On the geo-effectiveness of active regions: First results from the Bulgarian-Austrian bilateral project

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http://sab.astro.bas.bg/

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Шумен, България

Contents

Project description

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

Research: Magnetic properties of geoeffective ARs

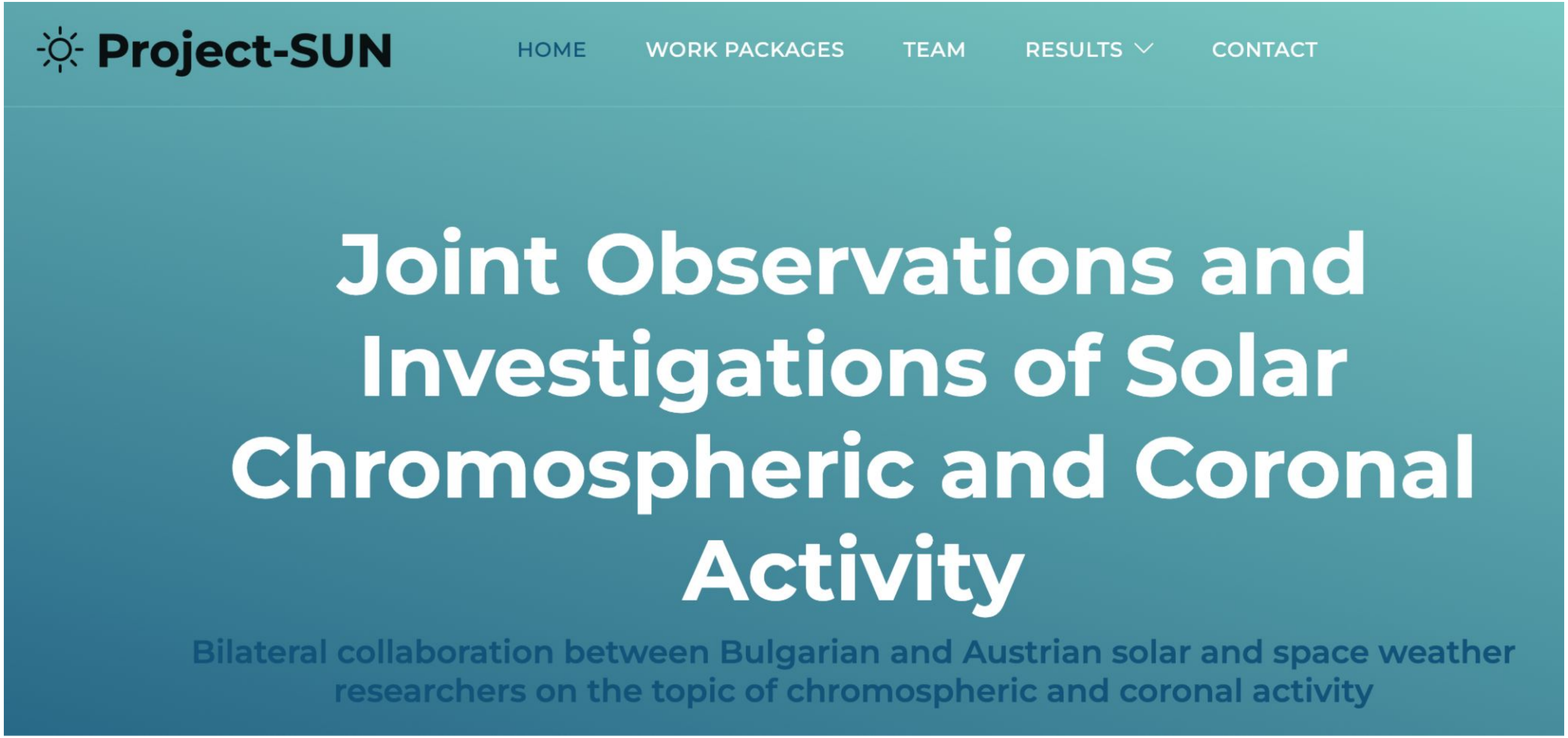
- Statistical analysis

Future plans

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

Project: General information

2023-2025
(2 yrs)
https://bnsf.bg/



Project: 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.

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

Project: Research topics

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

Project: Team & Exchange visits

BG:

R. Miteva (co-PI), M. Dechev, M. Nedal, K. Kozarev, N. Petrov, O. Stepanyuk, T. Tsvetkov, Y. Zinkova

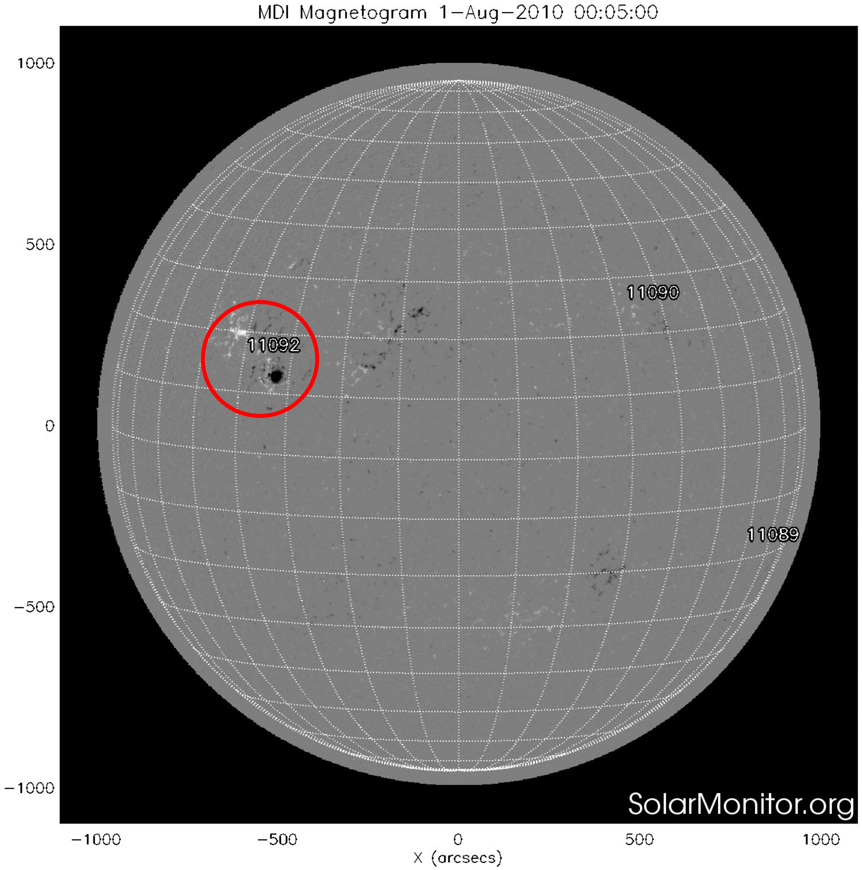
AT:

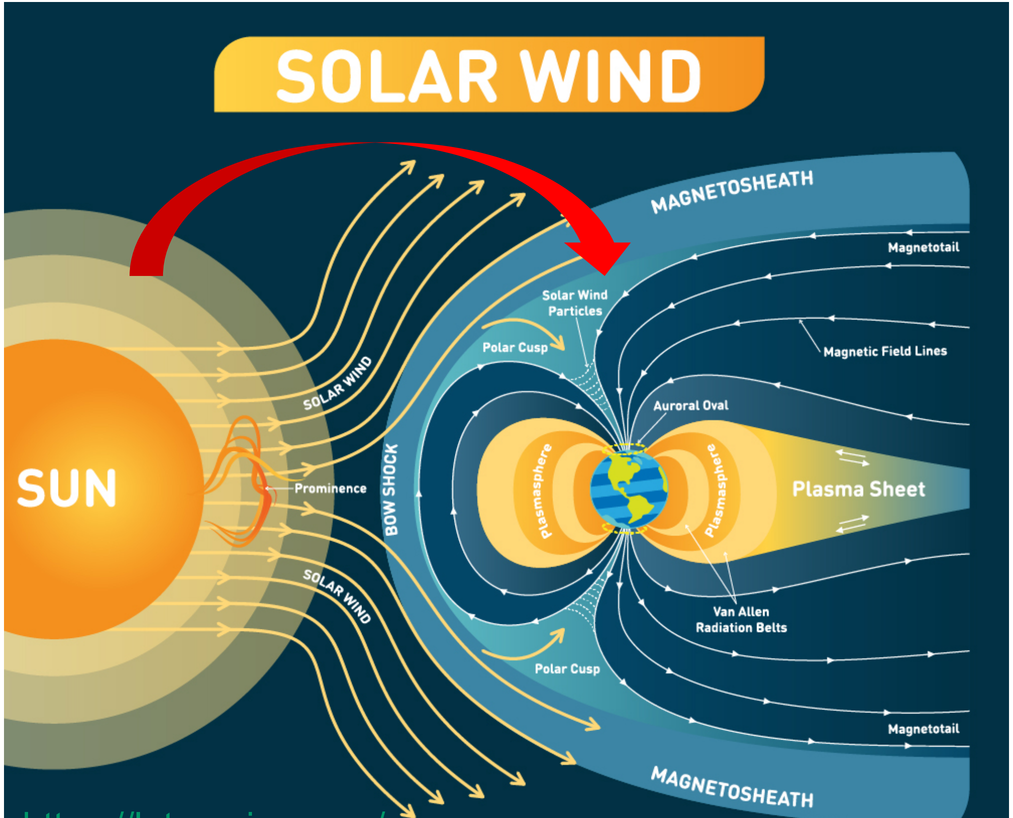
W. Poetzi (co-PI), R. Jarolim, S. Purkhart, C. Schiringer, A. Veronig

On site observing campaigns & collaborations:

- 2023 (Sofia & NAO-Rozhen): WP
- 2024 (KSO): OS
  - 2024 (Sofia & NAO-Rozhen): WP, AV
  - 2024 (Sofia): WP, CS
  - 2025 (KSO): BG-team

Background: ARs and geomagnetic storms





https://lotusarise.com/

Science objective: Geoeffective ARs

Research ?:

Are the magnetic configurations of geo-effective ARs distinct from those of non-geo-effective ARs?

(What is the potential for space weather forecasting of these AR parameters?)

Event selection & data analyses

Data selection:
SDO/HMI (after 2009-present),
SHARP data product
http://jsoc.stanford.edu/HMI/HARPS.html

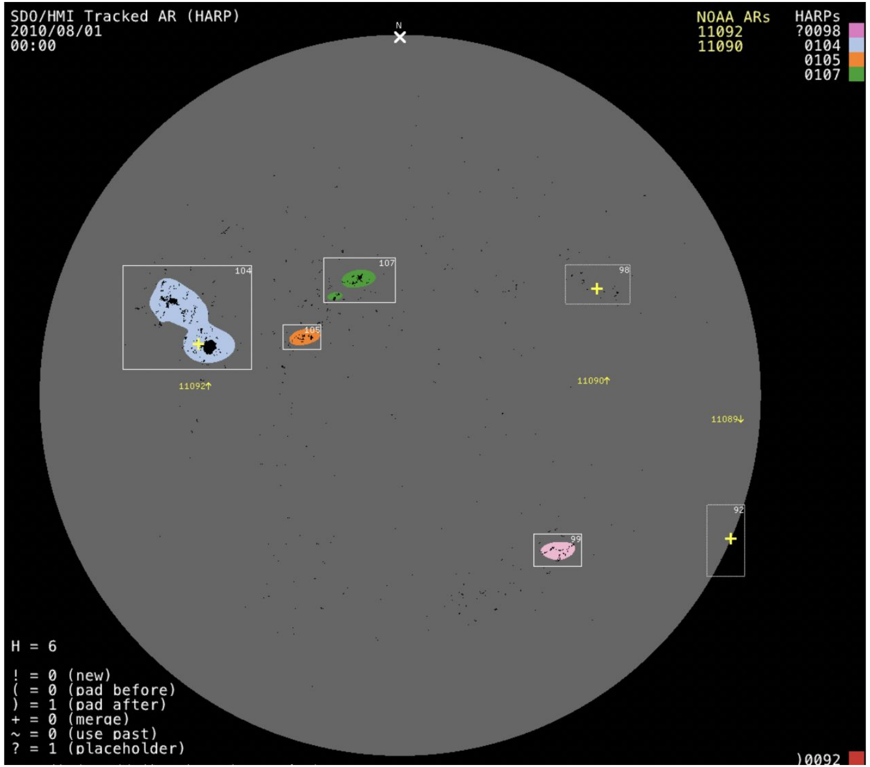
Event selection:
List of geomagnetic storms in SC24: 185
https://catalogs.astro.bas.bg/
(Miteva & Samwel, 2023)

→ with solar origin (flare): 70

→ with AR number: 70

→ with SHARP data: **65**

Extending to events in SC25 (mid-2023)
Presenting preliminary results for
50 events.



SHARP parameters

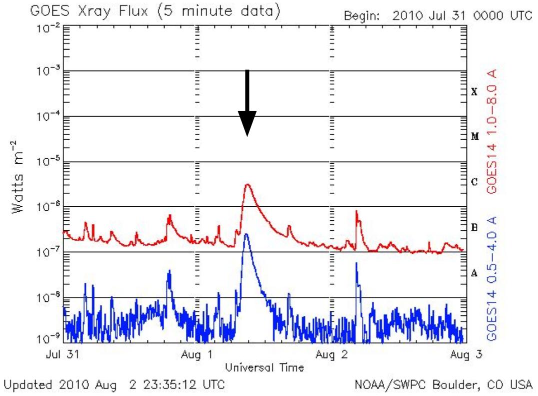
1. USFLUX (Maxwell): Total unsigned flux
2. MEANGAM (Degrees): Mean inclination angle, gamma
3. MEANGBT (Gauss/Mm): Mean value of the total field gradient
4. MEANGBZ (Gauss/Mm): Mean value of the vertical field gradient
5. MEANGBH Gauss/Mm Mean value of the horizontal field gradient
6. MEANJZD (mA/(m^2)): Mean vertical current density
7. TOTUSJZ (Amperes): Total unsigned vertical current
8. MEANALP (1/Mm): Mean twist parameter, alpha
9. MEANJZH (G^2)/m: Mean current helicity
10. TOTUSJH (G^2)/m: Total unsigned current helicity
11. ABSNJZH (G^2)/m: Absolute value of the net current helicity
12. SAVNCPP (Amperes): Sum of the Absolute Value of the Net Currents ...
13. MEANPOT (Ergs/cm^3): Mean photospheric excess magnetic energy density
14. TOTPOT (Ergs/cm^3): Total photospheric magnetic energy density
15. MEANSHR (Degrees): Mean shear angle for B_total
16. R_VALUE (Maxwell): Unsigned Flux R (Schrijver, 2007)

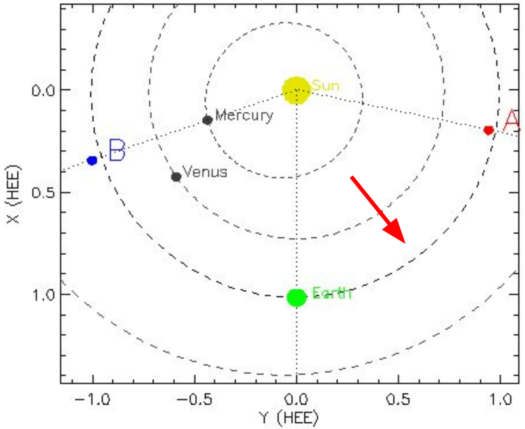
SHARP parameters

Keyword	Description	Unit[a]	Formula[b]
USFLUX	Total unsigned flux	Mx	$\Phi = \sum \lvert B_z \rvert \, dA$
MEANGAM	Mean angle of field from radial	Degree	$\overline{\gamma} = \frac{1}{N} \sum \arctan(\frac{B_h}{B_z})$
MEANGBT	Horizontal gradient of total field	G Mm^{-1}	$\overline{\lvert \nabla B_{tot} \rvert} = \frac{1}{N} \sum \sqrt{(\frac{\partial B}{\partial x})^2 + (\frac{\partial B}{\partial y})^2}$
MEANGBZ	Horizontal gradient of vertical field	G Mm^{-1}	$\overline{\lvert \nabla B_z \rvert} = \frac{1}{N} \sum \sqrt{(\frac{\partial B_z}{\partial x})^2 + (\frac{\partial B_z}{\partial y})^2}$
MEANGBH	Horizontal gradient of horizontal field	G Mm^{-1}	$\overline{\lvert \nabla B_h \rvert} = \frac{1}{N} \sum \sqrt{(\frac{\partial B_h}{\partial x})^2 + (\frac{\partial B_h}{\partial y})^2}$
MEANJZD	Vertical current density	mA m^{-2}	$\overline{J_z} \propto \frac{1}{N} \sum (\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y})$
TOTUSJZ	Total unsigned vertical current	A	$J_{z_{total}} = \sum \lvert J_z \rvert \, dA$
MEANALP	Characteristic twist parameter, α	M m^{-1}	$\alpha_{total} \propto \frac{\sum J_z B_z}{\sum B_z^2}$
MEANJZH	Current helicity (B_z contribution)	G^2 m^{-1}	$\overline{H_c} \propto \frac{1}{N} \sum B_z J_z$
TOTUSJH	Total unsigned current helicity	G^2 m^{-1}	$H_{c_{total}} \propto \sum \lvert B_z J_z \rvert$
ABSNJZH	Absolute value of the net current helicity	G^2 m^{-1}	$H_{c_{abs}} \propto \lvert \sum B_z J_z \rvert$
SAVNCPP	Sum of the modulus of the net current per polarity	A	$J_{z_{sum}} \propto \lvert \sum^{B_z^+} J_z \, dA \rvert + \lvert \sum^{B_z^-} J_z \, dA \rvert$
MEANPOT	Proxy for mean photospheric excess magnetic energy density	erg cm^{-3}	$\overline{\rho} \propto \frac{1}{N} \sum (\boldsymbol{B}^{Obs} - \boldsymbol{B}^{Pot})^2$
TOTPOT	Proxy for total photospheric magnetic free energy density	erg cm^{-1}	$\rho_{tot} \propto \sum (\boldsymbol{B}^{Obs} - \boldsymbol{B}^{Pot})^2 \, dA$
MEANSHR	Shear angle	Degree	$\overline{\Gamma} = \frac{1}{N} \sum \arccos(\frac{\boldsymbol{B}^{Obs} \cdot \boldsymbol{B}^{Pot}}{\lvert \boldsymbol{B}^{Obs} \rvert \lvert \boldsymbol{B}^{Pot} \rvert})$

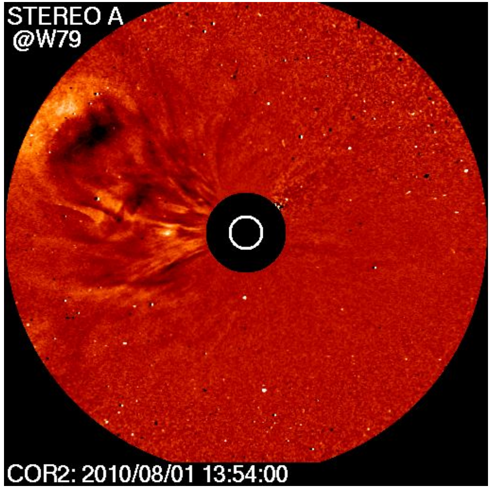
Solar & geomagnetic parameters

Solar flare (GOES)
- SXR class
- times: rise, decline and total duration

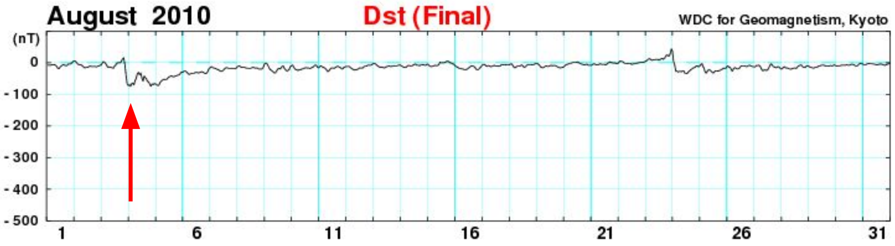




CME (SOHO)
- Speed
- Angular width

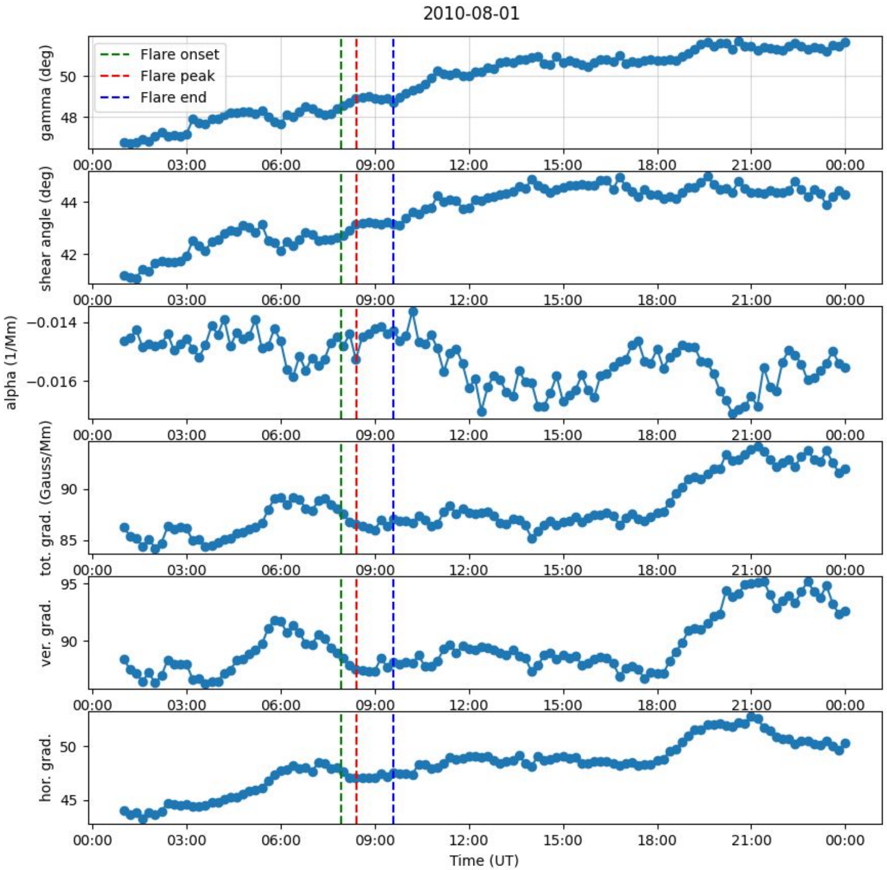


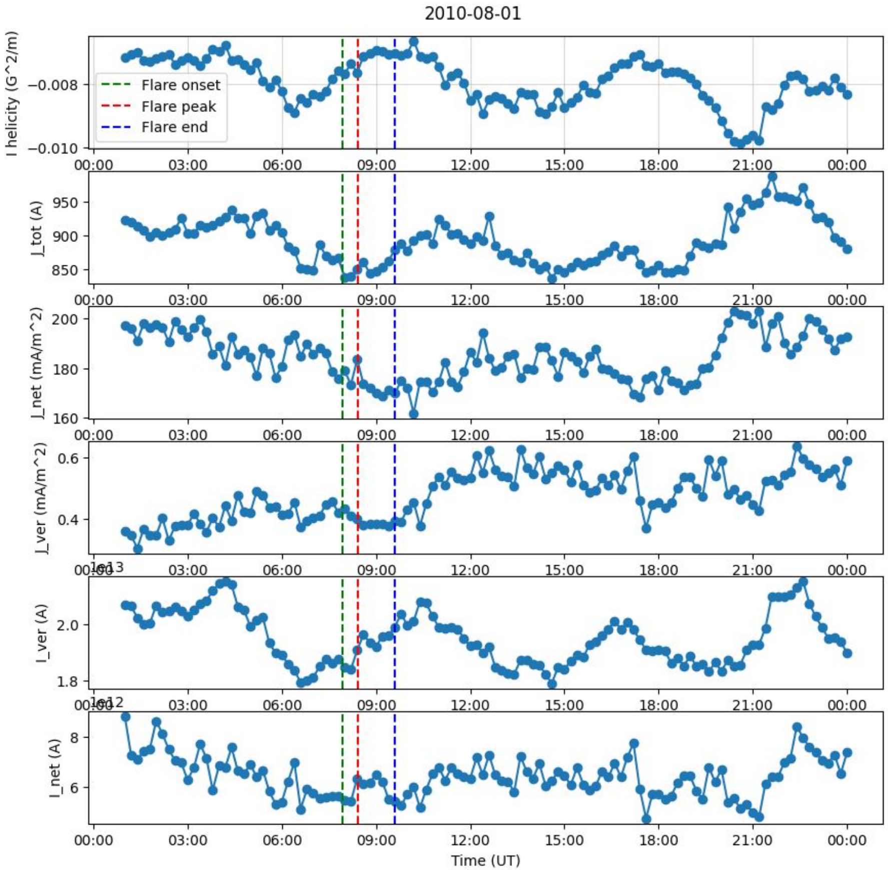
Geomagnetic Storms (Kyoto)
- Dst



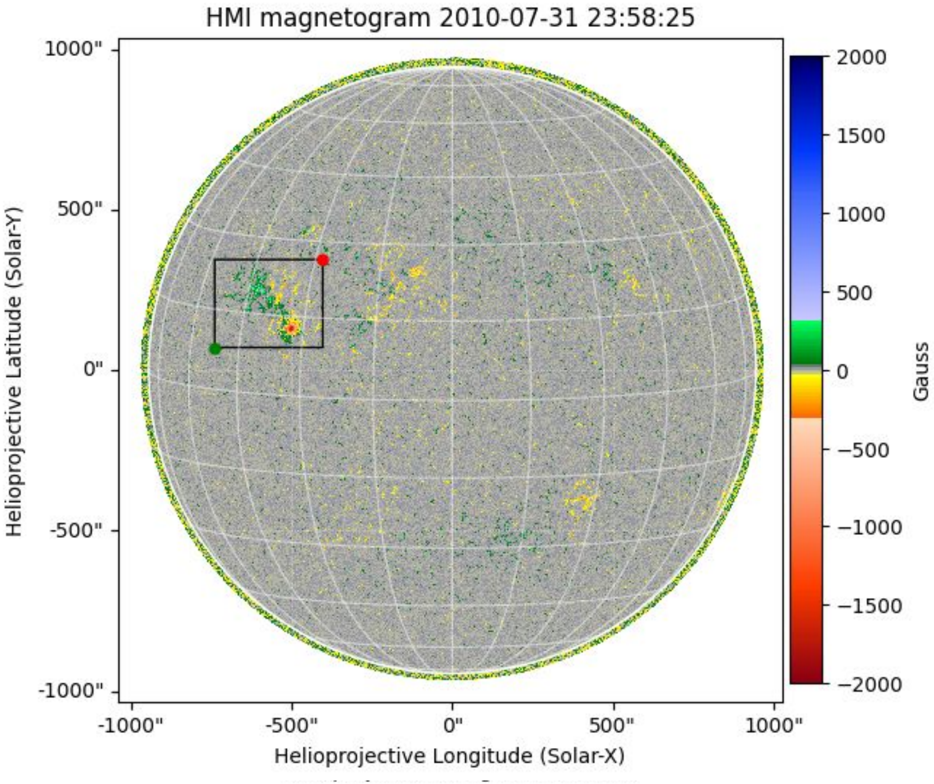
https://wdc.kugi.kyoto-u.ac.jp/dst_final/201008/index.html

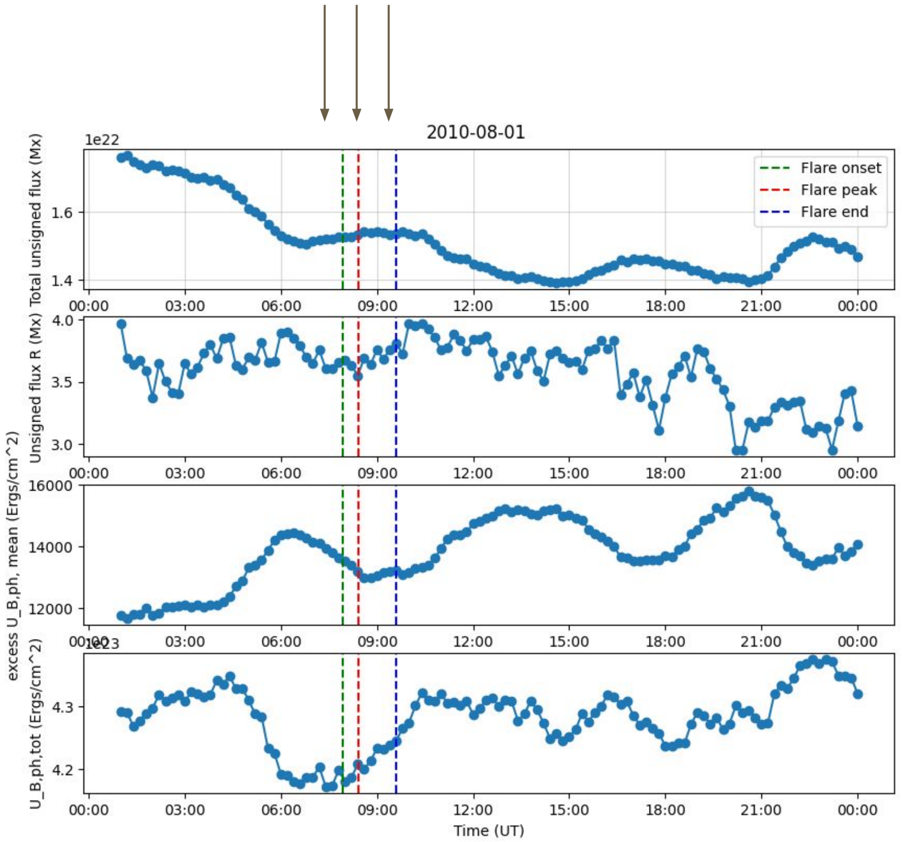
Preliminary results: Temporal evolution



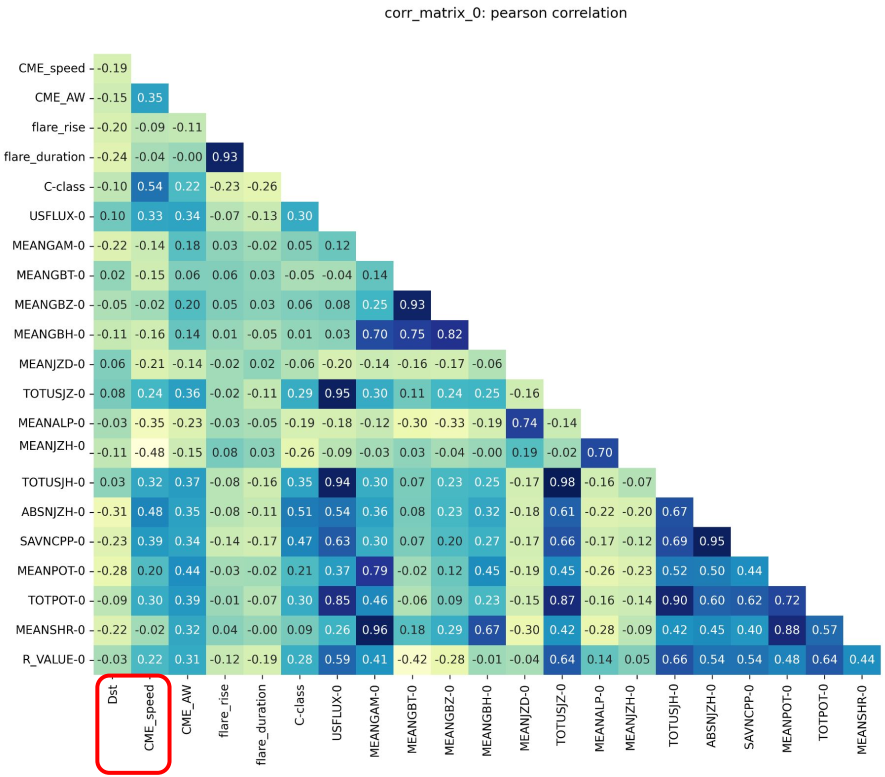


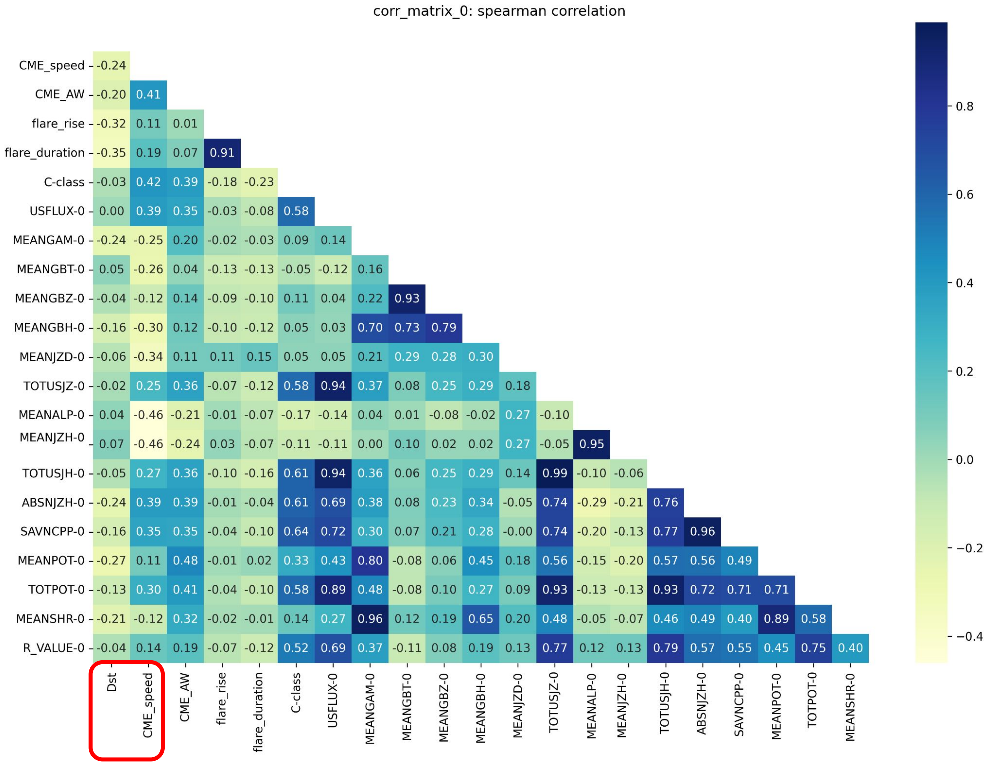
Preliminary results: Location





Preliminary results: Statistics (pre-flare timing)

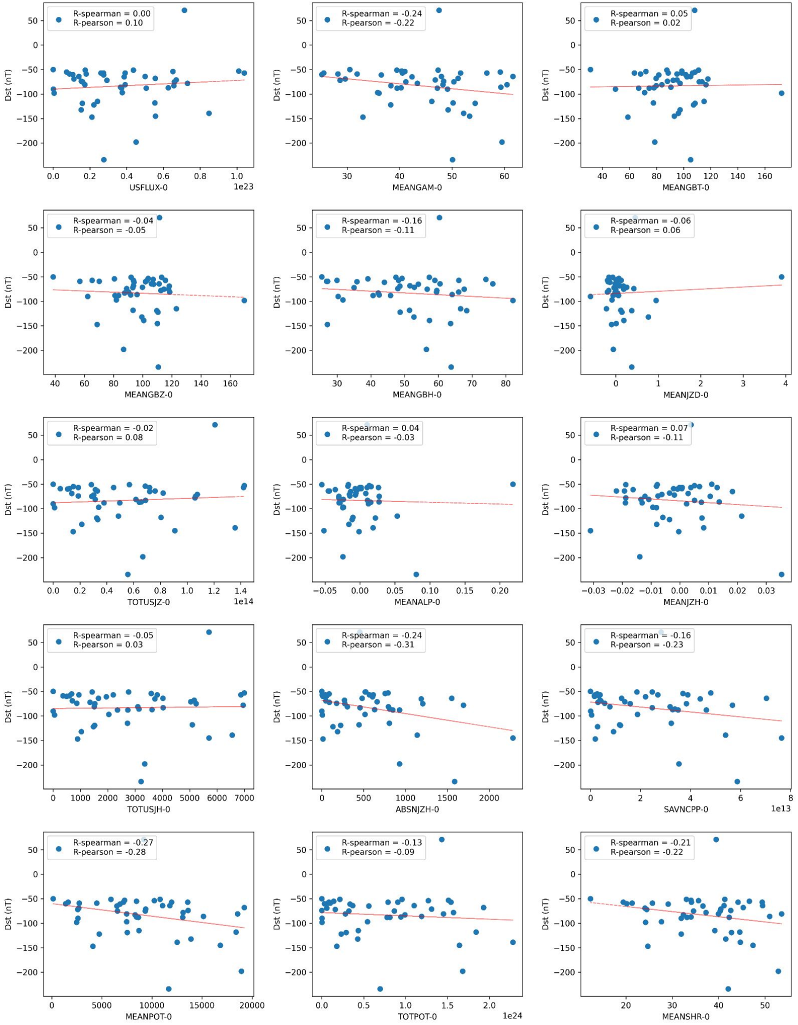




Preliminary results: Scatter-plots (pre-flare timing)

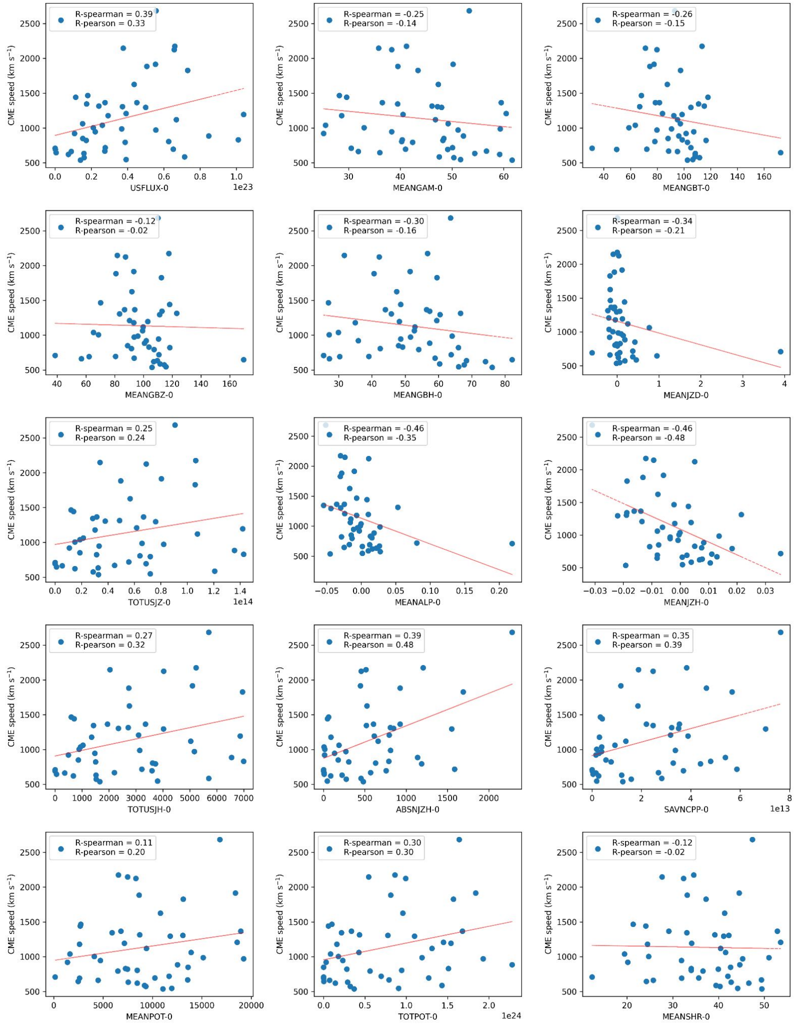
- Poor correlations with: Dst

(due to narrow range of Dst indices)



Summary & discussion

- Poor correlations with: Dst, CME parameters, flare rise/duration
- Stronger correlations with: solar flare class
- No significant difference in the correlations based on the timing of the SHARP parameter (e.g., before or during the flare)



Outlook

Comparison with control samples in solar cycle 24 (& ongoing SC25):

- Confined & eruptive (& non-geo-effective) ARs:

    49 X-class flares (Miteva 2021) &

    749 M-class flares (Miteva & Samwel 2022)

- 468 confined & 251 eruptive ARs (from Li et al. 2021)

using automatic routines for multi-parameter analyses (work in progress).

Acknowledgement

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ФОНД
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