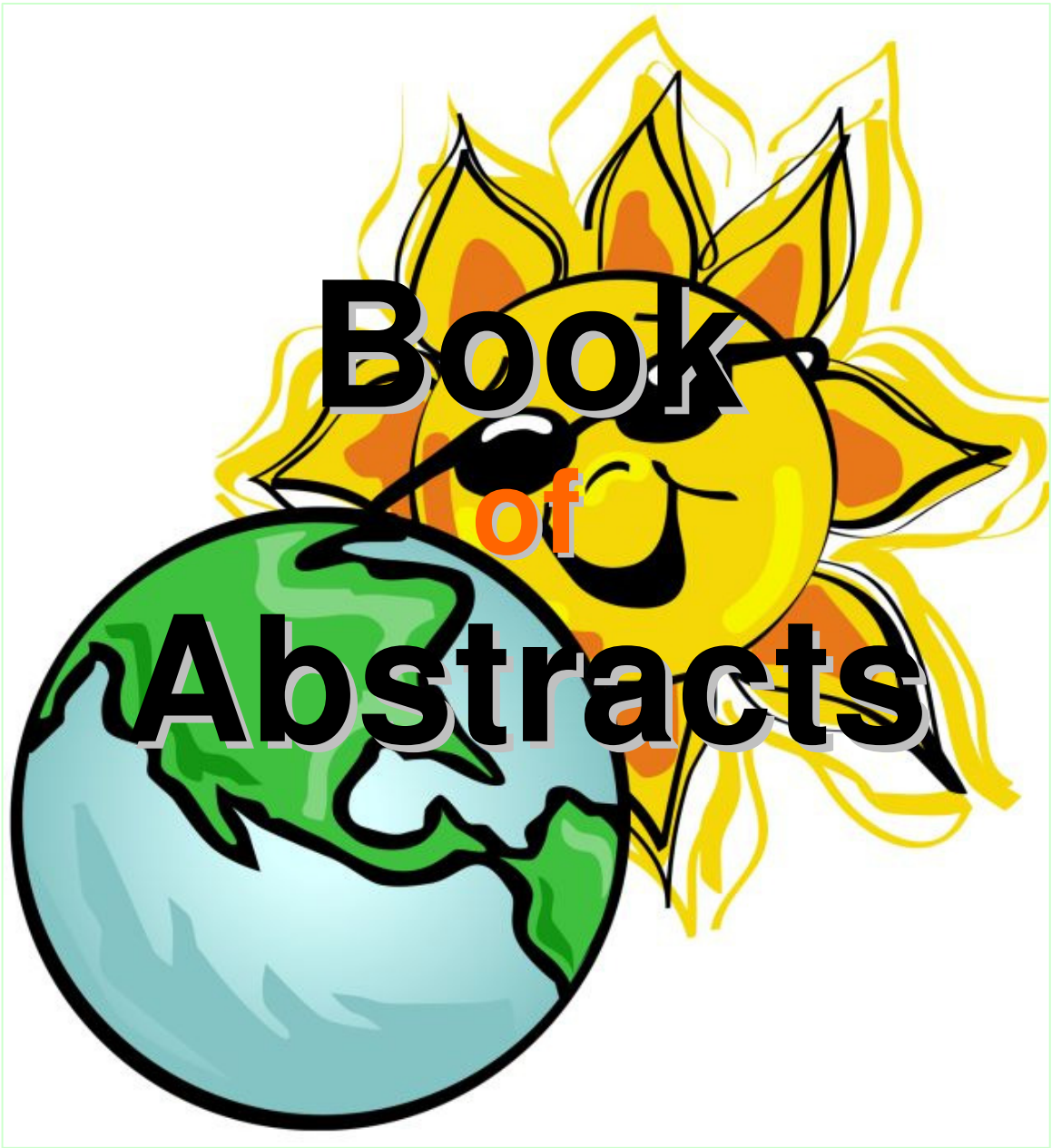
T E N T H W O R K S H O P

Solar Influences on the Magnetosphere, Ionosphere and Atmosphere

Primorsko, Bulgaria, June 4÷8, 2018



SPACE RESEARCH AND TECHNOLOGY INSTITUTE
BULGARIAN ACADEMY of SCIENCES

Scientific Organizing Committee

Katya Georgieva (Space Research and Technology Institute, Sofia, Bulgaria) – *Chair*
Christine Amory-Mazaudier (Universite Pierre et Marie Curie, Paris, France)
Nat Gopalswamy (NASA Goddard Space Flight Center)
Crisan Demetrescu (Institute of Geodynamics, Romanian Academy)
Ana G. Elias (Universidad Nacional de Tucuman, Argentina)
Petra Koucká-Knižová (Institute of Atmospheric Physics, Czech Republic)
Olga Malandraki (IAASARS, National Observatory of Athens, Greece)
Dibyendu Nandi (Indian Institute for Science Education and Research, Kolkata, India)
Vladimir Obridko (IZMIRAN, Moscow, Russian Federation)
Atila Özgüc (Kandilli Observatory, Turkey)
Dragan Roša (Zagreb Astrronomical Observatory, Croatia)
Jean-Pierre Rozelot (OCA-Lagrange, CNRS, Nice University, France)
Lev Zeleny (Space Research Institute RAS, Moscow, Russia)

Topics:

Sun and Solar Activity
Solar Wind-Magnetosphere-Ionosphere Interactions
Data Proccessing and Modelling
Instrumentation for Space Weather Monitoring
Solar Influences on the Lower Atmosphere and Climate
Long-term Solar Variability and Sunspot Indices
SEP Origin Project
Summer school "Sun, space weather and space climate"
Solar Effects in the Biosphere

Local Organizing Committee:

(Space Research and Technology Institute, Sofia, Bulgaria):

Boian Kirov – *Chair*;
Simeon Asenovski;
Dimitar Danov;
Rositsa Miteva

The workshop is partly supported by
Variability of the Sun and Its Terrestrial Impact
(VarSITI)

DOI: 10.31401/WSoz.2018.abs

Tenth Workshop
Primorsko, Bulgaria, June 4 ÷ 8, 2018

CONTENTS

Sun and Solar Activity

Solar Wind-Magnetosphere Interactions

Tenth Workshop
Primorsko, Bulgaria, June 4 ÷ 8, 2018

Data Proccessing and Modelling

Instrumentation for Space Weather Monitoring

Solar Influences on the Lower Atmosphere and Climate

Long-term Solar Variability and Sunspot Indices

Tematic Session on the SEP Origin Project

Summer school "Sun, space weather and space climate"

Solar Effects in the Biosphere

Sun and Solar Activity

Role of the Electric Field and Recombination in Formation of Solar Flare Images

Kostrov A.V., Malyshev M.S.
Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russia

Analysis of solar flare images in various spectral ranges allows making an assumption that radiation of highly ionized ions is connected with the process of recombination of the ions ionized inside the Sun. This separation of the processes of ionization and recombination in space (sometimes in time, as well) is well known from the results of laboratory experiments.

In this work, the trajectories of the ion motion above active regions in the electric and gravitational fields are constructed. The two-dimensional structure of the electric field above the active regions made it possible to obtain characteristic images of flares in various spectral ranges, which are similar to such coronal structures as arches, loops, arcades, etc.

It is found that flare images in different spectral lines of highly ionized ions depends on the ratio between the ion mass and the ion charge, M/Z. First of all, ions having a low M/Z ratio, about 1 and 2, can escape from the atmosphere of the Sun, which is confirmed by the distribution of ions in the solar wind near the Earth's surface. Electrically heavy ions (M/Z >> 2) can stop in the chromosphere and corona of the Sun and determine the structure and spectrum of the flare radiation in the characteristic radiation line of a specific ion.

Development of the Solar ALMA Observing Mode 2014-2017: Goals, the Story, Results, and Applications in Solar Research

Bárta M. [1, 2], *Skokič I.* [1, 3], *Brajša R.* [3] *& the Czech ARC-node team* [1, 2**1]
[1] European ALMA Regional Center – Czech node (EU ARC.CZ), Czech Republic
[2] Astronomical Institute ASCR, Ondrejov, Czech Republic
[3] Faculty of Geodesy, University of Zagreb, Croatia

ALMA is the far largest project of ground-based observational astronomy in the world. Solar research belongs to its science goals already from the very planning of this instrument. Indeed, potential of the ALMA observatory in solving many open issues in solar physics is enormous. On the other hand, observations of the Sun with ALMA are quite difficult, for many technical reasons. Simply, there are too many differences to the `standard` observations of other celestial bodies. In order that ALMA is being able to observe the Sun at all, a special Solar ALMA Observing Mode had to be developed that uses subtle procedures to overcome the issues introduced in detail in the talk. The development of this ObsMode has been performed in a broad international collaboration and nineteen scientists from all around the world formed so called Solar ALMA Development Team that has been intensively working on it. ESO and the European ALMA Regional Center (EU ARC) has mandated its Czech node (EU ARC.CZ; located at the Astronomical Institute ASCR in Ondrejov) by leading and coordinating the entire European participation in this project. The contribution aims at summarizing goals, procedure and outputs of this project, which was performed in the years 2014-2017. We shall focus on European contribution to the success of the project, namely the suggested procedures and their testing during two observing campaigns at ALMA OSF, Chile, and the software developed at the Czech ARC node specifically for the solar observations.

[1] see page 45

Comparision of Liulin-MO Dosimeter Radiation Measurements During ExoMars 2016 TGO Cruise to Mars and in High Elliptic Mars Orbit with Dose Estimations Based on GCR Model

Benghin V. [1], Semkova J. [2], Dachev Ts. [2], & Liulin-MO-ExoMars TGO team (B)[**2]
[1] IMBP – RAS, Moscow, Russia
[2] Space Research and Technology Institute – BAS, Sofia, Bulgaria

Two ExoMars 2016 TGO flight phases were analyzed - the cruise phase and the high elliptic Mars orbit phase. There was made a comparison of flux and dose rate measurements curried out by Liulin-MO dosimeter onboard the ExoMars 2016 TGO during the cruise of TGO to Mars with calculation based on galactic cosmic ray models. There are marked surplus of measured flux and dose rate on calculated. The dosimetric measurements in high elliptic Mars orbit had put the way to estimate the flux shadow by Mars effect. Results of 23 TGO pericenter crossing were investigated. The shadow effect amounted to 30%, but as a rule was less than calculated one. These results are important for manned mission to Mars radiation risk estimations.

Complex Dynamics of a Prominence Eruption Leading to a Partial-halo Coronal Mass Ejection

Dechev M., Duchlev P., Koleva K.
Institute of Astronomy and NAO – BAS, Sofia, Bulgaria

This report presents very rarely reported case of an eruptive prominence (EP) composed by both hot, bright flux rope (BFR) and cool massive flux ropes (MFR) and associated partial-halo coronal mass ejection (CME). We examine in detail the flux ropes (FRs) eruption and their associated activities in a complex magnetic configuration located beneath a multiarcade helmet streamer. We establish the sequence of activities appearance involved in causally linked chain of events on 2014 March 14. A surge-like event is the possible trigger of the bright FR appearance beneath the cool MFR. Plasma draining in the northern BFR footpoints is identified as the precursor for the EP eruption. We find that the EP FRs merging at the fast-rise onset and their splitting in the phase of strong acceleration are the main triggers for the flaring activity beneath the EP.

Initiation, Interaction and Eruption of Filament Flux Ropes from the Perspective of Their Magnetic Twist and Environment

Duchlev P., Koleva K., Dechev M.
Institute of Astronomy and NAO – BAS, Sofia, Bulgaria

We present a comparison examination of two filament/prominence eruptions driven by helical kink and torus instabilities. First one, eruptive prominence (EP) on 2014 May 4 represents kink induced eruptions of two flux ropes (FRs) of the same filament: the first FR undergo a confined eruption and the other FR - a full eruption. This EP was associated with a slow very poor CME that had a classical three-part stricture. The second, torus induced EP on 2014 March 14 was composed of both hot, bright flux rope (BFR) and cool massive flux ropes (MFR). It was associated with a partial halo coronal mass ejection (CME) that had also three-part structure, but with bi-component bright core produced by two EP FRs. The analysis in this study of the physical processes in the EPs environments, the type of EP FRs

[2] See page 44

interactions and the activity events accompanying the eruptions laid emphasis on specific conditions, which are crucial for the type of driving mechanism of the filament eruptions.

Theoretical Modeling of Chromospheric Emission Lines through the Solar Activity Cycles 21-23 According to the Observational Analysis Results

Goker U.D.
Istanbul Gelisim University, Faculty of Economics, Administrative and Social Sciences, Department of Aviation Management, Avcilar, Istanbul, Turkey

In our previous papers, we compared the connection between the sizes of faculae and plage regions, sunspots/sunspot groups (SGs), chromospheric emission lines and solar spectral irradiance (SSI) variability between the spectral ranges 121.5 nm-300.5 nm for the period 1981-2009 and discussed the changes in the sunspot counts (SSCs) and the number of SGs relative to the variations in solar activity indices. In this work, we tried to explain the theoretical reason of these variabilities and connected these changes to the temporal variations of solar activity indices in comparison to different type of SSCs/SGs for the first time in the literature. We found that the intensity of Fe II (298.5 nm) ion in the last solar minimum was higher than the two previous solar minima 21 and 22. So, the velocity of particles of Fe II ions increase with decreasing density of the medium and increasing plage surface. Increasing velocity causes an increase in the acceleration and intensity of particles.

Manifestations of the Current Low Solar Cycle on the Sun, in Interplanetary Space and in Earth's Environment

Ishkov V.N.
IZMIRAN – RAS, Russia

The main properties of the current cycle match almost completely those of low solar cycles, and it all features indicate a change in the generation mode of magnetic fields in the solar convection zone is over and have led to significant reduction of the general magnetic field of the Sun that has entailed: * considerable reduce (~ 700 Gs from the level of 1998) values of magnetic field in sunspots umbra which was stabilized at the level ~ 2050 Gs; * change of the mode of changes of polar magnetic fields: the size of polar magnetic field was about 7-8 Gs in phases of minima previous 3 SC and only 4-5 Gs in the last minimum of 2008÷2009; * the mean magnetic field densities of coronal holes ranged from 0.2 to 8.7 G with a mean value of 3.0+/-1.6 G derived in SC24 are significantly smaller than the values 3-36 G (21 SC) and about 20 G (23 SC); * rate of flare activity level in the current SC is significantly lower previous 5 SC: there were only 58 flare events of the x-ray class X≥1.0 (4-5).

Compared to solar wind values typically observed from the mid-1970s through the mid-1990s, the following proton parameters are lower on average from 2009 through 2014: solar wind speed and beta (11%), temperature (40%), thermal pressure (55%), mass flux (34%), momentum flux or dynamic pressure (41%), energy flux (48%), IMF magnitude (31%), and radial component of the IMF (38%).

Data on Solar Activity and Interplanetary Medium in WDC for STP

Sergeyeva N.[1], Ishkov V.N.[2], Zabarinskaya L.[1]
[1] Geophysical Center – RAS, Moscow, Russia
[2] IZMIRAN – RAS, Moscow, Troitsk, Russia

World Data Center for Solar-Terrestrial Physics, Moscow has a large historical and modern archive of global observations results such as geomagnetic variations, ionospheric phenomena, solar activity and interplanetary medium, cosmic rays. The Center was established in 1956 as member of ICSU-WDC system. Since 2012 it is a regular member of the ICSU-WDS. The web site of the WDC for STP (http://www.wdcb.ru/stp/index.html) provides its description, catalogues of data availability and access to data on all disciplines of the Center and other on-line resources.

The section `Solar Activity and Interplanetary Medium` covers the following subjects.

- ✓ Sunspot number data: Daily total sunspot number (1818÷2015), Monthly mean total sunspot number (1749-present) and Yearly mean total sunspot number (1700-present).
- ✓ Solar Flux Data. Each measurement of the 10.7cm Solar Flux is expressed in three values for the period 1947÷2014.
- ✓ Catalogues of Solar Flare Events with X-ray Class M1 for XXIII (1996÷2007) and XXIV (2009÷2017) cycles of solar activity.
- ✓ The interplanetary magnetic field sector structure. Stanford University data for the interplanetary sector structure 1947÷1975 by L. Svalgaard and the data from Vostok and Thule Observations are given for 1974÷2010.
- ✓ Solar proton events. The database of six Catalogues on solar proton events affecting the Earth environment are submitted. (1970÷2008).

The DOIs were assigned to the entire database and to each of the catalogues separately and registered in the Crossref system. Such identifier provides a unique opportunity to citate these data in scientific publications.

The TEC Perturbations of the South American Ionosphere before and after the Main Shock of the Powerful Chilean Earthquake of 2014

Ishkova L.M., Ruzhin Yu.Ya., Bershadskaya I.N.
IZMIRAN – RAS, Russia

The analysis results of the large-scale space-time variations of the total electron content (TEC) of the South American ionosphere before and after the powerful Chilean earthquake on April 1, 2014 (M=8.2) are presented.

The daily TEC variations were studied during the periods 25.03÷01.04.2014 and 02÷09.04.2014, characterized by high foreshock and aftershock activity, in comparison with the eight-day medians (δTEC,%, local time interval is 2 hours) in the longitudes 30º÷105ºW (Δλ=15º) and in the latitudes 15ºN÷60ºS (Δφ=5º). It was studied in the quiet geomagnetic conditions the development of anomalous TEC disturbances in the extended regions of the South American ionosphere.

It was noted the development of the strong positive TEC disturbances (from 30 to 50÷60% and higher) in both periods at the distances of up to several thousand kilometers. The spatial scales of the ionosphere regions with the maximum anomalous positive TEC perturbations were higher in the period 25.03÷01.04.2014, before the main shock of the Chilean earthquake.

Solar Wind by IPS Observations at Decameter Wavelengths

Kalinichenko M.[1], Konovalenko O.[1], Brazhenko A. [2],
Kuhai N.[3], Romanchuk O.[3], Lytvynenko O.[1]
[1] Institute of Radio astronomy – NAS of Ukraine, Kharkiv, Ukraine
[2] Poltava Gravimetrical Observatory of the IGP – NASU, Poltava, Ukraine
[3] Hlukhiv National Pedagogical University, Hlukhiv, Ukraine

The solar wind is one of the most powerful factors that affect the state of space weather. There are several methods that allow conclusions to be made on solar wind parameters. One of the most effective is observations of interplanetary scintillations (IPS). IPS strongly depends on observational frequency. IPS observations at decameter wavelengths allow the solar wind parameters at different distances from the Sun (up to several a. u.) to be determined. The effects of Earth`s ionosphere, which are strong at low frequencies, obstruct such determination and need the criteria for separation of the interplanetary and ionospheric scintillations. This report is devoted to the determination of the solar wind parameters by IPS observations at decameter wavelengths. Observations were carried out with the URAN-2 radio telescope (Ukraine, Poltava). Experiment includes two observational sessions (January 2016 and January 2017). Two radio sources were observed. The radio galaxy 3C274 scintillates only on the plasma irregularities of Earth`s ionosphere while the radio source 3C144 shows both interplanetary and ionospheric scintillations. It was found that the statistic characteristics of the interplanetary and ionospheric scintillations at decameter wavelengths were different. The day-to-day variations of the statistic characteristics were also found. Using the found differences we separate interplanetary and ionospheric scintillations. Then we obtained the solar wind parameters by fitting model IPS characteristics to the experimental ones. The obtained parameters of the solar wind were in good agreement with those obtained by spacecraft.

Can Superflares Occur on the Sun? A View from Dynamo Theory

Katsova M.[1], Kitchatinov L.[2, 3], Livshits M.[4], Moss D.[5], Sokoloff D.[4, 6], Usoskin I.[7]
[1] Sternberg Astronomical Institute, Moscow University, Moscow, Russia
[2] Institute for Solar-Terrestrial Physics, Russia
[3] Pulkovo Observatory, Russia
[4] IZMIRAN – RAS, Russia
[5] School of Mathematics, University of Manchester, Manchester, UK
[6] Department of Physics, Moscow University, Mosow, Russia
[7] Space Climate Research Unit and Sodankyla Geophysical Observatory

The Kepler mission has revealed the occurrence of superflares in sun-like stars which exceed by far any observed solar flares in release of energy. Radionuclides data do not provide evidences for occurrence of superflares on the Sun over the past eleven millennia. A natural idea is that the dynamo mechanism in superflaring stars differs in some respect from that in the Sun. We search for a difference in the dynamo-related parameters between superflaring stars and the Sun to suggest a dynamo-mechanism as close as possible to the conventional solar/stellar dynamo but capable of providing much higher magnetic energy. Dynamo based on joint action of differential rotation and mirror asymmetric motions can in principle result in excitation of two types of magnetic fields. First of all, it is well-known in solar physics dynamo waves. The point is that another magnetic configuration with initial growth and further stabilisation is also possible for excitation. For comparable conditions, magnetic field strength of second configuration is much larger rather of the first one just because dynamo do not spend its efforts for periodic

magnetic field inversions but use its for magnetic field growth. We analysed available Kepler mission data concerning the superflaring stars in order to find tracers of anomalous magnetic activity. We find that anti-solar differential rotation or anti-solar sign of the mirror-asymmetry of stellar convection can provide the desired strong magnetic field in dynamo models. We confirm this concept by numerical models of stellar dynamos with corresponding governing parameters.

Comparisons of the CMESI and Cosmic Rays for the Last two Solar Cycles

Kilcik A.[1], Ozguc A.[2], Yurchyshyn V.[3], Rozelot J.-P.[4]
[1] Department of Space Science and Technologies, Akdeniz University, Antalya, Turkey
[2] Kandilli Observatory and Earthquake Research Institute, Bogazici University, Istanbul, Turkey
[3] Big Bear Solar Observatory, Big Bear City, CA, USA
[4] Université de la Côte d'Azur (OCA-CNRS), Grasse, France

We compared the temporal variations of the maximum coronal mass ejection speed index (MCMESI) and cosmic ray intensities for the last two solar cycles. Also the MCMESI data are compared to sunspot number for the same time interval. To investigate the possible relationship between these data sets cross correlation and hysteresis analysis were applied. We found following two main results; 1) The MCMESI show a comparable/higher correlation with cosmic ray intensities compared to sunspot number time series, 2) the MCMESI and cosmic ray intensities show hysteresis behavior during the descending and maximum phases of solar cycle 23, while they have hysteresis behavior only the maximum phases of solar cycle 24.

Chaotic Analysis and Prediction of Solar Activity

Kilcik A., Sarp V.
Department of Space Science and Technologies, Akdeniz University, Antalya, Turkey

The dynamics of solar activity are not fully understood yet but there are various assertions on the chaotic process of long term solar activity. In order to evaluate it, nonlinear methods are applied to sunspot number time series in this study. To investigate complexity of the data the Hurst Exponent and Correlation Dimension are calculated. Embedding dimension and delay-time are chosen for prediction. Detailed analysis introduced a new parameter which is the starting point of prediction. Based on derived parameters, it seems that past patterns can be used to predict solar activity and this feature is a signature for chaotic dynamics. Last four cycle was predicted out of sample with an acceptable accuracy. According to the results of this study, sunspot number time series demonstrates chaotic behavior and the next cycle 25 is expected to be slightly weaker than solar cycle 24 and have a double peak.

Filament Eruptions Associated with Flares, Coronal Mass Ejections and Solar Energetic Particle Events

Koleva K.[1], Duchlev P.[1], Dechev M.[1], Miteva R.[2], Kozarev K.[1], Veronig A.[3], Temmer M.[3]
[1] Institute of Astronomy and NAO – BAS, Sofia, Bulgaria
[2] Space Research and Technology Institute – BAS, Sofia, Bulgaria
[3] IGAM-Institute of Physics, University of Graz, Graz, Austria

This report presents analysis of three cases of filament eruptions (FE) that occurred on 2011 August 4, 2011 November 9 and 2012 April 5 and their associations with flares as sources of solar energetic particles(SEPs) and coronal mass ejections (CMEs). The associated filament eruptions and SEP-related solar flares were selected by simultaneous observations in X-ray, EUV and radio wavelengths. We investigate the various pre- and eruptive signatures that were observed for these events and focus on the filament helical morphology and kinematic evolution

(heights, velocities, accelerations) in order to determine their eruption mechanisms and the rate of their connections with the associated flares, CMEs and SEPs, as well.

An Investigation of the Early Stages of Solar Eruptions: from Remote Observations to Energetic Particles

Kozarev K.[1], Miteva R.[2], Koleva K.[1], Duchlev P.[1], Dechev M.[1], Veronig A.[3], Temmer M.[3], Dissauer K.[3]
[1] Institute of Astronomy and NAO – BAS, Sofia, Bulgaria
[2] Space Research and Technology Institute – BAS, Sofia, Bulgaria
[3] IGAM-Institute of Physics, University of Graz, Graz, Austria

The aim of this investigation is to combine multi-wavelength observations with modeling of particle acceleration by CME compressions/shocks, focusing on the initial phase of the solar eruptions and their efficiency in particle acceleration. We selected a number of events with simultaneous observations in hard X-ray, EUV and radio wavelengths of the SEP-related solar flares, and analyzed the properties of the emission (light curves, spectra and temporal evolution). The effect of the various solar eruption phenomena as factors influencing the SEP productivity is evaluated.

Solar Modulation on Galactic Cosmic Rays

Krastev K.
Space Research and Technology Institute – BAS, Sofia, Bulgaria

Some manifestations of the propagation of galactic cosmic rays, caused by the solar wind are presented. The case of modulation by the high-speed solar wind flow is considered.

Variations of Solar Wind Parameter During 21-24 Solar Cycles

Lodkina I.G., Yermolaev Yu.I., Khokhlachev A.A
Space Research Institute (IKI) – RAS, Moscow, Russia

On the basis of solar wind data of OMNI2 database (GSFC/SPDF OMNIWeb interface on http://spdf.gsfc.nasa.gov/pub/data/omni/low_res_omni/) and our of Catalog of large-scale solar wind (SW) phenomena during 1976-2016 (see website ftp://ftp.iki.rssi.ru/pub/omni/ and papers Yermolaev Yu.I., et al., 2009; 2017) we study the variations of plasma and field parameters in different typed of solar wind for 21-24 solar cycles. Our analysis includes the following SW phenomena: 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). We use 2 methods of data analysis in different SW types: (1) averaging of each parameter in selected SW type during each solar cycle, and (2) calculation of temporal profiles of these parameters by the double superposed epoch analysis [Yermolaev Yu.I., et al., 2010]. Our results confirm that during 24 solar cycle the numbers of disturbed SW phenomena are less than during previous cycles. Both used methods indicate that several parameters (e.g., the ion density N, the proton temperature T, the solar wind bulk velocity V, the magnitude of interplanetary magnetic field B, the proton plasma beta-parameters β, Dst index) in 24 cycle are less than corresponding parameters in 21-23 solar cycles.

Large-scale and Small-scale Structure of Interacting Solar Wind Streams

Lukashenko A.[1], Rodkin D.[2], Kaportseva K.[3], Shugay Yu.[1], Veselovsky I.[1, 4], Slemzin V.[2]
[1] SINP MSU, Moscow, Russia
[2] Lebedev Physical Institute – RAS, Moscow, Russia
[3] Faculty of Physics, MSU, Moscow, Russia
[4] Space Research Institute – RAS, Moscow, Russia

A classification of solar wind (SW) streams according to the main hydrodynamic parameters – a combination of the velocity (fast or slow), temperature (hot or cold) or density (dense or rarefied) of protons – is considered. According to this approach, we specify eight types of SW: fast-hot-dense (fhd), fast-hot-rarefied (fhr), fast-cold-dense (fcd), etc. As an additional parameter, the proton plasma beta is taken into account for description of the magnetic state of the SW streams. The listed types of SW occur with different frequencies, depending on the phases of the solar activity cycles. This classification is compared with the classical division of SW streams into high-speed flows from coronal holes, CME and slow solar wind from the streamer belt. The comparison is carried out for the events in August 2010 and May 2011 when the interaction of two CME and CME with a high-speed solar wind stream from the coronal hole, respectively, was observed. In both cases there was the rare fcd-type of the wind. We concluded that the classical description of the large-scale structure of SW on the scale of hours and days, in particular, consideration of the SW ionic composition, makes it possible to determine the nature and source of SW streams, whereas consideration of the hydrodynamic parameters including beta is useful for a detailed description of the small-scale structure (minutes) of complex regions appeared in the cases of interaction of several streams in the heliosphere.

Solar Particle Radiation Storms Forecasting and Analysis: the HESPERIA HORIZON 2020 Project and Beyond

Malandraki O.E.
National Observatory of Athens, IAASARS, Athens, Greece

The two real-time prediction tools, developed in the framework of the HESPERIA project based upon the proven concepts UMASEP and REleASE are described. Near-relativistic (NR) electrons traveling faster than 30 MeV ions are used to forecast the arrival of protons of Solar energetic Particle (SEP) events with real-time measurements of NR electrons. The faster electrons arrive at L1 30 to 90 minutes before the slower protons. The REleASE forecasting scheme uses this effect to predict the proton flux by utilizing the actual electron flux and the increase of the electron flux in the last 60 minutes. Within the HESPERIA project, the same forecasting principle with use of the same forecasting matrices were in addition adapted to real-time electron flux measurements from the ACE/EPAM experiment. >500 MeV solar protons are so energetic that they usually have effects on the ground, producing what is called a Ground Level Enhancement (GLE) event. Within HESPERIA a predictor of >500 SEP proton events at near-Earth has been developed. The implemented system, HESPERIA UMASEP-500, correlates X-ray flux with each of the differential proton fluxes measured by the GOES satellites. When the correlation estimation surpasses a threshold, and the associated flare is greater than a specific X-ray peak flux, a >500 MeV SEP forecast is issued. Both forecasting tools are operational under the HESPERIA server maintained at the National Observatory of Athens (https://www.hesperia.astro.noa.gr/). (HESPERIA EU Horizon 2020 project, GA No 637324).

Morphology, Geomagnetic and Cosmic Ray Flux Effects of Corotating Interaction Regions in 2008 – 2014

Maričić D.[1], Roša D.[1], Šterc F.[1], Karlica M.[2]
[1] Astronomical Observatory Zagreb, Zagreb, Croatia
[2] Sapienza University of Rome, Roma, Italia

Abstract. We present an analysis of corotating interaction regions (CIRs) morphology, employing the data recorded from January 2008 to December 2014. We study in detail the correlation of basic solar wind (SW) parameters in different parts of CIRs, in front and behind the stream interface (SI). As additional inspections we estimated the corresponding changes in geoeffectiveness and cosmic ray flux. For this purpose we made a list of 283 solar wind disturbances incorporated into an online catalogue for general use. After we separeted solar wind signatures on: CIRs, interplanetary coronal mass ejections (ICMEs), interactions and complex signatures; we focused our attention on 173 CIRs (61% of all SW signatures) where SI was clearly recognisable. The correlation coefficients of magnetic field B, proton thermal speed vth and flow speed V between the region in front and behind the SI are: cc = 0.83, 0.78 and 0.6, respectively. Furthermore, correlation of proton density Np in front and behind the SI indicated two different families of CIRs with correlation coefficients cc = 0.83 and 0.96. It is also shown that in most events the main decreases of Dst index and cosmic ray neutron flux occurs between SI and reverse shock of CIR.

Long-term Cyclicity in the Hemispheric Solar Activity

Muraközy J.
Debrecen Heliophysical Observatory, Konkoly Thege Miklós Astronomical Institute, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences

It is a well-known phenomenon that the levels of the solar hemispheric activities are different. A longer-term cyclicity can also be pointed out in this hemispheric asymmetry. This is the exchange of the leading role every four cycles between the hemispheres. Thus, this longer-term cycle covers eight Schwabe-cycles and means 4 + 4 cyclic alternation in the solar hemispheric precedence.

I will analyse this phenomenon by using more than 140 years sunspot data, which cover almost 13 whole solar cycles. These data come from Greenwich Photoheliographic Result (GPR) and Debrecen Photoheliographic Data (DPD).

This study has been extended by using the historical Schwabe and Staudacher data covering other almost 100 years.

It will be shown that this variation can be detectable not only in the hemispheric distribution of the sunspots but the solar flares as well.

The possible interplanetary and geomagnetic analogues will also be discussed.

Differential Rotation of the Solar Corona According to the Data on the Magnetic Field

Obridko V.N., Badalyan O.G.
IZMIRAN – RAS, Russia

The differential rotation of the solar corona for 1976÷2004 is considered depending on the distance from the center of the Sun in a spherical layer from the base of the corona to the source surface. Magnetic field in the corona is used s a tracer. The change in the differential rotation of the corona with the distance reveals the following features: a) the gradient of the differential rotation of the corona decreases with the distance from the center of the sun; b) the synodic period of the corona rotation at the equator gradually increases with increasing distance; c) even

near the source surface the rotation of the corona remains differential; d) at distances close to the Sun at high latitudes, a certain decrease in the period of rotation is observed. Obtained results obtained are satisfactory agreement with the results obtained earlier using data on the brightness of the green coronal line 530.3 nm Fe XIV.

Two Sunspot Populations: the Gnevyshev-Ohl Rule

Nagovitsyn Yu.A.[1, 2], *Osipova A.A.*[1, 2], *Pevtsov A.A.*[3]
[1] Pulkovo Astronomical Observatory, – RAS, Russia
[2] Saint Petersburg State University of Aerospace Instrumentation, Russia
[3] National Solar Observatory, USA

The presence of two physically distinct populations in the distribution of sunspots (small sunspots with weaker field strength and large sunspots with stronger field strength) is confirmed. The lifetime of sunspot groups is used as a separating factor: Small Short-living Groups (SSG) live less than 6 days and Large Long-living Groups (LLG) live 6 days or more. The relative contribution of each population shows 11-year and long-term variations. SSG rotate fast, and LLG is divided into slow and fast rotating modes, with fast mode coinciding with SSG fast rotating mode. We introduce the concepts of `static` indices (when each group of spots participates in statistics once, characterizing the performance of the dynamo process) and `dynamic` indices (when all the days of the group`s existence are present in statistics, describing, in particular, the influence of solar activity on terrestrial processes and heliosphere). For static indices, the well-known Gnevyshev-Ohl rule is tested in various formulations. For the parameter of the number of SSG, the Gnevyshev-Ohl rule has the opposite character, and such groups form a pair in a 22-year cycle - a combination of an odd and subsequent even cycle, with an even cycle having a smaller amplitude. The results obtained confirm the need to revise existing dynamo models, as Gnevyshev-Ohl rule violations can be explained by changes in modes of operation of two parts of the dynamo process, independently responsible for the generation of large and small spots.

Search of Solar Flare Magnetic Field Configurations from MHD Simulation Results in Solar Corona

Podgorny A.I.[1], *Podgorny I.M.*[2]
[1] Lebedev Physical Institute – RAS, Russia
[2] Institute of Astronomy – RAS, Russia

During accumulation the energy flare the magnetic configuration must be stable and then it must transform into an unstable state. The problem is complicated by the fact that flare release of magnetic energy occurs in the solar corona at an altitude of 15 000 – 30 000 km. Such process can be explained by slow energy accumulation in current sheet. It is proved by high resolution X-ray and ultraviolet observations and by the absence of any appreciable change of the observed magnetic field on the solar surface during the flare. To study the flare magnetic field configuration the MHD simulation in corona above the real active is performed in which all conditions are taken from observations. The configuration of real current sheet in corona is complicated. The graphical system for search flare position in corona is developed. It uses the property of the sheet, local maximum of the current density is located in the center of a current sheet. The position of the current sheet coincides with the position of the thermal X-ray source for flares May 27, 2003 at 02:53 and May 29, 2003 at 00:51. The study of the magnetic field configuration near the current sheet for these flares shows that the physical meaning of the processes of accumulation and rapid release of flare energy is demonstrated by 2D magnetic

lines in the current sheet configuration plane that is perpendicular to the magnetic vector in the current sheet center.

A Series of Powerful Solar Flares in a Minimum of Solar Activity

Podgorny I.M.[1], *Podgorny A.I.*[2]
[1] Institute of Astronomy – RAS, Russia
[2] Lebedev Physical Institute – RAS, Russia

A powerful series of solar flares is occurred in the minimum of solar activity 2017 September 4 11 over the active region AR12673. Moving across the disk, this active region produces two large and many small flares. The last flare X8.2 is followed by solar cosmic rays. The active region at that time is situated on the back side of the Sun disk behind the Western limb. The front of the accelerated protons flow arrives to the Earth with a delay not exceeding the proton flight time. Such proton propagation can occur only along the lines of the interplanetary magnetic field. The flow of relativistic electrons does not show any connection with the recorded solar cosmic rays. Photos in spectral lines of ions obtained on the SDO spacecraft are used to study the presumptive state and development of the flare. The source of flare radiation in the spectral lines of the highly ionized iron FeXXIV and FeXXIII occurs in the corona outside the solar limb. The emission of these spectral lines sharp increases during x-ray radiation appearing. The temperature in the flare is greater than 20 MK. The size of the hot plasma cloud is ~10^{10} cm. The energy release of a flare occurs in the corona above an active region.

The Solar Clock: from a Tight Seismic Radius-Solar Cycle Relationship to Relevant Astrophysics

Rozelot J.-P.[1], *Kosovichev A.G.*[2], *Kilcik A.*[3]
[1] Côte d`Azur University, Nice-Grasse, France
[2] New Jersey Institute of Technology, Newark, NJ, USA
[3] Akdeniz University, Antalya, Turkey

Solar cycles seem to be paced by an accurate clock inside the Sun, persisting during period of great minima. For an external observer, does that mean that a non-static solar envelope leads to a pulsating star? Accurate measurement of the solar radius and its variations is one of the oldest astronomical problems. It is important for two primary reasons. First, the radius serves as an astronomical standard. Second, the solar radius variations reflect still poorly understood processes associated with the cyclic magnetic activity beneath the Sun`s surface. First accurate measurements of the size of the Sun performed in 18th and 19th centuries indicated that `the systematically larger diameters correspond to the time when the number of spots and protuberances is lower`. Since that the questions whether the Sun shrinks with the solar activity and what are the causes is a long-standing question. Helioseismology provides means to measure with high precision the radial displacement of subsurface layers, the co-called `seismic radius`. Analysis of twenty-one years of helioseismology data from two space missions, SoHO and SDO, show that most significant variations of the solar radius occur beneath the visible surface of the Sun at the depth of about 5,000 km, where the radius is reduced by 5÷8 km during the solar maxima. The changes can be explained by a strong subsurface magnetic field which is predominantly vertical at this depth. Other relevant astrophysics can be made through an accurate measure of the radius, leading to a better understanding of the solar core.

Recent Results for the Space Radiation Environment Provided by Liulin-MO Dosimeter Aboard Trace Gas Orbiter to Mars

Semkova J., Koleva R., Krastev K., Dachev Ts., & Liulin-MO-ExoMars TGO team (A)[**3]
Space Research and Technology Institute – BAS, Sofia, Bulgaria

ExoMars is a joint ESA - Rosscosmos program for investigating Mars. Two missions are foreseen within this program: one consisting of the Trace Gas Orbiter (TGO), launched on March 14, 2016; and the other, featuring a rover and a surface platform, with a launch date of 2020. On October 19, 2016 TGO was inserted into high elliptic Mars orbit and on April 16, 2018 has begun the science phase of ExoMars TGO in circular Mars orbit. Here we present recent results from measurements of the charged particle fluxes, dose rates, Linear Energy Transfer spectra and estimation of dose equivalent rates in the interplanetary space and in Mars orbit in the declining phase of Solar activity, provided by Liulin-MO dosimeter of FREND instrument aboard TGO. A comparison is made with the Galactic Cosmic Rays count rates provided by other particle detectors currently in space.

The obtained data show that during the cruise to Mars and back (6 months in each direction), taken during the declining of solar activity, the crewmembers of future manned flights to Mars will accumulate at least 60% of the total dose limit for the cosmonauts/ astronauts career in case their shielding conditions are close to the average shielding of Liulin-MO detectors - about 10g cm^{-2}.

Dynamics and Magnetic Properties in Coronal Holes Using High-resolution Multi-instrument Solar Observations

Krikova K., Utz D., Veronig A., Hofmeister S., Temmer M.
Institute of Physics, Department of Astrophysics, Geophysics and Meteorology,
University of Graz, Graz, Austria

Using high-resolution solar observations from the Hinode Instruments SOT/SP, EIS and XRT as well as IRIS from a coronal hole on the 26th of September 2017, we are investigating the dynamics within the coronal hole.

Further satellite data support is given by full disc images from SDO with the AIA and HMI instruments. EIS and IRIS data provide us crucial information about the plasma and energy flow from the sun`s chromosphere into the corona using the EUV and UV spectra and images. Investigating the magnetic configuration as well as the dynamics and changes within the coronal hole by using the SOT/SP data gives us crucial insides about the physical processes leading to the corresponding changes in the higher atmosphere. We compare the Hinode data with AIA and HMI data to get a firm comprehensive picture about the connection from high resolved photospheric fields and its dynamic with the higher layers.

In this poster contribution we will outline the state of the art of this investigation and give an overview of the further steps necessary. The data were obtained during a recent GREGOR campaign with the joint support of IRIS and Hinode (HOP 338).

[3] see page 44

Study of the Solar Photospheric Plasma and Magnetic Field Dynamics and the Temporal Evolution of Flow Motions

Campos-Rozo J.-I.[1], Utz D.[1], Vargas-Dominguez S.[2], Veronig A.[1]
[1] IGAM-Intitute of Physics – University of Graz, Graz, Austria
[2] Observatorio Astronomico Nacional – Universidad Nacional de Colombia, Colombia

The solar surface dynamics are dominated by the emergence of convective flows. These convective cells transport hot plasma as well as magnetic field from the inner layers to the surface. The main motivation of this work is to study the dynamics on the phostosphere using continuum images as well as Line-of-Sight (LOS) magnetograms during the time prior to the onset as well as druing the onset, and the first hours of the emergence of Active Region (AR) 11190 on 11-April-2010. The velocity fields are calculated using Local Correlation Tracking (LCT) techniques. Due to the nature of the velocity flow fields, the best suitable statistical distribution that describes such motions is a Rayleigh distribution.

However, in the moments of strong and newly magnetic field emergences, substantial changes in the dynamics within the FOV occur creating the necessity to model the velocity flow fields by using a mixture of two different statistical distributions. The main distribution is still a Rayleigh distribution related to the undisturbed background flows and the general behavior in the region of interest, whereas the second component describes the rapid and violent changes within the FOV. While the proposed model shows in general a strong correlation between the plasma motions and the movements of the detected magnetic elements, at time instances of strong and rapid magnetic flux emergence the direct relation starts to break down with an apparent faster movement of magnetic elements for short periods of time

Sunspot Number Prognosis for the 25th Solar Cycle Using Ar-models Separately for the Northern and Southern Hemispher

Werner R., Guineva V.
Space Research and Technology Institute – BAS, Stara Zagora, Bulgaria

The solar activity changes have important impacts on space weather and on the Earth atmospheric processes. It is therefore not surprising that in the past decades a multitude of methods were developed to predict the solar activity. Here the sunspot number, a proxy of the solar activity, was considered as a times series and its statistical characteristics were studied. As it is well known the dynamic processes in both Sun hemispheres are not strong coupled. Hence, the progress of the solar cycles was described by auto-regression models worked out separately for northern and southern hemispheres and by summation, the total sunspot numbers were calculated. It was used a data sampling of six month. For control ex-ante prognosis of the last solar cycle was carried out, giving a sunspot number of 130+/-34 in 2013 consistent with the observed sunspot number maximum. For the new 25th Solar cycle a similar progress as during the 24 cycle was predicted. The sunspot maximum in the northern hemisphere should be achieved before the maximum in the southern hemisphere, when a higher activity in the southern hemisphere would be expected. A total sunspot number of about 117+/-34 is predicted for 2023. (The sunspot maximum for the 24th and 25th Solar cycle determined by/with the data of the previous SILSO version 1 are 78+/-23 and 70+/-23, respectively).

Research and Graphical Representation of the Amount of Accumulated Solar Energy for Different Time Periods on the Earths Surface

Tashev V.[1], Manev A.[1], Werner R.[1], Goranova M.[2]
[1] Space Research and Technology Institute – BAS, Stara Zagora, Bulgaria
[2] Technical University of Sofia, Faculty of Computer Systems and Management, Sofia, Bulgaria

A Davis meteorological station Vantage Pro 2 Plus is operating in Stara Zagora since 2011. The station is of a semi-professional type, and one of its sensors is designed especially for measuring of the solar radiation. The amount of solar energy is measured in continuous mode every 15 seconds. The collected data from the sensor were integrated and the data were recalculated in order to obtain results for the solar energy that is absorbed during a certain time interval per unit Earth`s surface. The purpose of this research is to trace the repeatability during different periods. A high annual repetition provides a good opportunity to forecast of the energy yields for the coming years. The monitoring was carried out for the region of Stara Zagora.

Advection and Inter-component Connections in the Quasar

Yankova Kr.
Space Research and Technology Institute – BAS, Sofia, Bulgaria

In this paper is analyzes the impact of the restructuring in the accretion flow, over self-induction of the advection and exchange of energy in the stream. Emergence and action of non-deforming advection, builds connections between the elements in quasar; and for that allows to research the evolution of the mechanism in some of them.

MHD models of non-stationary accretion disc showed appear and quickly develop corona. Advective warming into the pad maintains vitality the corona.

Extension on advective hypothesis in the general relativity allows to trace the continuation of the advective spiral beyond event horizon.

Stealth Coronal Mass Ejections: Identification of Source Regions and Geophysical Effects

Zagainova Yu.S.[1], Fainshtein V.G.[2], Gromova L.I.[1], Gromov S.V.[1]
[1] IZMIRAN – RAS, Russia
[2] ISTP SB – RAS, Russia

Stealth coronal mass ejections (SCMEs) are observed in the coronagraphs` field of view. Coronal mass ejection is stealth if no coronal wave, filament eruptions, solar flares, coronal dimming and post-eruptive arcades. A growing interest to such sporadic events can be explained by applied problems related to tracking geoeffectiveness of these events and prediction of so called `problem` geomagnetic storms, i.e. storms without a clearly observed solar source. Analyzing several SCMEs, this paper demonstrates that such mass ejections can be associated with the lower solar corona fine-scale activity that includes subflares and eruptions of fine-scale magnetic flux ropes. In some cases, it is possible to detect emergence of SCME frontal structure at the initial stage of its formation. It has been found some SCMEs manifestations in the interplanetary magnetic field and in the solar wind close to the Earth`s orbit and their geophysical effects was studied.

Solar Wind-Magnetosphere Interactions

Towards Forecasting the Time of the Maximum Positive Ionospheric Storm Phase over Europe

Badeke R., Borries C.
German Aerospace Center (DLR), Institute for Communication and Navigation, Germany

An accurate forecast of the ionospheric Total Electron Content (TEC) gives valuable information to mitigate space weather influences on technical applications like satellite communication and navigation. Ionospheric storms that are a result of geomagnetic disturbances can lead to strong enhancements of TEC. One major challenge in space weather forecasting lies in the prediction of the maximum storm phase. This work aims to characterize the time difference between storm onset and the maximum positive storm phase.

TEC data are obtained from maps of the International GNSS Service (IGS). The study focusses on European latitudes between 30 and 70 degree N. Storm onsets are described with the help of the geomagnetic Dst index. Over 250 ionospheric storms during the years of 2001 to 2017 have been statistically described. They are further utilized to give a latitude-dependent range of forecasted maximum storm time. Two years of storm data are used to test the estimated storm time against measurements (map values) and give an outlook of the storm time predictability.

Investigation of Absorption of Radio Emission from Discrete Cosmic Sources under HF Modification of the Lower Ionosphere

Charkina O.V., Bezrodny V.G., Yampolski Y.M.
Institute of Radio Astronomy NASU, Kharkiv, Ukraine

The effect of additional absorption of the electromagnetic emission in the HF modified ionospheric D-layer is studied. Results of two special measuring campaigns of February and October 2008 on observations of emission at 38.2 MHz from two most powerful in the northern sky discrete cosmic sources (DCSs), namely Cassiopeia A, Cygnus A, which passed through the ionospheric region disturbed by powerful HAARP (High Frequency Active Auroral Research Program) transmitter (Alaska, USA) are discussed. Observations were performed with the use of a multibeam phased antenna array of the Gakona imaging riometer located in the immediate vicinity of the heater. The possibilities of modification of the weakly ionized plasma are theoretically and experimentally investigated in the frames of the different models of behavior of electron density. The dependence of the enhanced absorption of DCS radiation in the artificially disturbed ionospheric D-region on the amplitude of heating signal has been analyzed.

Short-term Effects in the Inner Radiation Belt During Geomagnetic Storms

Dachev Ts., Bankov N., Tomov B., Matviichuk Yu., Dimitrov P.
Space Research and Technology Institute – BAS, Sofia, Bulgaria

Active flux measurements was performed with the Radiation risk radiometer-dosimeters outside the International space station in 3 long-term periods between 2008 and 2016. Following short-term effects in the inner radiation belt was observed during geomagnetic storms: 1) Strong decreases of the SAA proton flux maximum and area is observed during the main phase of the magnetic storms. The protons losses can be caused by the Coulomb frequency collisions with

storm-enhanced neutral oxygen atoms. This hypothesis is proved by comparisons with the predicted by the NRLMSISE-00 model neutral Oxygen density, calculated in SPENVIS (https://www.spenvis.oma.be/help/background/atmosphere/models.html#MSIS); 2) Increases of the proton flux is observed during the sudden commencements (SSC) of the storms in presence of solar energetic protons; 3) Enhanced flux of relativistic electrons, which migrate from the outer radiation belt, is observed at the L-values higher than 1.7 during the recovery phase of the magnetic storms.

The Magnetospheric Ring Current Drives Certain Fluctuations in the Earths Rotation!

Demetrescu C., Dobrica V.
Institute of Geodynamics – Romanian Academy, Bucharest, Romania

It is well-known that the magnetospheric ring current is responsible for the depression of the horizontal component, H, of the geomagnetic field during geomagnetic storms. Its intensity is parameterized and characterized by the depression caused at the terrestrial equator the Dst index. Here we study the disturbances in the geomagnetic declination, D, the angular component of the geomagnetic field vector, that happen at decadal and intra-decadal time-scales, and link these variations to corresponding ones observed in the length-of-day (LOD). Of great interest are fluctuations at intra-decadal time scale the so-called 6-year variation considered of internal origin (part of the geodynamo) in the current literature, but seen as having an external source by the present authors. The source in view is variations of the magnetic field of the magnetospheric ring current, as a result of the interaction of the terrestrial magnetosphere with the solar wind and interplanetary magnetic field.

Solar Wind Drivers and Appearance of Magnetic Substorms

Despirak I.V.[1]*, Lubchich A.A.*[1]*, Kleimenova N.G.*[2]
[1] Polar Geophysical Institute, Apatity, Russia
[2] Schmidt Institute of the Physics of the Earth – RAS, Moscow, Russia

The effect of solar wind drivers on the magnetic substorms is considered. The data of SuperMAG global magnetometers network, IMAGE magnetometers, OMNI data base and the catalog of large-scale solar wind phenomena (ftp://ftp.iki.rssi.ru/omni/) have been combined. We considered only 6 solar wind streams types: high speed streams from coronal holes (FAST); interplanetary manifestations of coronal mass ejections: magnetic clouds (MC) or EJECTA; regions of compressed plasma before these streams - CIR and SHEATH; slow solar wind (SLOW). Three types of substorms have been analyzed: supersubstorms (the particularly intense substorms with SML index < – 2500 nT), the `polar` and `expanded` substorms observed at the geomagnetic latitudes higher ~ 70 degrees CGC. The 77 `supersubstorm` (SSS), 186 `polar` and 202 `expanded` events were selected. It is shown that the space weather conditions for the SSS, `polar` and `expanded` substorms are different. SSS events were associated with SHEATH, MC, EJECTA and almost did not observed during FAST. Whereas `expanded` substorms are observed during FAST and compressed plasma regions (CIR, SHEATH), as well as during EJECTA. `Polar` substorms are observed during SLOW and EJECTA that occur under the slow solar wind, as well as at the end or the beginning of FAST.

Some Ionospheric Affects on Navigation Signals in Arctic

Chernouss S.A.[1], Shagimuratov I.I.[2], Despirak I.V.[1], Ievenko I.B.[3], Filatov M.V.[1], Efishov I.[2]
[1] Polar Geophysical Institute, Apatity, Russia
[2] Kaliningrad Department of IZMIRAN, Kaliningrad, Russia
[3] Yakutsk Institute of Cosmophysic Research and Aeronomy – RAS, Yakutsk, Russia

Comparative study of optical auroras and irregularities of total electron content (TEC) in the high latitudes is made. The main data for this work are the raw GPS measurements provided by the ground-based IGS network of GPS receivers. RINEX format data were processed to obtain the dynamic characteristics of the ionospheric irregularities. Optical auroral data were obtained by digital all-sky camera in different places. On the base of famous models, we constructed temporal and spatial distributions of the rate of TEC index (ROTI) and optical auroras for several dates. It is shown that the similarity between of the auroral ovals and distributions of TEC irregularities exists. We performed a detail spectral analysis of auroras for the event on January 7, 2015. We used spectral images in the main auroral emissions OI 555.7, OI 630.0, N2+ 470.9 and H 486.1 nm in subauroral (Yakutsk) and auroral (Poker Flat) stations. For this day, high activity was observed during 07-13 UT. Both auroral activity and quantity of irregularities sharply increased in this time. This fact observed in the same sector of local time with some difference for different auroral emissions. ROTI images, which were calculated from signals of all satellites in the receiver field of view, demonstrated a good correlation as well OI green and red auroras, and N2+ blue ones. The correlation depends on the time span of a substorm and, perhaps, associated with the heights of TEC irregularities.

Substorm Activity on 24 December 2014: Themis and Main Camera System Observations

Despirak I.V.[1], Kozelova T.V.[1], Kozelov B.V.[1], Lubchich A.A.[1], Guineva V.[2]
[1] Polar Geophysical Institute, Apatity, Russia
[2] Space Research and Technology Institute – BAS, Stara Zagora, Bulgaria

Consequence of several substorm intensifications on 24 December 2014 in the interval 16:30-20:00 UT were investigated by simultaneous satellite and ground-based observations. The active auroras were observed by Multiscale Aurora Imaging Network (MAIN) in Apatity, the magnetic disturbances were recorded by IMAGE and Lovozero magnetometers. During considered interval the THEMIS-D (THD) and THEMIS-E (THE) satellites were located at |X|~ 7 Re and the projection of THD orbit crossed Kola Peninsula from ~18:30 to ~19:30 UT. Four substorm intensifications were selected during considered time period: substorm on 16:45 UT; small substorm-like disturbance on 19:18 UT; small substorm on 19:37 UT and substorm on 19:45 UT. Detailed comparative analysis of auroras and satellite observations for each of these events is made. Evolutions of different populations of energetic particles as well as current disturbances in the near-Earth plasma sheet were identified during the consecutive auroras intensifications

Space Weather Issues in Solar Cycle 24

Dobrica V.[1], Maris Muntean G.[1], Demetrescu C.[1], Besliu-Ionescu D.[1, 2]
[1] Institute of Geodynamics – Romanian Academy, Bucharest, Romania
[2] Astronomical Institute – Romanian Academy, Bucharest, Romania

The solar cycle 24, the weakest solar cycle in more than a century, follows a recent trend of weakening solar cycles which began with the solar cycle 22, with important geo-consequences, especially if they are part of a long-term pattern. The low level of solar activity in the present

solar cycle will be discussed in comparison with the previous solar cycle, in terms of geoeffective solar events number (CME, HSS). Several space weather events arised in the solar cycle 24 (2009-2016) as regards geoeffective CMEs and HSSs are detailed to show the cause-effect chain from Sun to Earths magnetosphere, on the background of space climate characterization at long-term timescales. The major magnetic storms, triggered by ICMEs and/or HSSs, are analyzed both from point of view of solar cause and from point of view of ground effects as recorded by certain European geomagnetic observatories.

Development of Magnetic Storms Induced by Different Types of Solar Wind Stream

Dremukhina L.A.[1], *Yermolaev Yu.I.*[2], *Lodkina I.G.*[2]
[1] IZMIRAN – RAS, Moscow, Troitsk, Russia
[2] IKI – RAS, Moscow, Russia

This study is a continuation of our research on the development of the main phase of magnetic storms induced by different types of the solar wind (SW). On the base of catalog of the identified SW types (website ftp://ftp.iki.rssi.ru/pub/omni/) and the OMNI data base for 1995-2016, 240 isolated magnetic storms were selected which were induced by four types of the SW: interplanetary manifestation of coronal mass ejections (ICME), including magnetic clouds (MC) and Ejecta, compression regions before ICME (Sheath), and compression regions before high-speed streams of the SW (corotating interaction region CIR). The effect of various interplanetary parameters on the magnetospheric activity was studied. We found out that the minimum values of the index Dst-min correlated with the mean values of the interplanetary electric field Ey for all storms, independently of their source. A significant correlation was also obtained between Dst-min and integral (for the main phase) Ey values for the storms induced by CIR, Sheath and Ejecta, while it was weak for MC-events. The average rate of the storm development in its main phase |ΔDst|/ΔT was also strongly correlated with the Ey values for CIR-, Sheath- and MC-induced storms, but there was no correlation between |ΔDst|/ΔT and Ey values for Ejecta-induced storms. The strongest correlation was obtained for the magnetic storms induced by Sheath structures. Obtained results confirm our previous conclusions that magnetic storm development depends on the type of its solar wind driver. The work was supported in part by the Russian Fundamental Research Foundation, project 16-02-00125.

Interplanetary Conditions Leading to Dayside Magnetic Bays During the Initial Phase of Magnetic Storms

Gromova L.I.[1], *Kleimenova N.G.*[2], *Gromov S.V.*[1]
[1] IZMIRAN – RAS, Moscow, Troitsk, Russia
[2] IFZ, Moscow, Russia

The solar wind (SW) and Interplanetary Magnetic Field (IMF) variations cause different disturbances in the geomagnetic field measured on the Earth's surface. We present a study of magnetic bay-like disturbances occurred in the dayside sector of the high geomagnetic latitudes under different IMF and SW conditions. As a rule, such disturbances are observed under the positive Bz component of IMF. This situation is often observed during a long-lasting initial phase of a magnetic storm. We compared the geomagnetic effects, such as dayside magnetic bay generation, caused by interplanetary shocks (SI) that attacked the magnetosphere during the initial phase of the storms on 7-8 September 2017 and 21-23 June 2015. Our study was based on the magnetic data from the Scandinavian IMAGE magnetometer chain and INTERMAGNET collection. We showed that the appearance of the dayside high-latitude bays were collocated with the enhanced Field-Aligned Currents (FAC) obtained by the AMPERE products from the Iridium satellite constellation. We found that the rapid fluctuations in IMF components could interfere the development of dayside bays associated with the interplanetary shocks.

The ground-based magnetograms demonstrate repeatable features in the conjunction with the Bz and By IMF components.

Features of Mid-latitude Substorms During Large Magnetic Storms

Guineva V.[1], Despirak I.V.[2], Kleimenova N.G.[3]
[1] Space Research and Technology Institute – BAS, Stara Zagora, Bulgaria
[2] Polar Geophysical Institute, Apatity, Russia
[3] Schmidt Institute of the Physics of the Earth – RAS, Moscow, Russia

We considered some peculiar properties of mid-latitudes substorms during different solar wind and geomagnetic conditions. The data of INTERMAGNET and IMAGE magnetometers networks and OMNI data base have been combined. Large magnetic storms (SYM/H<-100 nT) during the maximum, the ascending and descending phases of the 24th solar cycle have been analyzed. The substorms registered at middle and low latitudes in the main phases of the selected magnetic storms have been considered. We have also studied the solar wind and Interplanetary Magnetic Field conditions which could be favorable for occurrence of a possible relationship of the low-latitude substorms with the so called `expanded` substorms developing at high latitudes.

Unusual Pc1 Geomagnetic Pulsations Observed on the Ground in the End of 24-th Solar Activity Cycle

Feygin F.Z., Kleimenova N.G., Malysheva L.M., Khabazin Yu.G.
Schmidt Institute of Physics of the Earth (IFZ RAN), Moscow, Russia

A very unusual event of Pc1 geomagnetic pulsations, spanning from 56^0 to 66^0 CGC with very similar dynamic spectrum, has been observed in the late recovery phase of the last strong magnetic storm (7-8 September 2017) of 24-th solar cycle,. The dynamic spectrum of this Pc1 event looked like a superposition of two different emissions. The first low-frequency emission band represented 'classical' Pc1 pulsations with the almost constant carrier frequency (~1.6 Hz). The second Pc1 band demonstrated a very sharp onset at higher carrier frequencies rapidly decreasing from ~2.8 Hz to ~1.6 Hz with a large bandwidth of ~0.8 Hz. We suppose that these Pc1 waves were a result of the simultaneous wave generation at the different L shells. The source of the low-frequency 'classical' Pc1 emissions was associated with the 'old' plasmapause, formed under the previous quiet geomagnetic conditions (Kp=0). The source of the second high-frequency Pc1 band could be associated with a 'new' plasmapause which was formed under the moderate (Kp=3) magnetic conditions. The source location gradually expanded to the higher L shells in accordance with the solar wind dynamic pressure (Psw) decreasing. A theoretical interpretation of the considered Pc1 event and a possible scenario are discussed.

Ground-based Geomagnetic Signature of the 7÷8 September Magnetic Storm as a Farewell Gift from Solar Cycle 24

Kleimenova N.G.[1], Gromova L.I.[2], Gromov C.V.[2], Malysheva L.M.[1]
[1] Institute Physics of the Earth – RAS, Moscow, Russia
[2] IZMIRAN – RAS, Moscow, Troitsk, Russia

In the first half of September 2017, i.e. at the end of the 24-th cycle of the solar activity declining, there was suddenly occurring one of the most flare-productive periods. The coronal mass ejection associated with the 6 September X-9 flare produced severe (Kp=8) geomagnetic storms on 7 and 8 September. Here we study the high-latitude ground-based geomagnetic

variations in conjunction with the solar wind and Interplanetary Magnetic Field changes. Our analysis was based on the observations at the closely spaced Scandinavian IMAGE magnetometer chain. The information of the magnerosphere Field Aligned Currents was obtained from the AMPERE products derived from the Iridium satellite constellation. It was shown that in the first storm recovery phase, the main geomagnetic disturbances were concentrated at dayside polar latitudes. The specific behavior of geomagnetic pulsations was found in association with the variating space weather conditions.

Auroral Hiss Events Observed During the Declining of the 24-th Solar Cycle at two Stations Separated by 400 km in Longitude

Manninen J.[1], Kleimenova N.G.[2], Fedorenko Yu.V.[3], Gromova L.I.[4], Nikitenko A.[3], Turunen T.[1]
[1] Sodankylä Geophysical Observatory, Sodankylä, Finland
[2] Schmidt Institute of the Earth Physics – RAS, Moscow, Russia
[3] Polar Geophysical Institute – RAS, Apatity, Russia
[4] IZMIRAN – RAS, Moscow, Troitsk, Russia

Auroral hiss is the whistler mode emission with intensity maximum at frequencies of 7-10 kHz. These emissions are typically observed in the evening-night sector of the auroral zone and attributed to the Cerenkov instability developed by soft electron precipitation. Here we consider the simultaneous observations of auroral hiss at two ground stations at L~ 5.5 with longitudinal separation of ~400 km: Kannuslehto (Finland, KAN) and Lovozero (Russia, LOZ), during several winter campaigns in the declining of the solar cycle 24. It was revealed that the most favorable conditions for the auroral hiss generation are occurred during the magnetic storm recovery phase mainly prior a substorm onset. Simultaneous VLF observations at KAN and LOZ showed that the probability of the auroral hiss occurrence at the given ground-based station depends on the location of the ionospheric exit area of the VLF waves generating at the altitudes of about 500-2000 km and, may be, even higher above the ionosphere. The several examples of auroral hiss are presented in details.

Galactic Cosmic Rays Variations Caused by Solar Wind High Speed Streams Observed on Board of ExoMars TGO

Koleva R.[1], Semkova J.[1], Dachev Ts.[1], Matviichuk Yu.[1], Tomov B.[1], Krastev K.[1], Maltchev St.[1], Benghin V.[2], Mitrofanov I.[3], Malahov A.[3], Yermolaev Yu.[3]
[1] Space Research and Technology Institute – BAS, Sofia, Bulgaria
[2] IMBP – RAS, Russia
[3] IKI – RAS, Russia

The FREND dosimeter Liulin-MO on board ExoMars TGO measured GCR fluxes during TGO transit to Mars and on Mars high ecliptic orbit. During the interplanetary transit of TGO a good agreement between the fluxes provided by Liulin-MO and those measured by SIS instrument aboard ACE is observed. On high elliptic Mars orbit (31.10.2016 - 20.02.2017)Liulin-MO data match SIS data `delayed` by 5 days in average. During the plotted period no CME hit the Earth but multiple HSS were observed. We use the WSA-Enlil model (http://iswa.ccmc.gsfc.nasa.gov/) to look at the propagation of a possible HSS. We investigate the relation of GCR short-term variations to the observed solar wind parameters as measured aboard ACE to find how the flux depletions are related to the particular HSS.

About Extended Applying of the Space Weather Indices in the Analysis of the Artificial Satellites Drag in Circular and Elliptical Orbits

Komendant V.[1], Ryabov M.I.[1], Koshkin N.[2]
[1] Observatory "URAN-4", Institute of Radio Astronomy NAS of Ukraine, Ukraine
[2] Astronomical Observatory of I.I. Mechnikov Odessa National University, Ukraine

Consideration of the dependence of the nature of the artificial satellites drag, on circular and elliptical orbits, on the state of space weather was continued. Review of the data at different phases of the solar cycle and the application of a wider list of space weather indices was carried out. Among them: data of the change of the solar constant, solar wind parameters, Lyman alpha radiation was considered. The character of correlations of the drag coefficient from the indices, mentioned above, by years and phases of 23-24 solar cycles is shown.

Effect of Corotating Corpuscular Streams on the Ionospheric Absorption of Cosmic Noise. Based on the Observations of the Radio Telescope URAN-4

Lytvynenko O., Panishko S., Lytvynenko I., Galanin V.
Observatory "URAN-4" of the Institute of Radio Astronomy of NASU, Ukraine

In the first half of 2006, we could observe a rare situation when the density of charged particle fluxes near the Earth had a pronounced periodic change for a long time, associated with corpuscular corpuscular streams from the coronal hole. At the same time, other solar activity transients were not manifested. This made it possible to study the relationship between the corotation corpuscular streams and the turbulence of the midlatitude ionosphere. The ionospheric scintillation index of compact space sources was used as a parameter characterizing the turbulence. Data on ionospheric scintillations were obtained during observations on the radio telescope URAN-4. The developed technique for extracting riometric information from previously obtained monitoring data for compact space sources allows us to consider the effect of corotation corpuscular fluxes on the absorption of cosmic noise. The results obtained are discussed in the paper.

Investigating and Cataloguing High Speed Streams During Solar Cycle 24

Maris Muntean G.[1], Besliu-Ionescu D.[1, 2], Dobrica V.[1]
[1] Institute of Geodynamics – Romanian Academy, Bucharest, Romania
[2] Astronomical Institute – Romanian Academy, Bucharest, Romania

The High Speed Streams (HSSs) in the solar wind are travelling through the heliosphere towards the orbit of Earth and beyond. They induce a lot of interplanetary disturbances that could cause geomagnetic storms (GSs), polar auroras and malfunctions in spatial and even terrestrial technological systems.

We present our method of investigating and cataloguing HSSs used for events of the 24th solar cycle. A complex catalogue of HSSs and their effects in the terrestrial magnetosphere as geomagnetic storm was compiled (from 2009 up to 2016) and has been made available at www.geodin.ro/varsiti. An analysis of some specific HSS-GS event pairs is also presented, underlying how the HSS features could influence the GS characteristics (the storm magnitude, its main phase structure and the energy transfered from solar wind to magnetosphere during the storm).

Observational Evidence of the Kelvin Helmholtz Instability Associated with a Pc5 Wave at an Equatorial Location

Olugbon B.[1], Menk F.W.[2], Waters C.L.[2], Oyeyemi E.O.[1], Kascheev A.[3], Adeloye A.B.[1]
[1] University of Lagos, Nigeria
[2] University of Newcastle, Callaghan, NSW, Australia
[3] Institute for Radio Astronomy, Ukraine

A Pc5 wave event which was detected by the ground magnetometer near Abuja (Geographic: 7.55E, 10.50N; Dip latitude -4.68) is analysed in detail in this report. The event which occurred near local noon with frequency ~ 2.0 mHz had amplitude approximately 4 times the 3 year averaged Pc5 wave amplitude in that region. Solar wind proton density and flow pressure were low during the event (~ 2.5 N/cc and 2.0 nPa respectively). However, the solar wind flow speed was high (up to 650 km/s) which prompted investigation of the Kelvin Helmholtz instability (KHI). Analysis of geomagnetic field data from low latitude stations on both sides of the noon meridian showed a reversal in the Pc5 wave polarization azimuth across noon. Data from Time History of Events and Macroscale Interactions (THEMIS) spacecraft located close to the magnetopause during the event showed evidence of magnetopause crossings, consistent with surface waves triggered by the KHI. In addition, data obtained from the fluxgate magnetometers (FGM) on board THEMIS spacecrafts showed that the amplitude of the pulsations did not decay away spatially from the magnetopause thereby suggesting a fast mode resonance. Likewise, the pulsations detected by low latitude ground magnetometers did not show a consistent decay in amplitude away from noon towards dusk. Furthermore, the spectra of wave polarization azimuth at low latitude stations close to the sub-solar point showed clear reversals in the wave polarization azimuth, providing new observational evidence of possible fast mode wave reflection boundaries in the magnetospheric cavity.

The Catalog of Magnetic Storms for a Zone of Odessa Magnetic Anomaly

Sobitnyak L.I. [1], Ryabov M.I. [2], Sukharev A.L. [1], Orlyuk M.I. [2], Romenets A. [2]
[1] URAN-4 Observatory, Radio-astronomical Institute – NAN of Ukraine, Ukraine
[2] Institute of Geophysics – NAN of Ukraine, Ukraine

On magnetic observatory `Odessa` since 1948 measurements of a magnetic field of Earth are conducted, with a period 1 hour. At the same time measurements of three elements of a magnetic field are registered: horizontal component (H), vertical component (Z) and inducement (D). In this release of the catalog during 2000–2009 years include :date and time of the beginning and end of a storm, the storm duration, amplitude on three elements of a magnetic field are specified: H, Z, D, the characteristic of magnetic storms with the indication of the fissile periods. The magnetic station `Odessa` is located near a zone of a magnetic anomaly. Catalogue of magnetic storms Observatory `Odessa` is associated with catalog magnetic storms IZMIRAN (1950–2010 years).

For identification of reaction in the nature of the geomagnetic activity arising owing to existence of a magnetic anomaly comparison of S q variations and magnetic storms at stations `Odessa` and `Kiev` was carried out. For identification of fundamental periods and their changes over time the method of wavelet analysis was used.

Monitoring of Fluxes of Powerful Cosmic Radio Sources on RT "URAN-4" as Indicators of Extreme Conditions of Space Weather - Results of Calculations of Multiple Correlative Models

Sobitnyak L.I.
Odessa observatory "URAN-4" of Radio-astronomical Institute – NAN of Ukraine, Ukraine

The radio telescope "URAN-4" of radio-astronomical institute of NAN of Ukraine is the VLBI element of the URAN system located in the territory of Ukraine with the maximal removal of elements in 1000 km. From the moment of its begin observations in 1987 year on a radio telescope "URAN-4` monitoring of fluxes of high-power galactic and extragalactic radio sources is carried out.

Changes of fluxes of radiation sources on decameter waves are defined by a condition of an ionosphere as a result of changes of space weather. The program of monitoring includes radio galaxies: 3C274, 3C405 and supernova remnant: 3C144, 3C461.

The model of multiple correlative dependence of fluxes of radio sources on the factors forming space weather for the periods of its extreme condition is considered. More than 60 models of multiple correlative dependence were calculated. Values of a multiple coefficient of correlation in the range of 0.86–0.99 were received. The greatest contribution to the quantity of a multiple coefficient of correlation give: radio emission of the Sun on a wave 10.7cm (F10.7), the total area of groups of spots (Sp), flows: protons (P), electrons (E), Sounding of the ionosphere radiation powerful cosmic radio sources makes it possible to estimate the integral effect on solar and geomagnetic activity.

Dynamics of Geomagnetic Disturbances in Odessa Magnetic Anomaly Zone, Review of Observation and Measurement Results with a One Second Resolution

Sukharev A.L.[1], Ryabov M.I.[1], Orlyuk M.I.[2], Romenets A.[2]
[1] Observatory `URAN-4`, Institute of Radio Astronomy – NAS of Ukraine, Ukraine
[2] Institute of Geophysics – NAS of Ukraine, Ukraine

The results of measuring the variations of the geomagnetic field in region of Odessa magnetic anomaly are presented (Astronomical Observatory of I.I. Mechnikov Odessa National University). Continuous observations were conducted from November 2017 to May 2018 on a precision LEMI-008 fluxgate magnetometer with a time resolution of 1 second. The predominant quasiperiods of rapid pulsations during a day are about 9 to 30 minutes. At moments of strong magnetic storms, pulsations during 10-20 seconds appear. The largest bursts of their amplitude fall within a time interval of ≈ 8 - 15 hours. Similar pulsations are noted also on quiet days in the morning (6 - 10 hours). Geomagnetic disturbances were investigated in Odessa magnetic anomaly comparing with data of magnetic Observatory `Kiev` in various states of space weather.

Data Proccessing and Modelling

Unified Webbased Database With Liulin-type Instruments Cosmic Radiation Data

Dachev Ts.[1], Lilovski K.[2], Bankov N.[1], Tomov B.[1], Matviichuk Yu.[1], Dimitrov P.[1], Semkova J.[1], Koleva R.[1], Shurshakov V.[3], Benghin V.[3]
[1] Space Research and Technology Institute – BAS, Sofia, Bulgaria
[2] Linitrex, LTD, Sofia, Bulgaria
[3] IMBP – RAS, Moscow, Russia

A total of 14 different space instruments were developed, qualified and used in different space missions between 1988 and 2018 by the scientist from the Solar-Terrestrial Physics Section, Space Research and Technology Institute, Bulgarian Academy of Sciences (SRTI-BAS). The first was used on MIR space station between 1988 and 1994. 6 of them flight on the International space station in a more than year missions. Another 5 was flown on short-term low-earth orbits. 1 was for year in 100/200 km lunar orbit. Liulin-MO instrument was launched toward Mars in 2016 and now is operated at 400 km Mars orbit. During the implementation of the Contract No. 4000117692/16/NL/NDe with ESA an Unified webbased database with Liulin-type instruments cosmic radiation data was proposed and developed between 2016 and 2018. The database contains data from 10 space experiments performed between 1991 and 2018. The database covers the entire functional scope of the system: Source selection; Data export in CSV and TXT format; Charts which allowed: Visualization, Synchronized zoom, tooltip and hairline; Export to vector, JPEG and PNG format. The paper presents the database and demonstrates on-line its operation. This work was partially supported by Contract No. 4000117692/16/NL/NDe funded by the Government of Bulgaria through an ESA Contract under the Plan for European Cooperating States (PECS).

The Physico-chemical Model of the Auroral Ionosphere

Dashkevich Zh.V.[1], Ivanov V.E.[1], Sergienko T.I.[2], Kozelov B.V.[1]
[1] Polar Geophisical Institute, Apatity, Russia
[2] Swedish Institute of Space Physics, Kiruna, Sweden

The physicochemical model of the auroral ionosphere is presented. The model allows us to compute the altitude density profiles of both the excited and the neutral components of the ionosphere during electron precipitation. These are: O2+, N2+, O+(4S), O+(2D), O+(2P), O(1D), O(1S), N(4S), N(2D), N(2P), NO, NO+, N+, N2(A3), N2(B3), N2(W3) and electrons. The input model parameters are the auroral electron energy spectrum in the upper boundary of the ionosphere, densities of neutral components N2, O2, O. The model is composed of 56 physicochemical reactions characterizing the redistribution of electron energy and effecting on the components densities mentioned above. The features of the model are the computation method of the altitude profile of the atmosphere gases excitation rate and the reasonable calculation of electron-vibrational kinetics of N2 triplet states. The model is tested on the coordinated rocket and satellite measurements of the auroral event. The best, at present, fit between modeling and experimental data is achieved.

The Effect of Auroral Electron Precipitation on the Effective Recombination Coefficient

Dashkevich Zh.D., Ivanov V.E
Polar Geophysical Institute, Apatity, Russia

The analysis of expected effect of the precipitated electron flux parameters on the effective recombination coefficient of electron is presented. It is demonstrate, that in the ionosphere E-region the effective recombination coefficient value is related to the physico-chemical properties of environment. However, in the ionosphere F1-region the effective recombination coefficient becomes responsive from both the energy flux and the average energy of the precipitated electrons.

PEPSI/SDI Sun-as-a-star Observations of the 2017 August 21 Solar Eclipse

Dineva E.[1, 2], Denker C.[1], Strassmeier K.G.[1], Ilyin I.[1], Milic I.[3]
[1] Leibniz-Institute for Astrophysics Potsdam (AIP), Potsdam, Germany
[2] University of Potsdam, Potsdam, Germany
[3] Max Planck Institute for Solar System Research, Germany

The Potsdam Echelle Polarimetric and Spectroscopic Instrument (PEPSI) is a state-of-the-art, thermally stabilized, fiber-fed, high-resolution spectrograph for Large Binocular Telescope (LBT) at Mt.Graham, Arizona. During daytime the instrument is fed with sunlight from the 10-millimeter aperture, fully automated, binocular Solar Disk-Integrated (SDI) telescope. The main goal of SDI is to monitor the Sun daily for, at least, one activity cycle. The observed Sun-as-a-star spectra contain a multitude of photospheric and chromospheric spectral lines in the wavelength range of 380-910nm. One of the advantages of PEPSI is that solar spectra are recorded in the exactly same manner as nightime targets. Thus, we can compare solar and stellar spectra directly. In order to exploit this considerable amount of information, we developed a data pipeline for calibration and analysis of high-resolution spectra, which includes tools for monitoring and multi-wavelength investigation of solar atmospheric dynamics. PEPSI/SDI recorded 116 Sun-as-a-star spectra during the 2017 August 21 solar eclipse. The maximum obscuration was 61.6%. The spectra were taken with a spectral resolution of R=250000 and an exposure time of 0.3s.The high-spectral resolution enables us studying subtle changes in the spectra while the Moon passes the solar disk. The Sun-as-a-star spectra are affected by changing contributions due to limb darkening and solar differential rotation, and to a lesser extend by the resence of active regions on the solar surface. We investigate the temporal evolution of the chromospheric Na D1 and D2 lines, derive bisectors yielding height-dependent information, and compare observations with synthetic line profiles.

Special Campaign for Vertical Ionospheric Drifts Comparison - Idea and First Results

Kouba D., Mošna Z.
Institute of Atmospheric Physics – CAS, Prague, Czech Republic

Since 2004 the ionospheric observatory in Pruhonice (Czech Republic, 50N, 14.9E) provides regular ionospheric sounding using Digisonde. In addition to classical ionograms the drift velocities in both E and F region using DDA method are measured routinely. However, vertical component of the drift velocity vector can be estimated by several different methods which can be found in the literature; for example the indirect estimation based on the temporal

evolution of measured ionospheric characteristics is often used for calculation of the vertical drift component. The vertical velocity is thus estimated according to the change of characteristics scaled from the classical ionograms. However, using of indirect method is limited. We have therefore realized a special campaign to compare these methods with each other and to compare them with direct measurement on our ionospheric observatory. Ionogram and drift measurement was realized with one minute cadence (a typical cadence of measurement is 15 minutes).

Our comparison shows possibility of using different methods for calculating vertical drift velocity and their relationship to the direct measurement used by Digisonde.

Long-term Trends in Stratospheric and Mesospheric Dynamics – Longitudinal Dependence

Kozubek M., Lastovicka J.
Institute of Atmospheric Physics – CAS, Prague, Czech Republic

The MERRA reanalysis data completed by the NOGAPS-ALPHA data show that the wintertime distribution of meridional wind at the northern higher middle and high latitudes is substantially longitudinally dependent and also trends are longitudinally dependent. At heights between about (in average) 50 and 0.01 hPa the geopotential height distribution is characterized by the presence of the stationary planetary wave s = 1 (SPW1) with the peak formed by the Aleutian pressure high, which forces the dominant wintertime westerlies to blow along this high first with a significant northward component before the geopotential peak, and then return back with a significant southward component, thus forming two cells of much stronger and opposite meridional wind. There are some anomalous years which do not follow this simple pattern and it was found that this is caused by anomalous filtering of wind structures by stratospheric zonal winds.

Such longitudinal structure is expected to affect long-term trends and this is the case. The trends are different for different months or pressure levels. Temperature trends show negative trends over Eurasia and positive ones over North America in January at 10 hPa. For meridional wind trends in January we have found core structure which basically copy structure of the meridional wind climatology in the stratosphere.

3D Reconstruction of Solar Magnetic Field in Active Regions Using Magnetic Measurements above the Photosphere

Myshiakov I.[1], Fleishman G.[2], Anfinogentov S.[1],
Loukitcheva M.[2], Rudenko G.[1], Stupishin A.[3]
[1] Institute of Solar-Terrestrial Physics, Russia
[2] New Jersey Institute of Technology, USA
[3] St.-Petersburg State University, Russia

Coronal magnetic field is a key factor that controls the solar activity. However, direct measurements of the coronal magnetic field are limited. To fill this gap in observational diagnostics, various methods of magnetic field reconstruction have been proposed and implemented. Low plasma beta in the coronal volume justifies the use of force-free approach to approximate slowly evolving coronal magnetic field in active regions. Such reconstructions typically extrapolate the magnetic field from the photospheric boundary, where the magnetic field vector is routinely measured. However, the magnetic field at the photospheric level deviates from being force-free. This fact may negatively affect the reconstruction. Here we propose to take into account information on the magnetic field above the photosphere. Specifically, chromospheric line-of-sight magnetograms and diagnostics of the field magnitude as additional

constraints in conjunction with the photospheric magnetograms. Using a realistic MHD (Bifrost) simulation of an enhanced network region as a model of the real corona, we demonstrate that this approach improves reliability of the coronal magnetic field reconstruction even with incomplete knowledge of the magnetic field vector at the chromosphere.

Study of Resonant Alpha Particles Acceleration by a Single Electromagnetic Wave in Space Plasma

Shkevov R.[1], Erokhin N.S.[2], Loznikov V.M.[2], Zolnikova N.N.[2], Mikhailovskaya L.A.[2]
[1] Space Research and Technology Institute – BAS, Sofia, Bulgaria
[2] Space Research Institute – RAS, Moscow, Russia

A numerical study has been made of resonant alpha particle acceleration by a single electromagnetic wave in space plasma. The Cherenkov resonance realization at strong surfatron acceleration of alpha particles by an electromagnetic wave in space plasma at the presence of weak constant magnetic field is discussed. Analytical expressions and the final form of the second order nonlinear, nonstationary differential equation for the wave phase on the accelerated alpha particle trajectory are presented. The following assumptions are made: the particle initial energy is low relativistic; the wave electric field amplitude exceeds a threshold level value needed for resonance realization. The relationship between the initial particle energy, the wave`s propagating speed in space plasma, the capturing probability and the final energy of the accelerated alpha particle are studied. The results obtained by means of exact solution of differential equation are analyzed and compared with the experimentally registered data. The alpha particle capturing period, momentum dynamics, its components and phase plane structure on the time interval of numerical calculations are shown in graphics. Some estimations of the initial particle energy and the resulting one after acceleration process, based on calculated values of the momentum are included. Conclusions about alpha particles resonant acceleration by a single electromagnetic wave in space plasma and the possibility similar processes to have a contribution to the generation of ultrarelativistic energies are presented.

Efficiency Study of the Electrons Resonant Acceleration by a Wave Packet in Space Plasma

Shkevov R.[1], Erokhin N.S.[2], Loznikov V.M.[2], Zolnikova N.N.[2], Mikhailovskaya L.A.[2]
[1] Space Research and Technology Institute – BAS, Sofia, Bulgaria
[2] Space Research Institute – RAS, Moscow, Russia

The study of strong surfatron acceleration of electrons by an electromagnetic wave packet in space plasma by means of numerical analyses is conducted. The second order nonlinear, nonstationary differential equation for the wave phase on the accelerated electron trajectory is numerically solved. To analyze the efficiency of the surfatron mechanism the calculations are performed basically with two different sets of initial parameters as a reference point for both digital experiments. Electron initial energy and wave packet propagation speed in both cases are assumed as low relativistic. Calculations results obtained allow us to present particle dynamics main parameters in exact values and also in graphics. Estimations based on the calculations results for the input and output particle energy and acceleration time period length for this process, are made. This kind of analyses significantly improves the understanding on energy transfer from the wave packet to the charged particle at resonance interactions. The momentum dynamics, particle velocity components and phase plane structure for the time interval of numerical calculations are shown. Some interesting cases of the charged particle surfatron resonance trajectory of type W are presented. It is shown that the estimation of the maximum

electron energy is correlated with the registered experimental data. Conclusions about electron surfatron acceleration mechanism efficiency and particle energy rise amplitude are drawn.

Determination of the Total Ozone Column and the Estimation of the Ultraviolet Index with Consideration of the Cloud Optical Depth

Werner R.[1], Petkov B.[2], Valev D.[1], Atanassov A.[1], Guineva V.[1], Kirillov A.[3]
[1] Space Research and Technology Institute – BAS, Stara Zagora, Bulgaria
[2] Institute of Atmospheric Sciences and Climate (ISAC) – CNR, Bologna, Italy
[3] Polar Geophysical Institute (PGI) – RAS, Apatity, Russia

The penetration of the solar UV radiation in the atmosphere depends mainly on the zenith angle, on the optical transmission of the atmosphere and of the total ozone column (TOC). The irradiance at 380 nm is not affected by ozone and by other atmospheric constituents absorptions. By its relation to the value for clear sky conditions the cloud transmission factor (CLF) was determined. The effective cloud optical depths (COD) were determined using a Look up table (LUT), where the irradiances at 380 nm were calculated in depending on the zenith angle and the COD. The TOCs were retrieved by interpolation of a 3D-LUT, taking into account beside the ratio of the irradiance at 313nm, a wavelength with significant ozone absorption and at 340 nm, which is insensitive against ozone absorption, the zenith angle and the effective COD. For determination of the UV-index a LUT is created depending on the effective COD and TOC. For the radiation transfer calculations in the UV region an albedo of 0.03 is used. For the near visible region the albedo was set to 0.2. All LUTs were calculated based on the Tropospheric Ultraviolet and Visible (TUV) radiation transfer model.

Instrumentation for Space Weather Monitoring

Cosmic Dust and the Global Electric Circuit of the Earth

Kostrov A.V.
Institute of Applied Physics – RAS, Nizhny Novgorod, Russia

In this work, we propose considering a model of the global electric circuit, which is inseparably associated with electric processes in the atmosphere, ionosphere, and cosmic plasma.

it is well known that the charging of various bodies (probes or dust) situated in plasma is performed by the more mobile component. As a rule, it is electrons in classic plasma. The cosmic plasma, in which the Earth is situated, consists of ions, electrons, and negatively charged dust. Unlike electrons and ions, the cosmic dust penetrates easily the magnetic field and atmosphere and charges the Earth's surface negatively. The stationary electric state is achieved in the case of identical positive and negative currents to the Earth. The positive current to the Earth is due to ions from the cosmic plasma, which penetrate the atmosphere through northern and southern latitudes up to altitudes of about 100 km, where the frequency of collisions with neutrals exceeds the ion cyclotron frequency significantly. These ions can move along the Earth's surface and ionize the abnormal structure of the E-layer additionally, thus creating the 'fair-weather' current, which precipitates uniformly over the negatively charged surface of the Earth.

The issues of formation, charging, and discharging of clouds are considered in the presentation, as well as the influence of cosmic dust on the weather on the Earth.

Monitoring of Space Radiation and Other Hazards in Multi-satellite Project "Universat-SOCRAT"

*Bogomolov A.[1], for Universat-SOCRAT collaboration [1, 2 **4]*
[1] M.V. Lomonosov Moscow State University, Russia
[2] S.A. Lavochkin Space Corporation, Russia

D.V. Skobeltsyn Institute of Nuclear Physics of M.V. Lomonosov Moscow State University is developing a project `Universat-SOCRAT` of a system of small satellites for monitoring of the space threats: ionizing radiation, potentially dangerous objects of natural (asteroids, meteoroids) and artificial (space debris) origin, and electromagnetic transients of Earth`s and space origin.

One of the primary tasks for this satellite system is operational (close to `real time`) monitoring of the fluxes of energetic charged particles in the wide range of Earth`s radiation belts. For this purpose at least two satellites with a mass <50-100 kg will be launched to elliptical orbit with height of perigee and apogee ~700 and 8000 km and inclination 63.4 degrees, which crosses wide range of magnetic drift shells at different altitudes. Satellites will be equipped with multidirectional spectrometers of energetic protons and electrons.

Another satellite will be launched to Sun-synchronous low Earth orbit. It provides the payload mass about 100 kg and its aims besides the radiation monitoring also should be observation of other space hazards, such as space debris and asteroids and electromagnetic transients. Space debris and asteroids should be observed by several wide-field cameras and robotic telescopes of MASTER type. Satellite may also carry number of detectors for study of electromagnetic transients in different wavelength ranges - from infrared to gamma. This means observation of such phenomena, as transient luminous events (TLE) in the Atmosphere, terrestrial gamma ray flashes (TGF), cosmic gamma ray bursts (GRB) and solar flares in hard X-rays and gamma rays.

[4] See page 45

The Method and Technique of Riometric Measurements by the URAN-4 Radio Telescope, Simultaneously With the Monitoring of Compact Space Radio Sources in the Decameter Wavelength Rang

Lytvynenko O., Galanin V., Lytvynenko I., Derevyagin V.
Observatory `URAN-4` of the Institute of Radio Astronomy of NASU, Ukraine

When observing compact space sources in the HF range, all ionospheric propagation effects of radio waves (absorption, refraction, scattering, Faraday rotation, etc.) are clearly manifested. On the one hand, these effects reduce the accuracy of radio astronomy measurements and it is a need to take them into account. On the other hand, these effects are a source of data on the characteristics of the ionosphere and can be used in ionospheric studies. The ionospheric absorption of radio waves is one of these characteristics. Riometers are used to study ionospheric absorption. It is special radio receivers with controlled gain that measure of the cosmic noise absorption in the frequency range 20-50 MHz. To measure the intensity of compact space sources on the URAN-4 radio telescope, a low-base interferometer is used. This makes it possible to suppress the signal component related to cosmic noise. At the same time, information about ionospheric absorption is lost. In this paper, a method and technique is considered that allow riometric studies on the URAN-4 radio telescope, simultaneously with the measurement of the intensity of compact space sources. This significantly increases the information content of the observational data.

Results from Langmuir Probe Measurements Aboard the International Space Station

Kirov B.[1], Asenovski S.[1], Georgieva K.[1], Bachvarov D.[2], Boneva A.[2], Klimov S.[3], Grushin V.[3]
[1] Space Research and Technololy Institute – BAS, Sofia, Bulgaria
[2] IICT – BAS, Sofia, Bulgaria
[3] IKI – RAN, Moskow, Russia

The Langmuir probe is a classical instrument for plasma diagnostics, and among the first ones for in situ measurements of thermal plasma in the near-Earth environment. The parameters measured by Langmuir probes are the electron and ion concentrations Ne and Ni, the electron temperature Te, and the satellite body potential Us.

In this paper the Langmuir probes are described included in “Obstanovka” experiment aboard the International Space Station which has been operating since April 2013. One of the main goals of this experiment is to study the surface charging of super-big objects like the International Space Station. All earlier studies have been conducted for relatively small and homogenous spacecraft, while with the launch and gradual build-up of the International Space Station we face the problems of the interaction of a super-large structure at a low orbit with its environment. For the first time we have a structure which is not only that large but also so much energy consuming and emitting. Here we demonstrate how the various factors in the near-Earth space affect the surface charging of the International Space Station.

Scientific and Methodological Aspects of Spatial-temporal Resolution by the Plasma and Wave Parameters of the Ionosphere by Means of Microsatellites

Klimov S.[1], Vaisberg O.L[1], Gotlib V.M.[1], Grushin V.A.[1], Kostrov A.V.[2], Lichtenberger J.[3], Nagy J.[4], Novikov D.I.[1], Belyakova L.D.[1], Eismont N.A.[1]
[1] SRI – RAS, Moscow, Russia
[2] AFI – RAS, Nizhny Novgorod, Russia
[3] ELTE, Budapest, Hungary
[4] WANG, Budapest, Hungary

The main objective of the experiment is to study the deterministic spatial (0.1–10 km) and time gradients of electromagnetic parameters and plasma concentration, due to synchronous `two-point` measurements on two microsatellites (MS) `Trabant` (weight of each MS ~ 50 kg).

The equipment of each MS `Trabant` is designed to measure:

- 3-x component of the magnetic field in the frequency range 0.1 Hz–40 kHz;
- one component of the electric field in the frequency range 0.1 Hz–40 kHz;
- radio emissions in the frequency band from 15 to 48 MHz;
- plasma density N in the range from 10^{-3} to $5 \cdot 10^{-6}$ cm^{-3} and its fluctuations in the range from 1 to 1000 Hz;
- energy (with a narrow field of view) electron spectrum in the range from 1 to 10 KeV and its fluctuations with a frequency of 10 Hz;
- ion energy-mass (solid angle with a solution of 160') of the spectrum in the energy range from 10 to 5000 eV with the ability to measure the elemental composition of particle flows.

Bulgarian Space Instrumentation

Miteva R., Belichenova T., Zaharinova M., Mardirossian G., Getsov P.
Space Research and Technology Institute – BAS, Sofia, Bulgaria

We present an initiative to chronologically list the different Bulgarian space instruments and systems aboard satellites, rockets, interplanetary missions, orbital stations, as well as the scientific programs for the flights of the two Bulgarian astronauts. The first contribution to the space exploration of the Bulgarian scientists and engineers took place in 1972 with the construction of a payload for the Interkosmos 8 satellite. Since then the construction of a number of unique and successful space devices follows to present day. The most recent experiment is part of the ExoMars program. The aim of this first report is to present the list of instrumentation, programs and main achievements as well as the current structure of the dedicated website.

The European Solar Telescope EST

Utz D., on behalf of the EST consortium
IGAM-Institute of Physics, Karl-Franzens University Graz, Graz, Austria

The European Solar Telescope (EST) is a next-generation 4-metre aperture telescope designed to investigate our active Sun at unprecedented spatial and temporal resolution. Equipped with state-of-the-art instrumentation, it will help scientists understand the magnetic coupling of the solar photosphere and chromosphere. To achieve that goal, the thermal, dynamic and magnetic properties of the plasma will be determined over many scale heights using high-senstitivity, multi-wavelength imaging, spectroscopic and spectropolarimetric measurements. EST was included on the ESFRI Roadmap in 2016, and is therefore considered a strategic European research infrastructure. It will be installed in the Canary Islands (Spain) to benefit from unique observing conditions. First light is planned for 2026.

In this contribution an overview of the telescope, the legal framework, and the science requirements document and cases will be given.

Small-sized Radio Telescopes for Monitoring and Studies of Solar Radio Emission at Meter and Decameter Wavelengths

Yerin S., Stanislavsky A., Bubnov I., Konovalenko A., Tokarsky P., Zakharenko V.
Institute of Radio Astronomy, Kharkiv, Ukraine

We show wide prospects of a single dipole and a subarray of GURT radio telescope for continuous monitoring observations and studies of solar bursts of various types at low frequencies. Parameters of these small-sized radio telescopes were well studied using electromagnetic modeling and measurements. Lately, testing the instruments, a large number of solar events were registered in the range of 10-80 MHz at the site of S. Y. Braude radio astronomical observatory, Kharkiv in Ukraine. The ground-based observations have proved that these antennas, due to their sensitivity, effectiveness and stability of work all year round, can be used for studies of such types of solar emission like type-II, type III-IIIb, type-IV, drift pairs and others. Thus, the tools have a good potential for future low-frequency radio telescopes on the far-side of the Moon.

Sevan Particle Detector at Zagreb Astronomical Observatory: 10 Years of Operation

Šterc F.[1], Roša D.[1], Maričić D.[1], Hržina D.[1], Romštajn I.[1], Chilingarian A.[2], Karapetyan T.[2,1], Cafuta D.[3], Horvat M.[3]
[1] Zagreb Astronomical Observatory, Zagreb, Croatia
[2] Alikhanyan Physics Institute, Yerevan, Armenia
[3] Zagreb University of Applied Sciences, Zagreb, Croatia

Abstract. At the `Regional IHY (International Heliophysical Year) Planning Meeting for the Balkan and Black Sea Region`, organized by the Solar Terrestrial Influences Laboratory in Bulgaria 2005, the possibilities of new network of the Space Weather particle detectors designed by Armenian scientists were presented. Today the network is known as SEVAN (Space Environment Viewing and Analysis Network). In December 2008 the installation of the SEVAN particle detector at Zagreb Astronomical Observatory was finished. It is the first instrument for detecting cosmic rays in Croatia and its installation greatly promotes solar physics research in our country. Here we presented some results obtained from data collected by SEVAN particle detector at Zagreb Astronomical Observatory during the first 10 years of operation. We calculate the barometric coefficients using two statistical methods (least square method and least absolute deviation method). Pressure corrected data is available on a new section of the web page of the Zagreb observatory. Also we investigated diurnal variations of cosmic rays. Example of solar modulation effects (Forbush decrease) and first evidence of registration of TGE (Thunderstorm Ground Enhancement) are also given.

Keywords. SEVAN particle detector, Zagreb Astronomical Observatory, barometric coefficients, diurnal variations of cosmic rays, Forbush decrease, Thunderstorm Ground Enhancements

Solar Influences on the Lower Atmosphere and Climate

The Electronic Kinetics of Triplet Molecular Nitrogen and Carbon Monoxide in Upper Atmospheres of Titan, Triton, Pluto

Kirillov A.S.[1], *Werner R.*[2], *Guineva V.*[2]
[1] Polar Geophysical Institute – RAS, Apatity, Murmansk region, Russia
[2] Space Research and Technology Institute – BAS, Stara Zagora, Bulgaria

The simulation of N2(A3) and CO(a3) vibrational populations at the altitudes of upper atmospheres of Titan, Triton, Pluto is made. The simulation includes the consideration of the electronic excitation of N2 and CO triplet states by photoelectrons and the quenching processes in spontaneous radiation and in inelastic molecular collisions. Upper atmospheres of the planets are considered as mixtures of molecular nitrogen N2, methane CH4, carbon monoxide CO. The influence of metastable molecular nitrogen N2(A3) on the electronic excitation of CO molecules in inelastic collisions is studied. The role of molecular inelastic collisions in intermolecular electron energy transfer processes is investigated. It is shown that the increase in the density of upper atmospheres of the planets leads to more significant excitation of lowest vibrational levels of CO(a3) by intermolecular electron energy transfers from N2(A3) in comparison with direct excitation of the a3 state by photoelectrons.

Solar Terminator and Its Signatures in the Ionospheric Plasma

Koucká Knížová P., Kouba D., Mošna Z., Boška J., Obrazová D.
Institute of Atmospheric Physics – CAS, Prague, Czech Republic

Solar Terminator is defined as a border region between sunlit and dark atmosphere. It is characterized by sharp change in the intensity of the incoming solar radiation and consequently by gradients within atmospheric plasma parameters. Solar Terminator moves through the atmosphere with the rotation of the Earth inducing wave-like disturbances in the ionospheric plasma. The excited wave-like structures belong to the Acoustic-Gravity waves domain. The AGW, their sources, persistence, propagation, are systematically studied since sixties. They are permanently present in the atmosphere and ionosphere causing significant part of the ionospheric variability. However, their attribution to the particular source still remains an open task.

Solar Terminator (ST) has been identified as an important source of AGW in the Earth atmosphere-ionosphere system. The generation mechanism has been proposed by Chimonas and Hines in seventies. The cooling/heating of the Earth´s atmosphere induced by decrease/increase of the incoming solar radiation is a potential generator of the wave/like disturbances that are likely to propagate through the atmosphere-ionosphere system. Due to the systematic occurrence of AGWs during sunrise and sunset, it has been proven experimentally, that the moving region of atmospheric constituents with large gradients acts a source of AGW structures. However, the variability in periodicity and persistence of AGWs is very large and the observational techniques limited in sampling rates etc.

The contribution focuses on the wave-like structures detected at ionospheric heights that can be potentially attributed to the motion of the Solar Terminator. Data used for analyses are obtained from vertical ionospheric sounding.

High-speed Solar Wind Streams: a New Climate Driver

Mursula K., Asikainen T., Maliniemi V.
ReSoLVE Centre of Excellence, Space Climate Research Unit, University of Oulu, Finland

High-speed solar wind streams (HSS) are the most effective driver of magnetospheric energetic particles and geomagnetic activity. HSS maximize at the Earth in the declining phase of solar cycle when polar coronal holes have equatorial extensions. Although the energy related to solar wind is small, their atmospheric effects can be amplified by electromagnetic and chemical reactions. HSS-related energetic particle precipitation (EPP) can cause dramatic changes in chemistry and dynamics of the upper atmosphere. EPP creates NOx molecules that can be transported down to the stratosphere during polar winter, leading to ozone loss. There is increasing evidence that HSS-related effects have important consequences even to tropospheric climate, especially in winter at high latitudes. HSS have been found to modulate the winter NAO/NAM oscillation, the dominant climate pattern in the northern hemisphere. The positive NAO/NAM phase is favored in declining phase winters.

HSS-effects are strongly dependent on the phase of the Quasi Biannual Oscillation (QBO). Positive relation between HSS and NAO/NAM is valid in the easterly QBO(30 hPa) phase during the whole 20th century. EPP related ozone loss and polar vortex enhancement is significantly stronger in the easterly QBO phase. We find the Holton-Tan relation between QBO and polar vortex to be valid only during early/mid winter, while an anti-Holton-Tan relation is found in the late winter for strong geomagnetic activity. These results indicate an intimate, global connection between low and high latitudes, and underline the importance of considering the preconditioning of the atmosphere when studying the solar (wind)-related effects upon climate.

Space Weather and Hurricanes Irma, Jose and Katia

Radovanović M. M.[1, 2], Vyklyuk Y.[3], Milovanović B.[1], Milenković M.[1], Petrović M. [1, 2], Doljak D.[1], Milićević Sl.M.[4], Vuković N.[5], Vujko Al.[6], Matsiuk N.[7]
[1] Geographical Institute – Serbian Academy of Sciences and Arts, Belgrade, Serbia
[2] South Ural State University, Institute of Sports, Tourism and Service, Chelyabinsk, Russia
[3] Bukovinian University, Chernivtsi, Ukraine
[4] University Center for Meteorology and Environmental Modelling, University of Novi Sad, Novi Sad, Serbia
[5] Graduate School of Economics and Management, Ural Federal University, Yekaterinburg, Russia
[6] Novi Sad Business School, Novi Sad, Serbia
[7] Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine

This research is devoted to determinate the causal relationship between the flow of particles that are coming from the Sun and the hurricanes Irma, Jose, and Katia. In order to accomplish that, a lag correlation analysis was conducted. High correlation coefficients confirmed preliminary conclusion about the relationship between solar activities and hurricane phenomenon, which allowed further research. Five parameters i.e. characteristics of solar activity (Radio Flux 10.7, the flows of protons and electrons with maximum energy, speed and density of solar wind particles) were chosen as model input, while wind speed and air pressure of Irma, Jose, and Katia hurricanes were used as model output. Input data were sampled to six hours interval in order to adapt time interval to the observed data about hurricanes, in the period between 28 September and 21 December 2017. As a result of the preliminary analysis, using 12,274,264 linear models by parallel calculations, the six of them were chosen as best. The identified lags were the basis for refinement of models with the artificial neural networks. Multilayer perceptrons with back propagation have been chosen as common used artificial neural

networks. Comparison of the accuracy of both linear and artificial neural networks results confirmed the adequacy of these models. Sensitivity analysis has shown that Radio Flux 10.7 has the greatest impact on the wind speed of the hurricanes. Despite low sensitivity of pressure to change the parameters of solar wind, their strong fluctuations can cause a sharp decrease in pressure, and therefore the appearance of hurricanes.

Electrical Coupling of Auroral Ionosphere with Lower Atmospheric Regions During SEP

Tonev P.
Space Rresearch and Technology Institute – BAS, Sofia, Bulgaria

The behavior of the atmospheric electric current Jz flowing from the ionosphere to the ground at auroral latitudes is under consideration during events of solar energetic particles (SEP). According to theories, the current Jz and its variability can affect weather. Experimental studies demonstrate dramatic temporal variations of Jz at high latitudes during SEP. To explain these, we consider that such variations of Jz can be caused by dynamic changes of the atmospheric conductivity due to SEP accompanied by enhanced electrical coupling between auroral ionosphere and atmosphere which leads to significant modifications of the fair-weather current Jz of the global electrical circuit (GEC). The current Jz and its modifications are studied by modeling of the effect on GEC of ionospheric field-aligned currents (FAC). It is shown that, while the closure of FAC becomes principally in the middle ionosphere, a tiny (lower by several orders of magnitude) portion of these currents can penetrate during SEP events into mesosphere, stratosphere, or even below where they can contribute significantly to the undisturbed current Jz in GEC.

Research and Graphical Representation of Temperature Changes in the Atmosphere Measured by An Automatic Meteorological Station

Tashev V.[1], Manev A.[1], Werner R.[1], Goranova M.[2], Shishkova S.[3]
[1] Space Research and Technology Institute – BAS, Stara Zagora, Bulgaria
[2] Technical University of Sofia, Faculty of Computer Systems and Management, Sofia, Bulgaria
[3] NIMH – Plovdiv Department, Bulgaria

Meteorological Station Vantage Pro 2 Plus is designed to monitor atmosphere meteorological parameters such as temperature, relative humidity, barometric pressure, rainfall, wind speed and wind direction. Additionally the solar radiation in the visible spectral range and in the ultraviolet is measured. Thus except the directly measured meteorological parameters, other characteristics of the atmosphere and the sun can be calculated and examined. For example, by integrating solar radiation data, solar energy can be determined for a certain period of time from a single area of the earths surface. For other characteristics of the atmosphere special software is provided that calculates the dew point, heat index, a rainfall coefficient, as well as about thirty other parameters.

Long-term Solar Variability and Sunspot Indices

Recalibration of the Sunspot Indices: Causes and Consequences

Georgieva K.
Space Rresearch and Technology Institute – BAS, Sofia, Bulgaria

Since July 2015 the Royal Observatory of Belgium, the World Data Center created with the task to continue the International relative sunspot number record, discontinued the more than 400 years long International Sunspot number data and replaced it by a new entirely revised data series. In the meantime, a new Group sunspot number series was also created. Unlike the two original series, the two new, `recalibrated` series match very well, and again unlike the original ones, both have no long-term trend. Here we will discuss observations of solar activity manifestations and consequences to explore the reasons for the differences in the original series, the long-term trend of solar activity, and the reliability of the old and new series.

Comparison of Large and Small ARs for the Last Three Solar Cycles: Their Relation with Solar Flare Activity

Kilcik A.[1], Ozguc A.[2], Yurchyshyn V.[3], Rozelot J.-P.[4]
[1] Akdeniz University, Faculty of Science, Dep. of Space Sci. and Technologies, Antalya, Turkey
[2] Kandilli Observatory and Earthquake Research Institute, Bogazici University, Istanbul, Turkey
[3] Big Bear Solar Observatory, New Jersey Institute of Technology, Big Bear City, CA, USA
[4] Côte d'Azur University, Nice, France

In the modified Zurich classification system, sunspot groups are classified into seven different classes (A, B, C, D, E, F and H) based on their morphology and evolution. In this classification system, classes A and B, which are very small groups, describe the beginning of sunspot evolution; while classes D, E and F correspond to the large and evolved groups. Class C depicts the middle phase of sunspot evolution and the class H describes the end of sunspot evolution. In this study, the sunspot groups (ARs) were separated into two categories as small (A, B, C, and H modified Zurich classes) and large (D, E, and F). Then, their temporal variations were compared for nearly three solar cycles (1986 through 2016). The relationship between these categories of ARs and flare activity was also investigated. The main findings are as follows: i) temporal variations of the number of large and small ARs are quite different during a cycle and also they change from cycle to cycle, ii) temporal variations of monthly means of the daily total SSCs in flaring and non-flaring ARs behave differently during a solar cycle and the behavior varies from one cycle to another; during Solar Cycle 23 temporal SSC profiles of non-flaring ARs are wider than those of flaring ARs, while they are almost the same during Solar Cycle 22 and the current Cycle 24, (iii) about 75 per cent of all flaring sunspot groups are large and complex ARs.

Solar Activity from Detailed Sunspot Database – An Alternative Measure

Muraközy J.
Debrecen Heliophysical Observatory, Konkoly Thege Miklós Astronomical Institute, Research Centre for Astronomy and Earth Sciences – Hungarian Academy of Sciences, Hungary

To reconsider the physical meaning of the sunspot number we have to remember that there are different physical mechanisms which govern its two components: the number of observed sunspot groups (denoted by g) and the number of all observed spots (denoted by s). These are one of the reasons of the ambiguity of the sunspot number. To eliminate this ambiguity we need to take into account not only the sunspot sizes but the aspects of observability as well.

This talk will suggest a new activity index which can be given by using detailed sunspot data. The mentioned index is the amount of emerged magnetic flux which can be calculated by using the sunspot area dataset, the only long-term proxy measure. It can be calibrated to the magnetic flux.

The detailed Debrecen databases provide the opportunity to calculate the suggested sunspot index.

Activity Indices Represent the Solar Cycles and the Effects of Their Solar-terrestrial Connections

Ryabov M.I., Sukharev A.L., Sobitnyak L.I.
Odessa Observatory URAN-4, Radio-astronomical Institute NASU, Ukraine

Systematization of solar activity indices was held out that represent physical characteristics based on data from cycles of discreteness and continuity, N-S asymmetry of wave and corpuscular manifestations. As such indices daily data was examined on total area groups of sunspots-Sp, Wolf numbers-W, `Spotless` index separately for the northern and southern hemispheres of the Sun. Each of these indices shows properties of solar cycles that are not visible when you use their monthly and smoothed values for the full solar disk. Analysis of the total solar irradiance (TSI) according to the satellite observations for the period from 1978 to 2017 was conducted using correlations and Wavelet analysis. The properties of visibility function for indexes: Sp, W, total solar irradiance (TSI), and flux radio emission at 10.7 cm wave were considered. On this basis the substantiation of efficiency of their influence on the Earth was made. Additionaly we offer the records of Earth motion in orbit, when it turns out to be under the influence of activity of Northern, Southern hemispheres of the Sun or is in the plane of the equator. The result of the impact of solar activity on the Earth has a limited and selective character and can be determined according to the modified `geoeffectivity` indices.

Sunspot Number Series Calibration: Modern Methods Versus the Old Daisy Chain

Usoskin I.
University of Oulu, Finland

It has been found recently, that the `classical` sunspot number series, both Wolf and group sunspot numbers, are subjects to large systematic uncertainties and inhomogeneties because of improper calibration of different observers to each other. A set of corrections has been proposed. However, the proposed corrections were based on the same calibration technique using a daisy-chain linear regression. Several new methods, based on the modern statistical analyses, of the sunspot observer`s calibration have been developed recently, including the active-day fraction (ADF), the direct calibration matrix, expectation-minimization (EM), etc. At present, there is no scientific consensus regarding the best way to calibrate the data, but the solar research community works hard in this direction.

The methods, their advantages and drawbacks are briefly overviewed here, along with the current situation with the sunspot number calibration.

Long-term Trends of Magnetic Bright Points: the Evolution of Mbp Size and Modelling of the Number of Mbps at Disc Centre

Utz D.[1], [2], Van Doorsselaere T. [2], Gagelmans E. [2], O`Rourke C. [2], Vuerinckx A. [2], Muller R. [3], Veronig A. [1]
[1] IGAM-Institute of Physics, Karl-Franzens University Graz, Graz, Austria
[2] CmPA, KU-Leuven, Belgium
[3] Observatoire Pic du Midi, University Toulouse, France

Magnetic bright points are fascinating small-scale solar magnetic features seen in the photosphere. They are manifestations of kG strong magnetic flux tubes representing more or less the photospheric cross-section of these flux tubes. Due to their highly dynamic behavior, caused partly by the buffeting granular action, and due to their strong magnetic fields, it is thought that they play an important role for MHD wave driving and guiding of these waves into the higher atmosphere and thus for the coronal heating problem. Moreover, their cross-section appears brighter than their surrounding and thus the variation of the number and size of MBPs on longer time-scales might play an important role in the total solar irradiance variations.

In this contribution we wish to shed light on these two parameters, the size and the number of MBPs close to the disc centre, as well as their evolution over nearly a full solar cycle by investigating the Hinode/SOT/BFI synoptic data set obtained in the G-band.

Tematic Session on the SEP Origin Project

Analysing of the SEP Origins Based on Microwave Emission of Solar Flares

Kashapova L.[1], Meshalkina N.[1], Miteva R.[2], Myagkova I.[3], Bogomolov A.[3]
[1] Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia
[2] Space Research and Technology Institute – BAS, Sofia, Bulgaria
[3] Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, Russia

Magnetic reconnection in solar flares and shock waves driven by coronal mass ejections (CMEs) are two main models for particle acceleration in the solar corona suggesting the explanation of solar energetic particle (SEP) event properties. All arguments pro et contra are based on correlation analysis between selected parameters of the SEP origin (flares and CMEs) and the in situ particles. The microwave (MW) emission is a sensitive indicator of particle acceleration and energy release processes in solar flares. Earlier studies of solar sources of SEP events used different spectral parameters of this kind of emission as indicators. However, MW emission is sensitive to several parameters simultaneously (strength of magnetic field, accelerated particles parameters etc.), and the individual effects are difficult to isolate.

We present the results on the analysis of MW emission in solar flares related to strong SEP events observed during the previous solar cycle. The target of the work is to find a criteria based on the solar flare features that would allow us the separate the SEP events into groups with more homogeneous physical/topological properties. We carried out the study using different parameters of MW emission and CME speed. Obtained relationships are analyzed both for the entire event set and for the suggested groups. The main results are presented and discussed.

SOHO/ERNE Proton Event Catalog: Progress Results under the SEP Origin Project

Miteva R., Danov D.
Space Research and Technology Institute – BAS, Sofia, Bulgaria

The current status of the proton event catalog from SOHO/ERNE instrument (1996–2017) is presented and discussed. The aim is to compose for the first time a comprehensive list of in situ proton enhancements in 10 energy channels (from 14 to 131 MeV) over solar cycles 23 and 24. Standard correlation analysis with the solar origin (flares and coronal mass ejections) of the proton events is also outlined. Finally, the on-line version of the catalog, designed to host relevant information and plots, is shown.

The Efficiency of Solar Proton Generation During 17 March 2003 and 11 April 2004 Solar Flares - Comparative Analysis

Myagkova I.[1], Miteva R.[2], Kashapova L.[3], Bogomolov A.[1], Petrov N.[4], Tsvetkov Ts.[4], Myshiakov I.[3]

[1] Skobeltsyn Institute of Nuclear Physics, MSU, Moscow, Russia
[2] Space Research and Technology Institute – BAS, Sofia, Bulgaria
[3] Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia
[4] Institute of Astronomy and NAO – BAS, Sofia, Bulgaria

The results of the comparative analysis of the efficiency of proton generation during the March 17, 2003 (X1.5 GOES class) and April 11, 2004 solar flares (C9.6) are presented. The considered events had similar response in hard X-ray emission but they were significantly different in solar charged particle abundance. The maximal SEP electron fluxes in the both events were comparable, but the proton flux in the SEP event associated with the weaker GOES flare class (in April 2004) was more than order higher than in the SEP related with the more powerful solar flare (in March 2003). Both flares were associated with CMEs with velocities above 1000 km/sec. We added analysis of SEP fluxes and flare plasma parameters by study of magnetic topology of the active region (AR) and its evolution of the AR before and during the solar flares. The results indicate that the AR where the more powerful flare occurred is covered by arcade of high loops. In contrary, the flare associated with proton rich SEP event occurred in AR where the fan of high loops are associated with the open magnetic field lines. Moreover this flare was preceded by filament eruption and the filament evolution before the eruption indicates to the development of a twist of the flux ropes. The results of the analysis are discussed.

Comparison of Kinematics of the Solar Eruptive Prominence and a Spatial Distribution of the Magnetic Decay Index

Myshiakov I.[1], Tsvetkov Ts.[2], Petrov N.[2]

[1] Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia
[2] Institute of Astronomy and NAO – BAS, Sofia, Bulgaria

Theoretical studies of magnetic flux rope instabilities, designed to explain filament eruptions, indicate that the loss of equilibrium may develop in the case when surrounding magnetic field decreases sufficiently rapidly with height. The decay index, a parameter that reflects the measure of magnetic field decrease, is a useful instrument for predicting the behavior of filaments. In our study we perform potential extrapolation to obtain spatial distribution of the decay index in the coronal space, identified with the eruptive prominence. Analysis of time dependent height profile of the prominence revealed, that its speed had increased when the prominence reached height with certain values of the computed decay index.

Prominences and Solar Energetic Particles

Tsvetkov Ts.[1], Miteva R.[2], Petrov N.[1]
[1] Institute of Astronomy and NAO – BAS, Sofia, Bulgaria
[2] Space Research and Technology Institute – BAS, Sofia, Bulgaria

Solar eruptive events (flares and coronal mass ejections, CMEs) are able to accelerate particles to high energies that can reach Earth if propagating along interplanetary magnetic fields connecting the acceleration site and the observer. The intense fluxes of escaping solar energetic particles (SEPs) are a hazard for both humans in space and spacecraft. Solar prominences are an important part of the eruptive processes and their role as precursors of SEP fluxes needs to be quantified.

We present the most detailed statistical study to date between solar energetic protons and filaments relying both on observations from space, by Solar Dynamics Observatory/Atmospheric Imaging Assembly (He II 304 A), Solar Terrestrial Relations Observatory A&B/Extreme Ultraviolet Imager, Solar and Heliospheric Observatory/Large Angle and Spectrometric Coronagraph Experiment, and also ground-based H-alpha telescopes in Big Bear Solar Observatory or Kanzelhoehe Observatory. We inspected 156 in situ proton enhancements in the period between 2010 and 2016 and identified their related solar activity phenomena (e.g. flares, CMEs, prominences, radio bursts of type II, etc.). Proton events are associated with filaments in 92% of the cases, however the reverse association is as low as 5%. We discuss various temporal, location and statistical dependencies between the parameters of the investigated phenomena.

Results of Comparative Analysis of the SEP Events and the Microwave Bursts Observed by 2÷24 GHz and 4÷8 GHz Spectropolarimeters in 2010÷2016

Zhdanov D.A.[1], Kashapova L.K.[1], Miteva R.[2]
[1] Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia
[2] Space Research and Technology Institute – BAS, Sofia, Bulgaria

We present a relationship analysis between the solar energetic particle (SEP) events and the microwave spectral observations of the solar bursts detected in 2010–2016 years. The information about the SEP events was taken from the Wind/EPACT catalog that was based on data (1996–2016). We used the microwave data from the archive of microwave observations in the range 2-24 GHz for selection of event from the SEP event catalog. Observations were made by spectropolarimeters of the SSRT observatory (Russia). We found that the 40 events present in both catalogs. We tested the relationships between the proton spectral index of SEP events and the peak frequency of the microwave bursts and presence of the circular polarization in MW emission of selected events. The results are discussed.

Summer school
"Sun, space weather and space climate"

Stellar-solar Activity: How Does It Evolve?

Katsova M.
Sternberg State Astronomical Institute, Lomonosov Moscow State University, Russia

Several observational projects fulfilled during past 25 years allow us to trace changes of activity of sun-like stars throughout all stages of their lives from an epoch of star formation to the age when the cycle becomes regular, and up to the present. We will consider distinctions between saturated activity intrinsic to the youngest fast rotating low-mass stars and solar-type activity typical for older Suns. We discuss frequency of superflares on the Sun and other stars, and a role of local and large-scale magnetic fields in formation of flares. All these points are important for understanding space factors affecting on physical conditions on the Earth and its geo- and biosphere.

Solar and Stellar Magnetohydrodynamics

Nandi D.
Center of Excellence in Space Sciences India, IISER Kolkata, India

In this lecture a gentle introduction to the subject of astrophysical magnetohydrodynamics (MHD) will be provided. Specifically, we will apply the concepts of MHD to understand the origin of the Sun`s magnetic cycle and the subsequent dynamics of solar magnetic fields.

Solar Effects in the Biosphere

Statistical Relationships of Cerebral Malaria Series in Papua - New Guinea with Solar Activity Indices

Valev D.[1], *Werner R.*[1], *Atanasov At.*[2], *Parashkevova B.*[3]
[1] Space Research and Technology Institute – Bulgarian Academy of Sciences, Bulgaria
[2] Dep. of Physics and Biophysics, Faculty of Medicine, Trakia University, Stara Zagora, Bulgaria
[3] Dep. of Social medicine and health care management, Faculty of Medicine, Trakia University, Stara Zagora, Bulgaria

We carried out a statistical analysis of the monthly cerebral malaria cases in Papua - New Guinea for the period January 1987 – December 1996 and of the monthly solar activity and geomagnetic activity for the same period. The solar activity was describe by the sunspot numbers and the F10.7 solar flux. As a measure of the geomagnetic activity the aa-indices were used. It has been found a close negative correlation between cerebral malaria cases and solar activity indices. The correlation of cerebral malaria cases with F10.7 reaches – 0.66, and – 0.70 with sunspot numbers. The confidence level of relationships was determined by Student`s t-test and reaches 0.00001. No statistically significant relationship was found between cerebral malaria cases in Papua – New Guinea and geomagnetic aa-index. All calculations were performed with raw data without smoothing which supports the correctness of the results obtained. The close correlations of cerebral malaria found in Papua – New Guinea with solar activity indices could be important for the prognosis of cerebral malaria in this region, and possibly in other regions.

Author's List

Muraközy J. (2),
Mursula K. (1),
Myagkova I. (2),
Myshiakov I. (3),
Nagovitsyn Yu.A. (1),
Nagy J. (1),
Nandi D. (1),
Nikitenko A. (1),
Novikov D.I. (1),
O`Rourke C. (1),
Obrazová D. (1),
Obridko V.N. (1),
Olugbon B. (1),
Orlyuk M.I. (2),
Osipova A.A. (1),
Oyeyemi E.O. (1),
Ozguc A. (2),
Panishko S. (1),
Parashkevova B. (1),
Petkov B. (1),
Petrov N. (3),
Petrović M. (1),
Pevtsov A.A. (1),
Podgorny A.I. (2),
Podgorny I.M. (2),
Radovanović M.M. (1),
Rodkin D. (1),
Romanchuk O. (1),
Romenets A. (2),
Romštajn I. (1),
Rozelot J.-P. (3),
Roša Dragan (2),
Rudenko G. (1),
Ruzhin Yu.Ya. (1),
Ryabov M.I. (4),
Sarp V. (1),
Semkova J. (4),
Sergeyeva N. (1),
Sergienko T.I. (1),
Shagimuratov I.I. (1),
Shishkova S. (1),
Shkevov R. (2),
Shugay Yu. (1),
Shurshakov V. (1),
Skokič I. (1),
Slemzin V. (1),
Sobitnyak L.I. (3),
Sokoloff D. (1),
Stanislavsky A. (1),
Strassmeier K.G. (1),
Stupishin A. (1),
Sukharev A.L. (3),
Tashev V. (2),
Temmer M. (3),
Tokarsky P. (1),
Tomov B. (4),
Tonev P. (1),
Tsvetkov Ts. (3),
Turunen T. (1),
Usoskin I. (2),
Utz Dominik (4),
Vaisberg O.L (1),
Valev D. (2),
Van Doorsselaere T. (1),
Vargas-Dominguez S. (1),
Veronig A. (5),
Veselovsky I. (1),
Vuerinckx A. (1),
Vujko Al. (1),
Vuković N. (1),
Vyklyuk Y. (1),
Waters C.L. (1),
Werner R. (6),
Yampolski Y.M. (1),
Yankova Kr. (1),
Yerin S. (1),
Yermolaev Yu. (3),
Yurchyshyn V. (2),
Zabarinskaya L. (1),
Zagainova Yu.S. (1),
Zaharinova M. (1),
Zakharenko V. (1),
Zhdanov D.A. (1),
Zolnikova N.N. (2),
Šterc F. (2)

Liulin-MO-ExoMars TGO team (A):
Koleva R.[1], Benghin V[3]., Krastev K.[1], Dachev T.[1], Maltchev St.[1], Tomov B.[1], Matviichuk Yu.[1], Dimitrov P.[1], Mitrofanov I.[2]., Maklahov A.[2], Golovin D.[2], Maxim Mokrousov M.[2], Sanin A.[2], Litvak M.[2], Kozyrev A.[2], Tretyakov V.[2], Nikiforov S[2], Vostrukhin A.[2], Fedosov F.[2], Grebennikova N.[2], Zelenyi L.[2], Shurshakov V.[3], Drobyshev S.[3]
[1] SRTI – BAS , Sofia, Bulgaria
[2] IKI – RAS, Moscow, Russia
[3] IMBP – RAS, Moscow, Russia

Liulin-MO-ExoMars TGO team (B):
Shurshakov V.[1], Semkova J.[2], Dachev T.[2], Maltchev St.[2], Tomov B. [2], Matviichuk Yu.[2], Dimitrov P.[2], Koleva R.[2], K. Krastev K.[2], Mitrofanov I.[3], Malakhov A.[3], Mokrousov M.[3], Sanin A.[3], Litvak M.[3], Kozyrev A.[3], Tretyakov V.[3], Golovin D.[3], Nikiforov S.[3], Vostrukhin A.[3], Fedosov F.[3], Grebennikova N.[3], Drobyshev S.[1]
[1] IMBP – RAS, Moscow, Russia
[2] SRTI – BAS , Sofia, Bulgaria
[3] IKI – RAS, Moscow, Russia

Universat-SOCRAT collaboration

Sadovnichii V.A.[1]*, Panasyuk M.I.*[1]*, Lipunov V.M.*[1]*, Bogomolov A.V.*[1]*, Bogomolov V.V.*[1]*, Garipov G.K.*[1]*, Gorbovskoii E.S.*[1]*, Iyudin A.F.*[1]*, Kalegaev V.V.*[1]*, Klimov P.A.*[1]*, Kornilov V.G.*[1]*, Osedlo V.I.* [1]*, Petrov V.L.*[1]*, Podsolko M.V.*[1]*, Popova E.P.*[1]*, Rubinstein I.A.*[1]*, Svertilov S.I.*[1]*, Tulupov V.I.*[1]*, Yashin I.V.*[1]*, Grafodatskii O.S.* [2]*, Lemeshevskii S.A.*[2]
[1] M. V. Lomonosov Moscow State University, Russia
[2] S. A. Lavochkin Space Corporation, Russia

Czech ARC-node team

Miroslav Bárta [1]*, Pavel Jachym*[1]*, Wenjuan Liu*[1]*, Arek Berlicki*[1]*, Nataliia Muratova*[1]*, Abhijeet Borkar*[1]*, Rhys Taylor*[1]
[1] EU ARC – Czech node, Astronomical Institute ASCR, Czech Republic

EST consortium

EST Consortium encompasses 23 research institutions from 16 European member states.