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

Solar Influences on the Magnetosphere, Ionosphere and Atmosphere

Primorsko, Bulgaria, June 2-6, 2025

Book of Abstracts

SPACE RESEARCH AND TECHNOLOGY INSTITUTE
BULGARIAN ACADEMY of SCIENCES

Scientific Organizing Committee

Katya Georgieva (Space Research and Technology Institute, Sofia, Bulgaria) – *Chair*
Atila Özgüc (Bogazici Univ. Kandilli Observatory, Istanbul, Turkey)
Crisan Demetrescu (Institute of Geodynamics, Romanian Academy)
Dragan Roša (Zagreb Astrronomical Observatory, Croatia)
Jean-Pierre Rozelot (Université Côte d'Azur)
Nat Gopalswamy (NASA Goddard Space Flight Center)
Olga Malandraki (IAASARS, National Observatory of Athens, Greece)
Petra Koucká Knížová (Institute of Atmospheric Physics, Czech Republic)
Vladimir Obridko (IZMIRAN, Moscow, Russian Federation)

Topics:

Sun and Solar Activity
Solar Wind-Magnetosphere-Ionosphere Interactions
Solar Influences on the Lower Atmosphere and Climate
Solar Effects in the Biosphere and Lithosphere
Instrumentation for Space Weather Monitoring
Data Proccessing and Modelling

Local Organizing Committee:

(Space Research and Technology Institute, Sofia, Bulgaria)

SPACE CLIMATE GROUP

Boian Kirov – *Chair*;
Simeon Asenovski;
Kostadinka Koleva;
Volodymyr Komendant.

The 17th workshop is supported by
the Bulgarian National Science Fund,
Grant No КП-06-МНФ/53.

DOI: 10.31401/WSoz.2025.abs

CONTENTS

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

Solar Effects in the Biosphere and Lithosphere

Sun and Solar Activity

Solar-Type Activities and Brightness Variations in Three Binary Star Systems

Boneva D.[1], Yankova Kr.[1], Dimitrov W.[2]
[1]Space Research and Technology Institute, Bulgarian Academy of Sciences;
[2]Astronomical Observatory Institute, Faculty of Physics and Astronomy, Adam Mickiewicz University

This survey presents our study of brightness variations exhibited by three binary star systems at various time-scales. We use observational data obtained from several astronomical sources: the 2m telescope of the National Astronomical Observatory Rozhen; the American Association of Variable Star Observers (AAVSO); the Transiting Exoplanet Survey Satellite (TESS) and Swift – XRT Observatory. Observations cover the different periods of time in optical and X-ray bands of the selected binary systems: the visual binary 61 Cyg (Cygnus); the spectroscopic binary YY Gem (Gemini) and the ER UMa type dwarf novae IX Dra (Draco). The indicated types of brightness variations are compared to some solar type of activities, including flares, seen in the optical and X-ray bands. States of outbursts are also detected during the observational periods and we explore the possibility that the studied stars could exhibit solar-type bursts. We examine the similarities in the manifestation properties between the three targets and the Sun, and discuss their feasible sources.

Reconstruction of Kandilli Observatory Flare Index Data Using the Simplex Projection Method

Calisir M.A.[1], Gerceker K.[1], Ozguc A.[2], Kilcik A.[1]
[1]Department of Space Science and Technologies, Akdeniz University Faculty of Science, 07058, Antalya, Turkey; alikilcik@akdeniz.edu.tr; muhammed.calisirr@gmail.com;
[2]Kandilli Observatory and Earthquake Research Institute, Bogazici University, 34684 Istanbul, Turkey

A solar flare is a sudden, rapid, and intense variation in brightness in the solar atmosphere, result from the abrupt release of energy stored in magnetic fields. The flare index serves as a valuable metric for quantifying this short-lived solar activity. In our study, we aim to reconstruct the Kandilli Observatory total solar flare index data using the Simplex Projection method. The monthly mean flare index values were obtained from two main sources: Astronomical Institute Ondrejov Observatory of the Czech Academy of Sciences (1937–2024) and Kandilli Observatory of Istanbul, Turkey (1976–2024). We compared our prediction results with the Ondrejov Observatory dataset. Our methodology offers a promising approach by applying the Simplex Projection method typically used for forward predictions to reconstruct Kandilli data, contributing to enabling a deeper understanding of solar flare behavior over an extended period.

Variations of Umbral Magnetic Field Intensity with Umbral Area, Brightness, and Sunspot Number

Calisir M.A.[1], Kilcik A.[1], Yurchyshyn V.[2]
[1]Department of Space Science and Technologies, Akdeniz University Faculty of Science, 07058, Antalya, Turkey; alikilcik@akdeniz.edu.tr; muhammed.calisirr@gmail.com;
[2]Big Bear Solar Observatory, New Jersey Institute of Technology, Big Bear City, CA 92314, USA; vasyl.yurchyshyn@njit.edu

Sunspots are regions on the Sun where the magnetic field is highly concentrated. The magnetic field drives the physical conditions within and around sunspots. The study of the relationship between the magnetic field strength in the sunspot umbra and the umbral area, umbral brightness and sunspot number (SSN) provides important information about the physical properties of sunspots and the overall structure of the Sun. In this study, we analyzed high-resolution sunspot images obtained from the Big Bear Solar Observatory (BBSO)/Goode Solar Telescope (GST) for 2015 – 2022 time intervals. The corresponding daily sunspot number (SSN) data were taken from the Solar Influences Data Analysis Center (SIDC) website, and the magnetic field measurements were obtained from the GST/Near InfraRed Imaging Spectropolarimeter (NIRIS). The variations of the mean umbral magnetic field intensity with against to the umbral area, umbral brightness, and SSN were investigated, and Pearson correlation analysis was performed to explore the relationships between them. Our analysis revealed the following results: i) There is a power-law relationship between the mean umbral area and the magnetic field intensity and the magnetic field intensity increases with increasing umbral area. ii) The magnetic field intensity decreases with increasing mean umbral brightness. iii) A weak relationship was found between the umbral magnetic field intensity and the SSN; the magnetic field intensity tends to increase slightly as the SSN increases.

First Bulgarian Antarctic Astrophysical Obsrvatory

Dechev M.[1], Kozarev K.[1], Petkov P.[2], Radeva V.[3], Borisov G.[1], Nachev I.[2], Sotirov D.[1], Atanasov A.[3]
[1]Institute of Astronomy and NAO, BAS, Bulgaria
[2]Technical University of Sofia, Bulgaria
[3]Nikola Vaptsarov Naval Academy, Varna, Bulgaria

This poster presents the objectives, implementation, and preliminary results of the first Bulgarian polar astronomy project, ""Impact of Solar Activity on Ionospheric Dynamics and High-Energy Particle Fluxes over Antarctica"" (2024–2025), conducted at the Bulgarian Antarctic Base on Livingston Island. The study aims to investigate solar-terrestrial interactions, focusing on solar flares, coronal mass ejections, and their effects on ionospheric disturbances, geomagnetic field variations, and radiation levels. Four synchronized experiments were deployed: (1) HF radio spectrography for direct solar burst observations (75–750 MHz), (2) VLF monitoring of ionospheric D-layer disturbances via long-range ground-based transmitters, (3) magnetometric measurements of local geomagnetic field variations, and (4) radiation dosimetry using passive detectors.

Data analysis is ongoing, with plans for long-term monitoring to improve space weather forecasting and mitigate impacts on satellite communications. This initiative establishes Bulgaria's capacity for cutting-edge polar astrophysical research, supported by collaborations with TU-Sofia, the Naval Academy Varna, and international partners.

Keywords: Solar activity, ionospheric dynamics, Antarctic research, geomagnetic field.

Hemispheric Asymmetry of the Solar Dynamo

Georgieva K., Kirov B., Asenovski S.
Space Research and Technology Institute - Bulgarian Academy of Sciences (SRTI-BAS), Acad. G. Bonchev St, Bl. 1, 1113 Sofia, Bulgaria

The solar dynamo transforms the poloidal solar magnetic field prevailing during sunspot minimum into toroidal field which gives rise to sunspots, and back. The transition of poloidal into toroidal field is due to the differential rotation at the base of the convection zone. Two mechanisms are responsible for the recreation of the poloidal from the toroidal field: large-scale meridional circulation, and diffusion. The dynamo's regime of operation depends of the relative importance of these two mechanisms. If both are operational, the sunspot number has two maxima during the solar cycle: one advection-generated, the other one diffusion-generated.

Earlier we found that, averaged over the two solar hemispheres, the diffusion-generated peak seems to appear earlier and at higher heliolatitudes in all sunspot cycles from 15 to 19. The order is reversed in cycles 12-14 and 20-23.

Here we repeat this study separately for the two solar hemispheres, and compare the two Gleissberg cycles minima between the 19th and 20th centuries, and between the 20th and 21st centuries. We find that the solar dynamo did not operate in different regimes during the last two Gleissberg minima. Moreover, it does not operate in different regimes during these secular minima and the cycles between them. An unexpected result is that the evolution of sunspot activity generated by advection and diffusion is different in the Southern and Northern hemispheres. The pattern is the same in all studied cycles with the exception of cycle 19 – the cycle of the secular sunspot maximum, which is quite peculiar.

Daily and Monthly Predictions of the Maximum CME Speed Index for Solar Cycle 25

Gerçeker K., Kilcik A.
Akdeniz University, Antalya, Turkey

Coronal Mass Ejections (CMEs) and their speed are not only important indicators of solar activity, but also important indicators to describe geomagnetic activity. Therefore, predicting CMEs, especially their speeds, can improve our understanding of the potential shape of solar activity and identify possible perturbations in the Earth's magnetic field. In this study, we present daily and monthly predictions for Solar Cycle 25 using the Maximum CME Speed Index (MCMESI) and the Simplex Projection method. By generating both short-term and long-term predictions for MCMESI, we demonstrate the usability and predictability of this parameter for solar and geomagnetic activity studies. Two datasets were used: the daily MCMESI and monthly mean MCMESI. The monthly mean dataset was derived from daily values, and both datasets cover the period from May 1999 to December 2024. Predictions generated from the monthly mean data suggest that Solar Cycle 25 is expected to complete in the mid-2030s. Solar Cycle 25 appears to be stronger than Solar Cycle 24 in terms of amplitude, but somewhat weaker than Solar Cycle 23, although similar. For daily predictions, we successfully performed postcasts by excluding the last 9 data points from the dataset, which accurately reproduced the observed part. Following the successful prediction performance in the postcasts, we also present 7-day MCMESI predictions for the first week of 2025, covering data that had not yet been released.

Solar Cycle Variation of Sustained Gamma-ray Emission from the Sun

Gopalswamy N., Makela P., Akiyama S., Yashiro S.
NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

The sustained gamma-ray emission (SGRE) from the Sun is one of the fascinating high-energy phenomena closely related to the acceleration of protons to energies >300 MeV. Therefore, SGRE should have a solar cycle variation similar to high-energy solar energetic particle (SEP) events from the Sun. A simple comparison of the number of SEP events with ground level enhancement (GLE) between solar cycles provides an indication of the cycle strength. For example, there were 16 GLE events in cycle 23 compared to just 2 in the weak cycle 24. Solar cycle 25 has been predicted be similar to cycle 24 or slightly stronger by many authors. During the first five years of cycle 25, there have been 4 GLE events, confirming the higher strength than cycle 24. Over the same period, the number of SGRE events observed by Fermi's Large Area Telescope (LAT) has diminished significantly when compared to the corresponding epoch in cycle 24. One if the issues has been the reduced coverage of the Sun since 2018 due to a mechanical problem with a solar array of the Fermi mission. Fortunately, the gamma ray burst monitor was observing the Sun more or less continuously, so we were able to identify 100 keV hard X-rays even when LAT was not pointed to the Sun. We make use of the observation by Share et al. (2018) that each SGRE event is accompanied by a 100 keV hard X-ray burst. By quantifying the properties of the 100 keV HXR bursts associated with known SGRE events, we estimate the number of SGRE events that might have occurred during LAT gaps and hence assess their true solar cycle variation.

Association between Equatorial Coronal Hole Physical Parameters with the Sunspot Activity

Hiremath K.M., Hegde M.
Indian Institute of Astrophysics, Bengaluru-560034

Everybody is familiar with the well known sunspots with associated events such as flares, coronal mass ejections, etc., that create havoc and disturb Earth's ionosphere and magnetosphere in general and planetary atmospheres in particular. Another aspect of equally important solar activity is coronal holes that occur in the solar atmosphere which have discovered recently during initial phase of the space probes. Coronal hole activity phenomena were discovered mainly in EUV and x-ray wavelengths that have open magnetic flux and are intense sources of solar wind. Probably, during early history of solar system, these coronal activity phenomena might have played a major role in shaping the planetary atmospheres. Hence, it is not surprising that the planets in the vicinity of sun might have lost their atmospheres due to strong solar winds originated from coronal holes. Importantly, occurrence of solar coronal holes also leads to space weather effects that disturb the Earth's ionosphere, magnetosphere and create auroras. Considering the importance of space weather effects on the planetary atmospheres, for the years 2001-2008, SOHO/EIT 195 A, calibrated data is used for extracting coronal hole boundaries near the equator (40 deg north to 40 deg south). Average heliographic coordinates (latitude and longitude from the central meridian), area, average temperature, radiative flux and energy are estimated. Aims of present study are twofold: (i) to examine whether physical parameters of coronal hole vary with the well known sunspot cycle and, (ii) to verify whether coronal hole activity is a part of unified solar activity or not. To begin with, for different 10 deg latitude bins, average area of coronal holes is estimated and association between sunspot area and polar magnetic flux for the years 2001-2008 are examined. Preliminary results show that the area of equatorial coronal holes is inversely proportion to both the magnitudes of polar magnetic flux, sunspot area and sunspot number respectively.

The Forbush Decrease Observed by the SEVAN Particle Detector Network in the 25th Solar Activity Cycle

Karapetyan T., Chilingarian As.
A. I. Alikhanyan National Science Laboratory (Yerevan Physics Institute), Yerevan 0036, Armenia

The variations in cosmic-ray intensity, measured by ground-based detectors at various latitudes, longitudes, and altitudes, are associated with disturbances in the interplanetary magnetic field near Earth. When these variations interact with the magnetosphere, they cause worldwide Forbush decreases (FD), followed by a gradual recovery. The extent of the flux depletion depends on the type and energy of the detected particles, which are influenced by geographical coordinates, the detector's energy threshold, and selective power. The SEVAN particle detector network, with nodes in Europe and Armenia, identifies three types of particles that exhibit coherent depletion and recovery, corresponding to different energy galactic protons interacting with disturbed magnetospheric plasmas.

On November 3-4, 2021, an interplanetary coronal mass injection (ICME) struck the magnetosphere, sparking a strong G3-class geomagnetic storm and enabling auroras to be seen as far south as California and New Mexico. In a one-minute time series of count rates, all detectors of the SEVAN network recorded a 5% depletion. As we approached the maximum solar activity cycle, significant variations in particle flux intensity were noted on February 27, March 23, 2023, March 24, 2024, and May 11, 2024.

We present measurements of these FDs performed at mountain altitudes in Aragats (Armenia), Lomnicky Stit (Slovakia), Mileshovka (Czechia), and DESY (Hamburg, Germany) at sea level. We compared FD measurements made by the SEVAN detector and neutron monitors located on Aragats and Lomnicky Stit and analyzed the correlation of FD registration at different locations.

About Possible Jet Emission Effects on the Shape of the Flare Microwave Spectrum

Kashapova L., Shamsutdinova Yu.
Institute of Solar-Terrestrial Physics SB RAS

Microwave emission and X-ray emission both provide an opportunity to estimate the properties of flaring plasma. However, the values of the parameters derived from different spectral ranges could be different, and this is explained by various reasons. We present the results of a study of a compact flare with a jet where disagreement was found between spectral indexes derived from X-rays and microwaves. Using images obtained by the Siberian Radioheliograph, we were able to carry out imaging spectroscopy and reveal the contribution of jet emission to the flare spectrum. The possible effect of small-scale eruptions on the estimation of flare plasma properties is discussed.

Searching Planetary Influence Effects in Solar Activity Cycles

Katsova M.[1], Obridko V.[2], Sokoloff D.[2,3], Emelianov N.[1]
[1]Sternberg Astronomical Institute, Lomononsov Moscow State University;
[2]IZMIRAN Troitsk, Moscow;
[3]Dept. of Physics, Lomonosov Moscow State University;

Solar activity is a process driven by many independent but interconnected phenomena. If the 11-year cycle reflects the work of the dynamo mechanism, the cause of longer secular variations is unclear. When searching for such a cause, it would make sense to take into account the influence of the planetary system. We consider the action of all planets in the solar system reduced to the effect of a single barycenter. The tidal force is decomposed into radial and meridional components. The share of the radial tidal force is too small compared to the powerful radial gravity of the Sun. The meridional force is not compensated for by the Sun's gravity and depends on latitude. Since the latitude of the barycenter changes rather slowly, the sign of this component changes rather slowly with a characteristic time of about 5 years, during which time there is a constantly acting meridional acceleration on the solar surface. This acceleration can ultimately lead to speeds of several m/s, which, in principle, can greatly change the speeds of the meridional currents involved in generation of the magnetic field. However, it turned out that the variation found in the calculated speed does not agree with the observed periodicity of solar activity. Previously, the correspondence had been analyzed between the activity periods on solar-type stars and the periods of exoplanets. It turned out that in this case, no synchronization is observed either. Thus, the planetary hypothesis as a cause of long-term modulation of solar activity is not confirmed.

Dependence of Spicule Properties on the Magnetic Field—Results from Magnetohydrodynamics Simulations

Kesri K.[1,2,3], Dey S.[4,2], Chatterjee P.[3], Erdelyi R.[5,6,7]
[1]Campus Pierre et Marie Curie, Sorbonne Universite, 4 pl. Jussieu, Paris, IDF, France, 75005
[2]Indian Institute of Science Education and Research Bhopal, Bhauri, Bhopal, India, 462066
[3]Indian Institute of Astrophysics, Koramangla, Bengaluru, India, 560034
[4]University of Newcastle, University Drive, Callaghan, NSW 2308, Australia
[5]University of Sheffield, Hicks Building, Hounfield Road, Sheffield, S3 7RH, UK
[6]Eotvos Lorand University, 1/A Pazmany Peter setany, H-1117 Budapest, Hungary
[7]Hungarian Solar Physics Foundation (HSPF), Pet″ofi t´er 3., Gyula, H-5700, Hungary

Solar spicules are plasma jets observed in the interface region between the visible solar surface and the corona. At any given time, there is a forest of spicules originating in the chromosphere of the Sun. While various models attempt to elucidate their origin and characteristics, here, we consider the one driven by the magneto-convection undulations. The radiative magneto-hydrodynamical (rMHD) equations are solved using Pencil Code with a spatial resolution of 16 km using various magnetic field strengths. The obtained rMHD simulation data are investigated to unveil the various trends in spicular properties as a function of the applied magnetic fields. The important outcome of this study is the finding of a consistent reduction in both the number density and the maximum height reached

by spicules as magnetic field strength increases. We also use parabolic fitting on time-distance curves of spicules that are taller than 75th percentile in the distribution, in order to find a relation between the deceleration of the spicule tip and the magnetic field strength. Our results offer insights into the response of solar spicules to magnetic field strength.

Nonlinear and Causal Dynamics between Solar and Geomagnetic Activity Indices

Kilcik A., Gerceker K.
Akdeniz University, Antalya, Turkey

This study aims to identify the nonlinearity of selected indices of solar and geomagnetic activity, as well as to reveal the causal relationships among these indices. The monthly mean sunspot number (SSN) was selected to represent solar activity, while the monthly geomagnetic aa index, Ap index, and Dst index were chosen for geomagnetic activity from January 1957 to March 2025. The optimal selection of the time delay (τ) and embedding dimension (E) is crucial when examining the data in phase space. Therefore, the Average Mutual Information (AMI) method was first used to determine the optimal time delay (τ) for each dataset. Subsequently, the optimal embedding dimensions (E) were determined using the respective τ values and the False Nearest Neighbours (FNN) method. The Hurst exponent, Lyapunov exponent and correlation dimension calculations were performed for each dataset based on optimal τ and E values. The Convergent Cross Mapping (CCM) method was then applied to investigate causal relationships between the time series, using the SSN as the reference data set. We found that the Hurst exponent for the indices ranges between 0.85 and 0.93, indicating that series show a strong trend. The Lyapunov exponents range between 0.009 and 0.04, indicating that the series have a low to moderate level of chaos. The correlation dimension values range from 2.47 to 2.93, indicating that the complexity of the series is generally medium and relatively high. According to the CCM results, the CCM prediction skill (CCM - ρ) between monthly mean sunspot numbers and geomagnetic indices was found to be higher than the Pearson correlation coefficients (ρ).

Two Interacting CMEs and Related Eruptions

Koleva K., Duchlev P., Asenovski S.
Space Research and Technology Institute, Bulgarian Academy of Sciences

We investigate the morphology and kinematic characteristics of prominence eruption, occurring in the east solar limb on 2010 June 20. The event was observed by the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO), by the STEREO Observatory. Two successive CMEs were linked to the eruption, which was accompanied by an A6.4 GOES solar flare. We examine the associated CMEs' kinematics. The observed eruptions showed a strong non-radial motions towards the equator. We study the nonradial latitudinal offset of the prominence eruption and related CMEs. Both their impact on the space weather and the cause of the deflection are discussed.

Catalog of Solar Energetic Particles Events Registered by Liulin-MO Dosimeter in Martian Orbit during the Current Solar Cycle

Koleva R.[1], Semkova J.[1], Benghin V.[2], Gopalswamy N.[3], Matviichuk Yu.[1], Tomov B.[1], Krastev K.[1], Bankov N.[1], Dachev T.[1], Maltchev S.[1], Shurshakov V.[2], Drobyshev S.[2], Mitrofanov I.[4], Golovin D.[4], Sanin A.[4], Litvak M.[4], Mokrousov M.[4], Lukyanov N.[4]
[1]Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria,
[2]State Research Center, Institute of Biomedical Problems, Moscow, Russia
[3]NASA Goddard Space Flight Center, Greenbelt Maryland, USA
[4]Space Research Institute, Russian Academy of Sciences, Moscow, Russia

During the increasing and maximum phases of the current 25th solar cycle, up to 01 April 2025, the Liulin-MO dosimeter aboard the Trace Gas Orbiter registered 23 solar energetic particles (SEP) events in Martian orbit. The catalog consists of the radiation characteristics of the observed SEP events, Mars and Earth location relative the Sun, the corresponding solar eruptions and GOES proton fluxes data.

Type III Solar Radio Bursts: Recent Progress Due to PSP and Solar Orbiter Measurements

Krasnoselskikh V., Jebaraj I.Ch., Pulupa M., Dudok de Wit Th., Voshchepynets A., Larosa A., Bale S.D., Krafft C., Volokitin A., Agapitov O., Cooper T., Kretzschmar M., Balikhin M.

[1]CNRS-University of Orleans, LPC2E, Orleans CEDEX 2, France (vkrasnos@cnrs-orleans.fr)

[2]SSL, UCB, Berkeley, CA, 94720, USA

[3]Space Research Laboratory, University of Turku, Turku, Finland

[4]ISSI, Bern, Switzerland

[5]University of Uzhgorod, Uzhgorod, Ukraine

[6]Istituto per la Scienza e la Tecnologia dei Plasmi, Consiglio Nazionale delle Ricerche, 70126 Bari, Italy

[7]Physics Department, UCB, Berkeley, CA, USA

[8]École Polytechnique - Institut Polytechnique de Paris/Sorbonne Université, Rte de Saclay, 91120 Palaiseau, France

[9]IZMIRAN, Institute of Terrestrial Magnetism, Ionosphere. and Radio Wave Propagation, Russian Academy of Sciences. Russia, 142092, Troitsk, Moscow Region

[10]Physics Department, University of Orleans, Orleans, France

[11]University of Sheffield, Sheffield, S10 2TN, UK

The Parker Solar Probe and Solar Orbiter missions are uniquely equipped to study Type III solar radio bursts. Both spacecraft measure two components of the radio-frequency electric field with unprecedented time and frequency resolution. In addition, for the first time, both spacecraft are equipped with high-frequency magnetic sensors (up to 1 MHz), allowing direct measurements of the magnetic component of both Z-mode (slow extraordinary) and ordinary electromagnetic wave modes.

PSP repeatedly came closer to the source region than any other satellite before. This unique combination of capabilities provided exceptional data. The analysis of these wave data provided unambiguous evidence of the basic elements of the wave generation mechanisms: the initial generation of Langmuir or slow extraordinary waves, and the transformation of the primary waves into electromagnetic waves, producing fundamental and harmonic electromagnetic waves.

A major discovery is the determination of the polarization properties of these emissions: the fundamental emission is produced as a highly polarized ordinary wave, while the harmonic emission is produced as a much more diffuse, weakly polarized combination of ordinary and extraordinary waves. This discovery can be used to distinguish between fundamental and harmonic emissions.

These experimental studies were accompanied by theoretical and computer simulation studies, which allowed to determine the main physical mechanism of fundamental emission generation as a direct transformation of electrostatic waves into electromagnetic waves, and to confirm the generation of harmonic emission as a result of coupling of primary and reflected quasi-electrostatic waves.

The authors are greatful to ISSI for the support of the team "Beam Plasma Interaction and Type III Solar Radiobursts", and financial support by

NASA Grants: 80NSSC20K0697 and 80NSSC21K1770, and CNES Grants: “Parker Solar Probe” and “Solar Orbiter”

Energetic Particle Acceleration and Transport: Interplanetary Coronal Mass Ejections and shocks

Malandraki O.[1], Cohen C.M.S.[2], Giacalone J.[3], Trotta D.[4], Khoo L.Y.[5], Rodriguez-Garcia L.[6], Ding Z.[7], Kollhoff A.[7], Kouloumvakos A.[8], Mitchell J.G.[9], Mccomas D.J.[5], Schwadron N.A.[10], Rodriguez-Pacheco J.[11], Wimmer-Schweingruber R.F.[7], Ho G.C.[12], Mason G.[8]

[1]National Observatory of Athens, IAASARS, Athens, – Greece;
[2]California Institute of Technology – Pasadena, United States;
[3]University of Arizona – Tucson, United States;
[4]European Space Agency (ESA), European Space Astronomy Centre (ESAC), Villanueva de la Canada, Madrid – Spain;
[5]Department of Astrophysical Sciences, Princeton University, Princeton – United States;
[6]European Space Agency (ESA), European Space Astronomy Centre (ESAC), Villanueva de la Canada, Madrid, Spain & Universidad de Alcala, Space Research Group (SRG-UAH), Madrid, Spain;
[7]Institut fuer Experimentelle und Angewandte Physik, Christian-Albrechts-Universitaet zu Kiel, Kiel – Germany;
[8]The Johns Hopkins University Applied Physics Laboratory, Maryland – United States;
[9]NASA - Goddard Space Flight Center – Greenbelt, MD 20771, United States;
[10]University of New Hampshire, Durham, USA Department of Astrophysical Sciences, Princeton University, Princeton – United States;
[11]Universidad de Alcala, Space Research Group (SRG-UAH), Alcala de Henares, Madrid – Spain;
[12]Southwest Research Institute – San Antonio, United States

Solar Energetic Particles (SEPs) are accelerated at the Sun in association with solar flares and coronal mass ejection (CME)-driven shocks. We highlight important recent results of the study of Interplanetary CMEs and shocks in relation to energetic particle acceleration and transport. The Solar Orbiter (SolO) and Parker Solar Probe (PSP) pioneering missions have been providing unprecedented measurements of energetic particles in the near-Sun environment. The properties of an Interplanetary CME-driven shock and its evolution with heliocentric distance, observed on September 5, 2022 by PSP at an unprecedentedly low heliocentric distance of 0.07 AU, then reaching SolO which was radially well-aligned at 0.7 AU will be presented as well as an overview of the characteristics of the energetic particle population at each spacecraft. We also present the detailed analysis of the widespread SEP event on January 20, 2022, during which the measurements of the EPD experiment onboard SolO showed unusual first arriving particles from the anti-Sun direction. The aim is the study of how SEPs are accelerated and transported to SolO and near-Earth spacecraft as well as the examination of the influence of a magnetic cloud present in the heliosphere at the time of the event onset on the propagation of the energetic particles. An overview of interesting observations made by multiple spacecraft in the heliosphere during the widespread SEP event on February 15-16, 2022, one of the most intense SEP events observed so far in solar cycle 25 is also presented. Results from analyses of the corresponding Energetic Storm Particle (ESP) event (~0.05 – 2 MeV ions) as observed by the PSP ISIS/EPI-Lo instrument at 0.35 AU from the Sun on February 16, 2022 is also summarized. Inverse Velocity Dispersion (IVD) events, increasingly observed by spacecraft, will also be presented and discussed in terms of the underlying mechanisms.

Using Type III Radio Bursts as Evidence of Particle Escape from the Sun for Enhancing Solar Proton Forecasting Capabilities: HESPERIA REleASE+ & STEREO REleASE+

Malandraki O.[1], Posner A.[2], Tziotziou K.[1], Karavolos M.[1], Droege H.[3], Heber B.[3], Kuehl P.[3], Barzilla J.[4], Semones E.[5], Whitman K.[6], Leila Mays M.[7], Didigu C.[8], Stubenrauch C.[9], Laurenza M.[10], Maksimovic M.[11], Krupar V.[12], Tsipis L.[1]

[1]National Observatory of Athens, IAASARS, Athens – Greece (omaland@noa.gr);
[2]NASA Headquarters NASA & Johnson Space Center –USA;
[3]Christian-Albrechts-Universität zu Kiel – Germany;
[4]Leidos Inc. – USA;
[5]NASA Johnson Space Center – USA;
[6]KBR – USA;
[7]NASA Goddard Space Flight Center – USA;
[8]ADNET Systems – USA;
[9]NASA M2M/Catholic University of America – USA;
[10]INAF-Istituto di Astrofisica e Planetologia Spaziali – Italy;
[11]Observatoire de Paris – France;
[12]University of Maryland [Baltimore County] – USA

Reliable forecasts with sufficient advance warning of Solar Energetic Particle (SEP) events are vital for swift mitigation of threats to modern technology, spacecraft, avionics and under extreme circumstances commercial aircraft, as well as for minimizing radiation hazards to astronauts especially on future Lunar or Mars missions. To this end, the HESPERIA Relativistic Electron Alert System for Exploration (REleASE) forecasting tools provide real-time predictions of the proton flux (30-50 MeV) at L1 based on relativistic and near-relativistic electron measurements by the SOHO/EPHIN and ACE/EPAM experiments. The recently developed STEREO REleASE forecasting scheme provides real-time predictions of proton flux (21-40 MeV) at the current location of STEREO-A, relying on electron measurements by the SEPT and the HET instruments. We report on two novel implementations, namely HESPERIA REleASE+ and STEREO REleASE+, that combine for the first time real-time Type III solar radio burst observations by the STEREO S/WAVES instrument, as clear evidence of particle escape from the Sun, aiming to substantially improve the accuracy and reduce false alarms. The identification of Type III radio bursts and their qualification as a precondition for intense SEP events occurring either at Earth or STEREO location is provided by a robust automated algorithm that resulted from an international collaboration between partners with complementary expertise on particles and radio data. These real-time and highly accurate forecasting schemes, which are currently operational and accessible through the Space Weather Operational Unit of the National Observatory of Athens (http://www.hesperia.astro.noa.gr), have attracted attention from various space organizations (e.g., NASA/CCMC, SRAG) and some of them are now integrated and provided through the ESA Space Weather (SWE) Service Network (https://swe.ssa.esa.int/noahesperia-federated) under the Space Radiation Expert Service Center (R-ESC).

New Facilities for Solar Observations in Bulgaria

Markishki P.[1], Dechev M.[1], Latev G.[1], Simic Z.[2]
[1]Institute of Astronomy and NAO, BAS, Bulgaria
[2]Astronomical Observatory, Belgrade, Serbia

Solar observation initiatives at the Belogradchik Observatory and St. George International School and Preschool in Sofia, Bulgaria, represent a collaborative effort bridging professional astronomical research with educational outreach. This poster outlines the methodologies, instruments, and outcomes of solar monitoring activities that can be conducted at these two sites, emphasizing their complementary roles in advancing both scientific understanding and education. The Belogradchik Observatory, equipped with specialized solar telescopes (including H-alpha and white-light filters), provides high-resolution imaging capabilities for tracking dynamic solar phenomena such as sunspots, prominences, and flares. Concurrently, Saint George School in Sofia integrates solar observation into its curriculum, utilizing portable solar telescopes and digital imaging tools to engage students in hands-on data collection and analysis. Here we describe instrumentation in both places and planned activities in relation with the Join Bulgarian-Austrian project 'Joint Observations and Investigations of Solar Chromospheric and Coronal Activity'.

Keywords: solar observations, education, Belogradchik Observatory, Saint George School Sofia, sunspot monitoring, solar outreach.

Drivers of Hard X-Ray Footpoint Asymmetry in Solar Flares

Mirkamalov M.[1,2], Liu R.[1]
[1]University of Science and Technology of China;
[2]Samarkand State University

Flares are the most energetic manifestations of solar activity, they play a significant role in driving space weather. Understanding how flare-accelerated particles interact with the solar atmosphere is essential for uncovering the mechanisms of energy release and transport during eruptive events. Hard X-ray (HXR) emission, produced by non-thermal electrons precipitating into the lower atmosphere, provides a key diagnostic of energy deposition during flares. In this study, we present a statistical analysis of the asymmetry between conjugate HXR footpoints (FPs) in double-ribbon flares, and examine their relationship with photospheric magnetic fields and electric currents. This is achieved using high-resolution vector magnetograms from the Helioseismic and Magnetic Imager (HMI) and HXR imaging from the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI). Flare ribbons observed by the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) are used to confirm the spatial association with paired HXR sources. Our results aim to clarify how magnetic fields and electric currents regulate the precipitation of energetic electrons, contributing to the observed asymmetry in HXR emission.

Microwave Average Time Profile Application to Analysis of Long-Duration Energy-Release Flares

Motyk I.D., Kashapova L.K., Rozhkova D.V.
ISTP SB RAS;

We present the reconstruction results of the microwave average time profile (profile) of solar flares and its application to the analysis of specific solar flares. Modern models of solar flares use the so-called simple or "classical" flare profile for description, where a single energy release event occurs, followed by gradual attenuation of the emission. However, often a flare turns out to be a more complex phenomenon, where additional energy release events can occur. This means that several simple profiles can form a more complex, powerful and longer event. Average profiles obtained for different spectral ranges are suitable for the analysis of such complex events. With their help, it is possible to distinguish individual events from the general profile and take a fairly simple assessment of their contribution to the flare energy. Average profiles have already been obtained and used for X-ray and ultraviolet profiles in the study of thermal processes. However, no such profile has been constructed for non-thermal processes that play an important role in the flare energy balance. The microwave range is a sensitive tool for both thermal and non-thermal processes occurring in flare and this determined our choice.

To create the average profile, we selected 116 flares that had simple profile forms and broadband gyrosynchrotron spectra of non-thermal nature (Siberian Radioheliograph, 3-24 GHz). Analysis of the average profiles showed that the dominant contribution to the emission is made by the process of precipitation of accelerated electrons, rather than thermal processes. An analytical description of the average profile by functions describing the rise and decay phases of microwave radiation was obtained. The methodology for using the average profile to analyse flares is discussed using the example of the short flare C1.2 (GOES) 03.02.2022 and the possibility of using it to analyse long flares.

The study was supported by the grant of the Russian Science Foundation No. 24-22-00315, https://rscf.ru/project/24-22-00315/

Application of Microwave Average Time Profile to Analysis of Flares With Long-Duration Energy Release

Motyk I.D., Kashapova L.K., Rozhkova D.V.
ISTP SB RAS;

Evolution of solar flares can be described using a so-called "simple" or "classical" flare profile. It assumes a single event with a fast rise and gradual decay. More complex events can be considered as a composition of several simple time profiles. Average flare time profiles have been obtained for soft X-rays and ultraviolet data. However, no such profiles have been created for the microwave range, which is important for studying non-thermal processes. We present results of a microwave average time profile reconstruction and its use in analyzing solar flare evolution. Observations from the Siberian Radioheliograph at 3-24 GHz were used to create the average profile. An analytical description was obtained using functions that describe the growth and decay of microwave emission, and the methodology for analyzing flares using this profile was discussed. The study was supported by the grant of the Russian Science Foundation No. 24-22-00315, https://rscf.ru/project/24-22-00315/

Mean Field Dynamo and Solar Activity Forecasting

Obridko V.N.[1], Shibalova A.S.[1], Sokoloff D.D.[1,2], Livshits I.M.[3]
[1]IZMIRAN, 4, Kaluzhskoe Shosse, Troitsk, Moscow, 108840, Russia
[2]Department of Physics, Lomonosov Moscow State University, Moscow, 119991, Russia and Moscow Center for Fundamental and Applied Mathematics, Moscow, 119991, Russia
[3]Sternberg Astronomical Insititure, Moscow State University, 19991, Moscow, Russia"

According to the generally accepted theory, the field of local areas arises from the poloidal magnetic field. The field in the polar regions, which is measured directly by magnetographs, can be a proxy for the latter. It has been shown that the mean field dynamo is undoubtedly the main mechanism generating solar activity and the 11-year cycle. However, the magnetic flux generated in the dynamo, being the genetic basis of solar activity, still does not provide grounds for an unambiguous connection between the characteristics of the magnetic field and other indices of solar activity, including the most well-known index - the number of sunspots. Magnetic fields of active regions and spots are formed from the mean magnetic flux, based on the NEMPI mechanism (the effect of negative effective magnetic pressure). Its most important properties are the threshold nature and the preservation of the full flux. This is why a completely reliable long-term SSN forecast is possible after the occurrence of an equatorial wave approximately 18 months before the maximum. The processes in the leptocline play a decisive role in this case.

Solar Flare Location on the Extended Arc of Magnetic Lines with Increased Current Density, Obtained by Analyzing the Results of MHD Simulation

Podgorny A.[1], Podgorny I.[2]
[1]Lebedev Physical Institute RAS;
[2]Institute of Astronomy RAS

The study of the extended surface of magnetic lines with increased current density, having the form of an arcade, is continued. The appearance of such a surface can solve the problem of the coincidence of the positions of flares found from the results of MHD simulation with the observed positions of flares. According to the existing concepts, during a solar flare, the energy of the magnetic field of the current sheet formed in the vicinity of X-type singular line magnetic field is released. It is quite difficult to determine the flare position based on the MHD simulation results due to the complexity of the magnetic field configuration in the corona. For this purpose, a graphical system for searching for flare positions was created, based on searching for current density maxima. It is assumed that absolute value of current density reaches maximum in center of current sheet. However not always current density reaches maximum in center of current sheet. Therefore, although the developed system is useful for analyzing complex magnetic field configurations, its direct use often does not provide an opportunity to correctly determine the positions of flares. To study the locations of flare instability, an analysis of magnetic field configurations in areas with centers at different points of the arcade was performed. The analysis shows that the conditions determined by the magnetic field configuration are better promoted to the development of flare instability not at the location of the maximum current density, but at the top of the arch.

The Leptocline; a Solar Subsurface Layer Full of Potential

Rozelot J.P.
Université de la Côte d'Azur, Nice, France

Particular attention has recently been paid to the near solar subsurface layer, known as NSSL. On the one hand, because of the disruptive role of the magnetic field, whose properties are still far from fully understood in this region. Secondly, because of some unsuspected properties of solar rotation that have been also recently put in evidence, notably the reversal of the rotation gradient towards latitudes close to 60°. These two aspects, well identified by HMI's results on SDO, clearly highlight the role of subsurface magnetism. The NSSL could thus be divided into at least two layers (perhaps three) one of which, the leptocline (from Greek "letpos", thin and "klino", slope, by analogy with the tachocline "tachos", speed), would be the seat of numerous solar phenomena. Also a link explaining some properties of the solar gravitational moment. This lecture highlights the role of this shallow and sharp rotational shear layer lying from the surface to around 8 Mm in depth. Indeed, this layer could be the seat of many solar physical processes leading to a new vision of the structure and dynamics of the Sun. In such a way, it is not impossible, that this zone will play a significant role in the shaping of the solar activity cycles.

Do Flares Impact Neighbouring Quiescent Coronal Rain?

Şahin S.[1], Antolin P.[2]
[1]Akdeniz University, Antalya, Turkey;
[2]Northumbria University

Solar flares are energetic phenomena that influence coronal plasma dynamics through the magnetic reconnection-driven large-scale reconfiguration, heating and particle acceleration. Even though the energy release is usually strongly localised, it is well known that the flaring can impact a large part of the solar atmosphere through e.g. fast MHD shocks and particle acceleration. Coronal rain is a well known product of strongly stratified heating, seen in quiescent (non-flaring) and flaring conditions. This study investigates quiescent rain showers neighboring a flare site, focusing on their temporal evolution across the pre-flare, impulsive, and gradual phases. Using high-resolution imaging from IRIS/SJI and SDO/AIA, we perform a quantitative comparison of rain quantity, intensity, and velocity before and after a C7.5 flare. Our results reveal a decrease in the overall number of rain events, but a significant increase in average intensity and downflow velocity, suggesting a possible flare-induced change in the neighbouring loop conditions. These findings highlight the potential of using rain as a sensitive gauge for variations in the magnetic or thermodynamic environment, here attributed to external factors such as flares.

The Role of Sunspot Complexity and Area in Flare-Driven Coronal Rain

Şahin S., Özdüzenciler E., Aydın S., Tonkuç P.
Akdeniz University, Antalya, Turkey

Coronal rain (CR), characterized by cooled plasma condensing in coronal loops, provides key insights into thermal dynamics and energy transfer in solar active regions (ARs), yet the influence of photospheric structure remains underexplored. This study examines the role of sunspot class (A, B, C, D, E, F, and H) and sunspot area (SSA) on CR occurrence and duration in flare-associated events. Using a dataset of 241 flares (C, M, X classes) from Mason et al. (2022), of which 129 experienced CR, we incorporate sunspot classes and SSA from historical records. We group sunspot classes into four categories: small (A, B), medium (C), large (D, E, F), and end-stage (H), and analyse CR statistics across these and flare classes. We find that large sunspots classes exhibit significantly higher rain occurrence rates and longer durations (~90% and 172 minutes, respectively, for X-class flare). In contrast, no CR was observed in X-class flares from small or medium sunspot classes, highlighting importance of magnetic complexity. The correlation between SSA and CR duration, however, is weak across flare classes, suggesting SSA is not a reliable predictor of how long rain persists. Still, SSA may relate more to the quantity or spatial extent of CR, rather than its temporal characteristics. These findings emphasize the dominant role of sunspot complexity in shaping CR duration, while pointing to future work using high-resolution data to explore how sunspot size may influence CR dynamics and morphology.

Further Step in Development of Hydrogen Plasma Modeling, Modified Yukava Screening in Dense Hydrogen Plasma

Sakan N.M.[1], Simić Z.[2], Srećković V.A.[1], Traparić I.[1], Dechev M.[3]
[1]University of Belgrade, Institute of Physics, PO Box 57, 11001 Belgrade, Serbia, nsakan@ipb.ac.rs,
[2]Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
[3]Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences, 72, Tsarigradsko chaussee Blvd. Sofia, Bulgaria

The plasma of low and moderate non-ideality is of interest in solar and stellar plasma. The previous research of modeling a collective plasma influence onto the emitter in plasma was conducted with the modeling of electron screening influence by the usage of Debye screening mechanism. Although this was a known erroneous presumption a preliminary results has shown a expected behavior in respect to particles in plasma densities as well as temperatures that was present in modeled plasma. The more thorough research has shown that the modified Yukava type screening is more applicable. Here are presented preliminary results of plasma influence onto the emitter potential in pure hydrogen plasma. This is the further step in development of more detailed analysis of collective phenomena in area of moderate to dense plasma influence.

Comparison of GLE event of 11 May 2024 and Magnetospheric effect 5 November 2023

Sargsyan B., Chilingarian A.
A I Alikhanyan National Lab (Yerevan Physics Institute), Yerevan 0036, Armenia

We examine the energy spectra of secondary particles linked to solar events to identify and classify Forbush decreases (FD), ground-level enhancements (GLE), and magnetospheric effects (ME) detected by particle detector networks on Earth's surface.

We present energy spectra of neutrons related to the magnetospheric effect observed on November 5, 2023, and the GLE on May 11, 2024. The significant difference between the two highlights the importance of measuring energy spectra for identifying solar energetic events.

We refine the definition of the Magnetospheric Effect (ME). Our classification is based on the following observations:

1. Antarctic and near-polar NMs did not register flux enhancement, while middle latitude NMs and SEVAN detectors coherently registered count rate enhancements throw distances of 5,500 km.
2. Due to atmospheric cutoff rigidity, NMs and SEVAN detectors located on mountain tops at middle latitudes demonstrated flux enhancement, while ones at sea level did not.
3. The energy spectra of the shower particles measured during ME are significantly different from those of other sources of flux enhancement, making this criterion essential for identifying ME.

Radiation Conditions in Mars Vicinity During Different Phases of the Solar Cycle According Measurements by Liulin-MO Dosimeter Aboard the Trace Gas Orbiter

Semkova J.[1], Koleva R.[1], Benghin V.[3], Krastev K.[1], Matviichuk Yu.[1], Tomov B.[1], Bankov N.[1], Maltchev St.[1], Dachev Ts.[1], Mitrofanov I.[2], Golovin D.[2], Mokrousov M.[2], Litvak M.[2], Lukyanov N.[2], Shurshakov V.[3], Drobyshev S.[3]
[1]Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria,
[2]Space Research Institute, Russian Academy of Sciences, Moscow, Russia
[3]State Scientific Center of Russian Federation, Institute of Biomedical Problems, Russian Academy of Sciences, Moscow, Russia

Presented are the results for the dose rates and particle fluxes of the galactic and solar cosmic rays in the interplanetary space and in Mars orbit obtained during different phases of solar cycles 24 and 25 in the period April 2016- April 2025. Data are provided by Liulin-MO dosimeter aboard the ExoMars Trace Gas Orbiter. Discussed is the selection of the best time interval in the solar cycle for a future manned trip to Mars, regarding the radiation safety. The obtained results may be used for verification and benchmarking of the galactic and solar cosmic rays models in the free space and in Mars orbit.

Resonances in Parker Migratory Dynamo

Sokoloff D.D.[1,2]*, Azizov F.*[1]*, Yushkov E.V.*[1]
[1]Moscow State University,
[2]IZMIRAN

Periodic variations in stellar including solar) dynamo drivers arise due to perturbations in hydrodynamic flows in stellar convective shells due to tidal forces. If the orbital period of the planet is close to the stellar cycle length one can expect something like dynamo resonance. The point however is that the dynamo resonance effects are not very similar to those which arise in simple pendel excitation problems. Here we reported an example of such a problem where periodic variations transform a monotonically growing solution into an oscillatory behaviour.

Hemispheric Asymmetry of Sunspot Groups During Solar Cycles 23–25

Tirnakci M.[1,2]*, Kilcik A.*[1]
[1]Department of Space Science and Technologies, Akdeniz University Faculty of Science, Antalya, 07058, Türkiye;
[2]Türkiye National Observatories, TUG, 07070, Antalya, Türkiye

This study investigates the hemispheric asymmetry in solar activity by analyzing sunspot parameters across Solar Cycles 23, 24, and 25 using NOAA datasets. The dataset includes sunspot counts, group counts, and sunspot area measurements, categorized by hemisphere and sunspot group type. We analyzed sunspot groups into three main categories: small groups (A, B, H), large groups (D, E, F), and a medium (transitional) group (C). Each category is further divided based on its occurrence in the northern and southern hemispheres, allowing for a detailed assessment of hemispheric variations in solar activity. To explore the temporal variations, an 11-step running average was applied to the monthly data. Additionally, cross-correlation analysis was performed to identify and quantify any time lag between the northern and southern hemispheres. Asymmetry ratios indicate that small groups show near-balanced distribution across hemispheres. In contrast, large groups exhibit stronger and consistent southern dominance, especially in SC25. The C group displays intermediate behavior, with increasing asymmetry in later cycles. These patterns suggest that hemispheric asymmetry becomes more pronounced with sunspot group size and cycle progression.

Planning for Totality: Scientific Objectives of the 2026 Solar Eclipse Expedition in Spain

Tsvetkov Ts., Petrov N., Minev M.
Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences

We outline the objectives, logistics, and scientific significance of the planned expedition for observing the total solar eclipse on 12 August 2026 in Spain. It is part of ongoing efforts to study solar phenomena during totality, with a focus on high-resolution imaging of the solar corona and the atmospheric phenomena accompanying the eclipse. The selected observation site in Spain offers favorable weather prospects and optimal eclipse geometry, ensuring maximum duration of totality and minimal unfavorable atmospheric impact. We present the planned methodology, expected outcomes, and the broader context of eclipse observations in advancing heliophysical research.

Cross-spectral Analysis of the B-Star Drag Term and Solar and Geomagnetic Activity Indices

Komendant V.
Space Research and Technology Institute, Bulgarian Academy of Sciences

Cross-spectral analysis of time series is a technique in spectral analysis that is used to study the relationship between two time series in the frequency domain. It is especially useful when you are interested not just in whether there is a relationship, but also in the frequencies at which that relationship is expressed.

Regression models were used to obtain the set of indices that have the greatest influence on the studied parameter of satellites drag. Then these indices were used in cross-spectral analysis. For a joint analysis, the drag coefficient was taken for three satellites moving at mid-latitudes.

Interrelated periods for the satellite drag coefficient and the selected indices of solar and geomagnetic activity were obtained. The strength and linearity of the obtained interrelations are shown graphically. The phase shifts present between the interrelated periods are shown.

Coronary Activity at the Accretion Disk

Yankova Kr.
Space Research and Technology Institute, Bulgarian Academy of Sciences

In this paper, we consider the accretion disk of a compact object. In the process of evolution, zones of activity are formed. Activity, which is developed in the disk corona, is typical coronal activity like a Sun's. We analyze a zone features and looking for the connections of the disc behavior. We investigate energy exchange between disk and the corona.

Solar Wind-Magnetosphere-Ionosphere Interactions

Nonlinear Methods for Analyzing and Forecasting Geomagnetic Indices Driven by Solar Wind Variability

Asenovski S., Georgieva K., Kirov B.
Space Research and Technologies Institute, Bulgarian Academy of Sciences

Geomagnetic indices such as Dst and Ap reflect the dynamic response of Earth's magnetosphere to variations in the solar wind. These responses often involve complex, nonlinear interactions that cannot be fully captured by linear models or periodic representations. In this study, we apply nonlinear time series analysis to investigate the temporal structure of geomagnetic indices in relation to solar wind conditions.

Using phase space reconstruction techniques, we analyze the underlying dynamics of geomagnetic activity without relying on assumptions of linearity or statistical correlation. A locally based predictive model is developed to forecast short-term variations in geomagnetic indices, and its performance is evaluated across multiple intervals characterized by elevated solar wind speed and other solar wind parameters.

Our results demonstrate that nonlinear forecasting approaches outperform traditional linear methods, especially during periods influenced by fast solar wind streams and disturbed space weather conditions. This highlights the potential of nonlinear methods for improving the accuracy of geomagnetic activity forecasts in operational space weather models.

Global Ionospheric Response to Geomagnetic Storm in May 2024

Bojilova R., Mukhtarov P.
National Institute of Geophysics, Geodesy and Geography-Bulgarian Academy of Sciences

The main objective of this study is to investigate the time evolution of the spatial distribution of the ionospheric response to the geomagnetic storm occurred in the time interval 10–11 May 2024. The obtained ionospheric anomalies represented by the relative deviations of the global Total Electron Content (TEC) data have been utilized in the analysis. The used global TEC data have been converted to a coordinate system with a modip latitude and geographical longitude. The main results of the present study are summarized as follows: a) An interesting result is the negative response in mid latitudes caused by the spread of warmed air from the polar oval to low latitudes; b) The observed symmetric ionospheric response at 40°S and 40°N is explained by the extension of the Equatorial Ionospheric Anomaly and c) According to the selected geomagnetic storm, the maximum negative response in the magnetic equator region is observed at local time close to midnight. This type of response persists all the time in the night hemisphere. A detailed study of this geomagnetic storm can be found published in the following manuscript: Bojilova, R.; Mukhtarov, P.; Pancheva, D. Global Ionospheric Response During Extreme Geomagnetic Storm in May 2024. Remote Sens. 2024, 16, 4046. https://doi.org/10.3390/rs16214046.

Correlation Analysis between Geomagnetic Activity and Ionospheric Peak Electron Density Height of F2 Layer for Ionospheric Station Rome - Italy

Bojilova R., Mukhtarov P.
National Institute of Geophysics, Geodesy and Geography-Bulgarian Academy of Sciences

The basic aim of this research is to present an analysis of the relationship between the average ionospheric response of peak electron density height of the ionospheric F2 region (hmF2) and the geomagnetic activity for ionospheric station Rome, Italy. Significantly long data series for both quantities in the period 2002-2022 (including two solar cycles) were used, and the method for determining the relative deviation of the parameters from quiet (median) conditions was applied. To analyze the influence of geomagnetic activity represented by planetary Kp index on the hmF2, correlation analysis was used. The results show that a) the predominant ionospheric response is positive with a delay of about 1-2 hours; b) the influence of geomagnetic activity on hmF2 is maximal during the equinox months, during the night hours and around local noon. The obtained results of the positive correlation coefficient, indicating the presence of a relationship between hmF2 and Kp index (reaching up to 30%), show that the most significant influence on hmF2 is the vertical upward drift caused by the induced electric fields in the ionosphere from the "perturbed dynamo" and prompt penetration electric fields (PPEF). The choice of the selected ionospheric station Rome is related to the fact that this station is located at the geographic latitude coinciding with the latitude of Sofia, which suggests similar characteristics of the ionosphere for the territory of Bulgaria.

Slow Solar Wind and "Polar" Substorms

Despirak I.V.[1], Kleimenova N.G.[2], Lubchich A.A.[1], Setsko P.V.[1], Malysheva L.M.[2]
[1]Polar Geophysical Institute, Apatity, Russia;
[2]Schmidt Institute of Physics of the Earth, RAS, Moscow, Russia

The study focuses on substorms that originate and develop at very high geomagnetic latitudes, near the polar edge of the auroral oval. They are called "polar" substorms. The analysis is limited to the Scandinavian longitude sector, where the extensive IMAGE magnetometer network is located. In this sector, "polar" substorms develop over the Svalbard archipelago. "Polar" substorms are usually observed in quiet geomagnetic conditions, at low solar wind speeds (V ~ 300–450 km/s). Slow solar wind is associated with slow interplanetary coronal mass ejections, slow solar wind streams, and sometimes with the end of high-speed HSS streams, when the speed decreased from high to low values. We analyzed intervals of extremely low solar wind speeds (below 300 km/s) over an 11-year period covering the entire solar cycle. It was found that even in conditions of very slow solar wind, the appearance of a negative Bz component of the interplanetary magnetic field can lead to the observation of "polar" substorms at high latitudes near the polar edge of the oval. These substorms have the main characteristics of ordinary substorms. There are two types of "polar" substorms - magnetic disturbances occurring only at high polar latitudes, which are not reflected in the AL and SML indices. Another type of "polar" substorm is a continuation of an ordinary auroral substorm to high latitudes. Differences between these types of "polar" substorms were determined only by data of AMPERE satellites, since there are few ground-based magnetic stations at high latitudes.

Geomagnetically Induced Currents during May 2024 Superstorm

Despirak I.V.[1], *Setsko P.V.*[1], *Lubchich A.A.*[1], *Sakharov Ya.A.*[1], *Selivanov V.N.*[2]
[1]Polar Geophysical Institute, Apatity, Russia;
[2]Northern Energetics Research Centre KSC RAS, Apatity, Russia

One of the manifestations of space weather is geomagnetically induced currents (GICs). These are intense, low-frequency (~0.001–1 Hz), quasi-dc constant currents in ground-based technological networks. GICs are driven induced by electric fields generated by any rapid changes in the magnetic field during various space weather events. The aim of this study is to conduct the detailed analysis of the GICs sources during superstorm (SYM/H ~ -518 nT) on 10–13 May 2024. It was the second-strongest geomagnetic storm of the space era, following the 14 March 1989 storm (SYM-H = -720 nT). Superstorm on 10-11 May 2024 was had a long duration, from ~17:15 UT on May 10 to ~ 02:15 UT on May 11 was the storm main phase, on May 11-13 the recovery phase was observed. Extremely intense GICs (~50-62A) were recorded in the Karelian-Kola power transmission system line in north-west of Russia in this time period. Moreover, GIC recording registration stations moved were located successively through in all MLT sectors (evening, night, morning, daytime and i.e.). It was shown that geophysical sources of intense GICs were substorms, supersubstorms and Pc5/Pi3 geomagnetic pulsations. Besides, substorms were the main sources of GIC in the night MLT sector, while Pc5/Pi3 geomagnetic pulsations were the main sources of GIC in the morning MLT sector. Strongest GIC peaks of ~50-62 A were associated with the superposition of several sources at once: substorms, geomagnetic pulsations Pc5/Pi3 and strong local magnetic disturbances, caused by the characteristics features of the corresponding ICME.

MHD Instabilities in Shear Flows of Anisotropic Solar Wind Plasma

Dzhalilov N.
N.Tusi Shamakhy Astrophysical Observatory of the Science and Education Ministry of Azerbaijan

The stability of the anisotropic collisionless solar wind plasma layer to small disturbances in the MHD description is studied based on moment equations obtained from the Vlasov kinetic equation taking into account the heat flow along the spatially shearing flow. To find the complex spectral parameter that determines the growth rate of instability, on the base of the obtained wave equation, the boundary value problem is solved for the case of a smooth hyperbolic velocity profile. A general integral dispersion equation, based on these solutions is obtained. This equation describes all types of body and interface instabilities in the presence of heat flow along the magnetic field, well studied for infinite stationary and homogeneous anisotropic plasma. It is shown that reducing the layer width greatly enhances the mirror instability, and strongly suppresses the oblique fire-hose instability. We limited ourselves here to study how the spatial gradient of the plasma flow affects the properties of an aperiodical oblique fire-hose instability in a limited layer. It was found that the spatial gradient in flow velocity greatly enhances this instability. With a narrowing of the shearing layer width and an increasing of the velocity gradient, the body hose modes transform into surface Kelvin-Helmholtz modes existing on the interface between the two parts of the flow with the different velocities.

1-100 keV Electrons in the Inner Earth's Magnetosphere during Extreme Magnetic Storms

Ganushkina N.Yu.
University of Michigan, Ann Arbor, MI, USA/Finnish Meteorological Institute, Helsinki, Finland

Electrons with energies below 100 keV constitute a significant part of the inner magnetosphere population. They can cause surface charging, which is a build-up of electricity on the outer components of the satellite. These electrons are the seed population for the radiation belts. At present, the behavior of keV electrons is a puzzle in many ways. Their fluctuations occur on a time scale of minutes and their fluxes are local time (MLT)-dependent. there are no simple answers as to which of the solar wind parameters drive their variations. Moreover, increasing geomagnetic activity does not necessarily lead to the enhancements of their fluxes. We present the modeling results done during May 11, 2024 recent severe magnetic storm. The Inner Magnetosphere Particle Transport and Acceleration model (IMPTAM, imptam.engin.umich.edu) developed for < 200 keV electrons was operating online in real time during this storm. It is driven by the real time solar wind and IMF parameters and geomagnetic indices and provides the keV electron flux at all L-shells and at all satellite orbits inside the modeling domain of 10 RE. We found that keV electron fluxes were not significantly high. During the extreme events when the solar wind dynamic pressure and velocity are high, the magnetopause comes to the Earth at distances closer than geostationary orbit. Eectrons are lost in a rather wide region in MLT, both on dawn and dusk, not only at noon. On the nightside, the magnetosphere is very stretched, GEO and even MEO happens to be at much larger L-shells like 10 or even 15. Electrons are also lost on the nightside, so that at GEO and MEO the fluxes may be even lower than during non-extreme event. This is true for storm main phase, in particular. It is possible to determine the maximum electron flux at MEO only before the storm main phase.

High-Speed Electron Bulk Flows and Their Role in the Plasma Sheet Energy Conversion in Micro-Scales

Grigorenko E., Leonenko M., Petrovskyi I., Zeleyi L.
IKI RAN;

MMS spacecraft observations with high time resolution have revealed the appearance of high-speed electron Bursty Bulk Flows (eBBFs) in the Plasma Sheet (PS) of the Earth's magnetotail. The eBBFs are usually observed during the intervals of high-speed ion bulk flow propagation. But, unlike the ion bulk flows the eBBFs have very short duration (< 1s) and their velocities are tens and sometimes hundred of times larger than the velocity of the corresponding ion bulk flow. Due to the strong velocity shear the eBBFs generate the significant electric currents and can be sources of various plasma instabilities, e.g. beam-related instabilities and electron Kelvin-Helmholtz instability. As a result, strong electric fields with amplitudes up to hundreds mV/m can be generated in the vicinity of eBBFs. The electric fields and electron currents coupling lead to significant energy conversion with the power density sometimes of the order of that observed in the electron diffusion region of magnetic reconnection. In this work we study statistically the occurrence frequency and characteristics of eBBFs. We show that many of them could be accelerated in the regions of secondary micro-reconnections spontaneously formed within the ion bulk flow accelerated in the primary macro-scale reconnection.

This work is supported by Russian Science Foundation (grant # 23-12-00031).

Intense Magnetic Storms in the Maximum Phase of the 25th Solar Activity Cycle and Their Solar Sources

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

It is known that in the current epoch of lowered solar activity (SA), geomagnetic activity decreases. The number of intense magnetic storms in the 23rd and 24th SA cycles was lower than in the previous cycles. However, in the 25th SA cycle, geomagnetic activity has increased somewhat. The maximum phase of the 25th SA cycle began after November 2023. The number of flare-active regions significantly increased. In 2024-2025, there have been registered five flare events of class X ≥ 5, 45 events of class X1-X4.9; three solar proton events of class S4, and 17 events of class S3 that caused a sharp increase in the number and power of the geoeffective flare events. During this period, one extreme (G5) and three severe (G4) magnetic storms with Dstmin < -200 nT were recorded. Here we discussed the planetary features of these very intense magnetic storms and their solar flare sources.

The Geomagnetic Mid-Latitude Effects of the Supersubstorms During May 10-12, 2024 Superstorm

Guineva V.[1], Despirak I.V.[2], Werner R.[1], Lubchich A.A.[2], Raykova L.[1], Bojilova R.[3]
[1]Space Research and Technology Institute, Bulgarian Academy of Sciences, Stara Zagora Department, Bulgaria;
[2]Polar Geophysical Institute, Apatity, Russia;
[3]National Institute of Geophysics, Geodesy and Geography (NIGGG) - Bulgarian Academy of Sciences, Sofia, Bulgaria

The aim of this study is to conduct the detailed analysis of the geomagnetic auroral and mid-latitude disturbances during superstorm on 10–12 May 2024. It was the second-strongest geomagnetic storm of the space era (SYM/H ~ -518 nT). Storm main phase was observed from ~17:15 UT on May 10 to ~ 02:15 UT on May 11, the recovery phase was registered on May 11-13. Extremely intense geomagnetic disturbances so-called “supersubstorms” (SSSs: SML < −2500 nT) were recorded during the superstorm. According to the SuperMAG data base, there were several SSS events: at ~19:20 and ~19:50 UT, ~22:35 and ~ 22:40 UT on 10 May, at ~09:00 and ~09:50 UT, at ~12:45, ~13:32 and ~13:43 UT on 11 May, 2024. The planetary space-time distribution of the magnetic disturbances during this SSS were studied using the data collected from the ground-based networks (SuperMAG, INTERMAGNET and IMAGE) as well as the magnetic registrations by the Iridium constellation of 66 satellites at 780 km altitude, distributed over six orbit planes spaced equally in longitude (AMPERE project). We studied the extremal geomagnetic disturbances during SSS by examining the morphology of the auroral electrojets, the corresponding positive magnetic bays at mid-latitudes, and the solar wind driving conditions. Different features at mid-latitudes effects of these four SSS events are discussed.

Analysis of the Midlatitude Positive Bays Registered at the Panagjurishte Station during 2007-2024

Guineva V.[1], Werner R.[1], Raykova L.[1], Bojilova R.[2]
[1]Space Research and Technology Institute, Bulgarian Academy of Sciences, Stara Zagora Department, Bulgaria
[2]National Institute of Geophysics, Geodesy and Geography (NIGGG) - Bulgarian Academy of Sciences, Sofia, Bulgaria

This study presents a statistical analysis of midlatitude positive bays (MPBs) for the period 2007–2024, based on observations from the Bulgarian magnetic station Panagjurishte (PAG). The events are classified according to the maximal value of the X-component (Xmax) during each event. The MPB's are divided into four groups: Xmax ≤10 nT, 10<Xmax ≤20 nT, 20<Xmax ≤30 nT, and Xmax >30 nT, with weak events (Xmax ≤ 10 nT) comprising the largest share at 59.24%.

Distributions of events reveals a relatively stable occurrence rate of weak events over time, along with periods of increased occurrence rate, at the expense of a decrease in the number of events in the interval from 10 nT up to 20 nT, which periods are probably associated with a certain stage in the development of the solar cycle.

The monthly distribution of more intense events (Xmax > 20 nT) shows a pronounced maximum during February and March, with a secondary peak in September and October. This seasonal pattern suggests a potential influence of geophysical factors such as the tilt of the geomagnetic axis and the Russell-McPherron effect.

A strong MPB associated with a substorm on 10.11.2024 is presented as an example. A detailed analysis of the event and the concomitant solar wind conditions and interplanetary magnetic field is performed.

Space Weather Influences on Satellite Anomalies

Kirov B, Georgieva K., Asenovski S.
SRTI - BAS

The operation of space-based assets is increasingly threatened by various forms of space weather, which manifest in the form of satellite anomalies. These anomalies, which can lead to significant disruptions in satellite functionality, are primarily driven by solar phenomena such as Coronal Mass Ejections (CMEs), High-Speed Solar Winds (HSS), and Solar Proton Events (SPEs). This study presents a comprehensive analysis of the mechanisms by which these solar activities influence satellite anomalies, with a focus on the varying impacts across different orbital regimes, including Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Earth Orbit (GEO).

Observations indicate that LEO satellites, due to their proximity to the Earth's magnetosphere and Van Allen radiation belts, are particularly susceptible to Single Event Upsets (SEUs) caused by cosmic rays and trapped energetic ions. Meanwhile, GEO satellites are more prone to disruptions from SPEs and the cumulative effects of solar radiation. The study further examines the roles of deep-dielectric charging and surface charging—both absolute and differential—as significant contributors to satellite anomalies. The results demonstrate that these charging mechanisms can lead to various forms of discharges, including flashover between surfaces, punch-through from the interior to the surface, and discharges to space, each with distinct impacts on satellite subsystems.

Analysis of Drift Measurement in the Ionosphere

Mošna Z., Kouba D., Koucká Knížová P., Potužníková K.
Institute of Atmospheric Physics, Czech Academy of Sciences

We show results of ionospheric plasma drits from the bottom and upper ionosphere, particularly from the E, Es, and F regions. Plasma drifts are typically characterized by three vector components: northward, eastward, and vertical. Understanding all three components is essential for deciphering plasma transport, electron density fluctuations, and coupling between different regions of the ionosphere and thermosphere. We compare results from different ground based methods using Digisonde data. We analyzed plasma drifts computed by Digisonde Drift Measurement (DDM), and several types of indirect ionogram-based methods. We compared periods of high solar (geomagnetic) activity with quiet time. Wave activity appears to be nearly continuous throughout the analyzed intervals. While the results differed according to the methodes used, dominant wave patterns were consistently captured by all techniques, offering a robust multi-method approach for identifying, tracing, and characterizing ionospheric wave phenomena.

On Quasi-Discontinuous Solar Wind Flows

Shergelashvili B. M., Westrich L. Fichtner H.
[1]Centre for Computational Helio Studies at Ilia State University, Georgia;
[2]E Kharadze Georgian National Astrophysical Observatory, Georgia;
[3]Institute of Theoretical Physics, Ruhr-Universsität Bochum, Germany

A new class of one-dimensional solar wind models has been suggested, recently. Within the general polytropic, single-fluid hydrodynamic framework and by considering the particular case of quasi-adiabatic radial expansion the existence of solutions with a discontinuity at the critical point was revealed. After consideration of corresponding analytical solutions exhibiting a continuous Mach number over the entire radial domain their interpretation as a consequence of an implicitly included ideally localized heating source is discussed. By considering explicit heating functions that are varied in space and time the solutions attain a quasi-discontinuous character. We illustrate these new solutions and discuss potential observational evidence.

Examination of Peculiar Rocket-borne Electric Field Profile during Solar Proton Event October 19 1989

Tonev P.
SRTI-BAS

Examined is the atmospheric profile of the vertical electric field Ez which have been obtained by rocket measurements on October 21, 1989 at latitude 58.5S at altitudes between 25 and 70 km (Zadorozhny, Kikhtenko, et al. (1994), J. Geophis. Res., 99, D10, 21,059 - 21,069). The rocket experiment is conducted during strong solar proton event with ground-level enhancement with an onset on October 19, 1989. It also coincides with a major geomagnetic storm with planetary geomagnetic index Kp=8 at the time of the rocket flight (19:31 UT). The measured electric field Ez reaches two extremely big maximums: at 58 km altitude Ez points to downward and exceeds 12 V/m, and at 46 km altitude Ez is directed upwards and is almost 10 V/m. These peculiar results for Ez also mean that the height layer 46-58 km contains negative spatial electric charge, and that the electric conductivity in this layer should be extremely small. These peculiar features can be interpreted in consistency with the peculiar dc atmospheric electric response which has being experimentally observed in middle stratosphere, as well as at surface, during a series of major solar proton events.

Data Proccessing and Modelling

The Analysis of Observations of Ionospheric and Geomagnetic Time Series for Detection of Precursors of Earthquakes

Adibekyan M.
NSSP

The displays of earthquake preparation of Spitak (Armenia, 08.03.2025, M=4.6) and Van (Turkey, 23.10.2011, M=7.3) in time-series have been studied using the geomagnetic and ionosphere tools and aiming atearthquake precursors apportionment.

There were received some results, which are allowing to make out the difference of seismogenic anomalies of ionosphere between the longer anomalies. They are connected to magnetic activity of ionosphere by the method of vertical reconnaissance of ionosphere. For a research of assessment of the current seismic hazard were studied observation geomagnetic fields and vertical sounding of ionospheric time series. Results of the analysis observation have confirmed communication between earthquakes magnitude $M \geq 3.5$ and absorption of a radio-emission of discrete radiation sources radio atmospheric observations and also dependence between and geomagnetic parameters. Lebed - A and Cassiopeia - A (ionospheric station of observation Saravand), geomagnetic station observation of Garni have been used.

Keywords: Earthquake, precursors, ionosphere, time-series, geomagnetic

Applications of Chaos Theory to Astrophysical Time Series: Analysis of Blazar Light Curves from TESS

Bachev R., Strigachev A., Dechev M.
Institute of Astronomy and NAO, Bulgarian Academy of Sciences, 1784 Sofia, BG

Searching for low-dimensional chaos in time series is a rarely used, but very promising approach to reveal the systems' internal dynamics, which drives the observed temporal variability. In this work we use long and intermittent optical intensity time series from TESS satellite to search for signatures of low-dimensional attractors. We present briefly the commonly used for chaos searches Correlation Integral (CI) method and its application. This method is applied not only in astrophysics (including Solar physics), but also in the fields of meteorology, climate, geophysics, medicine, ecology, economy, etc. As an example, we apply the CI method to the TESS light curves of a relativistic jet-dominated active galactic nucleus - the blazar S5 0716+714. Even though our first results are inconclusive, such searches are promising and encouraging.

Dispersive Shocks and the Concept of Whistler Critical Mach Number

Balikhin M.[1], Agapitov O.[2], Krasnoselskikh V.[3], Roytershteyn V.[4], Walker S.[1], Gedalin M.[5], Jebaraj I.Ch.[6], Colomban L.[2]

[1]University of Sheffield, Sheffield, United Kingdom (m.balikhin@sheffield.ac.uk)
[2]Space Sciences Laboratory, University of California, Berkeley, USA
[3]Laboratoire de Physique et Chimie de l'Environnement et de l'Espace, Orléans, France
[4]Space Sciences Institute, Boulder, USA
[5]Ben Gurion University of the Negev, Beer-Sheva, Israel.
[6]University of Turku, Turku, Finland

If the dispersive scale of fast magneto-sonic waves exceeds spatial scales related to processes of anomalous resistivity the steepening of of the nonlinear fast magneto-sonic wave will lead to the formation of dispersive collisionless shock, providing the Mach number is not very high. In such a case for an oblique low Mach number shock an upstream whistler wave precursor will be formed. . Numerical simulations and data obtained by the MMS satellites are used to analyse propagation properties of the upstream whistler precursor for dispersive collisionless shocks. Results obtained show that the concept of the Whistler Critical Mach number should be revisited.

Modulation of the Particle Flux Detected by the Liulin-MO Instrument During Solar Proton Events Caused by the Orbital Motion of the Exomars TGO Spacecraft Around Mars

Benghin V.[1], Drobyshev S.[1], Semkova J.[2], Koleva R.[2], Dachev Ts.[2], Shurshakov V.[1], Krastev K.[2], Matviichuk Y.[2], Tomov B.[2], Bankov N.[2], Maltchev St.[2], Mitrofanov I.[3], Golovin D.[3], Mokrousov M.[3], Litvak M.[3], Lukyanov N.[3]

[1]State Scientific Center of Russian Federation, Institute of Biomedical Problems, Russian Academy of Sciences, Moscow, Russia
[2]Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria,
[3]Space Research Institute, Russian Academy of Sciences, Moscow, Russia

During the increase and maximum phases of the 25th solar cycle, a number of solar proton events (SPE) were observed, some of which were measured by the Liulin-MO instrument onboard the ExoMars Trace Gas Orbiter (TGO) in orbit around Mars. Liulin-MO is a module of FREND instrument on TGO. The results have been published in a series of presentations and articles. In this presentation, we will focus on the effect of the modulation of the flux measured by Liulin-MO, which we consider to be due to the orbital motion of the TGO spacecraft.

Rather strong increases in particle fluxes during the SPE on October 28, 2021, February 15, 2022, and May 20, 2024 were considered. Variations in the solar cosmic ray flux were compared with the relative position of Mars, the TGO spacecraft, and the direction of the force line of the interplanetary magnetic field (IMP). Shown is that the flux decreases when the calculated direction of the IMP force line from the Sun is shaded by Mars or by sufficiently thick structural elements of the FREND device and the TGO spacecraft. A possible explanation for the observed effect may be that the distribution of particle arrivals during a SPE is not isotropic in the vicinity of Mars, and the flux of particles coming from directions close to the direction of the IMP field line is noticeably higher than the average level.

The Atmosphere and Radiation: Screening or Generating?

Chilingarian A.
Yerevan Physics Institute

It is commonly understood that the atmosphere protects the Earth from harmful radiation. However, the atmosphere not only absorbs the vast energy of galactic and solar cosmic rays but also serves as a particle generator, producing vast fluxes of electrons, gamma rays, and neutrons. These particles are generated through several mechanisms, including relativistic runaway electron avalanches (RREAs), which manifest as thunderstorm ground enhancements (TGEs) when detected on the Earth's surface and gamma glows if detected above violent tropical thunderstorms. The Global Electric Circuit (GEC) governs enhanced particle fluxes of atmospheric origin. Thunderstorms create strong electric fields that extend across large areas within and around storm systems. Charge separation in thunderclouds, driven by updrafts of warm air and interactions among hydrometeors, generates oppositely directed dipoles within the cloud. The atmospheric electric field comprises upper and lower dipoles, accelerating free electrons toward both open space and the Earth's surface. Free electrons are abundant in the troposphere from extensive air showers (EASs). Electric fields induced by strong thunderstorms transfer energy to these electrons, accelerating them and, under specific conditions, forming electron-photon avalanches. These avalanches propagate through large atmospheric volumes and extend across extensive areas upon reaching the Earth's surface, significantly increasing the intensity of natural gamma radiation (NGR). These enhancements can last from seconds to tens of minutes.

The ionized channels created by these avalanches provide pathways for lightning leaders to propagate toward the ground. New observations on Aragats have revealed a previously overlooked intense gamma-ray source in high-altitude and polar environments. This novel wind-driven radiation mechanism differs from relativistic runaway electron avalanches and conventional radon progeny radiation models. Strong winds and dry, electrified snow concentrate gamma rays into a dense radioactive cloud that persists for many hours, enhancing NGR levels by more than 1000%. Total fluence can reach 2×10^7 gammas/cm² and beyond. Understanding these newly observed phenomena is essential for atmospheric physics, space weather studies, and environmental monitoring. This highlights the necessity for focused research into the interactions among snowstorms, radon transport, and atmospheric electricity.

The Geomagnetic Field as Both a Tool and a Hazard in Romania

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

Geomagnetic measurements from secular variation networks, in addition to those from the observatories, contribute on one hand to the knowledge of the temporal and spatial variation of the magnetic field, and on the other hand they have a practical purpose such as navigation, geomagnetic mapping for mineral exploration and space weather. The Earth`s magnetic field can, therefore, be regarded as both a valuable tool for navigation and a hazard for space weather. In this study, on one side, based on accurate systematic survey of the geomagnetic field at the National Secular Variation Network, consisting of 26 repeat stations almost evenly distributed over Romanian territory, isogonic charts and values of the magnetic declination for various epochs and locations have been provided for aeronautical safety and for certifying magnetic orientation of the airports runways, proving the relevance of geomagnetic field as a tool for aeronautics. On the other side, the variable magnetic field of geomagnetic storms have been used to reveal the surface electric field over Romania, the geophysical input in assessing ground space weather impact of geomagnetically induced currents, evidencing the hazardous image of geomagnetic field.

Study of Solar Differential Rotation Cyclic Variations Based on the Hα Filament Data

Japaridze D.[1,2], Mdzinarishvili T.[1], Chargeishvili B.[1]
[1]Evgeni Kharadze Georgian National Astrophysical Observatory;
[2]Center for Computational Helio Studies, Ilia State University, Georgia

The solar differential rotation changes with solar cycles were studied using Hα filaments based on data from the Abastumani Astrophysical Observatory. We considered discrete orthogonal polynomials for differential rotation regression models up to degree 4. When performing regression analysis, we applied the Akaike information criterion. Regression analysis of the Hα data indicated that the best fit for polynomial models of the solar differential rotation is achieved with discrete orthogonal polynomials of degree 2. The equatorial values of the rotation rates remained almost constant from 1957–1993, while the average rotation rate, called "rigid body rotation", decelerated from 1957–1993. In the solar differential rotation, the spatio-temporal distribution pattern of rotation rates hints at a 22-year periodicity.

Solar Proton Events Recorded by the Lyulin Instrument - Composition Analysis Using Numerical Modeling

Krastev Kr.[1], Semkova J.[1], Koleva R.[1], Benghin V.[2], Drobiyshev S.[2]
[1]SRTI-BAS,
[2]IMBP-RAS

In recent years, the LIULIN instrument has recorded many solar proton events that are associated with increased solar activity. This paper examines several of the most significant of these events. Based on numerical modeling, the composition of both the energies and the types of solar particle flux was determined. The estimates were made based on a numerical model running under GEANT4 and simulating the operation of the LIULIN device for detecting ionizing radiation.

Solar Influences on Aluminium Alloys: a Review

Miteva A.[1], Dimitrova M.[1], Hodjaoglu G.[2], Bouzekova-Penkova A.[1]
[1]Space Research and Technology Institute, Bulgarian Academy of Sciences
[2]Institute of Physical Chemistry, Bulgarian Academy of Sciences

This review systematically explores the diverse impacts of solar radiation on aluminium alloys, emphasizing the relevance of these effects across aerospace, automotive, solar energy, and marine applications. Aluminium alloys, valued for their strength-to-weight ratio and corrosion resistance, experience distinct degradation phenomena when subjected to prolonged solar exposure. The paper synthesizes current research on how ultraviolet radiation, solar thermal cycling, and associated environmental factors accelerate corrosion, alter mechanical properties, and impact surface integrity. Special attention is devoted to aerospace alloys (2xxx, 6xxx, and 7xxx series), critically evaluating the relationship between solar activity cycles and the alloys' fatigue resistance, structural durability, and corrosion behavior. Strategies for mitigation, including surface coatings, anodization, and novel alloy formulations designed for improved resistance under variable solar conditions, are discussed. Finally, the review identifies gaps in existing knowledge, suggesting areas for further research, particularly the need for predictive modeling to optimize alloy performance and extend service life in solar-intensive environments.

Accuracy Analysis of the Analytical Approximation Model for Electrons Resonant Acceleration in Space Plasma

Shkevov R.[1], Zolnikova N.N.[2,3], Mikhailovskaya L.A.[2]
[1]Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria
[2]Space Research Institute, Russian Academy of Sciences, Moscow, Russia
[3]Russian University of Transport, Moscow, Russia"

An electrons resonant acceleration analytical model is investigated. The model describes the process of the strong particle acceleration by the electromagnetic waves packet propagating across the weak constant magnet field in space plasmas by an analytical formula. The particle strong accelerations is carried out under strict compliance with the conditions for Cherenkov resonance. Based on the exact solutions of the second order nonlinear nonstationary differential equation for the wave phase on the charged particle trajectory the initial numerical results are obtained. At the same initial conditions, the calculations using the analytical model are also made. Compeering the numerical results, the accuracy of the analytical model was accessed. The results of the model accuracy are presented in graphical forms. Conclusions on the analytical model applicability in studies of charged particles resonant acceleration in space plasma are drawn.

Empirical Models for Assessing CMEs Potential Geoeffectiveness

Shlyk N., Belov A., Abunina M.
IZMIRAN

The behavior of various parameters of interplanetary CMEs (velocity, propagation time, subsequent disturbances of the geomagnetic field, proton flux values, etc.) is studied depending on the characteristics of the solar source (heliolongitude and class of the associated flare, initial CME velocity and background solar wind velocity). Based on a large statistical material covering 1995-2023, average values and regression dependences of various parameters are obtained. In particular, empirical models have been developed and described that allow to estimate the transit and maximum speeds of the corresponding interplanetary disturbance, the time of its arrival to the Earth's orbit, and the expected level of geomagnetic activity. In addition, the probabilities of registering increases in the flux of protons with various energies near the Earth have been estimated, and the expected levels of such enhancements have been calculated. The described models are successfully used in the daily work of the IZMIRAN Space Weather Prediction Center.

Updates from the LOFAR Station at the Irbene Radio Observatory

Šteinbergs J.
VIRAC

LOFAR in the Irbene observatory has been operational since 2019. LOFAR allows a wide range of scientific studies, from Earth's atmosphere to extragalactic astronomy. VIRAC LOFAR team is part of multiple collaboration projects and studies a variety of science topics. In my presentation, I will show updates from the LOFAR station at the Irbene radio observatory. In my presentation, I will show results from Pulsar studies, Solar observation, space weather, and more.

Basic Statistical Properties of the 10-year Ozone Daily Time Series from Stara Zagora

Werner R.[1], Petkov B.[2], Guineva V.[1], Valev D.[1], Raykova L.[1], Bojilova R.[3], Kirillov A.S.[4]
[1]Space Research and Technology Institute, Bulgarian Academy of Sciences, Stara Zagora Department, Stara Zagora, Bulgaria
[2]Institute of Polar Sciences, National Research Council, Bologna, Italy
[3]National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Sofia, Bulgaria
[4]Polar Geophysical Institute of the Kola Science Centre, Apatity, Russia

Total ozone time series on daily and monthly basis at mid-latitudes show a clear annual cycle caused by the formation of ozone on one hand and dynamic processes on the other hand. To investigate some of the important statistic parameters, the ozone series was detrended and deseasonalised. After that we have determined the central moments of the series. The distributions were analysed by means of histograms and Q-Q plots for different seasons. We have divided the series in two groups of time intervals – with high and low ozone variations. The group with high variation is from December to March (DJFM) and the one with lower variation includes the months from May to October (MJJAASO) showing standard deviations of 36 DU and 19 DU, respectively. The reason of the high ozone variation is the frequent change between air masses of polar origin and those of mid-latitudes and tropical origin. The constructed Q-Q plots demonstrate that the distributions for the two groups are close to the normal one. At short time scales of some days the ozone residuals can be describe by an AR (1). Long term persistences were studied by detrended fluctuation analysis. A Hurst coefficient of 0.7 to 0.75 at the scales of one week to about 2-3 weeks, and a Hurst coefficient of approximately 1 for greater scales up to about three months was found. This means, that the variations at these scales are similar to themselves independently from the location or in other words the ozone variations show fractal properties.

Inhomogeneous Plasma Enlightenment on the Base of Exactly Solvable Model

Zolnikova N.N.[1,2], *Shkevov R.*[3], *Mikhailovskaya L.A.*[1]
[1]Space Research Institute, Russian Academy of Sciences, Moscow, Russia
[2]Russian University of Transport, Moscow, Russia
[3]Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria"

Using exact solutions of one-dimensional Helmholtz equation, we study reflectionless transmission of electromagnetic waves through a wide periodically inhomogeneous plasma layer containing subwavelength structures. Applying numerical calculations we demonstrate that in an inhomogeneous plasma layer the wave amplitude profile may have a solitons-like structure. A large modulation of the wave amplitude and the wave vector was observed for relatively small variations of the local permittivity of the plasma. We show that small variations of the initial parameters of the problem may result is serious change of the profile of plasma inhomogeneity in the layer. Nevertheless, the full enlightenment of the gradient barriers is preserved. We discuss the possible profiles of the normalized amplitude of the electromagnetic wave, the effective plasma permittivity and the dimensionless wave number.

Instrumentation for Space Weather Monitoring

Low-Cost GNSS Receiver Observations for Space Weather Monitoring: Performance During a Geomagnetic Storms

Chougule S., Chougule P., Shetti D.
Smt. Kasturbai Walchand College of Arts and Science, Sangli, India

This study presents new results of ionospheric Total Electron Content (TEC) measurements obtained from a newly installed low-cost multi-frequency Global Navigation Satellite System (GNSS) SWIFT receiver at Sangli, India (Geographic: 16.52°N, 74.34°E). The findings highlight a strong correlation between TEC values from the low-cost receiver and a nearby commercial GNSS receiver, with correlation coefficients consistently exceeding 0.9 during the geomagnetic storms in April and November 2023. Additionally, significant agreement is observed between 5-minute ROTI values from both receivers, validating the low-cost receiver's reliability for TEC research in the Indian low-latitude region. The TEC values from the low-cost receiver are also compared with predictions from the IRI-20 and NeQuick ionospheric models, showing good agreement. The study examines the impacts of the geomagnetic storms on the ionosphere, with distinct differences between the April and November storms due to their occurrence at different local times. The April storm shows negative storm effects during the night and early morning, whereas the November storm is characterized by positive effects during the initial and recovery phases. These storm effects are aligned with previous studies, supporting the validity of our findings. These results suggest that the low-cost receiver is a reliable tool for TEC studies under geomagnetic storm conditions, indicating its potential for long-term space weather monitoring in the region.

Key Words: Low Cost GNSS, Geomagnetic storm, Total Electron Content (TEC), Rate of TEC Index (ROTI)

Space Radiation Measurements During a Round Trip from Varna, Bulgaria to Bulgarian Antarctic Base on Livingston Island

Dachev T.[1], Sapundjiev P.[2], Tomov B.[1], Matviichuk Y.[1], Mitev M.[1], Jordanova M.[1]
[1]SRTI-BAS;
[2]NIGGG-BAS

The spectrometer-dosimeter Liulin-AA performed radiation measurements during a round trip on board of the Bulgarian scientific research ship "St. St. Cyril and Methodius" from Varna, Bulgaria, to the Bulgarian Antarctic Base on Livingston Island. Different radiation and environment conditions were identified. The trip started with few days measurements in the Black Sea with an average dose rates of 0.0562 micro Gy/h, continued with recording of descending dose rates towards the magnetic equator while crossings in Atlantic Ocean and ended at the Bulgarian Antarctic Base on Livingston Island. Close to the magnetic equator, the averaged dose is 0.0494 micro Gy/h. This is the smallest dose observed by Liulin-AA during the registrations performed in the Arctic and Antarctic regions in 2024 and 2025. The average detected doses on Livingston Island were considerably higher and reached 0.0806-micro Gy/h. They were measured during snowmobiles trips between 15 January and 2 February 2025. The radiation doses measured on the way back from Livingstone Island to Varna were similar to those, already observed, during the first half of the round trip.

Effects of Geomagnetic Storms on the Mid-Latitude D-Region Ionosphere

Mustafa F.R.[1,2], Bayramova E.V.[1], Dzalilov N.S.[1]
[1]Shamakhy Astrophysical Observatory named after N. Tusi, Ministry of Science and Education of the Republic of Azerbaijan;
[2]Khazar University

The response of D Layer Preparation Time (DLPT) depth to geomagnetic storms during 2008-2011 is studied to investigate the effect of geomagnetic storms on the D layer of the Ionosphere. The Very Low Frequency (VLF) signal at 19.6 kHz transmitted from the GBZ transmitter station Anthorn, UK (54ºN, 3ºW) and recorded by the AWESOME receiver at the Shamakhy Astrophysical Observatory named after N.Tusi, Shamakhy, Azerbaijan (40ºN, 48ºE) is used for analysis. 5 geomagnetically disturbed days (Ap>26) are studied. A decrease in DLPT depth is observed for the storm day on October 11, 2008, while an increase is observed for all other storms.

Type II Burst Band Split and Their Space Weather Implication

Pulatov D., Mirtoshev Z.
Institute of Engineering Physics, Samarkand state university

Studying the relationship between solar radio bursts and CMEs is essential to understanding the origin of type II bursts.In this study, we examine a type II solar radio burst recorded by the CALLISTO radio spectrometer on December 25, 2024, and compare its characteristics with the kinematics of related CMEs observed by the STEREO and SOHO spacecraft.Type II burst showed good band split for estimating the magnetic field strength in the solar corona.Depending on the corona electron density model used, the magnetic field decreased with increasing distance.We found that two consecutive CMEs occurred within a 48-minute interval.Tracking of the shock that produced type II burst and comparison with the CMEs heights as observed by STEREO and SOHO spacecraft help us to deduce the driver of the shock.According to the analyses, it is unclear whether the emergence of the type II burst is due to the interaction of the shock driven by the second CME with the streamer located by the first CME, as the type II band splitting changed little during the shock-streamer interaction.Our results show that type II burst band splitting, as detected by coronal coronagraphic observations, is an important tool for understanding coronal burst processes and their impact on space weather.

Studies of Ionospheric Response to the Intense May 2024 Geomagnetic Storm Using NavIC Observations

Shetti D., Chougule S., Chougule P.
Smt. Kasturbai Walchand College of Arts and Science, Sangli, India

In May 2024, a severe geomagnetic storm, the most intense since 2003, affected Earth. This storm was caused by sunspot region AR13664, which generated multiple X-class flares and coronal mass ejections (CMEs). Our study focuses on the ionospheric response to this event at a low-latitude station in Sangli, India, using data from the Indian Regional Navigation Satellite System (IRNSS/NavIC) during the storm period from May 9 to May 14, 2024. By analysing Total Electron Content (TEC) variations, S4 and Rate of TEC Index (ROTI), we discovered significant TEC enhancements closely associated with solar flare activity. The most pronounced TEC increases after around 20 min followed by X5.8-class solar flare. Although no immediate ROTI and S4 activity were detected on May 10 and 11, significant peaks were noted on May 12 and 13, possibly linked to the storm's residual effects and plasmabubbles with small irregularities. These findings emphasize the critical role of IRNSS/NavIC in monitoring and understanding the complex interactions between solar activity, geomagnetic disturbances, and ionospheric dynamics in equatorial and low-latitude regions. Our study underscores the importance of IRNSS/NavIC data for enhancing space weather monitoring and mitigating the impacts of geomagnetic storms on navigation systems in the Indian region.

Key Words: NaviC, Geomagnetic storm, Total Electron Content (TEC), Rate of TEC Index (ROTI), Solar flares

Usage of the Solar Energy for the Solar Radio Observations with Mobile Antenna Array

Shevchuk M., Bubnov I., Dorovskyy V., Ulyanov O., Stanislavsky L., Zakharenko V., Konovalenko A., Stanislavsky A., Reznichenko A., Selin V., Belov A., Yerin S., Tokarsky P., Shevchenko V.
Institute of Radio Astronomy

The first results of registration of the various solar radio bursts with broadband (meter-decameter range) compact mobile quickly-deployable antenna array which can operate autonomously in field conditions, i.e. away of stationary alternating-current power network, being powered only by solar energy are presented in the report. The main characteristics of the antenna and the solar power station are also given.

Electromagnetic Fields Near the Magnetopause Based on Satellite Data

Teodosiev D., Bouzekova-Penkova A., Miteva A.
SRTI-BAS

To investigate energy transfer processes within the coupled solar wind magnetosphere, ionosphere, atmosphere system, spherical sensors with glassy carbon coatings are employed as part of the scientific instrumentation onboard satellites. This study presents and analyzes electromagnetic field measurements during magnetopause crossings obtained from the satellite pair Magion-4 and Interball-Auroral. Observations of ultra-low-frequency (ULF) electromagnetic fields in the range of 0.1 Hz to 30 Hz clearly reveal low-frequency instabilities below the ion cyclotron frequency. These instabilities are associated with the scale of plasma inhomogeneities in the observed regions of the magnetosphere. In the case of inhomogeneous plasma, such variations are particularly important for ion acceleration under cyclotron resonance conditions.

Solar Influences on the Lower Atmosphere and Climate

The Solar Activity Forcing on Hydroclimate in the Southeastern Europe

Dobrica V., Mares I., Mares C., Demetrescu C.
Institute of Geodynamics, Romanian Academy

A review of our studies regarding the influence of solar activity on hydroclimate parameters from Southeastern Europe is presented. By using the statistical approaches, the solar variability, described by various indices such as sunspot number, solar radio flux, aa geomagnetic index, was shown to have an influence, at various timescales, on several climatic parameters, such as the North Atlantic Oscillation, the Greenland-Balkan Oscillation, the precipitation at certain stations in the Danube basin and the Danube discharge at Orsova, a representative gauge for the Lower Danube basin. The wavelet total coherence and global coherence applied on the time series of annual and seasonal averages, showed the different results depending on the climate variable on which the solar influence was tested. The type of the correlations, linear/non-linear, was also tested, using elements from information theory, revealing the non-linear links between the solar and climate variables. It should be mentioned that the analysis on seasonal averages brought significant information in addition to the analysis for annual averages.

Sporadic E Variability during Low Geomagnetic Activity

Koucká Knížová P.[1], Arras C.[2,3], Podolská K.[1], Burešová D.[1], Potužníková K.[1], Bárta V.[4], Szarnya C.[4], Mackovjak Š.[5], Chum J.[1], Urbář J.[1], Hannawald P.[6], Schmidt C.[6], Kuechelbacher L.[6], Mosna Z.[1], Kouba D.[1], Truhlik V.[1]
[1]Institute of Atmospheric Physics, Czech Academy of Sciences, Prague, Czech Republic;
[2]Fachgebiet:GNSS Fernerkundung, Technische Universität Berlin;
[3]GFZ Potsdam;
[4]HUN-REN Institute of Earth Physics and Space Science, Sopron, Hungary;
[5]Institute of Experimental Physics, Slovak Academy of Sciences;
[6]German Aerospace Center, German Remote Sensing Data Center, Weßling, Germany

Ionosphere shows variability in a wide range of scales. Being formed by both neutral and ionized particles it responds to the both forcing from above (solar and magnetospheric activity) and from below to the processes in the entire lower laying atmosphere. It represents transition region between neutral atmosphere below and fully charged plasmasphere above. Especially in the ionospheric E region collisions of ions and neutrals plays an important role. Due to collisions ionized particles do not strictly move along the magnetic field lines. It brings an important component of motion across magnetic field. It eventually leads in favorable conditions to the convergence into the thin layers known as sporadic E (Es). During geomagnetically quiet periods the effects of lower atmosphere forcing are better pronounced and can be studied in detail. In the study we focus on the Es layer variability during summer season under low geomagnetic and stable solar forcing. In particular, we analyze the layer occurrence, its stratification and layer type. We involve in the study data from European sector.

Integration of a New Meteorological Station at the National Astronomical Observatory: Infrastructure for Neutron Monitoring

Petrov N., Tsvetkov Ts.
Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences

We present the establishment and initial operation of a newly constructed meteorological station at the National Astronomical Observatory, developed within the framework of a broader scientific initiative dedicated to neutron monitoring. The station provides continuous, high-resolution atmospheric data—temperature, pressure, humidity, wind speed and direction, and precipitation—which are critical for the interpretation and analysis of cosmic ray and neutron flux variations. This integration of meteorological and neutron data allows for more accurate corrections of atmospheric influences on neutron measurements, improving the precision of long-term monitoring and event-based studies. The development of the station involved the deployment of robust, automated sensors optimized for the observatory's high-altitude and remote conditions. Initial results demonstrate the station's reliability and the added value of synchronized atmospheric data in supporting the goals of the neutron monitoring project. This effort represents a significant step toward a comprehensive environmental and cosmic radiation monitoring system in the region.

Observation of GW in Connection with Severe Tropospheric Events

Potužníková K., Koucká Knížová P.
IAP CAS

Our contribution focuses on the mechanisms of atmospheric gravity waves (GW) associated with severe meteorological events in Central Europe region. Specifically, we investigate GWs generated by atmospheric jet-front systems and by convective systems (severe thunderstorms) associated with destructive windstorms that are not directly linked to atmosphere front passage, so-called weak-forcing derechos. These intense convective systems are characterized by strong updrafts penetrating several kilometers into the stratosphere and surface wind gusts that are extreme in both intensity and spatial extent.

In the presentation, we will complement nowaday knowledge of GW formation mechanisms and their characteristics with our satellite and ground-based observations.

Our goal is to contribute to a better understanding of how various severe meteorological phenomena influence gravity wave activity, and how this activity affects the dynamics of the middle and potentially upper atmosphere, including the ionosphere.

This research is supported by the Johannes Amos Comenius Programme (P JAC), project No. CZ.02.01.01/00/22_008/0004605, Natural and anthropogenic georisks, by the GA ČR GA24-14158L, and also by the ESA project HORIZON 2020, PITHIA-NRF 101007599.

Ionospheric Response to Gravity Waves Induced by Tropospheric Convection in Mid-Latitudes

Potužníková K., Koucká Knížová P., Mošna Z., Chum J., Kouba D., Podolská K., Obrazová D.
IAP CAS

Our case study investigates coincidental occurrence of intense tropospheric convection and upper atmospheric variability, focusing on gravity wave (GW) generation in the tropospheric height and its possible effects on the ionospheric layers E, sporadic E (Es), and F2. Our analysis present: several extreme convective storm events that occurred over Central Europe under tropical air mass conditions, not directly linked to the passage of a cold front. Two primary classifications of convective systems are considered: (1) rapidly propagating supercell thunderstorms characterized by strong, rotating updrafts and relatively short lifetimes; and (2) long-lived linear mesoscale convective systems (squall lines) connected to derecho windstorms. The latter are distinguished by their broad horizontal extent, long lifetimes of several hours and storm trajectories exceeding 400 km. Based on satellites data, meteorological radar data, and ionospheric radar and Doppler sounding techniques, we demonstrate that such types of severe weather events act as effective sources of gravity waves capable of propagating into the middle and eventually up to the upper atmosphere. Further we investigate GW induced effects in the E, Es, and F2 regions. Results contribute and enlarge our investigation of connection between the intense activity of the lower atmosphere and the dynamics of the upper atmosphere in mid-latitudes.

This research was supported by the Johannes Amos Comenius Programme (OP JAC), project No. CZ.02.01.01/00/22_008/0004605, Natural and anthropogenic georisks, by the GA ČR GA24-14158L, and also by the ESA project HORIZON 2020, PITHIA-NRF 101007599.

Study of Peculiar Multiphase Pattern of Atmospheric Electric Response to SEP

Tonev P.
SRTI BAS

Studied are variations of the main dc atmospheric electric characteristics (conductivity; vertical electric field *Ez* and current *Jz*) at high latitudes which have been experimentally obtained during strong solar proton events (SPE). Some experimental cases concern balloon measurements in the middle stratosphere; the rest ones represent measurements at surface. In each case variations of the electric current *Jz* have two main peculiar phases. On the earlier phase *Jz* is downward, but unusually big. This *Jz* variation is not transient - it continues longer than the relaxation time of electric charges in the global electric circuit (GEC). On the later phase the electric current *Jz* either is downward but too small, or is upward. Again, the variation is not transient. In general, more than two peculiar phases can present. This pattern of *Jz* variations is explained here by accumulation and dynamics of spatial electric charge in the middle atmosphere during SPE as result of the following factors acting at high latitudes with the progress of SPE: 1. Injection of unsatisfied and unbalanced positive charge in GEC by penetration of energetic protons. 2. Dramatic increase of the density of charged aerosol particles leading to strong conductivity modifications. 3. Specific sensitivity of the modified conductivity to variations in energetic proton flux. Supporting estimations are presented.

Hale Magnetic Cycle on the Sun: Manifestations in Geophysical Characteristics and Possible Influence of the Earth's Climate

Veretenenko S.[1], *Dmitriev P.*[1], *Obridko V.*[2]
[1]Ioffe Institute, Russian Academy of Siences,
[2]IZMIRAN

Oscillations with periods of about 22 years close to the Hale magnetic cycle on the Sun are observed in a large number of climatic characteristics and the amplitudes of these oscillations often exceed those of 11-year ones. In this work we study the manifestations of the solar Hale cycle in different geophysical characteristics, which can contribute to the formation of bidecadal oscillations in the Earth's climate. It was found that temporal variations of cosmic ray fluxes in the stratosphere, as well as geoeffective parameters of solar wind and characteristics of geomagnetic activity (aa-index, occurrence of magnetic storms with gradual commencement) differ significantly in even and odd solar cycles. The results obtained suggest that the solar Hale cycle contributes to bidecadal variations in the fluxes of energetic charged particles (cosmic rays and auroral electrons) affecting the ionization rate in the atmosphere of high latitudes. In turn, changes in the ionization rate affect the chemical composition and temperature regime of the high-latitudinal atmosphere, which can lead to changes of the atmospheric circulation and climate characteristics.

Research Unit for Solar Activity Monitoring, Climate Change and Light Pollution

Simić Z., Samurović S., Damljanović G., Živanović I.
Astronomical Observatory, Belgrade

In September 2023, a special Research Unit (RU) for Solar activity monitoring, climate change and light pollution was formed at the Astronomical Observatory of Belgrade. Here, we would like to present the efforts of our team gathered around the following three important tasks that are our guidelines in future research:

1. For monitoring the Sun's activity, data from available satellites are important, as is a joint project of bilateral cooperation between the Serbian Academy of Sciences and Arts and the Bulgarian Academy of Sciences.
2. Climate change affects the physical environment and therefore poses a fundamental threat to human health. If these changes are frequent and intense, storms, extreme heat, droughts or, on the other hand, floods, erosion and loss of fertile arable land appear. Which obviously puts all life, including its inhabitants, at risk.
3. Study of light pollution, one of the least understood forms of pollution on Earth using various observational instruments mounted at the Astronomical Observatory and Astronomical Station Vidojevica using standard astronomical techniques. Started in January 2024, with three-year duration, this research was supported by the Science Fund of the Republic of Serbia (grant no. 6775, Urban Observatory of Belgrade – UrbObsBel).

Solar Effects in the Biosphere and Lithosphere

Study of the Relationship between Solar Radiation and the Level of Geological Hazard

Jelev G.
Space Research and Technology Institute, Bulgarian academy of Sciences

The amount of solar radiation (WH/m^2) is an important element in considering all processes on the Earth's surface. The study of the distribution of solar radiation allows mapping and analyzing the effects of the sun and sunlight on a given geographical area for a certain period of time. The modeling of solar radiation is based on the digital elevation model (DEM). It depends on many factors, such as the influence of the atmosphere, latitude and altitude, steepness (slope) and direction of inclination (exposure) of the slope, daily and seasonal changes in the angle of the sun, etc. Mapping the spatial distribution of the amount of solar radiation is useful in a number of fields, such as agriculture, resource management, meteorology, civil engineering, environmental studies, tourism, etc.

This study examines the relationship between the amount of solar radiation, its spatial distribution and geological hazard. The study was conducted on the coastal zone of the Republic of Bulgaria. Bulgaria with a width of 20 km, as an important section of the country's critical infrastructure. A connection has been established between the amount of solar radiation, the relief and the areas with increased geological hazard.