

# Space Weather activities in Austria

**ISWI steering committee meeting @UN, Vienna :: February 10, 2023**

presenter: Manuela Temmer  
University of Graz (on behalf of the Austrian Space Weather Community)



# SWAP - Space Weather: The Austrian Platform

- Developing a national platform for space weather
- Currently at <https://cobs.zamg.ac.at/swap>
- Cooperative project running 2021 — 2024

The screenshot shows the SWAP website interface. At the top, there is a navigation bar with the SWAP logo and menu items: Home, SW-Live, Media-Center, Glossar, Über uns, and Kontakt. Below the navigation bar, the main content area is divided into several sections:

- SW-Live:** A central dashboard displaying various space weather metrics. It includes a large circular gauge on the left showing solar activity, a central panel with several smaller gauges and indicators, and a globe on the right showing the Earth's magnetic field. The date and time are displayed as "Do., 12. Jan. 2023 10:28:36".
- Weltraumwetter Glossar:** A glossary section titled "Weltraumwetter Glossar" with a subtitle "Hier werden Begriffe aus der Weltraumwetterforschung aufgelistet und kurz beschrieben. Die englische Übersetzung wird auch gleich angeführt." It lists terms under the letter 'A' (Aktive Regionen (active regions), Sonne: Sonnenflecken), 'C' (Chromosphäre), and 'D' (Direct Current Compensation (DC)).
- Call to Action:** A section titled "Interessieren Sie sich für Weltraumwetter?" with the text "Weltraumwetter informieren oder nach möglichen" and "Hier sind Sie richtig!". A button labeled "Live-Daten" is visible.

Below the screenshot, there are two callout boxes:

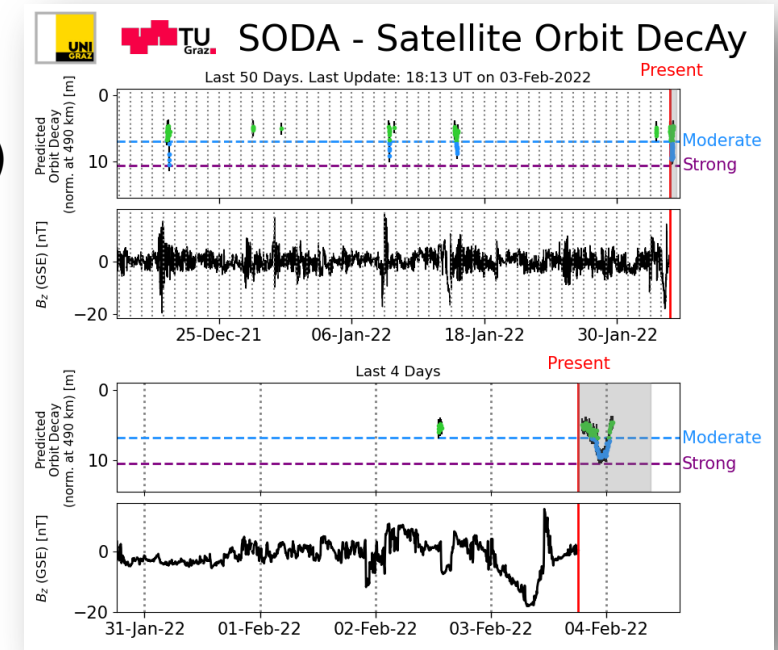
- Left Callout Box:**
  - Shows current space weather activity
  - Provides Austria-specific metrics
  - “Atlas” of national space weather competence
- Right Callout Box:**
  - German-language space weather glossary and list of press releases



**Institute of Geodesy (Working Group „Theoretical Geodesy and Satellite Geodesy“)**

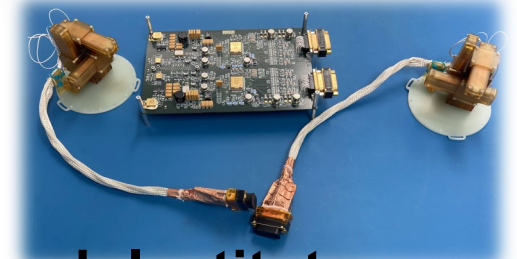
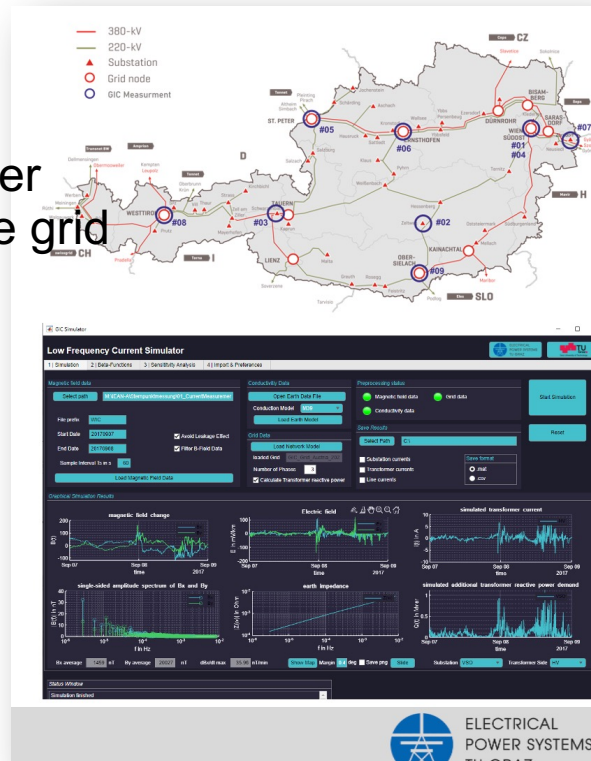
- Forecast of thermospheric densities and satellite orbit decays based on interplanetary observations at the L1 point (FFG Project).
- Investigation of atmospheric pre-conditioning and cooling effects in the Earth’s atmosphere (FWF Project).
- ESA I-ESC Expert Service Group
- Cooperation with:
  - University of Graz, Institute of Physics
  - Austrian Academy of Sciences, Space Research Institute

<https://www.tugraz.at/institute/ifg/projects/theoretical-geodesy-and-satellite-geodesy/>



**Institute of Electrical Power Systems**

- GIC measurement
- Continuous measurement of 9 transformer neutral points in the Austrian high voltage grid
- GIC calculation
- Analysis of GIC impact on power grids
- Detailed modelling of power grid assets
- Development of mitigation methods
- Simulation software available under <https://github.com/IEAN-TUGraz/LFC-Simulator>



**Space Research Institute**

Magnetometers in SWx missions

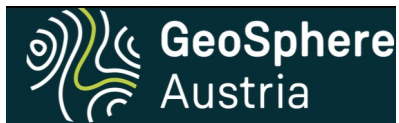
- GEO-KOMPSAT-2A, SOSMAG, SWFO, future: Vigil, FORESAIL2
- Data Analysis/Modeling on M-I coupling
- SoLo, BepiC, MMS, THEMIS, SMILE
- Cluster, THEMIS, MMS, Arase, Geotail
- Aurora & global boundaries: SMILE (2025)
- Data Analysis in collaboration with TUGRAZ, UNIGRAZ

## Kanzelhöhe Solar Observatory

- ESA Expert Service Group for Solar Weather alerting for real-time flare emission and filament eruption detection ([kso.ac.at](http://kso.ac.at))
- Regional Warning Center Austria (ISES network)

## Institute of Physics

- ESA Expert Service Group for Heliospheric and Ionospheric Weather ([swe.uni-graz.at](http://swe.uni-graz.at)): CME propagation tool, solar wind forecast, satellite orbit decay (cooperation with TUGRAZ)
- iSWAT-COSPAR international team member
- ESA L5 project for Vigil mission preparation in collaboration with Geosphere



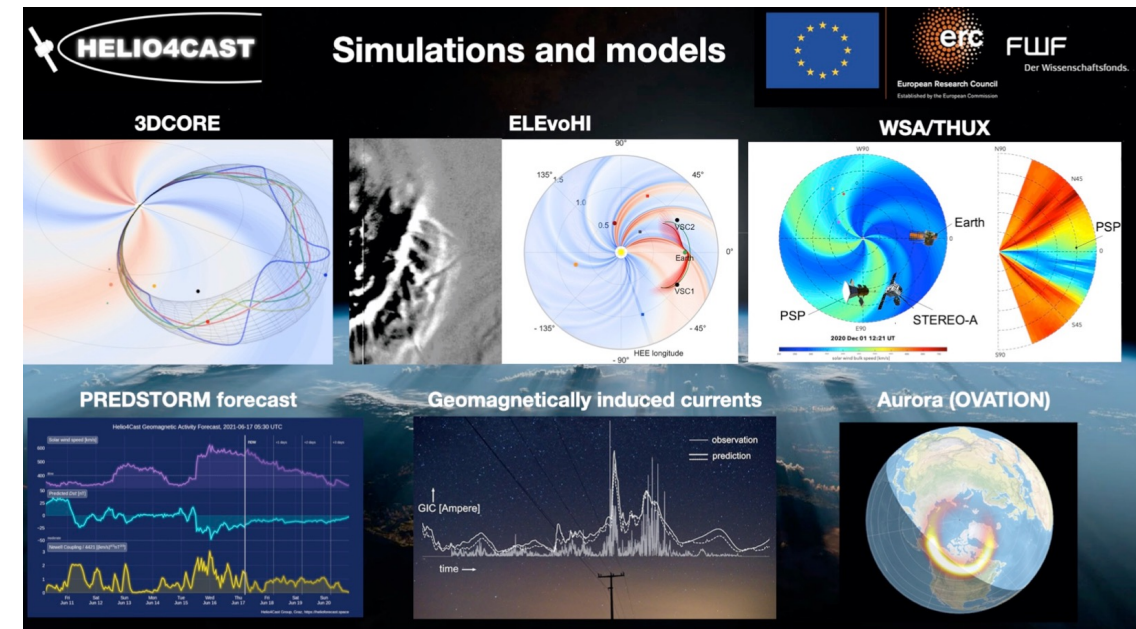
## Geosphere Austria

ZAMG = GeoSphere Austria (since Jan 2023)

- Austrian Space Weather Office (as of Sep 2022)
- Conrad Observatory for geomagnetic measurements

### Projects:

- Improving solar storm modeling with machine learning (FWF Project Amerstorfer)
- Helio4Cast (ERC Möstl; [https:// helioforecast.space](https://helioforecast.space))
- GIC now- and forecasting using geomagnetic field measurements from Conrad Observatory
- Improving solar wind forecasting at Earth





## Seibersdorf Laboratories

### Radiation exposure at aviation altitudes

- Galactic Cosmic Rays (GCR), Solar Energetic Particles (SEP)
- **AVIDOS** (aviation dosimetry) service for:
  - International Civil Aviation Organization (**ICAO**) via **PECASUS** - Partnership of Excellence for Civil Aviation Space weather User Services
  - European Space Agency - **ESA** Space Weather Service Network
  - Airlines

### Radiation detectors

- Tissue Equivalent Proportional Counter (**TEPC**) for
  - International Space Station (**ISS**)
  - On-board aircraft and terrestrial measurements

### Space radiation dose modeling

- Monte Carlo simulation techniques (**FLUKA, Geant4**)

### Radiation Hardness Assurance for space applications

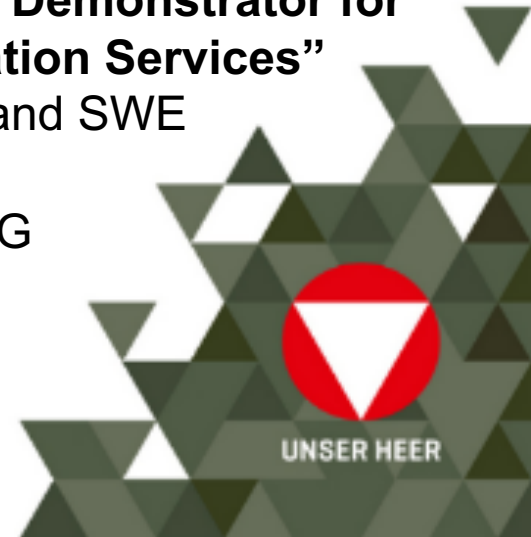
- **Accredited testing** services of space electronics

<https://avidos.seibersdorf-laboratories.at/avidos.html>



## Ministry of Defense (MoD) Austria

- **Capability Development in SSA (Space Situational Awareness) initiated:** Space Weather (SWE), Near-Earth Objects (NEO) and Space Surveillance and Tracking (SST), as well as special “military” SSA components (Space Domain Awareness)
- **Increase the awareness for SSA and SWE** (e.g. communication and PNT-services, IT, critical infrastructure) within the MoD and for national security participant in several **EDIDP** (European Defence Industrial Development Programme) and **EDF** (European Defence Fund) projects in SSA
- Development of an MoD-internal **Demonstrator for “SWE Information and Predication Services”**
- **Research cooperation** in SSA and SWE at national level
- POC: Bgdr Dr. TEICHMANN, IMG



# Summary

Space Weather is an important issue of global matter and global efforts but needs also coordinated collaboration on a national level.

- Austria with capabilities of Seibersdorf Laboratories, University of Graz, and Graz University of Technology contributes to 4 out of 5 Expert Service Centers on Solar Weather, Heliospheric Weather, Space Radiation, and Ionospheric Weather of the ESA Space Weather Service Network (<https://swe.ssa.esa.int/>).
- SWAP will further deepen and strengthen our national collaboration on Space Weather with industrial partners and “end-users” like MoD, APG, Aviation, etc. (**FFG project led by Geosphere Austria**)
- Space Weather – the Austrian Portal  
<https://cobs.zamg.ac.at/swap>
- ISES Regional Warning Center Austria (Kanzelhöhe Observatory)  
<https://spaceweather.at/weltraumwetter.at>
- Austria fully supports the UN COPUOS Expert Group Recommendations.



## Joanneum Research

- Vulnerability of satellite services and counter-measures
  - Expansion of satellite channels to higher frequencies
  - More robust satellite navigation or alternative solutions
  - Crisis management preparation
  - EMC - electromagnetic compatibility
  - EM wave propagation
- Projects on GNSS (ESA, FFG)



# Space Weather Activities in Azerbaijan

**Elchin Babayev**

**Baku State University, Baku, Azerbaijan**

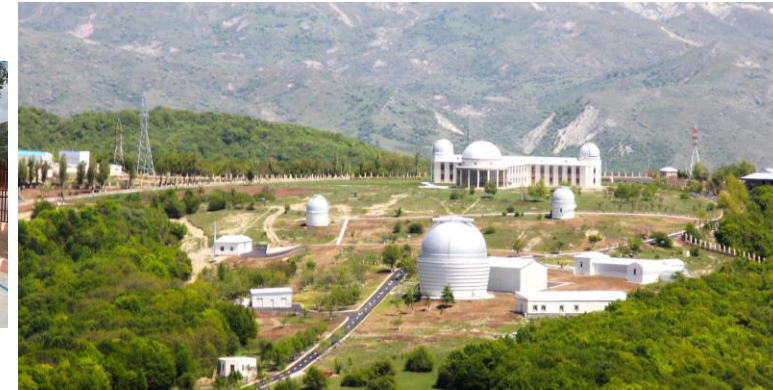
[rector@bsu.edu.az](mailto:rector@bsu.edu.az)

ISWI Steering Committee Annual Meeting

Vienna, Austria | 10 February 2023

## Main organizations

- **Baku State University (BSU):**
  - Astrophysics Department;
  - Astro-Space and Atmospheric Research Lab within Center of Excellence on Research, Development and Innovation;
  - Students' Scientific-Technical Creativity Centre.
- Shamakhy Astrophysical Observatory (ShAO)
- Batabat Astrophysical Observatory (BAO)
- Azerbaijan Space Agency (AzerCosmos)
- National Aviation Academy
- National Aero-Space Agency





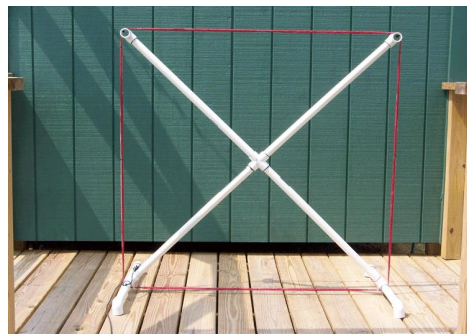
## Solar and Solar-terrestrial physics studies

- Solar and Solar-terrestrial physics - The BSU Solar Physics Group together with scientists from ShAO and BAO having collaboration and partnerships with colleagues from different countries, studies various problems of the Sun – from its interior to solar wind and space weather effects.
  - Theoretical studies:
    - Helioseismology (theoretical), global solar oscillations;
    - Solar-terrestrial physics – interplanetary magnetic field, solar wind, large-scale magnetic fields on the Sun, etc.;
  - Space weather effects' studies:
    - Impact on technologies (space-borne and on Earth);
    - Potential effects on ecological and biological systems (Heliobiological studies, etc.).

## Studies on Space Weather effects and Solar-Terrestrial Relations

- Space weather influence on technical and engineering systems (electric power supply grids, oil production activity, functioning of long pipelines, etc.);
- Space weather potential effects on human life and health (bioelectrical activity of human brain and its functional state, cardiovascular parameters, biologically active points of humans, traffic accidents, virus-epidemic diseases, influenza, etc.) and ecological systems (Caspian Sea level variations, climate changes, etc.);
- Propagation of very low frequency (VLF) electromagnetic waves in the Earth's ionosphere (AWESOME, SuperSID);
- Investigation of solar wind magnetic field distribution near the Earth;
- Study of relationship between the contrast of coronal holes on the Sun and parameters of the solar wind streams,
- etc.

## Instruments and data analysis



Horizontal solar telescope "ATsU-5"



Digitized electrocardiograms (ECGs)



Induction magnetometer



Digital EEG (Electroencephalogram)



Cardio-experiments

AWESOME

SUPERSID

We need multi-type (scientific, tutorial) instruments that can enable ground-based measurements of the space weather parameters and creating database for networking and collaboration on space weather researches

## Public awareness

We pay an attention to the public awareness and publication of scientific information about Space Weather, impending hazards from space, especially the prediction of solar and geomagnetic storms, etc. It is carried out in domestic media, newspapers, television and radio broadcasts, as regular space weather information, interviews, newspaper columns, which are addressed mainly to public, medical and technical specialists. Scientific-popular articles are usually published in special journals.



### 06-08 FEVRAL 2023-CÜ İL TARİXLƏRİ ÜÇÜN KOSMİK HAVA PROQNOZU

**Kosmik havanın hazırkı vəziyyəti** – ötən period ərzində günəş aktivliyi aşağı səviyyədə olmuşdur. C sinif aktivlik 3211 və hələ soralınmamış E limbini keçən oblastlarda müşahidə olmuşdur. 3209 və 3211 oblastlarında genişlənmə müşahidə edilmişdir. 3211 oblastında 05/10:51 UTC-də baş vermiş C6 alırması ilə əlaqədar yaranmış CME (Coronal Mass Ejection – Tac Kütlə Abılması)-nin Yere tərəf yönəlmədiyi ehtimal olunur. Hazırki periodda Yere yönəlmis müşahidə CME olunmamışdır.

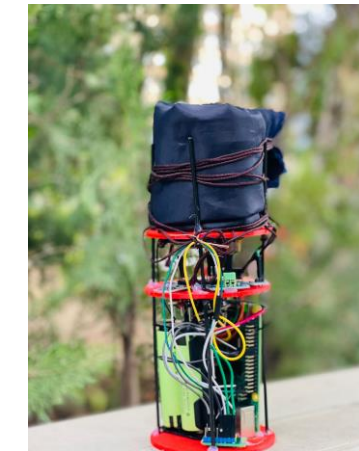
**Kosmik hava proqnozu** – 06-08 fevral 2023 -cü il tarixində müəyyən ehtimalla M (R1-R2, zəif radiokəsimlər) sinif alırmalar baş verə bilər.

**Günəşdən gələn yüklü zərrəciklərin hazırkı vəziyyəti və proqnozu** - Günəşdən gələn 2 Mev enerjili elektron seli parametrləri normal səviyyə ilə yüksək səviyyə arasında, enerjiləri 10 Mev-dən yüksək olan proton seli parametrləri isə fon səviyyəsində olmuşdur.

06-08 fevral 2023-cü il tarixində Günəşdən gələn enerjiləri 2 Mev enerjili elektron seli parametrləri yüksək səviyyədə olacaqdır. Bu periodda enerjiləri 10 Mev-dən yüksək olan proton seli parametrlərinin fon səviyyəsində olacağı gözlənilir.

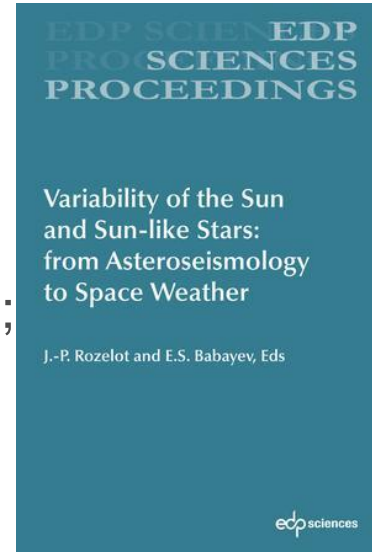
**Günəş küləyinin hazırkı vəziyyəti və proqnozu** – ötən periodda Günəş küləyinin parametrləri normal səviyyədə olmuşdur. Ümumi maqnit sahəsi 3 nTl -dən 1nTl kimi artmış, Bz komponenti +/-9 nTl intervalında olmuş, Günəş küləyinin sürəti isə 330-400 km/s ətrafında variasiya etmişdir.

06-08 fevral 2023 -cü il tarixləri üçün **CH HSS (Coronal Hole High Speed Stream- Tac Dəlilələrindən Çıxan Yüksək Sürətli Axınlar)** təsiri ilə Günəş küləyi



## Scientific events (Azerbaijan)

- International Conference “Variability of the Sun and Sun-like stars: from Asteroseismology to Space Weather”, 06-08 July 2015;
- International Space Weather Initiative (ISWI) School on Space Weather (SW) and Global Navigation Satellite Systems (GNSS), 08-12 October 2018;
- International Workshop “Actual Problems of Solar-Terrestrial Physics”, 04-07 April 2019;
- First ICESCO Workshop on Fundamentals of Instrumentation & Reverse Engineering, 04-07 October 2021;
- United Nations/Azerbaijan Workshop on the International Space Weather Initiative: The Sun, Space Weather and Geosphere, 31 October-04 November 2022.



## Upcoming scientific event

### Back in Baku after 50 Years

The origins of space activities in Azerbaijan can be traced to as far as the 13<sup>th</sup> century, and today's rapid development of the space sector in Azerbaijan builds upon this centuries-long heritage.

1973 was a milestone year for Azerbaijan's space industry as the 24<sup>th</sup> International Astronautical Congress under the theme "Space Research: Influence on Science and Technology" was held in Baku, the only city in the region that hosted this prominent event. The event has been a fundamental highlight in the history of the country - it is highly symbolic that the global space community will get together in Baku for the IAC once again half a century later, showcasing the world's latest developments and insights within the space sector.

Today, Azerbaijan is taking gradual, but firm steps towards becoming one of the leading players on the international space arena. The country and its people are dedicated to exploring the space together and tackling the global challenges through myriad opportunities that the space offers, and the 2023 edition of the IAC is another attestation of that.



On 02-06 October 2023, Azerbaijan will host the 74th International Astronautical Congress dedicated to the theme

**"Global Challenges and Opportunities: Give Space a Chance"**

<https://www.iac2023.org/>

### D5.3

#### Predicting, Testing, and Measuring the Effects of the Space Environment on Space Missions

The space environment can strongly impact the performance and reliability of space missions. It has several natural and induced components, including high-energy radiation, plasma, atomic oxygen, planetary dust, extreme temperature, vacuum, micro-gravity, micrometeoroid and debris, and molecular and particulate contamination. Environmental conditions yield constraints at the design phase, and important risks in the course of the mission. The evaluation of the nominal and worst-case conditions to be met, mitigation and protection options, and of their impact on missions and flight systems are thus of prime importance. This session will encompass the following topics: space weather, plasma, spacecraft charging, radiation, atomic oxygen, planetary dust, molecular and particulate contamination, plume-induced contamination effects and interactions, and combined environments such as flight measurements, physical processes, prediction of nominal or worst case condition, ground testing, flight experiments and lessons learned, modelling and prediction, and thermos-optical degradation effects.

#### Co-Chairs

**Henry de Plinval**  
Office National d'Etudes et de Recherches  
Aérospatiales (ONERA) — FRANCE

**Teppel Okumura**  
Japan Aerospace Exploration Agency (JAXA) — JAPAN

#### Rapporteur

**Carlos Soares**  
NASA Jet Propulsion Laboratory — UNITED STATES



**SEE YOU IN BAKU!**

**THANK YOU**

Space Weather Activities in Azerbaijan | E.S. Babayev



# ISWI Space Weather Report Bulgaria

Prepared by:

Simeon Asenovski,

Space Research and Technology Institute,

Bulgarian Academy of Sciences

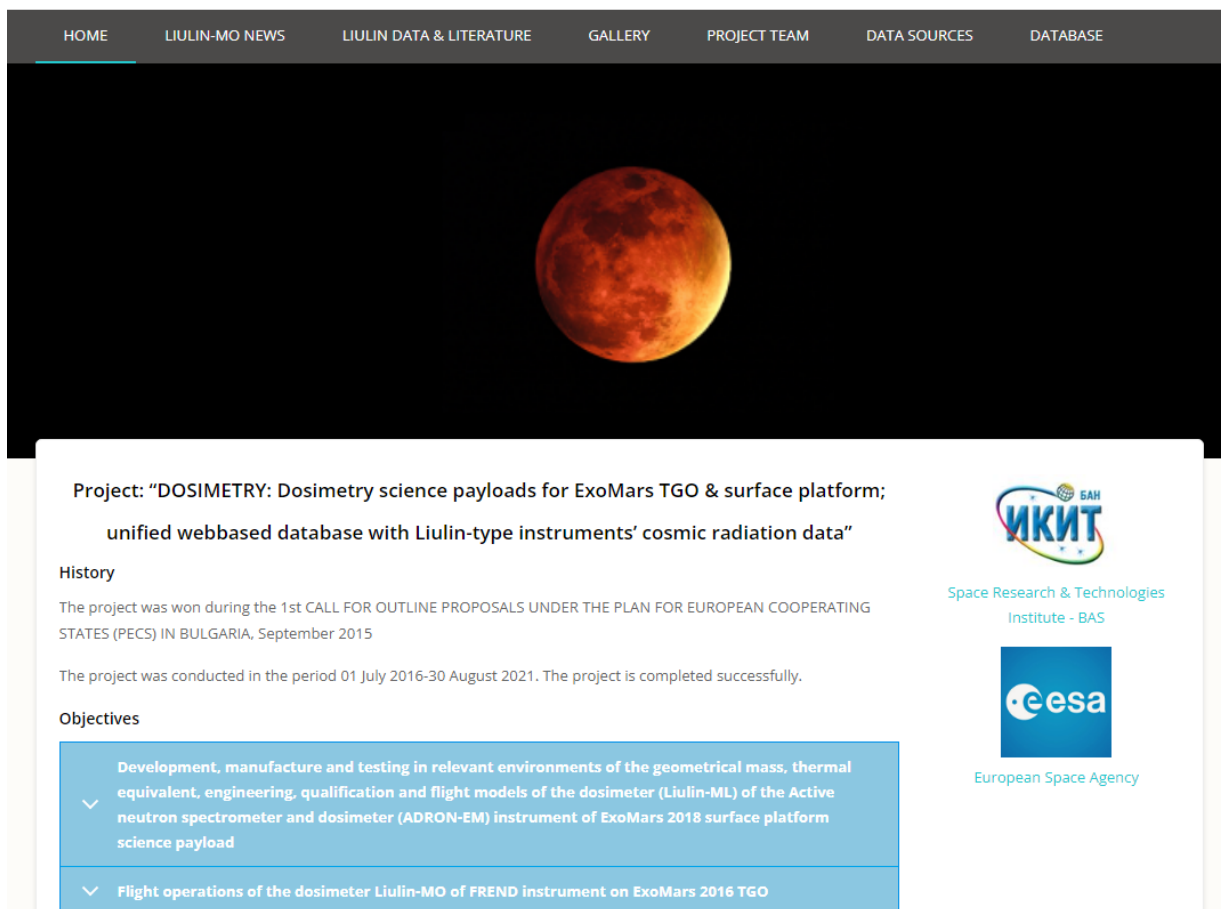
Sofia, Bulgaria




## Space weather investigations based on Liulin-MO FRENDO dosimeter onboard ExoMars TGO measurements

- Fluxes measured by the Liulin- MO instrument in Mars orbit were calculated. The calculation was made using GCR and albedo radiation models and taking into account the shadowing by Mars.
- The measured fluxes exceed the calculated values. The minimum difference between the measured and calculated fluxes is 20%. Considering the secondary radiation, the anomalous contribution of cosmic rays, and the gradient of the GCR spectrum from 1 AU to 1.5 AU, the calculated flux may increase to match the measured results.
- Based on the measured fluxes in TGO MSO, the fluxes in free space at 1.5 AU can be calculated, which can be used to benchmark the GCR models for free space at 1.5 AU
- <http://esa-pro.space.bas.bg/database>

 **DOSIMETRY: Dosimetry science payloads for ExoMars TGO & surface platform**  
Unified webbased database with Liulin-type instruments' cosmic radiation data



HOME LIULIN-MO NEWS LIULIN DATA & LITERATURE GALLERY PROJECT TEAM DATA SOURCES DATABASE




**Project: "DOSIMETRY: Dosimetry science payloads for ExoMars TGO & surface platform; unified webbased database with Liulin-type instruments' cosmic radiation data"**


**History**  
The project was won during the 1st CALL FOR OUTLINE PROPOSALS UNDER THE PLAN FOR EUROPEAN COOPERATING STATES (PECS) IN BULGARIA, September 2015  
The project was conducted in the period 01 July 2016-30 August 2021. The project is completed successfully.

**Objectives**

- Development, manufacture and testing in relevant environments of the geometrical mass, thermal equivalent, engineering, qualification and flight models of the dosimeter (Liulin-ML) of the Active neutron spectrometer and dosimeter (ADRON-EM) instrument of ExoMars 2018 surface platform science payload
- Flight operations of the dosimeter Liulin-MO of FRENDO instrument on ExoMars 2016 TGO

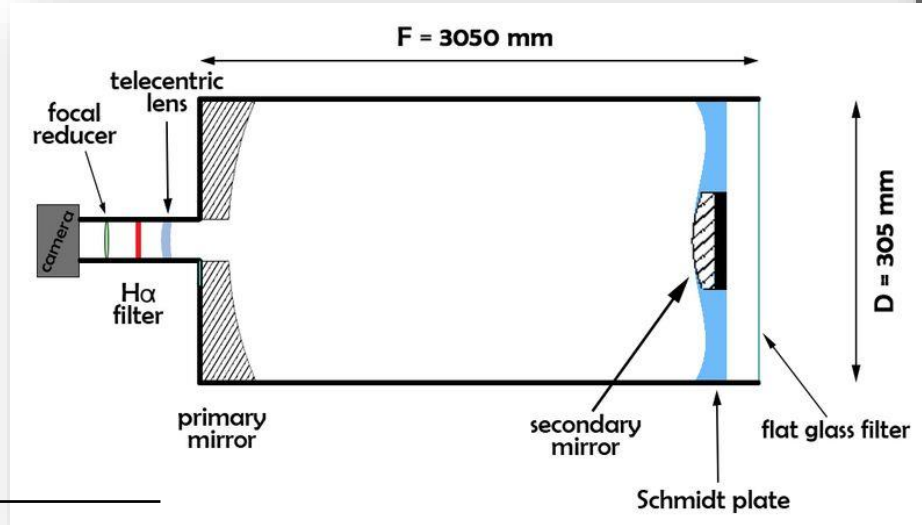


Space Research & Technologies Institute - BAS

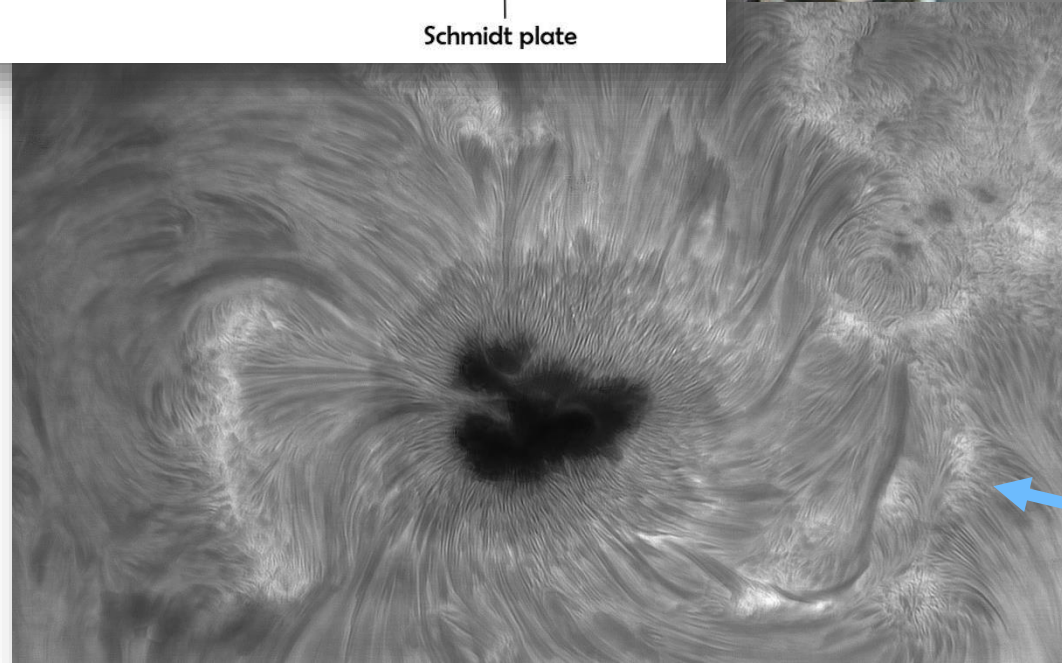


European Space Agency

# New 30-cm Chromospheric Telescope at NAO Rozhen



| Parameter                         | Value                               |
|-----------------------------------|-------------------------------------|
| Aperture $D$                      | 305 mm                              |
| Focal length $F$                  | 3050 mm                             |
| Effective focal length $F_{eff}$  | 5000-15000 mm                       |
| Field of view                     | $2.5' \times 2.5' - 10' \times 10'$ |
| Spectral range                    | 656.28 nm (H $\alpha$ )             |
| Spatial resolution                | 0.5''                               |
| Line-of-sight velocity resolution | 0-10 km/s                           |



First light



# Space, Ecology, Safety – SES 2022

## Sofia, Bulgaria 2022

- The Eighteenth International Scientific Conference “Space, Ecology, Safety - SES 2022”, Sofia, Bulgaria, was held from October 19 to 21, 2022
- Aerospace Technologies, Remote Sensing and Geoinformation Systems, Ecology and Risk Management, Space Material Science and Nanotechnology, **Space Weather**, (<http://www.space.bas.bg> )

*We are made of star-stuff. Carl Sagan (1934 – 1996)*  
*Изградени сме от звезден прах. Карл Сейгън (1934-1996)*

**SES 2022**  
 Eighteenth International Scientific Conference  
 SPACE, ECOLOGY, SAFETY  
 19 - 21 October 2022, Sofia, Bulgaria

**PROCEEDINGS**  
**SES 2022**

ИКИТ SPACE RESEARCH AND TECHNOLOGY INSTITUTE  
 БУЛГАРИЯ АСТРОНАУТИЧЕСКОТО ОБЩЕСТВО  
 БУЛГАРИЯ АКАДЕМИЯ НА НАУКИТЕ

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 p-ISSN 2603 – 3313 e-ISSN 2603 – 3321  
 2022

The conference was dedicated to the 50th anniversary of space research in Bulgaria.

<https://spaceclimate.bas.bg/ws-sozopol/>

## Welcome to 2022 Workshop Solar Influences on the Magnetosphere, Ionosphere and Atmosphere



ФОНД  
НАУЧНИ  
ИЗСЛЕДВАНИЯ  
МИНИСТЕРСТВО НА ОБРАЗОВАНИЕТО И НАУКАТА

**SOSTEP**  
Scientific Committee on Solar-Terrestrial Physics



Workshop Program

The 14th Workshop will be held during 6-10 June 2022 in Primorsko, Bulgaria.

The topics include but are not restricted to:

- 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 processing and modelling


ISSN 2367-7570

Workshop  
"Solar Influences on the Magnetosphere,  
Ionosphere and Atmosphere"

**Book  
of  
Proceedings**

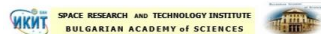
Fourteenth Workshop  
June, 2022

DOI: 10.31401/WS.2022.proc  
Book of Proceedings, Fourteenth Workshop, 2022



- About
- Practical Information
- 13th Workshop
- ● 14th Workshop
- Proceedings
- Publication Ethics
- Old Website

FOURTEENTH WORKSHOP  
Solar Influences on the Magnetosphere,  
Ionosphere and Atmosphere  
Primorsko, Bulgaria, June 06+10, 2022



DOI: 10.31401/WSoz.2022.abs  
Book of Abstracts, Fourteenth Workshop, 2022

WorkshopProgramFinal1.pdf 3 / 5 100% +

|               |   |
|---------------|---|
| 10:00 – 10:20 | <a href="#">Semkova J., Koleva R., Benahin V., Krastev K., Matviichuk Y., Tomov B., Bankov N., Maltchev S., Dachev T., Mitrofanov L., Malakhov A., Kozvrev A., Golovin D., Mokrousov M., Sanin A., Litvak M., Nikiforov S., Lisov D., Anikin A., Shurshakov V., Drobyshev S. Observation of Solar Energetic Particle Events Onboard ExoMars TGO in July 2021-March 2022</a> |
| 10:20 – 10:40 | <a href="#">Dachev T., Tomov B., Matviichuk Y., Dimitrov P., Semkova J., Koleva R., Jordanova M., Bankov N., Mitev M., Krastev K., Malchev S., Reitz G., Header D.-P. Overview of the Space Radiation Extreme Events Observed with Liulin Type Instruments</a>  |
| 10:40 – 11:00 | <a href="#">Kilcik A., Tirnakci M. Comparison of the Critical Frequencies of the Ionospheric F1 and F2 Layers with the X-Ray Solar Flare Numbers Observed during the Solar Cycle 24</a>   |
| 11:00 – 11:20 | Coffee break  |
| 11:20 – 11:40 | <a href="#">Demetrescu C., Dobrica V., Stefan C. Toward the Space Climate Characterization of the Heliosphere – Magnetosphere Environment for the Last 400 Years</a>  |
| 11:40 – 12:00 | <a href="#">Gerasimov M., Veselin E., Vasil U., Akhmetov S., Mihalev D. Effect of Solar Wind</a>  |

The 15<sup>th</sup> Workshop in 2023...

# Topic: On space weather effects at near Earth environment - from remote observations and in situ particle forecasting to impacts on satellites

New Bulgarian Egyptian inter-academy project (IC-EG/08/2022-2024)  
PI (BG) Rositsa miteva; PI (EG) Susan Samwel

## Objectives:

- (1) application of novel theoretical/numerical models and forecasting schemes,
- (2) analyses of remote and in situ observations and
- (3) research on the influence of these events on space technologies (satellites).

## Aim:

- to improve the scientific understanding of the chain of physical processes that take place from the solar corona to near Earth orbit,
- to evaluate the selected forecasting methods and
- to transfer the new results into operational guidelines where possible

## Work packages:

- (1) SEP events: Final development, validation and operational application of new SEP forecasting methods
- (2) Solar events: Remote observations and in depth data analysis
- (3) Impact on satellites: Qualitative and quantitative evaluation of satellite risks caused by space weather events



# **Space Weather Products and Services, Czech Republic**

**Dalia Buresova**

*Institute of Atmospheric Physics of the ASCR, Prague*

**Pavel Hejda,**

*Institute of Geophysics of the ASCR, Prague*

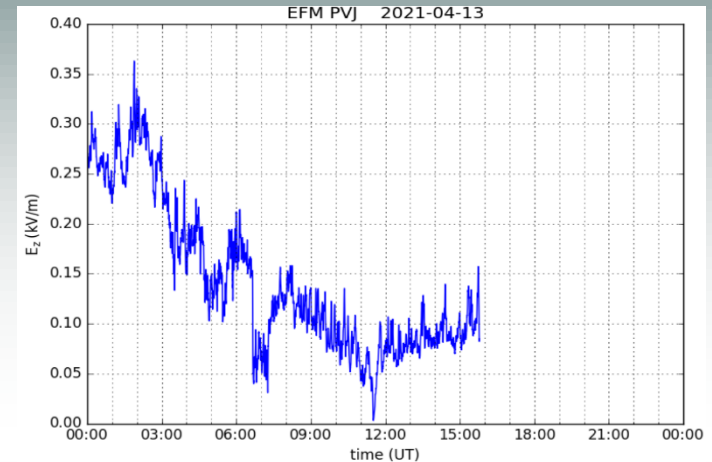
**and Regional Warning Center Prague Team**

## Services and products

- There is in operation Regional Warning Center (RWC) Prague of ISES which integrates activities of the Astronomical Institute (Solar Department), the Institute of Atmospheric Physics (IAP) and the Institute of Geophysics (Geomagnetic Department) of the Academy of Sciences of the Czech Republic. It provides users with the forecasts of solar activity, ionospheric conditions and geomagnetic activity. Actual as well as archived data and products can be found at <http://rwcprague.ufa.cas.cz>
- IAP runs the GIRO DIDBase (worldwide digisonde database) mirror database.
- Several own instruments and experimental networks to monitor SW effects on the Earth's upper atmosphere.
- Contributes with data and expertise to the international collaborative projects and world databases

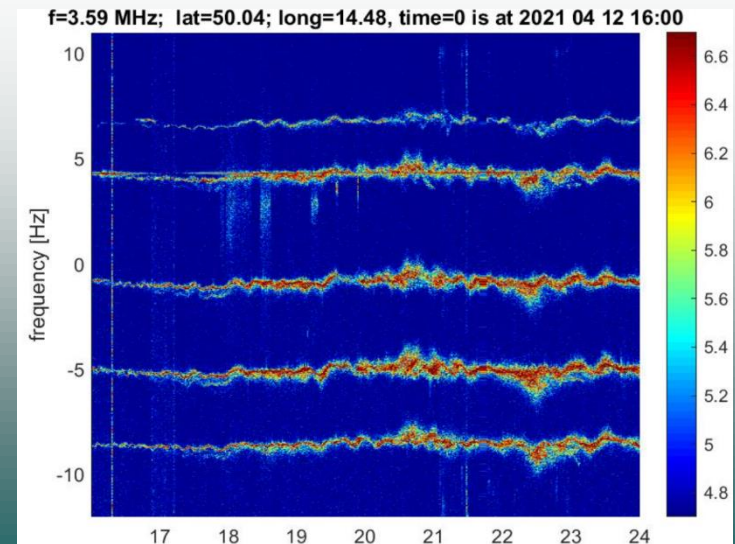
# Institute of Atmospheric Physics, Czech Academy of Sciences (IAP CAS) <https://www.ufa.cas.cz/>

## Atmospheric electricity monitoring



**Digisonde DPS4D** - vertical and oblique sounding, ionograms, ionospheric drifts and their parameters

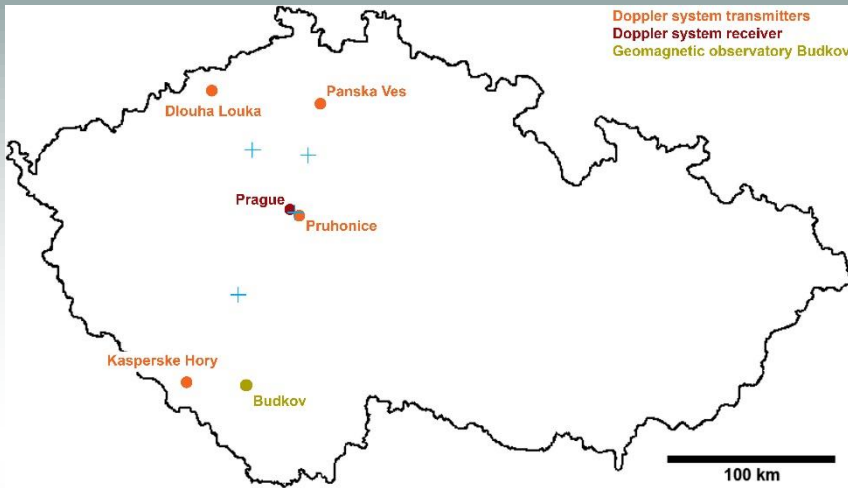
**Continuous Doppler Sounding System (CDSS)** – national and international networks (South Africa, Argentina, Taiwan, Belgium, Slovakia) provides ionospheric Doppler shift measurements, information on ionospheric irregularities and their characteristics and AGW activity.





# A distribution of the Doppler system over the Czech Republic (locations of transmitters and receiver)

The Doppler system is mainly sensitive to the vertical movement of reflection layer ( $f=f_p$ )

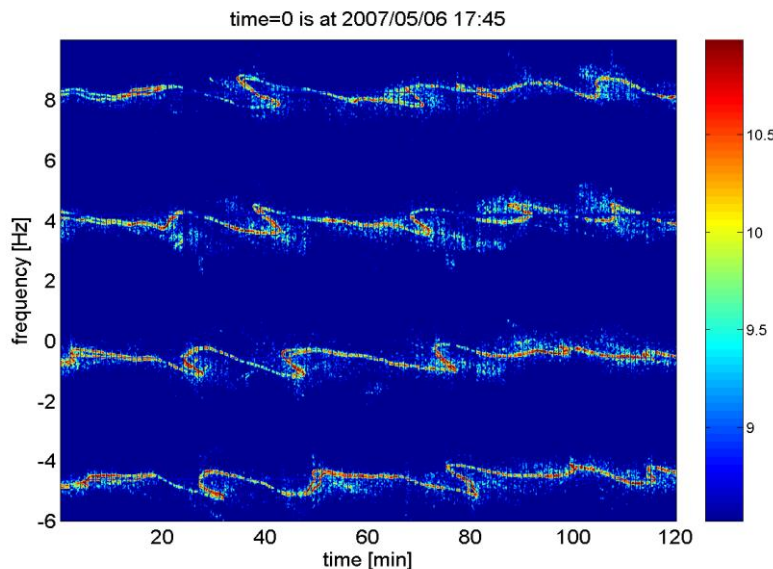


Transmitters (sounding frequencies in MHz shifted  $\sim 4$  Hz to have all traces in one spectrogram):

- 1) Panska Ves :  $50^{\circ}32'N, 14^{\circ}34'E$
- 2) Pruhonice:  $49^{\circ}59'N, 14^{\circ}32'E$
- 3) Dlouha Louka:  $50^{\circ}39'N, 13^{\circ}39'E$
- 4) Kasperske Hory:  $49^{\circ}08'N, 13^{\circ}35'E$

Receiver: ( $\Delta f=1$  Hz ...  $v_z=41.7$  m/s)

Inst. of Atm. Physics:  $50^{\circ}02'N, 14^{\circ}29'E$



Four stable sounding frequencies and five sites in the Czech Republic. Three of them are supported by microbarographs.

Main GW parameters could be obtained from the measured Doppler shifts.

# EC HORIZON - RIA T-FORS Project (10 European institutions involved)

**CDSS system will be used as part of instrumentation for monitoring of MSTIDs generated by different sources (e.g., SW events, seismic events, solar terminator, severe tropospheric convection)**

The main objective of the **T-FORS** project is the development of new validated models able **to issue forecasts and alerts for TIDs several hours ahead**, exploiting a broad range of observations of the solar corona, the interplanetary medium, the magnetosphere, the ionosphere and the atmosphere. The specific objectives:

- Develop new prediction models based on databases of detected TID characteristics and of their drivers developed in the frames of past Horizon 2020 and national projects, using Machine Learning (ML Learning) algorithms to forecast the occurrence and propagation characteristics of large scale TIDs and statistical modelling to estimate the occurrence probability and propagation pattern of medium scale TIDs;
- Propose a comprehensive architectural concept, including the densification of ground instrument networks, and new space missions, and possible future adjustments in order to develop a real-time operational service compatible and complementary to the ESA Space Weather services.

**The Sudden Ionospheric Disturbances (SID)** are measured at the Observatory Panska Ves. The observatory is located 60 km to the north of Prague. The SIDs are monitoring by means of radio wave propagation observation in the lower ionosphere. Short wave fade-out effects are evaluated at the distance of 610 km for a frequency of 5955 kHz. Sudden field anomaly effects are evaluated from measurements at the distances of about 1000-km for the frequencies of 162 and 198 kHz. Sudden enhancements of atmospherics are determined from measurements of the atmospheric noise level at 27 kHz. The measurements are evaluated daily and the relevant information is forwarded to the RWC Prague and WDC-A Boulder.



# TechTIDE project HF-TID network (including possible extension)



Pruhonice digisonde is a part of Digisonde-to-Digisonde (D2D) sounding network built to monitor and nowcast the LSTID activity over Europe.



## 1D Altitude profile of TID

- Detailed view of propagation along z-axis
- Pin-point to particular altitude region

## Sensitivity (amplitude) Detection

- of a 5% TID vs underlying density
- “TID are always present” < 2%

## Direction, Velocity, Wavelength

- Direct measurement
- Static platform
- No geometric transformation needed
- 24/7 operations with automatic intelligent system analysis



ILMATIETEEN LAITOS  
METEOROLOGISKA INSTITUTET  
FINNISH METEOROLOGICAL INSTITUTE

# Space weather activities in Finland

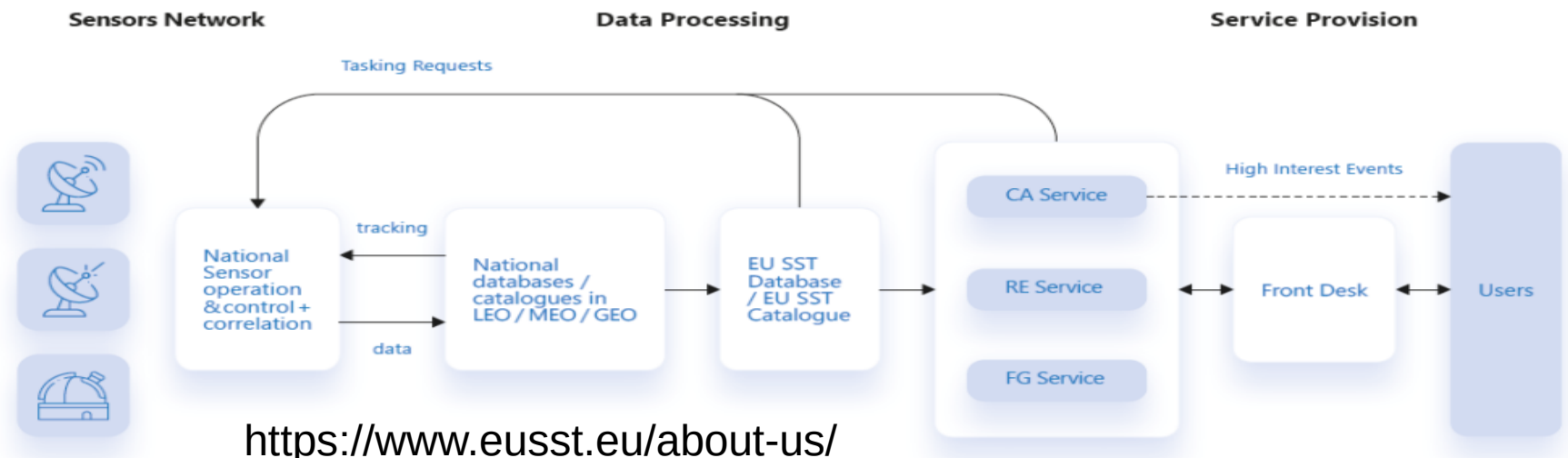
Ilja Honkonen

2023-01-31



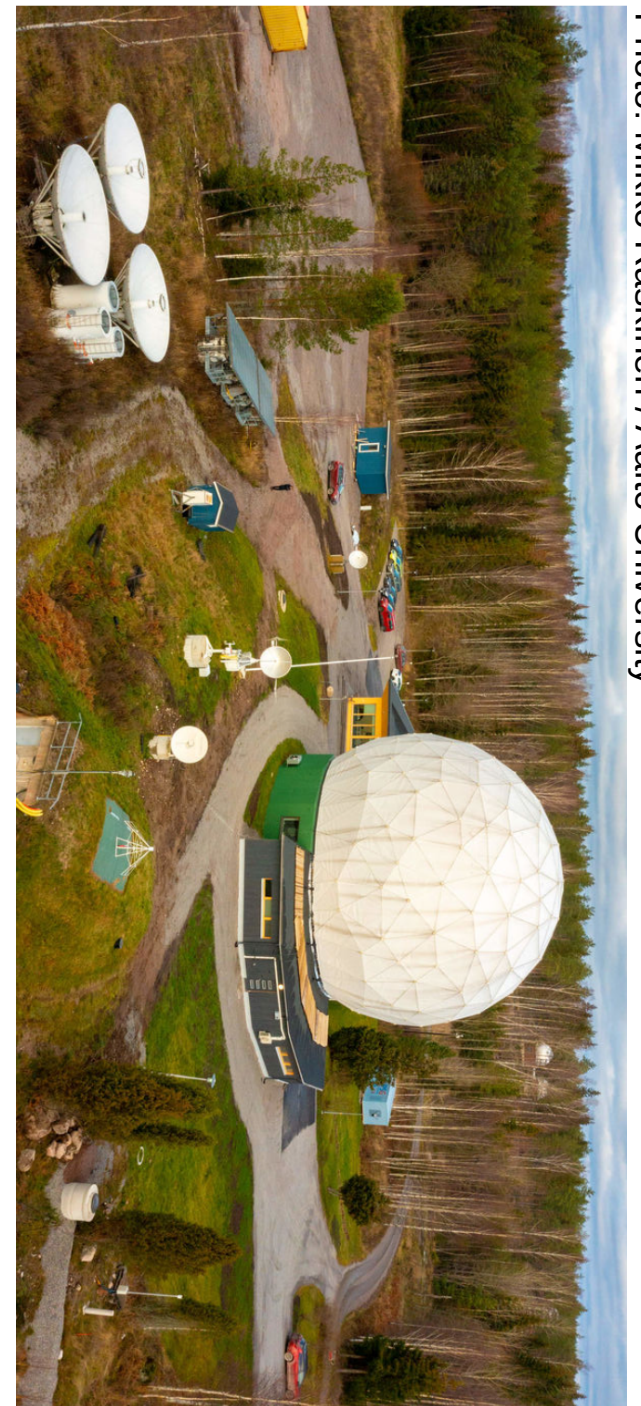
# Finland joined EU SST

- Space surveillance and tracking in EU
  - Sensors: radars, telescopes, laser ranging stations, etc.
  - Processing: coordination of data-sharing
  - Services: collision avoidance, re-entry and fragmentation analysis
- Newest members: AUT, CZE, DNK, FIN, GRC, LVA, NLD, SWE



# Major facelift in Metsähovi

- Radio observatory has new premises
  - Old buildings renovated
- 14 m radio telescope renewed
  - Steering system upgraded
  - Prototype water vapor radiometer
- New MCA telescope (5.5 m, 4-8 GHz)
  - Second under construction
- New auroral camera



# New satellite receiver in Sodankylä

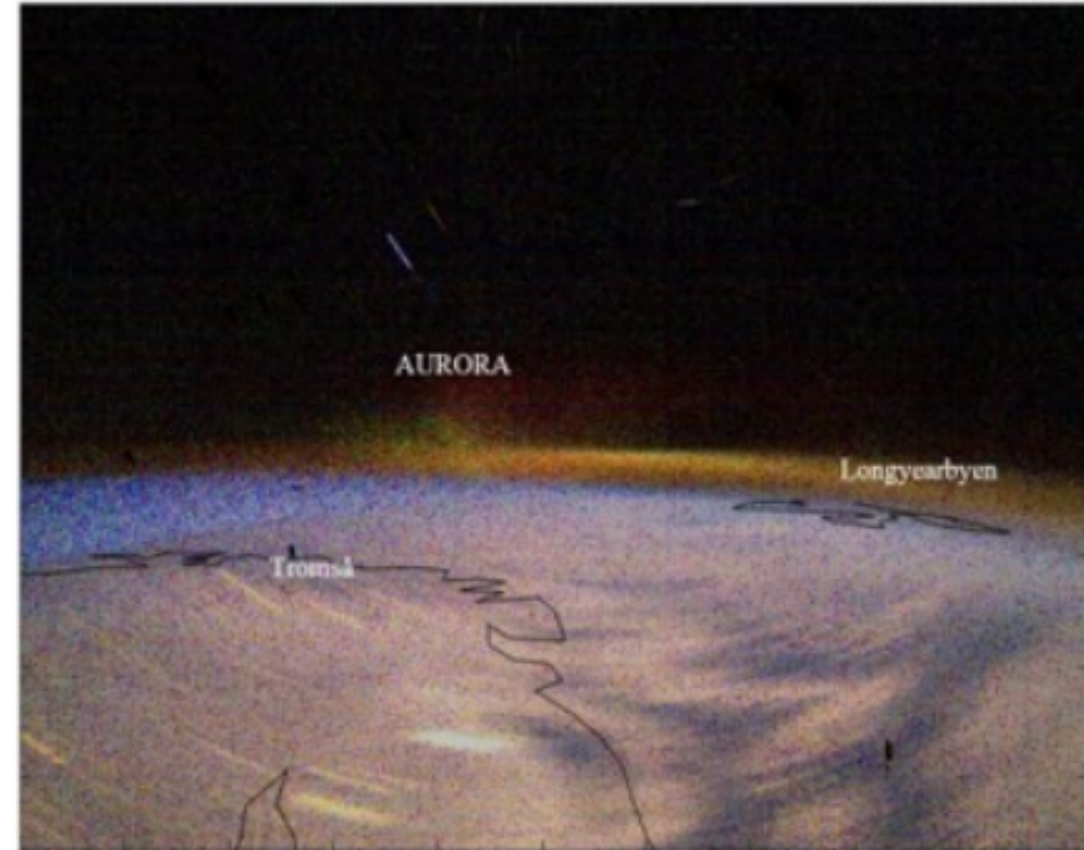
- SOD04
  - 3.7 m diameter antenna
  - NASA EOS
  - NOAA-20 and Suomi-NPP
  - EUMETSAT MetOp-B & C
- Identical SOD05 in ~2023
- Site already included two 7.3 m diameter antennas





# Satellites

- Suomi 100 was first cubesat to photograph an aurora
  - Launched in 2018-12-03
- Foresail 1
  - Launched in 2022-05-26
  - No contact since 2022-06
  - Declared lost in 2022-11
  - Second under construction



# Some ongoing research in Finland

- PECASUS space weather monitoring for civil aviation
- HISSA ionospheric situational awareness
- KAIRA 3D incoherent scatter radar
- [Vlasiator](#) ion-kinetic modeling of Earth's magnetosphere
- [Lapland satellite 1](#)
- [TomoScand](#) ionospheric tomography

Report by Frédéric Pitout  
National coordinator for France

Highlights on:

1. On-going efforts to offer space weather services
2. Deployment of VLF receivers
3. European Space Weather week
4. IMCP Europe-Africa-Pacific

## Space weather services

On-line services dedicated to space weather: data and orbit visualisation in 2D/3D, data mining, modelling, etc.

Several French labs participate to these efforts.

[cdpp.eu](http://cdpp.eu)

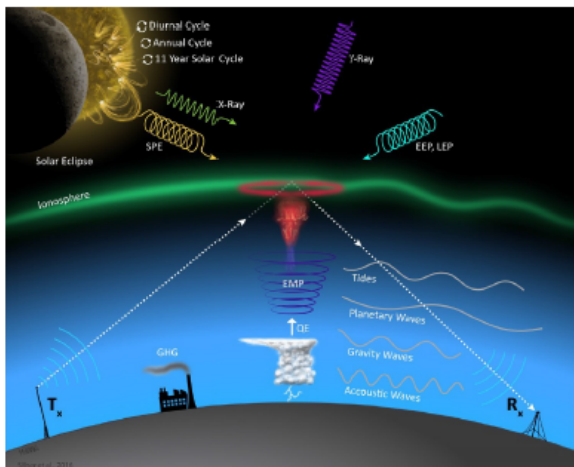


The screenshot displays the CDPP (Plasma physics data center) website. The header features the CDPP logo and the text "CDPP Plasma physics data center". The navigation menu includes "About", "Data", "Services", "Resources", "Mission support", and "EU/ESA projects". The "Services" menu is expanded, listing: "Amda", "3DView", "Propagation Tool", "Space Weather Tool", "TREPS", and "Scientific Libraries". The main content area shows a 3D visualization of a plasma structure with a "Moon" label. The footer contains "CDPP News" and a description: "The CDPP is the French national data centre for natural plasmas of the solar system."

The CDPP is the French national data centre for natural plasmas of the solar system.

# VLF for IONospheric Studies

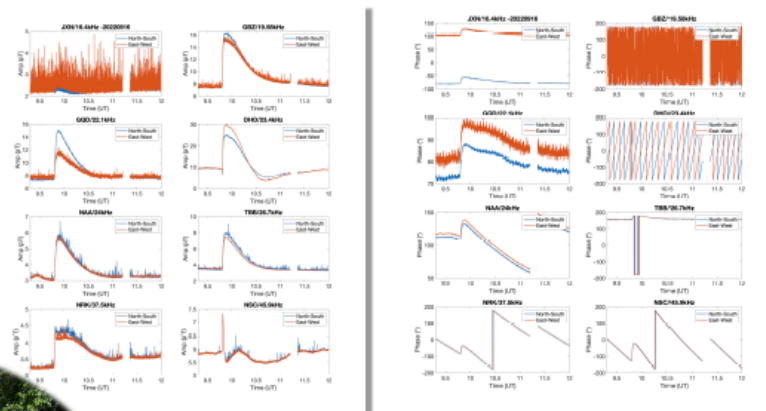
Why VLF/LF emissions to probe the ionospheric D-layers?



## Societal impact

The D-layer is partly responsible for the HF-emission absorption. Estimating the magnitude of the HF-absorption and its duration is of great interest for several industrial applications, in particular civil aviation communication. Estimating the HF-disturbances induced by solar flares is one of the goal of this project.

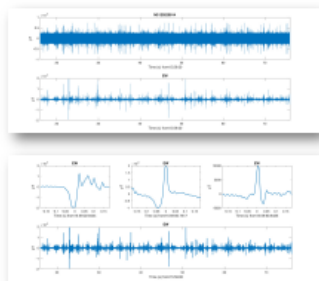
Flares signature in VLF



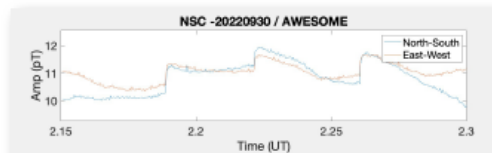
M8.2 Flare of Sept. 16th, 2022. Left: Amplitude; Right: Phase

## Lightning Signature

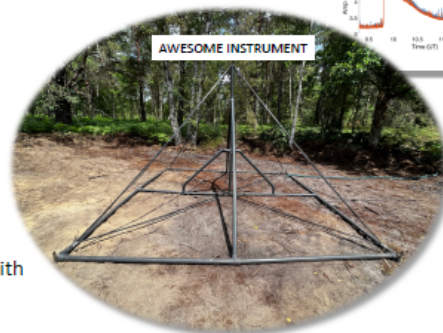
Return strokes generate heating and enhanced ionization of the D-layer. With climate change, the number and strength of strokes may increase. Sprites, Elves, and other strokes related event are clearly observed in broadband or narrowband measurements.



Broadband mode (@1MHz resolution)  
Top panel: waveforms on the two antennas during 60s  
Bottom panel: zoom on three stroke signatures from the EW antenna



Short time period during night. The amplitude increase is typical from Early/fast events. The storm was close to the Sardinia-Paris line



→ Electron density perturbation

Towards a VLF network across equatorial regions

A network of AWESOME instruments will be deployed around the equator, taking advantages of the French territories. The aim is to provide:

- ✓ A continuous survey of over-the-ocean ionospheric regions;
- ✓ Measurements strokes-related D-layers perturbations;
- +
- ✓ Real-time estimate of on-going flare strength;
- ✓ Real-time estimate of HF absorption.

Join the team of VLF4IONS project!

## European Space Weather Week

France will host the next edition of the European space weather week in Toulouse (20-24 November 2023).

Call for sessions has just opened.

The week or week-end before, a space weather school is planned. Would ISWI fund young researchers to attend ?



**19th European Space Weather Week**

Bringing Space Weather, Space Climate, And Engineering Together

20-24 November, 2023  
Toulouse, France

HOME ▾ COMMITTEES ▾ PROGRAM ▾ SUBMIT A PROPOSAL ▾ PARTNERSHIP LOCATION CONTACTS PAST EVENTS

The banner features a dark background with a large, fiery sun or solar flare in the center. The text is white and bold. The navigation menu is located below the main text. Below the menu is a photograph of a bridge at night with a large domed building in the background.

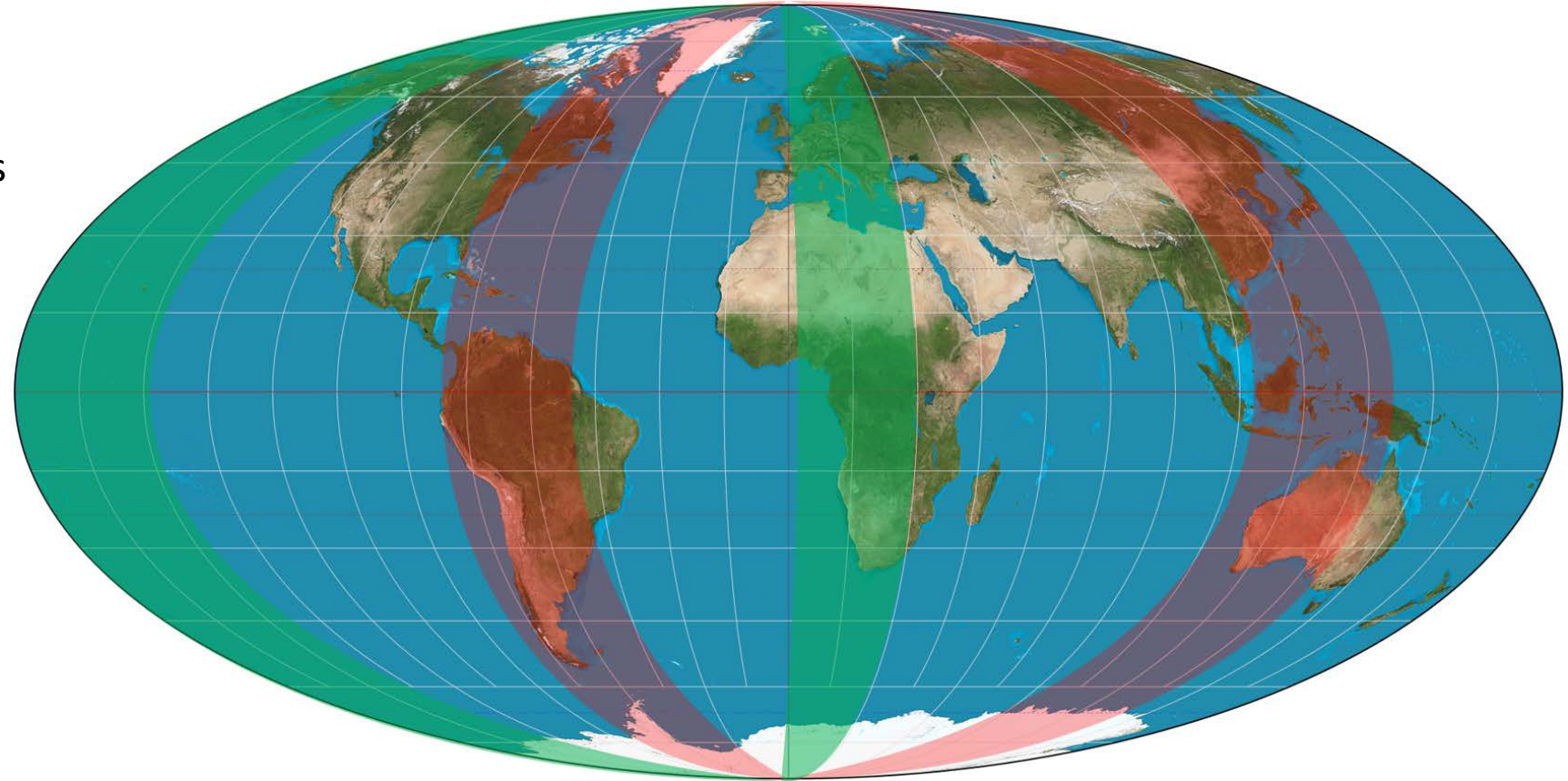
# International Meridian Circle Program

Objectives: deploy, exploit, and coordinate ground-based instruments along meridian circles.

China leads the  $120^{\circ}\text{E} + 60^{\circ}\text{W}$  meridian circle.

We would like to reactivate and extend the initial project with a Europe-Africa-Pacific meridian circle ( $165^{\circ}\text{E} + 15^{\circ}\text{W}$ ).

Could we count on ISWI to help us out?



# Solar and Space weather studies in Georgia

Bidzina Shergelashvili



Director of Centre for Computational Helio Studies, Associate professor Ilia State University  
and



Senior researcher at Division of the Sun and solar system studies of  
Evgeni Kharadze Georgian National Astrophysical Observatory

ISWI steering meeting, Vienna, 10th February 2023



## Our partners:



**KU LEUVEN**



**ÖAW**

RUHR-UNIVERSITÄT BOCHUM

**T $\Phi$  INSTITUT FÜR THEORETISCHE PHYSIK IV**  
LEHRSTUHL FÜR WELTRAUM- UND ASTROPHYSIK



**INSTITUTE OF RADIO ASTRONOMY**  
*National Academy of Sciences  
of Ukraine*

## Funding sources:



**DFG**  
Deutsche  
Forschungsgemeinschaft



# Solar high-degree p-modes in differentially rotating layer

Woodard, 1989 vol. 347 p. 1176

Shergelashvili and Poedts, 2005 A&A vol. 438, p. 1083

$$w = w_{n,k(x)} + m\Omega(x) . \quad \delta(k^2)/k^2 = \delta(k_\theta^2)/k^2 = 4g_{n,k} \delta w/w ,$$

$$w = w_{nl} + m\bar{\Omega} ,$$

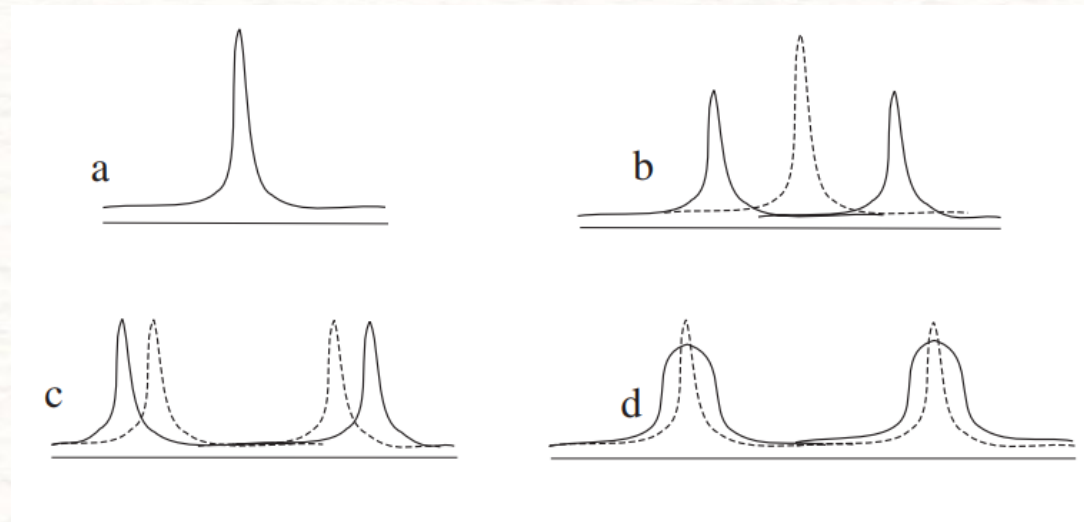
$$g_{n,k} = \frac{w}{2k} \left/ \frac{\partial w_{n,k}}{\partial k} \right. .$$

$$k_x = k_{x0}, \text{ but}$$

$$k_y(t) = k_{y0} - ak_x t.$$

$$k_z(t) = k_{z0} - (bk_{x0} + ck_{y0}) t + \frac{ack_{x0}}{2} t^2 .$$

$$\delta w(x) \equiv m[\bar{\Omega} - \Omega(x)] ,$$

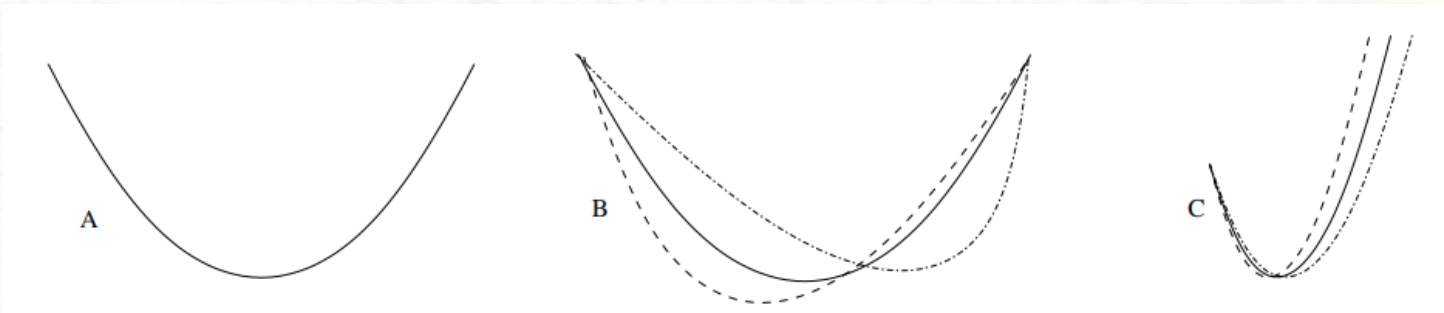


$$\begin{aligned} \omega &= V_{01}k_x + V_{02}k_y - y \frac{\partial k_y}{\partial t} - z \frac{\partial k_z}{\partial t} - \frac{\partial \varphi(t)}{\partial t} \\ &= (\mathbf{k} \cdot \mathbf{V}_0) - \frac{\partial \varphi(t)}{\partial t} , \end{aligned}$$

where,

$$\frac{\partial \varphi(t)}{\partial t} = -\sqrt{\frac{1}{2}W + \frac{1}{2}\sqrt{W^2 - 4\omega_b^2 C_s^2 k_h^2(t)}} ,$$

$$W = C_s^2 (k_h^2(t) + k_z(t)^2) + \omega_a^2 .$$



# MHD waves in shear flows

Shergelashvili et al, 2006 ApJL vol. 642 p. L73

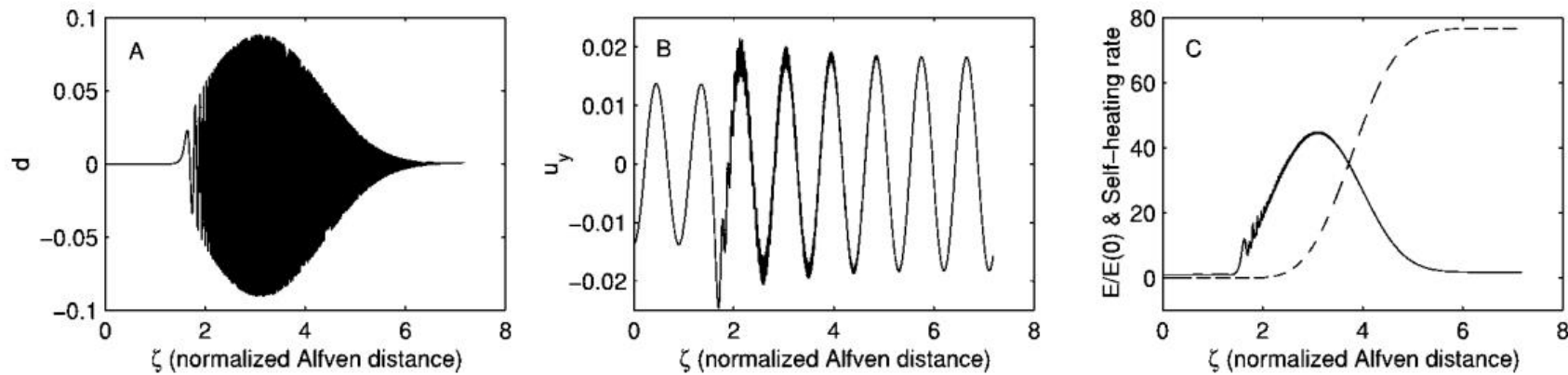


FIG. 1.—Plots of different physical quantities against the dimensionless time variable  $\zeta = V_A t / R_\odot$ , which represents the Alfvén distance ( $V_A t$ ) in units of the solar radius. (a) Normalized density perturbation  $d$ ; (b) dimensionless  $y$ -component of the velocity perturbation,  $u_y$ ; (c) total perturbation energy normalized by its initial value (*solid line*) and the self-heating function (eq. [7]) (*dashed line*).

# MHD in media with variable in time entropy

Shergelashvili et al, 2007 Phys. Rev. E vol. 76, p. 046404

$$\hat{\Omega}_{F,S}^2 = \frac{1}{2} [C_{11} + C_{22} \pm \sqrt{(C_{11} - C_{11})^2 + 4C_{12}^2}].$$

$$\ddot{X}_F + (\hat{\Omega}_F^2 - \dot{\theta}^2)X_F = \ddot{\theta}X_S + 2\dot{\theta}\dot{X}_S,$$

$$\ddot{X}_S + (\hat{\Omega}_S^2 - \dot{\theta}^2)X_S = -\ddot{\theta}X_F - 2\dot{\theta}\dot{X}_F,$$

$$\frac{Dp_0}{Dt} - \frac{\gamma p_0}{\rho_0} \frac{D\rho_0}{Dt} = (\gamma - 1)\mathcal{L}_{01}(t).$$

$$\mathcal{L}_{01} = T_0[-(\nabla \cdot \mathbf{J}_{s01}) + \sigma_{01}]$$

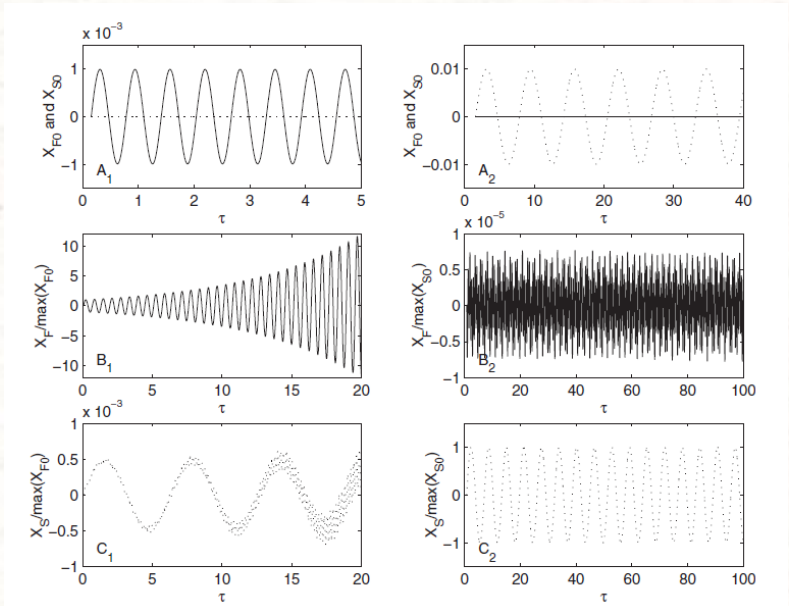


FIG. 1.  $X_F$  (solid lines) and  $X_S$  (dotted lines) plotted against time  $\tau$ .

$\beta \gg 1$

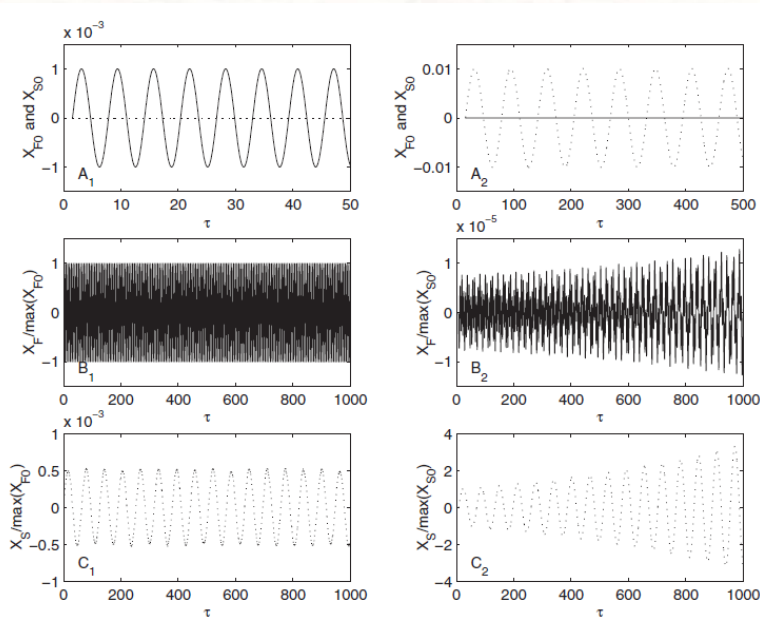


FIG. 2. As in Fig. 1 for  $\xi \ll 1$ .

$\beta \ll 1$

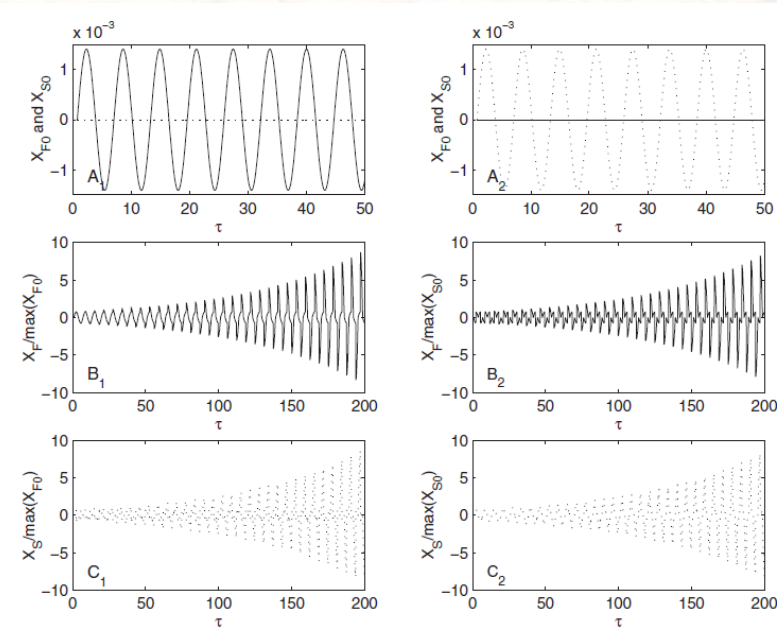


FIG. 3. As in Fig. 1 for  $\xi = 1$ .  $K_x = 0.00005$ .

$\beta \cong 1$

# (Alfvén) Wave Turbulence

Shergelashvili and Fichtner 2012 ApJ vol. 752 p. 142  
and references therein

$$\frac{\partial P}{\partial t} + \nabla \cdot [(\mathbf{u} + \mathbf{v}_A)P] + \frac{P}{2}(\nabla \cdot \mathbf{u}) = -\frac{\partial F}{\partial f}.$$

wave power  $P$  (Tu et al. 1984):

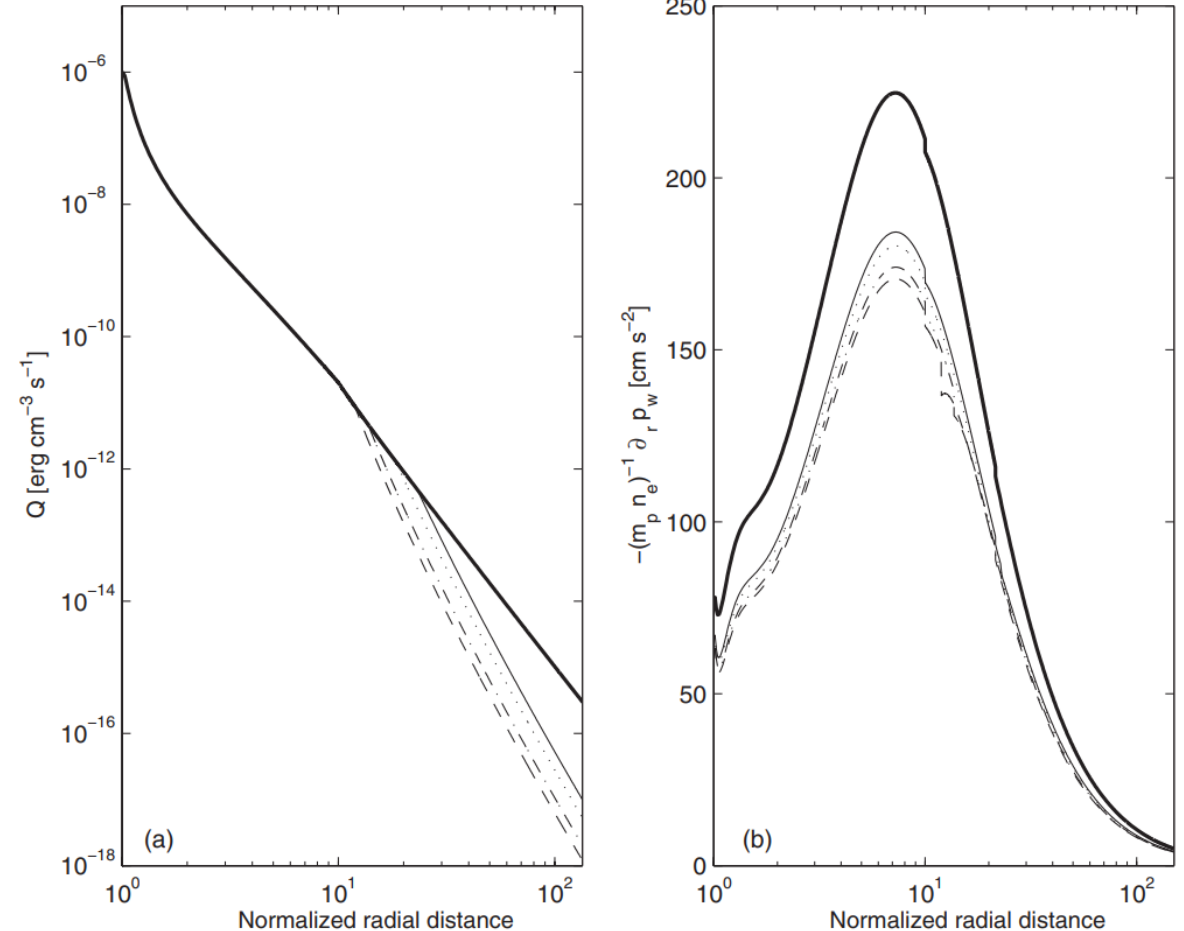
$$\nabla \cdot [(\mathbf{u} + \mathbf{v}_A)P] + \frac{P}{2}(\nabla \cdot \mathbf{u}) = -\frac{\partial F}{\partial f},$$

$$p_w = \frac{1}{8\pi} \int_{f_0}^{f_H} P df.$$

$$\frac{\partial p_w}{\partial t} + \nabla \cdot [(\mathbf{u} + \mathbf{v}_A)p_w] + \frac{p_w}{2}(\nabla \cdot \mathbf{u}) + \frac{Q_w}{2} = 0$$

$$Q_w = Q_{w1} + Q_{w2} = \frac{1}{4\pi} [F(f_H) - F(f_0)] + \frac{(\mathbf{u} + \mathbf{v}_A)}{4\pi} \cdot [P(f_0)\nabla f_0 - P(f_H)\nabla f_H].$$

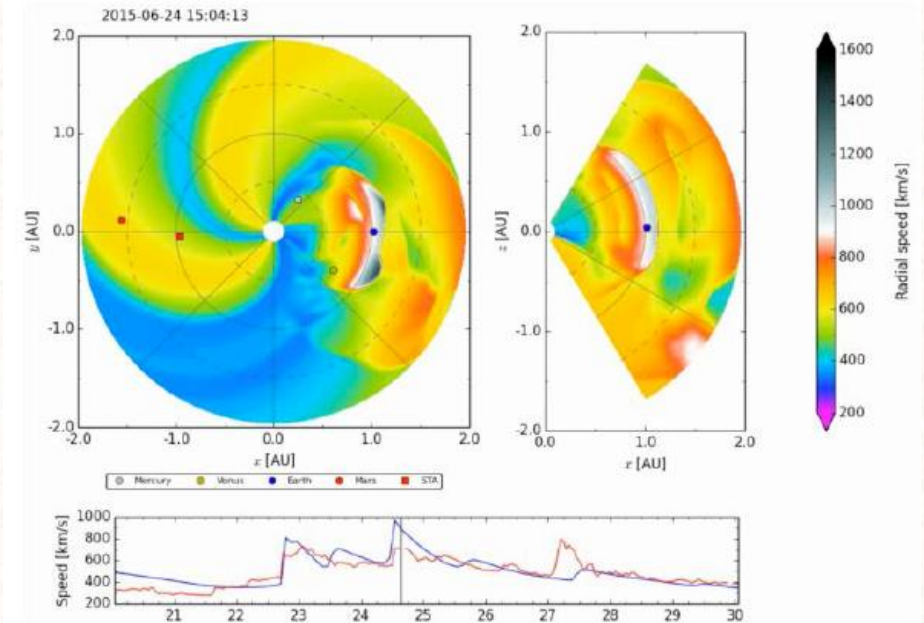
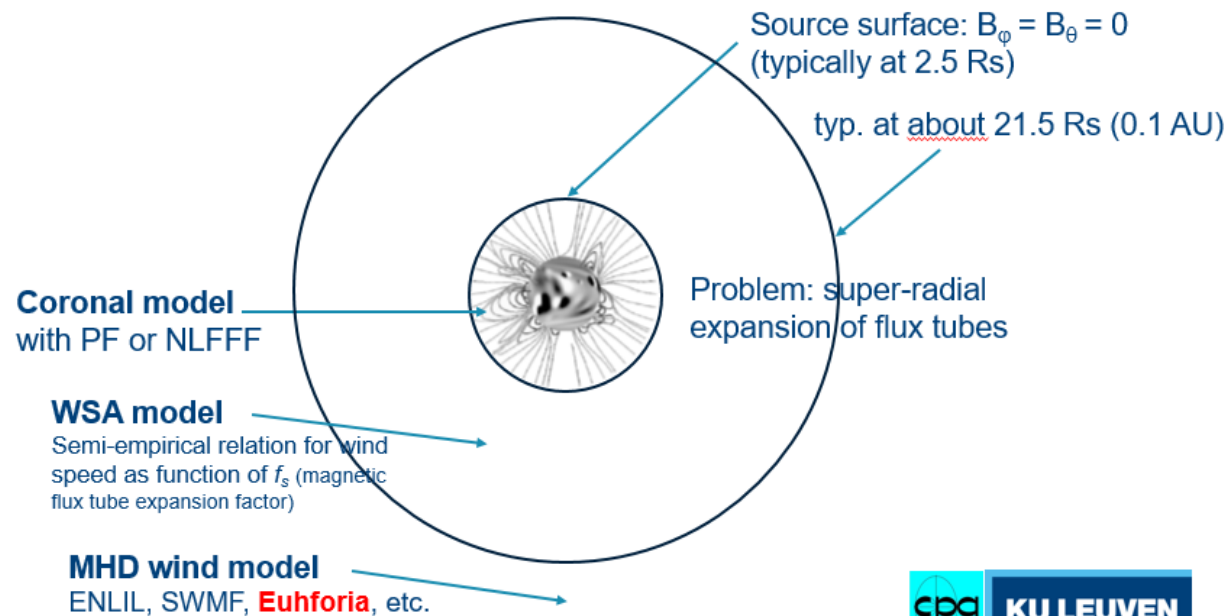
Hu et al. (1999)



- Need for the consistent parametrization of the velocity, density and temperature coronal (source region) profiles for the solar wind numerical models. Space weather and planetary science applications.
- Need for understanding of the Sun and the heliosphere as coupled, unified system in response to the Solar orbiter and other forthcoming missions.
- Need for the proper classification of the solar wind flows into the fundamental pattern libraries (ontologies) for the realization of the large observational and numerical dataset processing using methods of artificial intelligence.

## Solar wind modeling

Taking coronal model as lower boundary condition



**Figure 5.** Snapshot of a forecast simulation with EUHFORIA, showing the radial velocity in the equatorial plane (top left, viewed from above) and in the meridional plane through the position of Earth (top right, side view). Bottom: comparison of simulated (EUHFORIA, in blue) and measured (ACE, in red) radial velocity at L1 [from J. Pomoell].

# Space Weather Activities in Germany

Daniela Banyś

German Aerospace Center (DLR)  
Institute for Solar-Terrestrial Physics  
Space Weather Observations

E-Mail: [daniela.banys@dlr.de](mailto:daniela.banys@dlr.de)

A satellite view of the Earth from space, showing the curvature of the planet, the blue atmosphere, and the green and brown landmasses. The view is centered on the North Atlantic and Europe.

Knowledge for Tomorrow

# Space weather related institutions in Germany

## Universities

- Extraterrestrial Physics at Kiel University (CAU)
- Institute of Physics, University of Rostock
- Centre of Astronomy and Astrophysics (ZAA), TU Berlin (TUB)
- Institute of Astrophysics at the University of Goettingen (IAG)
- Institute of Geophysics and Meteorology at the University of Cologne
- Faculty for Physics and Astronomy at Ruhr University Bochum (RUB)
- Institute for Meteorology, University of Leipzig
- Insitute of Geophysics and extraterrestrial Physics, TU Braunschweig
- German Geodätic Research Institute at Technical University of Munich (DGFI-TUM)

## Societies

- Working Group Extraterrestrial Research e.V. (AEF e.V.)
- German Physical Society e.V. (DPG e.V.)
- German Geophysical Society e.V. (DGG e.V.)
- Vereinigung Cockpit e.V.

## Research Institutes

- Leibniz Institute of Atmospheric Physics in Kühlungsborn (IAP)
- German Aerospace Center (DLR):  
Institute for Solar-Terrestrial Physics,  
Earth Observation Center,  
Institute of Atmospheric Physics,  
Institute of Aerospace Medicine
- German Research Center for Geosciences (GFZ)
- Leibniz Institute for Astrophysics Potsdam (AIP)
- Max Planck Institute for Solar System Research (MPS)
- Institute of Meteorology and Climate Research at Karlsruhe Institute of Technology (KIT)
- Environmental Research Station Schneefernerhaus

## Federal Government & Industry

- Geodetic Observatory Wettzell at the Federal Agency for Cartographie and Geodesy (BKG)
- Weltraumlagezentrum (WRLageZ) at the German Armed Forces
- European Space Operations Centre (ESOC) at ESA
- Airbus Defence and Space (ADS)

## Color Legend

- Astrophysics
- Sun and Heliosphere
- Space Radiation
- Ionospheric Weather
- Atmospheric Physics
- Geomagnetic Conditions





# AEF e.V. – Working Group Extraterrestrial Research e.V.

**Director**

**Dr. Miriam Sinnhuber**

Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT)

**Deputies**

**Dr. Thomas Wiegelmann**

**Dr. Alexander Warmuth**

Max Planck Institute for Solar System Research Leibniz Institute for Astrophysics Potsdam

**Astrophysics**

Chair

**Dr. Michaela Kraus**  
Astronomical  
Institute, Academy of  
Sciences of the Czech  
Republic

Vice Chair

**Topics**

Massive stars,  
galaxies, galaxy  
evolution, structure of  
the interstellar  
medium

**Geospace**

Chair

**Dr. Stefan Bender**  
Department of  
Physics, Norwegian  
University of Science  
and Technology

Vice Chair

**Dr. Daniela Banyš**  
Institute for Solar-  
Terrestrial Physics,  
DLR Neustrelitz

**Topics**

Upper atmosphere,  
ionosphere,  
magnetosphere, space  
weather and  
remote sensing from  
space

**Exoplanets and Astrobiology**

Chair

**Dr. Lee Grenfell**

Vice Chair

**Dr. Konstantin Herbst**  
Institute for  
Experimental and  
Applied Physics, Kiel  
University

**Topics**

Exoplanets: diversity  
and habitability

**Planets and Small Bodies**

Chair

**Dr. Daniel Heyner**  
Institute of Geophysics  
and extraterrestrial  
Physics, TU  
Braunschweig

Vice Chair

**Dr. Miriam Rengel**  
Max Planck Institute  
for Solar System  
Research

**Topics**

Solar system planets  
and moons, asteroids  
and comets

**Sun and Heliosphere**

Chair

**Dr. Bernhard Kliem**  
Institute of Physics  
and Astronomy,  
University of Potsdam

Vice Chair

**Dr. Alexander  
Warmuth**  
Leibniz Institute for  
Astrophysics Potsdam  
(AIP)

**Topics:**

Cosmic rays, corona,  
solar wind, global  
heliosphere, inner  
sun, photosphere  
chromosphere

**Annual AEF meeting at  
DPG spring meeting**

→ Dresden, 20-24 March 2023

<https://smuk23.dpg-tagungen.de/>



**Annual meeting of DGG**

→ Bremen 5-9 March 2023

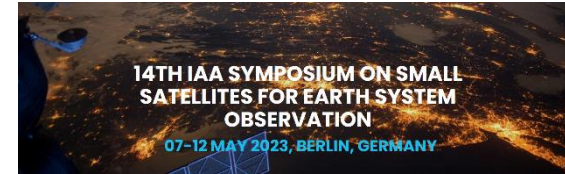
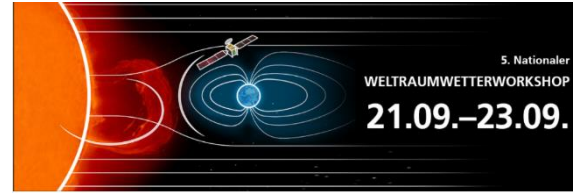
<https://dgg2023.dgg-tagung.de/>



# Space weather activities in Germany

## 5<sup>th</sup> National Space Weather Workshop in 2021 + Recommendations 2022

- Recommendations for Enhancing German Space Weather Capabilities and Capabilities in a Coordinated Approach



## Symposium on Small Satellites for Earth System Observation

- Berlin 7-12 May 2023  
<https://iaaspace.org/event/14th-iaa-symposium-on-small-satellites-for-earth-system-observation-2023/>

## IWGI: International Workshop on GNSS Ionosphere

- Neustrelitz 26-28 Sep 2022  
<https://iwgi2022.welcome-manager.de/>
- Shanghai 2023 TBD



## IRS: International Radar Symposium

- Berlin 24-26 May 2023  
<https://www.dgon-irs.org/home/>

## ISWC: International Space Weather Camp (formerly known as SW Summer Camp)

- A partnership between the UAHuntsville (Alabama), SANSA, DLR, the University of Rostock and the Institute of atmospheric research IAP
- Hermanus: 24 June – 7 July 2023  
Huntsville: 8- 23 Juli 2023  
[https://www.dlr.de/content/en/articles/news/2023/01/20230109\\_international-space-weather-camp-2023-apply-now.html](https://www.dlr.de/content/en/articles/news/2023/01/20230109_international-space-weather-camp-2023-apply-now.html)



## General Assembly of IUGG

- Berlin 11-20 July 2023  
(Abstracts until 14 Feb 2023)  
<https://www.iugg2023berlin.org/>



## URSI Germany: Kleinheubacher Tagung

- Miltenberg 27-29 Sep 2022  
<https://www.kh2022.de/>
- Miltenberg 2023 TBD

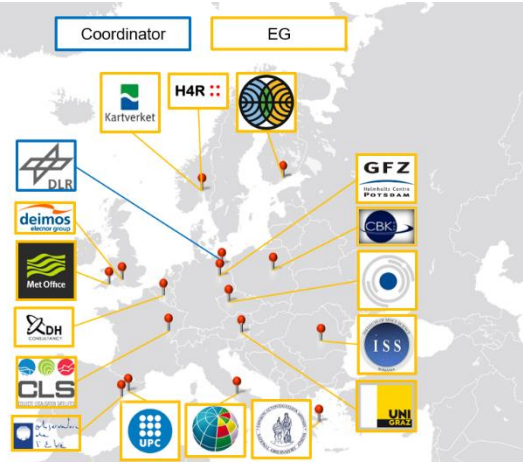


# Project Highlights

## ESA SSA SWE

DLR is coordinating the **Expert Service Center Ionospheric Weather (I-ESC)** and **GFZ** is coordinating the **Expert Service Centre Geomagnetic Conditions (G-ESC)** within the Space Weather segment of the ESA SSA.

<https://swe.ssa.esa.int/>



## PECASUS for ICAO Pan-European Consortium for Aviation Space weather User Services

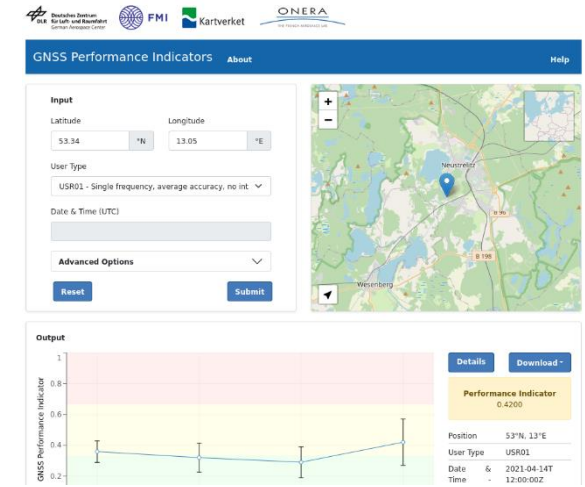
The consortium has been operating an **ICAO** global space weather center in which DLR-SO develops GNSS user services.

<https://pecasus.eu/>



## SWIGPAD Space Weather Impact on GNSS Performance Application Development

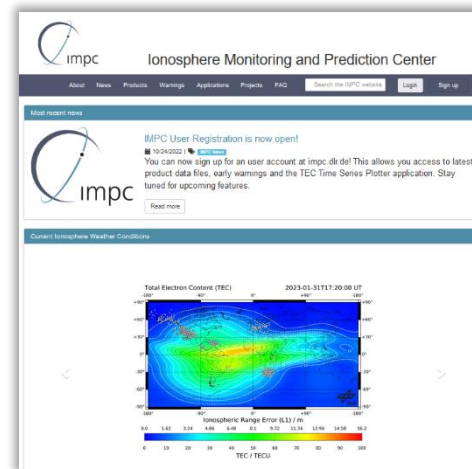
A software application for evaluating the effects of space weather on GNSS positioning available via the ESA portal.



## PITHIA-NRF Plasmasphere Ionosphere Thermosphere Integrated Research Environment and Access services: a Network of Research Facilities

<https://pithia-nrf.eu/>

PITHIA-NRF consortium involves 12 nodes providing organized access to experimental facilities, FAIR data, standardized data products, training and innovation services.



DLR provides data via IMPC: <https://impc.dlr.de/>

**MoNEWIC** Monitoring Network for Evil Waveform and Ionospheric Characterization Particular attention is paid to extreme scintillation events, and additional emphasis is placed on monitoring the Evil Wave Form, as technical distortions of GNSS signals are particularly important for Safety-of-Life applications



# National space weather instruments

## CALLISTO spectrometer:

- HF (10-80 MHz): Neustrelitz
- VHF/UHF (100 – 800 MHz): Neustrelitz in progress
- L-Band 1-1.6 GHz: Neustrelitz



## VLF receivers

- **GIFDS:** Neustrelitz, Boston, Stanford, Taiwan
- **SOFIE:** Neustrelitz, Berlin, Huntsville, Hermanus
- **SID Monitor:** Göttingen, Bergen



Airglow Imager Neustrelitz

Magnetometer: Potsdam, Braunschweig

Neutron monitors: Kiel (NMDB)

GNSS / Scintillation receiver: EVnet, EUREF

Beacon receiver: Neustrelitz

Bitgrabber: Neustrelitz (mobile), Tromsø, Andøya

indirect phase height measurements

Juliusruh, Collm



**Ionosonde:** Kühlungsborn

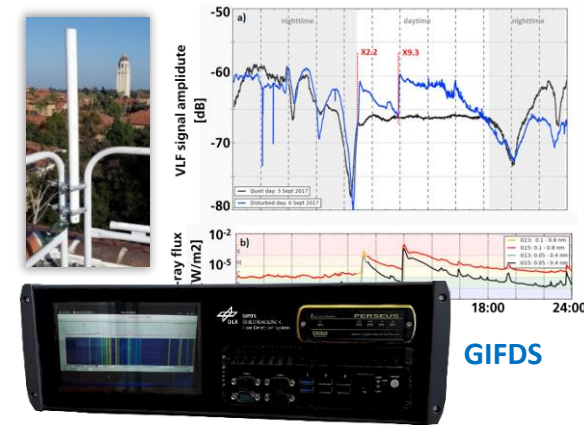
**MST radars:** MAARSY (Andøya), OSWIN (Kühlungsborn)

**Specular meteor radars:**

- **Monostatic meteor radars:** Juliusruh (32.55 MHz), Collm (36.2 MHz)
- **MMARIA multi-frequency receiving stations:** Neustrelitz, Bornim, Juliusruh, Kühlungsborn, Straumen,
- **SIMONE:** Santa Cruz, Peru

**MF radars:** Juliusruh, Andenes, Saura

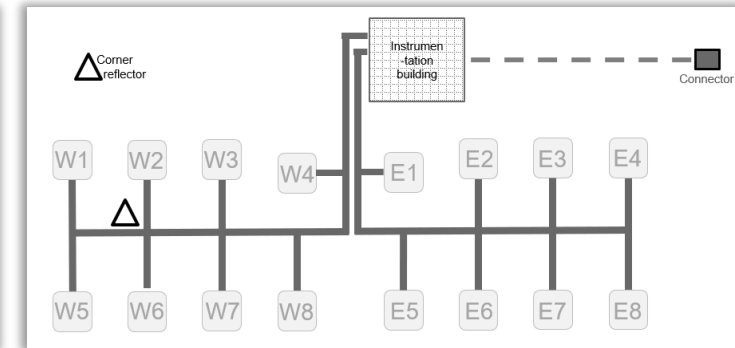
**SOFIE**



**GIFDS**



**CALLISTO**



**MIRA: Multi-instrument Ionospheric Radio Array, DLR Neustrelitz**





# Advances on Space Weather activities in ITALY

ISWI Italian Coordinators:

Yenca Migoya-Orué (ICTP)

Vincenzo Romano (INGV)



# Italian Coordinated Activities



- **SWICo - Space Weather Italian COmmunity**  
SWICo continues its activity with the goal to promote and coordinate the Italian community on SWx
- **Italian Air Force - INAF and INGV agreement**  
The agreement for the realization of the Italian SWx operative capacity is going on with the recent inclusion of ASI
- **CAESAR - Comprehensive spAce wEather Studies for the ASPIS prototype Realization**  
The project for the population of the SWx Scientific Database ASI-ASPIS is going on
- **URSI Italy**  
SWx objects are promoted in the framework of the Radio Science Italian community. URSI WIRS (Women in RS)
- **ARCTIC and ANTARCTIC National programs**  
SWx and S-T physics continue to be part of the two Italian polar programs with several approved projects
- **CEI6 - Circumterrestrial Environment: Impact of Sun-Earth Interaction**  
The PRIN2017 project to investigate the physical processes in the Earth environment in response to solar activity is going on



Italy

# Ongoing International Initiatives



- **PECASUS - Partnership for Excellence in Civil Aviation Space weather User Services**  
Consortium of Countries (Including Italy by INGV) to provide SWx services to ICAO
- **SWESNET - ESA Space Weather Service Network**  
SWESNET is the ESA project for the SWx products provision (INAF, INGV, UNIGE and ALTEC are product providers)
- **E-SWAN - European Space Weather and Space Climate Association**  
Italy is contributing (President et al.) to the non-profit association established to promote and support collaboration in SWx
- **PITHIA-NRF - Plasmasphere Ionosphere Thermosphere Integrated Research Environment and Access services: a Network of Research Facilities**  
H2020 Project to realise an European TNA and Research Infrastructure, including SWx
- **PAGINA - Pan-Arctic GNSS Infrastructure for Atmospheric science**  
Collaborative project between INGV, UNB and FMI to build a new platform for atmospheric observations in Arctic, incl. SWx
- **T-FORS - TRAVELLING IONOSPHERIC DISTURBANCES FORECASTING SYSTEM**  
Horizon Europe project aiming at providing new models able to issue forecasts and warnings for TIDs several hours ahead
- **STIRRED - STorm-related Study of Ionospheric iRregularities over southern Europe using digisondes and GNSS Data -**  
(Univ. Complutense Madrid, ICTP, BC under PITHIA-NRF-TNA )



Italy

# Ongoing National Projects (PNRR and other Initiatives)

- **PNRR - Italian funding program for NextGenerationEU**
  - **PEOS- Platform for Earth Observation from Space**  
Research infrastructure project to build a platform for data and products for space science, including SWx
  - **DOCTORAL PROGRAM**  
Coordinated PhD course by Universities and Industry for space research, including SWx
  - **SPACE Extended Partnership**  
Academic and industrial network to advance national knowledge in space-related objects, including SWx
- **PNRA - Antarctic National Program**
  - **"Upper Atmosphere Observation and Space Weather"** at the Italian stations MZS and Concordia in Antarctica and Arctic
  - **"Geomagnetic Observation"** at the Italian stations MZS and Concordia in Antarctica
  - **"SUPERDARN - Super Dual Auroral Radar Network"** at Concordia in Antarctica
  - **"SPIRIT - meteorologia SPaziale nella Ionosfera polare: il Ruolo della Turbolenza"**, a INGV project focused on the study of ionospheric turbulence at high latitudes
- **NORISK - New Observatory for Real-time Ionospheric Sounding over Kenya**  
An ASI-INGV project that aims to build a new ionospheric observatory in Kenya including training and capacity building
- **MULTIPARAMETRICA - SPACE WEATHER PECASUS** - INGV project to build a space weather monitoring room
- **TIRESIAS - Theoretical Ionospheric RESidual Investigation and Assesment** - (BC, CNR, ICTP) Study to set a theoretical limit to the predictability of ionospheric variability.
- **MARGE - Mappa di Rischio Geoelettromagnetico per l'Italia cEntrale** A INGV project for the realization of geoelectric risk maps aimed at a real-time risk assessment on potentially affected infrastructures.





Italy

# Capacity Building and Outreach



## 2022 Activities

- **International School of Space Science (ISSS):**  
**The different spatio-temporal scales of the solar magnetism**, April 2022, L'aquila, Italy.
- **West African Workshop on GNSS and Space Weather**, UNOOSA, ICTP, BC, CRASTE-LF, May 2022, Rabat, Morocco.
- **ISSS: Radiation Belt Dynamics and Remote Sensing of the Earth's Plasmasphere**, September 2022, L'Aquila, Italy.
- **African Capacity Building Workshop on Space Weather effects on GNSS**, October 2022, Trieste, Italy, ICTP, INGV, BC, UNOOSA, PU.
- **International Workshop on Machine Learning for Space Weather: Fundamentals, Tools and Future Prospects**, UNT, ICTP, UNOOSA, BC, SCOSTEP, 7 -11, November 2022.

## 2023 Planned Activities

- **Summer School "Mathematics for Signal processing and Applications in Geophysics and other fields" (MaSAG)**, INGV, Rome, May 15-20, 2023
- **ICTP-SCOSTEP-UN\_ISWI Workshop on the Predictability of the Solar-Terrestrial Coupling - PRESTO**, May 29 - Jun 2, 2023, Trieste.
- **First PITHIA-NRF Training School**, INGV, Rome, May 29 - June 1, 2023 (deadline March 15, 2023)
- **International School of Space Science on Operational Space Weather Fundamentals**, L'Aquila, Italy, September 2023
- **Eastern Africa Capacity Building Workshop on Space Weather and Low-latitude Ionosphere**, October 3 - 12, Malindi, Kenya.



Italy

# New Instruments/Observations

## 2022/23

- AIS ionosonde in Vietnam (Hanoi)
- Ionospheric Scintillation receivers in: Kenya(Broglio Space Center, Malindi), Nigeria, Ushuaia and Tucumán (Argentina)
- ICTP GNSS Calibration Service available at: <https://arplsrv.ictp.it//>
- SWEATERS (Space WEATHER Ena Radiation Sensors):  
an innovative instrument development for SW monitoring via ENA imaging in Low Earth Orbit (INAF-INFN; ASI funded 2020-23)

## Forthcoming

- AIS Ionosonde in Kenya, Broglio Space Center, Malindi
- All Sky Camera in Gibilmanna, Sicily, South Italy
- AIS ionosonde in Lerici, Liguria, North Italy



## Call for opportunities

- Young Scientist Awards for next **URSI** conference in Sapporo Japan, August 2023, deadline February 10 (In particular "Commission G")
- Forthcoming **schools** as reported in the previous slide (grants are available)
- **eSWua** - the INGV data management system is happy to host worldwide ionospheric data to provide free access and visibility in real time
- Membership to **E-SWAN**
- Post-doc and PhD **positions at PNRR** (not open yet)

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# ISWI contribution from Romania 2022



Astronomical Institute  
of the Romanian Academy

**Participating institutes**  
Astronomical Institute of the Romanian Academy<sup>1</sup>  
Institute of Geodynamics of the Romanian Academy<sup>2</sup>  
Institute of Space Science<sup>3</sup>  
National Institute for Earth Physics<sup>4</sup>  
“Dunărea de jos” University of Galați<sup>5</sup>  
Romanian Space Agency<sup>6</sup>

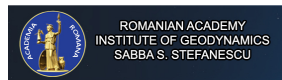
<sup>1</sup>AIRA, <sup>2</sup>IGSSAR, <sup>3</sup>ISS, <sup>4</sup>INFP, <sup>5</sup>UGAL, <sup>6</sup>ROSA





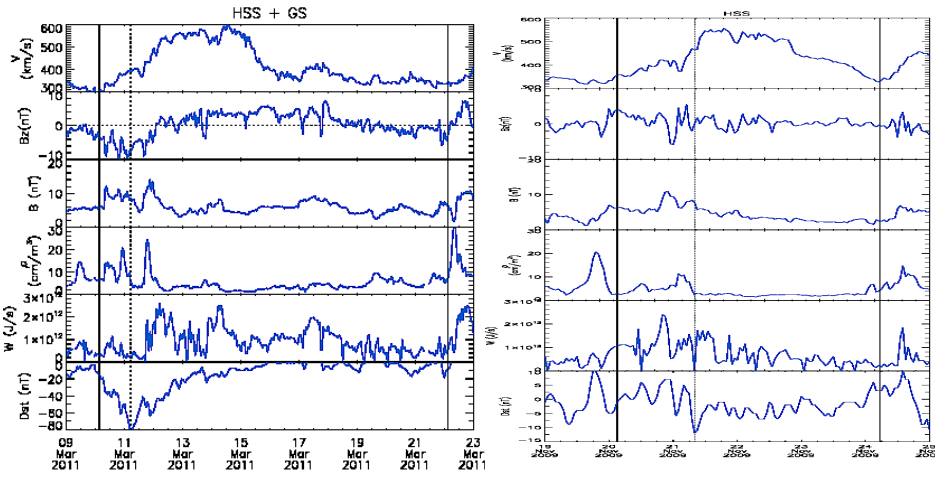
## Romanian Expertise and Research Topics

|   |                |  |                |
|---|----------------|--|----------------|
| Solar Observations/<br>Monitoring   | AIRA<br>ISS    | Space Weather –<br>Geomagnetic Storm<br>Studies  | AIRA<br>IGSSAR |
| CME&HSS impact on<br>magnetosphere/<br>Energetic transfer from<br>SW to magnetosphere<br>Filaments Catalogues | AIRA           | Assessment of the space<br>weather hazard over<br>Romania/<br>Goelectric hazard maps<br>over Romania | IGSSAR         |
| Space weather<br>ionospheric effects  | UGAL           | Ionospheric Monitoring   | ISS/ROSA       |
| HSS Studies/Catalogues  | AIRA<br>IGSSAR | Space climate/weather<br>and effects in terrestrial<br>atmosphere                                    | UGAL<br>IGSSAR |

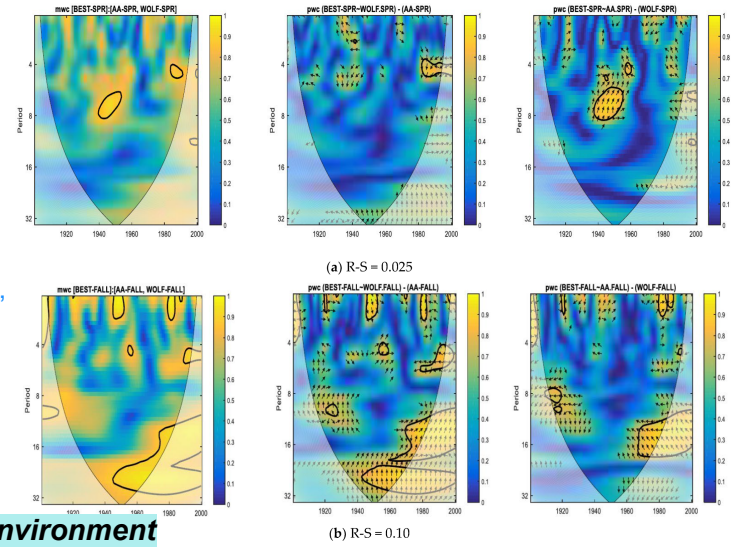




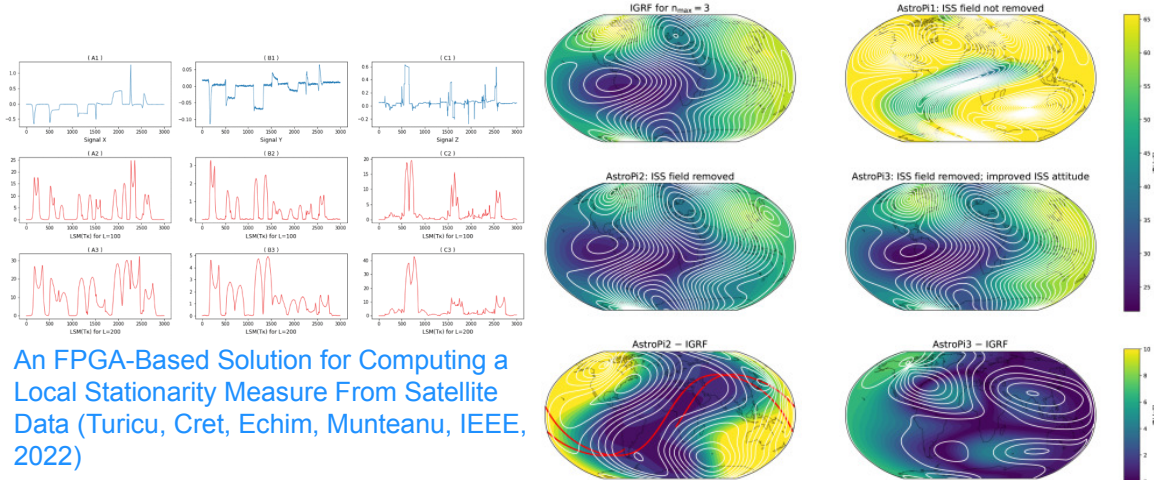
Complex Catalogue of High Speed Streams Associated with Geomagnetic Storms During Solar Cycle 24 (Besliu-Ionescu, Maris Muntean, Dobrica, Sol. Phys., 2022)



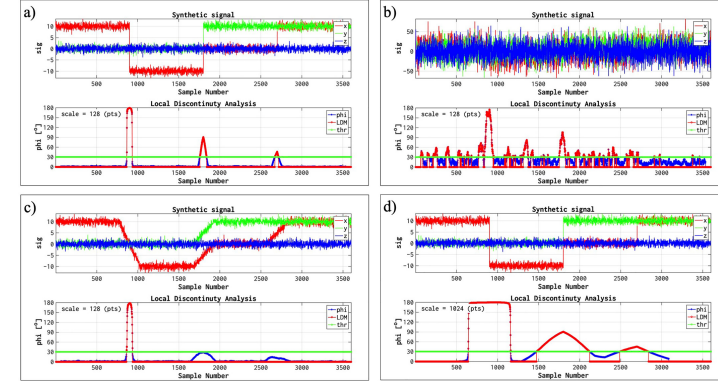
Solar Signature in Climate Indices (Mares, Dobrica, Mares, Demetrescu, Atmosphere 2022)



**Complex interdisciplinary research of Solar activity impact on the Earth's environment = Romanian Results =**



Astro Pi sensor onboard the International Space Station as magnetic field surveyor (Blagau, Ersen, Dobrescu, Marghitu, Acta Astronautica, 2022)



Detecting Discontinuities From In Situ Space Measurements: Method and FPGA Implementation, Earth and Space Science (Munteanu, C., Turicu, D. C., CreÅ, O., Echim, M., Earth and Space Science, 2022)

An FPGA-Based Solution for Computing a Local Stationarity Measure From Satellite Data (Turicu, Cret, Echim, Munteanu, IEEE, 2022)

# Space Weather activities in Serbia

**Nikola Veselinović**

(on behalf of the Serbian Space Weather Community)

ISWI Steering Committee Annual Meeting

2023 February 10



# Space weather related research

- Faculty of Mathematics, University of Belgrade,
  - [Department of astronomy](#)
    - Solar Physics magnetic field inference
- Institute of Physics, Belgrade
  - [Laboratory for astrophysics and physics of ionospheric](#) –VLF station
    - *lower ionospheric monitoring using VLF radio signals and modeling Solar forcing of the Earth's ionosphere system*
  - [Low-background laboratory for nuclear physics](#) – Muon station
    - Correlation analysis of solar energetic particles and secondary cosmic ray flux
    - Production of the cosmogenic radionuclides in soil



# Space weather related activity in 2022

## Some of the meetings

- Triennial Earth-Sun Summit, (TESS), Bellevue/Seattle, USA
- European Space Weather Week (ESWW), Zagreb, Croatia
- Astrophysics with Radioactive Isotopes, Budapest, Hungary
- United Nations/Azerbaijan Workshop on the ISWI, Baku, Azerbaijan
- ASSPECTRO 2022, Fruška gora, Serbia

## Some of the published papers

- [Influence of variations in the solar hydrogen Ly alpha radiation on the ionospheric D-region electron density during a year and solar cycle](#)
- [Multi-instrumental investigation of the solar flares impact on the ionosphere on 05-06 December 2006](#)
- [Monitoring solar activity during 23/24 solar cycle minimum through VLF radio signals](#)
- [New insights from cross-correlation studies between solar activity indices and cosmic-ray flux during Forbush decrease events](#)
- [Probing Chromospheric Temperatures and Dynamics with ALMA](#)

# Space weather related activity in 2023

Development of **small portable cosmic rays' muon detector** as a part of collaboration led by Georgia state university, Atlanta, USA. The goal is building a **worldwide network** of cosmic ray detectors for monitoring space & terrestrial weather in real-time at global scale.

Development of **first Serbian multi-purpose academic cubesat**. Primary scientific goal is X-ray and optical observations of the Sun and the Earth but also to undergraduate and graduate students in all aspects of this project and to rise public awareness.



A&M DATA

*AsSpectro23*

V meeting on Astrophysical Spectroscopy -

# Astronomy and Earth Observations

September 12-15 2023, Hotel "Prezident", Palić

Special Session: "Astronomy and Earth Observations: multi-instrumental approach and theory"

Dedicated to new research insights, theoretical and observational, related to magnetosphere, ionosphere, radiative transfer and influence of space weather climate on biosphere, with the focus on the research of solar-influenced extreme events in the atmosphere, ionosphere and magnetosphere and space weather related interactions and scope to address these topics as a multidisciplinary field of research, important in diversified areas of physics like plasma physics, atomic physics, meteorology, stellar and astroparticle physics.



<http://aspectro2023.ipb.ac.rs/>

# Space Weather activities in Slovakia

Ivan Dorotovič (SCO Hurbanovo, ivan.dorotovic@suh.sk), Šimon Mackovjak (IEP, SAS Košice, mackovjak@saske.sk)

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



- Slovak Rep. became ESA Associate Member state: the membership came into effect on 13 October, 2022 for an initial duration of seven years

[https://www.esa.int/About\\_Us/Corporate\\_news/Slovakia\\_becomes\\_ESA\\_Associate\\_Member\\_state](https://www.esa.int/About_Us/Corporate_news/Slovakia_becomes_ESA_Associate_Member_state)

## Solar Weather:

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


### **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 several public observatories:** \*  
telescopes with a lense and with a mirror for optical observation

of the sunspots in the solar photosphere + \* LUNT telescope with H-alpha filter for photographic observation of the solar chromosphere and prominences

### **Hurbanovo:**

- Radio spectrometer CALLISTO: solar radio bursts at 45 – 200 MHz (**ISWI instrument** )
- Measurements of solar continuum in VIS spectral band with the aim to detect solar flares (AI CAS, Ondřejov, Czech Republic)

- publication of Modified Coronal Index – MCI:

<https://www.kozmos-online.sk/slnko/modifikovany-koronalny-index-modified-coronal-index/>

and Modified Homogeneous Data Set – MHDS:

<https://www.kozmos-online.sk/slnko/modifikovany-homogenny-rad-modified-homogeneous-data-set/>

of solar coronal intensities.

- **Institute of Experimental Physics (IEP), SAS, Košice**  
(Department of Space Physics)
- **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
- **Space Radiation** Cosmic Rays measurements (ground based observations using both the Neutron monitor [<http://neutronmonitor.ta3.sk>] and the SEVAN (**ISWI instrument**) [http://crd.yerphi.am/Lomnicky\\_stit\\_SEVAN\\_Data](http://crd.yerphi.am/Lomnicky_stit_SEVAN_Data)
- **Ionospheric Weather**
  - AMON (Airglow MONitor) - processes in the thermosphere-ionosphere system
  - ASPIS - predictions of ionospheric scintillations More at <http://uef.saske.sk>
- **Geomagnetic Conditions**
- **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
  - Registration of the Earth's magnetic field in Hurbanovo within the **INTERMAGNET** (several types of magnetometers; [http://www.geomag.sk/index.php?option=com\\_content&view=section&layout=blog&id=18&Itemid=81](http://www.geomag.sk/index.php?option=com_content&view=section&layout=blog&id=18&Itemid=81))



- **International Space Weather Initiative (ISWI)** in Slovakia web page, [http://stara.suh.sk/id/iswi/iswi\\_SK-en.htm](http://stara.suh.sk/id/iswi/iswi_SK-en.htm)

**National Coordinator:** I. Dorotovič

**Event: National Solar Physics Meeting (NSPM)**

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

- **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.





- **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.

# National Report to ISWI February 10, 2023

## Swedish Space Weather Efforts

### Reporter: Hermann J. Opgenoorth, Umeå University

**SWx Research in Sweden is carried out by groups at :**

Umeå University , Luleå University,  
Stockholm University, Royal Institute of Technology,  
Swedish Geological Survey, SGU and the  
Swedish Institute of Space Physics, IRF  
(with Divisions in Kiruna, Uppsala and Lund)

**Other organisations related to SWx operational efforts:**

| <b>INSTITUTION</b>  | <b>OPERATIONAL SPACE WEATHER SERVICE</b>                      |
|---|---|
| <b>MSB</b> (SWEDISH CIVIL CONTINGENCIES AGENCY),<br><b>IRF</b> (SWEDISH INSTITUTE OF SPACE PHYSICS),<br><b>METOCC</b> (METEOROLOGICAL AND OCEANOGRAPHIC<br>CENTRE OF SWEDISH ARMED FORCES),<br><b>SVK</b> (SVENSKA KRAFTNÄT),<br><b>LFV</b> (THE SWEDISH CIVIL AVIATION ADMINISTRATION),<br><b>SMHI</b> (SWEDISH METEOROLOGICAL INSTITUTE),<br><b>FOI</b> (SWEDISH DEFENSE RESEARCH AGENCY) | CSG Rymdväder (Swedish Coordination<br>Team in Space Weather) |

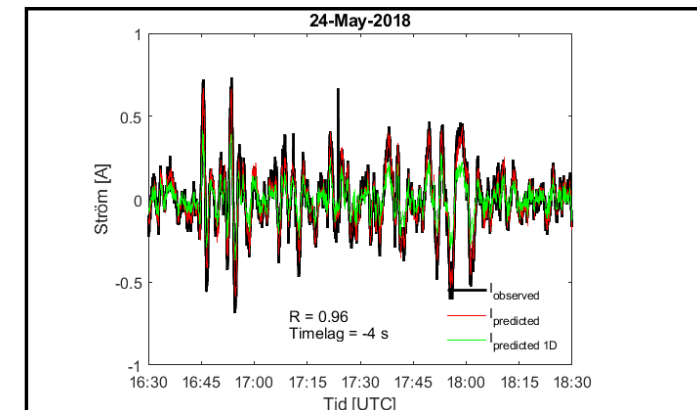
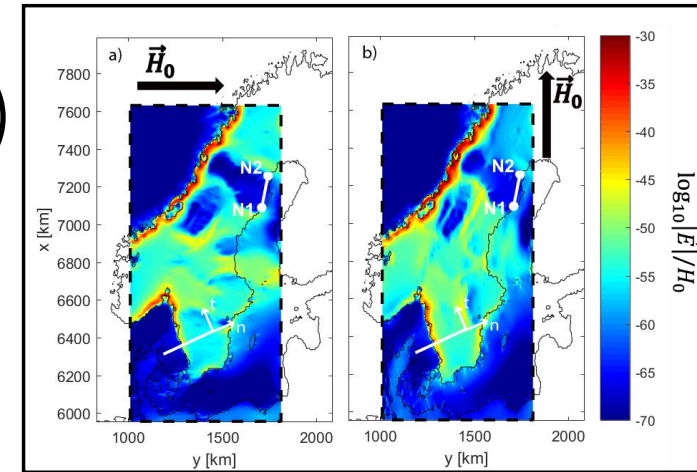
## IRF instrumentation contribution to the Swedish SWx Network

- *Instruments framework: table of important contributions for the ground and space-based space weather measurement infrastructure*

| INSTRUMENT (PROVIDER)        | LINK   |
|------------------------------|--|
| MAGNETOMETER (IRF)           | <a href="https://www2.irf.se/Observatory/?link=Magnetometers">https://www2.irf.se/Observatory/?link=Magnetometers</a>                        |
| PULSATION MAGNETOMETER (IRF) | <a href="https://www2.irf.se/maggraphs/puls.php">https://www2.irf.se/maggraphs/puls.php</a>  |
| RIOMETER (IRF)               | <a href="https://www2.irf.se/Observatory/?link=Riometers">https://www2.irf.se/Observatory/?link=Riometers</a>                                |
| IONOSONDE (IRF)              | <a href="https://www2.irf.se/Observatory/?link=Ionosondes">https://www2.irf.se/Observatory/?link=Ionosondes</a>                              |
| ALIS 4D (IRF)                | <a href="https://alis.irf.se/">https://alis.irf.se/</a><br>(under development: <a href="https://alis4d.irf.se/">https://alis4d.irf.se/</a> ) |
| ALL-SKY CAMERA (IRF)         | <a href="https://www2.irf.se/Observatory/?link=All-sky_sp_camera">https://www2.irf.se/Observatory/?link=All-sky_sp_camera</a>                |

# Contribution from FOI (Defense Res. Inst)

- 5 year project funded by the Swedish Civil Contingency Agency MSB (2017-2021)
- Consortium – FOI with Stockholm University and IRF
- Studied four parts of the space weather chain from Sun to Earth
- FOI has developed a 3D model of ground induced currents in Sweden (In collaboration with Luleå University)
- Performed field trials on transmission lines to validate the model
- Use the model to investigate the impact of severe Space Weather on the Swedish power grid

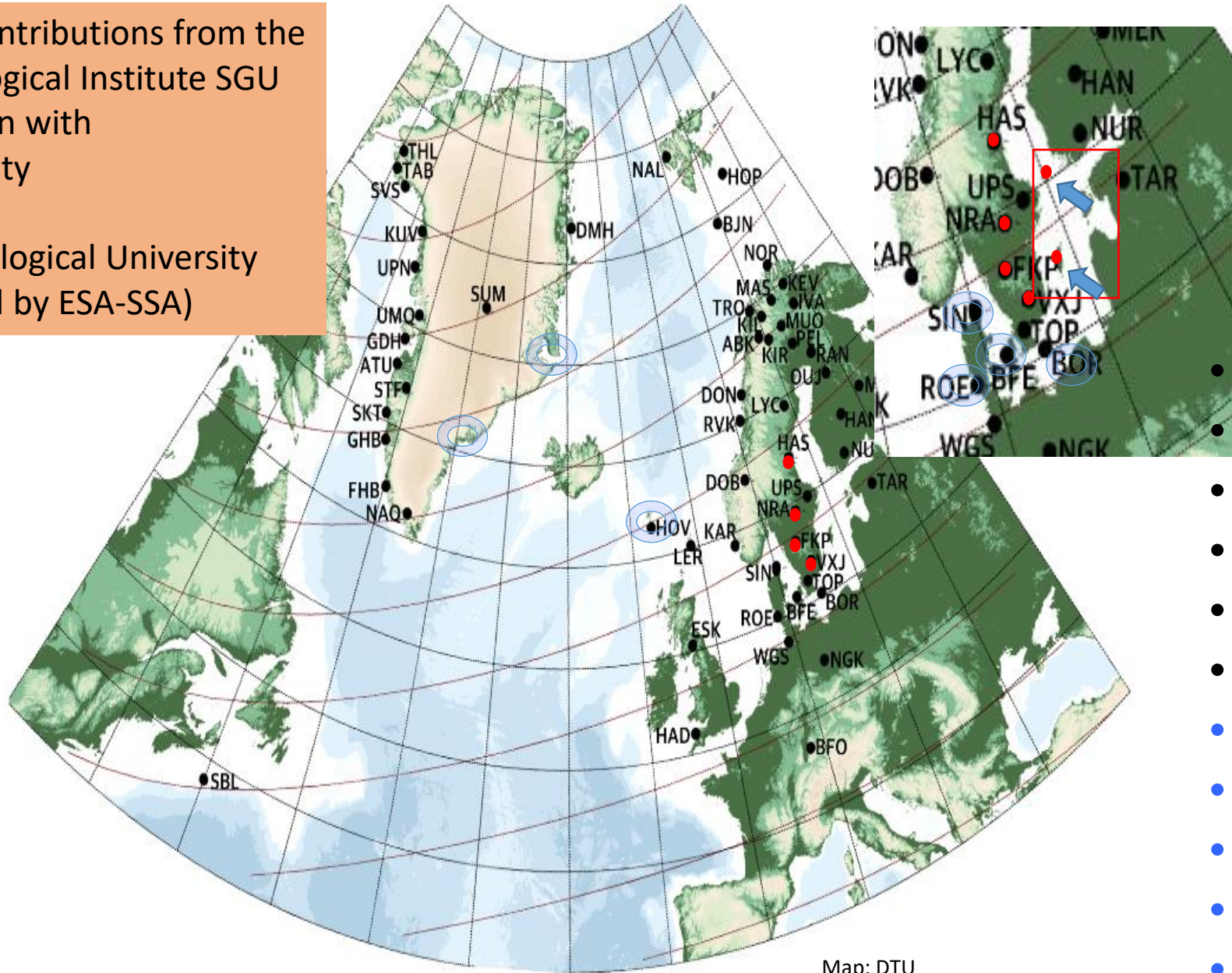


MODEL

MEASURE

VALIDATE

Instrument Contributions from the Swedish Geological Institute SGU in collaboration with Umeå University and the Danish Technological University DTU, (financed by ESA-SSA)

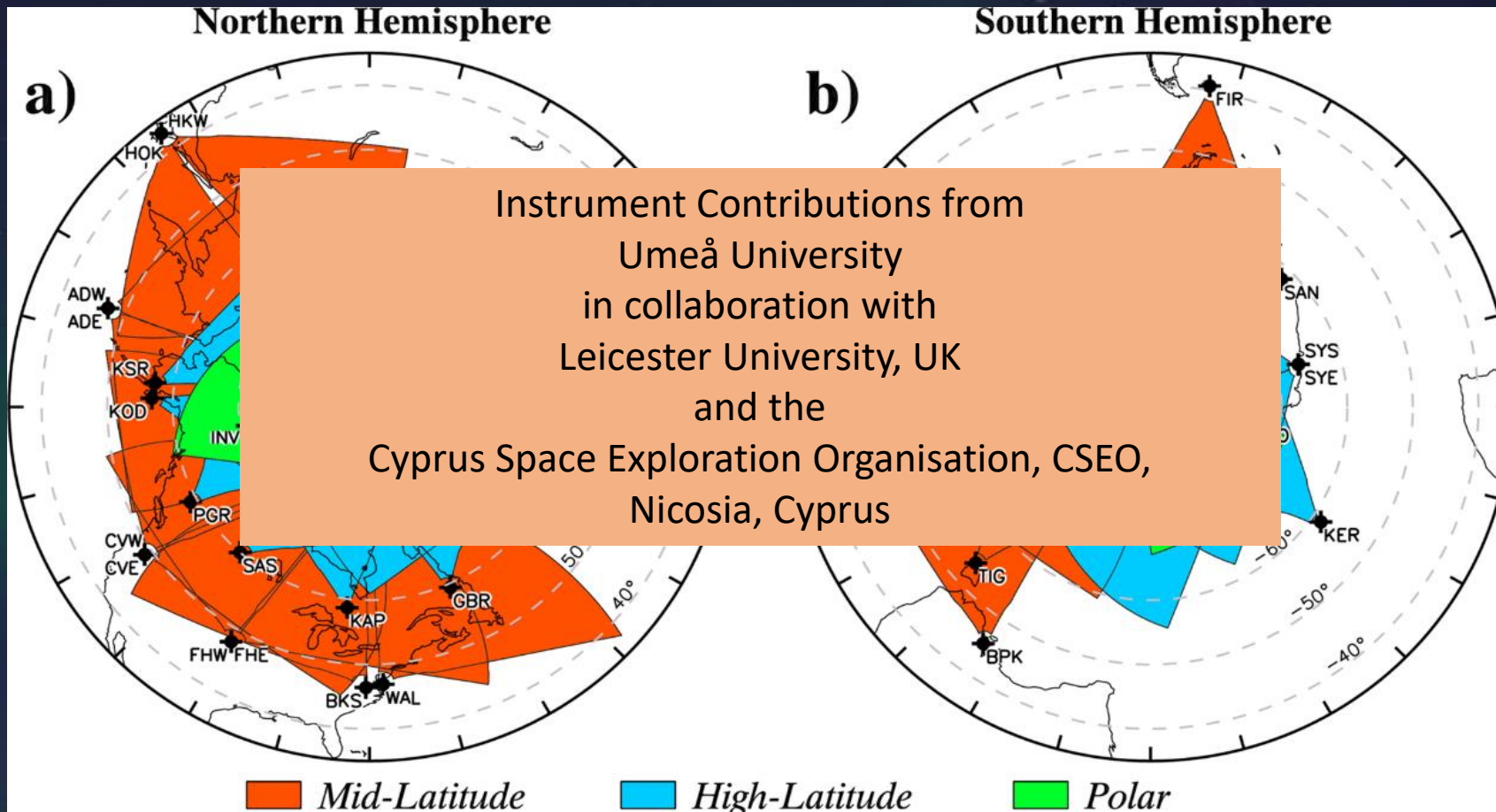


- Växjö
- Falköping
- Nora
- Hassela
- Åland
- Gotland
- Sindal
- Bornholm
- Rømø
- Brorfelde
- Hov -Farør
- Greenland

# MAGSWEDAN magnetometer network as part of IMAGE

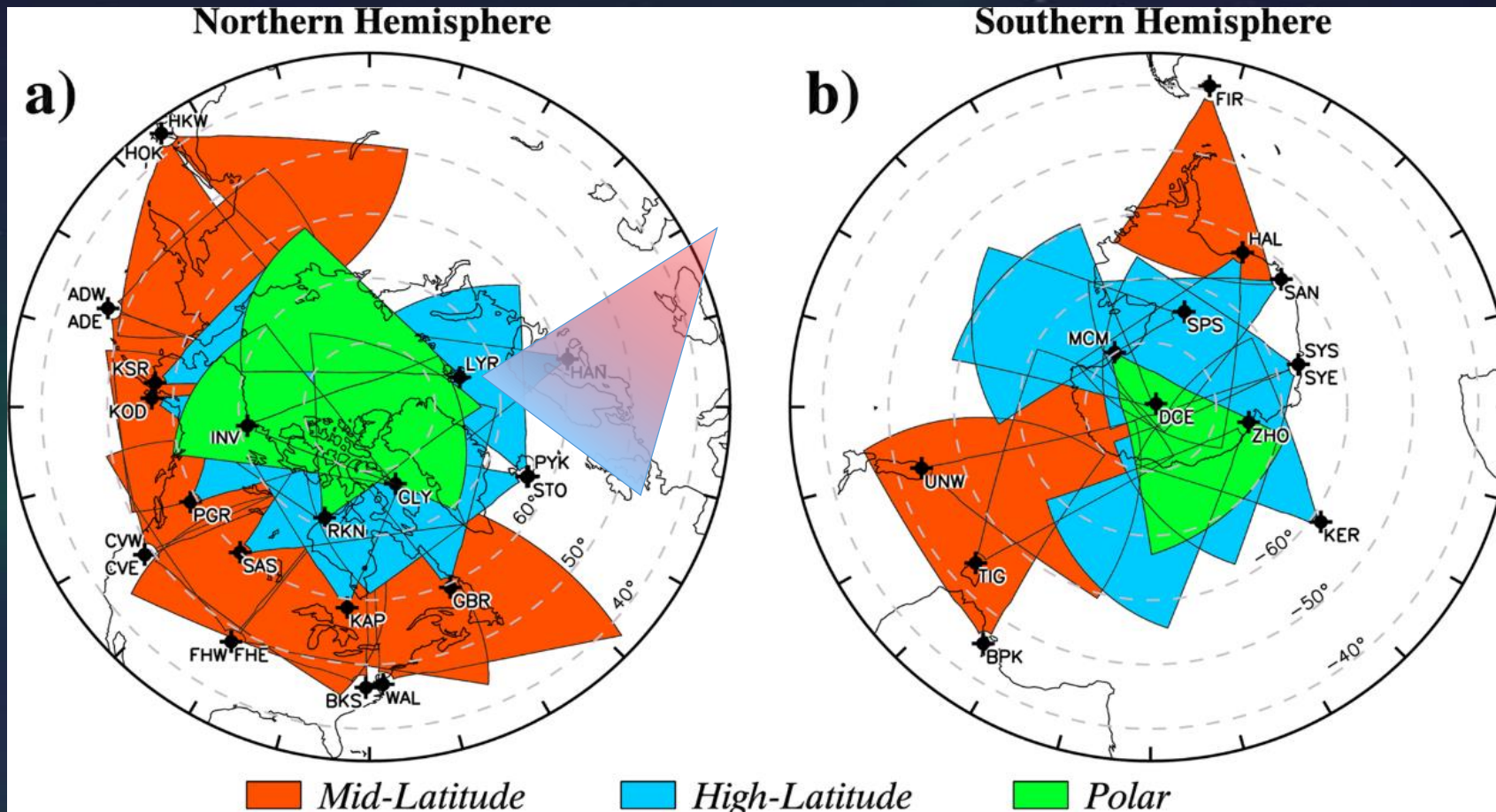
# SuperDARN Radars' Fields of View:

recent extension into sub-auroral latitudes (red)

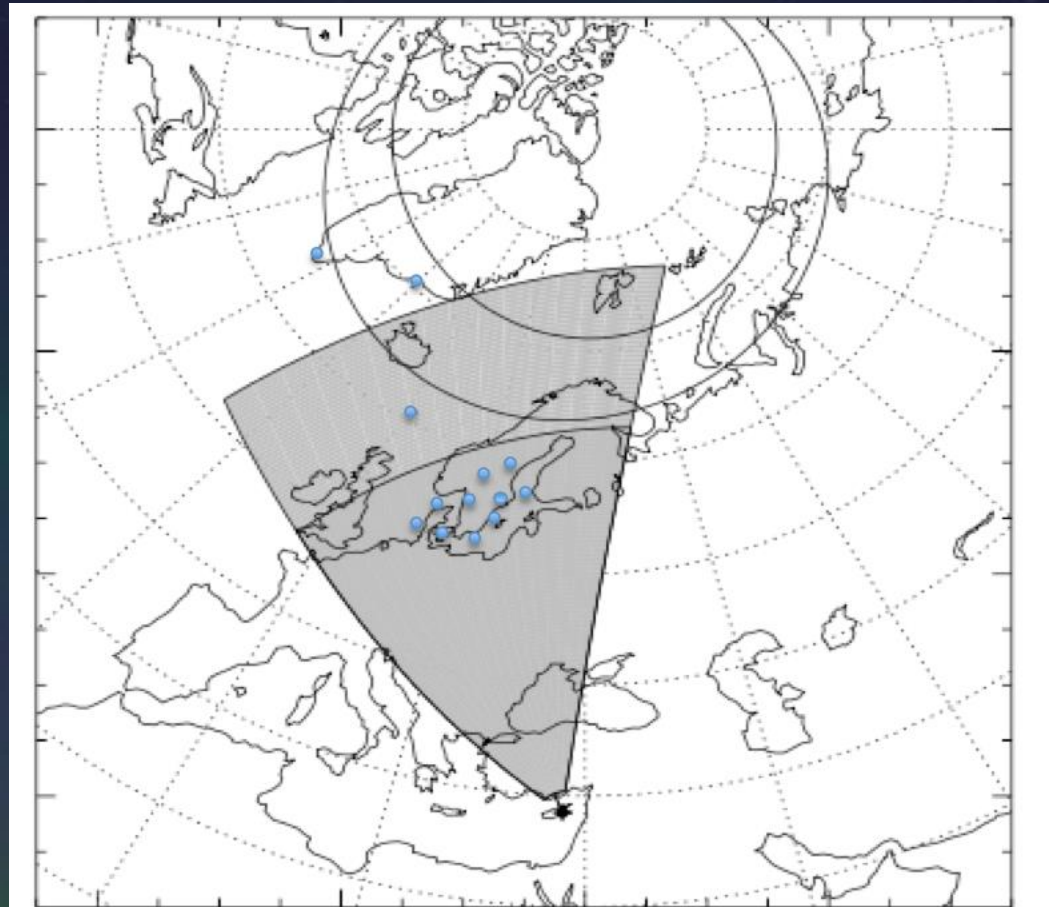


# SuperDARN Radars' Fields of View:

recent extension into sub-auroral latitudes (red)

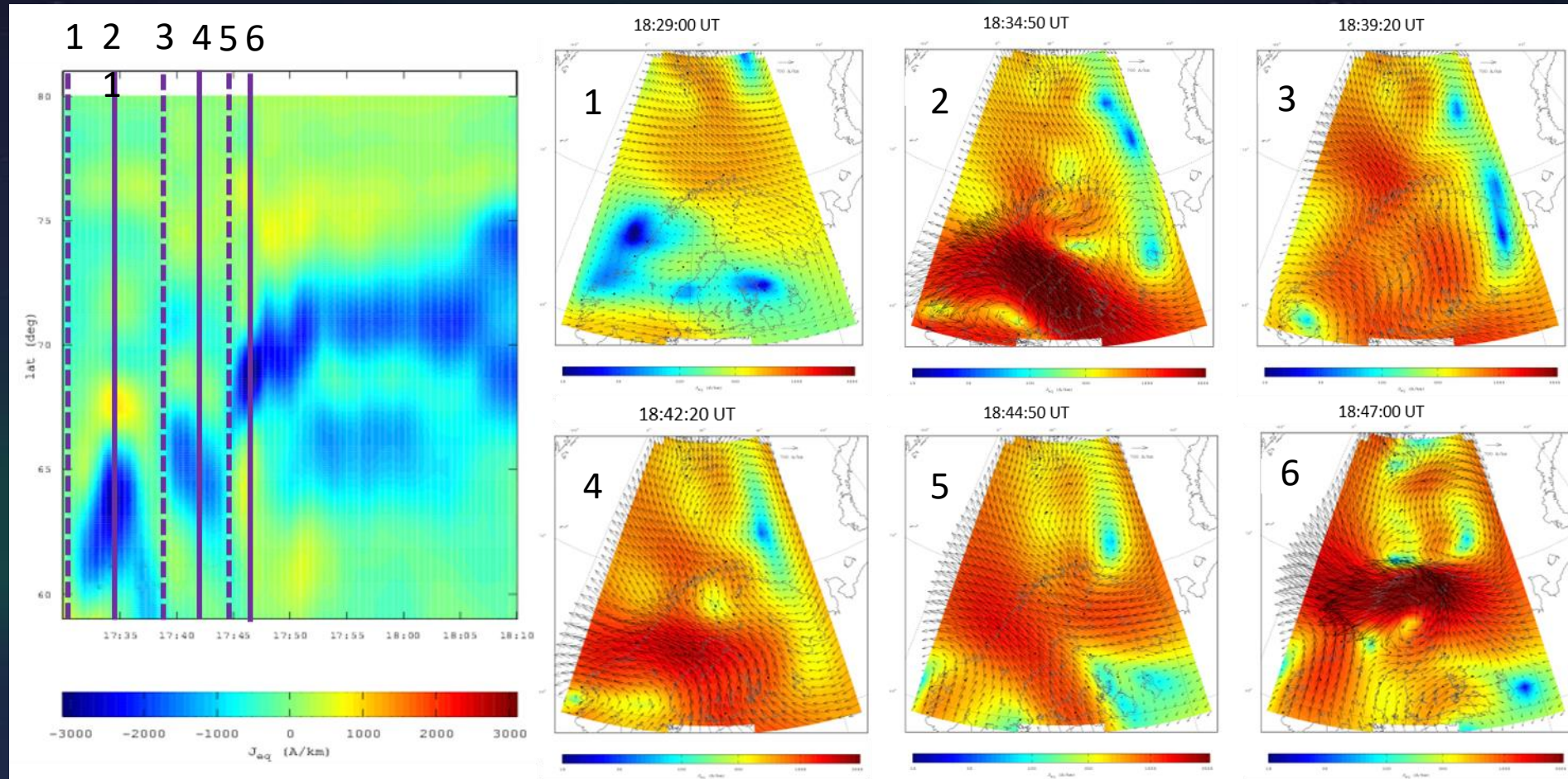


The new CyprioDARN Project is supporting the MAGSWEDAN network  
Radar, site, license (**some recent issues !**) and funding exist  
MoU with CSEO close to completion  
Installation as soon as permitted



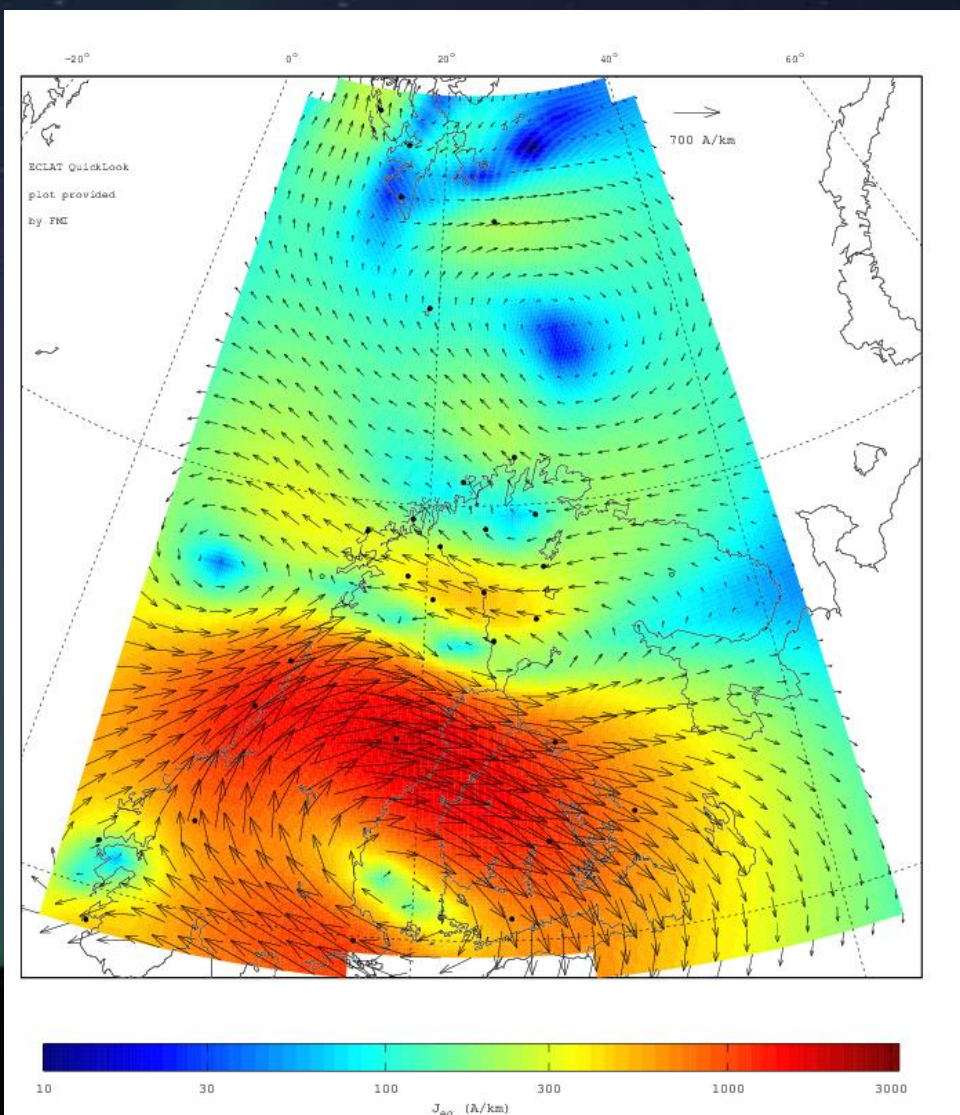
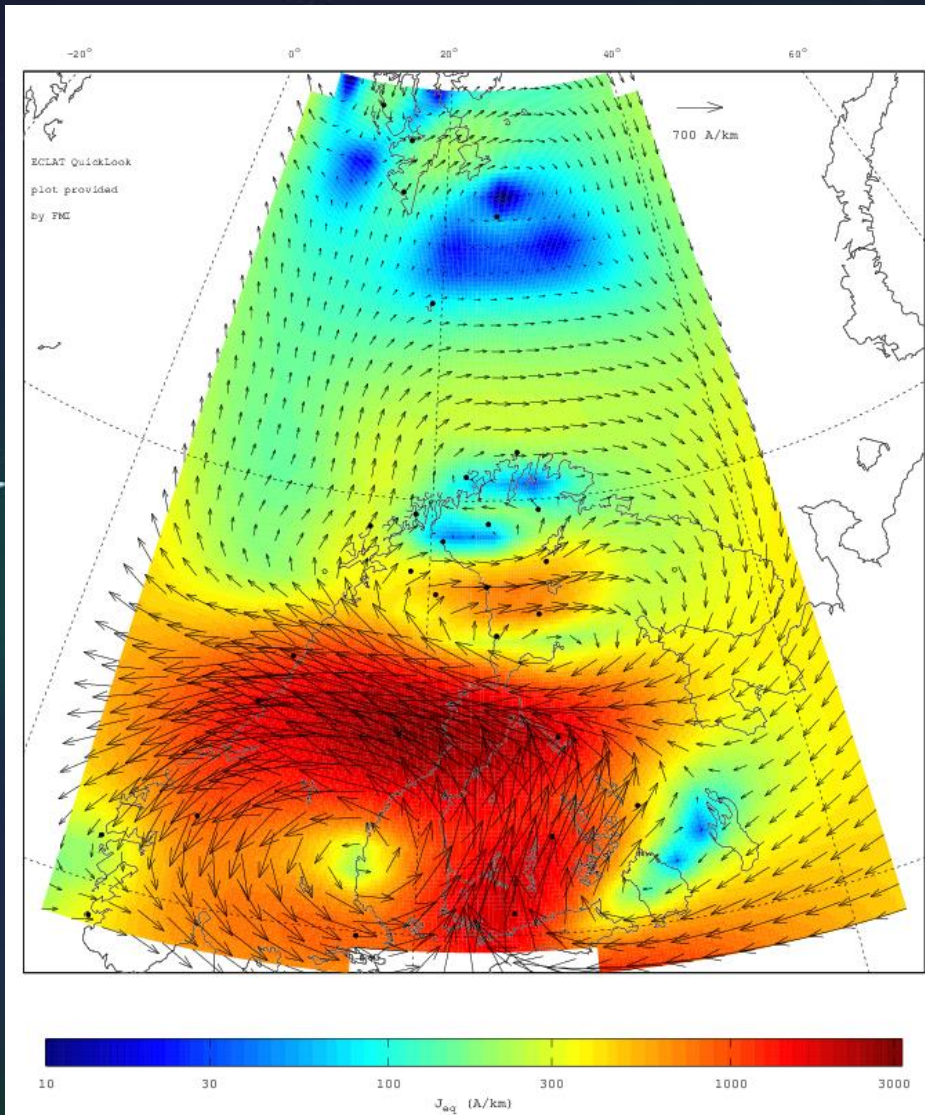


EXTRA SLIDES. Example to illustrate the nature of the SWx issues addressed with our research  
St. Patrick's Storm on 17. March, 2015

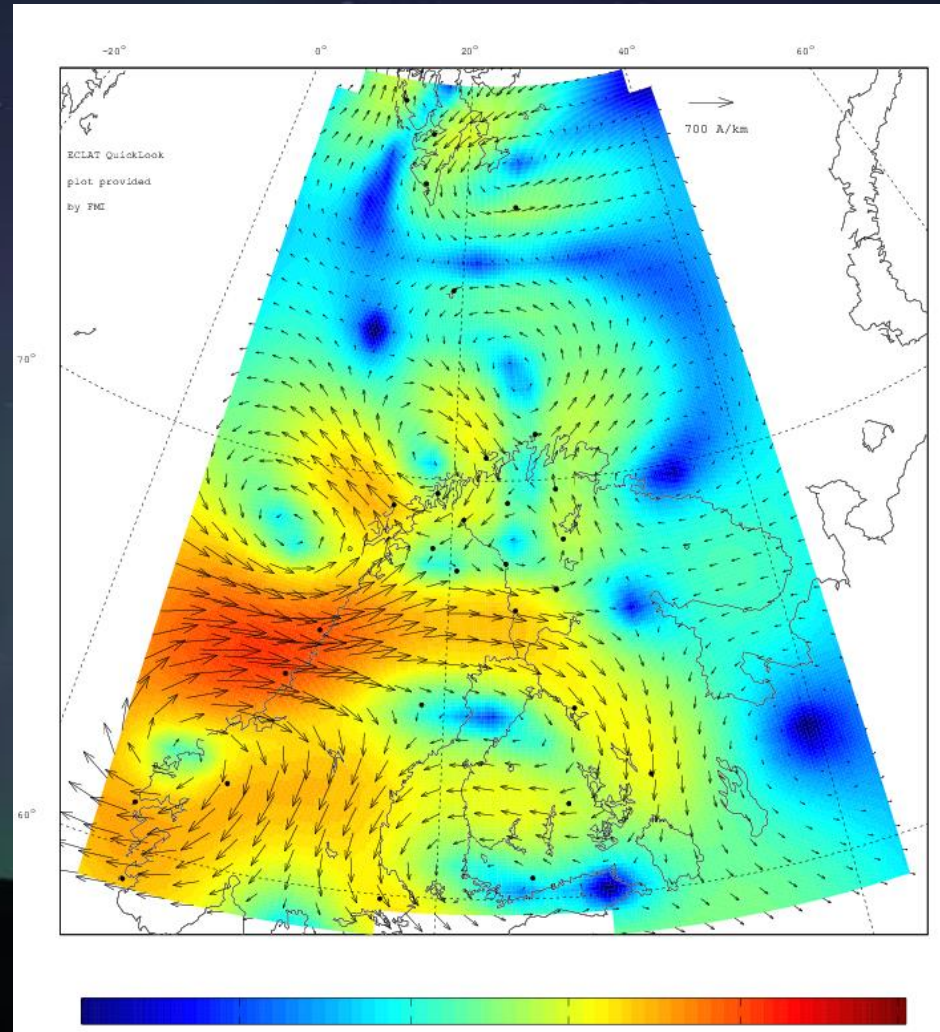
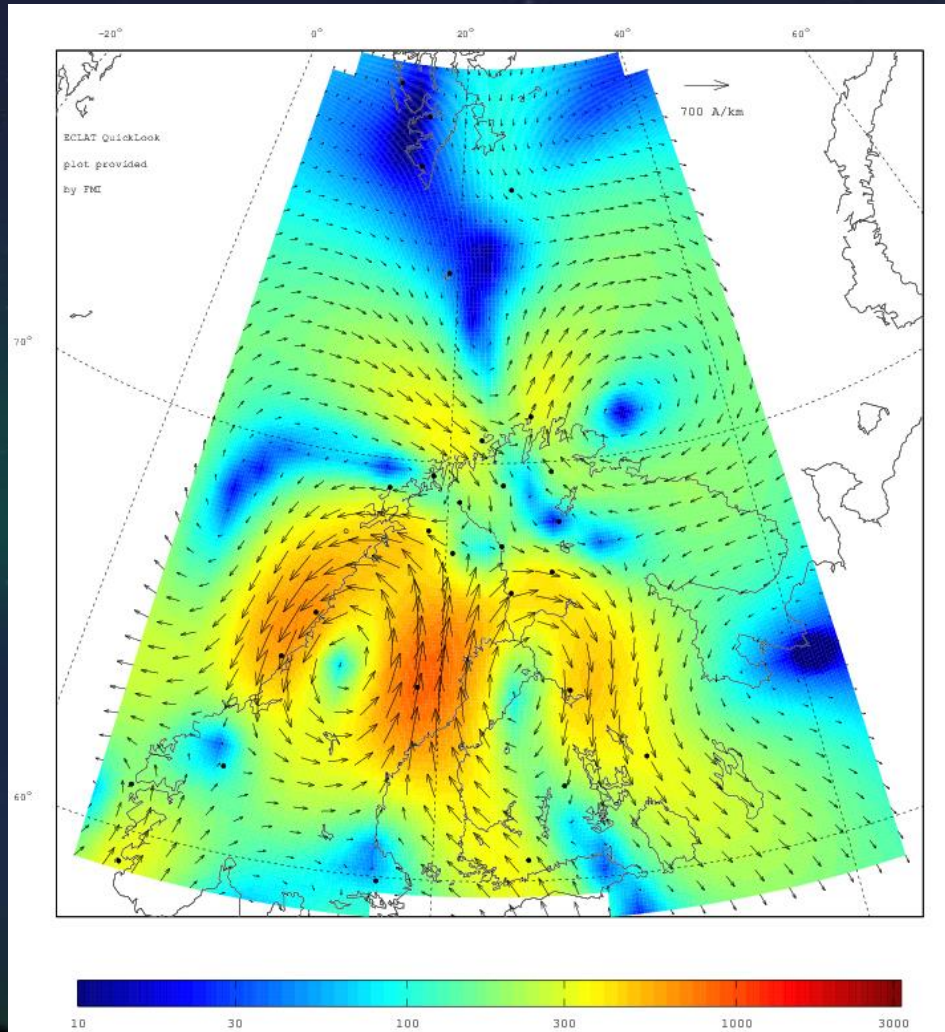


3 events in < 18 mins for entire sequence – 6 mins on average - much shorter than substorms

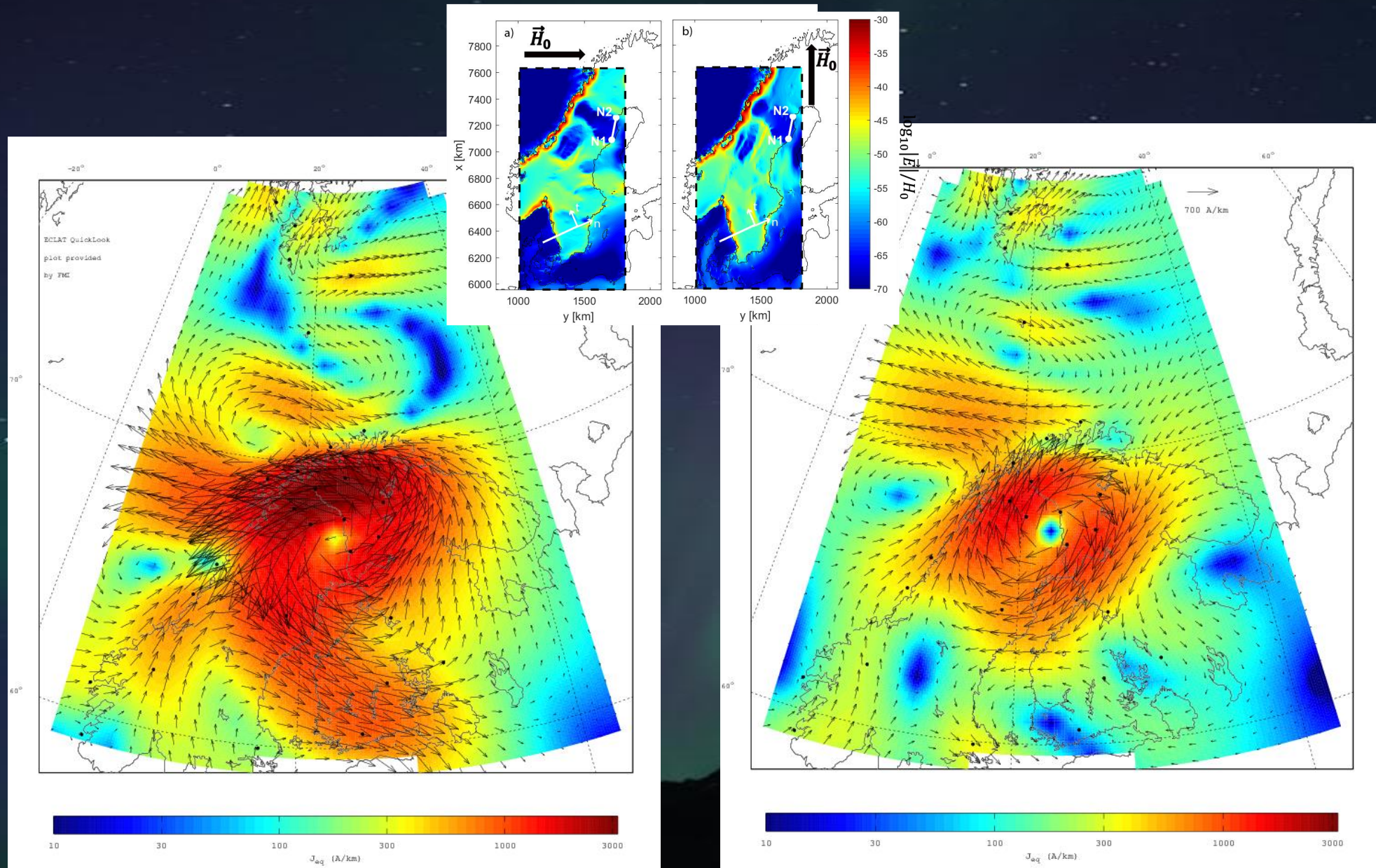
# Differential equivalent current vectors for built-up and dis-appearance of **first spike**



# Differential equivalent current vectors for built-up and dis-appearance of **second spike**



# Differential equivalent current vectors for built-up and dis-appearance of **third spike**



# Space Weather Activities in Switzerland

A.Csillaghy

- Institutions (NOT exhaustive):
  - University of Applied Science Northwestern Switzerland (FHNW)
  - Istituto ricerche solari Aldo e Cele Daccò (IRSOL)
  - Physikalisch-Meteorologisches Observatorium Davos/World Radiation Center (PMOD/WRC)
  - University of Bern
  - International Space Science Institute (ISSI)
- Involvement in diverse international associations including SCOSTEP and the new E-SWAN association

# Diverse activities

- Solar Orbiter: STIX, EUI, SPICE (FHNW and PMOD/WRC)
- PMOD/WRC has numerous instruments for TSI measurements
- e-Callisto: Instrument lead (Christian Monstein / IRSOL), main archive, and ESA Space Weather Element Archive (FHNW)
- Observing campaigns at GREGOR with ZIMPOL polarimeter (IRSOL)
- Sunspot observations at Specola Solare Ticinese (IRSOL) for the determination of the Sunspot Number (pilot station for the Sunspot Number determined at the SILSO in Brussels)

# Plans for 2023

- Continuation of instrumentation for space weather, including space missions
  - SMILE/SXI
  - Proba-3, Solar-C
- Pushing for an upgrade of e-Callisto for establishing a real-time monitoring system
  - IoT technology (MQTT)
  - Machine learning for automatic radio burst detection and calibration
- ML-based Flare forecasting

# SPACE WEATHER STUDIES IN TURKEY

Ali KILCIK



1. Flare Index values have been regularly calculated by the Kandilli Observatory Astronomy Laboratory since 1976, and these data are available to national and international scientific institutions and researchers.

<https://astronomi.boun.edu.tr/flare-index>

Also, sunspot observations have been made since 1946 and regularly sent to the sunspot number data centers such as SIDAC

<https://astronomi.boun.edu.tr/aylik-leke-sayilari>

2. There is one small group at Akdeniz University. Currently one master and one PhD thesis, which are focused on SEP events and upper atmosphere (Ionosphere-magnetosphere Interaction) respectively, are under preparation.

We have two scientific paper related to space weather during this year: "Temporal and Periodic Variations of the Solar Flare Index During the Last Four Solar Cycles and Their Association with Selected Geomagnetic-Activity Parameters, Ozguc, A; Kilcik, A and Yurchyshyn, V., Sep 2022, Solar Physics, 297.

A non-linear approach to predicting the amplitude and timing of the sunspot area in cycle 25, Chowdhury, P; Sarp, V; Kilcik, A; Ray, P.C; Rozelot, J.P; Obridko, VN, May 2022, MNRAS, 513 , pp.4152-4158

3. There is a one group at the Istanbul Technical university and they have space weather laboratory (<https://www.spaceweatherlab.itu.edu.tr/>)

The teams currently include five members and they are giving some lectures and courses related to space weather.

4. Last year the national space program of Turkey is announced and it includes one section that called Space Weather Research: It is aimed to create the scientific and technological infrastructure and know-how to ensure safety and sustainability of space missions, to raise national scientific competence in space weather and space science, and to contribute to universal science by increasing international cooperation of Turkey.

5. Eastern Anatolia Observatory (Doğu Anadolu Gözlemevi, DAG) has the biggest telescope in Turkey. The observatory site, "Karakaya Tepeleri", has a ~3170 m summit on a mountain range of 2500-3170 m altitude.

In this observatory, Cosmic muon measurement studies were initiated as of January 2022 within the scope of the DAG Project. For muon detection, detectors designed by DAG team are used, mainly consisting of a plastic scintillator, photomultiplier tube and DRS4 reading system. Currently, they are focuses on establishing a station that receives and analyzes data 24/7 and on new detector designs.

Also, DAG team introduced a new study subject or field called "Astrometeorology" (shortly Astrometeo), which brings together astronomy and space sciences such as Astronomical atmosphere, meteorology, satellite meteorology, remote sensing, atmospheric and meteorological information – products, space atmosphere and data analysis, etc.,).