Asia Osceania Geosciences Society (AOGS) 11th Annual Meeting
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All Abstracts of Session ST04-06 Solar Activity, Space Weather and Space Climate
Conveners:

Prof. Katya Georgieva, Bulgarian Academy of Sciences, Bulgaria;
Mr. George Maeda, Kyushu University, Japan

Oral Presentations

ST04-06 - Solar Activity, Space Weather and Space Climate
Friday, August 01, 2014 | Regent Hall | 08:30-10:30

1. **ST04-06-D5-AM1-RH-001** (ST04-06-A006)

Current Status of the MAGDAS Project - The Largest Magnetometer Array in the World

George MAEDA[1#+], Kiyohumi YUMOTO[2], Hideaki KAWANO[2], Akimasa YOSHIKAWA[2], Akihiro IKEDA[3], Teiji UOZUMI[2], Huixin LIU[2], Shuji ABE[2], Maria CARDINAL[1], Masakazu WATANABE[2]
[1] International Center for Space Weather Science and Education, Japan, [2] Kyushu University, Japan, [3] Kagoshima National College of Technology, Japan
[#]Corresponding author: maeda@serc.kyushu-u.ac.jp [+]Presenter

ICSWSE ("International Center for Space Weather Science and Education", formerly SERC, "Space Environment Research Center") is responsible for deploying and maintaining the MAGDAS Project. With 72 real time magnetometers in the field, it is the largest magnetometer array in the world. We will provide an update on the current status of this array and also discuss ULTIMA, which is an "array of arrays".

2. **ST04-06-D5-PM2-RH-023** (ST04-06-A003)

Relationship Between the Neutron Time Delay Distribution and the Rigidity Spectrum of Primary Cosmic Rays

Pierre-Simon MANGEARD[1#+], David RUFFOLO[1], Alejandro SAIZ[1], Waraporn NUNTIYAKUL[2], John BIEBER[3], Paul EVENSON[3], Roger PYLE[3], Marcus DULDIG[4], John HUMBLE[4]
[1] Mahidol University, Thailand, [2] Chandrakasem Rajabhat University, Thailand, [3] University of Delaware, United States, [4] University of Tasmania, Australia
[#]Corresponding author: psmangeard@gmail.com [+]Presenter

Neutron monitors are the premier instruments for precisely tracking time variations in the galactic cosmic ray flux at GeV-range energies above the geomagnetic cutoff at the location of measurement. Recently, a new capability has been developed to record and analyze the neutron time delay distribution (related to neutron multiplicity) to infer variations in the cosmic ray spectrum as well. In particular, we can determine the leader fraction L, defined as the fraction of neutrons that did not follow a previous neutron detection in the same tube from the same nuclear interaction, from time delay histograms. By analyzing data taken during 1995-2007 by a ship-borne neutron monitor latitude survey we confirm a strong dependence of L on the geomagnetic cutoff. We have also developed Monte Carlo simulations of cosmic ray interactions in the atmosphere and in a neutron monitor, and trace cosmic ray trajectories through Earth's magnetic field to model how the cosmic ray spectrum is suppressed at low rigidity at a given geographic location. The simulation results show a variation of L with geomagnetic cutoff as observed by the latitude survey, confirming that these changes in L can reasonably be attributed to changes in the cosmic ray spectrum.

3. **ST04-06-D5-AM1-RH-002** (ST04-06-A007)

Long Term Variation of the Solar Diurnal Anisotropy of Galactic Cosmic Rays

Observed with the Nagoya Multi-directional Muon Detector

Kazuoki MUNAKATA[1#+], Masayoshi KOZAI[1], Chihiro KATO[1], Jozsef KOTA[2]
[1] Shinshu University, Japan, [2] University of Arizona, United States
[#]Corresponding author: kmuna00@shinshu-u.ac.jp [+]Presenter

We analyze the three dimensional (3D) anisotropy of the galactic cosmic ray intensity observed with a multi-directional muon detector at Nagoya, Japan over four solar activity cycles between 1971 and 2011 and compare them with the anisotropy deduced from neutron monitor data to examine the rigidity dependence of the anisotropy. We clearly see the phase of the free-space diurnal anisotropy shifting toward earlier hours around solar activity minima in A>0 epochs from ~18:00 local solar time in A<0 epochs. We confirm that this phase-shift is due to the anisotropy component parallel to the mean magnetic field (after correction for the solar wind convection and the Compton-Getting effect due to Earth's orbital motion around the Sun) being larger (smaller) in A<0 (A>0) epochs. The magnitude of the phase-shift is much larger in the anisotropy seen in muon detector data than in NM data. In particular, we find that the anisotropy component perpendicular to the magnetic field is significantly larger in the muon detector data than that in NM data, while the parallel component in two data sets are quite similar to each other. This harder energy spectrum of the perpendicular anisotropy, which is seemingly due to the harder energy spectrum of the drift streaming than the diffusion in this energy region, naturally explains the larger phase-shift observed in muon detector data.

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4. **ST04-06-D5-AM1-RH-003** (ST04-06-A036)

Recalibrating the Sunspot Number (SSN): The SSN Workshops

Edward CLIVER[#+]
National Solar Observatory, United States
[#]Corresponding author: ecliver@nso.edu [+]Presenter

The sunspot number (SSN) is the primary time series in solar and solar-terrestrial physics. Currently there are two widely-used sunspot numbers, the International SSN and the Group SSN, which differ significantly before ~1885. Thus the SSN is potentially a free-parameter in models of climate change or solar dynamo behavior. To reconcile the International and Group SSNs, we have organized a series of workshops at Sunspot, NM, USA in 2011, Brussels, Belgium in 2012, Tucson, AZ, USA in 2013, and Locarno, Switzerland in May 2014. The end goal of this effort is a community-vetted time series of sunspot numbers, with stated uncertainties, for use in long-term studies. We are about half way through the process, with the International and Group SSN time series reconciled back to 1826. We expect to complete the reconciliation back to the beginning of the SSN time series (1610) at the Locarno workshop. The methodology of the workshops and the lessons learned (or re-learned) along the way will be discussed and the recalibrated series will be compared with the current International and Group SSN time series.

ST04-06 - Solar Activity, Space Weather and Space Climate
Friday, August 01, 2014 | Regent Hall | 11:00-12:30

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1. **ST04-06-D5-AM2-RH-004** (ST04-06-A039)

Reconstruction of the Heliospheric Magnetic Field Strength 1835-2014

Leif SVALGAARD[#+]
Stanford University, United States
[#]Corresponding author: leif@leif.org [+]Presenter

After C. F. Gauss and W. E. Weber's invention of the Magnetometer in 1833 systematic [e.g. hourly] measurements of the variation of the Earth's magnetic field were begun at

several newly erected observatories around the World ["the Magneic Crusade"]. These observations [greatly expanded] continue to this day. Magnetometers on the first spacecrafts to explore interplanetary space in 1962 showed that the, long hypothesized and then detected, solar wind carried a measurable magnetic field, which was soon identified as the main driver of disturbances of the magnetic fields observed at the Earth. Vigorous research during the last decade has shown that it is possible to 'invert' the causative effect of the magnetic field in near-Earth interplanetary space [the near-Earth Heliospheric Magnetic Field] and to infer with good accuracy the value of that field [and also of the solar wind speed and density] from the observed magnetic changes measured at the surface of the Earth. In this talk we describe the remarkable consensus reached by several researchers of the variation of the Heliospheric Magnetic Field (and thus of its source: the solar magnetic field) since the 1830s to today. We place the 23-24 minimum in context of the long-term variation.

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2. **ST04-06-D5-AM2-RH-005** (ST04-06-A023)

400 Years of Space Climate Information from Long-term Main Geomagnetic Field Models

Crisan DEMETRESCU#+, Cristiana STEFAN, Venera DOBRICA
Institute of Geodynamics of the Romanian Academy, Romania
#Corresponding author: crisan@geodin.ro +Presenter

Space climate refers to long-term changes in the Sun and its effects in the heliosphere and upon the Earth, being the background on which space weather evolves (acts). The solar-terrestrial science has long benefited, especially before the space era, from the study of geomagnetic phenomena known as geomagnetic activity. Except solar activity proper, monitored since the 17th century, information on heliosphere behaviour in terms of solar wind and heliospheric (interplanetary) magnetic field variability could be retrieved mostly from geomagnetic observatory data via geomagnetic field variability expressed as time series of geomagnetic indices. The information is, however, limited to the last 150 years, the life-time span of geomagnetic observatories. We expand the information on geoeffective solar/heliospheric activity back to 1600, valuing two main geomagnetic field models, namely gufm1 (Jackson et al., 2000) and COV-OBS (Gillet et al., 2013). The former (1590-1990) is based on geomagnetic observatory data and prior geomagnetic measurements taken during sea voyages, while the latter (1840-2010) is based on geomagnetic observatory data and satellite geomagnetic measurements. Characteristics of the retrieved information, at time scales of the 11-year solar cycle and of the Hale magnetic solar cycle, are discussed, including activity during solar grand minima.

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3. **ST04-06-D5-AM2-RH-006** (ST04-06-A033)

Improving Space Weather Forecasting Through the Observation of the Coronal Magnetic Field

Michael THOMPSON#+, Steven TOMCZYK, Joseph PLOWMAN
National Center for Atmospheric Research, United States
#Corresponding author: mjt@ucar.edu +Presenter

The Coronal Multichannel Polarimeter (CoMP) instrument, operated by HAO at the Mauna Loa Solar Observatory, is the only existing observational asset that obtains routine measurements of the coronal magnetic field. The CoMP instrument is moreover the prototype for the proposed Coronal Solar Magnetism Observatory (COSMO) large coronagraph. CoMP and, in the future, COSMO thus provide unique data for

incorporating into space weather forecasting. I shall discuss the potential for CoMP and COSMO magnetic field measurements to improve observational models of the 3D magnetic field of the corona and to better forecast the expect magnetic configuration within CMEs, a property that is crucial for establishing their geoeffectiveness.

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4. **ST04-06-D5-AM2-RH-007** (ST04-06-A030)

How the PROBA2 Satellite is Helping us Better Understand Solar Activity and Space Weather

Thanassis KATSIYANNIS[1,2#+]
[1] Royal Observatory of Belgium, Belgium, [2] National Observatory of Athens, Greece
[#]Corresponding author: katsiyannis@oma.be [+]Presenter

PROBA2 is an ESA technology demonstration micro-satellite launched in 2009. Its science payload consists of two major instruments (SWAP & LYRA) which observe the solar corona and two in-situ (DSLP & TPMU) which measure the space environment around the satellite.
SWAP is an EUV imager which observes the solar corona at a temperature of ~1 MK with a high cadence (~1 image per min), a field-of-view of 54 arcmin and a number of cutting-edge space technologies (namely an APS detector, advanced data compressing techniques, on-board data prioritisation algorithms, etc). LYRA is a UV irradiance radiometer that observes the Sun in four passbands at an extremely high cadence of up to 100 Hz. It is consisted of three redundant units, each having a full suit of the four passband detectors. As with SWAP, LYRA also features a number of advanced technologies as it is the first space instrument utilising bandgap detectors based on diamonds.
A number of very meaningful scientific advances obtained by PROBA2's main instruments will be presented during this talk. The study of solar eruptions (such as Lyman-alpha flares and coronal mass ejections), and the observation of the results of magnetic reconnection events are some typical examples of the very substantial contribution that the aforementioned instruments have made. Their relevance and their implications to solar physics and space weather will also be extensively discussed.

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5. **ST04-06-D5-AM2-RH-008** (ST04-06-A008)

Relation of Solar Wind Types with Solar Activity and Their Role in Transfer of Disturbances from the Sun to the Earth

Yuri YERMOLAEV[#+], Nadezhda NIKOLAEVA, Irina LODKINA
Space Research Institute of Russian Academy of Sciences, Russian Federation
[#]Corresponding author: yermol@iki.rssi.ru [+]Presenter

We classified various large-scale types of solar wind streams (HCS, CIR, Sheath, MC and Ejecta) for period 1976-2000 on the basis of OMNI dataset of interplanetary plasma and magnetic field measurements (see for details “Catalog of large scale phenomena during 1976-2000” published by Yermolaev et al, Cosmic Research, 2009, Vol. 47, No. 2, pp. 81-94 and presented on websites: ftp://ftp.iki.rssi.ru/pub/omni/ ftp://ftp.iki.rssi.ru/pub/omni/catalog/). We discuss the connection of these interplanetary events with solar corona phenomena and their role in transfer of disturbances from the Sun to the Earth and generation of magnetosphere activity. The main result of our investigation is the dependence of magnetosphere reaction on type of interplanetary drivers (see details on site http://www.iki.rssi.ru/people/yyermol_inf.html). This work was supported by the RFBR, project 13-02-00158a, and by the Program 22 of Presidium of Russian Academy of Sciences.

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6. **ST04-06-D5-AM2-RH-009** (ST04-06-A021)

Development of a Geomagnetic Storm Model to Forecast Its Start Time, Probability, and Strength Using CME Parameters

Yong-Jae MOON#+, Jae-Ok LEE, Soojeong JANG, Hyeon-Ok NA, Jin-Yi LEE
Kyung Hee University, South Korea
#Corresponding author: moonyj@khu.ac.kr +Presenter

Current techniques to forecast a geomagnetic storm mostly use solar wind in-situ measurements that provide only a short lead time, which is not sufficient to prevent from space weather disasters. One of the challenging issues is to forecast a geomagnetic storm with a longer lead-time. In this study, we are developing a geomagnetic storm model to forecast its start time, probability, and strength using CME parameters with a lead time of 1-3 days. For this we are going to answer the following three questions: (1) when does a CME arrive at the Earth? (2) what is the probability that a CME can induce a geomagnetic storm? and (3) how strong is the storm? To address the first question, we forecast the arrival time and other physical parameters of CMEs at the Earth using the WSA-ENLIL model with three CME cone types. The second question is answered by examining the geoeffective and non-geoeffective CMEs depending on CME observations (speed, source location, earthward direction, magnetic field orientation, and cone-model output). The third question is addressed by examining the relationship between CME parameters and geomagnetic indices (or IMF southward component). The forecast method will be developed with a three-stage approach, which will make a prediction within four hours after the solar coronagraph data become available. We expect that this study will enable us to forecast the onset and strength of a geomagnetic storm a few days in advance using only CME parameters and the physics-based models.

ST04-06 - Solar Activity, Space Weather and Space Climate

Friday, August 01, 2014 | Regent Hall | 14:00-15:30

1. **ST04-06-D5-PM1-RH-010** (ST04-06-A016)

Space Weather Forecasting: From the Scientific Observations to the Operational Practice – The COMESEP Alert System

Olga MALANDRAKI[1#+], Allan J. TYLKA[2], Norma CROSBY[3], Athanasios PAPAIOANNOU[4], Ioanna PATSOU[4], Mark DIERCKXSENS[3], Kostas TZIOTZIOU[4], Chee NG[5], Douglas PATTERSON[6], Thomas ARMSTRONG[6], Louis J. LANZEROTTI[7]
[1] National Observatory of Athens, Greece, [2] NASA Goddard Space Flight Center, United States, [3] Belgian Institute of Space Aeronomy, Belgium, [4] The Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, Greece, [5] George Mason University, United States, [6] Fundamental Technologies, LLC, Lawrence, KS, United States, [7] Center for Solar-Terrestrial Research, New Jersey Institute of Technology, United States
#Corresponding author: omaland@astro.noa.gr +Presenter

During an eleven year cycle the Sun goes from quiet conditions at minimum to levels of high activity at maximum. In the latter case, energetic phenomena as coronal mass ejections (CMEs) and solar flares (SFs) accompanied by explosive releases of mass, magnetic flux and solar energetic particles (SEPs) are common. Damaging effects due to these phenomena have been recorded on satellites, on-board detectors and in extreme cases on ground based systems (e.g. pipelines, power-grids). Furthermore, the intense SEP radiation can damage human DNA and cause cell replications. To this end, ensuring the safety of astronauts from the extreme conditions of space, especially the energetic particle environments, is a key goal for both ESA and NASA. The analysis, the risk management and the possible forecasting of such events constitutes the scientific field of Space Weather. The forecasting of SEP radiation storms and geomagnetic storms based

on scientific data analysis and extensive modeling has been recently incorporated into an automated operational European Space Weather Alert system by the COMESEP consortium. In this work we will present the aforementioned novel forecasting system and its building blocks. The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n^o 263252 (COMESEP).

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2. **ST04-06-D5-PM1-RH-011** (ST04-06-A019)

Geosynchronous Flux Dropout by Magnetopause Shadowing During a Weak Geomagnetic Storm of November 7, 2008

Junga HWANG[#+]
Korea Astronomy and Space Science Institute, South Korea
[#]Corresponding author: jahwang@kasi.re.kr [+]Presenter

We investigate a geosynchronous flux dropout event during a weak storm of which Sym-H minimum value is -37 nT on November 7, 2008. During this event period, two dropouts are observed by GOES observation. Interestingly we found that there is local time dependence by THEMIS SST observation such that the GEO flux dropout starts first from noon-dusk MLT and recovers from midnight-dawn MLT in a few hundreds of keV electrons. This tendency is confirmed with RBE simulation results for both lower and higher energies' electrons; a few hundreds of keV and ~Me V. There is no observed atmospheric precipitation during the first dropout period and there are just negligible atmospheric precipitations during the second dropout by all available NOAA POES satellites' observations. We also check wave activities can provide the indirect proof of the atmospheric precipitation through wave-particle interactions, Chorus wave power from THEMIS exists just only during the second dropout period. EMIC waves do not appear from THEMIS observations while ground observations by CARISMA network show that there are clear EMIC waves during both dropouts. Finally we conclude that the first dropout event is caused by purely magnetopause shadowing effect and the second one might be the result of the combination of magnetopause shadowing and atmospheric precipitation into the earth's atmosphere by wave-particle interaction.

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3. **ST04-06-D5-PM1-RH-012** (ST04-06-A009)

Emergence of Kinked Flux Tubes into Solar Atmosphere

Shinsuke TAKASAO[1#+], Yuhong FAN[2]
[1] Kyoto University, Japan, [2] National Center for Atmospheric Research, United States
[#]Corresponding author: takasao@kwasan.kyoto-u.ac.jp [+]Presenter

The so-called "delta-sunspots" are known to be among the most flare-productive active regions in the solar atmosphere. Observations show that a fraction of the delta-spots emerge with strong magnetic shear and with polarity orientations not following the Hale-polarity rule obeyed by the majority of active regions. To understand the observed evolution of these active regions, we carried out MHD simulations in which a subsurface twisted flux tube with kinked or knotted geometry emerges from the convection zone into the solar atmosphere. From the numerical experiments, we found the followings: 1. Although the initial twist is strong, the magnetic shear near the apex is reduced due to kinking in the early phase of the emergence. This leads to a larger growth rate of the magnetic Rayleigh-Taylor (RT) instability, and therefore many current sheets are formed due to RT instability. 2. The current carried by the twisted flux tube in the convection zone, which can be the main source of the free energy, is transported to the upper atmosphere by the torsional Alfven wave. 3. Magnetic reconnections take place above the neutral line at the photosphere. This causes the plasma ejections in the corona. We

will give a detailed picture of the emergence of a kinked flux tube on the basis of the numerical experiments, and clarify the difference between the unkinked tube emergence and the kinked tube emergence. These results could be important for understanding the magnetic field evolution in flare productive active regions.

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4. **ST04-06-D5-PM1-RH-013** (ST04-06-A018)

New Insights into the Origin and Evolution of CMEs

Ilia ROUSSEV[1#+], Klaus GALSGAARD[2], Cooper DOWNS[3], Jun LIN[4], Elena MOISE[5]
[1] National Science Foundation, United States, *[2] Niels Bohr Institute, Denmark*, *[3] Predictive Science Inc., United States*, *[4] Yunnan Astronomical Observatory, China*, *[5] Institute for Geodynamics of the Romanian Academy , Romania*
#Corresponding author: iroussev@nsf.gov +Presenter

Coronal Mass Ejections (CMEs) play a leading role in driving the Sun-Earth System (SES) because of their large-scale, energetics and direct impact on the Earth. As CMEs evolve in interplanetary space they drive shock waves, which act to produce Solar Energetic Particles (SEPs). CMEs and SEPs can strike our planet, and they can disrupt satellites and knock out power systems on the ground, among other effects. That is why it is important to better understand and predict the ever-changing environmental conditions in outer space due to solar eruptive events, the so-called Space Weather.
This talk summarizes recent advances in modeling the evolution of CMEs in the low solar corona and inner heliosphere by means of 3-D compressible MHD simulations. By comparing simulations results with directly observable quantities (e.g., Thompson-scattered white light, EUV, and X-ray intensities), it becomes possible to constrain the physical models of CMEs, and learn a great deal about the interaction of the ejecta with the pre-existing magnetic field and ambient solar plasma. We will present new physical insights into the evolution of CMEs gathered from our numerical investigations.

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5. **ST04-06-D5-PM1-RH-014** (ST04-06-A032)

Simultaneous Observation of Moreton Waves, EUV Waves, and Filament Oscillations

Ayumi ASAI[#+], Kazunari SHIBATA, Takako ISHII, Hiroaki ISOBE, Takuya TAKAHASHI
Kyoto University, Japan
#Corresponding author: asai@kwasan.kyoto-u.ac.jp +Presenter

Moreton waves, flare-associated wavelike features seen in H-alpha, have been observed to propagate in restricted angles with arc-shaped fronts. Moreton waves are expected to be the intersection of the fast-mode MHD shock propagating in the corona with chromosphere. Associated with flares, remote filaments and prominence are sometimes excited to oscillate, and these "winking filaments" are also caused by flare associated waves. After the launch the SOHO satellite, the EUV Imaging Telescope (EIT) found flare-associated wavelike phenomena, which are called "EIT waves". Although EIT waves were expected to be the coronal counterpart of Moreton waves, they show different physical characteristics from those of Moreton waves. Therefore, the mechanism of EIT waves remains very controversial.
Recently, by the Atmospheric Imaging Assembly on board the Solar Dynamic Observatory (SDO), fast coronal waves have been observed associated with flares. These waves are thought to be the fast-mode MHD waves. Although these fast coronal waves seem to be the coronal counterpart of a Moreton wave, they are seen in EUV images, and it remained to be confirmed whether it is a classical H-alpha Moreton wave. We present simultaneous observations of EUV waves and Moreton waves by using EUV and H-

alpha images with high spatial and temporal resolutions. We also present winking filament triggered by the coronal waves (Moreton waves).

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6. **ST04-06-D5-PM1-RH-015** (ST04-06-A015)

Discovery of Two Sun-like Superflare Stars Rotating as Slow as the Sun
Daisaku NOGAMI[1#+], Yuta NOTSU[1], Satoshi HONDA[2], Hiroyuki MAEHARA[3], Shota NOTSU[1], Takuya SHIBAYAMA[1,4], Kazunari SHIBATA[1]
[1] Kyoto University, Japan, [2] University of Hyogo, Japan, [3] The University of Tokyo, Japan, [4] Solar-Terrestrial Environment Laboratory, Nagoya University, Japan
[#]Corresponding author: nogami@kwasan.kyoto-u.ac.jp [+]Presenter
We report on the results of high dispersion spectroscopy of two `superflare stars', KIC 9766237, and KIC 9944137 with Subaru/HDS. Superflare stars are G-type main sequence stars, but show gigantic flares compared to the Sun, which have been recently discovered in the data obtained with the Kepler spacecraft. Though most of these stars are thought to have a rotation period shorter than 10 days on the basis of photometric variabilities, the two targets of the present paper are estimated to have a rotation period of 21.8 d, and 25.3 d. Our spectroscopic results clarified that these stars have stellar parameters similar to those of the Sun in terms of the effective temperature, surface gravity, and metallicity. The projected rotational velocities derived by us are consistent with the photometric rotation period, indicating a fairy high inclination angle. The average strength of the magnetic field on the surface of these stars are estimated to be 1-20 G, by using the absorption line of Ca II 8542. We could not detect any hint of binary in our spectra, although more data are needed to firmly rule out the presence of an unseen low-mass companion. These results claim that the spectroscopic properties of these superflare stars are very close to those of the Sun, and support the hypothesis that the Sun might cause a superflare.

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1. **ST04-06-D5-PM2-RH-016** (ST04-06-A012)

Activity of the Corona Over a Solar Cycle and a Half
Philippe LAMY[#+], Tatiana BARLYAEVA, Antoine LLEBARIA
Astrophysics Laboratory of Marseille (LAM), France
[#]Corresponding author: philippe.lamy@lam.fr [+]Presenter
The LASCO coronagraph aboard SOHO has now completed 18 years of quasi-continuous white-light imaging of the corona, thus allowing an unprecedented view of its evolution over a solar cycle and a half. The solar corona reflects to a large extent the magnetic activity of the Sun and is the source of the solar wind and transient events that interact with planets with possible impacts on their climate. We report on a quantitative analysis of the evolution of the corona based on its radiometry, either global or integrated in limited regions (e.g., equatorial versus polar regions). Their temporal variations are compared to various indices of solar activity in order to identify the driving mechanisms that control the activity of the corona and its effects on the inner heliosphere. We further analyze the properties of coronal mass ejections during these 18 years.

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2. **ST04-06-D5-PM2-RH-017** (ST04-06-A038)

CMEs and Solar Energetic Particle Events During Solar Cycle 24
Nat GOPALSWAMY[#+]
NASA Goddard Space Flight Center, United States

#Corresponding author: gopals@ssedmail.gsfc.nasa.gov +Presenter
Fast coronal mass ejections (CMEs) driving shocks in the corona and interplanetary medium are thought to be responsible for large solar energetic particle (SEP) events. The weak solar activity during solar cycle 24 seems to affect the SEP production in a peculiar way: the number of large SEP events is similar to that in cycle 23, but the particles are not accelerated to high energies, as evidenced by the lack of ground level enhancement (GLE) events. In order to understand these results we explore source and environmental factors affecting SEPs. The source is CMEs and we found some marked difference between SEP-producing CMEs of solar cycles 23 and 24. Almost all SEP-producing CMEs of cycle 24 are halos, compared to about 70% in cycle 23. This may be due to unusual expansion of CMEs owing to the weak total pressure in the heliosphere. Using in-situ measurements of density, temperature, and magnetic field, it is found that the total pressure (magnetic + plasma) is indeed lower in cycle 24. This is an important environmental factor that affects SEP production. The weakened ambient magnetic field means reduced efficiency of shock acceleration, which is one possible reason for the lack of highest energy particles. The number of large SEP events did not drop significantly in cycle 24, despite the drop in the rate of fast and wide CMEs in cycle 24. This can be attributed to the reduced Alfven speed in the corona compared to that in cycle 23. Lower Alfven speed makes it easier for CMEs to drive shocks, which might explain why the number of large SEP events did not drop significantly in cycle 24. I also discuss additional environmental factors involving magnetic connectivity of the shock nose: higher energy particles might have been produced but they did not reach Earth.

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3. **ST04-06-D5-PM2-RH-018** (ST04-06-A035)

Long Term Change in Global Distribution of the Solar Wind During Cycles 22-24

Munetoshi TOKUMARU#+, Ken'Ichi FUJIKI, Tomoya IJU
Solar-Terrestrial Environment Laboratory, Nagoya University, Japan
#Corresponding author: tokumaru@stelab.nagoya-u.ac.jp +Presenter
Interplanetary scintillation (IPS) observations of the solar wind have been carried out regularly since 1980s at the Solar-Terrestrial Environment Laboratory (STEL) of Nagoya University using the 327-MHz multi-station system. IPS observations enable determination of the solar wind distribution on the whole source surface for a given solar rotation. In this paper, we report long-term change in the global solar wind distribution derived from STEL IPS observations during 1985-2013, i.e. Cycles 22-24. The current cycle (Cycle 24) is known as a peculiar cycle associated with a significant decline in the solar activity to 100 year low, so a special attention is paid here on different aspects of the solar wind distribution in this cycle. Our IPS observations reveal that the solar wind systematically changes its large-scale structure with the solar cycle. We find the following points concerning evolution of the solar wind structure during last two cycles. (1) In the extended solar minimum between Cycles 23 and 24, the area of fast wind regions significantly increases at low heliographic latitudes, but decreases for all latitudes. (2) The solar wind structure in the extended minimum is not stable, but variable. (3) Isolated fast wind regions are frequently observed at mid- or low-latitudes during Cycle 24, even at its maximum. (4) Marked north-south asymmetry of polar fast winds, which arises in Cycle 23 maximum, extends to Cycle 24. (5) Solar wind density fluctuations distinctly drop in the declining phase of Cycle 23, and keep its low level during Cycle 24. These facts are considered as manifestations of weaker solar dynamo activity in Cycle 24. While our result (5) is consistent with marked reduction in the solar wind density observed in situ, our IPS data suggest that the density reduction occurs globally, and confirm the hypothesis about the shrinkage of the heliosphere. Here, it

should be noted that the relation between the solar wind distribution and the polar field strength observed in Cycle 24 is slightly different from that in the past cycles. This fact suggests that higher order magnetic moments may influence the solar wind formation more importantly in this cycle.

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4. **ST04-06-D2-PM2-P-032** (ST04-06-A028)

Sources and Complexity of the Strong Geomagnetic Storms During the Maximum Phase of Solar Cycle 24

Georgeta MARIS MUNTEAN[#+], Diana BESLIU-IONESCU, Venera DOBRICA, Dana LACATUS, Alin PARASCHIV
Institute of Geodynamics of the Romanian Academy, Romania
[#]Corresponding author: gmaris@geodin.ro [+]Presenter

Solar wind (slow and fast components) and its extensions in the interplanetary space are governing and perturbing the planetary magnetospheres. The response of the terrestrial magnetosphere displayed as geomagnetic storms induce significant effects on the space and ground technological systems. This paper analyses the intense geomagnetic storms (Dst < –100 nT) during the maximum phase of solar cycle 24 (2011 – 2013) as well as two different types of the fast solar wind (co-rotating high speed streams and ejecta or magnetic clouds) that proved to be their solar sources. The B and Bz variability registered simultaneously with the fast solar wind and their role in the strength of the geomagnetic storm and the energy transfered to the terrestrial magnetosphere is emphasized.

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5. **ST04-06-D5-PM2-RH-020** (ST04-06-A043)

Rise and Maximum of Solar Cycle 24

Shinichi WATARI[#+], Takashi WATANABE
National Institute of Information and Communications Technology, Japan
[#]Corresponding author: watari@nict.go.jp [+]Presenter

Signatures of declining or minimum phase of the cycle 23 suggests lower maximum of cycle 24. For example, two hundred and sixty five no-sunspot days were recorded in 2008. Present maximum value of sunspot number of cycle 24 is 66.9 in February, 2012 according to the monthly smoothed sunspot number by the Solar Influences Data Analysis Center (SIDC). There is a positive correlation between rise time and maximum sunspot number. Cycles with shorter rise time usually tend to have larger maximum sunspot number. The rise time of cycle 24 is shorter comparing with past cycles if we assume the maximum occurred in February, 2012. We will report the result of our statistical analysis on activity of cycle 24.

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6. **ST04-06-D5-PM2-RH-021** (ST04-06-A037)

Hemispheric Asymmetry of Solar Cycle Activities

Kanya KUSANO[1#+], Daikou SHIOTA[2], Daishi SYUKUYA[2]
[1] Nagoya University, Japan, [2] Solar-Terrestrial Environment Laboratory, Nagoya University, Japan
[#]Corresponding author: kusano@nagoya-u.jp [+]Presenter

The prolonged last solar minimum and current weak maximum suggest that the recent solar activity shows some peculiar features of dynamo compared to that in the previous several decades. In this talk, we will focus on the symmetricity of solar dynamo with respect to equator, and discuss about the relationship between the hemispheric asymmetry and the variability of solar activity in order to understand the cause of the recent peculiar cycle. First, we review the observational studies of hemispheric asymmetries for various structures and dynamics; sunspots, polar magnetic field,

integrated photospheric magnetic field, solar flares, solar wind and heliospheric current sheet, etc. These observations indicate that the solar activities systematically create the hemispheric asymmetries. Second, based on the flux transport dynamo model, we try to explain the cause of the asymmetry from the theoretical point of view. The numerical simulations indicate that the competitive action between the dipole-type component and the quadrupole-type component of magnetic field determines the asymmetry. Finally, on the basis of the reviews for observations and theories, we will discuss about the causal relationship between the hemispheric asymmetries and the peculiarity of solar cycle.

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7. **ST04-06-D5-PM2-RH-022** (ST04-06-A046)

Magnetic Evolutions at Extremely High Latitude Region During Polarity Reversal Observed with Hinode

Daikou SHIOTA[1#+], Masumi SHIMOJO[2], Anjali JOHN KAITHAKKAL[3], Nobuharu SAKO[3], Saku TSUNETA[2]
[1] Solar-Terrestrial Environment Laboratory, Nagoya University, Japan, [2] National Astronomical Observatory of Japan, Japan, [3] The Graduate University of Advanced Studies, Japan
[#]Corresponding author: shiota@stelab.nagoya-u.ac.jp [+]Presenter

The magnetic field in the Sun's polar region is a key ingredient of the solar dynamo mechanism because the polar field strength at a solar minimum has a correlation with solar activity of the following cycle. The evolution processes of the polar field (its polarity reversal and its build-up after the reversal) are thought to be caused by magnetic flux transport due to meridional flow and diffusion by turbulent convection. Nevertheless, our understanding of the meridional flow and diffusion in the polar region is still poor because of many difficulties in magnetic observation near the limb.
We recorded time evolution of magnetic polarity distribution within the whole of both polar regions derived from the high-accuracy spectropolarimetric observation with Solar Optical Telescope aboard *Hinode*. In the north polar region, the latitudinal polarity inversion line (PIL) between the preexisting negative polarity region and transported positive polarity region migrates from 60 degrees latitude at January 2012 to 68 degrees latitude at September 2012. Then the whole of the north polar region becomes positive at September 2013. The migration speed of the PIL is 5 m s^{-1} (January - September 2012) and then becomes 8.5 m s^{-1} (September 2012 - September 2013). According to a flux transport model, the speed-up is understood as a result of a diffusion process. In contrast, the whole of the south polar region observed in March 2013 has still ample positive field. The PIL locates out of the observed region (over 67 degrees latitude).
We examined a few parameter sets of the meridional flow pattern and the diffusion coefficient with an advection-diffusion model. The observed PIL migration in the north polar region can be explained well if there is slightly strong diffusion without the meridional flow.

Six abstracts, part AM2 (Friday, August 01, 2014,11:00-12:30), along with Photos of six Presenters can be downloaded as one PDF file. , 285KB, 6pages

Poster Presentations

ST04-06-D2-PM2-P-024 (ST04-06-A004)

Variations in the Neutron Time Delay Distribution at the Princess Sirindhorn Neutron Monitor

Pierre-Simon MANGEARD[1#+], David RUFFOLO[1], Alejandro SAIZ[1], Nattapong KAMYAN[1], Suttiwat MADLEE[2], Tanin NUTARO[3], Supon SUMRAN[3], Chawewan CHAIWATTANA[3], Nipon GASIPRONG[3], Chanruangrit CHANNOK[3], Manit

RUJIWARODOM[4], Paisan TOOPRAKAI[4], Burin ASAVAPIBHOP[4], John BIEBER[5], John CLEM[5], Paul EVENSON[5], Kazuoki MUNAKATA[6]
[1] Mahidol University, Thailand, [2] Prince of Songkla University, Thailand, [3] Ubon Ratchathani University, Thailand, [4] Chulalongkorn University, Thailand, [5] University of Delaware, United States, [6] Shinshu University, Japan
[#]Corresponding author: psmangeard@gmail.com [+]Presenter
The Princess Sirindhorn Neutron Monitor (PSNM) has operated since late 2007 at the summit of Doi Inthanon, Thailand's highest mountain (2565 m altitude). PSNM records the flux of galactic cosmic rays with the world's highest vertical cutoff rigidity for a fixed station, 16.8 GV. In addition to monitoring the count rate, PSNM has special electronics to record the time delay of each neutron from the previous one in the same tube. We accumulate and collect hourly time delay histograms for individual tubes, which show an exponential tail at long times (> 1 ms) due to chance coincidences, i.e., counts associated with independent atmospheric secondary particles. Shorter time delays, however, are dominated by counts from the same interaction between an atmospheric secondary particle (usually a nucleon) and a Pb nucleus in the neutron monitor, thus containing information about the energy distribution of atmospheric shower particles. We use time delay analysis to derive the leader fraction, *L*, i.e., the fraction of neutron counts not associated with a previous neutron count in the same tube from the same nuclear interaction. *L* has a similar meaning as inverse multiplicity, except that the effects of chance coincidences have been removed. While time variations in PSNM multiplicity are dominated by "contamination" from variations in chance coincidences according to the count rate (uncorrected for pressure), this is not evident for *L*. We report on variations of *L* with time, their possible origin and the close match obtained from Monte Carlo simulations of cosmic ray interactions in the atmosphere and in the PSNM station and detector.

ST04-06-D2-PM2-P-025 (ST04-06-A010)

Relationship Between Relativistic Electron Flux in the Inner Magnetosphere and ULF Pulsation Associated with Long-term Variations of Solar Activity

Kentarou KITAMURA[1#+], Tsutomu NAGATSUMA[2], Takahiro OBARA[3], Hideki KOSHIISHI[4], Satoko SAITA[5], Yoshimasa TANAKA[6], Akira KADOKURA[6], Hisao YAMAGISHI[6]
[1] Tokuyama College of Technology, Japan, [2] National Institute of Information and Communications Technology, Japan, [3] Tohoku University, Japan, [4] Japan Aerospace Exploration Agency, Japan, [5] Research Organization of Information and System, Japan, [6] National Institute of Polar Research, Japan
[#]Corresponding author: kitamura@tokuyama.ac.jp [+]Presenter
Relativistic electrons in the inner magnetosphere are thought to be a cause of the internal charging of the satellite, so that the prediction of variations of the electron flux is one of the most important objectives of the space weather study. Recently, ULF pulsations with Pc5 range (150-600s) come up in a prevalent candidate of an acceleration mechanism of the relativistic electrons. Sources of the Pc5 waves are thought to be KH instability at the flank side of the magnetopause or large disturbance of the solarwind dynamic pressure. In both cases, the characteristics of the solar wind conditions are the most important factors to generate the possible acceleration process of the relativistic electron in the inner magnetosphere.
The long-term variation of the solar wind conditions observed by ACE and the relativistic electron flux observed by DRTS and GOES satellites are compared to consider the implication of the Pc5 waves. We also use the magnetic variation data

obtained at the ground stations in the latitudinal range from the auroral to equatorial latitudes. As a result of the analysis, the electron flux enhanced continuously during the passage of the CIR (Corotating Interaction Region), whereas the flux does not increase effectively during the passage of the CME (Coronal Mass Ejection). The same signature can be shown in the time variability of the Pc5 power on the ground. These results indicate that the solar wind condition strongly affects the acceleration process of the relativistic electron flux by the ULF wave. In particular the occurrence frequencies of the CME and CIR are strongly associated with the phase of the solar cycle in terms of the long term variation.

ST04-06-D2-PM2-P-026 (ST04-06-A011)

Prediction of Solar Flares Based on Statistical Analysis of ASSA Sunspot Catalogue

Sangwoo LEE[1#+], Sunhak HONG[2], Ki Chang YUN[3], Jaehun KIM[2], Yung Kyu KIM[3], Jeong-Deok LEE[1], Seung Jun OH[1]
[1] SELab, Inc, South Korea, [2] National Radio Research Agency, South Korea, [3] Korean Space Weather Center, National Radio Research Agency(RRA), South Korea
[#]Corresponding author: lee@spweather.com [+]Presenter

Conventionally, empirical flare prediction models have been constructed based on statistical analysis of long-term archives of sunspot groups and flare occurrence records. Most of them used identification and classification result of NOAA Solar Region Summary(SRS) in order to associate sunspot groups with flares. However, flare prediction models based on McIntosh classification result of SRS have limitation of giving the same amount of flare probability to the sunspot groups with identical McIntosh class, even though they exhibit continuously varying physical conditions such as group area, sunspot number, complexity of magnetic neutral line. Therefore we need a new approach to flare prediction in order to give continuous flare probabilities according to continuous physical properties. In our study, we have constructed a new catalogue of sunspot groups by applying the detection and classification algorithms of ASSA(Automatic Solar Synoptic Analysis) to the past archive of solar image data. ASSA is a realtime software system for detection and classification of sunspot groups running every hour, which is in operation both at KSWC(Korean Space Weather Center) and NASA CCMC(Community Coordinated Modeling Center). Continuum and magnetogram images of SOHO MDI from 1996 to 2011 and SDO HMI from 2011 to 2013 have been processed through ASSA algorithm to yield a new sunspot group catalogue with 17-year time span. This catalogue presents not only the classification results of McIntosh and Mt. Wilson magnetic class but also various quantities such as group area, longitudinal extent, asymmetry factor, roughness of magnetic neutral lines, etc. used for classification. By associating the ASSA sunspot catalogue with X-ray events, we analyzed statistical relationship between flare occurrences and various quantities presented by ASSA catalogue. Then, we produced forecast equations for flare probability based on the selected good predictors. This newly constructed flare prediction model is expected to provide short-term flare probabilities for operational use.

ST04-06-D2-PM2-P-027 (ST04-06-A017)

Ionospheric Index Calculated for MEXART and STEL Data Using Wavelet Tools

Mario RODRIGUEZ-MARTINEZ[1#+], Ernesto AGUILAR-RODRIGUEZ[1], Juan Americo GONZALEZ ESPARZA[1], Veronica ONTIVEROS[1], Munetoshi TOKUMARU[2], Julio MEJIA-AMBRIZ[3], Esmeralda ROMERO-HERNANDEZ[1]
[1] Universidad Nacional Autonoma de Mexico, Mexico, [2] Solar-Terrestrial Environment Laboratory, Nagoya University, Japan, [3] University of California, San Diego, United

States
#Corresponding author: mrodriguez@enesmorelia.unam.mx +Presenter

In this work, we have estimated an *ionospheric index*, *i*, through the wavelet analysis applied to the Mexican Array Radio Telescope (MEXART) and the Solar-Terrestrial Environment Laboratory (STEL) data. This analysis was made in order to quantify how the Ionospheric Disturbances (IOND) could affect the radio signals observed from extragalactic sources. The ionospheric index was obtained directly from the wavelet spectra specifically for the 3C48 radio source using both: MEXART and STEL instruments. Additionally, the selected data of this radio source was made for several dates over the year 2012, in which there were intense solar flares (X class) and CMEs Halo kind affecting the terrestrial ionosphere. Wavelet techniques has give us a simple way to select those frequency ranges where the IOND overlap with those frequencies due to interplanetary scintillation (IPS). Finally the ionospheric index also has give us the opportunity of quantify the IOND over radio signals.

ST04-06-D2-PM2-P-028 (ST04-06-A020)

GEMSIS-Sun Numerical Model of Sun-earth System (SUSANOO): Application for Extremely Strong IMF CMEs

Daikou SHIOTA[1#+], Ryuho KATAOKA[2], Yoshizumi MIYOSHI[1], Kanya KUSANO[3]
[1] Solar-Terrestrial Environment Laboratory, Nagoya University, Japan, [2] National Institute of Polar Research, Japan, [3] Nagoya University, Japan
#Corresponding author: shiota@stelab.nagoya-u.ac.jp +Presenter

Solar wind including coronal mass ejections (CMEs) is a main driver of various space weather disturbances. MHD modeling of the solar wind is a powerful tool to understand the solar-terrestrial environment and to forecast space weather accurately. Recently, we developed an MHD model of the inner heliosphere on the basis of time series of daily synoptic observation of the photospheric magnetic field [Shiota et al. 2014]. The MHD results at the Earth position are passed to a radiation belt model [Miyoshi et al. 2004]. The programs are automatically executed everyday and the results are uploaded on the web site (http://st4a.stelab.nagoya-u.ac.jp/susanoo/). This system is named as Space-weather-forecast-Usable System Anchored by Numerical Operations and Observations (SUSANOO).

In order to examine the condition of CMEs associated with an extreme event such as the Carrington event, we modeled a series of CMEs with the inner heliosphere MHD simulation (used in SUSANOO). In the model, multiple CMEs are injected as a twisted magnetic flux rope accompanying with a velocity pulse through the inner boundary and propagate into the solar winds. Because there is almost no information associated with the Carrington event and the solar wind, instead, we used observational data of CMEs associated recent large-scale active regions: NOAA 10486 in October - November 2003 and NOAA 11520 in July 2012. Only fast (V > ~1000 km/s) and wide (angular width > 60 degree) CME data are extracted from LASCO CME catalog (http://cdaw.gsfc.nasa.gov/CME_list/). As a result, the strength of compressed magnetic field becomes as high as about four times of background IMF when a fast CME interacts with the background solar wind. However, successive CMEs interact with each other to form much stronger magnetic filed due to compression of the magnetic cloud of the preceding CME by shock associated the following CME.

ST04-06-D2-PM2-P-029 (ST04-06-A022)

Joint Collaborations for Space Weather Forecasting Models by KHU and KMA

Kap-Sung KIM[1#], Jin-Yi LEE[1+], Yong-Jae MOON[1], Ensang LEE[1], Tetsuya MAGARA[1],

Khan-Hyuk KIM[1], Suk-Kyung SUNG[1], Kangjin LEE[1], Jinhye PARK[1], Eun-Young JI[1], Jun-Mo AN[1], Jong-Sun PARK[1], Jun-Hyun LEE[1], Jongyeob PARK[1], Jae-Gwang WON[2], Dong-Su KIM[2], Ji-Hee LEE[2]
[1] Kyung Hee University, South Korea, *[2] Korea Meteorological Administration, South Korea*
#Corresponding author: kskim@khu.ac.kr +Presenter

The Kyung Hee University (KHU) is collaborating with the Korea Meteorological Administration (KMA) for the development of space weather forecasting models. We have worked on the development of several empirical models for the prediction of solar flares, proton events, and magnetic index Kp. An empirical flare prediction model has been developed by estimating the flare probabilities of previous solar active regions. The model utilizes the area change (a proxy of flux emergence) of sunspots as well as McIntosh classification. Using solar flare data from 2010 to 1012, we found that our model is superior to NOAA's. An empirical SPE (Solar Proton Event) prediction model has been developed using flare input parameters (strength, rise time, and location) as well as CME parameters (speed, angular width, and location). A Kp forecast model based on solar wind data has been developed using neural network. In addition, several physicsbased and empirical models in solar wind, magnetosphere, and ionosphere are being prepared for the space weather forecasting service at KMA in future.

ST04-06-D2-PM2-P-030 (ST04-06-A025)

Study of Occurrence of GNSS Losses-of-lock and Count Omissions During Solar Radio-bursts

Elvira ASTAFYEVA[1#+], Yuryi YASYUKEVICH[2], Malini AGGARWAL[1], Denis DO PACO[1]
[1] Institute of Earth Physics of Paris (IPGP), France, *[2] Institute of Solar and Terrestrial Physics, Russian Federation*
#Corresponding author: astafyeva@ipgp.fr +Presenter

It is known that the performance of satellite navigational systems can be significantly perturbed during space weather events. Thus, intense solar radio-bursts (SRB) which often accompany solar flares, and are the source powerful radio noise, can significantly disrupt the performance of the GNSS and HF-based communication on the whole sunlit hemisphere of the Earth.

In this work, we analyze the performance of GNSS-receivers during a series of SRB of different intensity that occurred in 2002-2013. For our analysis, we used data of GPS receivers from global networks IGS and UNAVCO, as well as numerous regional networks (in New Zealand, Australia, North and South America, Africa, Eurasia, and including Greenland and Antarctica), in order to have better data coverage.

The performance quality was estimated from several parameters: 1) density of GPS/GNSS Losses-of-Lock (LoL); 2) ratio of count omissions in the GNSS output files (RINEX files); 3) ratio of TEC-slips. GPS LoL and count omissions were calculated from RINEX files for all satellites and for each GPS frequencies L1 and L2. The ratio of TEC slips was calculated from the data recorded by the receivers.

ST04-06-D2-PM2-P-031 (ST04-06-A027)

Inferring Geoeffective Solar Variability Signature in Stratospheric and Tropospheric NH Temperatures

Venera DOBRICA#+, Razvan PIRLOAGA, Cristiana STEFAN, Crisan DEMETRESCU
Institute of Geodynamics of the Romanian Academy, Romania
#Corresponding author: venera@geodin.ro +Presenter

Possible climatic effects related to geoeffective solar variability have been investigated by means of long-term statistical correlations between stratospheric and tropospheric temperature and solar/geomagnetic indices. Our previous work on solar variability signature in the long records of air temperature in Europe showed that there were significant solar signals at Schwabe (11 years) and Hale (22 years) solar cycles, with peak to trough amplitudes of several degrees, and, respectively, of 0.6-0.8 °C. In the present study we extend the investigation using NCEP/NCAR reanalysed data for the Northern Hemisphere, from Earth's surface to stratospheric levels. Features of these signals will be discussed on various spatial scales of the Northern Hemisphere and at specific levels in troposphere and stratosphere. The seasonal dependence of the long-term correlations is also investigated.

ST04-06-D2-PM2-P-033 (ST04-06-A029)

Climatology of Equatorial Electrojet in the Philippines from Years 2010-2012 Using MAGDAS Data

Quirino Jr SUGON[1,2#+], Ruel APAS[2], Clint Dominic BENNETT[2], Roland Emerito OTADOY[3], Maria CARDINAL[4], Teiji UOZUMI[5], Akimasa YOSHIKAWA[5], Daniel MCNAMARA[1]
[1] Manila Observatory, Philippines, [2] Ateneo de Manila University, Philippines, [3] University of San Carlos, Philippines, [4] International Center for Space Weather Science and Education, Japan, [5] Kyushu University, Japan
[#]Corresponding author: qsugon@ateneo.edu [+]Presenter

The Philippines MAGDAS network has 6 ground magnetometers in equatorial region from from 7.00 to 17.66 degree latitudes. The measurements in these magnetometers are affected by different current systems in the ionosphere and the magnetosphere: electrojets, counter electrojets, and ring currents. The first two current systems define the climatology of ionospheric currents, while the ring currents describe the the geomagnetic storms. Our problem is how to isolate the magnetic contributions of electrojets and counter electrojets from ring currents and define the three-year magnetic climatology of the Philippines from years 2010-2012.
To solve this problem, we reduce the descriptions of current-induced magnetic field variations to four parameters: (1) peak field strength, (2) time of peak field strength, (3) starting time at half maximum, and (4) ending time at half maximum. These three parameters are sufficient to characterize the mean, width, and skewness of the gaussian-like curves. We tabulate the parameters per day. We separate magnetic field variations with positive peaks from those with negative peaks. We classify the variations further according to widths and skewness, and deduce the regularity of each magnetic variation type. We define the climatology of electrojets and counter electrojets by taking the average parameters for the same day of the three-year data, with anomalous variations removed. Finally, we combine the climatologies of the different stations to create the magnetic climatology of the Philippines from years 2010-2012.

ST04-06-D2-PM2-P-034 (ST04-06-A034)

Statistic Analysis of the Relativistic Electron Variations in Different Energy Levels During the Geomagnetic Storm

Lun XIE[#+]
Peking University, China
[#]Corresponding author: xielun@pku.edu.cn [+]Presenter

Geomagnetic storms can either increase or decrease relativistic electron fluxes in the outer radiation belt. In this work, we analyze the variation of relativistic electrons fluxes

during 84 isolated geomagnetic storms selected from nearly one solar cycle (from 1992 to 2004) database. Based on the relativistic electrons observations of one high energy channel (2.5~14 MeV, observed by PET/SAMPEX) and two low energy channels (1.5~2.5 MeV, observed by PET/SAMPEX and 0.3~2.5 MeV, observed by MEPED/POES), we found that the relativistic electrons in different energy levels responses to the geomagnetic storm are different. According to the superposed epoch analysis, we conclude that low energy relativistic electrons (0.3~2.5 MeV) can be more likely to be accelerated during the intense storms with long gradual recovery phase accompanied by prolonged substorm activity and high speed solar wind, which is consistent with research of predecessors. Besides the conditions mentioned before, lower solar wind number density and negative IMF By component in GSM coordinate are very important for the acceleration of high energy relativistic electrons (2.5~14 MeV).

ST04-06-D2-PM2-P-035 (ST04-06-A041)

Weak Ionization of Global Ionosphere Since Solar Cycle 24

Yongqiang HAO#+, Hao SHI, Zuo XIAO, Donghe ZHANG
Peking University, China
#Corresponding author: yong.hao@gmail.com +Presenter

Following a prolonged and extreme quiet solar activity during 2008-2009, the 24th solar cycle started slowly and nearly 5 years have passed since then. The measurement of ionospheric critical frequency (foF2) shows that it has been significantly lower in the first half of cycle 24, compared to the average level of cycle 19 to 23; the global average total electron content (TEC) data confirm that the global ionosphere around cycle 24 peak is much more weakly ionized in contrast with cycle 23. The weak ionization is even more notable after year 2012, when both the ionosphere and solar activity are expected to be approaching solar maximum level. The undersupply of solar extreme ultraviolet (EUV) irradiance somewhat continues after the 2008-2009 minimum, and is principally responsible for the weak ionization. It further imply that, the thermosphere and ionosphere in the first solar cycle of this millennium would probably behave differently from what we have known from the previous cycles of the space age.

ST04-06-D5-PM2-RH-019 (ST04-06-A040)

The Solar Wind During the Recent Solar Minimum

John RICHARDSON#+
Massachusetts Institute of Technology, United States
#Corresponding author: jdr@space.mit.edu +Presenter

The recent solar minimum was unusually long and unusually deep. This paper discusses the solar wind conditions during this solar minimum and how they relate to solar wind observations over the past 50 years. The solar wind magnetic field was 20% less than observed during any previous solar cycle. The solar wind flux was lower than recent data but not as low as in the 1969 solar minimum. What is unusual is that the flux has not recovered as the solar cycle has progressed. The minimum in dynamic pressure is likewise not as low as in 1969, but the very low pressures have persisted much longer than during other solar cycles. We discuss the effects these low pressures have on the outer heliosphere as well for the solar wind interaction with Earth's magnetosphere.