

Space Weather activities in Slovakia

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- The research related to **space weather (SWE)** has one of the longest history among other space research topics in Slovakia.

• SK-AD03 Slovakia National Space Safety Programme (S2P) Study



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Technical report 4

Collection of Capabilities and Assets in Slovakia related to SWE frameworks

Table 5.1: List of Slovak entities in space weather framework.

Entity	HQ	Industry	Domains	Type of business	Website
Institute of Experimental Physics, Slovak Academy of Sciences (IEP SAS)	Košice, Slovakia	Academia, R&D institution, Observatory	SWE - Heliospheric Weather SWE - Space Radiation SWE - Ionospheric Weather	HW, SW, services, expertise	https://uef.saske.sk
Astronomical Institute, Slovak Academy of Sciences (AI SAS)	Tatranská Lomnica, Slovakia	Academia, R&D institution, Observatory	SWE - Solar Weather	HW, SW, services, expertise	https://astro.sk
Slovak Central Observatory Hurbanovo (SUH)	Hurbanovo, Slovakia	Academia, Observatory	SWE - Solar Weather	services, expertise	www.suh.sk
Earth Science Institute, Slovak Academy of sciences (ESI SAS)	Bratislava, Slovakia	Academia, Observatory	SWE - Geomagnetic Conditions	services, expertise	http://www.geosav.sk
Faculty of Mathematics, Physics and Informatics (FMPI)	Bratislava, Slovakia	Academia, University, Observatory	SWE - Geomagnetic Conditions	expertise	https://fmph.uniba.sk/
Astronomical Observatory Prešov (AOP)	Prešov, Slovakia	Observatory, Public outreach	SWE - Solar Weather	public outreach	https://astropr.esov.sk/
Astronomical Observatory Rimavská Sobota (AOR)	Rimavská Sobota, Slovakia	Observatory, Public outreach	SWE - Solar Weather	public outreach	http://www.astro.sobota.sk
Roztoky Observatory (RO)	Roztoky, Slovakia	Observatory, Public outreach	SWE - Solar Weather	public outreach	https://roztoky.space
Astronomical Observatory Hlohovec (AOH)	Hlohovec, Slovakia	Observatory, Public outreach	SWE - Solar Weather	public outreach	http://hvezdar.en.org
Faculty of Electrical Engineering and Informatics, Technical University of Košice	Košice, Slovakia	Academia, University, R&D institution,	SWE - Ionospheric Weather	SW, services, expertise	https://kkui.feituke.sk
GlobalLogic Slovakia s.r.o.	Košice, Slovakia	IT company	SWE - Ionospheric Weather	SW, services	https://www.globallogic.com/sk/
SPACE::LAB startup	Košice, Slovakia	Startup	SWE - Ionospheric Weather	SW, services	https://spaceoffice.sk/space-incubator/
Q-Products a.s.	Bratislava, Slovakia	Company	SWE - Heliospheric Weather	HW, services	https://www.qproducts.sk
CTRL s.r.o.	Košice, Slovakia	Company	SWE - Heliospheric Weather	HW, services	http://www.ctrl11.eu

Table 4.1: List of Slovak assets in space weather framework (according domains presented in Section 3).

NAME	TECHNOLOGY	OPERATOR	COUNTRY	Location	LON [deg]	LAT [deg]	ALT [m]
Coronagraphs	Telescopes for solar corona observations	AI SAS	SK	Lomnický štít	20.2131	49.1951	2634
CoMP-5	Spectropolarimeter for solar corona and prominences	AI SAS	SK	Lomnický štít	20.2131	49.1951	2634
Solar telescopes	Telescopes for solar atmosphere observations	SUH	SK	Hurbanovo	18.1911	47.8734	114
Solar telescopes	Telescopes for solar atmosphere observations	AOP	SK	Prešov	21.2563	48.9997	282
Solar telescopes	Telescopes for solar atmosphere observations	AOR	SK	Rimavská Sobota	20.0051	48.3742	218
Space R&D	Laboratory infrastructure for Space R&D	IEP SAS	SK	Košice	21.2609	48.7060	203
Neutron Monitor	Detectors of secondary cosmic rays	IEP SAS	SK	Lomnický štít	20.2131	49.1951	2634
SEVAN	Detectors of secondary cosmic rays	IEP SAS	SK	Lomnický štít	20.2131	49.1951	2634
AMON-ES, AMON-net	Detectors of thermosphere-ionosphere	IEP SAS	SK	Kolonicke sedlo	22.2737	48.9347	448
INTERMAGNET	Detectors of the Earth's magnetic field	ESI SAS	SK	Hurbanovo	18.1911	47.8734	114

A composite image of space. On the left, a bright orange and red comet streaks across the dark sky. In the center, the Earth is shown from space, with several satellites in orbit. On the right, a large, dark, irregularly shaped asteroid or near-Earth object is visible. The background is a deep black space with some distant stars.

SLOVAK NATIONAL SPACE SAFETY PROGRAMME (SK-S2P) WORKSHOP

- Space Weather (SWE)
- Planetary Defence, Near-Earth objects (NEO)
- Space debris and Clean space

 **ASTROS**
solutions

**15th
FEBRUARY
2022**



- **Astronomical Institute (AI) of Slovak Academy of Sciences (SAS),
Tatranská Lomnica**

3.1) Solar Weather [<https://swe.ssa.esa.int/solar-weather>]

- Development of instruments for ground-based observations of solar disk and corona in VIS and IR spectral lines by the coronagraph
- Observations of solar prominences and solar corona in emission spectral lines with the coronagraph
- New instrument for spectropolarimetry of the solar corona and prominences at the Observatory Lomnický Štít:

COMP- S: Coronal Multi-channel Polarimeter for Slovakia

- Lyot filter with polarimeter (VIS and IR, 500 – 1100nm)

<https://www.astro.sk/l3.php?p3=iso>

- **Solar telescopes for solar atmosphere observations at public observatories:**
 - Slovak Central Observatory in Hurbanovo, Astronomical Observatory in Prešov, Astronomical Observatory in Rimavská Sobota, Astronomical Observatory in Hlohovec

3.1) Solar Weather [<https://swe.ssa.esa.int/solar-weather>]

- Study of solar activity during solar cycles:
 - Telescopes with a lense and with a mirror for optical observation of the sunpots in the solar photosphere
 - LUNT telescope with H-alpha filter for photographic observation of the solar chromosphere and prominences

Hurbanovo:

- Radio spectrometer CALLISTO: registration of solar radio bursts at 45 – 800 MHz (ISWI instrument)
- Spectrometer Ocean Optics HR4000 and horizontal solar telescope (50/3500 cm): measurements of solar continuum in VIS spectral band with the aim to detect solar flares (Astronomical institute, CAS, Ondřejov, Czech Republic)
- publication of Modified Coronal Index (MCI, <https://suh.sk/online-data/modifikovany-koronalny-index>) and Modified Homogeneous Data Set (MHDS, <https://suh.sk/online-data/modifikovany-homogenny-rad>) of solar coronal intensities.

- **Institute of Experimental Physics (IEP), SAS, Košice**
(Department of Space Physics)
 - **3.2) Heliospheric Weather** [<https://swe.ssa.esa.int/heliospheric-weather>]
 - Measurements of energetic particles by own instruments on space missions: as Radioastron, Double Star, BepiColombo, JUICE, and etc.
 - Infrastructure for Space R&D projects
 - **3.3) Space Radiation** [<https://swe.ssa.esa.int/space-radiation>]
 - Cosmic Rays measurements (ground based observations using Neutron monitor and SEVAN) [<http://neutronmonitor.ta3.sk>]
 - **3.4) Ionospheric Weather** [<https://swe.ssa.esa.int/ionospheric-weather>]
 - AMON (Airglow MONitor) - processes in the thermosphere-ionosphere system
 - ASPIS - predictions of ionospheric scintillations

More at <http://uef.saske.sk>

- **Earth Science Institute (ESI), Slovak Academy of sciences (ESI SAS), Bratislava**
 - Geomagnetic Observatory located in Hurbanovo
- **Faculty of Mathematics, Physics and Informatics (FMPI) of the Comenius Univ., Bratislava**
 - Astronomical and Geophysical Observatory (AGO), located in Modra

3.5) Geomagnetic Conditions [<https://swe.ssa.esa.int/geomagnetic-conditions>]

- Registration of the Earth's magnetic field:

Technical details of instruments in Hurbanovo within the **INTERMAGNET**:

- DI-fluxgate magnetometer (type ELSEC 810, Zeiss Theo 015B)
 - DI-fluxgate magnetometer (type LEMI 203)
 - proton magnetometer (type PMG 1)
 - Torsion photoelectric magnetometer (TPM) employing Bobrov-type quartz variometers
 - Magson fluxgate magnetometer
- Investigation of the **geomagnetic bursts**.

- **Potential new players:**
 - **Q-Products a.s.** (ruggedized computers and displays, <https://www.qproducts.sk/about-us/>)
 - **CTRL s.r.o.** (cyber-physical systems, <http://www.ctrl1.eu>)
 - **Faculty of Electrical Engineering and Informatics, Technical University of Košice** (space/geo data processing and support of their decision processing using machine/deep learning approaches, <https://kkui.fei.tuke.sk/en/>)
 - **GlobalLogic Slovakia s.r.o.** (leader in digital engineering, <https://www.globallogic.com>)
 - **SPACE::LAB startup** (Slovak Space Incubator team connected directly to the IEP SAS in Košice: digital solutions by advanced machine learning techniques)

- **EU Space Programme and European Union Agency for the Space Programme (EUSPA)**
- Two Slovak scientists are nominated as National representatives to the EU Space Programme Committee - the Space Situational Awareness (SSA)/Space Weather (SWE).



- The National **Commission for Space Activities in the Slovak Republic** is coordinated by the Slovak Space Office at the Ministry of Education, Science, Research and Sport of the Slovak Republic.



International Space Weather Initiative (ISWI) in Slovakia

web page, http://stara.suh.sk/id/iswi/iswi_SK-en.htm

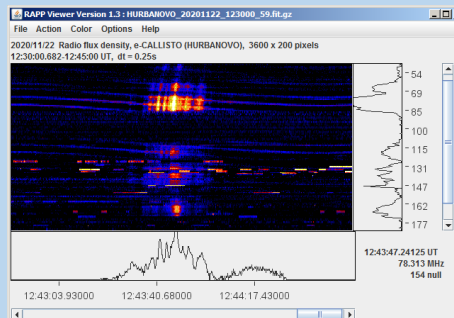
National Coordinator: I. Dorotovič

Instruments:

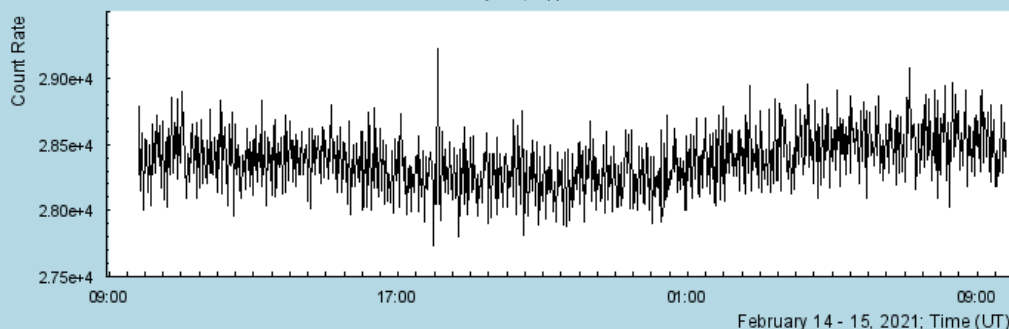
- 1. **CALLISTO** in the Slovak Central Observatory in Hurbanovo
- operational since **December 2011**

http://newserver.stil.bas.bg/SUNGEO/00SGArhiv/SG_v9_No1_2014-pp-105-107.pdf

Data available at: <http://soleil.i4ds.ch/solarradio/callistoQuicklooks/>



- 2. **SEVAN** in the Department of Space Physics of the IEP SAS, Lomnický Peak Observatory
- operational since **March 2014**



<https://earth-planets-space.springeropen.com/articles/10.1186/s40623-020-01155-9>

Data available at: http://crd.yerphi.am/Lomnicky_stit_SEVAN_Data

Events:

National Solar Physics Meetings (NSPMs)

- 26th NSPM in June 2022
- contributions on space weather events and studies as well

Space weather research in Slovakia and related ISWI activities in the last decade

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ABSTRACT

Space weather research in Slovakia is performed at a leading institutions: (1) Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica (Department of Solar Physics), (2) Institute of Experimental Physics, Košice (Department of Space Research), (3) Earth Science Institute, Slovak Academy of Sciences, Bratislava (Division of Geophysics, Geomagnetic Observatory Hurbanovo), (4) Slovak Central Observatory, Hurbanovo (Scientific and Observational Department). This contribution presents the main research fields and related ISWI projects and activities performed in Slovakia in the last decade. Web page: http://www.suh.sk/id/iswi/iswi_SK-en.htm

INSTRUMENTS AND RESEARCH TOPICS

Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica

- Spectropolarimetric measurements of sunspot spots and umbrae cores in the prominent spectral and chromospheric lines using the CaII H, Calcium Multi-Channel Radiometer (Instrument) (since October 2012)
- Continuation of the Lomnický Peak magnetometer, heating, operation, CaIIISTO instrument: installation, testing
- Spectropolarimetric observations of the chromospheric magnetic field with CaII H (Solar Chromospheric Detector) Instrument
- Rapid measurement of the green (844.6 nm, CaII H) and red (854.2 nm, CaII H) coronal emission lines (Solar Spectro-Imaging) - Lomnický Peak Observatory, 4 m diameter telescope equipped with a diffraction grating
- Polar imaging of H-alpha prominence (until August 2007) - Lomnický Peak Observatory, 4 m diameter telescope
- Investigation of the solar chromosphere, transition region and corona using satellite (GOES, TRACE, SOHO, SDO, STEREO) and ground-based telescopes (DOT, SST, VTT, Hinode, GONG)
- Dynamics and energy transport of the magnetic event in the upper solar atmosphere (Lomnický Peak Observatory, 4 m diameter telescope, heating mechanism (the solar instrument))
- Solar observation of solar corona
- Member of the Consortium S4T - European Solar Telescope
- Member of the Infrastructure S4T project (European Solar Telescope)

Earth Science Institute SAS, Bratislava, Geomagnetic Observations, Hurbanovo

- Magnetometer and muon monitor SEVAN at Lomnický Peak high-altitude laboratory, 3434 m above sea level
- Cooperation in several space projects:
 - I4D S4T analysis solar wind and particle measurements on satellite (ACE, COSMIC-2, International Space Station) - energetic particle flux measurements on TCI satellite, method: GLE instrument data for Solar Storms
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Slovak Central Observatory, Hurbanovo

- Daily drawings of the sunspot
- CaIIISTO instrument
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ISWI RELATED RESEARCH TOPICS

- Solar-terrestrial connections and Earth's magnetosphere and climate
- Solar proton events and geomagnetic activity
- Trends of geomagnetic activity based on space weather phenomena (Flare, CMEs, STPs) using artificial neural networks
- GO instrument in muon monitor installation of the INTERMAGNET Network for geomagnetic measurements

SOME OTHER ISWI ACTIVITIES

- SOI in Hurbanovo organizes national solar physics meetings with participation from abroad. Last one was held in 2015 and the next meeting is planned for 2024.
- I4D S4T in Tatranská Lomnica - has suitable facilities for organization of international conferences or training workshops, such as was the 2011 ISWI Summer School on Space Science.

2011 ISWI-EUROPE SUMMER SCHOOL IN SPACE SCIENCE

August 21-27, 2011, Astronomical Institute of the SAS, Tatranská Lomnica, Slovakia

http://stara.suh.sk/id/iswi/summer_school

- **COSPAR and SCOSTEP:**

Slovak scientists are actively participating also in both the

- COSPAR, <http://nccospar.saske.sk/>

and the

- SCOSTEP/PRESTO, <https://scostep.org/presto-science-program/>

activities.