Third International Symposium on Space Climate

March 15-22, 2009

Saariselkä, Finnish Lapland

Program & Abstracts

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Space Climate Symposium 3

Wednesday 18.3.2009

16.00-16.20 Opening ceremony

16.20-17.00 Keynote talk: Mike Lockwood, Measurement of open solar flux by various spacecraft in the heliosphere and their implications for long term solar variability

17.00-17.50 Session 1

17.00-17.30 Sami Solanki, Modelling the variation of solar total and spectral irradiance

17.30-17.50 Werner Schmutz, The relation between TSI and SSN reinvestigated

Coffee break

18.20-19.30 Session 2

18.20-18.40 Natalie Krivova, Reconstruction of solar spectral irradiance back to 1947

18.40-19.00 Thierry Dudok de Wit, Total solar irradiance variability in comparison to other solar proxies

19.00-19.30 Jean-Pierre Rozelot, How do the Sun's dimensions vary in time?

19.30-21.00 Poster viewing session and Ice breaker

21.00- Dinner

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09.30-10.00 Dibyendu Nandi, The physics of solar cycle predictions

10.00-10.20 Antonio Ferriz-Mas, Energy budget for the solar dynamo

10.20-10.50 Eric Priest, Heating the solar corona

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11.15-13.05 Session 4

11.15 -11.35 Paul Charbonneau, Solar cycle fluctuations and precursor schemes

11.35-11.55 Kirill Kuzanyan, Helical properties of solar magnetic fields as a proxy of dynamo mechanism – results of 20 years monitoring

11.55-12.15 Nadezhda Zolotova, Long-term asymmetries in the butterfly diagrams

12.15-12.45 Laurent Gizon, What does helioseismology tell us about the solar dynamo and long-term solar magnetic activity?

12.45-13.05 Sylvaine Turck-Chieze, On the sources of the solar cycle variability

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16.00-17.05 Session 5

16.00-16.20 Valentina Zharkova, Observational properties of sunspot and background magnetic fields during the solar cycle

16.20-16.50 Saku Tsuneta, HINODE results on solar magnetic field: solar dynamo, MHD waves and acceleration of solar wind

16.50-17.05 Yuto Shiozu, Global Temperature Distribution of the Sun as obtained with Hinode

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20.30-21.15 Studia Generalia: Tauno Turunen, Aurora borealis in science, history and human mind

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09.30-09.50 Barbara Bromage, Variation of open magnetic flux on the Sun over the last solar cycle

09.50-10.20 John Richardson, Variation in the Solar Wind

10.20-10.40 Alexis Rouillard: STEREO observations of solar wind transients in white-light and in-situ

10.40-11.00 Martin Leitner, The solar wind Quasi-Invariant observed by Stereo A and B at solar minimum and comparison with solar maximum results

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11.30-13.10 Session 7

11.30-11.50 David Berghmans, Long-term properties of Coronal Mass Ejections

11.50-12.20 Bruce Tsurutani, High speed solar wind streams during the declining phase of the solar cycle: Resultant geomagnetic activity at Earth

12.20-12.40 Kalevi Mursula, Long-term measures of geomagnetic activity and ring current and their implications on solar change

12.40-13.10 Kanya Kusano, Multi-scale simulation study of solar-cosmic and terrestrial environment

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15.00-17.00 Session 8

15.00-15.30 Juerg Beer, Cosmogenic radionuclides and solar variability: Potential and limitations

15.30-15.50 Ilya Usoskin, Grand minima and maxima of solar activity in the multi-millennial time scale

15.50-16.10 Jose Angel Abreu, For how long will the current grand maximum of solar activity persist?

16.10-16.30 Crisan Demetrescu, On the long-term variability of the heliosphere-magnetosphere environment

16.30-17.00 Katya Georgieva, Solar dynamo and terrestrial climate

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09.30-10.00 Alexander Ruzmaikin: Solar influence on climate: The role of climate patterns

10.00-10.20 John Moore, Examining causality relationships between sunspot cycles and global climate

10.20-10.40 Eugene Rozanov, Climate and Ozone response to the solar irradiance variability during 20th century

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11.40-12.00 Dan Marsh, WACCM simulations of the chemical response of the high-latitude middle atmosphere to solar proton events

12.00-12.20 Jan Maik Wissing, Modeling 3D atmospheric ionization by energetic charged particles

12.20-12.40 Luis Vieira, Southern Hemisphere subtropical stratospheric ozone depletion during the October-November 2003 solar extreme events

12.40-13.00 Jasa Calagovic, Forbush decreases and clouds: Do changes in cosmic ray intensity influence the cloud cover?

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16.00-16.20 Irina Mironova, Mechanisms of aerosol formation under the effect of atmospheric ionisation

16.20-16.40 Radan Huth, Effects of the 11-year solar cycle on various characteristics of the Northern Hemisphere tropospheric circulation in winter

16.40-17.00 Svetlana Veretenenko, Solar activity, cosmic rays and cyclonic processes in the North Atlantic

17.00-17.20 Nir Shaviv, Quantifying the solar cycle related radiative forcing using oceans

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P5 **Budnik, Alex**: Topology of the Heliospheric Current Sheet from magnetic synoptic charts and spacecraft observations

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P12 **D'Huys, Elke**: Visualization of distributed solar data and metadata with the Solar Weather Browser

P13 **Dobrica, Venera**: On the response of the European climate to the solar/geomagnetic long-term activity

P14 **Dreschhoff, Gisela**: Galactic Cosmic Rays, ocean conveyor belt, regional climate and polar temperatures

P15 **Gburek, Szymon**: Analysis of TRACE flare kernels using diffraction affected observations

P16 **Getko, Ryszarda**: The mid-term periodicities of sunspot area fluctuations

P17 **Gil, Agnieszka**: On the rigidity spectrum of the 27-day variation of the galactic cosmic ray intensity in different epochs of solar activity

P18 **Gordeev, Evgeniy**: Comparison of different methods of tail magnetic flux calculation.

P19 **Holappa, Lauri**: Increased local time accuracy of the corrected Dst index

P20 **Huth, Radan**: A comparison of geomagnetic and solar effects on tropospheric circulation in the Northern Hemisphere in winter

P21 **Ivanov, Vladimir**: Key parameters of the Space Climate over different time scales: data and conclusions

P22 **Ivanov, Vladimir**: Latitudinal characteristics of sunspot generating zone

P23 **Ivanov, Vladimir**: Reconstruction of the Maunder butterfly diagram in XVIII-XIX centuries

P24 **Jungner, Hogne**: Variations in tree ring stable isotope records from northern Finland and their connection to solar activity.

P25 **Kepa, Anna**: Analysis of a strong flare observed by RESIK soft X-ray Bragg spectrometer.

P26 **Korhonen, Heidi**: Activity signatures in stars and the Sun

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P29 **Ludmany, Andras**: The number of spotless days as a predictive parameter

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P53 **Vaquero, Jose**: Solar rotation during the period 1847–1849

P54 **Vaquero, Jose**: "HSunspots": a tool for the analysis of historical sunspot drawings

P55 **Wauters, Laurence**: Solar sub-cycles

P56 **Wawrzynczak-Szaban, Anna**: On the influence of the changes of the Interplanetary Magnetic Field and the Solar Wind velocity on the rigidity spectrum of Forbush decreases of the Galactic Cosmic Ray intensity

P57 **Veselovsky Igor**: Multiplicative and additive processes of the solar wind and interplanetary magnetic field formation

P58 **Virtanen, Ilkka**: Active rocket water release experiment in the upper atmosphere

P59 **Virtanen, Ilpo**: Comparing the solar magnetic field in the corona and in the inner heliosphere during solar cycles 21-23

P60 **Yakovchouk, Olesya**: Reconstruction of strongly perturbed Heliospheric magnetic fields in the past based on geomagnetic data

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TALKS

For how long will the current grand maximum of solar activity persist?

J. A. Abreu[1], J. Beer[1], F. Steinhilber[1], S. M. Tobias[2], N. O. Weiss[3]

(1) EAWAG, Dübendorf, Switzerland
(2) Department of Applied Mathematics, University of Leeds, Leeds, UK
(3) Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Cambridge, UK

Understanding the Sun's magnetic activity is important because of its impact on the Earth's environment. The sunspot record since 1610 shows irregular 11-year cycles of activity; they are modulated on longer timescales and were interrupted by the Maunder minimum in the 17th century. Future behavior cannot easily be predicted - even in the short-term. Recent activity has been abnormally high for at least 8 cycles: is this grand maximum likely to terminate soon or even to be followed by another (Maunder-like) grand minimum? To answer these questions we use, as a measure of the Sun's open magnetic field, a composite record of the solar modulation function Φ, reconstructed principally from the proxy record of cosmogenic 10Be abundances in the GRIP icecore from Greenland. This Φ record extends back for almost 10,000 years, showing many grand maxima and grand minima (defined as intervals when Φ is within the top or bottom 20% of a Gaussian distribution). We carry out a statistical analysis of this record and calculate the life expectancy of the current grand maximum. We find that it is only expected to last for a further 15 - 36 years, with the more reliable methods yielding shorter expectancies, and we therefore predict a decline in solar activity within the next two or three cycles. We are not able, however, to predict the level of the ensuing minimum.

Cosmogenic Radionuclides and Solar Variability: Potential and Limitations

J. Beer, J. Abreu, F. Steinhilber

EAWAG, PO Box 611, CH-8600 Duebendorf, Switzerland

Cosmogenic radionuclides are widely used to reconstruct solar variability. At present, they are the only tool to gain information about the solar magnetic activity on millennial time scales. However, they do not only reflect solar modulation of the galactic cosmic rays. Geomagnetic modulation, atmospheric transport and deposition processes play a role as well. In this talk the potential and the limitations of cosmogenic radionuclides to reconstruct past solar variability is discussed.

Long-term properties of Coronal Mass Ejections

D. Berghmans[1], E. Robbrecht[2], R.A.M. Van der Linden[1]

(1) SIDC, Royal Observatory of Belgium, Brussels, Belgium
(2) Naval Research Laboratory, Washington D.C., USA

The LASCO coronagraphs onboard SOHO have systematically observed coronal mass ejections throughout solar cycle 23. Many thousands of events have been witnessed in variable coronal configurations from solar minimum to solar maximum and back. For the first time in history, data is now available to statiscally study this evolution of CME characteristics along a full solar cycle. However, such long term studies require to extract the CMEs using a fixed definition of the criteria which the candidate event should fulfill in order to be classified as CME. We have developed the computer program "CACTus" (Computer Aided CME Tracking) that scans systematically the many thousands of LASCO images and produces consistent CME lists. CACTus runs in an operational way and its realtime output are available at http://sidc.be/cactus. We present a statistical analysis of a CME list produced by CACTus covering a full solar cycle. We will point out important differences exist between CME statistics produced by human inspection at one hand and by computer codes such as CACTus and others at the other hand. These differences bring us to new insights in what CMEs are and their relevance to the heliospheric climate.

Variation of open magnetic flux on the Sun over the last solar cycle

B. Bromage, S. Chapman

Jeremiah Horrocks Institute, University of Central Lancashire, Preston, U.K.

The open magnetic flux has been determined from EUV observations of coronal holes using the CDS spectrometer on board SoHO. The SoHO (Solar and Heliospheric Observatory) mission was launched at the end of 1995 and began scientific observations of the Sun in May 1996, close to solar minimum. The satellite was placed in orbit around the L1 Lagrangian point; from here the instruments had a continuous view of the solar disk. This work focuses on just one of the many instruments on board, the CDS (Coronal Diagnostic Spectrometer). It was designed to observe coronal emission in the EUV wavelength range, in order to study the quiet Sun. About 7 hours out of every 24 hours of observations were devoted to a synoptic study. The CDS study (SYNOP) which ran at this time selected windows of observation which contained some of the strongest EUV spectral lines with temperatures of peak emission ranging from the chromospheric, through the transition region and the low corona, to peak coronal temperatures. The instrument scanned nine 4X4 arcmin fields of view, covering the central meridian of the Sun, recording the above range of spectral information for each pixel (2 arsec square). As the Sun rotated through about 4 arcmin per day it was possible to record a full 360 deg of the surface in approximately 27 days. The spectral information obtained in this way enabled spectral images of the meridian strip to be formed each day, in each of these strong emission lines. The information obtained from the different lines was combined to identify the coronal hole regions, distinguishing them from other dark regions such as prominences and prominence channels. These data have now been produced for more than 12 years, covering a complete solar cycle. An automated procedure was developed to analyse the data and extract the coronal holes, measuring the area of these open flux regions on the solar disk at any time. The variation of this area with time over the cycle is presented here, both for the whole disk and for the two hemispheres separately. The coronal hole areas have then been multiplied by the disk-averaged magnetic flux density obtained daily from Kitt Peak observations and, later, the SOLIS facility, in order to obtain the variation in open flux over the solar cycle. These results are presented here showing the variation seen in the two hemispheres which is particularly clear during the period of the polarity reversal.

Forbush Decreases and Clouds: Do changes in Cosmic Ray intensity influence the Cloud Cover?

J. Calogovic[1], F. Arnold[2], L. Desorgher[3], E.O. Flueckiger[3], C.J. Stubenrauch[4], J. Beer[5]

(1) Hvar Observatory, Faculty of Geodesy, Kaciceva 26, HR-10000 Zagreb, Croatia
(2) Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany
(3) University of Bern, Physikalisches Institut, CH-3012 Bern, Switzerland
(4) Institut Pierre-Simon Laplace, Laboratoire de Métorologie Dynamique, CNRS, Ecole Polytechnique, Palaiseau, France
(5) EAWAG, PO Box 611, CH-8600 Duebendorf, Switzerland

The cosmic ray cloud hypothesis postulates that fluctuations in cosmic ray intensity cause significant changes in the Earth's cloud cover, with important consequences for the climate. According to Svensmark and Friis Christensen (1997), the global cloud cover changed in phase with the GCR flux by 2-3% during one solar cycle. Further studies neither confirmed nor completely denied this hypothesis, initiating heavy debates in the scientific community. Instead of analyzing cosmic ray changes over the 11-year solar cycle, we concentrate on rapid changes, so-called Forbush decreases, which are comparable in amplitude but last only about a week. For each of six selected Forbush decreases, extensive Monte Carlo simulations were carried out to calculate the global change in the atmospheric ion production rate. For each grid cell, the ion production change was compared with the corresponding cloud data change allowing for time lags ranging from 0 to 10 days. The results of these comparisons for different cloud heights, latitudes, and areas will be presented and discussed.

Solar cycle fluctuations and precursor schemes

P. Charbonneau

Département de Physique, Université de Montréal, Canada

Forecasting the properties of upcoming solar activity cycles (amplitude, duration, timing, etc.) remains a very active area of research in space weather and climate. In this presentation I will use a variety of mean-field-like solar cycle models exhibiting cyclic fluctuations arising from a variety of sources (stochastic noise, deterministic chaos, etc) to examine the viability of precursor schemes, where properties of the current cycle (e.g. peak sunspot number, polar field strength at solar minimum, etc) are used to forecast the subsequent cycle. In particular, I will present specific examples demonstrating that the precursor ability (or lack thereof) of the polar fields depends rather sensitively on the nature of the mechanism responsible for poloidal field regeneration, on the type of dynamo in operation, and on the mechanism responsible for driving cycle fluctuations. These results make it possible to assess the strength and limitations of many precursor schemes currently in use for cycle forecasting.

On the long-term variability of the heliosphere-magnetosphere environment

C. Demetrescu, V. Dobrica, G. Maris

Institute of Geodynamics, Bucharest, Romania, crisan@geodin.ro

A detailed study of the relationship between solar wind characteristics (velocity, density) and several current systems in the magnetosphere-ionosphere system (as described by specific geomagnetic indices such as Dst, AE, PC, and general geomagnetic activity indices such as aa, IHV, IDV), in the presence of the interplanetary magnetic field, is undertaken for the last four solar cycles (nos. 20-23). A special attention has been given to the high speed streams in the solar wind, in the context of their sources. At the centennial timescale, the signature of Hale and Gleissberg solar cycles in the geomagnetic activity is presented and several implications of the geomagnetic activity and the solar quiet daily variation relationship with various solar outputs at the Hale and Gleissberg timescales are discussed. As well, an attempt is made to infer a possible effect of a 80-year variation, seen in the main geomagnetic field evolution in the last 150 years, on the solar wind - magnetosphere interaction.

Total solar irradiance variability in comparison to other solar proxies

T. Dudok de Wit, M. Kretzschmar

LPC2E, CNRS and University of Orléans, France

Most attempts to reconstruct the Total Solar Irradiance (TSI) one or two centuries back in time involve the use of various solar proxies. This raises the question about how good such proxies actually are in fitting the variability of the TSI. This can be tested on existing TSI data using information theoretical criteria. Such an analysis reveals two interesting points:

1) the difference between TSI reconstructions based on some of the widely-used solar indices can actually exceed the discrepancy between different versions of the TSI (PMOD, ACRIM, SARR).

2) the TSI is not properly described by an instantaneous combination of indices, but more by a temporal convolution of them, which bears the signature of a diffusive mechanism. The physical nature of this mechanism will be discussed.

Energy budget for the solar dynamo

A. Ferriz-Mas[1], O. Steiner[2]

(1) Instituto de Astrofisica de Andalucia & Universidad de Vigo, Spain
(2) Kiepenheuer-Institut für Sonnenphysik, Freiburg, Germany

A topic of active research aims at understanding how solar magnetic activity influences (and has influenced in the past) the Earth's climate. We are trying to elucidate possible mechanisms connecting the 11-year magnetic activity cycle with solar luminosity variations on a temporal scale from tens to several hundreds of years. Standard solar dynamo theory has never dealt with the global energy budget of the dynamo mechanism. In the past decade, evidence has accumulated that the reservoir of kinetic energy available in differential rotation does not suffice to account energetically for the so-called "Omega effect" (i.e., the generation of toroidal magnetic field from the poloidal part of the field). Additional mechanisms such as the conversion of gravitational potential energy or internal energy into magnetic energy have been invoked in order to account energetically for the 11-year activity cycle of sunspots. The virial theorem of Chandrasekhar and Fermi is an interesting tool for studying global connections among the different energy reservoirs in the Sun.

Solar dynamo and terrestrial climate

K. Georgieva

Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Sofia, Bulgaria

Solar activity influencing the Earth can be decomposed into two parts (Feynman, 1982): one related to the solar toroidal field and proportional to the sunspot number (ST), and one related to the solar poloidal field and unrelated to the sunspot number (SP). Earlier studies have demonstrated that variations in terrestrial phenomena including geomagnetic activity and climate, are better correlated to SP than to ST. ST and SP are manifestations of the action of the solar dynamo which transforms the solar poloidal field into toroidal field and this toroidal field back into poloidal field. According to the flux-transport dynamo mechanism, a crucial role in this process plays the solar large-scale meridional circulation. The magnitudes of the poloidal and toroidal fields generated by the solar dynamo depend on the interplay between the speed of the surface and deep circulation, respectively, and the diffusivity in the solar layers involved in these large-scale motions. We demonstrate how the long-term variations in SP and ST, and in their relative importance for the Earth, are caused by the long-term variations in the action of the solar dynamo.

What does helioseismology tell us about the solar dynamo and long-term magnetic activity?

L. Gizon

Max Planck Institute for Solar System Research, Kaltenburg-Lindau, Germany

A dynamo is a flow capable of maintaining the magnetic field against Ohmic decay. Thus any information that can be gathered about flows or the magnetic field in the solar interior is relevant to the study of the solar dynamo problem. I will review what helioseismology has to say about internal differential rotation, the meridional flow, and smaller scale flows. While rotation is now known throughout most of the convection zone, the meridional flow, which has a much smaller amplitude, has proved to be more difficult to measure below the surface. Eleven-year variations in both rotation and the meridional flow have been detected, which may (or may not) give us additional observational constraints on the dynamo. Helioseismology provides a wealth of information about near-surface, localized flows, which tell us about turbulent convection and its interaction with the magnetic network, complexes of activity, and even rotation. Finally, the detection of the magnetic field itself has become one of the most important goals of helioseismology. The strategy, here, is to study the seismic signature of sunspots and active regions and to learn how to interpret the observed wave field in terms of the various direct and indirect effects of the magnetic field. Armed with patience we may be able to tell some day how the magnetic field makes it to the surface and how it is connected to the deeper layers.

Observations of Sun-Like Stars and their Implications for Long-Term Solar Activity

J. C. Hall

Lowell Observatory, USA

Long-term records of the variability of Sun-like stars now span over 40 years, beginning in 1966 with Olin Wilson's stellar cycles program. As Wilson accumulated his initial data, work in the 1960s and 1970s focused on characterizing the morphology of stellar cycles and their similarity (or lack thereof) to the solar cycle. In the 1980s and 1990s, the increasingly lengthy time series allowed examination of the physical processes driving stellar cyclic variability, while at the same time, the discovery of the 0.1% solar cycle TSI variability led to efforts to relate the stellar chromospheric activity proxies to luminosity variations. The relevance of the stellar activity-brightness correlations that emerged from these new programs to the long-term brightness variations of the Sun has prompted much attention since 1990 to the behavior of the so-called solar analogs, especially those stars that appear to be in stellar equivalents of the Maunder Minimum. In this talk, I will review the development of these areas of study and discuss the most recent results. In particular, I will discuss our present understanding of the magnetic states of cycling and flat activity solar analogs and the implications of the stellar observations for the likely behavior of the Sun in cycling and grand minimum states.

Effects of the 11-year solar cycle on various characteristics of the Northern Hemisphere tropospheric circulation in winter

R. Huth[1], D. Barriopedro[2], L. Pokorná¡[1], J. Kyselý[1], R. Beranová[1], J. Bochnicek[3]

(1) Institute of Atmospheric Physics, Prague, Czech Republic
(2) Centre of Geophysics, University of Lisbon, Lisbon, Portugal
(3) Institute of Geophysics, Prague, Czech Republic

We examine solar activity effects on various aspects of tropospheric circulation in the Northern Hemisphere. The analysis concerns winters in 1950-2003. Separate analyses are conducted for low, moderate, and high solar activity, which is characterized by the 10.7 cm radio flux. Tropospheric circulation is described by modes of low-frequency variability (teleconnections); teleconnectivity, i.e., maximum negative spatial autocorrelations; blocking events; correlations between the variability modes and surface temperature and precipitation in Europe; and frequency of synoptic types according to Hess-Brezowsky (defined over Europe). Data used are mainly 500 hPa heights from the NCEP/NCAR reanalysis. Statistically significant differences between solar maxima and minima appear for all the circulation characteristics, e.g. in the position and intensity of the action centres of the variability modes, position and duration of blocking events, area involved in teleconnection patterns, and the frequency of groups of Hess-Brezowsky synoptic types. A general effect is that under a high solar activity, the circulation tends to zonalize and the geographical extent of the modes and blocks is larger. One of the effects of a high solar activity is a tendency towards splitting the NAO. Some effects, e.g., the activization of the North Asian mode, are pronounced for a moderate solar activity, which poses a warning that in investigations of solar effects on the troposphere, one should not rely on the extremes of the solar cycle only, but should consider the non-extreme phases as well.

Reconstruction of solar spectral irradiance back to 1947

N.A. Krivova, S.K. Solanki, T. Wenzler, B. Podlipnik

Max Planck Institute for Solar System Research, Katlenburg-Lindau, Germany

Variations of solar spectral irradiance, specifically in the UV, are believed to play a crucial role in the Sun - climate link. We present a reconstruction of solar spectral irradiance between 115 and 160000 nm since 1947. Different techniques are employed for different spectral ranges and periods of time in order to achieve maximum coverage.

Multi-scale Simulation Study of Solar-Cosmic and Terrestrial Environment

K. Kusano[1], D. Shiota[1], S. Inoue[1], T. Sugiyama[1], S. Shima[1], Y. Kawamura[1], R. Kataoka[2], T. Miyoshi[3], E. Asano[4], Ta. Matsumoto[4], T. Ogino[5], K. Shibata[4]

(1) JAMSTEC, 3173-25 Showa-machi, Kanazawa-ku, Yokohama, 236-0001, Japan
(2) RIKEN, 2-1 Hirosawa, Wako, 351-0198, Japan
(3) Graduate School of Science, Hiroshima University, 1-3-1 Kagamiyama, Higasih-hiroshima, 739-8526, Japan
(4) Kwasan Observatory, Kyoto University, 17 Ohmine-cho Kita Kazan, Yamashina-ku, Kyoto, 607-8471, Japan
(5) STEL, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan

Although solar and heliospheric activities are believed to be able to influence the electromagnetic and atmospheric conditions of the Earth, our understanding of the mechanism is still severely limited. In this paper, we like to present our recent simulation studies for space weather and space climate dynamics, respectively. The first topic is the data-driven simulation of solar storm, which has been developed aiming at predicting the influence of solar eruption on the terrestrial environment using the high-resolution observations with the Hinode satellite. We like to discuss the predictability of influence of solar storm event based on the simulation results. The second topic is the simulation study of relationship between the ion-induced nucleation and the cloud formation, which was addressed by Svensmark and Friis-Christensen (1997) to explain the correlation between the solar modulation of galactic cosmic ray (GCR) and the variation of cloud. We are developing the several new models to explain multiscale connection from the ionization due to GCR to the climate variation; molecular dynamics model for nucleation of sulfuric aerosol, particle-based new cloud microphysics model, and cloud-resolving climate model. We like to demonstrate some preliminary results of them and to discuss about the future plan of our simulation. This work is a multi-institution collaboration supported by the Grant-in-Aid for Creative Scientific Research "The Basic Study of Space Weather Prediction" (17GS0208, Head Investigator: K. Shibata) from the Ministry of Education, Culture, Sports, Science, and Technology of Japan, as well as by JAMSTEC (Japan Agency for Marine-Earth Science and Technology) as a part of the Earth Simulator Project for "The Development of Macro and Micro Interlocked Simulation Algorithm."

Helical properties of solar magnetic fields as a proxy of dynamo mechanism - results of 20 years monitoring

K.M. Kuzanyan[1], V.N. Obridko[1], D.D. Sokoloff[2], H. Zhang[3], Y. Gao[3]

(1) IZMIRAN, Moscow region, Russia
(2) Moscow State University, Russia
(3) National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China

We discuss results of 20 years systematic monitoring of the solar vector magnetic fields in active regions taken at Huairou Solar observing station in China along with other observatories in the USA and Japan. We show that the mirror asymmetry of the magnetic field at the photospheric level has a significant hemispheric preference, which can be computed as average value of helicity and twist parameters over a hemisphere at a given interval of time. This hemispheric rule is persistent on very large amount of observational data. In the Northern hemisphere these quantities are mainly positive while at the Southern negative. This rule, however, is valid from one cycle to another despite the absolute values of these quantities vary a lot with the phase of the solar cycle.

Furthermore, we have shown that these helical quantities are extremely fast changing on a short range of spatial and temporal scales, related to the size of individual active regions as well as their life time (or the time of available observations) of several days. This indicates that helicity and twist at photospheric level are significantly influenced by a small scale sub-surface magnetohydrodynamics. Due to this variability the hemispheric rule can be established only in the sense of large scale averages in latitude and time.

Nevertheless, we have established particular latitudes and times over the phases of the solar cycle at which this rule fails, mainly at the raise and fall of the 11-yr cycle, and we have shown that this violation is statistically significant. These findings on spatial distribution and temporal variation of helical properties of the solar magnetic fields indicate global properties of their generation and shed light on the mechanism of the solar dynamo, therefore provide us with useful constraints on theoretical modelling of the solar activity.

The solar wind Quasi-Invariant observed by Stereo A and B at solar minimum and comparison with solar maximum results

M. Leitner[1], J.C. Farrugia[2], A. Galvin[2], H.K. Biernat[3], V. Osherovich[4]

(1) Institute of Astro- and Particle Physics, University of Innsbruck, Technikerstrasse 25/8, A-6020 Innsbruck, Austria
(2) Space Science Center and Dep. of Physics, Univ. of New Hampshire, Durham, NH, USA
(3) Space Research Institute, Austrian Academy of Sciences, Graz, Austria
(4) NASA Goddard Space Flight Center, Greenbelt, MD, USA

The solar wind quasi-invariant (QI) is defined as the ratio of the solar wind magnetic energy density to the kinetic energy density, i.e. the inverse square of the Alfvén Mach number. Previous work has found this quantity to be a good proxy for solar activity, correlating very well with the solar sunspot number. It has the advantage of being locally determined from in situ observations. Using Stereo-A and B data and WIND data we obtain the distribution of QI over 2007-2008. (1) During this period of solar minimum activity the solar wind is dominated by corotating streams and stream - stream interaction regions. To see if this minimum is indeed weaker than previous ones we compare this distribution with the one during 1995, using WIND data, and 1974, using Helios data at 1 AU. Further, we contrast these distributions with those obtained over the last solar cycle, where at maximum the solar wind is increasingly dominated by interplanetary coronal mass ejections. The effect of alpha particles on QI is considered too. (2) In all phases of the solar cycle we find that the QI-distributions are best represented by a lognormal distribution and we give the respective mean and standard deviations. With the Helios data set we show the change of the distributions with heliospheric distance, and with WIND the changes over solar cycle 23 (1996-2008) are provided.

Measurement of open solar flux by various spacecraft in the heliosphere and their implications for long term solar variability

M. Lockwood[1], A. Rouillard[1], M. Owens[2]

(1) Southampton University and Rutherford Appleton Laboratory, U.K.
(2) Blackett Laboratory, Imperial College, London, U.K.

Problems related to the open solar flux are discussed, e.g., how its measurement at Earth needs a correction for kinematic effects and how the low values during the current solar minimum have implications for the long term reconstruction of total solar irradiance.

WACCM simulations of the chemical response of the high-latitude middle atmosphere to solar proton events

D.R. Marsh , D.E. Kinnison

National Center for Atmospheric Research, Boulder, Colorado, USA

During the declining phase of solar cycle 23, ionization from energetic particle precipitation in the polar regions during several large solar proton events (SPEs) lead to significant increases in the concentration of hydrogen and nitrogen species. Large changes in ozone and NO_x concentrations in mesospheric and stratospheric were observed by several satellite instruments. In this study, NCAR's Whole Atmosphere Community Climate Model (WACCM) is used to examine the chemical response of the middle atmosphere to this series of SPEs. WACCM is a global coupled chemistry-climate model that extends in altitude from the surface to the lower thermosphere. We find that the simulated response in WACCM of ozone and NO_x is in good agreement with observations. The magnitude of the chemical response is assessed by comparing simulations with and without SPE forcing.

Mechanisms of aerosol formation under the effect of atmospheric ionisation

I. A. Mironova

St.Petersburg State University, Institute of Physics, Petrodvorets, St.Petersburg, 198504, Russia

Results of recent studies and discussions on the possible role of cosmic rays in variations of Earth climate are highly controversial. A major point of discussion is the absence of a clear quantitative model for a physical mechanism linking atmospheric compounds to cosmic rays. An apparent way is via the atmospheric ionisation produced mainly by cosmic rays, but their role in aerosol formation is still not clearly determined. Here we present discussion of possible mechanisms of aerosol formation under the effect of atmospheric ions and analyse recent experimental data.

Examining causality relationships between sunspot cycles and global climate

J. Moore[1,2], A. Grinsted[1,3], S. Jevrejeva[4]

(1) Arctic Centre, University of Lapland, Rovaniemi, Finland
(2) Thule Institute, University of Oulu, Oulu, Finland
(3) Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen, Denmark
(4) Proudman Oceanographic Laboratory, Liverpool, U.K.

Several authors have found significant correlations between solar variability on decadal scales and various climate indices such as large scale circulation patterns, global temperature and global sea level. However, correlation analysis is not the optimum way to establish causality between time series. There are much better statistical tools available that examine phase relationships which are a stronger requirement and test of causality than correlation can possible provide. These tests include granger causality, mutual information, wavelet coherence and wavelet lag regression. Furthermore when determining statistical significance it is very important to consider the noise background that is used. In the case of solar cycle variability simple white or red noise backgrounds are not suitable as they are a poor representation of the power spectrum of the time series. More suitable backgrounds are form randomizing phases of Fourier decompositions of the time series. Using phase sensitive causality tests with appropriate noise backgrounds we find little or no evidence for solar driving of climate at 11 year periodicity.

Long-term measures of geomagnetic activity and ring current and their implication on solar change

K. Mursula

Department of Physical Sciences, University of Oulu, Oulu, Finland

Changes in the properties of the solar wind and the heliospheric magnetic field (HMF) lead to disturbances of the Earth's space environment that are collectively called geomagnetic activity. Continuous measures of geomagnetic activity exist since the mid-19th century, covering more than 160 years. The standard measure of magnetic storms, the Dst index now covers the last 75 years. Several studies have recently noted of problems in standard measures of geomagnetic activity and storminess. E.g., it is now known that the longest and most used long-term geomagnetic index, the aa index, is inhomogeneous and depicts an excessively large centennial increase. Errors in archival magnetic data have been found that lead to seriously flawed estimates of the centennial trend in some indices of geomagnetic activity. Moreover, the Dst index is known to include several random and systematic. These problems have led to the development of new indices of geomagnetic activity and magnetic storms. The new indices are based on digitally available hourly values of the geomagnetic field, which allow for a detailed examination of their properties. Thus they are more straightforward and reliable than earlier indices. We discuss two groups of new indices of geomagnetic activity, the IHV indices and the Ah indices, and new versions of the Dst index. The Ah indices modify the traditional definition of the 3-hourly K index method, yielding a highly correlative extension of the Kp/Ap index and a more reliable substitute for the aa index for the last 100 years. All estimates prove that geomagnetic activity, and thereby solar activity has significantly increased during the last century. However, this increase is considerably slower than given by the aa index. Also, the modified long-term Dst indices suggest a change in the parameters of typical storms. I will review these recent developments in traditional and new indices of geomagnetic activity and magnetic storminess, and discuss their implications for the long-term change of the Sun.

The Physics of Solar Cycle Predictions

D. Nandi[1,2]

(1) Montana State University, USA
(2) Indian Institute of Science Education and Research-Kolkata, India

Following a brief description of the theoretical ideas underlying solar dynamo theory, I will discuss the predictability, or lack thereof, of the sunspot cycle. The physical processes that determine this predictability will also be described and some recent dynamo-based predictions of the solar cycle will be presented. Finally I will discuss what physics is missing from current dynamo models and how taking them into account may affect solar cycle predictions.

Heating the Solar Corona

E. Priest

St. Andrews University, U.K.

The classical model for heating the corona was the nanoflare model of Parker. Here we summarise the Tectonics Model, which is a development of the nanoflare model that takes account of the magnetic carpet. We also address one important question, namely, if the corona is heated in many small sporadic current sheets, how does the energy spread out from them to heat the entire corona – surprisingly, we find that an important role is played my MHD waves carrying energy away from each sheet as they dissipate dynamically.

Variation in the Solar Wind

J. Richardson

M.I.T., USA

Spacecraft have been observing the solar wind for over 4 decades. The observations provide information on temporal changes in the solar wind on scales from minutes to solar cycles and have revealed the total range of SW variability. Recent data suggest the Sun's output this solar minimum is the smallest observed. We show the solar wind observations and their variability in both the inner and outer heliospheres. The solar wind variations affect the inward transport on cosmic rays and thus modulate the cosmic rays fluxes at Earth.

STEREO observations of solar wind transients in white-light and in-situ

A.P. Rouillard[1], J.A. Davies[2], B. Lavraud[3], N.P. Savani[4], R.J. Forsyth[4], M. Lockwood[1,2]

(1) University of Southampton, U.K.
(2) Rutherford Appleton Laboratory, U.K.
(3) Universite de Toulouse et Centre National de la Recherche Scientifique, France
(4) Imperial College London, U.K.

The Heliospheric Imagers (HI) onboard the STEREO spacecraft provide white-light images of the solar corona from the Sun to Earth-like distances. The constellation of spacecraft located near 1AU can be used to compare directly in-situ observations of solar wind transients with their white-light signatures. Two classes of transients are monitored by the HI instruments; large-scale Coronal Mass Ejections (CMEs) and smaller magnetohydrodynamic irregularities which form part of the slow solar wind. These observations allow a detailed analysis of the interaction between CMEs and the ambient solar wind. The kinematic and dynamic evolution of CMEs is here analysed by comparing HI images with in-situ observations recorded between 0.72AU and 1AU by STEREO/ACE/WIND/Venus Express and MESSENGER. The continual release of the smaller scale transients in the slow solar wind is also analysed providing new insights on the evolution and recycling of the heliospheric magnetic field.

Climate and Ozone Response to the Solar Irradiance Variability during 20th Century

E. Rozanov[1,2], T. Egorova[1], W. Schmutz[1], A. Fisher[2], S. Brönnimann[2], T. Peter[2]

(1) Physical-Meteorological Observatory/World Radiation Center, Dorfstrasse, 33, Davos, Switzerland
(2) Institute for Atmospheric and Climate Science ETH, Zurich, Switzerland

The attribution of the climate and ozone changes in the past requires understanding of the effects of different natural forcing such as volcanic eruptions, solar irradiance and sea surface temperature changes. To elucidate the influence of the solar irradiance variability we carried out the 9-member 100-year long transient ensemble simulation with the CCM SOCOL spanning the entire 20th century, driven by the prescribed time evolution of the sea surface temperature, sea ice distribution, volcanic aerosols, solar spectral irradiance, greenhouse gases, ozone depleting substances, sources of CO and NOx, land use, and quasi-biannual oscillation and one reference run without solar variability. The simulated time series of different atmospheric quantities were analysed by using different techniques (multiple linear regression analysis, composite analyses, time filtering) to estimate the climate and ozone sensitivity to the solar irradiance variability and its evolution in time. The analyses showed statistically significant solar signal from the mesosphere down to the surface temperature. The maximum ozone response (4%) is found in tropical middle stratosphere, while the temperature response maximizes in the tropical stratopause reaching 1.2 K. The land surface temperature response in the northern hemisphere is found to be 0.3K. The results also revealed that ozone response to the solar variability is almost time independent in the 35-60 km layer, while in the mesosphere the magnitude of ozone response decreases significantly with time from 9% at the beginning to 4% at the end of the century. The same behavior can be also seen for the temperature response. It is rather stable in the 35-60 km layer, while its magnitude increases from 0.8 to 1.6 K in the mesosphere. The causes of such behavior will be discussed. We will also discuss the dependence of the temperature and ozone response to the solar irradiance variability on the QBO phase.

How do the Sun's dimensions vary in time?

J.P. Rozelot[1], C. Damiani[2]

(1) OCA-FIZEAU (UMR 6525), Université Nice-Sophia-Antipolis, Av. Copernic, 06130, Grasse, France, rozelot@obs-azur.fr
(2) INAF-Osservatorio Astronomico di Roma via Frascati 33, 00040 Monteporzio Catone, Italy, cilia.damiani@obspm.fr

Based on historical records, the Sun's dimensions are temporal dependent. Up to a recent past, such sizes were keenly disputed. Recent accurate observations have allowed raising the doubt, whatever by direct limb observations or by heliosismology f-modes analysis. A shrinking or an expanding shape is ultimately linked to solar activity as even a small variation in solar radius cause variation in gravitational energy. Orders of magnitude indicate that the energy is released or absorbed at a rate larger than the solar luminosity variation. In this lecture we will show how helioseismology results allow us to look at variations below the surface, where changes are not uniform (within the leptocline). Based on accurate space and ground-based observations, we will show that the oblateness of the Sun is also time dependent, in phase with solar activity. In a time of low activity, the equatorial diameter slightly increases under the influence of J_4, with no effect of J_4, so that the oblateness is decreasing (reverse mechanisms happen when the solar activity is higher). We will show that any variation in shape has to be confined to outer layers, but indicates structural changes in the solar interior. More studies are needed, to get accurate measurements from space, which will provide us a unique opportunity to study detailed changes of the global solar properties.

Solar Influence on Climate: The Role of Climate Patterns

A. Ruzmaikin

Jet Propulsion Laboratory, California Institute of Technology, U.S.A.

Early attempts to find how solar activity can influence the Earth's climate involved comparison of solar irradiance or solar particle fluxes with global terrestrial variables such as the Earth's global temperature or cloud cover. It appears however that global response is weak and more strong responses were found in particular regions of the Earth such as near the poles and in tropics. These responses are always associated with the Earth's atmosphere and ocean dynamics (c.f. Hadley and Walker circulation in tropics, Brewer-Dobson circulation in the stratosphere near the poles). In my talk I will discuss how solar variability influences the dynamical regimes generated by coherent climate patterns. Examples of these patterns are the Northern and Southern Annular Oscillations. The patterns are generated and supported by random processes involved in the ocean-atmosphere interaction and usually have two basic states. Solar variability breaks the symmetry of the residence in these states. The solar effect is stronger and can easily be identified during prolong maxima or minima of solar activity.

The relation between TSI and SSN reinvestigated

W. Schmutz

PMOD/WRC, Switzerland

It is common knowledge that there is an overall relationship between Total Solar Irradiance (TSI) and Solar Sunspot Number (SSN): Both are positively correlated on time scales of a solar cycle but on a daily time-scale, there is no obvious relation. The presentation will report a re-investigation of the the TSI to SSN relationship which a new result.

Observations of the solar effect upon the middle and upper atmosphere

A. Seppälä[1,2]

(1) British Antarctic Survey, Cambridge, U.K.
(2) Finnish Meteorological Institute, Helsinki, Finland

This presentation will give an overview of what we have recently learned about the Sun's impact on the polar middle and upper atmosphere, the area of the Earth's atmosphere covered by altitudes from about 20 to 150 km (stratosphere - mesosphere - lower-thermosphere). Much new information of the solar impact on the polar middle and upper atmosphere has been gained in the recent years thanks to new kinds of observations becoming available. Of key role have been especially the observations made from satellite platforms such as the European Space Agency's Envisat satellite, but also from utilisation of ground based measurements in novel ways.

The focus of this presentation will be particularly on observations of the effects of solar storms and energetic particle precipitation on the chemical composition, such as ozone, NO_x, and HO_x, and dynamics of the polar middle and upper atmosphere. The possible further implications of these to the polar climate will also be discussed.

Quantifying the solar cycle related radiative forcing using the oceans

N. J. Shaviv

Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem, 91904 Israel

We use the oceans as a calorimeter to quantify the solar radiative forcing variations which are in sync with the solar cycle. Three independent data sets, including 3D buoy data, surface temperature measurements and tide gauge records, all reveal that the amount of heat which periodically enters the oceans is almost an order of magnitude larger than can be explained through solar irradiation variations only. This implies that a mechanism which amplifies solar activity variations must be operating.

Global Temperature Distribution of the Sun as obtained with Hinode

Y. Shiozu[1,2], S. Tsuneta[2]

(1) Osaka Kyoiku University, Japan
(2) National Astronomical observatory, Japan

Temperature distribution on the solar surface is not thought to be uniform due to the influence of the solar rotation. The measurement of the photospheric temperature distribution potentially provides a new diagnostic tool of the solar interior, for instance, interaction between convection and rotation and convective heat transport. Indeed, various numerical simulations imply temperature difference between the polar and the equatorial regions ranging from a few to 20 [K]. Here we report precision photometric observations with Hinode that result in accurate latitudinal temperature distribution from the center of the solar disk to both polar regions. Hinode performed cross mosaic observations consisting of 132 four-color photometric images with field of view 223-112 [arcsec] along meridional and East-West lines Data used in the analysis were obtained from 2007 October 12 through October 15. There was no apparent active region nor plage in the images. The wavelength is three continuum bands of Red 668.4[nm], Green 555.0[nm] and Blue 450.5[nm], and G band 430.5[nm]. To avoid the influence of the limb darkening, the temperature distribution in the meridian is calculated as a difference from the uniform temperature distribution along the East-West line. The self-calibration using the data was performed to obtain spatial map of the CCD sensitivity, and the throughput of the telescope (whole optical chain including CCD) for 3 photometric bands. The temperature may be affected by faculae, and we removed all the candidates of faculae form the photometry data. It turns out that the influence was small. The temperature distribution in the photosphere from the latitude -55° to 67° was obtained. We find that the sun has temperature distribution along latitude. We are in the process of confirming the final result, and the final result will be presented in the conference.

Long term evolution of the heliospheric magnetic field: Ulysses legacy

E. J. Smith

California Institute of Technology Jet Propulsion Laboratory, USA

Ulysses highly inclined orbit and long lifetime have made continuous observations of the 3- D heliosphere possible for 18 years or most of the 22 year Hale cycle. Heliospheric magnetic field (HMF) measurements show that the magnetic flux, the radial magnetic field component multiplied by the square of the radial distance or BRr2, is independent of heliolatitude throughout the sunspot cycle. This discovery has made in-ecliptic measurements of BR of greater significance than before because they now represent a longer record of total magnetic flux in the heliosphere and, in addition, are highly correlated with field strength, B. The combined Ulysses and in-ecliptic measurements reveal the solar cycle variation in greater clarity. Magnetic flux is a minimum at sunspot minimum, gradually increases with increasing solar activity, decreases temporarily to a secondary minimum when the Sun's polar cap fields disappear and reappear and then continues to a maximum in the descending phase when the polar cap field is also at its maximum. The recent observations show that BRr2 reached the lowest level since the space age began and at a time when the Sun's polar cap fields have also decreased by a factor of about two. The contribution of Coronal Mass Ejections to the heliospheric magnetic flux near solar maximum is still unresolved but "open" flux in the solar wind continues to make a significant contribution of at least one-half of the total and is clearly dominant at solar minimum. Ulysses has also shown that the HMF has a dipole-like character throughout the solar cycle with the Heliospheric Current Sheet (HCS) continuously present. The tilt of the HCS to the Sun's rotation axis or its inclination undergoes a cyclic change with the solar cycle. The inclination is low near solar minimum and gradually rotates to a high inclination at solar maximum corresponding to a nearly equatorial dipole when the polar cap fields disappear. Thus, the HCS is the symmetry axis of the heliosphere and its inclination affects the 3-D solar wind structure of the heliosphere and the access of energetic particles including galactic cosmic rays to high heliolatitudes.

Modelling the variation of solar total and spectral irradiance

S. K. Solanki

Max Planck Institute for Solar System Research, Germany

The variation of total solar irradiance (TSI) has been measured since 1978, that of the spectral irradiance for an even shorter amount of time. Semi-empirical models are now available that rather accurately reproduce the measured TSI variations and a large fraction of the SSI variations. An extension of these models into the more distant past is needed in order to serve as input to climate simulations. A range of such models have been constructed with rather different underlying assumptions and techniques. Consequently the results are also rather inhomogeneous. Some of the modern models are beginning to converge towards a rough consensus regarding the TSI since the Maunder minimum.

HINODE results on solar magnetic field: solar dynamo, MHD waves and acceleration of solar wind

S. Tsuneta

National Astronomical Observatory, Japan

The solar polar region (Tsuneta et al, 2008) is characterized by vertical kilogauss patches with super equi-partition field strength, coherence in polarity, short lifetime of 5-15 hr, and ubiquitous weaker transient horizontal fields (Ishikawa & Tsuneta, 2009). The presence of kG patches in the polar regions potentially alleviates the omega-problem to have strong troidal field from weak poloidal field.

The polar region has abundant vertical fields much stronger than the quiet Sun, and the larger magnetic pressure sustains the lower pressure coronal hole. Potential field calculation for the polar region and for the quiet sun with Hinode data shows completely different coronal magnetic structures. Flux tubes in the polar region have large expansion factor very close to the photosphere, while those of the quiet sun have essentially closed loop structure. Open field lines forming the polar coronal hole essentially originate from kG magnetic patches, and the fast solar wind would emanate from these vertical flux tubes seen in the photosphere.

We conjecture that vertical flux tubes with large expansion around the photospheric-coronal boundary serve as efficient chimneys for Alfven waves that accelerate the solar wind due to lower Alfvenic cutoff frequency. Indeed, we discovered propagating Alfven waves (kink mode) with magneto-acoustic waves (sausage mode) in the solar photosphere with period of 4-13 minutes with Hinode spectro-polarimeter (Fujimura and Tsuneta, 2009). We interpret that these fluctuations are superposition of ascending and descending Alfven waves with similar intensities from the analysis of the phase relationship between transverse magnetic and velocity fluctuations. Aflven waves along flux tubes in the quiet sun appear to be efficiently reflected back probably at photosphere-corona boundary. Small leakage flux, however, is enough to potentially heat the corona.

High Speed Solar Wind Streams During the Declining Phase of the Solar Cycle: Resultant Geomagnetic Activity at Earth

B. T. Tsurutani

Jet Propulsion Laboratory, Calif. Inst. Tech., USA

Solar wind fast streams emanating from solar coronal holes cause recurrent, moderate intensity geomagnetic activity at Earth. Intense magnetic field regions called Corotating Interaction Regions or CIRs are created by the interaction of fast streams with upstream slow streams. Because of the highly oscillatory nature of the GSM magnetic field z component within CIRs, the resultant magnetic storms are typically only weak to moderate in intensity. CIR-generated magnetic storm main phases of intensity Dst $<$ -100 nT (major storms) are rare. The elongated storm "recovery" phases which are characterized by continuous AE activity that can last for up to 27 days (a solar rotation) are caused by nonlinear Alfven waves within the high streams proper. Magnetic reconnection associated with the southward (GSM) components of the Alfvén waves is the solar wind energy transfer mechanism. The acceleration of relativistic electrons occurs during these magnetic storm "recovery" phases. The magnetic reconnection associated with the Alfvén waves cause continuous, shallow injections of plasma sheet plasma into the magnetosphere. The asymmetric plasma is unstable to wave (chorus and other modes) growth, a feature central to many theories of electron acceleration. It is noted that the continuous AE activity is not a series of substorm expansion phases. Arguments are also presented why these AE activity intervals are not convection bays. The auroras during these continuous AE activity intervals are less intense than substorm auroras and are global (both dayside and nightside) in nature. Owing to the continuous nature of this activity, it is possible that there is greater average energy input into the magnetosphere/ionosphere system during far declining phases of the solar cycle compared with those during solar maximum. The discontinuities and magnetic decreases (MDs) associated with interplanetary Alfven waves may be important for geomagnetic activity. In conclusion, it will be shown that geomagnetic storms associated with high-speed streams/CIRs will have the same initial, main, and "recovery' phases as those associated with ICME-related magnetic storms but that the interplanetary causes are considerably different.

On the sources of the solar cycle variability

S. Turck-Chieze and the Saclay team

CEA/IRFU/SAp, CE saclay, 91191 Gif sur Yvette, France

The Sun is a magnetic star but its dynamical interior is still poorly known so the solar cycle variability is not yet totally understood. I shall mention first the theoretical progress we have done on the deep interior to better characterize the rotation of the core, the excitation of gravity waves, the deep magnetic field, the different ingredients of the dyamo processes which describe the eleven year solar cycles through 1D, 2D and 3D solar models. Such new efforts generate more questions than they solve others up to now. Consequently I shall summarize in the second part the new idea we are pushing near the space agencies to partly solve them and the instrumental development that we are realized (GOLF-NG observations) to improve our understanding of the long term Sun-Earth connection. I deduce a possible roadmap for the next decades.

Long-term trends in the upper atmosphere

T. Ulich[1], M. Clilverd[2], M. Jarvis[2], H. Rishbeth[3]

(1) Sodankylä Geophysical Observatory, Oulu unit, University of Oulu, Finland
(2) British Antarctic Survery, Cambridge, U.K.
(3) School of Physics and Astronomy, U of Southampton, Southampton, U.K.

About a solar cycle and a half ago it was suggested that while changes of the chemical composition of the lower atmosphere will lead to "global warming" in the troposphere, they will be accompanied by "global cooling" in the mesosphere and lower thermosphere. Since the 1930s, and most comprehensively since the IGY in 1957, the ionosphere has been monitored regularly by vertical ionospheric sounders (ionosondes). These radars make rather straightforward measurements of ionospheric properties and the results are readily available in electronic form.

Here we summarise some of the research on long-term trends in the ionosphere and we outline some of the difficulties in determining trends from historic geophysical long-term data sets.

Grand Minima and Maxima of Solar Activity on Multi-Millenial Time Scale

I.G. Usoskin[1], S.K. Solanki[2], G.A. Kovaltsov[3]

(1) Sodankyla Geophysical Observatory, Oulu unit, University of Oulu, Finland
(2) Max-Planck Institute for Solar System Research, Katlenburg-Lindau, Germany
(3) Ioffe Physical-Technical Institute, St. Petersburg, Russia

Using a reconstruction of sunspot numbers stretching over multiple millennia derived from 14C data, we analyze the statistics of the occurrence of grand minima and maxima. A list of grand minima and maxima of solar activity is presented for the Holocene (since 9400 BC) and the statistics of both the length of individual events as well as the waiting time between them are analyzed. We also discuss robustness of their definition is discussed. The occurrence of grand minima/maxima appears to be driven not by long-term cyclic variability, but rather by a stochastic/chaotic process. The waiting time distribution of the occurrence of grand minima/maxima deviates from an exponential distribution, implying that these events tend to cluster together with long event-free periods between the clusters. Two different types of grand minima are observed: short (30-90 years) minima of Maunder type and long (>110 years) minima of Spoerer type, implying that a deterministic behaviour of the dynamo during a grand minimum defines its length. The duration of grand maxima follows an exponential distribution, suggesting that the duration of a grand maximum is determined by a random process.

Solar activity, cosmic rays and cyclonic processes in the North Atlantic

S.V. Veretenenko, V.A. Dergachev, P.B. Dmitriyev

Ioffe Physico-Technical Institute RAS, St.Petersburg, Russia

Effects of solar activity and cosmic ray variations on cyclonic processes at extratropical latitudes in the North Atlantic are considered on different time scales. An intensification of cyclone deepening associated with energetic solar proton events is observed in the region of the Arctic frontal zone near the Greenland coasts. The long-term variations of cyclone tracks and of cyclogenesis intensity in the North Atlantic reveal the main period about 80 years that seems to be correlated with the secular variations of solar/geomagnetic activity and cosmic ray variations. The 22-yr periodicity found in geomagnetic activity and cosmic ray variations is observed in the cyclone track latitudes, being the most pronounced in the region of the Arctic frontal zone. The results obtained provide evidence of the changes of the thermo-baric field structure of the troposphere at middle and high latitudes associated with solar/geophysical factors and, in turn, influencing the development of cyclonic processes. The role of the frontal zones which are the regions of high temperature contrasts and the cyclogenetic areas is emphasized.

Southern Hemisphere subtropical stratospheric ozone depletion during the October-November 2003 solar extreme events

L. E. Antunes Vieira[1], L. Alves da Silva[2]

(1) Max-Planck-Institut fur Sonnensystemforschung, 37191 Katlenburg-Lindau, Germany
(2) Instituto Nacional de Pesquisas Espaciais, 12227-010 Sao Jose dos Campos, Brazil

Extreme solar events and their heliospheric consequences were observed on October-November 2003. Several physical processes of the Sun-Earth system, such as active region size and potential energy, total solar irradiance, flare occurrence rate and peak intensity, solar mass ejections speed and energy, shock occurrence rate, solar energetic particles occurrence rate and intensity, geomagnetic activity, and, changes in the middle and upper atmosphere composition, presented large departures from quiet conditions. However, most of the changes reported in the neutral atmosphere were restricted to high latitudes, in the auroral region. Here we show that significant ozone depletion in the Southern Hemisphere Stratosphere was observed near the region of the Southern Hemisphere Magnetic Anomaly after the beginning of the solar events increasing the longitudinal asymmetry of the ozone distribution. Furthermore, a reduction of the temperature was observed in the same region. We found that the southern hemisphere subtropical stratosphere is sensitive to extreme solar events in terms of atmospheric composition and thermal structure. The reduction of the ozone mixing ratio at 28 km from the ground near 40o E compared to 100o W was about 30% and the reduction of the temperature was about 5%. One source of the enhancement of the ionization of the neutral atmosphere in the magnetic anomaly during extreme solar activity conditions is the precipitation of high energy particles trapped in the Van Allen belt, which was dramatically compressed, distorted and enhanced during the Halloween events. Our results suggest that changes of the ozone distribution and thermal structure in the Southern Hemisphere during the last century could be related to changes of the geomagnetic field configuration, which increased the area affected by particle precipitation in the Southern Hemisphere as well as the increase of the solar activity. The effects of the zonal asymmetry in the ozone distribution on climate seem to have had important impacts on climate. Furthermore, changes in the lower atmosphere circulation and cloud patterns in the large area covered by the magnetic anomaly could be partially related to these changes of the geomagnetic field configuration.

Modeling 3D Atmospheric Ionization by Energetic Charged Particles

J. M. Wissing, M.B. Kallenrode

University of Osnabrueck, Germany

We present a 3D numerical model of atmospheric ionization due to precipitating particles with high spatial resolution for an atmosphere extending from ground up to 1.7×10^{-5} Pa, corresponding to an upper boundary between 250 to 600 km.

To our knowledge, this is the first high resolution 3D model covering such a large height range in a consistent manner.

The Atmospheric Ionization Model OSnabr"uck (AIMOS) consists of two parts: a GEANT4-based Monte Carlo simulation and a sorting algorithm to assign satellite observations to horizontal precipitation cells, depending on geomagnetic activity. We describe the parts of the model, in particular the calculation of the precipitation site depending on geomagnetic activity and local magnetic time. Extensive testing of both parts of the model is presented together with a comparison to earlier approaches on the simulation of atmospheric ionization due to precipitating particles. Implications of the model for the modeling of atmospheric chemistry and dynamics are also discussed.

Observational properties of sunspot and background magnetic fields during the solar cycle

V.V. Zharkova[1], S.I. Zharkov[1,2]

(1)Department of Mathematics, University of Bradford, U.K.
(2) Department of Applied Mathematics, University of Sheffield, U.K.

We provide a statistical analysis of long series of the solar magnetic field measurements in sunspots and solar background in the cycle 23 observed with SOHO/MDI and WSO instruments and the appearances of solar H-alpha flares. A correlation analysis is carried out of the selected datasets at different latitudes and longitudes. PCA approach is used to detect the major components of the magnetic field variations in time and latitude in the cycles 21-23. The analysis allowed us to establish the two characteristic periods in the magnetic field changes: a full cycle (11 years) and a quarter of it, which vary for different latitudes and solar cycles. Possible implications of the observed findings to the dynamo theories are discussed.

Long-term asymmetries in the butterfly diagrams

N. V. Zolotova[1], D. I. Ponyavin[1], N. Marwan[2], J. Kurths[2]

(1) Institute of Physics, Saint-Petersburg State University, Russia
(2) Potsdam Institute for Climate Impact Research, Germany

The Northern and Southern sunspot activities demonstrate striking synchronous behavior on the scale of a Schwabe cycle. However, sometimes bilateral symmetry of the Butterfly diagram relative to the solar equatorial plane fails. The investigation of this phenomenon is important to explain the non-periodical behavior of solar cycles. We use cross-recurrence plots for the study of the time-varying phase asymmetry of the northern and southern hemisphere and compare the results with the toroidal magnetic flux. We observe a long-term persistence in phase leading of one of the hemispheres, which probably corresponds to the Gleissberg cycle. Long-term variations of the hemispheric leading do not demonstrate clear periodicity but are strongly anti-correlated with the long-term variations of the area-weighted mean latitudes.

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POSTERS

Galactic cosmic ray variation influence on baric system dynamics at middle latitudes

I. V. Artamonova[1], S. V. Veretenenko[2]

(1) Saint-Petersburg State University, Russia
(2) Ioffe Physico-Technical Institute of the Russian Academy of Sciences, St. Petersburg, Russia

Variations of atmospheric pressure in the North Atlantic region during Forbush-decreases of galactic cosmic rays were investigated. A noticeable pressure growth with the maximum on the 4th day after the Forbush-decrease onsets was revealed over Scandinavia and the northern region of the European part of Russia. It was shown that the observed pressure growth was caused by the blocking anticyclone formation in the region of the climatic Arctic front, as well as by the sharp slowing of the movement of North-Atlantic cyclones in the eastern direction. It was suggested that the particles which precipitate in the climatic region of the Arctic (E $\approx$ 20 - 80 MeV) and Polar (E $\approx$ 2 - 3 GeV) fronts may be involved in the processes of cyclone and anticyclone formation and development.

Hemispheric and longitudinal asymmetries in CME occurrence

T. Asikainen(1), K. Mursula(1), E. Robbrecht(2), D. Berghmans(3)

(1)Department of Physical Sciences Centre of Excellence in Research, University of Oulu, Finland
(2)Naval Research Laboratory, Washington DC, USA
(3)Royal Observatory of Belgium

A considerable amount of evidence has accumulated in support of the existence of persistent, systematic north-south (hemispherical) and longitudinal (active longitudes) asymmetries in the Sun. These features have been observed, e.g., in sunspots, solar flares, solar wind and the heliospheric magnetic field. In this work we analyze the occurrence of Coronal Mass Ejections (CMEs) observed by the SOHO LASCO instrument during the solar cycle 23. We use the manually compiled LASCO CME catalog maintained at the CDAW Data Center and for comparison the CACTus CME catalog based on automatic detection of CMEs by the CACTus software developed at SIDC in the Royal Observatory of Belgium. We discuss the temporal evolution of the occurrence rate of CMEs and study the north-south and east-west asymmetries and their temporal change. We also present a preliminary analysis of CME occurrence in a rotating coordinate system. We discuss the observations in view of the earlier evidence for hemispherical asymmetries and active longitudes.

Calibrating the energetic particle measurements by NOAA/POES during three solar cycles

T. Asikainen, K. Mursula, V. Maliniemi

Department of Physical Sciences Centre of Excellence in Research, University of Oulu, Finland

Nearly all long-term studies of ring current have relied on the Dst/Dcx index as a proxy of ring current energy content. However, using the Dst/Dcx (or any other ground based index) inherently contains contributions from all other magnetospheric and ionospheric current systems as well, and thus does not truly represent the ring current intensity.

As a first step towards studying the long-term evolution of the ring current using satellite measurements, we have compiled an extensive database of energetic particle measurements by MEPED instrument onboard the low-altitude polar orbiting NOAA/POES satellites since 1978. These satellites have obtained nearly continuous measurements of energetic particle fluxes in the magnetosphere during three complete solar cycles. The most significant problem in using these data is that the solid state detectors of the MEPED are known to decay rather rapidly resulting in underestimated particle fluxes already couple of years after satellite launch. Before the MEPED data can reliably be used in any long term study the data has to be calibrated taking into account the decay of the detectors. In this paper we present a method for calibrating the measurements and show an estimate of energetic particle fluxes from 1978 to present.

The Effect of Severe Geomagnetic Storms on the Atmospheric Circulation in the Winter Northern Hemisphere

J. Bochnicek[1], H. Davidkovova[1], P. Hejda[1], R. Huth[2]

(1) Institute of Geophysics, Prague, Czech Republic
(2) Institute of Atmospheric Physics, Prague, Czech Republic

Our previous results have shown that after the severe storm onset, deepening of the Icelandic Low and intensification of the stratospheric polar vortex occur, followed by an increasing daily NAO index about 5 days after the storm's onset in the majority of cases. The aim of this study is to prove our previous results on an extended data set. For this purpose, temperature and geopotential height fields at 20 hPa and 500 hPa and daily NAO index were investigated during severe geomagnetic storms (Ap $>$ 60) in winter months (December-March) of 1955-2003. The results indicate that the impact of geomagnetic storms is modulated by the solar activity, phase of quasibiennial oscillation, and internal atmospheric processes such as stratospheric warmings, causing the breakdown of the stratospheric polar vortex or tropospheric blocking events over western Europe, which suppress the impact of stratospheric polar vortex on the dynamical processes in the troposphere.

Topology of the Heliospheric Current Sheet from Magnetic Synoptic Charts and Spacecrafts Observations

A. Budnik, D. Ponyavin

St. Petersburg State University, Institute of Physics, Russia

We have reconstructed the topology of the heliospheric current sheet (HCS) using synoptic charts for periods of maximum and minimum of solar activity. For this task we have developed a kinematic model that takes into account such factors as solar differential rotation and magnetic field evolution on the source surface. Special attention is devoted to limitations and artifacts of this approach. A set of verification tests based on mapping back technology using ACE and Ulysses data proved that this approach works fine for near-ecliptic plane up to heliocentric distances of 3-4 AU. Moreover the results show that we can neglect solar wind acceleration factor for HCS reconstruction problem as it gives a trifling impact. The statistics has been collected for two satellites (ACE and Ulysses) for each Carrington rotation for the period of 10 years. Verification has revealed a number of drawbacks that come from source surface models, used in the Wilcox Solar Observatory: 1) they underestimate the neutral line shift towards polar area 2) the error of mapping back grows with distance from Sun to spacecraft because of inability of synoptic charts to reflect the real magnetic field dynamics. To increase success rate of the model we have attempted to create TEF (Transient Event Filter). Though this part requires still needs much to be done it has already given some promising results.

Statistical study of halo CMEs and their influence on the Earth magnetic field

I. Chifu[1], M. Mierla[1,2], L. Rodriguez[2]

(1) Astronomical Institut of Romanian Academy, Bucharest, Romania
(2) Royal Observatory of Belgium, Brussels, Belgium

Most of the halo coronal mass ejections (HCMEs) which are directed towards the Earth are responsible for major disturbances of the geomagnetic field. In order to see what are the conditions for a HCME to produce a geomagnetic storm we analysed the frontsided HCMEs between 1996 and 2008. We followed these HCMEs from the solar disk into the interplanetary space to the Earth. We analysed the correlations between the parameters characterizing the total and partial HCMEs, the ICMEs and the geomagnetic storms.

Past and future sunspot indices: new goals for SOTERIA

F. Clette

SIDC - Observatoire Royal de Belgique, Belgium

The recent developments of Earth climate models and solar dynamo theories have brought new needs in terms of long-term direct solar activity indices. Sunspot drawings and images are the base observational material at our disposal to derive more detailed information than the classical total sunspot index R_i over long durations. In the context of the new SOTERIA FP7 project, the SIDC–WDC Sunspot will pursue two complementary goals addressing those emerging needs. We will develop tools to digitize and encode the full and mostly unexploited information recorded in sunspot drawing collections, applying them first to the entire drawing series from the Uccle station (ROB, Brussels). Turning towards the future, we will define and evaluate possible global activity indices based on full-disk sunspot CCD imagery. Here, we describe the main steps of this work and the available data sets. We also outline the prospects and resulting products in the 3-year framework of the SOTERIA project and beyond.

Space Weather Effects due to Energetic Particles

N. B. Crosby

Belgian Institute for Space Aeronomy, Avenue Circulaire 3, 1180 Brussels, Belgium

Compared to the time-scales considered in space climate studies, space weather studies cover much shorter periods of time (minutes to years). In simple terms space weather can be defined as how solar activity may have unwanted effects on technological systems and human activity. Indeed spacecraft have to survive very hostile environments which can severely limit space missions as well as pose threats to humans. Phenomena such as UV, X- and gamma-radiation, energetic charged particles, plasmas, as well as space debris and meteoroids, must all be taken into consideration when going to space. In this presentation the various populations of energetic particles in the energy range from eV to more than 10^21 eV that fill our solar system are considered. The most energetic among them are the constant flux of galactic cosmic rays and the sporadic solar energetic particle events. Earth's radiation belts, principally composed of naturally occurring energetic charged particles trapped in Earth´s inner magnetosphere, must also be considered for missions to space. Space weather effects due to energetic particles include radiation damage to on-board electronics, electrical discharges, and some biological effects. An introduction to these effects in regard to spacecraft, aircraft, and human health will be given. In parallel procedures to mitigate against these effects will be described.

Visualization of distributed solar data and metadata with the Solar Weather Browser

E. D'Huys[1], B. Nicula[1], C. Marqué[1], D. Berghmans[1]

Royal Observatory of Belgium, The Solar Influences Data analysis Center (SIDC), Belgium

The Solar Weather Browser (SWB) is an open-source software tool designed to display solar images with context overlays. It was originally developed for the space weather forecast activities of the Solar Influence Data analysis Center (SIDC), but it is more generally well suited to display the output of solar feature recognition methods. The SWB is also useful in the context of distributed solar image archives, where it could play the role of a quick-look viewer. The SWB allows the user to visually browse large solar data sets and investigate the solar activity for any given date or a longer time period like the solar cycle. The client is readily available for Linux, Mac OS X and Windows at http://sidc.be/SWB.

Sunspot tilt angle dependence on solar cycle

M. Dasi[1], S.K. Solanki[1], N.A. Krivova[1], R. Cameron[1], T.M. Penuela[1,2]

(1) Max-Planck Institute for Solar System Research, Germany
(2) University of St. Petersburg, Russia

It is well known that the tilt angles of active regions increase with their latitude (Joy's Law). It has never been checked before, however, whether the average tilt angles change from one cycle to another. We use Mount Wilson and Kodaikanal sunspot data covering cycles 15-21 in order to study the variation of tilt angles with time. Since stronger cycles have sunspots on average at higher latitudes, Joy's law would suggest larger tilt angles during stronger cycles. In contrast, we find an anti-correlation between the mean tilt angle and the cycle strength, which becomes even stronger after taking Joy's law into account. We also find a strong correlation between the maximum smoothed tilt angle weighted by the area and latitudes of sunspots and the amplitude of the next solar cycle. It appears that tilt angles play an important role in the built up of magnetic field for the following cycle, which has important implications for prediction of future solar activity.

The Possible Effect of Geomagnetic Activity on Stratospheric Major Mid-Winter Warmings: a Case Study

H. Davidkovova[1], J. Bochnicek[1], P. Hejda[1], R. Huth[2]

(1) Institute of Geophysics, Prague, Czech Republic
(2) Institute of Atmospheric Physics, Prague, Czech Republic

Our studies (Bochnicek and Hejda 2002, 2005) have shown that increased geomagnetic activity causes the deepening of the Icelandic Low and, according to Arnold and Robinson (2001), also cooling of the winter polar lower stratosphere. As a result of such cooling the polar vortex becomes steady and strong. These points were taken into account to investigate the possible effect of geomagnetic activity on stratospheric warmings. Major Mid-Winter Warming of the north polar region is defined as the situation when the westerlies in the Arctic are replaced by easterlies so that the centre of polar vortex moves south of 60-65^{0}N. This process is also connected with the reversal of the meridional temperature gradient. Stratospheric and tropospheric temperature and pressure fields behaviour was analysed in the winter months (December-February) of 1966-2002, in which Major Warmings occurred. The results indicate that the increased geomagnetic activity stabilizes the tropospheric low over the Atlantic sector. This effect was observed also in stratosphere where, in preference, the polar vortex splitting occurred.

Joint analysis of a set of data on variations in cosmic ray fluxes, solar activity, geomagnetic field, and climate variability from the Present to the Quaternary

V.A. Dergachev[1], P.B. Dmitriyev[1], O.M. Raspopov[2], S.S. Vasiliev[1], **H. Jungner**[3]

(1)Ioffe Physico-Technical Institute, Russian Academy of Sciences, Russia
(2)Institute of Terrestrial Magnetism, Ionosphere, and Radiowave Propagation, St. Petersburg Branch, Russian Academy of Sciences, Russia
(3)University of Helsinki, Finland

The effect of the external factors on long-term climate changes has become a very actual problem. This is related to the fact that the global temperature almost monotonically increased during the last century. The physical causes of this warming are now intensely discussed. It is unclear whether this effect is caused by the natural climate variability or by the anthropogenic impact. A joint analysis of a set of paleodata on variations in cosmic ray fluxes, solar activity, geomagnetic field, and climate during the period from the Present to the Quaternary has been performed. Data on the time variations in the concentration of 14C and 10Be cosmogenic isotopes, which are generated in the Earth's atmosphere under the action of cosmic ray fluxes modulated by solar activity and geomagnetic field variations, were used to detect variations in solar activity and the geomagnetic dipole. Information about climate changes has been obtained mainly from variations in the concentration of stable isotopes in the natural archives. As was established the direct relation exists between long-term variations in cosmic ray intensity and the Earth surface temperature. A performed analysis indicates that the variations in cosmic ray fluxes under the action of variations in the geomagnetic field and solar activity are apparently one of the most effective natural factors of long-term climate changeability on a large time scale.

On the response of the European climate to the solar/geomagnetic long-term activity

V. Dobrica, C. Demetrescu, G. Maris

Institute of Geodynamics, Bucharest, Romania, venera@geodin.ro

The response of the European climate to the solar/geomagnetic activity is investigated by using surface air temperature and solar/geomagnetic indices. A set of 24 time series of air temperature measured at European stations between 1900 and 2006, and 4 European and 14 Romanian stations with 150 year long records, has been processed to show solar/geomagnetic activity signatures at decadal and centennial timescales. The time series were filtered by means of 11- and 22-year running averages and the corresponding variations were compared to solar/geomagnetic variability. A cross-correlation analysis on temperature and solar/geomagnetic 22-year variations shows that the temperature lags behind the solar and geomagnetic activities by about 5-9 years. Results show a similar temporal behaviour at all analysed stations with amplitude differences that can be understood in terms of large-scale atmospheric circulation patterns influenced by the solar/geomagnetic forcing at the corresponding timescales, but with local intensity differences.

Galactic Cosmic Rays, Ocean Conveyor Belt, Regional Climate and Polar Temperatures

C. A. Perry[1], **G. Dreschhoff**[2]

(1) U.S. Geological Survey, 4821 Quail Crest Place, Lawrence, KS 66049, USA
(2) University of Kansas Department of Physics and Astronomy, Lawrence, KS 66045, USA

The effect of solar variability on regional climate is examined using a sequence of physical connections between total solar irradiance (TSI) modulated by galactic cosmic rays (GCRs), and ocean and atmospheric patterns that affect regional precipitation and temperature. The amount of solar energy reaching the EarthÂ´s surface and its oceans is thought to be controlled through an interaction between GCRs, which are theorized to ionize the atmosphere and increase cloud formation, and TSI. High (low) GCR flux may promote cloudiness (clear skies) and higher (lower) albedo at the same time that TSI is lowest (highest) in the solar cycle which in combination creates cooler (warmer) ocean temperature anomalies. These anomalies have been shown to affect atmospheric flow patterns, temperature and precipitation, and ultimately runoff in the Mississippi River Basin. The geomagnetic index aa (GI-AA) is used as a proxy for GCRs. There appears to be a solar "fingerprint" that can be seen in climatic time series in various regions of the world, with each series having a unique lag time between the solar signal and the climatic response. A progression of increasing lag times, beginning with the Indian Monsoon can be spatially linked to the ocean conveyor belt, which transports the solar signal around the world. The lag times for anyone region vary slightly and may be linked to the fluctuations in the velocity of the ocean conveyor belt.

Analysis of TRACE Flare Kernels Using Diffraction Affected Observations

S. Gburek, J. Sylwester, M. Siarkowski, B. Sylwester, A. Kepa, M. Kowalinski

Space Research Centre, Polish Academy of Sciences, Solar Physics Division, Kopernika 11, 51-622 Wroclaw, Poland

TRACE images of stronger flares observed in the extreme ultraviolet (EUV) energy band are usually affected by pronounced diffraction effects and saturation. The diffraction comes from a dense nickel mesh which supports the three TRACE EUV filters. TRACE EUV measurements cover wavelength bands roughly centred at 171, 195 and 284 Angstroms. It is shown that observed diffraction effects can be quantitatively modelled in terms of the TRACE point spread function (PSF). Such a PSF model can next be used to unveil the actual shape of flare kernels and provide a way to derive physical parameters of the EUV source such as the temperature and emission measure. This kind of analysis is available even from a single TRACE image and even in case the image is saturated. We present results of the diffraction effects analysis for a number of selected flare kernels observed in TRACE images.

The mid-term periodicities of sunspot area fluctuations

R. Getko

Astronomical Institute of Wroclaw University, Poland

A statistical study of the sunspot area fluctuations over the epoch of 12 solar cycles (12-23) is presented. Because the variance of fluctuations is time-dependent, the transformations of fluctuations with a constant variance for the northern and the southern hemispheres of the Sun are considered. The autocorrelation functions of both the new time series are different during the high- and the low-activity periods. The asymmetry of the fluctuation probability distribution indicates that the positive and the negative fluctuations should be analysed separately. The autocorrelation analysis of all fluctuations (the original, the positive and the negative fluctuations) prefers three quasi-periods: around 10, 17 and 23 rotations. Two shorter ones mainly exist during high-activity periods, the third one exists during the whole solar cycles. The wavelet maps of all fluctuations and their transformations show one dominant quasi-period at about 10 rotations. It is mainly detected during the high-activity periods, but there are small fluctuations with this quasi-period during a few low-activity periods.

On the rigidity spectrum of the 27-day variation of the galactic cosmic ray intensity in different epochs of solar activity

A. Gil[1], M.V. Alania[1,2]

(1) Institute of Math. And Physics of University of Podlasie, 3 Maja 54, 08-110 Siedlce, Poland
(2) Institute of Geophysics, Georgian Academy of Sciences, Tbilisi, Georgia

We study peculiarities of the rigidity spectrum of the 27-day variation of the galactic cosmic ray (GCR) intensity for different periods of solar activity. We found that the power rigidity spectrum of the 27-day variation of the GCR intensity is harder in the maximum epochs and softer in the minimum and near the minimum epochs in contrary to the rigidity spectrum for the 11-year variation of the GCR intensity; it seems that different processes should be responsible for the formation of the rigidity spectra of the 11-year and the 27-day variations of the galactic cosmic rays intensity. We discuss our findings within the framework of our present understanding of this phenomenon.

Comparison of different methods of tail magnetic flux calculation.

E. Gordeev[1], M. Shukhtina[1], V. Sergeev[1], A. DeJong[2]

(1)Institute of Physics, SPbU, St.Petersburg, Russia
(2)Department Atmospheric Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI, USA

One of the basic parameters, characterizing the state and dynamics of the Earth magnetosphere, is the magnetotail magnetic flux F. However, until recently only rare estimates of the F value were available. Petrinec and Russell (1996) proposed a method of magnetic flux calculation, based on measured tail lobe magnetic field and the magnetotail radius R value as well as solar wind dynamic pressure and IMF Bz. However, the same solar wind conditions may result in different magnetospheric states and, so, in different R values. We propose an alternative method of R calculation based on instantaneous pressure balance at the magnetopause. Recently global MHD modelling of magnetosphere became possible. It gives the opportunity to determine the magnetopause position (i.e. the R value), the tail magnetic field and, finally, the magnetotail magnetic flux. In the present study we compute magnetic flux for several simulated events. To determine the magnetopause, we compare three different methods, based on: 1) density gradient, 2) current density peak, and 3) fluopause, which is the surface of the boundary solar wind streamlines. All three methods demonstrate a good mutual agreement. Several simulated events (including substorms) are compared using MHD modelling and our empirical method. The results of two methods reasonably agree. Polar cap images from Polar and IMAGE spacecraft allow determine the polar cap area, i.e. the polar cap magnetic flux. The F value, obtained from polar cap images in several events (including steady magnetospheric convection, substorms and sawtooth events), are compared with our prediction and show similar behaviour, though the values may differ. In conclusion, all three methods demonstrate comparable results. It opens the opportunity of using these methods to monitor the tail magnetic flux on the regular basis, which is important for monitoring of the magnetosphere.

Increased local time accuracy of the corrected Dst index

K. Mursula(1), **L. Holappa(1)**, V. Jordanova(2)

(1) Department of Physical Sciences, University of Oulu, Finland e-mail: kalevi.mursula@oulu.fi
(2) LOS ALAMOS National Lab, NM, USA

The Dst index is one of the most used geomagnetic indices which has been constructed to monitor the most dramatic events in the near-Earth space, the geomagnetic storms. However, it has been known for some time that the Dst index includes random and systematic errors, e.g., an excessive, seasonally varying quiet-time level, the so called "non-storm component" which is unrelated to the intensity of the ring current or magnetic storms. Therefore, we have developed a corrected and extended version of the Dst index, the so called Dcx index which exists now in 1932-2007. So far, the Dcx index, in analogy with the Dst index, is based only on four stations, roughly evenly distributed over the longitude. Such a coarse longitudinal accuracy does not allow for a detailed study of the local time structure of global disturbances during storms, in particular the current systems like the symmetric and asymmetric ring current or the tail current. Here we reconstruct, based on the corrected method implemented in the Dcx index, a longitudinally enhanced index called the Dcx16 index, which is based on the data from 16 low and mid-latitude stations. We study the detailed local time structure of storm-time disturbances and calculate the maximum momentary asymmetry in the disturbance level. We compare our results with similar results based on the four stations and the conventional Dst index during recent years. We also compare the local time properties during storms driven by high speed streams and coronal mass ejcetions.

A comparison of geomagnetic and solar effects on tropospheric circulation in the Northern Hemisphere in winter

R. Huth[1], L. Pokorná¡[1], J. Kyselý[1], J. Bochnicek[2]

(1) Institute of Atmospheric Physics, Prague, Czech Republic
(2) Institute of Geophysics, Prague, Czech Republic

Our recent results indicate, among others, significant effects of the phase of the 11-yr solar cycle on (i) the shapes, spatial extent, and intensity of modes of low-frequency variability of atmospheric circulation (also called "teleconnections") in the Northern Hemisphere and (ii) frequency of synoptic types after Hess and Brezowsky over Europe, both in winter. Here we extend the analysis to the geomagnetic activity, and compare the results with the solar activity. The winter months and 10-day periods are stratified by the geomagnetic activity into three classes, low, moderate, and high. The variability modes are determined in the 500 hPa geopotential height field by rotated principal component analysis separately in each class of geomagnetic activity. The effects of geomagnetic activity differ from those of solar activity in that they tend to be weaker and a high geomagnetic activity is usually not connected with a tendency to zonalization of the modes. Short-term geomagnetic effects (10-day means) are weaker than the effects on a monthly time scale, and the effects lagged by five days are weaker than the simultaneous effects. The separate analysis conducted for three classes of solar activity, but only for days with a quiet or unsettled geomagnetic field, suggests that most of the solar effects on tropospheric circulation are direct, that is, not mediated through geomagnetic activity.

Latitudinal characteristics of sunspot generating zone

V.G. Ivanov, E.V. Miletsky

Central astronomical observatory at Pulkovo of RAS, Russia

In the report we investigate links between the power of solar activity and the space distribution of its manifestations.

We demonstrate that the latitudinal width of the sunspot generating zone is closely related to the magnitude of the solar activity. We show that for the average density of sunspot latitudinal distribution, which is determined as a ratio of the sunspot activity level to the width of the corresponding zone, a certain threshold exists, which is reached at some level of the activity. After reaching of this threshold further increasing of the activity continues only due to expanding of the sunspot generating zone. In all explored sunspot cycles (Nos. 12-23) the density of sunspot distribution reached this threshold and, therefore, does not depend upon amplitudes of the cycles.

We investigate a characteristic related to the sunspot latitude distribution that in a certain moment - usually in the fourth year after the maximum of the current solar cycle - shows a high correlation with the amplitude of the next cycle. On the base of this regularity we make a forecast of the next cycle amplitude, according to which the 24th cycle will be 20-30% as high as the 23rd one.

Reconstruction of the Maunder butterfly diagram in XVIII-XIX centuries

V.G. Ivanov[1], E.V. Miletsky[2], Yu.A. Nagovitsyn[3]

Central astronomical observatory at Pulkovo of RAS, Russia

In the report we show that such parameters of the latitudinal distribution of sunspots as the average latitude and a typical width of the sunspot generating zone can be reconstructed on the base of information about solar activity level, in particular - on the Group Sunspot Number index (GSN). Using GSN index by Hoyt and Schatten we make a reconstruction of the time-latitude distribution of sunspot groups (the Maunder butterfly diagram) for 18th and the first half of the 19th centuries.

Key parameters of the Space Climate over different time scales: data and conclusions

Yu.A. Nagovitsyn, **V.G. Ivanov**, E.V. Miletsky

Central astronomical observatory at Pulkovo of RAS, Russia

A multi-scale approach to reconstruction of key parameters describing long-term behaviour of the Space Weather (the Space Climate) is presented. Its central purposes are the following:
- Reconstructing the solar activity, geomagnetic parameters and the interplanetary magnetic field, we select successively increasing time scales, which naturally follow from capabilities of the available observational data. Altogether the four scales are selected: 150-200 years, 400 years, 1000 years and 10000 years.
- In construction of the time series on each subsequent time scale the data of the previous scale are used as a base.
- If possible, we turn from time series of traditional (statistical) indices to series of physical parameters.
- Deriving relations between parameters of the solar activity, geomagnetic disturbances level and interplanetary magnetic field, we take into account differential character of links on different time scales, using the MSR and DPS methods proposed earlier (Nagovitsyn Yu.A. et al, Solar Phys., 224, 2004; Nagovitsyn Yu.A. Astron. Lett., v.31, 2005).
- For verification of the obtained reconstructions we apply "the principle of witnesses", which uses independent (sometimes indirect) data as initial points.
Following the consideration stated above, we have produced new long-term series of different indices (parameters of the Space Climate) such as: a) the absolute total sun-spot magnetic flux, b) the open magnetic flux, c) the dipole-octupole (A-) index of the solar large-scale magnetic field, d) the IDV index of geomagnetic activity, e) the aa-index of geomagnetic activity, f) the interplanetary magnetic field strength. Besides, series describing both the polar magnetic field of the Sun and the north-south asymmetry of the solar activity are purposed. We discuss application of the obtained reconstructions to solution of some problems of solar-terrestrial physics. In particular, we consider possible contributions of the solar activity to global climate changes. We show that this contribution is probably small for typical times of 11-years cycle and strongly grows (up to 50 percent of the complete variation) for time scales about 100-200 years.

Variations in tree ring stable isotope records from northern Finland and their connection to solar activity.

M. Ogurtsov[1], E. Sonninen[2], V. Dergachev[1], I. Koudriavtsev[1], E. Hilasvuori[2], M. Oinonen[2], **H. Jungner**[2]

(1) Ioffe Physico-Technical Institute, St Petersburg, Russia
(2) Radiocarbon Dating Laboratory, University of Helsinki, Finland

Within a project on climate in Europe during the past few hundred years we have collected a record on stable isotopes, carbon, oxygen and hydrogen in tree ring cellulose from Pine trees in Northern Finland. The records cover 400 years for carbon and oxygen with an annual time resolution. The carbon stable isotope record from northernmost Finland correlates quite strongly with local growth period temperature. Fourier analysis on the carbon and oxygen records reveals variations in the periods around 100, 10 and 3 years. Wavelet spectra show that the intensity of these periods varies during the 400 years studied. In the carbon record the 10 year period is strongest in the first half of the 18th century and in the oxygen record the 100 year period is most pronounced in the 17th century and the last half of the 20th century. The linear correlation between the decadal scale carbon isotope record and the solar Schwabe cycle is weak varying over the studied period. A centennial scale climate-solar connection is more evident. These results based on stable isotope records support previous similar results based on tree ring width from the region.

Analysis of a Strong Flare Observed by RESIK Soft X-ray Bragg Spectrometer.

A. Kepa, B. Sylwester, J. Sylwester, M. Siarkowski, S. Gburek, M. Kowalinski

Space Research Centre, Polish Academy of Sciences, Solar Physics Division, Kopernika 11, 51-622 Wroclaw, Poland

We analysed the X-ray spectra obtained for X1.5 GOES class flare which occurred on 30 August 2002 at 13:35 UT (the soft X-ray maximum). This event was well observed by the Polish spectrometer RESIK. Our instrument was recording spectra in the spectral range 3.3 Å- 6.1 Å, where strong emission lines of H- and He-like ions of Si, S, Ar, and K are present. Based on the analysis of selected absolute line fluxes it has been possible to investigate the important thermodynamic parameters of flaring plasma like temperature and emission measure. In the context analysis of coronal morphology concerning this event the TRACE and RHESSI images have been used also.

Activity signatures in stars and the Sun

H. Korhonen[1], S. Jarvinen[1], K. Olah[3], Z. Kollath[3]

(1) ESO, Karl-Schwarzschild-Str. 2, D-85748 Garching bei Muenchen, Germany
(2) AIP, An der Sternwarte 16, D-14882 Potsdam, Germany
(3) Konkoly Observatory of the Hungarian Academy of Sciences, H-1525 Budapest, Hungary

Starspots and their cyclic behaviour are the most prominent signs of magnetic activity seen in stars. In rapidly rotating active stars the spot configuration can be studied with great spatial resolution using high resolution spectroscopy and Doppler imaging techniques. Even though these methods show the stellar surface structures in unprecedented detail, they do not yet provide decades long time series for studying activity cycles. This information is still best obtained from photometric observations. In this work we compare the activity cycles and detailed spot configurations on active stars and the Sun. We investigate the different activity cycles seen in stars using decades long time series of photometric observations, and compare the results to the behaviour seen in the Sun. We also present detailed surface temperature maps of two young solar analogues, EK Dra and V889 Her, for several different epochs, and investigate the changing spot configurations during the photometrically detected activity cycle. Thus, studying the activity cycles that the young Sun could have had.

A statistical analysis of measured UV spectral irradiance variations

M. Kretzschmar[1], I. Ermolli[2], T. Dudok de Wit[1]

(1) LPC2E / CNRS / Universite d Orleans, UMR 6115, Orleans, France
(2) Osservatorio Astronomico di Roma - INAF, Monte Porzio Catone, Italy

The Solar irradiance spectrum varies accordingly to the magnetic activity of the Sun. However, since the spectral irradiance depends on the formation height, temperature, and the detailed physical processes leading to the emission, its variations differ when observed at different spectral and temporal ranges. In this work, we present the results obtained by applying a Principal Component Analysis to the UV irradiance data provided by the experiment SOLSTICE on board of UARS (from 1991 to 2001) and of SORCE (from 2003- to present). We show relevant temporal behaviours and investigate how different spectral ranges relate to them. We also discuss the influence of solar activity on the results over the cycle and the con sequences for empirical modelling of irradiance variation.

The number of spotless days as a predictive parameter

J. Murakozy, **A. Ludmany**

Heliophysical Observatory, H-4010 Debrecen P.O.Box 30, Hungary

Possible connections have been examined between the number of spotless days in activity minima and the height of the consecutive activity maxima. Similar earlier works were based on the Wolf number, whereas the present work used the Greenwich Photoheliographic Results (GPR) an the Debrecen Photoeliographic Data (DPD) in order to separate the northern and southern hemispheres. The relation is basically similar to those found earlier but it is more expressed in the northern hemisphere. Some considerations are presented about this asymmetry.

Search for active solar longitudes with hemispheric distinction

N. Gyenge, **A. Ludmany**

Heliophysical Observatory, H-4010 Debrecen P.O.Box 30, Hungary

Longitudes of enhanced activity have been studied in the years 1986-2002 on the basis of the Debrecen Photoheliographic Data (DPD). The northern and southern hemispheres have been separated by assuming that the two toruses might be independent in yielding flux emergence. We also assumed that the active longitudes can be found in a frame connected to the toruses, whose angular velocity differs from that of the Carrington system. Preliminary results of frequency analysis as well as longitudinal distributions of active regions will be presented for both hemispheres.

Maxwellâ's equations for the irregular heliolongitudinal solar wind velocity and consequences for galactic cosmic ray intensity variations

R. Modzelewska[1], A. Wawrzynczak[3], M.V. Alania[1,2]

(1) Institute of Mathematics and Physics, University of Podlasie, 3 Maja 54, 08-110 Siedlce, Poland
(2) Institute of Geophysics, Georgian Academy of Sciences, Tbilisi, Georgia
(3) Institute of Computer Science of University of Podlasie, Sienkiewicza 51, 08-110 Siedlce, Poland

We develop three dimensional (3-D) models of the Forbush decrease and 27-day variation of the galactic cosmic ray (GCR) intensity taking into account the azimuthally dependence of the solar wind velocity. We show that the proposed models of the 27-day variation and the Forbush decrease of the GCR intensity including the solutions of Maxwell's equations for changeable solar wind velocity are more realistic and compatible with the experimental data.

Towards better Constrained Solar Dynamo Models

A. Munoz-Jaramillo[1], D. Nandi[2], P. C. H. Martens[3]

(1) Montana State University, USA
(2) Indian Institute of Science Education and Research-Kolkata, India
(3) Harvard-Smithsonian Center for Astrophysics, USA

The best tool we have for understanding long-term solar variability is the kinematic dynamo model. During the last decade this type of models has seen a continuous evolution and has become increasingly successful at reproducing solar cycle characteristics. However, some of the dynamo ingredients are still poorly constrained and are generally manipulated to yield the best possible solutions. Here we show the results of our effort to better constrain two of this ingredients: The internal velocity field (meridional flow and differential rotation) and the turbulent diffusivity. To accomplish this goal, we use the latest results in helioseismology for the velocity fields and apply mixing length theory to the Solar Model S in combination of magnetic quenching for the turbulent diffusivity.

What is the best method to calculate the solar wind propagation delay?

C. Munteanu[1], B. Mailyan[2], S. Haaland[3,4]

(1) Alexandru Ioan Cuza University, Iasi, Romania
(2) Yerevan State University, Armenia
(3) University of Bergen, Norway
(4) Max-Planck Institute for Solar Systems, Germany

We present a statistical study of propagation times of solar wind discontinuities between Advanced Composition Explorer (ACE) spacecraft orbiting the L1 libration point and the Cluster quartet of spacecraft near the Earth's magnetopause. The propagation times for almost 200 events are compared with the predicted times from four different models. The simplest model assumes a constant convective motion of solar wind disturbances along the Sun-Earth line, whereas more sophisticated models take the orientation of the discontinuity as well as the real positions of the solar wind monitor and target into account. The results show that taking orientation and real position of the solar wind monitor and target into account gives a more precise time delay estimation in most cases. In particular, we show that recent modifications to the minimum variance technique can improve the estimation of propagation times of solar wind discontinuities.

Common oscillatory modes in solar/geomagnetic activity and climate variability and their relations

M. Palus[1], **D. Novotna**[2]

(1) Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague, Czech Republic
(2) Institute of Atmospheric Physics, Academy of Science, Prague, Czech Republic

Common oscillatory modes were detected in monthly time series of geomagnetic activity aa index, NAO index and surface temperature from several mid-latitude European locations. Instantaneous phases of the modes underwent synchronization analysis and their statistically significant phase coherence has been observed.

Acceleration and heating of the solar wind

L. Ofman[1,2]

(1) Catholic University of America and NASA Goddard Space Flight Center, Greenbelt, Maryland, USA
(2) Department of Geophysics, Tel Aviv University, Israel

The fast and slow solar wind play a major role in shaping the space climate and the interplanetary plasma conditions. However, the exact mechanism of solar wind acceleration and heating has not been established so far. Observations suggest that the fast solar wind is fundamentally different than the slow solar wind. I will discuss the possible role of waves in the acceleration and heating of the solar wind, and the observational evidence in support of this mechanism. I will present the results of multi-fluid models with Alfvén wave driven wind, as well as the results of hybrid kinetic models of solar wind heating by ion-cyclotron waves, and by magnetosonic instability due to relative drift between protons and helium ions. I will discuss future observations that could be carried out by the Solar Probe+ mission to establish the solar wind heating and acceleration mechanism.

Solar variability induced in a dynamo code by realistic meridional flux variations

I. Lopes[1,2], **D. Passos**[2]

(1) Physics Department, University of Evora, Colegio Antonio Luis Verney, 7002-554 Evora, Portugal
(2) CENTRA, Multidisciplinary Centre for Astrophysics, Physics Department Instituto Superior Tecnico - IST Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal

We build a proxy for the solar magnetic toroidal field using the sunspot number. After building the phase space of this proxy, we combine it with an expression for the time evolution of the toroidal field that we derived from a simplified dynamo model. Afterwards we fit the phase space to the theoretical expression allowing us to infer variations in the meridional circulation, assuming an advective scenario for the dynamo process. This meridional flux variations are then fed into a computational dynamo model and we construct a sunspot like time series that acts as proxy for solar activity. Finally we study the correlation between the reconstructed and observable data. The large correlation coefficients found indicate that meridional circulation has a strong role in the modulation of solar variability.

Common trends and common cycles in sunspot and geomagnetic proxies of the solar activity

D. Ponyavin

Institute of Physics, St.Petersburg State University, 198504, Russia

Sunspots and geomagnetic activity due to their different nature do not exhibit synchronous changes on the short time scale. As at the longer time scale, sunspot and geomagnetic time-series demonstrate a common behaviour. We analyse similarities and differences between sunspot and geomagnetic variations in order to find common trends and common cycles on interannual scale. Current and future solar activity using predictive schemes based on geomagnetic proxies are presented and discussed.

Diagnostics of relationship between solar and geomagnetic activity dynamics by symbolic analysis

O.L. Oposhnyan[1], **D.I. Ponyavin**[1], N.G. Makarenko[2]

(1) Institute of Physics, St.Petersburg State University, Russia
(2) GAO RAN, Pulkovo, St.Petersburg, Russia

The symbolic approach for detecting of relationship between time series was applied to the solar and geomagnetic databases. The idea consists in the transformation of time series in the symbolic form when using strict ordering between sequent records. The major advantage is that it can be directly admit errors inherent in observations but saving ordering relationship. The symbolic technique allows us to detect the relationship between coupled dynamical systems, to estimate the strength of coupling and to compare of time series according to their semantic complexity. Based on the symbolic technique we have estimated the coupling between sunspot numbers and geomagnetic indices on different time scale and delay. The results are presented and discussed.

Cosmic Rays and their effects on the low atmosphere processes and cloudiness (on Memory and the 75th Anniversary of Prof. M.I.Pudovkin)

O.M. Raspopov[1], S.V. Veretenenko[2]

(1)St.-Petersburg Branch (Filial) of Pushkov Institute of Terrestrial Magnetism, Ionosphere, and Radiowave Propagation of RAS, St.Petersburg, Russia, oleg@or6074.spb.edu
(2)Ioffe Physico-Technical Institute of RAS, St.-Petersburg, Russia, SvetaVeretenenko@mail.ru

A review of the data obtained by Prof. M.I.Pudovkin, his associates and followers on the problem of the influence of solar activity on atmospheric processes and climate change are presented. Later research activities in this field are described. Attention is drawn to the necessity to include into consideration the atmospheric circulation when analysing the formation of the global pattern of the atmosphere-ocean system response to solar forcing.

The effects of 2003 SPE in the middle atmosphere simulated with chemistry-ionosphere-climate model SOCOL-i

T. Egorova[1], **E. Rozanov**[1,2], W. Schmutz[1], Y. Ozolin[3], M. Calisto[2], T. Peter[2]

(1) Physical-Meteorological Observatory/World Radiation Center, Dorfstrasse, 33, Davos, Switzerland
(2) Institute for Atmospheric and Climate Science ETH, Zurich, Switzerland
(3) Main Geophysical Observatory, Karbyshev 7, St. Petersburg, Russia

For the nowcasting of the neutral and ionic state of the middle atmosphere we have developed chemistry-ionosphere climate model SOCOL-i. The model consists of general circulation module ECHAM-4 and chemistry-transport module MEZON which includes complete description of the neutral and ion chemistry in the atmosphere from the ground up to 80 km. To validate the model we have simulated the short-term response of the composition, temperature and dynamics of the middle atmosphere to the intensive solar proton events occurred in October-November 2003. We have carried out two 2-month long 10-members ensemble model runs driven by the prescribed daily mean ionization rates using the explicit and parametrized representation of the ion chemistry and compare the results with the reference run carried out without the ionization caused by the SPE. The comparison of the simulated changes with available observations showed that the model is able to simulate observed short-term enhancement of the odd hydrogen, the long-term increase of the odd nitrogen reaching middle stratosphere and subsequent ozone depletion. In comparison with the MIPAS data the simulated HNO3 response is slightly underestimated in the model with ion chemistry. The model version with the parametrized representation of the ion chemistry reveals substantially underestimated HNO3 increase due to SPE and smaller response of the chlorine compounds, which emphasize the necessity of the new parametrization for the representation of the ion chemistry in chemistry-climate models.

Modelling of solar proton events with chemistry and transport model FinROSE

S.M. Salmi, P. T. Verronen, L. Tholix, L. Backman, S. Hassinen, S. Tukiainen

Finnish Meteorological Institute, Helsinki, Finland

Sporadic solar proton events (SPEs) are able to increase the amount of precipitating energetic particles into the atmosphere. The energetic particles affect the chemistry of the mesosphere and stratosphere and cause ionisation, which in turn leads to production of odd nitrogen (NOx) and odd hydrogen (HOx) species. These species can then destroy significant amounts of the upper atmospheric ozone in catalytic reactions.

We have used the chemistry and transport model FinROSE to simulate solar proton events, especially the October-November 2003 case. The FinROSE-CTM is a global 3-D model including the stratosphere and mesosphere. The model produces the distribution of 30 long-lived species/families and 14 species in photochemical equilibrium. The chemistry describes around 110 gas phase reactions ans 37 photodissociation processes. The model chemistry includes heterogeneous processing through and PSC sedimentation. The tropospheric abundances are gives as boundary condition. The dynamics are driven by ECMWF wind data.

FinROSE includes a new, improved parameterisation of SPE-related production of HOx and HNO3 based on detailed modelling of ion and neutral chemistry (Sodankylä Ion and Neutral Chemistry Model). The new parameterisation improves especially the HNO3 results because its production until now has been neglected in modelling studies. Results are realistic and they show the expected decrease of ozone and increase of HNO3, NOx and HOx.

Reconstructing the Spectral Solar Irradiance

M. Schoell[1,2], W. Schmutz[1]

(1) PMOD/WRC, Switzerland
(2) ETHZ, Switzerland

The variable solar irradiance is an important forcing of climate model as the climate reacts to a changing solar irradiance.

We present a method to reconstruct the EUV to near IR based on an modified four component model with the filling factors of the area of the quiet sun, sunspots, plague and the network. The corresponding synthetic spectra are computed with COSI, a non-LTE code to calculate the different synthetic spectra.

Applying the standard approaches to the EUV fails to reproduce the Ly-*alpha* variability. Ly-*epsilon* images extracted from the SOHO SUMER instrument show an increase in the active area compared to MDI magnetograms. Based on this we construct height dependent active area filling factors by comparing MDI data with SUMER images. This area enlargement is applied to all wavelength of the spectrum by calculating the corresponding factor from the formation height of optical depth unity at this wavelength. The result is a frequency dependent filling factors $alpha(lambda, t)$ leading to a more accurate spectral solar irradiance in the EUV region.

Additionally, to reconstruct the long-term trend in solar activity, the network is reconstructed using the open magnetic flux and the sunspots back to 1610.

The final product is a reconstructed spectral solar irradiance in 0.1AA resolution from the EUV to the IR going back to 1610 in varying temporal resolution, with a daily resolution back to 1848 and monthly averages before.

Space Weather & the Sun Watcher Using Active Pixel System and Image Processing (SWAP) Instrument Onboard the Upcoming PROBA2 Mission

D. B. Seaton and the SWAP team

Royal Observatory, Belgium

The Sun Watcher Using Active Pixel System and Image Processing (SWAP) is an instrument onboard ESA's PROBA2 mission to be launched mid-2009. SWAP will provide images of the solar corona at a temperature of roughly 1 million degrees with a cadence of about 1 image per minute and a field of view of 54 arcmin. In addition to providing coronal images for solar physics research and space weather operations, SWAP will also serve as a platform for testing the next-generation CMOS-APS detectors that will be used on future missions including Solar Orbiter. SWAP will also provide a better view of the off-limb corona than previously possible, both because of its large FOV and the ability to off-point by as much as a degree. SWAP will help study long-term solar variation by providing continuity between older missions like EIT and newer missions such as SDO. Additionally, with relatively low costs and operational needs, SWAP is likely to be a long-lived mission, possibly providing coverage of long-term solar variation for the entire upcoming solar cycle.

The contribution of molecular lines to the solar irradiance variability

A.I. Shapiro[1], W. Finsterle[1], W. Schmutz[1], M. Schoell[1,2]

(1) PMOD/WRC, Switzerland
(2) ETHZ, Zurich, Switzerland

The variability of the solar spectral irradiance has a strong direct influence on the upper atmosphere and ultimatively, influences the terrestrial climate. Therefore, modelling the variable spectral energy distribution is an important contribution for understanding the Sun-Earth connection. Molecular lines play an important role in forming the solar spectrum and even dominate in some spectral regions. We introduce the calculation of the chemical equilibrium and the formation of the most prominent molecular systems (e.g. G band , CN violet system, Herzberg band) to the NLTE radiative transfer code COSI. The code uses iterated opacity distribution function to include line blanketing self-consistently in the NLTE radiative transfer. We show that molecular lines significantly change the opacity distribution functions and hence, affect the whole solar spectrum. The strength of molecular lines strongly depends on the solar atmosphere model due to their extreme temperature sensitivity. We discuss the effects on molecular lines arising from shock waves in the solar atmosphere.

The response of the middle atmosphere to short-term solar irradiance variability: Comparison of different input data

A.V. Shapiro[1,2], E.V. Rozanov[1,2], T.A. Egorova[1], W. Schmutz[1], T. Peter[2]

(1) Physical Meteorological Observatory/World Radiation Center, Davos, Switzerland
(2) Institute for Atmospheric and Climate Science ETH, Zurich, Switzerland

Despite substantial progress in atmospheric modelling we still don't have good agreement between observed and simulated atmospheric response to solar variability on a decadal time scale. Insufficient observational data is one of the reasons, as satellite observations cover only the last two to three solar cycles. On shorter time scales, it is possible to investigate much more cases. Therefore, we aim at improving our theoretical understanding by investigating atmospheric responses to solar irradiance variability during a solar rotation. In this paper, we use the daily solar spectral irradiance compiled by Lean and compare the atmospheric responses to input data as observed by the instruments SUSIM and SOLSTICE on the UARS satellite.

On the Modeling of Galactic Cosmic Ray Long Period Variations with the Temporal Changes of the Interplanetary Magnetic Field Parameters

M. Siluszyk[1], A. Wawrzynczak[2], M.V. Alania[1,3]

(1) Institute of Mathematics and Physics, University of Podlasie, 3 Maja 54, 08-110 Siedlce, Poland
(2) Institute of Computer Science of University of Podlasie, Sienkiewicza 51, 08-110 Siedlce, Poland
(3) Institute of Geophysics, Georgian Academy of Sciences, Tbilisi, Georgia

Two-dimensional (2 - D) non-stationary model for describing the long period (11 - year) variations of the galactic cosmic ray (GCR) intensity has been developed. Besides the fundamental processes - convection, diffusion, drifts and adiabatic cooling, the changes of the exponent ν of the power spectral density (PSD) as a time dependent parameter are taken into account in the modeling. Clear relationships between the exponent gamma of the expected rigidity spectrum of the 11-year variations of the GCR intensity and the exponent ν of the PSD of the IMF turbulence are found. We show that the 2-D Parker transport equation including time dependent level of the PSD of the IMF and its exponent ν describes satisfactorily the 11-year changes of the GCR intensity.

Reconstruction of the interplanetary magnetic field during the Holocene using cosmogenic radionuclides

F. Steinhilber[1,2,3], J. Abreu[1,2], J. Beer[1]

(1) EAWAG Dübendorf, Switzerland
(2) ETH Zurich, Switzerland
(3) NCCR Climate, Swiss climate research, Switzerland

In the framework of the ETH Zurich poly-project "Variability of the Sun and Global Climate - Phase II" and the NCCR climate project a composite record of the force-field solar modulation function has been reconstructed for the Holocene period. This record is a compilation of different modulation functions that are based on data of the cosmogenic radionuclide 10Be measured in Greenlandic and Antarctic ice cores and data from neutron monitors. From this composite we derived the history of the interplanetary magnetic field and the open solar magnetic flux. We find that the open flux was not vanished during the Maunder minimum confirming earlier results that the Sun was magnetically active although no sunspots were observed. This result has important implications for the reconstruction of the solar magnetic activity and the solar irradiance.

High-throughput analysis of substorms during solar cycles 22 and 23

E. I. Tanskanen[1,2], A. Viljanen[2], G. Baumann[2] and T.I. Pulkkinen[2]

(1)University of Bergen, Norway
(2)Finnish Meteorological Institute, Helsinki, Finland

The annual and yearly variation of the substorm activity during a complete solar cycle, from year 1993 to 2003, has been examined. Almost 6,000 substorms were identified by an automated search engine. To examine the long-term (annual, yearly and solar cycle) variability in the substorm occurrence rate, we formed a measure called the substorm number. The substorm number and peak amplitude was found to only weakly follow the Sun's activity measured by a sunspot number. During the years of sunspot maxima in the solar cycle 23, the northern hemisphere auroral region was only moderately active. The largest substorm numbers and peak amplitudes were found during the declining solar cycles phases when the interplanetary high-speed streams hit the Earth. We found out that the substorms last longer during the least active season (i.e. summer months) and during the least active years (e.g. 1997 and 2001). Furthermore, the substorm number and peak amplitude show much larger values for winter than for summer, which may be partly due to the fact that the maximum southward component of the interplanetary magnetic field B_{south} occurs in February and minimum in June.

EISCAT 3D - European New Technology Atmospheric and Space Environment Radar Arrays

E. Turunen

EISCAT Scientific Association, Kiruna, Sweden

A major new research European infrastructure will be constructed in Northern Scandinavia, combining several very large phased-array transmitters/receivers with multiple receiver arrays. The new EISCAT 3D radar system has a design goal of ten times higher temporal and spatial resolution than the present radars, a volumetric radar imaging capability in an extended spatial area with simultaneous full-vector drift velocities, avoiding spatial and temporal ambiguities, having continuous operation modes, short baseline interferometry capability for imaging sub-beamwidth scales, real-time data access for technology applications and extensive data archiving facilities. Some arrays are very large, in the scale of 30 000 individual antenna elements. The receiver arrays will be located at 50-150 km distance from the illuminators, so that the total system will comprise in the order of 100 000 elements.

These extremely large scale atmospheric and space environment radar arrays open up unprecedented science opportunities, well beyond the traditional ground-based ionospheric remote sensing role of the old incoherent scatter radars. Science applications include continuous monitoring of the space environment - atmosphere coupling at the statistical southern edge of the polar vortex. EISCAT 3D was accepted on the European Roadmap for Research Infrastructures by the European Strategy Forum on Research Infrastructures in December 2008. The facility will be constructed as a modular concept by year 2015. The current status of the project is approaching the end of the first 4 MEUR design study, conducted during 2005-2009 by EISCAT Scientific Association, University of Tromsö, Lulea University of Technology, Swedish Institute of Space Physics, Rutherford Appleton Laboratory, and supported by EU FP6 funding. EISCAT Scientific Association operates currently three incoherent scatter radars in Northern Scandinavia on behalf of its associate members in Finland, China, Germany, Japan, Norway, Sweden and United Kingdom, as well as currently supporting partners in France and Russia.

MEDIPIX cosmic ray tracking device flown on ESA BEXUS stratospheric balloon flight

J. Urbar[1], J. Scheirich[2], J. Jakubek[3]

(1) Department of Space Science, Lulea University of Technology, Kiruna, 98137, Sweden
(2) Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University in Prague 6, 16627, Czech Republic
(3) Institute of Experimental and Applied Physics, Czech Technical University in Prague, Horská¡ 3a/22, Prague 2, 12800, Czech Republic

Results of the first experiment using a MEDIPIX-type detector for cosmic ray imaging in stratospheric environment are presented. The detector was used in its tracking mode allowing it to operate as an "active nuclear emulsion". The actual flight time was over 4 hours, with 2 hours at stable floating altitude of 26km. Different types of cosmic ray particles were acquired in the stratospheric radiation environment, sorted and analyzed. Detector performance is evaluated for further design implications of advanced concept focusing on Cosmic Ray Induced Ionization measurement.

Ionization effect of strong solar particle events in the low-middle atmosphere

I.G. Usoskin[1], A.J. Tylka[2], G.A. Kovaltsov[3], W. F. Dietrich[4]

(1) Sodankyla Geophysical Observatory, University of Oulu, Finland
(2) Space Science Division, Naval Research Laboratory, Washington D.C., USA
(3) Ioffe Physical-Technical Institute, St.Pteresburg, Russia
(4) Consultant, Naval Research Laboratory, Washington D.C., USA

Using a new precise reconstruction of the energy spectrum of major solar energetic particle (SEP) events, based on thorough fitting of a wide set of data from ground-based and space-borne instrumentations, we quantitatively evaluate the possible effect of the SEP events on the low and middle atmosphere. The computations of the effect are based on the numerical 3D OuluCRAC:CRII model. It is shown that the direct ionization effect is negligible or even negative, due to the accompanying Forbush decreases, in all low- and mid-latitude regions. The effect is positive only in polar atmosphere, where it can be dramatic in the upper atmosphere during major SEP events.

Verification methods of Space Weather forecast

P. Vanlommel, R. Van der Linden, L. Wauters, S. Willems

Royal Observatory, The Solar Influences Data analysis Center (SIDC), Belgium

The Solar Influences Data analysis Center (SIDC) is an official Regional Warning Center (RWC) of the International Space Environment Services (ISES). The activities of the RWC concern solar activity and space weather monitoring. Our space weather services include a daily forecast of the flare probability forecast, 10cm radio flux and geomagnetic disturbance predictions. We present here some statistics and verification indices. By comparing our forecast with other methods and with measurements. , we gain insight in the capability and limitations of our forecast. The quality control serves as a basis to adapt and sharpen the SIDC methods in order to offer a useful and effective service to our clients.

Solar rotation during the period 1847–1849

F. Sanchez-Bajo[1], **J. M. Vaquero**[2], M. C. Gallego[3]

(1) Departamento de Fisica Aplicada, Escuela de Ingenierias Industriales, Universidad de Extremadura, Avda de Elvas s/n 06071 Badajoz, Spain
(2) Departamento de Fisica Aplicada, Escuela Politecnica, Universidad de Extremadura, Avda de la Universidad s/n 10071 Caceres, Spain, jvaquero@unex.es
(3) Departamento de Fisica, Facultad de Ciencias, Universidad de Extremadura, Avda de Elvas s/n 06071 Badajoz, Spain

Solar rotation rate has been measured using the sunspot positions recorded by W.C. Bond during the period 1847–1849 at the Observatory of Harvard College. From the drawings carried out by Bond, we have selected the sunspots and groups with more reliable positions presented in three or more drawings on successive days. From the positions of the selected sunspots (41 in total), we have calculated a synodic rotation rate of $omega = [12.92(8) - 1.5(10) sin^2 phi]$ degrees/day, where *phi* is the heliographic latitude. This rate, although slightly lower, is similar to the actual solar rotation rate, confirming no important changes in the solar rotation during the last 160 years.

Historical Space Climate Data from Iberian Peninsula: A preliminary assessment

J. M. Vaquero

Universidad de Extremadura, Spain

In this work, I compile available information about historical space climate data from Iberian Peninsula: auroral sightings, sunspot observations, geomagnetic records and eclipse observations. I present here a preliminary catalogue of auroras observed from Iberian Peninsula. Spanish and Portuguese scientists have observed systematically the Sun (including sunspots and eclipses) and have recorded the variations of the geomagnetic field since late 19th century. I review these observations briefly. Regular solar observations were made at some astronomical observatories: San Fernando, Madrid, Valencia, Ebro, Cartuja, and Barcelona from Spain; Lisbon and Coimbra from Portugal. Also, some geophysical observatories have recorded geomagnetic observations (San Fernando, Ebro, Toledo, Lisbon and Coimbra). Moreover, there are a lot of reports of solar eclipses that were seen in Iberia (1860, 1870, 1900, 1905, and 1912). All these historical documents provide an outstanding data-bank for space climatologists. The compilation, recuperation and analysis of these data are a challenger for next years.

"HSunspots": a tool for the analysis of historical sunspot drawings

A. Cristo, **J. M. Vaquero**, F. Sanchez-Bajo

Universidad de Extremadura, Spain

Sunspot study and monitoring are activities already carried out by astronomers some centuries ago. The only remains of their results are drawings that could provide information of great interest for space climate studies. Sunspot automatic detection is practically impossible in drawings and it is necessary to make this task manually. In this contribution, we present a tool for the analysis of historical sunspot drawings. This application will be described briefly and some examples and results will be presented. The tool is freely available and it can be used by the space climate community.

Multiplicative and additive processes of the solar wind and interplanetary magnetic field formation

I.S. Veselovsky[1,2], A.V. Dmitriev[2,3], A.V. Suvorova[1]

(1) Institute of Nuclear Physics, Moscow State University, Moscow, 119992, Russia
(2) Space Research Institute (IKI) Russian Academy of Sciences, Moscow, 117810, Russia
(3) Institute of Space Science, National Central University, Chung-Li 320, Taiwan

Normal and lognormal statistical distributions of solar wind and interplanetary magnetic field parameters are found and investigated. Distributions of these types can be generated by multiplicative and additive processes correspondingly. We analyze available data obtained during last four solar cycles as well as explanatory theoretical models based on MHD and plasma kinetic approximations. The results indicate that non-linear (mostly multiplicative and exponentially unstable or dumped) and linear (mostly additive and stable) perturbations are responsible for this difference.

Active rocket water release experiment in the upper atmosphere

V. Hølland[1], T. Pitkänen[2], G. Baumann[3,4], G. Mellemstrand[1], A. Søreide[1], S. Njåstad[1], K. Slettebakken[1], C.-F. Enell[5], **I.I. Virtanen**[2], J. Vierinen[5], and E.I. Tanskanen[1,4]

(1)University of Bergen,
(2)Department of Physical Sciences, P.O.B. 3000, FI-90014 University of Oulu, Finland,
(3)Niels Bohr Institute, Copenhagen, Denmark,
(4)Finnish Meteorological Institute, Helsinki, Finland,
(5)Sodankylä Geophysical Observatory, University of Oulu, Finland

We present the Nordic Ionospheric Sounding rocket Seeding Experiment NISSE, which is a student research project to study the upper polar atmosphere. The project is conducted as a part of the REXUS BEXUS student rocket and balloon experiment program coordinated by the European Space Agency ESA Education Office, in which a sounding rocket REXUS 6 will be launched at the Esrange rocket range in Kiruna, Sweden, in March 2009.

In the NISSE experiment about 11 kg water will be released into the upper atmosphere at the REXUS 6 apogee altitude of about 95 km. The tri-static EISCAT UHF incoherent scatter radar system, which is located in Northern Fennoscandia, in Tromsø¸, Norway, Kiruna, Sweden, and Sodankylä, Finland, will be used for detection and observation of the possible effects of the released water on the upper atmosphere and ionosphere.

In addition, the ESRAD MST radar and the riometer in Esrange will be monitoring the atmospheric/ionospheric conditions prevailing close to the release region. Several mag-netometers of the other experiment on the REXUS 6 rocket, AGADE by a German stu-dent team, will measure the geomagnetic field.

Besides the scientific objectives, the NISSE experiment has a strong educational aspect. Participation to the REXUS BEXUS program with an own rocket experiment gives for students of our team a unique opportunity to obtain experience in planning, building, and executing a scientific experiment in space physics, not forgetting experience of wide international scientific collaboration.

Comparing the solar magnetic field in the corona and in the inner heliosphere during solar cycles 21-23

I.I. Virtanen III, K. Mursula

Department of Physical Sciences, University of Oulu, Oulu, Finland

We compare the open solar magnetic field estimated by the PFSS model based on the WSO photospheric field observations, with the inner heliospheric magnetic field. We trace the observed radial HMF into the coronal PFSS boundary at 2.5 solar radii using the observed solar wind velocity, and determine the PFSS model field at the line-of-sight footpoint. Comparing the two field values, we calculate the power n of the apparent decrease of the radial field. According to expectations based on Maxwell's equations, also reproduced also by Parker's HMF model, the radial HMF field should decrease with n=2. However, comparison gives considerably lower values of n, indicating the effect of HCS in the PFSS model and the possible superexpansion. The n values vary with solar cycle, being roughly 1.3-1.4 at minima and about 1.7 at maxima. Interestingly, the n values for the two HMF sectors show systematic differences in the late declining to minimum phase, with smaller n values for the HMF sector dominant in the northern hemisphere. This is in line with the smaller field value in the northern hemisphere, summarized by the concept of the bashful ballerina. We also find that the values of n during the recent years, the late declining phase of solar cycle 23, are significantly larger than during the same phase of the previous cycles. This is in line with the exceptionally large tilt of the solar dipole at the end of cycle 23. We also find that the bashful ballerina appears also during SC 23 but the related hemispheric differences are smaller than during the previous cycles.

Solar sub-cycles

L. Wauters[1], R.Van der Linden[2], S. Willems[1], P. Van Lommel[1], E. D'huys[1], D. Berghmans[3]

(1)Solar Terrestrial Center of Excellence (STCE), Royal Observatory of Belgium(ROB), Ringlaan -3- Avenue Circulaire B-1180 Brussels, Belgium
(2) ROB, Ringlaan -3- Avenue Circulaire B-1180 Brussels, Belgium
(3) ROB, Solar Influence Data Center(SIDC), Ringlaan -3- Avenue Circulaire B-1180 Brussels, Belgium

The eleven year solar cycle and the 27-day solar rotation are well known periods in various types of solar data. In this paper we present "sub-cycles": variations in solar activity on the order of several months. We will focus on solar X-ray events and on the International Sunspot Index(ISN). The ISN is computed by the Solar Influences Data analysis Center hosting the World Data Center for the Sunspot Index. A statistical treatment upon the time has been carried out to reveal sub-cycles. This variations in solar activity will be also presented for the period around the eleven year solar minimum.

On the influence of the changes of the Interplanetary Magnetic Field and the Solar Wind velocity on the rigidity spectrum of Forbush decreases of the Galactic Cosmic Ray intensity

A. Wawrzynczak[1], M.V. Alania[2,3]

(1) Institute of Computer Science of University of Podlasie, 3 Maja 54, 08-110 Siedlce, Poland
(2) Institute of Mathematics and Physics, University of Podlasie, 3 Maja 54, 08-110 Siedlce, Poland
(3) Institute of Geophysics, Georgian Academy of Sciences, Tbilisi, Georgia

We develop three dimensional non stationary model of the Forbush decrease (Fd) of the galactic cosmic (GCR) intensity for the constant solar wind velocity and the stationary three dimensional model including the changeable solar wind velocity and corresponding interplanetary magnetic field (IMF) components found as a solution of the Maxwell's equations. We show that the results of the theoretical modeling are in good agreement with the experimental data. We show that the change of the theoretical rigidity spectrum during the Fd is generally observed only due to the increase of the IMF turbulence, and it does not depend on the level of convection of the GCR stream.

Reconstruction of strongly perturbed Heliospheric magnetic fields in the past based on geomagnetic data

O.S. Yakovchouk[1], K. Mursula[2], I.S. Veselovsky[1,3]

(1) Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow 119992, Russia
(2) Department of Physical Sciences, University of Oulu, 90014, Finland
(3) Space Research Institute (IKI), Russian Academy of Sciences, Moscow 119992, Russia

The Bz component of the interplanetary magnetic field is the main heliospheric parameter responsible for the geomagnetic storms. We perform the statistical analysis of the peak values of the Bz component and the hourly Dst geomagnetic index for all identified perturbations in 1997-2006. Events with Dst < -50 nT (345 cases) and Dst < -100 nT(79 cases) are considered separately. The empirical formulae are derived which relate Dst and Bz values based on this material. Multiple magnetic storm onsets initiated by solar and interplanetary magnetic perturbations are non-linearly coupled. We discuss the predictability of Bz and Dst values. Based on the results of this analysis and correlations we estimate the maximum values of the Bz component in the heliosphere for several strongest geomagnetic storms before the space era, including the Carrington storm in September 1859.

List of participating authors

LIST OF PARTICIPANTS

Abreu, Jose Angel
EAWAG
jose.abreu@eawag.ch

Alexander, Caroline
University of Central Lancashire
calexander@uclan.ac.uk

Artamonova, Irina
Saint-Petersburg State University
artamonova@hotbox.ru

Asikainen, Timo
University of Oulu
timo.asikainen@oulu.fi

Beer, Juerg
Eawag
beer@eawag.ch

Berghmans, David
SIDC - Royal Observatory of Belgium
david.berghmans@sidc.be

Bochnicek, Josef
Institute of Geophysics, AS CR, Czech Republic
jboch@ig.cas.cz

Bondo, Torsten
DTU Space
tb@space.dtu.dk

Bromage, Barbara
University of Central Lancashire
bjibromage@uclan.ac.uk

Budnik, Alex
St.Petersburg State University
alexbudnik@gmail.com

Calogovic, Jasa
Hvar Observatory, Faculty of Geodesy, Zagreb, Croatia
jcalogovic@geof.hr

Charbonneau, Paul
Université de Montréal
paulchar@astro.umontreal.ca

Chifu, Iulia Ana Maria
Astronimical Institute of Romanian Academy
jercaniulia@yahoo.com

Clette, Frédéric
Royal Observatory of Belgium
frederic.clette@oma.be

Crosby, Norma Bock
Belgian Institute for Space Aeronomy
norma.crosby@oma.be

Dasi, Maria
Max-Planck-Institute for Solar System Research
dasi@mps.mpg.de

Davidkovova, Hana
Institute of Geophysics, AS CR, Czech Republic
davidkov@ig.cas.cz

Del Sordo, Fabio
NORDITA
fadiesis@gmail.com

Demetrescu, Crisan
Institute of Geodynamics
crisan@geodin.ro

D'Huys, Elke
Royal Observatory Belgium
elked@oma.be

Dobrica, Venera
Institute of Geodynamics
venera@geodin.ro

Dreschhoff, Gisela
University of Kansas
giselad@ku.edu

Dudok de Wit, Thierry
LPC2E, University of Orléans
ddwit@cnrs-orleans.fr

Ferriz Mas, Antonio
Universidad de Vigo
antonio.ferriz@googlemail.com

Gardner, Esko
Turku University, Dept. of Physics and Astronomy
esgard@utu.fi

Gburek, Szymon
Space Research Centre Polish Academy of Sciences
sg@cbk.pan.wroc.pl

Georgieva, Katya
Solar-Terrestrial Influences Institute, Bulgarian Academy of Sciences
katyageorgieva@msn.com

Getko, Ryszarda
Astronomical Institute of Wroclaw University
getko@astro.uni.wroc.pl

Gil, Agnieszka
Institute of Mathematics and Physics, University of Podlasie, Siedlce, Poland
gila@ap.siedlce.pl

Gizon, Laurent
Max Planck Institute for Solar System Research
gizon@mps.mpg.de

Gordeev, Evgeniy
V.A.Fock Institute of Physics, St.-Petersburg State University
evgeniy_gordeev@yahoo.com

Gyenge, Norbert
Heliophysical Observatory, Debrecen, Hungary
gyenge.norbert@hotmail.com

Haigh, Joanna
Imperial College London
j.haigh@imperial.ac.uk

Hall, Jeffrey
Lowell Observatory
jch@lowell.edu

Hietala, Heli
University of Helsinki
heli.hietala@helsinki.fi

Holappa, Lauri
University of Oulu
Lauri.Holappa@oulu.fi

Huth, Radan
Institute of Atmospheric Physics, Prague, Czech Republic
huth@ufa.cas.cz

Ivanov, Vladimir
Pulkovo Observatory
vgivanov@mail.ru

Jungner, Högne
University of Helsinki
hogne.jungner@helsinki.fi

Järvinen, Riku
Finnish Meteorological Institute
riku.jarvinen@fmi.fi

Kajava, Jari
University of Oulu, Department of Physical Sciences
jari.kajava@oulu.fi

Kalliomäki, Petri
University of Oulu
petrikal@paju.oulu.fi

Kalliopuska, Leena
University of Oulu
leena.kalliopuska@oulu.fi

Karppinen, Tomi
University of Oulu
tomikarp@paju.oulu.fi

Kepa, Anna
Space Research Centre Polish Academy of Sciences
ak@cbk.pan.wroc.pl

Kero, Antti
Sodankylä Geophysical Observatory
antti.kero@sgo.fi

Korhonen, Heidi
European Southern Observatory
hkorhone@eso.org

Kretzschmar, Matthieu
LPC2E / CNRS / Université d'orléans
matthieu.ktz@cnrs-orleans.fr

Krivova, Natalie
MPI for Solar System Research
natalie@mps.mpg.de

Kusano, Kanya
Earth Simulator Center, JAMSTEC
kusano@jamstec.go.jp

Kuzanyan, Kirill
IZMIRAN, Russia
kuzanyan@gmail.com

Leitner, Martin
Institute of Astro- and Particle Physics, University of Innsbruck, Austria
m.leitner@uibk.ac.at

Lockwood, Mike
Southampton University and Rutherford Appleton Laboratory, UK
mike.lockwood@stfc.ac.uk

Lopes, Ilidio
CENTRA - Instituto Superior Técnico
lopes@fisica.ist.utl.pt

Ludmány, András
Heliophysical Observatory, Debrecen, Hungary
ludmany@tigris.unideb.hu

Marsh, Daniel
National Center for Atmospheric Research
marsh@ucar.edu

Martini, Daniel
IIG/Space Res. Group, Oulu
daniel.martini.75@gmail.hu

Meyer, Karen
University of St Andrews
km334@st-andrews.ac.uk

Miletsky, Eugen
Pulkovo Observatory
solar1milet@mail.ru

Mironova, Irina
St.Petersburg State University
irini.mironova@gmail.com

Modzelewska, Renata
Math and Physics, University of Podlasie
renatam@ap.siedlce.pl

Moore, John
University of Lapland
john.moore@ulapland.fi 0

Mosna, Zbysek
Instute of Atmospheric Physics, Academy of Sciences Czech Republic
zbn@ufa.cas.cz

Munoz-Jaramillo, Andres
Montana State University
munoz@solar.physics.montana.edu

Munteanu, Costel
"Al. I. Cuza" University, Iasi, Romania
munteanu_costel_22@yahoo.com

Murakozy, Judit
Heliophysical Observatory
murakozyj@puma.unideb.hu

Mursula, Kalevi
University of Oulu
kalevi.mursula@oulu.fi

Nandi, Dibyendu
Montana State University
nandi@mithra.physics.montana.edu

Novotna, Dagmar
Institute of Atmospheric Physics Academy of Sciences of the Czech Republic
nov@ufa.cas.cz

Ofman, Leon
NASA
Leon.Ofman@nasa.gov

Partamies, Noora
Finnish Meteorological Institute
noora.partamies@fmi.fi

Passos, Dário
Instituto Superior Técnico, Lisbon
dariopassos@fisica.ist.utl.pt

Ponyavin, Dmitri
Institute of Physics, St.Petersburg University
dponyavin@mail.ru

Priest, Eric
St Andrews University
eric@mcs.st-and.ac.uk

Pulkkinen, Tuija
Finnish Meteorological Institute
tuija.pulkkinen@fmi.fi

Raynal, Sophie
Royal Observatory of Belgium
S.Raynal@oma.be

Rica da Silva, Amaro
Instituto Superior Técnico, Lisbon
ricadasilva@ist.utl.pt

Richardson, John
M.I.T.
jdr@space.mit.edu

Rodriguez-Camino, Ernesto
AEMET
e.rodriguez@inm.es

Rouillard, Alexis
University of Southampton
apr1e06@soton.ac.uk

Rozanov, Eugene
PMOD/WRC
e.rozanov@pmodwrc.ch

Rozelot Jean-Pierre
OCA-Nice University
rozelot@obs-azur.fr

Ruzmaikin, Alexander
Jet Propulsion Laboratory, California Institute of Technology
Alexander.Ruzmaikin@jpl.nasa.gov

Salmi, Sanna-Mari
Finnish Meteorological Institute
sanna.j.salmi@helsinki.fi

Saloniemi, Oskari
Space research laboratory, Turku university
oskari.saloniemi@utu.fi

Schmutz, Werner
PMOD/WRC
werner.schmutz@pmodwrc.ch

Schoell, Micha
PMOD/WRC
micha.schoell@pmodwrc.ch

Seaton, Daniel
Royal Observatory of Belgium
dseaton@oma.be

Seppälä, Annika
British Antarctic Survey
annika.seppala@fmi.fi

Shapiro, Alexander
PMOD/WRC
alexander.shapiro@pmodwrc.ch

Shapiro, Anna
PMOD/WRC
anna.shapiro@pmodwrc.ch

Shaviv, Nir
Hebrew University of Jerusalem
shaviv@phys.huji.ac.il

Shiozu, Yuto
Hinode Science Center, NAOJ
yuuto.shiozu@nao.ac.jp

Siluszyk, Marek
University of Podlasie, Poland
sil_m@ap.siedlce.pl

Smith, Edward
Jet Propulsion Laboratory
edward.j.smith@jpl.nasa.gov

Solanki, Sami K.
Max Planck Institute for Solar System Research
solanki-office@mps.mpg.de

Steinhilber, Friedhelm
Eawag Dübendorf / Switzerland
Friedhelm.Steinhilber@eawag.ch

Tanskanen, Eija
Univ. of Bergen, Norway
Eija.Tanskanen@ift.uib.no

Tsuneta, Saku
NAOJ
saku.tsuneta@nao.ac.jp

Tsurutani, Bruce
Jet Propulsion Laboratory
bruce.tsurutani@jpl.nasa.gov

Tuominen, Ilkka
University of Helsinki
tuominen@cc.helsinki.fi

Turck-Chieze, Sylvaine
CEA
cturck@cea.fr

Turunen, Esa
EISCAT Scientific Association
esa.turunen@eiscat.se

Ulich, Thomas
Sodankylä Geophysical Observatory
thu@sgo.fi

Urbar, Jaroslav
LTU, IRV Kiruna, Sweden
jaroslav.urbar@gmail.com

Usoskin, Ilya
Sodankylä Geophysical Observatory, University of Oulu, Finland
ilya.usoskin@oulu.fi

Vanlommel, Petra
Royal Observatory of Belgium
Petra.Vanlommel@oma.be

Vaquero, José M.
Universidad de Extremadura
jvaquero@unex.es

Veretenenko, Svetlana
Ioffe Physico-Technical Institute RAS, St.Petersburg, Russia
svetaveretenenko@mail.ru

Verronen, Pekka
Finnish Meteorological Institute
pekka.verronen@fmi.fi

Veselovsky, Igor
Moscow State University
veselov@dec1.sinp.msu.ru

Vieira, Luis Eduardo
Max-Planck-Institut für Sonnensystemforschung
vieira@mps.mpg.de

Virtanen, Ilkka
University of Oulu
ilkka.i.virtanen@oulu.fi

Virtanen, Ilpo
University of Oulu
Ilpo.Virtanen@oulu.fi

Vornanen, Tommi
Tuorlan observatorio
ttvorn@utu.fi

Wauters, Laurence
ROB
laurence.wauters@oma.be

Wawrzynczak-Szaban, Anna
Institute of Computer Sciences, University of Podlasie, Siedlce, Poland
awawrzynczak@ap.siedlce.pl

Willems, Sarah
Royal Observatory of Belgium
sarah.willems@oma.be

Wissing, Jan Maik
University of Osnabrueck, Germany
MaikWissing@gmx.de

Yakovchouk, Olesya
Institute of Nuclear Physics, Moscow State University
odrieole@mail.ru

York, George
AFOSR / EOARD
george.york@london.af.mil

Zhang, Liyun
National Astronomical Observotaries, Chinese Academy of Sciences
zhangliyun@bao.ac.cn

Zharkova, Valentina
University of Bradford, UK
v.v.zharkova@brad.ac.uk

Zolotova, Nadezhda
Institute of Physics, Saint-Petersburg State University
ned@geo.phys.spbu.ru

ORGANIZERS

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Contact address:

Third Space Climate Symposium

P.O.Box 3000

FIN-90014 University of Oulu

Finland

Phone: +358-8-5531378

Fax: +358-8-5531287

e-mail: *SpaceClimate@oulu.fi*

URL: *http://spaceweb.oulu.fi/spaceclimate/*