

Geo-efficiency of solar active regions

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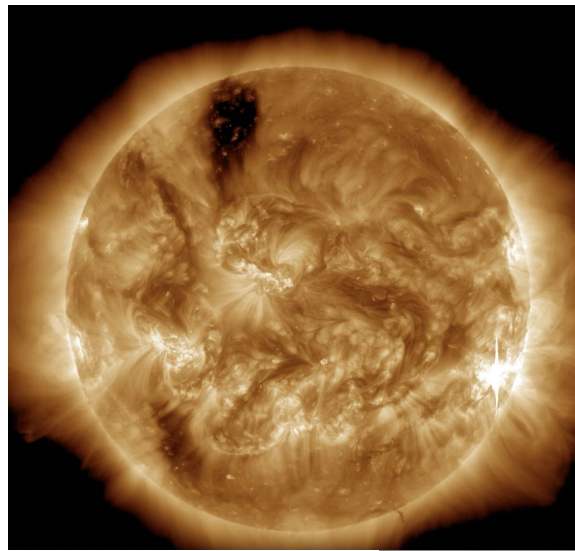
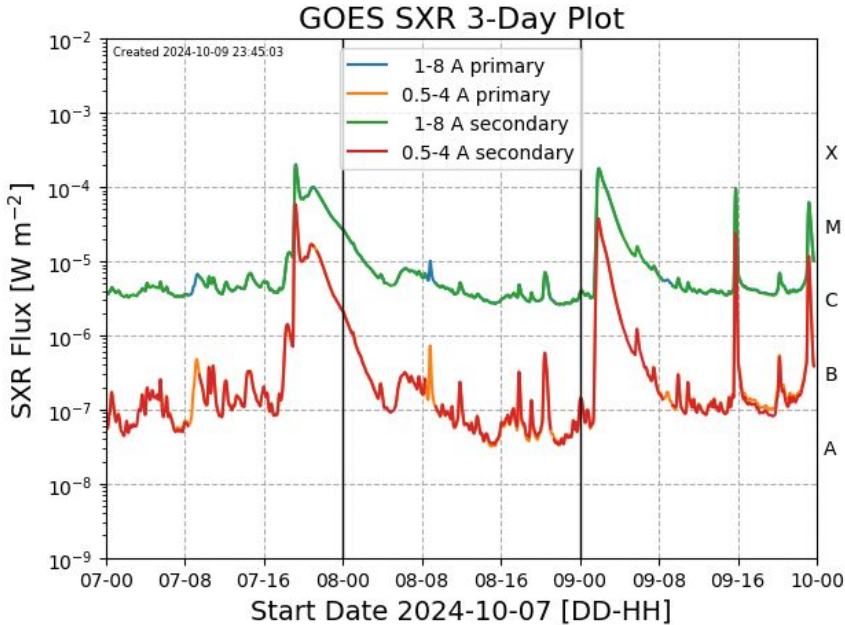
DIAS

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Bhaile Átha Cliath | Advanced Studies

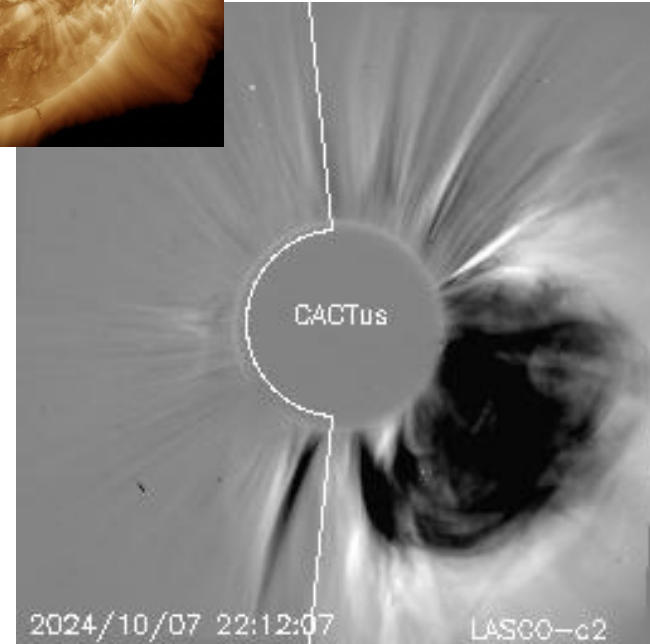


<https://bulgarianspace.online/en/nafski2024/>

Solar activity: Flares & CMEs



https://sdo.gsfc.nasa.gov/data/dailymov/movie.php?q=20241007_1024_0193
Solar flare (~X1)



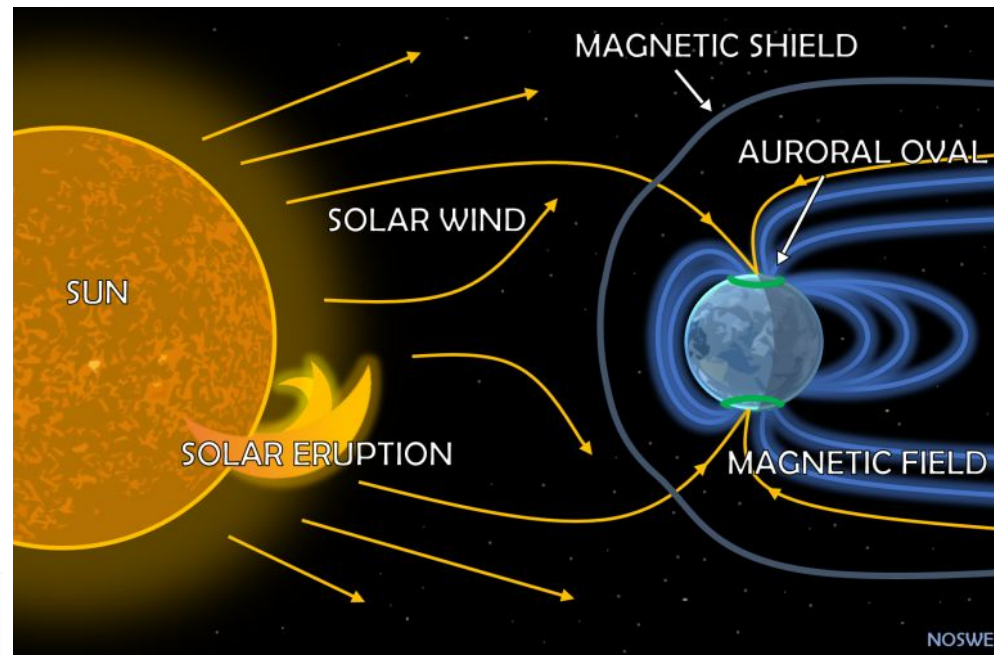
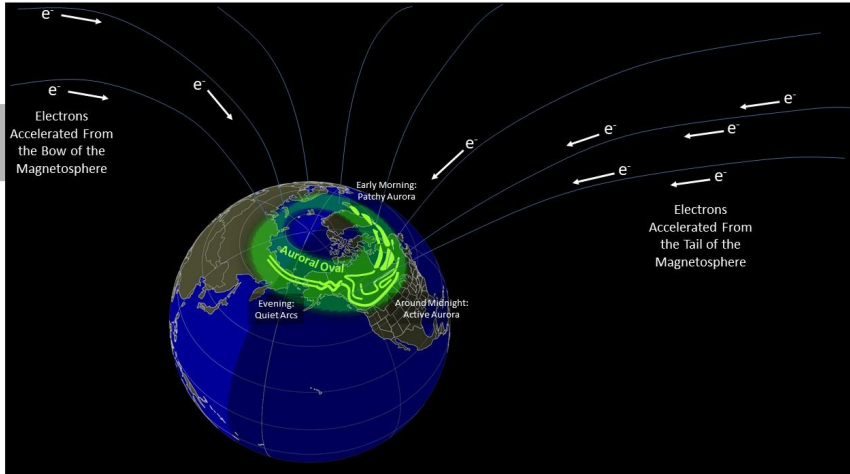
https://www.sidc.be/cactus/catalog/LASCO/2_5_0/gkl/2024/10/CME0042/CME.html

CME (480 km/s) +Type II

<https://solarmonitor.org/>

Space weather: Geomagnetic storms

“a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth” <https://www.swpc.noaa.gov/>



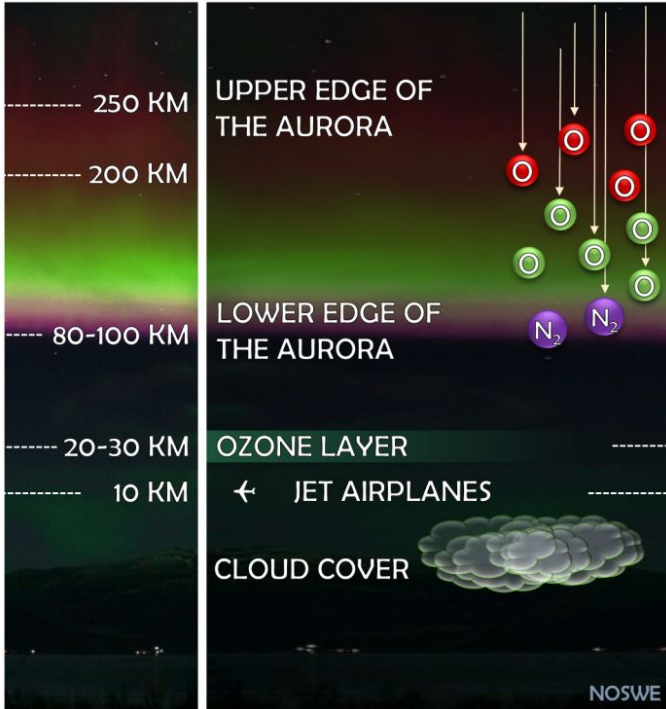
<https://site.uit.no/space-weather/aurora-borealis/>

Aurora

“electrons due to geomagnetic activity ionize atmospheric O & N”

<https://www.swpc.noaa.gov/content/aurora-tutorial>

Aurora



<https://site.uit.no/spaceweather/aurora-borealis/>



Milen Minev @
NAO-Rozhen



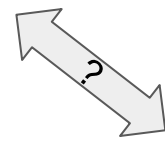
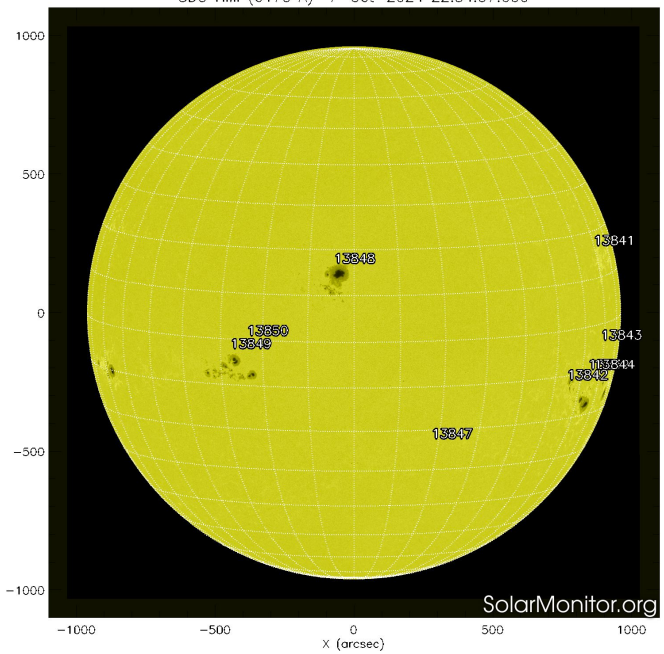
Pencho
Markishki @
AO-
Belogradchik
10/11
October
2024

Aim

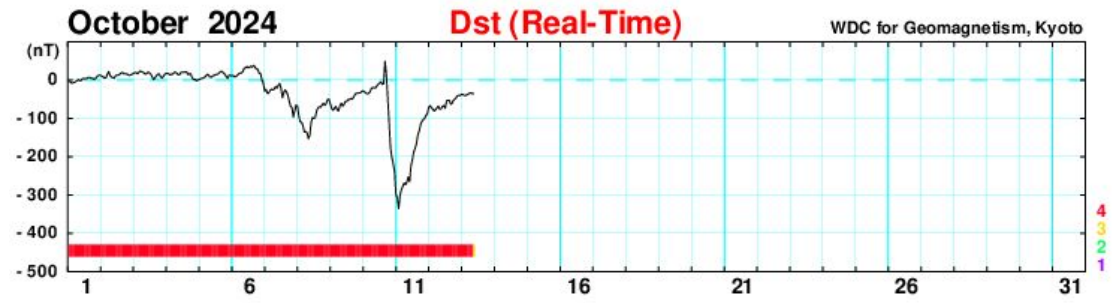
Active regions
(SHARP parameters)

Solar activity

- flares
(class)
- (I)CME
(speed, angular width)



Geomagnetic storms
(Dst parameter)



[Created at 2024-10-13 09:00UT]

Active regions

“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



ARs: SHARP parameters

Data: SDO/HMI (2009-present)

<http://jsoc.stanford.edu/HMI/HARPS.html>

12 min cadence

Event selection

- (1) List of GSs (2009-mid 2023): **125**
- (2) Association with ICMEs & CMEs: **84**
- (3) Association with flares, ARs & data availability: **64**

<https://doi.org/10.3390/atmos15080930>

Keyword Description Unit^a Formula^b
<https://doi.org/10.1007/s11207-014-0529-3>

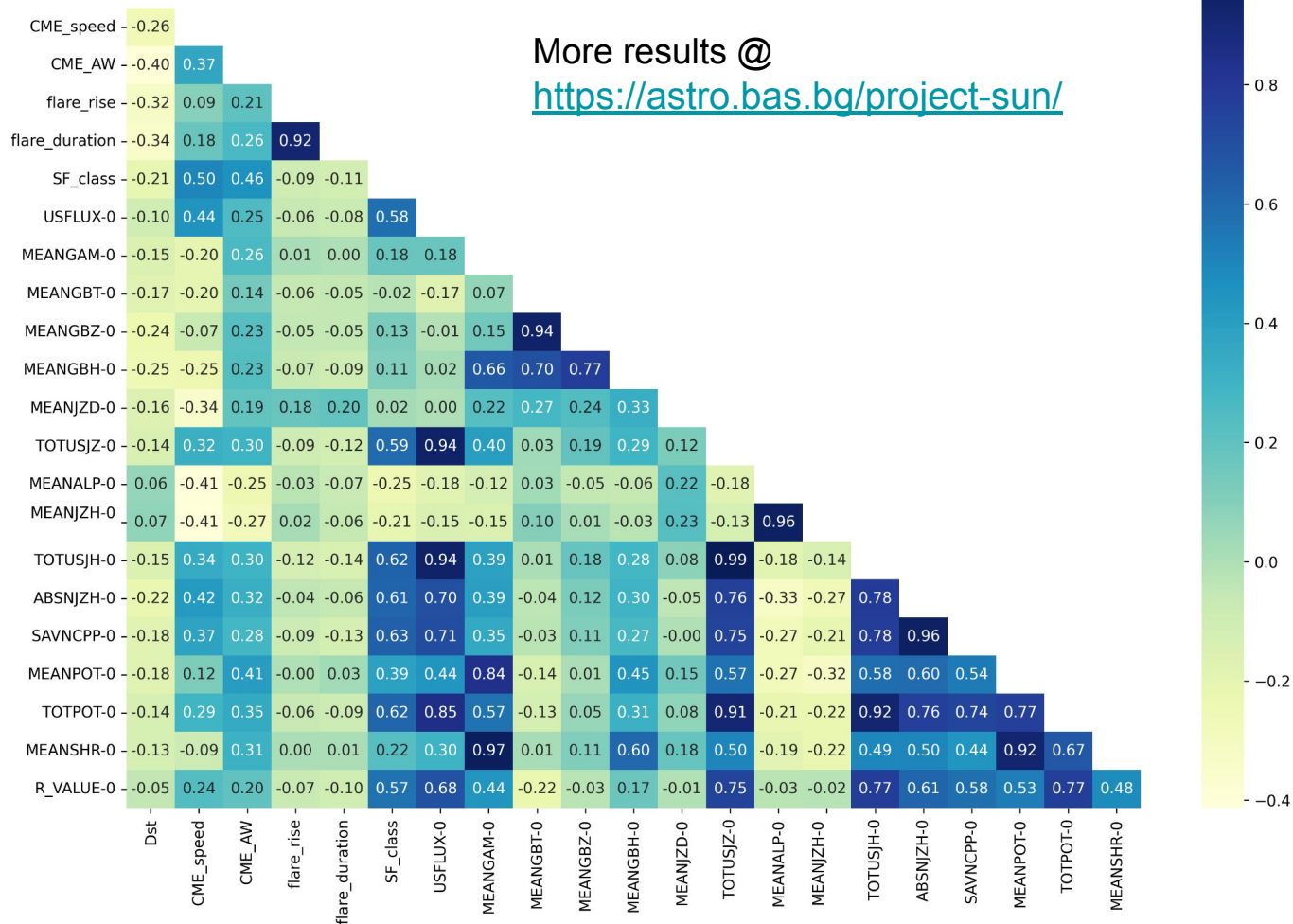
USFLUX	Total unsigned flux	Mx	$\Phi = \sum B_z dA$
MEANGAM	Mean angle of field from radial	Degree	$\bar{\gamma} = \frac{1}{N} \sum \arctan\left(\frac{B_h}{B_z}\right)$
MEANGBT	Horizontal gradient of total field	G Mm ⁻¹	$ \nabla B_{\text{tot}} = \frac{1}{N} \sum \sqrt{\left(\frac{\partial B}{\partial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

Results

Active regions
(SHARP
parameters)

Solar activity:
flares (class) &
CMEs (speed,
angular width)

Geomagnetic
storms (Dst)



Interpretation

SHARP parameters of ARs

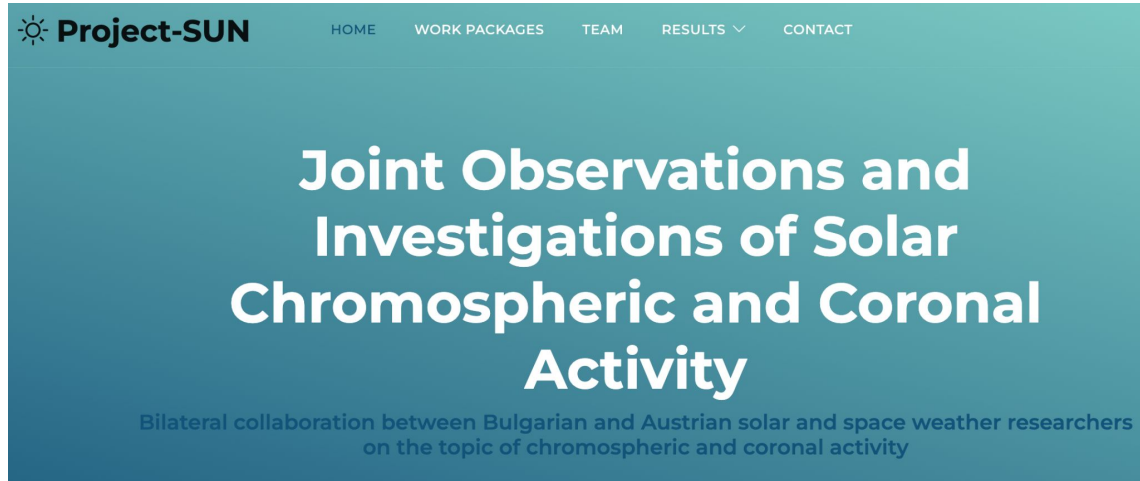
- are not an useful indicator for GS Dst intensity
- show moderate-to-strong correlations with flares

Planned tests:

- eruptive vs. confined flares
- geoeffective vs. not-geoeffective ARs

Acknowledgements

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