SPACE WEATHER RESEARCH: RECENT RESULTS AND ONLINE CATALOGS

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https://www.aob.rs/en/meetings/conferences/354-xiv-serbian-bulgarian-astronomical-conference

XIV Serbian-Bulgarian Astronomical Conference (XIV SBAC)
23rd – 27th September 2024, Vrnjačka Banja, Serbia

Outlook

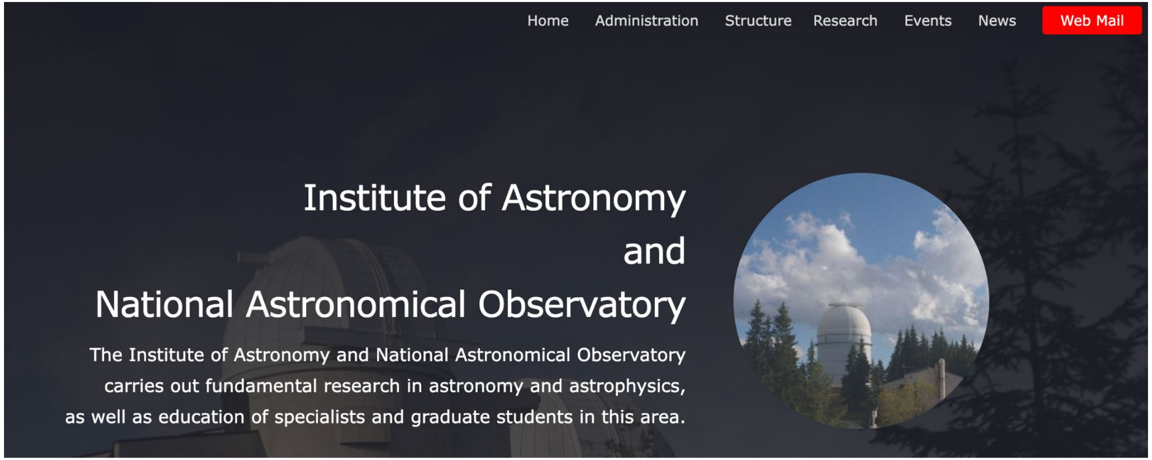
A brief introduction to Space weather

Solar & space weather research @ IANAO-BAS

- Catalogs of space weather phenomena
- Projects
- Future plans

Acknowledgements

https://astro.bas.bg/



Space weather

Definition:

‘conditions on the Sun and in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health’
US National Space Weather Program, The Strategic Plan of Space Weather (1995)

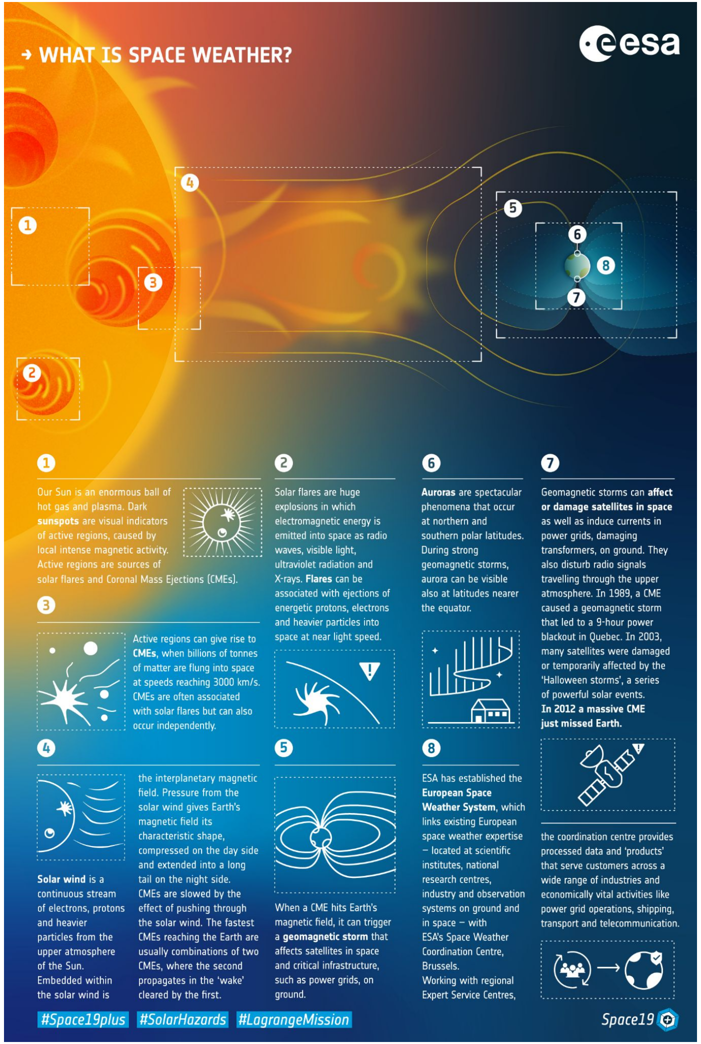
Agents:

Solar flares (SFs)
Coronal mass ejections (CMEs)
Solar energetic protons and electrons (SEPs, SEEs)
Fast streams of solar wind

Effects:

Geomagnetic storms (GSs), auroras
Satellite, communication, ground-based infrastructure disturbances & failures

https://doi.org/10.3390/astronomy2030012



https://www.esa.int/ESA_Multimedia/Images/2018/11/What_is_space_weather

Solar & space weather research @ IANAO

Topics of research

- ***Ground-based observations & data analyses***

BNSF/Bg-At project (PI: R. Miteva);
BNSF/Neutron monitor (PI: N. Petrov)

- ***Satellite observations & data analyses***

BNSF/Bg-At project (PI: K. Kozarev);
SCOSTEP (PI: R. Miteva);
BAS/Bg-Rs (PI: M. Dechev)

- ***Total solar eclipse observations***

BNSF project (PI: N. Petrov)
MES-Bg (PI: T. Tsvetkov)

- ***Modeling of particle acceleration & transport***

ESA/Spreadfast (PI: K. Kozarev)

- ***Machine learning***

BNSF/MOSAIICS (PI: K. Kozarev)

https://helio.astro.bas.bg/
http://edu-pro.astro.bas.bg/sun/?lang=en
https://astro.bas.bg/

Collaboration: Space weather catalog @ NRIAG

https://www.nriag.sci.eg/ace_electron_catalog

ACE/EPAM
Electron Event Catalog

@ NRIAG

Last modified 25/05/2021

Solar cycle 23: 1996-2008 | Solar cycle 24: 2009-2019

This catalog lists the electron enhancements from the ACE/EPAM instrument since 1997 in two energy channels. The catalog is organized as a table that presents the solar energetic particles (electrons) observed during solar cycle 23 (1996-2008) and solar cycle 24 (2009-2019). The catalog provides the following information: onset, peak times (in UT), peak electron intensity, and onset-to-peak electron fluence at 103-175 keV energy channel and also the peak electron intensity, and the onset-to-peak fluence at 175-315 keV energy channel. In addition, the solar sources (flares and coronal mass ejections) of the electron events are identified, where possible, with their properties noted. Furthermore, intensity and onset-to-peak fluence of the the associated solar energetic proton events (which have the same solar origin of the solar energetic electrons) at two energy channels; 19-28 MeV and 28-72 MeV, are listed. The properties of proton events are taken from Miteva R., Samwel S.W., Costa_Durate M.V., The Wind/EPACT Proton Event Catalog (1996-2016), 2018, Sol. Phy., 293: 27. Further information is given as a comment. Extensions of the catalog (or corrections if needed) will appear regularly online.

ACE/EPAM
Electron Event Catalog

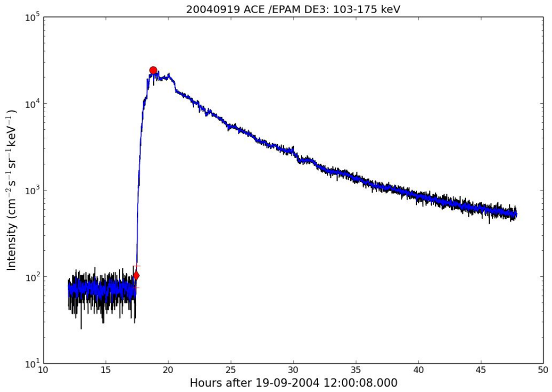
Solar cycle 24: 2009-2019

@ NRIAG 2021

Last modified 25/05/2021

Back to: Home Page | Solar cycle 23: 1996-2008

Date			Electrons		103-175 keV		175-315 keV		GOES SXR Flare				SOHO/LASCO CME				19-28 MeV		28-72 MeV		Comments
yyyy	mm	dd	Onset time	Peak time	J_e	F_e	J_e	F_e	Onset time	Peak time	Class	Location	Time	Speed	AW	MPA	J_p	F_p	J_p	F_p	
2009	11	3	03:48	05:38	319.953737	1652971	117.59	256431	u	u	u	u	19:36[pd]	226	47	274	no	no	no	no	
2009	11	5	01:11	02:10	86.370381	346789	no	no	u	u	u	u	u	u	u	u	no	no	no	no	
2009	12	22	06:09	07:44	96.688211	567443	45.209	221560	04:50	04:56	C7.2	S26W46	05:54	318	47	270	no	no	no	no	
2010	1	26	17:27	19:27	117.906222	688649	no	no	17:01	17:05	B3.2	N18W87	17:54	228	8	274	no	no	no	no	
2010	2	7	02:56	06:30	200.897786	2002295	67.556	3166													
2010	2	8	05:20	08:56	516.56869	2817255	117.34	7018													
2010	2	12	08:04	09:52	164.804865	833749	38.923	3895													
2010	2	12	12:25	14:03	743.912231	2485235	146.46	5955													
2010	3	4	13:28	13:48	127.504556	99023	no	no													
2010	5	8	20:37	21:54	174.563158	635385	37.364	2050													
2010	6	12	01:16	02:31	1947.666649	3460948	639.75	1091													



Space weather catalogs @ IANAO-BAS

https://catalogs.astro.bas.bg/

CATALOGS OF SOLAR ENERGETIC PROTONS AND SPACE WEATHER EVENTS

AIM | PROTON EVENTS | SXR FLARES | RADIO BURSTS | GEOMAGNETIC STORMS | TYPE II BURSTS

Home

This website contains information on SOHO/ERNE proton events, GOES solar flares, radio emission signatures of in situ ACE/EPAM electron events and geomagnetic storms over solar cycles 23 and 24 (1996-2019).

The catalogs are still under construction!

Contact: rmiteva [at] nao-rozhen.org

Archives

Meta

- Log in

Catalogs of Solar Energetic Protons and space weather events 2024 . Powered by WordPress

CATALOGS OF SOLAR ENERGETIC PROTONS AND SPACE WEATHER EVENTS

AIM | PROTON EVENTS | SXR FLARES | RADIO BURSTS | GEOMAGNETIC STORMS | TYPE II BURSTS

https://catalogs.astro.bas.bg/

Proton events

The catalog lists the proton events from the SOHO/ERNE instrument presented separately in solar cycle (SC) 23 (1996-2008) and SC24 (2009-2017). In contrast to other catalogs available elsewhere, this catalog utilizes the highest temporal resolution as provided, namely 1 min.

Results from the final SEP catalog are available here:

Miteva et al. Atmosphere (2024)

Preliminary results from the catalog are published here:

Miteva et al. SES-Proceedings (2023)

Miteva et al., Bulgarian Astronomical Journal, Vol. 33, pp. 99-108 (2020)

Miteva & Tsvetkov *AIP Conf. Proc.* 2075, 090014 (2019)

Miteva & Danov WS-Proceedings (2019)

Miteva SES-Proceedings (2017)

Funding: This research was supported by SCOSTEP/PRESTO project 'On the relationship between major space weather phenomena in solar cycles 23 and 24'; by the Bulgarian-Egyptian inter-academy project 'On space effects at near Earth environment—from remote observations and in situ forecasting to impacts on satellites' (2022–2024), Bulgarian Academy of Sciences IC-EG/08/2022-2024 and Egyptian Academy of Scientific Research and Technology (ASRT)/NRIAG (ASRT/BAS/2022-2023/10116) and by the Bulgarian-Serbian inter-academy project 'Active Events on The Sun. Catalogs of Proton Events and Electron Signatures in X-Ray, UV and Radio Diapason. Influence of Collisions on Optical Properties of Dense Hydrogen Plasma' (2023–2025).

Acknowledgements: SOHO/ERNE data was provided by Prof. Eino Valtonen (PI) and is also available via SEPServer data server. SOHO is a project of international collaboration between ESA and NASA.

Disclaimer: The data is a subject to instrumental saturation effects.

Contact: rmiteva [at] nao-rozhen.org

CATALOGS OF SOLAR ENERGETIC PROTONS AND SPACE WEATHER EVENTS

AIM | PROTON EVENTS | SXR FLARES | RADIO BURSTS | GEOMAGNETIC STORMS | TYPE II BURSTS

https://catalogs.astro.bas.bg/

Solar Cycle 23 – Protons

Abbreviations:

- AW – angular width (in degrees)
- CME – coronal mass ejection
- gap – data gap
- no – no proton event
- SF – solar flare
- u – uncertain

Notations:

- all times are in UT
- Channels (in MeV): **1**: 14-17; **2**: 17-22; **3**: 21-28; **4**: 26-32; **5**: 32-40; **6**: 40-51; **7**: 51-67; **8**: 64-80; **9**: 80-101; **10**: 101-131
- class: flare peak in GOES soft X-ray flux; C-class: *10^(-6) (W/m^2)
- CME speed: linear speed (km/s) from https://cdaw.gsfc.nasa.gov/CME_list/index.html
- flare latitude: North (positive); South (negative)
- flare longitude: West (positive); East (negative)
- SEP peak intensity: protons/(cm^2 sr s MeV)

Show 10 entries

Search:

Year	m	d	C-class	SF start	SF max	lat	long	CME onset	CME speed	CME AW	onset UT	peak UT	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 9	Channel 10
1996	7	9	260	09:05	09:11	-10	30	gap	gap	gap	10:13	11:03	0.004401	0.002427	0.001022	0.000979	no	no	no	no	no	no
1996	8	13	u	u	u	u	u	16:09	620	153	18:33	24:19	0.008504	0.005586	0.002268	0.001914	0.00121	0.000892	no	no	no	no
1996	11	26	0.9	20:48	24:32	u	u	21:36	548	78	24:39	28:49	0.001545	0.000702	0.000657	no	no	no	no	no	no	no

Space weather catalogs @ IANAO-BAS & NRIAG

Summary of results

- Online catalogs: 6 topics (SEPs, SEEs, SFs (X&M-class), SEE-related radio bursts, GSs (extreme, -100 nT, -50 nT); type II radio bursts); 9 lists

- Time coverage: SC23+24, SC24

- Publications: 5 Q1; 3 Q2; 2 Q4; 1 ref./no Q; 3 proceedings

MNRAS; Universe; Adv.Sp.Res.; Atmosphere; Solar Phys.; BgAJ

- Projects:

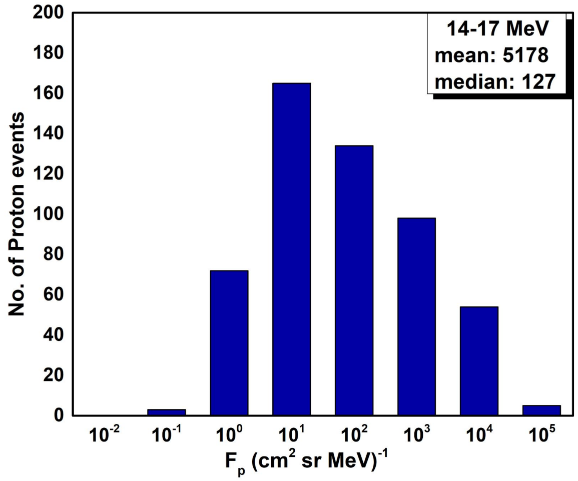
1 national (BNSF KP-06-H28);
3 bilateral (BAS BG-Egypt; BAS BG-Serbia; BNSF BG-India);
2 international (SCOSTEP/VarSITI & SCOSTEP/PRESTO)

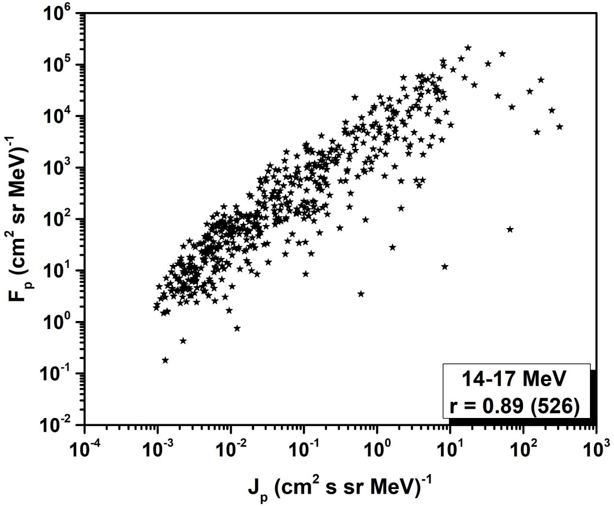
Space weather catalogs @ IANAO-BAS

Complementary work

SEP fluences vs. energy

- Properties: flux distributions, correlation with proton flux





Space weather catalogs @ IANAO-BAS

Complementary work

SEP fluences vs. energy

- Correlations with SFs and CMEs (Pearson, partial)
- Occurrence rates (%) with SEEs, IP-IIs, ICMEs, GSs
- Longitudinal (E vs. W) and SC (23 vs. 24) trends

Type	all	E	W
$F_{p1} - I_{SXR}$	$0.47^{\pm 0.05}$ (351)	$0.42^{\pm 0.08}$ (87)	$0.50^{\pm 0.06}$ (259)
$F_{p1} - I_{SXR} \vert V_{CME}$	0.34	0.32	0.35
$F_{p1} - I_{SXR} \vert V_{CME} AW$	0.30	0.32	0.30
$F_{p1} - V_{CME}$	$0.50^{\pm 0.04}$ (429)	$0.43^{\pm 0.09}$ (101)	$0.53^{\pm 0.04}$ (328)
$F_{p1} - V_{CME} \vert I_{SXR}$	0.38	0.33	0.40
$F_{p1} - V_{CME} \vert I_{SXR} AW$	0.34	0.43	0.32

Event types SC23+24	all (530)	F_{p1} E (111)	W (335)
SEPs–SEEs	45	55	68
SEEs–SEPs	30		
SEPs–IP-IIs	37	41	44
IP-II–SEPs	36^{u}		
SEPs–ICMEs	12	18	13
ICMEs–SEPs	12^{u}		
SEPs–GSs	17	27	18
GSs–SEPs	14		

Space weather effects to satellites: SpaceX storm (2022-02-03)

Summary of effects

EM emission: Satellite signal degradation and loss; Radio blackouts; Increased atmospheric drag.

Magnetized plasma: atmospheric and ground-based effects from geomagnetic storms

SEPs: Single-event upsets/single-event effects; Cumulative radiation effects (total ionizing dose and displacement damage dose); Surface discharges; Deep dielectric charging; Solar cell degradation, material aging/surface damage to materials.

astronomy MDPI

Article

Space Weather Effects on Satellites

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[3] European Innovation Council and SMEs Executive Agency (EISMEA), 1049 Brussels, Belgium; stela.tkatchova@ec.europa.eu
* Correspondence: rmiteva@nao-rozhen.org

Aim: to focus on **solar & near-Earth IP effects** during Starlink launches in order to evaluate the additional impact of the EM and radiation environment.

Solar and IP phenomena intensity: **minor-to-moderate** importance compared to the largest values on record.

The observed **weak-to-moderate SFs, particle events, and IP phenomena** (e.g., strength of IMF Bz-component) <u>are not expected to be responsible for the poor spacecraft performance, even less for its failure.</u>

To search for additional causes of the failure of Starlink satellites launched during an ongoing GS on 2022-02-03; the cumulative effects of multiple weak SW events carry a hidden risk to (V)LEO satellites.

https://doi.org/10.3390/astronomy2030012

Starlink satellite: effects to radio domain

ASTRON 75

17 september 2024

EMBARGOED UNTIL 18 SEPTEMBER 2024 07:00 UTC

Second-Generation Starlink Satellites Leak 30 Times More Radio Interference, Threatening Astronomical Observations

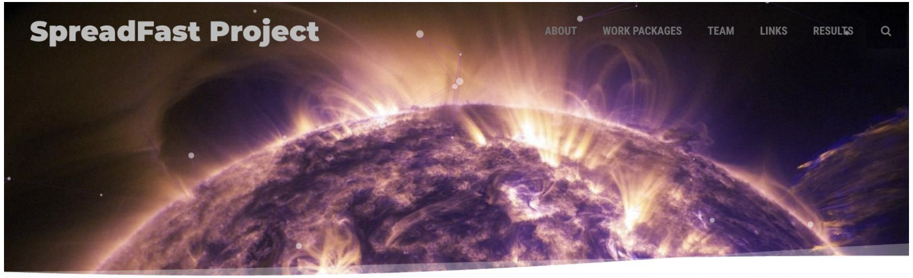
Observations with the LOFAR (Low Frequency Array) radio telescope last year showed that first generation Starlink satellites emit unintended radio waves that can hinder astronomical observations. New observations with the LOFAR radio telescope, the biggest radio telescope on Earth observing at low frequencies, have shown that the second generation 'V2-mini' Starlink satellites emit up to 32 times brighter unintended radio waves than satellites from the previous generation, potentially blinding radio telescopes and crippling vital research of the Universe.

Paper:
https://www.aanda.org/articles/aa/full_html/2024/09/aa51856-24/aa51856-24.html

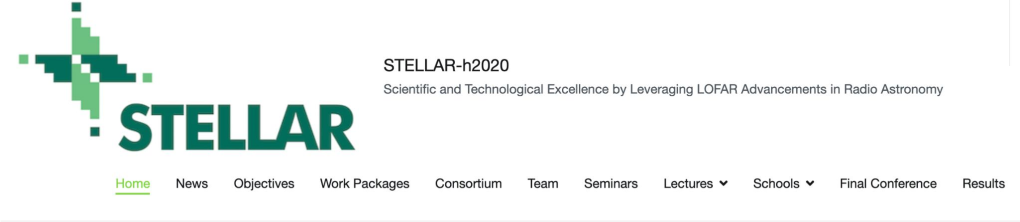
Space weather-related projects

Completed:

https://spreadfast.astro.bas.bg/

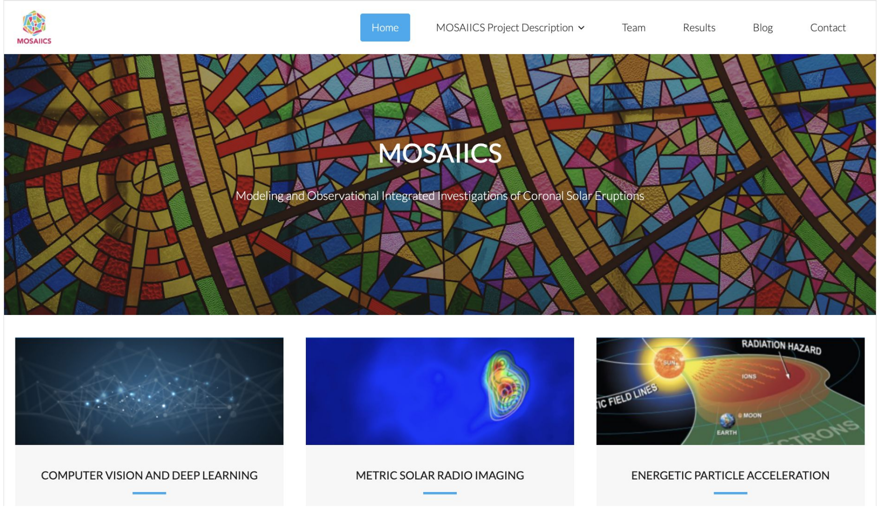


https://stellar-h2020.eu/



In progress:

https://mosaiics.astro.bas.bg/



https://astro.bas.bg/project-sun/

Solar observations @ IANAO-BAS

AIM

1

To set up the Rozhen Chromospheric Telescope (RCT), and develop standardized solar observing methodology and products, complementary to the Kanzelhohe Patrol Instrument (KPI) by means of strong technical cooperation between the team members.

2

To carry out combined solar observations with the two instrument suites and external (freely available space-based) resources, in order to study chromospheric signatures of quiet sun and pre-eruptive active regions and multi-wavelength manifestation of solar eruptive phenomena, their morphology and kinematics.

Work Packages

Work Package #1

Technical support of NAO-Rozhen Chromosphere Telescope and observation campaigns with KSO facilities

- Task 1.1: Telescope installation
- Task 1.2: Data processing
- Task 1.3: Observation Campaign
- Task 1.4: Image enhancement

Work Package #2

Joint investigations of solar chromospheric and coronal activity

- Task 2.1: Chromospheric Signatures of Quiet Sun and Pre-Eruptive Configurations
- Task 2.2: Multi-wavelength study of solar activity phenomena, their morphology and kinematics

Work Package #3

Dissemination of the project results

- Task 3.1: Project web-site
- Task 3.2: Scientific dissemination

"Joint Observations and Investigations of Solar Chromospheric and Coronal Activity"

Funding: Bulgarian National Science Foundation project No. KP-06-Austria/5 (14-08-2023) and Austria's Agency for Education and Internationalisation (OeAD) project No. BG 04/2023.

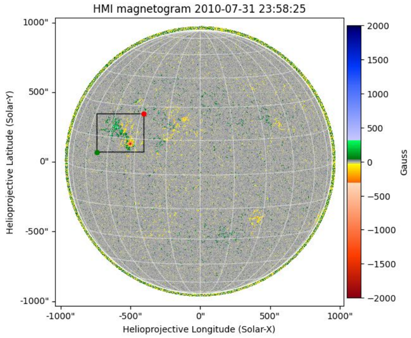
⇒ Poster "On geoeffective active regions"

results published in: **https://doi.org/10.3390/atmos15080930**

https://astro.bas.bg/project-sun/

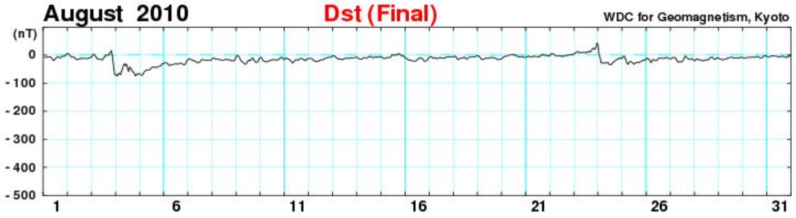
Active Region (AR):

"the totality of observable phenomena in a 3D volume represented by the extension of magnetic field from the photosphere to the corona. . ." [van Driel-Gesztelyi et al. 2015] including EM emissions and strong twisted magnetic field emergence



Geomagnetic Storm (GS):

major disturbances in the terrestrial atmosphere caused by the reconnection process between the incoming plasma ejecta in th solar wind and the planetary magnetosphere



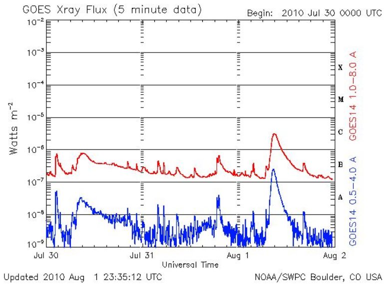
https://wdc.kugi.kyoto-u.ac.jp/dst_final/201008/index.html

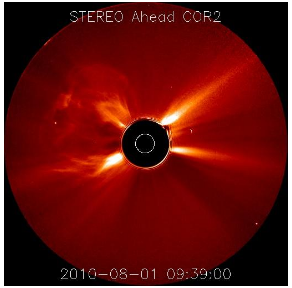
Aim:

to investigate the parameters of ARs leading to GSs (i.e. geoeffective ARs)

Novelty:

to investigate in detail the link between SHARP parameters (SDO/HMI instrument) and parameters of GSs (Dst index), SFs (class), and CMEs (speed & AW)





https://doi.org/10.3390/atmos15080930

https://astro.bas.bg/project-sun/

https://solarmonitor.org/

https://cdaw.gsfc.nasa.gov/CME_list/daily_movies/2010/08/01/

Methodology

Space-weather HMI Active Region Patch (SHARP) products:
http://jsoc.stanford.edu/doc/data/hmi/sharp/sharp.htm

- USFLUX: Total unsigned flux [Mx];
- MEANGAM: Mean inclination angle, γ [degrees];
- MEANGBT: Mean value of the total field gradient [G/Mm];
- MEANGBZ: Mean value of the vertical field gradient [G/Mm];
- MEANGBH: Mean value of the horizontal field gradient [G/Mm];
- MEANJZD: Mean vertical current density [mA/m^2];
- TOTUSJZ: Total unsigned vertical current [A];
- MEANALP: Mean twist parameter, α [1/Mm];
- MEANJZH: Mean current helicity [G^2/m];
- TOTUSJH: Total unsigned current helicity [G^2/m];
- ABSNJZH: Absolute value of the net current helicity [G^2/m];
- SAVNCPP: Sum of the absolute value of the net currents [A];
- MEANPOT: Mean photospheric excess magnetic energy density [Ergs/cm^3];
- TOTPOT: Total photospheric magnetic energy density [Ergs/cm^3];
- MEANSHR: Mean shear angle for B_{total} [degrees];
- R_{VALUE}: Unsigned flux, R] [Mx].

https://doi.org/10.3390/atmos15080930

https://astro.bas.bg/project-sun/

SHARP data:
12 min cadence [Bobra et al. 2014]
Rvalue [Schrijver 2007]
⇒ SHARP values taken prior to the SF onset

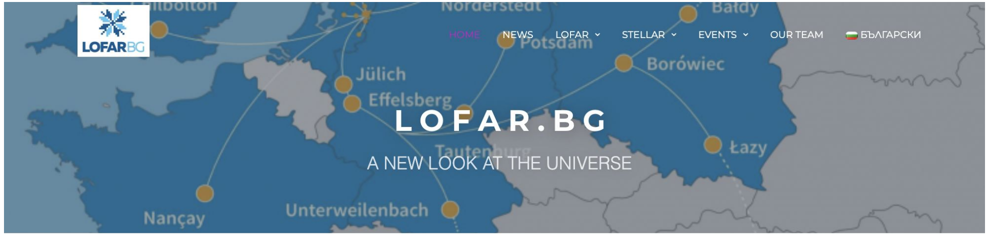
Event list:
64 events (2010-2023)

Correlation analyses:
- Pearson & Spearman coefficients, standard error
- Scatter plots

Results
total flux, current, current helicity, magnetic energy density, and shear angle show *moderate-to-strong correlations* also with the SF class and the CME parameters but not with the Dst index

Next steps
⇒ apply to confined vs. eruptive SFs

New infrastructure



Welcome to LOFAR-BG!

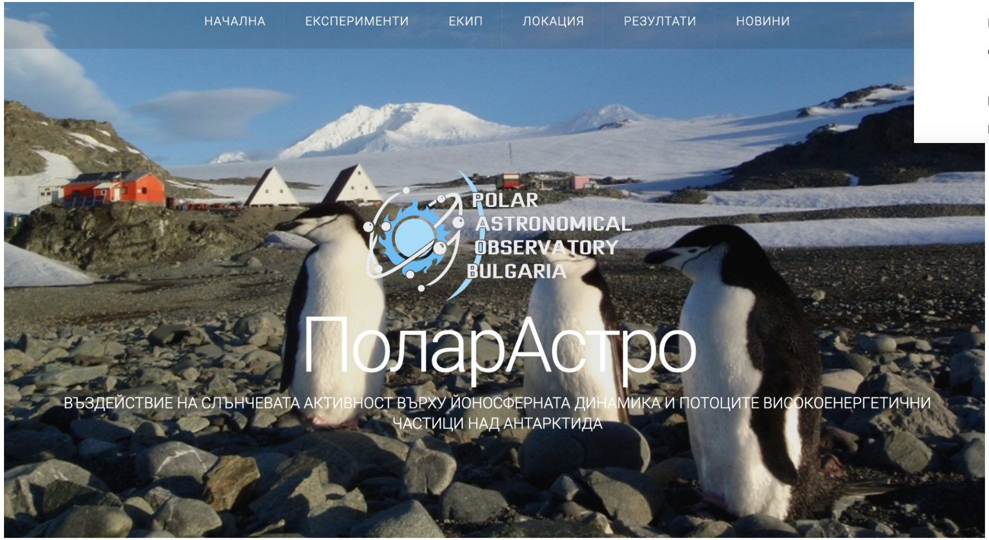
Here you will find up-to-date information on the development of a Bulgarian LOFAR station and joining the international LOFAR telescope. This includes establishing a National LOFAR consortium, as well as organisation of seminars and meetings.

The LOFAR telescope, originally developed in the Netherlands, is managed by the Netherlands Institute of Radio Astronomy – ASTRON. It is an advanced, pan-European, distributed, low-frequency radio telescope, consisting of separate observing stations with dipole antenna arrays. The signals from each individual antenna in every station are added into observing 'beams', electronically steered in any desired direction of the Northern sky.

LOFAR offers unique observing capabilities for studying astrophysical and geophysical phenomena in the near and distant Universe. Our goal is to develop national capabilities for observation, processing, and analysis of LOFAR data, as well as to build and develop a Bulgarian LOFAR station.

LOFAR-BG is part of the National Roadmap for Scientific Infrastructure (2020-2027), coordinated by the Ministry of Education and Science of Bulgaria (contracts D01-389/18.12.2020 and D01-177/29.07.2022).

https://astro.bas.bg/PolarAstro



https://astro.bas.bg/

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SCOSTEP/PRESTO 2020 grant https://scostep.org/presto/
'On the relationship between major space weather phenomena in solar cycles 23 and 24'

Bilateral project: Bulgaria-Austria https://astro.bas.bg/project-sun/
'Joint observations and investigations of solar chromospheric and coronal activity'
(2023-2025) Bulgarian National Science Foundation project No. KP-06-Austria/5 (14-08-2023) and Austria's Agency for Education and Internationalisation (OeAD) project No. BG 04/2023

Interacademy bilateral project: Bulgaria-Serbia
'*Active Events On The Sun. Catalogs Of Proton Events And Electron Signatures In X-Ray, UV And Radio diapason. Influence of Collisions on Optical Properties of Dense Hydrogen Plasma'* (2023-2025) Bulgarian Academy of Sciences