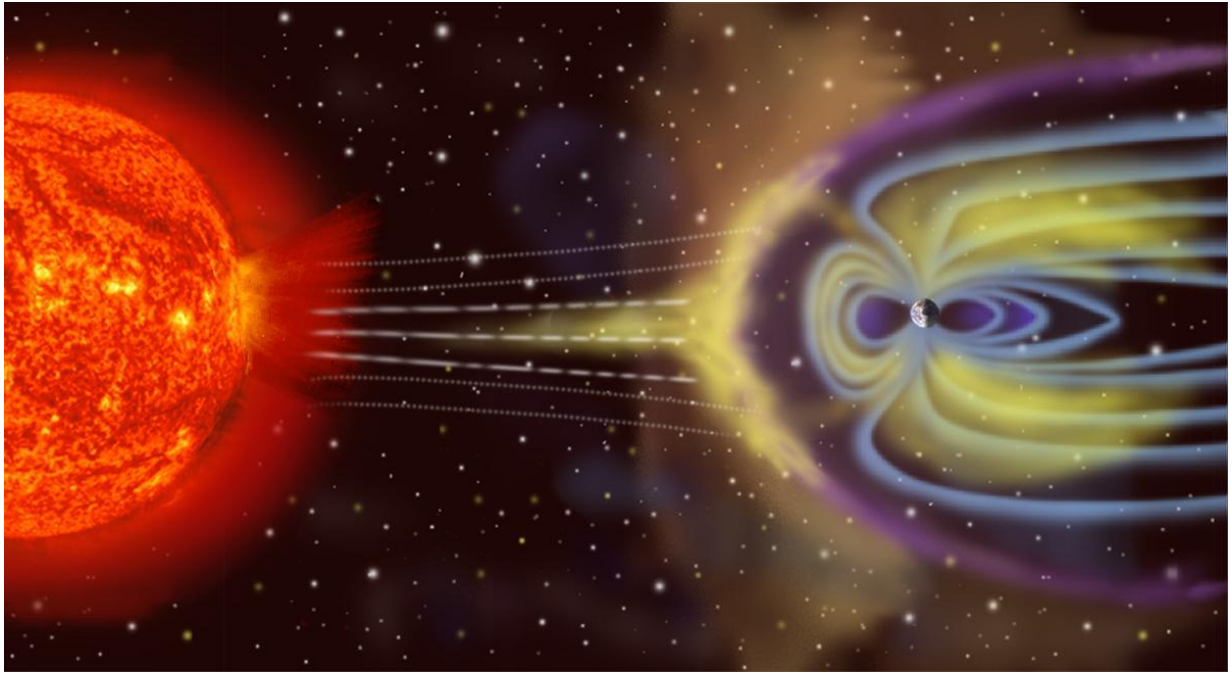
Most intense solar events on current cycle 25.

9th Young Researchers' Workshop

Olaf Enriquez Lizama

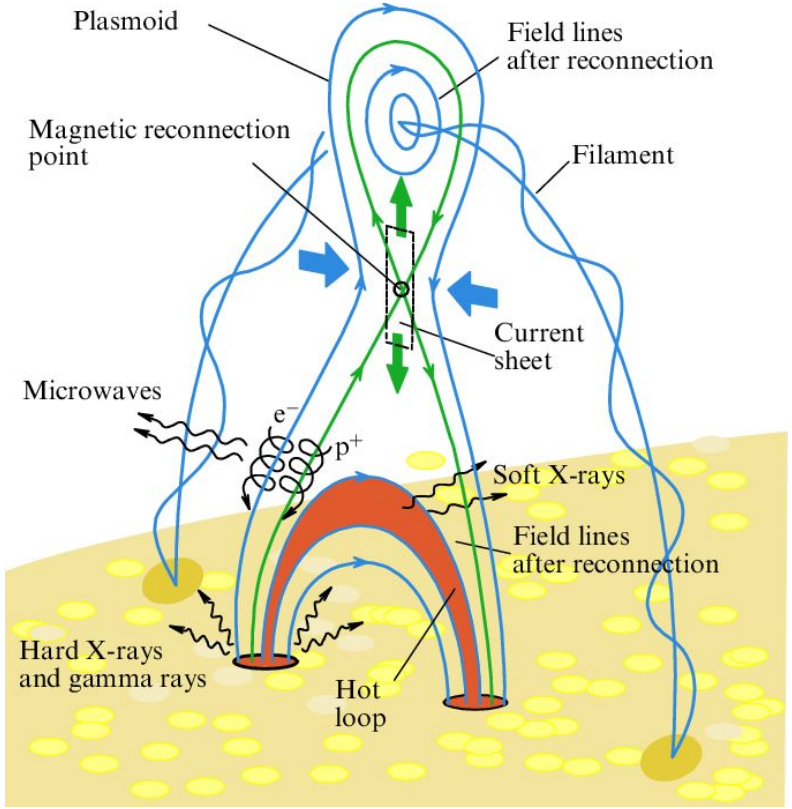
Space Weather



Conditions of the Sun-Terrestrial environment.

As changing as atmospheric weather, but more complex.

Solar Flares & Coronal Mass Ejections



Magnetic reconnection due to flux tubes instabilities.

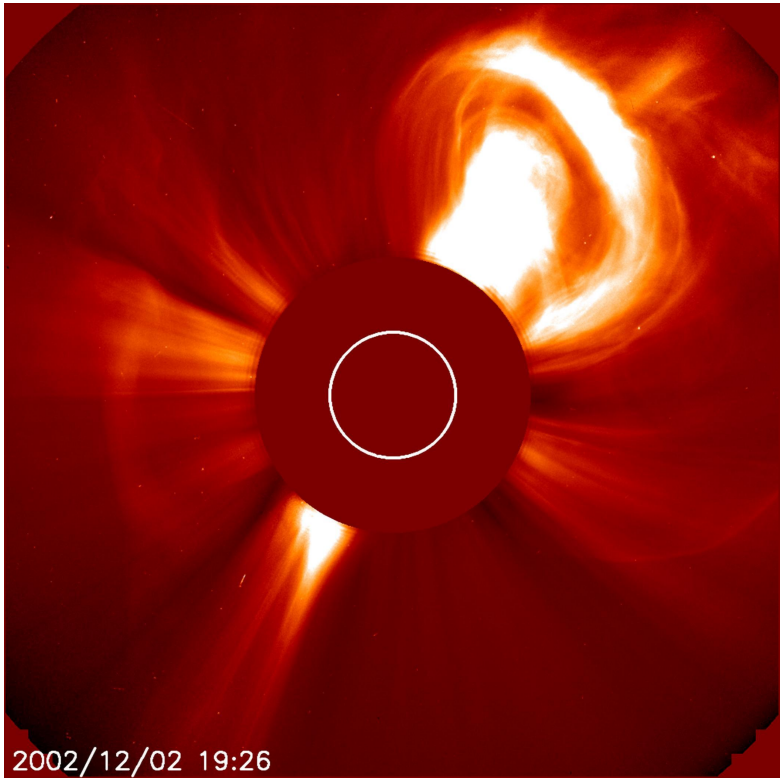
Magnetic energy converts to particle (protons and electrons primarily) kinetic energy.

Particles going down impact Sun's surface nuclei, emitting neutrons.

They classificated by energy release:

A (10^-7 W/m^2), B, C, M & X (>10^-4 W/m^2)

Solar Flares & Coronal Mass Ejections



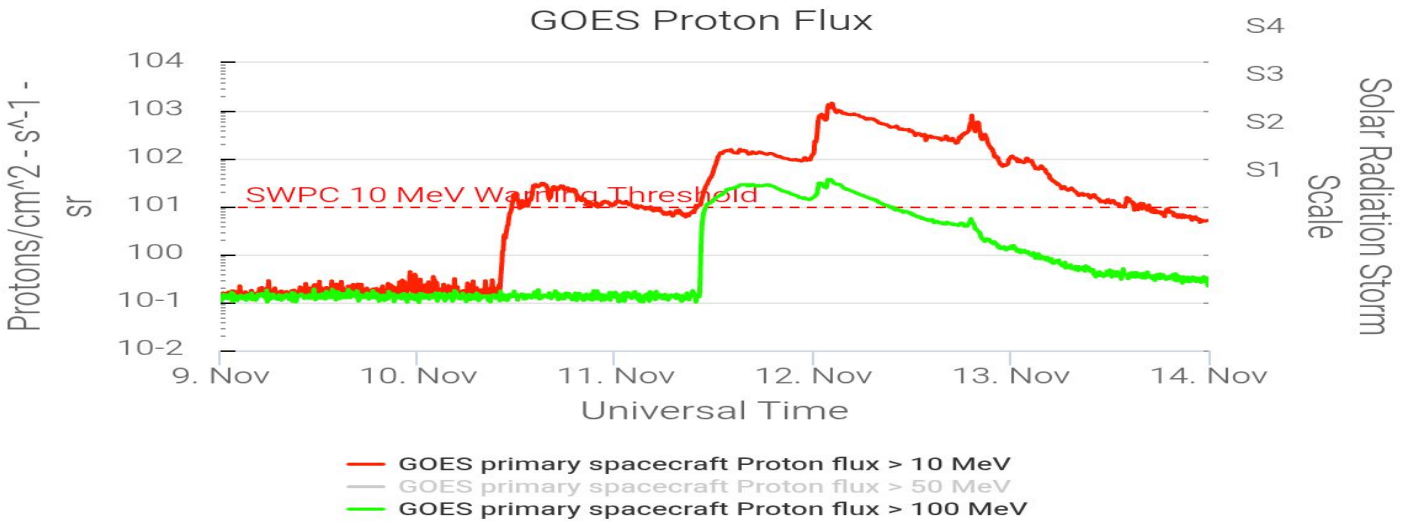
Big reconnections can accelerate large portions of plasma.

For SW, the two most important parameters are Bz and velocity.

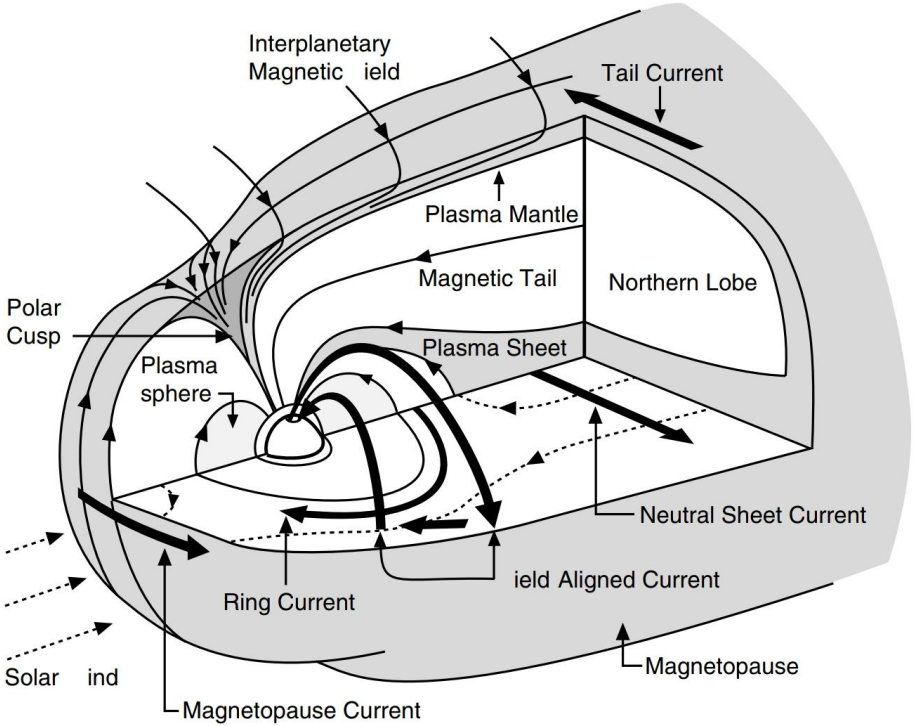
One bubble reach several Earth sizes at 1AU.

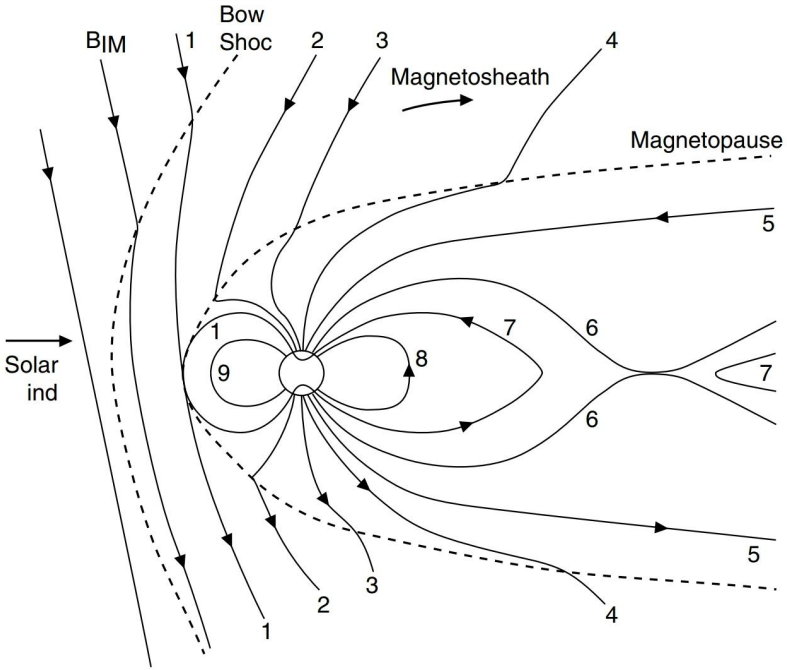
SEP Events

Usually, solar particles do not have enough energy to penetrate Earth's magnetosphere. But, sometimes they do.

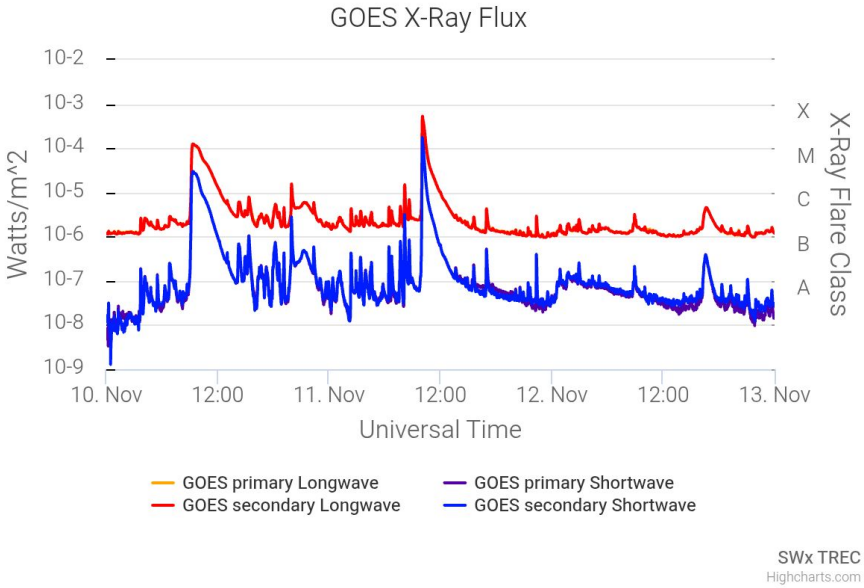


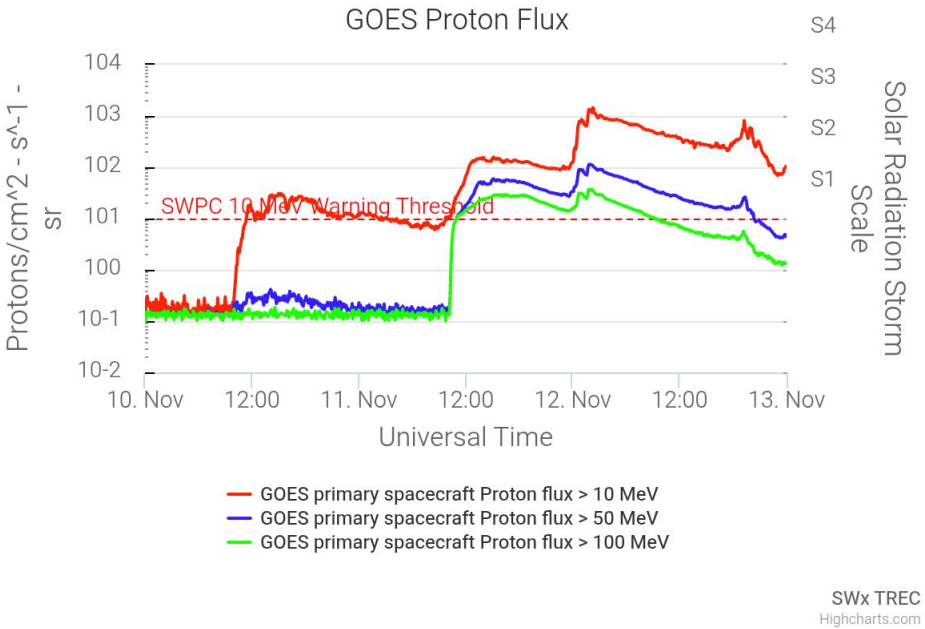
Geomagnetic Storms (GST)





November 11th, 2025 SEP Event

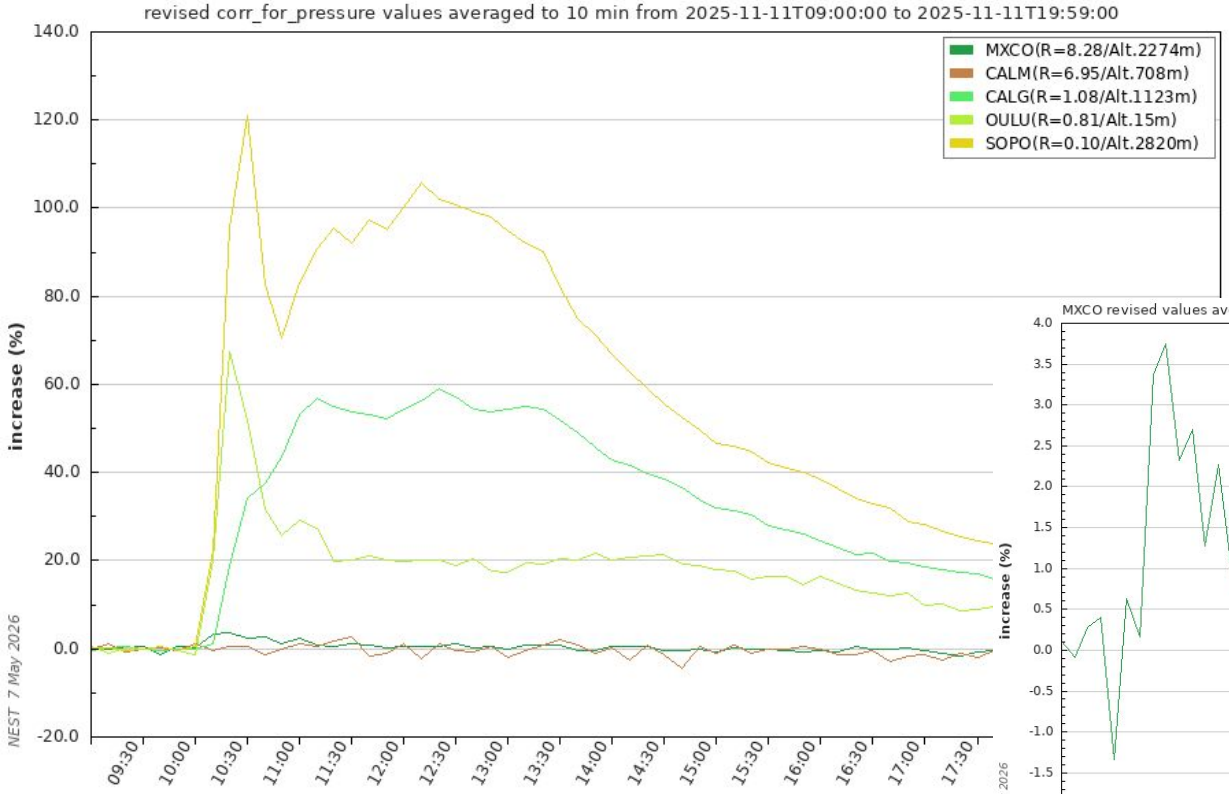


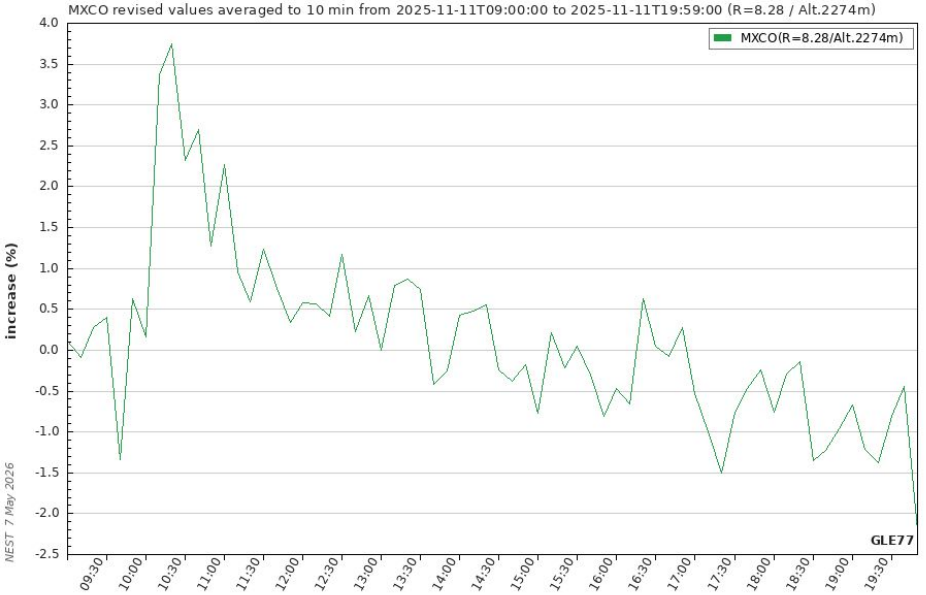


X1.2 Flare accelerated charged particles.

GLE of charged particles.

November 11th, 2025 SEP Event





November 11th, 2025 SEP Event

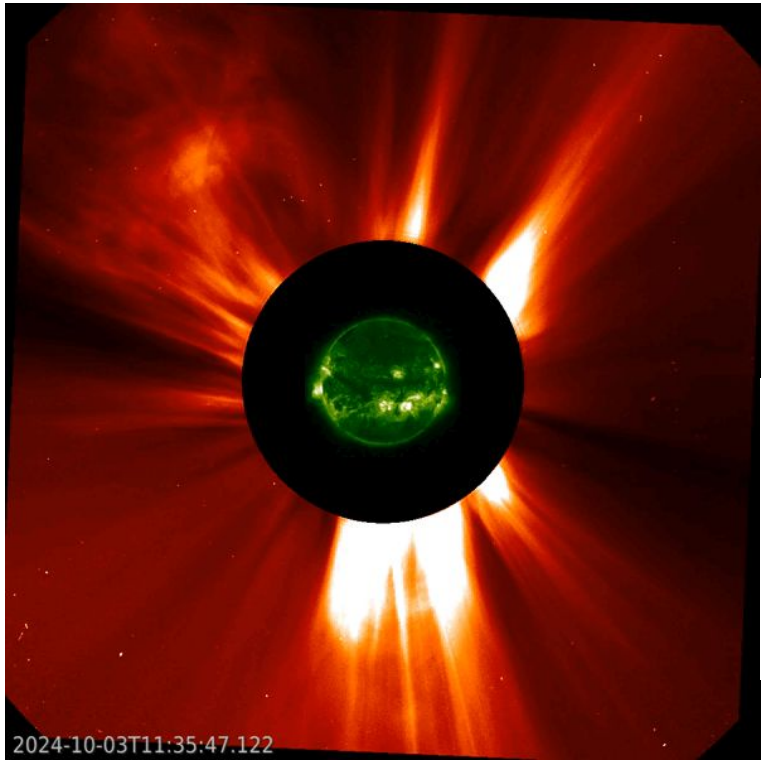
HF intermittency due to the afterwards geomagnetic storm.

Enhancement of radiation dose, 4x quiet.

GOES >2MeV electron channel “contamination”

Great opportunity to study SEP events for it occurred without significant geomagnetic perturbation.

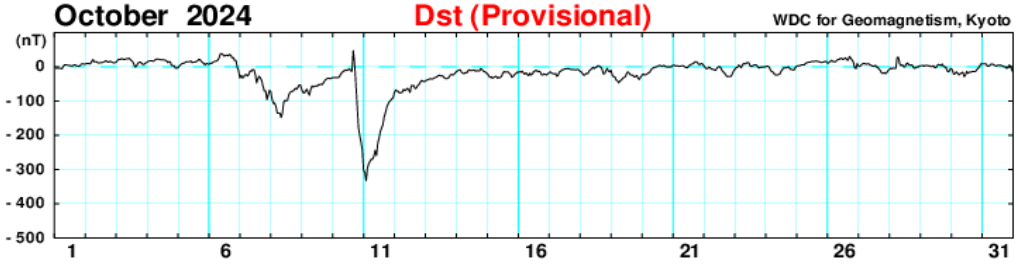
October 10th, 2024 GST



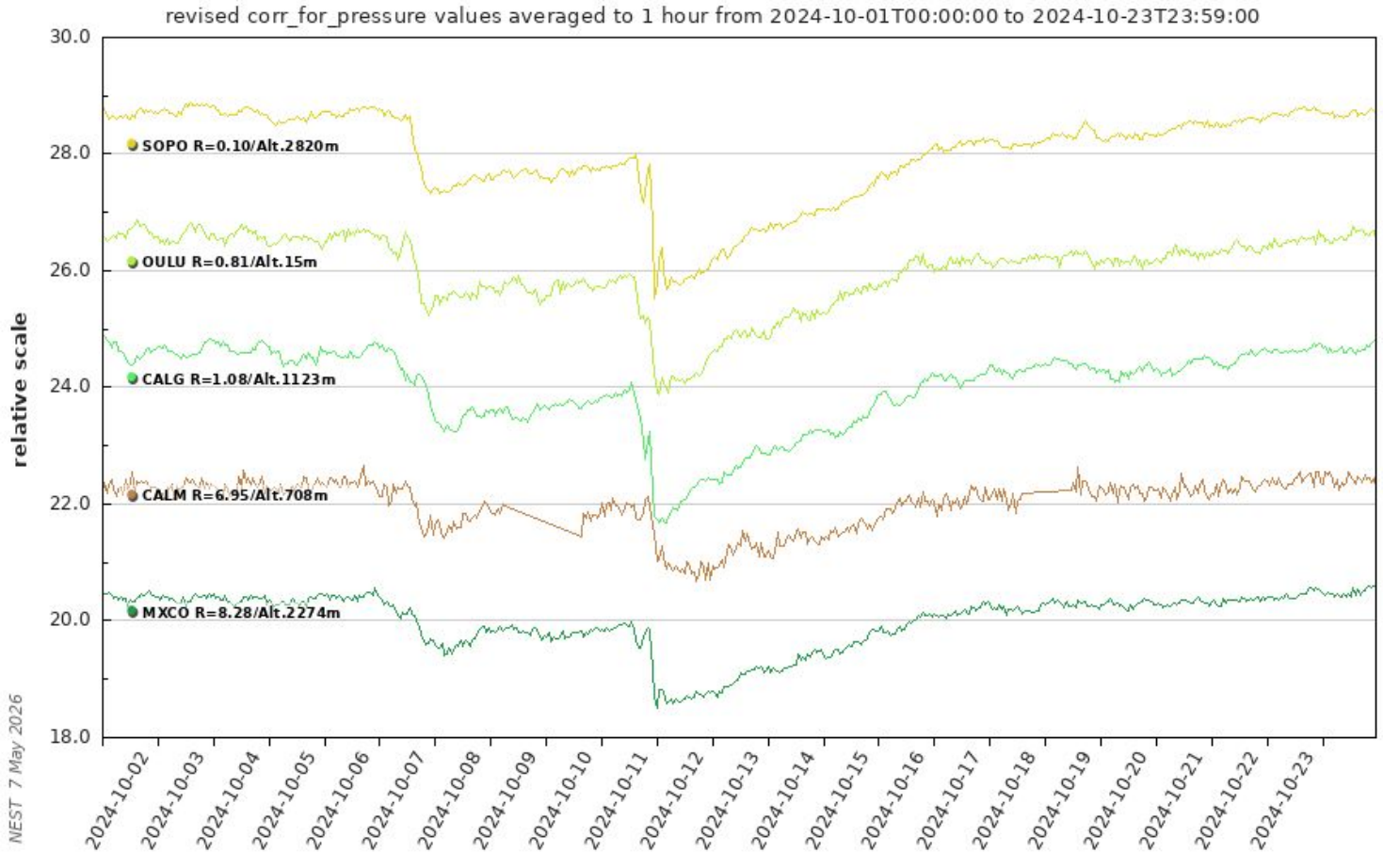
Active regions 3842 y 3848.

Main CME velocity around 800 km/h.

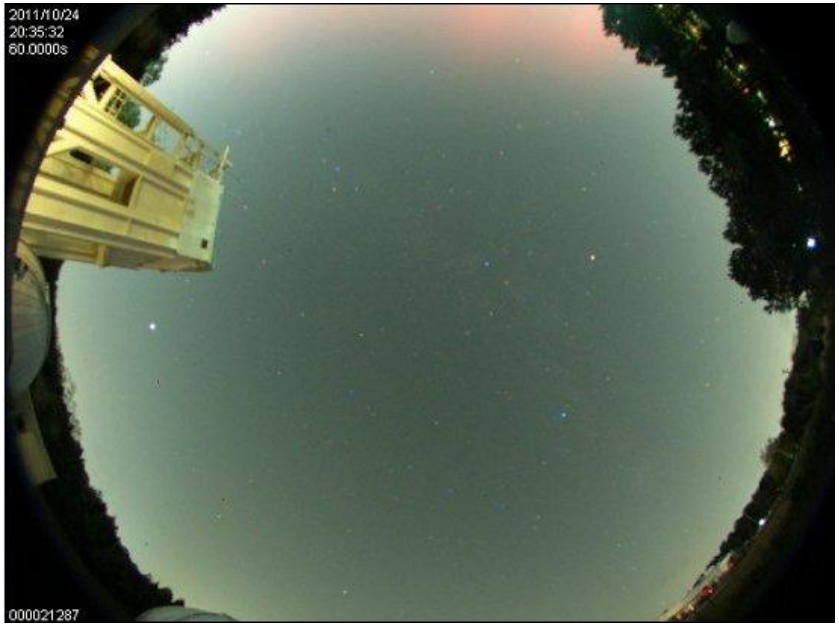
Kp index of 8, severe storm.



October 10th, 2024 GST



October 10th, 2024 GST



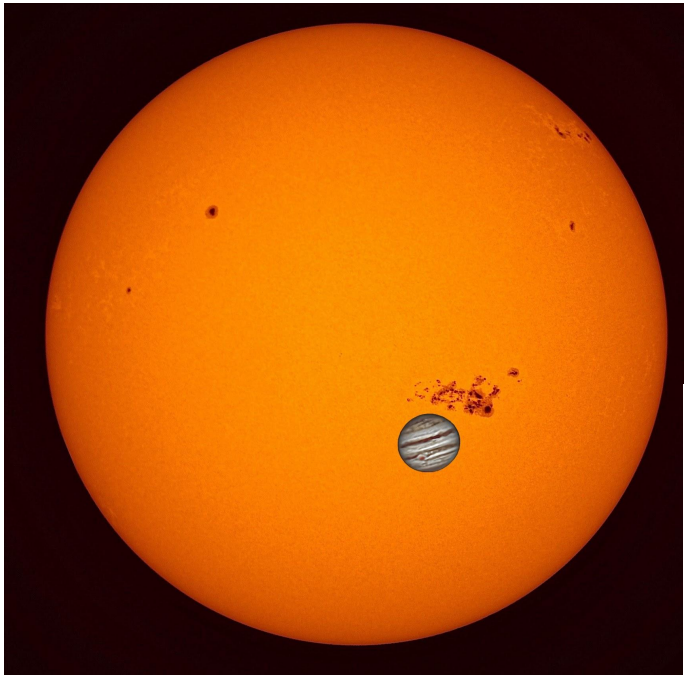
Aurora Borealis down to latitudes of 30°

HF intermittency.

GNSS errors of units of meters.

Starlink-1089 reentered prematurely after the storm, no public statement from company.

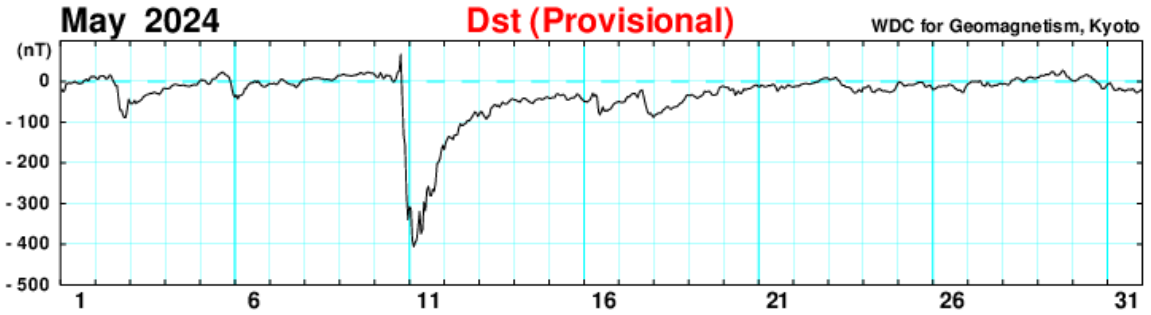
May 10th, 2024 GST



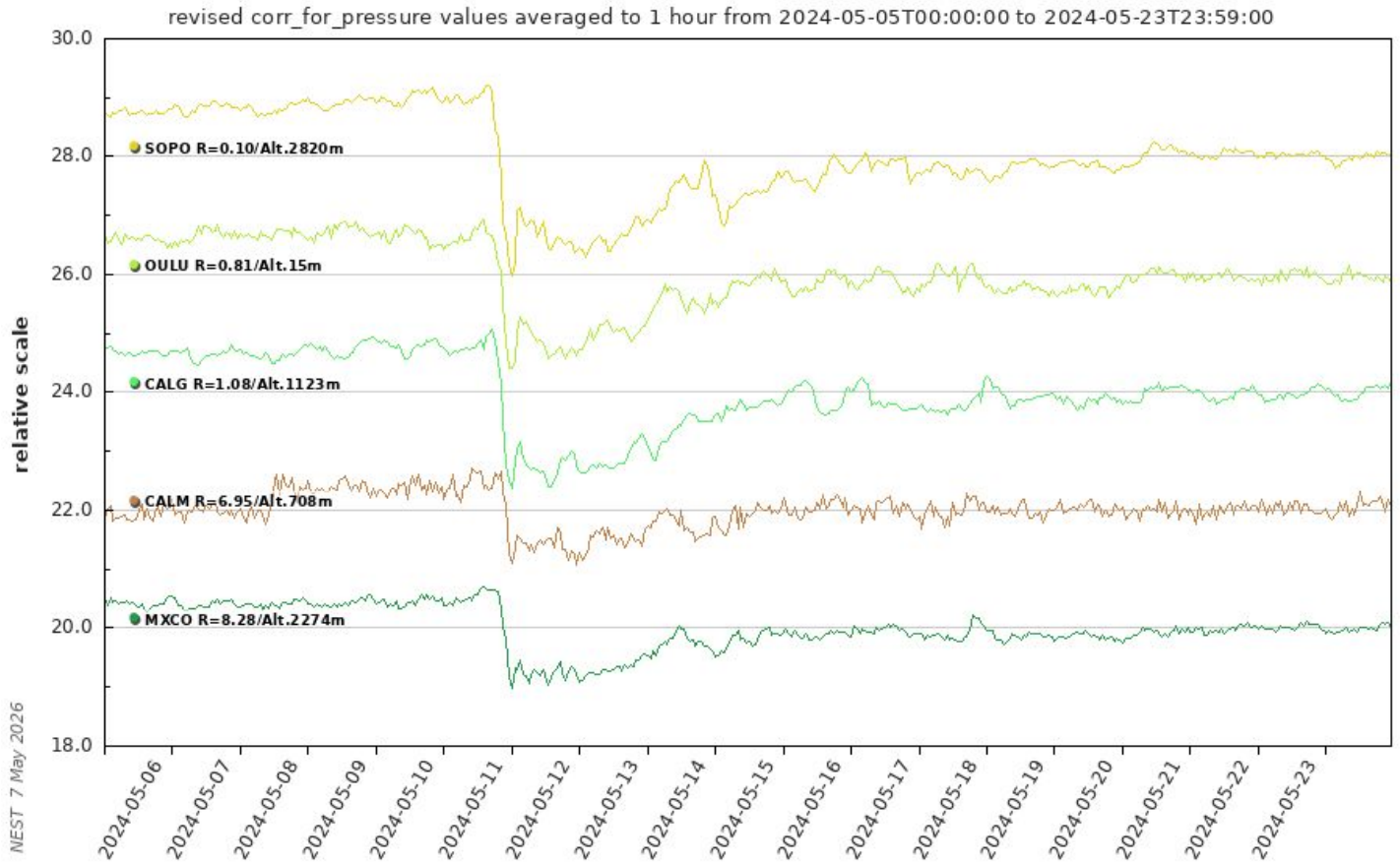
Active region 3664

Many CMEs of velocities around 10^3 km/h, overlapped in interplanetary medium.

Reached Kp index of 9, maximum possible.



May 10th, 2024 GST



May 10th, 2024 GST

Aurora borealis down to latitudes around 26°N.

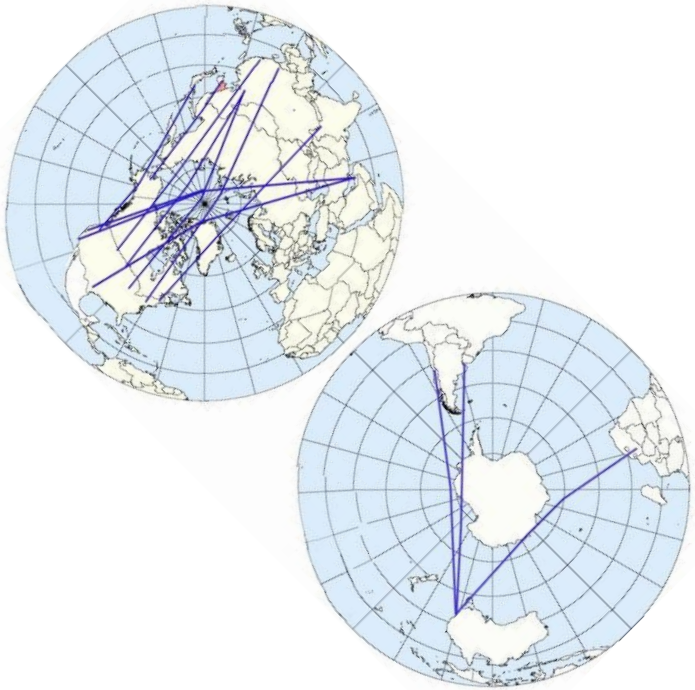
Minor problems reported by central and east Europe. New Zealand turned off to mitigate problems.

Loss of 600MW in the lines connecting Sweden, Denmark and Poland.

HF loss for hours, and VHF & UHF intermittency.

GNSS errors up to 70m, affecting many economic sectors.

May 10th, 2024 GST



Many satellites performed maneuvers to avoid damage.

Airlines delayed or modified flights

Economic cost estimated around 500 million USD

Conclusions

As variable as solar emissions are, continuous monitoring is essential.

Space weather threats are a nowadays problem.

Damage mitigation measurements need to be implemented in high latitudes countries.

The Sun is an interesting laboratory for plasma and particle physics

References

Webb, D.F., Howard, T.A. Coronal Mass Ejections: Observations. Living Rev. Sol. Phys. 9, 3 (2012). https://doi.org/10.12942/lrsp-2012-3

Moldwin, M. (2008). Plate section. In An Introduction to Space Weather. plates, Cambridge: Cambridge University Press.

Despirak, I. V., Setsko, P. V., Lubchich, A. A., Sakharov, Y., & Selivanov, V. (2025). Geomagnetically induced currents (GICs) during the strong geomagnetic storm on 10–12 May 2024. Advances in Space Research. https://doi.org/10.1016/j.asr.2025.06.081

Li, J., Hu, X., Xue, D., Liu, Z., Zhang, Q.-H., & Feng, X. (2026). Quantifying the impacts of the May 2024 geomagnetic storm on transatlantic aviation: Rerouting, delays, and economic losses. Space Weather, 24, e2025SW004685. https://doi.org/10.1029/2025SW004685

Solar Influences Data Analysis Center. (2024, November). Power grids during the 10–11 May storm. https://www.sidc.be/article/power-grids-during-10-11-may-storm