VarSITI – Variability of the Sun and Its Terrestrial Impacts

First VarSITI General Symposium

Book of Abstracts

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SCOSTEP Activities: An Update

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The Scientific Committee on Solar Terrestrial Physics (SCOSTEP) has been active for more than half a century. SCOSTEP has been providing leadership in the running of long-term programs in solar terrestrial physics that are timely and beneficial to the society. This paper summarizes the current activities of SCOSTEP and highlights results obtained during recent SCOSTEP scientific programs such as CAWSES (Climate and Weather of the Sun-Earth System and (VarSITI) Variability of the Sun and Its Terrestrial Impact.

Synergy Between SCOSTEP and NSF's GEM, CEDAR, and SHINE Programs

Roussev I.
National Science Foundation, USA

This talk summarizes the synergy between the SCOSTEP's VarSITI Program and the GEM, CEDAR, and SHINE Programs at the National Science Foundation in the USA.

SCOSTEP's Scientific Program VarSITI: Variability of the Sun and its Terrestrial Impact

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The Variability of the Sun and Its Terrestrial Impact (VarSITI) is the current scientific program operated by the Scientific Committee On Solar-TErrestrial Physics (SCOSTEP) in 2014-2018. VarSITI aimed to promote international interdisciplinary scientific activities in the various branches of solar terrestrial physics and its application for the benefit of humanity. VarSITI encourages more communication between solar and heliosphere scientists and Earth's magnetosphere, ionosphere, and atmosphere scientists in all occasion through meetings, campaign data analysis, web pages (www.varsiti.org), mailing lists, and newsletters. In this presentation, we will show the VarSITI's four Projects and their activities, and will highlight some of the results so far and plans for the future.

Solar and Heliospheric Drivers of Earth-Affecting Events

The X-class Flares Released During the Declining Phase of SC-24

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During the Solar cycle 24 decline phase, giving a new peak was given on January 7, 2014 and the release of x-class flare, with high energetic particles, bigger than that occurred during the mean peak of this cycle. After that a few X-class flares was released during year 2014, 2015. We note that during the last 5 solar cycles, a new peak has appeared releasing high energetic particles and X-class solar flares, which are called the secondary peak or the double peak of solar cycle.

The aim of this analytical study is to follow the X-class flares released study how can predict it, according to data analysis.

Furthermore, the causes of the release of these eruptive storms have been discussed for the period, year 2014, 2015 during the double peak of the solar cycle 24.

Short-term Solar Activity Influence on Regional Weather and Climate

Asenovska Y., Georgieva K.
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Most models for describing the solar activity influence on Earth's atmosphere neglect the velocity, the density and the magnetic field of the solar wind. Our preliminary results based on the Northern Annular Mode (NAM) show that the solar torodial and poloidal magnetic fields affect the atmospheric circulation in a different manner. In this report the short-term (time scale of several days) influence of the solar activity on the weather and climate in some regions on Earth is examined.

Comparison Between Negative Bz Duration and Main Phase Duration During Moderate Geomagnetic Storms of SC23

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We will present here a detailed analysis of the Bz component of the interplanetary magnetic field before and during moderate geomagnetic storms of the solar cycle 23. We focused our study on 80 such geomagnetic storms (-150 nT $\leq$ Dst $\leq$ -50 nT) that were correlated with interplanetary coronal mass ejections and were clearly associated with their solar counterpart.

We will study the duration of the Bz negative values compared to the duration and evolution of the storm and the time delay between the minimum Bz value and minimum Dst value. We will also present preliminary results of analysing temporal profiles of Bz, Dst and the Akasofu parameter in periods comprising the geomagnetic storms.

High Speed Streams in the Solar Wind During the 24th Solar Cycle (2008 – 2015)

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A catalogue of the High Speed Streams (HSS) in the solar wind during the 24th solar cycle (since the beginning of 2008 up to the end of 2015) was setting up by the authors using the OMNI 2 database. Our catalogue lists the basic parameters of the high speed streams: the time of start, the initial and maximum speeds (in km/sec), the maximum gradient of the plasma speed (in km/s), the duration (in days) and their solar source (coronal holes, coronal mass ejections or other solar eruptive phenomena). The main interplanetary magnetic field polarity during the streams is also mentioned. The statistics of the HSSs (by their duration, maximum velocity and, maximum gradient of the plasma velocity) in different phases of solar cycle 23 are presented here in comparison with the main features of the SC 24.

Study of Magnetic Substorms During the 23 and 24 Solar Cycles

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We presented the comparative analysis of the different types substorm behavior during the 23 and 24 solar cycles (MiniMax24). The substorms have been studied in: (a) close to the 23 solar cycle maximum (1999- 2000); (b) close to the last maximum (2012-2013), (c) during the 23 and 24 solar cycle minima (1995-1996 and 2008-2009). As in previous study, we divided the considered substorms into 3 types according to auroral oval dynamics. The first type – the substorms which are observed only in auroral latitudes (called “usual” substorms); the second type – the substorms which propagate from auroral latitudes to polar geomagnetic latitudes (called “expanded” substorms, according to an expanded oval); and the third type – the substorms which are observed only at latitudes above ~70 degrees of geomagnetic latitudes in the absence of simultaneous geomagnetic disturbances below 70 degrees (called “polar” substorms, according to a contracted oval). Our analysis was based on the 10-s sampled IMAGE magnetometers data, and the 1-min sampled OMNI solar wind and interplanetary magnetic field (IMF) data. The following substorm characteristics have been compared: (i) the seasonal variations of the occurrence, (ii) the latitudinal range (iii) solar wind parameters before the substorm onset, and (iiii) the polar cap PC-index values before the substorm onset. The new interesting result of our study is the finding the different values of the PC-index before the different types of substorms. It is shown also that the PC-index values are ~2.5-3.0 times higher for the `expanded` substorms than for the `polar` substorms.

Consequences of the Anomalous Expansion of Coronal Mass Ejections in Solar Cycle 24

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It was recently discovered that coronal mass ejections (CMEs) expand anomalously compared to those in solar cycle 24 owing to the reduced heliospheric total pressure [Gopalswamy et al. 2014, GRL 41, 2673, 2014]. In this paper, we extend the investigation to the maximum and declining phase of the cycle 24 and discuss the consequences of the anomalous expansion. We find that the speed-width correlation continues to be distinctly different from that in cycle 23. We find that the flare sizes associated with the CMEs in the two cycles are not significantly different. We confirm that the geoeffectiveness of CMEs is drastically reduced due to the reduced magnetic field content and speed of the magnetic clouds, which are the interplanetary counterparts of CMEs. The anomalous expansion seems to be responsible for the higher abundance of halo CMEs in cycle 24 and the increased number of halo CMEs originating away from the disk center. We also discuss additional consequences of the weak state of the heliosphere such as the continued high rate of interplanetary type II bursts.

Temporal Variation of CME Number During Solar Cycles 23 and 24: their Possible Connection with Geomagnetic Activity

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We studied the temporal variation of the number of coronal mass ejections (CMEs) detected by Large Angle and Spectrometric Coronagraph Experiment on board Solar and Heliospheric Observatory (SOHO/LASCO) since 1996 which covers solar cycle 23 fully and ascending and maximum phases of solar cycle 24. We also compared the CME numbers with geomagnetic Ap and Dst indices for each cycle separately and found that the fast CMEs show a better correlation with these geomagnetic indices.

Nonthermal Emission Initiating Explosive Solar Eruption Observed by Nobeyama Radioheliograph, RHESSI, and SDO/AIA

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We have investigated a pre-eruption phase of an active region filament which expelled out as a Halo CME. The main eruption accompanied a M-class flare which occurred in 2011 August 4. For this study, we used the Nobryama Radioheliograph (NoRH) 17 and 34 GHz, RHESSI Hard X-ray satellite, and Atmospheric Imaging Assembly (AIA) and the Heliospheric Magentic Imager(HMI) onboard the Solar Dynamic Observatory (SDO). During the pre-eruption phase, clear nonthermal emission was detected in microwaves of NoRH and hard-X-ray of RHESSI. At the moment that the nonthermal emission start, the nonthermal sources appeared at the one edge of the filament structure on a polarity inversion line, and the slowing rising filament structure in AIA 94 underwent a sudden acceleration on its ascendance. And, sequential magnetograms revealed that the positive magnetic field began to cancel out at there at around 4 hours before the nonthermal emission started. These results suggest that the magnetic reconnection at the lower layer, such as tether-cutting process, is a vital trigger which leads the ejective filament eruption.

Proton Enhancements of Solar Cosmic Rays in the Maximum of Solar Cycle 24

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The number of solar proton events registered on satellites are much higher than the number of ground level enhancements (GLEs) recorded on the ground, however, as a rule, GLEs tend to occur more frequently in higher level storms and thus have a considerable radiation impact. The behavior of the cosmic ray intensity at the worldwide neutron monitor network in the events of 2012, when there was a significant increase of the integral proton flux with energies > 100 MeV, namely in the events of January 27, March 7, March 13, and January 23 2012 was analyzed together with the parameters of the interplanetary space. On January 27, 2012 an increase of the neutron monitors (NMs) counting rate of ~2%, coincides in time with a proton increase at the integral intensity recorded onboard the GOES satellite (E>100 MeV) and also with increases at the differential intensities of HEPAD at several high energy channels (>500 MeV). The events in March 2012 occurred under very complicated situation in the interplanetary space. Nevertheless, these events may contain some contribution of solar cosmic rays in the ground level observations.

Source Locations of CME-driven Type II Radio Bursts

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Based on the observation of radio spectrograph, it has been known that there are two kinds of source regions of the type II radio bursts: One is CME leading edge and the other is CME-Streamer interaction region. In this study we have investigated the source regions of the Type II solar radio bursts by using radio imaging data obtained by NRH (Nancay RadioHeliograph). For this, we considered all type II bursts occurred from 2010 to 2014 using NRH and E-CALLISTO at Ireland and Belgium. The radio images are compared with the CME images obtained by SDO/AIA. As a result, we have selected 27 CME-driven type II bursts and classified their source regions into 19 CME leading edge, 5 CME flank, and etc. To interpret our finding, we have a plan to construct 2D Alfvén speed map and inspect the source location of the type II bursts in detail. We will report current status of this study.

The Geo-effectiveness of CME Shocks and Sheaths

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Past studies have found that about a quarter of geomagnetic storms are caused by forward fast magnetosonic shocks, most of them driven by CMEs, and the sheath plasma and magnetic field behind these shocks. Although an important cause of geo-effective events, overall only about 20% of fast-mode shocks have sheath which result in a moderate geomagnetic storm. Therefore, it is important to understand which shock and upstream properties are most effective in creating optimal conditions for the development of geomagnetic storms. To do so, we identify all fast-mode forwards shocks (~100), for which the sheath region resulted in a moderate or intense geomagnetic storm during solar cycles 23 and 24 (1997 - 2015). We find that about half such shocks are shocks propagating into a preceding CME or shocks propagating into the sheath region of a preceding shock. Overall, only a small fraction of shocks propagating through normal solar wind are geo-effective (less than 15%), whereas the majority of shocks propagating through a previous CME are geo-effective. We further discuss the conditions which can result in the formation of southward Bz in the sheath region behind a shock.

Comparison of Three SEP Events on 3 November 2011, 26 May 2012 and 5 March 2013 Originating from Solar Backside Eruptions

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The 3 November 2011 solar energetic particle (SEP) event has attained great interest because the associated solar eruption occurred far behind the east limb at N09E154, yet it produced significant increases of SEP intensity at widely separated spacecraft including those

near Earth. We compare this eruption with two other SEP events: the 26 May 2012 eruption that occurred closer to the west limb at N15W121, suggesting that SEPs might have easier access to Earth, and the 5 March 2013 eruption with a similar source longitude of N10E144 as the November 2011 eruption. The onset of the SOHO/ERNE proton flux increase at Earth of the November 2011 SEP event resembles that of the May 2012 SEP event, but is much faster than that of the March 2013 SEP event. However, the coronal mass ejection (CME) associated with the November 2011 eruption has a lower peak speed (~1200 km/s) than the CMEs associated with the May 2012 (~2600 km/s) and March 2013 (~1600 km/s) eruptions. Therefore, explanations other than the CME speed are needed to account for the differences in the SEP onset rates. The fast initial acceleration of the 3 November 2011 CME might explain the unusually fast onset of SEPs at Earth.

Propagation of Coronal Mass Ejections in Different Solar Wind Conditions

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We selected 20 interplanetary coronal mass ejections (ICMEs) in 2010 for which a unique CME could be identified. The ICMEs were observed by STEREO and SOHO satellite. We identified the interplanetary conditions through which these CMEs propagate, first by looking at in situ data. Then by using SECCHI/HI data and applying a drag based model, we compared the surrounding CME conditions with the in situ ones.

A discussion on the limitation of the data and methods will be given.

Annual Cosmic Ray Events Shown in 14C Data of Tree-rings

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Incoming cosmic rays produce cosmogenic nuclides like 14C in the atmosphere. A produced 14C becomes 14CO2 and is taken up by tree-rings. Then, 14C contents in tree-rings record the past cosmic ray intensities.

Recently, annual 14C increase events due to a rapid increase of the incoming cosmic rays have been found. The cause of these 14C events is considered to be extreme Solar Proton Events (SPEs). We will present about the 14C events and their cause in detail.

Stealth CMEs and Stealthy Geomagnetic Storms

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We sometimes encounter coronal mass ejections (CMEs) whose low coronal signatures are apparently missing, especially when viewed on disk. They are called stealth CMEs, which are usually slow and diffuse. Some of them have resulted in appreciable geomagnetic storms. It is also not uncommon that we cannot readily find in coronagraph data the CME that has resulted in an ICME (and a geomagnetic storm when strong and sustained southward

magnetic field is present). There are cases where the geomagnetic storm is likely related to a high speed stream but it is not clear if the solar wind disturbance in question is free of an ICME that should originate from a solar eruption. Some of these "problem" events have been studied as part of the effort of the Campaign Events Working Group of ISEST, one of the four elements of the SCOSTEP/VarSITI program. We summarize our recent analysis of stealth CMEs and stealthy geomagnetic storms, and address the following questions. How can further processing of SDO/AIA images reveal eruptive signatures in what initially appeared to stealth CMEs? What do STEREO COR-1 data tell us about the CMEs that are expected from ICMEs but are not detected in LASCO data? What is the effect of the adjacent coronal hole on a relatively weak eruption at its birth and propagation in the heliosphere?

X-ray Emission in Simulations of Flaring Coronal Loops.

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Solar flares are associated with intense X-ray emission generated by hot plasma and by energetic particles, and are often related to twisted flux-ropes in the corona. I will address the flaring of twisted flux-ropes by means of numerical 3D MHD simulations which use state-of-the-art numerical codes.

I will discuss the temporal, spectral and spatial evolution of the properties of the X-ray emission produced in simulated kink-unstable magnetic flux-ropes (using MHD and test-particle methods). The numerical setup used consists of a highly twisted loop embedded in a region of uniform and untwisted background coronal magnetic field. The magnetic flux-rope reconnects with the background flux after the triggering of the kink instability and is then allowed to relax to a lower energy state. Strong ohmic heating leads to strong and quick heating (up to more than 15 MK), to a strong peak of soft X-ray emission and to the hardening of the thermal X-ray spectrum. Particles are accelerated in all the flaring loop volume, but the associated synthetic hard X-ray emission is concentrated near the footpoints. The amount of twist deduced from the thermal X-ray emission alone is considerably lower than the maximum twist in the simulated flux-ropes. The flux-rope plasma becomes strongly multi-thermal during the flaring episode, and the emission measure evolves into a bi-modal distribution as a function of temperature during the saturation phase, and later converges to the power-law distribution during the relaxation/cooling phase.

About Solar Cosmic Ray Dynamics

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About 30 percents of large flares are accompanied by pulses of relativistic protons. The time of proton emission from a flare is not longer than the flare X-ray emission (20 -30 min), but the duration of the proton pulse recorded at the Earth's orbit may be several days - the time of solar wind propagation from the Sun to the Earth. It does not appear to be any difference in the form of a decaying part of the proton events generated by the western and eastern flares. However, there is a fundamental difference between fronts of the proton events of the western and eastern flares recorded at the Earth's orbit. The fronts of the western proton flux are steep outbreaks. The rise time of western flares does not exceed several tens of minutes, and the particles begin to register with a delay of no more than the time of flight of

the particles with their velocity. The eastern flares demonstrate the sloping fronts of proton flux. Their fronts may exceed ten hours. Archimedes magnetic field lines are responsible for the different structure of eastern and western fronts of proton pulses. The GOES spacecraft is situated at the noon meridian. The proton flux front from western flare can arrive to the GOES along magnetic field line without collisions. Apparently, these protons can excite beam instability, and the velocity of following particle is dropped. Protons from the eastern flares can arrive to the GOES only across the magnetic field lines.

New Insights into the Origin and Evolution of CMEs

Roussev I.
National Science Foundation, USA

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 heliospace they drive shocks, 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 Coronal Mass Ejections 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.

The Very Slow Solar Wind: Properties, Origin and Variability

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Solar wind slower than 300 km/s, hereafter termed very slow solar wind (VSSW), is seldom observed at 1 AU. It was, however, commonly measured inside 0.7 AU by the two HELIOS spacecraft, particularly during solar maximum. Magneto-Hydrodynamic (MHD) modeling reveals that the disappearance of VSSW at 1 AU is the result of its interaction with faster solar wind. The acceleration and compression of the VSSW contributes to the observed highly variable structure of the slow solar wind at 1 AU. The VSSW usually contains the heliospheric plasma sheet and current sheet. It has higher density and lower temperature than the regular slow solar wind, extending the known scaling laws below 300 km/s. Its helium abundance increases with solar activity even more significantly than the slow solar wind. Contrary to faster solar winds, the helium ions in the VSSW are slower than the dominant protons. Combining a Potential Field Source Surface (PFSS) model with ballistic back-tracing, we study the source region of the VSSW. We show that the proton density flux for the VSSW is much higher than for the faster winds, particularly at solar maximum.

Extreme Solar Storm Based on Solar Magnetic Field

Schmieder B., Aulanier G.
LESIA, Observatoire de Paris

Many questions have to be answered before understanding the relationship between the emerging magnetic flux through the solar surface and the extreme geoeffective events.

h Which threshold determines the onset of the eruption ?

h Which is the dominant mechanism of energy release ?

h What is the upper limit in energy for a flare ?

h What is the role of twist and stress of the emerging magnetic field ?

Based on observations and theory, we will review the main ingredients for getting X ray class flares and large Interplanetary Corona Mass Ejections: the built up of the electric current, the maximum flare free energy, the magnetic helicity role in the active region.

Using the observations of previous solar cycles, we will define the upper limit of solar flare energy in our era and the possible chances to get a super-flare.

How Extreme Can Solar Events Be ?

Shibata K.
Kyoto University

The total energy of a solar flare is typically 10^29 - 10^32 erg, whereas there are much more energetic flares (10^33 - 10^38 erg) in stars, especially in young stars with rapid rotation. These are called superflares. Recently, Kepler observations revealed that superflares with energy of 10^34 – 10^35 erg occur with frequency of once in 800 – 5000 years on Sun-like stars with slow rotation, which are similar to our Sun (Maehara et al. 2012, Shibayama et al. 2013). These superflares are usually associated with large spots with area A = 10^3 – 10^5 in unit of one millionth of solar hemisphere, much larger than normal sunspots (with area A= 100 – 1000) on the Sun. Spectroscopic observations by Subaru telescope confirmed that some of the Sun-like stars have actually large spots and slow rotation (Notsu et al. 2015). It has become clear that superflares can occur on slowly rotating Sun-like stars because very large star spots can be generated in these slowly rotating stars, though frequency is very small. These recent stellar observations suggest that superflares with energy of 10^34 – 10^35 erg (100 – 1000 times of the largest solar flares) may occur on the Sun with frequency of once in 800 – 5000 years (Shibata et al. 2013, Nogami et al. 2014). We shall discuss what would happen in the solar corona, solar wind, and the Earth if such superflares would really occur on the Sun.

Relationship of Solar Wind and Interplanetary Magnetic Field with Cosmic Ray Modulation.

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Galactic cosmic rays are modulated through their propagation in interplanetary medium by the effect of large scale disturbances in sun related interplanetary medium.medium. Often the interplanetary parameters used in modulation are solar wind velocity V and interplanetary magnetic field B. For this study, we have used the monthly, quarterly, half yearly and yearly mean values of solar wind velocity and IMF B for the period of 1996 to 2011,covering the

solar cycle 23 and ascending phase of solar cycle 24.The analysis brings out the long-term characteristics of changes in galactic cosmic rays. A negative and normal correlation exists between cosmic rays and solar wind velocity on long-term basis. Correlative analysis has been done for the set of data series (CRI and Vsw) for different phases of solar activity cycle. All the epochs of solar activity cycles show normal and negative e correlation. Product values of B.V for different periods show better correlation than for only for solar wind velocity or IMF alone. It is also investigated that product B.V is more important in producing enhancement in geomagnetic field variations.Analysis indicates a significant role of IMF B along with solar wind velocity in cosmic ray modulation process. It is suggested that electric drift is the basic cause of the observed solar modulation of cosmic rays on long-term basis.

Deflection of High-speed Solar Wind Streams from the Radial Direction Caused by Interaction with Transients in the Solar Corona

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Analysis of interaction between different coronal structures of solar wind (SW) sources in the solar corona is important for improving methods of forecasting for all types of SW streams. Several cases of considerable discrepancy between the forecasted and observed at 1 AU (spacecraft ACE) positions of recurrent SW streams in the 24th solar cycle were analyzed. Such discrepancy can be detected in profile (in magnitude of the SW speed) and in the arrival time of the SW stream. Possible reasons for this discrepancy related to the position and magnetic configuration of the sources of high-speed and transient SW streams in the solar corona were considered. It was found that deflection of high-speed SW streams produced by high-latitude coronal holes (CHs) aside from the ecliptic plane could be caused by interaction with transient streams originated in active regions located between CH and the solar equator. The arrival of high-speed SW stream up to two days earlier the forecast may be associated with the SW stream deflection to the West from the radial direction caused by interaction with the transients whose magnetic field lines adjoining to the CH are parallel to the lines of high-speed SW stream from the CH.

Identification of Coronal Origins of Interplanetary Coronal Mass Ejections Using Plasma Ion Composition Data

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Interplanetary coronal mass ejections (ICMEs) are the most geoeffective solar wind (SW) transients produced by spontaneous solar activity. Investigation of relationship between properties of coronal sources and types and parameters of ICMEs is important for overall modeling of ICMEs and forecasting of their geoefficiency. Commonly, identification of

coronal origins of ICMEs is based on kinematical and magnetic properties of SW transients, such as enhanced magnetic field strength, declining velocity profile and depressed proton temperature, but due to unknown evolution of these parameters in the corona and heliosphere, the result often is ambiguous. In addition to ordinarily considered empirical relations (flare/CME/ICME), for identification of the ICME coronal sources it is promising to use a physical relationship between the measured "in situ" ion composition of SW transients and ionization state of the coronal plasma in the supposed activity events. In the report, we present a statistical analysis of the ICME parameters identified in 24th solar cycle, properties of their probable coronal sources containing in various databases (ISEST database list, Demon and CACTUS databases, etc.) and consider a relationship between plasma parameters in the source and ion composition of ICME. The results obtained for 24th cycle are compared with those established earlier for the preceding cycles at different levels of solar activity.

Current Helicity and Magnetic Field Anisotropy in Solar Active Regions

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The electric current helicity density contains six terms, which are various combinations of derivatives of magnetic field component. Due to the observational limitations, only four of the above six terms can be inferred from solar photospheric vector magnetograms. By comparing the results for simulation we distinguished the statistical difference of above six terms for isotropic and anisotropic cases. We estimated the relative degree of anisotropy for three typical active regions and found that it is of order 0.8 which means the assumption of local isotropy for the observable current helicity density terms is generally not satisfied for solar active regions. Upon studies of the statistical properties of the anisotropy of magnetic field of solar active regions with latitudes and with evolution in the solar cycle, we conclude that the consistency of that assumption of local homogeneity and isotropy requires further analysis in the light of our findings.

Exceptions from the Rules – 'problem' CMEs

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Coronal mass ejections (CMEs) which are directed towards Earth, may cause severe geomagnetic storms as their embedded magnetic fields and shocks ahead compress and reconnect with the Earth's magnetic field. Statistically seen, CMEs are strongly related to flare emission, giving evidence of magnetic reconnection processes leading to the fast eruption of the system. Due to simple magnetic field reconfigurations, CMEs may leave the Sun without a noticeable trace, making them hard to detect. On the other hand, high-energetic flares may not at all be related to eruptive events. Obviously, the magnetic field configuration plays an important role in the initiation and early evolution of CMEs. During interplanetary evolution, CMEs are subject to variations in their kinematics because of the ambient

conditions. Besides the drag force owing to the solar wind, multiple CMEs and solar wind high-speed streams may strongly change the propagation behavior of a CME. All these parameters make Space Weather forecasting a very complex and difficult task.

In this talk we identify "problem" CME/flare events and discuss the cause of failed predictions.

Relation of the Pc Index to the Solar Wind Parameters and to Magnetic Disturbance Indices Al and Dst in Course of Magnetic Storms

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Relation of the PC index to the solar wind parameters (Vsw, By, Bz, Pd, Ekl) and to the magnetic activity indices AL and Dst was analyzed for 564 magnetic storms observed in 1998-2015. Correlation between the smoothed solar wind parameters and magnetic activity indices was examined within interval (T0±48 hours), where T0 is the moment of magnetic storm maximal intensity. The smoothed indices and solar wind parameters have been derived using the boxcar average of 30 min width which is optimal for analysis. Results of statistical analyses have demonstrated that the PC index is guided, with delay time ΔT=20-30min, by the interplanetary electric field Ekl. On the other hand, the PC behaviour predetermines the substorms and magnetic dynamics in the better way than Ekl field. The magnetic disturbances start to develop as soon as the PC index steadily exceeds the threshold level of 1.5 mV/m. The linear correlation between the PC and magnetic activity indices is typical of substorms and storms of any power, the delay time values in particular events being controlled by the PC growth rate (dPC/dt). The relationship between the PC and AL (Dst) indices seems to be independent on magnetic storm driver (CME or CIR). The maximal storm intensity (DstMIN) follows the PC index maximal value (PCMAX) with time delay of ~ 1hour, the values PCMAX and DstMIN being linearly correlated. The conclusion is made that the PC index can be used as a reliable ground-based means for monitoring and nowcasting the magnetosphere disturbances.

Understanding the Earth's Space and Atmospheric Environment and its Response to Solar Inputs

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The Sun affects the Earth's space and atmospheric environment in several ways: through solar photons, energetic particles accelerated in interplanetary space at Coronal Mass Ejection (CME) fast shocks, and through magnetic reconnection between intense southward interplanetary magnetic fields and the Earth's magnetopause northward magnetic fields. Magnetic storms at Earth are caused by ICMEs and their upstream sheaths during solar maximum and by Corotating Interaction Regions (CIRs) during the declining phase of the solar cycle. High speed streams proper cause High Intensity, Long Duration Continuous AE Activity (HILDCAAs) that can last days to weeks.

One topic generally not discussed in space weather is kinetic energy transfer by solar wind pressure pulses onto the magnetosphere. A new finding has shown that this energy transfer forms magnetospheric plasma waves, which throough a chain of processes may lead to climate change. This will also be discussed if time permits.

An Investigation of Solar Radio Bursts on Ionospheric Total Electron Content

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Solar transients events such as Coronal Mass Ejections (CMEs) and solar flares represent the cause of various aspects of space weather and can impact the modern man made technological system. Such solar transients are often associated with solar radio bursts (SRBs), particularly of type II and III that, at ground level can be detected by the CALLISTO (Compact Astronomical Low-frequency Low-cost Instrument for Spectroscopy and Transportable Observatories) solar spectrometer. The present study aims at investigating solar flares and associated SRBs impact on the ionospheric total electron content (TEC). SRBs data used are dynamic spectra covering the 2014-2015 period and detected by the CALLISTO instrument that is installed at the university of Rwanda, Kigali. To investigate ionospheric impact, we use TEC data from IGS stations located at almost the same universal time zone, and correlate the observed TEC changes to the corresponding observed solar bursts events. Preliminary observations resulting from this study indicate a slight enhancement in TEC during the burst event days. The observed TEC enhancement on the burst day can be associated to increased UV and X-rays radiations and particle acceleration that are associated with SRBs events. This still ongoing research work is expected to contribute on more understanding of the geo-space impact of solar transients phenomena for a better modeling and prediction.

Heliospheric Drivers and their Impact on Geomagnetic Storm Generation

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Study of the large-scale structure of the solar wind (SW) plays the key role in the space weather investigations because they can contain the southward component Bz<0 of interplanetary magnetic field and be geoeffective. We describe the average temporal profiles of plasma and field parameters in the disturbed large-scale types of solar wind [Yermolaev et al., 2015]: corotating interaction regions (CIR), interplanetary coronal mass ejections (ICME) (both magnetic cloud (MC) and Ejecta), and Sheath as well as the interplanetary shock (IS) on the basis of OMNI database and our Catalog of large-scale solar wind phenomena during 1976–2000 (see website ftp://ftp.iki.rssi.ru/pub/omni/ and paper [Yermolaev et al., 2009]) and our Method of double superposed epoch analysis [Yermolaev et al., 2010]. We present empirical relations between plasma and field parameters in the heliosphere and measured Dst and pressure-corrected Dst* indices. The highest geoeffectiveness (probability to generate magnetic storm) is observed for MC while the highest efficiency (generation stronger magnetic storm at the same interplanetary parameters) is observed for Sheath and CIR. We discuss solar cycle variations of geoeffectiveness and efficiency of different drivers.

The work was supported by RFBR project 16-02-00125 and by Program of Presidium of RAS.

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Yermolaev, Y. I., et al., (2010), Ann. Geophys., 28, pp. 2177–2186.
Yermolaev, Yu. I., et al., (2015), J. Geophys. Res. Space Physics, 120, doi:10.1002/2015JA021274.

A Tale of Two Super-active Active Regions: on the Magnetic Origin of Flares and CMEs

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From a comparative study of two super-active active regions, we investigate the physics origin of CMEs and flares. NOAA AR 12192 is one of the largest active regions in the recorded history with a sunspot number of 66 and area of 2410 millonths. During its passage through the front disk from Oct. 14-30, 2014, the active region produced 93 C-class, 30 M-class and 6 X-class flares. However, all six X-class flares are confined; in other words, none of them are associated with CMEs. This behavior of low-CME production rate for such a super active region is rather peculiar, given the usual hand-on-hand occurrence of CMEs with flares. To further strengthen this point, we also investigated the super-active NOAA AR 11429, which had a sunspot number of 28 and area of 1270 millionths. During its passage from March 02-17, 2012, the active region produced 47 C-class, 15 M-class and 3 X-class flares. All three X-class flares were accompanied by CMEs, and the same for most M-class flares. Through a careful study of the magnetic configuration on the surface and the extrapolated magnetic field in the corona, we argue that the generation of flares largely depends on the amount of free energy in the active region. On the other hand, the generation of CMEs largely depends on the complexity, such as measured by magnetic helicity. Further, the super strapping effect of overlying magnetic field may play a role of preventing the eruption of unstable magnetic flux ropes.

Long-term Variation of the Sun and Climate

The Role of the Heliospheric Current Sheet in the Geomagnetic Activity Floor

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Observable strong depressions of the Earth's magnetic field, known as geomagnetic storms, which are indicator for changes in the near-Earth space plasma parameters, are caused mainly by transient Interplanetary coronal mass ejections (ICME) and High speed solar wind streams (HSS). However, even in the absence of these two manifestations of the solar activity, when our planet "floats" in the relatively "quiet" space, there are still geomagnetic disturbances. The occurrence of these disturbances probably depends on the properties of the slow solar wind (SSW), which originates from regions near equatorial coronal streamers, fast solar wind (FSW) coming from polar coronal holes and conditions inside the magnetosphere. The influence of the first two on the geomagnetic activity floor is modified by the heliospheric current sheet (HCS), more precisely the position of the Earth relative to the HCS. This position is determined by the fact that the angle between the equator of the Sun, and the plane of the Earth's orbit is approximately 7,2o and also that HCS's warp is directly related to the solar activity. Considering the ICME and HSS free periods for the last four solar cycles, this report show that the role of HCC in the geomagnetic activity floor is significant, especially during solar minima, when almost all the time the Earth is shielded by it.

Development of Climate of the Upper Atmosphere and Ionosphere and the Role of Sun

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The climate of the upper atmosphere and ionosphere changes in response to increasing atmospheric concentration of greenhouse gases. However other drivers like long-term changes of solar and geomagnetic activity, secular change of the Earth's main magnetic field, or evolution of ozone layer play some role as well. Long-term changes in some parameters have also immediate practical impact like increase of concentration of space debris at LEO satellite orbits due to decreasing thermospheric density. Scenario of global change of the upper atmosphere and ionosphere will be presented, some recent results will briefly be described including those reached within project ROSMIC/VarSITI, and open questions and tasks for future research, particularly in relation to VarSITI, will be mentioned.

A Reconstruction of Infrared Radiative Cooling of the Thermosphere over the past 70 Years – Implications for Long-term Solar Variability

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We have reconstructed the global infrared energy budget of the thermosphere over the past 70 years. The reconstructions are based on measurements of infrared cooling by the SABER instrument on the NASA TIMED satellite. Standard solar and geomagnetic indices (F10.7, Ap, and Dst) are used in multiple linear regression fits to the observed SABER cooling rate time series. Extant databases of the solar and geomagnetic indices from 1947 are used to reconstruct the time series of radiative cooling by carbon dioxide and nitric oxide. This reconstruction allows us to examine the variability of the energy budget of the thermosphere over five complete solar cycles (19-23) and part of cycle 18. We find that the total infrared energy radiated by the thermosphere is remarkably constant from one solar cycle to the next. The mean reconstructed infrared power is 3.904 ± 0.26 e+15 W over the five complete solar cycles. The standard deviation of the power (0.26 e+15 W) is less than 7% of the mean. The small differences in radiated power from one solar cycle to the next imply that the variability in "geoeffective solar energy" is less than 7%. These results imply that, from the perspective of the thermosphere, and the energy deposited within it, that solar cycles are perhaps not that much different from one to the next. We also examine the relationship between peak sunspot number and peak radiative cooling, and find no consistent relationship between the times of occurrence of these two events.

Long-term Evolution of Solar Wind: Implications to Sun and Earth

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The properties of the solar wind have been directly measured by satellite observations since the early 1960s, thus covering only the declining phase of the Grand modern maximum (GMM) of solar activity. The information on the properties of solar wind in the earlier decades is based on different indices of geomagnetic activity. There are several independent series of observations from the early 1900s onwards, yielding a fairly reliable view of solar wind over the whole GMM. Geomagnetic activity is mainly produced by coronal mass ejections (CME) and high-speed solar wind streams (HSS). While CMEs cause the most dramatic individual storms, HSSs are the most effective long-term driver of magnetospheric energetic particles. The occurrence of CMEs and HSSs vary differently over the solar cycle, but also in the long-term. While CMEs had their long-term maximum during the maximum of cycle 19, HSSs were most frequent in the declining phase of the previous cycle 18, in a good agreement with the prediction based on the Ω-mechanism of solar dynamo.

The new long-term information also allows interesting possibilities to more reliably study the long-term evolution of solar effects in the Earth's atmosphere and climate. E.g., there is evidence that processes related to HSSs may modulate regional/hemispheric climate patterns, in particular the NAO/NAM oscillation. We review the different approaches used to obtain information on the centennial solar wind, as well as their suggested atmospheric and climatic effects.

Long-term Solar-stellar Magnetic Variability and its Impact on Planetary Environments

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The magnetic activity of stars such as the Sun exhibits variability on a wide range of timescales. This variability influences their space environment and forces planetary atmospheres. Most of our understanding of this intimate relationship between parent stars and planets that they host is based on studies of our own solar system. Here we will discuss the physical pathways through which magnetically active stars modulate planetary environments and highlight efforts to understand the long-term variations of the stellar dynamo mechanism that powers solar and stellar magnetism.

Solar Activity in the Following Decades Based on the Results of the ISSI/VarSITI Forum on Future Evolution of Solar Activity, 01.03-03.03.2015 ISSI, Bern, Switzerland

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A brain-storming forum jointly organized by the International Space Science Institute (ISSI) and the SEE/VarSITI project was held in Bern to assess the future evolution of solar activity in the following decades. After 3 days of very passionate discussion, we arrived at some conclusions: We expect that the next two cycles will not be higher than cycle 24, with cycle 25 of the same height or lower than cycle 24, and cycle 26 maybe even lower, but a grand Maunder type minimum is not expected. The absence of the polar branch of "torsional oscillations" and predominant activity in the southern hemisphere point at some probability of a Dalton type minimum. High correlation is observed between the polar field at the cycle minimum and the height of the following cycle. It may be due to the solar dynamo operating in the diffusion-dominated regime. The prediction of the polar field is complicated by the fact that most dynamo theories include stochastic effects (due to the tilt angle scatter, fluctuations in the meridional circulation, nonlinear chaos, and poleward surges of abnormal polarity) which is hard to include into modeling. We agree that the assimilation of data on the surface flux transport can reliably predict the polar fields years in advance. But the stochastic variations in supergranular flows and the tilt of emerging active regions make long-range predictions (more than a cycle into the future) based on direct observation of predictors unreliable. The use of periodicities of different type could prolong the prediction term.

Long-term Variations and Trends in the Polar Ionosphere and Thermosphere

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Theoretical models and observations have suggested that the increasing greenhouse gas concentration in the troposphere causes the upper atmosphere to cool and contract. However, our understanding of the long-term trends in the upper atmosphere is still incomplete, due to a limited amount of available and well-calibrated data. The European Incoherent Scatter

(EISCAT) radar has gathered data in the polar ionosphere above Tromsø, Norway since 1981. Using this long-term data set, we have estimated long-term variations and trends in the polar upper atmosphere. For examples, estimated trends of ion temperature indicate a cooling of 10–15 K/decade near the F region peak (220 –380 km altitude), whereas above 400 km the trend is nearly zero or even warming. The height profiles of the observed trends are close to those predicted by atmospheric general circulation models. In this paper we report recent observational results of the long-term variations and trends of the polar ionospheric parameters based on the EISCAT data analysis, and discuss plausible mechanisms underlying the variations and trends.

Centennial Gleissberg Cycle as a Driver of Climate Change

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At the beginning of the 21st century the Earth's global temperature trend decreased leveling almost to a plateau, called the climate hiatus. One of the potential contributors to this climate change could be the extended, deep minimum of solar activity associated with the low solar irradiance input to the Earth. The current extended, deep minimum of solar variability and the extended minima in the 19th and 20th centuries (1810-1830 and 1900-1920) are consistent with minima of the Centennial Gleissberg Cycle (CGC), a 90-100 year variation of the amplitude of the 11-year sunspot cycle observed on the Sun, solar wind, and at the Earth. The CGC has been identified in the Total Solar Irradiance reconstructed for over three centuries. The Earth's climate response to the prolonged low solar irradiance involves heat transfer to the deep ocean with a time lag longer than a decade. The CGC minima, sometimes coincidently in combination with volcanic forcing, are associated with severe weather extremes. Thus the 19th century CGC minimum, coexisted with volcanic eruptions, led to especially cold conditions in United States, Canada and Western Europe. However the timing and spatial pattern of the Earth’s climate response allows distinguishing the CGC forcing from other climate forcings.

Long–term Variation of the Sun as a Result Independent Activity of the Northern and Southern Hemispheres in 12-24 Cycles.

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We showed the basic properties of the cycles based on the application of wavelet analysis of daily e values of indexes of the North (N) and South (S) hemispheres: WN, WS (the Wolf number), SpN, SpS (summary of sunspots groups) in comparison with data for all solar disk .

We received the main data 12-24 cycles: the start and end time, increase phase, maximum and decrease phase, global Wavelet spectra, prevailing processes of cycle formation, time of their existence, spotless periods. We showed the difference of these indicators for the studied indexes. On the basis of the daily index values we identified features of alternating predominance of activity of the northern and southern hemispheres.

Application of the method of bandpass filtering results of wavelet analysis allows differentiating between the all cycles. The results obtained can be the basis for forecasting solar activity and should be taken into account in the theory of the formation and development of the activity cycle.

The Historical Variability of Solar Irradiance

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The Sun is a variable star whose magnetic activity and brightness change with time. The quasi-periodicity of the solar activity was noticed already in the 19th century when the 11-year activity cycle was discovered. At the same time the variations of solar irradiance are so subtle that all attempts to detect them with the ground-based instrumentation were inconclusive. Only since the advent of spaceborne measurements in 1978 was it established that solar irradiance varies on timescales from minutes to decades. Despite significant progress our understanding of solar irradiance variability is still incomplete. In particular, the magnitude of solar irradiance changes on centennial and longer timescales remains highly controversial. Also the magnitude (in the UV part of the spectrum) and even the phase (in the visible part of the spectrum) of the solar irradiance variations over the activity cycle are uncertain.

We give an overview of the long-term reconstructions of solar irradiance published over the last decade and discuss their similarities and differences. We examine the main sources of uncertainty in reconstructing the solar irradiance to the past and discuss observational programs which can help to constrain the estimations of solar long-term variations. We compare the reconstructed solar variability with the records of stellar photometric variability.

Solar Magnetic Field and Small-scale Dynamo

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Mean-field dynamo based on jint action of differential rotation and mirror-asymmetric convection creates magnetic field with cycliuc behaviour. There is however another kind of dynamo, namely small-scale one, which produces non-cyclic magnetic field. We discuss possible observational tracers for solar small-scale dynamo and relative contributions of both dynamos in solar magnetic field.

Solar Activity and Local Climate in the Zone of Karst Massifs

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The sun is the main source of energy for the Earth’s atmosphere and physical processes there. The mechanisms of solar-terrestrial interactions and transmission of energy in the chain Sun - magnetosphere - ionosphere have been studied quite detailed. Over the past 30 years it has been obtained data on the change in global temperature of the Earth's atmosphere across the entire spectrum of heights.

We propose version of the study of these interactions using surface air temperatures over the territory of Karst massifs with considerable depth. We use data from 4 standard meteorological stations in the period of 1968-2015. The relationship of average surface air temperature and solar and geomagnetic activity is shown. This relationship is probably connected to the internal dynamics of the ground atmospheric layer and the dynamic exchange of air masses with the cracks system of the open and covered surface of the Karst massif. The role of atmospheric pressure and fronts as generators of this process are discussed.

Atmospheric Response to Global Lightning Activity Affected by Decadal-scale Solar Variability – Model Estimations

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The global electric circuit (GEC) is considered as a mediator on decadal time-scale between solar variability and atmospheric processes related to formation of weather and climate. Downward fair-weather electric current Jz, as well as the related vertical field Ez and spatial charge density r in different atmospheric regions, and their correlation with solar activity on decadal time-scale are studied. In troposphere these correlated characteristics are responsible for storm development and energy redistribution through nucleation process in clouds based on electroscavenging which is controlled by Jz variations on decadal scale. At strato- and mesopshere variations of Jz and Ez may also have effects, for example, dust charging. We propose model estimations of decadal-scale changes of Jz, Ez and r forced by solar variability, together with their typical variations on much smaller time-scale accounting for separate lightning discharges in GEC. First, effect on solar variability on Jz, Ez and r realized through changes of stratospheric conductivity in GEC is examined. Then, effects of global lightning activity on Ez at different altitudes are estimated on sub-second time-scale. The respective superimposed Ez variations are consistent with transient response of ionospheric potential on global lightning activity, as well as its local response to lightning discharges in magneto-conjugated and antipodal regions. While in troposphere the response of Ez to global lightning activity is rather small, in mesosphere this response can lead in some cases to electric fields of the order of V/m (similarly to results obtained experimentally).

Long-term Solar Signals in the North Temperate Climate from Reanalysed Data

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Effects of solar variability in the climatic parameters (temperature, precipitation, etc.) from reanalyzed database NCEP/NCAR (1948-2014) and the recently developed 20th Century Reanalysis (1851-2014) have been investigated and compared. Our previous analysis showed the existence, at specific levels in atmosphere, of solar signals at Schwabe (11 years) and Hale (22 years) solar cycles timescales in the reanalyzed data from NCEP/NCAR database, with a more pronounced 11-year signal in the troposphere, and an important 22-year signal in the stratosphere. In this study features of these signals will be discussed on various spatial scales of the Northern Hemisphere and at specific levels in troposphere and stratosphere.

Influence of External and Internal Climate Factors on Regional Surface Temperatures

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External factors, such as the Academy of Sciencesatmospheric CO2 content, the volcanic emissions and the solar activity, as well as internal factors, such as the Atlantic multi-decadal oscillation, the Pacific decadal oscillation, the Northern Atlantic oscillation and the El Niño-Southern oscillation have been identified as the most important climate forcings by linear regression. The influences of these factors on the land-ocean, land and ocean surface temperatures at regional scales were determined using the Metoffice gridded temperature data sets HadCRUT4, Crutem4 and HadSST3. The obtained results suggested different feedback mechanisms in dependence of the studied geographic regions.

Two Principal Components of Solar Magnetic Field Variations and their Prediction on Multi-millennium Timescale

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Frequencies of solar own oscillations in time and latitude are derived from the solar background magnetic field measured from synoptic maps at Wilcox Solar Observatory (USA) in solar cycles 21-23 using Principal Components Analysis (PCA)and classified with symbolic regression analysis using Hamiltonian method. PCA reveals 4 pairs of magnetic waves with significant variance and the two principal components with the highest eigen values covering about 40% of the total variance. The summary curve of the two PCs is shown to resemble the average sunspot number curve for cycles 21-23 and can be used as a new proxy of solar activity. The summary curve extrapolated backward for 3000 years and forward for 1200 years reveals the occurrence of 350-400 year grand cycles and super-grand cycles of 1900-2000 years superimposed on 22-year cycles. The summary curve calculated for the next millennium predicts further three grand cycles with the closest grand minimum (Maunder minimum) occurring in cycles 25-27. We discuss a role of the 3 other pairs of magnetic waves in shaping the solar activity and compare our predicted curve with the previous predictions of the solar activity on a long timescale based on the terrestrial proxies. These grand cycle variations are probed by Parker's two layer dynamo model with meridional circulation formed in two cells of the solar interior.

Understanding the Earths space environment and its connection to space weather

On the Use of Total Electron Content as Index of Ionospheric Response to Magnetic Activity over Nigeria within Equatorial Anomaly

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GPS measurements simultaneously recorded in year 2011 at five Nigerian stations ranging between 4.80 and 12.40 geographic latitude within the equatorial anomaly region, were analysed to obtain the total electron content (TEC) values. The TEC was used to as index to investigate the local ionospheric response to magnetic activity. Different magnetic activities such as low (Dst > -20nT); medium (-20nT > -50nT); high (-50nT >DA-100nT), and extreme (Dst < -100nT) were identified with specific ranges of TEC values. The variability of this TEC index with hours and seasons were investigated. TEC index has some levels of correlation with existing universally adopted magnetic indices. Measured TEC could serve as proxy for monitoring ionospheric responses to magnetic activity in Nigeria. Possibility of extending this measure at regional levels were explored.

The 3D Structure of CMEs - Implications for Space Weather Forecasts

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This presentation will review the 3D structure of CMEs near the Sun as deduced from multipoint space observations with SOHO and STEREO. The conclusions will provide implications on state-of-the-art challenges for reliable space weather forecasts in terms of CME arrival times, L1 speeds and magnetic field configurations.

Response of the Dip Equatorial Lower-thermosphere-Ionosphere to Intense Space Weather Events

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The response of the Equatorial Electrojet (EEJ) induced geomagnetic field over a dip equatorial station to solar flares of varying strength occurred during different local times has been analyzed. It has been observed that, in general, the EEJ induced geomagnetic field response very rapidly to most of the intense flares, which occurred in different geomagnetic conditions. On an average 30-40 nT enhancement is observed in the geomagnetic field during the solar flares. However, there were extreme cases, which exhibit enhancements as high as ~100 nT. The response time of the magnetic field to the flares found to be varying between 4-50 minutes depending upon the class of the flares, their time of occurrence and the geomagnetic conditions. The extent of the field enhancement is found to be proportional to the intensity of the flare. During morning hours, an average time delay of ~10-15 minutes is observed during the morning flares and average time delay of 15-25 minutes is observed during the noon time. On the other hand, the time delay is found to be minimum during the evening hours (~5 minutes). These findings are discussed in detail in context of the prevailing electrodynamics over the dip equator.

Coherent Seasonal, Annual, and Quasi-biennial Variations in Ionospheric tidal/SPW Amplitudes

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In this study, we examine the coherent spatial and temporal modes dominating the variation of selected ionospheric tidal and stationary planetary wave signatures from 2007 - 2013 FORMOSAT-3/COSMIC total electron content observations using Multi-dimensional Ensemble Empirical Mode Decomposition (MEEMD) from the Hilbert-Huang Transform. We examine the DW1, SW2, DE3, and SPW4 components, which are driven by a variety of in-situ and vertical coupling sources. The intrinsic mode functions (IMFs) resolved by MEEMD analysis allows for the isolation of the dominant modes of variability for prominent ionospheric tidal / SPW signatures in a manner not previously used, allowing the effects of specific drivers to be examined individually.

The time scales of the individual IMFs isolated for all tidal/SPW signatures correspond to a semiannual variation at EIA latitudes maximizing at the equinoxes, as well as annual oscillations at the EIA crests and troughs. All tidal / SPW signatures show one IMF isolating an ionospheric quasi-biennial oscillation (QBO) in the equatorial latitudes maximizing around January of odd numbered years. This TEC QBO variation is in phase with a similar QBO variation isolated in both the GUVI zonal mean column O/N2 density ratio as well as the F10.7 solar radio flux index around solar maximum, while showing temporal variation more similar to that of GUVI O/N2 during the time around the 2008/2009 extended solar minimum. These results point to both quasi-biennial variations in solar irradiance as well as thermosphere / ionosphere composition as a generation mechanism for the ionospheric QBO.

Synchronous Orbit Relativistic Electron Flux One Week Dropout

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A phenomena that >2 MeV electron flux dropped and last 6days had been discovered by multi satellites such as Chinese FY series, Russian Metor-II and American GOES. During the period from 1 February to 6 February 2016, The >2 MeV electron flux from FY2G satellite had declined by more than two orders of magnitude to background levels and remained at the reduced levels for nearly one week . At the time of the flux dropout, the interplanetary conditions had the characteristics with around 400km/s low solar wind speed and less than 10/cc ion density. However 1 February full day Bz was <-5 nT and 3 February more than 10 hour Bz was <-5 nT, they had led to successively two small geomagnetic storms (reaching -50 nT) occurring on 1 February and 3 February respectively. The special response of the Earth's synchronous orbit environment to this type of solar driver had been revealed by multi spacecraft's observation and possible mechanism about the dropout have been also interpreted by some theoretical description. It is demonstrated that there is a one-week high safety period to various space activities near the Earth's synchronous orbit.

Ionospheric Response to the Storm -time Disturbance of 29 May, 2010

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The Ionospheric F2-layer peak parameters response to a magnetic storm had been investigated over Ilorin, Nigeria (Lat. 8:53°N, Long. 4.5°E, dip angle, -2.96°), Jicamarca, Peru (11.95°S, 76.87°W, dip angle, 0.8°) and Hermanus, South Africa (34.42°S, 19.22°E, dip angle, -60.77°), using percentage enhancement/depletion values. Our results showed an enhancement in NmF2 at all of these stations. Averagely, pre-noon and post-noon peaks are highest at Ilorin during quiet time. The similar pattern observed for quiet condition between Ilorin and Jicamarca was due to their latitudinal positions. For disturbed NmF2 condition, Jicamarca and Ilorin recorded higher peaks at nighttime than during the daytime for the storms main phase, and the reverse over Hermanus. The nighttime and daytime increases were observed respectively at Ilorin and Hermanus during the recovery period. The hmF2 variation recorded higher enhancement at Jicamarca during the daytime and at Hermanus at nighttime during the main phase. During the recovery phase, the highest enhancement was recorded during the daytime at Jicamarca, and over Hermanus at nighttime. These observations find their explanation in the magnetospheric current, solar wind and EX B drift.

Recent Advances in the Vertical Coupling in the Atmosphere– Ionosphere System – Review of IAGA WG II C/ICMA/SCOSTEP Activity

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The Atmosphere-Ionosphere system represents very complicated system that is significantly influenced from above and below. It reflects both solar, geomagnetic activity and processes in the neutral atmosphere. Earth's atmospheric regions are intricately coupled to one another via various dynamical, chemical, and electrodynamic processes. The coupling effects can be seen on the modulation of the waves from the lower to upper atmosphere as well as from low- to high-latitudes, electrodynamic and compositional changes, and plasma irregularities at different latitudinal regions around the globe due to the varying energy inputs.

MLT region is one of the key region of coupling. It represents a critical region in various coupling processes between the lower/middle atmosphere and the upper atmosphere/ionosphere since it forms physical processes filter and shape the flux of waves ascending through the mesosphere into the overlying thermosphere. Solar activity represents an important factor that directly or indirectly modulates the coupling processes. Varying energy inputs from the Sun and from the lower atmosphere and its influence on the coupling processes is one of the key issue that is not yet fully answered.

The traditional coupling workshops are held every 2-3 years around the word. These meetings are called to as "Workshops on Vertical Coupling in the Atmosphere-Ionosphere System". They are organized with a substantial support of the scientific international bodies, such as the International Association of Geomagnetism and Aeronomy (IAGA), International Commission for the Middle Atmosphere (ICMA) and Committee on Solar–Terrestrial Physics (SCOSTEP).

Atmospheric Dynamical Responses to Solar-wind-driven Current Density Changes in the Global Electric Circuit

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There is now convincing evidence that weather and climate are influenced in a way that is yet to be recognized and assessed by the Intergovernmental Panel on Climate Change, or included in any General Circulation Model. This underexplored influence involves changes, due to both solar and to thunderstorm-driven modulation, of the global atmospheric electric circuit (GEC). It is well established that magnetic fluctuations from the Sun cause changes in the electric field in the polar ionosphere and consequently of a downward current Jz to the ground. We present results linking these changes to variations in temperature and pressure in the polar troposphere, and to changes in atmospheric planetary wave structure. These effects are large enough to affect weather forecasts but the longer-term climate impacts are currently unknown. The missing link in current understanding is the mechanism by which the downward current affects temperature and pressure. A strong candidate is electrical charging effects on cloud droplet concentrations and size distributions. Droplet distribution is known to affect energy conversions between latent heat and kinetic energy and the partitioning of the short-wave and long-wave radiative transfer. We quantify solar wind/GEC-driven changes in temperature and pressure in the polar troposphere in the presence and absence of local cloud cover observed from the surface, in order to elucidate the potential role of clouds in these phenomena.

Concurrent Responses of the Ionosphere and Thermosphere to Solar Flares

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Solar flare is one of the most extraordinary processes occurring on the Sun, and is also one of the major sources disturbing the Earth's upper atmosphere. Flare effects on the ionosphere have been investigated for decades using rich ionosphere measurements like the TEC, and NmF2, the electrojet, etc. However, examination of its neutral counterpart in the thermosphere has been limited. This talk focuses on the contrasting behavior of the thermosphere and ionosphere in response to solar flares at low latitudes. In particular, coupling and decoupling in their temporal variation and latitudinal structures are compared, and the relative contribution from ionization and electrodynamics processes is discussed.

Scientific Highlights from ROMIC

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The German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) has launched a research initiative in 2013/2014 called ROMIC (Role of the Middle Atmosphere in Climate). The aim of ROMIC is to improve our understanding of long term variations in the stratosphere, mesosphere, and lower thermosphere and to investigate their potential role for climate changes in the troposphere. This includes to study coupling mechanisms between various layers and the relative importance of anthropogenic and natural forcing, e.g., by the Sun. Scientists at a total of 15 research institutes in Germany are involved and cover a large range of experimental and theoretical Topics relevant for ROMIC. Some scientific highlights from the research projects within ROMIC will be presented.

Seasonal and Year-to-year Patterns of Atmospheric and Ionospheric Variabilities over Eastern Siberia

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We investigated seasonal and year-to-year patterns of atmospheric and ionospheric variabilities over Eastern Siberia. The analysis is based on 2008-2015 dataset of mesopause temperature (Tm) obtained from spectrometric measurements of the OH emission (834.0 nm, band (6-2)) at the ISTP Geophysical Observatory (51.8°N, 103.1°E), and the data of F2 peak electron density (NmF2) from Irkutsk DPS-4 Digisonde (52.3° N, 104.3° E). Data on variations of geomagnetic and solar activities were involved in the analysis. Day-to-day and diurnal variations of Tm and NmF2 were analysed. The period range included day-to-day (periods $T > 24$ hrs) and tidal (8 hrs $\leq T \leq$ 24 hrs) variations as well as variations in the internal gravity wave period range ($T < 8$ hrs). Comparative analysis of these variations revealed manifestation of wave activity of various time scales over a wide height range of the upper atmosphere. We revealed significant seasonal changes of Tm and NmF2 variabilities within a year. The comparison revealed both common features and distinctions in the seasonal patterns of the ionospheric and atmospheric variability. In both Tm and NmF2, winter variability is higher than summer one for all the considered period ranges. The largest variability is seen in winter or near-equinox months. High winter variability may be caused by impact of sudden stratospheric warmings on the upper neutral atmosphere and ionosphere. Maxima around the equinoxes may be explained by manifesting of seasonal (springtime/fall) transition of the atmospheric circulation.

The work was supported by Russian Foundation for Basic Research Grant 14-05-92002-HHC_a.

Variations of the 63 Micron Atomic Oxygen Emission in the Upper Atmosphere

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We analyzed and systematized published data on the results of the rocket and balloon measurements of the intensity of 63 micron atomic oxygen emission in the upper atmosphere. Based on these data, we obtained quantitative estimation of the 63 micron emission variations. The dependence of the emission intensity on the solar activity was revealed and analytically described. In the seasonal variations of the 63 micron emission intensity was revealed the summer maximum (~10 %). Diurnal variations from these data were not found.

The work was supported by Russian Foundation for Basic Research Grant 16-05-00120.

Manifestation of the February 2016 Sudden Stratospheric Warming in the Neutral Atmosphere and Ionosphere Parameters

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Minor sudden stratospheric warming (SSW) on February 2016 caused significant disturbances of zonal characteristics of the middle atmosphere of the high and middle latitudes. Comprehensive analysis of the parameters of the neutral atmosphere and ionosphere over Eastern Siberia (52E, 103N) revealed the SSW manifestations in a large height range. For the analysis we used data from spectrometric measurements of the OH (~87 km, 834.0nm, (6-2)) and At O_2 (~94 km, 864.5 nm, (0-1)) emissions, data about ionospheric F2-layer parameters from Irkutsk DPS-4 Digisonde measurements, satellite data from Aura MLS and data on the stratospheric zonal characteristics of MERRA and ECMWF reanalysis. At the MLT heights, unusual nocturnal variations in the intensities of the OH and O_2 emissions, and the OH rotational temperature decrease were revealed.

At the F2-layer peak height significant disturbances of the electron density night variations were found. Possible reasons of the observed effects are discussed.

This study was supported by the Grant of the Russian Scientific Foundation (Project No. 14-37-00027) and RAS Project II.16.1.2.

Latitudinal and Longitudinal Ionospheric Sq Current Response in the African Chain Due to the 2009 Sudden Stratospheric Warming Event

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We present magnetometer data from the Magnetic Data Acquisition System (MAGDAS) horizontal (H) field intensity records in Africa during the period of January and February 2009 which was characterized by an unusually strong, prolonged sudden stratospheric warming (SSW) event. Our results reveal that the hemispheric asymmetry between the northern and southern hemisphere during the pre-warming phase of SSW (with stronger Sq currents in the south due to greater conductivity in summer) is not evident as reported by Yamazaki et al. (2012c). Interestingly, we found a different morphology of Sq current intensity during the SSW peak phase, where the Sq current intensity in the northern hemisphere is significantly stronger than the southern hemisphere. A novel feature of this work is the existence of longitudinal differences at the African magnetic equator during SSW events. The longitudinal variation of ionospheric Sq currents during the 2009 SSW is further demonstrated by comparing the Sq currents at Addis Ababa (AAB) longitude with the Sq

currents at Huancayo (HUA), Trivandrum (TIR), and Phonpei Island (PON) longitudes. One obvious longitudinal feature is that the enhancement and depression of Sq currents are significantly stronger in the South American longitude. No obvious effect of the SSW can be easily seen in the Sq current maximum at PON longitude in all the phases under investigation. In addition, we compare Sq current results with the growth of Equatorial Ionization Anomaly (EIA) in the African chain, and both parameters show consistent variations in the SSW peak phase

Global Distribution and Climatological Variability of Quasi-two-day Waves: Results Based on NOGAPS-ALPHA Reanalysis Model and MLS on the NASA Aura Satellite Measurements

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Quasi-two-day waves (QTDWs) are one of the most important features in the dynamics of the middle atmosphere. They have been intensively studied since recent decades. The primary features of the QTDWs have been revealed from ground-based observations. Although significant achievements have been attained these observations cannot provide insight into the global picture of the QTDW distribution. Satellite measurements can do this however they suffer from aliasing and poor temporal resolution problems. In order to overcome the above mentioned weak points of the satellite observations we employ first NOGAPS-ALPHA reanalysis model that provides output on an hourly basis. It allows for short-term, observationally-based, estimates of tides and planetary waves to be done. We analyze 14 months (January 2009 –February 2010) continuous hourly measurements of all meteorological fields (neutral winds, temperature and geopotential height) for altitudes between ~10 km and ~95 km and latitudes between ±80°. Additional data for January-February, 2005, 2006 and 2008 have been used for tracking out the interannual variability of the QTDWs. The comprehensive understanding of the global spatial QTDW distribution is achieved by simultaneous separations of all tides and considered planetary waves from the free of aliasing hourly reanalysis data. To prove that eastward propagating QTDWs are genuine waves, not products of nonlinear interactions, a new approach for investigating the planetary wave variability is used. The climatological variability of the QTDWs, particularly in the fields of temperature and geopotential height, is studied by the use of the MLS/Aura satellite measurements for the period of time 2005-2012.

Monitoring the High-latitude Ionosphere by Science and Technology Satellite-I of Korea

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Science and Technology Satellite-I (STSAT-1) was the first Korean satellite dedicated to space science and astronomy. It was launched into a Sun-synchronous (local time~22:45) low-Earth orbit (altitude~680 km) on 27 September 2003. An onboard Electro-Static Analyzer (ESA) can measure auroral electron spectrograms. Two Solid State Telescopes (SSTs) in the directions parallel and perpendicular to the geomagnetic field count sub-relativistic electrons (170-360 keV) of the terrestrial radiation belt. Cylindrical Langmuir Probes (LPs) diagnose cold ionospheric plasma at the orbit altitude. Here we investigate various phenomena observed by STSAT-1 in the high-latitude ionosphere: such as polar rain, polar arc, double auroral oval, and polar cap patches. The observation results are discussed in the context of previous studies.

The Correspondence Between Dayside Long-period Pulsations and the Open-closed Field Line Boundary

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Long-period pulsations in the Pc5-6 band (periods about 3-20 min) have been known to be a persistent feature of dayside high latitude electrodynamics. A mixture of broadband irregular pulsations and nar-rowband Pc5 waves is observed often, though there is no well-established criterion to separate these phenomena. The outmost closed field line Alfven oscillations and magnetopause surface eigenmodes were suggested as a potential source of dayside ULF waves at high latitudes. A ground response to these modes is expected beneath the ionospheric projection of the open-closed field line boundary (OCB). To unambiguously resolve the uncertainties regarding mechanism of the dayside high-latitude ULF activity, multi- instrument study using data from Svalbard has been undertaken. We examine local latitudinal structure of high-latitude ULF pulsations recorded by magnetometers covering near-cusp latitudes. This structure was compared with location of the equatorward boundary of the cusp aurora, as identified by automatic algorithm, using data from the meridian scanning photometer at Longyearbyen. This boundary is assumed to be a proxy of the OCB. The comparison has shown that a peak in the distribution of narrowband Pc5 power is located about 2-3 degrees southward of the equatorward cusp boundary. Therefore, narrowband dayside Pc5 wave activity cannot be associated with oscillations of the last closed field lines under the cusp proper, but maximizes inside the auroral oval. At the same time, latitudinal maximum of the broadband long-period pulsations lies in a close vicinity of the OCB proxy. These pulsations could be the ground image of the magnetopause surface modes.

Construction and Validation of ULF Wave Indices as Indicators of Turbulent Energy Transfer into the Magnetosphere

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All existing geomagnetic indices and IMF/SW parameters characterize the steady-state level of the electrodynamics of near-Earth environment. Here we describe the construction, verification and introduction into space geophysics of a new hourly ULF wave index to characterize the turbulent level of the solar wind-magnetosphere-ionosphere system. The ground ULF index in frequency range of the Pc5 band (2-7 mHz) characterizing world-wide ULF activity is derived from 1-min data from array of magnetometers in the Northern hemisphere. A similar wave index is be calculated from IMF/SW data with appropriate time delays to quantify the short-term interplanetary space variability. These wave indices have been calculated since 1991 up to nowadays. A wide range of the space physics studies, such as substorm physics, relativistic electron energization, solar wind-ionosphere coupling, etc. will benefit from the introduction of the wave indices. The index database is freely available via the specially designed website for all interested researchers for testing, validation, and statistical studies.

On the Spatio-temporal Variation of GPS-Measured Total Electron Content over Nigeria within Equatorial Ionospheric Anomaly Region

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This paper examined the spatial and temporal variations of the ionospheric Total Electron Content (TEC) over Nigeria, a country within the equatorial ionospheric anomaly region, using the GPS data obtained from 11 stations of the Nigeria GNSS Network (NIGNET) in the year 2012 during the ascending phase of solar activity. TEC is considered as a proxy to space weather. At sunrise at about 07:00 LT, TEC decreases westwards across all the latitudes. Meanwhile, at about sunset (around 17:00 LT), TEC decreases eastward across all latitudes. This variability pattern is attributed to the depreciation in the ionization due to the relative motion of the earth with respect to the position of the Sun. Daytime TEC value is found to be consistently weakest at sunrise and maximized in daytime at about local noon across all latitudes. Generally, daytime values of TEC are observed to be greater than the nighttime values. Seasonal variation with semiannual pattern gave equinoctial maximum across all latitudes.

Application of the ANFIS Models and Parallel Calculations for Establishing Potential Causal Link Sun-hurricanes

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In this paper we examined the potential causative link between the flow of charged particles that are coming from the Sun and hurricanes. For establishing eventual link, the methods of Big Data, such as Adaptive neuro fuzzy inference system (ANFIS), Parallel Calculations, Fractal analysis etc., are applied. There are nine parameters which are observed as an input, and daily values of the hurricane phenomenon are observed as an output in the period May-October 1999-2013. The nonlinear R/S analysis was conducted to determine the degree of randomness for time series of input and output parameters. The phase shift of 0-10 days was taken into account in the research. It led to growing input parameters up to 99. The problem of finding hidden dependencies in large databases refers to problems of Data Mining. The ANFIS with Sugeno function of zero order was selected as a method of output fuzzy system. The "brute-force attack" method was used to find the most significant factors from all data. To do this about 500 000 ANFIS models were tested on Computer Cluster using Parallel Calculation. Within the experiments, eight input factors were calculated which became the basis for building the final ANFIS models. These models can predict up to 34% of the hurricanes. This means that, if causal link exists, every third penetration of charged particles from coronary hole(s) or/and from the energetic region(s) toward surface can generate hurricanes.

Energetic Particle Effects on the Atmosphere and Climate

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The Earth's atmosphere is under permanent influence of different precipitating energetic particles. Lower energy electrons continuously produce substantial amount of nitrogen oxides in lower thermosphere, which are transported down inside polar vortices during the polar night influencing the ozone in the middle atmosphere. The amount of nitrogen and hydrogen containing radicals in the mesosphere and stratosphere can be enhanced after solar proton events or strong geomagnetic perturbations. Chemical composition of the lower stratosphere and upper troposphere is modulated via several processes initiated by highly energetic particles of galactic origin. All particles affect ozone balance and heating rates in the atmosphere leading to the changes of winds and temperatures in the stratosphere followed by changes of tropospheric climate. Modeling of this chain of processes requires application of complicated numerical models, which include all relevant processes and their interaction. In this review talk I will discuss all involved mechanisms and their representation in the state-of-art models. The simulated atmospheric response to energetic particle precipitation will be presented and compared with the observation data.

Radiation Investigations on the International Space Station: Summary of Results for Years 2007/2015 Obtained with Liulin-5 Charged Particle Telescope

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Since June 2007 the Liulin-5 charged particle telescope has been observing the radiation characteristics in two different modules of the International Space Station (ISS). In the period from 2007 to 2009 measurements were conducted in the spherical tissue-equivalent phantom of MATROSHKA-R project located in the PIRS module. From 2012 to 2015 measurements were conducted in and outside the phantom located in the Small Research Module of ISS. In this paper attention is drawn to the obtained results for the dose rates, particle fluxes and dose equivalent rates in and outside the phantom from the galactic cosmic rays, trapped protons and solar energetic particle events occurred in that period.

Dynamical Perturbations of the Thermosphere Inferred from Satellite Observations of O(1D) Nightglow

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Manifestations of thermospheric dynamics have been observed in the variations of the upper atmosphere density, temperature, neutral winds and F-region plasma over a wide time range. These fields are influenced by perturbations propagating vertically from the lower and middle atmosphere (e.g. tides) and from above through variations in the solar and geomagnetic activity. The Wind Imaging Interferometer (WINDII) flown on the Upper Atmosphere Research Satellite provides multiyear observations of O(1D) nightglow volume emission rates, Doppler temperatures and neutral winds over the altitude range of 150 – 300 km with continuous latitude coverage of 42°N – 42°S. These data are employed in the study of the global and seasonal extent and variability of the thermospheric midnight temperature maximum(MTM), a large scale neutral temperature anomaly with wide-range effect on the nighttime thermospheric dynamics at low latitudes. It is found that the MTM extends well into midlatitudes and coincides in local time with the appearance of a wave 4 signature, observed in the vertical and zonal variability of the O(1D) volume emission rates, Doppler temperatures and neutral winds (zonal and meridional).

The current understanding is that the wave 4 is associated with non-migrating tides propagating upward from the lower atmosphere. The vertical and global extent of the wave 4 as the source of the MTM will be discussed.

Observations of Equatorial Plasma Bubble at Low Latitude by Optical and Radio Techniques

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Simultaneous observations of OI630 nm and TEC were carried out using a CCD based All-Sky Imaging system and GPS system respectively during the month of February /April - 2012 at low latitude station Kolhapur (16.8˚N, 74.2˚E). The radio observation of GPS is also carried out at the nearby station, Hyderabad (17.67°N, 83.32°E) and Bangalore (13.020N, 77.570E). The day-to-day variability in the occurrence of Equatorial Spread F (ESF) or Equatorial Plasma Bubble (EPB) is addressed using radio and optical observations from low latitude stations. We have found out the simultaneous occurrence of EPBs in both TEC and OI 630.0 nm emissions using both the techniques. In the present work we have also discussed the possible mechanism of day-to-day variability in the occurrence of EPBs and compared with solar activity.

Gravity-wave Coupling of the Mesosphere, Thermosphere, and Ionosphere Observed by the Optical Mesosphere Thermosphere Imagers (OMTIs)

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The vertical coupling of the atmosphere and ionosphere is a key to understand the dynamical variations of the upper atmosphere. The airglow emissions are useful indicator of these vertical coupling, since they come both from the mesopause region at altitudes of 80-100 km and from the ionosphere at 200-300 km. The Optical Mesosphere Thermosphere Imagers (OMTIs) observe two-dimensional images, Doppler winds, and temperatures through these airglow emissions, using fourteen all-sky cooled-CCD imagers, five Fabry-Perot interferometers (FPIs), three meridian scanning photometers, and four airglow temperature photometers. They are in automatic operation at 14 stations at Australia, Indonesia, Thailand, far-east Russia, Japan, Canada, Hawaii, Norway, and Nigeria. Station information and quick look plots are available at http://stdb2.stelab.nagoya-u.ac.jp/omti/. In this presentation we show recent observations of OMTIs for the vertical coupling of atmospheric gravity waves from the troposphere to the mesopause region and to the thermosphere/ionosphere, and their relation to the yearly-scale solar and tropospheric activities, based on long-term (7-16 years) measurements of airglow images in Indonesia and in Japan.

Observation of ELF/VLF Waves Associated with Two Intense Magnetospheric Compressions of January 18, 2013 and December 23, 2014

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We report two outstanding events on the response of ELF/VLF waves associated with magnetospheric sudden impulses. The former event was observed at 12:35-12:40UT on January 18, 2013 at Athabasca, Canada, Kannuslehto, Finland and Syowa Station, Antarctica. The solar-wind density and speed increased by ~20 /cm3 and ~40 km/s, respectively, while the IMF-Bz was kept northward, resulting in no development of storm and substorm. The three ground stations show enhancement of ELF/VLF hiss starting at 1235 UT at Syowa (15LT), 1236 UT at Kannuslehto (14LT), and 1240 UT at Athabasca (05LT) from dayside to dawn side, indicating that the ELF/VLF hiss was globally excited associated with this sudden impulse. The 4-min delay at 05 LT at Athabasca may suggest delay of wave generation until the energization of magnetospheric electrons reaches a certain level. The latter event was observed at 11:17 UT, 2 to 3 minutes after a very intense sudden impulse (SYM-H amplitude ~63 nT) during northward IMF, at both Athabasca and RBSP-B, which are at nearly conjugate locations at 03 MLT. A chorus-like burst was centered at ~2.5 kHz lasting approximately 3 minutes. At RBSP-A, a hiss emission was observed below 1.5kHz first at 11:16 UT about one-minutes before the chorus burst, while such hiss was not observed at Athabasca. This fact indicates that the generation mechanisms of hiss and discrete chorus emissions are different at the beginning of electron acceleration, and that their propagation process from the source magnetosphere to the ground station is also different.

Ionosphere Response to the Winter Stratospheric Jet Stream in the Northern Hemisphere from Vertical Radio Sounding Data

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The effects of middle atmosphere dynamics influence on midlatitude and sub-auroral ionosphere during the winter jet stream at the heights of the stratosphere/lower mesosphere in the Northern Hemisphere in 2008-2013 were studied. The ionosphere data were obtained from measurements made at the vertical sounding ionosonde chain covering the entire Eurasian continent. The regional features of the F2-layer ionosphere response to the dynamic processes during the developing of winter circumpolar vortex at the strato-mesosphere were revealed. Variations of the ionosphere parameters observed at different longitudes of the northern hemisphere significantly depended on the ionosonde position relatively to the jet stream zone in the strato-mesosphere. The difference in the critical frequency values for the ionosondes spaced longitudinally by only 15-20 degrees could reach about 1.5-2 MHz, depending on the location of the observation point under the jet stream or outside it. As mechanism of the underlying atmosphere impact to the ionosphere we considered the upwelling/downwelling molecular gas to/from lower thermosphere in active regions of circulations. Irregular variations of the ionosphere parameters could also be caused by wave disturbances of various spatial and temporal scales (including internal gravity waves) propagating in the thermosphere from the underlying atmosphere. The source of the mesoscale waves generation at the strato-mesosphere heights was associated with the baroclinic instabilities in the spatially non-uniform, high-speed winter jet stream.

This study was supported by the II.16.1.2 RAS Project, by the Grant of the Russian Scientific Foundation (Project No. 14-37-00027) and by the Russian Foundation for Basic Research, project No. 15-05-05227.

Ionosphere Response to Major Geomagnetic Storm in March 2015 on the Base of Data from Eurasian High-midlatitudes Ionosonde Chain

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In the paper we study the ionosphere response to major geomagnetic storm on March 2015 on the base of long high-midlatitude ionosonde chain of Eurasian continent. Investigation showed that during the storm there existed a significant longitudinal inhomogeneity of ionosphere response on the propagation of disturbances from high to low latitudes. Few observational points were situated in zone where ionosondes showed full signal absorption. On all stations were registered ionograms typical for auroral ionosphere and the effect main ionosphere trough polar wall movement below 50°N was registered. All ionosondes registered irregular structure of lower ionosphere as a specific sporadic layers and travelling ionospheric disturbances.

This study was supported by the II.16.1.2 RAS Project and by the Grant of the Russian Scientific Foundation (Project No. 14-37-00027).

Study of Pulsed Signals in UV Spectra Lines of Free Atmosphere above the Antarctic Station Novolazarevskaya: Effect of the Solar Irradiance?

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Registration of the UV irradiation in zenith of free atmosphere at the station Novolazarevskaya (Antarctica) revealed strong UV fluctuations in range of 297-330 nm, named as pulsed signals. The pulsed signals can be highly repetitive during some certain periods, but absent in other periods, the periods being different for various frequencies. Analysis of the pulsed signals for period of 2007-2015 showed that the daily run of the minute values of pulsed signals is repeated from day to day under the undisturbed conditions, the short-term oscillations being superposed on the longer variations. The spectral analysis of the pulsed signals observed in range of 297-330 nm reveals the following periods: 5-7 min, 30 min, 40-45 min, 60 min and 100-120 min. These periods are typical of the acoustic oscillations (p-mode), occurring in the Sun interior. Frequency of p-mode can change during the month in association with the solar activity related to state of the solar chromosphere. Synchronous observations of the UV fluctuations carried out in the Antarctica (Novolazarevskaya station) and Arctica (“Prof. Molchanov” vessel) during equinox in 2013 have demonstrated the pulsed signals coherence with coefficients changing from R=0.65 (for periods of ~40 min) to R=0.9 (for periods of ~5 min). It is demonstrated that the solar activity related to acoustic fluctuations (p-mode) in the Sun interior strongly affects the Earth's mesopause parameters: altitude of magnetopause, ozone content, content of ice water and other mesopause constituents.

Solar Wind Causes of Magnetospheric/magnetotail Loading and Unloading: Extreme Ionospheric and Atmospheric Disturbances

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A study of extreme AE/AL/SME/SML events have led to the discovery that the energy for the events are loaded into the magnetosphere/magnetotail prior to the event occurrence and are often unloaded/triggered by solar wind features. We will show evidence that these extreme events are exceptionally intense substorms. The occurrence of these events as a function of solar cycle and season will be discussed.

We will argue that it is these superintense substorms that cause power outages on Earth and perhaps not the storms themselves. However the relationship between the supersubstorms and storms is an important one. This relationship will be discussed in detail.

Polar Vortex Intensity as a Modulating Factor of Cosmic Ray Influence on Atmosphere Dynamics and Cloud Cover Anomalies

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In this work we continue studying the nature of correlations between low cloudiness and galactic cosmic ray (GCR) intensity on the decadal time scale. It was shown that at middle latitudes of the Northern and Southern hemispheres the correlation links observed between low cloud anomalies (LCA) and GCRs are due to the changes of extratropical cyclonic activity associated with GCR variations. The highest values of positive correlation LCA-GCR were observed in the 1990s when the intensity of cyclonic processes was highly correlated with GCR intensity. The sign reversals of LCA-GCR correlations occurred simultaneously in the Northern and Southern hemispheres in the early 2000s and coincided with the sign reversal of GCR effects on the troposphere circulation. It was suggested that a possible reason for the correlation reversals between atmosphere characteristics under study and GCR variations is the change of the stratospheric polar vortex strength which influences significantly the troposphere-stratosphere coupling. The evidences for a sharp weakening of the polar vortices of both hemispheres in the early 2000s are provided. The results obtained suggest an important role of the polar vortex state as a reason for temporal variability of solar-atmospheric links.

Comparative Analysis of Short-term Effects of Cosmic Ray Variations on the Development of Extratropical Baric Systems

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Effects of energetic solar proton events (SPEs) and Forbush decreases of galactic cosmic rays (GCRs) on the development of extratropical baric systems in the Northern and Southern hemispheres are compared. It is shown the SPEs with particle energies enough to penetrate the stratosphere heights (E>90 MeV) are accompanied by more intensive cyclone regeneration at Arctic/Antarctic fronts that turn out to be in the region of cosmic particle

precipitation with indicated energies. On the contrary, during Forbush decreases of GCRs cyclonic processes weaken and anticyclonic ones intensify at middle and subpolar latitudes, the effects being usually most pronounced in the areas of climatic lows. The presented results suggest an important part of ionization changes in the physical mechanism of solar variability influence on the lower atmosphere circulation, weather and climate.

Differences Between Electrified Medium-scale Traveling Ionospheric Disturbances Observed Simultaneously in Geomagnetic Conjugate Sites at Sata and Darwin

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The nighttime electrified medium-scale traveling ionospheric disturbances (EMSTIDs) are the wavelike disturbances occurring in the middle latitudes as goemagnetically conjugate structures. Geomagnetic conjugacy indicates that the features are plasma structures connected by the electric fields along equipotential geomagnetic field lines. They propagate equator-westwards in both the hemispheres with phase front alignments typically perpendicular to their direction of propagation. In this work, the all-sky airglow imaging observations of OI 630 nm emission from Sata in Japan and Darwin in Australia are used to study the simultaneous occurrence of EMSTIDs in geomagnetically conjugate locations. Supporting thermospheric wind information obtained from Fabry-Perot Interferometer measurements of OI 630 nm emission over Shigaraki in Japan and Darwin are used for analysis. In addition, ionospheric parameters measured by ionosondes operating at Yamagawa in Japan and Darwin are also used. Results indicate remarkable differences in the amplitude of EMSTIDs between the hemispheres on some nights. Further, the meridional wind in the Northern hemisphere appears to dominate the occurrence of EMSTIDs in this longitudinal sector.

Progress in ROSMIC Science

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The ROSMIC project is intended to investigate the coupling processes which link solar variability to variability in the terrestrial atmosphere. This involves both the characterization of those aspects of solar variability of significance to the atmosphere and the identification of the atmospheric processes which modify the manner through which the atmosphere responds to this variability. This project is organized into four sub-projects or themes: 1) Coupling through solar variability (radiative, electrodynamics, ionospheric and photochemical effects), 2) Coupling by dynamics, 3) Trends in Mesosphere and Lower Thermosphere, 4) Trends and solar cycle effects in the thermosphere (including technological aspects). In this talk, the organization of this project will be summarized and scientific advances and ongoing observing campaigns such as the Interhemispheric Coupling Study by Observations and Modeling (ICSOM) described.

Sun to Mud Campaign Study of March 15-17, 2015 Event and other significant events

The Occurrence of Equatorial Plasma Bubbles Around the World During the 2015 St. Patrick's Day Geomagnetic Storm: Modelling and Observations

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Decades of observations show that the occurrence of Equatorial Plasma Bubbles (EPBs) follows a consistent and well-defined climatological pattern that is largely dependent on the season and the local magnetic field direction at the magnetic equator. However, the question of why EPBs grow after sunset on one day and not the next has not been fully answered. One primary cause of this daily variability is the geomagnetic activity level, which influences the plasma drifts and the EPB growth conditions at the equator. In this contribution, the occurrence of EPBs around the world is analysed before, during and after the 2015 St. Patrick's Day geomagnetic storm. The results are compared to outputs from a simulation of this storm using the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM), which shows significant storm-time changes in the calculated Rayleigh-Taylor (R-T) instability linear growth rate. In particular, a transition from post-sunset to post-midnight EPB growth over a 2-day period is modeled and observed in the American and African sectors. These changes are interpreted in terms of the storm-time disturbance dynamo and its influence on EPB growth conditions at the equator via the vertical plasma drifts. An analysis of the R-T growth rate terms also reveals that the higher altitude of the plasma in the late post-sunset sector initiates the post-midnight EPB growth during the storm recovery phase, followed by the disturbance dynamo electric field that dominates EPB growth in the early-morning hours.

Case Studies on Connection of CME and Interplanetary Conditions: September 2014 and March 2015 Events

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We have investigated a moderate geomagnetic storm (Dst~-75 nT) that occurred on 2014 September 12 and a strong storm (Dst~-223 nT) on 2015 March 17. The two storms of different strengths were caused by CMEs which have quite similar properties, e.g., angular width, speed, propagation direction, etc. It was found that the moderate storm was caused by small-scale outward magnetic fields in the sheath region of an interplanetary CME (ICME) that erupted in the western part of the NOAA active region (AR) 12518 with left-hand (LH) helicity during the X1.6 flare. The ICME (flux rope) itself had the northward magnetic fields and acted to cease the ring current development by carrying the northward magnetic field. An

interesting point is that the Earth traversed the portion of the Interplanetary Flux Rope (IFR) where only the northward fields are observed although the IFR axis is directed southward. In case of the 2015 March 17 event, the strong geomagnetic storm was caused by a fast halo CME associated with a filament eruption driven by a weak flare that occurred in AR 12287. Our IFR analysis revealed that the Earth passed the very portion where only the southward magnetic fields are observed throughout the passage. The resultant southward magnetic field with long-duration is the main cause of the strong storm. We conclude that the strength of a geomagnetic storms depends on not only the magnetic field structure of its associated IFR but also the location where the Earth passes through the IFRs.

The Induced Surface Electric Response in Europe to 2015 St. Patrick's Day Geomagnetic Storm. Comparison to Strongest Storms in Cycle 23

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The largest geomagnetic storm in solar cycle 24 is compared to geomagnetic storms in cycle 23, from the double perspective of (1) solar source – solar wind – geomagnetic storm chain and (2) the hazardous induced response as shown by the surface electric field. The study is based on flare, CME, and solar wind data, on one hand, and on recorded one-minute geomagnetic data from the INTERMAGNET network of European geomagnetic observatories, on information regarding the underground electric conductivity we obtained from modeling its lateral distribution, and on simulation of the surface electric field produced by the variable magnetic field of geomagnetic storms, on the other. The lateral distribution of the induced electric response for the European continent during the considered storms is shown.

Phase Fluctuations of GPS Signals and Auroral Activity During 17 March 2015 Geomagnetic Storm

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We analysed space weather conditions during 15-17 Mach 2015 storm. Dual-frequency GPS measurements for individual satellite passes served as raw data. The rate of TEC (ROT) fluctuation activity measured. The data of GPS stations spaced in latitudinal range 67-50 degrees of latitudes over longitude of 20 degrees were involved in this investigation. Observations of aurora were conducted in Lovozero, in Apatity and Sankt-Petersburg. The magnetograms of the IMAGE network and geomagnetic pulsations at the Lovozero and Sodankyla were used as indicator of auroral activity. It was found good similarities between temporary development of substorm activity and intensity of TEC fluctuations. The best correlation of GPS data and optical and magnetic disturbances was achieved during this storm. The intensity of TEC fluctuations during magnetic bay decreased from north to south. Some features of the strong geomagnetic storm coincided with the TEC fluctuations in time. Based on the daily GPS measurements from 130-150 selected stations, the images of spatial distribution of TEC fluctuations (index ROTI) in CGL and MLT coordinates were constructed. These images demonstrate the irregularities oval, which was comparing with the auroral oval model. During the storm the auroral and irregularities oval moved to equator. The

analysis shown that the high latitude phase fluctuations of GPS signals is very sensitive to change of auroral activity and can use as indicator of space weather conditions. We thank the Institutes who maintain the IMAGE Magnetometer Array, Grant of RFBR 14-05-98820 r-sever-a and PRAN (program № 7).

Substorms Observations During Two Strongly Disturbed Periods - in March 2013 and March 2015

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In this work two events of strong geomagnetic activity during Solar Cycle 24 were examined. The first event on 17 March 2015 is the so-called "St. Patrick's Day 2015 Event". This is the principal event covering the interval from 15 to 18 March 2015, in which solar eruptive phenomena (a long-enduring C9-class solar flare and associated CME(s) on 15 March) and a severe geomagnetic storm on 17-18 March (the minimal value of SYM/H index was -235 nT) were reported. This magnetic storm is the largest one observed in the current solar cycle. The second event is the period 17-18 March 2013 when a strong geomagnetic storm (the SYM/H index reached ~ -140 nT) developed. This storm was caused by a magnetic cloud (15 UT, 17 March – 6 UT, 18 March 2013) in the solar wind. Object of our study were the substorms observed during these periods. Observations of the Multiscale Aurora Imaging Network (MAIN) in Apatity have been used. Solar wind and interplanetary magnetic field parameters were taken from OMNI data base. Substorm onset time and the subsequent development were verified by data of IMAGE magnetometers network and by data of the all-sky camera at Apatity. The particularities in the behaviours of substorms connected with different storms and storm phases during these two interesting strongly disturbed periods were discussed.

Longitudinally-propagating Ionospheric Flow Structures Observed by SuperDARN During March 17-18, 2015 Storm

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We study an interesting wavy structure of ionosphere flow at sub-auroral latitudes observed by SuperDARN during a magnetic storm on March 17-18, 2015. The main phase of the storm shows at least two step development in Dst and apparently those two steps are associated with a more or less isolated substorm followed by a series of more intense substorms, respectively. The wavy modulation of ionospheric flow actually occurs during the relatively stagnant period between the two substorms. At sub-auroral latitude, the fast eastward flow prevailing from midnight to early morning during the first substorm ceases and subsequently the mid-latitude SuperDARN radars start to see a series of flow reversals of toward-radar flows and away-from-radar flows. Each of the flow reversal structures has a longitudinal wave length of roughly ~1h magnetic local time (MLT) and fairly large peak-to-peak amplitude of a few hundreds of m/s. Interestingly, those flow structures pass by the fields of view of the radars one after another, showing a clear westward propagation over a wide MLT range from early morning to midnight. From the radar observation, the

propagation velocity is roughly estimated to be ~2-3 km/s. The large propagation speed with the relatively slow background ionospheric flow (less than ~200 m/s) indicates that the corresponding westward-eastward electric field is not of the ionospheric origin, but would be the footprint of ULF waves propagating in the anti-sunward direction through the dawnside magnetosphere.

The Largest Geomagnetic Storm of Solar Cycle 24 on 17 March 2015: Radiation Belt Electron Response as Observed by Van Allen Probes

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The largest geomagnetic storm of solar cycle 24 occurred on 17 March 2015, when a strong interplanetary shock impacted the Earth's magnetosphere. In the immediate aftermath of the shock passage, the Relativistic Electron-Proton Telescope (REPT) instrument observed near-instantaneous injection of ultra-relativistic electrons deep into the magnetosphere. The coronal mass ejection (CME) that followed the shock resulted in a more gradual buildup of energetic electrons over several days. The shock injections were seen deep within the magnetosphere at L~3.3 at energies greater than 6MeV. The gradual response due to the CME also resulted in strong energization, again to ultra-relativistic energies. We present electron measurements from REPT and the Magnetic Electron Ion Spectrometer (MagEIS) onboard the Van Allen Probes mission. We discuss both the gradual development and the prompt energization of radiation belt electrons. Other aspects of this event include the presence of the "impenetrable barrier" to ultra-relativistic electrons, and butterfly pitch angle distributions deep inside the magnetosphere. The electron observations are complemented by the electric and magnetic field measurements from the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) instrument. In-situ measurements from the WIND and Themis fully characterize the interplanetary driver properties.

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Response of the Polar Middle Atmosphere to Electron Precipitation Events

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Long-term observations of chemical species by HALO (1991-2005) and SAGE II (1984÷2005) experiments allow to investigate the role of charged particles in the atmospheric processes. Analysis of these data bases helped to reveal more sensitive chemical species which respond to numerous events caused by energetic electron precipitation recorded in the atmosphere at polar latitudes.

Here we take into account the middle range energies (more then 200 keV) electrons, whose atmospheric impact is still to a large extent unknown.

Applying the superposed epoch analysis we show a clear response of stratospheric NO2 to the magnetospheric electron precipitation. As a data about key days we used the catalogue of electron precipitation events recorded during 58 years by members of cosmic ray balloon experiments of the Lebedev Physical Institute.

Overview of VarSITI ISEST/MiniMax24 Working Group 4 Studies on Campaign Events

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The goal of the ISEST (International Study of Earth-affecting Solar Transients) VarSITI project is to understand the origin, evolution and propagation of solar transients (CMEs, flares, CIRs) through the space between the Sun and Earth, and improve the prediction capability for space weather. This is a progress report on the work of the ISEST Working Group 4 on Campaign Events. The task of WG4 is to integrate theory, simulations and observations to better understand the chain of cause-effect activities from the Sun to Earth for a small number of carefully selected events. Textbook cases are provided to the community, and WG4 also examines less well understood events, such as stealth CMEs and problem ICMEs. WG4 is studying about a dozen events. Our group will discuss work on several recent events, including in January 2014, in September 2014, and the 15-17 March and 22-24 June 2015 “super” storms.

Modeling the connection from Sun to Mud (and all steps in between)

The Evolution of CME Properties with Radial Distance: Numerical Investigation

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Most of what is known about the evolution of CME properties comes from statistical studies using data from Helios, planetary missions and ACE/Wind. However, little is known about the changes of the CME magnetic field strength and structure during propagation. Here, we describe the evolution of the properties of simulated CMEs in the inner heliosphere, for different CME models. We compare the radial evolution of these properties with that found from previous studies. We find that the evolutions of the radial size and magnetic field strength are nearly indistinguishable for twisted flux ropes as compared to writhed CMEs. The evolution of those properties is also in very good agreement with past studies, primarily with recent statistical studies in the inner heliosphere using in-situ measurements and with study using remote observations of CMEs.

Risk of False Alarms in ICMEs, IMF and Solar Wind Predictive Capabilities of the Major Geomagnetic and Ionospheric Storms

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A statistical analysis is undertaken on ICME's, IMF and SW effectiveness linked to sudden storm commencements (SSC) for the major geomagnetic storms (Dst < -100 nT and AE > 1000 nT) and the intense positive ionospheric storms (Vp) and negative storm (Vn). Vp and Vn are signatures of disturbance of the total electron content (TEC) derived from the global ionospheric maps GIM-TEC during 1999-2015. The ionosphere variability index, V, is expressed in terms of TEC deviation from the median normalized by the standard deviation for 15 preceding days. Total 415 ICMEs events for 1999-2015 related with SSC are analyzed for their impact on AE, Dst, Vp and Vn major storms using Catalog by Richardson and Cane (Solar Phys., 264, 189-237, 2010). The storm onset is specified by SSC interacting with IMF parameters (B, dB/dt, Bz) and SW acceleration. The effectiveness of the specified precursors on geospace storms varies depending on accepted thresholds but reveals probability from 0.1 to 0.25 of the intense geospace storms which implies false alarms in their predictive capability in the majority of ICMEs, IMF and SW events. This study is partly supported by TUBITAK EEEAG 115E915.

Prediction Model of the Outer Radiation Belt Considering Local Acceleration Effect by Chorus Waves

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The Earth's outer radiation belt often suffers from drastic changes in the energetic electron fluxes. Since those energetic electrons can be a potential threat to the satellites, various efforts have long been made to model and predict such electron flux variations. In this paper, we describe a prediction model for the outer belt electrons that we have recently developed. The model is based on one-dimensional radial diffusion equation combined with new observational ingredients. First, the boundary condition of the outer edge of the belt is specified by empirical functions determined from the THEMIS observations of energetic electrons near the boundary of outer radiation belt. Second, the plasmapause locations are determined by using the electron density data of THEMIS. Third, the model incorporates the local acceleration effect by chorus waves into the one-dimensional radial diffusion equation. We determine this chorus acceleration effect by first obtaining an empirical formula of chorus intensity as a function of drift shell parameter L*, incorporating it as a source term in the one-dimensional diffusion equation, and lastly calibrating the term to best agree with observations of a certain interval. Forth, we adopt Van Allan Probe data for data-assimilation with ensemble kalman filter. We present a comparison of the prediction results with/without the chorus acceleration effect, and with/without data assimilation.

An MHD Modeling for the Onset and Dynamics of Solar Eruptions

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Solar eruptions are most explosive phenomena in our solar system, and they have been studied by many papers in terms of observational and theoretical aspects. Although it is widely accepted that solar eruptions are driven by the free magnetic energy in the solar corona, we cannot yet reach a common understanding for the onset mechanism and three-dimensional dynamics of solar eruptions. On the other hand, the comparative study between the stet-of-the-art ground-based and space-born observations, and the super-computing may allow us to lead to the answer of these problems. In this paper, we introduce our recent results obtained from the detailed data analysis and magnetohydrodynamic (MHD) simulations in the theoretical and realistic magnetic environment, focusing on the trigger of solar flares and the dynamics of solar eruptions. According to our studies, Kusano et al. 2012 found that the two types of small magnetic structures near polarity inversion line can trigger the large solar flares accompanied with the flux tube ascending. Furthermore, Inoue and Kusano 2016 (in prep.) revealed that an ideal MHD instability of the magnetic flux tube plays a crucial role for the dynamics of solar eruptions. Based on them, we will describe the entire process of solar eruptions from the onset to the ejective phase.

FRi3D: a Novel 3D Model of CMEs

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Currently, there is no 3D model of a CME that describes its magnetic field configuration and accounts for all major deformations it can experience in the interplanetary space. To improve our understanding of CME evolution in the heliosphere and reliability of space weather forecasts all these aspects have to be taken simultaneously into account. We present the first version of the FRi3D (Flux Rope in 3D) model that encapsulates magnetic configuration of a CME in 3D and unifies all key elements of its evolution: expansion, deflections, rotation, front flattening, `pancaking` and skewing. As such, the model is able to describe both white-light and in-situ observations of CMEs.

Canadian Atmosphere and Ionosphere Model: Model Status and Applications

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A newly developed Canadian Ionosphere and Atmosphere Model (C-IAM) is introduced. The C-IAM consists of two pre-existing first principles models: the extended Canadian Middle Atmosphere (CMAM) and the ionospheric part of the Upper Atmosphere Model (UAM). The model domain extends from the surface to the inner magnetosphere and two-way coupling between the neutral atmosphere and ionosphere is implemented. These features make the C-IAM a self-consistent whole atmosphere model that is capable of studying both the impact of the lower atmosphere on the thermosphere and the ionosphere and the impact of geomagnetic conditions on the neutral atmosphere. In addition to the first principles modelling blocks, the C-IAM includes alternative empirical models (e.g., MSISE) which can optionally be used for specific studies (i.e., switch on and off some interaction in order to study its role). In order to reproduce the response to specific space weather events, the model has an option to accommodate the real (observed by SuperDARN) high-latitudinal electric field distribution. The C-IAM has been applied to reproducing a number of observed thermospheric/ionospheric features. These include simulating the wave number 4 features observed in the nighttime O ionospheric emission at 135.6 nm, modeling the 732 nm O+ daytime emission and retrieving from it the atomic oxygen concentration, and explaining disturbances measured by the GOCE satellite accelerometers over high latitudes during geomagnetically active days.

The Development of Magnetic Storms Driven by Different Solar Wind Streams and for Various Solar Wind-magnetosphere Coupling Functions

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Today there are many coupling functions which allow to estimate current values Dst and (pressure-corrected) Dst* indices by using current values of solar wind (SW) and IMF parameters. The response of magnetosphere depends on the type of SW stream (for example [Yermolaev et al., 2015]). The present work is devoted to study the temporal development of Dst and Dst* indices during the main phases of storms, and efficiencies of magnetic storm generation by 4 different drivers. For this purpose on the basis of "Catalog of large-scale solar wind phenomena for 1976-2000" [Yermolaev et al., 2009] we distinguish the main phases of 93 magnetic storms (Dstmin<-50 nT) driven by magnetic clouds, ejecta, the compression region Sheath before MC and Ejecta, and CIR for which OMNI database have the required data for calculation of indices by 12 FCs described in different papers. We obtain that development of both (Dst and Dst*) indices at main phase of magnetic storms depends on type of interplanetary source of magnetic storm, and show that Sheaths have higher efficiency than MC.

This work was supported by the RFBR, project 16–02–00125, and by Program of Presidium of RAS.

References: Yermolaev, et al., (2009), Cosmic Research, 47(2), 81–94.
Yermolaev, et al., (2015), J. Geophys. Res. Space Physics, 120, doi:10.1002/2015JA021274.

Solar Wind Speed and Flux-tube Geometry

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The cyclic variations of the strength and geometry of the global background magnetic field strongly affect the solar wind flow and cause the segregation between the fast and slow wind flows. Fast wind flows develop exclusively within coronal holes, while the slow solar wind streams from the vicinities of the coronal hole boundaries (i.e, around streamers and pseudo-streamers) and/or active regions.

We investigate this problem by performing combined numerical simulations of the solar dynamo, corona and solar wind covering an 11 yr activity cycle. We analysed a large sample of open flux-tubes in order to investigate the dependence of the wind speed on geometrical parameters of the flux-tubes. We found that the total flux-tube expansion effectively control the locations of the slow and fast wind flows, but the actual asymptotic wind speeds attained -- specially those of the slow wind -- are also dependent on field-line inclination.

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Forecasting CME Arrival Times in 3D – the DDC Tool

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In the framework of the EU space weather project AFFECTS 3D CME arrival time prediction have been developed by applying the GCS forward modelling technique to CME multipoint observations from STEREO and by using SOHO observations as a third perspective. The CME forecasting methods have been automatized through the so called DDC tool. Its further development is currently underway in the framework of the EU space project HELCATS,taking into account that it is highly important for reliable forecasts to derive true CME initial speeds towards the direction of a heliospheric object and by taking into account the CME's 3D structure.

We show that these initial speeds can substantially differ from the CME apex velocities and plane of sky velocities. Here we present first results of testbed runs for selected CME events and compare them with commonly used methods, such as those listed in NASA's CCMC scoreboard. We also discuss the implications of different solar wind conditions on CME drag forces.

Numerical Simulation of the Solar Flare Mechanism

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The solar flare is the explosive process with the energy release of 10^{32} during several dozen of minutes. The flares take place above the active region, in which the magnetic field on the solar surface reaches 3000 G, so nobody doubts that during the flare the magnetic energy release. The solar flare appearance high in the corona can be explained by energy accumulation in the magnetic field of a current sheet which appears in the X-type singular line vicinity. To investigate the flare mechanism the numerical MHD simulation is performed above the real active region. For setting of conditions of simulation no assumptions about the flare mechanism are done. The 3D numerical MHD simulation shows current sheet creation above the active region before a flare. The solar flare electrodynamical model, which explains flares main observational manifestations, is proposed basing on results of observations and numerical simulations. According to this model primordial energy release takes place in the current sheet of the solar corona, where the source of soft X-ray emission appears. The sources of hard X-ray emission appear in the places of intersection with the photosphere of magnetic lines entering from the current sheet. The calculated current sheet position for flare May 27, 2003 at 02:53 coincides with the observed position of the X-ray source. The analysis of performed MHD simulation results to make preliminary conclusion that positions of hard X-ray sources coincide with the places of intersection of the photosphere by magnetic lines entered from the current sheet.

Topside Electron Density from Irkutsk Incoherent Scatter Radar, COSMIC/FORMOSAT-3 and International Reference Ionosphere

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The study of the topside ionosphere is important for both understanding the physical mechanisms of topside electron density formation and improving topside electron density prediction. Recent comparisons of the International Reference Ionosphere (IRI) model predictions with CHAMP and GRACE in-situ electron density measurements during the 2008-2009 solar minimum revealed significant discrepancies at 300-500 km altitudes. In this paper we compare simultaneous electron density measurements conducted by the Irkutsk incoherent scatter radar (52.9°N, 103.3°E) and the COSMIC/FORMOSAT-3 satellite near the radar location for the 2006-2014 periods. For comparison with the IRI model we used the long-duration Irkutsk incoherent scatter radar measurements in four seasons at two solar activity levels (low and moderate). These measurements allowed us to obtain monthly averaged patterns that were compared with the IRI prediction. The main aim of the mentioned comparisons is to reveal systematic differences in the topside electron density obtained from two instruments and the IRI prediction in different seasons at low and moderate solar activity levels.

This study was supported by Russian Foundation for Basic Research Grant 14-05-92002-HHC_a and RAS Project II.16.1.2.

ElEvoHI: a Novel CME Prediction Utility Using Heliospheric Imagery

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In this study we present a new method for forecasting arrival times and speeds of coronal mass ejections (CMEs) at any location in the inner heliosphere by using heliospheric imagery. This new approach enables the adoption of a highly flexible geometrical shape of the CME front with an adjustable CME angular width and an adjustable radius of curvature for its leading edge, i.e. the assumed geometry is elliptical. Using input from STEREO heliospheric imager (HI) observations, a new elliptic conversion (ElCon) method is introduced and combined with the use of drag-based model (DBM) fitting to gather the deceleration or acceleration experienced by CMEs during propagation. The result is then used as input for the Ellipse Evolution Model (ElEvo). Together, ElCon, DBM fitting, and ElEvo form the novel ElEvoHI forecasting utility. To demonstrate the applicability of ElEvoHI, we forecast the arrival times and speeds of 20 CMEs remotely observed from STEREO/HI and compare them to in situ arrival times and speeds at 1 AU. Compared to commonly used STEREO/HI prediction methods, such as Fixed–Phi, Harmonic Mean, and Self-Similar Expansion fitting methods, ElEvoHI improves the arrival time forecast as well as the arrival speed forecast. In particular, the remarkable improvement of the arrival speed prediction is potentially beneficial for predicting geomagnetic storm strength on Earth.

Data archiving

Using NASA Heliophysics Multi-mission Data Support for SCOSTEP/VarSITI

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The SCOSTEP/VarSITI program is organized into four science projects: (1) Solar Evolution and Extrema (SEE), (2) International Study of Earth-Affecting Solar Transients (ISEST/MiniMax24), (3) Specification and Prediction of the Coupled Inner-Magnetospheric Environment (SPeCIMEN), and (4) Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate (ROSMIC). As suggested by their titles, the projects are multi-disciplinary by design as they all cover multiple spatial or geophysical regimes; and thus their research activities will require the use of observations (i.e., data) across traditional heliophysics discipline boundaries. This presentation will present an overview of the multi-discipline datasets available from the NASA heliophysics data archives: the Space Physics Data Facility (SPDF) and the Solar Data Analysis Center (SDAC), and discuss how these data and those from other repositories can be accessed and used to support the SCOSREP/VarSITI research goals. The presentation will also emphasize the importance of archiving data with the adoption of standards for data format, metadata, and data access protocols in order to enable interoperability of data systems and optimize data accessibility by the international science community.

CDPP Activities for Sun / Planets Connections

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The French plasma physics data centre (CDPP, cdpp.eu) is established for nearly 20 years and proposes a wide range of plasma datasets together with refined analysis tools. The past years have seen the development of several approachs to tackle the questions relative to solar wind interaction with planetary environments. For instance, collaborations with agencies (NASA/PDS) and instrument consortia (Rosetta, JUICE) led the CDPP to offer varied datasets via its AMDA tool (amda.cdpp.eu); such data can also be visualized in their 3D context with the 3Dview tool (3dview.cdpp.eu). Moreover recent connections with simulation databases also permits direct models/observations comparisons. Integration in these tools of solar event catalogues from the HELCATS project is under way. Finally a solar wind propagation model (Tao et al.) has been deployed and enables parameters predictions at planets, comets and interplanetary spacecraft. This data+tools environment will be presented via scientific use cases.

Data Archive and Integrated Data Analysis Tools Developed by ERG Science Center

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The ERG (Exploration of energization and Radiation in Geospace) is a Japanese geospace exploration project. Its core component is the ERG satellite, an inner magnetosphere satellite with the full set of particle and field instruments launched in FY2016. The ERG project consists of the satellite observation team, the ground-based network observation team, and the integrated data analysis/simulation team. Besides these research teams, ERG Science Center (ERG-SC) has been organized to play an essential role in managing the data center for all kinds of scientific data as well as promoting close collaborations of the three teams and other research projects, maximizing scientific output from the ERG project. For studies of geospace, where different plasma populations are interacted with each other via cross-energy and cross-regional coupling processes, the integrated data analysis combining various kinds of data sets is key to comprehensive understanding of multiscale dynamical processes. For these purposes, the ERG satellite data of Level-2 (calibrated, in physical unit) and higher levels as well as the ground observation network data are archived in the NASA CDF format and basically open freely to the international science community from the ERG-SC data repository. The integrated data analysis tool is also developed on the basis of the Space Physics Environment Data Analysis Software (SPEDAS), in collaboration with the THEMIS and IUGONET projects. We believe that the developed data analysis platform contributes directly to the SPeCIMEN project as well as can support the capacity building activities promoted by VarSITI.

Solar Energetic Particle Catalogs: Assumptions, Uncertainties and Validity of Statistical Results

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Various solar energetic particle (SEP) catalogs have been recently updated and/or released. These proton event lists are based on data from different instruments (GOES, SOHO/ERNE, STEREO, Wind/EPACT). There are number of assumptions involved in the identification and the analysis of the proton enhancements. For example, the SEP onset time depends on the data resolution and quality, on the event profile but also on the adopted definition with uncertainty ranges hardly ever evaluated. On the other hand, the reported SEP peak time and intensity can be compromised by local shock-signatures and erroneous values can be given (larger in flux and delayed in time). For the purpose of statistical correlations, the solar origin (in terms of a flare and coronal mass ejection, CME) of these SEP events is needed. Usually, time constrains are employed to identify the SEP-associated flare and CME with the strongest pair chosen. However, subjectivity plays a role when multiple candidates are present. Projection effects, thresholds and selection criteria add to the above factors that results in biased statistical results and interpretations. The present report will address these caveats and provide guidelines to account for such limitations (including the use of de-projected CME speeds from the HELCATS project).

Kazakhstan Information Center for Collection, Archiving and Presentation of Geophysical Data

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In Kazakhstan there is an experimental complex for space weather study. It includes an experimental setup for records of cosmic ray intensity by using a neutron monitor, a magnetic observatory, a solar radio telescope for the measurements of the solar radio flux at frequencies of 1.078 GHz (27.8 cm) and 2.8 GHz (10.7 cm) and a Callisto radio spectrometer. All data are presented on the web site of the Institute of Ionosphere (http://www.ionos.kz/?q=en/node/21) in real time. Almaty Cosmic Ray station is a part of the worldwide neutron monitor network and contributes to the real-time database for high resolution neutron monitor mesurements called the NMDB (www.nmdb.eu) in Europe. Geomagnetic observatory at Alma-Ata is certified as a station of the INTERMAGNET (www.intermagnet.bgs.ac.uk). Now we have a complex database with data of cosmic ray intensity, geomagnetic field intensity and solar flux at 10.7cm and 27.8 cm wavelengths. The Institute of Ionosphere Information Center for collection, archiving and presentation of geophysical data is created. The data from the observatories are received in real time in the 1-minute resolution and archived into the general MySQL database. On-line and archived data in a graphical and digital form are submitted on the system website.

Data from the Neutron Monitor on Peak Musala, Bulgaria and Atmospheric Pressure

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Atmospheric parameters in the troposphere are under the influence of variations in the intensity of cosmic rays, and it is well understood at present. These studies have found the influence of long and short periodic variations of solar activity on the state of the lower atmosphere and climate. Moreover, the state of Earth's atmosphere is determined by the effect of solar and galactic cosmic rays.

The report shows scientific capabilities of the Basic Environmental Observatory on peak Musala, which has unleaded neutron monitor on the basis of proportional counters type SNM - 15. The neutron monitor detects variations of cosmic rays and their impact on certain atmospheric processes.

The results of measurements of the neutron monitor in the period of 2007 - 2015 are also shown. A comparison is made with the change of barometric pressure near the observatory. The results are discussed in the context of registration of solar proton events in the lower atmosphere. The possibility to get a connection between the intensity of cosmic rays and some environmental parameters of the ground atmospheric layer is evaluated.

Contribution of ICSU-WDS to Data-oriented Activities of VarSITI

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After extensive discussions in the SCOSTEP-WDS Workshop on Global Data Activities for the Research of Solar–Terrestrial Variability, held in Japan on 28-30 September 2015, SCOSTEP and WDS reached to understanding to enforce mutual collaboration on topics of common interest on data (e.g., quality assessment, long-term preservation, multidisciplinary usage, etc.). Among current members of WDS (95), more than 30 data centres or data networks provided with data relating to the endeavour of VarSITI. As the first step, a network of related WDS members will be established to connect their data activities to VarSITI. Inviting more WDS members from VarSITI community will be important to enforce their interdisciplinary recognition and to receive certification of data quality.

Catalog of Large-scale Solar Wind Phenomena: Current Status

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On the basis of OMNI database of 1-h solar wind (SW) plasma and IMF parameters we have made the `Catalog of large-scale solar wind phenomena during 1976–2000` (see website ftp://ftp.iki.rssi.ru/pub/omni/ and paper [Yermolaev et al., 2009]) which identifies reliably 3 types of quasi-stationary streams of the solar wind (heliospheric current sheet (HCS), high speed streams from the coronal holes (HSS), and slow streams from the coronal streamers), and 5 disturbed types (compression regions before fast streams HSS (CIR), and interplanetary manifestations of coronal mass ejections (ICME) that can include magnetic clouds (MC) and Ejecta with the compression region Sheath (SHEMC and SHEEj) preceding them) as well as the interplanetary shock (IS). Now we continue filling of our catalog since 2001. In the report we will described the procedures of SW type identification, data processing and visualization, and web site using. The work is supported by the VarSITI grant.

Reference:

Yermolaev, Yu. I., N. S. Nikolaeva, I. G. Lodkina, and M. Yu. Yermolaev (2009), Catalog of Large-Scale Solar Wind Phenomena during 1976-2000, Cosmic Research, Vol. 47, No. 2, pp. 81-94.

Special session on Heliospheric Cataloguing, Analysis and Technique Service (HELCATS)

A Catalogue of Geometrically-modelled Coronal Mass Ejections Observed by the Stereo Heliospheric Imagers

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We present a catalogue of the kinematic properties of Coronal Mass Ejections (CMEs) produced by applying geometric fitting techniques to CMEs observed by the Heliospheric Imagers (HIs) on-board both NASA STEREO spacecraft, as part of the EU FP7 HELCATS (Heliospheric Cataloguing, Analysis and Techniques Service) project. The catalogue builds on previous HELCATS work in which 1901 CMEs were identified in HI observations throughout the operational phase of the STEREO mission; 2007-2014. Time-elongation plots are used to track a subset of these CMEs and geometrical models are then applied to determine their speeds, propagation directions and launch times. This new catalogue contains a total of 1353 CMEs, 699 from STEREO-A and 654 from STEREO-B. A further subset of CMEs is identified, which are observable by both spacecraft, and stereoscopic fitting techniques are applied. The statistical properties of these catalogues are discussed, as is a comparison with the CDAW catalogue during the same period.

Deriving/cataloguing CME Kinematics from Modelling Multipoint Observations

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The objective of WP3 in the EU space project HELCATS is to derive kinematic properties of coronal mass ejections (CME) from geometrical and forward modelling techniques applied to multipoint observations. The modelling techniques are used to analyse CMEs observed both by the SECCHI HI and COR 2 telescopes on board the twin STEREO satellites. The modelling results are compared and compiled in the so called KINCAT catalogue. KINCAT contains a set of 109 CME events observed over the time interval 2007 until end of 2011. It is currently being upgraded by taking events after 2011 up to 2014 into account and by making use of additional CME observations from SOHO/LASCO providing a third perspective. The catalogue is used for further comparison of the CME kinematic properties with their low coronal and photospheric source region characteristics as compiled in catalogues, such as LOWCAT, and with their heliospheric in-situ properties as derived in HELCATS WP4 by analysing spacecraft data orbiting Earth, Venus, Mercury, Mars and Saturn. The comparative event list is called LINKCAT catalogue. This catalogue is highly important for further studies by the solar, heliospheric and planetary science communities.

Helcats - Heliospheric Cataloguing, Analysis and Techniques Service

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Understanding the evolution of the solar wind is fundamental to advancing knowledge of energy and mass transport in the solar system, rendering it crucial for space weather applications. The advent of truly wide-angle heliospheric imaging has revolutionised the study of both transient (Coronal Mass Ejections) and background (Stream/Co-rotating Interaction Regions) solar wind plasma structures, by enabling their direct and continuous observation out to 1 AU and beyond. The EU-funded FP7 HELCATS project combines European expertise in heliospheric imaging, built up in particular through lead involvement in NASA's STEREO mission, with expertise in solar and coronal imaging as well as in-situ and radio measurements of solar wind phenomena, in a programme of work that will enable a much broader understanding and wider exploitation of heliospheric imaging observations. Within HELCATS, we are (i) cataloguing transient and background solar wind structures imaged in the heliosphere by STEREO/HI, since launch in October 2006 to date, including estimates of their kinematic properties based on a variety of established techniques and more speculative, approaches; (ii) evaluating these kinematic properties, and thereby the validity of these techniques, through comparison with solar source observations and in-situ measurements made at multiple points throughout the heliosphere; (ii) appraising the potential for initialising advanced numerical models based on these kinematic properties; (iv) assessing the complementarity of radio observations (in particular Type II radio bursts and interplanetary scintillation) in combination with heliospheric imagery. We will, in this presentation, provide an overview of progress from the first 2 years of the HELCATS project.

Preliminary Catalogue of Radio Burst Measurements

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We present preliminary results of our endeavours, within the EU FP7 HELCATS (Heliospheric Cataloguing, Analysis and Techniques Service) project, to identify radio observations by STEREO/Waves that are associated with CMEs identified in STEREO/HI images and, thus, included in the HELCATS WP3 Catalogue. We have found that only about 10% of these CMEs were associated with interplanetary type II radio bursts. Moreover, very few type II bursts were observed during the solar minimum. Our results indicate that fast CMEs are more likely to produce interplanetary type II radio bursts. We also discuss possibilities of improving forecasting CME arrivals to 1 AU using radio observations.

Heliospheric Transients: Observations and Modeling

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Solar-terrestrial physics has historically focused primarily on the study of the solar atmosphere and corona and on the study of the near-Earth environment. The heliosphere, the region connecting the solar corona to the geospace, was not directly imaged until the mid 2000s with the launch of SMEI and STEREO, and had therefore been left out of many investigations. However, it is the region where corotating interaction regions (CIRs) form, coronal mass ejections (CMEs) expand, reconnect and interact with the solar wind and other transient structures. The past decade has witnessed great advances in our understanding of the heliospheric propagation of CMEs and the formation of CIRs, thanks to a combination of remote observations, in situ measurements and numerical modeling. Here, I will review some of the main achievements, the remaining roadblocks and the physical processes occurring to heliospheric transients during their propagation between the Sun and the Earth. I will also discuss how these new observations and techniques are paving the way for new space weather forecasting of impact and arrival of CIRs and CMEs at Earth and other planets.

The Novel Solar Energetic Particle Catalog from Wind/EPACT Instrument

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We present the recently compiled proton catalog from the Wind/EPACT instrument using data provided from CDAWeb database. We identified 365 individual proton events in the 19-28 MeV (low) energy channel and 345 events in the 28-72 MeV (high) energy channel. The first version of the on-line catalog is now released: http://www.stil.bas.bg/SEPcatalog/index.html where representative overview plots are given for each event. The final version of the catalog will report the proton onset time, peak time and peak intensity for the low energy channel and the peak intensity for the high energy channel. The main results from the catalog will be presented and discussed. The on-line version of the Wind/EPACT proton catalog is hosted by the Space Research and Technology Institute (Bulgarian Academy of Sciences).

Solar Coronal Mass Ejections Observed with the Heliophysics System Observatory

Moestl C. [1 2], and the HELCATS team
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Solar coronal mass ejections (CMEs) play a pivotal role in solar, heliospheric and planetary physics because they lead to connections of plasma phenomena from the Sun to the planets throughout the solar system. In the last 10 years, the field has made major advantages in understanding how CMEs evolve from the Sun to the planets. I will show data, as provided by the Heliophysics System Observatory (HSO), and their interpretation with various modeling efforts, focusing on heliospheric imaging and 3D flux rope models. The HSO can be understood as a web of sensors placed throughout the heliosphere, consisting of spacecraft such as STEREO, Wind, ACE, Venus Express and MESSENGER. They provide, mainly with their magnetometers, multipoint in situ observations of CMEs. The STEREO mission plays a key role, as it has provided for the first time data of heliospheric imagers far away from the Sun-Earth line. With these datasets, we establish the first linked catalogue of CME observations from the Sun to the planets and spacecraft. All this means that we are now entering a new era where big catalogues of solar and heliospheric events are routinely available.

Simulating and Cataloguing the Background Solar Wind from 1 to 21 Solar Radii

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The large-scale solar wind speed distribution varies in time in response to the cyclic variations of the strength and geometry of the magnetic field of the corona. Fast wind flows develop exclusively within coronal holes, while the slow solar wind streams typically from the vicinity of the coronal hole boundaries (i.e, around streamers and pseudo-streamers) and/or active regions. Based on this idea, semi-empirical predictive laws for the solar wind speed (such as in the widely-used WSA law) use simple parameters describing the geometry of the coronal magnetic field. In practice, such scaling laws require ad-hoc corrections and empirical fits to in-situ spacecraft data, and a predictive law based solely on physical principles is still missing.

I will present a new numerical solar wind model which takes a coronal magnetic field map as input, and computes a collection of solar wind profiles spanning a region of interest of the solar atmosphere (up to a full synoptic map) at any instant desired, while keeping a good description the plasma heating and cooling mechanisms. We used this model to estimate full sets of inner boundary conditions for ENLIL (at 21.5 Rsun), in order to produce detailed maps of the background solar wind in the heliosphere. These wind maps will be available as HELCATS catalogues.

Long-term Tracking of Corotating Density Structures Using Heliospheric Imaging. Catalogue Update

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The systematic monitoring of the solar wind in heliospheric images taken by the Solar-Terrestrial Relation Observatory (STEREO) spacecraft permits studies of the spatial and temporal evolution of variable solar wind flows from the Sun to 1AU. As part of the FP7 Heliospheric Cataloguing, Analysis and Techniques Service (HELCATS) project, we derived a catalogue listing the properties of 190 corotating structures well-observed by the heliospheric images taken by STEREO-A (ST-A). We present here the first long-term analysis of solar wind structures advected by the background solar wind. We derived the spatial-temporal evolution of each of these corotating structures by using well-established techniques. The mean radial propagation speed of the corotating structures was found to be 310 km/s. Such a low mean value corresponds to the terminal speed of the slow solar wind rather than the speed of stream interfaces typically situated between the slow and fast solar wind speeds (~400 km/s). Using our fitting technique, we could predict the arrival time of each corotating structure at different probes in the inner heliosphere. We show that CDS speeds derived by our catalogue track well the long-term variation of the radial speed of the slow solar wind during solar minimum years (2007-2008). Additionnaly, we demonstrate that the corotating density structures originate near the coronal neutral line that eventually becomes the heliospheric current sheet.

Methods of MHD Simulation and Graphical System of Search of Solar Flare

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MHD simulations above the real active region is performed to study solar flare mechanism. In such an approach it is not used any assumptions about the physical mechanism of flare. All conditions are taken from observations. The magnetic field measured on the photosphere is used for setting boundary conditions. To accelerate calculations the special numerical methods are developed. The methods are realized in PERESVET code on FORTRAN language. The absolutely implicit finite-difference scheme with upwind approximation of transport terms is used. This scheme is conservative relative to the magnetic flux. To find positions of sources of soft X-ray radiation in the current sheets in corona the graphical system is developed. The property of the current sheet is used, according to which the local maximum of the absolute value of the current density is located in the center of a current sheet. In any selected plane the lines of current density level are constructed. Furthermore, in this plane all positions of the local maxima of the current density in the plane and projections of all positions of the local maxima in the space on the plane are marked. In order to determine whether a given point of the current density maximum correspond the current sheet center the program can build the magnetic field configuration. The graphical system finds positions of the sources of beam hard X-ray emission in the places of intersection with the photosphere of magnetic lines, which enter from the current sheet.

Using the HELCATS Catalogue to Study the Connectivity of Probes to Coronal Shocks:

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We study the link between an expanding coronal shock and the energetic particles measured near Earth as a Ground Level Enhancement (GLE) on 17 May 2012. We developed a new technique based on multipoint imaging to triangulate the 3-D expansion of the shock forming in the corona. The triangulation technique uses images from three vantage points by mapping the outermost extent of the coronal region perturbed by the shock front as a function of time. We derive for the first time the 3-D velocity vector of the entire front as function of time. The strongest shock is found to form along the coronal neutral line where the heliospheric plasma sheet forms. Using the HELCATS catalogue, we demonstrate that magnetic connectivity between the accelerator (the coronal shock of 17 May 2012) and the near-Earth environment is established via a magnetic cloud that erupted from the same active region roughly five days earlier. It shows that the derivation of magnetic connectivity between the coronal shock and a probe must result from a full analysis of the interplanetary medium extending back in time by at least five days before the event of interest. The HELCATS CME catalogues are a valuable source of information to establish these magnetic connectivities.

Interactive Tools to Access the Helcats Catalogues:

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The propagation tool is a web-based interface written in java that allows users to propagate: solar eruptions (CMEs) radially sunward or anti-sunward (Radial Propagation), corotating structures (CIRs) in the heliosphere (Corotation) and solar energetic particles (along magnetic fields lines) sunward or anti-sunward. The added value of the tool is an easy access to unique datasets, catalogues and a fast interoperability. It integrates the orbital elements (using SPICE) of probes and planets, this allows you to determine via simple clicks the position/orientations of imagers that you would like to consider, it offers web-service access to summary plots of in-situ data stored at the CDPP as well as movies of solar images stored at MEDOC via JHelioviewer, it provides access to a wide range of Carrington maps of the solar surface to visualize the location of active regions, coronal holes and solar flares on the Sun. The great novelty of the tool is the immediate visualisation of J-maps that are generated by extracting bands of pixels in coronal and heliospheric images along the ecliptic planes and stacking them vertically (along the ordinate) with time (along the abscissae). The tool was designed to be user friendly and accessible to any scientist interested in locating CMEs/CIRs and particle fluxes in the ecliptic plane. A number of CME and CIR catalogues have been integrated in the interface including the HELCATS catalogues. We will demonstrate how these catalogues can be accessed in an interactive manner.

Automatic Detection of Prominence Eruptions Using SDO/AIA Images

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Prominence eruptions (PEs) are important for a clear understanding of coronal mass ejections (CMEs) because they are physically related. Unlike CMEs, PEs can be observed from close to the solar surface, thus providing information on the genesis of CMEs A technique to detect and characterize PEs automatically in the SDO/AIA images has been developed. Our technique detected 1,214 PEs from 2010 May to 2015 December. We validated our technique and found that almost all PEs were detected while 17% of the detections were artifacts (double counts) caused by complex PEs. Using the PE catalog it is found that there is no significant difference between high and low latitude PEs on their CME association rate (Gopalswamy et al. 2015). The PE catalog will soon be available at the CDAW Data Center (http://cdaw.gsfc.nasa.gov/).

Ionospheric response to geomagnetic storm and solar eclipse during March 2015

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We show results from ionospheric measurement at the Pruhonice station, Czech Republic, for the Solar Eclipse 20 March 2015 (SE). The DPS-4D Digisonde, continous Doppler measurement and wave analysis of electron density profiles were used to describe response of the ionosphere. The variability in plasma drifts and critical frequencies exists before the SE and can be attributed to the geomagnetically disturbed situation. Decrease in solar ionization flux during the SE leads to decrease in critical frequencies from the E, F1 and F2 layers with a delayed response for the F2 region. The results from Digisonde Doppler measurement show variations in velocity in the F2 region plasma compared to average situation from other days of the same season, reaching -100 to +100 m/s in horizontal, and -30 to +30 m/s in vertical components. Continuous Doppler drift measurement detect dominant south-east direction of the wave propagation. Analysis of electron density profiles shows increased wave activity after the SE in the domain of gravity waves.

List of Authors