Ontdekkingsreis naar de Zon

Petra Vanlommel
Solar-Terrestrial Centre of Excellence



WEATHER



SPACE WEATHER



STUDYING THE SUN



STUDYING THE SUN

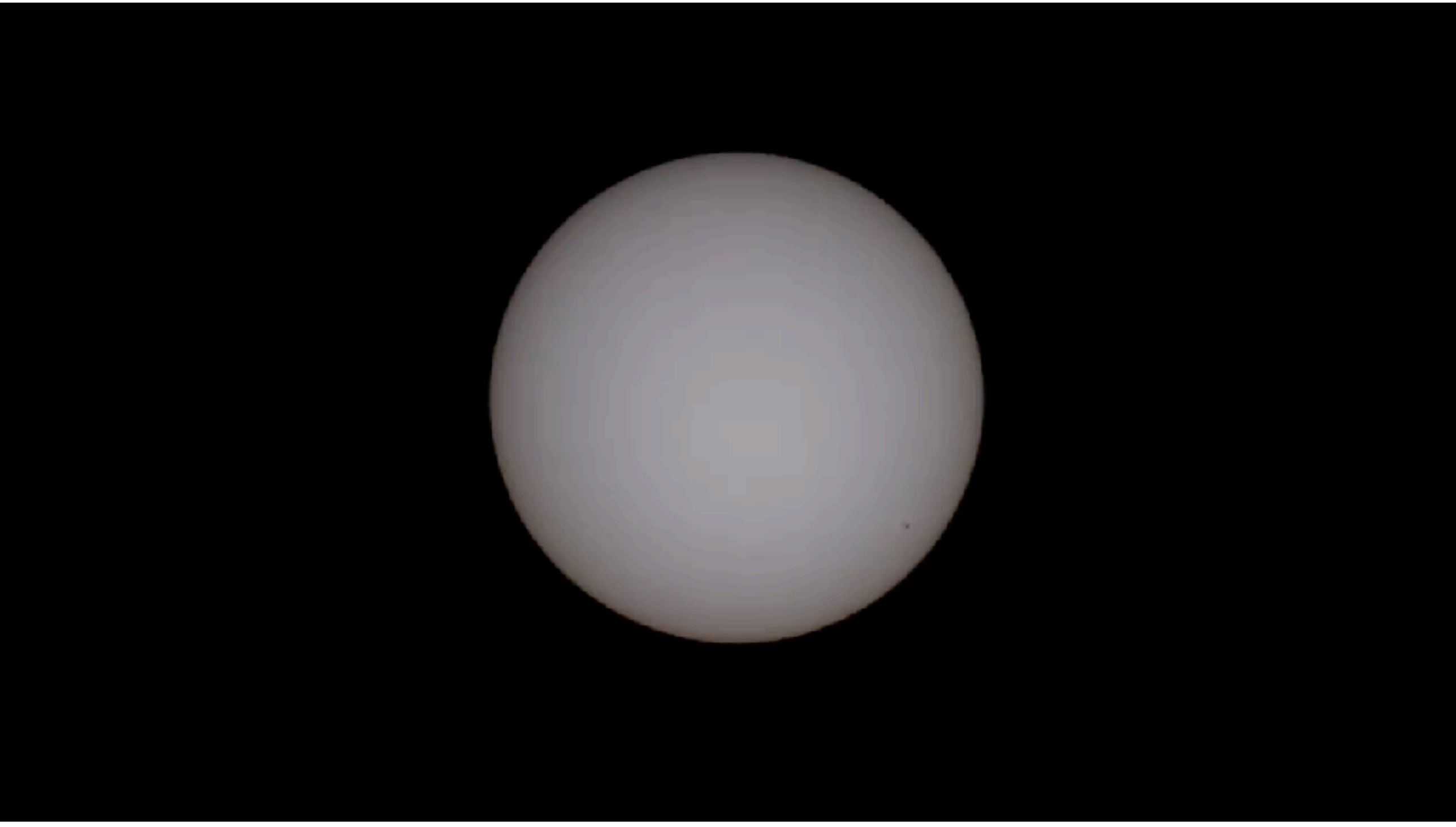
Simply by watching it, at special events.



Image: Siberia 20080801
J.M.P., W. G. Wagner and H. Druckmüllerová

STUDYING THE SUN

By watching it with a simple telescope from Earth in visible light .



LOOKING AT AN OBJECT

A picture of a hand in visible light.



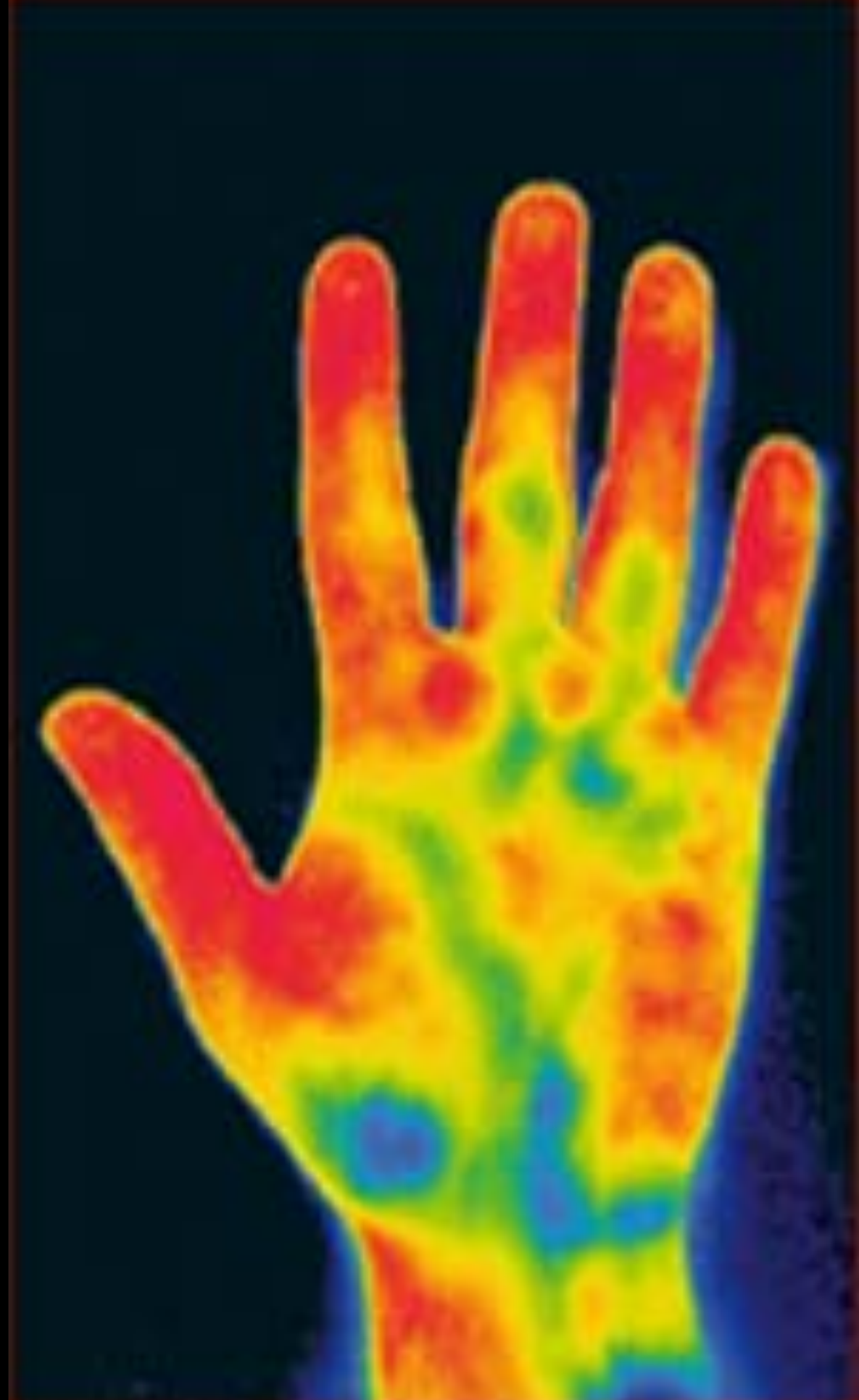
LOOKING AT AN OBJECT

...in x-rays.



LOOKING AT AN OBJECT

...in infra-red.

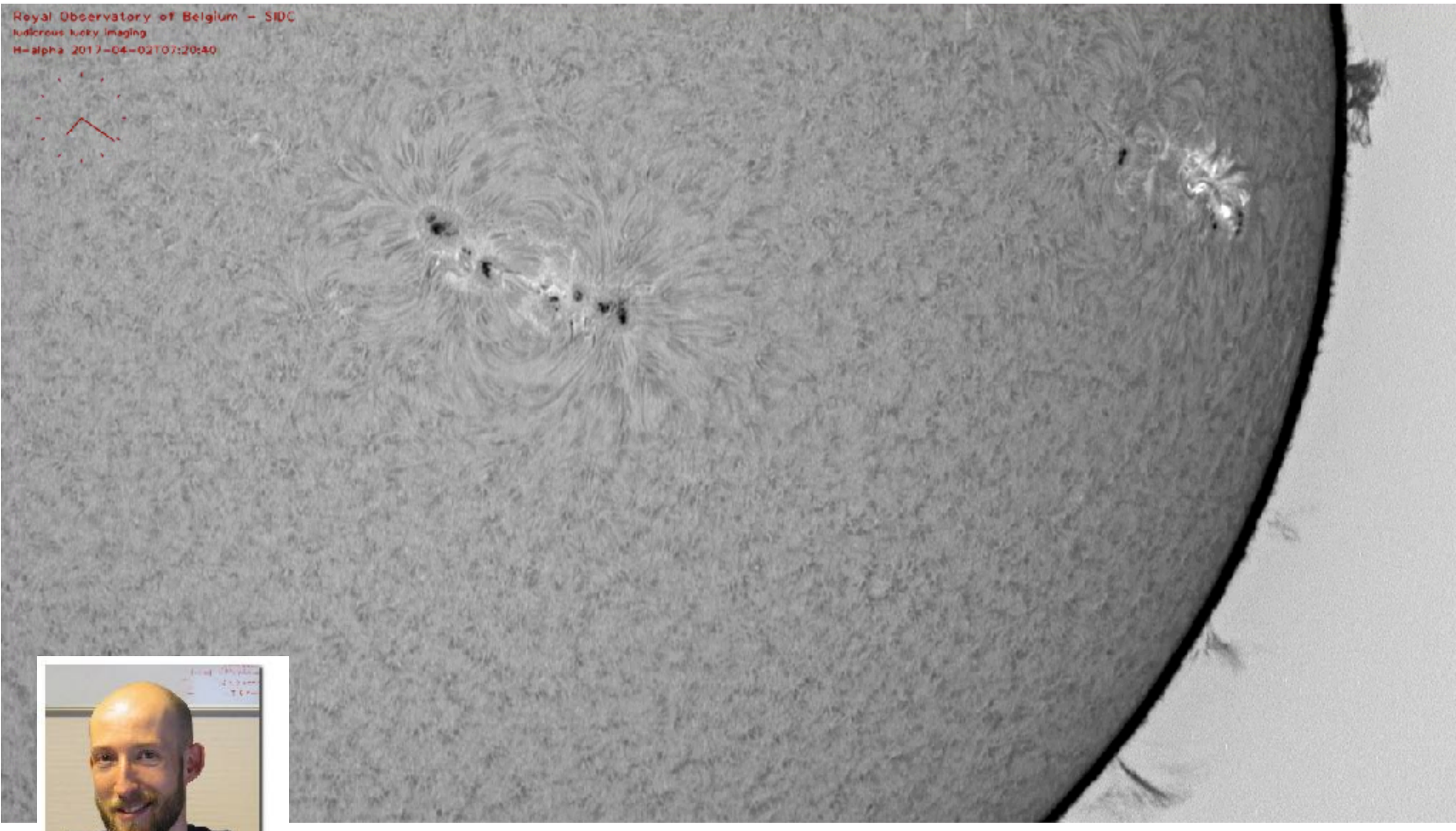


Earth to scale

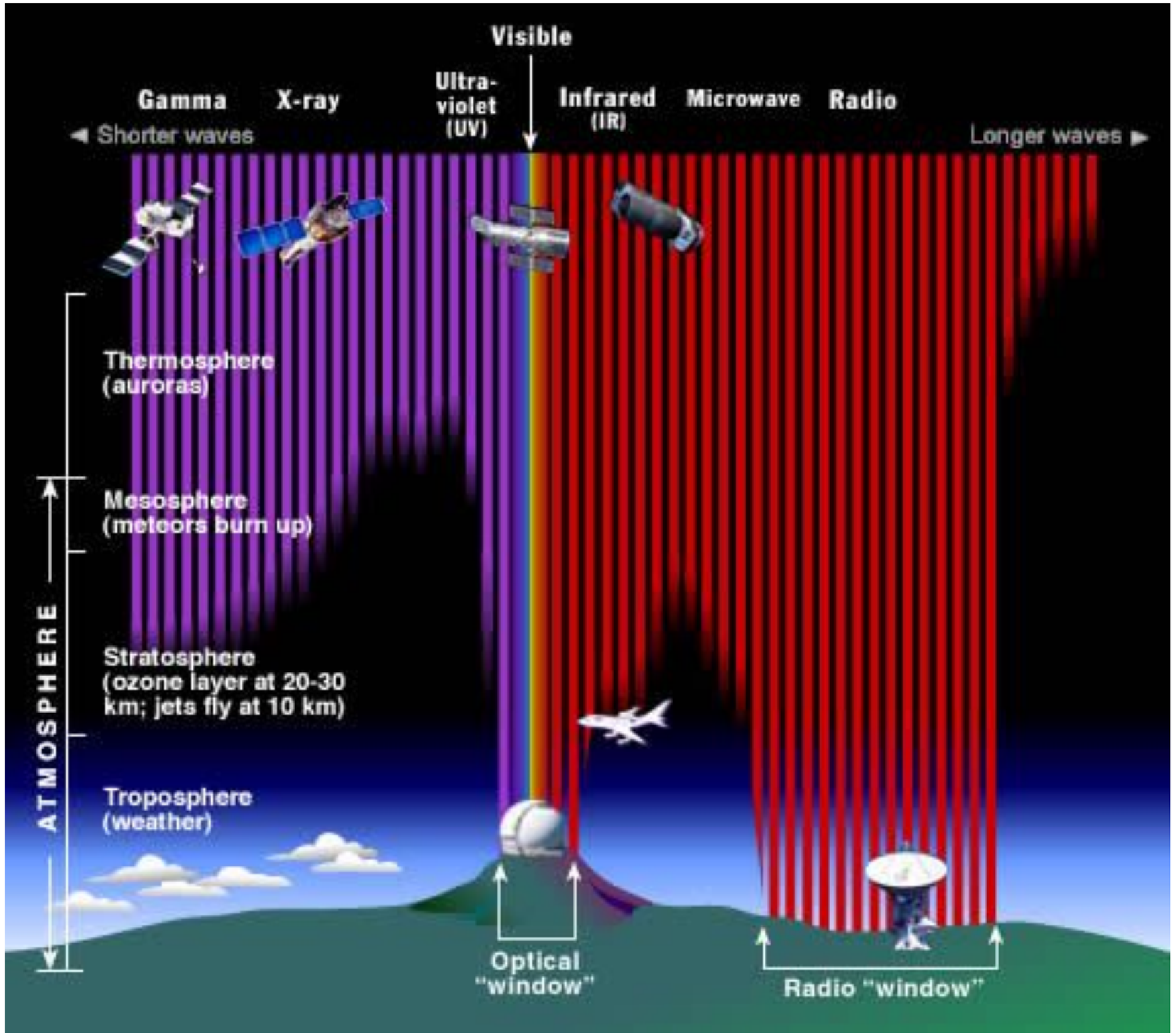
2012-May-01
00:00:04

HOME MADE BY USET - EMIL

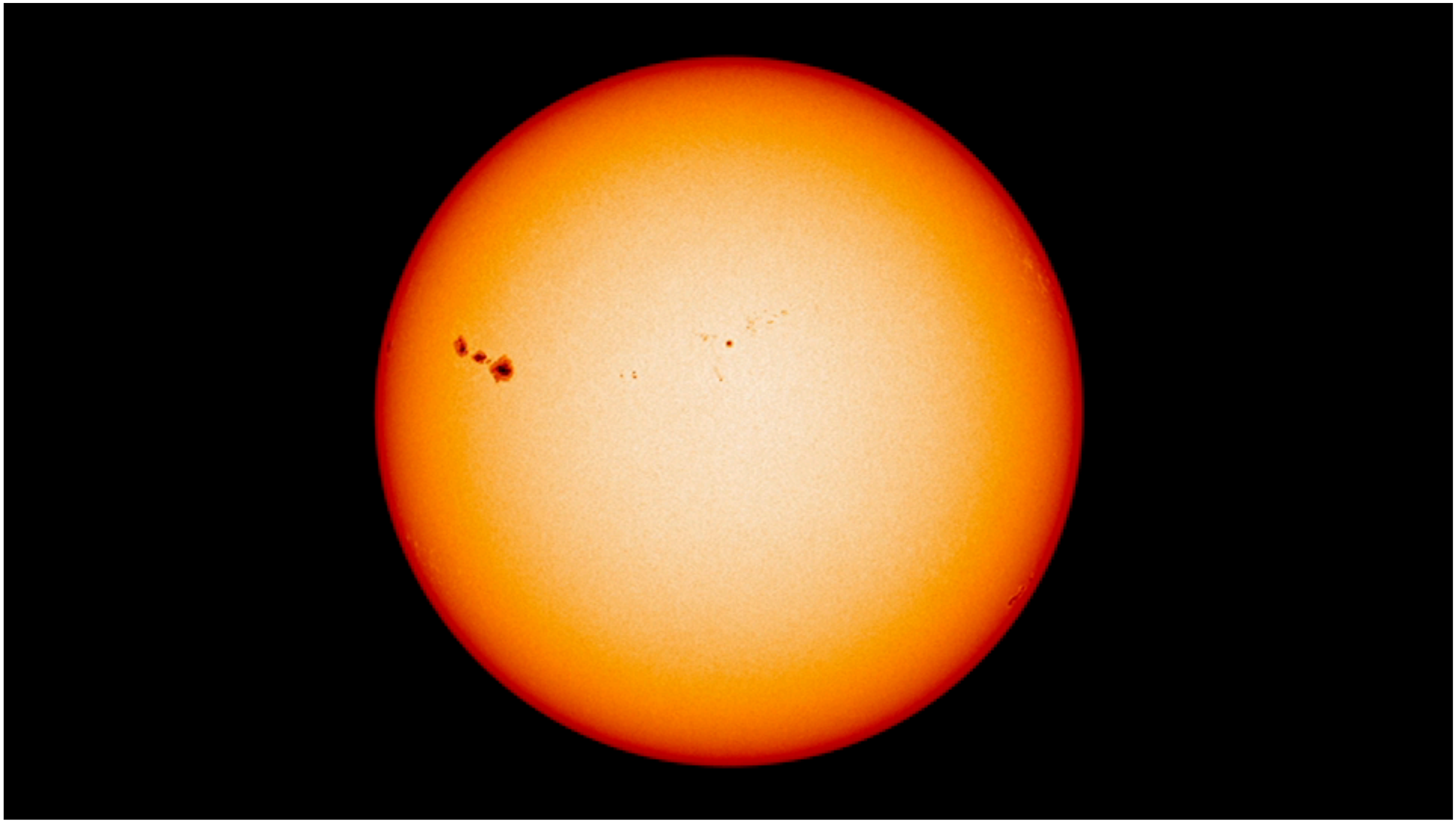




TRANSPARENCY OF OUR ATMOSPHERE



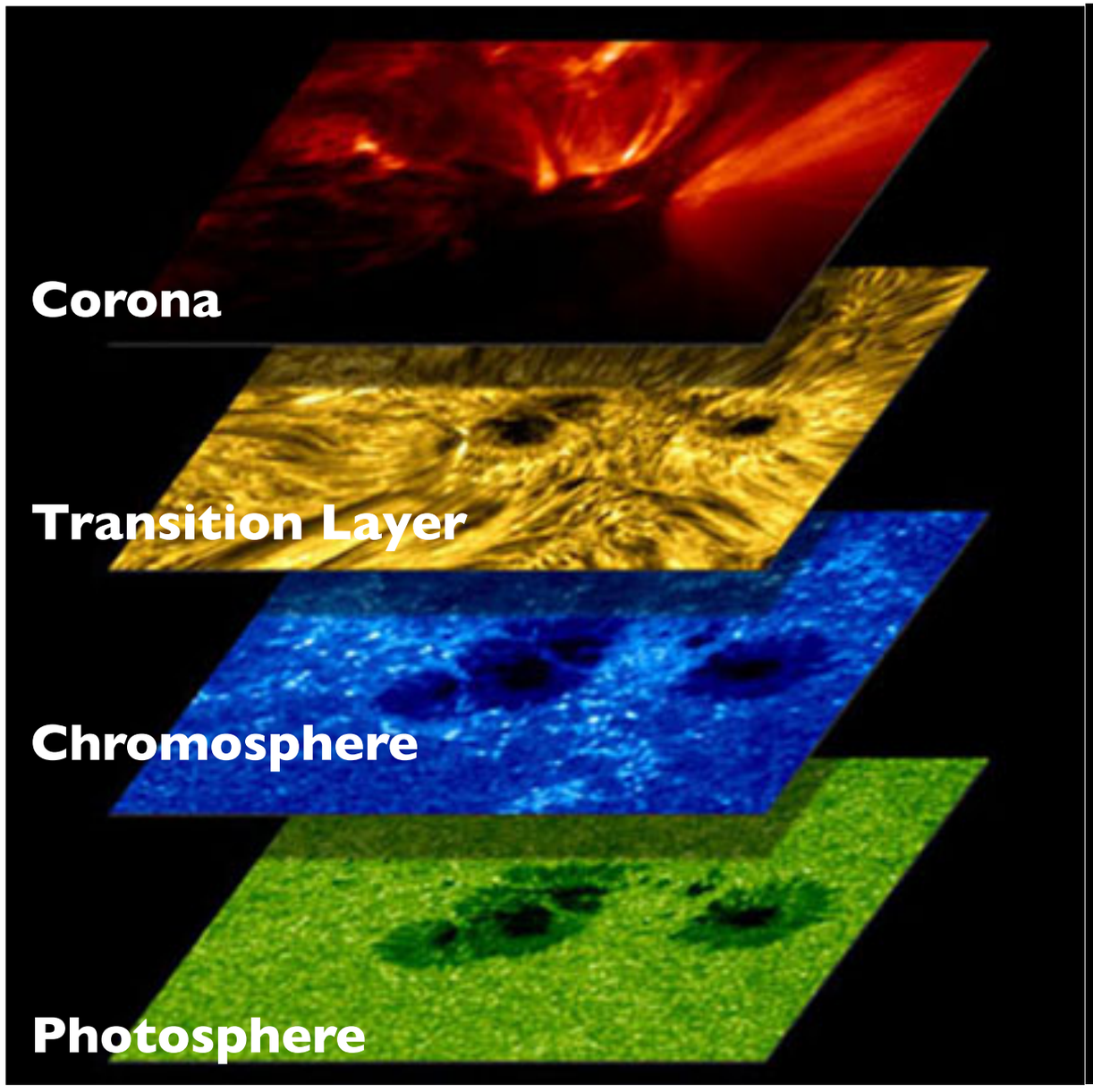
LOOKING AT AN OBJECT IN ALL SORTS OF LIGHT

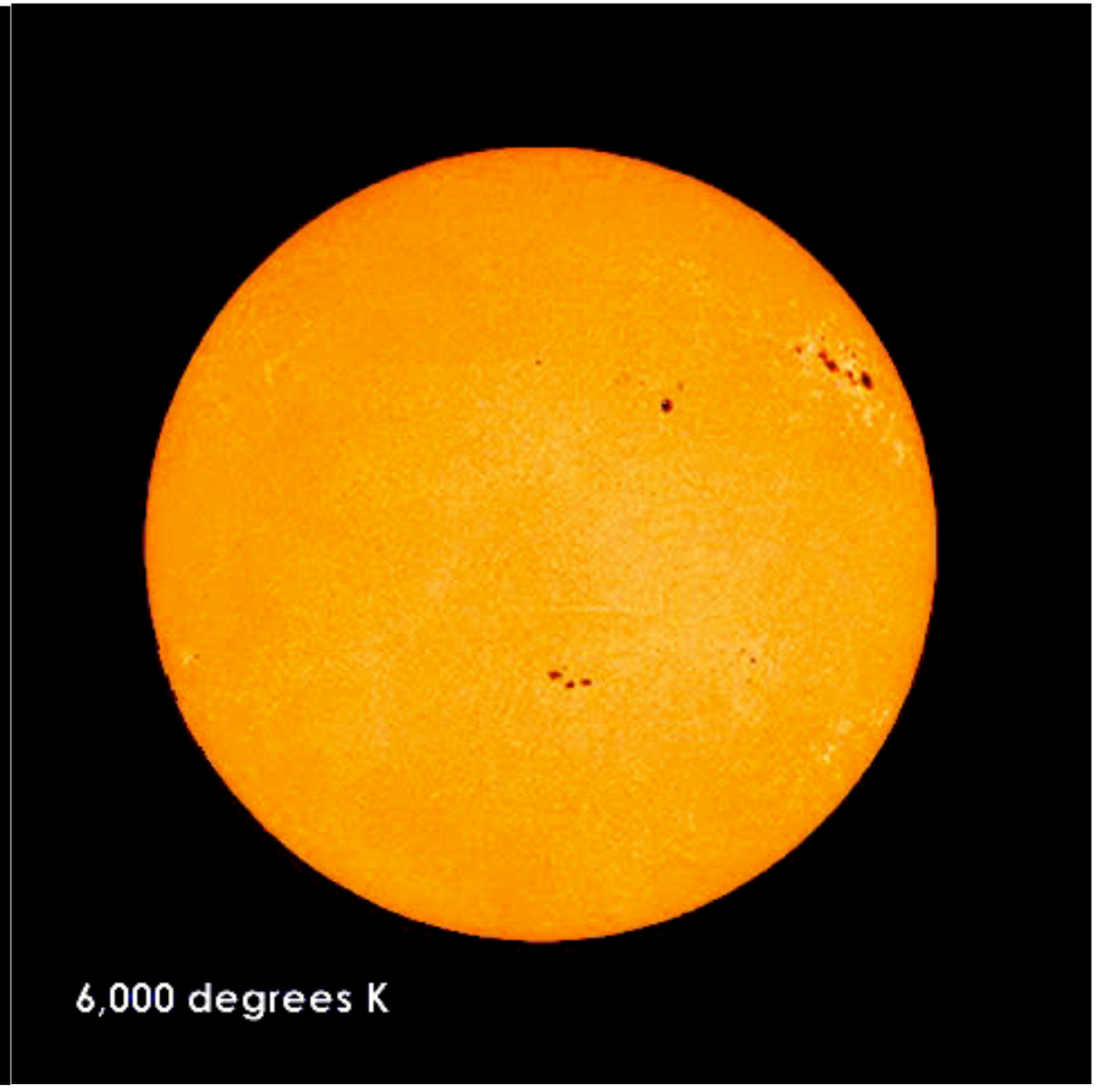


SUNLIGHT

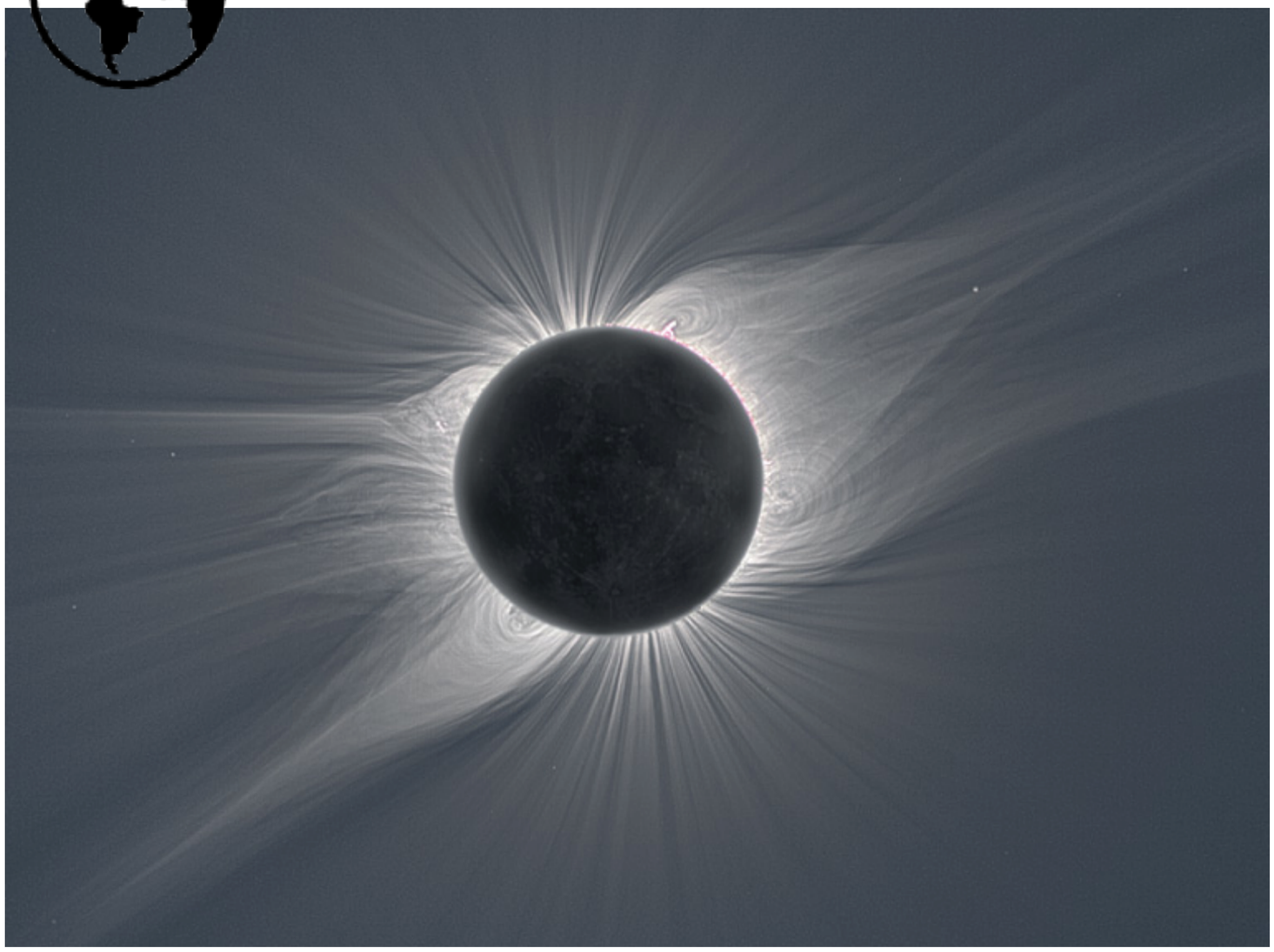
A particular wave length, gives view to a particular layer.

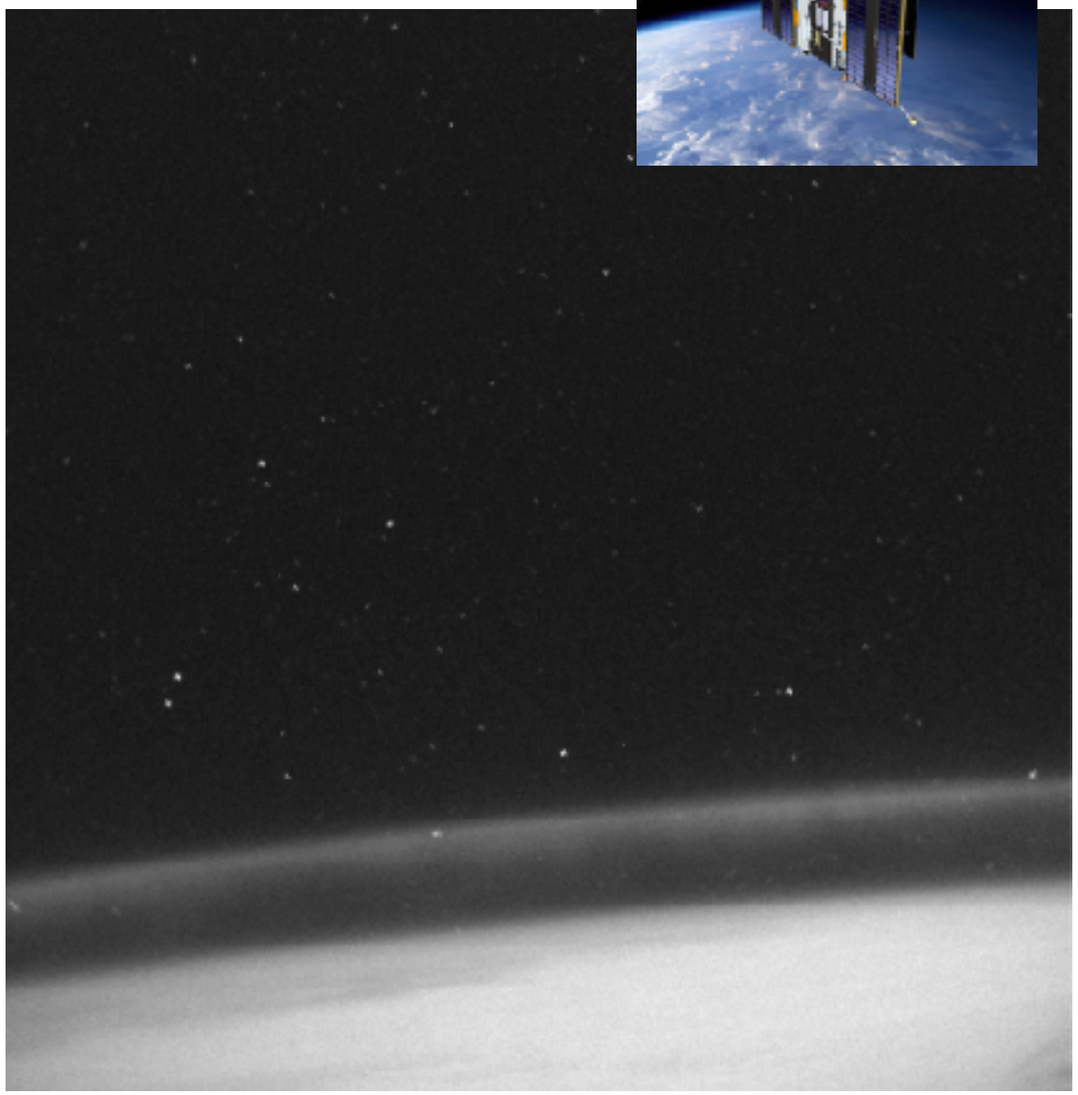
TRANSPARANT OUTER LAYERS - THE SOLAR ATMOSPHERE





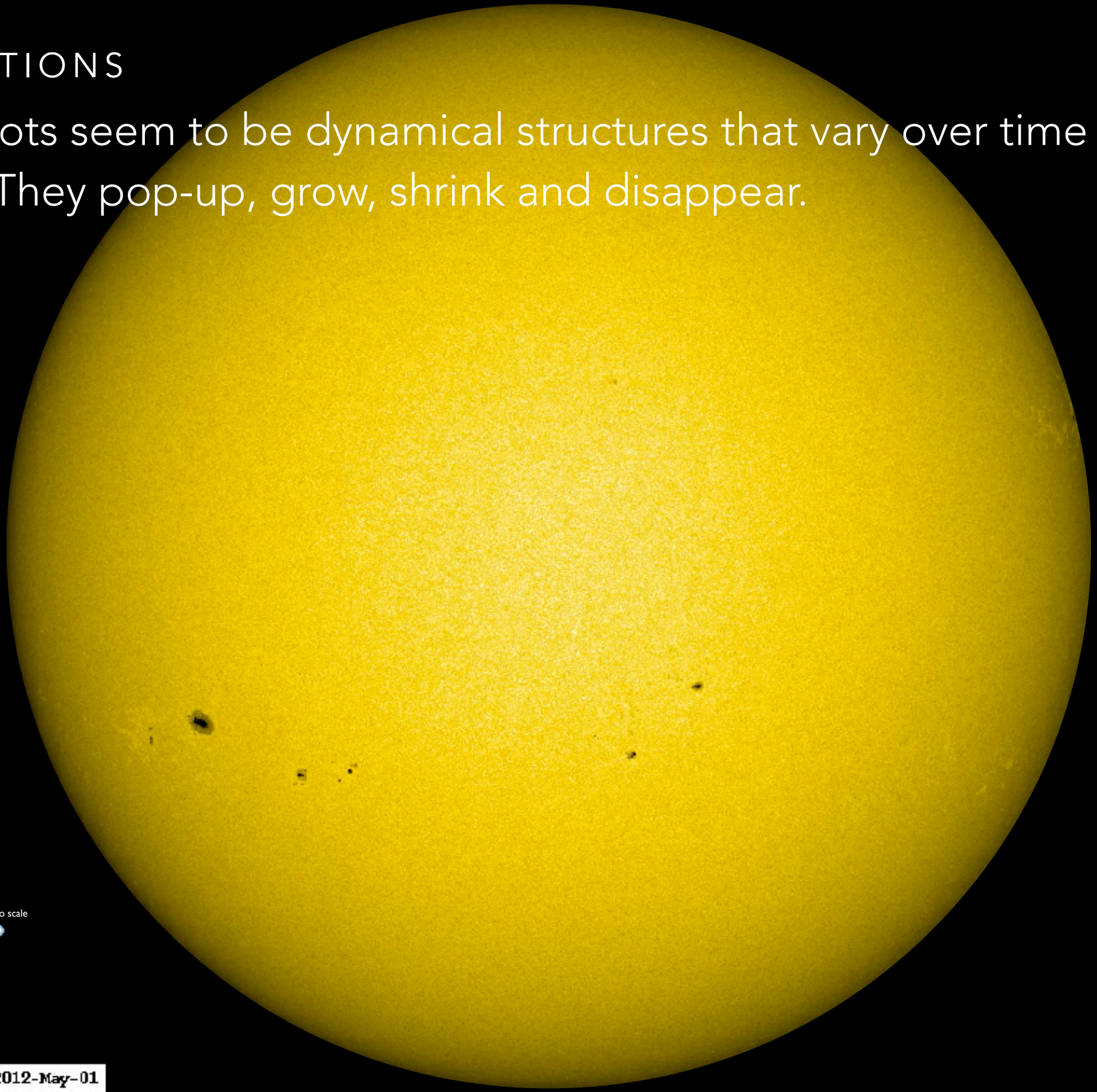
ONZE EERSTE ONTDEKKING





VARIATIONS

Sunspots seem to be dynamical structures that vary over time scales of days. They pop-up, grow, shrink and disappear.

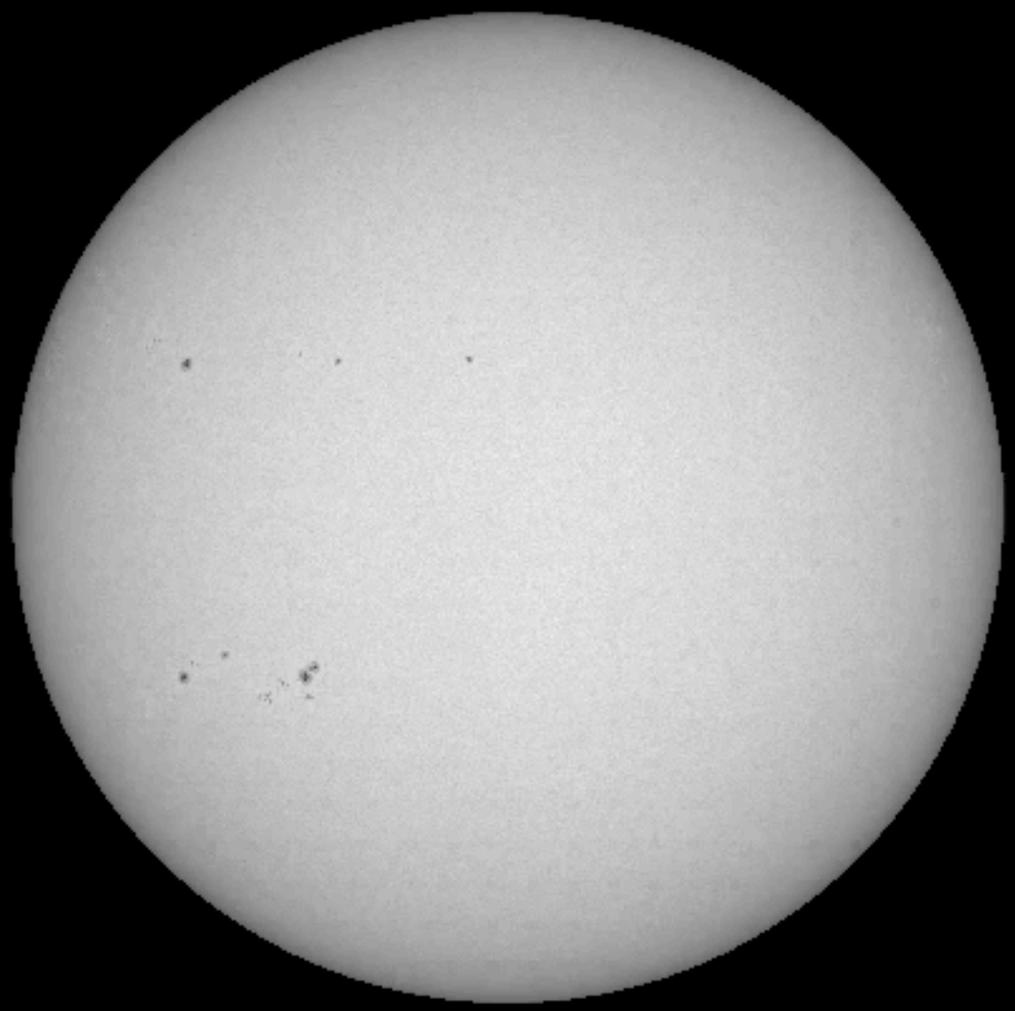


Earth to scale



VARIATIONS

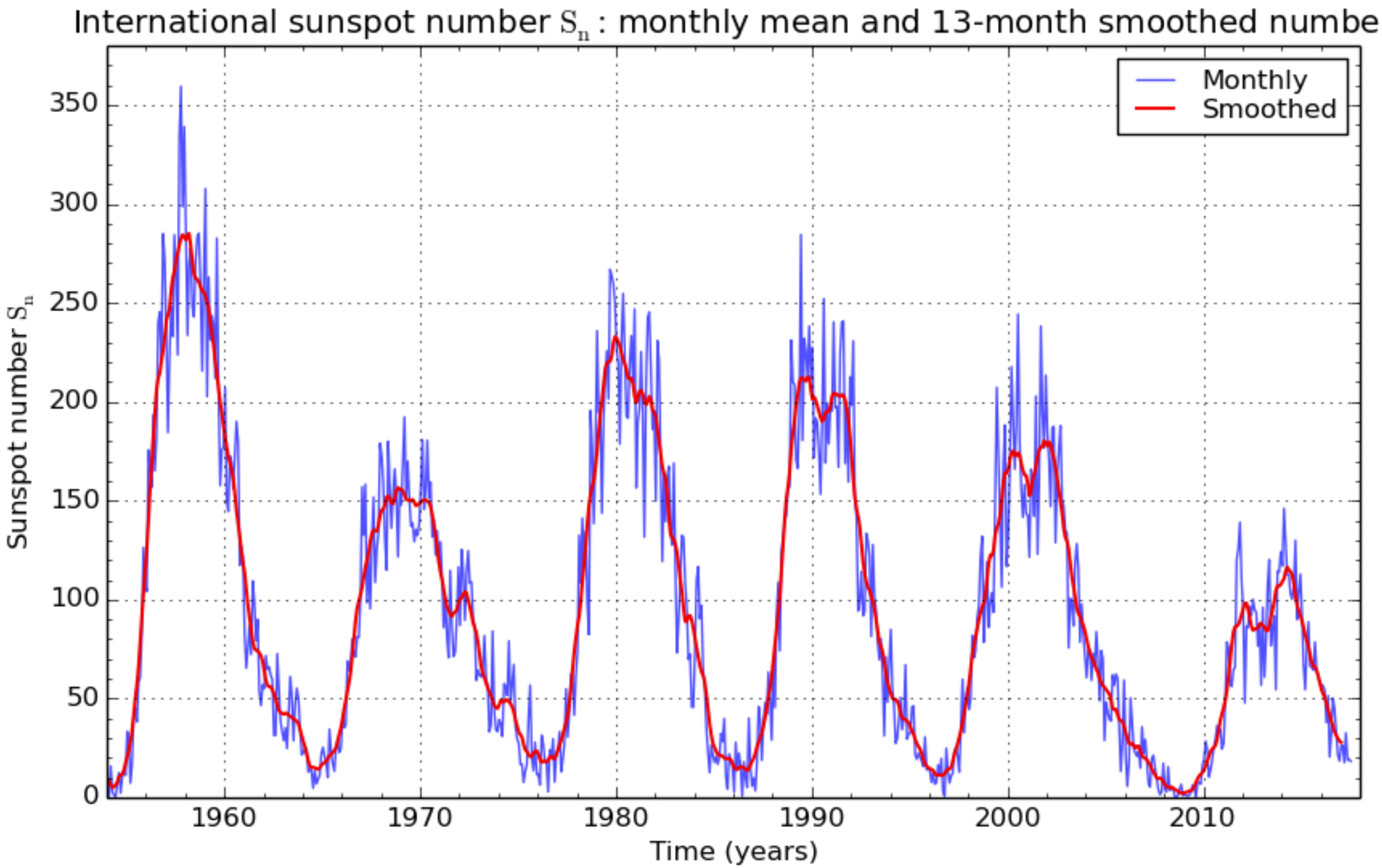
The number sunspots varies over time scales of years.



2011-06-01T23:59:55

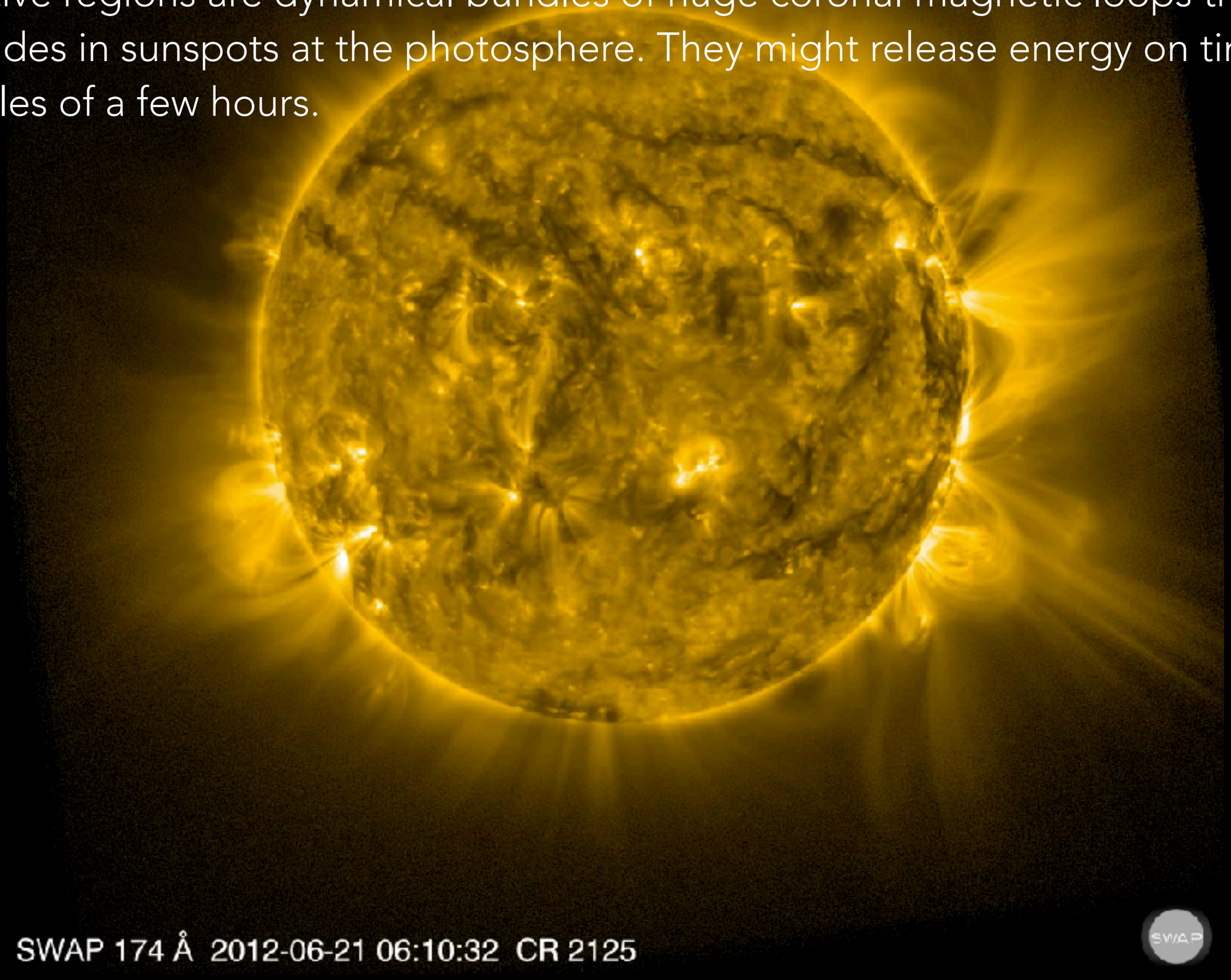
COUNTING SUNSPOTS

Stations worldwide count sunspots and calculate their Wolf number: R = k (10 x Ng + Ns). The WDC calculates the daily ISN.



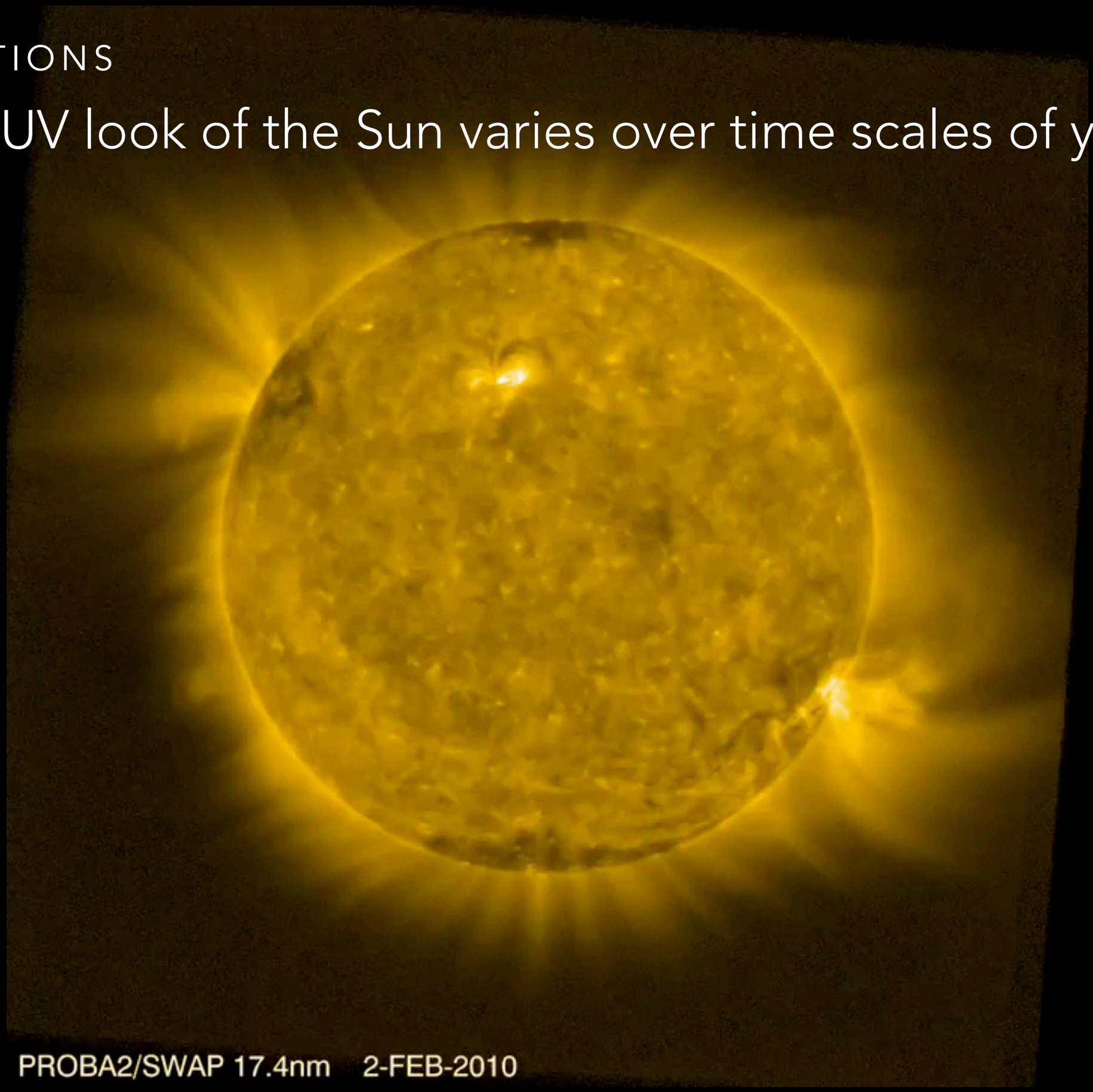
VARIATIONS

Active regions are dynamical bundles of huge coronal magnetic loops that resides in sunspots at the photosphere. They might release energy on time scales of a few hours.



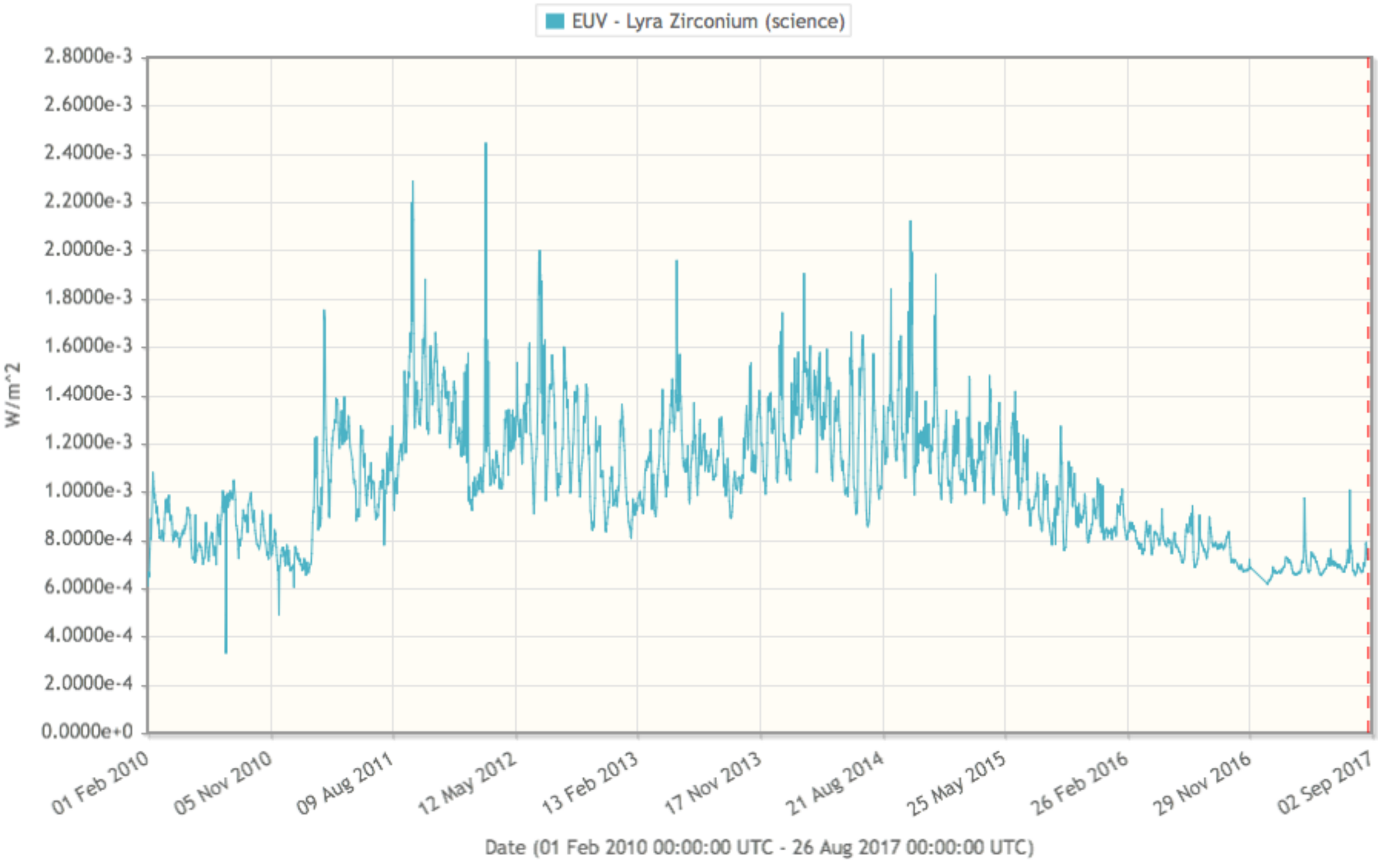
VARIATIONS

The EUV look of the Sun varies over time scales of years.

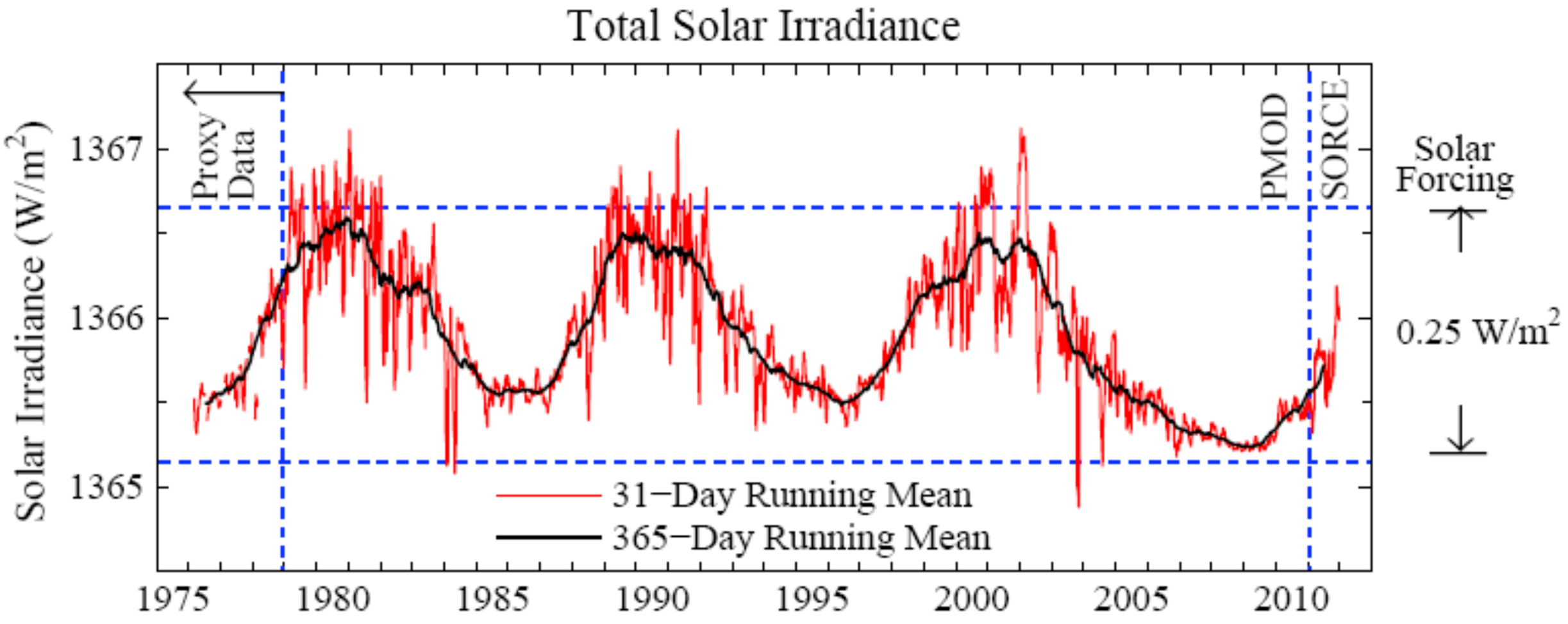


MEASURING 1 EUV WAVELENGTH

The radiometer LYRA onboard PROBA2 measures the EUV radiation in 4 wavelengths. The intensity varies over years.

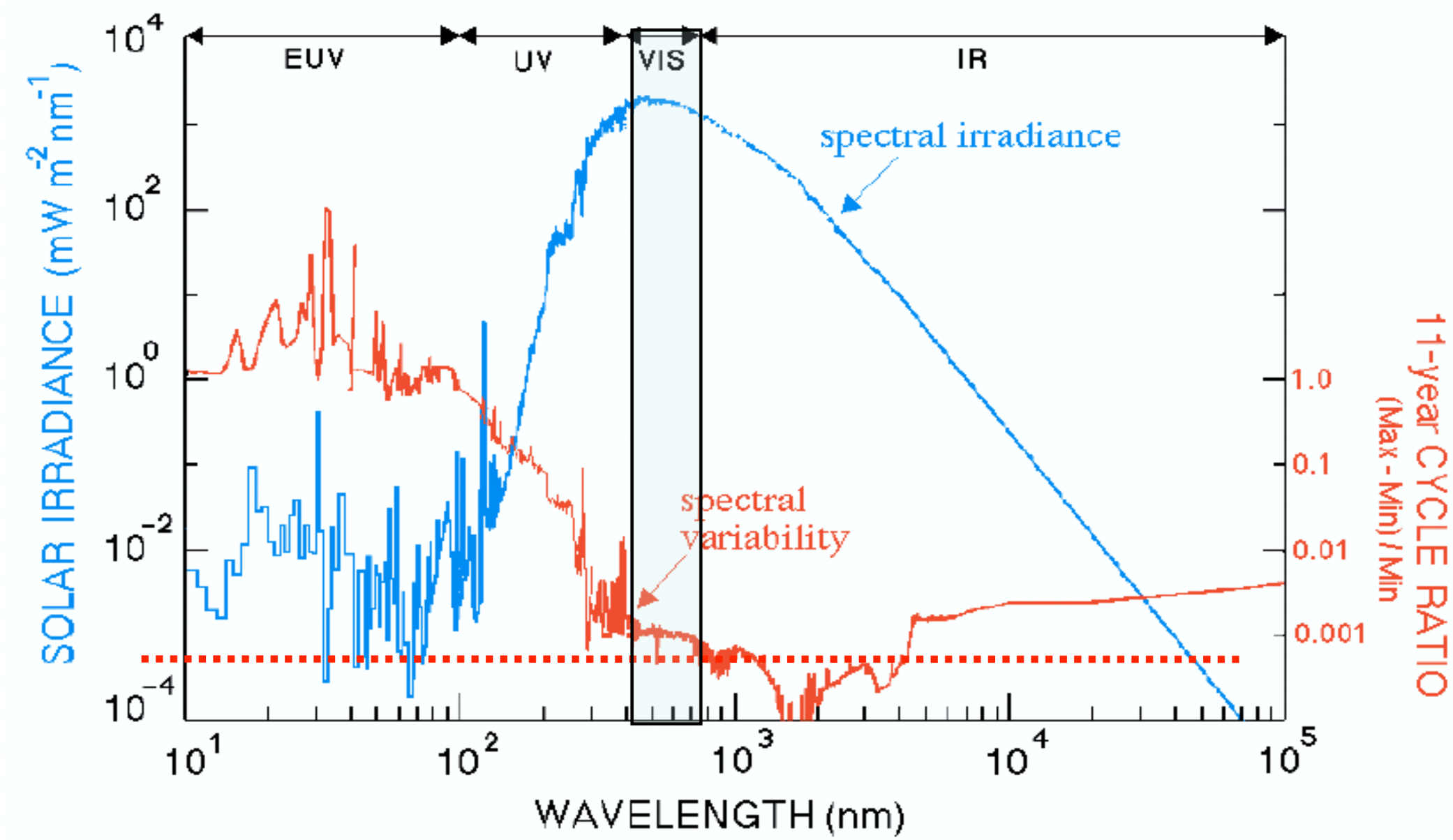


VARIATIONS


Total Solar Irradiance
Solar Irradiance (W/m^2)
1367
1366
1365
Proxy Data
PMOD
SORCE
Solar Forcing
0.25 W/m^2
31−Day Running Mean
365−Day Running Mean
1975
1980
1985
1990
1995
2000
2005
2010

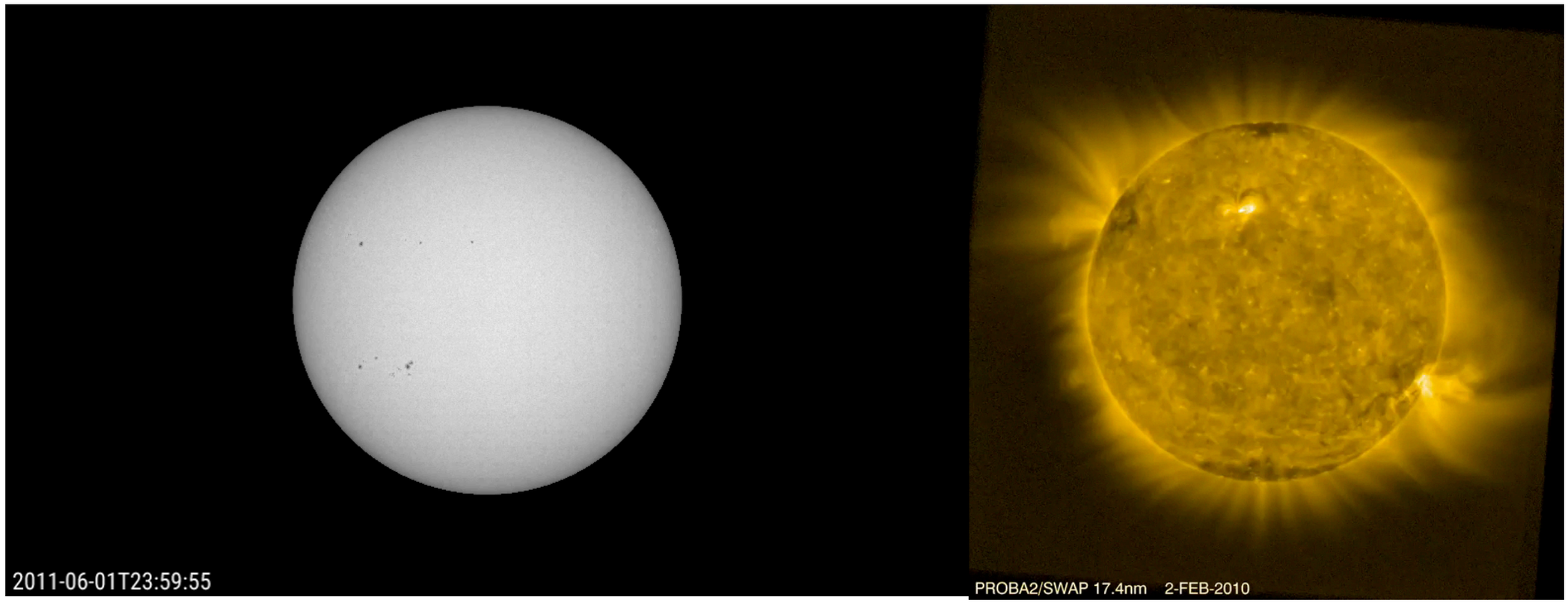
VARIATION PER WAVELENGTH

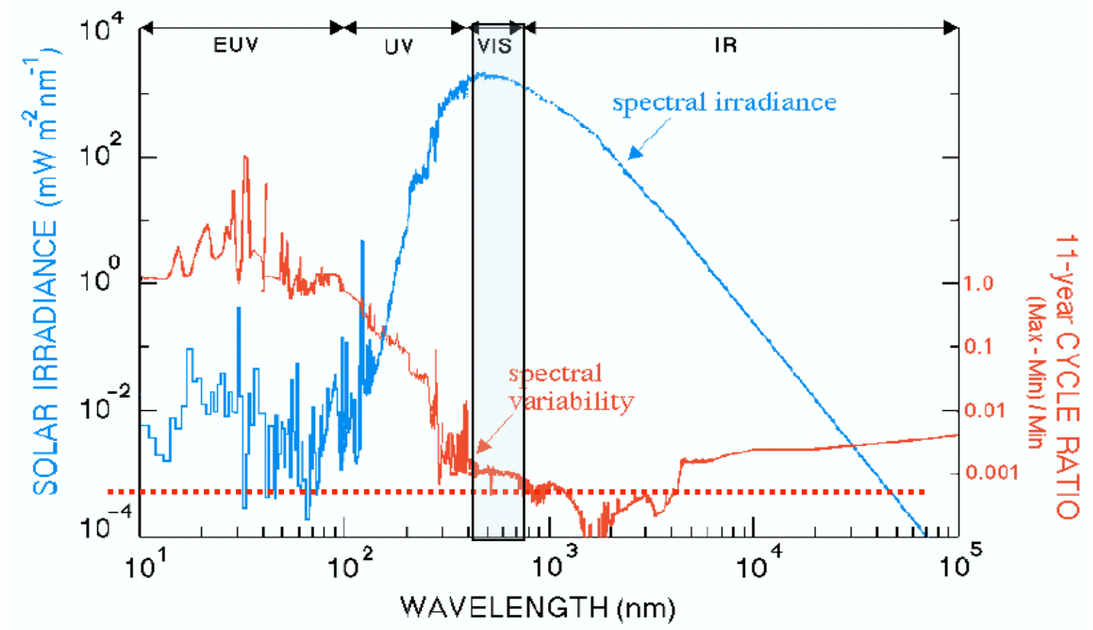
The variation is the strongest is the short wavelengths.



VARIATION PER WAVELENGTH

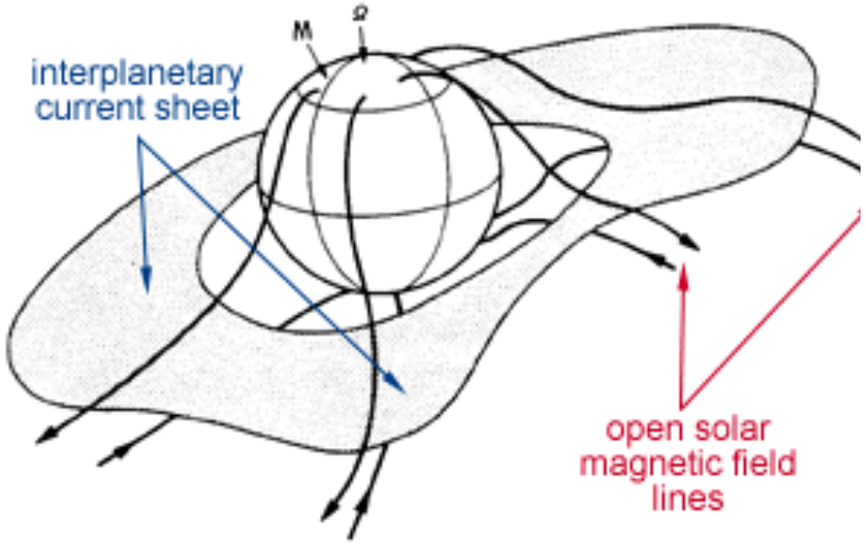
The variation is the strongest is the short wavelengths.

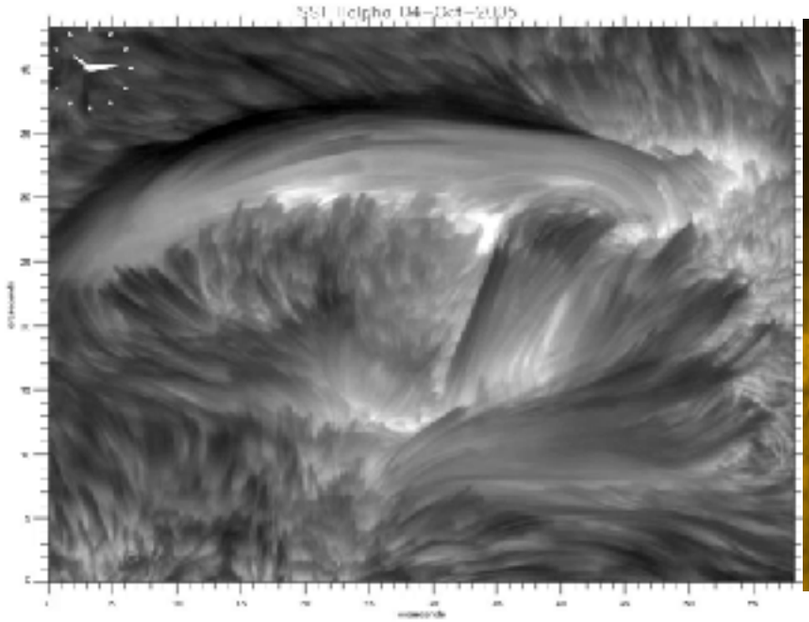


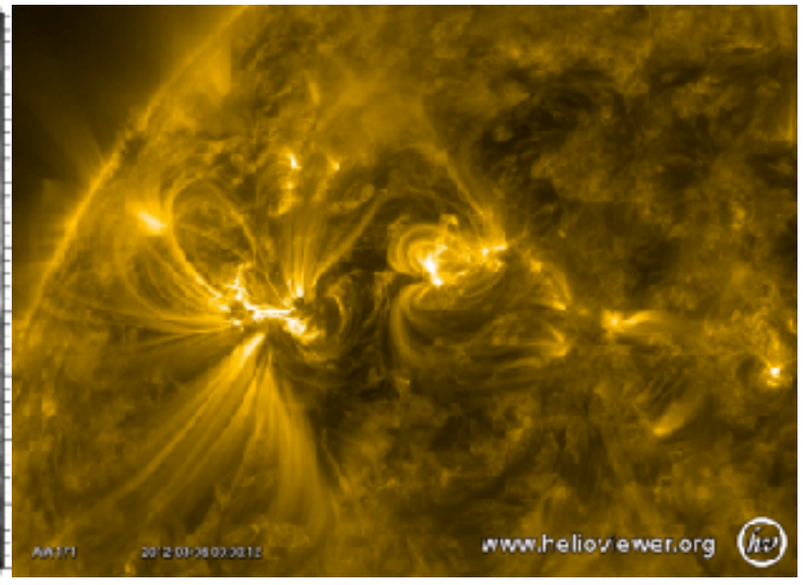


VARIATIONS IN MAGNETISM

Magnetic fields are the driving force behind solar activity. You have different spatial and time scales.

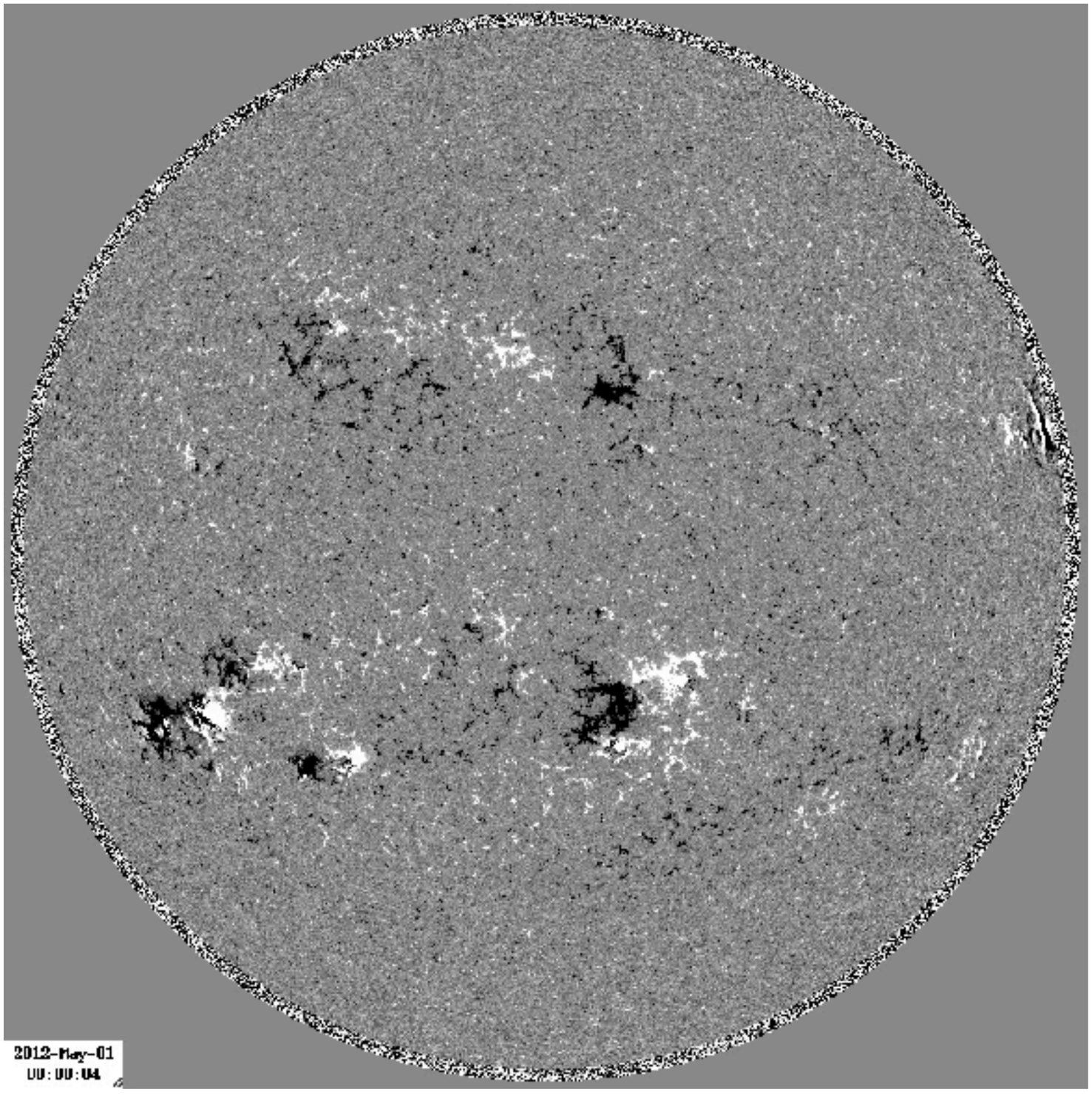






THE PHOTOSPHERIC MAGNETIC FIELD

Similar like sunspots and magnetic coronal loops, the photospheric magnetic field varies over time scale of days.



THE SOLAR ATMOSPHERE CHANGES OVER TIME

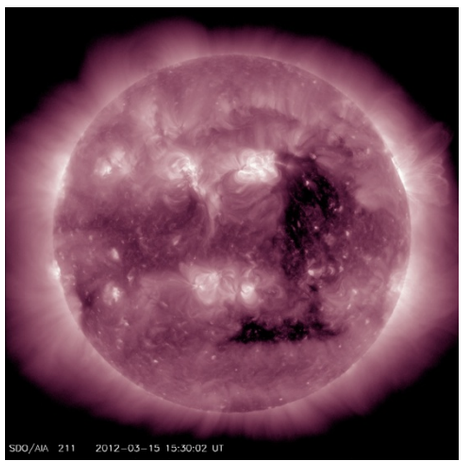


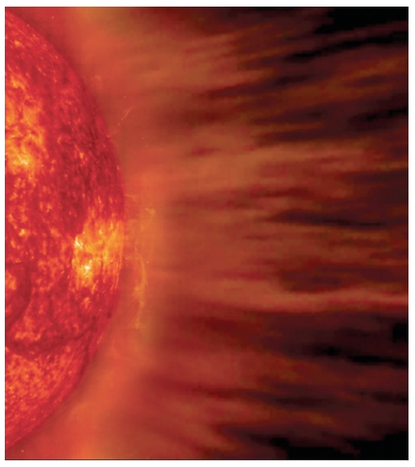
2008 2015 2017

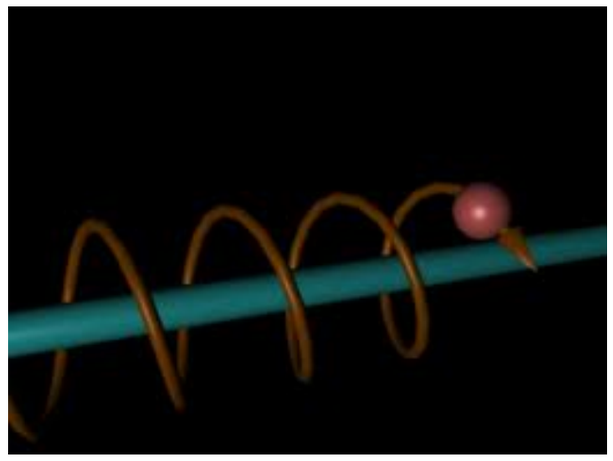
SPACE CLIMATE

The sun looses energy in different forms in a continuous way.

Light	Mass - wind	Particles











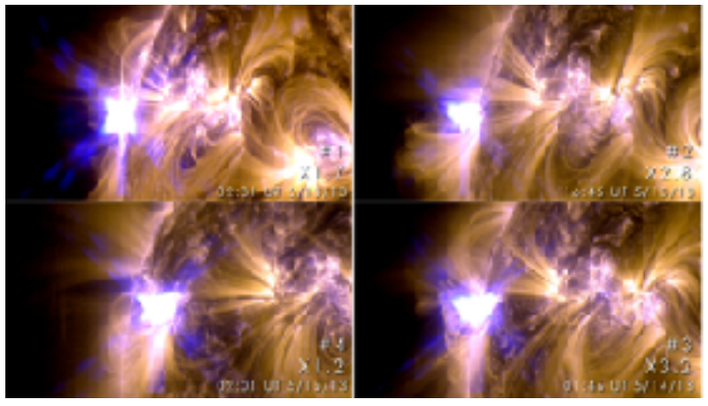




SPACE WEATHER

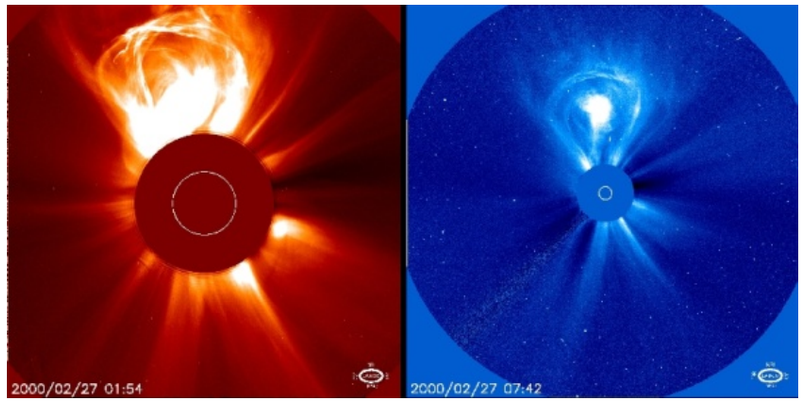
The sun looses energy in different forms in an abrupt, impulsive and brutal way.

Zonnevlammen



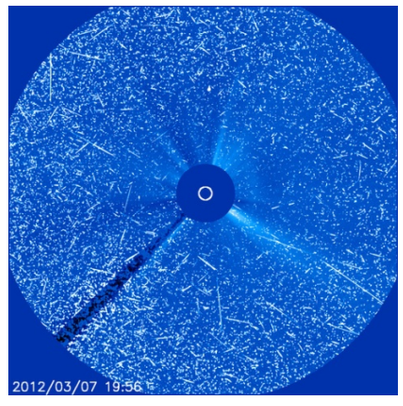


Wolken





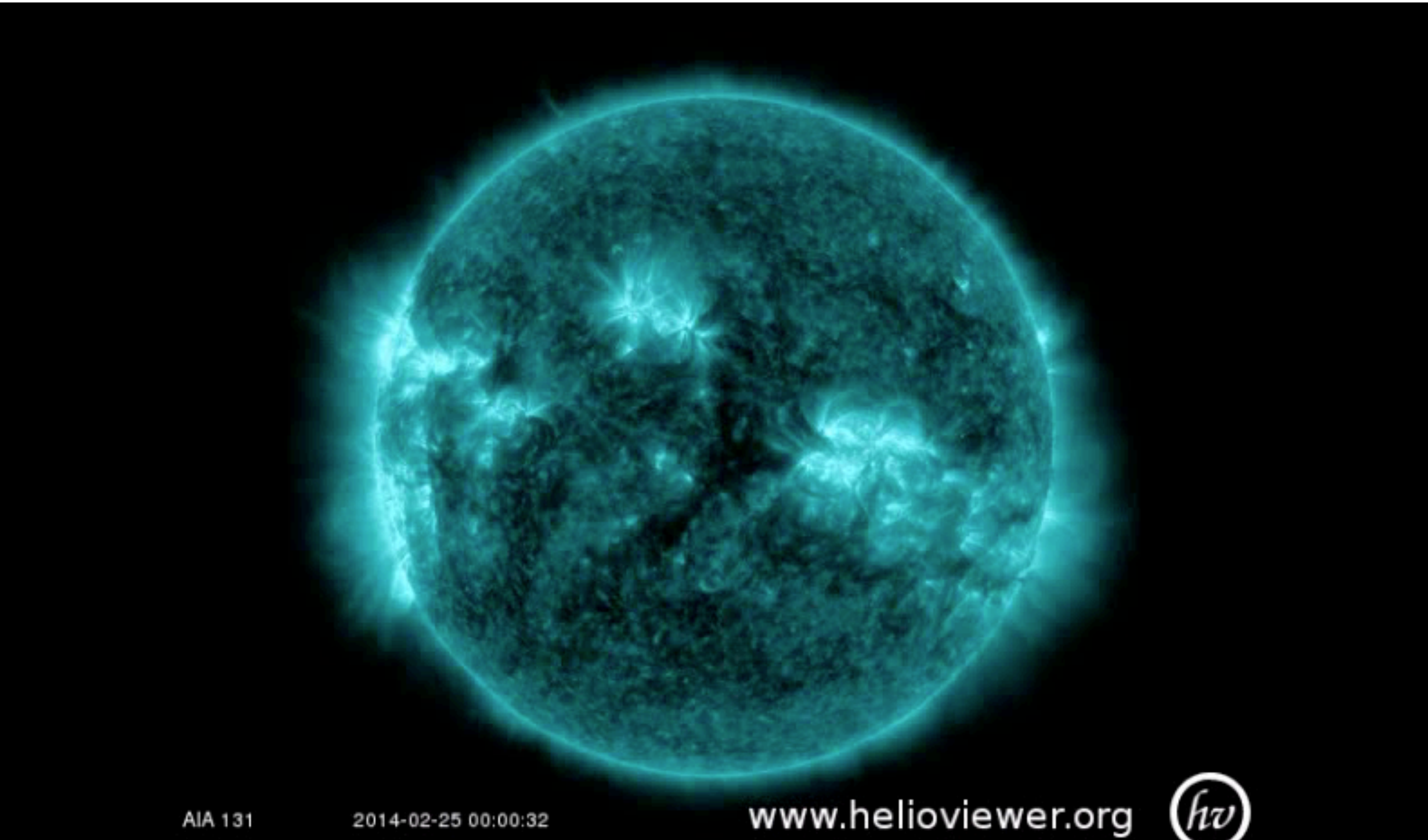
Proton storm

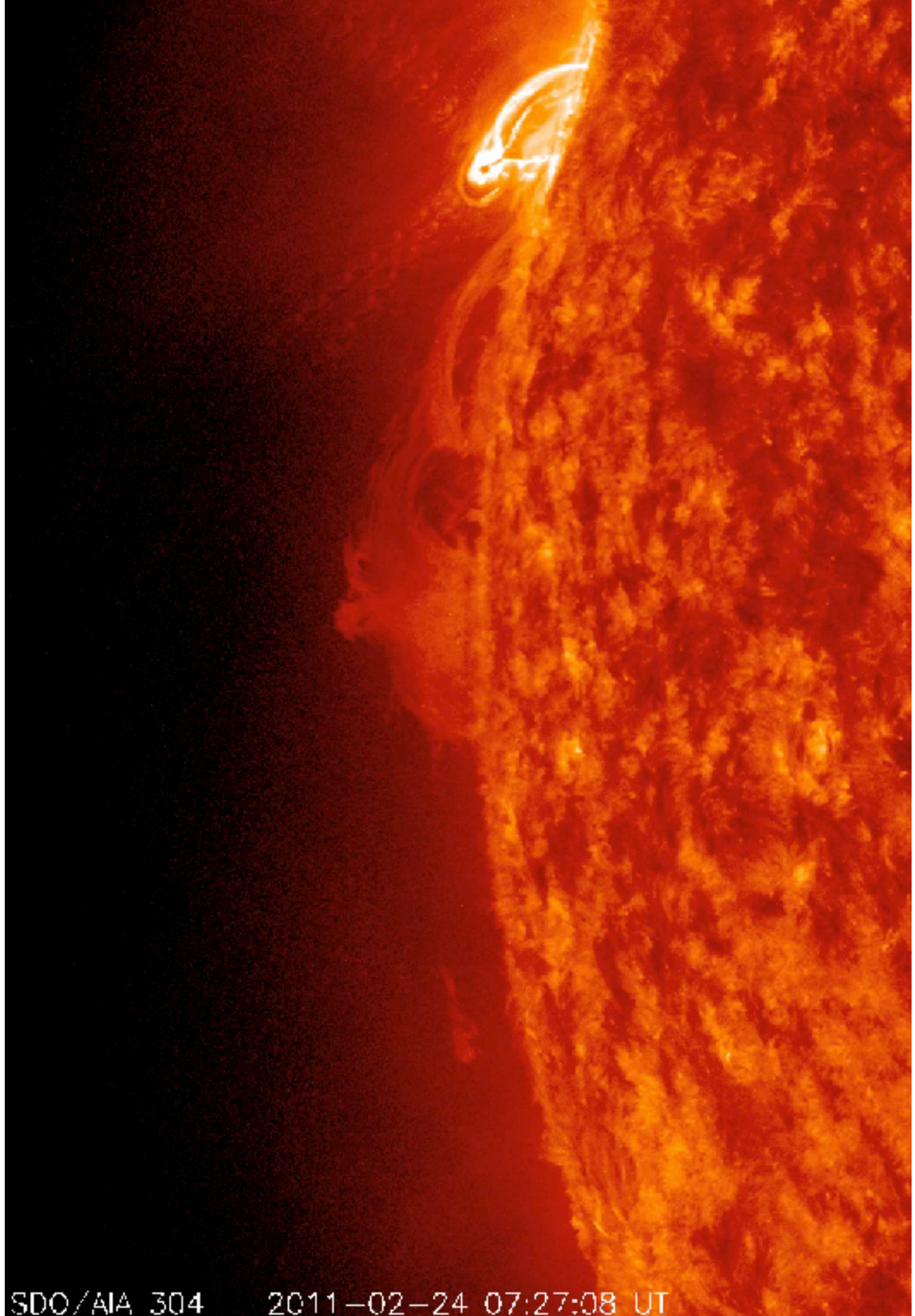




SOLAR STORMS

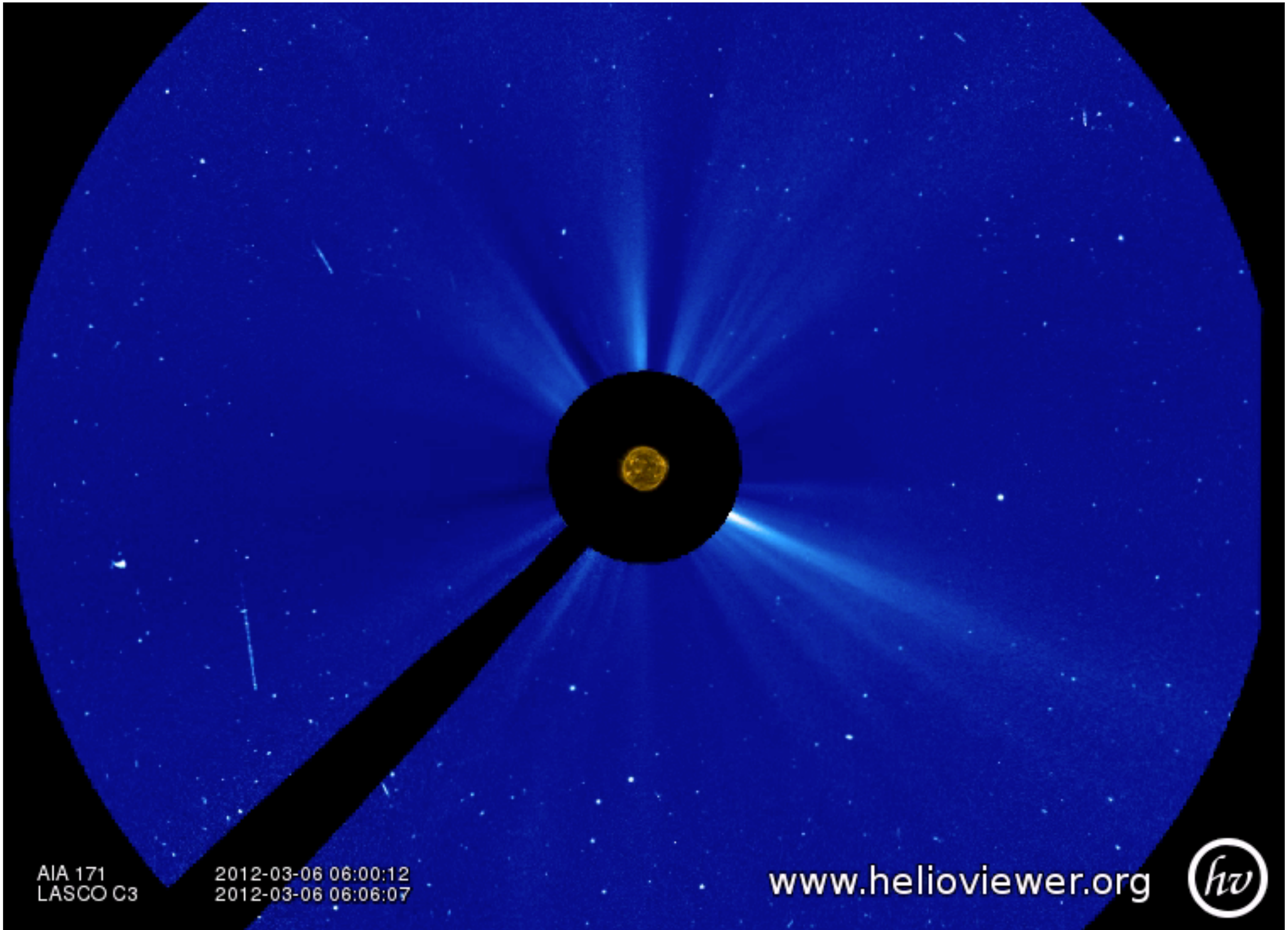
From time to time, we see light flashes. These are solar flares.




SDO/AIA 304 2011-02-24 07:27:08 UT

SOLAR STORMS

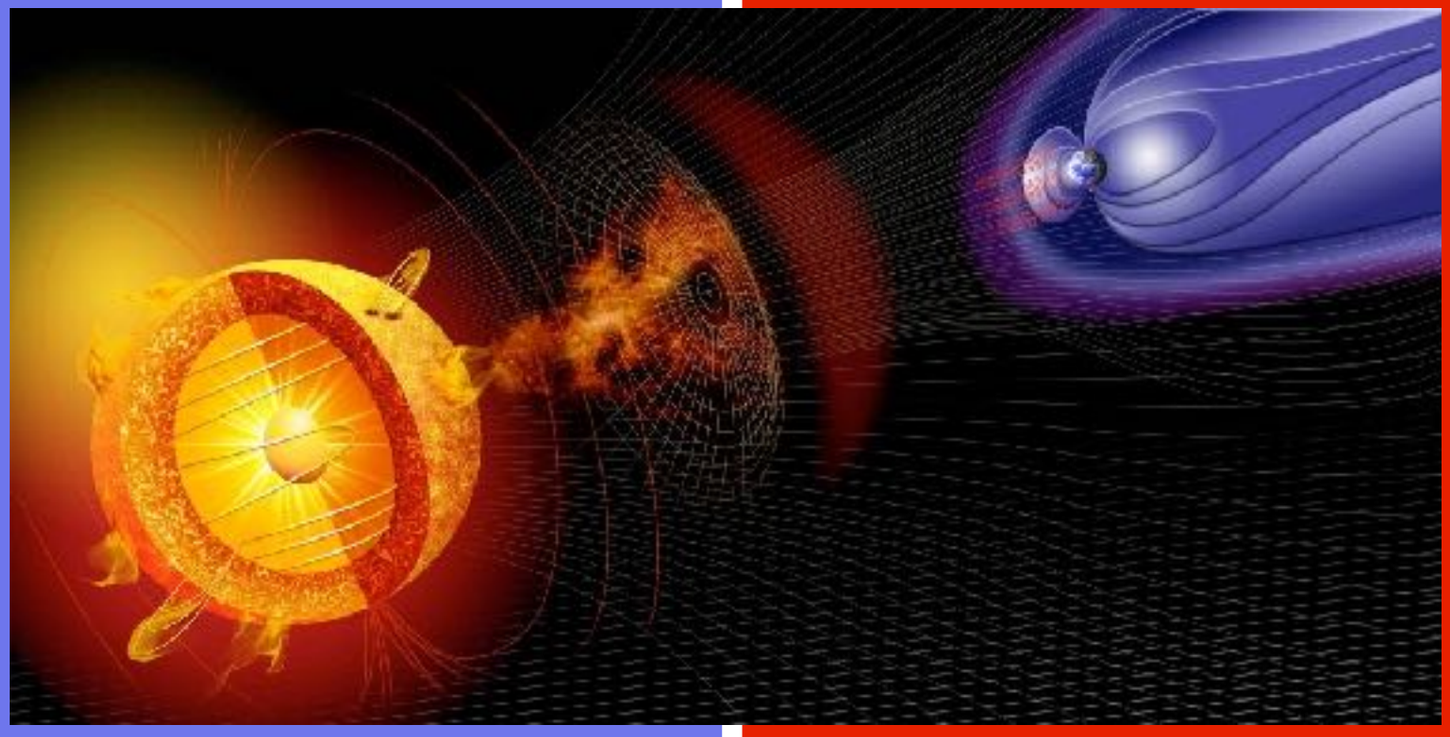
A solar cloud hurling through space. Solar particles hit the coronagraph.





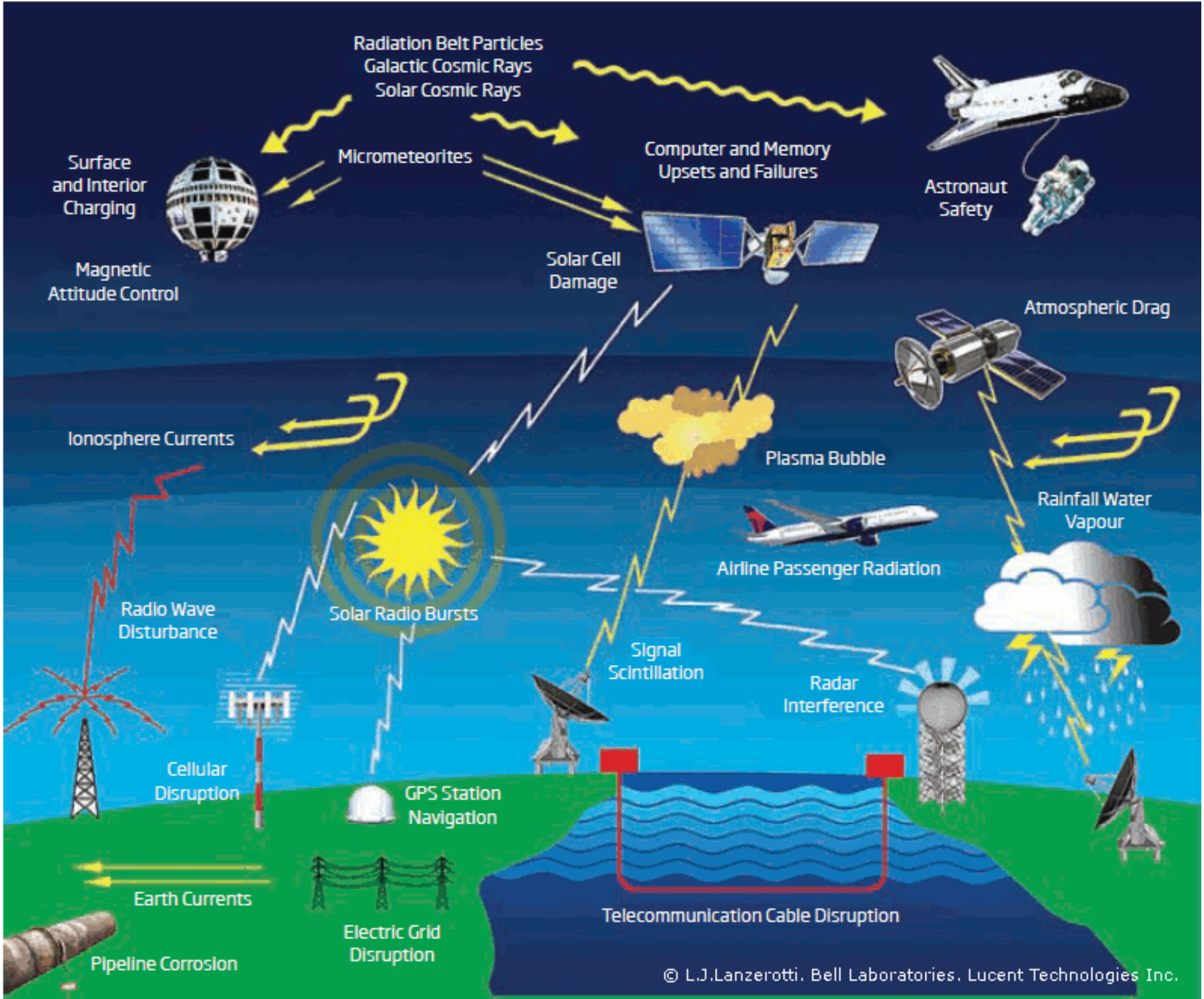
The earth’s atmosphere protects us against solar flares.
The earth’s magnetic shield protects us against solar clouds and particles.










Radiation Belt Particles
Galactic Cosmic Rays
Solar Cosmic Rays
Micrometeorites
Surface and Interior Charging
Magnetic Attitude Control
Computer and Memory Upsets and Failures
Solar Cell Damage
Astronaut Safety
Atmospheric Drag
Ionosphere Currents
Plasma Bubble
Rainfall Water Vapour
Airline Passenger Radiation
Radio Wave Disturbance
Solar Radio Bursts
Signal Scintillation
Radar Interference
Cellular Disruption
GPS Station Navigation
Earth Currents
Electric Grid Disruption
Telecommunication Cable Disruption
Pipeline Corrosion
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Studie van de zonneatmosfeer



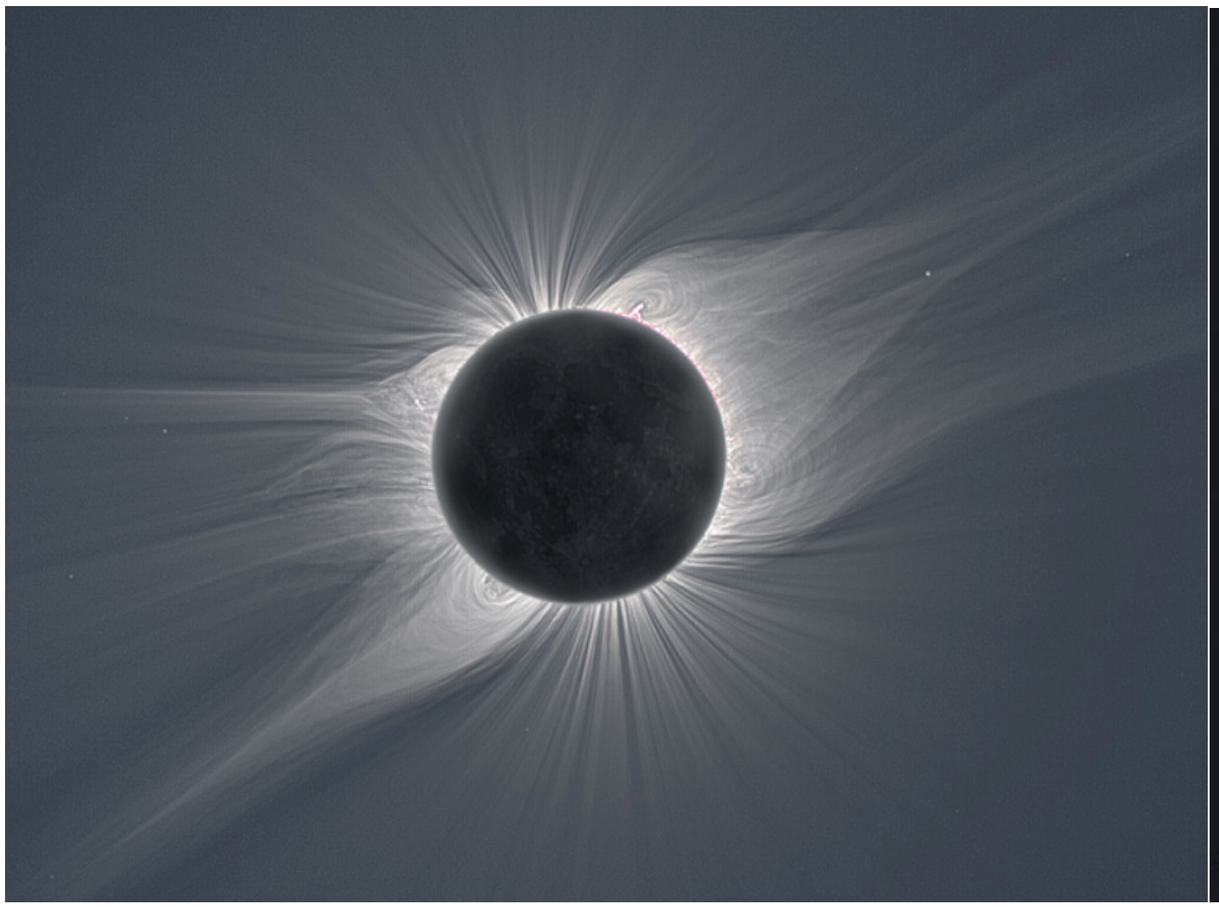
Image: Siberia 20080801
J.M.P., W. G. Wagner and H. Druckmüllerová

De atmosfeer van de zon is ongelooflijk groot.



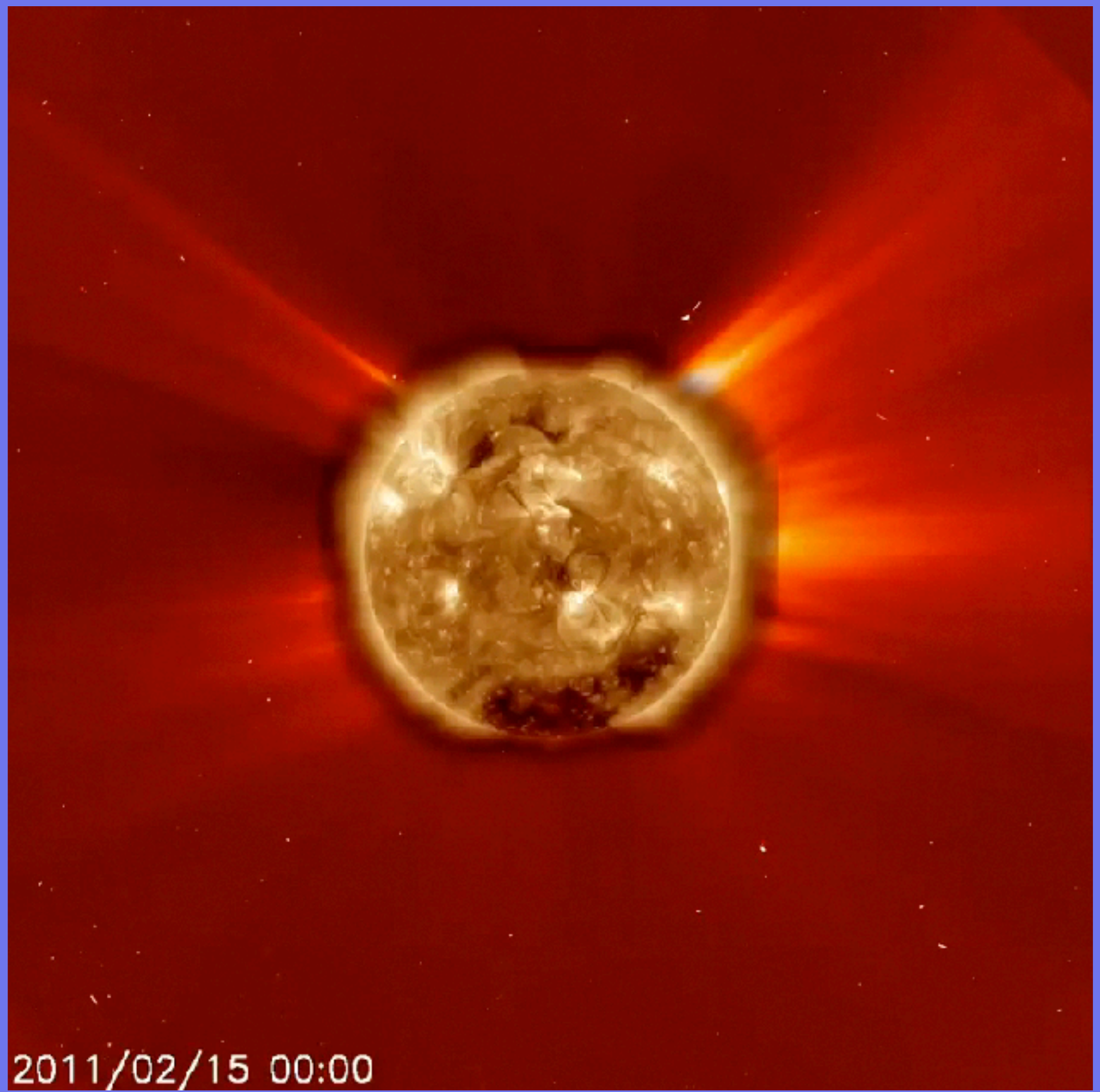
Image: Siberia 20080801
J.M.P., W. G. Wagner and H. Druckmüllerová

De atmosfeer van de zon is ongelooflijk interessant.



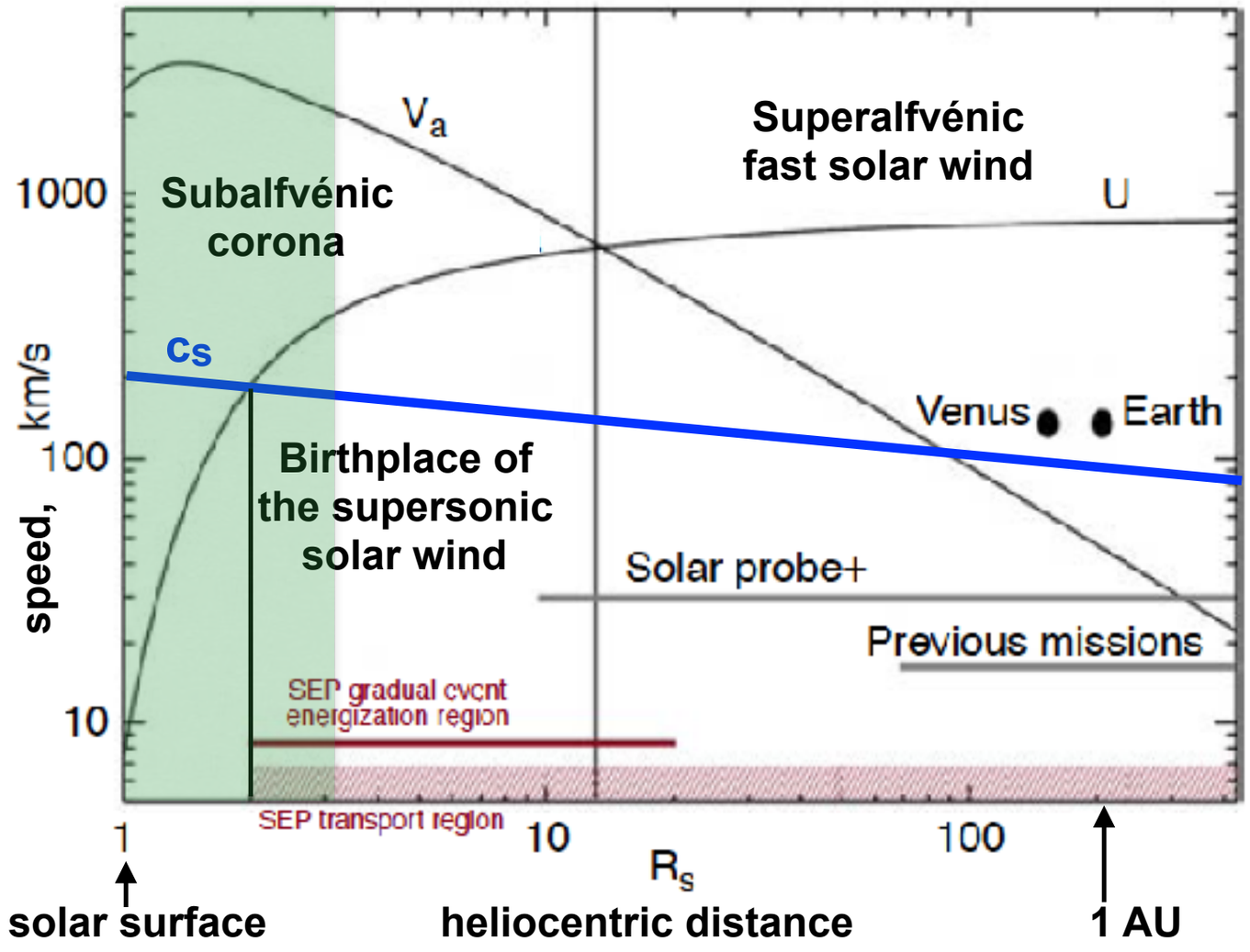


HALO CME



INNER SOLAR CORONA

That's the place where it all happens: the solar wind is generated, CME's are accelerated …



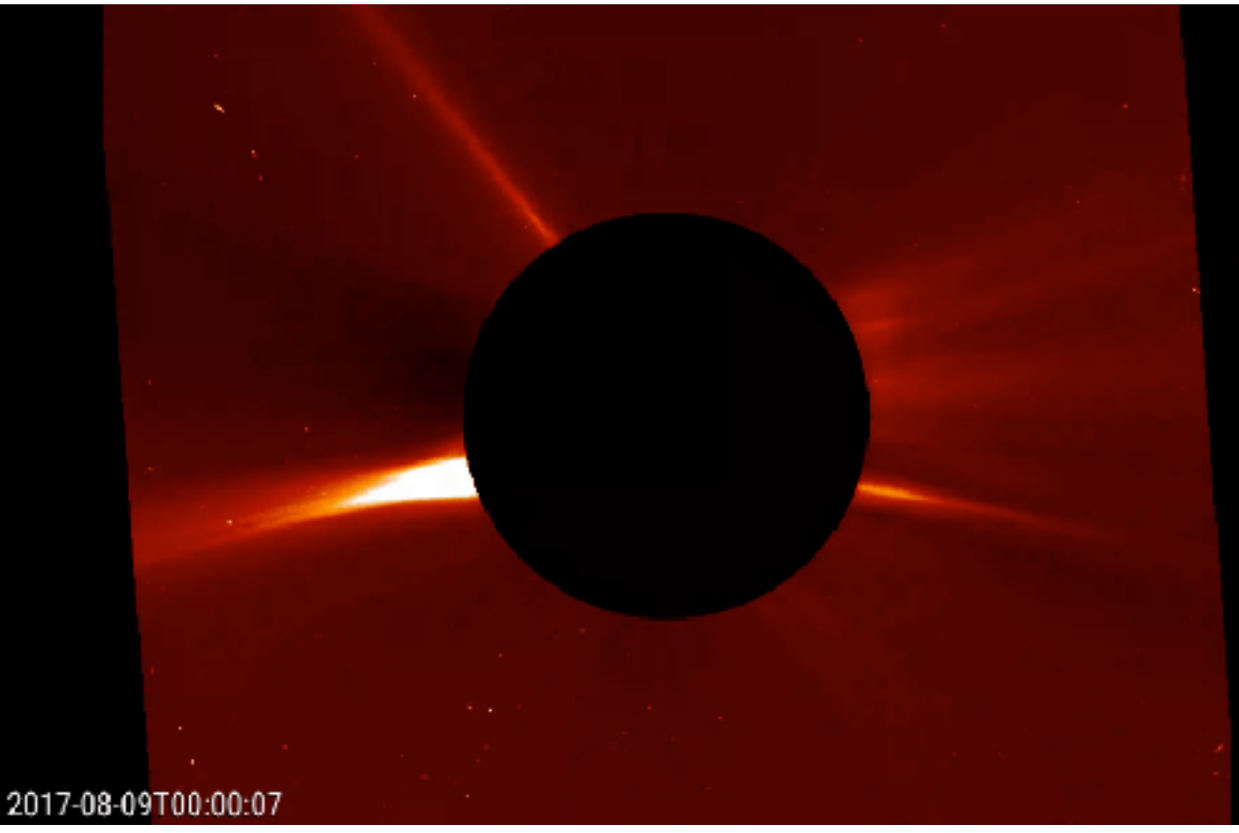
OBSERVATIONAL GAP

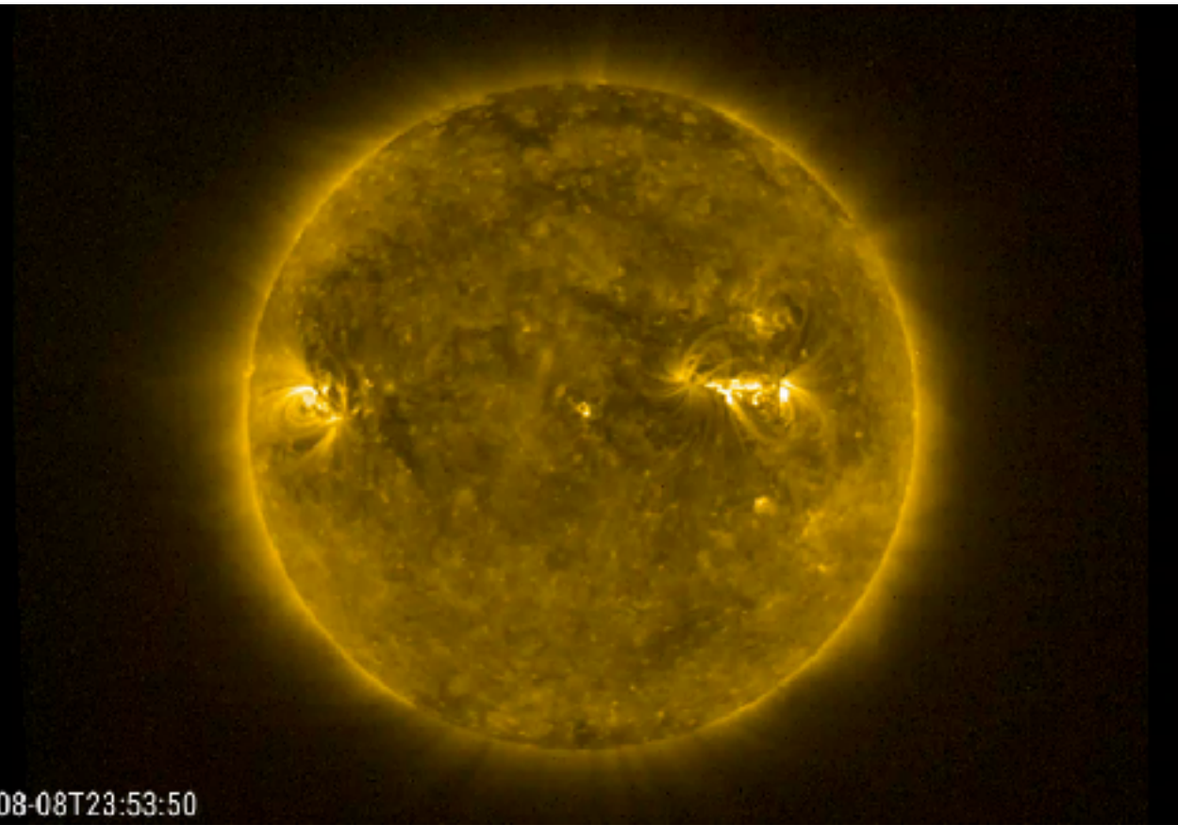
SWAP 174 2012-07-08 23:02:04
LASCO C2 2012-07-08 23:12:06
AIA 304 2012-07-08 23:01:32

www.helioviewer.org

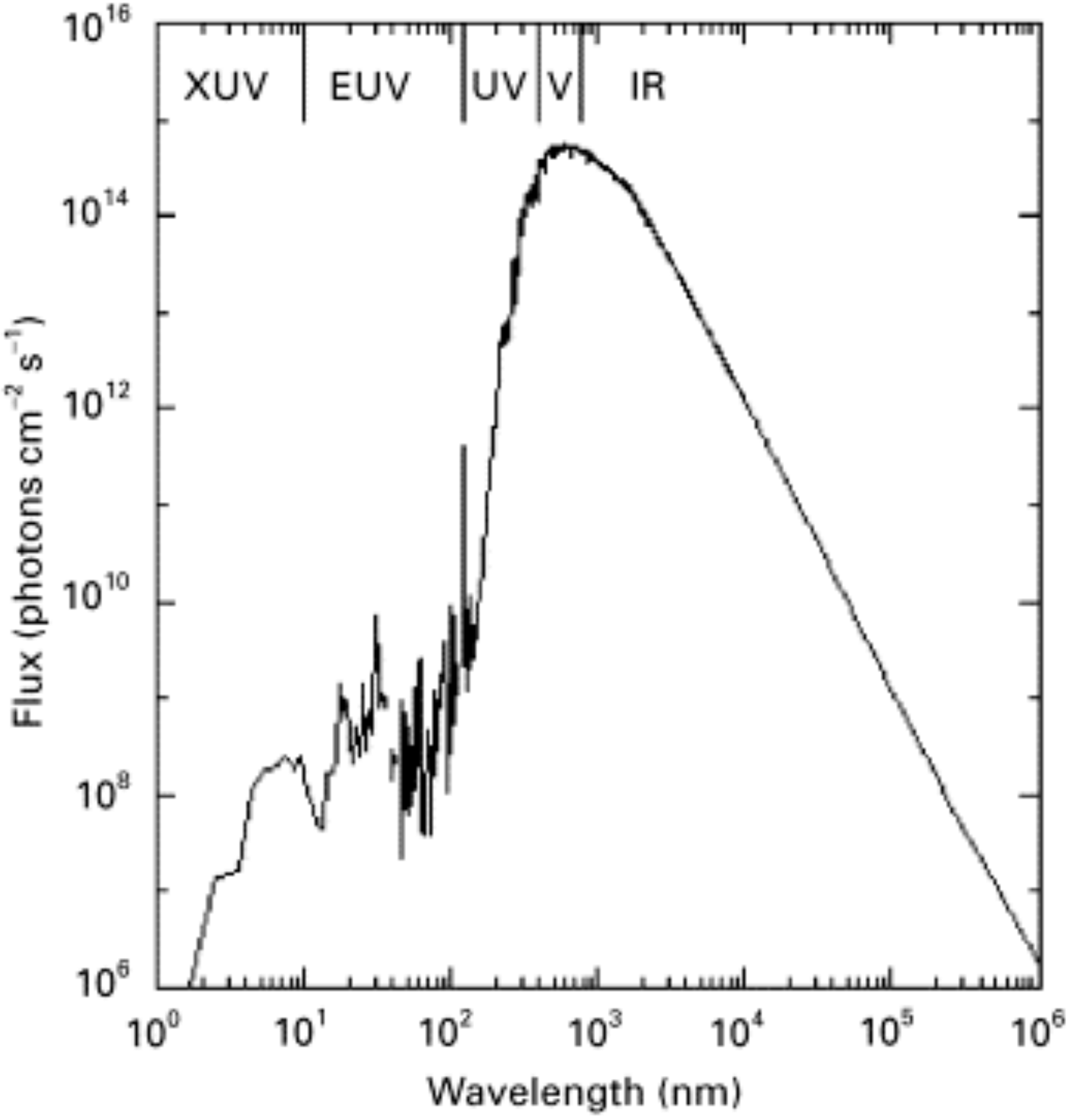
OBSERVATIONAL GAP

To close the gap, we could use coronagraphs and EUV imagers. Both show the corona. But how they work, is completely different.

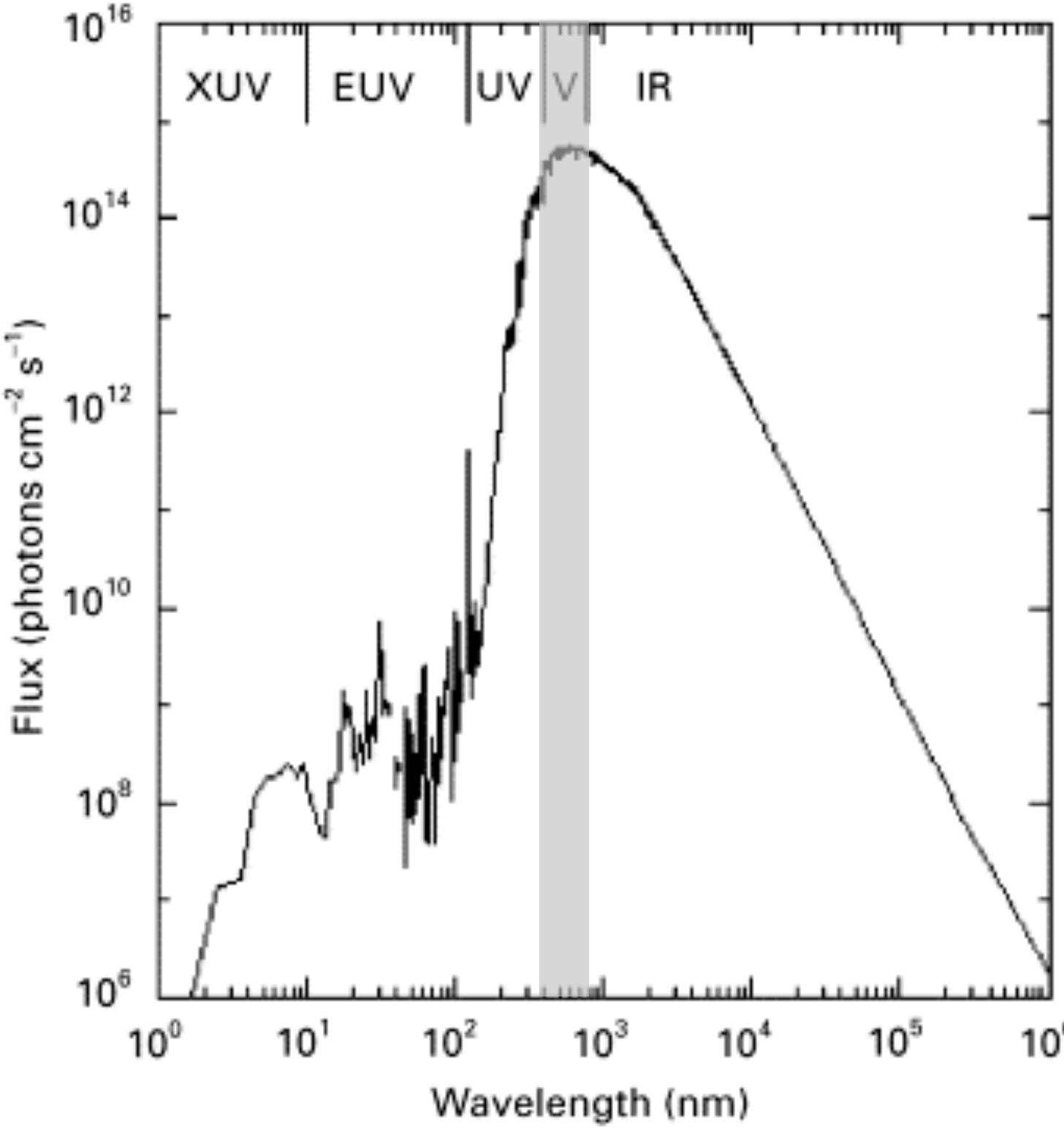


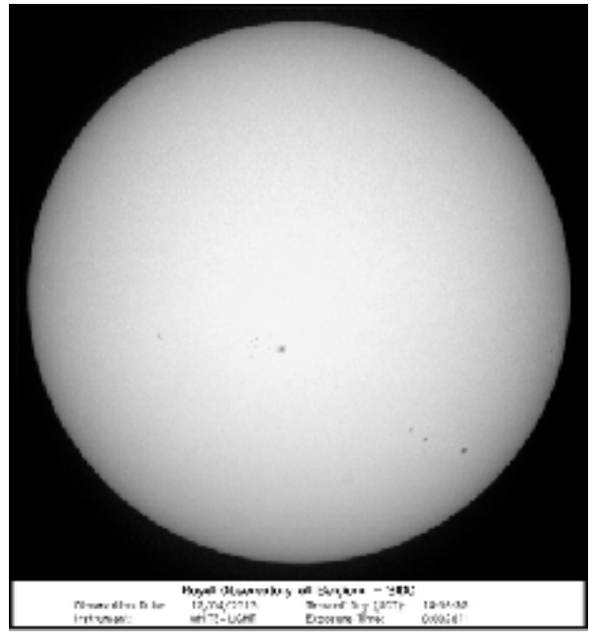


EUV imagers



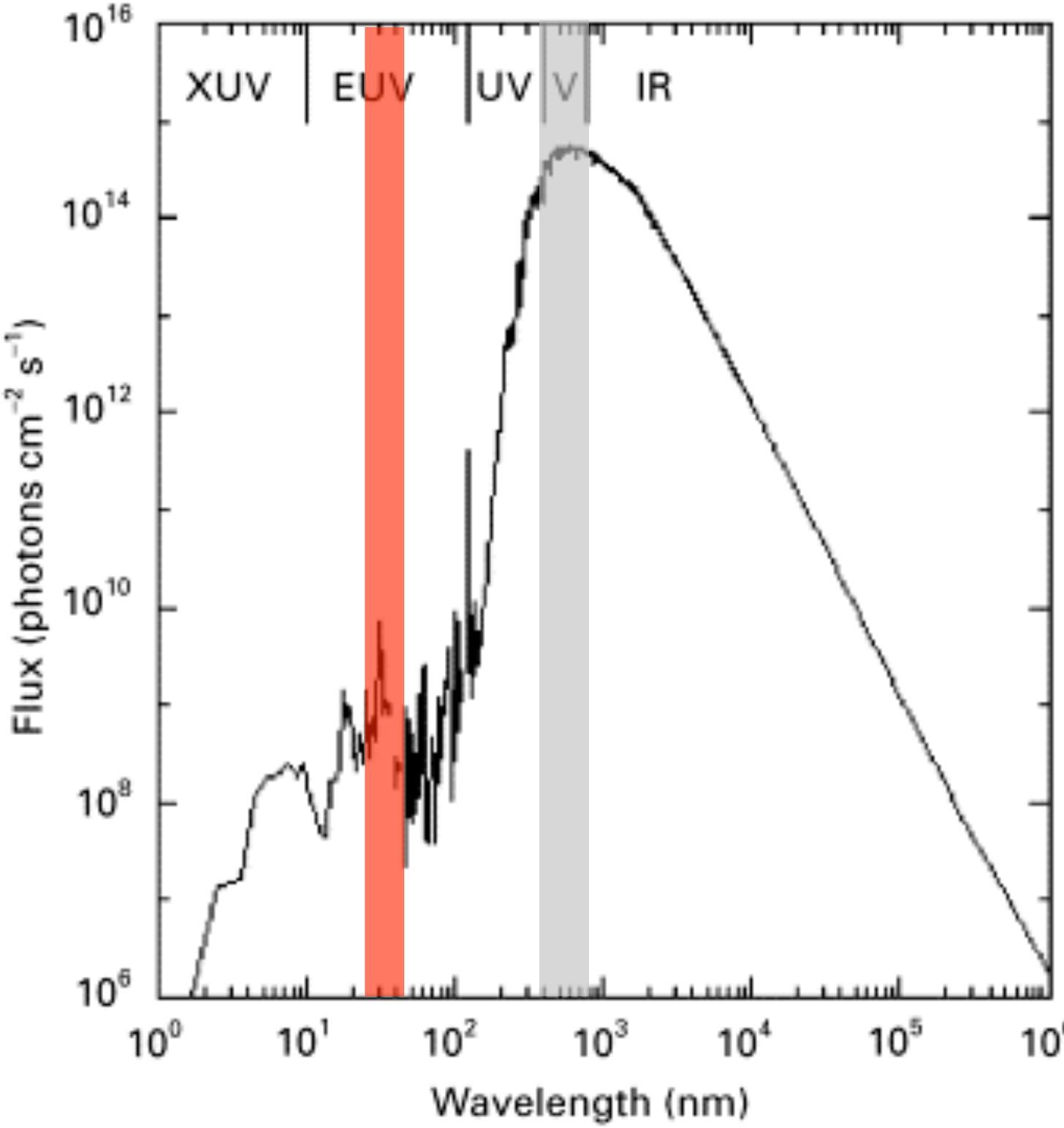
SOLAR2000, Tobiska 2000

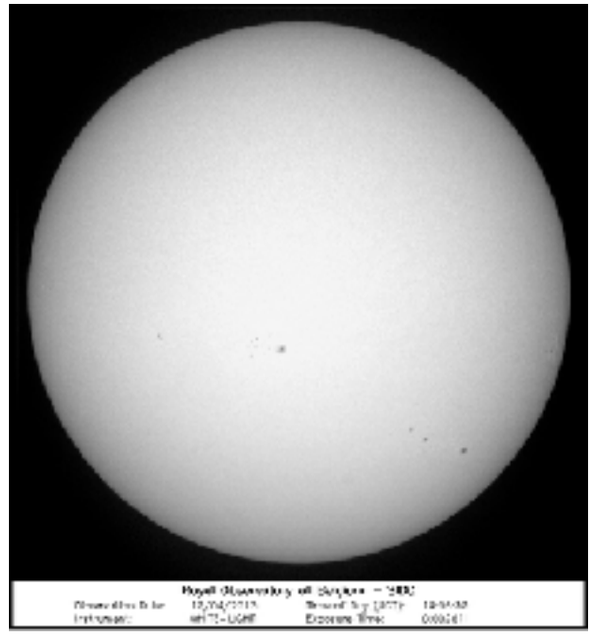




5700K

SOLAR2000, Tobiska 2000





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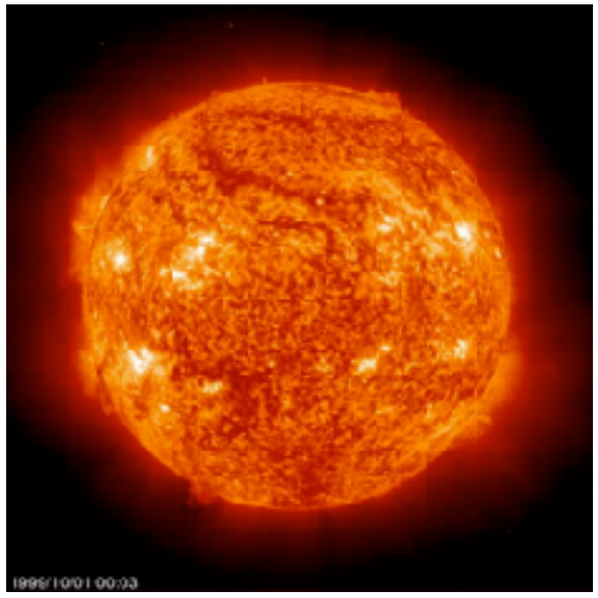
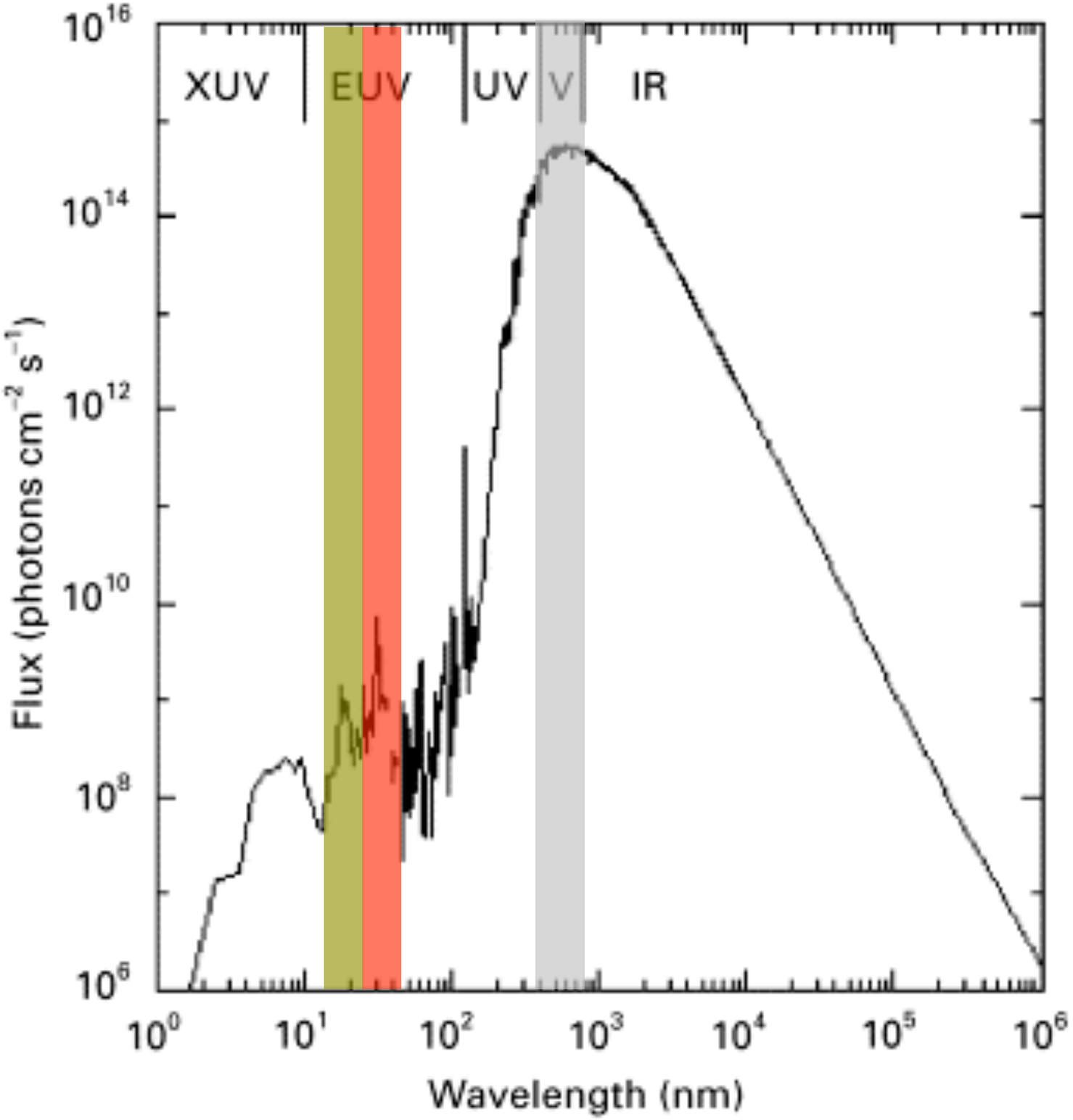
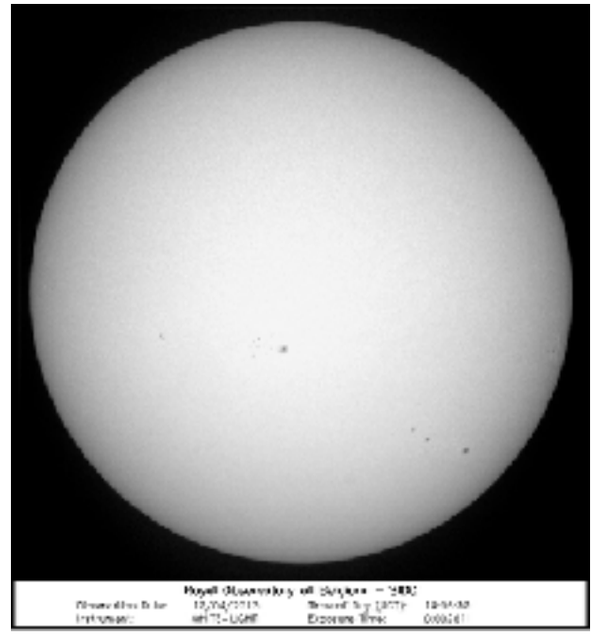


80000K

[SOLAR2000, Tobiska 2000]



[SOLAR2000, Tobiska 2000]



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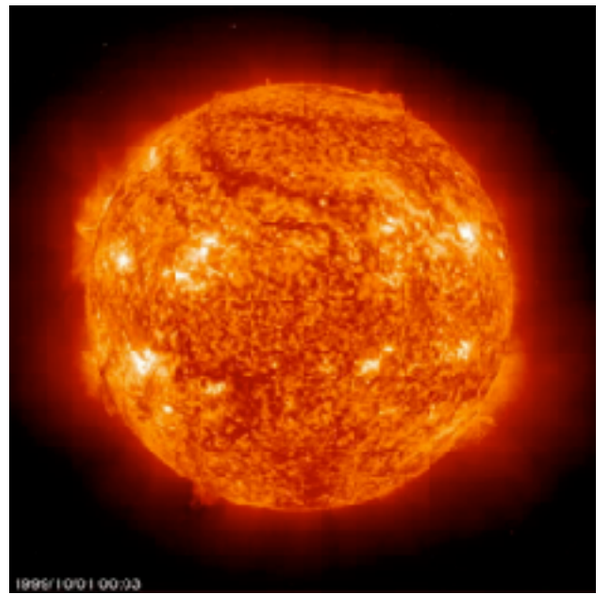

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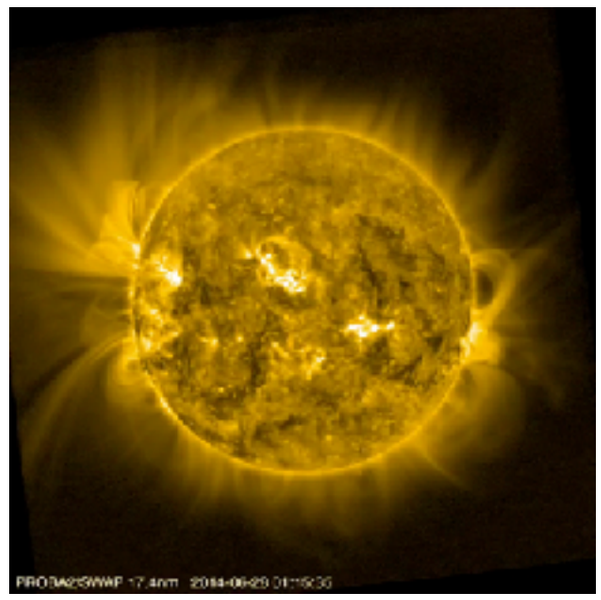
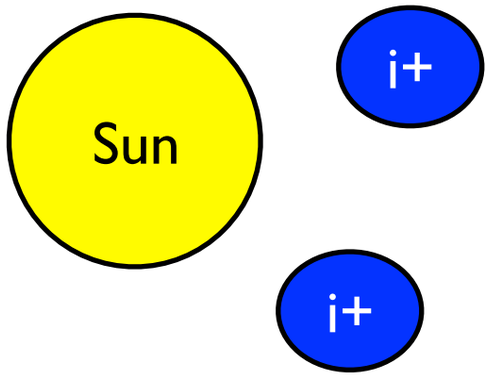


few MK

Sun

filter for EUV
only specific T
visible





collected light is emitted by ions ~ (density)^2

filter for EUV only specific T visible



collected light is emitted by ions ~ (density)^2

Sun

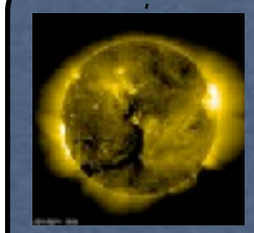
i+

i+

All emission along the line of sight is summed up equally

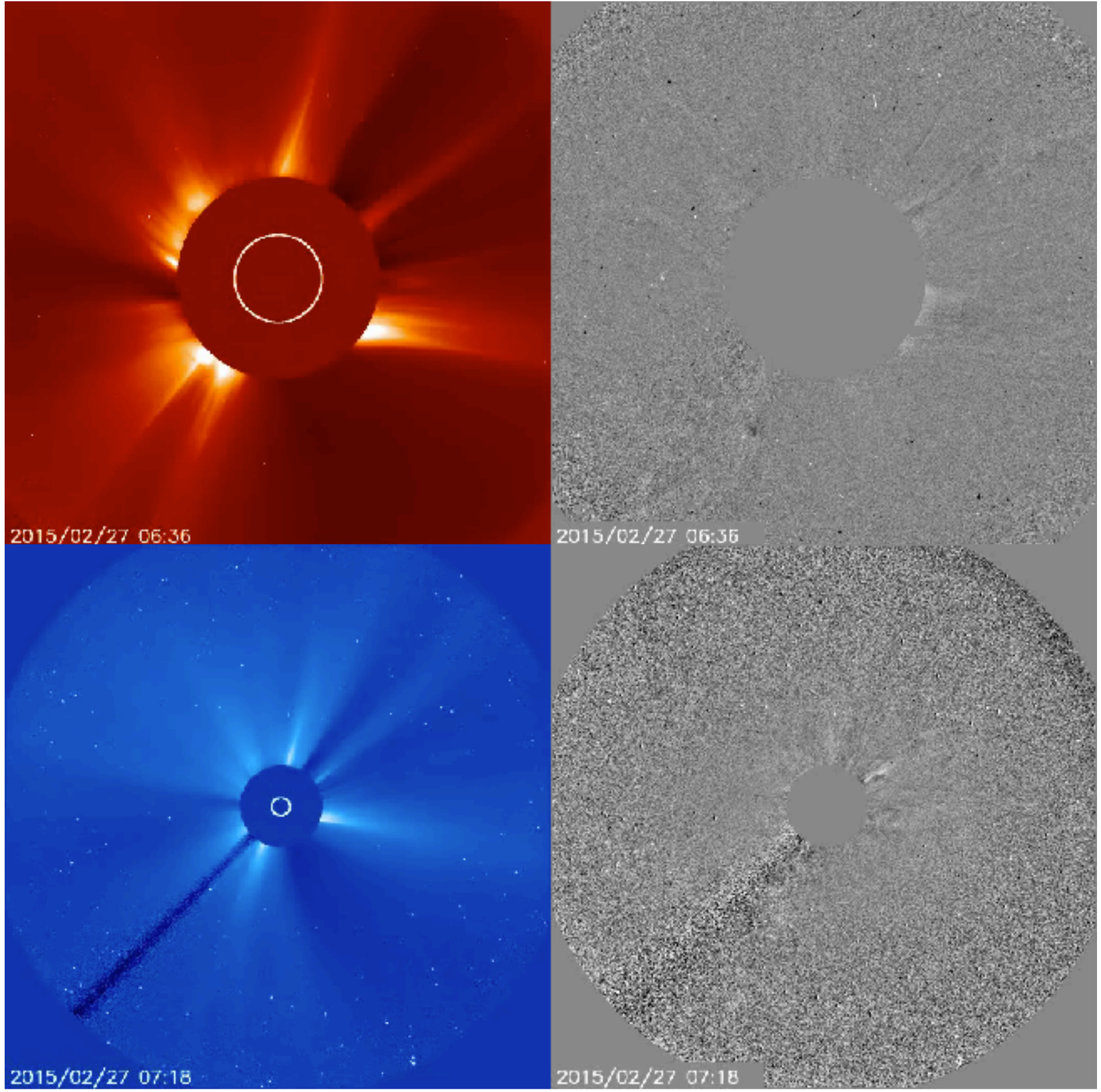
i+

filter for EUV only specific T visible



EUV telescope

Coronagraphs



SOHO / LASCO c2&c3 running difference



collected light is emitted by ions ~ (density)^2

Sun

i+

i+

All emission along the line of sight is summed up equally

i+

filter for EUV only specific T visible

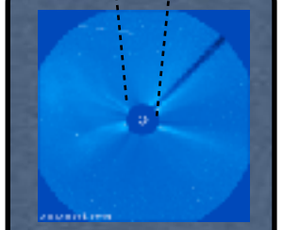
EUV telescope

Sun

occulter

visible light

Corona-graph



Sun

i+

i+

i+

collected light is emitted by ions ~ (density)^2

All emission along the line of sight is summed up equally

filter for EUV only specific T visible

EUV telescope

Sun

collected light is refracted on electrons ~(density)

e-

occulter

visible light

Corona-graph

collected light is emitted by ions ~ (density)^2

Sun

i+

i+

All emission along the line of sight is summed up equally

i+

filter for EUV only specific T visible

EUV telescope

e-

e-

e-

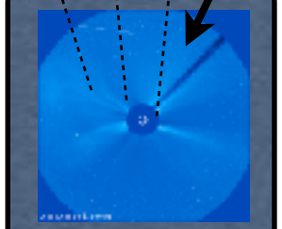
collected light is refracted on electrons ~(density)

Sun

e-

occulter

visible light



Corona-graph

collected light is emitted by ions ~ (density)^2

Sun

i+

i+

All emission along the line of sight is summed up equally

i+

filter for EUV only specific T visible

EUV telescope

e-

e-

Sun

collected light is refracted on electrons ~(density)

e-

e-

All emission along the line of sight is summed up but not equally

occulter

visible light

Corona-graph

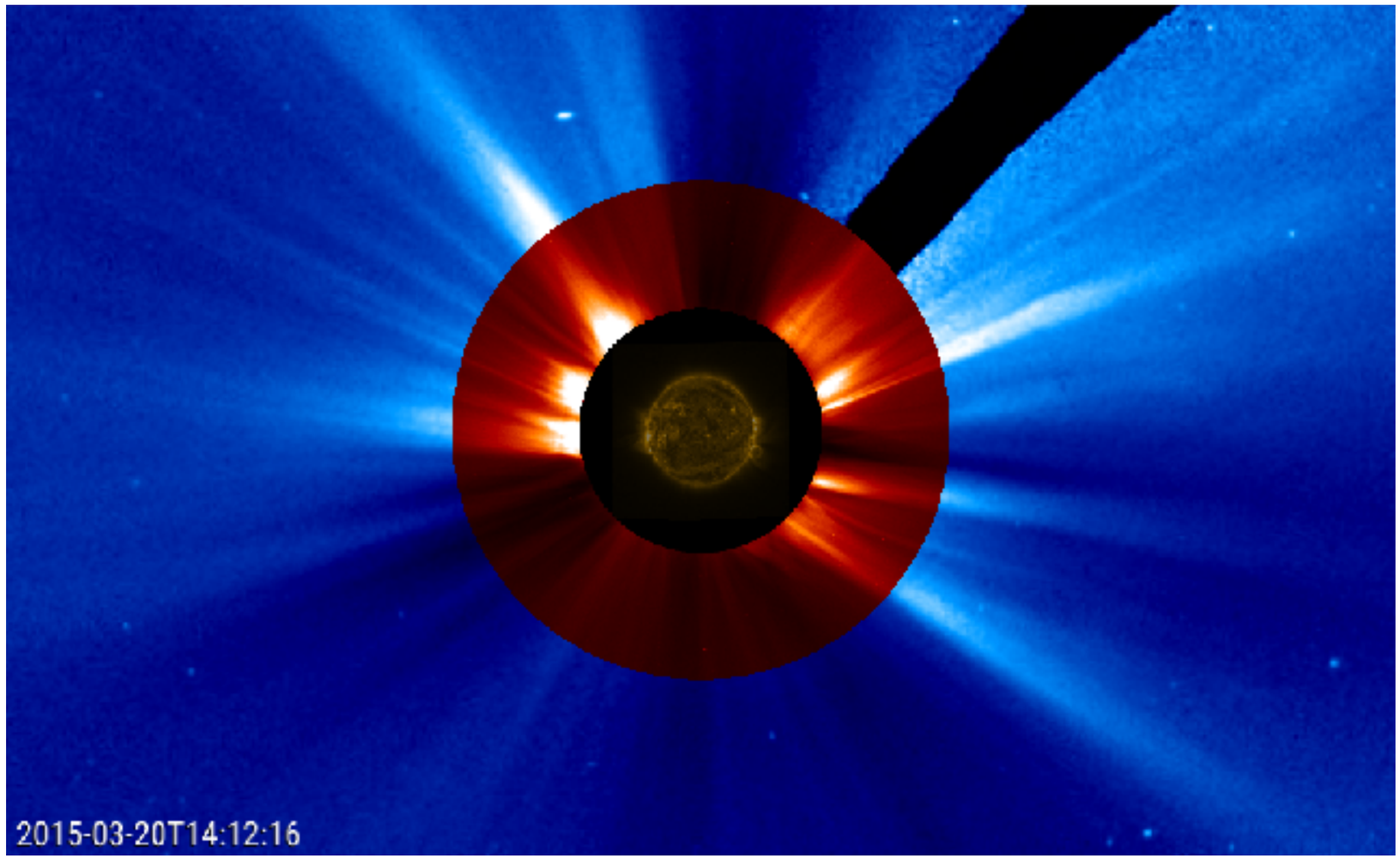
OBSERVATIONAL GAP

SWAP 174 2012-07-08 23:02:04
LASCO C2 2012-07-08 23:12:06
AIA 304 2012-07-08 23:01:32

www.helioviewer.org

OBSERVATIONAL GAP

We eclipse the bright sun and watch the corona in visible light.



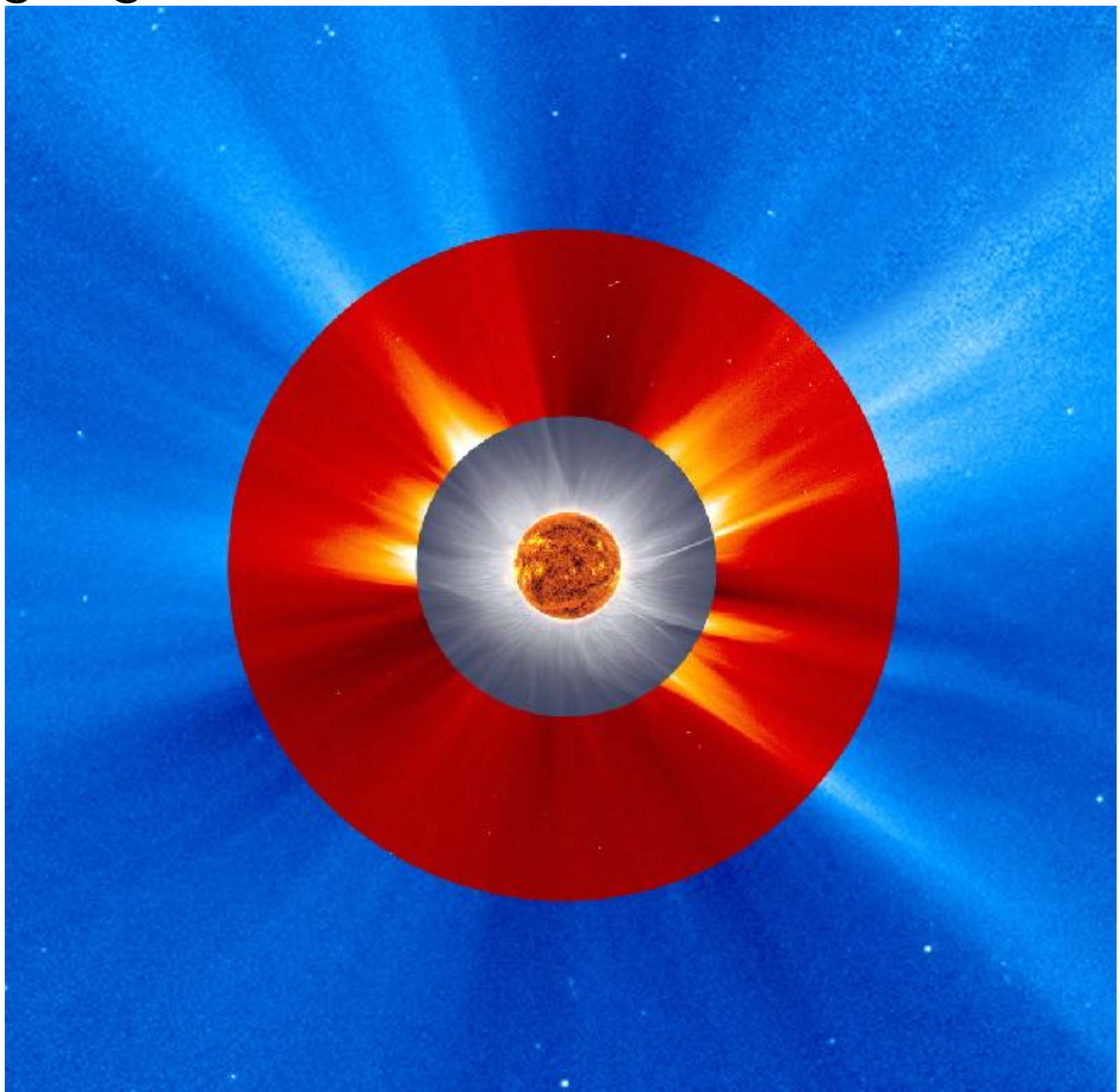
OBSERVATIONAL GAP

We watch natural solar eclipses.



OBSERVATIONAL GAP

We bring together both observations and close the gap.



OBSERVATIONAL GAP

Very nice but …



OBSERVATIONAL GAP

To close the ‘gap’, we make our own perfect eclipse with PROBA3.



OBSERVATIONAL GAP

The PROBA3 spacecraft will be launched by the end of 2020.





OBSERVATIONAL GAP

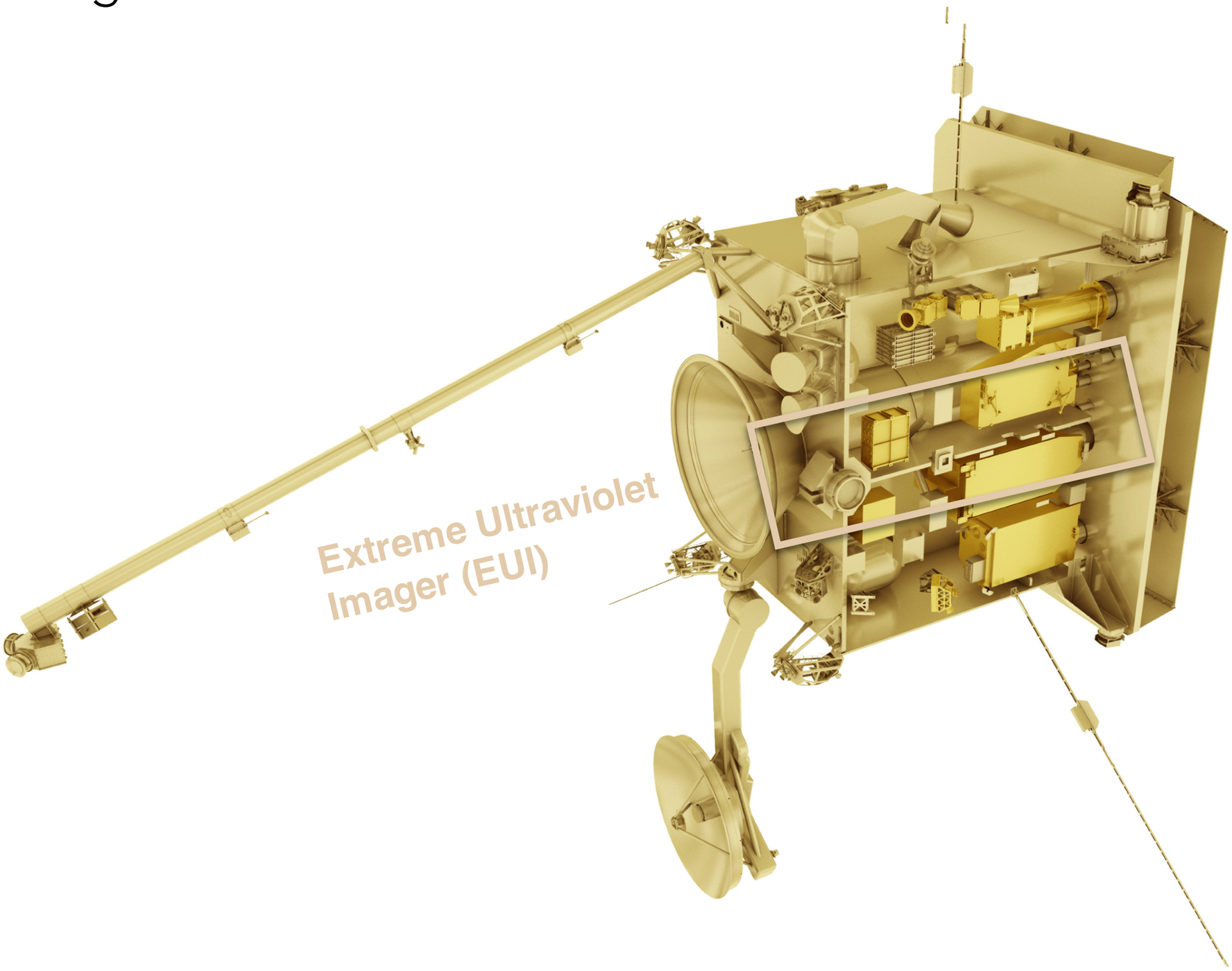
Or, to close the ‘gap’, we fly to it. SOLAR ORBITER will do so and make EUV images of parts of the solar corona .



Approaches the Sun < 0.28 AU or <60 SR
View >30° latitude


S TSC
-TC-10000
ET WEIGHT: 1500 KG
GROSS WEIGHT: 1860 KG
SWL: 360 KG
FRONT SIDE

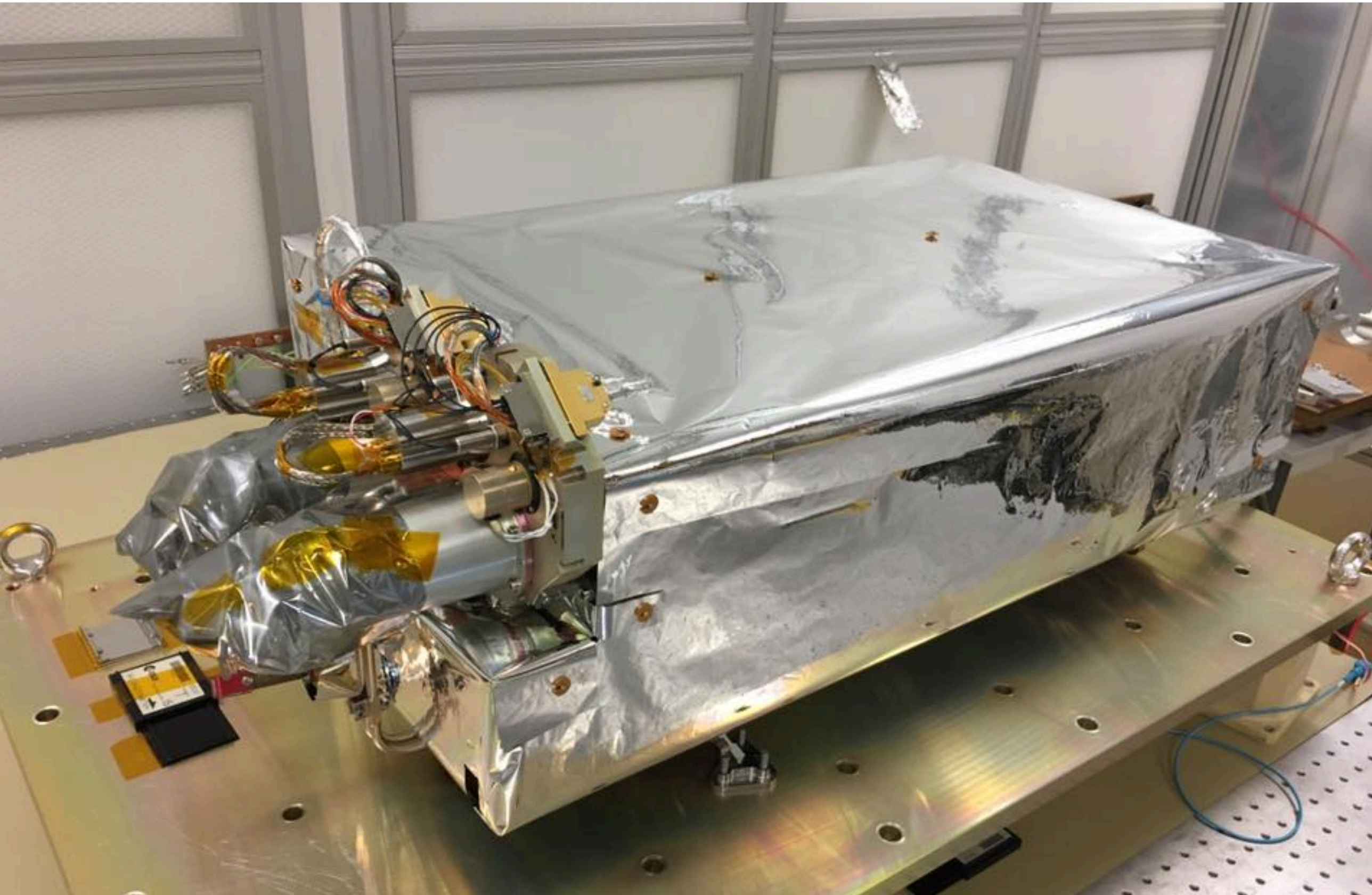
Launch Feb 2019 ; Mission 2019-2028 ; 10 instruments ; in-situ & remote sensing



EUI ARE IN FACT 3 TELESCOPES

Full Sun Imager (FSI) * High Resolution Imager (HRI) Lyman-alpha * High Resolution Imager (HRI) EUV

Inpakken ...

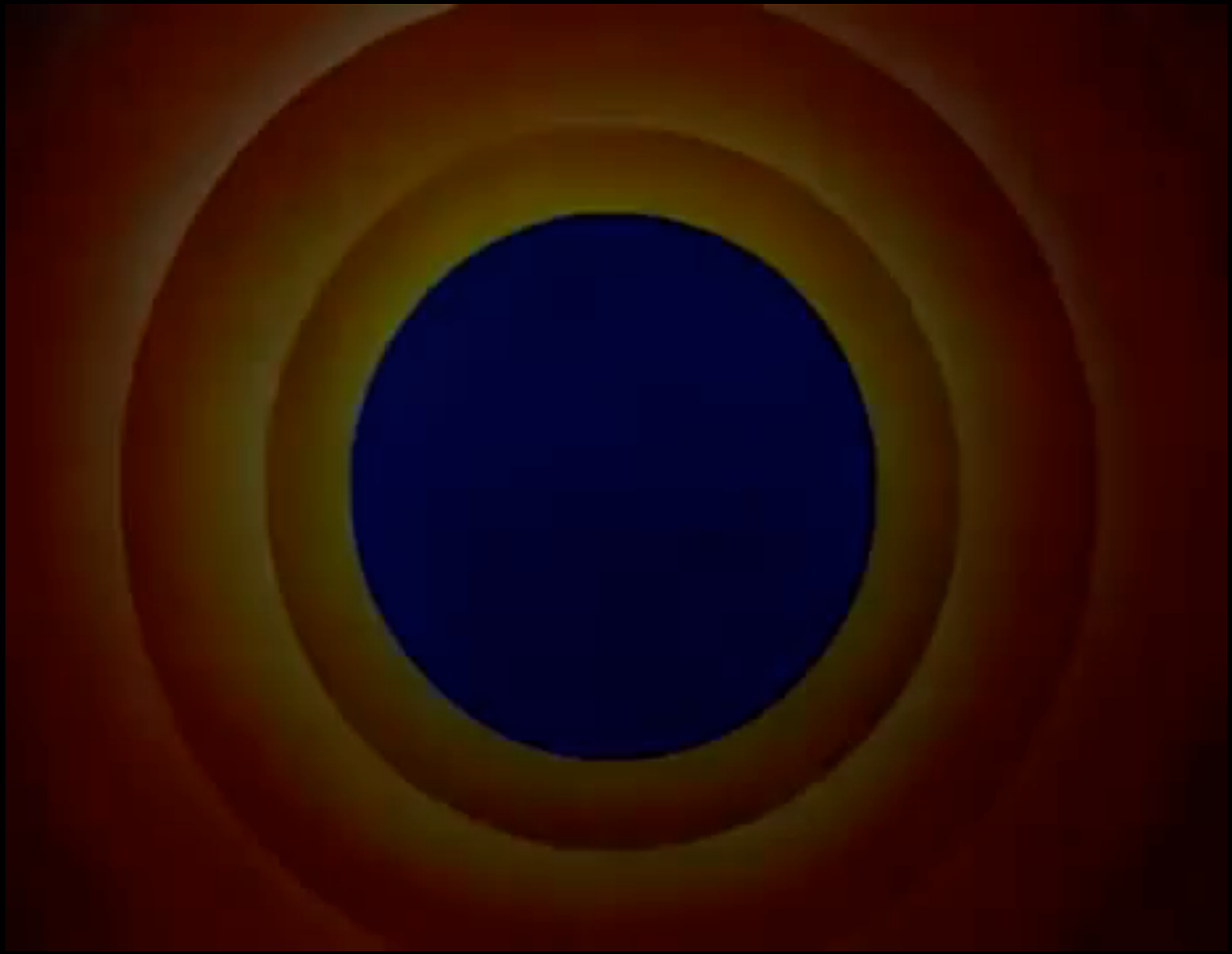


In een doos steken …



En een feestje geven!

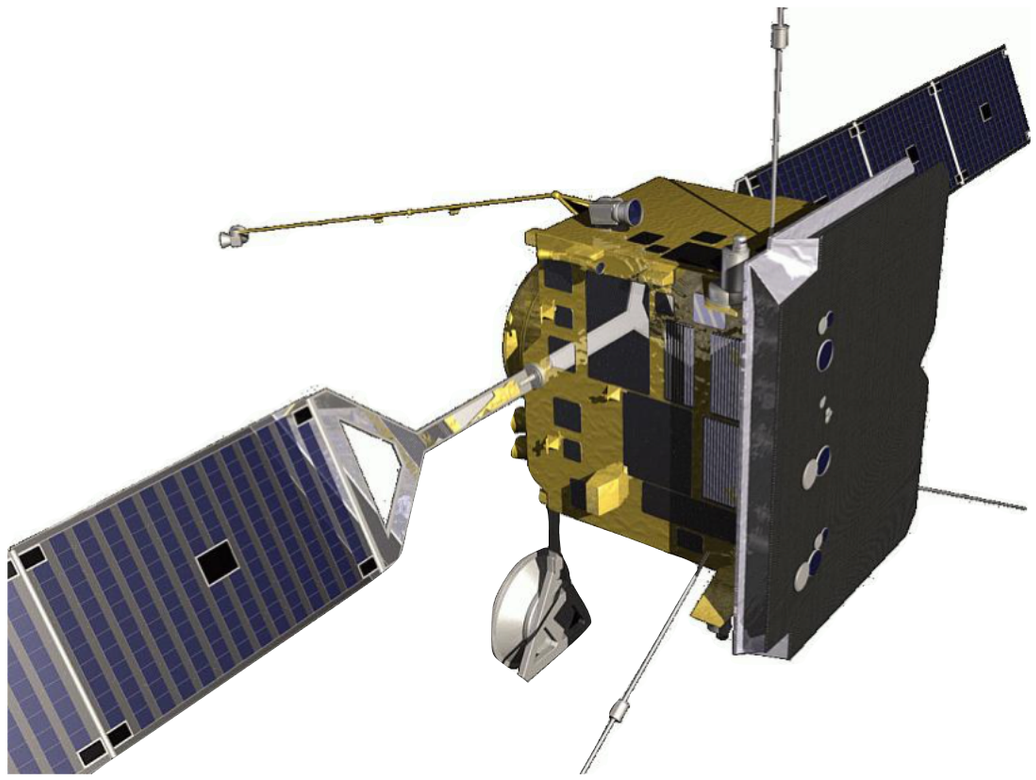




Solar Orbiter

- ESA project
- some instruments and launch contributed by NASA

- launch Feb 2019
- perihelion 60 solar radii
- in-situ measurements and solar and heliospheric images



Parker Solar Probe

- NASA project
- European participation in some instruments

- launch July 31 2018
- perihelion 9 solar radii
- in-situ measurements and heliospheric images

