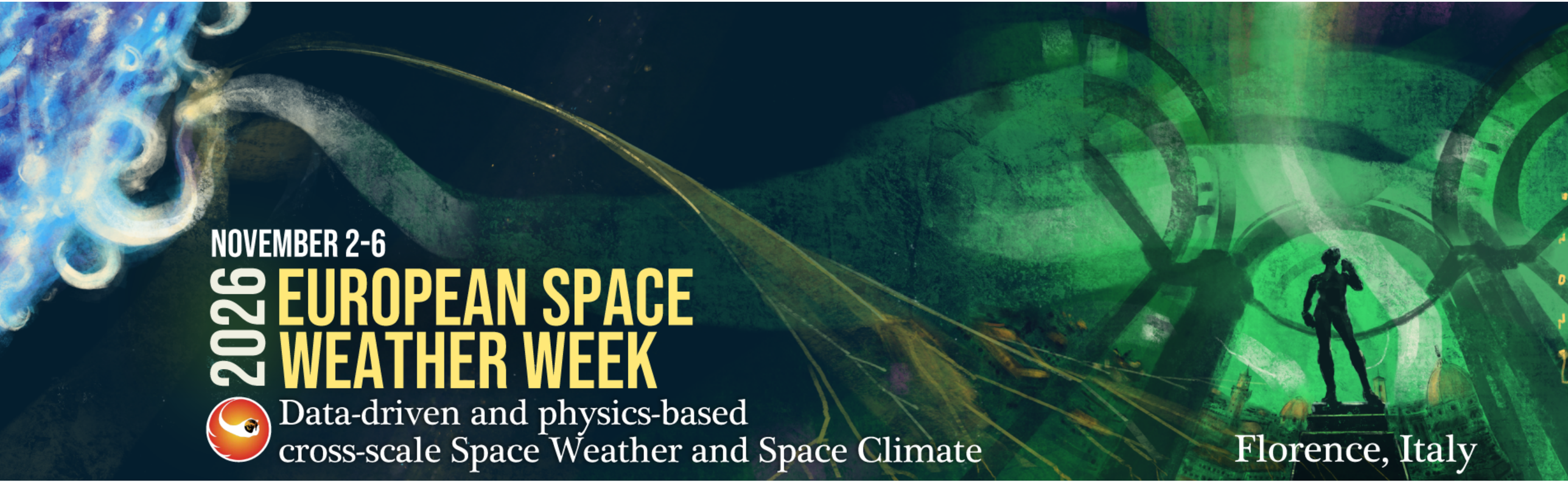
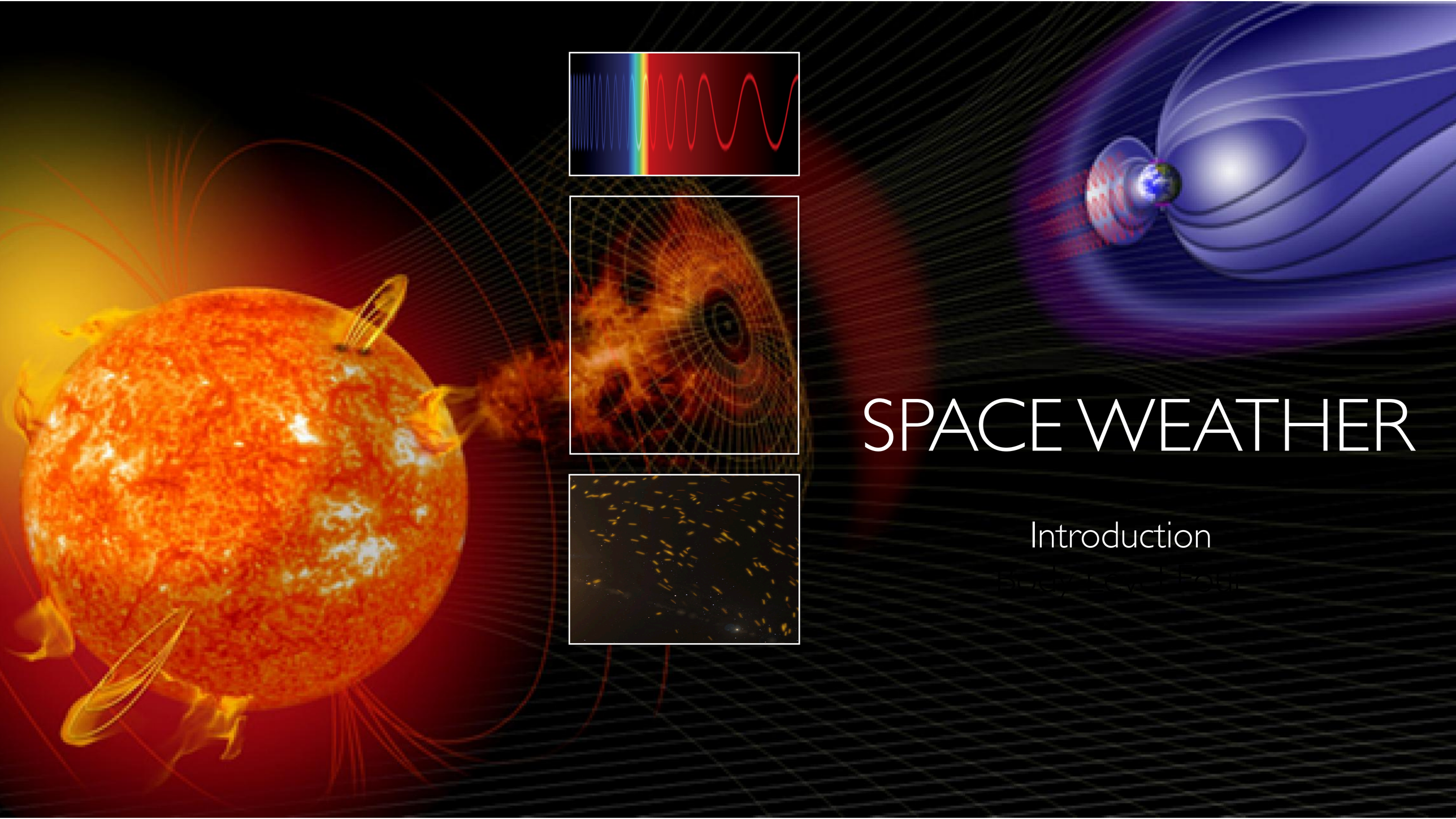
Space Weather Training Course



e-swan

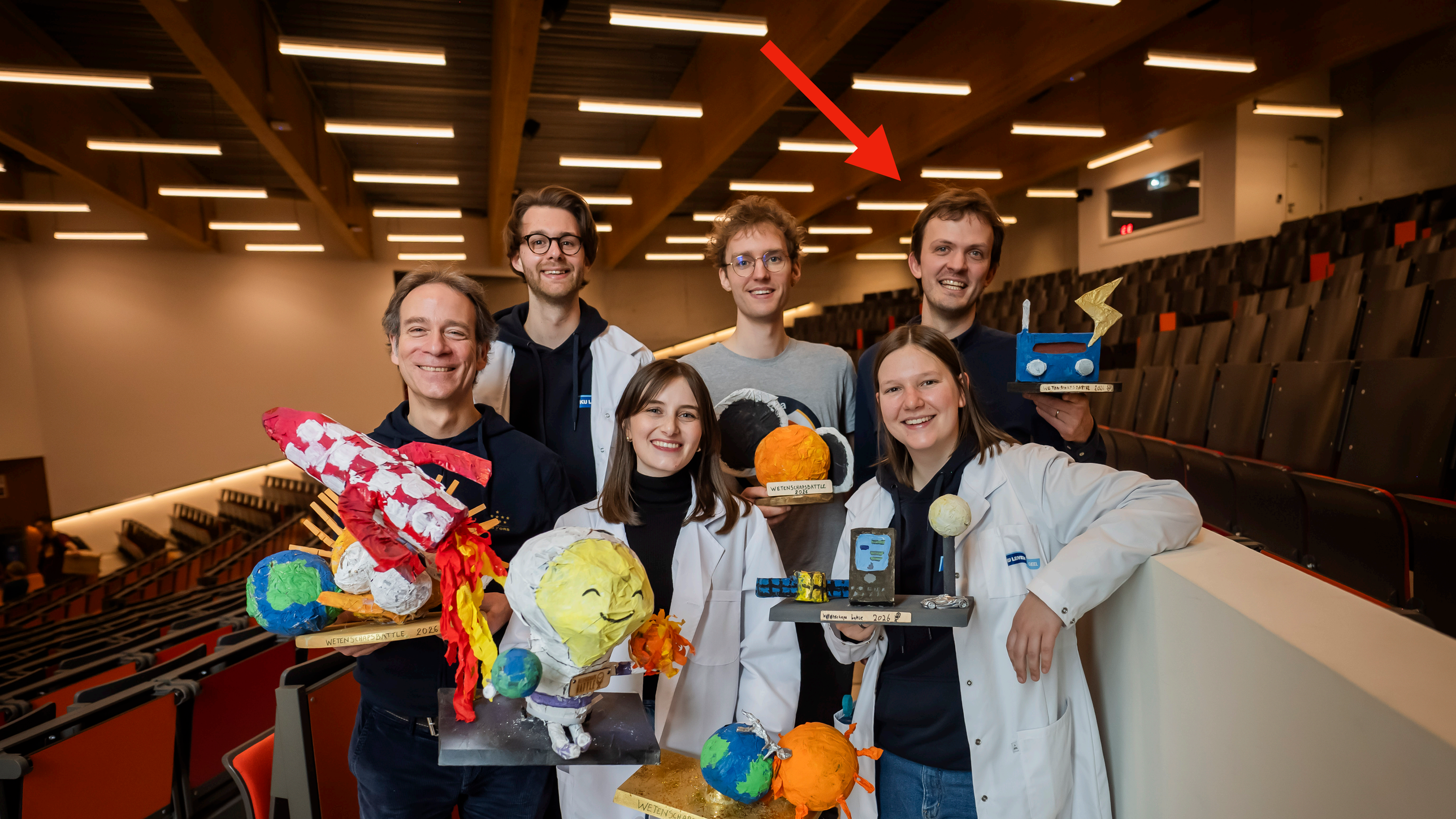
SWEC
Space Weather Education Centre

COMMUNITY COORDINATED MODELING CENTER

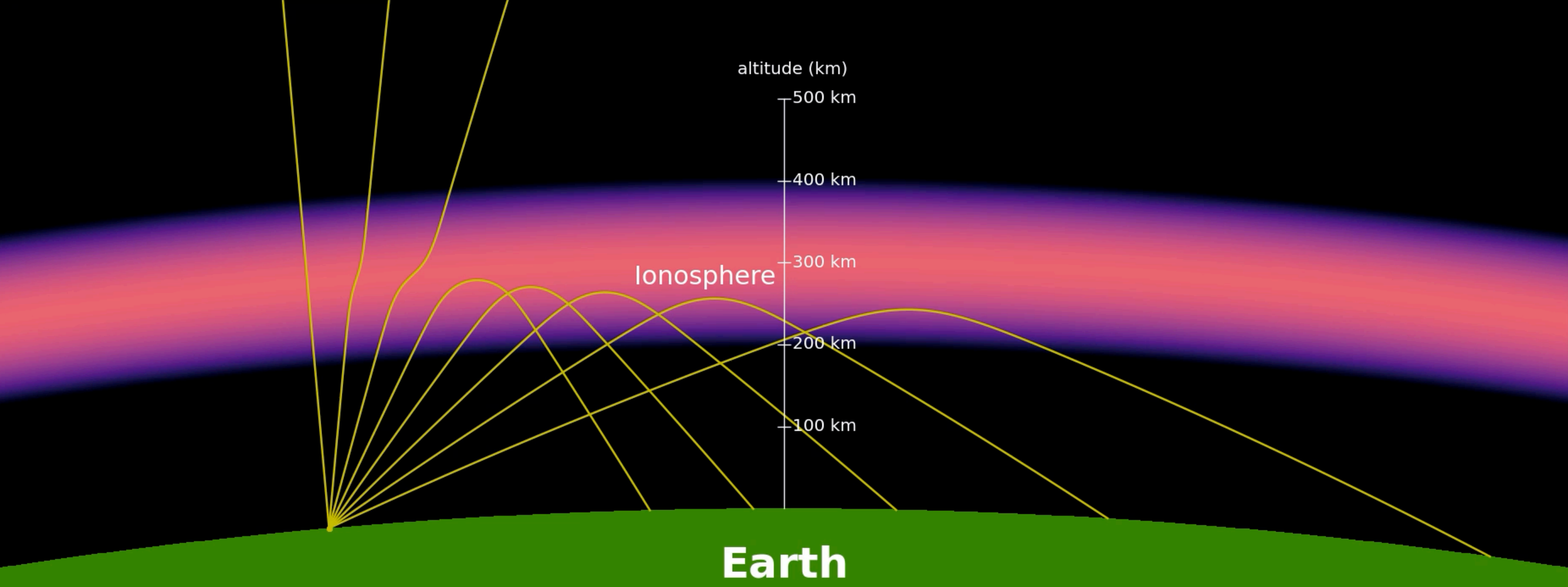


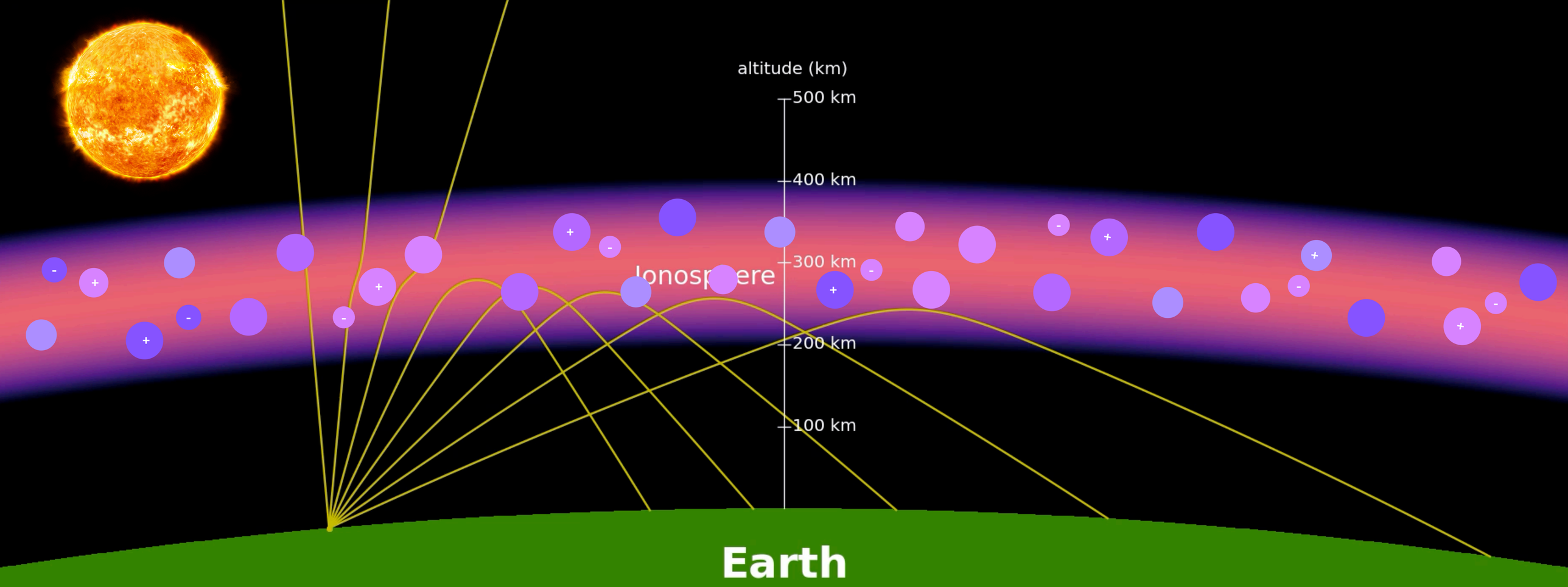
SPACE WEATHER

Introduction

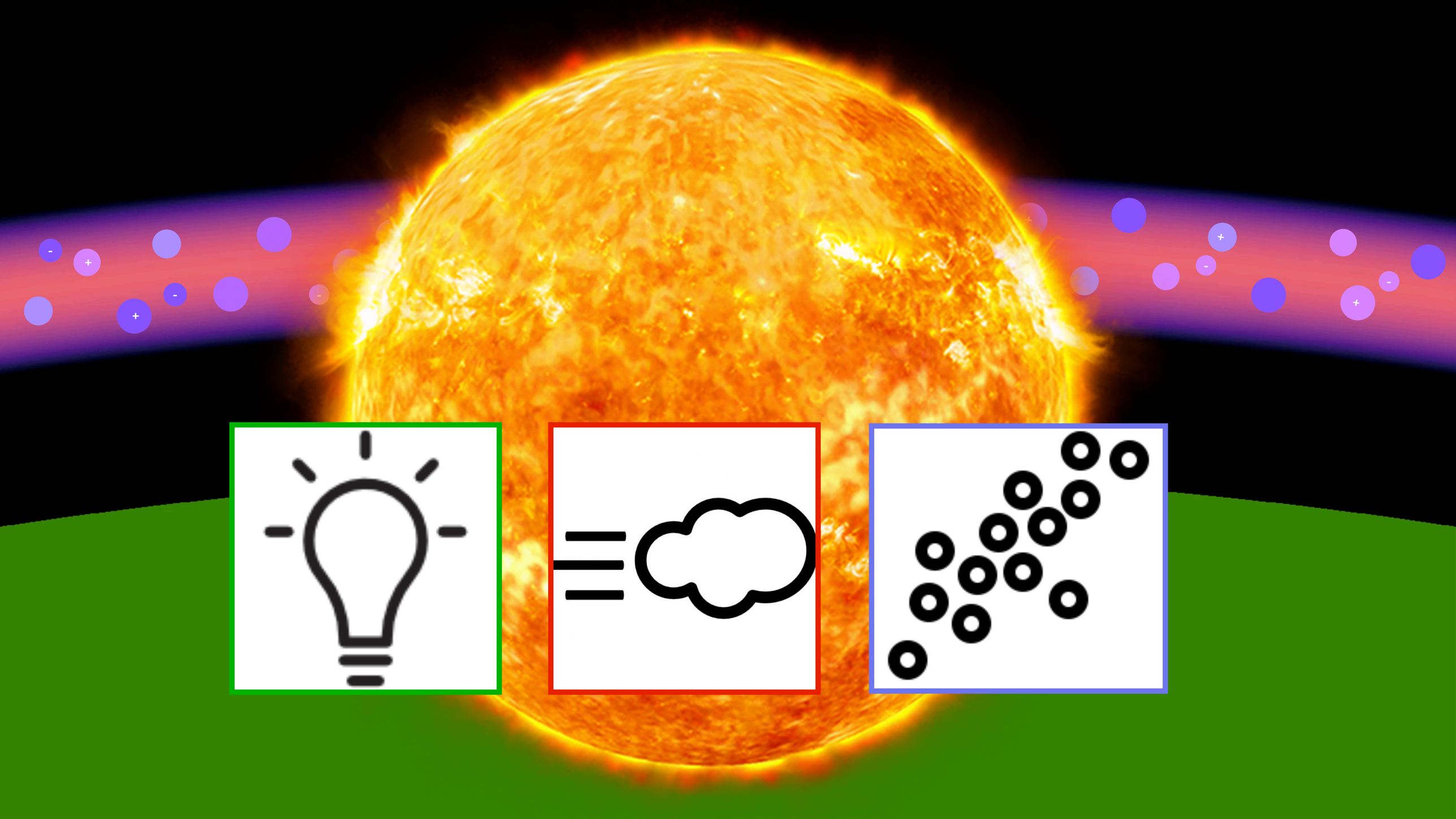

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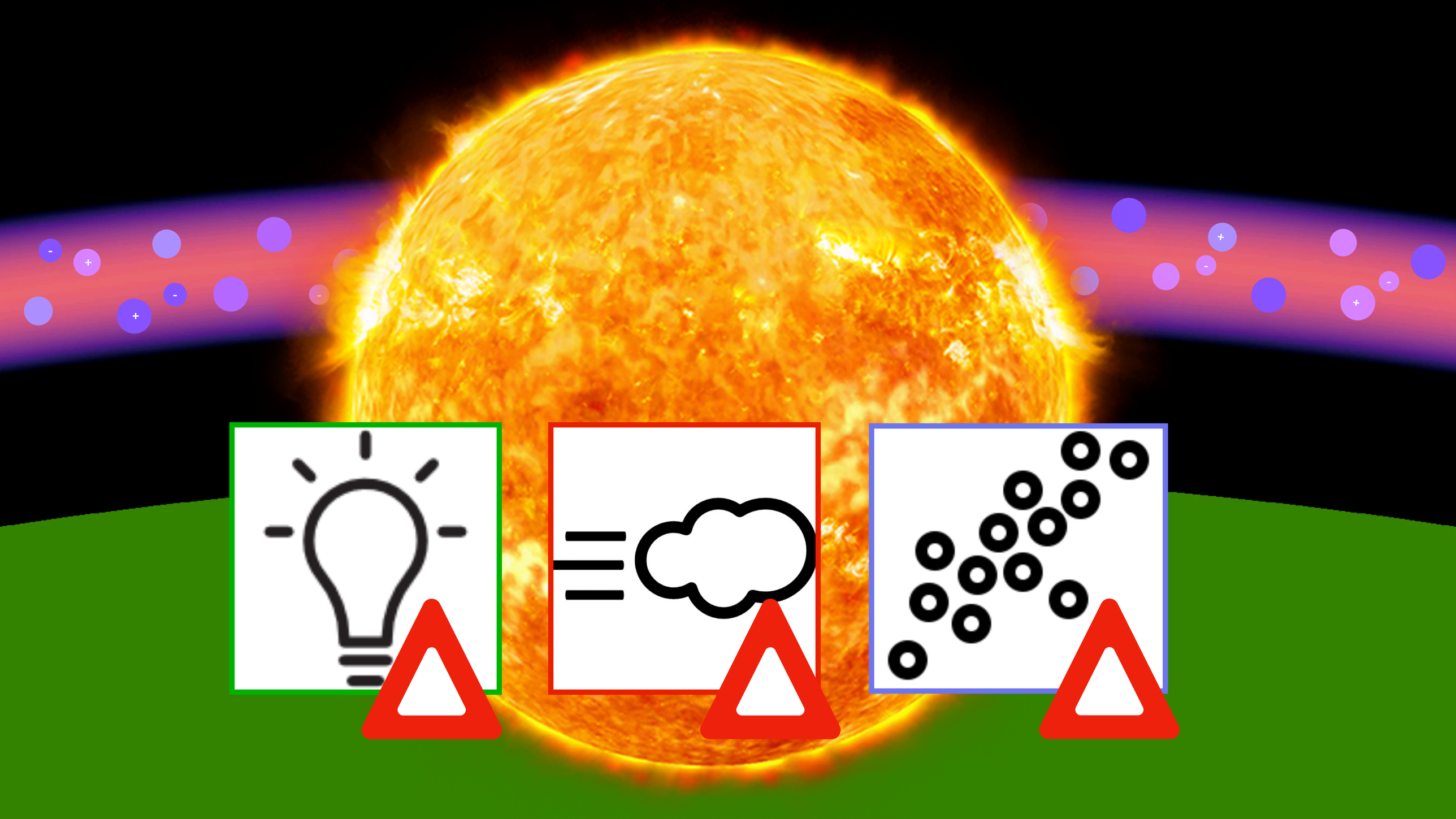

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Iceland
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Belarus
Norway
Poland
Denmark
Austria
United Kingdom
Ireland
France
Spain
Portugal
DEFENSIE


altitude (km)
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400 km
300 km
200 km
100 km
Ionosphere
Earth


altitude (km)
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Ionosphere
Earth



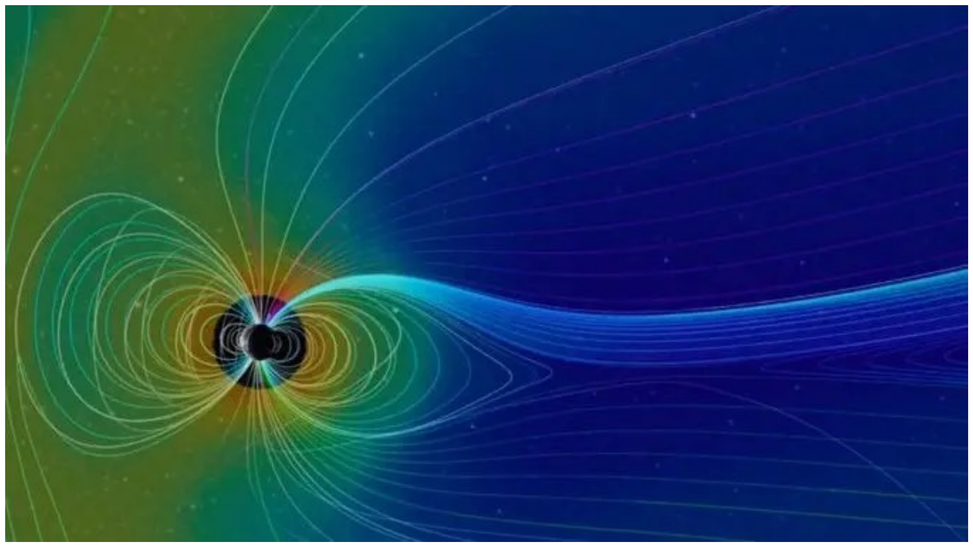




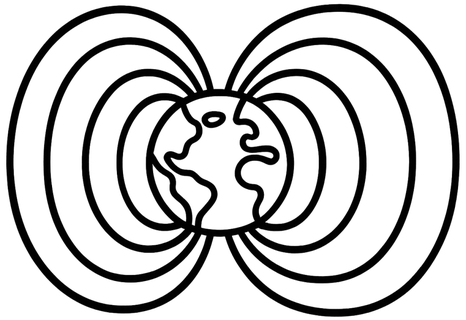
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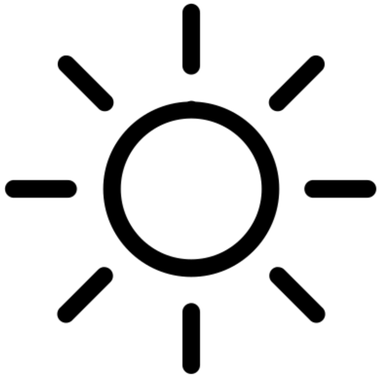
The Sun’s energy impacting earth’s atmosphere and magnetosphere











E.M. RADIATION



PLASMA



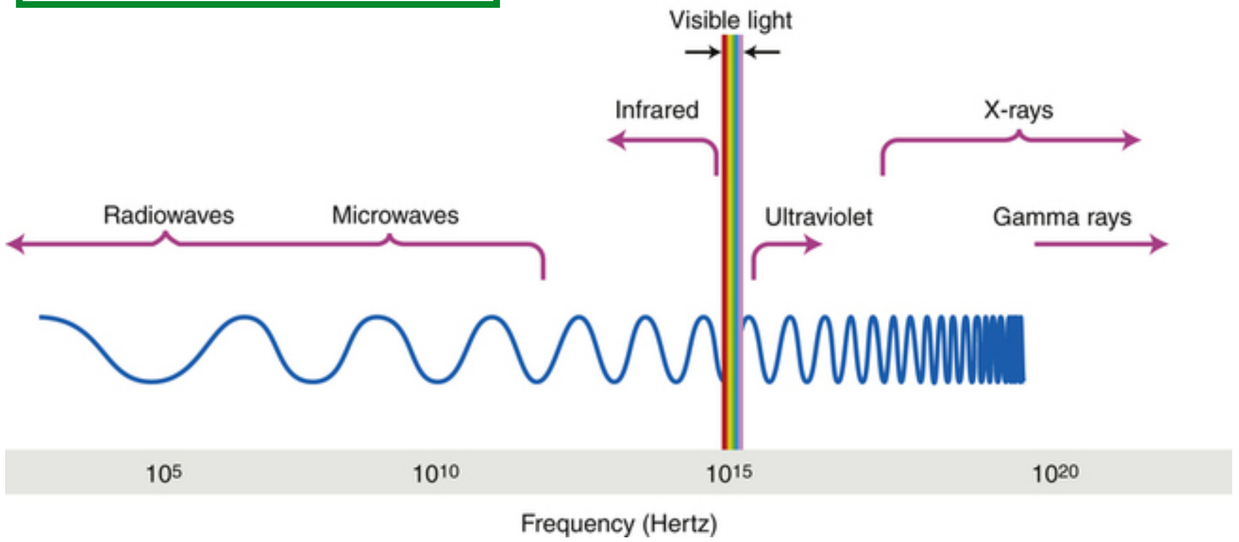
ENERGETIC PARTICLES



Electromagnetic radiation

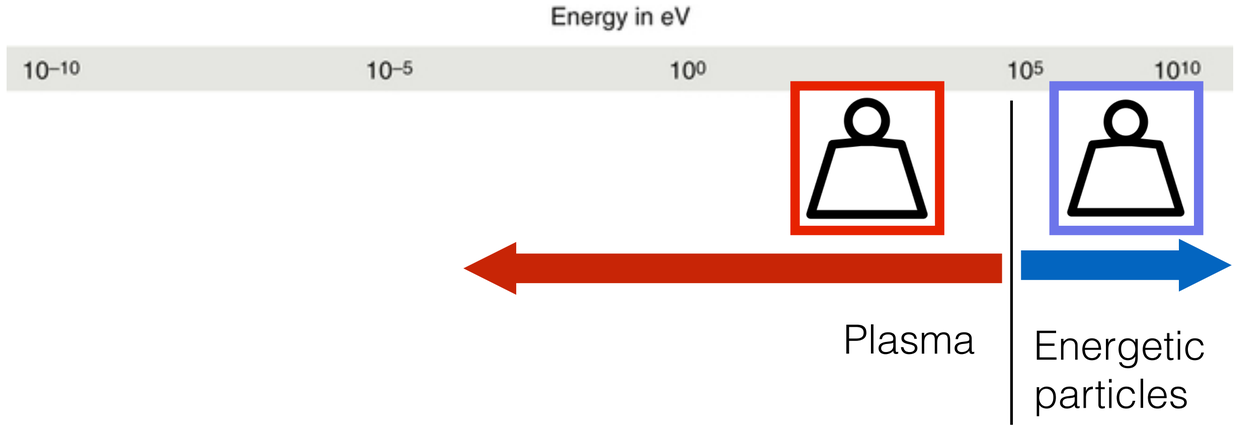


- Photons / electromagnetic waves
- Speed of light



Particles

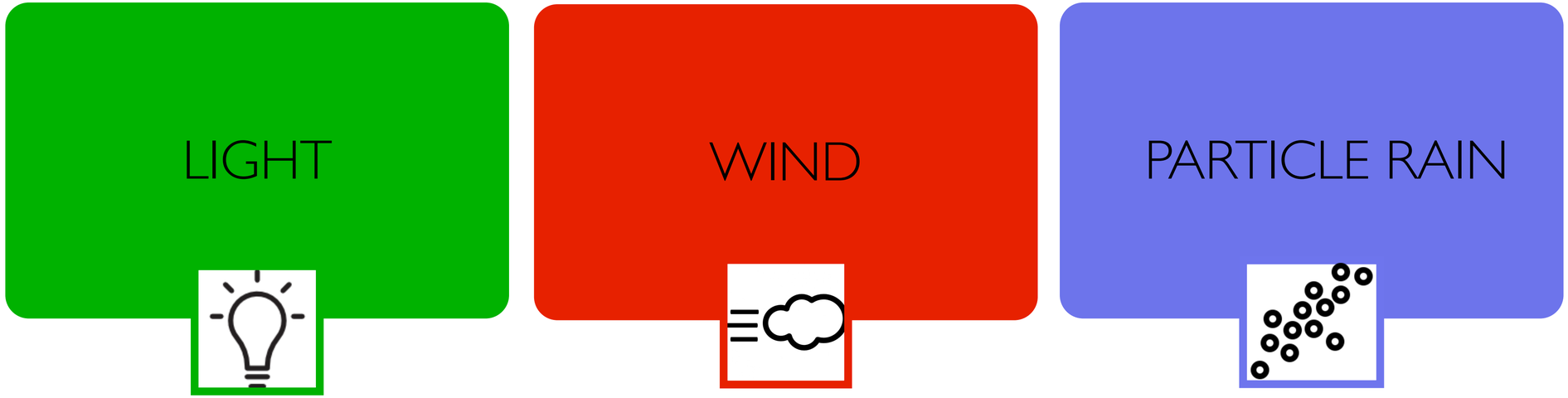
- Atomic & sub-atomic particles
- m/s to fractions of speed of light



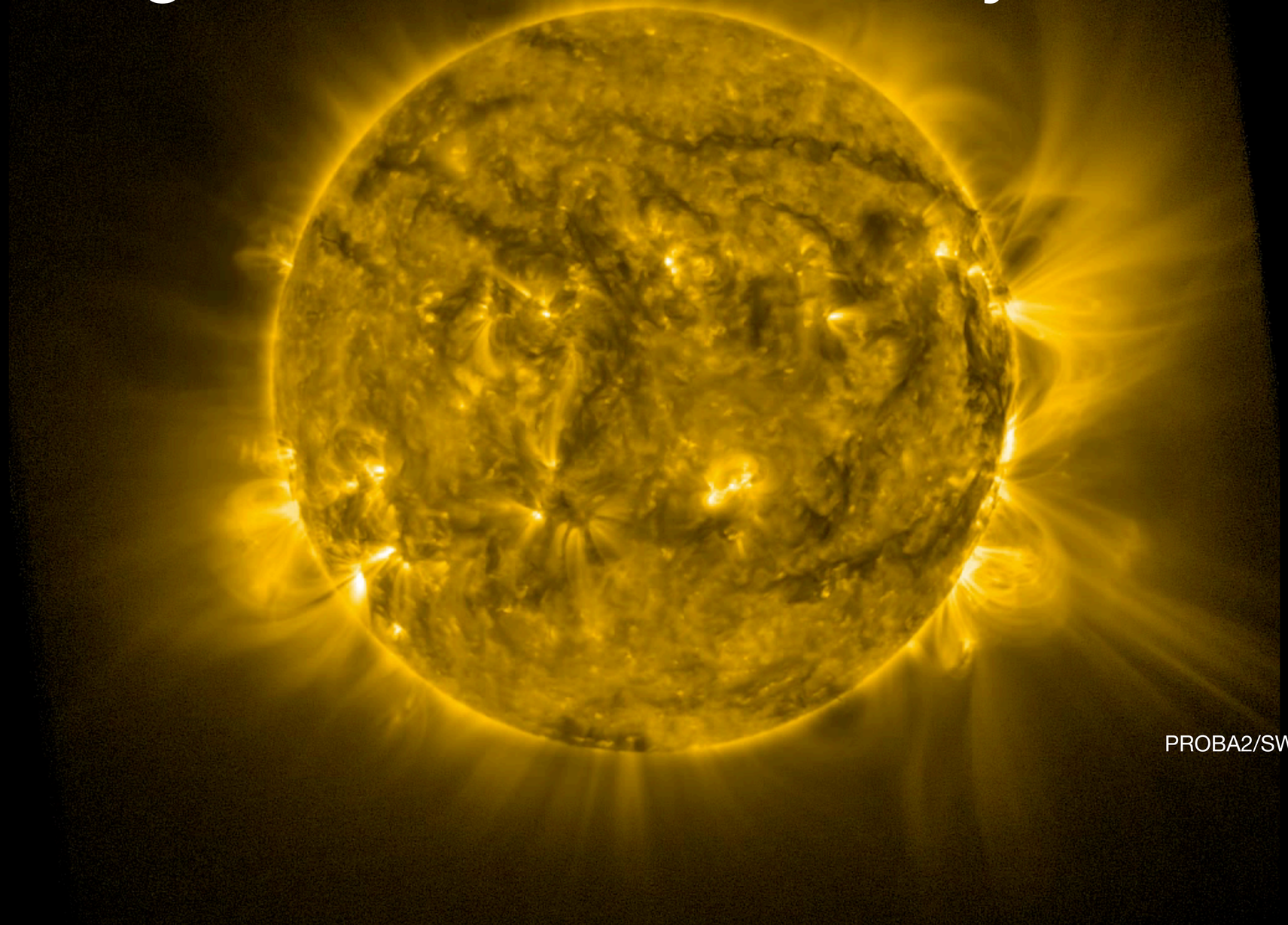
3 SPACE WEATHER PHENOMENA

The sun's energy reaches the earth in 3 forms: light, moving gas and particle precipitation. This energy interacts with the magnetosphere and the atmosphere of the earth. This is space weather.

How and where the interaction occurs depends on the type of energy.

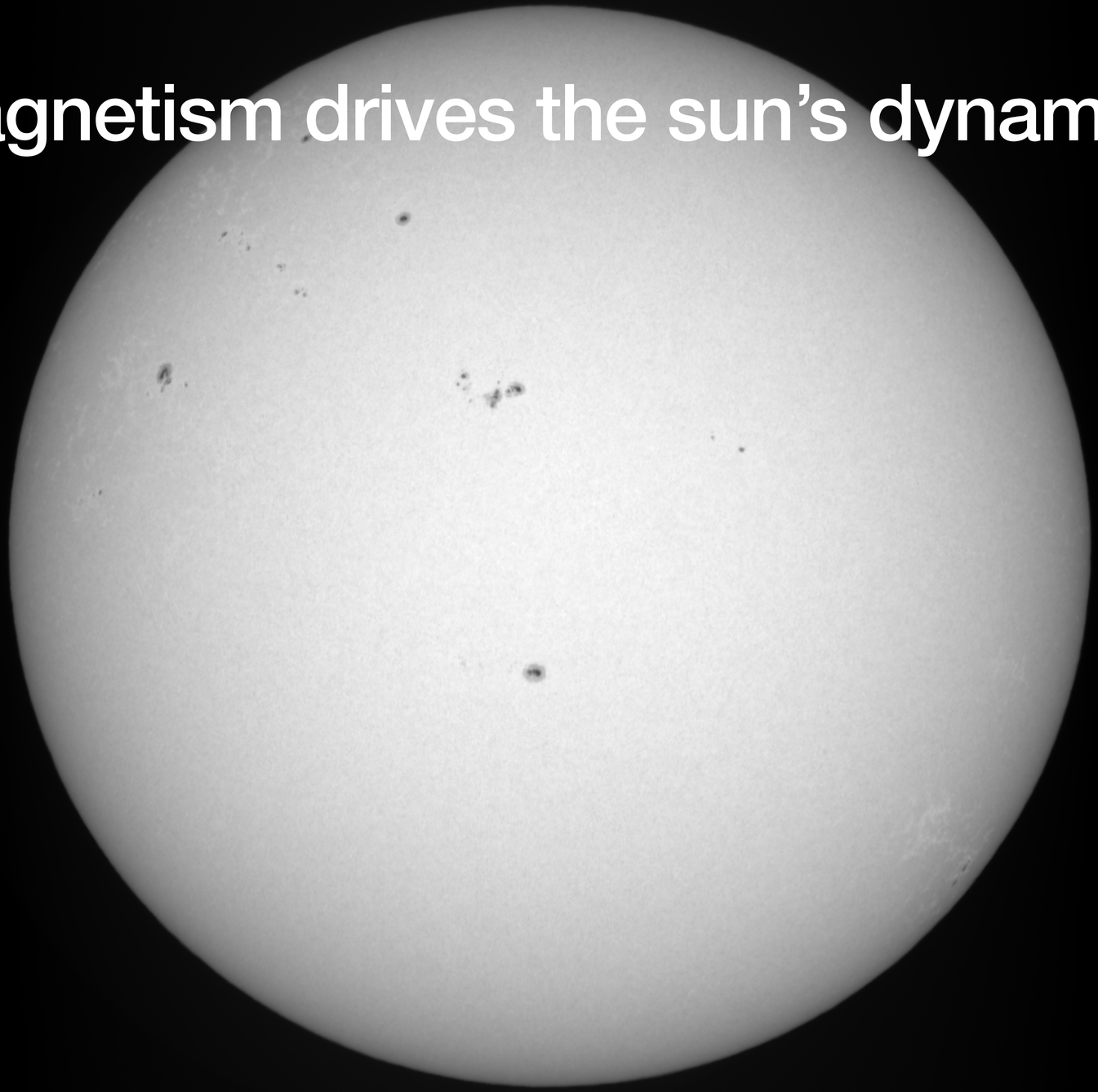


Magnetism drives the sun’s dynamics

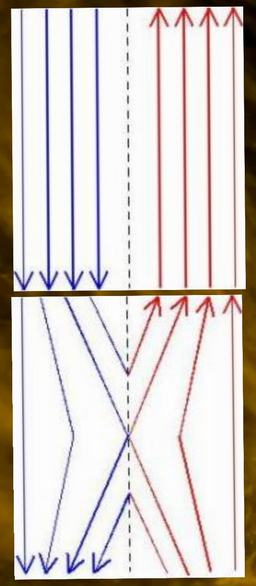


PROBA2/SWAP

Magnetism drives the sun’s dynamics



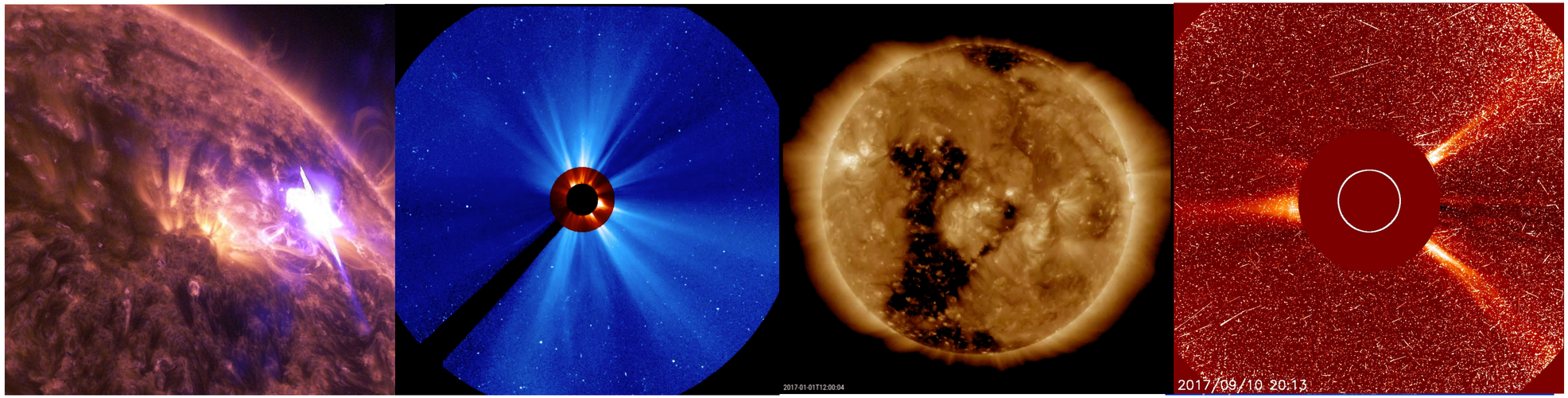
MAGNETIC RECONNECTION



2024-03-23T22:30:02 WOW-enhanced

SOLAR WEATHER & STORMS

Energy can be released on a shorter time scale. A solar feature like a sunspot, an active region, coronal hole, filament etc. lies at the base of a solar storm in which energy is released. The release of energy might be in an abrupt, impulsive and brutal way (flare, Coronal Mass Ejection or CME, proton storm) or in a non-eruptive manner (Coronal Hole - CH).



Flare

Coronal Mass Ejection
High Speed Stream

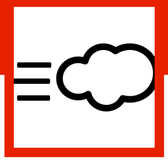
Particle Storm

SOLAR WEATHER & STORMS

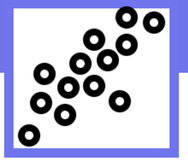
E.m. radiation
FLARE



Solar wind
CME - HSS



High Energetic
Particles









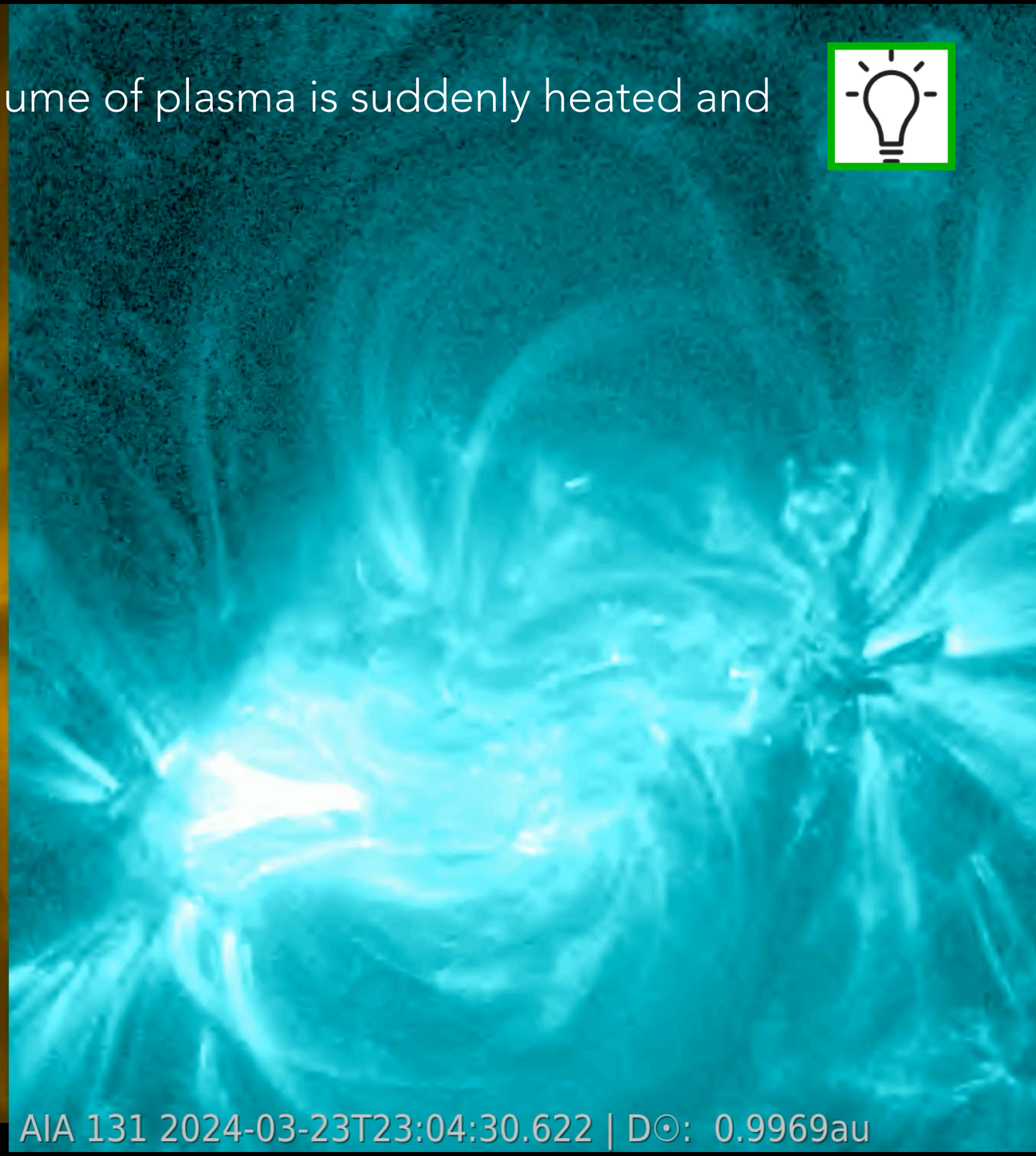






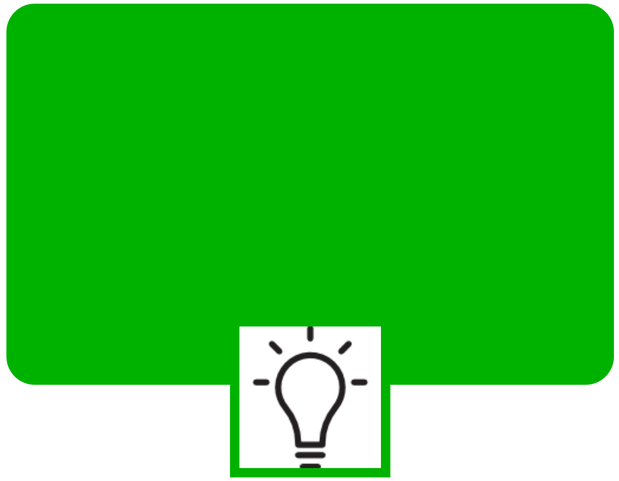
A flare is a light flash near an active region. A volume of plasma is suddenly heated and therefore lights up.





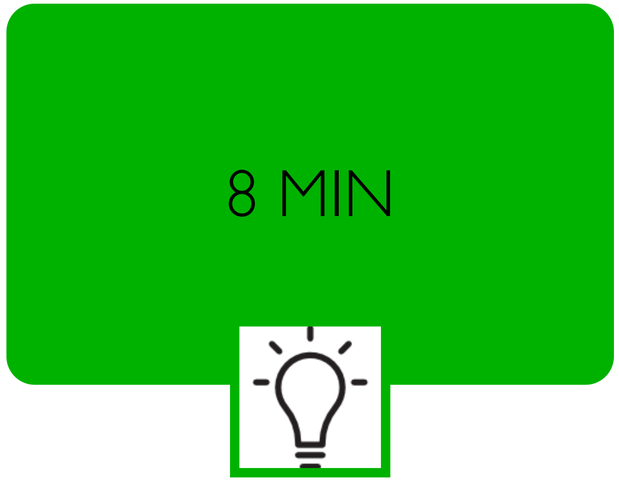
AU TRANSIT TIME

The energy released during a solar storm moves through space, each with its own typical speed: speed of light, ….



AU TRANSIT TIME

The energy released during a solar storm moves through space, each with its own typical speed: speed of light, …



STORM SCALE



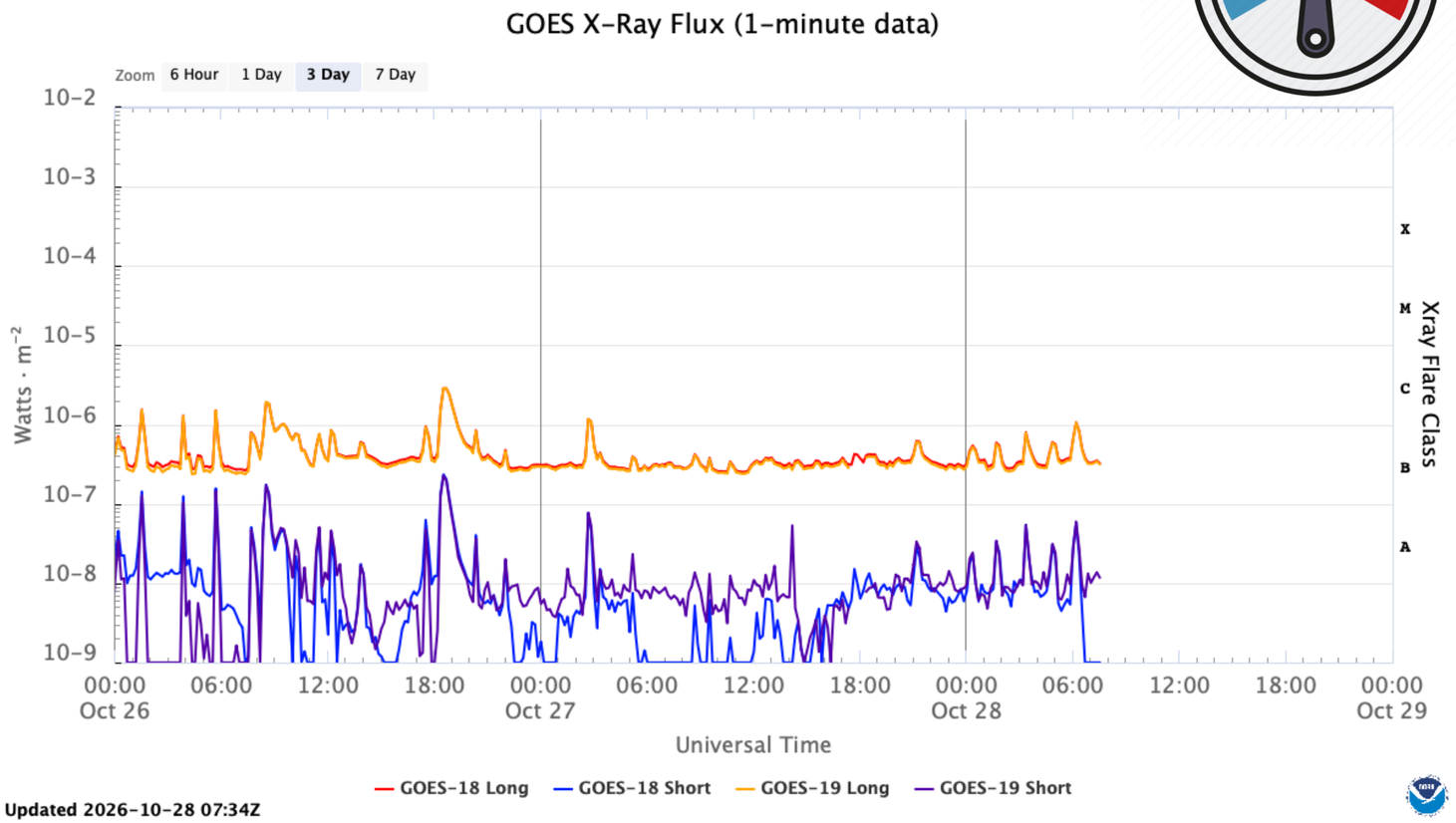
https://www.spaceweather.gov/products/goes-x-ray-flux



STORM SCALE

GOES

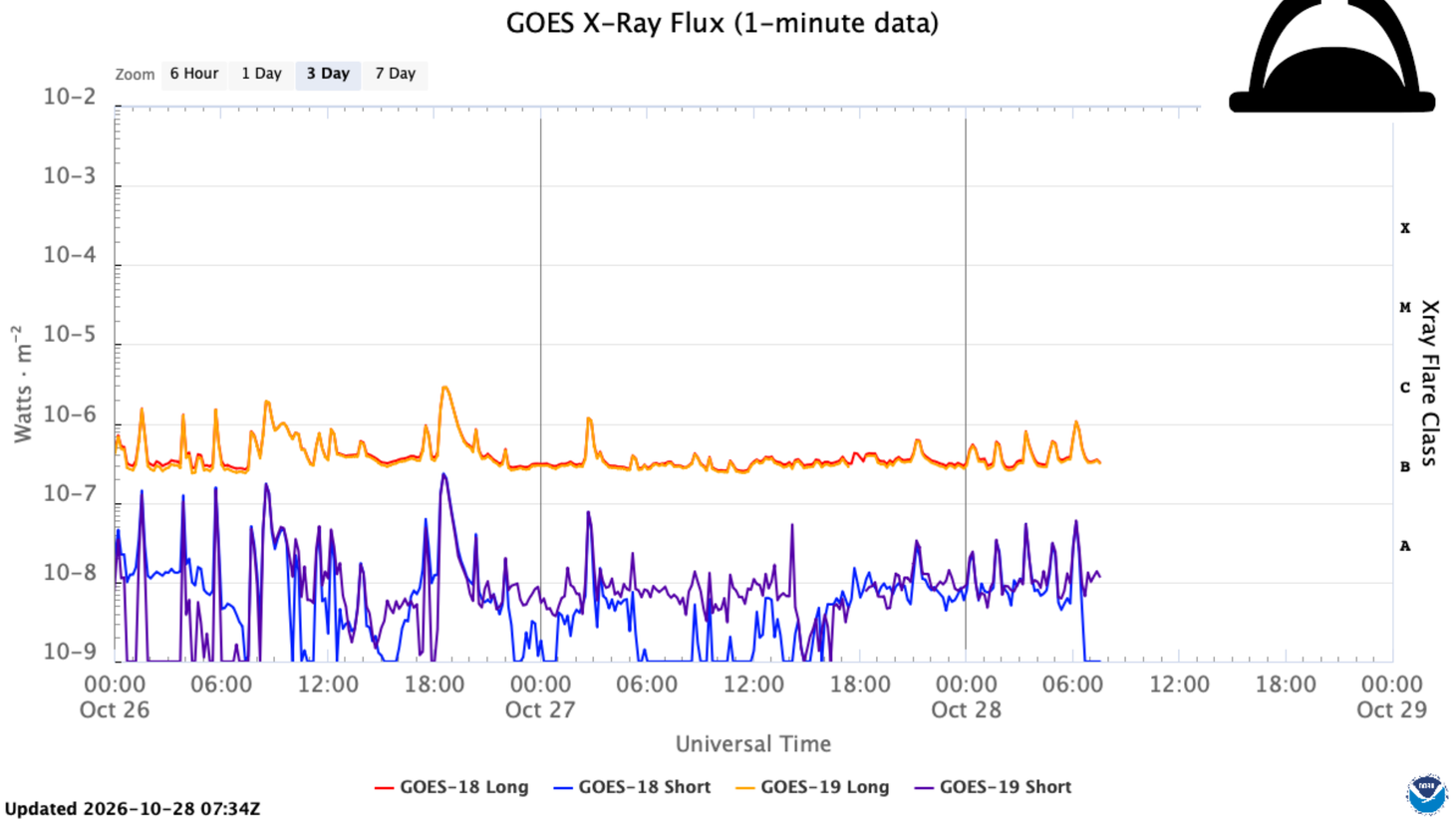
A,B,C,M,X



https://www.spaceweather.gov/products/goes-x-ray-flux

DURATION

MINs to HOUR



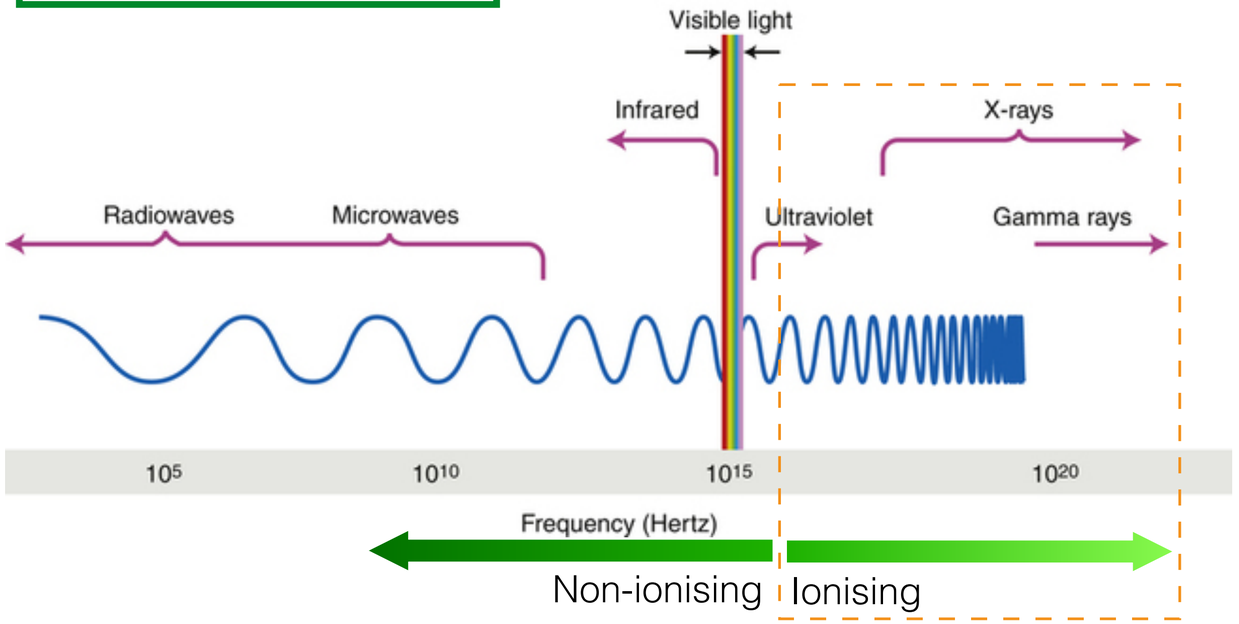
IMPACT



Electromagnetic radiation



- Photons / electromagnetic waves
- Speed of light



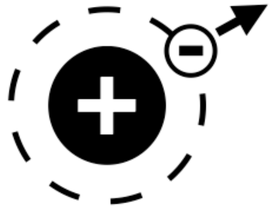
IMPACT





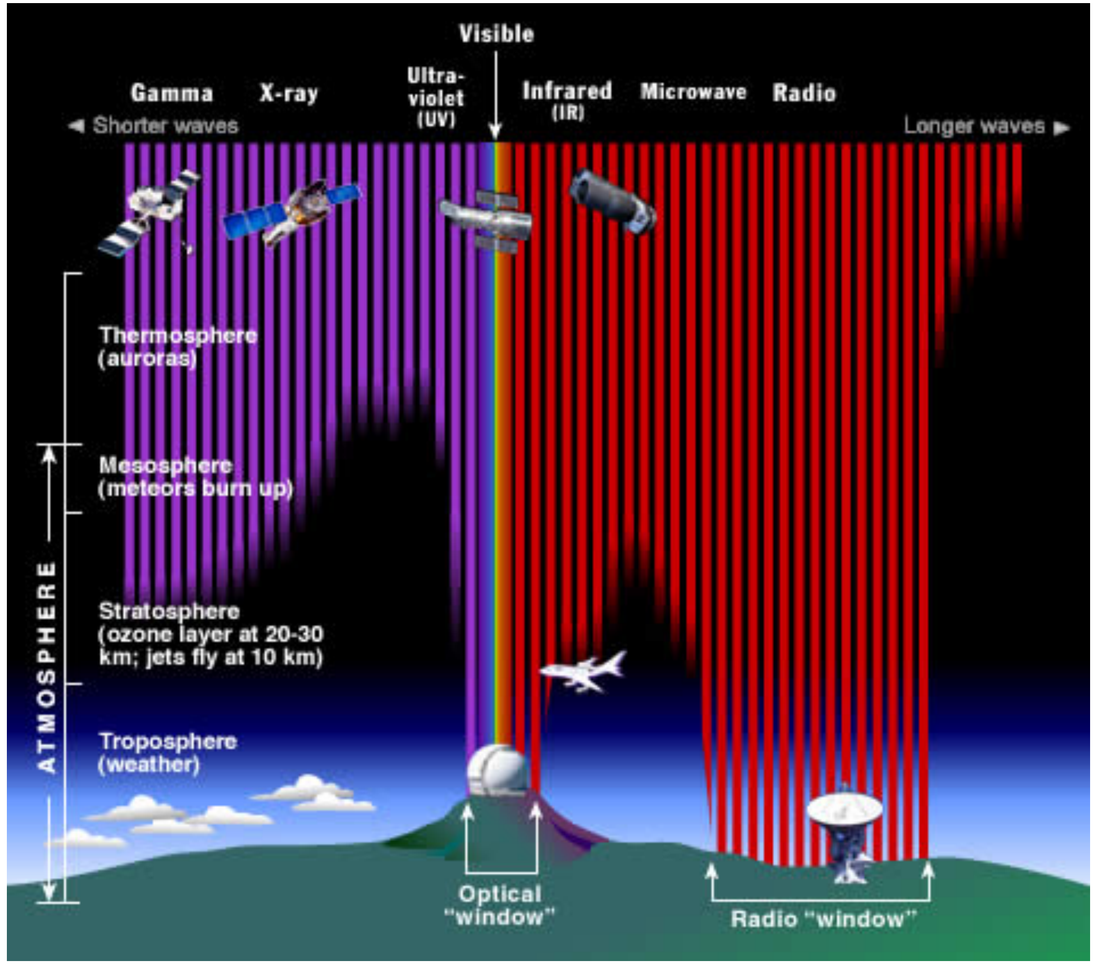
Ionisation





TRANSPARENCY OF EARTH ATMOSPHERE

Our atmosphere protects us against harmful solar light. This ionising solar light can penetrate only until a certain height.



AREA OF IMPACT

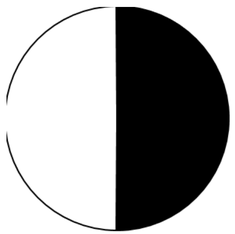


AREA OF IMPACT

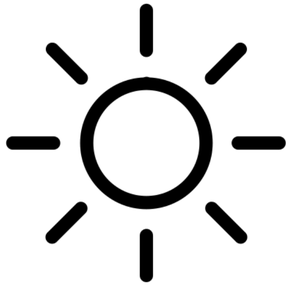


Illuminated area

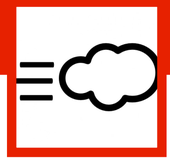


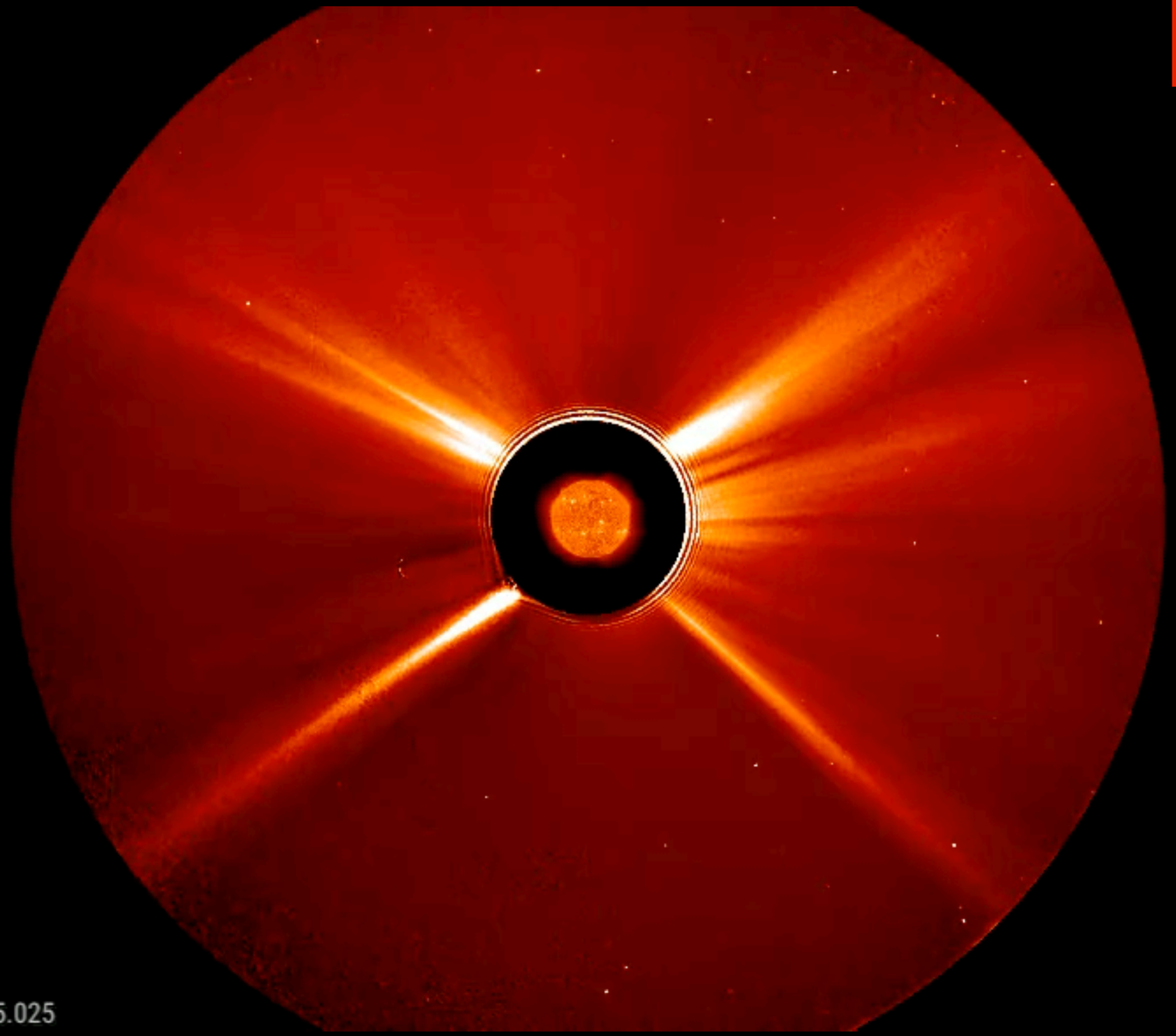


SOLAR WEATHER & STORMS



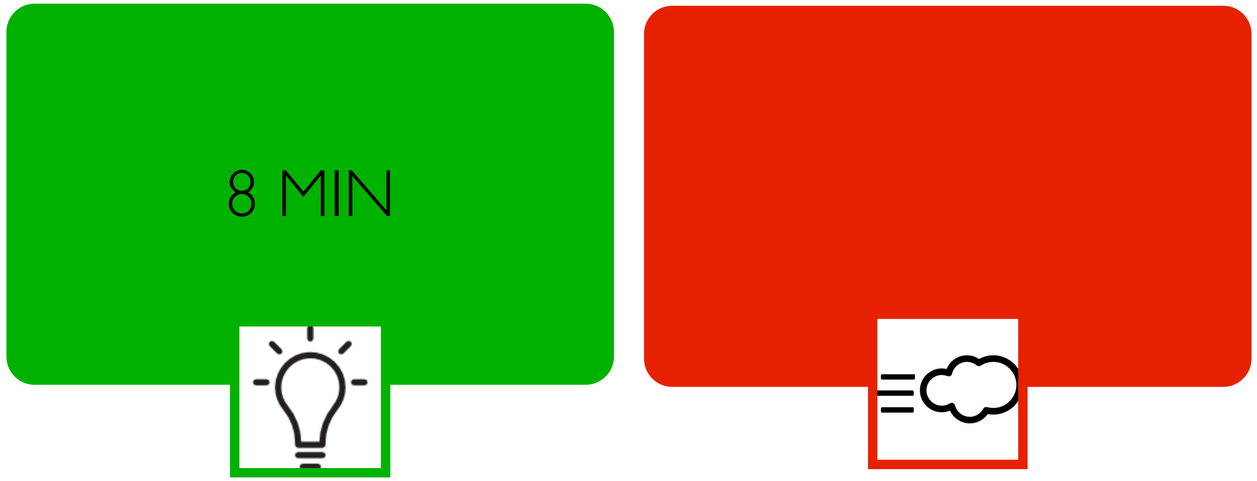
Solar wind
CME - HSS




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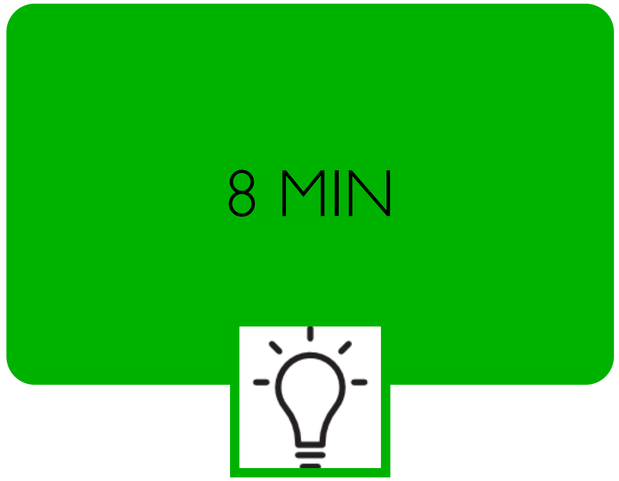
AU TRANSIT TIME

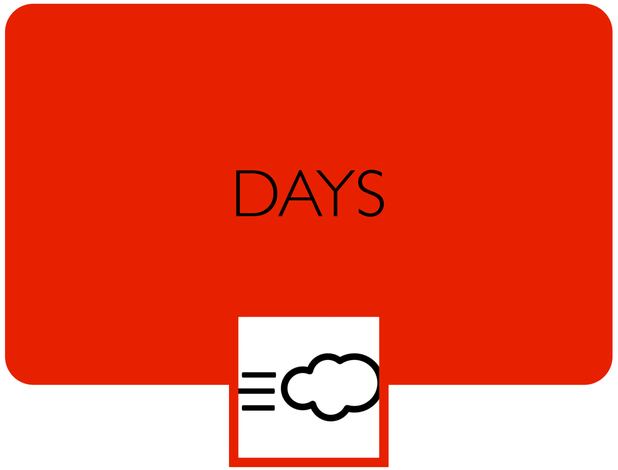
The energy released during a solar storm moves through space, each with its own typical speed: speed of light, order of a few 100 km/s,….

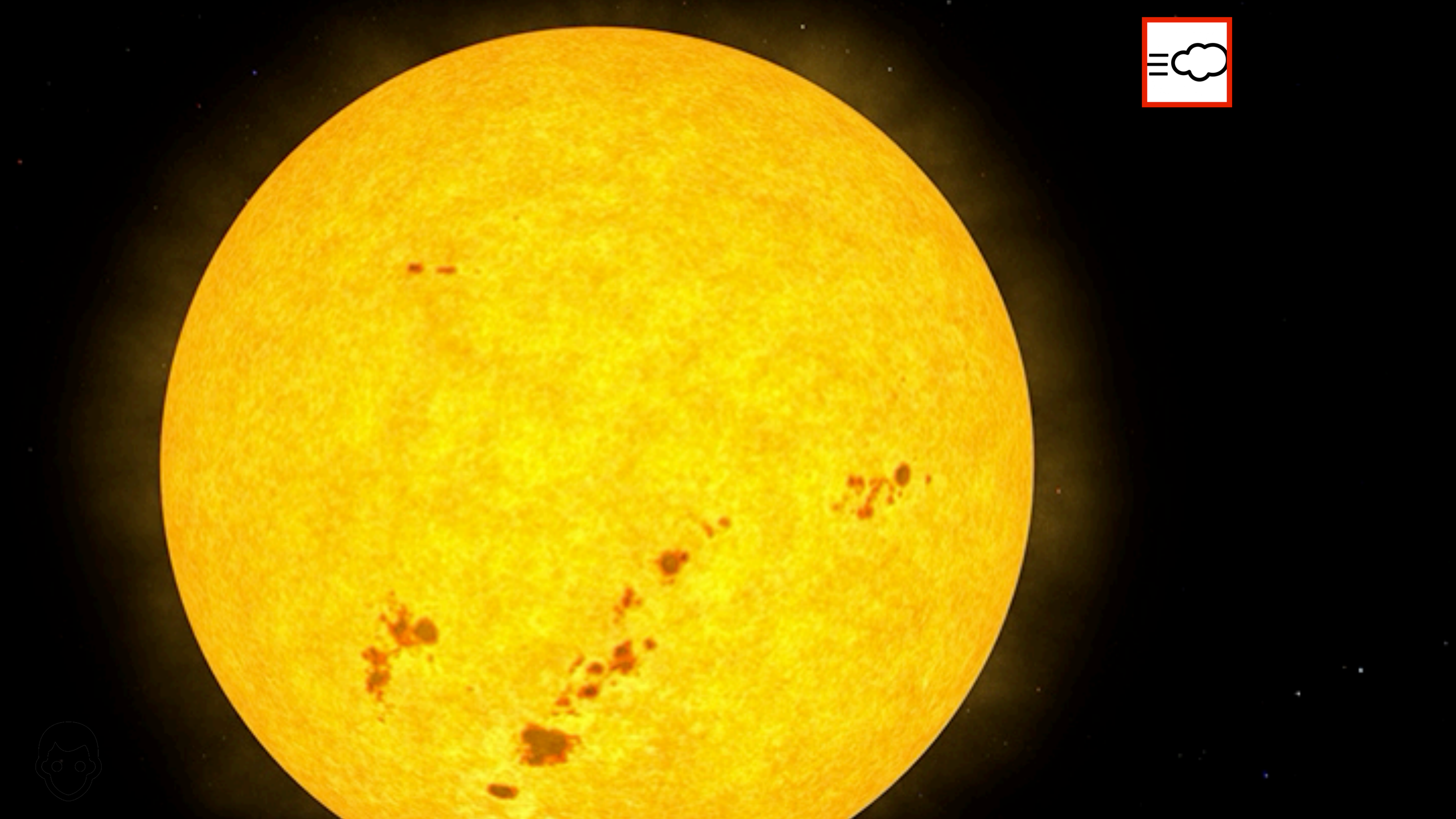


AU TRANSIT TIME

The energy released during a solar storm moves through space, each with its own typical speed: speed of light, order of a few 100 km/s, relativistic speeds.



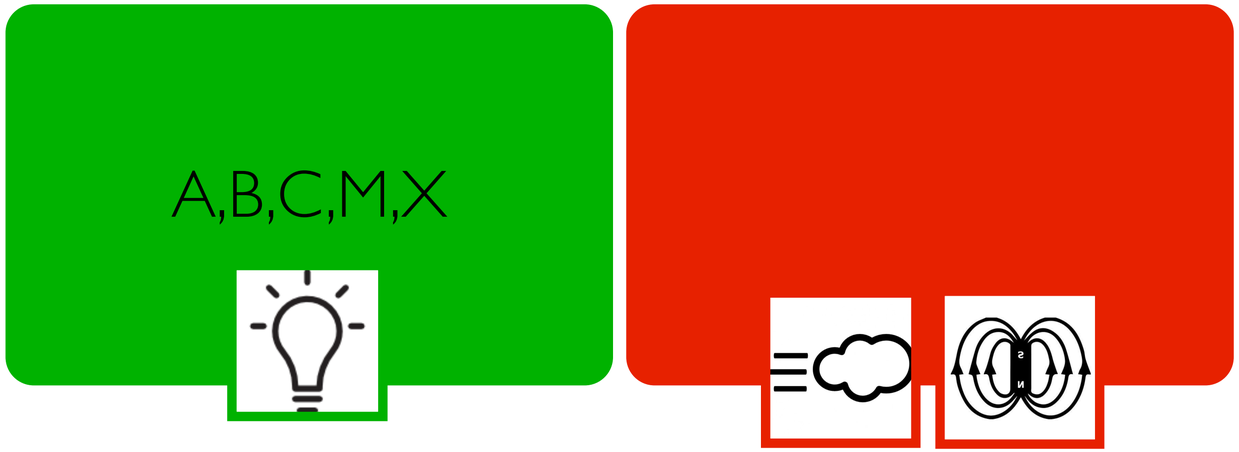




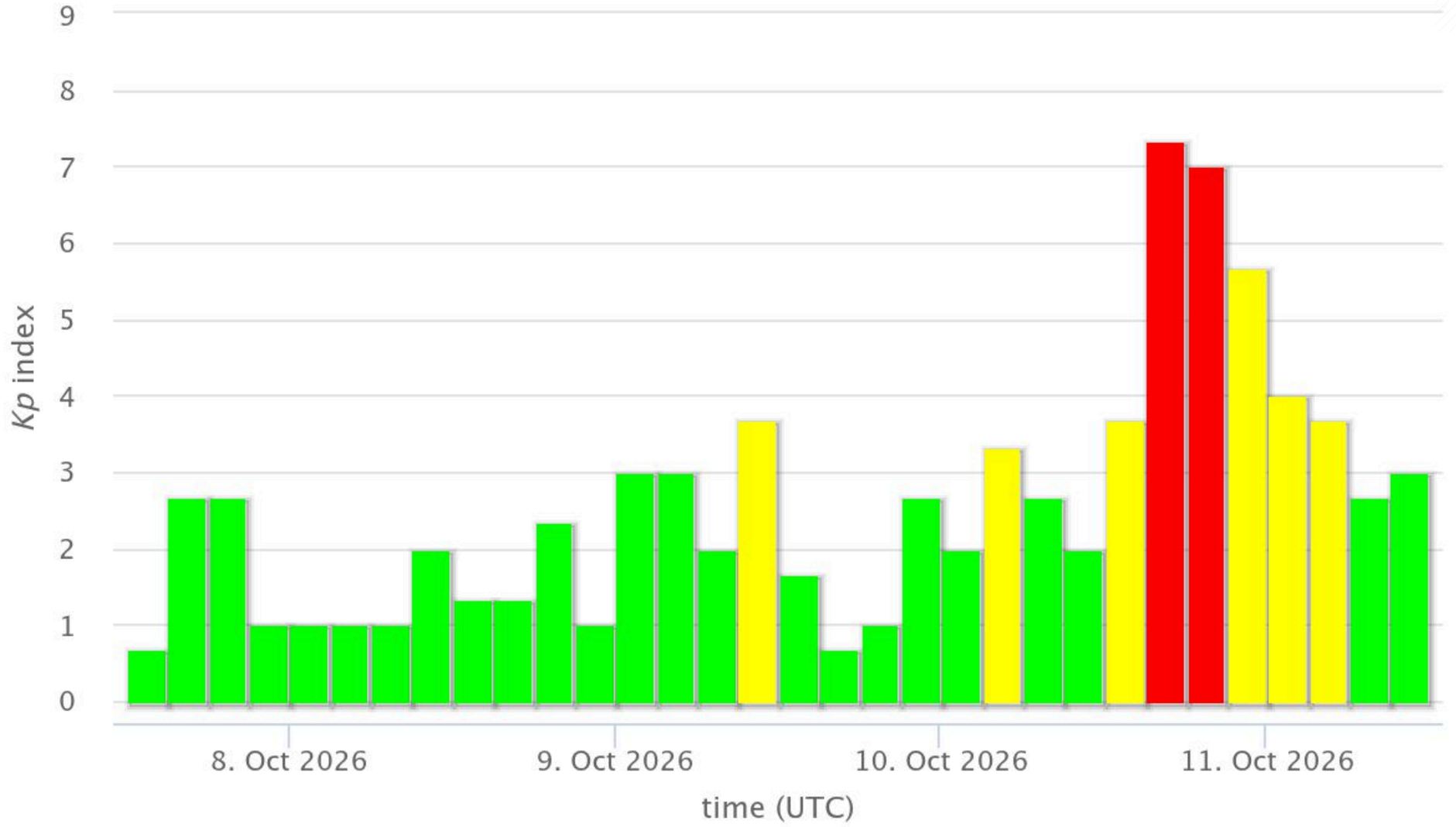
STORM SCALE



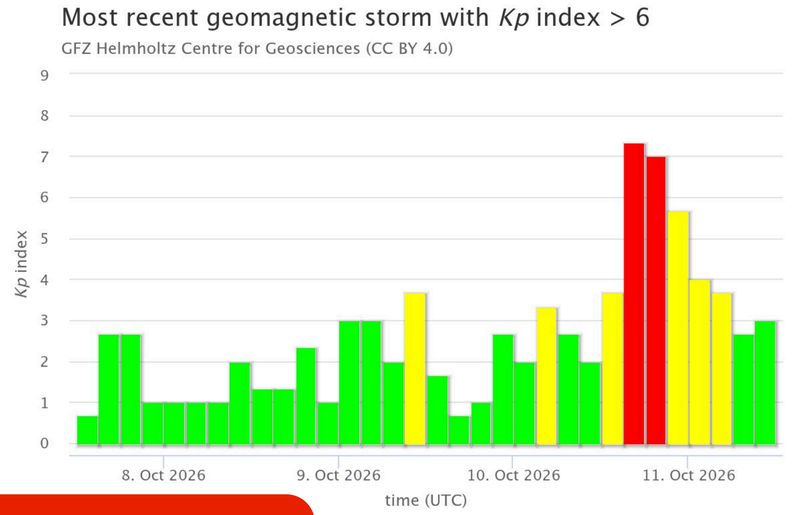
https://kp.gfz.de/en/



STORM SCALE


Most recent geomagnetic storm with Kp index > 6
GFZ Helmholtz Centre for Geosciences (CC BY 4.0)
Kp index
9
8
7
6
5
4
3
2
1
0
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11. Oct 2026
time (UTC)

STORM SCALE

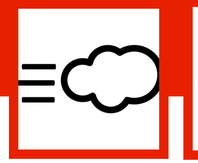


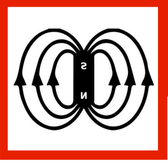


A,B,C,M,X



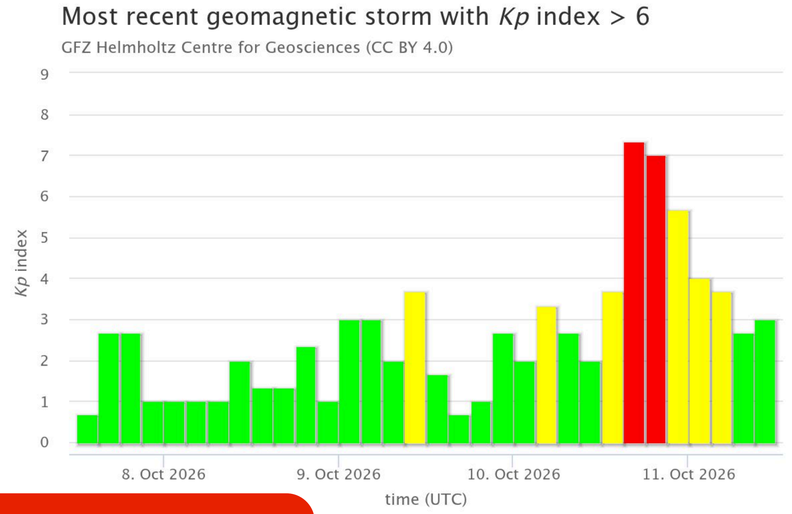
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DURATION

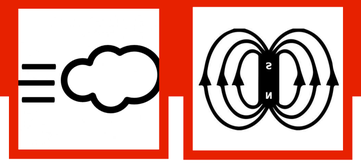




MINs to HOUR



DAY+





SWEC
Space Weather Education Center

IMPACT

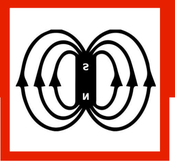


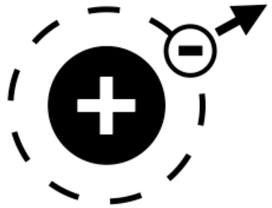


Ionisation

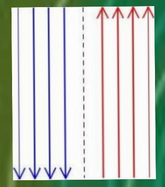


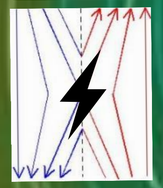


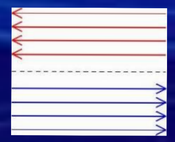


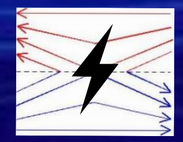






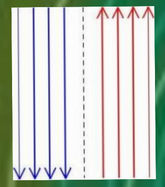


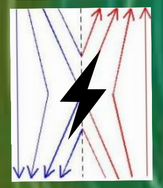


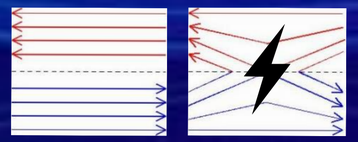










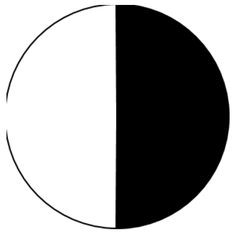


AREA OF IMPACT



Illuminated area



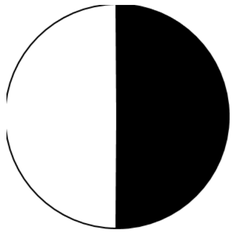


AREA OF IMPACT

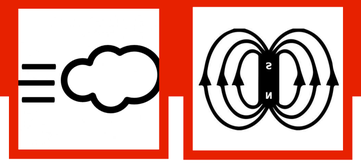


Illuminated area





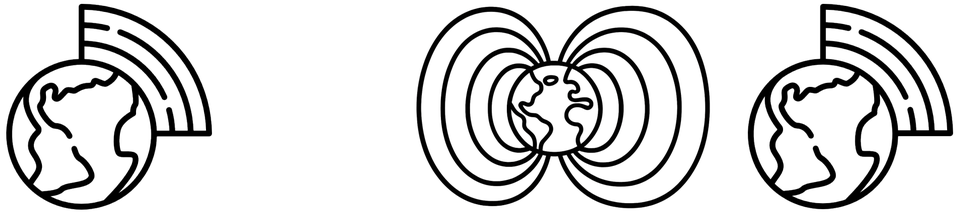
Auroral Oval & more Latitude





IMPACT

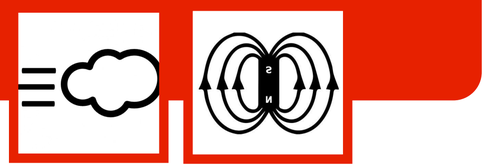


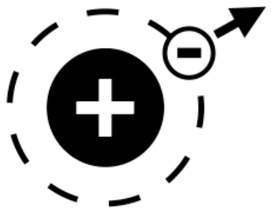


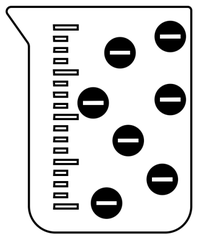
Ionisation

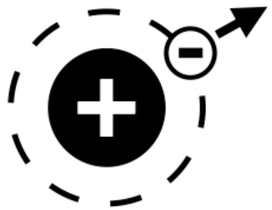
Particle content



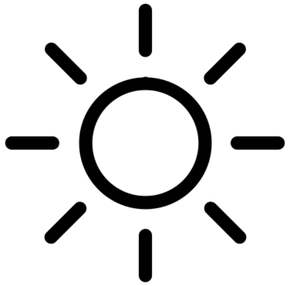






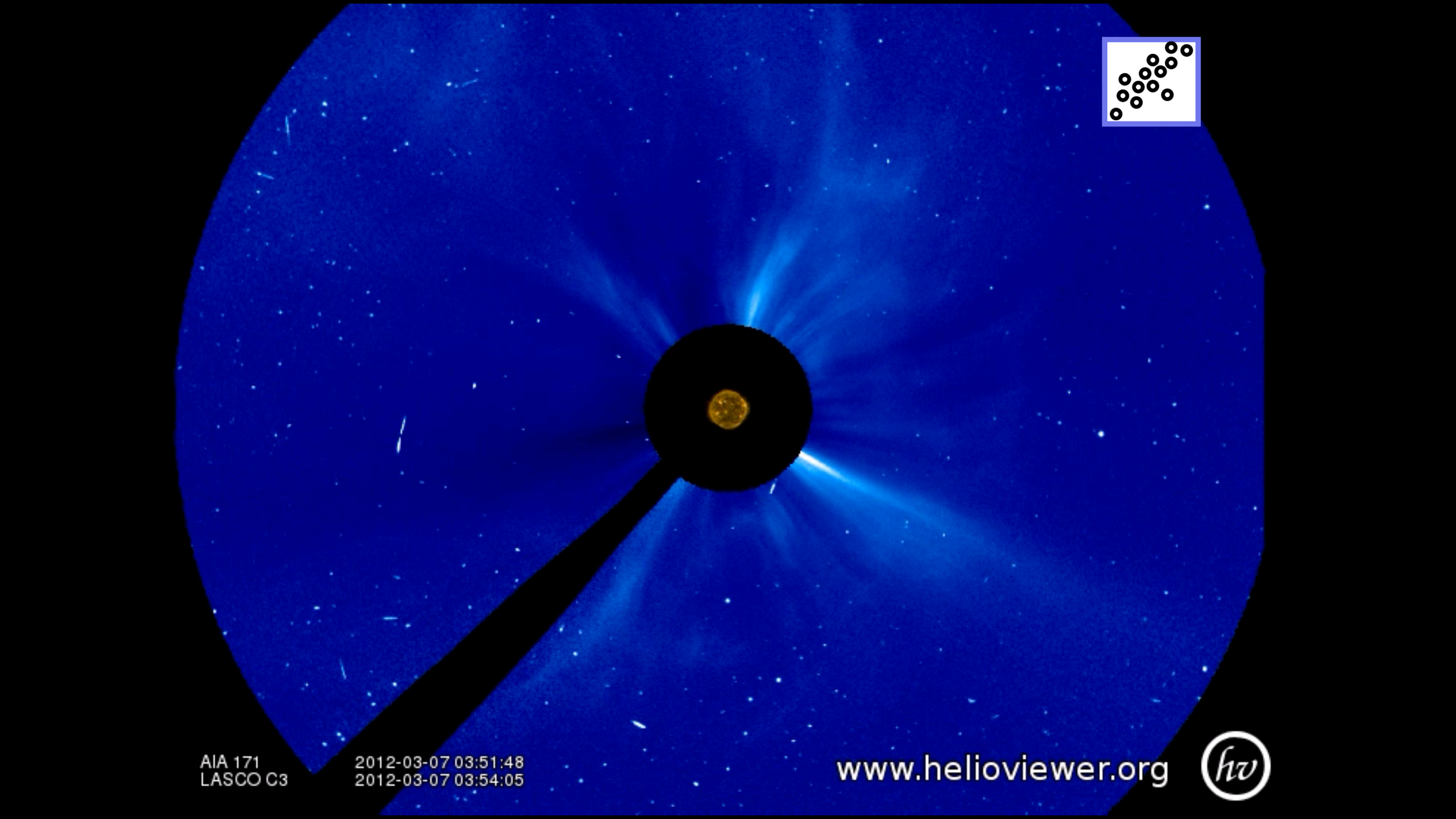


SOLAR WEATHER & STORMS



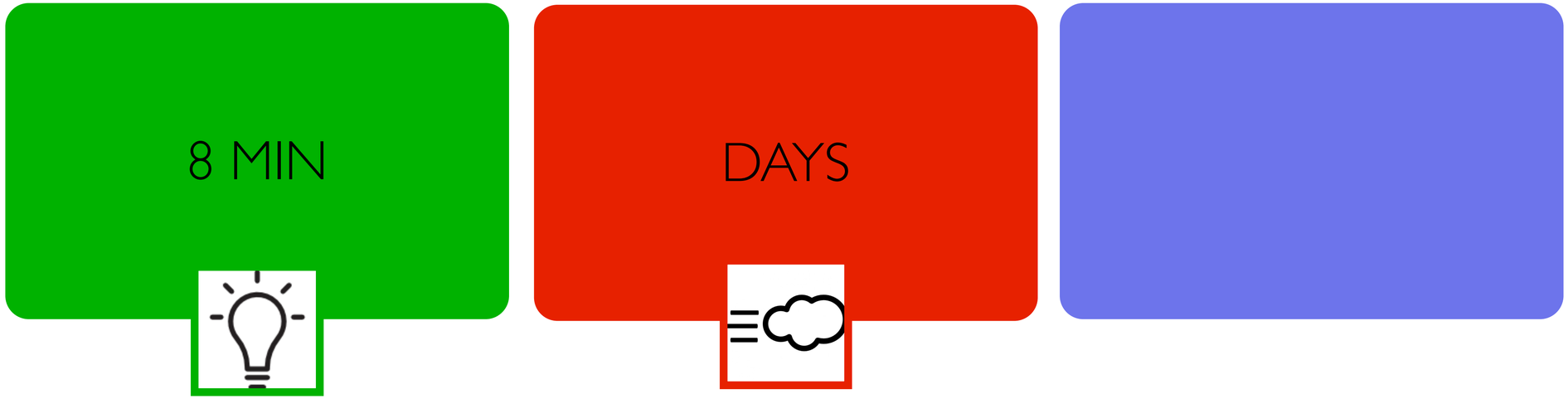
Energetic Particles




AIA 171
LASCO C3
2012-03-07 03:51:48
2012-03-07 03:54:05
www.helioviewer.org

AU TRANSIT TIME

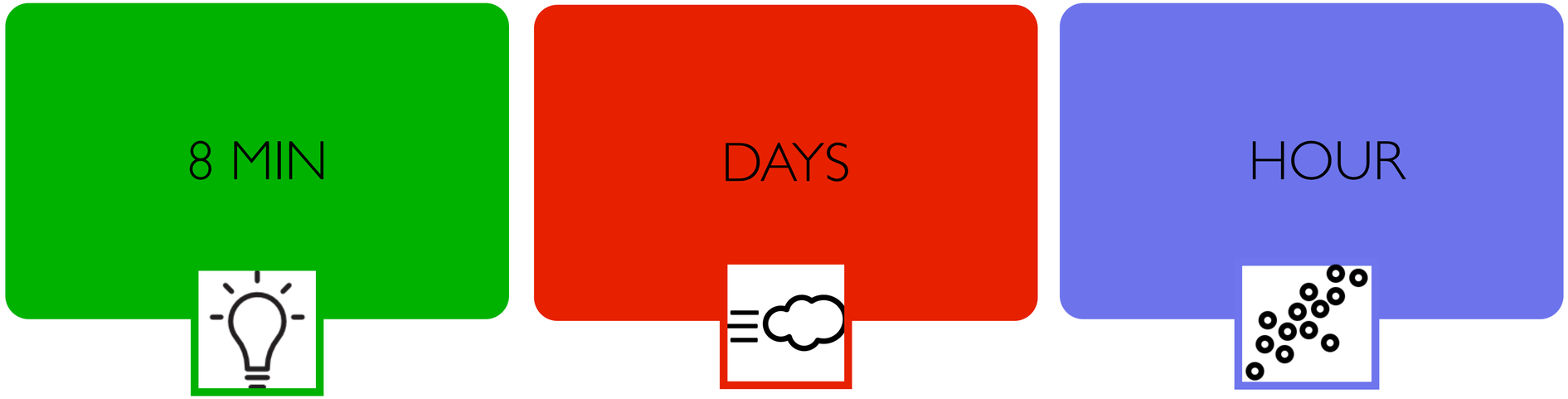
The energy released during a solar storm moves through space, each with its own typical speed: speed of light, order of a few 100 km/s, relativistic speeds.



AU TRANSIT TIME

The energy released during a solar storm moves through space, each with its own typical speed: speed of light, order of a few 100 km/s, relativistic speeds.

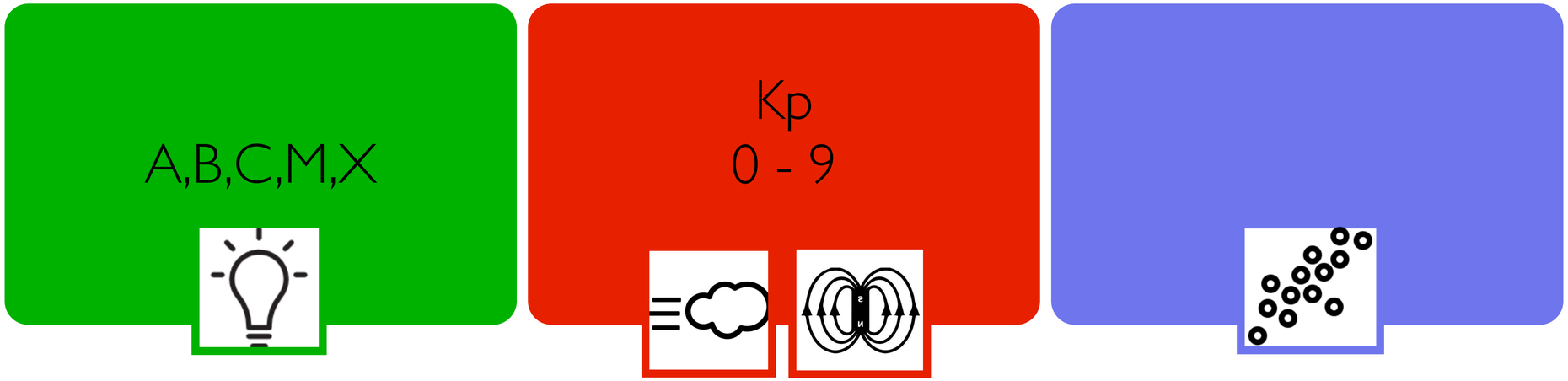


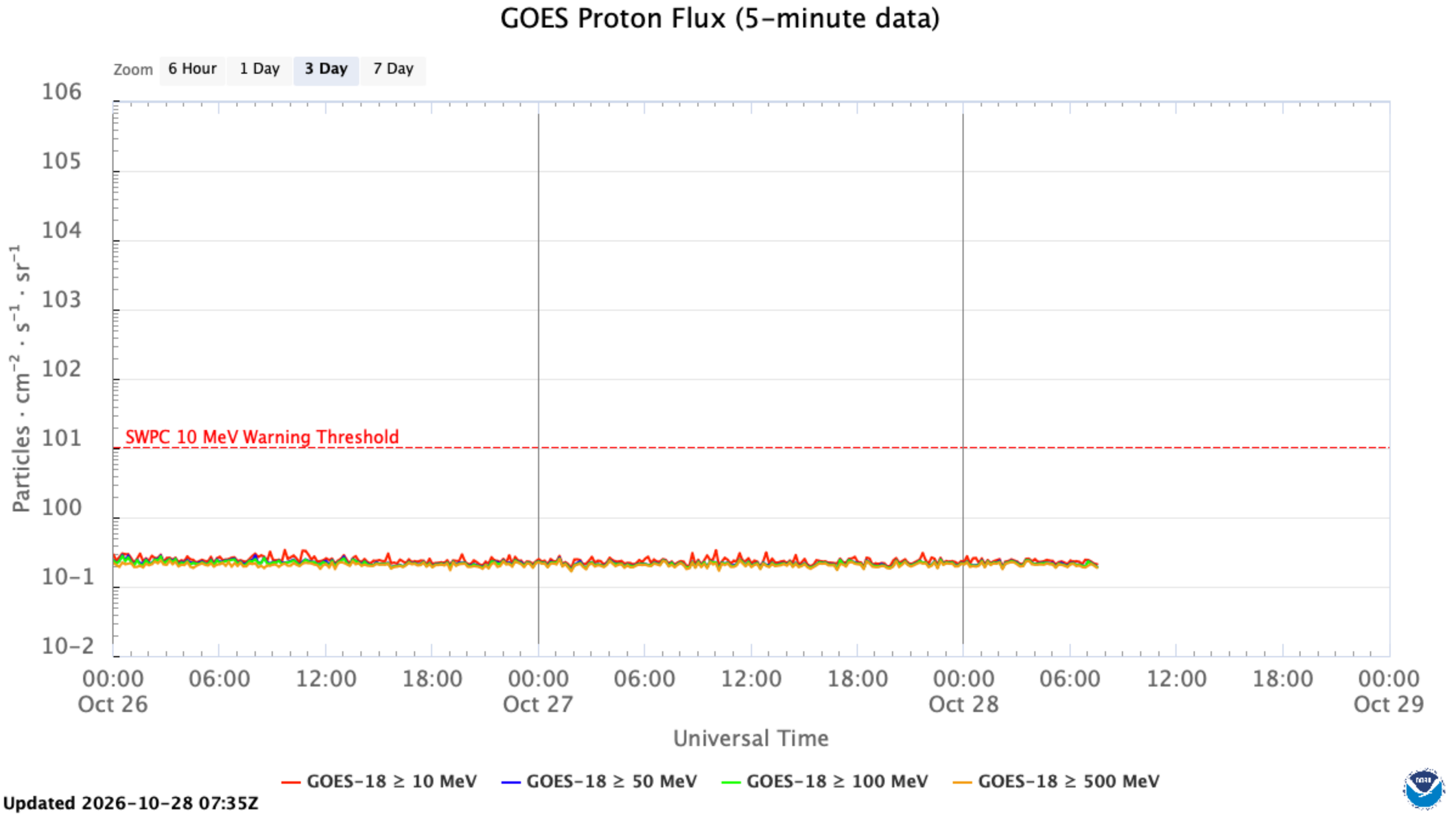


STORM SCALE



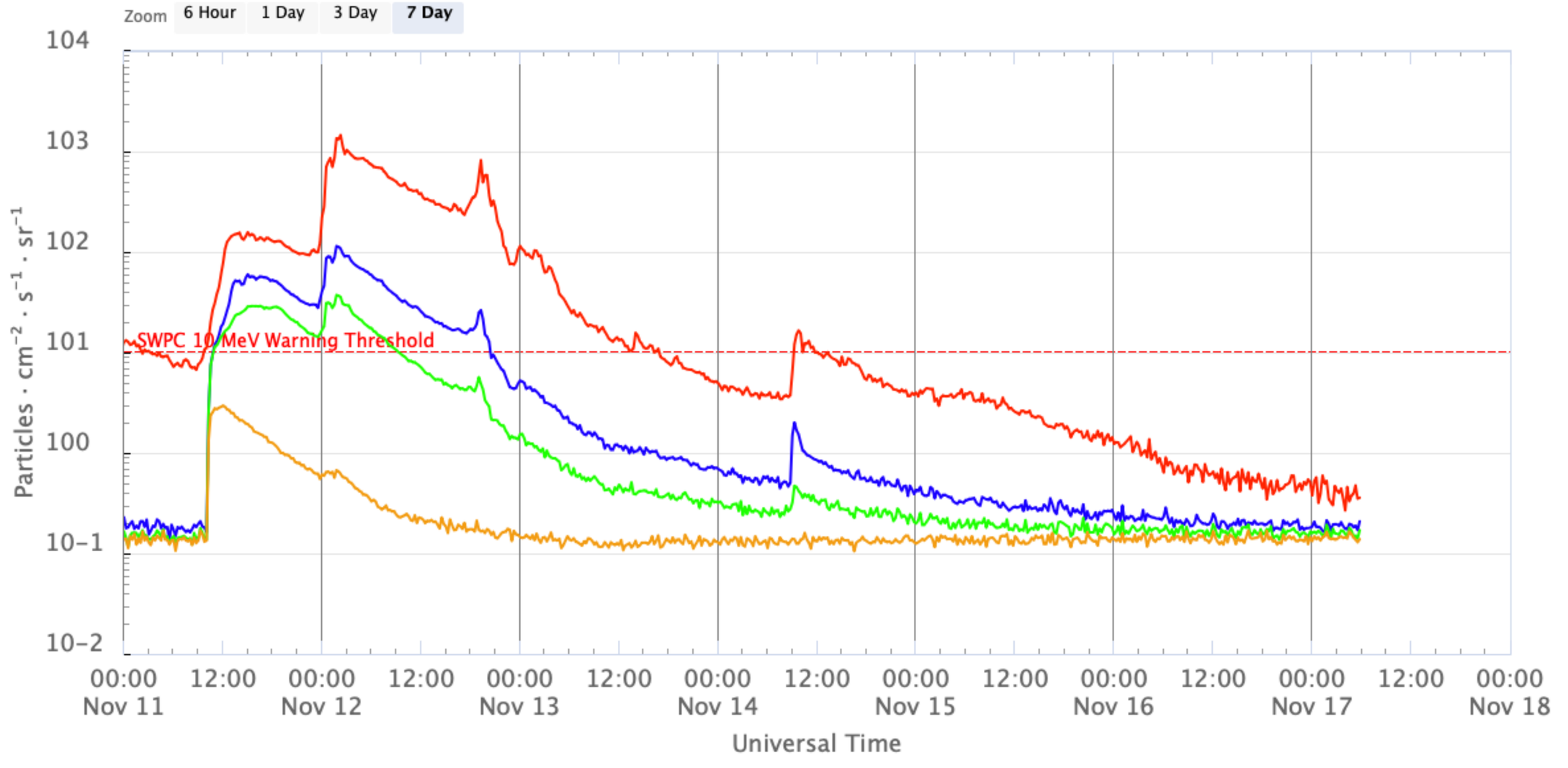
https://www.spaceweather.gov/products/goes-proton-flux





https://www.spaceweather.gov/products/goes-proton-flux

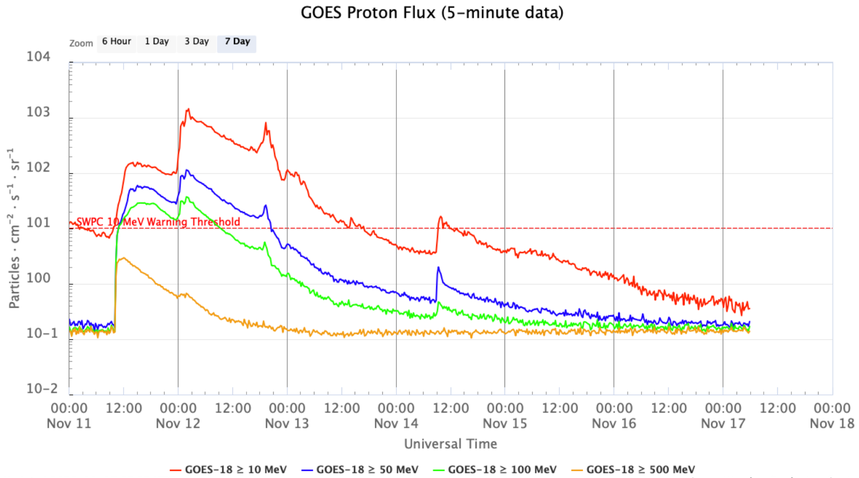
GOES Proton Flux (5-minute data)



Updated 2025-11-17 05:55 UTC

Space Weather Prediction Center

STORM SCALE

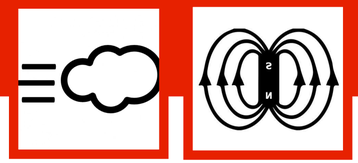




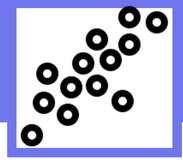
A,B,C,M,X



Kp
0 - 9



Storm - major storm





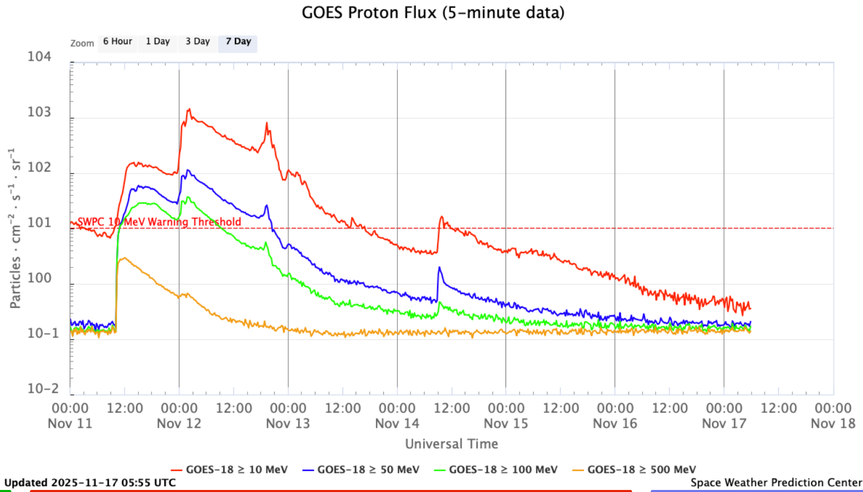


GOES





DURATION

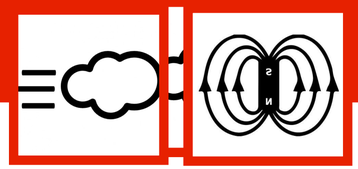




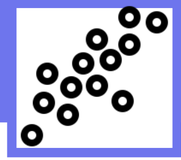
MINs to HOUR



DAY+



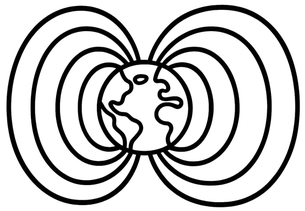
HOURS to DAYS



IMPACT





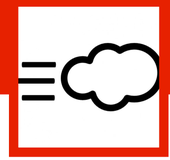


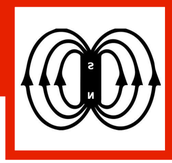


Ionisation

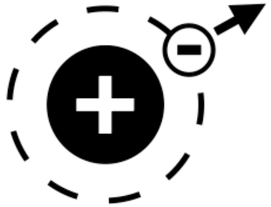


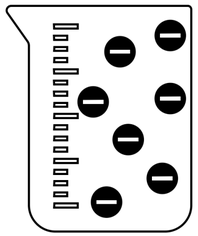
Particle content

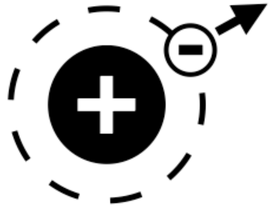






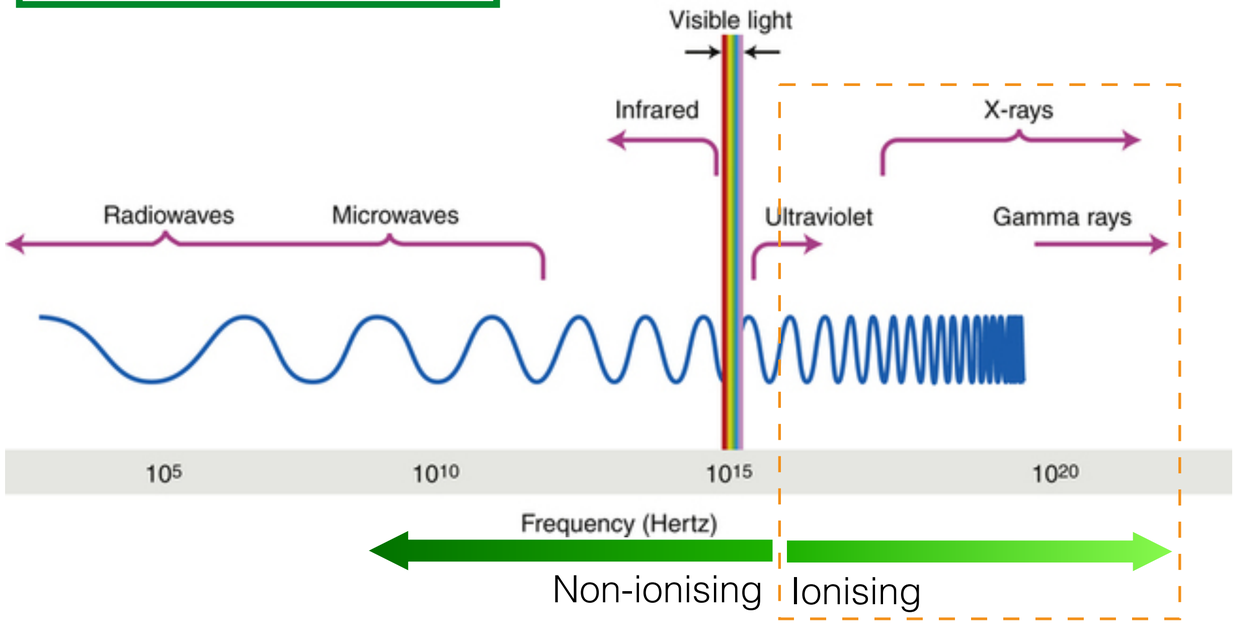






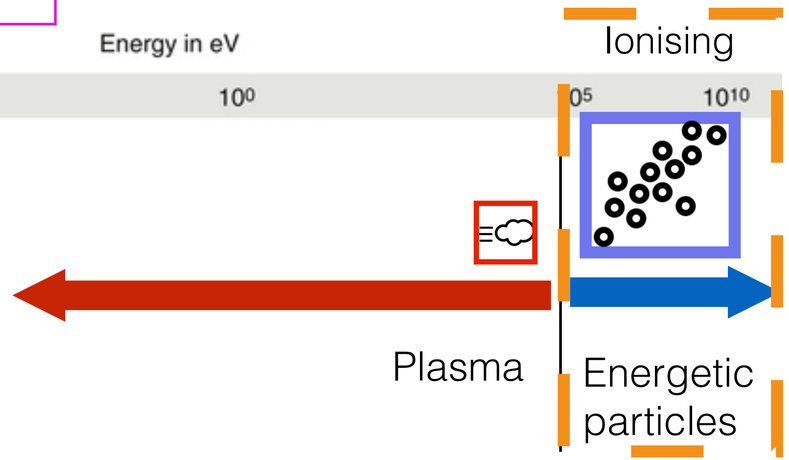
Electromagnetic radiation

- Photons / electromagnetic waves
- Speed of light



Particles

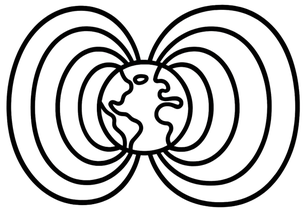
- Atomic & sub-atomic particles
- m/s to fractions of speed of light



IMPACT









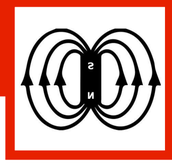


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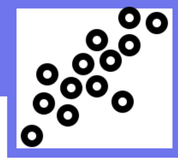


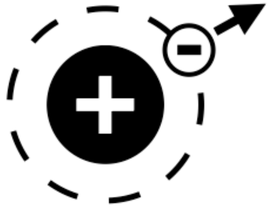
Particle content

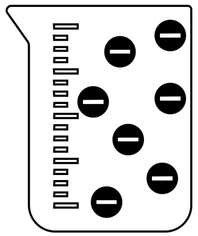


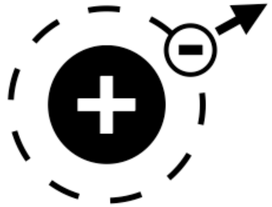


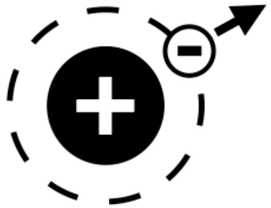
Ionisation
Particle Radiation















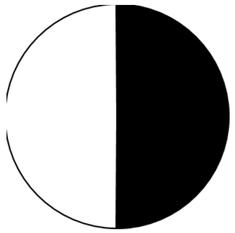
SWEC
Space Weather Education Center

AREA OF IMPACT

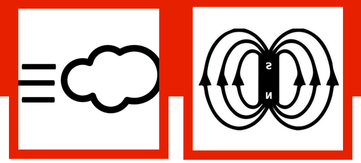


Illuminated area



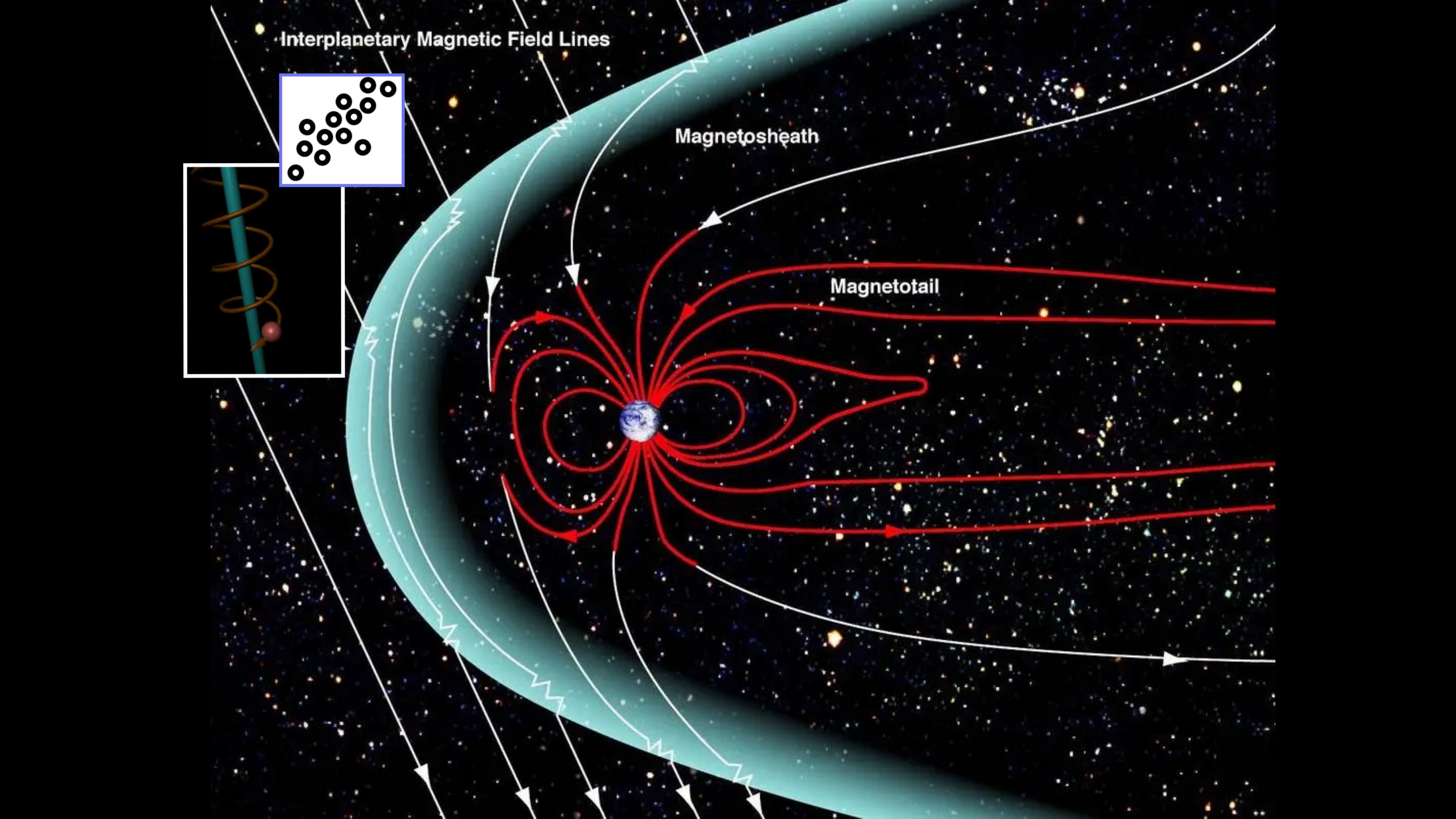


Auroral Oval & more Latitude







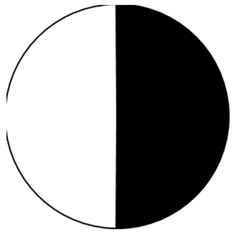

Interplanetary Magnetic Field Lines
Magnetosheath
Magnetotail

AREA OF IMPACT

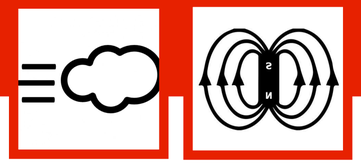


Illuminated area





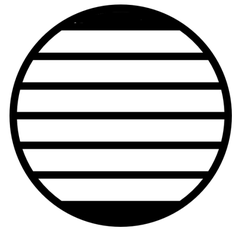
Auroral Oval & more Latitude

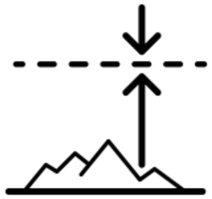




Polar Cap
High Altitude











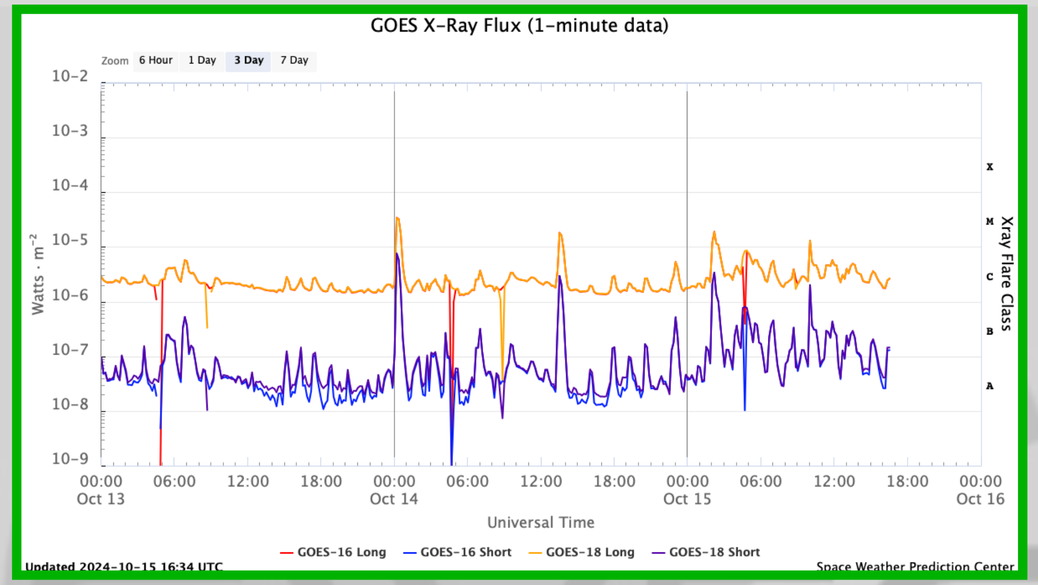






8 min	Days	Hour
X-ray: A,B,C,M,X	Kp: 0 - 9	Proton flux: (Major) Storm
Min to Hour	Day+	Hours to Days
Ionisation	Ionisation Particle content	Ionisation Particle radiation
Illuminated area	Auroral Oval & more Latitude	Polar Caps High Altitude

X-ray Flux Passport



Type

X-ray output (0.1-0.8 nm and 0.05-0.4 nm) of the solar spectrum versus time.

Use

To quantify solar flares happening on the side of the Sun facing Earth.

Units

Integrated over 1 min

$W \cdot m^{-2}$

Data location

https://www.swpc.noaa.gov/products/goes-x-ray-flux

Plot

X-axis: time in UTC
Y-axis: X-ray flux in W/m^2, i.e. how much energy (Joule) passes in 1 sec (W=Watt=J/s) through 1 square meter at geostationary height.

Classes

The long wavelength (0.1-0.8 nm, red and orange) is the reference for identification of the class. The red is measured by GOES 18, orange by GOES 16.
The flare classes are indicated on the right of the graphs. When the peak of the red/orange curve is in blue/green/yellow/orange/red, it is a A/B/C/M/X-class flare.

Sensor

GOES-16 s
GOES-18 s

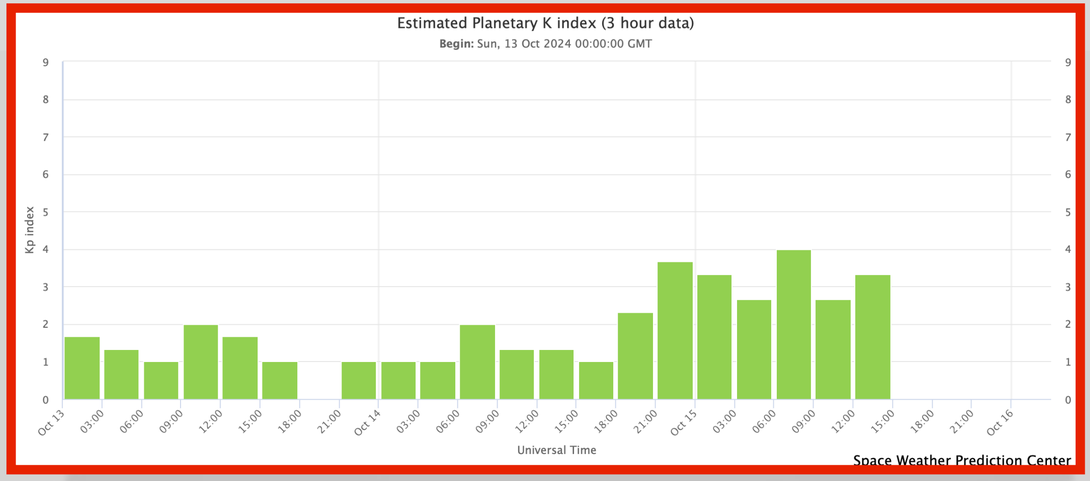
Sensor

Geostation

Caden

Integrated

Kp-index Passport



What

Kp-index (NOAA) represents the planetary geomagnetic condition or the state of the magnetic fi
globe.

Use

To quantify the disturbance of the magnetic field of Earth. The scale ranges from 0 to 9, with 0 ind
of the Earth magnetic field .

Plot

X-axis: data and time in UTC, time stamp every 3 hours. Ranges from 3 days in the left (left) to r
Y-axis:
coloured bars of 3 hours wide, height= Kp-index (NOAA)
Height of a bar represents a number: 0, 0+, 1-,1,1+, 2-,2,2+, … 8-,8,8+, 9-,9.

Estimated

by NOAA, US

Data location

https://www.swpc.noaa.gov/products/planetary-k-index

Definitive

The values become definitive after calculation and confirmation by the German Research Centre for Geosciences, Potsdam.

Magnetometers

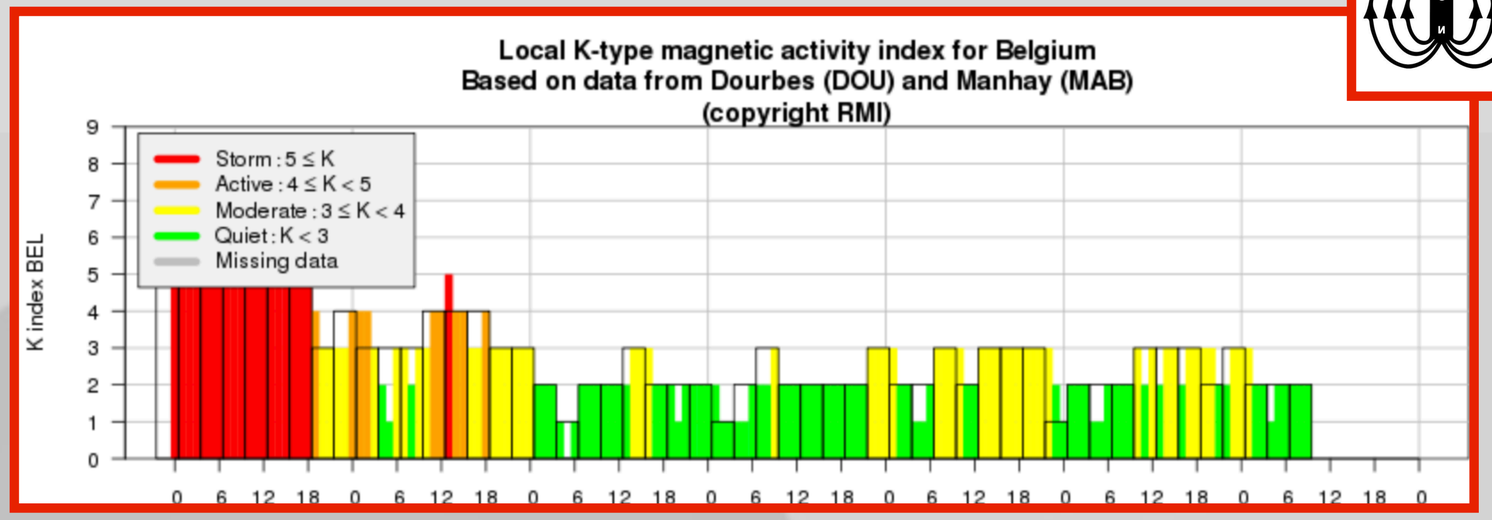
The calculation is based upon the measurements done by magnetometers.

Observatories

Thirteen (13) Geomagnetic Observatories between 44 degrees and 60 degrees northern or southern geomagnetic latitude.

SWEC Space Weather Education Center

K Belgium Passport



What

K Belgium represents the geomagnetic conditions or the state of the magnetic field of Earth above Belgium. It is an index for Belgium.

Use

To quantify the disturbance of the magnetic field of Earth. The scale ranges from 0 to 9, with 0 indicating no disturbance and 9 the highest disturbance of the Earth magnetic field .

Plot

X-axis: data and time in UTC. Ranges from 7 days in the left (left) to now (right).
Y-axis: coloured bars of 1 hour wide, height= K Belgium.
Height of a bar represents a natural number: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Sensors

The calculation is based upon the measurements done by the Royal Meteorological Institute of Belgium based on the measurements done in Dourbes and Manhay, Belgium.

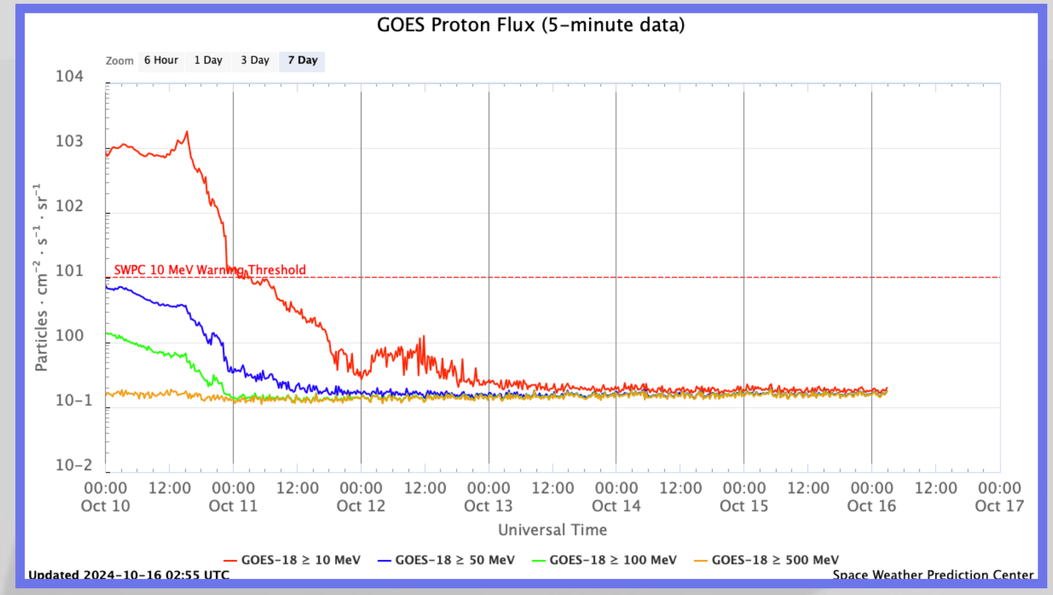
Provider

Royal Meteorological Institute of Belgium

Data location

http://ionosphere.meteo.be/geomagnetism/K_BEL/

Proton Flux Passport



Type

Graph, flux of solar protons versus time.

Use

To quantify proton events impacting Earth.

Units

Particles/(cm^2*s*sr) with s=second and sr=steradian

Data location

https://www.swpc.noaa.gov/products/goes-proton-flux

Sensor

GOES-18 s

Sensor

Geostation

Caden

Integrated

Plot

X-axis: time in UTC
Y-axis: Particles/(cm^2*s*sr), i.e. how many solar protons with a particular energy (eV) pass in 1 sec through 1 square centimeter from a cone with the Sun at the apex. The count is done at geostationary height.
The 4 colours represent 4 energies.

Space Weather Education Center