose of comparison we included data of quiet ionosphere period as reference point. Analyses of spatial and temporal phase gradients has been used as a basic tool for calculations of the properties of ionospheric electron concentration irregularities. The properties derived depend on the model of propagation of waves in ionosphere. We validated estimated properties of ionospheric irregularities using additional measurements.

Purpose of this investigation is to recognize ionospheric scintillation diffraction pattern, provide relation between phase measurements and properties of ionospheric irregularities for further forecasting and mitigation of ionospheric effects.

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Space Radiation Health Effects of Astronauts in Explorative Missions

Reitz, Guenther
DLR

Space missions in Low Earth Orbits (LEO) like the International Space Station (ISS) already suffer from space weather effects. Operations outside the space station have to be planned carefully in order to prevent high exposures due to changes in the radiation field caused by Solar Particle Events (SPEs). Even inside the ISS exposure levels may be heightened during such events. Common to these missions in LEO is the protection by the geomagnetic field which reduces the radiation exposure by the galactic cosmic radiation (GCR) and essentially eliminates the threat posed by the stochastically occurring SPEs. This is no longer the case for interplanetary missions. Radiation exposures in interplanetary space differ quite significant from that in LEO. There is a short exposure by radiation belt particles during crossing of the radiation belts followed by a more intense GCR irradiation and occasionally an unweakened exposure by solar particles during SEPs. Until now the forecasting capability of SPEs is very limited. Only approximate dose values from model calculation are availabe for different mission scenarios. There is a lack of physical measurements to benchmark the codes, although most recently measurements become available from missions to Moon and Mars, such as from Chandrayaan-1, the NASA LRO and MSL mission.

Shielding is the main countermeasure against the exposure to radiation cosmic radiation during interplanetary missions, although it does not help much against exposure to GCR. Moreover, with increasing shielding thickness the exposure increases due to secondary radiation as result of the interaction of the high-energy charged particles with the atoms of the shielding material. But, for solar particles the shielding is quite effective, so that exposures can be mitigated to reasonable values or even prevented.

Space radiation causes effects on crew health, performance, and, finally, life expectancy and potentially limits the duration of human's presence in space. Radiation effects are classified in early and late effects. Late effects materialize years to even decades after exposure, early effects can arise within hours and may extend to several weeks. At extreme doses the effects can appear within minutes after exposure. Mission design has to prevent a foreseeable worst case exposure to surpass the thresholds where symptoms for early, deterministic radiation health effects are to be expected. In interplanetary missions, acute doses can only be expected to be deposited during SPEs.

The main late effect in humans is carcinogenesis, more specifically, mortality from late radiation induced cancers. Cancer arises from both acute exposures during SPEs and low but chronic exposures by GCR. Late cancer mortality is the reference

risk utilized in radiation protection to derive limits of exposure which might be considered acceptable. For interplanetary missions damage to the central nervous system (CNS) gain in importance. Most of the uncertainty in risk estimates is related to the radiation quality of heavy ions and to tissue degenerative effects, which are unique to heavy ion exposure. Until today, cataracts are the only cosmic radiation-induced effect actually observed in astronauts.

For ISS operations maximum allowable radiation exposures are set by NASA, that the radiation risk is limited to 3% excess risk of exposure induced death (REID) including a 95% confidence level. For explorative missions there are no exposure limits defined, but the radiation risks are by far higher compared to that in ISS operation.

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How Space Weather could Influence on Human Cardiovascular System and Microcirculation

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The history of modern investigations of space weather influences on human health begin from Alexander Tchijevsky in Russia and M.Faure and G.Sardou in France (1927).

At the last two decades there were conducted several extensive studies that revealed dependence of cardiovascular pathologies from space weather events. The analyzing data collected by the Moscow ambulance services covering more then one million observations over three years, cleaned up by seasonal effects of meteorological and social causes, show that the number of cases of myocardial infarction increased during geomagnetic storms (Breus et al., 1995). Great contribution have made by Stupel et al., (1999) who studied geomagnetic activity and cosmic rays influence on different kind of human pathology. Our investigation during 14 years started at 1992 included more than 25000 cases of acute myocardial infarction and brain stroke collected at seven medical hospitals. We used only cases with established date of acute attack of diseases. Undated cases were excluded from the analysis. Average numbers of patients on geomagnetic active days and days with quiet geomagnetic condition were compared. It was shown statistically that during geomagnetic disturbances the frequency of myocardial infarction and brain stroke cases increased on the average by a factor of two in comparison with quiet geomagnetic conditions.

Laboratory tests as blood coagulation, platelet aggregation, and capillary blood velocity (CBV) in patients suffering from coronary heart disease (CHD) revealed a high dependence with a level of geomagnetic activity. Results of our recent study during "Mars-500" experiment has being conducted by Russian Space Agency and Russian Academy of Sciences, with extensive participation of ESA to prepare for future human missions to the Moon and Mars confirmed this conclusion. In total 58 good for reading records were analyzed. We compared CBV of each subject which measurements have coincided with days before and after beginning of geomagnetic storms (GMS).

Average values of CBV for all subjects for all period of study have made 515 ± 97 mm/s. Averages CBV values for days with quiet geomagnetic conditions have made 566 ± 217 mm/s. In active geomagnetic condition days average CBV values has registered as 389 ± 167 mm/s, that statistically significant ($p<0.05$) in comparison of CBV values for quiet geomagnetic conditions days. Unsettled geomagnetic condition days gave the higher values of CBV: 557 ± 202 mm/s. We suggest that geomagnetic fluctuations acting on blood, brain, adrenals involve the adaptation system. This leads to appearance in blood adrenals hormones that responsible for activation of the clotting system, rise in aggregation and spasm in the afferent vessels of the microcirculatory network.

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Space Weather in the Problem of Providing Radiation Safety of the Crews of the Manned Spacecraft

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The limitation of the irradiation of the crew of spacecraft by cosmic rays is one of the most conditions for the successful realization of space missions. For planning the countermeasures for providing of radiation safety it is necessary to know the radiation situation in the interplanetary and near-earth outer space and its forecast both to the nearest period (hours - week)

and the extended forecast, compared with the duration of cycle of solar activity. The dynamics of radiation fields in the interplanetary and near-earth outer space is determined by the sources of cosmic radiation (solar proton events - SPE, Earth radiation belts - ERB, galactic cosmic rays - GCR) and by electromagnetic conditions in the heliosphere and the magnetosphere, i.e., by space weather. Radiation component of this weather, necessary for the estimations of radiation hazard during space flight, includes the following information about the characteristics of radiation fields at the point of the trajectory of spacecraft and also the forecast of these characteristics: charge composition, the energy spectra of particles and their fluence during the period of exposure. Furthermore for the correct estimation of the radiation doses in organ of the body it is necessary to know angular distribution of the particles and dynamics of all enumerated values. The quantitative description of these factors and regularities is assigned by the model descriptions, which consider diverse astrophysical values - the characteristic of solar activity, the parameters of solar particle events, the degree of the perturbation of electromagnetic conditions in the interplanetary and in the near-earth space, etc. Using these models and results of the continuous monitoring of various indices of solar activity it is possible to prepare the forecasts of averaged doses of GCR by several years forward and a forecast of the averaged radiation characteristics of solar cosmic rays - SCR from the SPE appeared during the forecasted period of time. Forecast in each single SPE is based on the current physical manifestation of solar flare and registration of fluxes of SCR at the point of measurement. For describing the radiation fields in the near-earth space together with the parameters of particle fluxes of ERB large role they play the data about the geomagnetic storms, the defining both disturbances in ERB and the effect of geomagnetic restriction of GCR and SCR fluxes. The knowledge of current values of these characteristics of space weather and their forecasted values they are used for the calculations of the radiation doses of crewmembers, which determine the level of their radiation safety. In the proposed report the questions of the description of radiation conditions in the outer space, the methods of the short term and long-range forecasting of radiation fields and the connection of these factors with the characteristics of space weather are examined.

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Updates to the ESA Interplanetary and Planetary Radiation Model for Human Spaceflight

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Gaps in existing radiation environment and effects standards adversely affect human spaceflight developments. In the framework of the ESA project IPRAM (Interplanetary and Planetary Radiation Model for Human Spaceflight, ESA Contract No 4000106133/12/NL/AF), we investigate the most important drivers in the domain of interplanetary and planetary radiation environments, identifying appropriate data sources and modelling methods to address the needs of future interplanetary manned mission design and operation.

New radiation estimates have been compiled for missions to the Moon, Mars, and near-Earth asteroids, combining a comprehensive set of spacecraft and neutron monitor data with statistical models. A roadmap for future developments is presented, as well as a gap analysis of environment data and models of the radiation environment and effects on humans and spacecraft components.

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Modelling Satellite Interaction with Space Weather and Environment

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Detailed computer simulations of the interaction between satellites and space environment is now possible, thanks to the availability of today's computing resources, and advanced simulation algorithms. Several models have been developed over the years, and new ones continue to be created. The models used to design future missions and to interpret in situ measurements can account for realistic 3D geometry of satellites and their instruments. They can also account for many processes at play in satellite-space environment, including material properties, the effect of solar radiation, and fluxes of charged and neutral particles on satellite components. This talk will concentrate on recent developments and accomplishments made with PTetra, a 3D fully kinetic particle in cell (PIC) model to simulate satellite-space environment interaction. While initially intended for low Earth orbit (LEO) spacecraft-plasma interaction physics, PTetra has been upgraded

so as to better account for processes, such as secondary electron emission and photoelectron emission, of importance for spacecraft at higher altitudes or in the interplanetary solar wind. Examples are presented of benchmarking simulations in which results are compared with measurements made on DEMETER or in well controlled laboratory experiments. PTetra is also used to assess the effect of Earth magnetic field on possible aberrations in Swarm's Electric Field Instrument (EFI). These results are contributed as part of ESA's Swarm Calibration and Validation activity. Finally, PTetra results are presented as part of a concerted model cross-comparison and validation exercise sponsored by ISSI. This comparison between several model results obtained for a simplified satellite geometry, under well defined space environment conditions, is used to assess the level of confidence in model predictions.

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Space Weather During the Two Recent Solar Activity Minima.

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Space Research Centre Polish Academy of Sciences

Space weather conditions during solar activity minima between Cycles 22/23 and 23/24 are compared. Analysis of flaring activity, solar Active Region, CME, SEP productivity and X-ray flux variability in nine-month-long temporal intervals covering the last two minima is performed. The solar space weather indicators are next compared to geomagnetic indices characterizing the state of the Earth magnetosphere. Differences in space weather shaping factors for the last but one minimum and the recent unusually deep minimum between Cycle 23 and 24 are discussed. Effects of space weather events in the two analyzed periods on space-borne observations are shown.

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CMEs in the Inner Heliosphere - Propagation and Interaction with the Solar Wind

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The propagation behavior of coronal mass ejections (CMEs) in interplanetary (IP) space is mainly influenced by the ambient solar wind flow. The interaction of CMEs with the solar wind, as well as with other CMEs, can be expressed as drag force and manifests itself to decelerate CMEs that are faster than the ambient solar wind, whereas slower ones are accelerated until the CME speed is finally adjusted to the solar wind speed. This directly affects how strong the impact of a CME is on space weather.

With the SECCHI instrument suite aboard STEREO, CMEs can be observed during their entire propagation way from Sun to 1AU. In combination with in-situ measurements we are able to derive the direction and speed of a CME. We compare the kinematical behavior of well observed CME events in the IP distance regime with output from ENLIL (NASA/CCMC) MHD model runs of the background solar wind speed.

The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under grant agreements n°263252 [COMESEP] and n°284461 [eHEROES].

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The Role of Drifts in the Propagation of Solar Energetic Particles

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The radiation risk associated with Solar Energetic Particles (SEPs) poses a serious threat to humans involved in space exploration. A number of modelling approaches have been developed to predict SEP fluxes at various locations in space. The role of gradient and curvature drifts in cosmic ray transport within the heliosphere is a standard component of cosmic ray propagation models. However, the current paradigm of Solar Energetic Particle (SEP) propagation holds the effects of drifts to be negligible, and they are not accounted for in current SEP modelling efforts.

We present full-orbit test particle simulations of SEP propagation in interplanetary space which demonstrate that drifts perpendicular to the magnetic field can be significant. Thus, in many cases the assumption of field aligned propagation of SEPs may not be valid. We discuss the variation of drift effects with particle energy, co-latitude, and heavy ion species. The effect on the flux profiles of SEP events is also discussed. This paradigm shift has important consequences for the modelling of SEP events and is crucial to the understanding and interpretation of in-situ observations.
This work has received funding from the European Commission FP7 Project COMESEP (263252).

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Monte Carlo and Non-Monte-Carlo Techniques for SEP Statistical Model Generation and Assessment of Uncertainties

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Solar energetic particle (SEP) events present an important threat to the operation of spacecraft, as well as being of increasing concern to aviation safety from the perspective of flight control and radiobiological effects. Assessment of the risk from SEPs may involve the use of example events considered representative of a worst-case environment, with an assumed confidence that the environment will not be exceeded (e.g. the CREME96 models are based on the October 1989 event, and 99% confidence level). Alternatively, statistical models can be used, based on an analysis of the distribution of the event characteristic (e.g. event peak flux, fluence or duration), and integrating this distribution over the mission duration together with a representation of the probability per unit time of an event occurring at time t after the last event (the time distribution). Examples of statistical models include NASA's JPL, ESP and PSYCHIC models. Whilst the results of such models have been have been used to generate environment specifications for spacecraft design, there's been limited work addressing the influence of uncertainties in the SEP reference datasets used to build the models. In an activity sponsored in part under the ESA project ESHIEM (Energetic Solar Heavy Ion Environment Models), an analysis has been undertaken to assess the efficiency of different numerical integration techniques for SEP model generation, and methods for propagating uncertainties. Monte Carlo (MC) sampling, as used for the JPL model and updates (Feynman et al, 1993; Rosenqvist et al, 2005; Glover et al, 2008) as well as aspects of ESA's SEPEM system (Jiggens, 2012), is a standard and generally applicable method for integrating the time and event characteristic distributions over the mission duration. This technique provides a solution that is easy to conceptualise and implement into an algorithm, without requiring a detailed understanding of what would otherwise be a very complex, multidimensional numerical integration. However, the MC method for creating statistical models can be much less efficient computationally than standard numerical integration, and therefore, if it is also necessary to understand the influence of uncertainties in the reference datasets on the resulting statistical models, the computational requirements can become extremely high, depending upon the time distribution employed. This paper reports on the efficiencies of current standard (analogue) Monte Carlo approaches compared with variance reduction MC techniques that may be used to improve the statistical accuracy of the influence of larger, more impacting SEP events. These results are also compared with direct (non-MC) numerical integration, which are less flexible but often give a more direct and efficient method for quantifying uncertainties, and understanding of trends with event-fitted parameters. The results are applied to processed alpha-particle data from IMP8/GME and GOES/SEM instruments to demonstrate the influence on the resultant alpha-particle SEP statistical models, and the associated uncertainties in the models.

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Study of the Solar wind Effects on the Magnetosphere using Fully Kinetic Simulations

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For space weather applications, computer simulations have been extremely helpful in the analysis of detailed physical processes. Up until recently to study the effects of the global interaction between the solar wind and planetary magnetospheres the most commonly used numerical tool was MHD simulations. However, this approach is not well suited to analyze some important dissipation effects, since viscosity and resistivity are commonly described as phenomenological constants, ignoring the underlying kinetic effects. As a consequence, the physical processes responsible for important space plasma phenomena such as magnetic reconnection and diffusion are not accessible. To improve the quality of the simulations, Omidi et al. [1] showed that an hybrid description of the plasma interaction between the solar wind and dipolar

magnetosphere, at a global scale, can be performed. Such complex simulations were possible thanks to the use of an hybrid code in which the electrons are treated as a fluid and the ions as particles.

Herein, we go one step further: using the implicit moment Particle-in-Cell (PIC) code iPic3D (Markidis et al. [2]) we study the interaction between the solar wind and a dipolar magnetosphere using a fully kinetic description, where both electrons and ions are treated as particles. The simulation solves the coupled system of Maxwell and particle transport equations in a two dimensional domain of tens of planet radius in both directions around the planet, using a spatial resolution of the order of a fraction of the ion skin depth. Currently the number of global PIC simulations is still very limited worldwide and mainly based on explicit numerical schemes (Cai [3]). The present work is focused on 2D simulations based on a new implicit scheme which allows to use more realistic plasma parameters and to differentiate between processes at the electron and the ion scales. The results of this 2D simulation show the formation of the general features observed in planetary magnetospheres, including, magnetosheath, magnetotail, cusps and radiation belts. We analyze the new results in order to validate the code and to emphasize the features that are not accessible using MHD simulations.

Simulations were performed using the Curie and Fermi supercomputers, made available by the PRACE allocation SWEET. This work was also possible by the financial support of the European Commission through the FP7 projects SWIFF (reference number: 263340) and eHeroes (reference number: 284461).

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Space Debris in the Near-Earth Space: Impact on Space Missions Coronas-F and Coronas-Photon.

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Space debris represents one of the main hazards to manned flights and satellites. The estimated number of debris particles in the near-Earth space exceeds 300,000. Besides, this number can grow manyfold through the well-known Kessler syndrome. Though the largest objects can be successfully tracked and catalogued by means of ground radar and optical observations, the detection of objects smaller than 1 cm is complicated due to their faint visibility.

We propose a novel observing strategy of space debris with the use of optical orientation sensors, which most of space missions are equipped with. We have applied this method to datasets of optical sensors, that were installed on Russian space missions Coronas-F (2001 - 2005) and Coronas-Photon (2009). As a result we were able to detect objects as small as 1 mm, which approached to satellites closer than 1 km. Furthermore, we processed about 100,000 images of optical sensors and found over 600 such objects. For several of found objects we managed to calculate their orbital elements. The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under the grant agreement eHeroes (project n° 284461, www.eheroes.eu).

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Space Weather Impact on Aviation

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EUROCONTROL

Space weather can severely impact the earth infrastructure. As shown in the past, solar events are capable of damaging space vehicles, causing large power and communication grid failures, and degrading aviation's communications, navigation and surveillance systems. In addition to this, solar events can cause radiation levels being higher than usual which may lead to an excessive radiation dose for air travellers and crew but also may cause on board system failures. As a consequence, an extreme solar event would potentially impact European Air Traffic. EUROCONTROL, the European Organisation for the Safety of Air Navigation, has launched different projects in order to better assess the risk and define proportionate mitigations.

First, EUROCONTROL launched a project in 2009 to further assess the space weather impact on GNSS-based aviation operations. Indeed, aviation operations, including navigation and surveillance, rely more and more on GNSS services. GNSS performances under nominal ionosphere condition are already well known. However, before increasing reliance on these GNSS-based operations, the aviation community has to better assess GNSS performance under abnormal ionosphere conditions. Using existing GNSS ground station networks (IGS, EGNOS, EDCN, EUREF...), the ionosphere is monitored during the current period of maximum solar activity. These ionosphere measurements, in addition to the characterisation of past events, are being used to develop realistic ionosphere scenarios. These ionosphere scenarios have been evaluated using current and future GNSS receiver parameters and the impact of the ionosphere on the GNSS performance has been assessed. As a result, new mitigations means, either internal or external to the GNSS receiver, are being evaluated.

One such (organizational) mitigation is the European Aviation Crisis Coordination Cell (EACCC), which has identified space weather as a possible hazard for aviation. The EACCC has been established by the European Commission and EUROCONTROL and is composed of EASA, the EU Presidency and nominated representatives of airspace users, air navigation service providers (ANSPs), military and airports. To mitigate the space weather threat, appropriate plans are being developed which are focused on the provision of an early warning to the aviation community and continuous provision of reliable information during the space weather event. For that purpose, coordination between EUROCONTROL and space weather agencies and experts is being set up with organisations such as the US National Oceanic and Atmospheric Administration (NOAA) and the European Space Agency (ESA). Moreover, a number of airlines were approached to learn about operational practices in the event of increased space weather activity - particularly for flight operations over polar routes.

On the global level, International Civil Aviation Organisation has increased its recognition of space weather as a potential threat for the aviation and has mandated the International Airways Volcano Watch Operations Group (IAVWOPSG) to address space weather. This group aims at providing a framework and a standardization process that would allow airlines and other aircraft operators to make best use of the space weather information provided by space weather agencies and experts. EUROCONTROL took part in this process through the US Federal Aviation Agency – EUROCONTROL Memorandum of Cooperation. This MoC includes action plan 29 on meteorological issues, where space weather is included as an area of mutual interest. Consequently, action plan 29 provides a coordination mechanism and allows the development of appropriate joint positions relating to space weather.

This paper will briefly introduce the space weather impact on aviation and then, will further detail the EUROCONTROL activities on space weather. In addition, the space weather activities hosted by the International Civil Aviation Organisation (ICAO), the World Meteorological Organisation (WMO) and the European Aviation Safety Agency (EASA) will be highlighted.

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Space Weather Aspects - An Airline Pilots' perspective

Sievers, Klaus
Vereinigung Cockpit, Germany

This presentation focusses on an aviation, on a pilots' perspective on space weather. How is it experienced, what practical impact did space weather have in the past ?

A short overview of international efforts to find an appropriate way to deal with space weather is then presented. Practical examples of what space weather and radiation-warning information is available to pilots are given. Many information sources exist, but their products aren't standardized, and have yet to be developed to a point where they are compareable to aviation-standard weather information. Ideas and examples of how airlines can deal with space weather are presented.

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Space Weather and Aviation from the Perspectice of the European Aviation Safety Agency

Trautenberg, Hans
EASA

Space weather affects aviation in several dimensions:

- Effects on humans in the aircraft
- Effects on the equipment in the aircraft
- Effects on the communication and navigation systems external to the aircraft

EASA addresses these dimensions in certification, rulemaking, awareness campaigns and during a severe space weather event by contributing to the European Aviation Crisis Cell. The talk will elaborate on how EASA identifies and mitigates the risks arising from space weather effects in aviation and works together with other stakeholders to ensure a safe operation even during a space weather event.

Influence and Mitigation of Ionospheric Disturbances During Aircraft Precision Landing Approaches

Berdermann, Jens; Hlubek, Nikolai
German Aerospace Center (DLR)

Global Navigation Satellite Systems (GNSS) in combination with Ground Based Augmentation Systems (GBAS) allow precision landing approaches under normal ionospheric conditions. However, the ionosphere is subject to perturbations, due to the strong temporal and spatial variability of the ionospheric plasma. In particular ionospheric gradients and scintillations can prevent an aircraft precision approach since signal integrity cannot be ensured. Both perturbations are hard to predict and will lead to conditions, which are strongly deviate from the regular ionospheric behaviour.

While, to a certain extent, a disturbed ionosphere can be corrected by GBAS, these systems have difficulties in respect the disturbances mentioned above, i.e. ionospheric gradients and scintillations. To take into account ionospheric gradients, a threat model has been developed, which can estimate the worst case ionospheric threat from ionospheric gradients. This worst case is then added to the uncertainty of the positioning solution. We will discuss the threat model and its application to Germany.
While ionospheric gradients can be taken into account via the threat model, spontaneous signal scintillations are another big source of positioning uncertainty due to their random and uncorrelated nature. They can even lead to a complete loss of the signal in extreme cases. We will show that the new frequencies from Galileo and Glonass are also affected by signal scintillations.

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Space Weather Effects on Airline HF Radio Communications in the High Latitude Regions

Stocker, Alan[1]; Siddle, David[1]; Warrington, Mike[1]; Hallam, Jonathan[1]; Honary, Farideh[2]; Rogers, Neil[2]; Zaalov, Nikolay[3]; Boteler, David[4]; Danskin, Donald[4]

[1]University of Leicester; [2]University of Lancaster; [3]St. Petersburg State University; [4]Geological Survey of Canada

In some cases the shortest (and hence fastest and most economical) airline routes between cities (e.g. those on the eastern seaboard of the USA and those in China) cross the polar cap. In the polar regions, air traffic control relies on HF radio communications since ground-based VHF radio facilities are lacking (and are non-existent on the Russian side of the pole) and satellite communication systems are either not available or expensive to retrofit to current aircraft. Unfortunately, space weather can significantly affect the propagation of HF radio signals at these latitudes and the forecasting techniques currently employed by the airline industry are somewhat crude and overly conservative. In this paper, we will present some preliminary results from a new project that aims to provide forecasting of HF propagation characteristics for use by civilian airlines operating over polar routes. Previous work in this area [e.g. Stocker et al., 2007] has focussed on taking HF signal measurements (e.g. SNR, delay and Doppler spread, and direction of arrival) on a limited number of propagation paths and developing an ionospheric model that incorporates high latitude features (e.g. polar patches and arcs) which, when combined with raytracing, allows the broad characteristics of the observations to be reproduced [Warrington et al., 2012]. The new project will greatly extend this work and consists of a number of stages. Firstly, HF measurements from an extensive network of purpose built transmitters and receivers spanning the Arctic regions will be collected and analysed for a period covering the current (so far weak) solar maximum and part of the declining phase. In order to test a wide variety of scenarios, the propagation paths will have different characteristics, e.g. they will be of different lengths and cover different parts of the northern ionosphere (i.e. polar cap paths where both terminals are in the polar cap, trans-auroral paths, and sub-auroral paths) and observations will be taken at a range of HF frequencies. Simultaneously, high latitude absorption measurements utilising the Global Riometer Array (GLORIA) will be collected and analysed. Next, the observations of the signal characteristics (i.e. both reflection and absorption properties) will be related to prevailing space weather parameters. Furthermore, an auroral absorption prediction model based on solar wind and interplanetary data will be developed by Lancaster University taking into account the riometer observations. Algorithms for nowcasting and forecasting of radio propagation conditions for trans-polar aircraft will then be developed from the ionospheric model. In addition to the approach described above, the benefits of ground station diversity using both the experimental data and the models developed during the project will also be investigated. In this presentation, we will concentrate on the space weather effects on HF propagation.

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Warrington EM, Zaalov NY, Stocker AJ, Naylor JS, HF propagation modelling within the polar ionosphere, Radio Science, 47, Article number RS0L13, doi:10.1029/2011RS004909, 2012.

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Energetic Solar Cosmic Ray Events and their Effect on Radiation Exposure at Flight Altitudes

Flückiger, E.; Bütikofer, R.

University of Bern / HFSJG

During very energetic and intense solar energetic particle events, observed on Earth e.g. by ground-based cosmic ray detectors as Ground Level Enhancements (GLE), the radiation dose rates at flight altitudes can increase by orders of magnitude for a short time. Especially on polar routes the combined effects of Solar Cosmic Rays (SCR) and Galactic Cosmic Rays (GCR) may have the potential of becoming hazardous. In contrast to the radiation effects due to GCR, where a number of validated codes are available for flight dose assessments, procedures for the sporadic GLEs satisfying the needs of airline companies are still under development and evaluation (e.g. within EURADOS). At present, respective radiation dose rates are typically determined in post event analysis by computer models using as input SCR flux and anisotropy parameters that are derived from worldwide neutron monitor and/or satellite measurements. However, for a specific GLE, published SCR characteristics may vary considerably. This may lead to significant differences in the radiation exposure assessment. We will review the field and illustrate results of dose assessments for specific flights during selected GLEs. In particular, we

will compare published SCR characteristics for the GLEs on 15 April 2001 and 20 January 2005, and we will demonstrate the effect of discrepancies in these characteristics on flight dose calculations. In conclusion, we will discuss perspectives of improvements in SCR dose estimates.

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Radiation Monitoring of GLE on Board Commercial Flight

TROMPIER, François[1]; BONOTTE, Frank[2]; DESMARIS, Gérard[2]; BOTTOLLIER-DEPOIS, Jean-François[1]
[1]IRSN; [2]Air France

Dosimetry of aircrew is nowadays done routinely by calculation for a large number of aircrews among the world. This numerical approach has been validated by comparison with numerous on board measurements performed with adequate instrumentations such as Tissue Equivalent Proportionnal Counter (TEPC).This approach to assess the occupational exposure of aircrew is approved and recommended in many countries. In case of Solar proton event (SPE) classified as Ground Level Event (GLE), dose rates at flight altitudes can possibly increased, leading to an additional dose that has also to be taken account for aircrew dose records. Some routine dosimetry softwares give an estimation of these extra doses. Nevertheless, the models used for dosimetry are based or compared to very few sets of in flight measurements during GLE. There is obviously a clear need of additional data to improve the existing models. The dedicated instrumentations for aircrew and space dosimetry are rather expensive and need most of the time connection to on board power supply, regular maintenance... As a consequence, very few systems only are continuously operated on board commercial flights, limiting the probability to measure such events.

Thus, IRSN and Air France has launched a joint program for monitoring the GLE effect on the dose rate at flight altitude. The objective is to have at least 2 measurement devices flying at the same time on different routes.
The approach lies in selecting small electronic dosimeters that offer the advantage to be cheap , with a large battery autonomy (up to 6 months), and to discriminate neutron component and high LET particles from photon and low LET radiation, having a FIFO memory type (no limitation due to data storage). After installation on board, the dosimeters are collected and analyzed only in case of GLE. Such dosimeters are able to assess a 30% increase of dose rate. The easiness of installation and maintenance makes possible to install a significant number of devices on different commercial aircrafts. With a dozen of this type of dosimeter, it is possible to cover the main long haul route flights. As this type of dosimeters is not design for cosmic radiation, a specific calibration has been established by comparing data from electronic dosimeters with a reference instrumentation during a long haul flight.

In addition, this approach, based on measurements, makes also possible to estimate rapidly and accurately the effect of a GLE on dose rate and thus on additional dose by flight received by public and aircrew.

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Epidemiological Investigations of Aircrew - an Occupational Group with Low-Level Cosmic Radiation Exposure

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Leibniz-Institute for Prevention Research and Epidemiology - BIPS

Primary cosmic radiation from the depth of the universe interacts with atmospheric molecules, leading to the generation of neutrons and other charged particles at flight altitudes. Several factors determine the exposure of aircrew and passengers, among them flight altitude and flight trajectory as well as solar cycle. Annual effective doses for flight crew have been estimated to be in the order of 2-5mSv, with maximum lifetime doses usually below 100mSv. The recognition that aircrew is exposed to appreciable doses of cosmic ionizing radiation has motivated a fair number of epidemiological studies in this occupational group over the last 15-20 years, usually with a focus on radiation-associated cancer. The fact that aircrew is a highly selected group with many specific characteristics and exposures, among them disruption of the biological day-night rhythm, poses a major challenge for these investigations.

Both cancer incidence and mortality have been evaluated in large cohorts of cockpit and cabin crew in North America, Europe and several other countries. Cohort data from 9 European countries with follow-up into the late 1990ies were jointly analysed in the ESCAPE project, with an extended follow-up conducted in 2009. Nordic studies were jointly analysed

regarding cancer incidence. Some results showed consistency across most relevant studies: overall cancer risk was not elevated, while malignant melanoma (standardised incidence ratios SIR= 1.85, 95% CI 1.41-2.38), other skin cancers (2.47, 95% CI 1.18-4.53) and breast cancer in female aircrew (1.50, 95% CI 1.32-1.69) have shown elevated incidence (Pukkala et al. 2002, 2012), with lesser risk elevations in terms of mortality (Zeeb et al. 2003). In some studies including the large German cohort, brain cancer risk of cockpit crew appears elevated with a two-fold increase compared to the general population (Standardised Mortality Ratio SMR= 2.13, 95% CI 1.03-3.93) (Zeeb et al. 2010). Cardiovascular mortality risks were generally very low probably partly due to the so-called health worker effect.

Dose information in these studies was usually derived from reconstruction approaches based on routine licence information, types of aircraft and routes/hours flown, but not from direct measurements. However, dose estimates have shown high validity when compared with measured values. No clear cut dose-response patterns pointing to a higher risk for those with higher cumulative doses were found in statistical analyses. Overall, aircrew is exposed to low levels of ionizing radiation of cosmic origin, but radiation-associated health effects have not been clearly established.

A third follow-up of the large German cohort is currently in the planning stages to provide more robustness in the statistical analyses due to the extended follow-up period with regard to radiation-associated health effects. Routine dose monitoring data from the German radiation protection registry will be used for this study.

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The Impact of the Halloween Storms on Radiation Exposure in Aviation: 10 Years After

Meier, Matthias
DLR

Solar Particle Events (SPEs), which are often referred to as solar flares in aviator's jargon, can temporarily contribute to the radiation field at aviation altitudes and generate a significant increase in the corresponding dose rates. TV reported on these SPEs and gave rise to public awareness all over the world. Due to the public pressure some airlines even operated their flights at lower altitudes between 29th and 31st October 2003. This paper presents a case study of dealing with an SPE (GLE 65) concerning radiation protection in aviation during the Halloween solar storms.'

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ODI - Open Data Interface

Wintoft, Peter[1]; Heynderickx, Daniel[2]; Evans, Hugh[3]
[1]Swedish Institute of Space Physics; [2]DH Consultancy; [3]ESA/ESTEC

The Open Data Interface (ODI) is a database system for storing space environment data and metadata in an SQL database. The system is compliant with the SPASE data model. Data can be ingested from text files and CDF/ISTP/PRBEM files. Currently

there are more than 100 datasets in the database such as IMP8/GME, SREM, XMM/ERMD, GOES particle and radiation data, and indices such as Dst, Kp, and SSN. Adding new datasets is straightforward. Model and code have been developed to convert CDF metadata into SPASE metadata. The process proceeds in two steps where the metadata can be further edited before stored in the database. If the raw data to be ingested are CDF files these are automatically converted before the data are stored into ODI. For non-CDF files, like plain text files, a few lines of code need to be edited to correctly parse the raw data files. As ODI is based on SQL it is accessible to a large range of different software platforms. As part of the development, interfaces to IDL, PHP, Python, Matlab and Java have been developed, but the ODBC interface also can provide direct access from many other programs. Interfaces to existing platforms can therefore be set up and applications have been updated to connect to the ODI system like SAAPS, SEDAT, and SPENVIS.

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Integration of new Space Weather Services into the SSA Data Centre: Regional Aurora Forecast and Ionospheric Monitoring

Beltrami, Pablo[1]; Keil, Ralf[1]; Martinez, Unai[1]; Navarro, Vicente[2]; Kauristie, Kirsti[3]; Yaya, Philippe[4]; Béniguel, Yannick[5]
[1]etamax space GmbH; [2]ESA-ESAC; [3]FMI; [4]CLS; [5]IEEA

The Space Weather (SWE) Data Centre being developed in the frame of ESA's SSA pro-gramme is intended to provide a central Service Oriented Architecture framework capable of integrating new space weather services and tools. In the frame of the project DC-IV, "Evolution of the Pilot Data Centres", two new precursor services are being developed and integrated:

- The Regional Aurora Forecast (RAF) service. This service will provide maps depicting the current and forecasted current situation of an auroral occurrence in a given region together with visibility and cloudiness information.
- The Ionospheric Scintillation Monitoring (ISM) service providing nowcasted and forecasted worldwide and regional maps of ionospheric scintillations together with indices and alerts.

These services will make use of newly developed models and data assimilation techniques being developed within the project. They are implemented by the domain experts in the consortium and then integrated into the SSA data centre to make use of the available functionalities, such as data import and storage services and the SWE web portal. The main challenges of this task include:

The services to be integrated have not been developed with a SOA approach in mind. In the frame of the project all aspects relevant to the SSA's SOA infrastructure need to be addressed before the integration into the overall system architecture.

- Development of new user interfaces for the SWE web portal. The web portal will be extended to provide access to the functionalities provided by the new services. This will include both interfaces for external users and for the service administrators.
- Integration of the services and its interfaces into the COSIF. The services will be integrated into the SSA COSIF framework at Redu, Belgium, validated and tested to ensure the quality of the results.

In this presentation, an overview will be given on the new services being developed and on the approach being followed for their integration into the data centre. A description will be provided on how the available infrastructure of the SSA data centre can be used to implement a common platform for future developments.

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From the Sun to Earth (and beyond) - Cross-use of three FP7 Heliophysics Projects.

Perez-Suarez, David[1]; Tanskanen, Eija[1]; Kallio, Esa[1]; Pierantoni, Gabriele[2]
[1]Finnish Meteorological Institute; [2]Trinity College Dublin

Three complementary projects have been funded under the EC's Seventh Framework Programme (FP7) during the last years, namely HELIO, IMPEx and ESPAS. This presentation demonstrates how to proceed on a use case of studying an event produced on the Sun and gather all the information available on its travel through the heliosphere - helped by HELIO-, the observations in the magnetosphere - with the tools provided by IMPEx - and finally its effects on Earth (eg, ionosphere) - capability offered by ESPAS. The projects aim to help the interaction between communities which have evolved

independently over decades by creating a set of tools to find relevant datasets easily (and provide relevant metadata). The use of standards and workflow tools (eg., Taverna) simplifies this exercise by offering to the scientist a comprehensive view of the event under study.

In addition, it will be shown here the progress made by the ER-flow project for the heliophysics community. ER-flow is a FP7 project that builds community focused portals that run complex workflows.

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Surfing the Heliosphere: Integrating Heterogenous Data for Visualization, Browsing and Discovery

Ireland, Jack[1]; Stys, Jeffrey[1]; Hughitt, V. Keith[2]; Mueller, Daniel[3]
[1]ADNET Systems, Inc. / NASA's GSFC; [2]University of Maryland; [3]ESA

The Sun and heliosphere is a complex, connected system, observed by many different instruments. The data collected by these instruments is heterogenous, and can consist of images, time series, emission spectra, etc. Further, there are a number of feature and event catalogs, both manually and automatically populated, that describe discrete occurrences of physical phenomena, such as solar flares. These data have multiple uses, and multiple audiences who want to interrogate these data for different purposes.

This talk will describe our efforts in designing and implementing the Helioviewer Project, an ESA/NASA funded project to give users everywhere the capability to explore the Sun and inner heliosphere and to give transparent access to the underlying data. We describe our experience in creating browsing, visualization and discovery tools that present different data types from different data sources. We discuss the challenges that have arisen in integrating important services such as the Heliophysics Event Knowledgebase and the Virtual Solar Observatory into Helioviewer Project tools. Finally, we advocate the notion that interoperability is the key to creating a service ecosystem that not only promotes all existing tools for solar and space weather science and services, but can also nurture new ones.

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SEISOP, a System enabling Space Weather Services for the SSA

Angela, Rivera Campos; Esther, Parrilla-Endrino; Maria Jesús, Enríquez; Noelia, Sánchez; Sandra, Negrín
Elecnor Deimos

The Space Environment Information System to support Operations (SEISOP) is a data and knowledge system being developed by DEIMOS for the European Space Operations Center (ESOC) of the European Space Agency (ESA).

The objective of the SEISOP project is to provide to the mission operators, project teams, spacecraft development engineers and scientists a set of services capable to supply, extracted knowledge related to the Space Environment and its effects in the spacecraft as well as plug-in interfaces for new models.

This paper will present the innovate Service Oriented Architecture and technologies used to implement SEISOP and its deployment in the context of the European Situation Awareness Program (SSA) lead by ESA and will focus on the gathering and processing of data from different sources in order to make it available to users of the system in an standardized way.

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Swiff Approach to Basing Space Weather Forecasts on Fundamental Physics Models

Lapenta, Giovanni[1]; Swiff Consortium, EC-FP7 Network[2]
[1]KU Leuven; [2]Swiff

Swiff is a project funded by the European Commission FP7 program. Swiff is chartered with the task of space weather forecasts on fundamental physics models. We will present three examples developed by Swiff partners:

First, SEP are generated by macroscopic events such as flares and CMES that are typically modeled by fluid models that do not retain a full kinetic description of the particle life. Statistical or empirical models are then deployed to represent the generation of SEP from a certain event. The Swiff approach is to interlock directly kinetic and fluid simulations so that the particles and the fields are advanced self consistently. This is crucial because particle acceleration in shocks and reconnection regions are very sensitive to wave particle interactions that require a self-consistent treatment of fields and particles. The approach is used in Ref. 1.

Second, global models of the Earth environment typically rely on fluid MHD and in the most advanced cases on hybrid (fluid electrons and kinetic ions). Swiff has developed a pioneering approach for a full kinetic approach: the implicit moment method [2,3] implemented in the code iPic3D [4]. We will report 2D and 3D models of the global magnetosphere based on a full kinetic model where both electrons and ions are kinetic and driven by solar wind drive as can be obtained either from models of the heliosphere (e.g. ENLIL) or direct data (e.g. ACE).

Third, general space weather models require to couple many methods and codes. Swiff started a collaboration in particular with the Space Weather Modelling Framework (SWMF) based in Michigan and is working to import the iPic3D in the SWMF framework. A first demonstration of coupling the code BATS'R'US with iPic3D was demonstrated at the annual meeting at EGU in Vienna [5]. The approach demonstrated the ability to resolve fully kinetically regions of reconnections fully coupled within a larger fluid model.

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Accessing Near-Earth Space Data through the ESPAS e-Science System: Design and Demonstration of first Working Prototype

Ventouras, Spiros[1]; Belehaki, Anna[2]; Hapgood, Mike[1]; Lebesis, Antonis[3]
[1]RAL; [2]National Observatory of Athens; [3]ATHENA Research and Innocation Center

The aim of ESPAS platform is to integrate heterogeneous data from the earth's thermosphere, ionosphere, plasmasphere and magnetosphere. ESPAS supports the systematic exploration of multipoint measurements from the near-Earth space through homogenised access to multi-instrument data. It provides access to more than 40 datasets: Cluster, EISCAT, GIRO, DIAS, SWACI, CHAMP, SuperDARN, FPI, magnetometers INGV, SGO, DTU, IMAGE, TGO, IMAGE/RPI, ACE, SOHO, PROBA2, NOAA/POES, etc. The concept of extensibility to new data sets is an important element in the ESPAS architecture. Within the first year of the project, the main components of the system have been developed, namely, the data model, the XML schemas for metadata exchange format, the ontology, the wrapper installed at the data nodes so that the main platform harvest the metadata, the main platform built on the D-NET framework and the GUI with its designed workflows. The first working prototype supports the search for datasets among a selected number of databases (i.e., EDAM, DIAS, Cluster, SWACI data). The next immediate step would be the implementation of search for characteristics within the datasets. For the second release we are planning to deploy tools for conjunctions between ground-space and space-space and for coincidences. For the final phase of the project the ESPAS infrastructure will be extensively tested through the application of several use cases, designed to serve the needs of the wide interdisciplinary users and producers communities, such as the ionospheric, thermospheric, magnetospheric, space weather and space climate communities, the geophysics community, the space communications engineering, HF users, satellite operators, navigation and surveillance systems, and space agencies. The final ESPAS platform is expected to be delivered in 2015.

The abstract is submitted on behalf of the ESPAS-FP7EU team (http://www.espas-fp7.eu): Mike Hapgood, Anna Belehaki, Spiros Ventouras, Natalia Manola, Antonis Lebesis, Bruno Zolesi, Tatjana Gerzen, Ingemar Häggstrom, Anna Charisi, Ivan

Galkin, Jurgen Watermann, Jesse Andries, Matthew Angling, Timo Asikainen, Alan Aylward, Henrike Barkmann, Peter Bergqvist, Andrew Bushell, Fabien Darrouzet, Dimitris Dialetis, Carl-Fredrik Enell, Daniel Heynderickx, Norbert Jakowski, Magnar Johnsen, Jean Lilensten, Ian McCrea, Kalevi Mursula, Bogdan Nicula, Michael Pezzopane, Viviane Pierrard, Bodo Reinisch, Bernd Ritschel, Luca Spogli, Iwona Stanislawska, Claudia Stolle, Eija Tanskanen, Ioanna Tsagouri, Esa Turunen, Thomas Ulich, Matthew Wild, Tim Yeoman

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The ESA Virtual Space Weather Modelling Centre - Phase 1B

Poedts, Stefaan[1]; Lapenta, Giovanni[1]; Deconinck, Herman[2]; Lani, Andrea[2]; Fontaine, Bernard[3]; Depauw, Jan[3]; Diet, Fabian[3]; Diep, Ho Hgoc[3]; Mihalache, Nicolae[3]; Heynderickx, Daniel[4]; De Keyser, Johan[5]; Crosby, Norma[5]; Rodriguez, Luciano[6]; Van der Linden, Ronald[6]

[1]KU Leuven/CmPA; [2]VKI; [3]Space Applications; [4]DHConsultancy; [5]BIRA-IASB; [6]ROB

The ESA ITT project (AO/1-6738/11/NL/AT) - to develop Phase 1 of a Virtual Space Weather Modelling Centre - has the following objectives and scope:

1. The construction of a long term (~10 yrs) plan for the future development of a European virtual space weather modelling centre consisting of a new 'open' and distributed framework for the coupling of physics based models for space weather phenomena;
2. The assessment of model capabilities and the amount of work required to make them operational by integrating them in this framework and the identification of computing and networking requirements to do so.
3. The design of a system to enable models and other components to be installed locally or geographically distributed and the creation of a validation plan including a system of metrics for testing results.

The consortium that took up this challenge involves: 1)the Katholieke Universiteit Leuven (Prime Contractor, coordinator: Prof. S. Poedts); 2) the Belgian Institute for Space Aeronomy (BIRA-IASB); 3) the Royal Observatory of Belgium (ROB); 4) the Von Karman Institute (VKI); 5) DH Consultancy (DHC); 6) Space Applications Services (SAS). The project started on May 14 2012 and will take 24 months for completion. In November 2013, Phase 1B will be ongoing which means that the blueprint of the framework is ready, the implementation of the VSWMC Framework Prototype software has been finalized and the models are being adapted and packaged in such a way that they become usable in the Prototype VSWMC System. A status report will be given here.

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Why would a Modeller Take the trouble to Comply with a Shared Modelling Framework?

De Keyser, Johan[1]; Gamby, Emmanuel[1]; Kruglanski, Michel[1]; Poedts, Stefaan[2]; Lapenta, Giovanni[2]; Lani, Andrea[3]; Deconinck, Herman[3]; Heynderickx, Daniël[4]

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ESA invests in model execution environments such as Vispanet, SPENVIS, and the VSWMC. In the U.S., NASA operates CCMC, but there are also collaborations based on the Space Weather Modelling Framework and on the Center for Integrated Space Weather Modelling Framework. But why would a modeller actually take the trouble to comply with such a common modelling framework? Indeed, this requires a considerable investment of time. In general, the model computations may also incur a computational overhead. We will therefore review a number of good reasons and benefits that could convince model developers to comply with a shared modelling framework, but this puts some requirements on the framework.

A first objective is to minimise the effort for the modeller. The framework should operate based on a clear definition of the data structures to be read or written, or to be exchanged with other models, so that it is actually self-documenting. A minimum coding effort should be needed to comply with the framework. A development environment must be provided that includes testing and debugging facilities for contributed models, e.g. for monitoring the data flows.

A second objective is to maximise the return to the modeller. A modelling framework can provide model performance metrics, so that the modeller himself no longer has to invest in implementing such an infrastructure. Using a common framework, a modeller can easily collaborate with others in a modular approach to multi-physics modelling. The framework can provide a flexible way of swapping models in a coupled model set, which would allow to evaluate model performance from the scientific point of view through comparative studies. This allows a modeller to easily compare and evaluate various versions and improvements to his model. Being able to incorporate one's model into a more complete description of the problem at hand will heighten the modellers awareness of the qualities and limitations of his model, which is likely to benefit space weather modelling in general and to bring the scientist closer to the end user application. In addition, the modeller will get useful feedback on possible improvements.

Current efforts in the community, such as ESA's Virtual Space Weather Modelling Centre, envisage to provide this kind of support, at least in the long run.

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Debate on the Future of Infrastructures

Csillaghy, Andre[1]; Heynderickx, Daniel[2]; Nicula, Bogdan[3]
[1]FHNW; [2]DH Consultancy; [3]OMA

For session 12 we intend to organize a debate on the future of the infrastructures supporting space weather science and services. The debate will consist of a 10 minutes presentation by the session conveners, followed by targeted questions to session speakers and to the public. This debate will last 30 minutes.

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A Generic Description of Planetary Aurora

De Keyser, Johan; Maggiolo, Romain; Maes, Lukas
Belgian Institute for Space Aeronomy

A comparative study of the magnetospheres of the planets in our own Solar System helps to gain insight into the generic mechanisms that drive aurora. In this discussion, we will limit ourselves to quasi-static aurora. Even a relatively simple model is able to describe the variety of auroral generators found in the Earth's magnetosphere, but also in that of the gas giants. From current continuity one can infer a number of properties of the auroral circuit, of the particle precipitation associated with it, and also of the resulting ionospheric outflow. The auroral emissions are further determined by the composition of the ionosphere of the planet. We will propose a classification of different types of magnetised planets and explain how their properties determine the nature of the auroras that can be expected. Auroral emission may, eventually, be detected in exoplanet atmospheres and in such cases it would provide information on atmospheric composition.

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Airglow and Auroral Emission from Ganymede

Barthelemy, Mathieu[1]; Cessateur, Gael[2]; Abisset, Antoine[3]
[1]UJF/CNRS; [2]Physikalisch-Meteorilogisches Observatorium Davos / World Radiation Center; [3]IPAG; UJF/CNRS

In term of space environment Ganymede is a unique object in the solar system. Its own magnetic field in the jovian magnetosphere gives rise to particles precipitation. Although these object have a very faint atmosphere, their exosphere can show some emissions features due to both solar UV flux and precipitating particles. We recently calculated the effects of the solar UV flux (Cessateur et al 2012). However, in the case of the polar region of Ganymede the precipitating electrons play an important role in the emission features as measured by Hall et al. (1997) and Feldman (2000) for the O 130 nm triplet. To calculate these emissions, we use the atmospheric model produced by Marconi (2007). We use a simple primary ionization calculation. This is justified by the fact that the atmosphere is essentially non collisionnal except at very low altitudes and latitudes.For the solar UV flux, we used the configuration already explained in Cessateur et al. (2012). For the electrons, we used several type of spectrum. By comparison between the data of Feldman et al., we hope to constraint the electrons fluxes precipitating in the atmosphere of Ganymede. These calculations give strong information on the processes involved in the

Ganymede environment. In particular, we will be able to produce constraints on the electrons spectrum precipitating in Ganymede atmosphere.

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Satellite Retrieved Cloud Data Limitations and the Evaluation of a Solar - Cloud Llink

Calogovic, Jasa
Faculty of Geodesy

A hypothesized link between the solar-modulated cosmic ray (CR) flux and the Earth's cloud properties is still the subject of intense debate. Numerous authors have examined a hypothesized link between CR and clouds during Forbush decrease events using daily timescale epoch-superpositional (composite) methods. However, such studies have arrived at a range of conflicting results. Using extensive Monte Carlo simulation techniques, we demonstrate that for the two most widely used satellite cloud datasets, the International Satellite Cloud Climatology Project (ISCCP) and the MODerate Resolution Imaging Spectroradiometer (MODIS), high noise levels present in composites of small sample sizes or and/or overly isolated sample areas, coupled with incorrect methods of assessing significance may account for the inconsistent results. From our quantification of sample uncertainty we review some of the important investigations which have claimed to identify a significant solar - cloud link, and conclude that no strong evidence to support this hypothesis has yet been identified from satellite observations.

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Longterm Reconstruction of the Solar EUV for Planetary Science Applications

Haberreiter, Margit[1]; Beer, Jürg[2]; Delouille, Veronique[3]; Mampaey, Benjamin[3]; Verbeeck, Cis[3]; Schmutz, Werner[1]
[1]PMOD/WRC; [2]EAWAG; [3]ROB

Variations of the solar irradiance determine the temperature, density, and composition of any planetary atmosphere. For our understanding of the longterm changes of planetary atmospheres it is important to be able to provide realistic variations of the EUV. Here, we present first preliminary results of the longterm reconstruction of the solar EUV since 1610. This work is based on the one hand on segmentation maps of EIT images for the SOHO era. Synthetic spectra, emitted by the identified coronal features, are weighted by the filling factors derived from the segmentation maps, yielding the variations of the EUV for Solar Cycle 23. Moreover, for the reconstruction of the EUV since the Maunder Minimum we use the cosmogenic isotopes determined from ice cores along with the Sunspot number and neutron monitor data following the approach by Shapiro et al., 2011. The results will be compared to existing EUV reconstructions and their potential for planetary applications will be outlined.

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Where and how much is Solar Irradiance increasing during Flare ?

Kretzschmar, Matthieu
LPC2E, CNRS & University of Orléans

Solar and stellar flares impact the atmosphere of planets through electromagnetic radiation and particles. The lack of simultaneous observations at all wavelengths as well as very different contrasts over the spectrum make the spectral distribution of the flare energy still poorly known, while it is essential for characterizing their impact on planetary atmospheres. In this study, we will use different datasets to address this question. In particular, we will present a statistical analysis of solar flares observed by the EUV variability experiment (EVE) onboard SDO and quantify the energy released at various wavelength relevant for space weather. Our results suggest that most of the flare energy goes into the visible range as well as at very short wavelengths.

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What is the Contribution of Different Magnetic Structures to the Solar Spectral Irradiance Variability?

Vuets, Anatoly; Dudok de Wit, Thierry; Kretzschmar, Matthieu
LPC2E

The solar radiative output in the UV and Extreme-UV (EUV) is a crucial quantity for space weather applications that require a specification of the thermosphere/ionosphere system, but also for the forcing of climate. Numerous studies have shown that the salient features of the solar spectral variability can be reconstructed from the evolution of the photospheric magnetic field.
We make an empirical study on how the irradiance in different spectral regions is related to characteristic classes of magnetic structures based on their size and intensity.

In particular we build proxy time series based on magnetograms that best describe UV and EUV variations. These proxies are used to model solar spectral irradiance variability and allow to make a reconstruction when no observations are available. Employing of synoptic map images allows us to forecast solar spectral irradiance with a horizon of 1 month.

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The PREMOS/PICARD Radiometer: An Overview after 3 Years of Observations

Cessateur, Gaël; Shapiro, Alexander; Schmutz, Werner
PMOD/WRC

Total and Spectral Solar Irradiance are key input parameters to atmospheric/oceanic and space weather models. We present here spectral solar irradiance data from the radiometer PREMOS onboard the PICARD satellite for three years. This instrument covers the solar spectrum from the Ultraviolet to near-infrared, and provide valuable information, which helps to constrain theoretical models.

An overview of the results involving PREMOS observations will be presentedincluding analysis of several solar eclipses and variability modeling. The analysis of eclipse observations allows us to accurately retrieve the center-to-limb variations (CLV) of the solar brightness. We use radiative transfer code COSI to model the variability of the irradiance, assuming that the latter is determined by the evolution of the solar surface magnetic field as seen with SDO/HMI data. A direct comparison shows a very good correlation for mostof channels from PREMOS.

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The Comparison of Solar and Stellar Variabilities

Shapiro, Alexander; Schmutz, Werner; Cessateur, Gael; Rozanov, Eugene
PMOD/WRC

Monitoring of the photometric and chromospheric HK emission data series of stars similar to the Sun in average activity level and age showed that there is a correlation between the stellar average chromospheric activity level and photometric variability. We aim to understand whether the Sun obeys the empirical relationship prompted by the stellar data and to identify possible reasons for the Sun to be currently outside of this relationship. Our analysis suggests that although present solar variability is significantly smaller than indicated by the stellar data, the temporal mean solar variability might be in agreement with the stellar data.

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Space Weather Warnings: When Should Operators Really Be Worried?

Monham, Andrew
EUMETSAT

As a spacecraft operator for the provision of high availability meteorological data services, EUMETSAT is finding itself increasingly bombarded with media reports of impending crisis, based upon detection of solar flares or coronal mass ejections. These reports tend to create a climate of uncertainty in the user community and across the organisation, evidenced by many enquiries as to what is going to be done to secure our space assets. From the operational perspective, the answer is consistently "do nothing". The benefit of the doubt is given to the assumed robustness of the satellite design and no protective counter measures are taken. Time and time again, the cry of "Wolf!" is heard, but to no consequence. But will the wolf really appear one day only to be ignored?

We are assuming the satellite is sufficiently radiation hardened, but would it cope with a once in a hundred years magnitude event, an event never seen before in the space age? Considering that a typical EUMETSAT programme may last two to three decades and service continuity capability may be impacted after the loss of a single satellite, operators need to understand the limitations of their satellite design more clearly.

Related to this, the operators also need to be able to comprehend the threat level posed by the space weather event in order to assess the possible impact on the spacecraft and have a clear decision process in place for taking counter measures. A comparison with the situation with debris avoidance is made, where the situation is well parameterised and uncertainty levels are given on the conjunction predictions, allowing a probabilistic analysis to be performed and thresholds set for taking avoiding actions or not. Can such a parameterisation and risk assessment process for space weather events be achieved?

As EUMETSAT is set to increase the number of GEO and LEO satellites in orbit in the coming years, and world communities are increasingly reliant on our data, we are examining how we can move towards a clear space weather operational risk management process.

Examples of EUMETSAT experience of space weather effects, as well as cooperative activities with partners are provided as background.

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Space Environment Impacts on Geostationary Communications Satellites: Amplifier Anomalies and Solar Array Degradation

Lohmeyer, Whitney; Cahoy, Kerri
MIT

Energetic particles in our space environment can damage geostationary communications satellite systems. However, it is difficult to obtain satellite telemetry, which is required to accurately understand the causal relationship of space weather and satellite performance and to quantify the actual effects of the space environment on these satellites. We approach this challenge by teaming with two communications satellite operators, Inmarsat and Telenor, to acquire telemetry data. We analyze more than one million operational hours (~7 GB) of telemetry, and focus on amplifier anomalies and solar array degradation. For eight Inmarsat satellites, we compare 665,112 operational hours of housekeeping telemetry from two generations of satellites, designated Fleet A and Fleet B. Each fleet experienced thirteen solid-state power amplifier (SSPA) anomalies for a total of 26 anomalies from 1996 to 2012. We also collaborate with Telenor to analyze 344,496 operational hours of satellite telemetry from four unique satellites operating between 1997-2012. The Telenor satellites are equipped with a different type of amplifier, known as a traveling wave tube amplifier (TWTA). Our goals are to investigate possible relationships between the space weather environment, in terms of low-energy electrons, the Kp index, high-energy protons and electrons, and galactic cosmic rays, and the performance of geostationary communication satellites. Similarly, we wish to determine whether geostationary communication satellite telemetry can be used to infer observations of the space environment. We obtain space environment data from the OMNI2 database, the Geostationary Operational Environmental Satellite (GOES), the Solar Influences Data Center, and Los Alamos National Labs (LANL) geostationary satellites. We compare this data with the Inmarsat and Telenor telemetry to statistically understand the space environment at the time of anomalies, and for periods of up to two weeks prior to each of the satellite anomalies. We also examine the satellite telemetry, not just

at the time of known anomalies, but as a comprehensive data set on its own, to assess whether satellite telemetry can accurately relay information on space environment activity and provide more subtle information about the satellite system itself. The goal of this work is to use geostationary satellite telemetry to better understand the effects of space weather on satellite systems to improve satellite performance as well as current and future satellite design.

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Connecting the Other 3 Billion in a Relatively Unknown Space Radiation Environment

Robert, Morris
O3b Networks USA LLC

O3b Networks was founded in November 2007 to provide broadband connectivity to the "other 3 billion" who are without low latency access. As such, the constellation altitude was established such that the signal latency enables the end user to have the "feel" of fiber speed but with the reach of a satellite. The constellation orbit has an altitude of approximately 8,069 km about the equator. This relatively unknown region of the space environment required exceptional anticipation of the radiation environment and a conservative comprehensive satellite design all within reasonable economic constraints. The presentation shall review the developmental approach for the O3b satellite with respect to the radiation environment as well as the current design implementation status.

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A Case for Miniature Targeted Space Weather Sensors

Likar, Justin; Bogorad, Alexander; Lombardi, Robert; Herschitz, Roman
Lockheed Martin Space Systems Company

Operation of miniaturized targeted space weather sensors aboard modern spacecraft adds value for all entities associated with space environment characterization or modeling, spacecraft operation, cost-optimized spacecraft design, and space weather situational awareness via,

- Real-time situational awareness, anomaly detection, and resolution.
- In situ natural environment characterization in the presence of the spacecraft.
- Spacecraft-influenced or spacecraft generated environment characterization.
- Increased spatial and temporal fidelity in improved environmental models and tools such as AE9 / AP9.

A burgeoning small satellite (1 kg to 1000 kg) market, increased access to space, decreased size, weight, power, and cost of capable space environment or interaction detectors / instruments, and increased recognition of space weather impacts has resulted in a growing catalog of useful sensors whereby the challenge shifts to ensuring the sensors are flown - correctly - and data managed, disseminated, and utilized in a productive manner.

Lockheed Martin Space Systems Company (LM SSC) has, collaboratively with spacecraft operators, operated a suite of targeted space weather sensors at geostationary orbit that has accumulated more than 75 equivalent-spacecraft-years on-orbit operation [1, 2]. A technical, and business-case, review of LM SSC sensors will be used to demonstrate a favorable Return On Investment (ROI) for modern spacecraft operators and manufacturers seeking increased technical capability / complexity, high reliability, and low-cost.

The recent release of the AE9 and AP9 next generation natural space radiation environment model [3] (Ver. 1.04.001) enables spacecraft designers to probabilistically assess space radiation-related risks associated with space vehicle design. Initial published comparisons [3, 4] have yielded insightful results pertinent to spacecraft designers or operators seeking to optimize mission costs via low-thrust, or "All Electric", transfer to GEO (e.g. telecommunications missions) or MEO (e.g. navigation missions) or performing mission operations in such orbital locations. Candidly stated, we endeavor to place spacecraft, for increasingly longer durations, in regions where the best models are predicting a more severe environment. The present manuscript further illustrates the utility of distributed, targeted sensing by the inclusion of a general trade study, comparing trapped particle environments as determined by AE9 / AP9 and predecessor state-of-the-art models. The example

trade studies also consider design and operational impacts associated with radiation dose and high-level design aspects of a modern spacecraft implementing a low-thrust, "All EP" transfer mission to MEO or GEO.

1. Bogorad, A. L, et al. "On-Orbit Total Dose Measurements from 1998 to 2007 using pFET Dosimeters." Presented at 47th IEEE Nuclear and Space Radiation Effects Conference, 2010.
2. Likar, J. J., et al. "Geosynchronous ESD Environment Characterization via in situ Measurements on Host Spacecraft." Presented at IEEE International Symposium on EMC, 2011.
3. Huston, S. L., et al. "Comparisons of AE9 and AP9 with Legacy Trapped Radiation Models". Accepted for presentation at 50th IEEE Nuclear and Space Radiation Effects Conference, 2013.
4. Lindstrom, C. D., et al. "Enhanced Proton Levels in Slot Region and Displacement Damage Effects on Solar Arrays." Presented at AGU Fall Meeting, 2012.

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The COMESEP Space Weather Alert System

Rodriguez, Luciano[1]; Devos, Andy[1]; Bourgoignie, Bram[1]; Kraaikamp, Emil[1]; Nicula, Bogdan[1]; Bonte, Katrien[2]; Verbeeck, Cis[1]; Crosby, Norma[3]; Dierckxsens, Mark[3]; Calders, Stijn[3]; Kruglanski, Michel[3]; Veronig, Astrid[4]; Rotter, Thomas[4]; Temmer, Manuela[4]; Vrsnak, Bojan[5]; Dumbovic, Mateja[5]; Zic, Tomislav[5]; Calogovic, Jasa[5]; Vennerstrom, Susanne[6]; Kristoffer, Leer[6]; Malandraki, Olga[7]; Tziotziou, Kostas[7]; Patsou, Ioanna[7]; Lygeros, Nikos[7]; Dalla, Silvia[8]; Marsh, Mike[8]; Robbrecht, Eva[1]
[1]Royal Observatory of Belgium; [2]Centre for mathematical Plasma-Astrophysics, KU Leuven; [3]Belgian Institue for Space Aeronomy; [4]University of Graz; [5]Hvar Observatory; [6]Technical University of Denmark; [7]National Observatory of Athens; [8]University of Central Lancashire

COMESEP is a new European space weather alert system. It consists of several interconnected tools that work together to analyse data and automatically provide alerts for geomagnetic storms and SEP radiation storms. The system is triggered by different solar phenomena, such as CMEs, solar flares and coronal holes. After the automatic detection in solar data of any of these transients, the different modules of the system communicate in order to exchange information. For example, an automatic CME detection (by CACTus) triggers the drag-based model of CME propagation in order to calculate arrival times to Earth. A database of model runs of a test particle SEP model is consulted to generate an SEP radiation forecast. Overall the system produces a series of coherent alerts that are then displayed online. In this talk the different tools and the general functioning of the system will be presented. This work has received funding from the European Commission FP7 Project COMESEP (263252).

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Potential Operational uses for Directional Observations of Solar Proton Fluxes at Geostationary Orbit

Rodriguez, Juan[1]; Mazur, Joseph[2]; Green, Janet[3]; Kress, Brian[4]
[1]University of Colorado; [2]The Aerospace Corporation; [3]National Oceanic and Atmospheric Administration; [4]Dartmouth College

As stated in 1975, the original purpose of the U. S. National Oceanic and Atmospheric Administration (NOAA) in flying solar proton monitors at geostationary orbit was 'to monitor the radiation hazard to manned and unmanned operations in space, and the ionospheric effects at high latitudes, from solar protons and alpha particles produced during large flares.' These ends remain essentially unaltered; the successors to the original instruments continue to support the Solar Radiation Storm alerts issued by NOAA. The goal of the work reported here is to determine whether the directionality of current and future Geostationary Operational Environmental Satellite (GOES) solar proton measurements can be exploited to provide support to spacecraft operators beyond that currently provided by NOAA. Potential operational uses of this directionality include (1) more precise specification of solar proton fluxes at geostationary orbit and (2) real-time specification of solar proton fluxes inside geostationary orbit for enhanced situational awareness. Through GOES-7, the NOAA geostationary satellites were spin stabilized, and although the solar proton monitors were directional, their accumulation time was much longer than the satellite spin period, resulting in an approximately omnidirectional average of solar proton fluxes. Thus, for example, the October 1989 GOES solar proton fluxes used to define extreme proton events for spacecraft designers were effectively omnidirectional. Such is not the case with measurements from subsequent GOES satellites, which have been three-axis stabilized. The directional nature of these observations, often exhibiting pronounced east-west anisotropies, is now clear, as is their non-local nature, owing to the finite gyroradii (of order 1 Earth radius) of solar energetic protons at geostationary

orbit. Starting with GOES-13, two solar proton detectors are flown on each satellite, one looking westward and one looking eastward. While the westward-observed fluxes are usually little affected by the cutoff effects of the geomagnetic field and therefore are used by SWPC for real-time alerts, the eastward-observed fluxes are strongly affected by magnetospheric currents associated with storms and substorms as well as the pressure balance between the solar wind and the magnetosphere. Therefore, future environmental specifications based on the directional GOES observations may benefit by accounting for the observed anisotropies. The non-local nature of the observations implies that GOES eastward observations are equivalent to remotely sensing some point well inside geostationary orbit and are therefore referred to as 'inner fluxes'. The location of these 'inner fluxes' has been investigated by comparing the GOES fluxes with solar proton fluxes measured on the NASA Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX), NOAA Polar Operational Environmental Satellites (POES) and EUMETSAT MetOp satellites in low-earth polar orbits (whose data latencies of order one orbital period inhibit real-time usage). Under relatively quiet conditions, such as those observed prior to the arrival of the shock ahead of the coronal mass ejection(CME), the GOES 'inner fluxes' match the fluxes in low-earth-orbit in a narrow geomagnetic latitude band around 65 degrees, with a weak day-night latitudinal asymmetry. If the solar wind dynamic pressure carried by the shock increases above 5 nPa, the dayside inner flux latitudes can increase up to 10 deg and the nightside inner flux latitudes decrease up to 5 deg, exhibiting a strong day-night asymmetry. The decrease in the ring current index Dst during the main phase of a geomagnetic storm is associated with a decrease in both the dayside and nightside inner flux latitudes. Therefore, a successful 'nowcast' of solar proton fluxes in the inner magnetosphere based on the GOES eastward solar proton observations will require ancillary real-time Dst and solar wind plasma data, or some proxy for these quantities, and will account for day-night asymmetries.

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Low Energy Electrons (5-50 keV) in the Inner Magnetosphere

Ganushkina, Natalia[1]; Amariutei, Olga[1]; Pitchford, David[2]; Liemohn, Michael[3]

[1]Finnish Meteorological Institute; [2]Power/Thermal Subsystems \& Spacecraft Survivability, SES ENGINEERING; [3]University of Michigan, Ann Arbor, MI

The fluxes of low energy electrons with energies from about 5 to 50 keV are not usually analyzed in details when studying electron radiation belts. These fluxes constitute the low energy part of the seed population which is critically important for the radiation belt dynamics. Radiation belt models need to specify the flux at a low energy boundary at all L shells. Moreover, energetic electrons with energies less than about 100 keV are responsible for such a hazardous charging phenomena as surface charging. The electron flux at these energies varies significantly with geomagnetic activity and even during quiet time periods.

Transport and acceleration of the low energy (5-50 keV) electrons from the plasma sheet to geostationary orbit were investigated. We modeled one rather quiet, non-storm event on November 24-30, 2011, when the presence of isolated substorms was seen in AE index. We used the Inner Magnetosphere Particle Transport and Acceleration Model (IMPTAM) with the boundary at 10 R_E with Tsyganenko and Mukai boundary conditions for the electrons in the plasma sheet. The output of the IMPTAM modeling was compared to the observed electron fluxes in ten energy ranges (from 5 to 50 keV) measured onboard the AMC 12 geostationary spacecraft by the CEASE II ESA instrument. The variations of fluxes as observed by CEASE II ESA instrument onboard AMC 12 satellite during non-storm period are due to substorm activity. The behavior of the fluxes depends on the electron energy. We introduced the substorm-associated electromagnetic fields by launching several pulses at the substorm onsets during the modeled period. The IMPTAM driven by the observed parameters such as IMF By and Bz, solar wind velocity, number density and dynamic pressure and Dst index was not able to reproduce the observed peaks in the electron fluxes, when no significant variations are present in those parameters. The observed variations in the electron fluxes can be reproduced if the model parameters show changes big enough. The substorm-associated increases in the observed fluxes can be captured when substorm-associated electromagnetic fields are taken into account. Modifications of the pulse model used here are needed, especially related to the pulse front velocity and arrival time.

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Impact of Space Weather on Spacecraft Operations at ESA/ESOC

Reid, Simon[1]; Kirsch, Marcus[2]; Pantaleoni, Mauro[1]
[1]RHEA System S.A.; [2]ESA

The European Space Operations Centre (ESOC), located in Darmstadt Germany, hosts the mission control centres for the majority of European Space Agency (ESA) spacecraft and has done so for more than forty years. In addition, Launch and Early Orbit Phase (LEOP) phase for third party missions are regularly conducted. The operations of ESA's European Tracking Network of ground stations (ESTRACK) are also performed here.

ESOC's full portfolio of missions (historical, operational and in development) represents a huge variety of mission types, ranging from low earth orbits, trajectories passing close to the sun and into the further depths of the Solar System. Each spacecraft is fundamentally affected by the environment in which it operates and the variations in this environment (the Space Weather).

Each spacecraft and its payload is subject to various long term effects of effects of this environment, but also carry a significant risk of anomalies or damage caused perturbations resulting from solar storms and other phenomena. Naturally these effects are of prime concern to ESOC's operations teams, who are responsible for maintaining the long term health of the hardware in space.

This presentation will give results of an informal survey of ESOC's Spacecraft Operation Managers (SOMs), detailing some of their experience of space weather events, some insight into how space weather effects their routine or standard procedures, together with some thoughts on future needs and potential new services offered by the Space Weather community.

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An Evaluation of the AP9/AE9 Radiation Belt Models for Application in an ESA Context

Heynderickx, Daniel[1]; Truscott, P.R.[2]; Evans, H.[3]; Daly, E.J.[3]
[1]DH Consultancy BVBA; [2]Kallisto Consultancy Limited; [3]ESA/ESTEC

Since the beginning of the space age, considerable effort was invested in building models of the trapped proton and electron populations, culminating in the NASA AP-8 and AE-8 models which have been the de facto standards since the seventies. In the intervening years, there have been several new models created, but none with the coverage in energy or space provided by these original models. Recently, a new version of these models (preliminary called AP9/AE9) has been released with significantly improved capabilities and including a significantly greater quantity of data.

The first usage of the AP9/AE9 model in radiation analysis applications has revealed significant differences with results obtained with older radiation belt models for some orbit types. Consequently, an ESA sponsored activity was started to validate the new model results against other radiation belt models and in situ datasets. In addition, the optimal implementation of the new models in existing ESA software packages and tools was investigated.

The conclusions of the validation activity will lead to recommendations for updates to the ECSS-E-ST-10-04 space environment standard.

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Modelling the High-Energy Electron Flux throughout the Radiation Belts using the BAS Radiation Belt Model

Glauert, Sarah A.; Horne, Richard B.; Meredith, Nigel P.
British Antarctic Survey

The flux of relativistic electrons in the Earth's radiation belts is highly variable and can change by orders of magnitude on timescales of a few hours. Understanding the drivers for these changes is important as energetic electrons can damage satellites. The BAS radiation belt model is a physics-based model that has been developed to simulate the energetic electron flux throughout the radiation belts, incorporating the effects of radial transport, wave-particle interactions and collisions. It is

now used to forecast the energetic electron flux as part of the EU-FP7 SPACECAST project. Here we apply a new version of the BAS model that includes better modelling of wave-particle interactions to a number of space weather events. We show that during quiet periods the new model of plasmaspheric hiss and lightning generated whistlers are responsible for the slot region between the inner and outer radiation belts where new satellites are planned to operate. During storms, the increase in electron flux is best reproduced when chorus waves are also included particularly for medium Earth orbit where GNSS satellites operate. Finally, we model changes in the outer boundary of the Earth's magnetic field and show how these changes can cause rapid radiation belt losses much closer to the Earth that can affect satellites in MEO and GEO orbits.

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Solar Flare Forecasting: a "State of the Field" Critical Review.

Leka, K.D.
NorthWest Research Associates

It can be argued that the most stringent test of understanding a system, is to be able to use available observables to forecast a future outcome. It can also be argued that solar flares may not be deterministic, and even if they are, our present understanding is nowhere close to being able to predict the time, location, magnitude and space weather impact of a solar flare with any certainty. Still, solar flare prediction is a needed component of our international space weather infrastructure.

Many research groups around the world are investigating ways to improve flare forecasting methods, especially in light of new observational data available. I present a brief report of the "state of the field", summarizing insights gained from recent workshops (held in 2009 and 2013) aimed at head-to-head comparisons of flare forecasting methods in specific contexts. In summary, today's methods combine sophisticated data analysis with statistical or machine-learning algorithms which generally result in probabilistic forecasts. While the question of whether any of the presently developed methods clearly outperforms the others is still under investigation, the problem of how to answer that question presents interesting challenges for study design, data handling, statistical verification algorithm development (and psychology). I describe the standard skill scores being applied to the careful comparisons and some of the preliminary results, including what appear to be common successes and continued challenges among today's methods.

(Funding for the workshops and subsequent analysis was made possible by NASA/Living with a Star contract NNH09CE72C and NASA/Guest Investigator contract NNH12CG10C.)

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How can Subsurface Flow Properties Contribute to more Accurate Solar Flare Predictions?

Reinard, Alysha[1]; Komm, Rudolf[2]; Hill, Frank[2]
[1]NOAA/SWPC; [2]National Solar Observatory

Subsurface flows beneath active regions provide information about the processes that occur prior to and during flares. We have shown (Reinard et al. 2010) that subsurface flows exhibit measurable changes prior to flare occurrence. However, this relationship is not yet reliable on a case-by-case basis. We present recent research designed to improve the correlation between subsurface flow properties and solar flaring. We use measurements derived from GONG data using the ring-diagram technique, which provides flow properties between 0-16Mm below the solar surface. Our investigations include the effects of CME-association, hemispheric origin, and nearby active regions.

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On Fractal and Multifractal Parameters as Flare Precursors

Ermolli, Ilaria[1]; Giorgi, Fabrizio[2]; Romano, Paolo[3]; Zuccarello, Francesca[4]
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Several studies show that fractal and multifractal parameters derived from photospheric magnetic field measurements may help assess the eruptive potential of Active Regions (AR). However, the results derived from a recent analysis seem to discard

all previously collected evidences, by showing that none of the widely-used indicators analyzed in the study allows to distinguish AR with major flares from flare-quiet ones, though both regions exhibit significant fractality and multifractality. In this framework, we explore whether higher-resolution, higher-cadence, and higher-sensitivity data than those employed in previous analyses might help to clarify the reason of conflicting results presented in the literature. To this aim, we analyzed two datasets of photospheric magnetograms of a flaring and a flare-quiet ARs, NOAA 1158 and NOAA 1117 respectively, which were observed simultaneously with SOHO/MDI and SDO/HMI. The latter observations are characterized by a higher spatial and temporal resolution than the SOHO/MDI data, which are analysed for comparison here and were widely employed in previous studies. Besides, we analyze a larger sample of ARs observed with SDO/HMI and associated with M- and X classes flare events. The results obtained are discussed with respect to those published in the literature.

This study has been carried out in the framework of the EU FP7 project "eHEROES - Environment for Human Exploration and RObotic Experimentation in Space" (grant n. 284461).

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Pre-Flare Dynamics of Sunspot Groups

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The most probable sites of flare onset are the regions of high horizontal magnetic field gradient in solar active regions. Besides the localization of flare producing areas the aim of the present work is to reveal the characteristic temporal variations in these regions prior to flares in order to improve the forecast capability. The method uses sunspot data instead of magnetograms and follows the behaviour of a suitably defined proxy measure representing the horizontal magnetic field gradient. The empirical basis of the analysis is the SDD (SOHO/MDI-Debrecen Data) sunspot catalogue. The following pre-flare signatures seem to be diagnostically useful predicting tools in the variation of the magnetc field gradient: i) steep increase, ii) high maximum, iii) significant fluctuation and iv) a gradual decrease between the maximum and the flare onset. The achived maximum has a linear relationship with the intensity of the flare. After the maximum the gradual decrease of the gradient has a characteristic time of about 10 hours. Close tracking of the variations of the magnetic field gradient allows to esteem the intensity of the flare and the expected time of the flare onset.

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2012-2015) under grant agreement No. 284461.

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Does Quantifying the Evolution of the Photospheric Magnetic Field Lead to Improved Solar Flare Prediction?

Barnes, Graham; Leka, K.D.
NWRA

Knowledge of the state of the photospheric magnetic field at a single instant in time does not appear sufficient to completely predict solar flares, although it may provide necessary conditions, such as the free magnetic energy needed for a flare to occur. Given the necessary conditions, evolution of the field, possibly by only a small amount, may trigger the onset of a flare. We present the results of a study using time series of photospheric vector field data from the Helioseismic and Magnetic Imager (HMI) on NASA's Solar Dynamics Observatory (SDO) to quantitatively parameterize both the state and evolution of active regions - their complexity, magnetic topology and energy - as related to solar flare events. Statistical tests based on linear and nonparametric Discriminant Analysis were used to compare pre-flare epochs to a control group of flare-quiet active regions. The improvements in forecasts that include evolution of the field, as quantified by standard skill scores, will be presented.

Funding for this work was provided by NASA/Guest Investigator contract NNH12CG10C.

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Exploiting Solar Flare Statistics for Flare Prediction

Wheatland, Mike
The University of Sydney

The solar flare mechanism remains incompletely understood, and existing methods of flare prediction are probabilistic, rather than deterministic, relying on imperfect indicators of flare likelihood. The existing methods of prediction are briefly reviewed, and then an approach to the problem, relying only on the past time series of flare occurrence (Wheatland 2004; 2005), is revisited. A specific improvement to the method is presented: an implementation of a new optimal Bayesian change-point algorithm (Scargle et al. 2013) to determine the current rate of occurrence of small flares.

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Chromospheric Magnetic Field of Exploding Solar Active Regions

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California State University Northridge

How changes in the three-dimensional magnetic field of solar active region are related to Coronal Mass Ejections (CME) is an important question for contemporary solar physics. Complex active regions are the predominant source of powerful high-speed CMEs, which can result in strong geomagnetic storms. In this paper we present the properties of chromospheric magnetic field of active regions that produced solar flares and CMEs using observations of the Synoptic Optical Long-term Investigations of the Sun (SOLIS) facility operated by the National Solar Observatory. Currently, the SOLIS Vector Spectromagnetograph (VSM) is the only instrument that is capable of obtaining full Stokes profiles in both the photospheric Fe I ë630.2 nm and chromospheric Ca II ë854.2 nm lines on a daily basis. VSM also has the capability of making rapid scans covering an area sufficiently large to contain an active region. We shall present the Stokes profile characteristics of photospheric and chromospheric lines of few CME source regions.

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The Role of Magnetic Reconnection in Flares and CME Energetics: Lessons Learned from Analytical Theory

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[1]Royal Observatory of Belgium; [2]University of New Hampshire; [3]Harvard-Smithsonian Center for Astrophysics

It is widely accepted that magnetic reconnection is the primary mechanism for energy release during solar eruptions. However, the question of how, exactly reconnection works in the solar corona remains very much under discussion. In fact, we can learn much about how reconnection drives flares and CMEs from relatively simple, analytical models. Here we discuss some recent analytical results and the relevance of these results for flare and CME forecasts. In particular we will discuss how the reconnection rate and location, and therefore the rate and locations of energy release, can be influenced by the local conditions and asymmetric magnetic fields in the corona at the time of an eruption. We highlight some lessons that can be gleaned from analytical theory for real-time space weather forecasters and model developers.

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Perturbation of Nuclear Decay Rates During Solar Activity: A Method of Solar Storm Prediction

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Introduction

A possible basis for an early warning system for solar flare activity was observed by happenstance during otherwise routine measurements of Mn-54 decay gammas with an ordinary scintillation detector [Astropart. Phys. 31, 407 (2009)]. Further investigation by our group led to additional evidence pointing to a possible solar influence on terrestrial nuclear decay rates [Astropart. Phys. 32, 42 (2009), Space Sci. Rev. 145, 285 (2009)]. The only known particles emitted by the Sun which could have caused the observed phenomena are neutrinos, particularly in light of the fact that whatever agent is causing the decay rate changes experienced unimpeded passage through the Earth and the Sun. As noted in [Astropart. Phys. 31, 407 (2009)],

the observed decrease in the Mn-54 decay rate began to occur up to 36 hours prior to the flares, thus providing a possible predictive method, which could offer stakeholders the ability to protect vulnerable assets and systems.

Background

A significant body of work has been published to date detailing the observations of this putative solar influence beyond the flare-associated decay rate changes. Annual and sub-annual periodicities (~2/yr and 10-12/yr) have also been observed, and these are difficult to attribute to possible known environmental influences. Moreover, the number of observations--by independent groups--of similar periodicities, across a number of different isotopes and diverse detector types [see Table 1 in Appl. Radiat. and Isotop. 74, 50 (2013)], essentially eliminate all known environmental influences as the cause. Although there is no physical mechanism presently to explain these effects, particularly in light of the extremely low cross-section for known neutrino interactions, it is likely that these effects arise from some new phenomenon.

The work done by our group in November and December of 2006, at the end of solar cycle 23, exhibited decay rate changes associated with several flares during the time period. This prompted further investigations of the literature, and analyses of nuclear decay data generously offered by other groups at different institutions world-wide. These analyses led to the identification of the aforementioned periodicities, or non-random behavior, in what should be randomly distributed data [Astropart. Phys. 34, 121 (2010), Solar Phys. 267, 251 (2010), Solar Phys. 272, 1 (2011)].

Method Development Additional measurements of Mn-54 decays to search for have been underway for the last five years, and recent results are promising. While is it certain that this methodology does not show the same effects for all solar flares, decay rate changes associated with a reasonable percentage of C, M and X class flares can be identified. Analytical methods are being developed that may provide real-time predictive capability for major flares with the ability to attach confidence levels to the flare prediction. Additional detector systems are being installed to increase data flow and offer a better statistical basis for observed flare correlations. As we are nearing the peak of Solar Cycle 24, we have an excellent opportunity for observations and development of the algorithms that will be used.

System Development Several years of data on Mn-54 decays, taken at 1-hour intervals, are currently available from sites at Purdue University (Indiana, USA) and at the United States Air Force Academy (Colorado, USA). In addition, a third site in Santiago, Chile, has recently been established. Our goal is to establish a world-wide network of similar installations, acquiring data synchronously, and transmitting these data to one or more central servers. Software is currently under development which would allow these data to be combined and analyzed in real-time to search for common features, which would signal an imminent solar storm. Since the statistical power of such an array would increase as $N^{1/2}$ for N sites, an order of magnitude improvement could be realized by an appropriate world-wide array of 100 systems.

Future Plans The fact that changes in decay rates of some radioactive isotopes can precede solar storms by more than a day makes our technology quite promising. Moreover, it seems likely that this technology can be combined with other techniques presently being studied to predict solar flares (See J. Space Weather Space Clim. 3, A17 (2013), and http://www.cost.eu/domains_actions/essem/Actions/ES0803]. Our eventual goal is thus to establish a larger network combining these various technologies. In that network, the obvious scalability of our system utilizing radioactive decay measurements is likely to play a significant role.

Acknowledgements

The authors wish to thank Catherine Ansbro, Eammon Ansbro, Jeff Sinard, John Voeller and Linda Yu for their helpful advice.

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SEP Events Conditioned by the Primary Suprathermal Populations

Lazar, Marian; Poedts, Stefaan
KU Leuven

Here we propose to review the role played by the primary flux of suprathermal particles, electrons and protons, in the initiation of flares and CMEs. The existence of a critical level of the suprathermals is investigated, giving preliminary estimates for the relationship with the threshold conditions of the wave instabilities responsible for the particle reacceleration at these sites.

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The Role of the Cold Plasma Density in Radiation Belt Dynamics: New Measurements from the Van Allen Mission

Friedel, Reinhard[1]; Jorgensen, Anders[2]; Skoug, Ruth[3]; Kletzing, Craig[4]
[1]Los Alamos National Laboratory; [2]New Mexico Tech; [3]LANL; [4]University of Iowa

The dynamics of the high energy electron radiation belt is of central importance to space weather and a topic of intense scientific interest, highlighted by the recently launched Val Allen Mission's Radiation Belt Storm Probes (RBSP). While significant progress has been made in understanding the underlying physical processes (radial diffusion, wave particle interactions) our ability to accurately model these dynamics is still limited by our insufficient knowledge of critical model inputs and boundary conditions. In this talk we will concentrate on the role the cold plasma density in controlling these dynamics, highlighting the the need for accurate, global cold plasma density models as a pre-requisite for high fidelity space weather modeling and prediction. In addition we will present the state of data resources from the RBSP satellites for cold plasm density measurements.

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Ground-Based Remote Sensing of the Plasmasphere and Space Weather Applications

Menk, Frederick
University of Newcastle

The plasmasphere is often regarded as a reasonably uniform region of dense, co-rotating cold plasma, but in fact is a dynamic environment varying over a range of time and distance scales and populated by both low and high energy particles. Some of the most important space weather processes involve wave-particle interactions, but wave properties may also be used to remote sense plasmasphere dynamics. Since satellites move rapidly at low altitudes such remote sensing efforts can provide significant contributions to the development of plasmasphere models. This presentation will outline some key remote sensing techniques based on ULF and VLF wave measurements, and will present examples of space weather applications. While ground-based magnetometers are often the platform of choice for ULF wave measurements, HF radars offer many advantages, some of which will also be illustrated.

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Plasmaspheric Electron Densities and Plasmashere-Ionosphere Coupling Fluxes

Lichtenberger, János[1]; Ferencz, Csaba[1]; Hamar, Dániel[1]; Steinbach, Péter[1]; Rodger, Craig[2]; Clilverd, Mark[3]; Collier, Andrew[4]
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The Automatic Whistler Detector and Analyzer Network (AWDANet) is able to detect and analyze whistlers in quasi-realtime and can provide equatorial electron density data. The plasmaspheric electron densities and ionosphere-plasmasphere coupling fluxes are key parameters for plasmasphere models in Space Weather related investigations, particularly in modeling charged particle accelerations and losses in Radiation Belts. The global AWDANet [1] detects millions of whistlers in a year. The system has been recently completed with automatic analyzer capability in PLASMON (http://plasmon.elte.hu) project. It is based on a recently developed whistler inversion model [2], that opened the way for an automated process of whistler analysis, not only for single whistler events but for complex analysis of multiple-path propagation whistler groups [3]. In this paper we present the first results of quasi-real-time runs processing whistlers from quiet and disturb periods. Refilling rates, that are not yet known in details are also presented for the various periods.

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Magnetospheric Plasma Density inferred from Field Line Resonances: Effects of using Different Magnetic Field Models

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The technique for remote sensing the plasma mass density in magnetosphere by geomagnetic field line resonances detected at ground-based stations is getting more and more popular after the establishment in the last few years of extended magnetometer arrays, such as the EMMA network recently formed in the framework of the EU FP-7 PLASMON project. It is important therefore to quantify the level of accuracy associated to such technique. In this talk we examine the effect of using different magnetic field models.

First the equatorial plasma mass density estimates obtained using the dipole approximation are compared with those obtained using the IGRF model for low-mid latitudes. It is found that the use of the dipole model may result in an error in the inferred density appreciably larger than what is usually assumed. In particular it shows a significant longitudinal dependence being, for example, of the order of +30% in the american sector and -30% at the opposite meridian for field lines extending to a geocentric distance of 2 Earth radii. This may result in an erroneous interpretation of the longitudinal variation in plasmaspheric density when comparing results from ground-based arrays located at different longitudes. A simple modification of the technique is proposed which allows to keep using the dipole approximation but with a significant error reduction.
Then the results of using the T01 Tsyganenko model are compared with those based on dipole/IGRF models. With respect to previous evaluations of the differences in the inferred equatorial density we take into account the different equatorial crossing points of the IGRF and T01 field lines traced from a given ground position by considering reasonable radial gradients of the equatorial density. For average solar wind/magnetospheric conditions, mass densities computed using the IGRF model result to be moderately overestimated (less than 20%) for L values < 4. The uncertainty obviously increases for higher L values and the bias may become negative for steep radial variations of the equatorial density. For storm-time conditions the error dramatically increases beyond L ~ 4, but may remain within ~ 20% for L < 4 assuming radial variations of the equatorial density which are typical for such magnetospheric conditions.

We also present some specific case studies using measurements provided by the european magnetometer network EMMA.

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A 3D Model of the Plasmasphere to Study its Links with the other Regions of the Magnetosphere

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A three-dimensional dynamic model of the plasmasphere has been developed using the kinetic approach to determine the number densities and temperatures of the different particle species.The plasmapause is determined by the location where field-aligned plasma interchange motion becomes convectively unstable. The position of the plasmapause in the different MLT sectors is controlled by the convection electric field combined with co-rotation. During geomagnetic storms and substorms, a plasmaspheric plume is generated.

The model has been coupled with the ionospheric model IRI. A relation between the plasmapause position and the ionospheric trough has been found in the night sector. Ionospheric densities and temperatures are used as boundary conditions for high latitude polar wind as well.

The position of the plasmapause has been compared with sub-oval aurora spots and with the radiation belts boundaries observed by different spacecraft. It is found that the plasmasphere has an influence on the dynamics of the energetic electrons in the radiation belts since the plasmapause and the radiation belt boundaries show an interesting correlation.

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Data Assimilation Results from PLASMON

Jorgensen, Anders[1]; Lichtenberger, Janos[2]; Duffy, Jared[1]; Friedel, Reiner[3]; Clilverd, Mark[4]; Heilig, Balazs[5]; Vellante, Massimo[6]; Raita, Tero[7]; Manninen, Jyrki[7]; Rodger, Craig[8]; Collier, Andrew[9]; Reda, Jan[10]; Holzworth, Robert[11]; Ober, Daniel[12]; Boudouridis, Athanasios[13]; Zesta, Eftyhia[14]; Chi, Peter[15]

[1]New Mexico Tech; [2]Eotvos University; [3]Los Alamos National Laboratory; [4]British Antarctic Survey; [5]MFGI; [6]University of L'Aquila; [7]Sodankylä Geophysical Observatory; [8]University of Otago; [9]SANSA Space Science; [10]Institute of Geophysics, Polish Academy of Sciences; [11]University of Washington; [12]Air Force Research Laboratory; [13]Space Science Institute; [14]NASA; [15]University of California Los Angeles

VLF and magnetometer observations can be used to remotely sense the plasmasphere. VLF whistler waves can be used to measure the electron density and magnetic Field Line Resonance (FLR) measurements can be used to measure the mass density. In principle it is then possible to remotely map the plasmasphere with a network of ground-based stations which are also less expensive and more permanent than satellites. The PLASMON project, funded by the EU FP-7 program, is in the process of doing just this. A large number of ground-based observations will be input into a data assimilative framework which models the plasmasphere structure and dynamics. The data assimilation framework combines the Ensemble Kalman Filter with the Dynamic Global Core Plasma Model. In this presentation we will describe the plasmasphere model, the data assimilation approach that we have taken, PLASMON data and data assimilation results for specific events.

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A Model of Energetic Electron Precipitation Fluxes inside and outside of the Plasmasphere during Space Weather Events

Clilverd, Mark[1]; Rodger, Craig[2]; Lichtenberger, Janos[3]; Jorgensen, Anders[4]

[1]British Antarctic Survey; [2]University of Otago; [3]Eötvös University; [4]New Mexico Institute of Mining and Technology

In this study was will present a description of the PLASMON-developed model of energetic electron precipitation (EEP) fluxes inside and outside of the plasmasphere during space weather events. The aim of the PLASMON EEP model is to identify 3 or 4 MLT zones which are populated by ULF/VLF waves that can generate energetic electron precipitation. The MLT zones are influenced by the MLT-dependent plasmaspheric density structures such as the plasmapause. During geomagnetic disturbances the intensities of the ULF/VLF waves are enhanced, plasmaspheric structures are modified, and differing levels of precipitation flux are generated. The model will characterise the storm-time variations in electron precipitation relative to the plasmapause, building on the outputs of the data assimilative model of plasmasphere undertaken by the PLASMON project, and observations of EEP characteristics made by the PLASMON ground-based VLF receiver network.

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Variability of the Ionosphere/Plasmasphere Electron Content

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Nowadays GPS TEC (total electron content) is one of the mostly used parameter in the ionosphere's investigation. In fact, the TEC value can be considered as the combined contribution of the ionosphere and overlying plasmasphere. However one of the main limitations of the GPS technique is that the value of GPS TEC has an integral character and it is difficult to determine the contribution of the ionosphere/plasmasphere regions to GPS TEC based on ground-based GPS measurements only.

In the given report we used the International Reference Ionosphere Extended to Plasmasphere (IRI-Plas) model (Gulyaeva et al., 2002) to obtain model-derived estimates of plasmaspheric and ionospheric TEC. IRI-Plas was developed within the framework of Project WD 16457 of International Standardization Organization, ISO. One of the main advantages of IRI-Plas that it has the plasmasphere extension and is able to provide electron density profiles and total electron content at altitudes of 80 to 35,000 km for any location of the Earth. To make comparison with Jason-1 data possible, some changes in the default parameters were done: the ionosphere was considered within altitudes' limits of 100-1,336 km, plasmasphere – from 1,336 km (Jason-1 orbit) up to 20,000 km (GPS orbit). IRI-Plas results were retrieved for different seasons and different solar activity conditions. Main peculiarities of the IRI-Plas-derived ionosphere/plasmasphere electron content variability for solar minimum and solar maximum conditions are discussed; obtained results were compared with Jason-1 observations, reported in (Lee et al., 2013).

References.

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A Critical View on the Space Weather Forecasts at the Regional Warning Center in Belgium

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Royal Observatory of Belgium

The ISES Regional Warning Center in Brussels for space weather forecasting at the Royal Observatory of Belgium (ROB) has been providing daily space weather forecasts for more than a decade. As part of the FP7 project AFFECTS (Advanced Forecast For Ensuring Communications Through Space), ROB has applied a thorough verification analysis of the forecasts of the RWC over the past decade. From now on this procedure will be applied annually.

Forecasts of fundamental space weather parameters as the K value (the local geomagnetic index), the 10.7 cm radio flux and solar flaring probabilities are under critical evaluation. Strengths and weaknesses are determined compared to common numeric models. The verification analysis can easily be extended with extra analysis and facilitate embedding new forecasting models in the future.

Descriptive model statistics, common verification measures, error analysis and conditional plots between forecasts and observations are available on http://www.sidc.be/forecastverification. The analysis allows us for example to detect the influence of solar activity on the confidence level of the forecasts. The output aids to identify the strong and weak points of forecasting as well as those of the models considered. As such, it creates the opportunity to continuously reevaluate, stimulate ideas for improvement and increase the reliability of space weather forecasting.

This work has received funding from the European Commission FP7 Project AFFECTS (263506).

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Developing an Ensemble Prediction System for Operational Space Weather Forecasting

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At present, almost all space weather forecasts are made using a deterministic approach to numerical space weather prediction (NSWP), that is, a single forecast (estimate of the future state of the heliosphere) is obtained from a single known initial state. However, due to intrinsic uncertainties in initial conditions, finite model resolution, and the use of simplifying

MHD equations that do not fully capture the relevant processes in the heliosphere, forecast uncertainty and predictability limitations are an important, but unexplored, property of NSWP. Dynamically specifying an error for each forecast is essential for assessing the quality of a forecast, both in absolute terms and for comparing forecast models.

We describe ongoing research on an ensemble prediction system for use in an operational space weather environment. The numerical model used in our ensemble prediction system is Enlil, a time-dependent, 3D-MHD code that predicts CME arrival time at Earth. We assess the relative importance of the model inputs (CME size, speed, and direction as derived from near-real-time coronagraph observations), as well as background stream structures, for determining an accurate arrival time at Earth and the contribution of these inputs to the forecast uncertainty. We also discuss ways of analyzing the output from a multitude of model runs to arrive at a consensus forecast. Finally, we present an ensemble visualization that will convey information about the ensemble inputs and forecast.

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The NWRA Flare-Forecast Comparison Workshops: Approaches for Meaningful Verification and Comparison.

Barnes, Graham[1]; Leka, K.D.[1]; The Int'l Flare Forecasting, Comparison Group[2]
[1]NWRA; [2]N/A

Two workshops have been held recently, in 2009 and 2013, to begin systematic comparisons of methods for forecasting solar flares. We discuss here the requirements for the data and the methods in order to provide meaningful comparisons of the performance of participating methods. These include standardized data sets for input to the forecasting methods, and standardized event definitions that allow for statistically useful sample sizes. Crucially, meaningful comparisons require the use of standard verification statistics such as skill scores and reliability estimates. Given the often low sample size for the larger solar events, estimates of the uncertainties in these verification statistics are particularly important. We present here the approaches used for these two workshops, and some of the preliminary results which have been obtained thus far, with a particular emphasis on the uncertainty estimates.

Funding for the workshops and the data analysis was provided by NASA/Living with a Star contract NNH09CE72C and NASA/Guest Investigator contract NNH12CG10C.

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Statistical Study of False Alarms of Geomagnetic Storms

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[1]DTU Space; [2]UniGraz; [3]ROB; [4]HVAR Observatory

Coronal Mass Ejections (CMEs) are known to cause geomagnetic storms on Earth. However, not all CMEs will trigger geomagnetic storms, even if they are heading towards the Earth. In this study, front side halo CMEs with speed larger than 500 km/s have been identified from the SOHO LASCO catalogue. A subset of these halo CMEs did not cause a geomagnetic storm the following four days and have therefore been considered as false alarms. The properties of these events are investigated and discussed here. Their statistics are compared to the geo-effective CMEs.
The ability to identify potential false alarms is considered as an important factor when forecasting geomagnetic storms. It would therefore be very helpful if there were a signature in the solar data that could indicate that a CME is a false alarm. The strength and position of associated flares have been considered as possible candidates for false alarm signature.

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Forecast Evaluation as Applied to Geomagnetic Activity Categories

Clarke, Ellen; Thomson, Alan
British Geological Survey

Daily forecasts of geomagnetic activity have been provided by BGS since the 1990s. The predictions are globally averaged levels of activity over a 24-hour period, going from noon to noon (UT), for one, two and three periods ahead. Noon to noon was chosen in order to capture storms occurring in the night time local to the UK. Four possible categories are used: QUIET-

UNSETTLED (*Ap* <= 15); ACTIVE (16 <= *Ap* <= 29); MINOR-STORM (30 <= *Ap* <= 49); and MAJOR-STORM (*Ap* >= 50). These forecasts are prepared daily by a duty forecaster reviewing all available information on solar activity, solar wind parameters and other space weather data, to predict the impact at the Earth. Recipients of these forecasts have been power companies and the oil and gas industry.

Evaluation methods for categorical forecasts of this type are not yet well established in Space Weather, unlike those used for meteorological forecasts. Using examples applied in meteorology, we first investigate the use of various skill scores and other metrics for a "STORM" vs. "NO-STORM" prediction using 2x2 contingency tables. We then extend this to 4x4 contingency tables for predictions which fall into all 4 categories.

Results over 14 years are presented and we discuss the merits of equitable skill scores (ESS), such as that proposed by Gandin and Murphy (1992) and improved by Gerritt (1992) for forecasts of more than two categories. Comparisons are made between individual forecasters, over time and also against benchmark forecasts. The value of ESS is discussed with respect to both the end-user and the individual forecasters.

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Verification and Validation System of the UAH-SWS Service

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[1]University of Alcala, Space Research Group - Space Weather; [2]E.U. Cardenal Cisneros, Space Research Group - Space Weather

The adopted model for verification and validation of the UAH-SWS (Space Weather Service of the University of Alcala) has been running in V&V (Verification and Validation) mode during more than one year. Data of every step involved in the process to produce the outputs of the service have been saved in order to be able to reproduce the execution of different versions of the software when needed. We show in this presentation, the structure of the system and the configuration of the modules we have adopted in order to accomplish the needs for V&V. We review some hints and failures of the service allowing us to assess the accuracy of the physics of the model by being able to discard failures due to software design or operation errors.

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Exploring the use of ESPAS Data for Validation of a Thermosphere-Ionosphere Physical Model Data Assimilation System

Bushell, Andrew; Henley, Edmund; Jackson, David
Met Office

As test users for FP7 project **ESPAS**, we plan to exploit the *Near-Earth Space Data Infrastructure for e-Science* which is currently under development for a set of experimental cases (historical events, not in real time) in which a thermosphere-ionosphere physical model data assimilation system will run for an extended period.

A free-running simulation of a selected case run with the *Coupled Middle Atmosphere Thermosphere* (CMAT2) model, developed at University College London, is under way to produce results for comparison with data accessible from the ESPAS system. The purpose of this activity is (i) to gain experience with accessing data from the system and (ii) to establish what ESPAS data is best-suited for comparison with the model output either for validation or for data assimilation purposes. Preliminary assessment may be at the level of spatial- and time-aggregated fields from the model and data, although for data assimilation purposes the requirement is rather for comparison to be carried out locally, which implies access to individual profiles (satellite passes) from the database.

In order to run an experiment with the CMAT2 model as part of a data assimilation system that cycles through an extended case period, there is a further requirement to access metadata with which to calculate errors associated with observation data, used

- in quality control of data assimilation and
- to calculate the weighting given to the data (observation error covariance matrix) when calculating the optimal model analysis.

Such scenarios explore both the behaviour of the model data assimilation system and that of the ESPAS data infrastructure, helping to define its relevance for future user communities.

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Verification of DIAS Ionospheric Forecasts in the high Latitude Ionosphere

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National Observatory of Athens

Ionospheric forecasting products and services for Europe are provided routinely by the European Digital upper Atmosphere Server (DIAS, http://dias.space.noa.gr). These include alerts and warnings for upcoming ionospheric storm time disturbances as well as single station and regional ionospheric forecasts up to 24 hours ahead for the middle latitude European region. As a step forward, in the frame of the ESA/SSA Programme the DIAS forecasting services are upgraded to cover the whole European region, including Scandinavia, based on the expanded implementation of the Solar Wind driven autoregression model for Ionospheric short-term Forecast (SWIF).

In the operational mode, SWIF combines historical and real-time ionospheric observations with solar wind parameters obtained in real time at L1 point from ACE spacecraft through the cooperation of an autoregression forecasting algorithm, namely TSAR with an empirical ionospheric storm time model, namely STIM that is triggered by solar wind disturbances detected by STIM's alert detection algorithm. The ionospheric storm time response is then empirically formulated taken into account the latitude and the local time of the observation point at the storm onset.

While SWIF's prediction efficiency has been fully documented previously for the middle latitude ionosphere, the work presented here includes the evaluation of the SWIF's performance over high latitude locations under disturbed geophysical conditions. For this purpose, high latitude foF2 observations obtained during a significant number of storm events occurred in the previous as well as the current solar cycle are analyzed in respect with the foF2 reference level and the model's predictions. The results verify the validity of SWIF's storm alert detection algorithm for high latitudes and quantify the accuracy of SWIF's forecasts through relevant metrics' estimations.

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Verifying GIC Nowcast Models with Geo-Electric Field Measurements

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British Geological Survey

To understand how space weather impacts the GB power grid, the British Geological Survey Geomagnetism team have developed a near real-time system for "nowcasting" geomagnetically induced currents in the high voltage electrical network. External magnetic field measurements from the three UK geomagnetic observatories (Lerwick, Eskdalemuir and Hartland) are used to predict the induced surface electric field within the conductive Earth. A model of the network topology of the power grid is then used to determine the size of GICs at each node from the predicted electric field.

Previously we have been unable to verify the electric field model, as electric field measurements have not been routinely undertaken anywhere in the UK. However, in 2012, the British Geological Survey initiated a project to produce long-term measurements of the electric field at each of our observatories. We are now able to make comparisons between the output from our electric field model and measured electric field data.

We describe the field set up and instrumentation and present our initial results from this project, including comparisons between measured and modelled data for recent geomagnetic storms. The measurements are already helping us to constrain our electric field models and hence should improve the estimation of induced currents in the GB power system. The results will also ultimately aid numerical model developments of surface conductivity.

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The Role of Neutron Monitors in Space Weather Forecasting and Specification

Bieber, John
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Neutron monitors are ground-based instruments that record the byproducts of collisions between cosmic rays and molecules in Earth's atmosphere. When linked together in real-time coordinated arrays, these instruments can make valuable contributions to the forecasting and specification of major space weather events. Neutron monitors can provide the earliest alert of elevated radiation levels in Earth's atmosphere caused by the arrival of relativistic solar particles (Ground Level Enhancement). Early detection of such radiation events is of interest to the aviation industry because of the associated radiation hazard for pilots and air crews, especially for those flying polar routes. A pair of detectors at the South Pole has the capability of making an early determination of the energy spectrum at relativistic energies, which in turn can provide useful forecasts of the intensity of the later-arriving lower-energy particles. Neutron monitors can also act as remote sensors of large-scale interplanetary magnetic disturbances such as interplanetary coronal mass ejections (ICME). A "loss cone" anisotropy (or Forbush predecrease) typically exists some distance upstream of an approaching ICME, and can provide an alert of impending geomagnetic disturbance in major events.

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Space Weather Study with the Directional Anisotropy of Galactic Cosmic-Ray Intensity

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Because of the large detector volume that can be deployed, ground-based detectors remain state-of-the-art instrumentation for measuring high-energy galactic cosmic-rays (GCRs). The most recent results obtained from ground-based observations are introduced to demonstrate how useful informations can be derived from observations of the directional anisotropy of the high-energy GCR intensity. The anisotropy observed with the global muon detector network (GMDN) provides us with a unique information of the spatial gradient of the GCR density which reflects the large-scale magnetic structure in the heliosphere. The solar cycle variation of the gradient gives an important information on the GCR transport in the heliosphere, while the short-term variation of the gradient enables us to deduce the large-scale geometry of the magnetic flux rope and the interplanetary coronal mass ejection (ICME). Real-time monitoring of the precursory anisotropy which has often been observed at the Earth preceding the arrival of the ICME accompanied by a strong shock may provide us with useful tools for forecasting the space weather with a long lead time.

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NMDB - the Database of Real-Time Neutron Monitor Measurements: An Excellent Cornerstone for Space Weather Applications

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The worldwide network of neutron monitors (NMs) is in operation since the fifties of the last century. Together with the geomagnetic field, it acts as a giant magnetic spectrometer in the energy range from ~500 MeV to ~15 GeV. NM data therefore reflect the spectral variations of galactic cosmic ray particles and the occasional impact of relativistic particles from the Sun. This makes the NM network one of the best suited instruments to describe the Earth's cosmic ray environment in space weather applications.

The Neutron Monitor Database (NMDB) project was funded in 2008/2009 by the European Commission's 7th framework program (FP7). The aim of NMDB is to provide the data of the worldwide network of NM stations in a common format with a high time resolution and in real-time in a single database. Today, NMDB includes the data of ~40 stations, with about 25 stations in real-time. The goal of NMDB is to make the data from all NM stations of the worldwide network available in real-time. The NM count rates are stored as one minute and hourly values in NMDB together with further station information. Although there are already some space weather applications implemented in www.nmdb.eu, the database offers the

possibility to improve the existing tools and to develop new space weather applications that include NM data. The data from NMDB is publicly accessible via an easy to use web interface, but expert users can also directly access the database to build new applications, as e.g. real-time space weather alerts.

The present status of NMDB, examples of selected tools and applications, and the different possibilities of data mining will be presented.

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Operation of the Space Environmental viewing and Analysis Network (Sevan) in 24-th Solar Activity Cycle

Chilingarian, Ashot; Arakelyan, Karen; Bostanjyan, Nikolai; Daryan, Ara; Reymers, Artur; Pokhsraryan, David
Yerevan Physics Institute

Space Environmental Viewing and Analysis Network (SEVAN), is a worldwide network of identical particle detectors located at middle and low latitudes aimed to improve fundamental research of space weather conditions and to provide short- and long-term forecasts of the dangerous consequences of space storms. SEVAN detected changing fluxes of different species of secondary cosmic rays at different altitudes and latitudes, thus turning particle detector network into a powerful integrated device used to explore solar modulation effects. Till to now the SEVAN modules are installed at Aragats Space Environmental Centre in Armenia (3 units at altitudes 800, 2000 and 3200 m a.s.l.), Bulgaria (Moussala), Croatia and India (New-Delhi Univ.) and now under installation in Slovakia, Lomnicky stit). Recently SEVAN detectors were used for research of new high-energy phenomena originated in terrestrial atmosphere - Thunderstorm Ground Enhancements (TGEs). In the report we present the characteristics of SEVAN modules: detector design and electronics, purity and efficiency to detect neutral and charged cosmic ray fluxes, barometric coefficients, daily variations in different fluxes, as well as first joint measurements of solar modulation effects detected in the beginning of 24-th cycle of solar activity.

SEVAN network provides following advantages upon existing detector networks measuring single species of secondary Cosmic rays:

- Cheap and simple operation;
- Probe different populations of primary cosmic rays with rigidities from 7 GV up to 20-30 GV;
- Reconstruct Solar Cosmic Ray spectra and determine position of the spectral "knees";
- Classify Ground level Enhancements in "neutron" or "proton" initiated events;
- Estimate and analyze correlation matrices among different fluxes;
- Significantly enlarge the reliability of Space Weather alerts due to detection of 3 particle fluxes instead of only one in existing neutron monitor and muon telescope world-wide networks.

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Establishing a Space Weather Service based upon Neutron Monitors for the ESA SSA Program

Mavromichalaki, Helen[1]; Papaioannou, Athanasios[1]; Souvatzoglou, George[2]; Dimitroulakos, John[2]; Paschalis, Pavlos[1]; Gerontidou, Maria[1]; Sarlanis, Christos[2]
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Ground level enhancements (GLEs) are observed as significant intensity increases at neutron monitor measurements, following by an intense solar flare and/or a very energetic coronal mass ejection. Due to their space weather impact it is crucial to establish a real-time operational system that would be in place to issue reliable and timely GLE Alerts. Such a Neutron Monitor Service that will be made available via the Space Weather Portal operated by the European Space Agency (ESA), under the Space Situational Awareness (SSA) Program, is currently under development. The ESA Neutron Monitor Service will provide two products: a web interface providing data from multiple Neutron Monitor stations as well as an upgraded GLE Alert. Both services are now under testing and validation and will probably enter to an operational phase next year. The core of this Neutron Monitor Service is the GLE Alert software, and therefore, the main goal of this research effort is to upgrade the existing GLE Alert software and to minimize the probability of false alarms. The ESA Neutron Monitor Service is building upon the infrastructure made available with the implementation of the High-Resolution Neutron Monitor

Database (NMDB). In this work the structure of the ESA Neutron Monitor Service, the core of the novel GLE Alert Service and its validation results will be presented and further discussed.

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Neutron Monitor: New Life and Potential

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Polar Geophysical Institute

High-speed data acquisition system for a neutron monitor (NM) is developed in PGI. At the present moment it is installed at the fourth station - in Barentsburg (Spitzbergen, cutoff rigidity 0 GV), Apatity (0.6 GV), Moscow (2.4 GV) and Baksan (Northern Caucasus, 5.4 GV). The system is turned to study fast and transient phenomena into NM. Multiplicity events of M from M = 5 to M = 100 were studied from the Polar cycle to high mountain middle latitude zone. Using the system it is possible to research hadronic core of extensive air shower and local hadronic shower both. Using special procedure we found different populations of particles in NM. Also multiplicity events were carried out.

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Atmospheric Electric Field Effect for total NM Intensity and Different Multiplicities

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Cosmic rays (CR) are an important element of space weather and instrument of space weather forecasting. From this point of view, it is necessary to take into account all factors influencing CR intensity. One of these important factors is the influence of atmospheric electric fields (AEF) during thunderstorms on CR intensity. This is caused by local acceleration (or deceleration, depending on the direction of the AEF and the sign of charged particles) of secondary CR particles (mostly muons and electrons, for CR observations in the low atmosphere or underground). We analysed one minute data on AEF obtained by the ESF-1000 sensor in our observatory on Mt. Hermon, and one minute neutron monitor data corrected on barometric effects and on the effect of snow. While AEF does not influence neutrons, we found significant effects in the observed total neutron intensity and in the intensities of different multiplicities. This is caused mostly by soft negative muons, captured by nuclei of lead (instead of the atom's electrons) with the formation of mesoatoms. While the cross section of muons relative to strong interactions is very small (the same order as for neutrino), because the captured muon moves about inside the nucleus with very high density, the probability of muon interaction with nucleus is higher than the decay of muon. As result of this interaction the total energy of the rest muon about 100 MeV goes to the excitation of lead nuclei, with emanation of a few neutrons which are detected by the neutron monitor. Therefore, a neutron monitor is an ideal detector for separating positive and negative soft muons (without using a big magnetic system). We obtained results for positively and negatively directed AEF and show existing significant AEF influence on CR intensity, biggest for small multiplicities. We give a theoretical explanation of obtained results.

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The First Ground Level Event of Solar Cycle 24 and its Longitudinal Distribution in the Inner Heliosphere

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Ground level events (GLEs) are the most energetic solar particle events (SEPs) that are detected not only by space born instrumentation but also by ground-based instruments like e.g. neutron monitors. On May 17 2012 at 01:25 UT a M5.1 X-ray flare from the active region 1476 (N07, W88) was detected. The event was accompanied by a type III radio burst starting at 1.30 UT and a coronal mass ejection heading towards Stereo A. The corresponding shock wave passed STEREO A on May 18

at 12:43 UT but missed the Earth. The event onsets of near relativistic electrons have been detected at 06:05 UT, 03:38 UT, and 01:51 UT aboard STEREO A and B (125-335 keV) and at SOHO (250 -700 keV), respectively. In contrast to observations close to the Earth no strong anisotropies have been observed at both STEREO A and B. The neutron monitor network recorded the first GLE for solar cycle 24. The Electron Proton Helium INstrument on board SOHO measured protons with energies of more than 600 MeV (rigidities of more than 1.2 GV). The interplanetary field direction was such that neutron monitor stations with asymptotic direction in the 1 to 2 GV range over Australia were connected best and recorded the biggest increase of 17\% (Apatity and Oulu) with an onset time of 1:52 UT. Data observed close to and at Earth will be presented and the longitudinal structure of the event in the inner heliosphere will be discussed.

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Cosmic Ray Variations caused by Magnetic Clouds in the Interplanetary Disturbances

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[1]IZMIRAN; [2]University of Athens

In this report the variation of cosmic rays obtained by the global survey method from the world wide neutron monitor network, were studied for 99 events identified with the magnetic clouds. There was found many examples of cosmic ray density decreases in the magnetic clouds that are consistent with the cylindrical symmetry. However, there are some events in which a maximum of the cosmic ray density in the cloud is observed instead of the minimum. In several cases variations of the cosmic ray density have complicated character, with alternating local minima and maxima, possibly reflecting the toroidal structure of the cloud. One can see that galactic cosmic rays not only react to the magnetic cloud in common, but also can display the internal structure of its magnetic field. In many cases one can identify the boundaries of the magnetic cloud according to the data on density and anisotropy of the cosmic rays.

Posters:

The Variation on the High Frequency (HF) Radio Frequency in West Malaysia

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Malaysian National University

High Frequency (HF) system is absolutely depending upon the ionosphere because ionosphere acts as a radio reflector. The Sun has an enormous impact on HF radio propagation because it affects the ionosphere which gives rise to most of the long distance effects that enable long distance radio communications on the HF bands. Survival of the ionosphere is directly related to radiations emitted from the sun, thus the movement of the Earth around the Sun or changes in the Sun's activity will result in variations in the ionosphere. Hence the variation of ionosphere gives an important role to the HF propagation that is a frequency which may provide successful communication now may not achieve an hour later. There are two general types of variations that is regular and irregular. Both regular and irregular variations have important effects on radio wave propagation. The regular variations that affect the extent of ionization in the ionosphere can be divided into three main classes: daily, seasonal, and sunspot variations. This paper is to study the variation of HF radio frequency and find the better HF channel for transmission in West Malaysia. The study will be limited to daily and sunspot variations. The study of HF in Malaysia is not very explored, so this study is the onset of HF study. Maximum usable frequency (MUF) is the highest frequency that allows reliable long-range communication between two points on the earth. In this study lower decile MUF, which is the optimum working frequency (OWF), has been selected to be predicted and transmitted because it provides a successful communication for 90% of the month. The transmission tests are conducted between Kajang (Lat. 2°097'N, Long. 101°079'E) Batu Arang (Lat. 3°032'N, Long. 101°047'E) and Lumut (Lat. 4°022'N, Long. 100°063'E), which is located at West Malaysia. The tests have been conducted from April 2009, at the beginning of solar cycle 24, to November 2011, the smoothed sunspot number (SSN) varying from low levels in 2009 (Rz12 = 4.18) to much higher levels in 2011 (Rz12 = 50.37), making it suitable to observe the variation of HF frequencies employed. Several predicted HF frequencies (OWF), whose value was obtained by the Advanced Stand Alone Prediction System (ASAPS) software produced by the Ionospheric Prediction Service (IPS) Australia, were selected for the transmission tests. As a result of this study it has been found that HF frequencies variations subsist in the transmission test. Occurrence of daily variations in the ionosphere are a result of the 24 hour rotation of the Earth about it axis and different layers of the ionospheric region. 27-day sunspot variations and the 11-year sunspot cycle have major effects on atmospheric ionization. It is observed that as SSN values increase, the range of operating HF frequencies that can be used also increases. SSN values also have effect on frequencies that can be used for daily HF communications. The occurrence of HF frequencies variations shows that there are need to find the best HF channel for transmission of HF signal. Moreover it is significant to choose the right frequencies for communication because to obtain better quality signals, better quality communication channels must be selected.

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Assessment of Extreme Geomagnetically Induced Currents in the Norwegian Power Grid

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Finnish Meteorological Institute

The Norwegian high-voltage power grid is the northernmost one in the world. Consequently, it is regularly affected by large geomagnetic variations. We have modelled geoelectric fields and geomagnetically induced currents (GIC) in Norway using 10-s magnetic recordings of 1994-2011. Based on this 18-years period, we have estimated the strength of an extreme 10-s value of the electric field occurring once in 100 years. We found that this value is approximately twice the modelled maximum in 1994-2011. On the other hand, the large geomagnetic storm on 13-14 July 1982 produced such extreme values in a large area in North Europe, and caused some disturbances in the Swedish grid. We also found that the 13-14 March 1989 and 24-25 Mar 1991 storms were equally large to the Halloween event in Oct 2003.

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Analysis of Sun-Earth Connections in the 100 Biggest Geomagnetic Storms Recorded Since 1868.

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[1]ROB; [2]Hvar; [3]DTU

We present research on Sun-Earth connections in the context of the most extreme space weather events of the last 150 years. To identify the key-factors leading to these extreme events, we have selected the 100 most important geomagnetic storms in this time period based on the well-known aa index. Here we focus on characterizing the active regions most probably responsible for these major geomagnetic storms.

We use detailed sunspot catalogs as well as solar images and drawings. For the most recent geomagnetic events, vast amounts of detailed solar data is promptly available and thus solar terrestrial connections easy to access through numerous detailed studies. Events posterior to the creation of the H-alpha flare patrol in 1938 are still relatively easy to study, and numerous solar drawings span this period. However, back to the beginning of the aa index in 1868, solar data from catalogs become scarce as well as detailed sunspot drawings. For this study, we have systematically gathered the most interesting sunspot parameters back to 1868, hunting solar drawings from the old Greenwich archives, and extracting sunspot parameters ourselves.

We present a detailed statistical analysis of the active region parameters relative to the flare/geomagnetic parameters, which leads us to clues on how to characterize future storms from these specific sunspot parameters.

The presented work has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no 263252 [COMESEP].

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Carrington as a Benchmark: Comparisons of the September 1859 Storm using Newly Digitised Data for London

Humphries, Thomas; Clarke, Ellen; Dawson, Ewan; Williamson, John
British Geological Survey

In September 1859, scientists observed what has gone down in history as the first ever Space Weather event, and what is also thought to be the greatest magnetic storm on record. At this time the development of magnetic observatory networks was in its infancy with few in existence and methods to continuously record the magnetic field variations were rare. Two competing London observatories, Greenwich and Kew were an exception and both recorded the Carrington storm on photographic paper. These magnetograms provide near-continuous measurements, from one or other of these two London observatories, for the entire Carrington storm. Over the past year, we have been running a project to glean time-series data from digital traces of these plots, as well as of fourteen other of the most powerful geomagnetic storms prior to the digital recording era. This has resulted in a new trove of data for studying these events.

In this poster, we briefly describe the process of digitally-tracing, scaling and interpolation used to derive this data supply. We then go on to compare the results with other available data or the Carrington storm, including samples in observatory yearbooks. The results are also discussed in relation to the Dst results of Tsurutani et al (2003). Comparisons with other digitised storms are also made. Finally, we describe our efforts to derive dB/dt values, which are relevant for estimating Space Weather effects on technology, from the analogue records.

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Identification of Extreme Ionospheric Weather Events with Global Maps of total Electron content

Gulyaeva, Tamara; Poustovalova, Ljubov; Tsarevsky, Alexey
IZMIRAN

The GPS-derived Global Ionospheric Maps of Total Electron Content (GIM-TEC) provide an opportunity to identify the extreme ionosphere - plasmasphere storm events characterized by the ionospheric W-index at each cell of a map. Two extreme events are identified for a period from January 1999 to May 2013 in the present study: (1) 20-21 May, 2001, with the peak occurrence of storm W-index (W = -3, -4, 3, 4) observed at 73% of the global ionosphere map; and (2) 07-11 November,

2004, with 64% of the global map with TEC storm occurrence. The 1st event was the autonomous ionosphere storm under quiet solar and geomagnetic conditions, and the 2nd event was typical solar - magnetosphere - ionosphere storm well identified in space weather studies. The characteristics of the both events are discussed in the paper.

This study is supported by the joint grant from TUBITAK 112E568 and RFBR 13-02-91370-CT_a.

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Solar Conditions for Large Ground Geomagnetic dB/dt Events

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Only a few solar and geomagnetic events exist that have caused electrical power blackouts. However, many more events exist that have caused less severe but manageable effects. In this work geomagnetic data since 1996, during which good solar and solar wind data are available, have been analysed in terms of time derivative of the local ground geomagnetic field (dB/dt). Criteria to define large dB/dt events are derived from the distribution of dB/dt and associated power grid effects. Only large events are studied, considering the analysed time period, leading to approximately 15 individual events. The events are related to the conditions in the solar wind, the associated coronal mass ejection(s), and the solar active regions. The minimum solar conditions causing large dB/dt events are derived and are discussed in terms of their occurrence rate and their use in warnings and alerts with lead time of days.

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Extreme Value Statistics applied to Geoelectric Activity in Europe

Dr. Wesztergom, Viktor[1]; Clarke, Ellen[2]; Dr Thomson, Alan W.P.[2]; Dawson, Ewan B.[2]; Nagy, Tamás[3]; Baillie, Orsi[2]
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The Nagycenk observatory now has more than 50 years of geoelectric (or telluric) field data. In this poster we apply the technique of extreme value statistics to these data to determine the 1 in 100 and 1 in 200 year peak values of the surface electric field. In 2012, geoelectric monitoring sites were installed at each of the three UK geomagnetic observatories. The data now being recorded at these sites is also analysed in comparison with the Nagycenk data, to provide an initial look at the wider European scale view of surface geoelectric fields.

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Analyses of Space Weather Events Impact on Highly Elliptical Orbit

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[1]Natural resources Canada; [2]Natural Resources Canada

Highly elliptical orbit is used for the communication and surveillance satellites. The analyses of radiation data on HEO orbit were undertaken to provide an impact of space weather events on radiation hazard for spacecrafts on these orbits. HEO data were provided online by the Aerospace Corporation at http://virbo.org/HEO . These data cover 1998-2006 and include years with high and low solar activity as well as data for extreme space weather events like the Bastille Day Event in July 2000 and Halloween events in October-November 2003.

The radiation data for highly elliptical orbit was analyzed using methods of robust and non-robust statistics. It was shown that the robust statistics give the better description of the impact of strong space weather events on the radiation environment. The results of the analyses provide distribution of radiation environment on highly elliptical orbit and its dynamics during space weather events. The influence of severe space weather events on the dynamics of the radiation environment is discussed.

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Space-Weather Impact on the Power Grid - An International Perspective

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[1]European Commission Joint Research Centre; [2]MSB Swedish Civil Contingencies Agency; [3]NOAA Space Weather Prediction Center

Many modern technological infrastructures on the ground and in space are vulnerable to the effects of severe space weather. Of particular concern is the long-distance high-voltage power grid, which is vulnerable to the effects of geomagnetic storms through the induction of GICs that can damage or destroy equipment and lead to grid collapse due to cascading effects. While there is some awareness and knowledge among European power-grid operators and regulators of the space-weather hazard, levels of awareness, as well as vulnerabilities differ from country to country.

In order to launch a dialogue on the topic and invite European countries to learn from each other, the European Commission's Joint Research Centre (JRC), the Swedish Civil Contingencies Agency, and NOAA will organize a 2-day workshop on the impact of extreme space weather on the power grid to be held on 29-30 October 2013 at the JRC's Ispra site. The event aims at attracting power-grid operators and regulators, as well as representatives of policy making and academia. The primary goal of the workshop is to raise awareness of the hazard and to encourage vulnerability and risk analyses including scenario development which is lacking to date. Topics for discussion will be space-weather phenomena and the dynamics of their potential impact on the grid including modeling, experiences with prediction and now-casting in the US and in Europe, risk assessment and preparedness, and policy implications.

This talk will present the main conclusions and recommendations from the JRC-MSB-NOAA event.

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Interactive Web Application for Visualization of Geomagnetically Induced Currents

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[1]Polar Geophysical Institute; [2]NeuroSpace; [3]FMI

We have developed a web application for visualization of geomagnetic fields and their time derivatives, modelled geoelectric fields, and modelled geomagnetically induced currents (GIC) on a geographical map. This interactive tool was created as a part of the EU/FP7 EURISGIC project to demonstrate the occurrence of GIC in the European prototype power grid model in 1996-2008. The user-friendly server provides a starting point for a further development for operational or educational use by power companies, universities, authorities and civil contingency agencies.

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The EURISGIC Forecast Service

Wintoft, Peter[1]; Wik, Magnus[2]; Pulkkinen, Antti[3]; Chigomezyo, Ngwira[4]; Viljanen, Ari[5]; Clarke, Ellen[6]; Thomson, Alan[6]
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One of the goals with the EU/FP7 EURISGIC project is to provide short-term realtime forecasts of geomagnetic and geoelectric fields covering Europe. The models are driven by ACE solar wind data and provide approximately 30 minute forecast of the time derivate of the geomagnetic field and the electric field at several locations in Europe. The forecasts are also compared with real time geomagnetic data from a number of stations. Two different types of forecast models have been implemented: empirical models based on neural networks and the Solar Shield model based on MHD simulations. The observed and forecast data are provided on a dynamic web page that shows the observed or forecast data selected by the user. The provided service could be used by power grid operators and emergency agencies as a tool to monitor current and short-term forecast of disturbances related to geomagnetically induced currents.

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Solar Activity and Transformer Failures in Greece (3): New Results on non Linear Regression Analysis

Zois, Ioannis
PPC

We want to assess the effects of solar activity onto large transformers in the Greek National Electric Grid. For short term effects we present specific cases of transformer failures during days of storm (namely days with Dst less or equal to -100) and we briefly analyze them. For long term effects we use statistical and analytic methods. During the 8th European Space Weather Week linear regression and correlation was applied. In the 9th European Space Weather Week last year we presented our results on non linear regression analysis (types of functions used include polynomials, exp, log, hyp etc). Now we have some further new results: (1.) We try to push polynomial regression to the limit, namely increase the polynomial degree up to the maximum value for which the least squares method can be successfully applied (i.e. the coefficients can be determined-namely one does not have an over-constrained or over-determined system, that the coefficients are unique and without singularities, Runge's phenomenon appearing etc).

(2.) Based on the Stone-Weierstrass theorem in functional analysis, we try to use another, more elaborate unital subalgebra of C([a,b],R) which separates points in [a,b], like the algebra of orthogonal polynomials (Gegenbauer algebras) instead of the algebra of ordinary (raw) polynomials (see for example Zois 2009 and Zois 2010). We used the code written in R (see Chambers & Hastie 1992 and Kennedy & Gentle 1980). However in order to do that, one has to prove that this new algebra satisfies the Stone Weierstrass theorem and this required the use of some heavy mathematical machinery (like K-Theory). Our task was highly rewarding: We get coefficients of determination as high as 0.89 (compared to about 0.5 using ordinary polynomials) when we use the annual number of days with Dst less or equal to -40 as a long term, earth affecting solar activity index.

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Solar Demon: Dimming and EUV wave Monitor for Space Weather

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Dimmings and EUV waves have been observed routinely in EUV images since 1996. They are closely associated with coronal mass ejections (CMEs), and therefore provide useful information for early space weather alerts. On the one hand, automatic detection and characterization of dimmings and EUV waves can be used to gain better understanding of the underlying physical mechanisms. On the other hand, every dimming and EUV wave provides extra information on the associated front side CME, yielding improved estimates of the geo-effectiveness and arrival time of the CME.

Solar Demon has been designed to detect and characterize dimmings, EUV waves, as well as solar flares in near real-time on Solar Dynamics Observatory/Atmospheric Imaging Assembly (SDO/AIA) data. It is running continuously at the Royal Observatory of Belgium, and is the result of collaboration between the FP7 projects COMESEP and AFFECTS. We present an overview of the system, show several interesting events, and present general statistics of the detections made during solar cycle 24.

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SEPServer SEP Event Catalogue in and out of the Ecliptic; a Ulysses and L1 Particle Data Driven Study

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SEPServer is a three-year collaborative project funded by the seventh framework programme (FP7-SPACE) of the European Union. The objective of the project is to provide, among other things, access to state-of-the-art observations and analysis tools for the scientific community on solar energetic particle (SEP) events. The study of SEPs at different latitudes and under different conditions provides useful information about energetic particle propagation and acceleration, and is one of the focus areas of the project. The Ulysses mission, launched in 1990, explored the three dimensional heliosphere during

different solar activity conditions until the spacecraft was finally switched off on June 30, 2009. The mission has been the only one that allowed us to study the characteristics of SEPs at low and high latitudes. In this work, the Cosmic Ray and Solar Particle Investigation (COSPIN) Kiel Electron Telescope (KET) data of 38 to 125 MeV has been used to identify a number of 40 events SEPs observed in and out of the ecliptic plane over solar cycle 23. Using electron observations from the Heliosphere Instrument for Spectra, Composition and Anisotropy at Low Energies (HISCALE) and proton intensities from the COSPIN Low-Energy Telescope (LET), different characteristics of these events have been determined and compared with simulation based analysis and remote sensing data from radio and optical observation. The event catalogue presented in this paper will be available to the community for further analysis through http://server.sepserver.eu.

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L1 solar wind ACE Data Alerts by AFFECTS

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To quantify the space weather effects of the solar wind on the Earths magnetosphere and ionosphere in-situ measurements are indispensable. Satellites like the ACE (Advanced Composition Explorer) spacecraft at L1 are thus necessary to obtain real-time solar wind parameters. We use these data to generate L1 based near real-time warnings of severe space weather and its effects through RSS feeds.

As derivatives we provide Kp and aurorae feeds too. The services are freely available through the AFFECTS website and the feedback of current users testing them is extremely encouraging. The space weather services in use and their soon provision as solar wind mobile phone apps will help greatly increasing space weather awareness to the scientific community and general public.

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The International Sunspot Number Revisited: From SIDC to SILSO

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Royal Observatory of Belgium

With the advent of a new generation of dynamo models, the interest for long-term impacts of space weather and the current issues about climate change, the sunspot number (SSN) is now being used more than ever before as the multi-secular tracer of solar activity in a wide range of science studies.This has motivated new efforts to revisit, improve and expand this reference index of solar activity, which had been left largely untouched for many decades.

Here, we review the main advances achieved recently, both in the early historical part of this series but also in modern SSN values. We also compare the different sunspot-based indices and identify their usefulness and shortcomings relative to the international SSN. Based on all new corrections identified in the SSN series by a collective work, the publication of a new revised SSN series is now planned for 2014, bringing the first thorough revision of the sunspot number series since the time of Rudolph Wolf.

In parallel to this major update of the main data series, we also entirely updated and reworked the operational production of the SSN and its quality control. For our users, this transition will materialize in the form of a new web site, new data products as well as a new name for our World Data Center: SILSO, for "Sunspot Index and Long-term Solar Observations". We describe the new features of this new central portal serving the sunspot number to our growing community of scientific and non-scientific users.

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Lists of Solar Energetic Particle (SEP) Events Based on STEREO Recordings: 2007-2012

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The STEREO (Solar TErrestrial RElations Observatory) mission employs two nearly identical space-based observatories - one ahead of Earth in its orbit (STEREO-A: STA), the other trailing behind (STEREO-B: STB) aiming at providing the first-ever stereoscopic measurements of the Sun. The intensities of SEP events are strongly a ected by the properties of the interplanetary magnetic

Field that control the acceleration and propagation of particles throughout the heliosphere. The study of SEP events provides useful information on the physics of solar particle genesis, propagation and acceleration. Therefore the usage of STEREO recordings provides an unprecedented opportunity to identify the evolution of such events at di erent observing points within the heliosphere. In this work, two instruments onboard STEREO have been used in order to identify all SEP events observed within the rising phase of solar cycle 24 from 2007 to 2012, namely: the Low Energy Telescope (LET) and the Solar Electron Proton Telescope (SEPT). A scan over STEREO/LET protons within the energy range 6-10 MeV has been performed for each of the two STEREO spacecraft (i.e. STA & STB). We have tracked all enhancements that have been observed above the background level of this particular channel and cross checked with available lists on STEREO/ICMEs, SIRs and shocks as well as with the reported events via literature. Furthermore, parallel scanning of the STEREO/SEPT electrons in order to pin point the presence (or not) of an electron event has been performed in the energy range of 55-85 keV, for all of the aforementioned proton events, included in our lists. Simulation based analysis has also been performed for two events of this catalog using the inversion methods that were developed within SEPServer.

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Comprehensive Event and Feature Catalogues are Essential if you want to Analyse the Causes of Space Weather

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An essential step in understanding space weather effects is being able to relate them back to their causal phenomena. Uncertainties in the relative timing of events in different parts of the Solar System are a result of the difficulties in measuring propagation velocities and being unable to accurately define the propagation path length. It is therefore essential that a large number of events are analysed so that general trends can be determined

As part of the **HELIO** project we have assembled comprehensive event and features catalogues of solar and heliospheric phenomena. The **Heliophysics Event Catalogue** (**HEC**) now contains more than 60 event lists covering all the domains that constitute heliophysics while the **Heliophysics Feature Catalogue** (**HFC**) has details of 7 different solar and heliospheric features. Both catalogues cover a time interval of more than 15 years; some events lists in the HEC go back many decades. Both catalogues can be accessed through user-friendly interfaces or from SolarSoft/IDL.

There are difficulties if defining what constitutes an event or feature. In both cases the detection algorithms used are based on criteria that represent an opinion of an individual or group. They do not represent an absolute description and care needs to be exercised when undertaking statistical studies based on this type of data. It is therefore beneficial to be able to compare and contrast lists that describe the same event or feature derived by different teams.

For both catalogues we have tried to find multiple ways of defining the items being reported. In the feature catalogue several techniques have been used to detect active regions and coronal holes - the results from all are included in the catalogue. In the event catalogue we have sought out lists from different sources identifying events and have multiple lists for flares, energetic particle events and coronal mass ejections.

It is clear from the event lists that we assembled that they need to be used collectively. Each individual list will include some of the occurrences of a particular type of phenomena but event major events can sometime be missed because of criteria used.

We discuss the implications of this and steps that need to be taken to make this type of capability even better.

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First Steps towards a Homogeneous Solar Spectral Irradiance Dataset – - Selection, Merging and Quality Assesment.

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The sun varies over different timescales, from minutes to month, decades and millennia. Its variation is an important driver to terrestrial climate changes and as such an important input to climate models. While several observation exists to date over a broad frequency range, they are sparse over both time and frequency.

As part of the SOLID (First European comprehensive SOlar Irradiance Data Exploitation) project we show first results of constructing a homogeneous solar spectral irradiance dataset of the UV.

We present the data used, together with preliminary error-estimates and self-consistent quality assessments, gap-filling methods and selection criteria. In a next step, we utilize a combination of observed solar spectral irradiance from several missions starting with OSO III in 1967 together with available proxy data, to further quantify the data quality.

The SOLID project is part of the seventh European framework programme. It aims to join a large variety of different solar spectral irradiance data sets and combine them into one dataset and to reconstruct the spectral solar variability further back in time. The overall goal is to deliver a dataset that can be used by e.g. climate researchers in order to account for the non-constant solar forcing.

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Bucharest Solar Station (1956-2013)

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Bucharest solar station is located on the first meridian of the ESA countries visited by the Sun.
The systematic solar observations began in Bucharest in 1956, with two refractors on a unique mounting: the lunette for photosphere - a Zeiss equatorial 130/1950 mm and the other one, 80/1200 mm, for chromosphere.
The 130/1950 mm refractor (Zeiss, 1957) has been used at daily, visual and photographic observations of the photosphere for: sunspot relative number; sunspot coordinates and evolution; sunspot area. The sunspot data monthly buletin were sent to Data Centers of Pulkovo (1957-1968), Zürich (1957-1982), Freiburg (1957-1968), and Bruxelles (1983-1997).
The 80/1200 mm refractor (Zeiss, 1958), equiped with a Halle Lyot-Ohmann filter (0.5 A pass-band), until 2004, has been used for chromospheric patrol observations, visual and photographic.

Distribution at data centers: Boulder Colorado, Meudon, Moscow (1958-1997), Pulkovo (1958-1997).
Past programs for both instrument: Solar patrol; International Geophysical Year (1957-1968), International Quiet Sun Years (IQSY, 1964-1965), Proton Flare Project (PFP, 1967), Rapid Variations of the Solar Magnetic Fields (KAPG, 1966-1974); INTERCOSMOS (1964-1977).

Publications: Solar Geophysical Data (USA), Quarterly Bulletin of Solar Activity (Japan), Solnechnye Dannye (Russia), Observations Solaires (Bucharest, Romanian Academy Publ.House, 1956-1997).

After 1997, the solar activity daily survey ceased, but observational campaigns were performed using a ST-7 CCD camera, 765 x 510 pixels (fov 0.7x0.5 from the solar disk), on the in Halpha instrument.

The solar dome was damaged and need need to be refurbished after 2002. A new Halpha filter, Solar Observer Filter S-1.5 (0.3+/- 0.05 Å, were mounted after 2012.

Currently, new CCD cameras and the financing of the program are necessary, in order to perform full disk solar patrol of the chromosphere and photosphere, as a space weather service.

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On the Possible Use of Radio Occultation Middle Latitude Electron Density Profiles to Retrieve Thermospheric Parameters

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A method to retrieve the main thermospheric parameters (Tn, [O], [N2], [O2]) from electron density profile is applied for the first time to middle latitude daytime COSMIC and CHAMP ionospheric radio occultation (IRO) electron density profiles (EDP). It is shown that COSMIC IRO EDP can be used with the method under solar minimum (2007-2008) conditions to give neutral gas density with 10% inaccuracy. This agrees with the declared absolute inaccuracy of (10-15)% of CHAMP observations. However about 50% of the tested profiles from COSMIC either did not provide solutions at all or gave incorrect solutions due to their insufficient accuracy. The large percent of rejections indicate that IRO EDP must be carefully treated to eliminate some artificial results that are not consistent with the mid-latitude daytime F2-layer formalism that our method relies on. Consequently further filtering is required to be applied to the near-real time IRO EDP in order to be ingested as in put to our method for future on-line implementation. For solar maximum conditions the method was tested with IRO EDP from CHAMP and its performance was found to be quite stable. However CHAMP EDP are confined around 400 km in altitude and this is too low for getting correct solutions under solar maximum conditions.

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Ionogram Conversion Algorithm from Oblique to Vertical and Impact Analysis by the Solar Storm

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The conversion of the oblique ionogram to vertical ionogram is a very useful inversion technology. The vertical ionogram can provide the important ionospheric parameters, such as critical frequency, vertical height and electron density, for ionospheric research. The oblique ionosonde has the ability to detect the ionoshpere over sea and other terrain where it is not practical to deploy vertical sounder and provide more ionograms with less transmitting and receiving devices.

There are two ionosonde stations in Korea named Jeju and Icheon. Jeju station is locate in 420km south from the Icheon station. The converted vertical ionogram from the oblique iongrom is a estimated vertical ionogram of midpoint between two stations.

In this paper we discribe ionogram conversion algorithm and results of ionogram conversion to estimate vertical ionogram of midpoint between two stations. The converted ionogram was compared with vertical ionogram measured at two stations for the verfication. This paper also including impact analsys of ionogram conversion by the solar storm.

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Empirical Modelling of the ROTI at high Latitudes for L Band Ionospheric Channel Studies.

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GNSS position errors due to ionosphere are partially linked to scintillations. This study focuses on scintillation activity observed under high latitude regions.. Three ISM (Ionospheric Scintillation Monitor) have been running measurements at 50Hz since end of 2012 in Norway in the frame of a collaboration between CNES and NSC/NMA for the ionosphere scintillations modelling. As the period of ISM data collection is not long enough for a valuable modelling, we first attempt to

model the ROTI, the index of TEC rate of change which is among the observables affected by ionosphere disturbances, using data collected over many years (since around 1994) from the NMA GNSS network stations. In this study we have integrated electron flux obtained on the NOAA POES satellites to get a good statistics of the electron flux. Taking advantage of the 5 current POES satellites (POES 15 to 19) scanning at the same time several local times, and the fact that the first spacecraft has spent more than one solar cycle in orbit, the obtained statistics is very good, as for example more than 60,000 points with 8s resolution were obtained at extreme magnetic activity (for magnetic index Kp>8+). Averages of the electron energy flux in a McIlwain parameter L versus magnetic local time map were obtained and correlated to the ROTI measurements made at two latitude distant GNSS stations: Tromsoe and Tronheim. Therefore a model of ROTI was developed with as input parameters the station location and the time in day, the magnetic activity Kp, and the viewing direction (elevation and azimuth). This model can be used, associated with a Kp prediction, to forecast the ROTI, anywhere in the Scandinavian Norway. Intermediate analysis made to obtain it will be presented as well. Possible improvements will also be discussed.

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GPS Performance during Ionospheric Storms and Solar Radio-Bursts

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It is known that the performance of global navigation satellite systems (GNSS) can be significantly perturbed during space weather events. Propagation of GNSS signals depends directly on the state of the ionosphere, since intensive irregularities and/or gradients of electron density modify the parameters of propagating waves. Ionospheric perturbations during geomagnetic storms are known to be the major source of such intensive ionospheric irregularities, indicating on large impact on GPS/GNSS performance. A part from the ionospheric storms, intense solar radio-bursts can significantly disrupt the operation of GNSS communication, as such solar events are the source powerful radio noise.

In this work, we analyze global distribution of GPS cycle slips and of GPS positioning errors during ionospheric storms and solar radio-bursts of different intensity. For our analysis we used data of GPS receivers from global networks IGS and UNAVCO, as well as numerous regional networks (in New Zealand, Australia, North and South America, Africa, Eurasia, and including Greenland and Antarctica), in order to obtain better global coverage and to better understand the effects of the space weather events in different longitudinal and latitudinal regions. The total number of stations used in our study is about 2500-4000 for each event.

The performance of GPS was estimated from several parameters: 1) ratio of GPS cycle slips; 2) ratio of count omissions in GPS output files; 3) GPS positioning errors. GPS cycle slips and count omissions were calculated from RINEX files for all satellites and for each GPS frequencies L1 and L2. The positioning errors were calculated as standard deviation between the known precise coordinates of a ground-based GPS receiver and coordinates computed by a receiver at each moment of time.

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SSA SWE RTIM -- Real-Time Ionospheric Monitoring Service for High Latitudes

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Norwegian Mapping Authority

This year, a new service was integrated into the SSA SWE portal. The main products that is offered by the service are plots and data files of VTEC, ROTI and scintillation measured in Scandinavian region.

In addition to the real-time data, archived data is also available. Here we give an overview of the different data products and show some examples of data measured during various ionospheric activity levels.

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Dst Index As An Indicator of Space Weather: A Probabilistic Approach

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High Frequency (3-30 MHz) (HF) Ionospheric Channel is used for military, civilian and amateur communications. By using Ionosphere, communication for distances beyond the line of sight is achieved. The main advantage of this type of communication is that it does not to require a satellite to communicate with a point beyond the line of sight. Actually the Ionosphere is used instead of a satellite. To use Ionosphere but not a satellite means independent communication for a country.

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Upgrade of the DIAS Models for Nowcast and Long-Term Prediction of the foF2 over the European Middle and High Latitudes

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The European Digital Upper Atmosphere Server (DIAS) provides since 2006 at a routine basis long term prediction (up to 3 months ahead) and nowcasting maps of the foF2 parameter over the European middle latitudes (34° - 60°N), based on the implementation of the Simplified Ionospheric Regional Model (SIRM) and the real time updating of SIRM (SIRMUP) methods, respectively. Recently, the DIAS middle latitude maps were extended to cover the whole European region up to 80°N, as part of the integration of DIAS services into the ESA/SSA Space Weather Service Network. To this effect, the background SIRM and SIRMUP methods were upgraded to expand the DIAS prediction capabilities to the high latitude ionosphere. In particular, the SIRM output at middle latitudes is now combined with the CCIR results for the region above 60°N. For the collaboration of the two distinct modeling approaches, special consideration is given to the buffer zone between the global CCIR and regional SIRM models in an attempt to avoid large gradients due to the complex behavior of the ionospheric conditions at high latitudes. For this purpose, an interpolation routine is applied to formulate the ionospheric predictions between 50° and 60°N and the final map is obtained as the combination of the three grids: the middle latitude, the high latitude and the buffer zone grid. The real time updating of SIRM&CCIR grids is then achieved through the SIRMUP concept that is now adjusted to incorporate the estimation of the effective sunspot number (Reff) separately at middle and high latitudes. The paper reports the results from the development of the new models and their implementation in DIAS, as well as indicative results on their performance in each latitudinal zone.

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Ionospheric Response to the Solar X-Ray Flare Associated with Radio Bursts

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A solar flare is a burst of light occurring in the chromosphere near a sunspot and is observed at a wide band of wavelengths (radio to X-rays). Together with coronal mass ejections (CMEs), a flare is an explosive event that releases high energy protons and electrons, including intense radiation in all wavelengths which can affect the Earth's upper atmosphere. The solar radio bursts are intense radio emissions from the Sun that are usually associated with solar flares. The recent development of ground-based networks of GPS as well as satellite systems has opened a new means to study the ionospheric effects during the solar flares. The effects of radio bursts associated with x-ray flare also known as extreme space weather events is of practical importance as being a cause of interference in wireless communications, disruption of HF and GNSS communication and other radio systems which has not yet being explored much. In this regard, we found 34 events of radio bursts (>1000 sfu at 1GHz) using Nobeyama observations and are found to be closely associated with x-ray flare and CMEs during 2000-2012. We found 2 C-, 18 M- and 14 X-class flare respectively associated with it. The preliminary results of the effects of these events on the earth’s ionosphere using satellite observations will be presented.

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A Single-Station F-Layer Critical Frequency Model from the Dourbes Digisonde Data

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Single-station ionospheric parameter models offer more accurate results for a particular ionosonde station than global models and are easy to update. The models employ decomposition of the measured data and its correlation with different solar and geophysical parameters like sunspot number, geomagnetic index, etc. Their purpose is to provide short and long term prediction of the monthly-median f_0F_2. In this work we have investigated deterministic and non-deterministic methods for analysis of the f_0F_2 from the Dourbes Digisonde, Belgium and determination of diurnal, seasonal and solar cycle dependence of the F-layer critical frequency.

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Performance of IRI-SIRMUP-P Mapping of the Ionosphere for Disturbed Periods

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The three-dimensional (3-D) electron density mapping of the ionosphere given as output by the assimilative IRI-SIRMUP-P (ISP) model for three different geomagnetic storms is described. The goodness of the model results is tested by comparing the electron density profiles given by the model with the ones measured at two testing ionospheric stations: Roquetes (40.8 N,0.5 E), Spain, and San Vito (40.6 N,17.8 E), Italy. The reference ionospheric stations from which the autoscaled foF2 and M(3000)F2 data as well as the real-time vertical electron density profiles are assimilated by the ISP model are those of El Arenosillo (37.1 N,353.3 E), Spain, Rome (41.8 N,12.5 E), and Gibilmanna (37.9 N,14.0 E), Italy. The representation of the ionosphere made by the ISP model is on the whole better than that made by the IRI-URSI and the IRI-CCIR models. However, a few cases show that the assimilation of the autoscaled data from the reference stations causes either a strong underestimation or a strong overestimation of the real conditions of the ionosphere, which is in these cases better represented by the IRI-URSI model. This misrepresentation made by ISP is mainly due to the fact that the reference ionospheric stations covering the region mapped by the model turn out to be few, especially for disturbed periods when the ionosphere is very variable both in time and in space and hence a larger number of stations would be required.

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Scientific questions and algorithm development in the CALIBRA project

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GNSS is making a significant impact in support of operations where high accuracy is required, as in precision agriculture, where the meticulous application of pesticides and fertilizers translates into efficiency gain and profit. Other examples are surveying, geodesy, land management, off-shore operations. GNSS high accuracy techniques such as RTK (Real Time Kinematic), WARTK (Wide Area RTK) and PPP (Precise Point Positioning), exploiting the precision of GNSS signals carriers, are at the core of these applications and are especially sensitive to ionospheric perturbations, in particular scintillation phenomena, which are latitude and solar cycle dependent. Brazil sits in one of the most affected regions of the Earth and can be regarded as a test-bed for worst case scenarios. Problems with ambiguity fixing, crucial for GNSS carrier phase based techniques, have even before the rise of the solar cycle impeded the levels of availability expected by industry. A risk exists that the impact of high solar activity leads not only to disruption but even to disbelief on GNSS to support such applications. This issue is particularly relevant for the establishment of Galileo, and due to the technical challenge it poses. CALIBRA (Countering GNSS high Accuracy applications Limitations due to Ionospheric disturbances in BRAzil), a project funded by the European Community under the call FP7-GALILEO-2011-GSA-1a, aims to develop algorithms to be applied to the highly precise GNSS carrier phase observables, which will be implemented in GNSS receivers in order to counter the adverse ionospheric effects. The project has a two-year duration and started on November 2012. This paper presents initial progress on the project, with focus on the scientific and computational challenges that must be tackled to translate the assessment of

temporal and spatial TEC gradients typical of the perturbed Equatorial ionosphere into tools that can support the development of algorithms capable to effectively counter the space weather threats to GNSS high accuracy positioning.

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Mapping HF Radio Relevant Ionospheric Parameters in Near Real Time using GPS Total Electron Content Measurements.

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We present an approach to assimilating GPS total electron content (TEC) measurements into an empirical model of the ionosphere in near real time. The goal of this project is to extract maps of HF radio relevant parameters, such as foF2 and hmF2, from this model. We present our results in comparison to ionosonde measurements and discuss the techniques used including an ensemble Kalman filter and the role of ionospheric models such as NeQuick as part of the assimilation process.

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Swing Project

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The project "Short Wave critical Infrastructure Network based on a new Generation high survival radio communication system", SWING, deals with the study and design of a system of HF radio connections to link European Critical Infrastructures (ECIs). This system will replace broad band internet transmission when the latter fails. The HF network will withstand adverse conditions such as those encountered in case of a terrorist attack, guaranteeing the communication between ECIs and the transmission of necessary data for the survival and minimum operability of ECIs. SWING will be designed to evaluate the threat and increase the security awareness, as well as the level of protection, of analogous and/or interdependent ECIs. The project has to develop the standard software and hardware tools necessary for implementing communication protocols suited for a reliable and interoperable Short Wave (High Frequency) radio network back up. Therefore, SWING must also analyze the HF network requirements necessary for alerting and controlling ECIs in case of threat or attack, understand the particular characteristics of the ionospheric channel in order to establish a suitable control system for the frequencies to be employed, and design a radio-communication architecture for a HF radio network over Southern Europe. The use of proper ionospheric channels for data communication requires, in fact, the support of a geomagnetic and ionospheric awareness to provide information on the terrestrial effects generated by the arrival of interplanetary disturbances. Particularly intense solar events can affect the geomagnetic field and ionospheric plasma, changing the ionospheric structure especially in the HF band. The activities, organized in Working Packages (WPs), are distributed among four partners (INGV-Italy, CNIT-Italy, NOA-Greece, OE-Spain).

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Short Period Ionospheric Disturbances; Observational Techniques and Methods to Estimate their Origin.

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The ionosphere is influenced by a broad spectrum of waves propagating in ionized gas as well as in the neutral atmosphere. Periods of the waves extend from seconds to days. High frequency continuous wave Doppler shift sounding is an effective method for the monitoring of ionospheric oscillations in the period range from tens of seconds to tens of minutes. One of the frequent sources of such oscillations is geomagnetic micropulsations. The micropulsations are magnetohydrodynamic waves of periods of seconds to minutes that originate in the magnetosphere. Ionospheric disturbances caused by geomagnetic micropulsations occupy similar period range like infrasound. Infrasound is mechanical waves that propagate in the neutral atmosphere and it is coupled with the ionospheric plasma via collisions between neutral and ionized gas particles. A method is presented here which may help to distinguish ionospheric response to geomagnetic micropulsations from ionospheric infrasound. It is based on the comparison of multipoint ionospheric Doppler type measurements with records of local geomagnetic fields at several stations close to the Doppler sounder. This way of data evaluation reduces the chance that an incidental local disturbance of geomagnetic record at a single station leads to misinterpretation of studied Doppler records

containing infrasound on one hand. On the other hand, a chance is reduced that ionospheric response to geomagnetic micropulsations will be misinterpreted as infrasound, which is relevant particularly when evaluating Doppler data of lower signal quality.

To demonstrate the method, an event is analysed here when suitable conditions for observations of ionospheric response to geomagnetic micropulsations occurred together with a potential tropospheric source of infrasound - intense convective storms in the region of ionospheric Doppler sounding.

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Interference Effect in the Collection of Gnss Ionospheric Scintillation Data.

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The free electrons present in the earth's ionosphere affect GNSS (Global Navigation Satellite Systems) signals by introducing delays in their propagation that may be corrected in part or entirely by the use of several known techniques. But the ionosphere is not a regular medium and electron density irregularities may appear that can strongly affect wave propagation, causing rapid fluctuations in the amplitude and phase of the GNSS signals called scintillations. Scintillations can cause serious degradation problems to the performance of GNSS receivers by inducing cycle slips, losses of lock of the signals and decreasing the accuracy of the PVT solution. Scintillation activity depends on solar and geomagnetic activity, season, local time, geographic location and frequency. The approach of the next solar maximum predicted for 2013 will bring an increase of ionospheric disturbances, with possible degradations of the services relying on GNSS. This have driven the research interest both from the academy and industry to improve the robustness of GNSS to the threats posed by ionospheric activity.

Ionospheric Scintillation Monitoring Receivers (ISMR) are specialized receivers able to track and monitor scintillations in order to collect data that can be used to model the phenomenon, study its affects at receiver level and possibly predict its occurrence in the future. They make use of correlation data from the tracking processing blocks to measure the amount of scintillation affecting a satellite signal in both amplitude and phase. This is normally done by computing the S4 and phase deviation indexes in a minute by minute basis.

Within this work we deal with a specific environment of an ISMR where the monitoring of scintillation activity is threatened by the presence of radio frequency interference in the operation area. Given the crowded telecommunication environment where ISMR are likely to work in the next years, it is of interest to study the effects that other telecom systems transmitting at carrier frequencies close to the GNSS bands may have on the estimation of scintillation indexes due to unintentional leakages of power out of their allocated bandwidth. Robust tracking of GNSS signals under such conditions must be guaranteed and it must also be ensured as best as possible that the typical scintillation indices output by these receivers are not affected by the additional error source. RFI is, among the different error sources that corrupt satellite navigation waveforms, a particularly harmful error since in some cases it cannot be mitigated by a simple correlation process. This is indeed a problem that may affect the detection of ionospheric scintillation when monitored by GNSS signals, and will be analyzed in several interference scenarios.

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F2 Region Response to Geomagnetic Disturbances Across Low Latitude Ionosphere

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The morphology of ionospheric storm has been investigated across equatorial and low latitude of Indian region. The deviation in F2 region parameters at equatorial station Thiruvananthapuram (8.5°N, 76.8°E) and low latitude station Delhi (28.6°N, 77.2° E) have been studied during five geomagnetic storm periods. The southward polarity reversal of the z component of the interplanetary magnetic field, Bz, is found to be highly correlated with the storm sudden commencement (SSC). Both positive and negative phases have been noticed during the study and it is observed that in spite of local time variation in Dst, the corresponding deviation in F layer parameter vary with the intensity of the storm as well as latitude of the observing stations. The positive storm phase over equatorial stations are found to be more frequent while the drop in ionization in most of the

cases have been noticed at low latitude station of varying amplitude of deviations from the mean quiet day value. Due to disturbed electric field the simultaneous height rises have been noticed at these stations, with higher amplitude at Delhi in between 0000 to 0600 EMT. Positive deviation in foF2 is also observed across low latitude station during the storm which is attributed to daytime eastward electric field penetrating promptly from high to low latitudes. It may also be concluded that the reaction as seen at different ionospheric stations may be quite different during the same storm depending on the station coordinates, local time of the magnetic disturbance beginning.

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Comparative Analysis of Ionospheric Storms Development on the Background of Low and Medium Solar Activity

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The extended solar minimum and new solar cycle gives an opportunity for comparative study of the ionosphere disturbances at background of extremely low and medium solar activity. For analysing of the global structure and dynamics of ionospheric disturbances we used data provided by different ground-based and satellite ionosphere measurements. It was processed the data from European, American, Japanese, and Australian ionosonde networks as a benchmark data source. The ionosphere modification on a global scale have been checked with use of Global Ionospheric Maps, provided by international GNSS Service, and data from FORMOSAT-3/COSMIC RO mission. Additionally for estimation of the electron density dynamic at high latitudes there were analyzed TEC fluctuations maps, created by IGS/EPN, PBO and POLENET data.

As case study events there have been selected geomagnetic disturbances, occurred during the years 2008-2013, with significant ionospheric responses. The global maps of TEC were used in order to estimate large scale storm effects, ionosonde data gives possibilities to study the local peculiarities of the ionosphere disturbances (two parameters have been processed - the NmF2 and hmF2). The ionospheric slabthickness parameter was calculated for corresponded ionosones location. Additionally for analysis of the height ionospheric structure we combined ionosonde-derived data with the Ne profiles from FORMOSAT-3/COSMIC RO measurements and global distribution of electron density at selected altitudinal intervals. It was resulted that selected moderate geomagnetic storms (Kp ~ 6) lead to the different ionospheric response (positive and negative) over European, American, Japan and Australian areas.

The global pattern and local temporal and quantitative characteristics of the ionosphere disturbances during selected storms were revealed. For example geomagnetic storm October 11, 2008 lead to short time positive ionospheric disturbance over Europe in TEC values with factor 2, foF2 - with factor 1,5-1,8 and uplifting of F2 layer maximum up to 100 km. Additionally it was carried out the comparison of the ionosondes-derived foF2 values with IRI-2012 model, that have the storm-time option. It was obtained the qualitative agreement between the ionosonde-derived foF2 values and model calculations for cases of negative ionospheric storms. The best agreement between model and observations results corresponds to the Northern Hemisphere mid-latitude stations.

We acknowledge the Australian IPS Radio and Space service and the National Institute of Information and Communications Technology (NICT) in Japan for providing ionosonde data. The authors would like to thank B.W. Reinisch and the Center of Atmospheric Research, University of Massachusetts Lowell for the ionogram data of DIDBase. We are also grateful to International GNSS Service (IGS) for GPS TEC products.

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Spacecraft Charging with iPIC3D

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Long before the space age began, one had realized that space was not empty. Comet tails, meteors, and other extraterrestrial phenomena demonstrated the presence of a "space environment". Also spacecraft of course are affected, or better, interact with this plasma environment and may become charged. Given that our society becomes increasingly dependent on space technology, it is therefore imperative to develop a good understanding of spacecraft-plasma interactions, in which two things are important. First, one needs to be able to design a reliable spacecraft that can survive in the harsh solar wind conditions. Second, a very good knowledge of the plasma structure around the spacecraft is required to be able to interpret and calibrate scientific measurements from the on-board instruments.

Using the implicit Particle-in-Cell code iPIC3D [1] we contribute to this second point. iPIC3D has been updated with a set of open boundary conditions designed for solar wind-body interaction studies. Particles are injected at the inflow sides of the computational domain and absorbing on all others. The immersed boundary method [2] is applied to model various spacecraft geometries including the Solar Probe Plus spacecraft (NASA, launch 2018) and the Solar Orbiter satellite (ESA, launch 2017), for which we will present our findings. The physical model takes into account both photo- and secondary electron emission at the object's surface and various other secondary particle effects, such as backscattered electrons and particle reflection, are currently in development.

The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under the grant agreement eHeroes (project n° 284461, www.eheroes.eu).

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[2] Lapenta, "DEMOCRITUS: An adaptive particle in cell (PIC) code for object-plasma interactions", Journal of Computational Physics 230 (2011): 4679-4695.

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Lunar Dusty Plasma Environment: A 3D Simulation

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Dust particles have been observed to be present in almost all space environment, such as in the ionosphere, interplanetary space and large celestial bodies. A 3D simulation code has been developed to study dusty plasma environment such as lunar surface which is known as lunar dusty exosphere. This presentation illustrates our simulation results of lunar surface charging and levitation. It explains how the electric field developed from the charging of the surface causes dust originating from around the crater to be deposited inside the crater. In addition, investigation of the dynamics of lunar dust near a simple conducting lunar exploratory vehicle for two different lunar regions has revealed that dust particles appear to engulf the rover in terminator region but move outward from the rover in the dayside region.

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Radio Signatures of Multiple Shock Waves

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The generation of large-scale shock waves in the solar corona, their propagation to the interplanetary space and possibility of arrival to the Earth are major questions in the science of solar-terrestrial relationships with far-reaching consequences for space explorations. In particular, coronal and interplanetary shock waves accelerate energetic particles which can impact

spacecraft. Two or more subsequent shock waves, appearing in the close time window, can have complex radio signatures, so-called multiple type II radio bursts. We present a statistical study of multiple type II radio bursts, i.e., radio signatures of two subsequent shock waves which appear in a time window of up to 40 minutes. The data set contained 590 radio events observed by the Green Bank Solar Radio Burst Spectrometer (GBSRBS) and Bruny Island Radio Spectrometer (BIRS) from 2004 to 2012. We identified 140 type II bursts, and among them 32 multiple type II pairs. For the multiple type II bursts we also used complementary observations from Culgoora and IZMIRAN observatory. In the study the characteristics of multiple type II burst pairs and associated flares and CMEs were analyzed. It was found that the delay between start time of the two type IIs peaks at 5 - 8 min. The first type II burst of the pair always starts at higher frequencies that the second type II, and the speed of the first type II is usually higher (1000 -1400 km/s) than the speed of the second one (500 - 800 km/s). Inspecting the characteristics of the solar flares associated with the multiple type II pairs it was found that more than a half of the events were associated with M-class flares. On the other hand, the multiple type II pairs were associated with flares originating from active regions of very different magnetic complexity. About 70 % of the CMEs associated with multiple type II bursts were either halos or partial halo CMEs suggesting that wide CMEs create favorable conditions for the generation of multiple type II bursts.

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Time Scales of Energy Fluxes Deposition and Joule Dissipation Governing the Dynamical Conditions in Space Environment

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National Institute of Geophysics, Geodesy and Geography

Space Weather conditions are a direct consequence of the energy, momentum and mass fluxes initiated by the solar wind (SW)-magnetosphere interaction. Various simulation models have been developed to enable exploration and discovery of the behavior of coupled systems as the SW-Magnetosphere-Ionosphere-Thermosphere (M-I-T) system. These simulations address the main question of how the geospace system responds to solar variability, to understand the fundamental physical processes of the space environment from the Sun to Earth, and to develop the capability to predict extreme and dynamic conditions in space. In this connection the energy fluxes and Joule dissipation mechanisms in the M-I-T system emerge as a key factor that controls the energy deposition distribution both in height and in latitude and longitude. Ionospheric conductivity dynamical changes are thus responsible for the energy deposition rates in the M-I-T system. When the impulse momentum conservation law is applied to electric conductivity analyses of the M-I-T, the basic equations of charge motion becomes coupled even under weakly-ionized plasma conditions (Nn>>N, where Nn and N are neutral and plasma concentration densities). An estimation of the electric conductivity perpendicular to the ambient magnetic field B and parallel to the electric field E$\hat{J}$ (assuming that E$\hat{J}$ is perpendicular to B) predicts that maximum dissipation emerges basically at heights below and close to the corresponding maxima of the ionosphere plasma distributions. The obtained result differs qualitatively and even quantitatively from the expected time scales of Joule dissipation expected by conventional approaches. Characteristic times controlling the Pedersen/Hall currents dynamics in the M-I-T system are examined and introduced. These time scales should be definitely taken into account for Space Weather/Exploration purposes.

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How Space Weather could Influence on Human Cardiovascular System and Microcirculation

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The history of modern investigations of space weather influences on human health begin from Alexander Tchijevsky in Russia and M.Faure and G.Sardou in France (1927).

At the last two decades there were conducted several extensive studies that revealed dependence of cardiovascular pathologies from space weather events. The analyzing data collected by the Moscow ambulance services covering about six hundreds thousands observations over three years, cleaned up by seasonal effects of meteorological and social causes, shows that the number of cases of myocardial infarction increased during geomagnetic storms (Breus et al., 1995). Great contribution have made by Stoupel et al., (1999) who studied geomagnetic activity and cosmic rays influence on different kind of human pathologies. Our investigation during 14 years started at 1992 and included more than 25000 cases of acute myocardial infarction and brain stroke collected at seven medical hospitals. We used only cases with established date of

acute attack of diseases. Undated cases were excluded from the analysis. Average numbers of patients on geomagnetic active days and days with quiet geomagnetic condition were compared. It was shown statistically that during geomagnetic disturbances the frequency of myocardial infarction and brain stroke cases increased on the average by a factor of two in comparison with quiet geomagnetic conditions.

Laboratory tests as blood coagulation, platelet aggregation, and capillary blood velocity (CBV) in patients suffering from coronary heart disease (CHD) revealed a high dependence with the level of geomagnetic activity. Results of our recent study during "Mars-500" experiment has being conducted by Russian Space Agency and Russian Academy of Sciences, with extensive participation of ESA to prepare for future human missions to the Moon and Mars confirmed this conclusion. In total 58 good for reading records were analyzed. We compared CBV of each subject which measurements have coincided with days before and after beginning of geomagnetic storms (GMS).

Average values of CBV for all subjects for all period of study have made 515 ± 97 mm/s. Averages CBV values for days with quiet geomagnetic conditions have made 566 ± 217 mm/s. In active geomagnetic condition days average CBV values has registered as 389 ± 167 mm/s, that statistically significant ($p<0.05$) in comparison with CBV values for quiet geomagnetic conditions. Unsettled geomagnetic condition days gave the higher values of CBV: 557 ± 202 mm/s. We suggest that geomagnetic fluctuations acting on blood, brain, adrenals involve the adaptation system. This leads to appearance in blood adrenals hormones that responsible for activation of the clotting system, rise in aggregation and spasm in the afferent vessels of the microcirculatory network.

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Capturing the Physics of CME Propagation from the Sun to 1AU: An Update.

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Remote-sensing observations of the Sun and the corona provide the earliest warning of a potential geomagnetic storm. They provide the kinematic and magneto-plasma properties of the erupting solar event near the Sun. To correctly predict the arrival time and properties of Coronal Mass Ejections (CME) at 1AU, analytical/empirical results and numerical modeling are usually employed (combined) to capture the relevant physics associated with the propagation effects of the CME in the interplanetary medium. Many physical processes need to be simulated such as the effect of the magnetic tension force, of plasma and magnetic pressure gradients, drag and mass loading and the formation of shocks. For extreme events the production and presence of high-energy particles in the vicinity of the shock may also have an effect upon the arrival time and properties of the shock. We concentrate on several major CME events in 2011-2013. We determine the initial conditions of the corona and initial properties the CME by combining EUV and white-light observations from three vantage points. To do so, we use various tools developed by the CDPP at IRAP in Toulouse, in particular the recently developped 'propagation tool'. We then compare the results of several transit calculations by using the ENLIL and the analytical EFR 3-D MHD models based on the initial conditions obtained in the previous step. We evaluate the importance of simulating the background solar wind correctly for predicting the transit time of the CME and the associated shock to 1AU.

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Properties and Initiation Mechanisms for CMEs without Distinct Coronal Signatures

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We study the properties and initiation mechanisms for CMEs without distinct coronal signatures. Though easily visible in coronagraph observations, these so-called stealth CMEs do not obviously exhibit any of the low-coronal signatures typically associated with solar eruptions (changes in magnetic configuration, flows, solar flares, the formation of post-flare loop arcades, EUV waves, or coronal dimmings). We focus on what the presence or absence of these signatures can tell us concerning the mechanisms by which these stealth CMEs are initiated and driven.

To identify these CMEs without low coronal signatures, various data sets are used. We compare CMEs from the CACTus catalog to GOES event lists and output of SoFAST (Solar Flare Automated Search Tool), based on observations from

SWAP/PROBA2. Using STEREO observations, we can exclude the back-sided CMEs. We use this list to characterize the general properties of events without low coronal signatures and, from this list, select a few eruptions to study in detail using both observations and numerical models.

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Study of Stealth CMEs Arriving at the Earth in the Period 2009 - 2010

Mierla, Marilena[1]; Rodriguez, Luciano[1]; Kilpua, Emilia[2]; D'Huys, Elke[1]; Zuccarello, Francesco[3]; Zhukov, Andrei[1]; Seaton, Dan[1]
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During the very calm year 2009 and the slightly more active year 2010 there were few Earth directed CMEs without any signatures on the solar disc. Using data from STEREO/COR and SOHO/LASCO it was possible to derive the propagation direction of these CMEs and their radial speeds. Furthermore, EUVI and COR1 data showed that these CMEs may form higher up in the corona, explaining the lack of signatures on the solar disc. The possible triggering mechanisms of these events is investigated by comparing them with the available models (magnetic breakout model, solar wind drag etc.).

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Comparison of the High-Speed Solar Wind Streams during the First Four Years of Last Five Solar Cycles (nos. 20 - 24)

Maris Muntean, Georgeta[1]; Besliu-Ionescu, Diana[1]; Mierla, Marilena[2]
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The behavior of the high-speed streams in the solar wind is investigated during the period of the first four years of the 24th solar cycle (2009 - 2012). The analysis is performed taking into account their frequency of appearance and the following parameters: the durations (in days); the maximum velocities; the velocity gradients; the importance of the streams. The time variation of the high speed stream parameters and their occurrence rate is compared with the corresponding ones during the first four years of the solar cycles nos. 20 - 23. The levels of the geomagnetic variability during the same intervals are also analysed taking into account the aa geomagnetic index and the intensity of the registered geomagnetic storms.

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High-Energy Sep Modelling for Large Solar Particle Events

Jiggens, Piers[1]; Vainio, Rami[2]; Tylka, Allan[3]; Aran, Angels[4]; Heynderickx, Daniel[5]; Truscott, Pete[6]; Lei, Fan[7]; Sanahuja, Blai[4]; Daly, Eamonn[1]
[1]ESA/ESTEC; [2]University of Helsinki; [3]Goddard Space Flight Center; [4]University of Barcelona; [5]DH Consultancy; [6]Kallisto Consultancy; [7]RadMod Research

Predicting the radiation environment is critical for any space mission and one important source of radiation is the Sun. In the specification of the solar energetic particle (SEP) environment, previous work has focussed on the 5 - 200 MeV range (Jiggens et al. 2012) as this is critical for electronics components behind nominal spacecraft shielding. It is also well measured by a variety of space-borne instrumentation. However, for human spaceflight the shielding levels are far greater and therefore the critical energy of incident particles is also higher. Unfortunately, the high energy solar proton measurements come with a great deal of uncertainty as a result of the width of the energy bins of monitors meaning that the correct average energy of particles is difficult to discern and, furthermore, there are fewer instruments taking measurements in this range thus reducing the length of the high-energy solar proton dataset and the ability to calibrate measurements.

The most important source of data for overcoming these dataset limitations is the data from neutron monitors (NMs) which see flux enhancements as a result of the secondary neutrons produced when high energy solar protons are attenuated in the upper atmosphere. By first subtracting the contribution from galactic cosmic rays (GCRs) and then accounting for the particle cut-off rigidity based on the location of the NM measurements for very high-energy protons can be discerned. Work done by Tylka and Dietrich (2009) provides a reliable starting place by describing the combined satellite and neutron-monitor event-integrated proton spectra with a Band function (Band et al. 1993).

Using this data, we present probabilistic models for the high energy proton environment for use in spacecraft missions where solar particles from 200 MeV to 1 GeV are important. We also present the results of a study into the rise times of fluxes to assess reasonable warning times for astronauts to halt an EVA and/or get to a storm shelter on the spacecraft. The work is supported by ESA's General Studies Programme.

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Heliospheric Propagation of ICMEs: The Drag-Based Model

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New space-weather forecast-tool for predicting the arrival of Interplanetary Coronal Mass Ejections (ICMEs) is presented. The forecast-tool is based on the "Drag-Based Model" (DBM), developed in the frame of the European Commission FP7 Project SOTERIA (SOlar-TERrestrial Investigations and Archives) and advanced within FP7 Project COMESEP (Coronal Mass Ejections and Solar Energetic Particles). The DBM is based on a hypothesis that the driving Lorentz force that launches CME ceases in the upper corona, and that beyond certain distance the dynamics becomes governed solely by the interaction of the ICME and the ambient solar wind. This assumption is founded on the fact that in the interplanetary space fast ICMEs decelerate, whereas slow ones accelerate, showing a tendency to adjust their velocity with the ambient solar wind. In particular, we consider the option where the drag acceleration has the quadratic dependence on the ICME relative speed, which is expected in the collisionless environment, where the drag is caused primarily by emission of MHD waves. This is the simplest version of DBM, where the equation of motion can be solved analytically, providing explicit solutions for the Sun-Earth ICME transit time and the impact speed. DBM offers easy handling and straightforward application in the real-time space-weather forecasting. DBM results are compared with remotely-measured interplanetary kinematics of several ICMEs, whereas forecasting abilities are tested on the statistical basis by employing in situ measurements. Finally, the advantages and drawbacks of DBM are summarized. This work has received funding from the European Commission FP7 Project COMESEP (263252).

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Systematic Testing of Different De-Projection Methods for STEREO Imagery

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Using single spacecraft measurements from STEREO-COR2+HI1+HI2 we study the propagation behavior of a sample of well observed coronal mass ejections (CMEs) in interplanetary space. For this we started to do a systematic testing on different de-projection methods for transforming off-pointed and wide field HI1/HI2 images to Sun centered polar coordinate system (NRL tool versus SATPLOT/JPL tool). First results for the ecliptic plane showed that both tools deliver reliable results for the measurement of elongation of CME structures.

The time-elongation measurements from NRL and SATPLOT are further used for deriving CME speeds and arrival times at 1AU, by assuming constant CME speed and direction. We use geometrical modeling for single spacecraft HI data, approximating the evolution of the CME front with different geometrical shapes (Fixed-Phi, Harmonic Mean - HM, Self-Similar Expansion - SSE). The results will give error estimations for forecasting CMEs using the different methods. The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under grant agreements n°284461 [eHEROES] and n°263252 [COMESEP].

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Evolution of Flare Loops of the X1.4 Class Flare of 22 September 2011

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Coronal mass ejections (CMEs) and flares are transient phenomena with huge energy releases originating from the solar corona. They can immensely influence the conditions of the heliosphere and space weather at Earth. We investigate and

analyze the evolution of the X1.4-class flare/CME event of 22 September 2011 that took place on the eastern limb of the Sun and produced a distinct system of flare loops. From Earth, the event was observed on the solar limb from enabling us to derive de-projected height-time curves of the evolving loops. For a continuous tracking of the loop system in EUV using SDO/AIA data of 5s time-resolution, we developed a method that automatically detects the height of the loop tops over a given reference point by analyzing the intensity profile perpendicular to the solar limb. With this method, we measured the height-time profiles of the loop system in the different wavelength channels (AIA 171, 211, and 304 A, H-alpha data from the Kanzelhoehe Observatory, the Hvar Observatory, and from the GONG H-Alpha Network) over a time period of 12 hours after the flare onset. We identify characteristic features in the height-time curves which stem from non-uniform growth of the flare-loop system. At different wavelength channels such features show a slight delay in space and time that can be interpreted in terms of cooling processes. In addition, we put special focus on the early phase of the event for which we compare the growth of the loop system with the kinematics of the CME and try to find a connection between rapid growth of the loop system and other parameters, like enhanced X-ray flux.

The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under grant agreement n°284461 [eHEROES].

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Space Weather at Other Planets

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Space weather increasingly influences our technology-dependent modern-day life on Earth and in its orbit. Future manned missions to the Moon, Mars, and beyond will be even more vulnerable to space weather effects and require careful preparation. Moreover, longer-term effects of space weather determine the properties of surfaces of moons and asteroids, and even short-term properties of planetary magnetospheres and atmospheres. I will present some first measurements of the radiation environment on the surface of another planet, Mars, and discuss space weather effects throughout the solar system and beyond.

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On the Radial Evolution of Magnetic Clouds

Rollett, Tanja[1]; Veronig, Astrid M.[1]; Leitner, Martin[1]; Vrsnak, Bojan[2]; Möstl, Christian[1]; Ibsen, Tina[3]; Farrugia, Charles J.[4]; Vennerstrøm, Susanne[5]; Temmer, Manuela[1]
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Magnetic clouds (MCs) are a subset of interplanetary coronal mass ejections. They are characterized as intervals of enhanced, smoothly rotating interplanetary magnetic field, low plasma beta and temperature in spacecraft in situ data. In this study we analyze the evolution of a sample of MCs, observed by at least two radially aligned spacecrafts at different heliocentric distances. The data-sets are fitted with a force-free, constant-alpha flux rope model, assuming a cylindrical flux tube of circular cross-section. Using the outcome of this fitting model we calculate the estimated cross section diameter, the poloidal and the axial magnetic field, the electric current, the magnetic flux and the inductance. All these parameters are further studied as a function of heliocentric distance. In this way, eroded magnetic flux can be directly estimated. This work has received funding from the European Commission FP7 Project COMESEP (263252). C.F. was supported by NSF grant AGS-1140211 and Wind grant NNX10AQ29G.

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Influence of the Upper Atmosphere of the Earth on Solar EUV Observations from LEO Satellites

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Absorption in the atmosphere below 500 km results in attenuation of the solar EUV flux, variation of its spectra and distortion of solar images acquired by solar EUV instruments operating on LEO satellites even on solar-synchronous orbits. Occultation measurements are important for planning of solar observations from these satellites, and can be used for monitoring of the upper atmosphere as well as for studying its response to the solar activity.

We present the results of the occultation measurements of the solar EUV radiation with the SPIRIT and TESIS telescopes onboard the CORONAS satellites, with the SWAP telescope and LYRA radiometer onboard the PROBA 2 satellite in different phases of solar activity. The results are compared with simulations by the NASA MSIS atmospheric model and can be helpful for occultation studies of atmospheres at other planets.

The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under the grant agreement eHeroes (project n° 284461, www.eheroes.eu).

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Structure of Magnetic Field in ICMEs: Multi-Spacecraft Diagnosis Technique.

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Magnetic field reconstruction codes, have been often utilized to provide an insight into the magnetic field structure of coronal mass ejections (CMEs). The launch of STEREO 6 years ago have made multi-spacecraft measurements of CMEs possible. However, due to the approximations made when building these methods, the CME magnetic field may not always be reconstructed correctly. In some cases, it could be totally at fault, as we have shown in a previous work, where the reconstruction of a simulated CME with minimal twist yielded a helically twisted magnetic field (this was the longest sentence ever). Here, we investigate the same structure using multiple synthetic satellites at different positions with respect to the CME axis, and see how much we can learn about the global magnetic structure of the CME from multi-spacecraft measurements.

Radiation Doses Received by Astronauts during Future Interplanetary Travels with DREADCode and Comparison of Results.

Cazzola, Emanuele; Lapenta, Giovanni

KULeuven

In the next decades, many world wide space agencies are planning to colonize new celestial bodies, such as the Moon, Mars and the asteroids. In order to undertake this type of missions different risks have to be taken into account, including space radiations, which are one of the biggest issue to consider.

This work aimed to develop a quick and easy tool able to assess doses received by astronauts during these interplanetary journeys, with the particular feature to take data source directly from satellite recordings and online available dataset. After setting in advance the number, composition and thickness of each layer shielding the incoming ionizing particles, this tool evaluates the effective dose or the ambient dose equivalent released by those particles able to penetrate trough these layers, thanks to the Bethe-Bloch's equation for the stopping power assessment.

Finally, comparisons with results obtained from SPENVIS for both the case to the Moon and to Mars are presented and analyzed.

The research leading to these results has received funding from the Euro- pean Commission's Seventh Framework Programme (FP7/2007-2013) under the grant agreement eHeroes (project n 284461, www.eheroes.eu).

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IMPTAM: Providing < 100 keV Energetic Electrons along Satellites' Orbits Responsible for Hazardous Surface Charging

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Finnish Meteorological Institute

The fluxes of low energy electrons with energies < 100 keV are responsible for such a hazardous charging phenomena as surface charging. The electron flux at these energies varies significantly with geomagnetic activity and even during quiet time periods. We present the Inner Magnetosphere Particle Transport and Acceleration Model (IMPTAM) which provides the distribution of low energy electrons in the inner magnetosphere and along any orbit of any satellite, for both already in space and at the planning stage. The IMPTAM model follows distributions of ions and electrons with arbitrary pitch angles from the plasma sheet to the inner L-shell regions with energies reaching up to hundreds of keVs in time-dependent magnetic and electric fields. We trace a distribution of particles in the guiding center, or drift, approximation, and the drift velocities are considered such that relativistic effects for electrons are taken into account. The IMPTAM is driven by the observed parameters such as IMF By and Bz, solar wind velocity, number density and dynamic pressure and Dst index. The substorm-associated increases in the observed fluxes can be captured when substorm-associated electromagnetic fields are taken into account. We introduced the substorm-associated electromagnetic fields by launching several pulses at the substorm onsets. We present the results for GEO and MEO orbits.

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Statistical Model for Predicting Arrival and Geoeffectiveness of CMEs Based on near Real-Time Remote Solar Observations

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One of main issues of space weather is the timely prediction of strong geomagnetic storms, mainly caused by coronal mass ejections (CMEs) arriving at Earth. However, with current knowledge on CMEs, we are not yet able to predict the arrival time, velocity and magnetic field, or even if it will hit or entirely miss the Earth. Therefore, an empirical statistical model was established and implemented that can be used as an early geomagnetic storm warning. For every detected CME, the alert system provides a probability estimation of both arrival and geoeffectiveness using near-real time remote observations of CMEs and associated flares.

The probability estimation for CME arrival resulted from an analysis of front-sided halo CMEs. For each of these CMEs the relationship with an Interplanetary CME (ICME) was identified based on in-situ data. As such an empirical probabilistic relationship was established for the CME arrival based on the source position.

The statistical geoeffectiveness model was set up using a dataset of front-sided, solar flare-associated CMEs and association was made with a specific Dst (disturbance storm time) index. This sample contains geoeffective and non-geoeffective CMEs. The results of an extensive statistical analysis confirmed some previously known connections between remote solar properties and geomagnetic storms, namely the importance of CME speed, apparent width, source position and associated solar flare type. We quantify these relationships and use them to construct a statistical model for predicting the probability of geomagnetic storm level. Both probability models for CME arrival and geoeffectiveness are combined to provide a geomagnetic storm alert in case of CME detection.

This work has received funding from the European Commission FP7 Project COMESEP (263252).

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A Semi-Analytical Foreshock Model for Space Weather Applications

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We present a semi-analytical model of the ion foreshock for CME-driven shock waves. The model utilizes the theory of diffusive shock acceleration to describe the ion mean free path in the foreshock region. However, we make use of an extensive set of self-consistent Monte Carlo simulations of the coupled particle acceleration and wave generation at the shock to recalibrate the parameters of the simplified theory. As a result, we obtain an analytical model of the mean free path upstream of the shock, which has parameters that can be determined from observations of energetic particle fluxes at 1 AU and from MHD simulations of shock propagation. The model provides a computationally effective formulation of wave-particle interactions upstream of a coronal/interplanetary shock, which can be integrated to space-weather relevant models of particle acceleration/transport during large solar energetic particle events. The tool will enable the specification of the peak fluxes and fluences during shock passages at small distances from the Sun, not yet accessed by spacecraft measurements.

These results have been obtained in the EU/FP7 project SPACECAST, grant agreement no. 262468.

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An Interactive 3-d Tool for Visualising the Geometry of Coronal Mass Ejections

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We present an interactive graphics tool that can easily visualise the idealized shape of a coronal mass ejection (CME) and its orientation with respect to Earth and other planets. The software is based on S2PLOT, an advanced 3-d plotting library developed by Barnes et al. at Swinburne University of Technology, Australia. S2PLOT can be used with C, C++, FORTRAN, and Python programs on Linux and Mac OS X platforms. The library features dynamic geometries that can be controlled by the user via mouse and keyboard.

The current version of our tool takes a 3-d point cloud generated by the Graduated Cylindrical Shell (GCS) model of Thernisien et al. (2006) as input and displays the CME as a textured wireframe. Precise ephemerides and orbits for Earth and other terrestrial planets (Mercury, Venus, Mars) are computed with the help of the Naval Observatory Vector Astrometry Software (NOVAS) package. The graphics on the screen can be freely rotated and zoomed by the user. Keyboard callbacks allow the user to alter display options like transparency, coordinate grids or labelling. Velocity information can be used to geometrically propagate the CME into interplanetary space and estimate the arrival time at Earth.

The aim of our software tool is to help visualise coronal mass ejections: their shape, size, orientation, propagation, and arrival at planets in the inner solar system, primarily Earth. It can be applied in support of space-weather forecasting (e.g. as developed in the framework of the AFFECTS project), for education and public outreach activities, as well as for the display and interpretation of GCS modelling results.

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Application of Space Environment Information to Operations of Spacecraft and Manned Space Mission in Japan

Koshiishi, Hideki

Japan Aerospace Exploration Agency

Information on space weather for safety of spacecraft and manned space mission has been gathered and analyzed by the space environment group in the Japan Aerospace Exploration Agency (JAXA) since 1987. Several instruments for in-situ measurements of space environment have been developed and installed to Japanese and French satellites, Space Shuttle flights, and International Space Station, which are particle detectors for electrons, protons, heavy ions, and neutrons, magnetometer, atomic oxygen monitor, dosimeter, single event monitor, potential monitor for electrostatic charge and discharge, and space micro debris detector. Information obtained from these instruments has been gathered into the Space Environment and Effects System (SEES) in the JAXA as well as other information obtained from other spacecrafts and ground-

based equipments. The SEES has several functions by using these data as follows; (1) to inform real-time information on space environment for operators of spacecraft and manned space mission, (2) to alert space radiation hazard for those operators in case of solar flares, coronal mass ejections, and geomagnetic storms and sub-storms, (3) to provide usual space environment models such as solar, interplanetary, geo-magnetospheric, and cosmic ray activities for spacecraft engineers, (4) to analyze the gathered data with international scientific researchers for understanding of solar-terrestrial physics as well as for development of more precise space environment models for future space missions. In this presentation, each function of the SEES will be reported.

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High Resolution Spectro-Polarimetric Observations of a Delta Spot

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Delta spots are characterized by umbrae of opposite polarities sharing a common penumbra. Due to this magnetic configuration, delta spots are often the sites where major flares occur and their study might provide new insights on the mechanisms leading to the instabilities that trigger flares and eventually CMEs. High resolution observations of these features are quite rare and the opportunity offered by a data set recently acquired at the Swedish 1-m Solar Tower (SST) has been exploited in order to study the evolution of a delta spot hosting some flare events. Active region NOAA 11267 was observed on August 6, 2011 from 09:00:05 UT to 09:37:37 UT, using CRISP at the SST. CRISP acquired full Stokes profiles over the Fe I line at 630.25 nm, and spectroscopic data over the Fe I line at 557.6 nm. Filtergrams in the core of the Ca II H line at 396.8 nm were simultaneously acquired. The spectro-polarimetric data have been processed using the MOMFBD (Multi-Object Multi-Frame Blind Deconvolution) technique. The results obtained from the SIR inversion of these data are discussed with respect to those reported in the literature.

This study has been carried out in the framework of the EU FP7 project "eHEROES - Environment for Human Exploration and RObotic Experimentation in Space" (grant n. 284461).

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Magnetic Anomalies and Mini-Magnetospheres on the Lunar Surface. Do we want to live there?

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[1]KU Leuven; [2]KTH

The Moon has no general overall magnetic field to shield it. But limited regions of the Moon surface show significant local magnetic fields with strengths that are comparable to that found in the Earth magnetotail or even stronger. So there is no doubt that they can play a dominant role in determining the local environment in those magnetized regions. The literature refers to these regions as magnetic anomalies. Important recent papers have investigated the issue theoretically and observationally. The Lunar Science Laboratory at the University of Colorado even conducts experiments in the laboratory to model such anomalies.

A key question is the characterization of the response of these regions to the incoming solar wind plasma and especially its perturbances and the solar energetic particles generated in magnetic storms.

What does the local magnetic field to those incoming particles? And what action they have on the local environment. A possible future mission of exploration what radiation environment should expect in those location? Are they prime real estate or should they be avoided?

We at eHeroes, www.eHeroes.eu, are developing an analysis tool that can answer all these questions by conducting a complete first principle model of the anomaly and its interaction with solar wind and SEPS. The model is based on iPic3D, a fully kinetic tool for space weather modeling.

The Moon is there waiting for us to return. But we need to prepare and understand the territory better than in the roaring days of the Apollo missions. We want to do that.

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Solar particle flux peaks detected on board ISS

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Solar activity poses substantial risk for astronauts of the International Space Station (ISS) both on board and during extravehicular activity. We present in this work a parallel analysis of the ALTEA-ISS on board data and of the solar flares on the 7th of March 2012 produced by NOAA AR11429, described in the framework of space weather. The ALTEA (Anomalous Long Term Effects on Astronauts) experiment mounted on the ISS is an active detector composed of six silicon telescopes and is able to follow the dynamics of the radiation flux. During its operation in 2012 a number of flux peaks were detected in correspondence with solar events.

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Forecast of Radiation belt fluxes using coupled VERB and NARMAX models

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The Earth's outer radiation belt is highly variable with high-energy electrons presenting a constant threat to hardware. The development of accurate energetic particles flux models is therefore essential for the protection of space assets This study is concerned with forecasting of energetic electron fluxes in the outer radiation belt by combining data-driven NARMAX predictions with physics-based VERB simulations. The data fusion allows forecasting electron fluxes with a high degree of accuracy and potentially avoids the need to run coupled simulations to account for a variable outer boundary, which is one of the inputs for the VERB code. On the other hand, a combined convection-diffusion simulation combined with a data-driven model has the potential to provide flux forecasting in the whole inner magnetosphere. The model allows to calculate total radiation dose that spacecraft is subjected to within the inner magnetosphere.

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Improving HF Communications Availability Forecasts for Aircraft on Trans-Polar Routes

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An increasing number of aircraft operate on polar routes for which radio communications via VHF or geosynchronous satellite relays are unavailable. Airlines and air traffic control (ATC) authorities nonetheless require reliable HF communications with high availability and the ability to predict outages several hours in advance of a flight departure. However, ionisation of the D region polar cap and auroral ionosphere due to solar flares and energetic particle precipitation increases the absorption of HF radio waves in this region.

This paper describes a new research programme at the University of Lancaster in collaboration with the University of Leicester, Solar Metrics Ltd and Natural Resources Canada that addresses these issues. The project will develop a nowcasting and forecasting model of HF radio absorption in high northern latitudes that incorporates measurements from a Global Riometer Array (GLORIA). Real-time satellite measurements of the solar wind, interplanetary magnetic field, solar X-ray flux and energetic particle precipitation will be utilised as input to the model to improve its forecast capability.

Maps of absorption will be combined with the Leicester University three-dimensional HF ray tracing model. As part of this project, the Leicester HF propagation model will utilise data from a network of HF transmitters (collocated with ATC stations) and direction-finding receivers at high northern latitudes. Measurements on these paths will further improve and validate the HF predictions by ensuring that non-great-circle propagation paths are adequately modelled. The main product of the research programme will be an online HF communications planning and forecasting tool designed for the particular needs of civilian airlines.

This presentation will focus on the space weather effects on auroral absorption.

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The Importance of Space Weather Awareness for Atmospheric Research after the Nuclear Incident in Fukushima

Santen, Nicole; Matthiae, Daniel; Meier, Matthias
DLR

Space Weather Awareness is a crucial factor in the field of airborne radiation monitoring since solar radiation storms can significantly affect measurement results. For instance, a Solar Particle Event (SPE) can lead to an additional contribution to the radiation exposure of aircrew at aviation altitudes, which is generated by interactions of primary high-energetic particles of cosmic origin with atoms of the Earth's atmosphere.

Here, a case study of a measuring flight is presented, which was performed by the German Aerospace Center on 23rd March 2011, twelve days after the nuclear disaster of Fukushima, where large amounts of radioactive isotopes were released and spread across the entire globe. The flight aimed at gaining information about and samples from the radioactively unpolluted atmosphere at aviation altitudes in Germany. Radiation protection of aircrew and scientists required online-monitoring of the dose rate aboard the research aircraft in order to detect potential elevated airborne radioactivity in addition to the radiation exposure at aviation altitudes due to galactic cosmic rays and prevent the aircraft from contamination. The fact that two days before the measuring flight NOAA had issued an alert due to a solar radiation storm, which indicated the possibility of an event that could lead to increased dose rates at aviation altitudes as well, required the permanent observation of the space weather situation in order to attribute a possible additional contribution to either a space weather event or the nuclear accident.

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Influence of Solar Energetic Particle Drift on the Detection of Ground Level Enhancements

Dalla, Silvia[1]; Marsh, Mike[1]; Agueda, Neus[2]; Dierckxsens, Mark[3]; Laitinen, Timo[1]
[1]University of Central Lancashire; [2]University of Barcelona; [3]Belgian Institute for Space Aeronomy

Solar Energetic Particles (SEPs) with energy in the GeV range can propagate to Earth from their acceleration region at the Sun and produce Ground Level Enhancements (GLEs). These events cause large increases in the radiation experienced by air passengers and crew. Many questions related to the production and propagation of GeV-energy particles remain unanswered. For example, while it is established that GLEs are associated with very large flares and fast CMEs at the Sun, there are many examples of such solar events that did not produce a GLE. We present results of test-particle simulations of the transport of GeV-energy solar particles from the Sun to Earth, showing how gradient and curvature drifts influence their propagation. We also analyse GLE data and >100 MeV proton data from the GOES satellite, made available through the SEPEM project, to verify whether drift patterns can help to explain and predict the occurrence or non-occurrence of a GLE following a solar event at the Sun. This work has received funding from the European Commission FP7 Project COMESEP (263252).

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SIEVERT and SiGLE: Assessing Radiation Doses Aboard Aircrafts.

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[1]Observatoire de Paris; [2]IRSN

In 2000, the European Commission directive (EU directive 96/29/EURATOM) set limits to the exposure of aircraft crew to cosmic radiation. The effective dose should not be higher than 100 mSv over 5 years with a maximum of 50 mSv for a given year (specific rules apply to pregnant air crew). The radiation doses onboard aircraft are due to two sources: Galactic Cosmic Rays (GCR) and Solar Proton Events (SPE). The doses are the result of the numerous secondary particles created in the atmosphere by high energy primary particles. The galactic component is permanent but modulated by the solar activity in the course of the 11-year solar cycle. The SPE, when detected at ground level by neutron monitors (GLE), may enhance significantly the doses received onboard aircraft. A specific semi-empirical model named SiGLE was developed (Lantos & Fuller, 2003) to take into account these events. Within the European Radiation Dosimetry Group (EURADOS), doses computed by several models were compared and assessed for the GCR. The same comparison is ongoing for SPEs models and a measurement campaign initiated by IRSN (Institute for Radiation Protection and Nuclear Safety) should give important clues to validate the different approaches in the near future. Using EPCARD and SiGLE, the computerized system for flight assessment of exposure to cosmic radiation in air transport, or "SIEVERT" (Bottollier-Depois, 2003), was proposed to airline companies to assist them in the application of this legal requirement. This professional service is also accessible to any passenger who whish to estimate the dose received during a given flight (www.sievert-system.org). SIEVERT was developed by the French General Directorate of Civil Aviation (DGAC), the IRSN and Paris Observatory.

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Influence of Strong Scintillation Effects during Aviation Landing Procedures and Their Mitigation

Berdermann, Jens[1]; Hlubek, Nikolai[2]
[1]German Aerospace Center; [2]DLR

Ground Based Augmentation Systems (GBAS) can correct the majority of the GNSS pseudo range errors experienced by an aircraft in the vicinity of an airport. The normal behavior of the ionosphere has a very limited impact on the position error. However, the ionospheric medium is subject to perturbations due to the strong temporal and spatial variability of the ionospheric plasma. In particular short term disturbances of the ionosphere lead to fluctuations of phase and amplitude in the GNSS signals. These fluctuations are called signal scintillations and can be caused by ionization fronts, Travelling Ionospheric Disturbances, plasma bubbles and plasma turbulences. Therefore scintillations are one of the biggest sources of positioning uncertainty in modern GNSS receivers and can even lead to a complete loss of the signal in extreme cases. Their random and uncorrelated nature cannot be corrected by two frequency measurements. We will present the ionospheric threat model developed at the DLR to provide information about the worst case ionospheric threat, which can occur in each epoch. A mitigation of such scintillation effects can be done by preventing the aircraft from using unsafe combinations of GNSS satellites.

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Space Weather at the UK Met Office: Operations & Development

Bingham, Suzy; Jackson, David; Gibbs, Mark
Met Office

The UK Met Office provides a space weather forecasting service which operates 24/7. Through working with a range of partners, including the US National Oceanic & Atmospheric Administration (NOAA), the British Geological Survey (BGS), the UK Space Agnecy & the British Antarctic Survey (BAS), the Met Office have developed this service to monitor solar activity. Described here is the Enlil model which has been implemented operationally at the Met Office & provides a back-up for the NOAA SWPC model. Also described are a number of models which will be implemented to provide futher information for the Met Office Hazard Centre forecasters. These models include the Multi-Instrument Data Analysis System (MIDAS) which performs 3D tomography of the ionosphere, & SPACECAST which forecasts the high energy electron flux in the radiation belts.

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The STAFF Viewer: A Powerful Tool for Space Weather Forecasters and Researchers

Malisse, Vincent; Verbeeck, Cis
Royal Observatory of Belgium

The Solar Timelines Viewer for AFFECTS (STAFF) is a dynamical online viewer that provides a whole range of timelines related to solar activity and space weather. It is currently being developed at the Royal Observatory of Belgium (ROB) as part of the FP7 project AFFECTS (Advanced Forecast For Ensuring Communications Through Space).

The STAFF viewer and its database have been designed to allow the user to view and compare timelines from different data sources in any time interval, ranging from real time to the full archive of past data. STAFF is a web-based application based on JSP, HTML, CSS and JavaScript and is built on top of a PostgreSQL database.

Since it is tailored to space weather operations, STAFF provides easy and dynamical access to realtime space weather timelines such as GOES X-ray curves, ACE data and geomagnetic indices. It also serves solar activity timelines such as the International Sunspot Number and the F10.7 radio flux. Furthermore, STAFF will provide in the near future some brand new proxies extracted automatically from coronal EUV images (AIA, SWAP, EIT), like the total flux observed in the telescope passband, active region area, and total EUV intensity within active regions. Finally, STAFF can show views of previous Carrington rotations and has a feature that allows grafting customized plots into other webpages.

The STAFF database infrastructure is designed for quick access of timelines and allows for long term research on all datasets.

We present the STAFF viewer and database, its principles and design, as well as its power and ease-of-use for the user.

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Making Solar FITS Files Interoperable

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Astronomically images in general, and solar images in particular, are traditionally stored and distributed as FITS files. In its simplest version, a FITS file consists of a human-readable ASCII header of keyword-value pairs containing the metadata, followed by a binary part containing the actual data. In addition, a FITS file may contain several extensions, and each of these may contain a data object.

Over the years, the FITS format has become very popular. Nevertheless in a world where interoperability is the norm, the FITS format has to face a few problems. One of them is that the keywords are limited to 8 characters and their meaning not always unique nor clear. Several attempts have been made to standardise the keywords, ranging from full FITS standard keywords, IAU approved keywords to more discipline specific keyword dictionaries. In addition, specific papers exist for describing world & celestial, spectral and time coordinates in FITS (http://fits.gsfc.nasa.gov/fits_wcs.html).

The keyword description documents we are aware of are not machine readable. This is a strong limitation on interoperability as it means that essentially manual work has to be done when combining solar images from different sources (e.g. in versatile image viewers) or when porting the images to virtual observatory efforts with their own data model.

In this paper we explore solutions to this problem by encapsulating the FITS file in a VOTable (XML format) with the metadata referring to IVOAA standards. We then propose a procedure to translate form this exploded view to any destination data model. As a real-life example we show the conversion of SWAP and LYRA FITS files to the ESPAS data model.

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The Need for a Standardized Data Format for Solar Radio Spectrograms

Marqué, Christophe; Bourgoignie, Bram
STCE - Royal Observatory of Belgium

Solar radio spectrometers are a key element for the monitoring of the solar activity, providing information on flare-accelerated particles and shock waves propagating in the corona or the interplanetary medium. For historical reasons, each observatory operating such instruments (ground-based or space-based) has developed his own data format, sometimes proprietary, sometimes derived from international data format (FITS, CDF...), but even in that case without much coordination, hampering therefore the possibility to easily combine these data together. We review here the current situation, discuss which information is needed for a better integration and propose some solutions.

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NMDB: An e-Infrastructure Funded by the European Union's Framework Programme

Steigies, Christian
Christian-Albrechts Universität zu Kiel

The Real-time database for high-resolution neutron monitor measurements (NMDB) provides access to ground-based cosmic ray measurements from Neutron Monitors. As the project was funded only for two years, we have created a database that can be operated in the long term without incurring license fees. For this only an open source database comes into consideration. We chose MySQL as our database,

since at the time of the creation of NMDB, MySQL provided the easiest solution to replicate the data to different servers, by which we can improve the accessibility of the data due to full NMDB mirrors at different institutes. Since 2007, there have been many changes in MySQL land: MySQL has been sold twice and there are some concerns that the development of MySQL may be stopped by its current owner.

Fortunately there are several open source forks of MySQL, which guarantee the future of our database. In addition to this, current versions of MySQL (and MariaDB) include improvements which allow for a real multi-master setup. With this setup a NMDB 2.0 database with several distributed masters could be created, so that NMDB can continue to grow without overloading our database and providing even faster access for data providers and users.

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SEPServer - A new Tool for SEP Research

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The EU/FP7 project SEPServer has produced a new tool, which greatly facilitates the investigation of solar energetic particles (SEPs) and their origin: a server providing SEP data, related electromagnetic (EM) observations and analysis methods, comprehensive catalogues of the observed SEP events, and educational/outreach material on solar eruptions. The project has combined data and knowledge from eleven European partners and several collaborating parties from Europe and the US. The datasets provided by the consortium partners have been collected in a MySQL database on a server, which also hosts a web interface providing browsing, plotting and post-processing and analysis tools developed by the consortium, as well as the SEP event catalogues. SEPServer adds value to several space missions and Earth-based observations by facilitating the

coordinated exploitation of and open access to SEP data and related EM observations, and promoting correct use of these data for the entire space research community.

The server will be released to the public during the Tenth European Space Weather Week.

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Space Weather Data Services at Sodankylä Geophysical Observatory

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Sodankylä Geophysical Observatory (SGO) is located in Finland 120 km north of the Arctic Circle. SGO, which celebrates its 100th anniversary this year, has some of the longest time series of geospace observations in existence; geomegnetic observations since 1914 and ionosoundings since 1957. For the first 48 years, SGO ionograms were stored on 35 mm film and scaled manually. Since 2005 a new digital chirp ionosonde is used but ionospheric parameters are still read manually.

As part of the ESPAS project, SGO is committed to improve the online availability of these unique datasets. ESPAS data services at SGO will to a large extent be based on the MADRIGAL database, which is the de facto standard for incoherent scatter radar data. The SGO MADRIGAL service is deployed in collaboration between SGO and the radar groups at Millstone Hill and EISCAT. In this way ESPAS benefits from developments in the incoherent scatter radar community.

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KAIRA Space Weather Facility - First Results

Ulich, Thomas[1]; McKay-Bukowski, Derek[1]; Vierinen, Juha[2]; Virtanen, Ilkka[3]; Kero, Antti[1]; Fallows, Richard[4]; Orispää, Mikko[1]; Postila, Markku[1]; Lehtinen, Markku[1]
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Since August 2012, the KAIRA, the Kilpisjärvi Atmospheric Imaging Receiver Array, which is a facility for Space Weather and Astronomy Research, has been in operation. KAIRA is located at Kilpisjärvi, Northern Finland, about 85 km east of Tromso, Norway. Originally, KAIRA was built for prototyping work related to develop receiver technology for the EISCAT_3D Incoherent Scatter Radar, which is a large, phased-array 3D-imaging radar system for Northern Europe.

KAIRA, however, is a highly versatile and interesting facility in its own right. It is a broad-band receiver operating between 10 MHz and 88 MHz (LBA) and 110 MHz and 270 MHz (HBA). It can be used, e.g., to monitor interplanetary as well as ionospheric scintillations, as an imaging riometer, as a receiver for passive radar applications using the signals of other transmitters in the area, or indeed as a receiver for the current EISCAT VHF incoherent scatter radar.

Here we highlight a selection of the first results and tell about the facilities capabilities for space weather research.

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The Heliophysics Event Knowledge Base, and Beyond.

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The immense volume of data generated by the suite of instruments on the Solar Dynamics Observatory (SDO) requires new tools for efficient identifying and accessing of data.

Cataloguing events and features is necessary in order to facilitate access to dataset of interest for the users. The Heliophysical Events Knowledge base (HEK) infrastructure was developed by LMSAL in order to fill in this need. The HEK gathers a set of feature-detection algorithms (some of which coming from the NASA-funded Feature Finding Team effort) in a common 'Event

Detection System' which share a.o. a common vocabulary for the metadata. Web services and clients are provided for searching the metadata, reviewing the results, and efficiently accessing the data. For example, the HEK database can be queried from within IDL or Python, and selected datasets can be retrieved via the 'Virtual Solar Observatory' (VSO) infrastructure, for which an interface exists both in IDL and Python.

Recently, these clients were also used to display HEK events within visualization software such as the Helioviewer system. This link between HEK database and visualization software can be further utilized in order to display 'Space Weather alerts', as it is foreseen in the Space Weather Helioviewer software currently under development at the Royal Observatory of Belgium.

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GIC Recordings at the North-West of Russia for EURISGIC Project: Data and Modeling

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Geomagnetically induced currents in neutrals of the five transformer substations are used to investigate the effects of space weather on power grid in the framework of EURISGIC Project. Two years of continuous registration was given ample material to assess the dependence of GIC on the level of geomagnetic activity. Recorded GIC are compared with the results of model calculations. The research leading to these results has received funding from the European Community's Seventh Framework Program (FP7/2007-2013) under grant agreement no260330.

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TRANSMIT Data System: An infrastructure for the Advancement of Ionospheric Science and Services

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At a COST 296 MIERS (Mitigation of Ionospheric Effects on Radio Systems) workshop held at the University of Nottingham in 2008, the establishment of a sophisticated Ionospheric Perturbation Detection and Monitoring (IPDM) network (http://ipdm.nottingham.ac.uk) was proposed by major European experts and encouraged by the Euroean Space Agency (ESA)as the way forward to deliver the state-of-the-art to protect the range of essential systems vulnerable to ionospheric threats. It was proposed the establishment of an operational European wide information service, capable of detecting and monitoring the whole spectrum of ionospheric perturbations and related scintillations (via geo-plasma warnings, now-casts and forecasts) for the wider European user community, including SME's, government offices, commercial and public users. Concurrent related research will help to develop effective techniques for mitigating ionospheric threats.

TRANSMIT (Training Research and Applications Network to Support the Mitigation of Ionospheric Threats),an FP7 Marie Curie Initial Training Network, is the precursor for the establishment of the IPDM network and focuses on GNSS and business sectors reliant to it. The project (www.transmit-ionosphere.net) exploits the existing specialized European science base and take advantage of insight and full commitment from European GNSS industry and end-users in order to prove the IPDM network concept and setup its prototype. TRANSMIT prototype is based on a consortium that brings together some of the biggest GNSS Rx manufactures and precise positioning service providers, as well as leading research institutes and universities around the Europe, to provide the requirements, final validation and lead the system development, respectively. The dissemination of the developed capabilities will be achieved via the web-based prototype system, which will operate on a number of pre-selected scenarios regarding the state of the ionosphere, and not in real-time.

In the recent TRANSMIT Newsletter (http://www.transmit-ionosphere.net/transmit/newsletters.aspx)important constraints that are expected to influence the development of the TRANSMIT prototype system were presented. These constraints are: 1) the need for various levels of asset management (data/information/knowledge), 2) the rapid change of the development environment, which is worse further by the immaturity of the research layer to quickly comprehend and respond to the business needs, 3) the "integration" in terms of data, policies and processes and 4) the "data budget" which resembles similar data management requirements as the ones in the so-called Big-data or e-science environments.

This paper covers some of the main on going activities related to the development of the "Data System" (DS) that implements the various Data services required by the TRANSMIT prototype system. The preliminary infrastructure (hardware/software) to respond to the above mentioned constraints will be described and the results from the interfacing between the data and the application layers will be shown.

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Space Weather Helioviewer : Challenges of Visualizing Heterogeneous Solar Data

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Royal Observatory Belgium

Helioviewer aims to become the sidekick of virtual observatories and aggregators of solar observations by providing quicklook data, context data and model visualisation. The Space Weather Helioviewer (SWHV, ESTEC/ITT AO/1-7186) is an extension of the JHelioviewer application (http://jhelioviewer.org) with space weather relevant capabilities within a streamlined user interface. The Helioviewer project can be seen from two sides: On one hand, it involves the visualisation of the various datasets and their combination in new ways. On the other hand, it develops and implements standards and APIs in order to be able to quickly handle this data in new contexts without much overhead. The data itself is heterogeneous: it contains 1D data (timelines); 2D data (solar images and spectrograms); 3D data (multi-spacecraft imaging, magnetic field lines modeling), solar event detections (e.g. HEK) and space weather alerts. Therefore one of the main goals of the project is to present this quicklook data through a uniform and convenient API.

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Creating a Collaborative Research Environment for Space Weather

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Understanding space weather phenomena requires access to many different types of information and tools. Advances in technology have resulted in a wealth of capabilities being easily accessible through the Internet; some of these can easily be used together but this is not the general case. We propose to try to work towards a more general research environment that incorporates as many of the existing tools as possible.

In the **HELIO** project we have developed a comprehensive set of services that can be used to address science use cases in heliophysics including space weather effects on the Earth. The interfaces of the **HELIO** services are compliant with standards developed by the International Virtual Observatory Alliance (IVOA) although some extensions have been necessary because of differences in the types of query that need to be made.

In the **CASSIS** project we have been examining ways of improving interoperability between services and data and metadata sets. The **HELIO** project is a good template to work from but clearly other ideas will need to be factored in if we try to incorporate

We report on the experience we have gained in developing capabilities that are compliant with standards and the adjustments that have been necessary. We also describe the steps need to create a collaborative research environment for space weather.

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An Automated Solar Synoptic Analysis Software System

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We have developed an automated software system of identifying solar active regions, filament channels, and coronal holes, those are three major solar sources causing the space weather. Space weather forecasters of NOAA Space Weather

Prediction Center produce the solar synoptic drawings as a daily basis to predict solar activities, i.e., solar flares, filament eruptions, high speed solar wind streams, and co-rotating interaction regions as well as their possible effects to the Earth. As an attempt to emulate this process with a fully automated and consistent way, we developed a software system named ASSA(Automated Solar Synoptic Analysis). When identifying solar active regions, ASSA uses high-resolution SDO HMI intensitygram and magnetogram as inputs and providing McIntosh classification and Mt. Wilson magnetic classification of each active region by applying appropriate image processing techniques such as thresholding, morphology extraction, and region growing. At the same time, it also extracts morphological and physical properties of active regions in a quantitative way for the short-term prediction of flares and CMEs. When identifying filament channels and coronal holes, images of global H-alpha network and SDO AIA 193 are used for morphological identification and also SDO HMI magnetograms for quantitative verification. The output results of ASSA are routinely checked and validated against NOAA';s daily SRS(Solar Region Summary) and UCOHO(URSIgram code for coronal hole information). A couple of preliminary scientific results are to be presented using available output results. ASSA will be deployed at the Korean Space Weather Center and serve its customers in an operational status by the end of 2012.

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The Design of Value Added Services to Serve ESPAS Users

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The primary objective of ESPAS is to support the access to observations from the near-Earth space environment. This is a region that extends from the Eart's atmosphere up to the inner magnetosphere. Observing instruments that are linked to ESPAS include ionosondes, incoherent scatter radars, magnetometers, GNSS receivers and a large number of space sensors and radars. The ESPAS platform supports the systematic exploration of multi-point measurements from near-Earth space through homogeneous access to diverse data, enhances researchers' capability to develop advanced models of the geospace, supports data assimilation and provides tools for validation of models. Although the system development is in its early phase, the consortium has already started to analyse indicative scientific problems, whose study will be possible through the use of ESPAS services. The scientific advances resulting from these studies will lead to the development of validated scientific models and consequently to reliable predictions and related products and value-added services that will meet the needs of scientists, operators, decision makers, system developers, etc. An important work done within the ESPAS project is the definition of several scientific scenarios called "use cases". The "use cases" express the user requirements on the ESPAS system, in other words they express "what" the system should be able to perform. These scenarios are exploring the required behaviour of ESPAS and form a solid basis for testing the system's behaviour as it responds to a request that originates from outside of the system. The following main groups of use cases are under analysis and first results will be reported in the ESWW10: a) Homogenised access to the main ESPAS data repositories b) coincidences and conjunctions between ground-space and space-space monitoring units c) tools to validate models d) on line implementation of models able to support space weather prediction services.

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SWEMEP: A Platform as a Service (PaaS) for Executing Space Weather Models in the Cloud

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Space Weather Software Models are used to support analysis and forecasting of space weather phenomena and the effects of these phenomena on spacecraft and other critical infrastructure. Exploitation depends on efficient ICT infrastructure for coupling models and supporting heterogeneous execution; software, hardware and networks capable of supporting challenging CPU and communication requirements.

Recent developments in technology in cloud computing offer significant benefits such as flexibility and immediate scalability ("elasticity") that are particularly well suited to these challenges.

We will present the concepts, architecture and technology choices as interim results of a study being conducted for ESA on this topic. The overall objective of the study is to assess needs and define a blueprint for an ESA-wide cloud solution, comprising two layers:

- A common IaaS (Infrastructure as a Service) in which the service provided to users consists of access to virtual servers, likely to be deployed as a combination of private and public cloud services. The technical solution is complemented by strong focus on security and governance aspects.

- A space weather Paas (Platform as a Service) built using IaaS services, which will provide developers with the building blocks and semantics for managing complex mathematical models and their data, the business logic to describe the processing sequence, handling scalability, fault tolerance, etc. in their applications.

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The COMESEP Alert System

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Tools for forecasting geomagnetic storms and solar energetic particle (SEP) radiation storms have been developed under the three-year EU FP7 COMESEP (COronal Mass Ejections and Solar Energetic Particles) collaborative project. To enhance our understanding of the 3D kinematics and interplanetary propagation of coronal mass ejections (CMEs), the structure, propagation and evolution of CMEs have been investigated. In parallel, the sources and propagation of SEPs have been examined and modeled. During the third year of the COMESEP project the produced tools have been validated and implemented into an operational space weather alert system. The COMESEP alert system provides notifications for the space weather community. To achieve this the system relies on both models and data, the latter including near real-time data as well as historical data.

Geomagnetic and SEP radiation storm alerts are based on the COMESEP definition of risk. The COMESEP alert sysem is being launched during ESWW10 and will be demonstrated at the Fair. For more information see the project website (http://www.comesep.eu/). This work has received funding from the European Commission FP7 Project COMESEP (263252).

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space weather monitoring and analysis system at moscow state university

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Space monitoring data center of Moscow State University provides operational information on radiation state of the near-Earth space. Complex, fully automated information system gives access to the actual data characterizing the level of solar activity, geomagnetic and radiation conditions of the magnetosphere and heliosphere via the Internet portal http://swx.sinp.msu.ru/ in the real time mode. The main components of the system are real-time data and the models of space environment. Operational data are coming from space experiments, both, Russian and foreign, on charged particle fluxes in energy channels from hundreds keV to hundreds MeV. The UV images of the Sun and solar wind parameters are also used in forecasting and now-casting. The models of the space environment working in an autonomous mode are used to generalize the information obtained from observations on the whole magnetosphere. Interactive applications and operational forecasting services are created on the base of these models. Velocities of high speed streams in solar wind on the Earth orbit are reconstructing with advance time of 3-4 days on the basis of automatic estimation of parameters of the coronal holes detected on the images of the Sun received from the SDO satellite. By means of neural network approach Dst-index online forecasting at 0.5-1.5 hours forward depending on solar wind and the interplanetary magnetic field, measured by ACE satellite is carrying out.

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Deployment architecture to support the IT capabilities of Brazilian Space Weather Program

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The Brazilian Space weather information and prediction Center (EMBRACE) was held in 2008, and today we provide several near real-time information on the ionosphere, geomagnetic fields, cosmic rays over the south America and solar radio wave radiations, in addition to the solar and interplanetary ambient conditions from the other space weather centers. The ground based sensors and receivers generate data with different volumes and different frequencies ranging from a few seconds to a few hours. Furthermore, there is a need of receiving such data in real time to perform the monitoring 24 hours per day,7 days per week. In order to support such a demand five applications were developed for receiving, processing and visualization of data from the instruments spread out over Brazil. These applications use an architecture based on components that interact asynchronously. In order to meet the requirements of performance, availability and fault tolerance was developed for components in a high performance system. This architecture is based on the replication of the components used by the application and the distribution of each component in a dedicated server. Virtual machines are used to enable the creation of multiple copies of components with servers and databases. The TI infrastructure of the center currently has 16 servers, each one with 16 processors and 32 GB of RAM. Furthermore, there is used an 32 TB for storing the virtual machines, raw data and database. All servers have CentOS 6 and virtualization is through native Linux solution, called Kernel-based Virtual Machine (KVM). We will summarize the operations and applications developed for our Space weather center.

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Modeling of Electron Production Rate Profiles in the Ionosphere during GLE 70 on 13 December 2006 using Various Models

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he ground level enhancement (GLE) of cosmic rays (CRs) on December of 13, 2006 is one of the biggest GLEs in 23rd cycle (behind GLE 69 from 20 January 2005 only) in minimum phase of solar cycle. The greatest maximum was recorded at Oulu Neutron Monitor Station (92.1 %), i.e. the maximum of GLE70 was recorded at sub-polar stations, which shows that the anisotropy source was located near the equator.

Here we compute in details the ionization effects in the terrestrial middle atmosphere and ionosphere (30-120 km) for various latitudes. The computation of electron production rate profiles q(h) is according the operational model CORIMIA (COsmic Ray Ionization Model for Ionosphere and Atmosphere). This improved CR ionization model is important for investigation of the different space weather effects. The influence of galactic and solar CR is computed with the new version of CORIMIA code, which is with fully operational implementations. The solar CR spectra are taken from recent reconstructions from ground based measurements with neutron monitors. Hence we compute the time evolution of the electron production rates q(h) in the ionosphere and middle atmosphere. The full 24h ionization effect is also determined. Comparison between the effects on GLE 70 (13 December 2006) and the major GLE 69 (20 January 2005) is made. In addition, a comparison between the results obtained by COIIMIA and CORSIKA in the region 30-40 km have been carried out. The cosmic rays determine to a great extent the chemistry and electrical parameters in the ionosphere and atmosphere. They create ozonosphere and influence actively the stratosphere ozone processes. But the ozonosphere controls the meteorological solar constant and the thermal regime and dynamics of the lower atmosphere, i.e. the weather and climate processes.

The CR flux varies during the solar cycle in an opposite face to that of sunspots. This hypothesis of the solar-terrestrial relationships shows the way to a non-contradictory solution of the key problems of the solar-terrestrial influences.

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H2 Emissions of the Upper Atmosphere of Uranus

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Recent observations of Uranus allow us to re-detect an auroral emission of Uranus during the progression of an interplanetary shock [1]. However during this campaign some low-resolution observations have been performed with the STIS spectrometer. Our aim is to use the Trans* family code to calculate the intensity of the H2 emission on Uranus. The Trans* family code have been used to calculate the emission of a large set of planet from the Earth [2] to Jupiter [3] and exoplanets [4]. It is a kinetic transport code, which calculates the effect of primary and secondary electrons in the upper atmosphere of planets especially the ionizations, excitations and thus the spectral lines emissions. By coupling this code to the emission code developed by Menager et al. for the jovian H2 emissions, we are able to calculate these emissions. The comparison with the data has been done along the STIS slit. Depending on the S/N for H2 lines, we integrated on the entire disk. We are able to obtain an evaluation of the electrons spectrum that produces these H2 emissions and to detect the specific H2 emission of an auroral event the 29th october 2011.

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Variability of the Atmosphere in Mid-Latitudes

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IAP ASCR

Terrestrial atmosphere displays high variability on wide scales. All atmosphere regions are strongly influenced and consequently modified by the solar activity. Energy input from the Sun (solar flux and IMF) varies significantly in a broad time-scale range from short extreme events (for instance geospheric storms) through regular diurnal and seasonal changes, solar cycles to secular variations of periodic and quasi-periodic character. Monitoring of the atmosphere reflects changes on scales from seconds up to long periods of tens of years or even secular changes. We present temporally and spatially dependent ionospheric response to solar, geomagnetic, and neutral atmosphere effects in midlatitudes.

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The Shielding Effect of Honeycomb Sandwich Panels and a Method for Consideration in Radiation Analysis for Space

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The shielding effect of honeycomb sandwich panels which are common in spacecraft structures could be relevant in terms of mass saving - especially on challenging missions like in Jupiter's radiation belts. An usual conservative approach was to neglect the mass of the honeycomb cores. On the other hand it is hardly impossible to model these panels for a complex spacecraft in detail.

To enable the consideration of the honeycomb core material in a radiation analysis of a complete satellite, the shielding effect of these panels was investigated. This was done by modelling a small honeycomb sandwich panel with realistic core dimensions which was compared to a model, where the whole core mass was smeared on an extra plate placed between the cover sheets. These models were created in the GDML (Geometry Description Markup Language) format and then analysed with GRAS (Geant4 Radiation Analysis for Space), a Geant4-based radiation analysis tool provided by ESA. In the simulation the models were irradiated from a plane source with three different spectra (solar protons and trapped electrons in GEO, Jovian electrons in the JUICE Mission). Total dose was measured by two silicon targets placed on the backside of this setup and fluence through the panel was calculated too.

The comparison of all results showed, that there is a remarkable shielding effect of the core material, although it is a bit lower than with a plate of full equivalent core mass. Therefore a correction factor of the usable mass for an equivalent plate could be given.

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Validating the BAS Radiation Belt Model with Giove-B Satellite Data

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[1]British Antarctic Survey; [2]European Space Agency

The EU FP7 project SPACECAST uses the BAS radiation belt model to forecast high energy electron fluxes in the Earth's radiation belts and to provide an associated risk index for satellites in Earth orbit. Part of the project is model verification and this is particularly important in the heart of the Earth's outer radiation belt where the flux of energetic electrons are highest, and, potentially, most damaging. This is the region which is traversed by global positioning satellites such as the US GPS system and the developing European Galileo satellite navigation system. In this study we take output from the latest BAS radiation belt model and apply calibration curves to convert electron differential number flux to counts observed by SREM on Giove-B. We show comparisons of the SREM data with modelled count rates for L > 4.5 for a selection of geomagnetic storms.

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Upgrades on the Orbit Generator Tool for the new Spenvis-ng System

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[1]Deimos Space; [2]DH Consultancy; [3]BIRA-IASB

In this paper we present the upgrades done for the Orbit Generator tool developed by DEIMOS in the context of SPENVIS-NG. The key objective of this ESA project (ESTEC Contract number: 4000104812) is the upgrading of the current SPENVIS system into a new web-based service-oriented distributed framework supporting plug-in of models related to the hazardous Space Environment. The Orbit Generator on SPENVIS-NG will be implemented making use of the experience gathered by the current Orbit Generator and adding improvements that, for example, allow both direct download of TLE data from available web servers or use of ephemeris information using ESOC LTOF and CCSDS OEM formats. The addition of these new features will entail the development of a new input model to interface the Orbit Generator with the newly developed system and models.

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The Recent Anomalities of Space Weather Characteristics Fixed by the Russian Federal Space Agency Monitoring System

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The latest anomalous dose rate increasing events detected by the space radiation exposure on electronic components engineering Monitoring System elements are discussed. The subjects considered are the space-borne control of TID effects on electronic components, the space-borne and ground-based control of some space weather characteristics.
The base component of space-born segment is set of TID sensors, operating on MNOSFET dosimetry principle. More than 36 TID sensors were placed onboard more than 18 spacecrafts at the circular orbit ~20000 km with inclination ~65° since October 2008.
The analysis of the last flight data is presented. An anomalous increasing dose rate was observed on March, 2012 (as 100 times as more), on July, 2012 (as 11 times as more), on October, 2012 (as 14 times as more). The TID sensor data were compared with average dose rate from the International Space Station, ELECTRO electron flux, ground measurements of cosmic rays variations by Moscow Neutron Monitor and GOES proton and electron flux data. An excellent coincidence of TID sensor data with integral flux of GOES 2 MeV electrons and ELECTRO 2.3 MeV electrons for all these events was observed. The one can note the absence of abrupt increasing of dose rate at the MEO during the solar flare with proton flux increasing and without electron flux increasing at the GEO.

The experimental dose rate values for 2009, 2010, 2011, 2012 years are presented. The experimental total dose value and the average dose behind the different aluminum shield types values were compared.

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Self-Consistent Monte Carlo Simulations of the Re-Acceleration of Protons in the Downstream Region of a Coronal Shock

Afanasiev, Alexandr; Vainio, Rami
University of Helsinki

We present results of Monte Carlo simulations of proton re-acceleration in the downstream region of a coronal shock, which were carried out in the framework of the SEPServer project. This effect, as suggested by observations, can be important at the early (coronal) phase of gradual SEP events, producing various features in the observed characteristics, e.g. non-power-law energy spectra of particles. The results are obtained using our simulation model of interactions of protons with a spectrum of Alfvén waves. The model treats the wave-particle interactions self-consistently under the quasi-linear approximation and employs the full form of the quasi-linear resonance condition governing the interactions. The simulations reveal that the particle energy spectra developed due to the re-acceleration process can have different shapes, not necessarily a power-law one, depending on the initial ratio of the particle energy density to the wave energy density in the system.

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Comparison between Path Lengths Traveled by Solar Electrons and Ions in GLE Events in Solar Cycle 23

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We have examined the Wind/3DP/SST electron and Wind/EPACT/LEMT ion data to investigate the path length difference between solar electrons and ions in the Ground-Level Enhancement (GLE) events in solar cycle 23. Assuming that the onset time of metric type II or decameter-hectometric (DH) type III radio bursts is the solar release time of non-relativistic electrons, we have found that within an error range of±10% the deduced path length of low-energy (~27 keV) electrons from their release site near the Sun to the 1 AU observer is consistent with the ion path length deduced by Reames from the onset time analysis. Furthermore, the solar longitude distribution and IMF topology of the GLE events examined are in favor of the coronal mass ejection-driven shock acceleration origin of observed non-relativistic electrons. We have also found an increase of electron path lengths with increasing electron energies. The increasing rate of path lengths is correlated with the pitch angle distribution (PAD) of peak electron intensities locally measured, with a higher rate corresponding to a broader PAD. The correlation indicates that the path length enhancement is due to the interplanetary scattering experienced by first arriving electrons. The observed path length consistency implies that the maximum stable time of magnetic flux tubes, along which particles transport, could reach 4.8 hr.

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Self-Consistent Plasma Simulations of Particle Acceleration and Radio Emission in the SEPServer Project

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Self-consistent plasma simulations in the framework of the SEPServer project were designed to aid the interpretation of the experimental results obtained from the analysis of the SEP events. We considered the acceleration of ions and electrons in coronal shocks, the acceleration of electrons in coronal current sheets and the radio emission through the plasma emission mechanism upstream of coronal shocks. Ion transport and acceleration was modeled under the quasi-linear approximation, i.e., as resonant interaction between the charged particles and the Alfvénic fluctuations carried by a prescribed large-scale plasma flow, using the CSA code (Vainio & Laitinen 2007: ApJ, 658, 622) and a new code (Afanasiev & Vainio 2013: ApJS, submitted) developed in the framework of SEPServer. Electron acceleration and radio emission was simulated using local

plasma simulations making use of the Particle-in-Cell code ACRONYM (Kilian et al., High Performance Computing in Science and Engineering '11, 2012). In this paper, we will present a summary of the simulation work performed in SEPServer and discuss the implications of the simulation results in the light of data analysis performed in the project.

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New Data and Forecasting Products in the Framework of the EU FP7 Project SPACECAST

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Solar activity can trigger sporadic bursts of energetic particles in the solar wind and increase the number of high and low energy particles trapped inside the Earth's radiation belts. These cause damage to satellites and are a hazard for manned spaceflight and aviation. They are difficult to predict due to uncertainties over the basic physical processes, and the need to access reliable data in real time.

The SPACECAST project (European Union Framework Programme 7 Project 262468) aims to protect space assets from high and low energy particles in the electron radiation belts and during solar energetic particle events by developing European dynamic modelling and forecasting capabilities.

SPACECAST uses a MySQL database server (using the ESA Open Data Interface under licence) operated by DH Consultancy to collect magnetic indices, solar wind parameters and GOES particle fluxes in near real time, and combines this with web services to distribute the data to model servers at NERC/BAS, ONERA and FMI, where model runs are executed to obtain forecasts of high energy electron fluxes and nowcasts of low energy electron fluxes in the radiation belts. The model results are collected by the DH Consultancy server, post-processed and displayed on the SPACECAST web site (http://fp7-spacecast.eu/) in the form of panel plots, movies and alerts (including a satellite risk index for GEO deep dielectric charging). All processes are fully automated and run at hourly intervals.

Most recently, modelling of solar energetic protons and a service to calculate radiation doses have been added. In addition, alert services are being defined which can be tailored by registered users.

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Space Weather Services at the Belgian Institute for Space Aeronomy

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Belgian Insitute for Space Aeronomy

In this poster we briefly outline the main activities of the Space Weather section, that is part of the Space Physics department of the Belgian Institute for Space Aeronomy. Through participation in several projects the Space Weather section has acquired a rich experience in developing and operating scientific services. One of our prime projects is SPENVIS (Space Environment Information System), which has been running at BIRA since 1996 and is now rebuild with new technologies in order to better meet the current and future needs of the user community. The new system is foreseen to be operated in the context of ESA's SSA programme. Also within this framework, the group actively participates in the operation of the SSA Space Weather Coordination Centre (SSCC) at the Belgian Royal Observatory.

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SEPServer Advances Overview on Solar Energetic Particle Events

Malandraki, Olga E.[1]; Papaioannou, A.[1]; Agueda, N.[2]; Klein, K.-L.[3]; Heber, B.[4]; Valtonen, E.[5]; Nindos, A.[6]; Dresing, N.[4]; Herbst, K.[4]; Vainio, R.[7]; Braune, S.[8]; Kouloumvakos, A.[6]; Dröge, W.[9]; Kartavykh, Y.[9]; Rodríguez-Gasén, R.[10]; Vilmer, N.[10]; Heynderickx, D.[11]; Aurass, H.[8]; Hamadache, C.[12]; Kiener, J.[12]; Riihonen, E.[5]; Tatischeff, V.[12]; Sanahuja, B.[2]

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SEPServer hosted activities related to the scientific analysis of SEP event observations, including data analysis using both data-driven and simulation-based methods. The scientific conclusions of this effort are drawn with the implementation and release to the SEP community of multiple SEP event catalogs based on different spacecrafts and instruments, covering a broad timescale from 1975 to 2013 as well as a variety of distances from 0.3 to ~5 AU in the heliosphere. SEP events from Helios A & B missions, going back to 1975, at distances 0.3-1 AU, together with their Electromagnetic (EM) counterpart from OSRA data are being released for the first time. A catalog covering solar cycle 23 based upon the Solar and Heliospheric Observatory (SOHO)/ Energetic and Relativistic Nuclei and Electron (ERNE) high-energy (~68 MeV) protons at 1 AU with parallel analysis of SOHO/ Electron Proton Helium Instrument (EPHIN) and Advanced Composition Explorer (ACE) / Electron, Proton and Alpha Monitor (EPAM) data, including the relevant EM associations has also been delivered. Furthermore, the first complete Solar TErrestrial RElations Observatory (STEREO) SEP catalog based on the Low Energy Telescope (LET) protons (6-10 MeV) and the Solar Electron Proton Telescope (SEPT) electrons (65-105 keV) covering the rising phase of solar cycle 24 has been implemented. Moreover, the Cosmic Ray and Solar Particle Investigation (COSPIN) Kiel Electron Telescope (KET) data of 38-125 MeV has been used to identify a new catalog of SEP events observed in and out of the ecliptic plane over solar cycle 23, with simultaneous analysis of electrons recorded by the Heliosphere Instrument for Spectra, Composition and Anisotropy at Low Energies (HISCALE). For selected cases simulation based analysis has been applied in order to identify the timing of the injection history and to provide a cross reference to the EM emissions, leading to a comprehensive treatment of these events and to the corresponding testing of the data-driven analysis methods. SEPServer brings together a wealth of SEP data, analysis methods and diverse but at the same time interconnected solar and heliospheric communities. It thus provides an open tool that will advance our understanding of SEP propagation and acceleration, under different conditions, an important element of Space Weather.

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Solar Energetic Particle Spectral and Compositional Invariance in the 3-D Heliosphere: Ulysses and ACE/WIND Comparisons

Malandraki, Olga E.[1]; Tylka, Allan J.[2]; Ng, Chee K.[3]; Marsden, Richard G.[4]; Tranquille, Cecil[4]; Patterson, Doug[5]; Armstrong, Thomas P.[5]; Lanzerotti, Louis J.[6]

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We carry out the first detailed examination and comparison of elemental spectra and composition in the late decay phase of two Solar Energetic Particle (SEP) events in the so-called 'reservoir' regions, between spacecraft widely separated in latitude, as well as in longitude and radial distance in the Heliosphere. Energetic particle data from instruments onboard the Ulysses spacecraft located at a high heliospheric latitude of ~ 70 deg N and at a heliocentric distance of ~ 2.5 AU and from spacecraft at L1 are used in this work. Particle intensities over time are observed to be in close agreement following the shock passage over the widely separated spacecraft. Electron measurements were used to identify the extent of the particle reservoir. In this update on reservoir composition studies, we extend our previous work to sub-MeV/nucleon energies, using measurements from HI-SCALE on Ulysses and EPAM on ACE. Implications of the observations for models of SEP transport are also discussed.

Acknowledgments: The presented work has received funding from the European Union FP7 project COMESEP (263252) and has also been supported by NASA under grants NNH09AK79I and NNX09AU98G (AJT).

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Modelling of Large Solar Energetic Particle Events for Space Weather Applications: Testing the Q(VR)-Relation

Pomoell, Jens[1]; Aran, Angels[2]; Poedts, Stefaan[1]; Sanahuja, Blai[2]
[1]KU Leuven; [2]Universitat de Barcelona

As a result of our previous modelling of gradual solar energetic particle (SEP) events, a relation known as the Q(VR)-relation between the injection rate of shock-accelerated particles, Q, and the jump in the radial velocity across the shock front, VR, at the cobpoint position (i.e. the position at the shock front to which the observer is magnetically connected during a SEP event) was established. Utilizing the relation a first space weather tool to predict proton fluxes and fluences at different locations in the heliosphere, the SOLPENCO tool, was constructed. Further developments of the physics-based model lead to an extended version of the tool, SOLPENCO2 (within the SEP model of the ESA/SEPEM project).

As the Q(VR)-relation is the foundation upon which the aforementioned space weather tools are based, a better characterization of the relation is necessary in order to further improve the tools. This can be achieved by improving the accuracy of the modelled SEP events, as well by extending the number of modelled events.

In this work, we present our modelling results of a selection of SEP events using a new shock-and-particle model. Our modelling approach consists of combining 1) a simulation of the propagation of a shock from the Sun to the Earth driven by a coronal mass ejection (CME) and 2) the transport of shock-accelerated particles along the interplanetary (IP) magnetic field line connecting the shock front with the observer at 1 AU.

In particular, we have developed a new shock propagation model that utilizes numerical magnetohydrodynamic (MHD) simulations in the ecliptic plane for obtaining a realistic temporal evolution of the parameters of the propagating shock. This is ensured by choosing the free parameters of the model CME initialized at ~two solar radii in such a way that the observed plasma parameters at 1 AU as well as the transit time of the shock are accurately reproduced.

Next, the results of the MHD simulation are used as input in a particle transport model, which is used in order to reproduce the proton differential intensity-time profiles (and first order anisotropies whenever possible) measured during the studied SEP events. Analyzing the output of the new coupled shock-and-particle model, we are able to address the Q(VR)-relation in detail.

The work is performed in the framework of SPACECAST, a Collaborative Project funded by the European Union Framework 7 programme to help protect satellites on orbit by modelling and forecasting particle radiation.

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Evaluating the Effect of Proton Anisotropies in the Inner Heliophere: 2006 December 13 SEP Event Case Study

Aran, Angels[1]; Vainio, R.[2]; Pönni, A.[2]; Sanahuja, B.[1]; Jacobs, C.[3]; Lario, D.[4]; Heynderickx, D.[5]; Daly, E.J.[6]; Jiggens, P.[6]; Lei, F.[7]; Truscott, P.R.[8]
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A missing ingredient in present solar energetic particle (SEP) environment empirical models is particle flux anisotropies. In the interplanetary space, anisotropies are obtained from particles pitch angle (i.e. the angle between the magnetic field and particle velocity). Directionality information of SEP intensities at high-energies (> 10 Mev) is relatively rare, mostly comes from 1 AU measurements, and pitch-angle coverage is usually limited. Hence, a purely empirical modelling of the effect of anisotropies on fluxes and fluences in the interplanetary medium does not, a priori, seem like a very reasonable approach. However, this information is essential to determine the radiation harness required on the different sides of a spacecraft.

Alternatively, experimental data available can be used to determine omni-directional intensities and first-order anisotropies of SEPs as a function of time and energy. These data can then be fitted using a particle transport model which is able to reproduce the full angular distributions of SEPs, not only at the measurement position but at other locations in the inner heliosphere.

In the context of the ESA IPRAM project (Interplanetary and Planetary Radiation Model for Human Spaceflight, ESA Contract No 4000106133/12/NL/AF), we have analysed the effect of anisotropies by modelling the large gradual SEP event during 13-14 December 2006. We use observations from ACE, SOHO and STEREO spacecraft. We have reproduced the observed proton differential intensities and anisotropies using a shock-and-particle model that combines the simulation of the propagation of the associated CME-driven shock from 4 solar radii up 1 AU and the simulation of the particle transport via the cobpoint concept.

Using this model we have determined the pitch-angle distributions at several proton energies for virtual observers placed at 0.4 AU and 1.6 AU along the same magnetic field line as the 1 AU spacecraft. Next, we obtain the directional fluxes and fluences for these observers by folding in the temporal evolution of the direction of the local magnetic field (an estimate for the away from 1 AU observers) in order to obtain the full directional distribution of SEPs in a fixed coordinate system. The maximum-to-minimum ratios of the flux and fluence distributions as a function of the viewing direction were analysed. For this specific event, the results show that the variations of the radiation field during the time of maximum flux and integrated over time show little variation (a factor less than 1.7 for the fluence and a factor less than 3.4 for the peak flux) at distances > 1 AU. At 0.4 AU, however, the results yield substantial effects from the anisotropies, in some cases by a factor higher than 7.

In conclusion, we recommend that a model for interplanetary flux anisotropies for distances shorter than 1 AU will be developed. It is peremptory for this purpose that the field direction is properly taken into account since the variability of the local magnetic field may be great enough to average out a part of the anisotropies.

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The Updated Solar Energetic Particle Environment Modelling Tool

Crosby, Norma B.[1]; Heynderickx, Daniel[2]; Jiggens, Piers[3]; Aran, Angels[4]; Sanahuja, Blai[4]; Poedts, Stefaan[5]; Truscott, Pete[6]; Lei, Fan[7]; Gabriel, Stephen[8]; Sandberg, Ingmar[9]; Glover, Alexi[10]; Hilgers, Alain[3]

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Solar energetic particle (SEP) events are a serious radiation hazard for spacecraft as well as a severe health risk to humans travelling in space. Indeed, accurate modeling of the SEP environment constitutes a priority requirement for astrophysics missions and human exploration. ESA's Solar Energetic Particle Environment Modelling (SEPEM) application server is a WWW interface to SEP data and a range of modelling tools and functionalities intended to support space mission design. New SEP engineering models and tools to address current and future needs have been implemented by incorporating recent scientific results and a complete set of cross-calibrated data. SEPEM moves beyond mission integrated fluence statistics to peak flux statistics and durations of high flux periods. SEPEM has also integrated effects tools to allow calculation of single event upset rate and radiation background for a variety of engineering scenarios. Both statistical and physical modelling techniques have been addressed, covering not only 1 AU but also SEP environments ranging from 0.2 AU to 1.6 AU using a newly developed physics-based shock-and-particle model to simulate particle flux profiles of gradual SEP events. Away from 1 AU modelling is now available on the updated version of the SEPEM application server and provides the user community with a unique new tool. In the update all users now have access to the effects tools and can apply them to the SEPEM reference proton dataset that has been extended by four years and now ranges from 1973 to 2013. Furthermore, new data cleaning tools (de-spiking, median filtering) are available for the user to use on the available datasets.

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The PERICLES Long Term Data Preservation Project: Application to a Solar Database for Space Weather Applications.

Muller, Christian[1]; PERICLES consortium, a[2]; ISS-SOLAR team, b[3]

[1]B.USOC; [2]FP-7; [3]ESA-ISS

B.USOC manages several space experiments on the ISS and other platforms at the benefit of the science investigators who have proposed these instruments. One of these projects is the SOLAR package, monitoring the solar spectrum since February 2008. The operations of SOLAR, normally foreseen for less than two years, have been extended and are now planned to last

until 2017. B.USOC has a mandate to preserve the data and distribute it to the Principal Investigators who then derive scientific products which are published and archived in science database. SOLAR is used as a case study for the ICT FP7 project PERICLES (http://pericles-project.eu/). PERICLES aims to ensure that digital content remains accessible in an environment that is subject to continual change. This can encompass not only technological change, but also changes in semantics, academic or professional practice. PERICLES will take a 'preservation by design' approach that involves modelling, capturing and maintaining detailed and complex information about digital content, the evolving environment in which it exists, and the processes and policies to which it is subject. PERICLES represents a way for B.USOC of not only preserving the data and documentation of SOLAR but to transform this collection into a living archive. It is planned to include the products derived by the scientists and the related metadata generated by the science teams. In a further stage, in relation with the evolution of the mission duration itself and changes in operation procedures (for example since 2012, SOLAR measures full solar rotations near the solstices), the science teams can envisage higher level products and develop them from the newly reorganised archive. The relation of these new products and space weather applications will be presented. This talk discusses the current state of PERICLES (started in February 2013) and the tools which are under development to achieve these objectives.

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Improving User Experience with the new SPENVIS-NG Human Machine Interface

Esther, Parrilla-Endrino[1]; Angela, Rivera[1]; Noelia, Sanchez[1]; Daniel, Heynderickx[2]; Michel, Kruglanski[3]
[1]Deimos Space S.L.U; [2]DHConsultancy; [3]BIRA

In this paper we present the new Human Machine Interface developed by DEIMOS in the context of SPENVIS-NG. The key objective of this ESA project (ESTEC Contract number: 4000104812) is the upgrading of the current SPENVIS system into a new web-based service-oriented distributed framework supporting plug-in of models related to the hazardous Space Environment. We introduce the brand new HMI that will be implemented using the latest state-of-the art technologies; the new solution will increase the reliability, security and stability of the current SPENVIS-4 HMI which has become old-fashioned. Also the system will be modular and flexible enough to support an advanced interface for user and contents management, the addition of new features such as new data analysis, workflow editor and visualization improvements, compliant with the proposed architecture. These capabilities will be easy enough to be used by a non-software skills person.

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Linking HERSCHEL SEUs to local Space Environment Conditions

Kidger, Mark; Glover, A.
ESA

The current sunspot cycle has so far been the smallest since early in the 20 th Century. In addition, during the extended minimum period between the peak of Cycle 23 and the start of Cycle 24 (2006-2010), cosmic ray fluxes were measured by both space and ground based observatories to be unusually high. The Herschel mission was operational during the solar minimum period and rise phase of Cycle 24 between 2009 and 2013. The four year record of the cosmic ray flux from Herschel¡¯s SREM shows a drop of a factor ¡Ö2 in the proton flux between 10 and 166MeV between the end of 2009 and the end of mission. As no enhancement of SEUs is seen during SPEs it is assumed that the energetic particle flux (energies >>160MeV) is the cause of Single Event Upsets (SEUs), bit-flips in the on-board memory that affects instruments and the satellite mass memory. While there is evidence that the rate of SEUs in Herschel¡¯s SPIRE and HIFI instruments were lower around the time of peak solar activity in 2011, a study of bit-flips in Herschel¡¯s mass memory finds that although there was a significantly higher rate of bit flips in the first 6 months of the Herschel mission, the rate of bit flips was constant to a high degree from then on. Furthermore, no variations in the rate of bit flips in mass memory exist above the errors between the start of 2010 and the end of mission.

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Some aspects of the impact of the radiation environment at L2 on the operations of Planck

Mendes, L.
ESA

I use data acquired by the Standard Radiation Environment Monitor on board the Planck satellite to analyse the impact of the radiation environment at L2 on the operations and data acquisition of Planck. I will summarise the most important radiation events observed during the lifetime of the Planck mission and will illustrate their impact on the thermal stability of the instruments on board Planck.

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Daily Normalized Helicity of Subsurface Flows

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Flare-productive active regions are associated with subsurface flows with large values of kinetic helicity density. Kinetic helicity is related to mixing and turbulence of fluids. Reinard et al. 2010 have developed a parameter that captures the variation of kinetic helicity with depth and time, the so-called Normalized Helicity Gradient Variance (NHGV). This parameter increases 2-3 days before a flare occurs and the NHGV values for flaring and non-flaring active regions represent clearly separate populations. We derive subsurface flows from the surface to a depth of 16 Mm using GONG Dopplergrams analyzed with the ring-diagram technique. From the measured velocities, we calculate kinetic helicity density as a function of position on the solar disk. We will then calculate the NHGV parameter exploring different normalization schemes and depth ranges. We will calculate daily NHGV maps of the solar disk for different levels of magnetic activity. We will present the latest results.

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Groups of Type III Bursts Associated with CME Events at Decameter Wavelengths

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We report on the observations of solar type IV bursts and their precursors, namely groups of type III bursts, in the frequency range of 8 - 33 MHz. The observational data obtained with the ground-based radio telescope UTR-2 (Kharkiv, Ukraine) during 2012 campaign completed by spacecrafts data are used. We consider the CMEs (Coronal Mass Ejections), which correspond to type IV radio bursts, and electrons, which generate groups of type III radio bursts observed before type IV bursts, simultaneously originate from the same active regions. The main properties (frequency drift rate, duration, flux) of type III and type IV bursts are analyzed. Several physical characteristics of the CME are estimated.

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Lower Hybrid Drift Instability in Coronal Loops

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KU Leuven/CmPA

Almost 70 years after the discovery, the solar coronal heating puzzle is still one of the major challenges in astrophysics. A self-consistent coronal heating model must fulfil a lot of requirements imposed by observational facts. It is commonly accepted that many mechanisms contribute to the temperature of the solar corona.

However, determining which process dominates in what region, has proven to be very difficult. Many heating models have already been proposed for the coronal heating problem, and the two theories that currently stick out are the theory of wave heating and the theory of magnetic reconnection. Although a lot of research is still needed on these two theories, it is very unlikely that they will be able to fully explain the problem since they rely on the continuum or fluid approximation (Magnetohydrodynamics, MHD). Hence, these models cannot really explain coronal heating completely because i) it is clear that the actual heating takes place at length scales much smaller than those on which the (macroscopic) MHD model is justified; and ii) it is obvious that the observed discrepancy between ion and electron temperatures in the corona, as well as

iii) the observed large temperature anisotropy in the inner corona and iv) the observed preferential heating of the heavier ions are beyond the (single!) fluid model.

The alternative that is explored here is based on the kinetic theory of drift waves. Assuming drift waves as the cause of the coronal heating implicitly states that the energy source of the heating is located in the corona itself, viz. in the ubiquitous density gradients present there. Though drift waves are studied intensively in the context of nuclear fusion research, not much studies are available on drift waves in solar context. Hence, it is important to look for methods to confirm the presence of drift waves in e.g. the solar corona. Here, the Vlasov theory will be used to study the presence of the lower hybrid drift instability in plasmas with a density gradient perpendicular to the magnetic field. A new approach for this study of Vlasov theory will be used. The main idea consists of expanding the distribution function in a series of Hermite polynomials in velocity space. This approach will facilitate the interpretation of the results obtained, as every expansion term has a specific physical meaning. The study has bot numerical and analytical components in an attempt to quantify the presence of drift waves in the solar corona and their contribution to the heating problem.

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Proportional Number of Released Near-Relativistic Electrons and SXR Intensity in Solar Flares

Agueda, Neus[1]; Sanahuja, Blai[1]; Vainio, Rami[2]; Pönni, Arttu[2]; Klein, Karl-Ludwig[3]; Rodríguez-Gasén, Rosa[3]; Vilmer, Nicole[3]
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We examine the emission of near-relativistic (NR; >50 keV) electrons during solar flares. NR electron events observed in the heliosphere by spacecraft such as ACE, Wind or STEREO provide us with crucial information to unravel the release history of solar energetic particles (SEPs).

We use inversion methods developed within the EU/FP7 SEPServer project to extract, from directional intensities observed near 1 AU, the electron release history for a sample of flare-accelerated events. For each event, we compare the inferred number of released electrons with the intensity of the associated soft X-ray (SXR) flare. We find a close proportionality between the intensity of the SXR flare and the number of released electrons; correlation coefficient 0.949.

This empirical law is combined with an interplanetary transport model database of simulation results, publicly available through the SEPServer website, to predict the expected time of arrival and the in-situ electron event peak intensities for different flare sizes. The tool is used to estimate the maximum amount of NR-electron radiation that solar flares might produce near 1 AU, for an early warning system of flare-related SEP events.

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Which Data? Is Flare Prediction More Efficient through Proxy Quantities, or via Fundamental Physical Parameters?

Georgoulis, Manolis
Academy of Athens

Flare-prediction parameters roughly fall into three distinct classes: proxy parameters, that mostly depend on or quantify the morphology of the source active region, complexity parameters, that explore the fractal/multifractal nature of the region, and fundamental physical parameters, calculated mainly via simplifying assumptions. Recently, it has been suggested that complexity metrics are not expected, and seem to be unable, to distinguish between flaring and non-flaring solar active regions. If this result is further established, flare prediction must rely on proxy quantities and physical parameters, namely the free magnetic energy and, for several models, the magnetic or kinetic helicity of the regions. We examine the pros and cons of each class of predictors, considering ease and speed of the calculations and discussing their predictive ability. Relevant examples are also given. We conclude that the local nature of the flare-triggering process, plus the lack of information to unambiguously calculate fundamental physical quantities makes adequately-defined proxy quantities more efficient for continuous, routine prediction. However, (1) cutting-edge physical understanding is required to produce a suitable proxy, and (2) fundamental physical parameters may enclose a short-term predictive ability for major flares, provided that their timeseries on a candidate flaring region are properly treated for various unrelated effects.

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Athens Effective Solar Flare Forecasting (A-EFFort)

Georgoulis, Manolis[1]; Tziotziou, Konstantinos[2]; Maneas, Efthymios[3]; Magiati, Margarita[3]; Luntama, Juha-Pekka[4]; Glover, Alexi[5]

[1]Academy of Athens; [2]RCAAM of the Academy of Athens; [3]BRF of the Academy of Athens; [4]ESA/ESAC; [5]ESA/ESTEC

An online solar-flare forecasting utility is currently implemented in the premises of the Academy of Athens. Upon completion, A-EFFort will be used as an ESA federated service in the framework of the Agency's Space Situational Awareness (SSA) Programme. The core of the A-EFFort utility comprises two pattern-recognition and computational-analysis techniques: a proven active-region identification algorithm (ARIA), used to automatically extract solar active regions from full-disk line-of-sight magnetograms acquired by the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO), and an automatic calculation of the effective connected magnetic field strength (Beff) for each of the identified active-region patches. From the derived Beff-values and existing statistics we will provide and validate flare probabilities assigned to a given forecast window for each active region separately and the earthward solar hemisphere as a whole. In its nominal operation, A-EFFort will deliver routine 24-hour forecasts for X-, M-, and C-class flares updated every three hours. During periods of exceptional solar activity and enhanced likelihoods of major or great solar flares, automated electronic messages will be sent to a list of subscribed service users. Plans for service updates and maintenance are in place for a number of years after the conclusion of the project's implementation, aiming to establish A-EFFort as a core tool of the ESA/SSA method arsenal.

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The NWRA Flare-Forecast Comparison Workshops: Goals, Participants, and Methodology

Leka, K.D.[1]; Barnes, Graham[1]; The Int'l Flare Forecasting, Comparison Group[2]

[1]NorthWest Research Associates; [2]N/A

Two workshops have been held recently, in 2009 and 2013, to begin systematic comparisons of methods for forecasting solar flares. The first, also known as the "All-Clear Forecasting Workshop" was held jointly with NASA/Space Radiation Analysis Group and NOAA/Space Weather Prediction Center, had a focus on predicting "All-Clear periods" from the standpoint of major flares and solar energetic particle events. The second more recent workshop, held at NorthWest Research Associates in Boulder, CO, USA, focused on using and exploiting the recent data from the NASA/Solar Dynamics Observatory (SDO) Helioseismic and Magnetic Imager (HMI), particularly the vector magnetic field time-series now available. For both workshops, many researchers active in flare-forecasting research participated, and diverse methods were represented in terms of both how the methods characterize the Sun, and the statistical approaches used to create a forecast. We describe here the goals of both workshops, the participating methods, and the approaches developed for allowing standardized, testable comparisons between methods.

(Funding for the workshops and the data analysis was provided by NASA/Living with a Star contract NNH09CE72C and NASA/Guest Investigator contract NNH12CG10C.)

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Spatial Distribution of the Magnetic Helicity Flux in a Flaring Site

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[1]INAF - Catania Astrophysical Observatory; [2]Dipartimento di Fisica e Astronomia - Catania University

We use HMI/SDO line-of-sight magnetograms to analyze the spatial distribution of the magnetic helicity flux in active region (AR) NOAA 11283. Applying an algorithm to identify areas characterized by similar magnetic helicity flux in sign, we determine how fragmented was the helicity flux in the active region. The results clearly show that areas characterized by the lower difference in the number of patches with helicity flux of opposite sign are the most favourable for eruptive events occurrence.
We also show that flares and CMEs occurred in this AR are linked to the interaction between magnetic systems characterized by opposite sign of magnetic helicity flux.

The research leading to these results has received funding from the European Commissions Seventh Framework Programme under the grant agreement no. 284461 (eHEROES project).

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Predicting Flaring Activity through Supervised Classification on Predictor Variables

De Visscher, Ruben; Delouille, Veronique
Royal Observatory of Belgium

Recent years have seen a resurgence in the field of solar flare prediction. Most of these methods aim at evaluating a flare probability in the next 24h based on the current or past status of an active region.

In this project sequences of magnetogram and continuum images are used to distinguish active regions with strong flaring activity.

A homogeneous dataset of magnetogram and continuum images of active regions in their growth phase is produced. These images are summarized into various scalar predictor variables, which are used as the input for the supervised classification methods.

These methods take into account the time evolution of the active regions through lagged values of the predictors. The performance of various supervised classification algorithms as well as the predictive power of each predictor variable are assessed.
Special care is taken to handle the imbalance between the number of active regions with and without strong flaring activity.

In our poster we will discuss preliminary results from this project.

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Acceleration and Solar Origin of Solar Energetic Particles Observed by SREM Units

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[1]National Observatory of Athens; [2]Academy of Athens/ RCAAM; [3]National Observatory of Athens and Department of Physics, University of Athens; [4]ESA/ESTEC

Within the previous solar cycle 23, SREM units onboard ESA's INTEGRAL and Rosetta spacecraft detected several tens of Solar Energetic Particle Events (SEPEs) and accurately pinpointed their onset, rise, and decay times. We have undertaken a detailed study to determine the solar sources and the subsequent interplanetary coronal mass ejections (ICMEs) that gave rise to these events, as well as the timing of SEPEs with regard to the onset of possible geomagnetic activity triggered by these ICMEs. We find that virtually all SREM SEPEs can be associated with CME-driven shocks. Moreover, for a number of well-studied INTEGRAL/SREM SEPEs we see an association between the SEPE peak and the shock passage at L1, subject to the heliographic location of the source solar active region. Shortly after the SEPE peak (typically within a few hours), the ICME-driven modulation of the magnetosphere kicks in, often associated with a dip of the Dst index, indicating storm conditions in geospace. In essence we find that SREM SEPEs can be seamlessly fit into a coherent and consistent heliophysical interpretation of solar eruptions all the way from Sun to Earth. Their contribution to space-weather forecasting may be significant and warrants additional investigation.

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Correlation of Solar Flares with Long-Term Irradiance and Sunspot Levels

Dammasch, Ingolf; Dominique, Marie
Royal Observatory of Belgium

For more than three years, the radiometer LYRA on the ESA micro-satellite PROBA2 has been observing the Sun in the ultraviolet and gained a considerable data base. On its websites, LYRA presents not only EUV and SXR time series in near real-time, but also information on flare parameters and long-term irradiance and sunspot levels. It will be discussed how these parameters correlate, and whether it is possible to aid space weather forecast with these statistical data, especially for the prediction of expected flare strength.

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Torus Instability and Filament Eruptions: An Observational Investigation

Zuccarello, Francesco[1]; Seaton, Daniel[2]; Mierla, Marilena[2]; Berghmans, David[2]; Poedts, Stefaan[1]; Romano, Paolo[3]; Zuccarello, Francesca[4]
[1]CmPA / KU Leuven; [2]Royal Observatory of Belgium; [3]INAF - Catania Astrophysical Observatory; [4]University of Catania

Several models have been proposed to explain the initiation of CMEs. However, which model better explains the different aspects of the initiation process and the early evolution of the CMEs is a subject of ongoing discussion.

Using the vantage points of the STEREO spacecraft we reconstruct the three-dimensional position of the erupting structure, while the magnetic field evolution is used in order to identify eventual persistent photospheric plasma flows and/or the emergence of new magnetic flux. Finally, potential field extrapolations are used to determine the stability properties of the relevant active region and to disentangle which is the driver of the investigated eruption.

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Space Weather and Ultraviolet Solar Variability (SWUSV) Microsatellite Mission: Prediction of Major Flares and CMEs

Damé, Luc
LATMOS/IPSL/CNRS/UVSQ

We present the Space Weather and Ultraviolet Solar Variability (SWUSV) Microsatellite Mission proposed to ESA and CNES for a better/earlier prediction of major flares and CMEs and their geoeffectiveness. Mission is an evolution of PROBA-2 and PICARD based on high cadence imaging of the solar disk in Lyman Alpha coupled to H-Alpha from ground network. Objectives, payload and mission, based on a MYRIADE Evolution platform, will be described. Mission is under consideration by CNES in its prospective exercise and could be in service as early as 2018.

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Towards a Predictive Model for SEPs

Linker, Jon[1]; Schwadron, Nathan[2]; Torok, Tibor[1]; Gorby, Matthew[2]; Downs, Cooper[1]; Lionello, Roberto[1]; Falconer, David[3]; Mikic, Zoran[1]; Riley, Pete[1]
[1]Predictive Science Inc; [2]University of New Hampshire; [3]University of Alabama, Huntsville

Solar energetic particles (SEPs) are an important space weather phenomena. SEPs can damage satellite instrumentation, and they can be hazardous for crews of Low Earth Orbit spacecraft and the International Space Station, especially when engaged in extravehicular activity. They also represent a significant risk to crews of future manned lunar or interplanetary missions. SEPs are one of the most difficult phenomena to predict: their generation and propagation spans very different plasma regimes and large regions of the heliosphere. Successful prediction will ultimately involve many elements: prediction of flares/CMEs prior to eruption, simulating CMEs and associated shocks, and modeling SEP acceleration and propagation. In this paper, we describe an approach to this problem that combines empirical and physics-based models. We discuss how, given a prediction for a flare/CME, CMEs can be modeled in the corona and inner heliosphere. We show initial results for SEP fluxes generated from coupled CME/SEP modeling.

Research supported by NSF and NASA.

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A Space Weather Service for Solar Flare Forecasting

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We report on the re-implementation of the Wheatland (2004, 2005) solar flare prediction model as an active online space weather service for the daily prediction of GEOS X-ray flares. The model uses a Bayesian approach to predict solar flare activity based on a database of event statistics from GOES measurements spanning over almost 40 years. This approach has the advantage of being objective without the need for users to make ad hoc assumptions. It uses only the past history soft X-ray flare events, and the statistical rules of solar flare occurrence.

We use the model to retrospectively validate M- and X-class event occurrence rates for periods of past solar activity, and also illustrate the results of the online prediction service running daily flare predictions for the present phase of this solar cycle. We also investigate the use of Bayesian analysis to predict occurrence rates for solar energetic particle events, given the similarity of the statistical properties of events for flares and energetic particles.

Wheatland, M.S., A Bayesian approach to solar flare prediction, Astrophys. J., 609, 2004.
Wheatland, M.S., A statistical solar flare forecast method, Space Weather, 3, 2005.

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Solar Eruptions observed by the AIA and SECCHI on Board the SDO and STEREO.

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Astronomical Institute, University of Wroclaw

In this study we focus on the analysis of the early phase of flares initiation associated with the CMEs. The aim of this work is to determine kinematical properties and important structural components of these solar eruptions. We analyzed multi-thermal observations of eruptive plasmoids associated with coronal mass ejections and/or flares using the data recorded by the Atmospheric Imaging Assembly (AIA) on board the *Solar Dynamics Observatory* (*SDO*). The six coronal EUV channels, high spatial and temporal resolution and large field of view provide us the opportunity for verifying the existing models of solar eruptions. In addition, in order to observe the further propagation of these solar eruptive phenomena in the heliosphere we also use data taken by Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) on board the *Solar TErrestrial RElations Observatory* (*STEREO*).

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On the origin of solar energetic particles

Miteva, Rositsa[1]; Klein, Karl-Ludwig[1]; Samwel, Susan[2]; Reid, Hamish[3]; Nindos, Alexander[4]; Kouloumvakos, Athanasios[4]
[1]LESIA-Observatoire de Paris; [2]National Research Institute of Astronomy and Geophysics; [3]University of Glasgow; [4]University of Ioannina

The aim of this study is to identify the solar origin (flares vs. CMEs) of the solar energetic particles observed during solar cycle 23. For each SEP event, a flare and CME candidate was found by searching into specific temporal and spatial window. A pre-selection of SEPs associated with X and M-class flares was done and thus 180 events in total were analyzed. In order to argue in favor of flare, CME or mixed contribution to the escaping particle fluxes, we utilized all available dynamic radio spectral and single frequency radio (RSTN) records. Our analysis shows that about half of all SEP events are accompanied by high-frequency radio emission signatures that argues in favor of flare acceleration. Less than a third of the events show radio signatures from the high corona only and/or confinement.

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Solar UV Emission as a possible Reason of long-term Preflare Fluctuations in H-Component of the Geomagnetic Field

Sheiner, Olga; Smirnova, Anna; Snegirev, Sergey
Radiophysical Research Institute

It was shown before that long-term fluctuations of geomagnetic field can be considered as prognostic parameter for solar proton flares. This paper is devoted to the comparison of pre-flare behavior of long-term spectral components in the spectrum of the solar ultraviolet radiation and the horizontal component of the geomagnetic field. This study is based on wavelet spectra of solar ultraviolet emission during the period preceding solar proton flares. It is found the congruence in the behavior of spectral components with periods of 30-60 minutes in the ground-based measurements and in UV emission for 3-1 days before the proton flare.

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Determining Energetic Electron Precipitation Fluxes Inside and Outside of the Plasmasphere during a Space Weather Event

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[1]British Antarctic Survey; [2]University of Otago

Energetic electron precipitation into the atmosphere acts as a loss mechanism for the outer radiation belt electron population, and as an indicator of the mechanisms taking place. Through a complex interplay between the acceleration, transport, and loss of electrons, individual geomagnetic storms can drive large changes in the flux of relativistic electrons within the outer radiation belts, potentially damaging satellites, and endangering astronauts. Subionospherically propagating very low frequency (VLF) radio waves can be used to monitor electron precipitation through changes in the ionization rate at altitudes of 50-90 km. In this study we analyse data from a VLF receiver located in Churchill, Canada, and concentrate on signals from two US VLF transmitters in order to provide some estimate of precipitating electron fluxes originating from the outer radiation belt. We show analysis from a space weather event, which induced changes in the radiation belt environment through enhancing relativistic electron fluxes, in July-August 2010. We combine the data from the two transmitters in order to confirm estimated fluxes, calculate the error bars, and inter-compare the results. The location of the plasmapause is taken into account in order to interpret the evolution of the electron precipitation characteristics throughout this space weather event.

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Plasmaspheric Density Models in Whistler Inversion and Whistler-FLR Cross-Calibration

Lichtenberger, János[1]; Vellante, Massimo[2]; Ferencz, Csaba[1]; Heilig, Balázs[3]; Regi, Mauro[2]
[1]Eötvös University; [2]L'Aquila University; [3]Geological and Geophysical Institute of Hungary

One of the major objective in PLASMON project (http://plasmon.elte.hu) is to provide plasma densities for data assimilative modeling of plasmasphere from two ground based measurements: whistlers and field line resonances (FLRs). The whistler inversion method used in this procedure includes various model, such as wave propagation, magnetic field, field aligned density distribution and equatorial electron density models. The latter one is a special one used for multiple-path whistler groups. In this paper we will present the effect of various models used in the inversion procedure.
As one can obtain electron densities from whistler inversion and plasma mass densities from FLRs, the ion constitution would be required to connect the to data set (that are intended to use in the plasmasphere model), which is rarely known or available. Therefore we have developed a method for cross calibration of the data from the two sources. It includes physics based and experimental field aligned plasma density distribution models as well as comparison with in situ wave and density (IMAGE, Cluster and Van Allen Probes) measurements.

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Plasmapause Detection by Means of a Meridional Magnetometer Array

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[1]Geological and Geophysical Institute of Hungary; [2]L'Aquila University; [3]New Mexico Institute of Mining and Technology; [4]Eötvös University; [5]Geophysical Institute of Polish Academy of Sciences

Although our knowledge on the plasmasphere dynamics has improved greatly thanks to some recent space missions (IMAGE, CLUSTER), continuous monitoring of the plasmapause position remains unsolved. Ground based observation of geomagnetic field line resonances (FLRs) has the potential to achieve this goal. A meridional array of properly spaced magnetometers, such as EMMA (European quasi-Meridional Magnetometer Array set-up in frame of PLASMON EU FP7 project), can provide dayside plasma density profiles. Compared to VLF whistlers FLRs have the advantage that they are often observed not only in the plasmasphere, but also outside it, in the plasmatrough making them suitable for the detection of the plasmapause. The detection of FLRs is based on the phase gradient observed between stations closely spaced in north-south direction. At normal conditions FLR can be identified by a maximum in the cross phase spectra. In case when the plasmapause moves over a station pair the phase difference at the resonant frequency changes its sign temporarily. This feature yields another possibility for the detection of the plasmapause.

We present some events to demonstrate how the motion of the plasmapause can be monitored by means of EMMA. Data assimilative model of the plasmasphere developed in the frame of PLASMON combines the observations and physics to provide plasmapause positions in all local time sectors. Results are compared to in situ plasma density measurements (IMAGE RPI) and various empirical models.

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A Calculation of Electron Density Profiles from h'(f) of Obliquely Sounded Ionogram

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[1]Electronics and Telecommunications Research Institute(ETRI); [2]Electronics and Telecommunications Research Institute (ETRI)

The conventional ionosondes are used to collect data of ionosphere right above the ionosonde location and to provide a picture of the ionospheric properties. Although these ionosonde stations are located worldwide, there are locations where it is not easy to operate one, like oceans, deserts and other remote places. Knowing the ionospheric properties and behaviors at these parts of the world is also very important to know. The oblique sounding technique is one method to achieve this and reach those locations.

With oblique sounding the transmitter and the receiver locations are far apart from each other, even thousands of kilometers or miles. The oblique ionospheric sounding technique have some advantages in terms of that the obliquely sounded HF signal have the abilities to monitor the ionosphere of some places where it is not deployed vertical sounder between transmitter and receiver and of course, to vertically detect the ionosphere of area where it is deployed itself. It allows obtaining more information of ionosphere, such as critical frequency, vertical height and electron density, MUF (maximum usable frequency) over a wider area with no additional ionosonde.

We present the results of experimental studies of oblique sounding for research purpose between Jeju and Icheon stations in Korea which are about 420km apart. The extraction algorithm of electron density profiles after conversion of the oblique to vertical ionogram which should be considered the incidence angle, the Doppler frequency, the influence of traveling ionospheric disturbances (TIDs), the multipath propagation, and the error probability are mainly focused in this paper. This paper is also concerned with the auto scaling of oblique sounding ionogram for analysis of propagation conditions on a fixed point-to-point measurement as a near term activity.

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Analysis of Ionosphere and Plasmasphere Contribution to the GPS TEC on the Base of GPS and COSMIC RO Measurements

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There are presented results of the comparative analysis of GPS TEC data and FORMOSAT-3/COSMIC radio occultation measurements during period of quiet and disturbed conditions. COSMIC-derived electron density profiles were integrated up to the height of 700 km (altitude of COSMIC satellites), the estimates of ionospheric electron content (IEC) on a global scale were retrieved with use of spherical harmonics expansion. Joint analysis of GPS TEC and COSMIC data allows us to extract and estimate electron content corresponded to the ionosphere (its bottom and topside parts) and the plasmasphere (h>700 km) for different conditions. In order to analyze seasonal behaviour of PEC contribution to GPS TEC at the different regions we selected several specific points with coordinates, corresponded to the approximate positions of different, mid-latitude and low-latitude, ionospheric sounding stations. For each specific points GPS TEC, COSMIC IEC and PEC estimates were analyzed. During solar minimum conditions percentage contribution of ECpl to GPS TEC indicates the clear dependence from the time and varies from a minimum of about 25-50% during day-time to the value of 50-75% at night-time. Contribution of both bottom-side and topside IEC has minimal values during winter season in compare with summer season (for both day- and night-time). Several case-studies of geomagnetic storms were analyzed in order to estimate changes and redistribution of electron content between ionosphere and plasmasphere. The obtained results were compared with TEC, IEC and ECpl estimates retrieved by Standard Plasmasphere-Ionosphere Model that has the plasmasphere extension up to 20,000 km (GPS orbit) .

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The Main-Ionospheric Trough as an Indicator of Ionosphere Magnetosphere Coupling

Rothkaehl, Hanna[1]; Przepiorka, Dorota[1]; Matyjasiak, Barbara[1]; Krankowski, Andrzej[2]; Liu, Y-J[3]
[1]Space Research Center PAS; [2](2) Geodynamics Research Laboratory, University of Warmia and Mazury; [3]Institute of Space Science, National Central University, Chung-Li

The mid-latitude electron density trough observed in the topside ionosphere has been shown to be the near-Earth signature of the magnetospheric plasmapause, and thus its behaviour can provide useful information about the magnetospheric dynamics, since its existence is dependent on magnetospherically induced motions. Mid-latitude trough is mainly the night-time phenomenon, which detailed characteristics and features depend on the solar cycle, season, time of the day and many others.
The trough is narrow in latitudes but extended in longitudes. The main ionospheric trough features is very dynamic structure. It is well-known fact that the trough structure moves to the lower altitudes both with increasing the level of geomagnetic activity as with increasing the time interval from the local magnetic midnight However the longitude dependence of the main ionospheric structures has been detected still the source of this physical phenomena is not well understood. Using the DEMETER in situ satellite particle and waves measurements, GPS observations collected at IGS/EPN network, and the data retrieved from FORMOSAT-3/COSMIC radio occultation measurements the mid-latitude trough characteristics with regard to the geographic and magnetic longitude at fix local time has been presented. In this presentation, based on the selected number of geomagnetic storms, we analize also the energy deposition in areas adjacent to the structure of the main ionospheric trough. The investigation confirmed the storm-phase dependence of the trough properties.The special emphasizes has been placed on analysis of behavior main ionospheric trough region during

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Models of the Plasmaphere and the Radiation Belts

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Belgian Institute for Space Aeronomy

On www.spaceweather.eu we provide a dynamic plasmasphere model, which can be used for nowcasting and forecasting during quiet periods and during geomagnetic storms. We provide colorful plots and data files of the density and temperature of the electrons, protons and helium ions. Plasma plumes are generated during disturbed periods. This 3D model contains the ionosphere, the plasmasphere, the plasmatrough and the polar wind.

Based on CLUSTER satellite measurements, a dynamic model of the radiation belts is in development. This model forecasts particle fluxes based on the predicted Dst index. In the outer electron belt it generally shows a particle dropout during the main phase of a geomagnetic storm and a particle flux increase of several orders of magnitude after the storm.

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Connecting white Light to In Situ Observations of Coronal Mass Ejections from the Sun to 1 AU

Möstl, C.[1]; Amla, K.[2]; Hall, J. R.[2]; Liewer, P. C.[2]; De Jong, E.[2]; Veronig, A.[1]; Rollett, T.[1]; Temmer, M.[1]; Liu, Y.[3]; Davies, J. A.[4]; Lugaz, N.[5]; Farrugia, C. J.[5]; Luhmann, J. G.[6]; Galvin, A. B.[5]

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We study the feasibility of using a Heliospheric Imager (HI) instrument, such as STEREO/HI, for unambiguously connecting remote images to in situ observations of coronal mass ejection (CMEs). Our long-term goal is to develop and test methods to predict CME parameters from heliospheric images, suitable for real-time operational space weather forecasting. We do this with an eye on future missions, for example Solar Orbiter, when it is in a suitable position with respect to the Sun-Earth line, or for a dedicated space weather mission at the L5 point in the Sun-Earth system (e.g. EASCO mission concept). We compare the predictions for speed and arrival time for about 20 CME events, each observed remotely by one STEREO spacecraft, to the speed and arrival time observed at various in situ observatories. We use "geometrical modeling", which means we approximate the CME fronts with various shapes (Fixed-Phi, Harmonic Mean (HM), Self-Similar Expansion (SSE)). These models are fitted to the time-elongation functions extracted from STEREO/SECCHI images with the SolarSoft SATPLOT package. We use these techniques for a single-spacecraft HI observer, and consequently assume constant CME speed and direction. For assessing the accuracy of the parameters derived from HI we look at plasma and magnetic field data of interplanetary CME sheath regions by Wind (MFI, SWE instruments) and STEREO-A/B (IMPACT, PLASTIC), all located close to 1 AU. The results show that the arrival times derived from imaging generally closely match the in situ ones to within roughly 6 hours, and speeds agree to within 200 km/s for slow CMEs. However, for very fast CMEs in the range > 1500 km/s, the predicted speeds are too high by up to 1000 km/s, even though we include effects caused by the ICME flank, which moves slower than the apex in the HM and SSE models. This calls for an update of these methods to include deceleration, if they want to be successfully used to predict the fastest and potentially most geoeffective CMEs from outside the Sun-Earth line. This work has received funding from the European Commission FP7 Project COMESEP (263252).

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Verification of Solar Microwave Precursors of Geoeffective Coronal Mass Ejections

Sheiner, Olga; Fridman, Vladimir; Ledaschev, Sergey
Radiophysical Research Institute

It has been shown that a significant number of coronal mass ejections in a two-hour interval before their recording by coronagraphs are preceded by sporadic radio emission that can be defined as radio precursors of coronal mass ejections. The results of statistical studies evidence that the width of the most developed CMEs affecting the near-Earth space depends on the characteristics of microwave sporadic radio emission observed during two-hour intervals preceding CME registration on coronagraph. It was shown also that the absolute majority of such CMEs an the stage of their formation is associated with sporadic microwave radiation having the certain characteristics, such as its broadband and time duration of more than 10 minutes. This allows to assess potential geoeffectiveness of CMEs using data on the radio emission, taking into account expected CME source position on the solar disk.

The verification of geoeffective CMEs forecast is carried out on the base of SOHO/LASCO data.

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SuperDARN HF Radar Data Coverage for Ionospheric Electric Field Measurement

Chisham, Gareth; Freeman, Mervyn; Kavanagh, Andrew
British Antarctic Survey

Specification of the ionospheric electric field, and its extension into the magnetosphere, is of fundamental value to many space weather research problems, and will be essential to assimilate into whole atmosphere, magnetospheric, and radiation belt models now under development for space weather forecasting. To this end, we analyse the data coverage provided by the Super Dual Auroral Radar Network (SuperDARN) which currently comprises 33 radars around the world and has data going back over 20 years from some radars. We compare the coverage with the observing goals set by the World Meteorological Organisation and that needed by current models and identify the main factors influencing coverage.

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Investigation of Ionospheric and Magnetospheric Processes using High Frequency Induction Coil Magnetometers in the UK

Beggan, Ciaran; Kelly, Gemma; Thomson, Alan
British Geological Survey

In June 2012, the British Geological Survey Geomagnetism team installed two high frequency (100 Hz) induction coil magnetometers at the Eskdalemuir Observatory, in the Scottish Borders of the United Kingdom. The induction coils permit us to measure the very rapid changes of the magnetic field.

We present initial results from first year of data. Analysis of spectrograms and power spectral density plots in the frequency band of 3-40 Hz from the coils show diffuse bands of peak power around 7.8 Hz, 14.3 Hz, 20.8 Hz, 27 Hz, 34 Hz and 39Hz related to the global Schumann resonances. We also detect a strong narrow peak at 25 Hz, which is a harmonic of the UK electrical power system.

There are a number of features in the data of interest, such as intermittent variation of the Schumann resonance harmonics and magnetospheric pulsations. The data are freely available on request to the community.

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Geomagnetic Conditions Forecasting by using Solar Activity Parameters

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National and Kapodistrian University of Athens

Enhancements of geomagnetic activity resulted from the interaction of solar wind originated from solar flares, coronal mass ejections and coronal holes at the Earth magnetosphere have been studied in the frame of Space Weather. The space weather effects can roughly be divided into two categories: those effects quickly and directly associated with solar activity, and those effects resulting from the impact of solar activity-generated interplanetary coronal mass ejections on Earth's magnetosphere. The scientific community managed to implement centers for the continuous monitoring of the geomagnetic conditions which resulted into short and long term forecasting of the planetary geomagnetic activity such as Ap index. A new forecasting center at the Athens Neutron Monitor Station (A.Ne.Mo.S) has been established from 2012. A first estimation of the accuracy of the predicted Ap index which provided by the Athens Forecasting Center is calculated about 82% during the first year of its operation. In this work a statistical treatment of crucial parameters of about 119 X-Ray flares and 1408 M-class flares as well as their associated coronal mass ejections during the time period 2000-2012 has been performed. These results have been used in order to have a first estimation of the geomagnetic Ap index. This method has been applied on the Space Weather Forecasting Center of University of Athens and these results are briefly discussed.

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The Spatial and Temporal Distribution of Solar and Galactic Cosmic Rays

Shatov, Pavel[1]; Tasenko, Sergey[1]; Skorohodov, Ilya[1]; Getselev, Igor[1]; Podzolko, Mikhail[1]; Anashin, Vasily[2]; Protopopov, Grigory[2]
[1]Fiodorov Institute of applied geophysics; [2]Institute of Space Device Engineering

The areas of energy particles on the Sun from 1956 to 2012 are considered. The significant irregularity of their distribution is registered.
The ranges of longitudes, in which particles are considerably injected, are discovered. The areas of the Sun with very law radiation effectiveness are at particular interest. The deficiency of the solar proton events during the inversion period of the Earth's main magnetic field is noticed. The one made a conclusion about the obtained data reasonability for estimation of the observation probability and solar cosmic ray appearance risk.

For the estimation of the charged particle contribution, going from the interplanetary space on the measuring instruments, the data base on cosmic rays is created. It includes maximum, minimum and average values of proton fluence from 1 month to 10 years space of time.

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Variability of the Main Ionospheric Parameters during Magnetic Storm Recovery Phase

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Institute of Atmospheric Physics AS CR

Intensive ionospheric research, numerous multi-instrumental observations and large-scale numerical simulations of ionospheric response to magnetic storm-induced disturbances during the last several decades were primarily focused on the storm main phase, in most cases covering only a few hours of the recovery phase following after storm culmination. Ionospheric behaviour during entire recovery phase still belongs to not sufficiently explored and hardly predictable features. In general, the recovery phase is characterized by an abatement of perturbations and a gradual return to the "ground state" of ionosphere. However, observations of stormy ionosphere show significant departures from the climatology also within this phase. This paper deals with the quantitative and qualitative analysis of variability of the main ionospheric parameters during magnetic storm recovery phase over middle latitudes and under high and low solar activity conditions for nowadays and future modelling and forecasting purposes. We compared critical frequencies, peak heights and TEC observed during recovery phase with the corresponding outputs of the IRI and NeQuick models.

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3D CME Parametrization - Comparison of GCS and CAT Techniques and ENLIL Applications

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Since launch of the STEREO twin spacecraft in October 2006, 1071 large-scale CMEs were identified in STEREO/SECCHI/COR2 observations between January 2007 and December 2011 covering the full range of spacecraft separation angles between 0 and 180 degrees. Based on their bright and clear white-light appearance in the COR 2 field of view 242 CMEs were selected and analyzed with the Graduated Cylindrical Shell (GCS) modeling technique developed by Thernisien, Vourlidas and Howard. For a set of selected modeled CMEs their 3D topology, direction of propagation and speed was analyzed based on multipoint observations (STEREO, SOHO) with the CME Analysis Tool (CAT) developed by Millward et al. at the Space Weather Prediction Center, Boulder, CO, and with the GCS model. The analyzed events comprise earthward directed CMEs of low (~300 km/s), medium (~600 km/s) and high (>1.000 km/s) speed observed by STEREO and SOHO under various viewing angles. The results from the modeling comparison provide important implications for the use of CME parameters as input for ENLIL simulations yielding CME arrival times and 1 AU CME speeds.

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Accuracy Assessment of the Space Weather Aspects Forecasts used in the Russian Federal Space Agency Monitoring System

Anashin, Vasily[1]; Protopopov, Grigory[1]; Gaidash, Sergey[2]; Belov, Anatoly[2]
[1]Institute of Space Device Engineering; [2]Pushkov institute of terrestrial magnetism, ionosphere and radio wave propagation (IZMIRAN)

The Russian Federal Space Agency Monitoring system of space radiation exposure on spacecraft electronic equipment elements were developed by the Institute of space device engineering and operates successfully.
The Monitoring System covers two parts: the scientific monitoring system (ground-based segment) and the engineering monitoring system (space-born segment). The ground-based segment comprises forecast station that provides the following daily forecasts and alerts:

- Geomagnetic activity forecast for 1 - 3 days;
- Geomagnetic activity forecast for 6 - 8 days;
- Daily GSO high energy electron fluence forecast for 27 days;
- Space weather review and forecast, covering solar proton increasing forecast;
- Proton events alert;
- GSO high energy electron fluence increasing alert (electronic equipment killers).

Efficiency and accuracy are the major criteria of performance forecast usage. Forecasts are made promptly owing to round-the-clock space weather characteristics monitoring and use of modern communication facilities.
The paper presents accuracy assessment of the given forecasts which were made by forecast correlation analysis with the measured values in various time intervals. These estimations were correlated with the similar results from the world forecast centers.

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Comparison of Thermospheric Data Assimilation with a Drag Temperature Model for Operational Nowcasting and Forecasting.

Murray, Sophie A.[1]; Henley, Edmund M.[1]; Jackson, David L.[1]; Bruinsma, Sean L.[2]
[1]Met Office; [2]CNES

The thermosphere hosts thousands of low-earth-orbit objects, including operational satellites. In addition to regular patterns, local variations of drag forces can be induced in the wake of intense solar activity. Accurate orbit prediction is thus imperative to keep satellites operational. The work of the Advanced Thermospheric Modelling for Orbital Prediction FP7 project aims to improve upon current semi-empirical models used for prediction in order to enable accurate forecasting.

A thermospheric data assimilation procedure has been developed using general circulation models (such as the Coupled Middle Atmosphere-Thermosphere model, and the Thermosphere-Ionosphere-Electrodynamics General Circulation Model) with inferred neutral densities from satellite observations (e.g., from CHAMP, GRACE, and GOCE). Data assimilation results were compared with the outputs of an advanced semi-empirical drag temperature model (DTM) that uses proxies to describe the solar and geomagnetic forcing of the thermosphere, as well as some corrections from observations. Independent observations from periods at solar maximum (2002) and solar minimum (2009) were also used for inter-comparison with analyses and forecasts from the two approaches. The results of this work will allow schemes to be developed for near-real-time assimilation of thermospheric data into the predictive DTM and physical models, ultimately enabling near-real-time modelling.

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The Polar Cap (PC) Index and Power Grid Disturbances.

Stauning, Peter
Danish Meteorological Institute

The strong geomagnetic storm in the evening of 30 October 2003 caused high-voltage power grid disturbances in Sweden that expanded to produce hour-long power line outage in Malmoe located in the southern part of the country. Similar events have occurred earlier, among others, during the great storms of 13 - 14 July 1982, 8 - 9 February 1986, and 13 March 1989. Most cases of space weather related power grid disturbances are caused by extraordinarily intense substorm events. Such events may have a sudden onset but are usually preceded by lengthy intervals of very high values of the Polar Cap (PC) index. The PC index monitors the transpolar convection of plasma and magnetic fields building the stresses in the magnetospheric tail region that are released in strong substorms. During the 30 October 2003 event the intense solar proton radiation disabled the ACE satellite observations widely used to provide forecast of magnetic storm events. Hence in this case the alarmingly high PC index could provide useful warning of the storm in back-up of the missing ACE-based forecast. In further cases, on-line monitoring of the PC index could provide alternative or supplementary magnetic storm and substorm warnings to the benefit of power grid operators.

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Differences of Slow and Fast Solar Wind Stream Effects on the Earth Foreshock: THEMIS Observations

Urbar, Jaroslav
Czech Space Office

We provide the foreshock model of plasma parameter modification based both on magnetic fluctuations and energetic particle fluxes.

In the statistical study, we separate effects of the slow and fast solar wind streams on the foreshock region. We use multi-point observations from the THEMIS-ARTEMIS mission and compare to WIND solar wind monitor, estimating evolution of solar wind during interactions in the foreshock. We evaluate the differences emerging from the fast or slow solar wind streams, taking advantage of the recent prolonged solar minima. Most studies of the solar wind-magnetosphere interaction rely on L1 observations that are propagated toward the Earth assuming negligible evolution of upstream parameters along the solar wind path and not taking proper account on the different instrumentation and measurement modes being used. We quantify the effect of a systematic deceleration of the average solar wind speed with a decreasing distance to the bow shock that is controlled by the level of magnetic field fluctuations and by the flux of reflected and accelerated particles in the foreshock region with evaluating the established physical mechanisms. We show that the reflected particles not only excite the waves of large amplitudes but also modify mean values of either fast or slow solar wind parameters measured either in the foreshock or in an un-perturbed solar wind within broad range of Mach numbers.

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TEC Mapping and Short Time Forecast

Pozoga, Mariusz; Tomasik, Lukasz; Dziak-Jankowska, Beata; Stanislawska, Iwona
Space Research Centre

GNSS permanent station are valuable source data for TEC mapping. In this work we presents maps and short time forecast of TEC valule over Europe region. For this purposes we have tested universal kriging and autocovariance for forecast. Using historical data we test our method for quite and disturb space weather conditon.

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The EISCAT_3D Science Case

Tjulin, Anders[1]; Mann, Ingrid[1]; McCrea, Ian[2]; Aikio, Anita[3]; Ulich, Thomas[4]
[1]EISCAT Scientific Association; [2]STFC Rutherford Appleton Laboratory; [3]University of Oulu; [4]Sodankylä Geophysical Observatory

The EISCAT_3D radar system will be a world-leading international research infrastructure located in the Fenno-Scandinavian Arctic, using the incoherent scatter technique to study geospace and to investigate how the Earth's atmosphere is coupled to space. The EISCAT_3D phased-array multistatic radar system will be operated by EISCAT Scientific Association and thus be an integral part of an organisation that has successfully been running incoherent scatter radars for more than thirty years.

The baseline design of the radar system contains a core site with transmitting and receiving capabilities located close to the intersection of the Swedish, Norwegian and Finnish borders and five receiving sites located within 50 to 250 km from the core. The EISCAT_3D project is currently in its EU FP7 funded Preparatory Phase and can smoothly transit into implementation in 2014, provided sufficient funding. Construction would then start in 2016 and first operations in 2018.

The EISCAT_3D Science Case is prepared as part of the Preparatory Phase. It is updated annually with new releases, and it aims at being a common document for the whole future EISCAT_3D user community. The areas covered by the Science Case are atmospheric physics and global change; space and plasma physics; solar system research; space weather and service applications; and radar techniques, new methods for coding and analysis.

Although incoherent scatter radars, such as EISCAT_3D, are few in number, the power and versatility of their measurement technique mean that they can measure parameters which are not obtainable otherwise, and thus also be a cornerstone in the international efforts to measure and predict space weather effects. Accordingly, the incoherent scatter data is also useful for verifications of space weather forecast.

Two of the other aims for EISCAT_3D are to understand the ways the natural variability in the upper atmosphere, imposed by the Sun-Earth system, can influence the middle and lower atmosphere, and to improve the predictivity of atmospheric models by providing higher resolution observations to replace the current parametrised input. The EISCAT_3D observations will also be used to monitor the direct effects from the Sun on the ionosphere-atmosphere system and those caused by solar wind magnetosphere-ionosphere interaction. In addition, EISCAT_3D will be used for remote sensing the large-scale behaviour of the magnetosphere from its projection in the high-latitude ionosphere.

EISCAT_3D can also be used to study solar system properties. Thanks to the high power and great accuracy, mapping of objects like the Moon and asteroids is possible. With the high power and large antenna aperture, incoherent scatter radars can be extraordinarily good monitors of extraterrestrial dust and its interaction with the atmosphere.

Finally, over the years the EISCAT radars have served as a testbed for new ideas in radar coding and data analysis. EISCAT_3D will be the first of a new generation of "software radars" whose advanced capabilities will be realised not by its hardware but by the flexibility and adaptability of the scheduling, beam-forming, signal processing and analysis software used to control the radar and process its data. Thus, new techniques will be developed into standard observing applications for implementation in the next generation of software radars.

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Activities at SANSA Space Weather Centre

Nxele, Teboho; Tshisaphungo, Mpho; McKinnell, Lee-Anne; Wentworth, Laura
South African National Space Agency

The South African National Space Agency (SANSA) operates the Regional Warning Center (RWC) for Space Weather in Africa. The RWC is located within the Space Science Directorate of SANSA in Hermanus, South Africa. SANSA Space Science is a research facility for Space Science in South Africa, and operates a Space Weather Unit within its Research Group. The combination of ground and satellite based data is piped into the centre for predictions and forecasts analysis. This paper will outline the prediction and forecast procedures applied at the centre, present the measurements that are available for use by the center, and look at the applications that are currently being served within South Africa.

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Validation of the DIAS TEC Maps developed with the TaD Topside Profiler

Belehaki, Anna[1]; Tsagouri, Ioanna[1]; Tziotziou, Kostas[1]; Kutiev, Ivan[2]; Marinov, Pencho[2]; Bergeot, Nicolas[3]; Chevalier, Jean Marie[3]

[1]National Observatory of Athens; [2]Bulgarian Academy of Sciences; [3]Royal Observatory of Belgium

TaD is a topside model that extrapolates the electron density profile up to 20,000 km retrieving Digisonde characteristics at hmF2 and TEC estimates from GNSS receiver co-located with Digisonde. The TaD is based on the Topside Sounders Model (TSM), which is a set of empirical functions for the O+/H+ transition height (hT), the topside electron density scale height (HT), and their ratio, derived from the Alouette/ISIS topside soundings. To further increase the TSM accuracy, analytical formulas were developed for obtaining the shape of the vertical plasma distribution in the topside ionosphere and plasmasphere based on TSM parameters. This profiler models separately the O+ and H+ density profiles. To obtain the density distribution, the profiler needs specification of the F layer maximum density (NmF2), its height (hmF2) and its scale height (Hm) at its lower boundary. These are obtained from Digisonde measurements which are ingested to the TaD for the reconstruction of the electron density profile from the F layer peak to GNSS orbits. Above the transition height, the model calculates in addition to the other species, the distribution of He+, extracted from the analysis of the electron density profiles from ISIS-1. The plasmaspheric scale height is approximated as a function of altitude, latitude, local time, and season using an optimization procedure to achieve best fit with the measured profiles.

A major problem that had to be resolved in order to implement the model in the DIAS environment, had to do with the accuracy of the autoscaled scale height at the hmF2, provided by the Digisondes. This was very often out-of-range, leading to unrealistic results for the modeled electron density profile. Therefore, the TEC parameter calculated from TaD model was adjusted with the TEC parameter calculated by GNSS transmitting RINEX files provided by receivers co-located with the Digisondes. This adjustment forces the model to correctly reproduce the topside scale height, despite the inaccurate values of Hm, and it is therefore very important for the application of TaD in an operational environment, such as the DIAS system. Based on this latest version of the TaD model, the DIAS system calculates maps of TEC over Europe, using (1) autoscaled bottomside electron density profiles from 8 European Digisondes and (2) TEC parameters at the Digisondes locations extracted from the ROB GNSS-based TEC maps over Europe. These maps are released in near-real time at 15 minutes resolution since November 2012.

In this paper we present the validation of the maps, including the control for internal consistency of the model and the comparison of modeled TEC values with independent data. The validation extends to quiet and to geomagnetic storm intervals. First results show a reasonable agreement between TEC maps derived with TaD and other regional and global maps collected over a period of 6 months, with a maximum discrepancy of 3 TECU for the 96% of the cases, depending on the latitude of the geographic location under consideration. Based on this analysis, it is possible to reach conclusions about the parameters that affect the quality of the maps, i.e. the number of Digisondes contributing with data to each specific map, their geographic distribution, and the accuracy of the Digisonde autoscaled values.

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LDi: A Local Disturbance Index for Space Weather Purposes

Palacios, Judith; Guerrero, Antonio; Saiz, Elena; Cid, Consuelo; Cerrato, Yolanda

University of Alcala

Real time monitoring of geomagnetic field is relevant for space weather purposes. Although some geomagnetic indices as Dst, ap or Kp are estimated in real time as proxies of global magnetic activity, in some cases, as GICs, local geomagnetic disturbances better comply with the phenomena than with the global ones. As a consequence, local magnetic activity timely available is essential for accurate forecasting of this kind of events. In this work a new index is proposed: the 'Local Disturbance index', i.e., an index (i) with local (L) information of the disturbance (D) during the storm time, obtained from the H component of geomagnetic field measured at a determined observatory.

The requirements for a real time index for Spain guide us also to compare data recorded at three magnetic observatories (SPT, EBR and GUI) spread in longitude and latitude, looking for a relationship among them with the aim of providing a national local disturbance index. The results of this study are shown in this presentation.

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Comparison of EnOI Data Assimilation into Two Physical Models of the Thermosphere

Henley, Edmund; Murray, Sophie A.; Jackson, David R.
Met Office

The ATMOP project (www.atmop.eu) aims to improve orbital predictions for satellites close to Earth, through improved predictions of space weather effects on the thermospheric density responsible for the drag on the LEO satellites.

A key part of ATMOP is using a physics-based model, as a complement to the semi-empirical DTM model used operationally. Specifically, we have worked on building data assimilation systems, using in situ density observations, such as those from the CHAMP satellite, to constrain the model density predictions, bringing them closer to the observed density values.

Here we compare the results of assimilating observations into two different physical models: UCL's CMAT2 model and NCAR's TIEGCM model. Both simulate the thermosphere-ionosphere region, but differ in some details. The assimilation is performed using an ensemble optimal interpolation (EnOI) scheme, and the forecast results from both models are compared to observations not included in the assimilation.

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On the Present Status of Solar Activity

Brajsa, Roman[1]; Verbanac, Giuli[2]; Sudar, Davor[3]; Skokic, Ivica[4]; Hanslmeier, Arnold[5]; Woehl, Hubertus[6]; Roth, Markus[7]; Ludmany, Andras[8]; Murakozy, Judit[8]; MacLeod, Chelsea L.[9]; Ivezic, Zeljko[10]; Mursula, Kalevi[11]; Zhang, Liyun[11]
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The amplitude and time for the actual solar cycle maximum are predicted using different methods:

(i) asymmetry method
(ii) correlation between relative sunspot numbers in minimum and maximum
(iii) autoregressive moving average model (ARMA)
(iv) damped random walk model (DRW)
(v) connection between the starting latitudes and amplitudes of solar cycles
(vi) relation between the number of spotless days and the subsequent amplitude
(vii) Waldmeier effect: a relation between the rising time and maximum amplitude.

Now it is already clear that the maximum of the 24th solar cycle will be weaker than the previous one. The estimated time of the maximum is in the years 2013-2014. Several data sets, including those from SIDC, ROB, Greenwich and Debrecen are used.
Finally, the nonlinear effects of the solar activity and its influence on the prediction possibilities on short and long temporal scales will be briefly discussed.

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A prototype of a quick Information System for Space Weather Events effects on the ionosphere.

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In this poster we present a prototype of a quick Information System aimed at warning about the ionospheric effects following a geomagnetic storm and based on the daily analysis of the behaviour of the ionosphere. After receiving a warning message from the different Space Weather Forecast Centres, as British Geological Survey and NOAA Space Weather, the System analyses a representative sample of ionospheric information and produces a new warning message if a ionospheric storm is detected. In this way, positioning and navigation can be more realistically calculated. For the analysis of the ionospheric state the prototype uses RINEX files from 5 International GNSS Service stations belonging to the International GPS Service network located on the South of Europe and the North of Africa. The data are obtained at 30 seconds sampling rate for the ten days previous to the day studied. This RINEX files are processed with a calibration algorithm developed at the Istituto di Fisica Applicata "Nello Carrara" of Florencia and the Abdus Salam International Center for Theoretical Physics of Trieste. This processing technique assumes the ionospheric thin shell model to obtain vertical total electron content (vTEC) from slant total electron content (sTEC) at the Ionospheric Pierce Point, IPP. The vTECmean obtained from the vTEC values of the 10 previous days is used to calculate the relative vTEC values that inform about on the changes in the ionosphere. When the values are higher than 50% or below -50% the prototype detects and anomaly and issues a message. We also present the first test of our system using five past alerts and known geomagnetic storms; four occurred in 2012 and one in 2011.

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Detailed Computation of Ion Production Rate Profiles in the Earth Atmosphere during GLE 70

Mishev, Alexander[1]; Velinov, Peter[2]

[1]SGO(Oulu unit) University of Oulu; [2]ISST-BAS

The cosmic ray ground level enhancement (GLE) on December of 13, 2006 is among the strongest recorded events during the previous solar cycle 23. This event is well studied on the basis of ground based data records from worldwide network of neutron monitors. At present it is known that solar protons of relativistic energies following major solar eruptions cause an excess of ionization in the atmosphere and ionosphere, specifically over the polar cap regions. Here we compute in details the ionization effect in the terrestrial atmosphere and ionosphere for various latitudes during this event. The computation of ion production rates is according previously developed numerical model for cosmic ray induced ionization, based on a full Monte Carlo simulations of atmospheric cascade. We apply direct simulation of atmospheric cascade with the CORSIKA 6.990 code using FLUKA 2011 and QGSJET II hadron generators and realistic winter atmospheric model. The ion rates during the event are computed on 30 min step, which allows good precision. The solar energetic particle spectra are taken from recent reconstructions from ground based measurements with neutron monitors. Hence we compute the time evolution of the ion rate production. The full 24h ionization effect is also determined. The obtained results are discussed and compared with previously obtained data concerning ionization profiles during other major GLEs.

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Analysis of Ground Level Enhancements of Solar Cycle 23 and 24 in the Frame of the SEPServer Project

Mishev, Alexander[1]; Usoskin, Ilya[1]; Vainio, Rami[2]; Agueda, Neus[3]; Afanasiev, Alexander[2]; Kocharov, Leon[1]

[1]SGO(Oulu unit) University of Oulu; [2]University of Helsinki; [3]Universitat de Barcelona

Solar energetic particles (SEP)s are accelerated during eruptive energy releases on the Sun and/or by acceleration processes in the interplanetary space. They impinge on the atmosphere of the Earth sporadically, with a greater probability during periods of high solar activity. In some cases they lead to an increase of the intensities recorded by neutron monitors on the surface of the Earth, known as ground level enhancements (GLE)s. The main instrument used to study such events and to reconstruct of primary SEPs characteristics such as energy spectra and anisotropy is based on ground-based data records from standard neutron monitors i.e. the world network of neutron monitors (NM)s. The reconstructed energy spectra and anisotropy bring crucial information to understand the acceleration mechanisms of (SEP)s and their propagation in the interplanetary medium.

An analysis of GLEs from NM data consists of several consecutive steps: definition of asymptotic viewing cones of the NM stations by computation of particle trajectory in a model magnetosphere; calculation of the NM responses i.e. an initial guess of the inverse problem; application of an optimization procedure (inverse method) for determination of primary solar proton parameters: energy spectrum, anisotropy axis direction, pitch-angle distribution. In our model we assume a modified power law energy spectrum and superposition of various distributions for the pitch angle.

Assymptotic directions are computed using the MAGNETOCOSMICS code and realistic magnetospheric models, namely IGRF as the internal model and Tsyganenko 89 with the corresponding Kp index as the external one. The inverse problem solution is performed using non-linear least squares method, namely Levenberg-Marqurdt.

In the study presented here, we analyse several major GLEs of the solar cycle 23 as well as the first GLE event of the solar cycle 24, namely GLE 71 of May 17 2012. The SEP spectra and pitch angle distributions are obtained at different time moments after the event's onset time. The obtained characteristics are compared with previously reported results. In addition satellite data are used for the analysis of GLE71. The obtained results and their application are discussed.

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Following Solar Activity with CaLMa after Two Years

Blanco, Juan Jose[1]; Medina, Jose[1]; Garcia, Oscar[1]; Gomez-Herrero, Raul[1]; Catalan, Edwin[2]; Garcia, Ignacio[1]
[1]University of Alcala; [2]CaLMa-SRG

The Castilla-La Mancha (CaLMa) neutron monitor is continuously operating since 26 October 2011. It is located at Guadalajara (40° 38'N, 3° 9'W) at 708 m above sea level and 55 km away from Madrid. It is covering a gap in the Neutron Monitor Data Base (NMDB), thanks to its geographical location, its height above sea level and its vertical cutoff rigidity (6.95 GV). CaLMa is providing counts of galactic cosmic rays (GCRs) with a temporal resolution of 1 min, being the mean count rate 5 c/s/counter. This high cadence allows the monitoring of solar activity by mean the observed variation in count rate. Both in the sort term and in the long term activity, i.e., flare or coronal mass ejections and solar modulation, can therefore be studied with CaLMa's measurements. During this last year, CaLMa has measured variations in the GCR count rate related to interplanetary coronal mass ejections, fast solar wind streams, shocks and stream interaction regions. In this work we analyze the solar wind condition associated to variations in CaLMa's count rate and we compare them with other neutron monitors.

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Recording System for Cosmic Ray Measurements at Lomnicky Stit.

Strhárský, Igor; Langer, Ronald; Kudela, Karel
IEP SAS Kosice

Recording System for Cosmic Ray Measurements at Lomnicky stit.

New system for recording informations on cosmic ray intensity in multichannel measurements of cosmic rays at Lomnicky stit is described. System allows to register data with 1 second resolution, writing barometric pressure and other parameters important for analysis of cosmic rays and their relations to atmospheric processes. In addition to neutron monitor measurements, the system is used in testing mode also for the SEVAN installation at the site (developed by Yerevan Phys. Inst.) and in modified version can be used for the thermal neutron detection (joint device with FIAN Moscow) as well as for dosimetric measurements. In the presentation we discuss the possibility of use the system for space weather monitoring and possible alerts, as well as for studies of relations between cosmic rays and atmospheric electricity. Current status of experiments on cosmic ray studies at Lomnicky stit and in Kosice and their perspectives are reported.

Presentation is created by the realisation of the project ITMS No. 26220120029, based on the supporting operational Research and development program financed from the European Regional Development Fund.

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Ground Level Event on December13 2006: Implications for VLF Transmission

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We study the ground level enhancement event of December 13 2006 (GLE70) by analyzing and quantifying the ionization effect of the high energy solar protons on the lower ionosphere, as monitored by two different ground-based observational tools. The GLE70, triggered at 0240 UT by the powerful X3.4 class X-ray Solar flare, has been detected by the ground-based network of neutron monitors (data stored by Neutron Monitor Database, NMDB, http://nmdb.eu), even at midlatitudes, on one hand. Large attenuation of amplitude in coincidence with increase of phase of the Very Low Frequency (VLF< 30 kHz) wave propagating on the night path between the Tx NAA/24.0 kHz (Main, Cuttler) and the Rx at the Belgrade VLF Observatory have been recorded, on the other. Namely, high-energy protons induced severe ionization enhancement of the lower ionosphere, altering the VLF transmission along the Earth-ionosphere waveguide. The event has been recognized by the time correlation between the distinctly enhanced neutron monitor (NM) registration, VLF amplitude decrease/ phase increase, and the satellite measurements of the high energy proton spectra (e.g. GOES, PAMELA).

On the basis of (i) published work on the energy spectra of accelerated protons, and (ii) the stopping power of protons due to ionization, from the PSTAR program (http://physics.nist.gov), we have evaluated the induced ionization rate in the ionospheric D-region (50-90 km in altitude), which is shown to exceed significantly the background ionization rate by galactic cosmic rays (GCR). Ionization effects on VLF wave propagation have been modelled by the traditional Long Wavelength Propagation Capability (LWPC) code, indicating enhancement of electron density profile throughout the D-region by 1 to 3 orders of magnitude, in dependence of height, with respect to regular conditions. The results arrived at are compared and discussed, complementing the two observational methods, to provide an unique and coherent picture of the GLE70.

The author, VZ, acknowledges the Slovak National Scholarship for conducting this research at the Institute of Experimental Physics, SAS in Kosice.

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CR and Other Space Weather Factors Influenced on the Earth's Climate

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It is obvious now that according to data from the past on big variations of planetary surface temperature on scales of many millions and thousands of years, the Earth's global climate change is determined mostly by space factors, including: the moving of the Solar system around the center of our galaxy, the crossing of galactic arms and molecular dust clouds, nearby supernova and supernova remnants. Another important space factor is the cyclic variations of solar activity and the solar wind (mostly on the scale of hundreds of years and decades). The effects of space factors on the Earth's climate are realized mostly through cosmic rays (CR) and space dust influencing the formation of clouds, thereby controlling the total energy input from the Sun into the Earth's atmosphere. The propagation and modulation of galactic CR (generated mostly during supernova explosions and in supernova remnants in our galaxy) in the heliosphere are determined by their interactions with magnetic fields frozen in the solar wind and in coronal mass ejections (CME), which are accompanied by interplanetary shock waves (producing big magnetic storms during their interactions with the Earth's magnetosphere). The most difficult problem in monitoring and forecasting the modulation of galactic CR in the heliosphere is that the CR intensity in some 4D space-time point is determined not by the level of solar activity at the time of observations and electro-magnetic conditions in this 4D-point, but rather by electromagnetic conditions in the whole heliosphere. These conditions in the whole heliosphere are determined by the development of solar activity over the course of many months before the time-point of observations. This is the main cause of the so-called hysteresis phenomenon in connection with galactic CR ï¿½ solar activity. On the other hand, detailed investigations of this phenomenon give the important possibility to estimate conditions in and the dimension of the heliosphere. To solve the problem described above of CR modulation in the heliosphere, we considered as the first step the behavior of high energy particles (more than several GeV, for which the diffusion time of propagation in the heliosphere is very small in compared to the characteristic time of modulation), on the basis of neutron monitor data in the frame of convection diffusion theory, then taking into account drift effects. For low energy galactic CR detected on satellites and space probes, we also need to take into account the additional time lag caused by diffusion in the heliosphere. We then consider

the problem of CR modulation forecasting for several months and years ahead, which gives the possibility to forecast some part of the global climate change caused by CR.

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Cosmic Ray Intensity and Anisotropy under the Influence of High-Speed Streams from Coronal Holes

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Analysis of the events in cosmic ray intensity caused by high-speed streams from low-latitude coronal holes is presented. The database on Forbush effects created at IZMIRAN, with cosmic ray density and anisotropy calculated by the Global Survey Method (GSM) on the basis of Neutron Monitor network data has been used. From the analysis of the events it was found the dependence of the Forbush effect magnitude on the solar wind characteristics.

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The NMBANGLE PPOLA as a Space Weather-Modeling Tool: Application to the GLE71 on May 17, 2012

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On May 17, 2012 the worldwide network of neutron monitors recorded the first ground level enhancement of solar cosmic rays (GLE71) of the current solar cycle.

In this work we present a first attempt to derive the characteristics of this recent proton event, registered also at ground level, by applying an updated version of the NMBANGLE PPOLA model, already used for modeling past GLEs (e.g. GLE70). In general, this model uses as inputs the response of the worldwide neutron monitor network to big proton events and the disturbance level of the geomagnetic field (through the use of kp) in order to retrieve information on: the solar cosmic ray spectrum evolution outside the Earth's atmosphere; the direction of arrival of the solar cosmic ray flux maximum and the evolution of its spatial distribution; the solar cosmic ray differential and integral fluxes spatial distributions through time. In its current version the model assumes that the primary solar cosmic ray particles during this event are protons. Application of the NMBANGLE PPOLA model to GLE71 shows an initially hard solar cosmic ray spectrum and a flux concentrated mainly above the near-equatorial latitudes moving with time towards southern latitudes; after 02:05 UT the maximum solar cosmic ray flux is always located above the Earth' southern hemisphere. The average differential solar cosmic ray flux of 1GV protons remains at high levels for the whole first 1.5 h of the event ranging between 4d3 particles m-2 s-1 sr-1 GV-1 and 1d5 particles m-2 s-1 sr-1 GV-1.

In this study the initial cosmic ray data required for the model run were obtained from the NMDB (www.nmdb.eu). The derivation of the GLE71 properties through the NMBANGLE PPOLA application is an example of how neutron monitor network data can be efficiently used for space weather modeling and, specifically, for getting information that cannot be directly obtained by space instruments (e.g. the higher energy part of the solar cosmic ray spectrum during the event). The NMBANGLE PPOLA, therefore, inside the context of a neutron monitor network of widely distributed stations, represents a new useful tool for the study of solar physics and space weather providing solar cosmic ray information that is complementary to that obtained by space techniques.

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Using Neutron Monitor Stations as Seeders of the GLE Alert: the Space Weather Perspective

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A significant space weather impact (i.e. risks and failures at communication and navigation systems, spacecraft electronics and operations, space power systems, manned space missions, and commercial aircraft operations) is being imposed from Ground Level Enhancements (GLEs) which are defined as significant intensity increases at neutron monitor measurements. A timely and reliable GLE Alert signal requires both the availability of actual-real time data in a continuous data flow scheme. Given the special characteristics of each neutron monitor station (cut-off rigidity, altitude, latitude, longitude), and the underlying common detection design, all NMs can be used as a unified mutli-directional detector. In this work the availability of each NM station with respect to their delivery of real-time data and their continuous data flow into NMDB as well as the characteristics of the NM stations that contributed to the establishment of timely GLE Alerts for the last 13 GLE events will be presented and discussed.

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Forbush Effects and Precursors: Forecasting Strong Shock Waves using one Hour CR Data

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Cosmic ray (CR) Forbush effects and precursors are important for space weather forecasting of phenomena that pose dangers to satellite electronics and other technologies even on the ground. We select Forbush effects observed on Mt Hermon. Then, using data from other stations, we construct for each event diagrams that show precursor effects using the method of ring stations. These precursor effects can be used for forecasting big magnetic storms. We also performed some statistical analysis of the obtained ring station diagrams and discuss the possibility of using the described method in a real time scale.

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Snow Effect for total NM Intensity and Different Multiplicities

Dorman, Lev[1]; Ben Israel, Itzik[2]; Dai, Uri[2]; Kazantsev, Vasily[1]; Kozliner, Lev[1]; Pustil'nik, Lev[1]; Sternlieb, Abraham[3]; Zukerman, Igor[1]

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All CR stations on mountains and at about sea level at middle and high latitudes in winter periods are covered by snow with the depth (in g/cm2) varied in time. To use this data for space weather forecasting, it is necessary to determine the snow effect for each moment in time and correct observation data not only from barometric and temperature effects (as usual), but also from the snow effect. According to observations on Mt. Hermon, the snow effect in the NM total intensity and different multiplicities is comparable with 11-year variation. The other problem is, that with increasing of snow depth, the sensitivity of the CR detector changed - it moved to higher energies. To determine the snow effect in NM on Mt. Hermon, we made the following investigations step by step: 1) we determined the connection of CR intensity observed on Mt. Hermon during periods without snow with CR intensity on stations which are never covered by snow; 2) by finding the regression coefficients we determine the expected CR variations on Mt. Hermon in winter time on the basis of data of stations which in winter time are not covered by snow; 3) the difference between observed CR intensity and that calculated in point 2 will give the snow effect. This method can be used for any CR station that is covered at some periods by snow.

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Coupling Functions for NM total Intensity and Different Multiplicities: Analytical Approach

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Coupling functions for NM total intensity and different multiplicities play important role when we by observed data of cosmic ray (CR) variations on the ground based detectors (mostly neutron monitors and muon telescopes) tried to determine the primary variations of CR energy spectrum out of the Earth"s atmosphere and magnetosphere, into interplanetary space. This is especially important for forecasting expected radiation hazards from solar CR, because by determined primary solar CR energy spectrum in the interplanetary space it is possible to determine effective time of solar CR ejection into solar wind, source function and the diffusion coefficient of solar CR propagation in space in dependence of particle energy and distance from the Sun. Coupling functions are important also for investigations of Forbush effect and precursory effects for forecasting dangerous interplanetary shock waves. We check obtained results for coupling functions by latitude expedition experimental data. We found how coupling functions depend from the level of solar activity and pressure on the level of observations. Obtained results are presented in the analytical forms that are convenient to use for any NM at any place on the Earth.

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Utilizing Forbush Decreases in Space Weather: Estimating the Expected Efficiency of CMEs as the Modulator of GCRs

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Coronal mass ejections (CMEs) and their interplanetary counterparts (ICMEs) propagate through the interplanetary medium and can modulate the intensity of galactic cosmic rays, resulting into non-recurrent Forbush decreases (FDs). In this work, we investigate the expected efficiency of CMEs as the modulator of GCRs resulting into a Forbush decrease (FD). We use specially processed data from the worldwide neutron monitor network (NMN) to pinpoint the characteristics of the recorded FDs together with CME related data from the detailed online catalog of SOHO/LASCO. Correlations of the FD magnitude to the CME initial speed, the ICME transit speed and the maximum solar wind (SW) speed are presented. Comparisons between the features of CMEs (mass, width, velocity) and the characteristics of FDs are also demonstrated. FD features for halo, partial halo and non halo CMEs is being displayed and discussed.

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Real Time Visualisation by Means of Cosmic Rays: CMEs, Air Showers and Earthquakes.

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It will be visualized in real time CME clouds by means of the GMDN (Global Muon Detector Network). In addition the real time visualization of cosmic ray air showers on a planetarium dome in the DLR_School_Lab Bremen are shown. The relationship between cosmic ray muons and earthquakes will be sketched.

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Simulation of Neutron Monitor by Using Geant4

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The neutron monitors measure data that are of great importance for the study of the solar activity and the prediction of the space weather. The last years, the neutron monitors have been organized in a network and their measurements are easily accessible to all the scientific community through the Neutron Monitor Database (NMDB). Several applications which make use of these measurements have been developed and provide with information about the cosmic rays and the prediction of the space weather. The knowledge of the interactions that take place in the atmosphere and inside the neutron monitor helps to determine the connection between the measurements of the neutron monitors and the cosmic ray particles that

reach the earth. We present in this work a study of the interactions, based on Geant4 simulations, regarding the propagation of cosmic rays into the atmosphere and the detection procedure inside the neutron monitor.

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Propagation and Acceleration of Protons during the First Ground Level Enhancement of Solar Cycle 24 on 17 May 2012

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The first Ground Level Enhancement (GLE) of solar cycle 24 was recorded on 17 May 2012. In this work we try to identify the acceleration source of energetic protons by combining in situ particle measurements from GOES 13, and solar cosmic rays registered by several NMs, as well as remote-sensing solar observations from SDO/AIA, SOHO/LASCO, and RHESSI. To this end, we derive the interplanetary magnetic field (IMF) path length and solar particle release time and we also present time-shifting analysis (TSA) for the first arriving particles that were detected at Earth by NMs. We demonstrate that the IMF direction was such that the NMs that were better connected, as derived by the particles asymptotic directions at 1-2.5 GV rigidity range, were Oulu (0.80 GV) and Apatity (0.65 GV) resulting into a prompt and fast rise in their counting rate. Furthermore, we discuss modeling results for GLE71 (i.e. spectrum, pitch-angle distribution and direction of anisotropy) obtained by the data made available via the Neutron Monitor Database (NMDB).

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Data Analysis of Dourbes Neutron Monitor Data for Solar Events Forecast

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Royal Meteorological Institute

In the search for suitable precursors of solar events, the data from the neutron monitor at Dourbes, Belgium have been subjected to various deterministic and non-deterministic analyses. These analyses covered the entire available data from 1965 to 2013 and focused on examination of the data immediately before a Ground Level Enhancement and Forbush decrease events. In this work we report the results from this investigation and its application to a single-station model for prediction of solar events by ground based neutron monitors.

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Estimation of the Maximal Energy of Solar Accelerators

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Yerevan Physics Institute

On January 20, 2005, 7:02–7:04 UT the Aragats Multidirectional Muon Monitor (AMMM) located at 3200 m registered enhancement of the high energy secondary muon flux (threshold ~5 GeV). The enhancement, lasting 3 min has statistical significance of ~4ó and was related to the X7.1 flare seen by the GOES, and very fast (>2500 km/s) CME seen by SOHO. Worldwide network of neutron monitors detects Ground Level Enhancements (GLE) #69 arriving very fast after flare; recovered energies of solar protons demonstrate rather hard spectra prolonged up to 10 GeV. The solar proton spectrum incident on the Earth's atmosphere was simulated and transport till AMMM detector located beneath 14 m of soil and concrete. The most probable minimal solar proton energy corresponding to the measured 5 GeV muon flux is ~25 GeV. On March 7, 2012 Large aperture telescope of Fermi gamma-ray observatory detected the ever highest energy gamma rays from the Sun with energy about 4 GeV. The minimal energy of the solar protons accelerated during the flare and producing 4 GeV gamma rays should be ~25 GeV. Thus, both measurements with secondary muons and gamma rays prove maximal energy of solar accelerators not smaller than 25 GeV.

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Detailed Study of Solar Cosmic Rays Transport through the Earth's Atmosphere

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Using the PLANETOCOSMICS simulation framework we simulated solar proton transport through the Earth's atmosphere and estimated angular and energy distributions of secondaries (protons, electrons, positrons, muons, photons and neutrons) at various atmospheric levels. As the source spectrum of solar protons at the boundary of atmosphere the spectra obtained with the GLE modeling from the data of neutron monitor network in a number events have been used. These Monte Carlo simulation results were compared with the available solar cosmic ray neutron monitor and balloon measurements. The calculated solar proton spectra are in good agreement with the balloon and neutron monitor observational data.