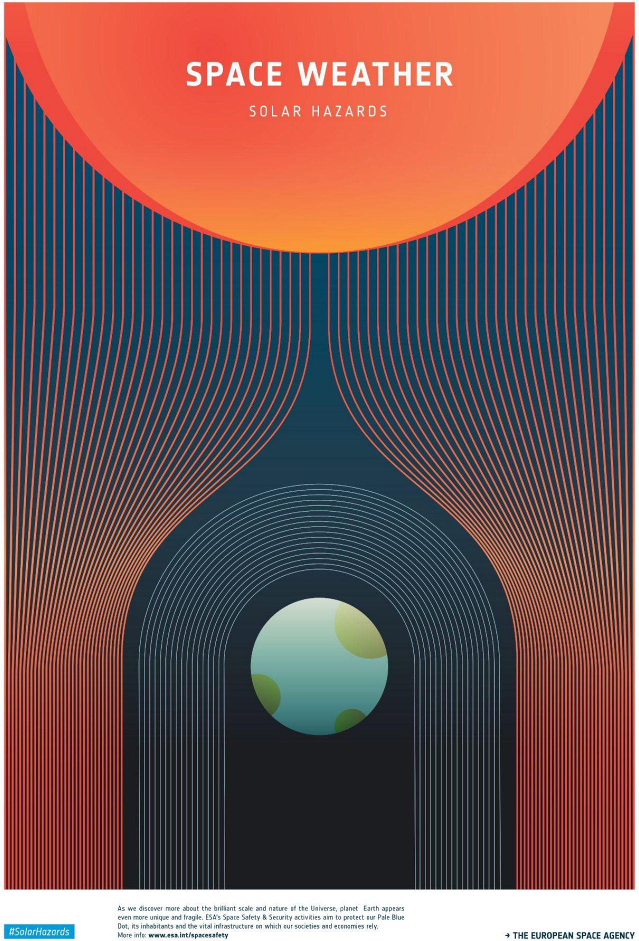
Capabilities in Slovakia related to SWE frameworks

SK-S2P workshop, 15 Feb 2022

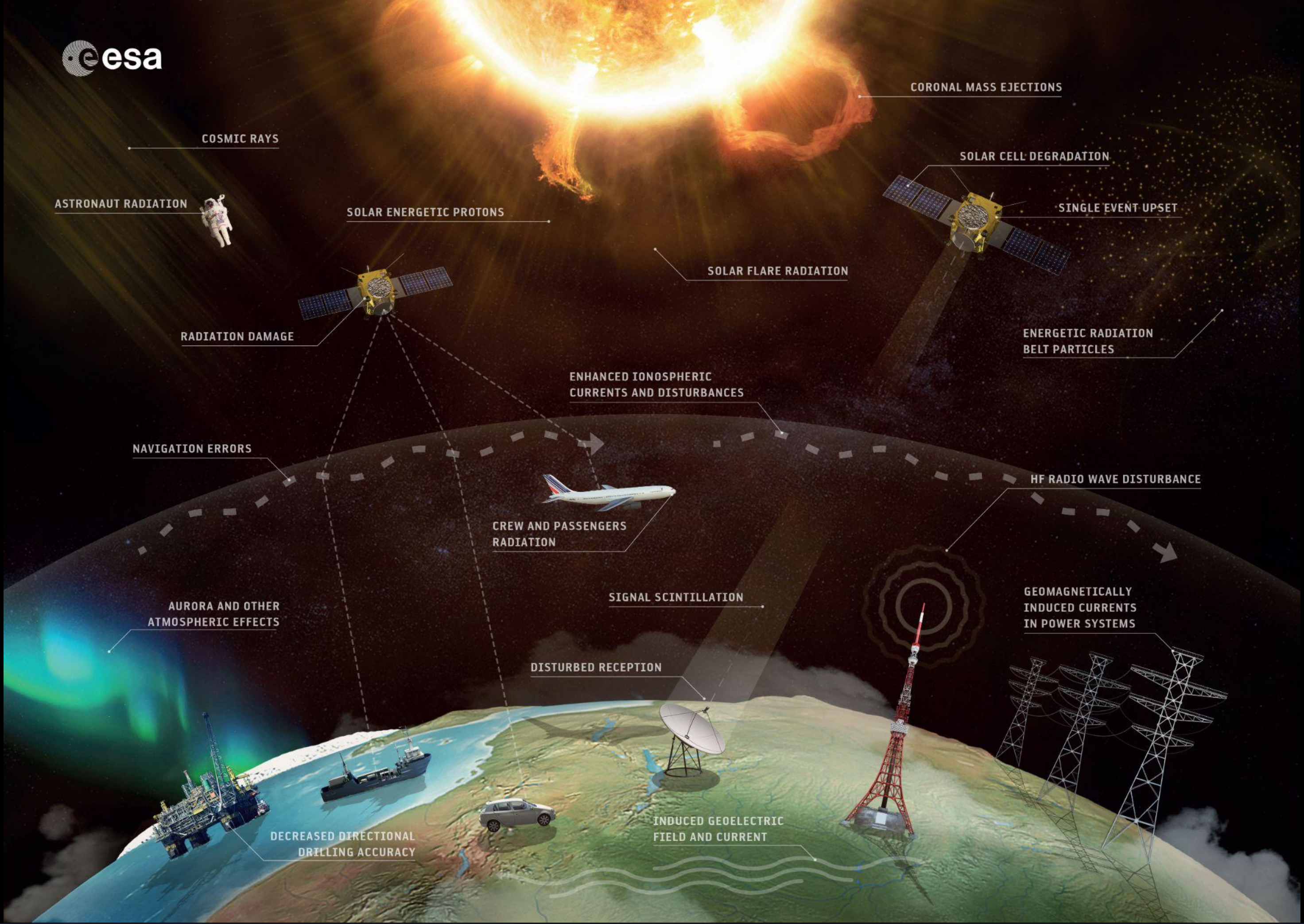


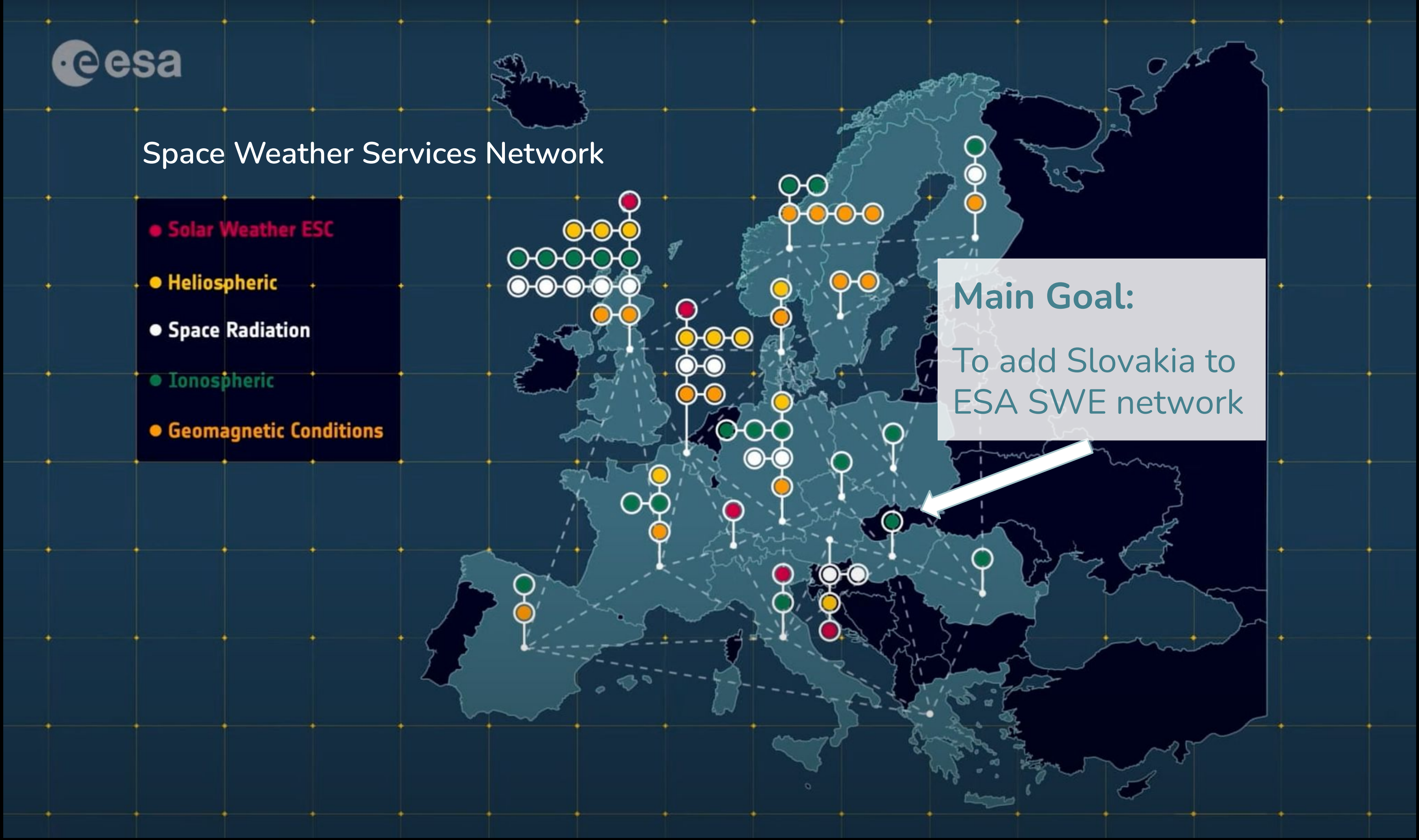
TECHNICAL UNIVERSITY OF KOŠICE

Introduction to SWE

Dr. Simon Mackovjak

Institute of Experimental Physics,
Slovak Academy of Sciences, Košice


esa
CORONAL MASS EJECTIONS
COSMIC RAYS
SOLAR CELL DEGRADATION
ASTRONAUT RADIATION
SOLAR ENERGETIC PROTONS
SINGLE EVENT UPSET
SOLAR FLARE RADIATION
RADIATION DAMAGE
ENERGETIC RADIATION
BELT PARTICLES
ENHANCED IONOSPHERIC
CURRENTS AND DISTURBANCES
NAVIGATION ERRORS
HF RADIO WAVE DISTURBANCE
CREW AND PASSENGERS
RADIATION
GEOMAGNETICALLY
INDUCED CURRENTS
IN POWER SYSTEMS
AURORA AND OTHER
ATMOSPHERIC EFFECTS
SIGNAL SCINTILLATION
DISTURBED RECEPTION
INDUCED GEOELECTRIC
FIELD AND CURRENT
DECREASED DIRECTIONAL
DRILLING ACCURACY

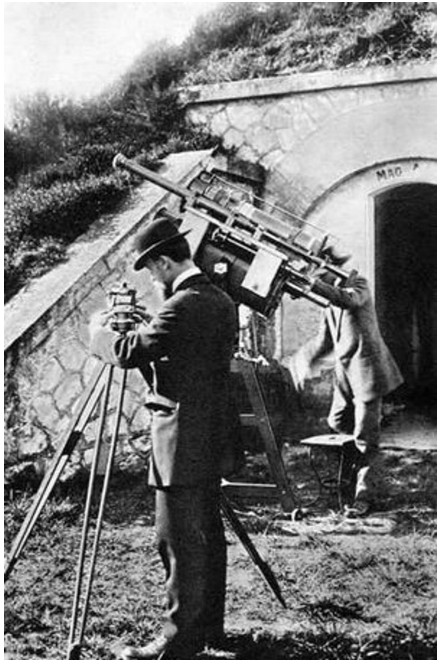


Main Goal:

To add Slovakia to ESA SWE network

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

Maximilian Hell, ~1770

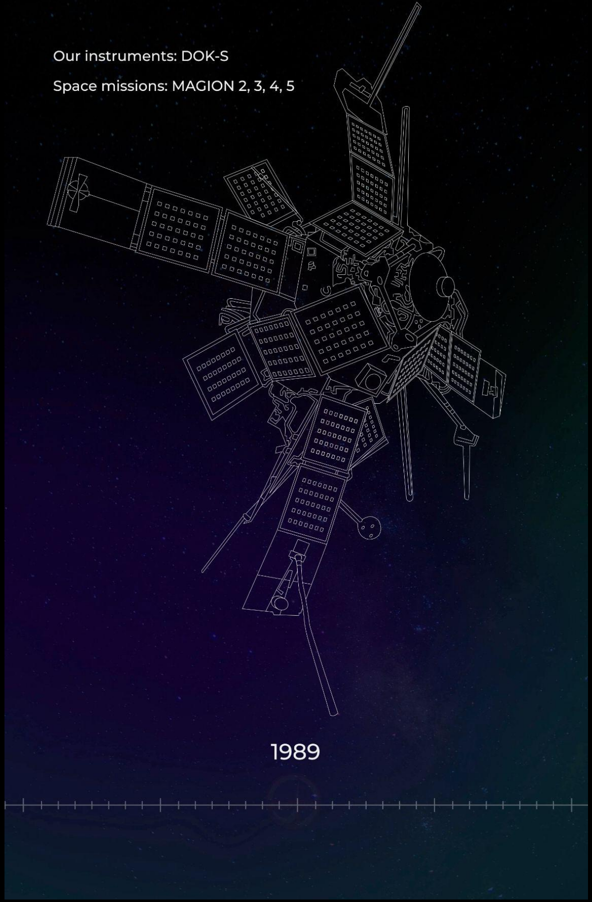


Milan Rastislav Štefánik, ~1905

Juraj Dubinský, ~1970

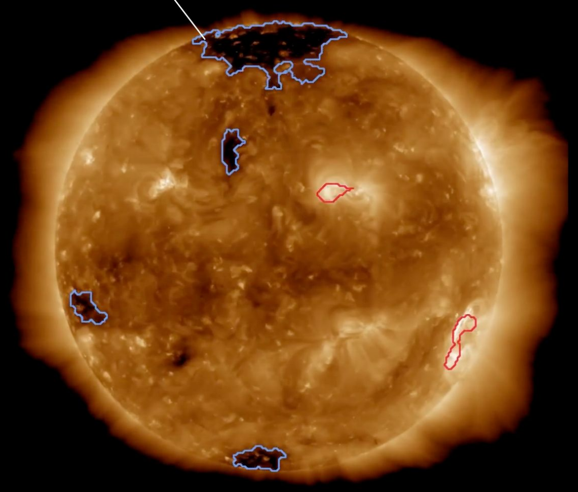
Own measurements

Cooperation in Space



Digital solutions

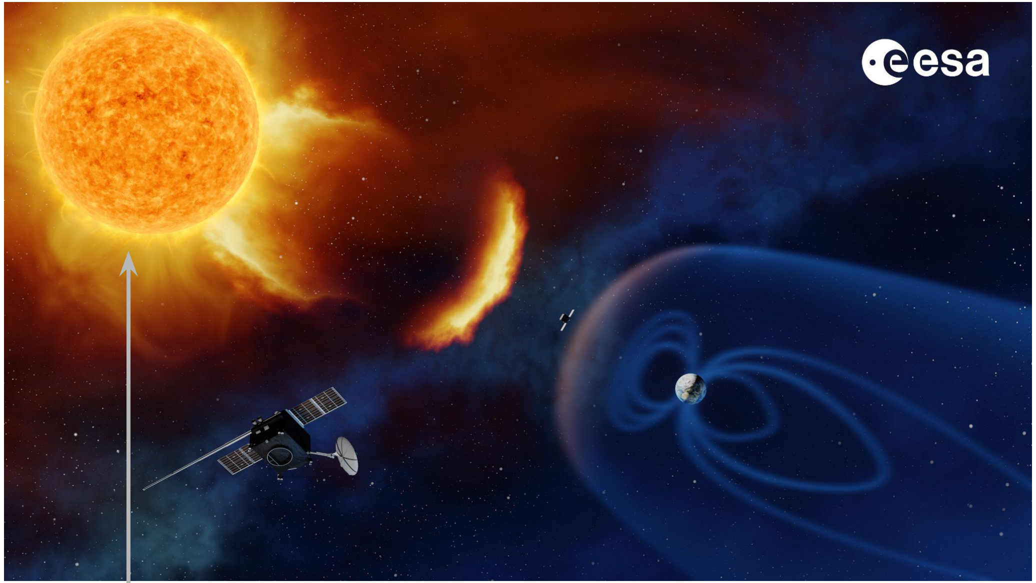
Our deep learning model for automatic segmentation of solar corona



SWE Session - Agenda

SK-S2P workshop, online, 15 Feb 2022 - Space Weather session				
Start	**Duration**	**Name**	**Speaker**	**Organization**
11:10	**8**	**Intro about SWE**	Dr. Šimon Mackovjak	IEP, SAS
11:18	**12**	**Solar Weather SWE**	Dr. Ivan Dorotovič, Dr. Ján Rybák	SUH; AI, SAS
11:30	**7**	**Heliospheric Weather SWE**	Dr. Ján Baláž	IEP, SAS
11:37	**7**	**Space Radiation SWE**	Dr. Ján Kubančak	IEP, SAS
11:44	**7**	**Ionospheric Weather SWE**	Dr. Šimon Mackovjak	IEP, SAS
11:51	**7**	**Geomagnetic Conditions SWE**	Dr. Fridrich Valach	ESI, SAS
11:58	**10**	**New Slovak potencional SWE players**	Assoc. Prof. P. Butka; M. Varga	FEI, TUKE
12:08	**17**	**ESA SWE network**	Dr. Alexi Glover	ESA
12:25	**10**	**Q&A**		
12:35	**60**	**Lunch break**		

SWE: Solar Weather



Dr. Ivan Dorotovič

Slovak Central Observatory Hurbanovo

❑ The regular solar observational program began in Hurbanovo (Ó-Gyalla) in 1872 **(150 years ago).**

- micrometric measurements of sunspots positions

<u>History</u>: N. Thege Konkoly performed the first drawing of sunspots on May 16, 1872.

- Since **1885:** Wolf's sunspot number was determined daily in Ó-Gyalla.
- Since **1967** we have a continuous database of sunspot observations, contribution to various databases (national in Prešov, SILSO, Sonne Netz) **55 years**

❖ **Solar weather** (sunspots, chromosphere, prominences, total solar eclipses, solar spectrum, solar radio bursts - CALLISTO, spectral continuum near the Balmer jump vs. solar flares)

and **heliospheric weather** (CME, cosmic radiation).

Main activities and results

- MSc. Thesis: Five minute oscillation in the solar photosphere
- PhD. Thesis: Solar cycles in the solar corona

- Staff member of the Slovak Central Observatory since **1987.**

- ➢ N-S asymmetry of Ca II K Plages and polar coronal holes
- ➢ Plasma motions and MHD sausage wawes in and around a solar pore
- ➢ Statistics of CMEs during the solar cycle 23
- ➢ Magnetic Turbulence in the Solar Wind and the Earth's Plasma Sheet
- ➢ Evolution of several space weather events connected with Forbush decreases

•Rotation of the solar corona / Differential rotation profile

-we used both the **tracer** and the **cross-correlation method**

a)software tools for automatic **detection** and **tracking** of various solar features (tracers)

ELSEVIER

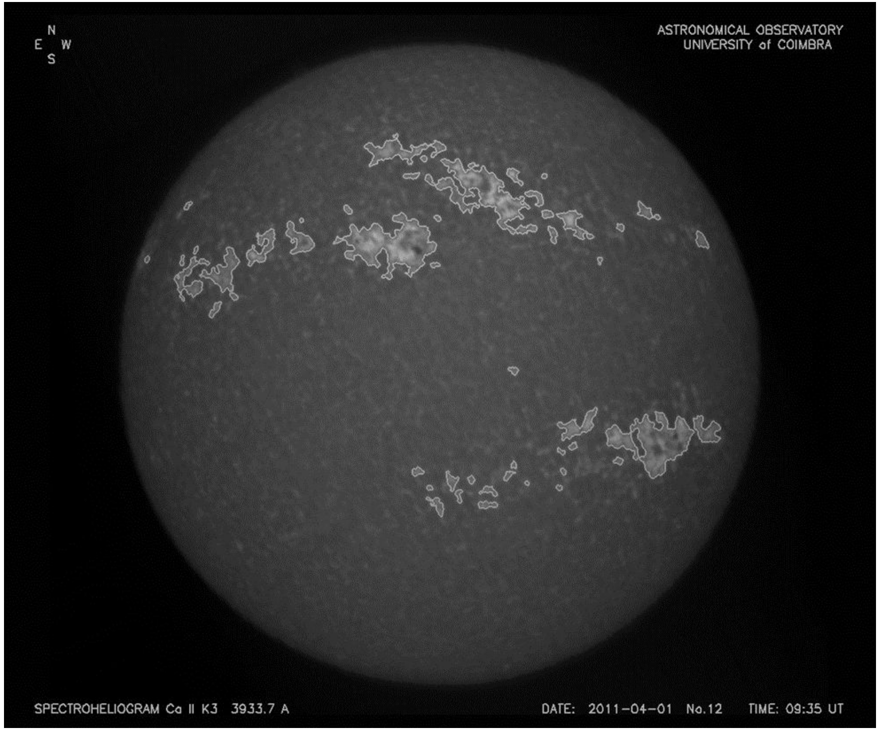
Astronomy and Computing

Volume 24, July 2018, Pages 70-83

Full length article

Software tool for automatic detection of solar plages in the Coimbra Observatory spectroheliograms

T. Barata [a], S. Carvalho [a, b], I. Dorotovič [c, d], F.J.G. Pinheiro [a], A. Garcia [a, e], J. Fernandes [a, e, f], A.M. Lourenço [a]



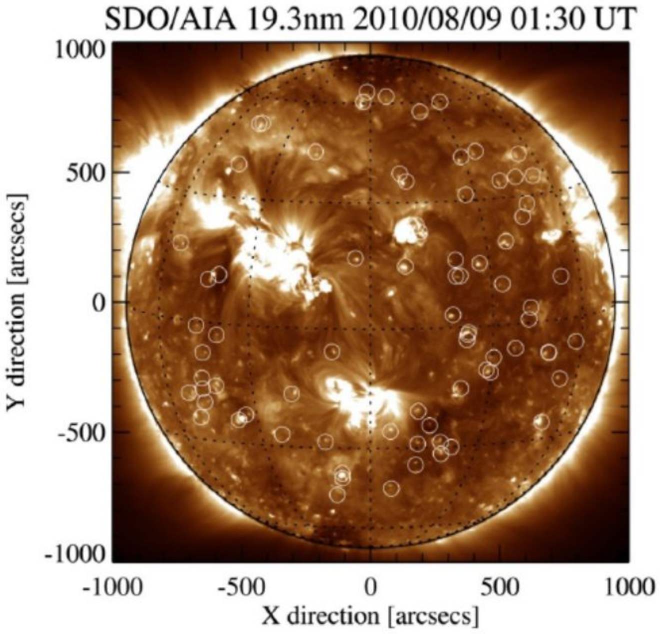
Sun and Geosphere, 2018; 13/2: 129 - 133 ISSN 2367-8852

Gradient Path Labeling (GPL) method:

Automatic detection and tracking of coronal bright points in SDO/AIA images

I. Dorotovič [1,2], A. Coelho [2], J. Rybák [3], A. Mora [2], R. Ribeiro [2], W. Kusa [4], R. Pires [2]

[1] Slovak Central Observatory, Hurbanovo, Slovak Republic
[2] CTS/UNINOVA-CA3, FCT-UNL, Caparica, Portugal
[3] Astronomical Institute SAS, Tatranská Lomnica, Slovak Republic
[4] Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland



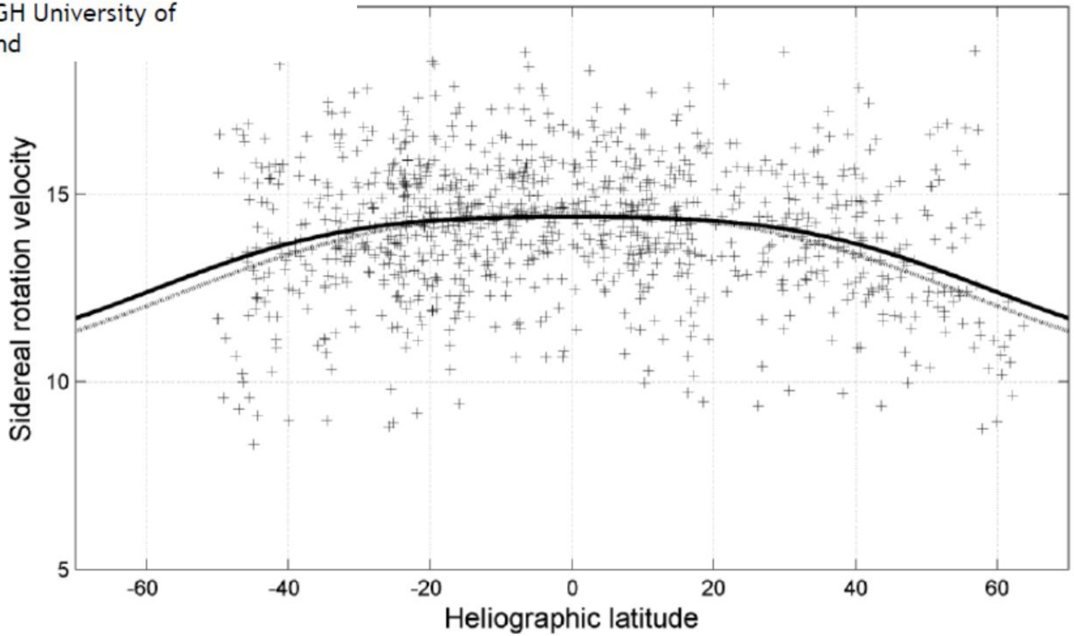
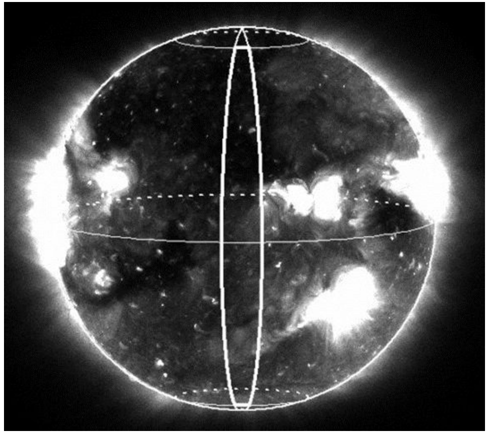
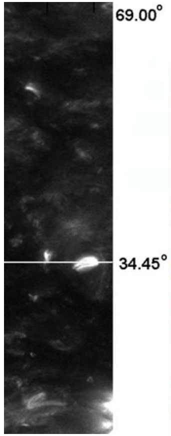


Figure 4. Individual observations of rotational velocity in respect to latitude. Thick solid black line indicates the best fit to these values. The values of the optimum fit (solid line) parameters A, B, C are 14.392 ° day^{-1}, –0.567 ° day^{-1}, and –2.8 ° day^{-1}, respectively.

b) cross-correlation method:



Solar corona on 30 August 2016



Northern part of the selected region

Rotation of Some Solar Coronal Bright Features as Derived from the *Solar Dynamics Observatory/Atmospheric Imaging Array* (SDO/AIA) 21.1 nm Images (for the Years 2011 – 2018)

I. Dorotovič & M. Rybanský

Solar Physics **294**, Article number: 109 (201

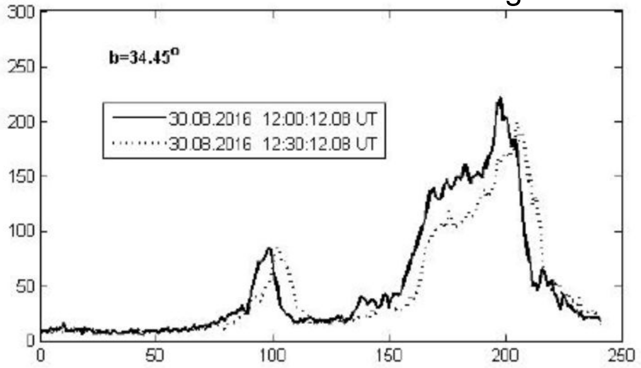


Figure 3. Evolution of intensities in two neighboring images from 30 August 2016 at the latitude of 34.45°.

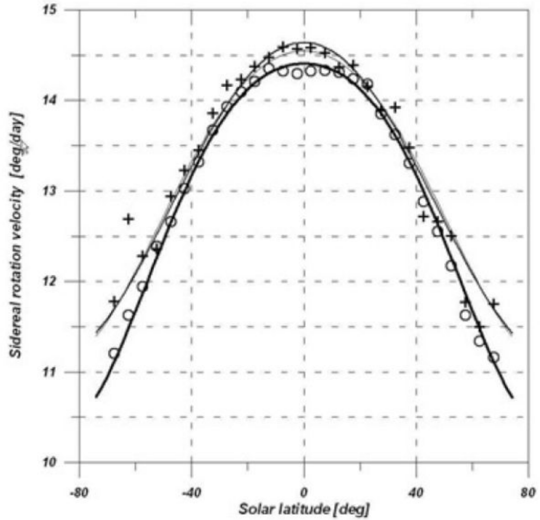


Figure 6. Profile of sidereal rotation velocity according to Table 2, showing BCG data (*circles*) and CBP data (*crosses*). *Solid lines* show approximations, for o: $\omega = 12.183\, sin^2 b - 1.955\, sin^4 b$ and for +: $\omega = 14.642 - 3.185\, sin^2 b - 0.304\, sin^4 b$. The thin line represents the profile presented by Brajša *et al.* (2004).

❑ Possible cooperation with ESA

SEIS: "Space Environment Information System" - Past Research Projects

- Scientific advisor in the ESA project SEIS (2003-2006) for solar weather features and space weather effects.

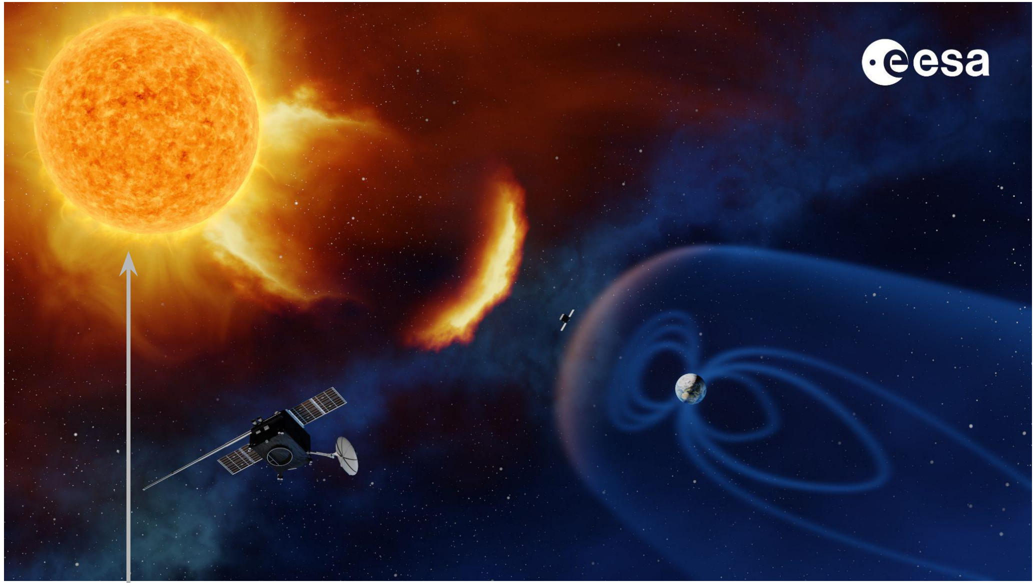
UNINOVA

Caparica, Portugal

SEISOP - Space Environment Information System for Operations

Financing: ESA / ESOC-ESAC

- Development of a software tool for automatic image processing, feature recognition and tracking.



SWE: Solar Weather

Dr. Ján Rybák

Astronomical Institute,
Slovak Academy of Sciences, Tatranská Lomnica

Astronomical Institute of SAS – Solar physics department:

- a small group of astrophysicists and engineers
- research on solar atmosphere and solar activity
- usage of the best European ground-based solar telescopes & data of different satellites for solar observations
- broad international cooperation
- involvement in the EST project

At first glance no clear relation to SWE ESA activities, but…

Astronomical Institute of SAS – Solar physics department:

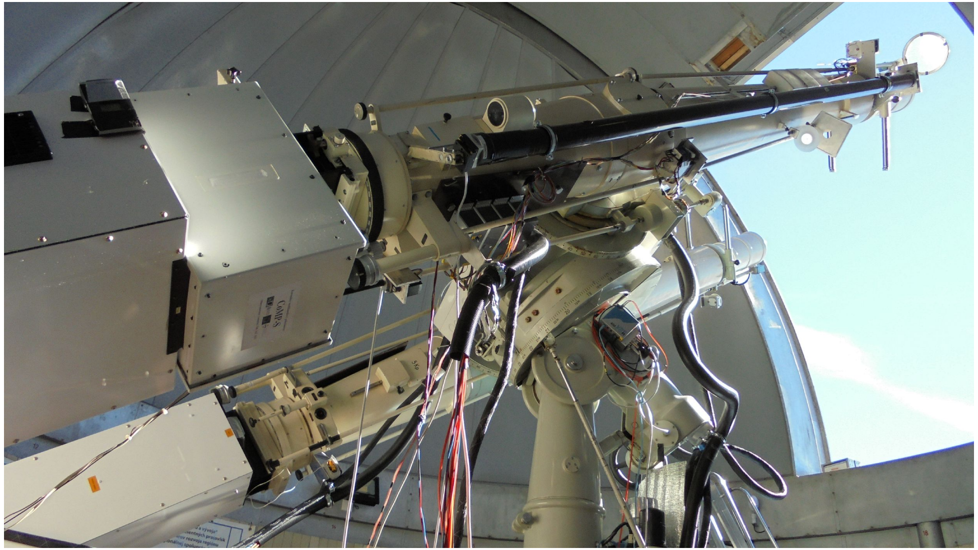
- expertise in classical solar **coronagraphic observations** of the emission lines of prominences and solar corona at the **high-altitude observatory**

- AISAS is operating **Lomnický Štít Observatory** (LSO) - quite unique in Europe (*Pic du Midi (F)*, *Kislovodsk (Russia)*)

In our opinion the LSO might be of interest for ESA SWE activities

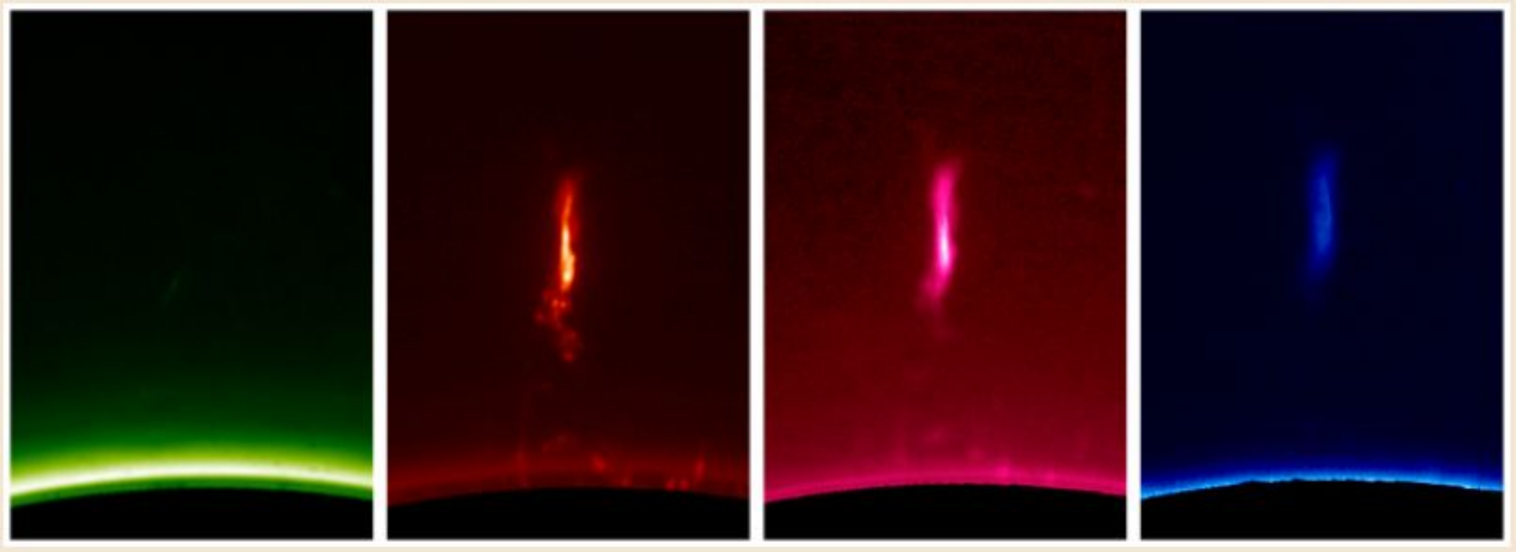
Lomnický Štít Observatory (2633 m asl):

- two ZEISS 200/3000/4000 coronagraphs @ common mount
- spectro-polarimetric post-focus instruments – CoMP-S, SCD
- all year round operation



Lomnický Štít Observatory (2633 m asl):

- CoMP-S instrument (tunable Lyot filter) observations:
  - sp. line profiles: He I D3 587, Fe X 637, H I 656, Ca II 854 + ...
  - maximum FoV: ~430 x290 arcsecs



He I D3 587 H I 656 Ca II 854 He I 1083

Suggestions of possible cooperation with ESA:

- a **test bed** for testing of the methods/instruments for future ESA instruments for solar coronagraphic measurements: two identical telescopes, pointing mechanisms, flexible corona-graph rear side interface for fixing of post-focus instruments

Previous activities:

- CorMag instrument – prof. S. Fineschi OAT, Torino (I), for PROBA-3 mission
- WAMIS instrument – Dr. Y.-K., Ko, NRL, Washington (USA), for NASA stratospheric balloon progra

Future activities:

- SLED instrument – Dr. P. Rudawy, for natural eclipse observations

Suggestions of possible cooperation with ESA:

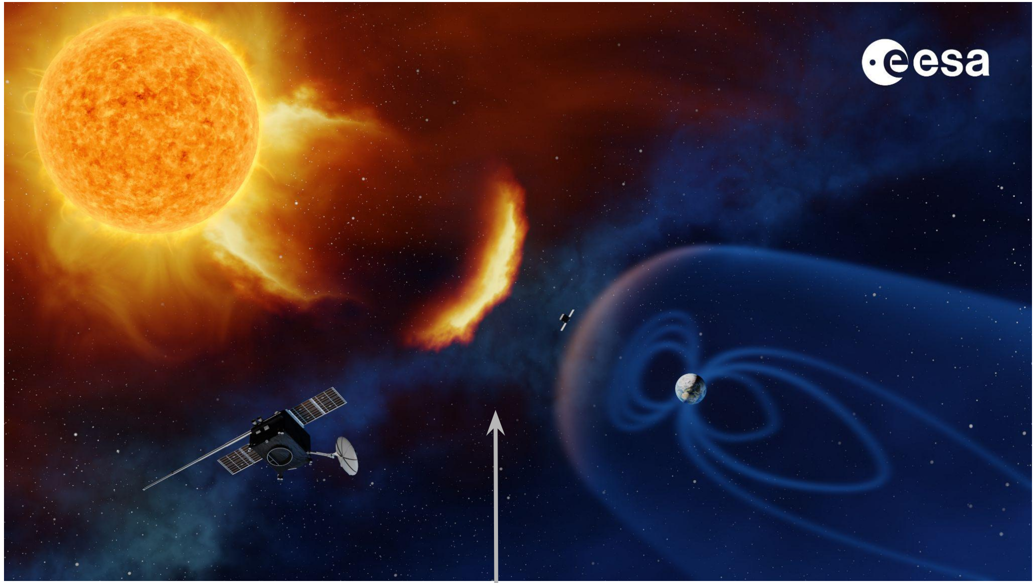
- supporting of **coordinated measurements** with the ESA solar missions with solar coronagraphs (SolO, Proba-3,...)

Previous activities:

- ESA PECS 5th call for Slovakia, 2019: proposal *“Lomnicky Stit Observatory - instrumentation upgrade and the ground-based support of the ESA solar coronagraphy (LSOforESA)”* , support of the SolO/METIS PI (Dr. M. Romoli) and PROBA-3 PI (Dr. A. Zhukov), not supported (“no interest for ESA”)
- involvement in the Parker Solar Probe coordinated supporting campaigns

Future activities:

- SolO and PROBA-3 support



SWE: Heliospheric Weather

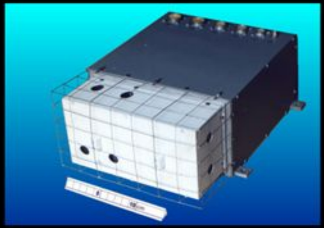
Dr. Ján Baláž

Institute of Experimental Physics,
Slovak Academy of Sciences, Košice

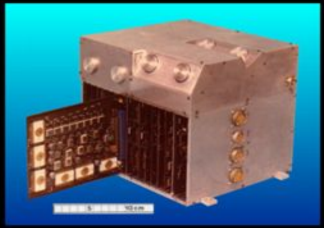
Department of Space Physics has been developing space science equipment related to Space Weather for decades, especially energetic particle detectors

SK-1
Interkozmos-17 (1977)

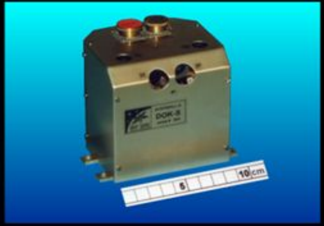
DOK-T
Prognoz-10 (1981)



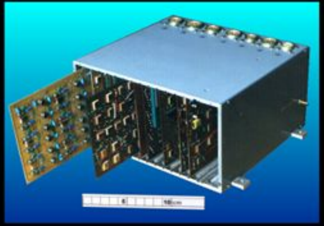
DOK-1
Intershock (1985)



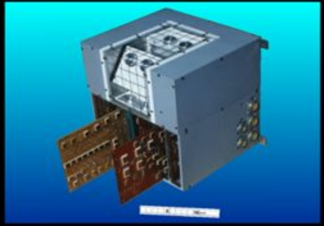
SPE-1
Active (1989), MIR (1996)



DOK-S
Active (1989)...1996 (4x)



SONG-E
Coronas-I (1994), -F.(2001)



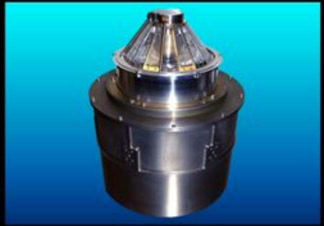
DOK-2
Interball (1995, 1996)

SLED-2
MARS-96 (1996)

NUADU
Double Star (2004)

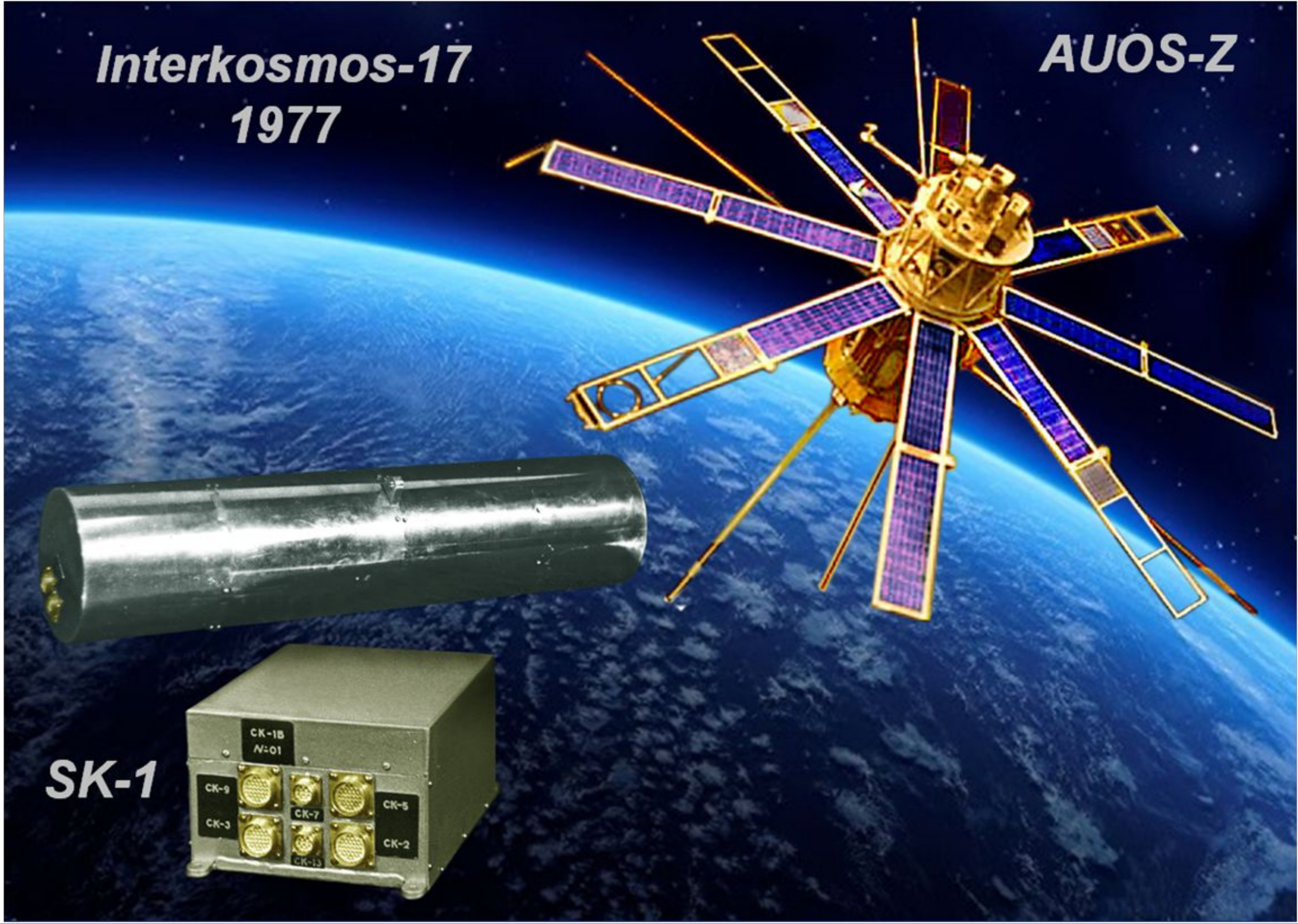
MEP-2
Radioastron (2011)

PICAM
BepiColombo (2018)

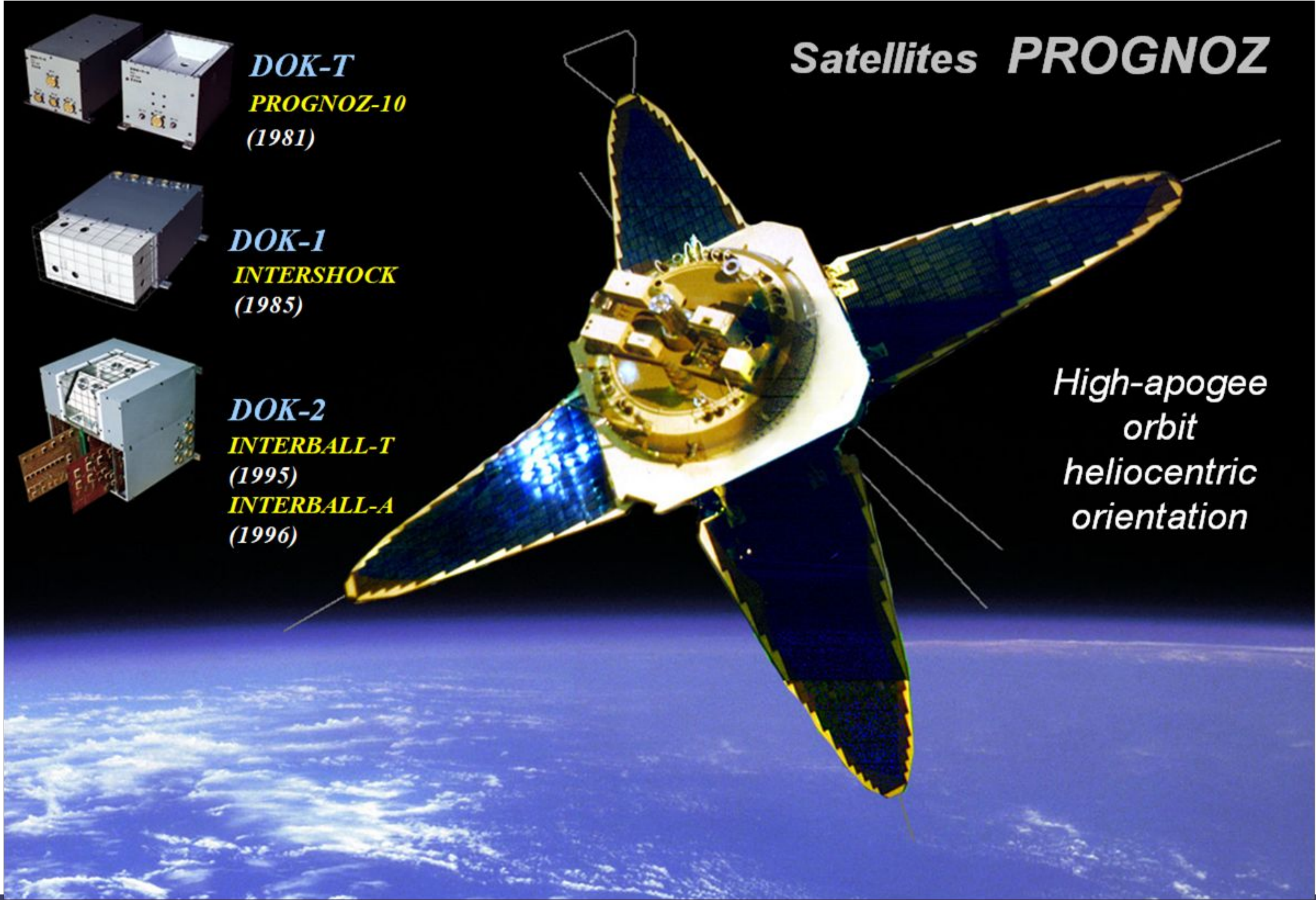


PEP - JDC
JUICE (2023)

SK-1
First
space detector
developed
and
constructed
at the Institute
has been
launched to
space
in September
1977

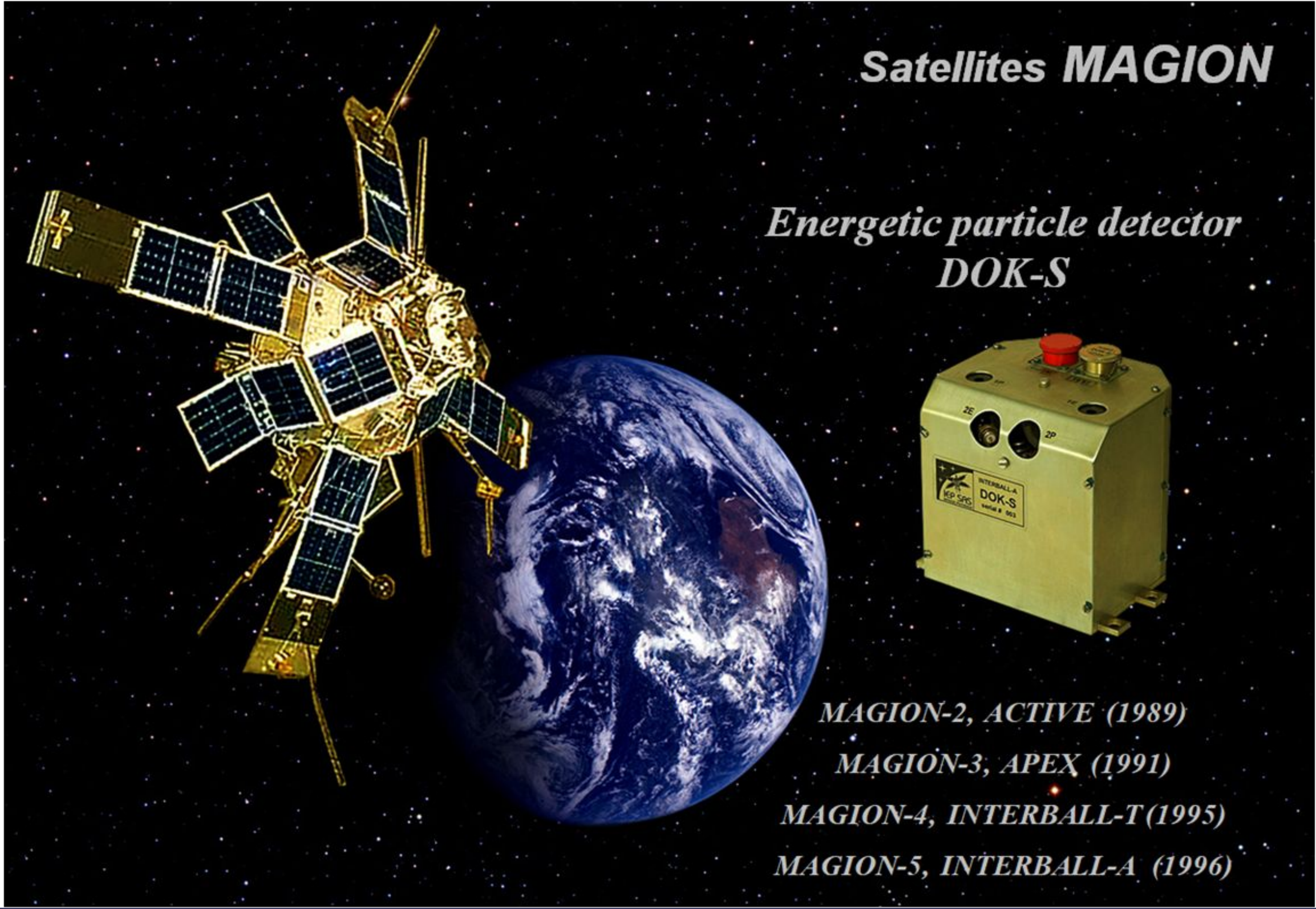


Series of successful passive-cooled "DOK" particle detectors operated on four PROGNOZ satellites



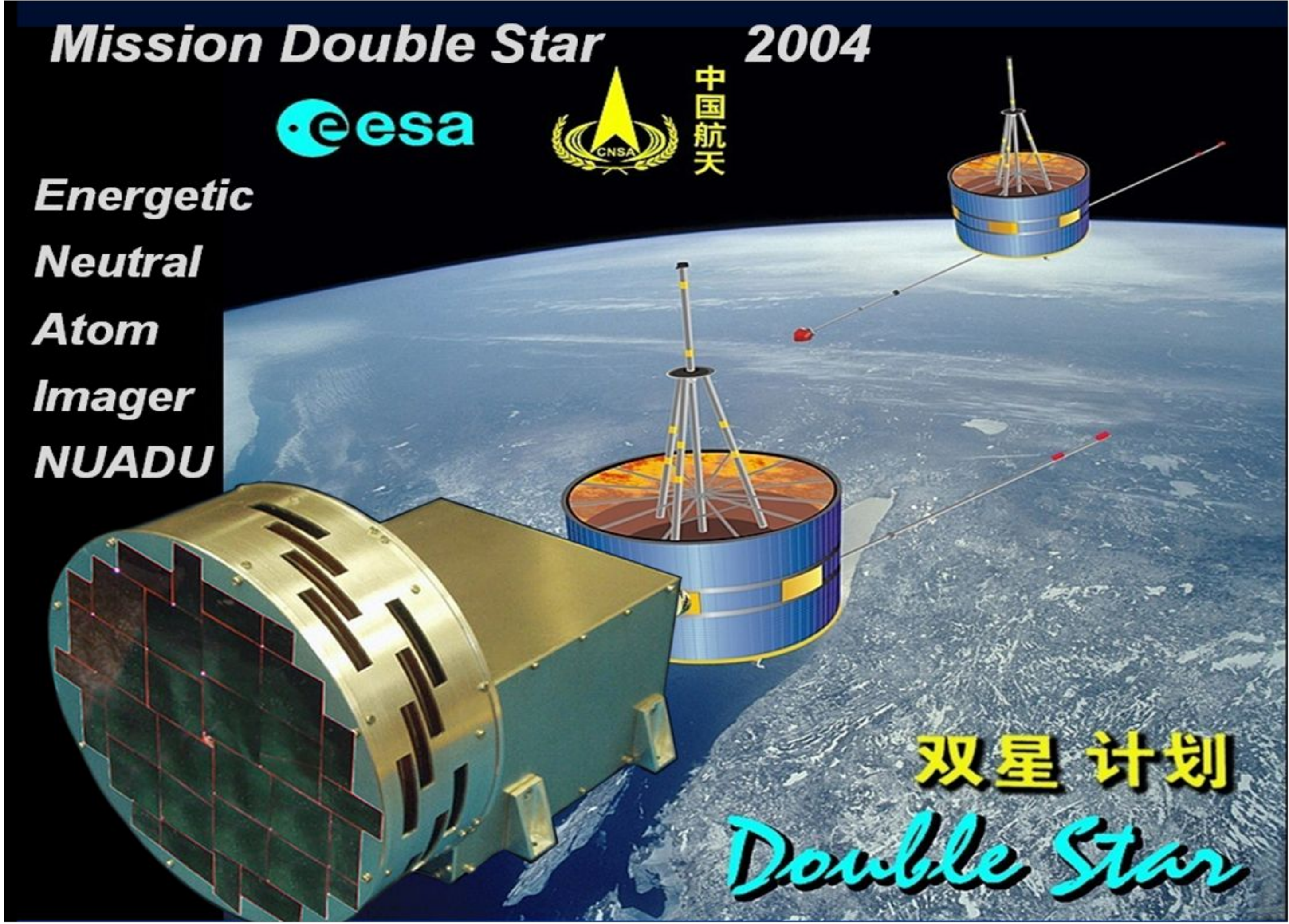
DOK-S

particle detectors operated on four MAGION satellites



Successful ENA imager NUADU on board of Double Star TC-2 satellite

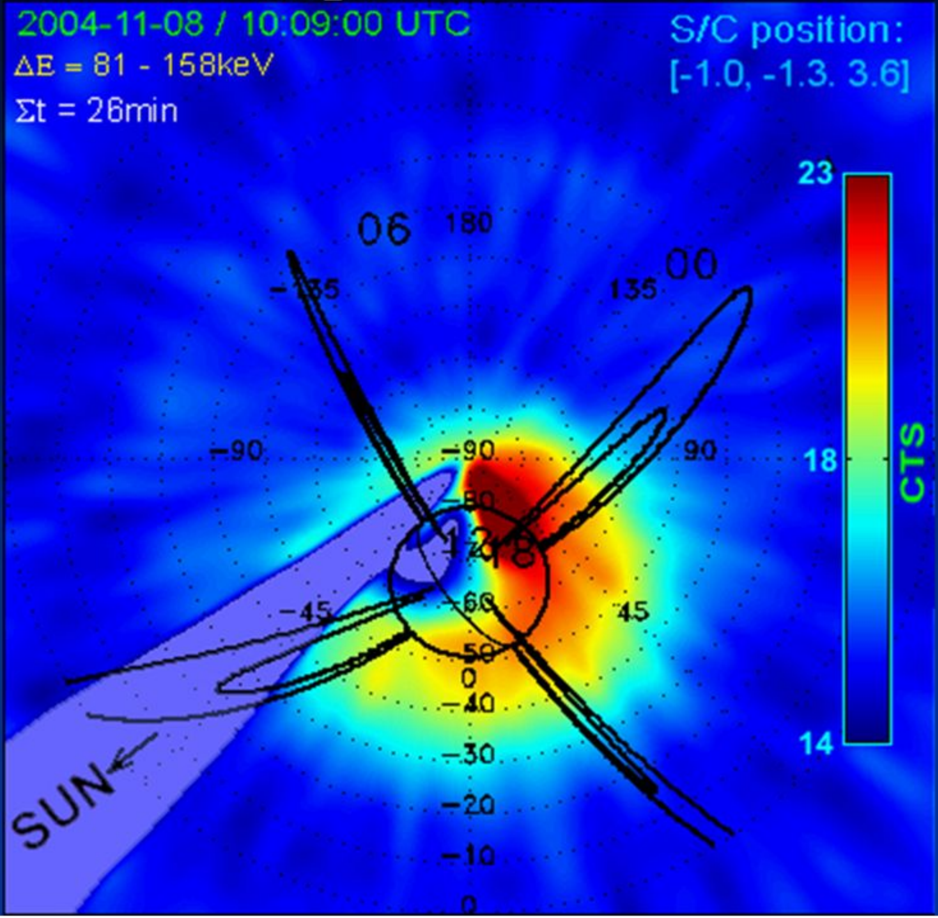
(cooperation with Ireland Sweden & China)



Magnetospheric Ring Current morphology and development as recorded by NUADU during geomagnetic storm

(NUADU 39000 km above north pole)

NUADU ENA image of magnetospheric ring current during Geomagnetic Storm 8.11.2004



Some published results from NUADU obser- vations

JGR Space Physics

Magnetospheric Physics | Free Access

Moderate geomagnetic storm (21–22 January 2005) triggered by an outstanding coronal mass ejection viewed via energetic neutral atoms

Susan McKenna-Lawlor, Lu Li, Iannis Dandouras, Pontus C. Brandt, Yihua Zheng, Stas Barabash, Radoslav Bucik, Karel Kudela, Jan Balaz, Igor Strharsky

Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
Nuclear Instruments and Methods in Physics Research A 530 (2004) 311–322
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

The energetic NeUtral Atom Detector Unit (NUADU) for China's Double Star Mission and its calibration

Susan McKenna-Lawlor[a,*], Jan Balaz[a], Igor Strharsky[a], Stas Barabash[b], Klas Brinkfeldt[b], Lu Li[c], Chao Shen[c], Jiankui Shi[c], Qingang Zong[c], Karel Kudela[d], Suiyan Fu[e], Edmond C. Roelof[f], Pontus C:son Brandt[f], Iannis Dandouras[g]

Annales Geophysicae, 23, 2953–2959, 2005
SRef-ID: 1432-0576/ag/2005-23-2953

Annales Geophysicae

Electron pitch angle variations recorded at the high magnetic latitude boundary layer by the NUADU instrument on the TC-2 spacecraft

L. Lu[1], S. McKenna-Lawlor[2], S. Barabash[3], Z. X. Liu[1], J. Balaz[2], K. Brinkfeldt[3], I. Strharsky[2], C. Shen[1], J. K. Shi[1], J. B. Cao[1], S. Y. Fu[4], H. Gunell[2,3], K. Kudela[5], E. C. Roelof[6], P. C. Brandt[6], I. Dandouras[7], T. L. Zhang[8], C. Carr[9], and A. Fazakerley[10]

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Iterative inversion of global magnetospheric information from energy neutral atom (ENA) images recorded by the TC-2/NUADU instrument

LU Li[1†], S. MCKENNA-LAWLOR[2], S. BARABASH[3], J. BALAZ[2,4], LIU ZhenXing[1], SHEN Chao[1], CAO JinBin[1] & TANG ChaoLing[5]

SCIENCE CHINA
Earth Sciences
• RESEARCH PAPER •
doi: 10.1007/s11430-015-5121-7

The causal sequence investigation of the ring current ion-flux increasing and the magnetotail ion injection during a major storm

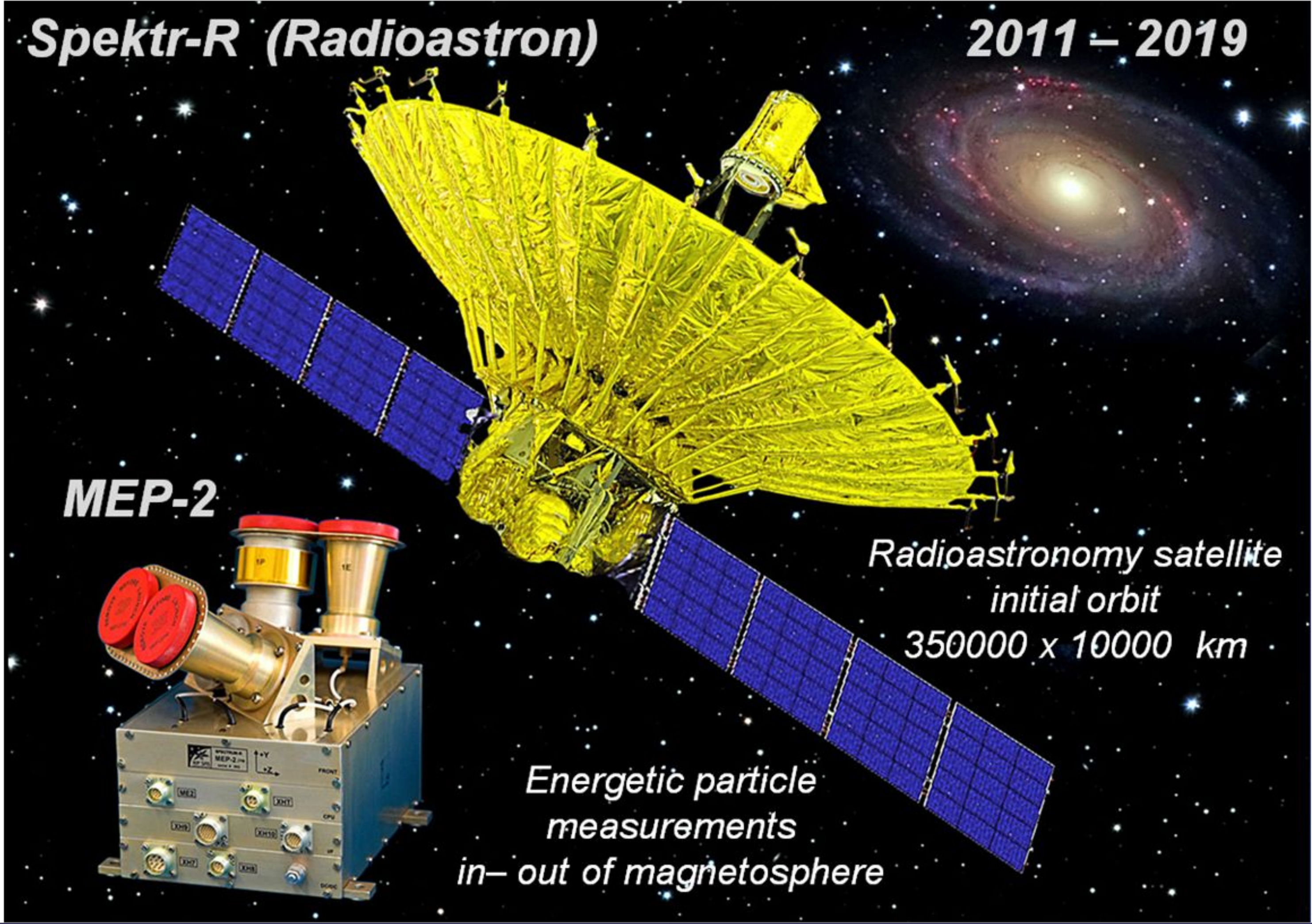
LU Li[1*], S MCKENNA-LAWLOR[2], CAO JinBin[3], K KUDELA[4] & J BALAZ[2,4]

SCIENCE CHINA
Earth Sciences
CrossMark
• RESEARCH PAPER •
https://doi.org/10.1007/s11430-018-9307-a

Close up observation and inversion of low-altitude ENA emissions during a substorm event

Li LU[1*], Susan MCKENNA-LAWLOR[2] & Jan BALAZ[2,3]

Successful programmable energetic particle detector MEP-2 on board of SPEKTR-R spacecraft operated for 8 years



Most prestigious result from MEP-2 observations:

Oscillations of energetic ions in foreshock of Earth's magneto-sphere

AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Space Physics

RESEARCH ARTICLE

10.1002/2015JA021077

Key Points:

- Oscillations of energetic ions are found in the foreshock
- Energy range is 4–400 keV, periods 10–60 s
- Events are related to fast solar wind

Supporting Information:

- Readme
- Data Set S1
- Table S1

Correspondence to:
A. A. Petrukovich,
apetruko@iki.rssi.ru

Oscillations of energetic ions flux near the Earth's bow shock

A. A. Petrukovich[1], T. Inamori[1], J. Balaz[2], K. Kudela[2], M. Slivka[2], I. Strharsky[2], V. A. Gladyshev[1], T. Sarris[3], and E. Sarris[3]

[1]Space Research Institute, Russian Academy of Sciences, Moscow, Russia, [2]Institute of Experimental Physics, Slovakian Academy of Sciences, Kosice, Slovakia, [3]Electrical & Computer Engineering Department, Democritus University of Thrace, Xanthi, Greece

Abstract A new type of variability in the foreshock and magnetosheath is revealed with the recent energetic particle experiments monitor of electrons and protons (MEP) onboard Spectr-R spacecraft and solid-state telescope onboard Time History of Events and Macroscale Interactions during Substorms spacecraft, which have high time resolution. Oscillations of energetic ion fluxes are observed in the broad energy range ~4–400 keV, with periods 10–30 s, often rather monochromatic waveform and accompanied with magnetic oscillations. Such events are not so rare (~100 cases are found for 2007–2012) but are associated mostly with high-speed solar wind.

Participation on BepiColombo mission to Mercury

Contribution to SERENA PICAM Ion mass spectrometer *(Cooperation with Ireland and Austria)*

Bepi Colombo mission status

and

SERENA publications

Mission status

Launch Oct. 2018
Earth Apr. 2020
Venus Oct. 2020
Venus Aug. 2021
Mercury Oct. 2021
…

Mercury Jun 2022
Mercury Jun 2023
Mercury Sep 2024
Mercury Dec 2024
Mercury Jan 2025
M. orbit Dec 2025

ELSEVIER
Available online at www.sciencedirect.com
ScienceDirect
Planetary and Space Science 58 (2010) 166–181
Planetary and Space Science
www.elsevier.com/locate/pss

SERENA: A suite of four instruments (ELENA, STROFIO, PICAM and MIPA) on board BepiColombo-MPO for particle detection in the Hermean environment

S. Orsini[a,*], S. Livi[b], K. Torkar[c], S. Barabash[d], A. Milillo[a], P. Wurz[e], A.M. Di Lellis[f], E. Kallio[g], the SERENA team[1]

Space Sci Rev (2021) 217:11
https://doi.org/10.1007/s11214-020-00787-3

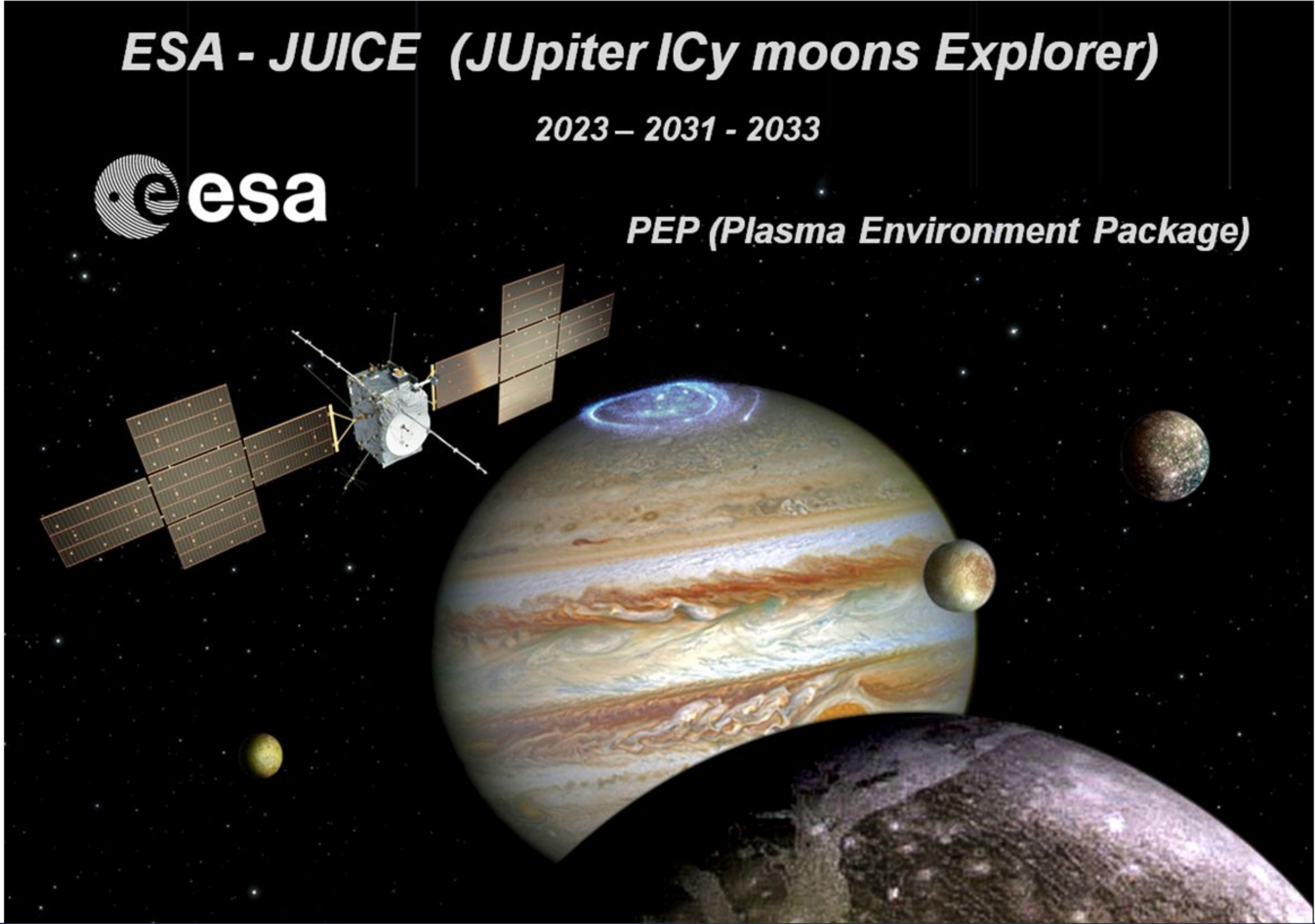
Check for updates

SERENA: Particle Instrument Suite for Determining the Sun-Mercury Interaction from BepiColombo

Title: First observations of Mercury's inner southern magnetosphere by BepiColombo/SERENA ion sensors.

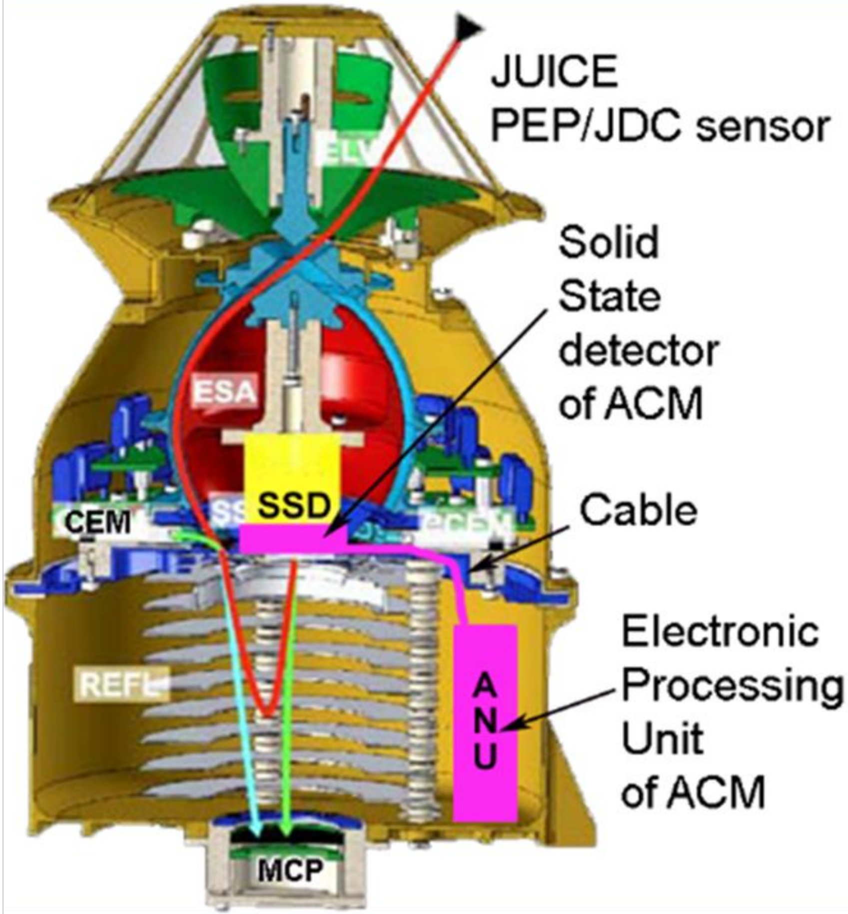
Authors: S. Orsini[1*], A. Milillo[1], H. Lichtenegger[3], A. Varsani[3], S. Barabash[4], S. Livi[2,8], E. De Angelis[1], G. Laky[3], H. Nilsson[4], M. Phillips[2], A. Aronica[1], E. Kallio[5], P. Wurz[6], T. Alberti[1], A. Olivieri[7], C. Plainaki[7], J. A. Slavin[8], I. Dandouras[9], J. M. Raines[8], J.-J. Berthelier[10], M. Dosa[11], G. C. Ho[12], R. M. Killen[13], S. McKenna-Lawlor[14], K. Torkar[3], O. Vaisberg[15], F. Allegrini[2], I. A. Daglis[16,17], C. Dong[18], C. P. Escoubet[19], S. Fatemi[20], M. Fränz[21], S. Ivanovski[22], N. Krupp[21], H. Lammer[3], François Leblanc[10], V. Mangano[1], A. Mura[1], R. Rispoli[1], M. Sarantos[13], H. T. Smith[12], M. Wieser[4], F. Camozzi[23], A. M. Di Lellis[24], G. Fremuth[3], F. Giner[3], R. Gurnee[25], J. Hayes[12], H. Jeszenszky[3], B. Trantham[2], J. Balaz[26], W. Baumjohann[3], M. Cantatore[23], D.

Contribution to JUICE mission to Jupiter's icy moons Anti-coincidence detector ACM for Particle Environment Package PEP *(Cooperation with Sweden)*



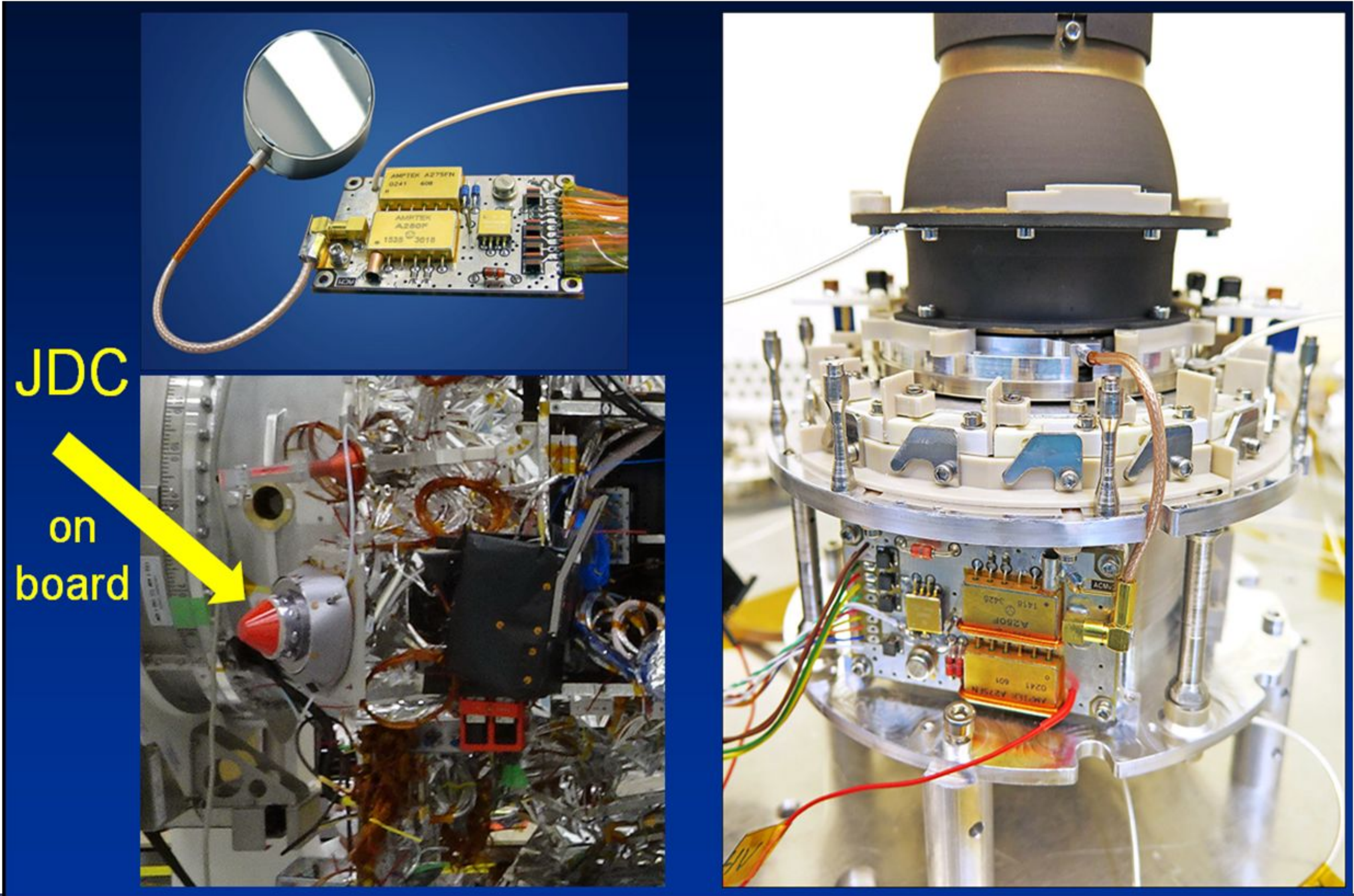
Anti-coincidence detector module ACM for PEP-JDC

ACM anticoincidence detector as part of the PEP-JDC ion mass spectrometer suppresses false detections from high-energy electrons of the Jupiter radiation belt

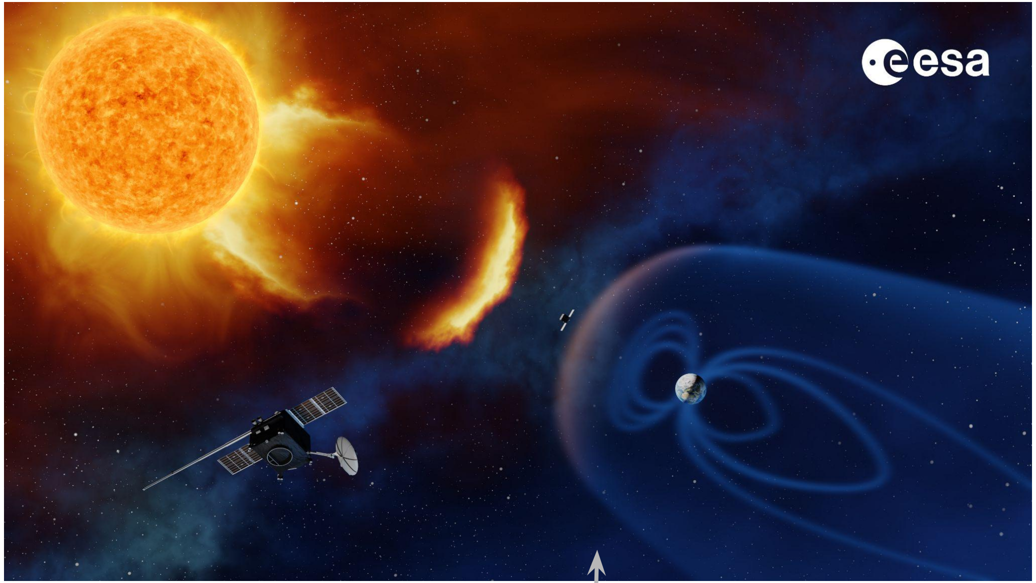


ACM integration to PEP-JDC

JDC is already installed on JUICE spacecraft (launch 2023)



SWE: Space Radiation



Ján Kubančák, Ph.D.

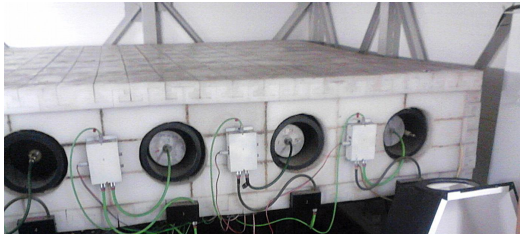
Institute of Experimental Physics,
Slovak Academy of Sciences, Košice

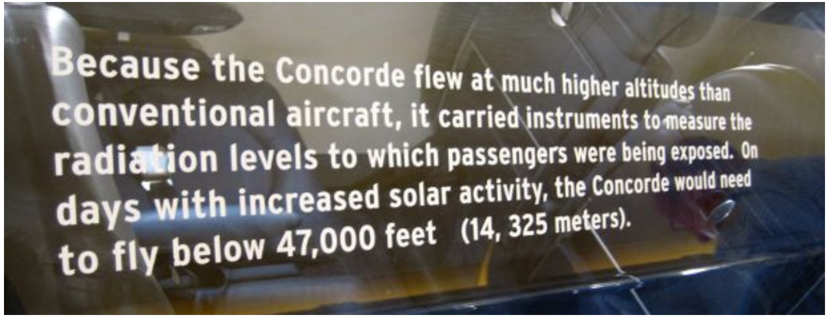
Cosmic rays observatory at the Lomnický štít (CROLS) Introduction

- *CROLS (GEO: 49.40°N, 20.22°E, 2634 m. a.s.l., vertical cut-off rigidity ~4GV) is operated by the Department of Space Physics of IEP SAS and its activities primarily focus on:*
  - ***long term observations** of cosmic rays and their secondary radiation fields induced in the atmosphere (incl. data evaluation)*
  - ***testing of instruments** for measurements of cosmic rays and mixed radiation fields*
  - ***radiation protection from cosmic rays***
    - *measurement and computation of radiation protection quantities including Monte Carlo calculations*
    - *design of radiation shielding against cosmic rays*

Cosmic rays observatory at the Lomnický štít (CROLS) Instrumentation

- *CROLS instrumentation*
  - ***8 NM64 type neutron monitor***
  - ***SEVAN** instrument*
- *auxiliary equipment*
  - *Open Testing Platform (OTP)*
  - *aircrew doses calc. codes*
  - *Monte Carlo simulation codes*
  - *IT infrastructure*



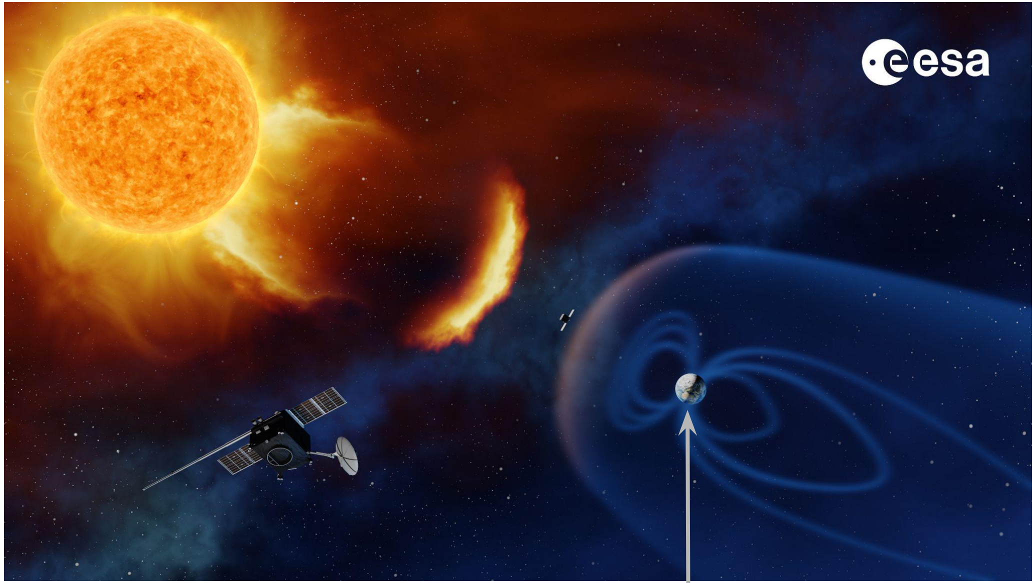


Cosmic rays observatory at the Lomnický štít (CROLS)
Main activities and results

- ***Basic research***
  - *experience with cosmic rays measurements since 1957*
  - *On quasi-periodic variations of low-energy cosmic rays observed near earth, Karel Kudela, Ronald Langer, https://doi.org/10.1093/rpd/ncv325*
  - *Significant enhancements of secondary cosmic rays and electric field at the high mountain peak of Lomnický Štít in High Tatras during thunderstorms, J. Chum, R. Langer ... M. Kollárik, I. Strhársky ... https://doi.org/10.1186/s40623-020-01155-9*
- ***Applied research***
  - *Overview of aircrew exposure to cosmic radiation in the Czech Republic, Ján Kubančák ... Ronald Langer .... Igor Strhársky .... Karel Kudela https://doi.org/10.1093/rpd/ncz204*

Cosmic rays observatory at the Lomnický štít (CROLS) Possible future cooperation with ESA

- ***current projects with ESA***
  - *ESA SIREN (Space Ionizing Radiation Experts Nursery)*
- ***future cooperation***
  - *long-term testing of radiation protection instrumentation for use in cosmic rays radiation environment within the OTP*
  - *short term testing in cooperation with other facilities like e.g. CERF field in CERN etc.)*
  - *“custom - tailored” aircrew and spacecrew radiation protection solutions (metrology and dosimetry, calculation of shielding etc.)*



SWE: Ionospheric Weather

Dr. Simon Mackovjak

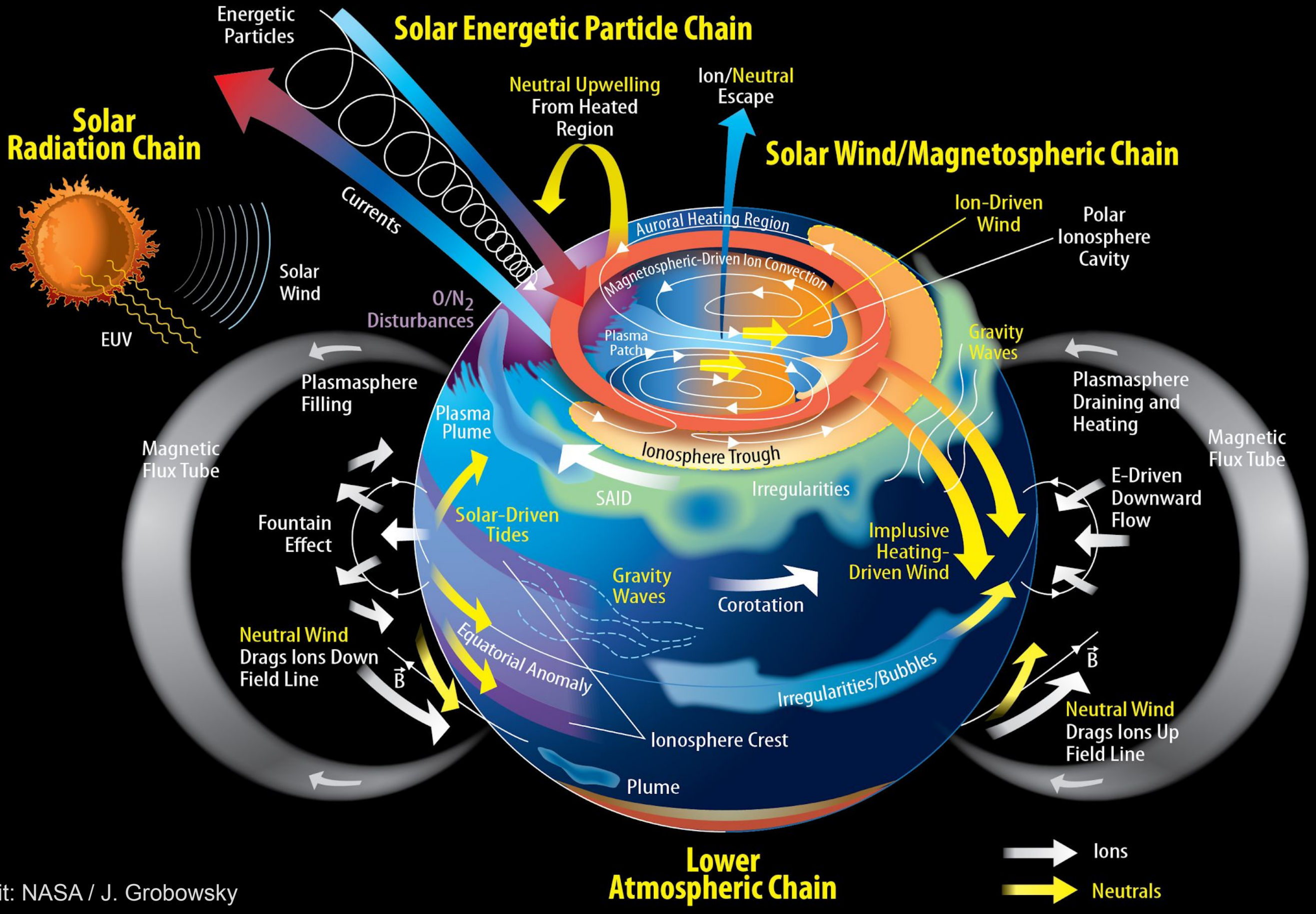
Institute of Experimental Physics, Slovak Academy of Sciences, Košice

SPACE::LAB

ÚEF SAV

SLOVAK ACADEMY OF SCIENCES ACADEMIA SCIENTIARUM SLOVACA

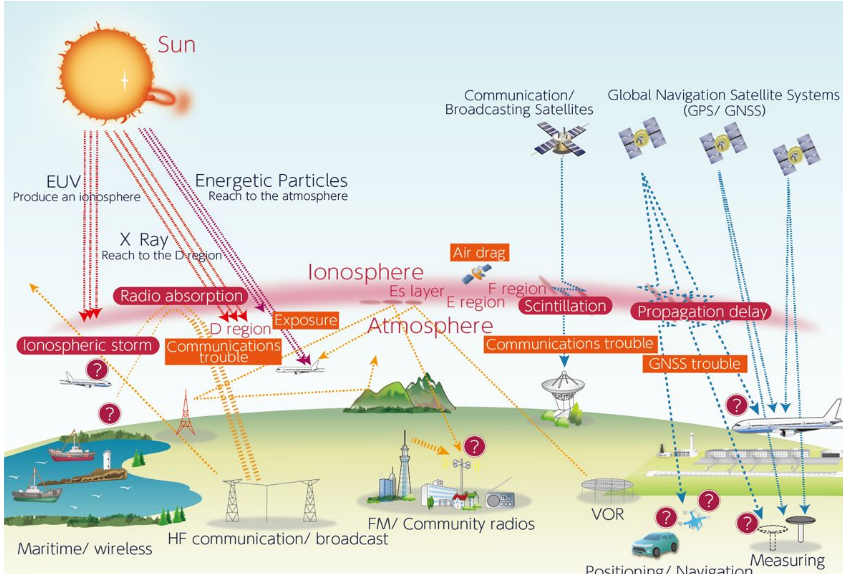
Terrestrial Atmospheric ITM Processes



Credit: NASA / J. Grobowsky

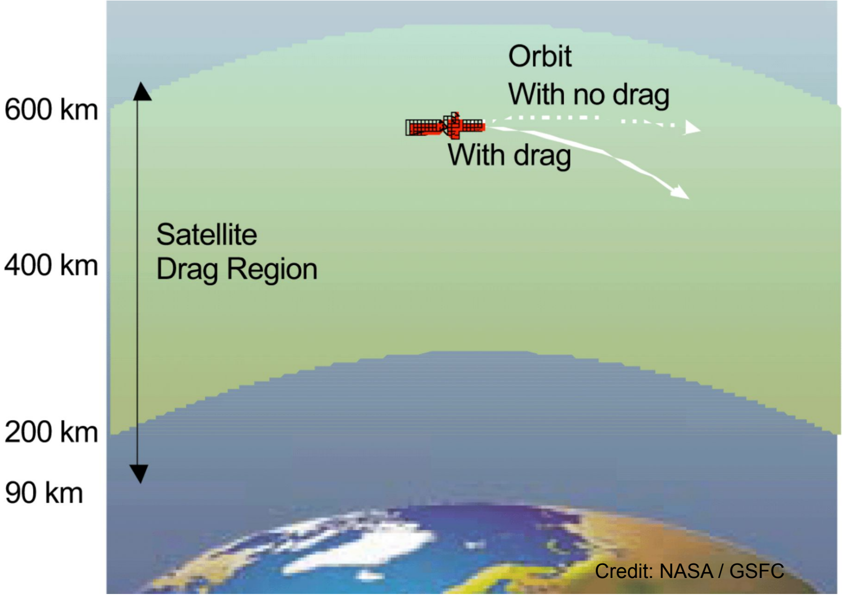
Two main consequences:

- Communication problems



Credit: Radio Research Institute

- Satellite Drag

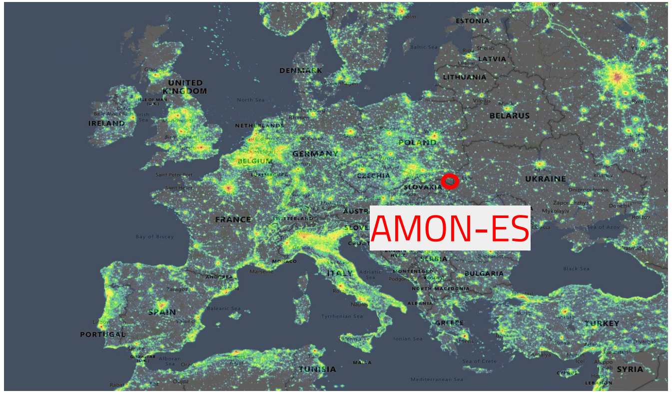


Credit: NASA / GSFC

Our main activities:

Own observations

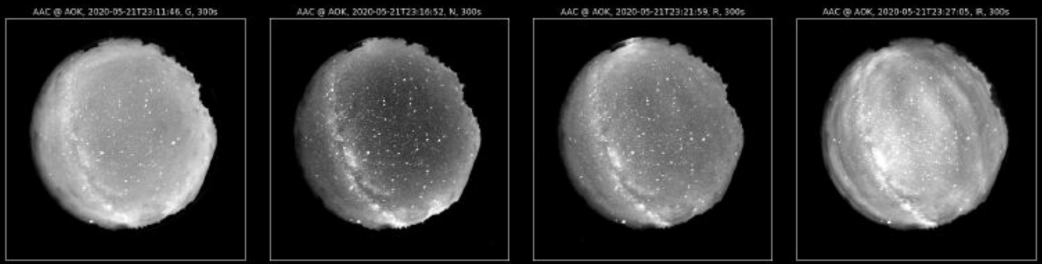
- AMON-ES at Astronomical Observatory at Kolonica Saddle



AMON-ES

All-sky Airglow Camera

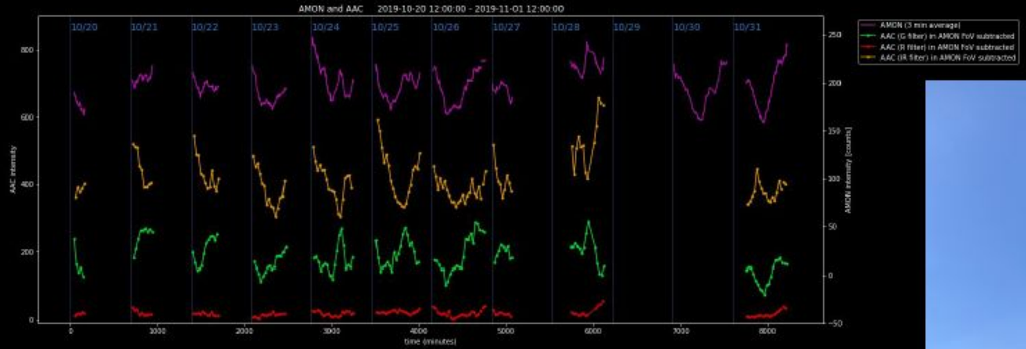
- 557.8 nm (OI - green line)
- 568.5 nm (no airglow)
- 630.0 nm (OI - red line)
- 700-900 nm (OH)



Composition of DSLR Images
http://slovinsky.art

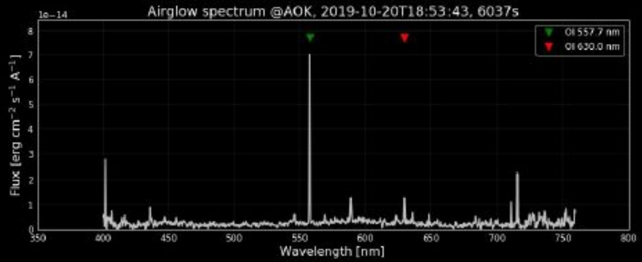
AMON photometer

We've detected consistency between airglow variation measurements by AMON (Mackovjak et al. 2019, https://doi.org/10.1016/j.nima.2018.12.073) UV photometer (300-480 nm) and All-sky Airglow Camera data



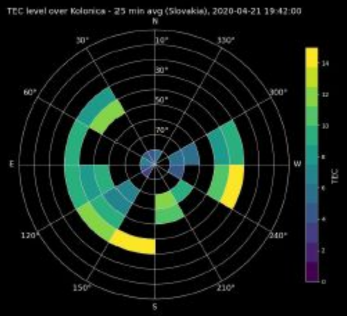
AMON-ES (Airglow MONitor - Extended Station) at Astronomical Observatory on Kolonica saddle

Spectrometer - airglow in physical units is ensured



GNSS receiver

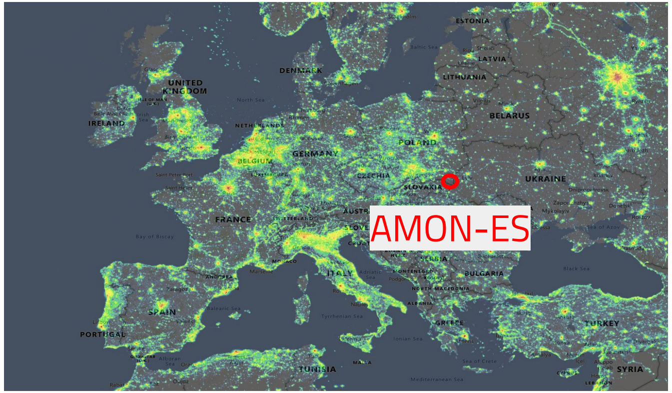
Ionosferic parameters (TEC, S4, Sigma phi) appends airglow data and provide insights to presence of disturbances



Our main activities:

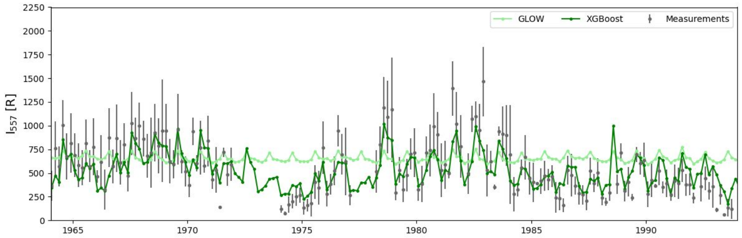
Own observations

- AMON-ES at Astronomical Observatory at Kolonica Saddle
  - Mackovjak et al. (2019, https://doi.org/10.1016/j.nima.2018.12.073)
  - Amrich et al. (2021, https://doi.org/10.1088/1748-0221/16/12/T12016)
  - ESA / PECS projects: SK1-05, SK2-09 (https://github.com/space-lab-sk/amon-es)



Machine Learning approach

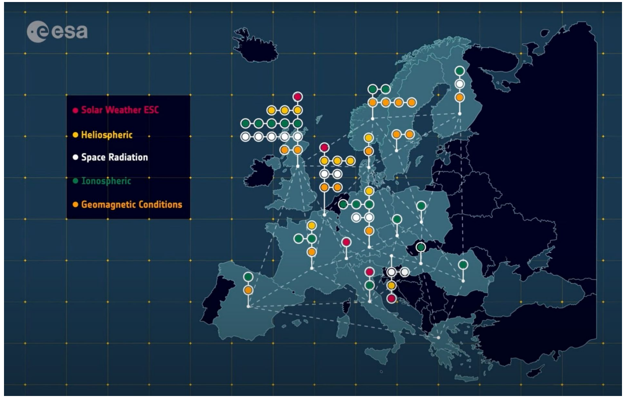
- Modeling of thermosphere-ionosphere variability
  - Mackovjak et al. (2021a, https://doi.org/10.1029/2020JA028991)
  - ESA / PECS project: SK6-29 - ASPIS
- Automatic identification of variability drivers
  - Mackovjak et al. (2021b, https://doi.org/10.1093/mnras/stab2536)
  - Maslej-Krešňáková et al. (2021, https://doi.org/10.1029/2021EA002007)



Ongoing cooperation with ESA

Ionospheric Weather Expert Service Centre

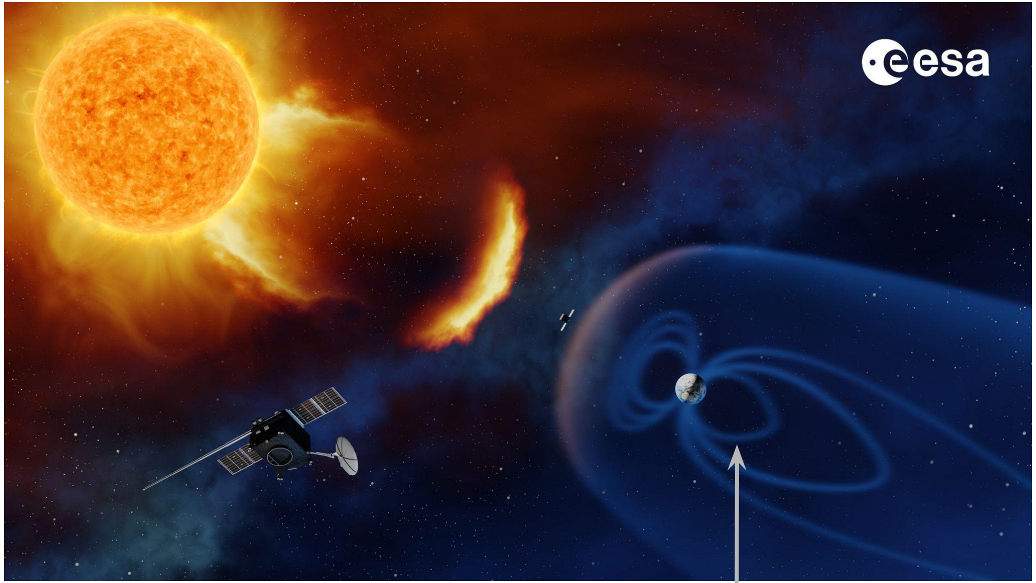
- ESA MONITOR program
- DLR / IMPC - Ionosphere Monitoring and Prediction Center (DE)
- IAP CAS - Institute of Atmospheric Physics, CAS (CZ)



ESA Vigil mission (Lagrange 5)

- towards direct participation
- digital solution based on real-time data stream

SWE: Geomagnetic Conditions



Dr. Fridrich Valach

Earth Science Institute,
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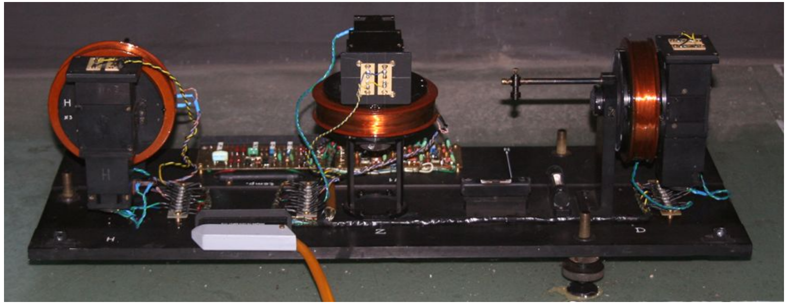
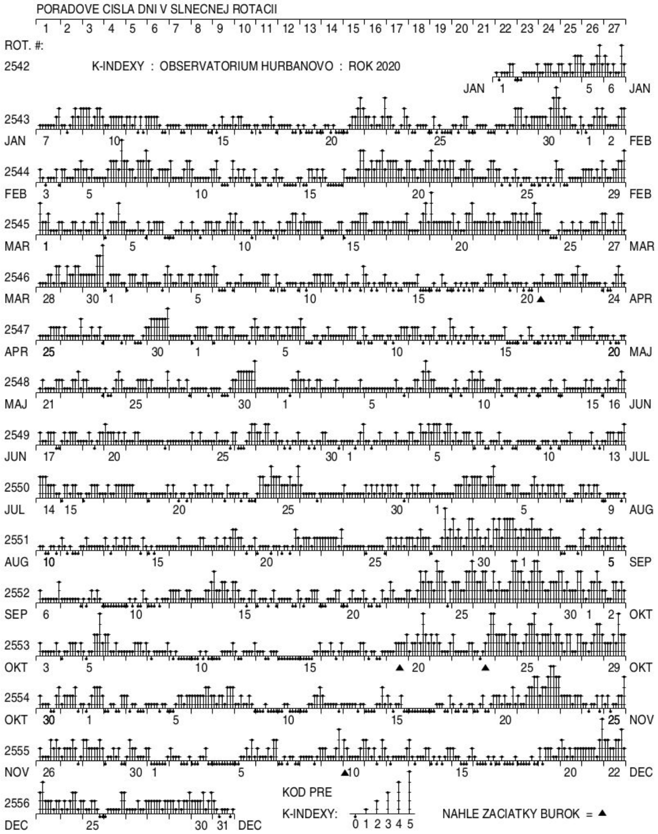
Geomagnetic observatory Hurbanovo

- member of the INTERMAGNET since 1997
  - monitoring the variations of the local geomagnetic field
- monitoring the local geomagnetic activity (GA)
- contributing to modelling the GA (e.g. Revallo et al., J. Atmos. Sol.-Terr. Phys., 110-111, 9-14, 2014)
- **studying historical extreme magnetic storms**



Torsion Photoelectric Magnetometer in Hurbanovo



Local K-indices in Hurbanovo

Historical storms are important

Some valuable data about geomagnetic storms have been observed for two centuries.

The most intense storms occurred long before the space era:

- Carrington event on 1-2 September 1859
- the superstorm on 4 February 1872

Interpretation of historical events from the modern point of view has considerably improved our understanding the mechanisms of extreme geomagnetic storms (e.g.↖ ➡) .

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 108, NO. A7, 1268, doi:10.1029/2002JA009504, 2003

The extreme magnetic storm of 1–2 September 1859

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W. D. Gonzalez
Instituto Nacional de Pesquisas Espaciais, Sao Paulo, Brazil

G. S. Lakhina and S. Alex
Indian Institute of Geomagnetism, Mumbai/Bombay, India

Received 28 May 2002; revised 31 October 2002; accepted 6 December 2002; published 3 July 2003.

J. Space Weather Space Clim., **5**, A16 (2015)
DOI: 10.1051/swsc/2015017

RESEARCH ARTICLE | OPEN ACCESS

A Carrington-like geomagnetic storm observed in the 21st century

Consuelo Cid*, Elena Saiz, Antonio Guerrero, Judith Palacios, and Yolanda Cerrato
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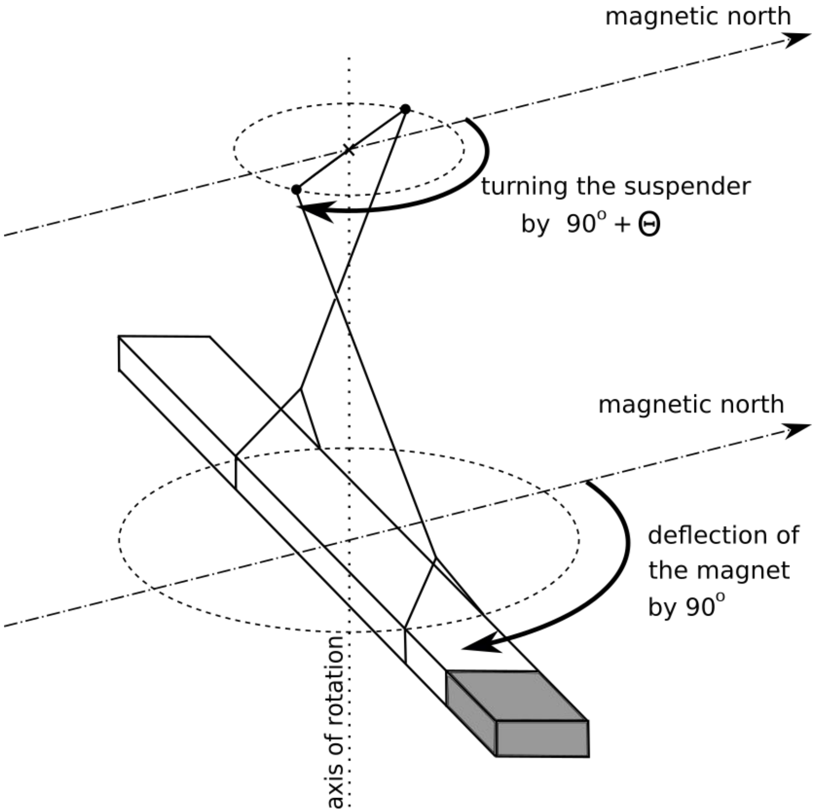
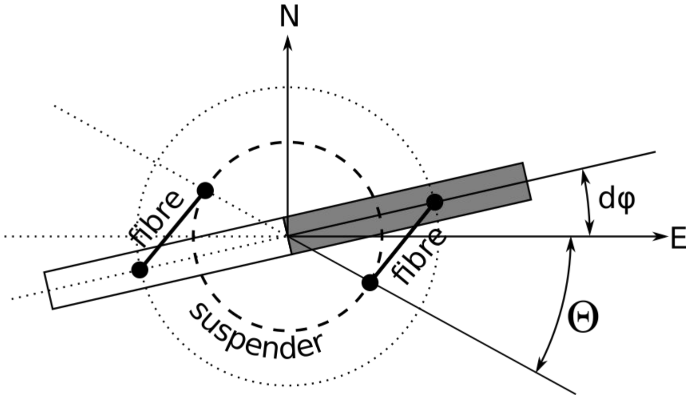
*Corresponding author: consuelo.cid@uah.es

Received 19 March 2014 / Accepted 21 May 2015

Bifilar – almost forgotten device





Principle: a large magnetized needle – which hangs on two fibres.

The movement of the needle is in the horizontal plane.

By the torsion of the two fibres, the needle is hold in a position perpendicular to the magnetic meridian.

The variations of the horizontal intensity can be observed as a small deflection of the needle in the horizontal plane:

$$\frac{dB_H}{B_H} = cotg\,\Theta . d\,\varphi$$

Complications with the magnetic needle:

- the magnetization weakens with time
- the magnetization strongly **depends on temperature**

Ann. Geophys., 39, 439–454, 2021
https://doi.org/10.5194/angeo-39-439-2021

Annales Geophysicae
Open Access
EGU

The geomagnetic data of the Clementinum observatory in Prague since 1839

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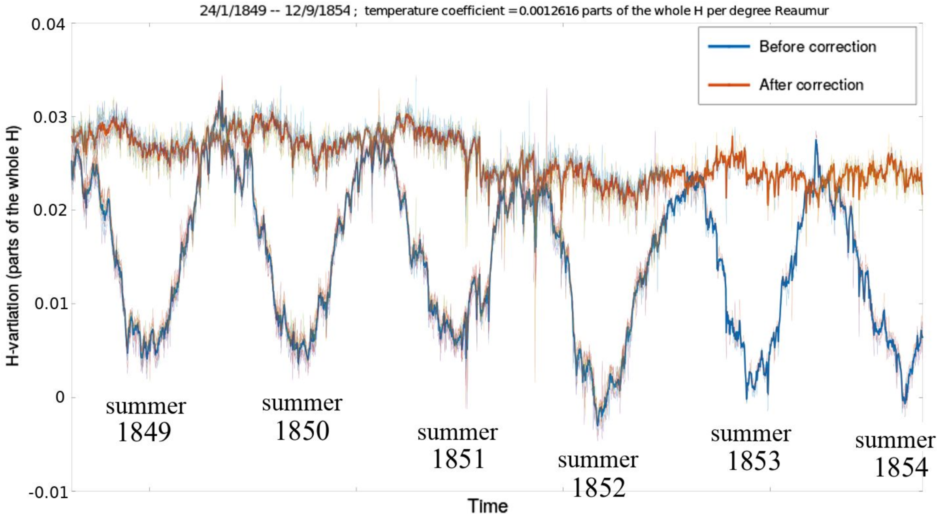
[2]Geomagnetic Observatory, Earth Science Institute, Slovak Academy of Sciences, Komárňanská 108, 947 01 Hurbanovo, Slovakia
[3]Geophysical Division, Earth Science Institute, Slovak Academy of Sciences, Dúbravská cesta 9, 840 05 Bratislava, Slovakia

Correspondence: Pavel Hejda (ph@ig.cas.cz)

Received: 29 January 2021 – Discussion started: 19 February 2021
Revised: 8 April 2021 – Accepted: 9 April 2021 – Published: 17 May 2021



Old geomagnetic storms in Prague

Received: 20 August 2021 | Revised: 27 October 2021 | Accepted: 3 December 2021
DOI: 10.1002/gdj3.141
Geoscience Data Journal RMetS WILEY

DATA PAPER

Magnetic storm and term-day observations at the Prague observatory Clementinum in the mid-19th century

Pavel Hejda[1] | Miloš Revallo[2] | Fridrich Valach[3]

We digitized, processed and made available the data on old geomagnetic storms recorded in Clementinum/Prague:

- number of events: 73
- time range: 1839-1849
- elements: H-intensity and declination

PANGAEA.

Data Publisher for Earth & Environmental Science

Hejda, Pavel; Revallo, Miloš; Valach, Fridrich (2021): Magnetic storm observations from the Prague-Clementinum observatory on 1839-09-03. *PANGAEA*, https://doi.org/10.1594/PANGAEA.936848,

In: Hejda, P et al. (2021): Data of magnetic storms and term-day observations from the Prague-Clementinum observatory (1839-1849). *PANGAEA*, https://doi.org/10.1594/PANGAEA.936921

Datasets listed in this publication series

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1. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1839-09-03. https://doi.org/10.1594/PANGAEA.936848
2. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1839-09-15. https://doi.org/10.1594/PANGAEA.936849
3. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1839-10-18. https://doi.org/10.1594/PANGAEA.936850
4. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1839-10-22. https://doi.org/10.1594/PANGAEA.936851
5. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-01-04. https://doi.org/10.1594/PANGAEA.936852
6. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-02-06. https://doi.org/10.1594/PANGAEA.936853
7. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-02-07. https://doi.org/10.1594/PANGAEA.936854
8. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-02-09. https://doi.org/10.1594/PANGAEA.936855
9. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-03-13. https://doi.org/10.1594/PANGAEA.936856
10. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-05-30. https://doi.org/10.1594/PANGAEA.936857
11. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-09-22. https://doi.org/10.1594/PANGAEA.936858
12. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-09-23. https://doi.org/10.1594/PANGAEA.936859
13. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-10-19. https://doi.org/10.1594/PANGAEA.936860
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16. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1840-12-19. https://doi.org/10.1594/PANGAEA.936863
17. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-01-13. https://doi.org/10.1594/PANGAEA.936864
18. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-01-19. https://doi.org/10.1594/PANGAEA.936865
19. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-01-31. https://doi.org/10.1594/PANGAEA.937177
20. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-02-07. https://doi.org/10.1594/PANGAEA.937178
21. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-02-22. https://doi.org/10.1594/PANGAEA.936868
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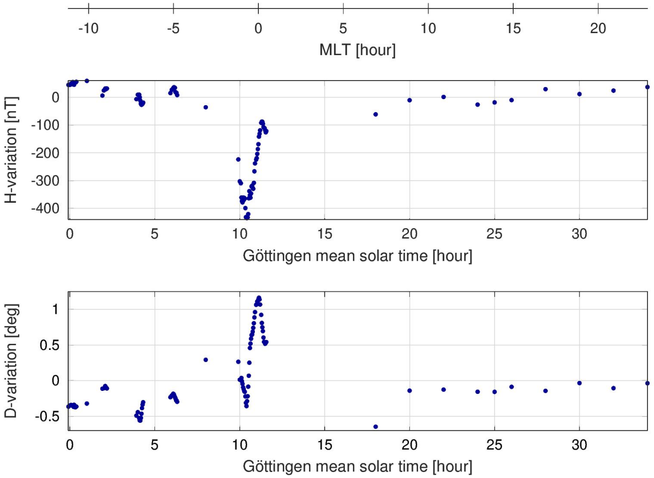
23. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-05-10. https://doi.org/10.1594/PANGAEA.937180
24. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-07-24. https://doi.org/10.1594/PANGAEA.936871
25. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-08-15. https://doi.org/10.1594/PANGAEA.936872
26. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-09-01. https://doi.org/10.1594/PANGAEA.936873
27. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-09-13. https://doi.org/10.1594/PANGAEA.936874
28. **Hejda, P; Revallo, M; Valach, F (2021):** Magnetic storm observations from the Prague-Clementinum observatory on 1841-09-25. https://doi.org/10.1594/PANGAEA.937181

Interpreting historical geomagnetic storms



J. Space Weather Space Clim. 2019, 9, A11
https://doi.org/10.1051/swsc/2019008
JSWSC
Available online at:
www.swsc-journal.org
Agora – Historical space weather events and observations OPEN ACCESS

Possible role of auroral oval-related currents in two intense magnetic storms recorded by old mid-latitude observatories Clementinum and Greenwich

Fridrich Valach[1,*], Pavel Hejda[2], Miloš Revallo[3], and Josef Bochníček[2]

[1] Geomagnetic Observatory, Earth Science Institute, Slovak Academy of Sciences, Komárňanská 108, 947 01 Hurbanovo, Slovakia
[2] Institute of Geophysics, Academy of Sciences of the Czech Republic, Boční II/1401, 14131 Prague, Czech Republic
[3] Earth Science Institute, Slovak Academy of Sciences, Dúbravská cesta 9, 840 05 Bratislava, Slovakia

Storm recorded at **Clementinum** (in **Prague**) on 17 November 1848

The substorm electrojet then flowed at a magnetic latitudes lower than Prague.

The depression of H-intensity might be caused by the substorm electrojet. (See also the Magnetic Local Time.)

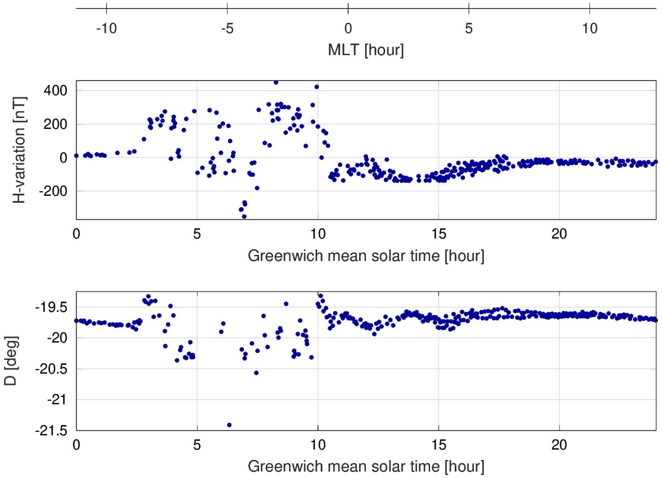
The variation in declination was most likely caused by field aligned currents (FACs).

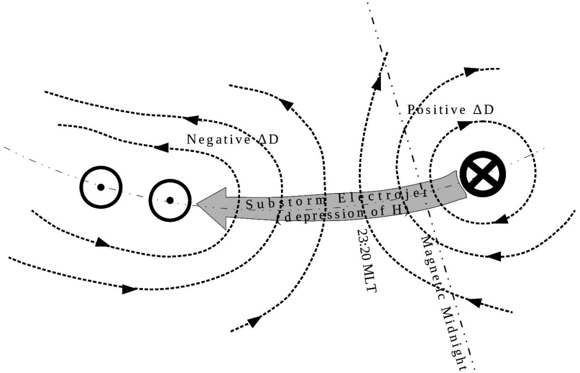
– – – – –

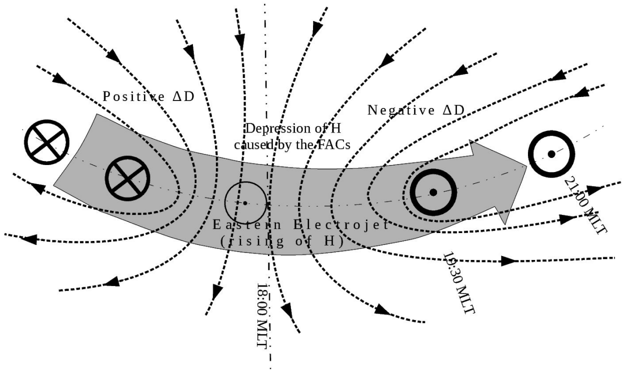
The storm on 4 February 1872, **Greenwich**.

The eastward electrojet flowed at lower magnetic latitudes than is the magnetic latitude of Greenwich.

The strange variations in the H-intensity were probably caused by the ring current and modified by FACs.







Suggestion of possible cooperation with ESA

- The benefits of ESA's activities for our work:
  - SOHO mission (the ESA cooperative mission with NASA): for studying the causes of the geomagnetic activity
  - new knowledge based on missions such as Cluster II and Swarm

- There may still be unprocessed old records from bifilar instruments in some archives in the world.

  Therefore, our possible cooperation with ESA could be in the following fields:

  - processing the geomagnetic observations from the middle of the 19th century, which require knowledge of the bifilar device
  - participation in interpreting historical geomagnetic storms in the context of modern knowledge (interplanetary causes of the geomagnetic activity etc.)

New Slovak potential SWE players

Assoc. Prof. Peter Butka

Faculty of Electrical Engineering and Informatics,
Technical University of Košice

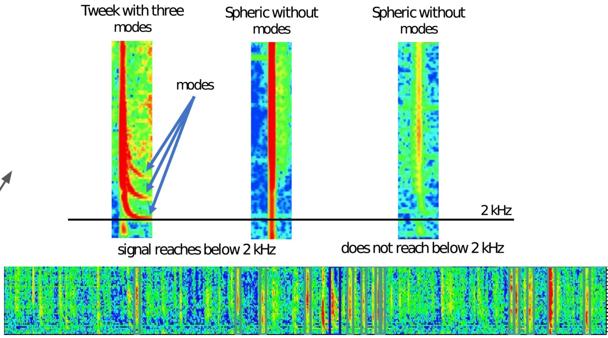
Machine learning and its potential for SWE

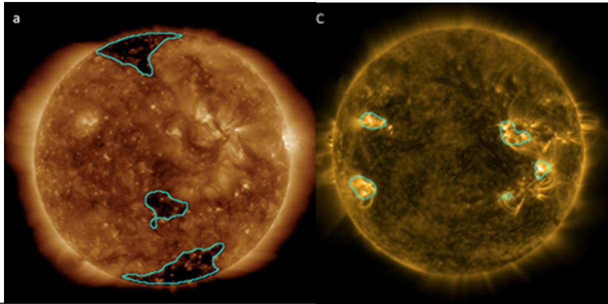
- My institution: TU Košice, Faculty of Electrical Engineering and Informatics, *Department of Cybernetics and Artificial Intelligence*
  - research / education in Artificial Intelligence, Machine Learning, Data Analysis, etc. – for more than 30 years, our group - DA/ML projects in different domains (medicine, industry, e-gov, …) => recently also new domains: **space/geo data**
- **Machine Learning**
  - Wide family of methods for analysis and modelling of data (e.g. neural networks / deep learning) => provide **data-driven approach** to analysis in science
  - Very versatile & robust way (with **efficient ML frameworks**) to **explore** and **process** data => to better solve classification, detection, prediction tasks and help with understanding domain
  - When it is useful?
    - Solid defined tasks or need for better understanding of data using data-driven analysis
    - Amount of the data or scope of analysis is beyond “human power”
- **Why ML in SWE ? Is there a “space” for Machine Learning in Space Weather ?**
  - There are many aspects fulfilling the usefulness of the ML application:
    - Interesting tasks (prediction of different indices, detection/segmentation/classification in analysis of image data, analysis of spatio-temporal measurements, etc.)
    - Large amount of high-quality data from ground and space observations
  - How is ML vs SWE application now ? … small experiment: Web of Science => for query: ‘machine learning’ AND ‘space weather’ => **73 % of articles in last 3 years** … It’s **HOT** topic!

Some of our results on processing space/geo data

- Beginnings: COST action TD1403 **BIG-SKY-EARTH - Big Data Era in Sky and Earth Observation** - machine learning and its application to analysis of different space/geo data (32 countries involved)
- Lead to more collaborations with partners on processing of astro/geo data
    - 5 international partners (Czech republic, South Africa, 2 x Finland, Canada), 3 Slovak partners (IEP SAS, UPJŠ in Košice, Comenius University Bratislava)
- Machine / deep learning for different classification, detection or segmentation tasks (published):
    - Morphological classification of radio galaxies (with partner from South Africa)
        - Morphological classification of compact and extended radio galaxies using convolutional neural networks and data augmentation techniques. *Monthly Notices of the Royal Astronomical Society*, *505*(1), 1464-1475, 2021.

      Classification of eclipsing binary stars
        - Automatic classification of eclipsing binary stars using deep learning methods. *Astronomy and Computing*, *36*, 100488, 2021.
    - **Detection of lightning events in radio spectrograms**
        - Automatic detection of atmospherics and tweek atmospherics in radio spectrograms based on a deep learning approach. *Earth and Space Science*, Volume8, Issue11, November 2021.
    - **Segmentation of coronal structures (coronal holes, active regions) using DL U-Net architecture**
        - SCSS-Net: solar corona structures segmentation by deep learning. *Monthly Notices of the Royal Astronomical Society, 508(3),* 3111-3124, 2021.





Suggestion of possible cooperation with ESA

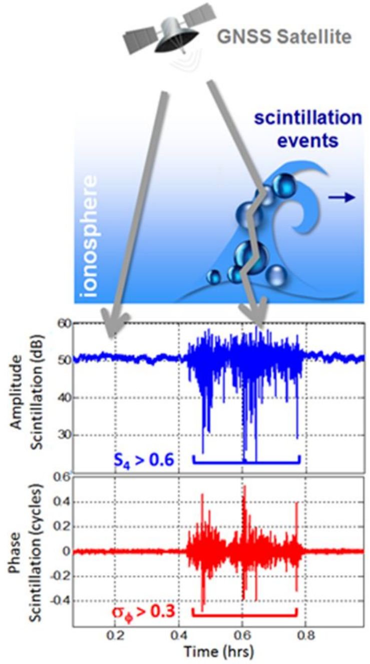
<u>Existing cooperation due to new project in ESA 6th PECS call</u>

ASPIS - Feasibility study of data-driven Autonomous Service for Prediction of Ionospheric Scintillations, started January 2022 (subcontractor, main contractor IEP SAS)

- Useful cooperation for running project
  - Help with understanding the available ESA products and users requirements
  - Access to high quality data can help to achieve better predictions

<u>Possible place for us in the future</u>

- As education institution
  - Preparation of ML engineers with the knowledge of S2P/SWE domain for Slovak/EU market (industry/research) => more / stronger partners for ESA
- As research institution:
  - Partner for Data analysis, ML, Explanaible AI topics in processing of S2P/SWE data
- Help from ESA? … Simple answer - access to high quality data, interesting tasks and domain experts => *then ML can be very useful tool*



Data supplied by J.-M. Sleewaegen, Septentrio, Belgium

New Slovak potential SWE players

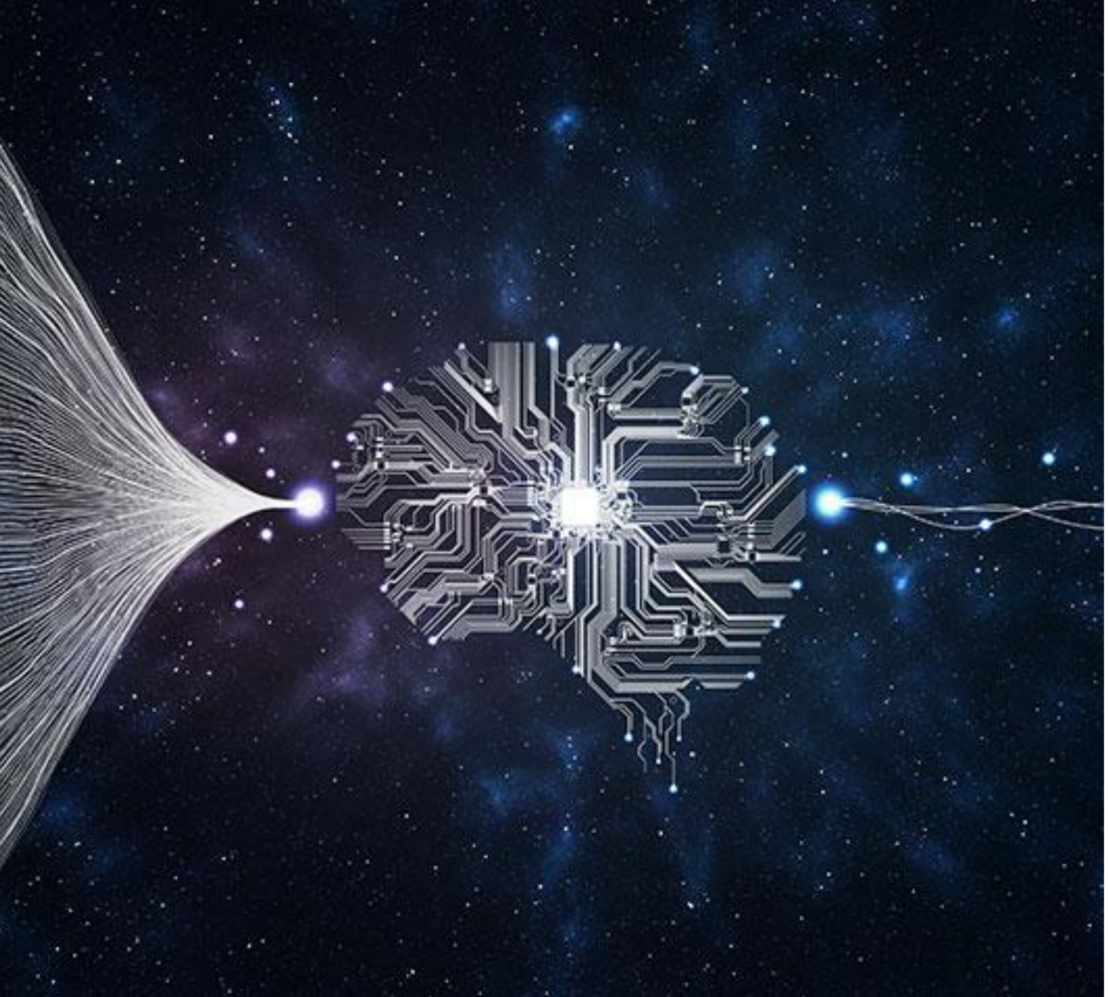
Matej Varga

SPACE::LAB startup

Problems

- Increasing number of satellites generates more and more data that needs to be processed
- Too long time from data acquisition through data processing to visualization
- Data cleaning and organizing takes 60-80 % of time during data science job
- Unused potential of modern IT technologies

- **Our customers:** scientists, satellite operators, space companies



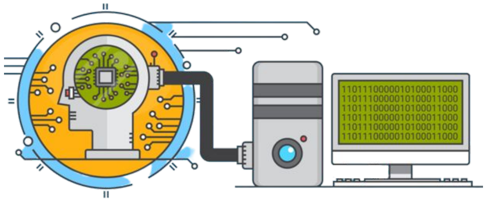
Source: https://www.industrialdefender.com/how-quality-data-builds-foundation-machine-learning/

Solution

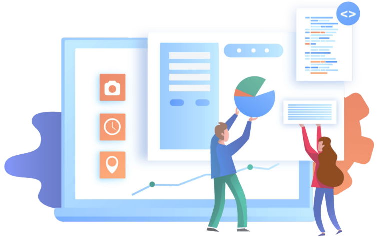
- Simple data organization
- Advanced analysis / classification / prediction
- Clear dashboard visualization
- **Make the most of your data with machine learning**

Our advantage

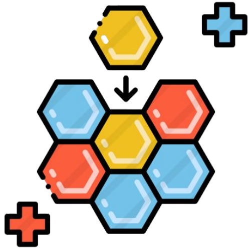
In-house Space expertise



ML technology



Fully customizable

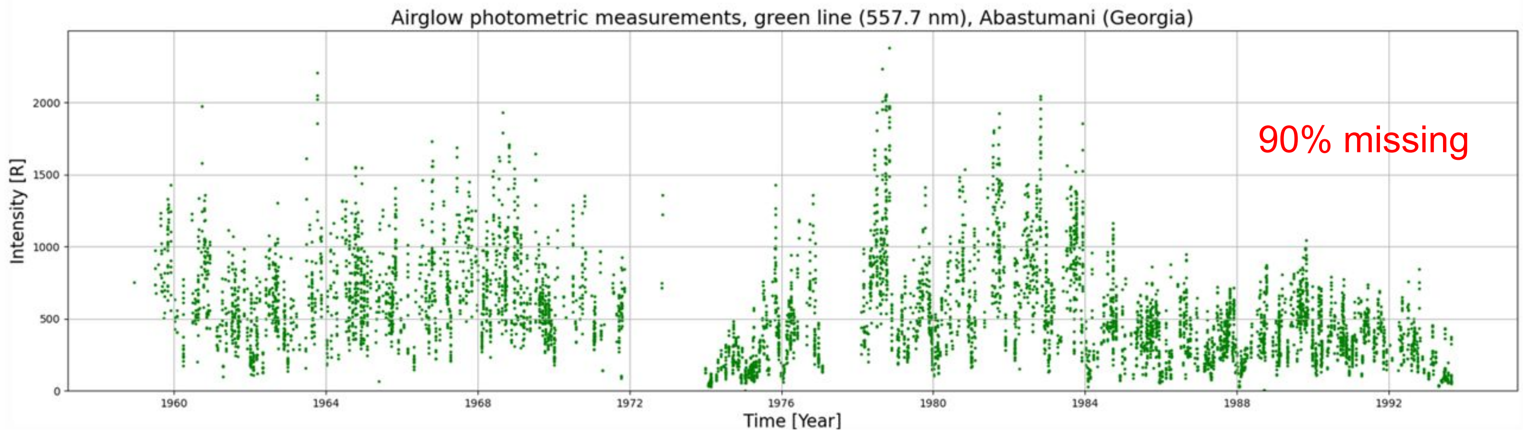


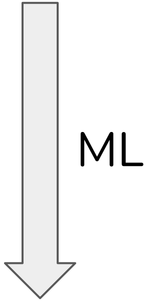
Flexibility

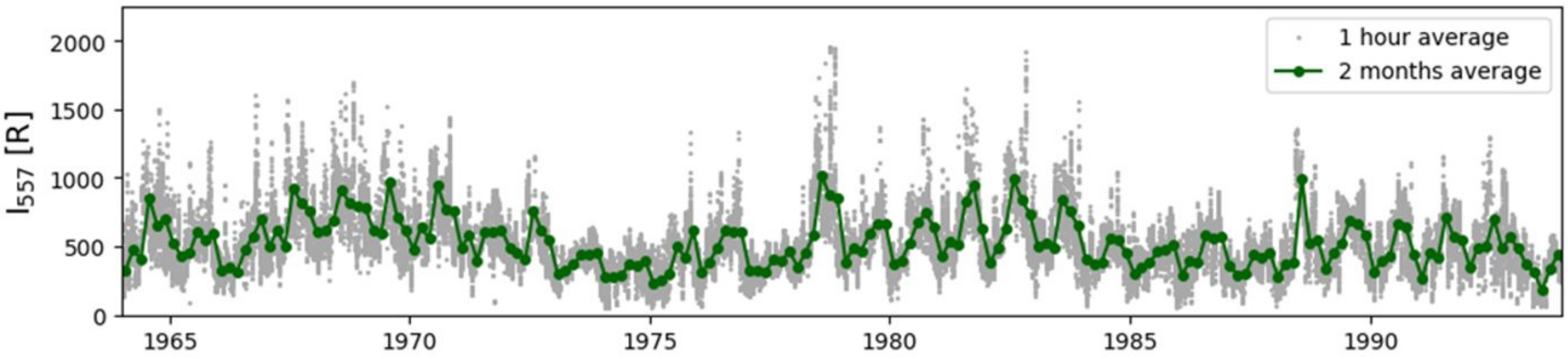
Easy communication

Agile methodology

Example: modeling of missing data







Follow-up events

ESA SWE Service Network Workshop 2022

10-12 May 2022

Europe/Berlin timezone

- Overview
- Survey
- Sessions and Time table - from March 18
- Registration - from March 18
- Organising Committee

Contact

petra.vanlommel@stce.be

The ESA SWE Service Network Workshop 2022 will take place from 10th to 12th May 2022 as a hybrid meeting (online in combination with in-person presence onsite in the ESA premises of ESOC at Darmstadt, Germany) or as fully online.

As part of the ESA Space Safety Programme, the ESA SWE Service Network aims to provide timely and reliable space weather information to end users. The Network builds on data from ground and from space, along with the latest forecasts and models in order to provide user-focussed products, tools and alerting covering the full Sun-Earth system. These individual elements are then combined with end-user support into pre-operational services targeting a wide range of affected sectors including spacecraft operation, aviation, navigation and power distribution networks amongst others.

This workshop addresses the full range of development and pre-operational service provision activities ongoing within the context of the ESA Space Weather Service Network and is organised within the

https://events.spacepole.be/event/133/overview

Hlavné Menu

- Úvodná stránka
- O nás
- Navštívte nás
- Naša ponuka
- Organizujeme
  - Astronomický krúžok
  - Vzdelávanie
  - Meetingy
    - 26. celoštátny slnečný seminár
    - Coimbra Solar Physics Meeting 2015
    - Unlocking the Universe
    - Medzinárodná konferencia "150 rokov hvezdárne v Hurbanove"
    - Nemzetközi konferencia "150 éves az ógyallai csillagvizsgáló

26th NSPM - brief english version

26th National Solar Physics Meeting, 6 - 10 June 2022, Piešťany, Slovakia

Slovak Central Observatory in Hurbanovo organises the **26th National Solar Physics Meeting** which will be held from **6 to 10 June 2022** in the **Hotel Magnólia** **in** **Piešťany**.

Registration form No. 1 (in Slovak)

The goal of the Meeting is to present new results of solar physics and from the field of the Sun-Earth connections, to provide overview of present status in selected fields of solar physics and geophysics.
A separate space will be devoted to the presentation of research results of undergraduate and PhD students of university and academic departments and also to results of scientific and popularisation activities of Astronomical Observatories in the Slovak Republic and the Czech Republic. Invited talks, short contributions and posters should cover the following fields: physical phenomena in the solar atmosphere, solar activity, total solar eclipses, space weather and geoactivity.
The SCO plans to publish Proceedings of the meeting with presentations in PDF format on CD/DVD and at our webpage.

Organizers:

- Slovak Central Observatory, Komarnanska 137, SK-94701 Hurbanovo, Slovakia;

tel.: +421 35 2451115 (I. Dorotovič, direct), e-mail: ivan.dorotovic [at] suh.sk

https://suh.sk/organizujeme/meetingy/26-celostatny-slnecny-seminar