STP ACTIVITIES IN SLOVAKIA 2015 - 2018

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Research activities in the field of Solar Terrestrial Physics in Slovakia during the period of 2015-2018 were mainly performed in the Slovak Central Observatory, the Slovak Academy of Sciences (SAS) and the Faculty of Mathematics, Physics and Informatics of the Comenius University:

(1) Slovak Central Observatory – Research and Observational Department (**SCO ROD**), Hurbanovo http://www.suh.sk
(2) Astronomical Institute of SAS (**AISAS**), Tatranská Lomnica http://www.ta3.sk
(3) Institute of Experimental Physics of SAS (**IEPSAS**), Košice http://www.saske.sk
(4) Earth Science Institute of SAS (**ESISAS**), Bratislava http://gpi.savba.sk
(5) Geomagnetic Observatory, Earth Science Institute of SAS (**GO ESISAS**), Hurbanovo http://www.geomag.sk
(6) Department of Astronomy, Physics of the Earth and Meteorology Faculty of Mathematics, Physics and Informatics, Comenius University (**DAPEMCU**), Bratislava http://www.fmph.uniba.sk

1. STP ACTIVITIES IN SLOVAK CENTRAL OBSERVATORY (SCO ROD)

The main topics of the STP research carried out at SCO-ROD are as follows: solar cycle variations, space weather effects, differential rotation of the solar corona, MHD oscillations in the solar photosphere.

I. Dorotovič (SCO-ROD) is since 2014 a Science Discipline Representative (SDR) to SCOSTEP in his respective scientific area of expertise – solar physics and space weather.

Ground-Based Observations

Regular observations of sunspots, H-alpha prominences using a Lyot coronagraph, solar spectrum using a horizontal spectrograph, solar radio radiation using a CALLISTO radiospectrometer (www.e-callisto.org) were performed at Hurbanovo. Sudden Ionospheric Disturbances (SID) monitoring was accomplished at frequencies 20.9 kHz and 27 kHz. This is an indirect registration of chromospheric flares.

Online data

Scan of daily drawings, H-alpha prominence images, Wolf sunspot number are published regularly at the webpage of the SCO: http://www.suh.sk/obs/aktivita/activity.htm. More, SID monitor and CALLISTO plots, data on modified coronal index (MCI) of solar activity and modified homogeneous data set (MHDS) of coronal intensities are published at the webpage, too (http://www.suh.sk/online-data/modifikovany-koronalny-index and http://www.suh.sk/online-data/modifikovany-homogenny-rad, respectively). MCI is calculated from the measurements of the TIMED (Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics) satellite. Two of four instruments of the satellite measure EUV radiation in the same spectral range as CELIAS/SOHO. These instruments measure the solar radiative power in the range of wavelengths 27 – 34 nm. MHDS is calculated from the images taken by the SOHO/EIT (Extreme-ultraviolet Imaging Telescope) at 28.4 nm.

International Meetings

Coimbra Solar Physics Meeting (CSPM-2015) „Ground-based Solar Observations in the Space Instrumentation Era", 5 – 9 October 2015, University of Coimbra, Portugal. This CSPM-2015 scientific meeting (http://www.mat.uc.pt/~cspm2015/overview.html) covered various aspects of solar dynamic and magnetic phenomena which are observed over the entire electromagnetic spectrum: white-light, Hα, Ca II, and radio from ground and in a variety of other wavelengths (white light, UV and EUV, and X-rays) from space. SCO-ROD co-organized the conference jointly with the Geophysical and Astronomical Observatory of the University of Coimbra. Total of 92 participants participated in the CSPM-2015. This events served also as an experts meeting on capacity building of young researchers.

National Meetings in Slovakia

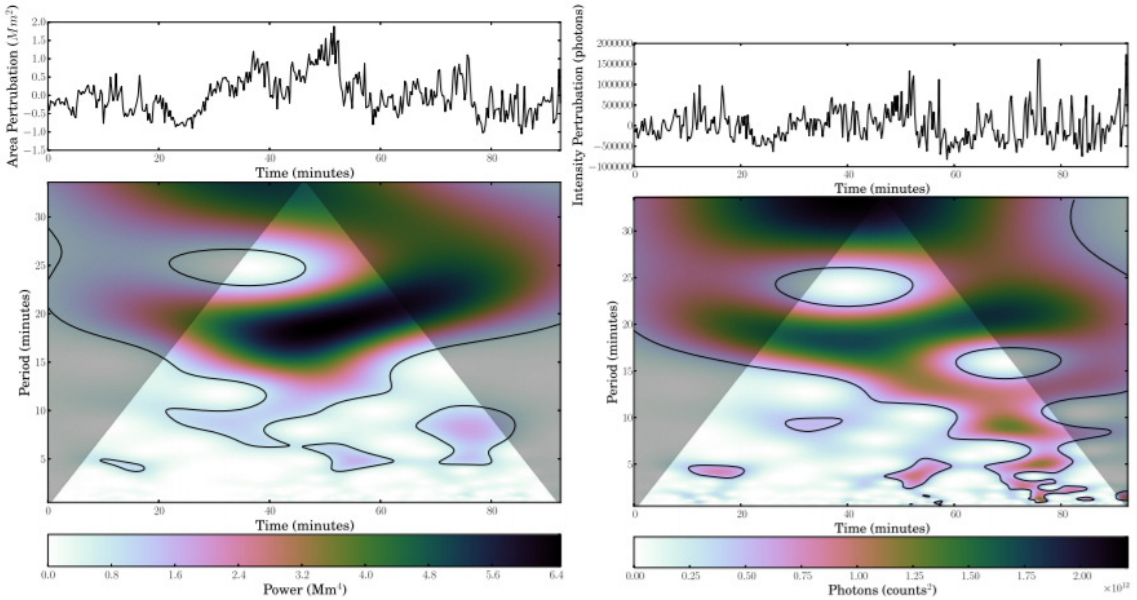
23rd National Solar Physics Meeting, Liptovský Mikuláš 2016, May 30 - June 3, 2016 was organized by the SCO-ROD with an aim to present the results of research work on solar physics, geophysics and space weather. Total of 51 participants from Slovak Republic, Czech Republic, Belgium, Columbia, Germany, Poland and Ukraine.

24th National Solar Physics Meeting, Kežmarok 2018, May 21 - 25, 2018 was organized by the SCO-ROD with an aim to present the results of research work on solar physics, geophysics, space weather, and meteorology. Total of 56 participants from Slovak Republic, Austria, Czech Republic, Germany, Russia, Portugal, USA, and Ukraine.
Both these events served also as experts meetings on capacity building of young researchers.

Results of scientific investigations

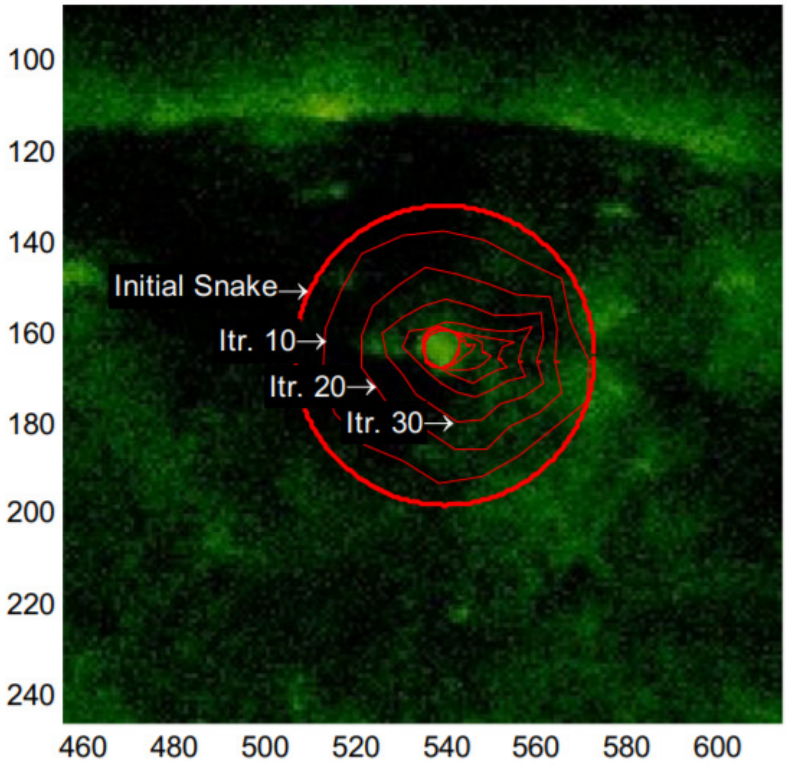
Solar Physics

- Phase relations between the area and intensity of two magnetic pores in order to identify the wave mode of the observed oscillations was studied Freij et al. (2016). This information, combined with the methods of solar magneto-seismology, allows us to determine several key properties of these oscillations and of the magnetic structures themselves. Combining wavelet analysis and empirical mode decomposition (EMD), we determined characteristic periods within the cross-sectional (i.e., area) and intensity time series.



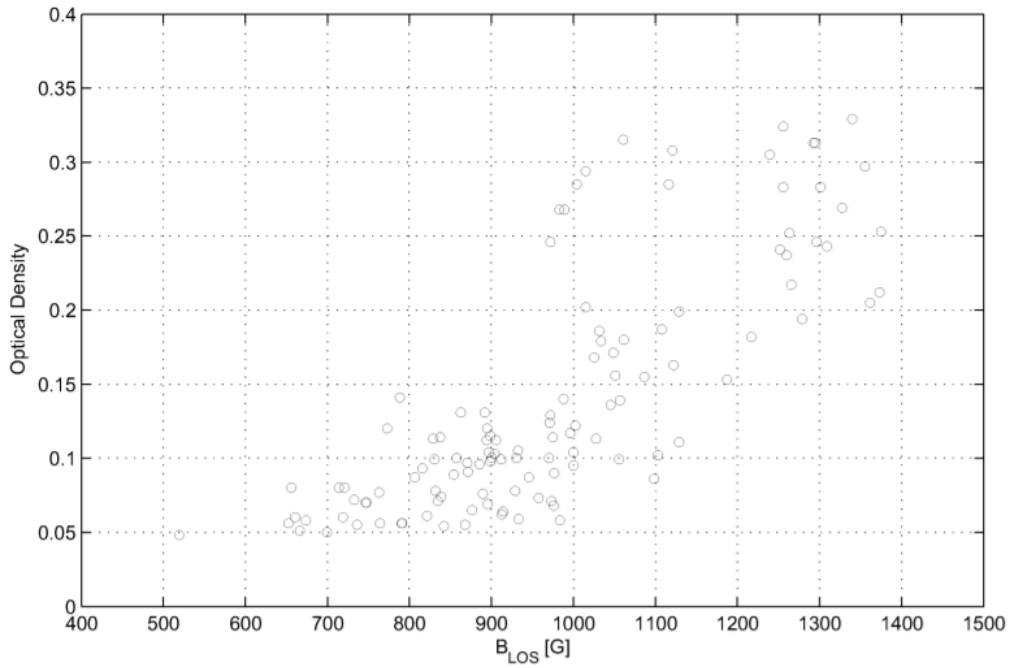
Upper panels: evolution of the area of the pore observed with DOT. Lower panels: the corresponding wavelet power spectrum for a white noise background. The cone of influence is marked as the shaded region and the contour lines show the 95% confidence level.

- A prototype of a modular framework for solar feature detection, characterization, and tracking was presented by Shahamatnia et al. (2016). To develop an efficient system capable of automatic solar feature tracking and measuring, a hybrid approach combining specialized image processing, evolutionary optimization, and soft computing algorithms was being followed. The specialized hybrid algorithm for tracking solar features allowed automatic feature tracking while gathering characterization details about the tracked features. The hybrid algorithm takes advantages of the snake model, a specialized image processing algorithm widely used in applications such as boundary delineation, image segmentation, and object tracking. Further, it exploits the flexibility and efficiency of Particle Swarm Optimization (PSO), a stochastic population based optimization algorithm. The application of the PSO-Snake algorithm for calculating the sidereal rotational angular velocity of the solar corona was discussed.



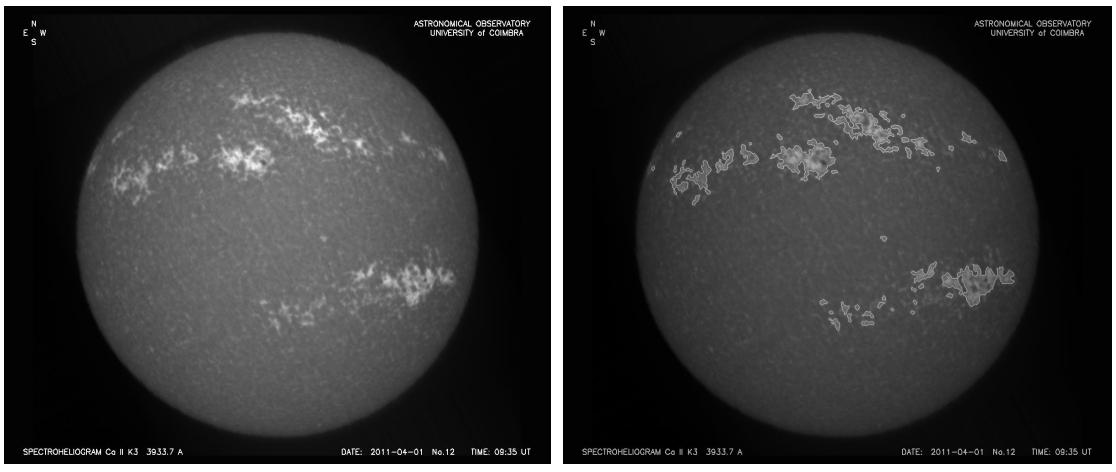
Detection process of a selected CBP (2010-10-05). Initial contour around the region of interest is evolved to precisely delineate the CBP boundaries. The outer contour is the initial snake and the inner contours are the transitional contours of every 10 iterations of the PSO-Snake detection algorithm. In the final stage contours converge and do not change much through iterations.

- Dorotovič et al. (2016) described conditions of pore formation in relation to the configuration and intensity of magnetic field, using observations of the SDO/HMI instrument. An area with a diameter of 35" containing 6 pores during the period from October 10, 2013, 22:01:30 UT to October 11, 2013, 20:01:30 UT was selected from the HMI full-disk images. We analyzed the temporal evolution of the area and brightness of the pores (time step 15 minutes), their statistics, and in parallel a time-sequence of the line-of-sight magnetic field intensity and its correlation with the area and brightness. We found that the pores become visible when their intensity decreases below 0.85 of the photospheric surrounding intensity and the magnetic field increases to 650 G in the HMI measurements.



Relation between optical density of a pore and the line-of-sight magnetic field.

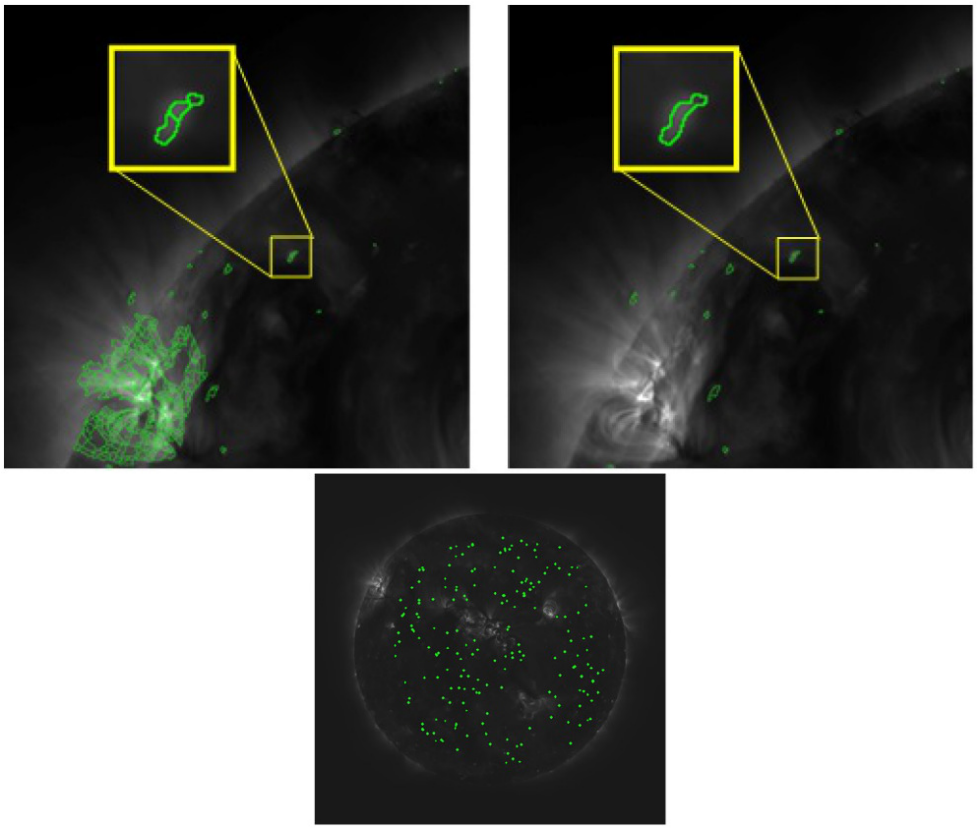
- Barata et al. (2018) presented a mathematical morphology approach applied to the CaII K3 spectroheliograms from the Coimbra Observatory. The objective was to create a tool based on the segmentation by watershed transform combined with other morphological operators to detect automatically and analyze chromospheric plages during the solar cycle 24. The tool was validated by comparing its results for cycle 23 with those presented in earlier studies. The results obtained are in very good agreement with those, including on images obtained in non-ideal meteorological conditions (eg. some clouds in sky). The results were also qualitatively compared with the results obtained through the application of ASSA model to SDO HMI magnetograms.



Left: Example of a CaII K3 spectroheliogram (acquired at 1st of April, 2011). Right: Facular regions superimposed of the original image.

- Dorotovič et al. (2018) applied a segmentation algorithm called Gradient Path Labelling (GPL), used originally to identify drusens in medical retinal images, to detect and track the coronal bright points (CBPs) using images from the AIA instrument onboard the SDO satellite. The CBPs have a tendency to change shape and size along time, to disappear and

reappear at a corresponding heliographic position, therefore, decision trees were also included in the tracking solution. Since our CBP detection algorithm uses an active region mask to filter out the CBPs, whose centroid is inside the active regions, the number of identifications clearly depends on the level of solar activity. Our approach uses the commonly applied fitting relation to the latitudinal dependence of the rotational velocity, which resulted in calculation of the optimum fit parameters as well as the Gegenbauer orthogonal polynomials.



Top panel: Remerge illustration with a highlighted region: result of GPL segmentation (left) and after remerge operation (right). The contour of the GPL segmented objects is displayed in green. Bottom panel: Location of detected and filtered CBPs in the original solar image.

International collaboration – projects
Project SRDA Mobility Slovakia – Portugal 2016 - 2017 (SK-PT-2015-0004)

Period: 1 January 2016 – 31 December 2017
Partners:
Slovakia: Slovak Central Observatory, Hurbanovo and Astronomical Institute SAS (AISAS), Tatranská Lomnica
Portugal: Geophysical and Astronomical Observatory of the University of Coimbra (Observatório Geofísico e Astronómico da Universidade de Coimbra – OGAUC), Coimbra and Computational Intelligence Research Group of the Institute of Developing New Technologies – CTS/UNINOVA-CA3, Caparica
In this project we were investigating the evolution of solar features over the 24th solar cycle using the high spatial and temporal resolution observations using the instruments Helioseismic and Magnetic Imager (HMI) and Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) and using the spectrograms (Ca K1 and K3, H-alpha) taken by the Geophysical and Astronomical Observatory in Coimbra (Portugal). The main aim was to obtain knowledge about the distribution of solar features on the solar disc over a solar cycle (north-south asymmetry) and about characteristics of differential rotation of the Sun. The developed software tool for detection, identification and automatic tracking of various solar phenomena (sunspots, plages, coronal bright

points) is based on an evolutionary optimization model, a combination of Particle Swarm Optimization (PSO) and an Active Contour Model as an image processing framework, and also on segmentation algorithm. The papers Barata et al. (2018) and Dorotovič et al. (2018) resulted from this collaboration.

Future plans

The SCO-ROD has intensive collaboration with the Solar Department of the Astronomical Institute of the ASCR, Ondřejov (Czech Republic). A new ground based device for the measurement of the Balmer continuum flux in solar flares was recently developed and installed at the Ondřejov Observatory (Kotrč, Procházka, and Heinzel, 2016). Their analysis of the data proved that the described device is sufficiently sensitive to detect variations in the Balmer continuum during solar flares. Temporal changes in the Balmer continuum flux starting well before the onset of the flare in Hα. The same instrument was constructed in the SCO-ROD and test observations are being performed. Afterwards, regular patrol observations of the Balmer continuum flux will be performed using the twin instrument in the SCO-ROD.

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2. STP ACTIVITIES IN ASTRONOMICAL INSTITUTE (AISAS)

Main topics of the STP research carried out

The main topics of the STP research performed in AISAS in the 2015-2018 period were: research of prominences, emission corona, and flares using ground-based and space-born observations and development of instrumentation for the coronagraphic ground-based observations at the Lomnicky Stit Observatory (LSO) of AISAS (2633 m a.s.l.).

Summary of STP research carried out during the reported period, with highlights of the results obtained

Results of the particular interest are that on quiescent filaments/prominences e.g., 2D non-LTE modelling, statistical analysis of UV spectra, visibility in Hinode/XRT images, and total mass of quiescent prominences from their multi-spectral observations. Other works were devoted to spectral diagnostics of different flares, namely on loops using Ca II 8542 Å and Hβ lines, on mapping the magnetic field of flare coronal loops, on chromospheric evaporation flows and density changes in a flare. Moreover, also radio measurements of different features of the flare induced radio emission were analyzed. A separate branch of the research was focused on evolution of sunspots and on the temporal evolution of arch filaments and erupting flux ropes in particular.

Outreach activities

The AISAS and its LSO were involved in several outreach activities in media, in public lectures and Door Open Days. Some of them were organized in frame of the international activities like e.g., IAU 100, European Researchers' Night, and other in frame of national activities like Science and Technology Week in the Slovak Republic organized on the yearly basis.

Capacity building activities

The LSO was operated by the AISAS to keep alive one of the four high-altitude ground-based observatories in the world devoted to the research of the solar emission corona. This task is recognized as an important issue both for the scientific research of the solar atmosphere as well as for development and testing of the instruments specifically focused on coronagraphic solar research equally ground-based and space-born. Specifically, the two post-focus instruments attached to the Lyot coronagraphs CoMP-S and SCD are in the testing period, and new pointing system for the two coronagraphs is developed.

The CoMP-S and SCD instruments attached to two ZEISS 200/3000 coronagraphs at the Lomnicky Štít Observatory.

Important international collaborations and initiatives

The AISAS was involved in the project of the instrument called „Waves and Magnetism in the Solar Atmosphere (WAMIS)“ a a member of a consortium led by PI Dr. Yuan-Kuen Ko (Naval Research Laboratory, Washington, USA, Co-I: J. Rybák, AISAS). Application for the NASA funding of this instrument for the stratospheric balloon project of NASA in Antarctica has not been successful yet.

Current and upcoming missions and campaigns

The LSO is planning its activities to be completely involved in the ground-based support of the SolO/METIS and PROBA-3/ASPIICS instruments of ESA since 2022 providing prominence and emission corona measurements in several spectral lines (the same as measured by these instruments and some complementary ones) in frame of the cooperative observing campaigns.

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3. STP ACTIVITIES IN INSTITUTE OF EXPERIMENTAL PHYSICS (IEPSAS)

The main topics of the STP research carried out at the Institute of Experimental Physics of Slovak Academy of Sciences (IEPSAS) include:

(1) Research focus on long term continuous measurement of cosmic rays (CR) by neutron monitor (NM) with high statistics and temporal resolution at Lomnicky stit (LS, 2636 m. a.s.l. 1982-2019) and by SEVAN detector system (2014-2019) along with other measurements allowed to describe the quasi-periodic variations of CR intensity in wide frequency range [1] and obtain experimental characteristics of CR modulation at middle latitudes [2]. Measurements allow finding the highest energy response from GLE 72 [3]. Most notably analysis of measurements at LS allows finding the relation between vertical component of the electric field and increases in count rate (TGE) in SEVAN system upper channel [4]. Since March 2014, there is a continuous measurement of secondary cosmic rays by the detector system SEVAN (Space Environmental Viewing and Analysis Network) at LS. Starting from June 2016, the count rates (1 s resolution) obtained from the three SEVAN detectors and their coincidences are available, along with selected meteorological characteristics. Since 30 May 2016, the electric field measurements have been installed at the same site. Several events with a clear increase of the count rate in the upper detector of SEVAN were observed during the thunderstorms until 17 September 2016. It is shown that the 2 min averaged increases of count rates measured by SEVAN correspond with periods of the high electric field (with

higher probability during negative polarity) rather than with the individual discharges (lightning).

LS (2634 m above sea) - suitable location for CR observations. Measurements by NM, in real time http://neutronmonitor.ta3.sk, in network: http://nmdb.eu, and by SEVAN, in network: http://crd.yerphi.am/Lomnicky_stit_SEVAN_Data

(2) Analysis of satellite measurements leads to the following results. Fluxes of suprathermal electrons and ions contributed to the description of fluctuations near the Earth's bow shock [5, Interball]. Measurements of high energy neutral emissions allowed to obtain information about acceleration in a solar flare on October 29, 2003 [6, Coronas-F]. Radiation camera MiniPIX TIMEPIX was tested on the angular resolution of secondary CR muons [7].

(3) Research of cosmic rays modulation in the heliosphere. In last years focused mainly on new analytical methods development and validation of precision widely used stochastic methods. In the article [8] we present a comparison of forward-in-time and backward-in-time methods to solve the cosmic rays transport equation in the heliosphere. For the sake of clarity, this work is focused on one-dimensional solutions. Results were compared with an alternative numerical solution, namely, the Crank-Nicolson method, specifically developed for the case under study. The forward-in-time stochastic integrations method showed a systematic uncertainty <5%, while the backward-in-time stochastic integrations method showed a systematic uncertainty <1% in the studied energy range. In the article [9] we present the development of an analytically iterative method for solving steady-state as well as unsteady-state problems of cosmic-ray (CR) modulation. Iterations for obtaining the solutions are constructed for the spherically symmetric form of the CR propagation equation. The main solution of the considered problem consists of the zero-order solution that is obtained during the initial iteration and amendments that may be obtained by subsequent iterations. The finding of the zero-order solution is based on the CR isotropy during propagation in the space, whereas the anisotropy is taken into account when finding the next amendments. The method is applied to solve the problem of CR modulation where the diffusion coefficient and the solar wind speed are constants with a Local Interstellar Spectra (LIS) spectrum. The solution obtained with two iterations was compared with an analytical solution and with numerical solutions. Finally, solutions that have only one iteration for two problems of CR modulation with constant solar wind speed and the same form of LIS spectrum were obtained and tested against numerical solutions. There was a good matching of the obtained solutions with the numerical solutions as well as with the analytical solution for the problem where the discussion coefficient is constant.

(4) Research of airglow light produced in the upper atmosphere. Theoretical study of airglow production and its radiative transfer in Earth's atmosphere with respect to season, location, and solar activity focused on airglow production was presented in [10].

Considering outreach activities *SPACE::LAB - a place to attract, educate and involve the young generation in space science and engineering* project supported by European Space Agency under the PECS SK03-02 call start in 2018. All information about the project could be found at http://www.space-lab.sk.

In future, we plan to continue in research of quasi-periodic and irregular CR variations and comparison with parameters of interplanetary space, Earth's magnetosphere, state of atmosphere; relations of fluxes of low energy CR to space weather effects (SW); changes of magnetospheric transmissivity for CR; CR modulation in heliosphere according to exp. data; development of new devices or their parts for satellite/space probe observations of suprathermal particles in magnetosphere, in interplanetary space and in other space plasma populations; analysis of satellite/space probe data with the aim to contribute to understanding sources, acceleration mechanisms, transport, losses in magnetosphere and role of the particles in SW effects; update of measurements at LS including SEVAN, dosimetric observations, study of CR relations to atmospheric electricity. Further, plans include also further development of cosmic rays modulation in heliosphere models and particle trajectories evaluation in the Earth's magnetosphere.

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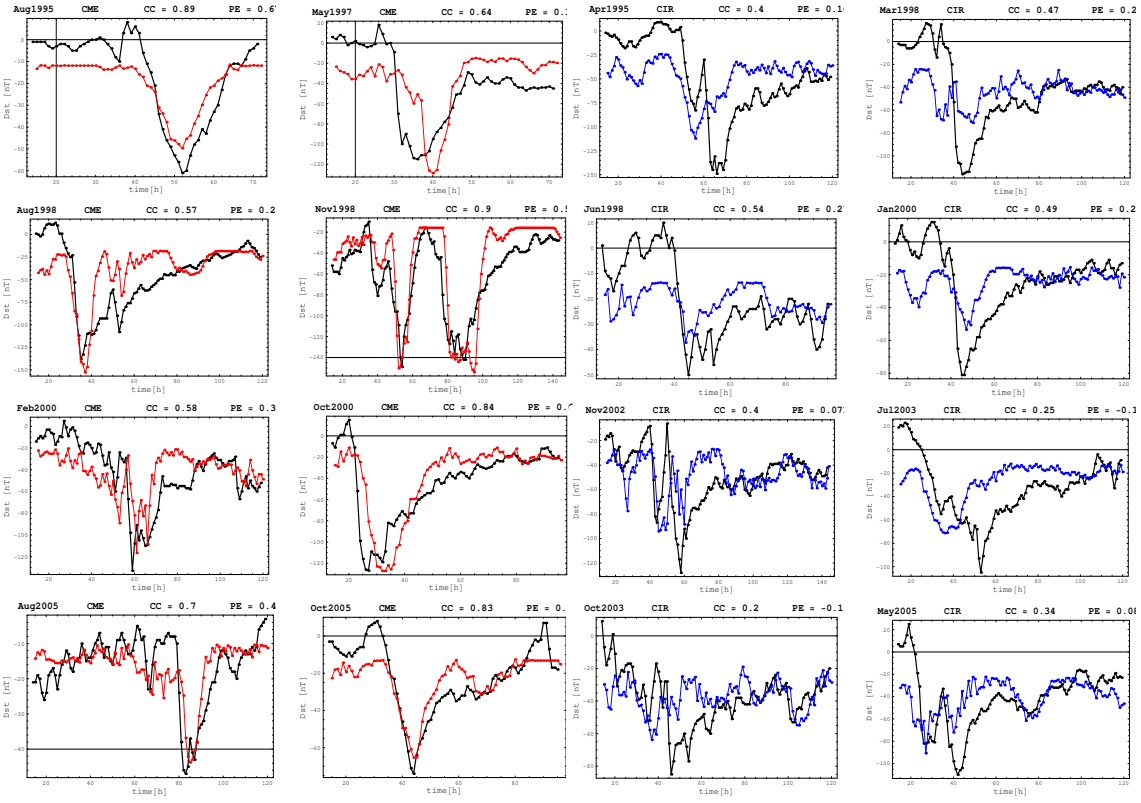
4. PHYSICAL PROCESSES IN THE NEAR-EARTH SPACE ENVIRONMENT (ESISAS)

In the ESISAS, some particular topics related to the terminal part of the causal solar-terrestrial chain were studied: geomagnetic storm modelling using the solar wind data and numerical modelling of the plasmosphere.

A model of geomagnetic storms based on the method of artificial neural networks (ANN) combined with an analytical approach was presented in [1]. Two classes of geomagnetic storms, caused by coronal mass ejections (CMEs) and those caused by corotating interaction regions (CIRs), of medium and week intensity were studied. As the model input, the hourly solar wind parameters measured by the ACE satellite at the libration point L1 were used. The time series of the Dst index was obtained as the model output. The simulated Dst index series was compared with the corresponding observatory data. The model reliabilisty was assessed using the skill scores, namely the correlation coefficient and the prediction efficiency. The model performance was better for the CME driven storms than for the CIR driven storms. At the same time, it appears that in the case of medium and weak storms the model performance was worse than in the case of intense storms.



The observational Dst index series (black line) and the model Dst index series for the CME driven geomagnetic storms (red line) and for the CIR driven geomagnetic storms (blue line).

The Dynamic Global Core Plasma Model (DGCPM), studied in [2], is a dynamical model of the flux-tube content in the plasmasphere which is widely used in space physics. The comparison of this model with the results of the observations of the plasma mass density

made by means of the field-line resonance technique yielded relatively large disagreement. On the basis of data from the European quasi-meridional magnetometer array (EMMA), three of the parameters of the DGCPM were changed: characteristic time for depletion of the flux-tube, maximum flux from the ionosphere to the flux-tube, and saturation value of the plasma density. The functional form of the equations in the DGCPM as well as the other parameters of the model were preserved. For changing the parameters, only the data observed at the McIlwain L-value equal at 3.24 were used. Nonetheless, it turned out that the modified model well agrees also with the observations at other L-values.

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5. GROUND-BASED GEOMAGNETIC OBSERVATIONS AND RESEARCH ON GEOMAGNETIC RECORDS (GO ESISAS)

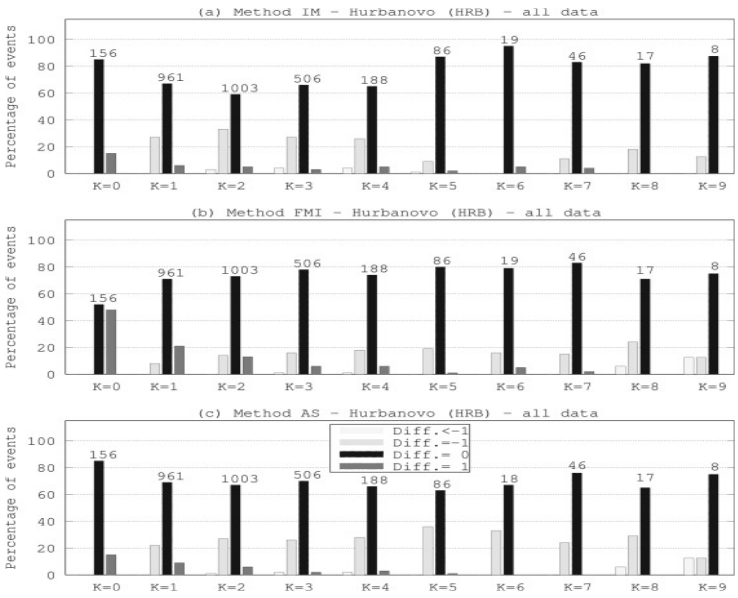
At Geomagnetic Observatory (GO) of the ESISAS in Hurbanovo geomagnetic field measurements were performed and qualitative aspects of current as well as historical geomagnetic records were studied.

GO ESISAS is a certified workplace for geomagnetic field measurements in Slovakia. Its geographic and geomagnetic coordinates are (47.874°N; 18.188°E) and (46.67°N; 101.18°E) respectively, and its altitude is 112 meters. Although the observatory was officially established on 30 September 1900, continuous series of the geomagnetic field data from this station has existed since 1893. The historical names of the observatory were successively Ógyalla and Stará Ďala. Since 1998 the Observatory has been participating in INTERMAGNET, which is the global network of real-time working geomagnetic observatories. The variations of the geomagnetic field are continuously recorded with two instruments: torsion photoelectric magnetometer (TPM) and three-axis fluxgate sensor Magson. The absolute measurements are performed once a week; for this purpose DI-flux theodolite (type Lemi) and proton precession magnetometers (types Elsec 820 and PMG 1) are used.

Regular measurements at the observatory were supplemented by geomagnetic observations at 12 temporary observation points evenly distributed throughout Slovakia, see [1]. The distribution of the geomagnetic elements in Slovakia was expressed in the form of the 1st-degree polynomial model. In addition, regular measurements of the magnetic declination were carried out at selected airports.

Geomagnetic activity is evaluated monthly. Two methods are used to determine the activity expressed by the K indices: the FMI method is used by default and an interactive IM method, which has been developed at our workplace [2], is used experimentally. Preliminary tests of the IM method were performed on data from Hurbanovo and Budkov observatories [3]. The test results indicated good performance of the IM method for high values of the geomagnetic

activity. More specifically, for K indices being at least 5, the IM method provided the values of K indices that satisfactorily matched the K indices obtained by the traditional hand-scaling done by an experienced observer. An unfortunate feature of the method is a certain degree of subjectivity that is introduced when the operator determines the non-K variation. On the other hand, a similar degree of subjectivity was also a part of traditional hand-scaling. This somehow limits the use of the IM method to producing indices that prolong a homogeneous series of traditional K indices, which were derived from analogue magnetograms in the past.



Differences between computer produced K indices and hand-scaled K indices for the Hurbanovo Geomagnetic Observatory (HRB). Here the computer methods are (a) IM, (b) FMI and (c) AS. The items are grouped according to the values of the hand-scaled K indices. The amounts of the differences are coded with a grey scale. The legend "Diff.<−1" means the difference that is equal to −2. There is only one exception from that; in one case the IM method provided K index 1 while the authentic index was 4. The numbers that are written above the columns give the total number of analysed events for the particular hand-scaled K indices.

Besides recording new data within the INTERMAGNET programme, research on geomagnetic field records in archives that go back to the period before the introduction of digital registrations is also important. We have contributed to the HISTMAG, which is a new database that combines the historical records with archaeo- and paleomagnetic data. The HISTMAG database extends to the 50,000-year-old past and puts together the data from existing databases and newly acquired historical records from Central Europe. It is available via the website of the Conrad Observatory, Austria, see [4]. We explored the magnetic declination recorded in observation logs and historical mining maps that were found in the archives of the Slovak Mining Museum in Banská Štiavnica. Recent direct measurements of the geomagnetic field in Slovakia have also been included in the study. A detailed examination of the accuracy of the historical data in the database is a part of the published work. We believe that the HISTMAG database might significantly contribute to the modelling of the historical development of the Earth's magnetic field.

Another reason for exploring the historical records of geomagnetic field is the study of transient geomagnetic disturbances. However, the occurrence of such extreme phenomena, which represent a serious threat to our technologically advanced society, is rare. Therefore, extending the amount of recorded events is highly desirable. In [5], we examined the storm of

8 March 1918, during which auroral oval-related electric currents likely affected the geomagnetic field at mid-latitudes. The auroral oval was then extensively shifted equatorward and the magnetic storm was accompanied by very intense northern lights there. It was found that that event consisted of a pronounced storm sudden commencement, two auroral substorms that merged together forming a forceful disturbance, and the main phase caused by the ring current.

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6. STUDY OF SCHUMAN RESONANCES (DAPEMCU)

At DAPEMCU, the study of Schuman resonances and their diurnal/seasonal variations continued.

Schumann resonances (SR) are resonant electromagnetic oscillations in extremely low frequency band (ELF, 3 Hz – 3 kHz), which arise in the Earth-ionosphere cavity due to lightning activity in planetary range. The time records in the ELF-band consist of background signals and ELF transients/Q-bursts superimposed on the background exceeding it by a factor of 5 – 10. The former are produced by the common worldwide thunderstorm activity (100 – 150 events per second), the latter origin from individual intense distant lightning discharges (100 – 120 powerful strokes per hour). A Q-burst is produced by a combination of direct and antipodal pulses and the decisive factor for its shape follows from the source-to-observer distance (SOD). Diurnal/seasonal variations of global thunderstorm activity can be deduced from spectral amplitudes of SR modes. In [1], the focus was made on diurnal/seasonal variations of the number of ELF-transients assuming that it is another way of lightning activity estimation. To search for transients, our own code was applied to the SR vertical electric component measured in October 2004 – December 2008 at the Astronomical and Geophysical Observatory of Faculty of Mathematics, Physics and Informatics of the Comenius University, Slovakia. Limits (min-max) for the width of primary spike, time difference between primary and secondary spike and the amplitude of the spike were chosen as criteria for the identification of the burst. Cumulative spectral amplitude of the first three SR modes compared with number of ELF-transients in monthly averaged diurnsal variations

quite successfully confirmed, that the number of transients can be a suitable criterion for the quantification of global lightning activity.

Specifically, in [2] criteria for the identification of the burst were chosen on the basis of the transient amplitudes and their morphological features. Monthly mean daily variations in number of transients showed that African focus dominates at 14h -16h UT and it is more active in comparison with Asian source, which dominates at 5h - 8h UT in dependence on winter or summer month. Third America's source had surprisingly slight response. Meteorological observations in South America aiming to determine lightning hotspots on the Earth indicate that flash rate in this region is greatest during nocturnal 0h-3h local standard time. This fact may be interpreted that Asian and South American sources contribute together in same UT.

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