Aalto University
School of Electric
Engineering

Magnetism and applications

ELEC-E9550
Tuesday 15th June, 2021

Prof. Eija Tanskanen

Aalto University
School of Electrical Engineering
Department of Radio Science and Engineering

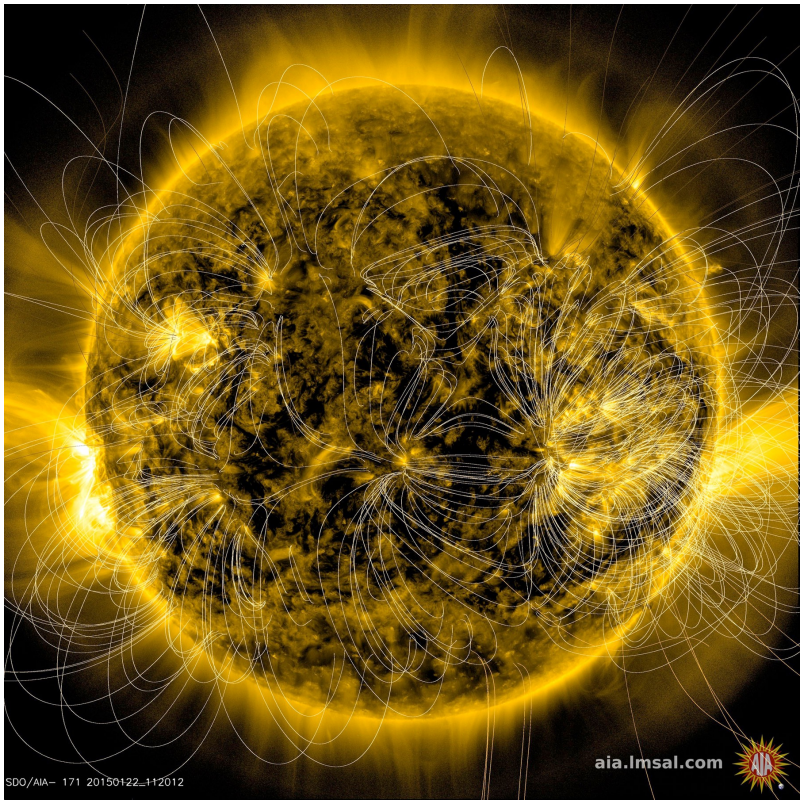
Aalto University
School of Electrical
Engineering

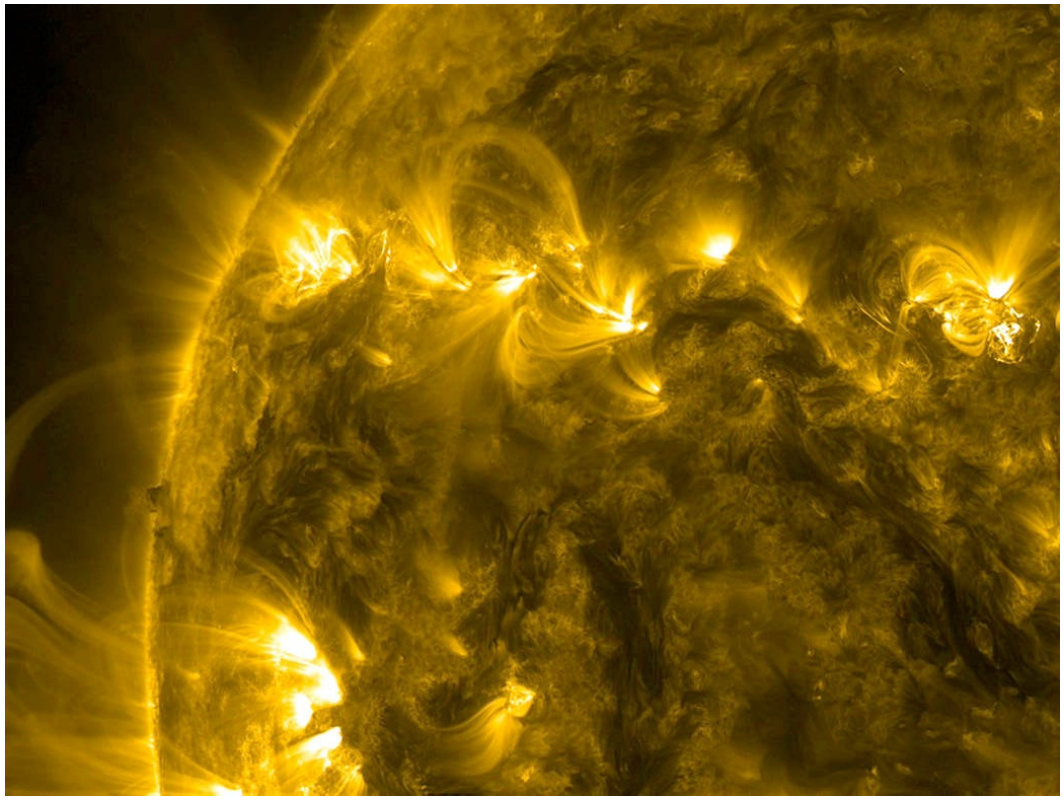
Today

Solar and solar wind data and disturbances

Solar measurements
Solar wind plasma and magnetic data
Solar wind disturbances

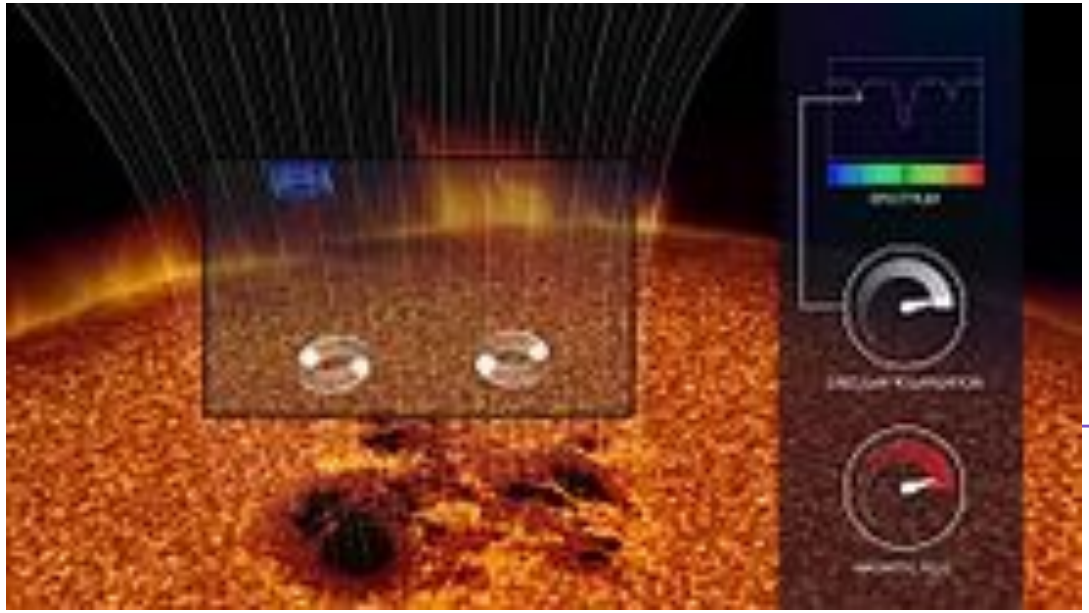
The Sun and it´s magnetic fields



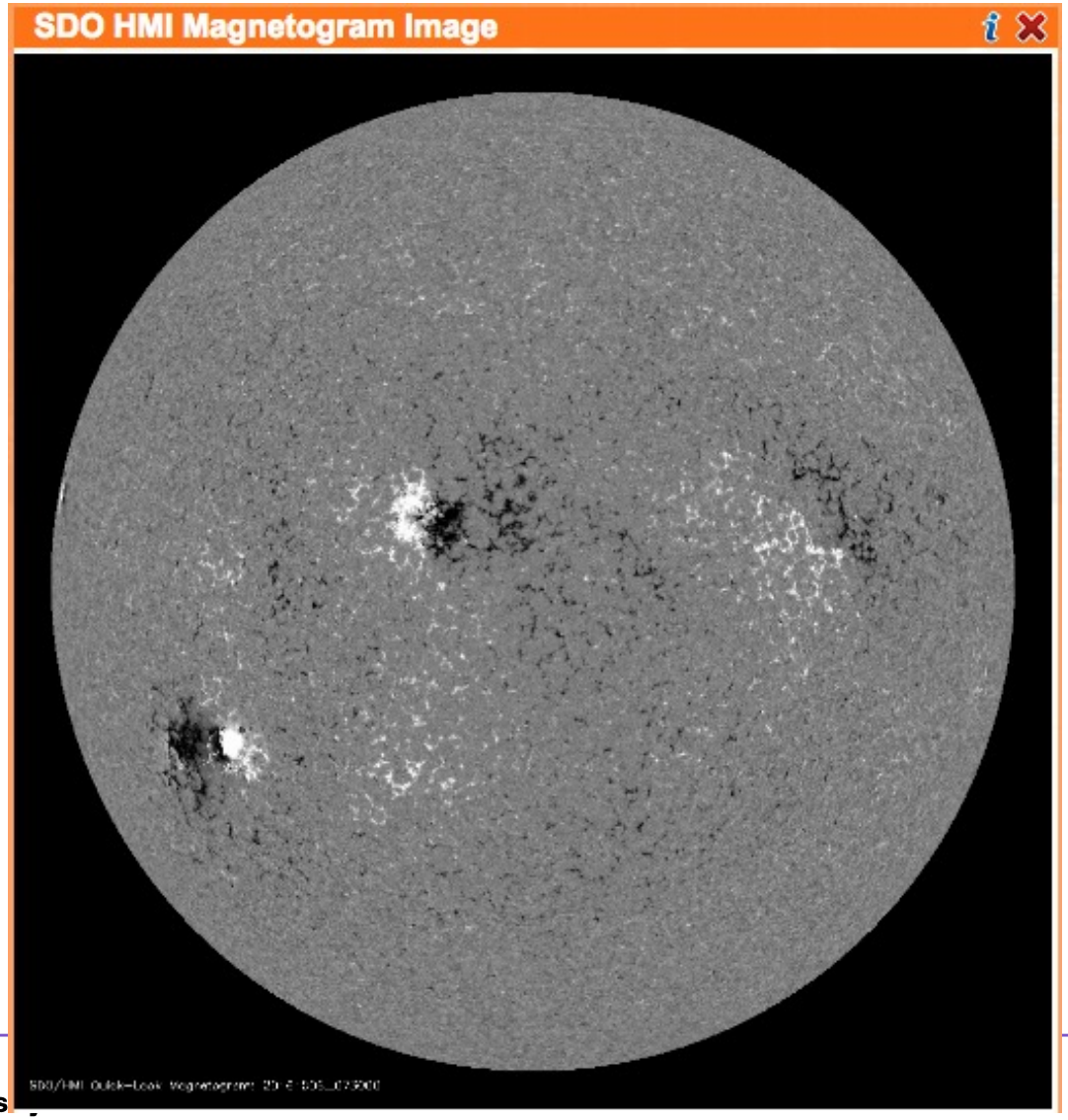


Zeeman effect

- Is an effect of splitting a spectral line into several components in the presence of a static magnetic field.
- The effect can be used to measure stellar magnetic fields.
- When the starspot forms solar magnetic field increases, circular polarisation increases.

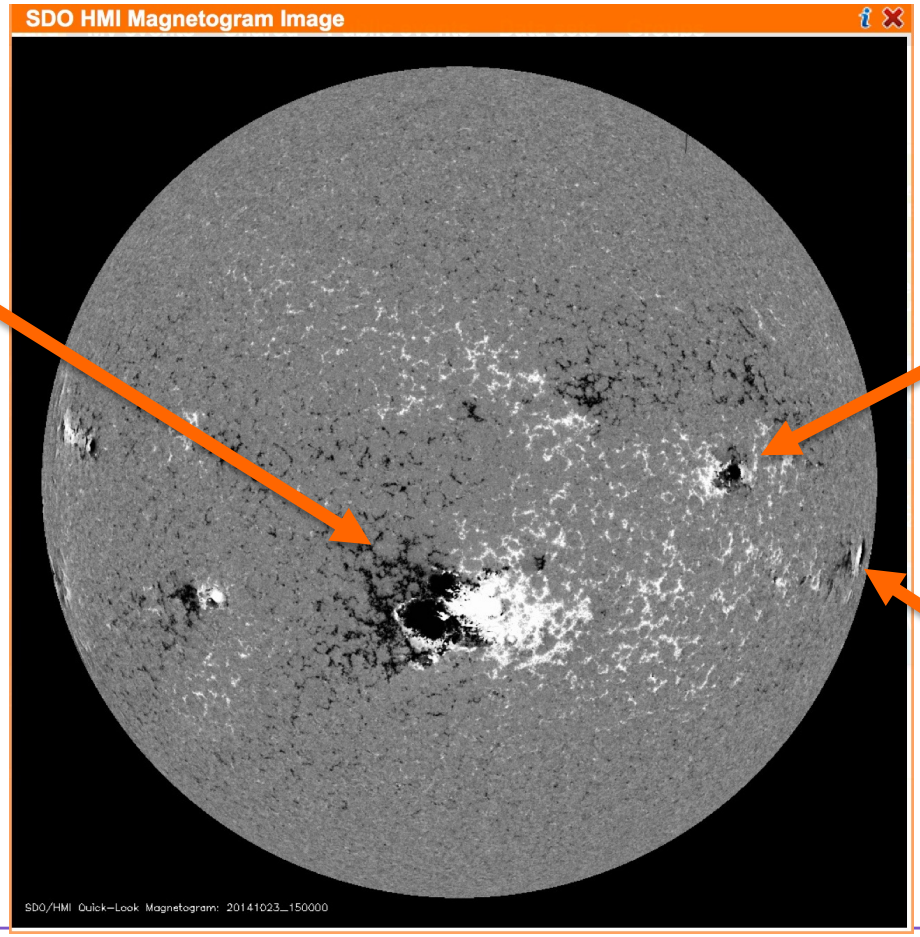


Sunspots today



Different sunspots

Big, ugly and angry

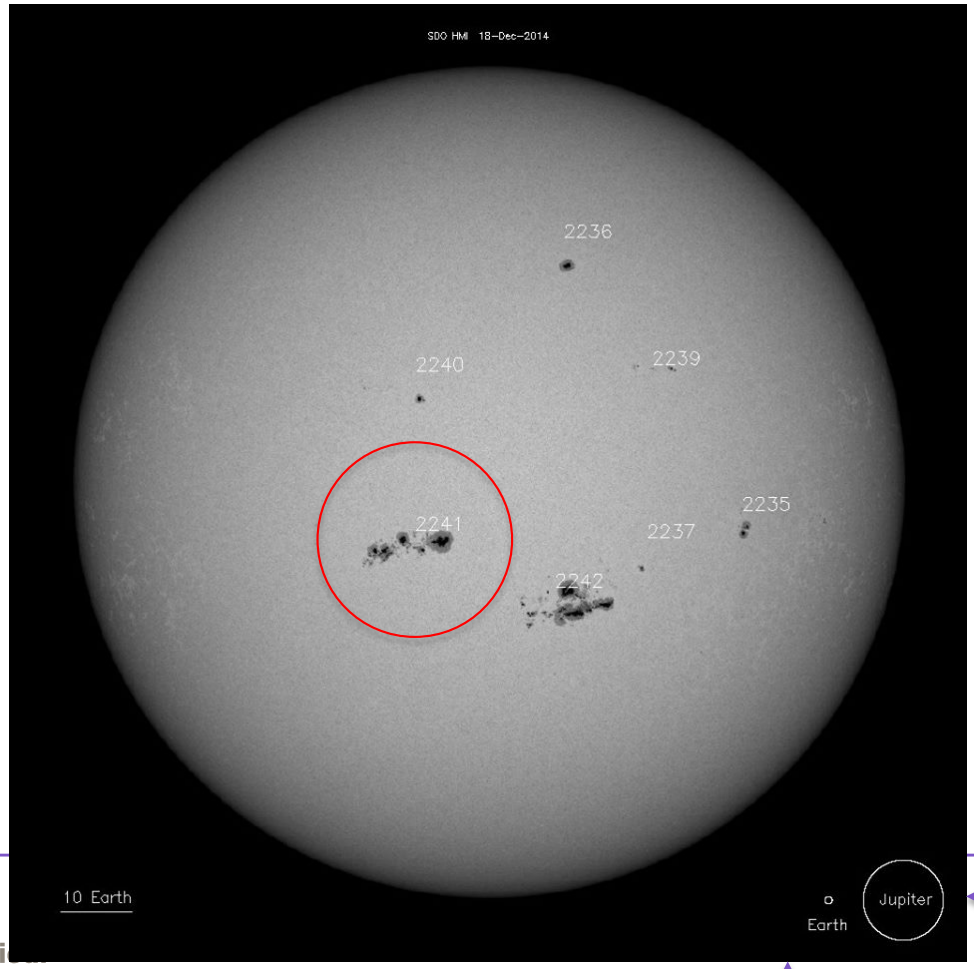


Ugly and angry

Ugly sunspot

Sunspots and active regions

Sunspot group = solar active region



Size of Jupiter

Size of the Earth

Sun at different wavelength, SOHO s/c

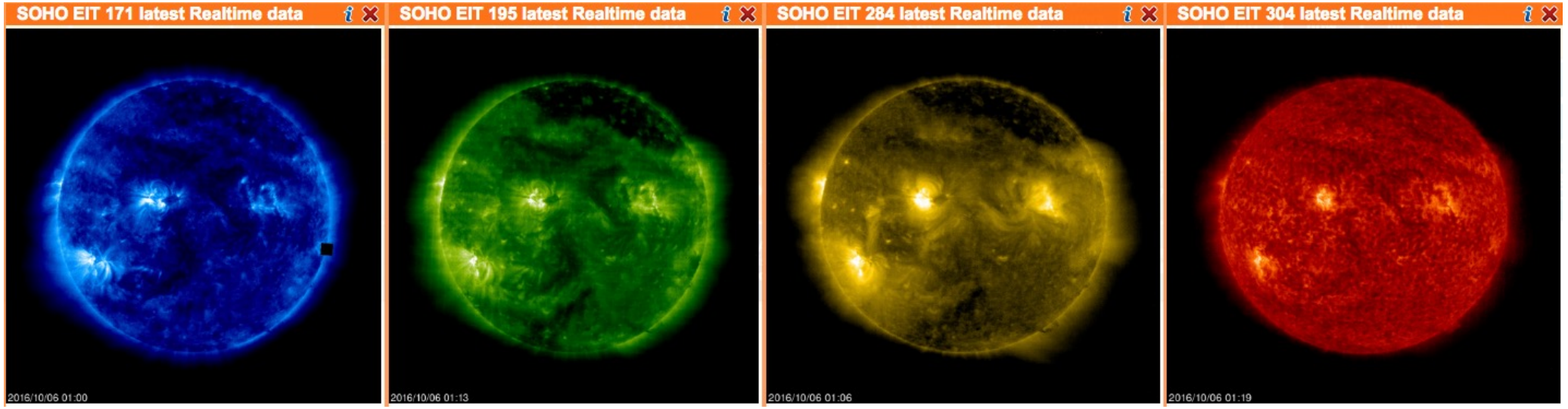
* High-resolution extreme ultraviolet images (EIT) from solar corona.
* EIT took images on different wavelengths: 17.1, 19.5, 28,4 and 30,4 nm.
* These corresponds to light produced by highly ionized iron and helium.

19,1 nm iron XII

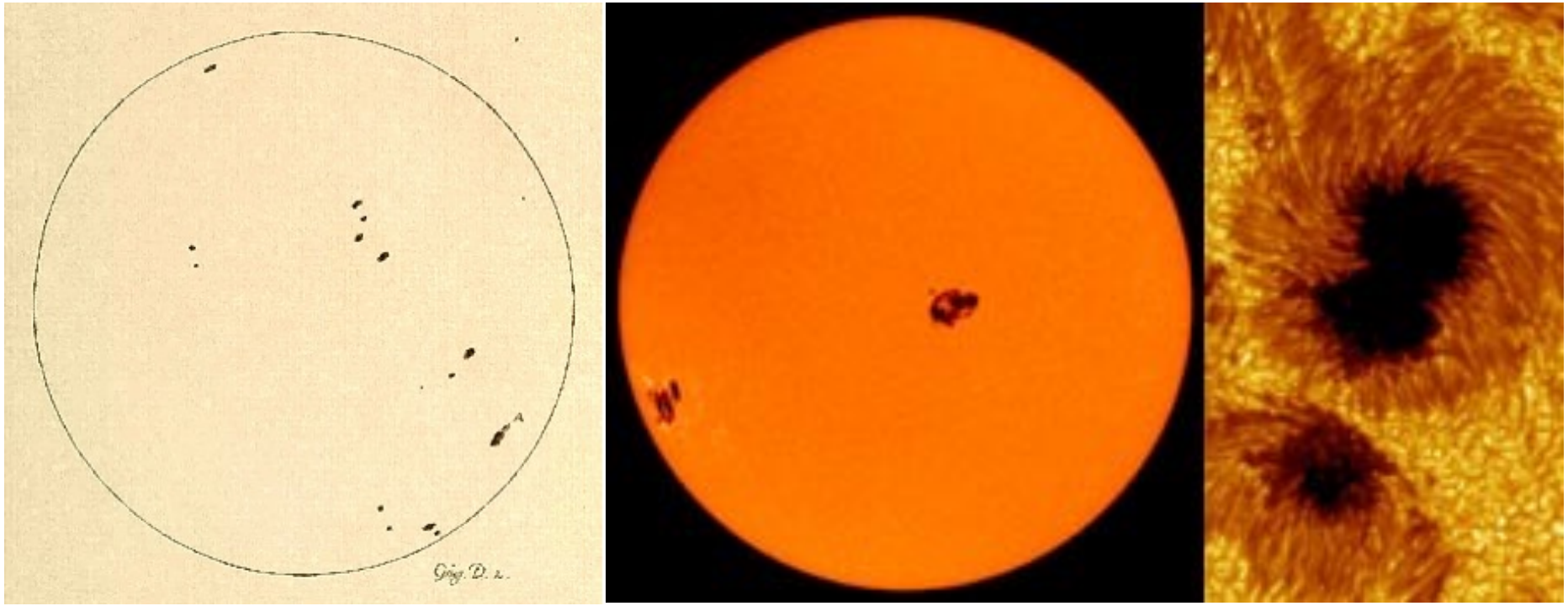
30,4 nm helium

17,1 nm iron XI/X

28,4 nm iron XV



From historical to modern solar data



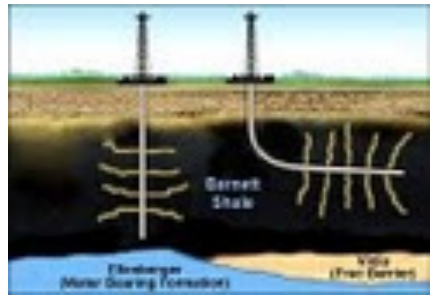
→ Modern data give more detailed information on the solar magnetic field.

Energy from the Sun

Sun is responsible for most energy forms used on the Earth:

- Stored solar energy:
oil, coal, gas, peat, tree, geotherm,...

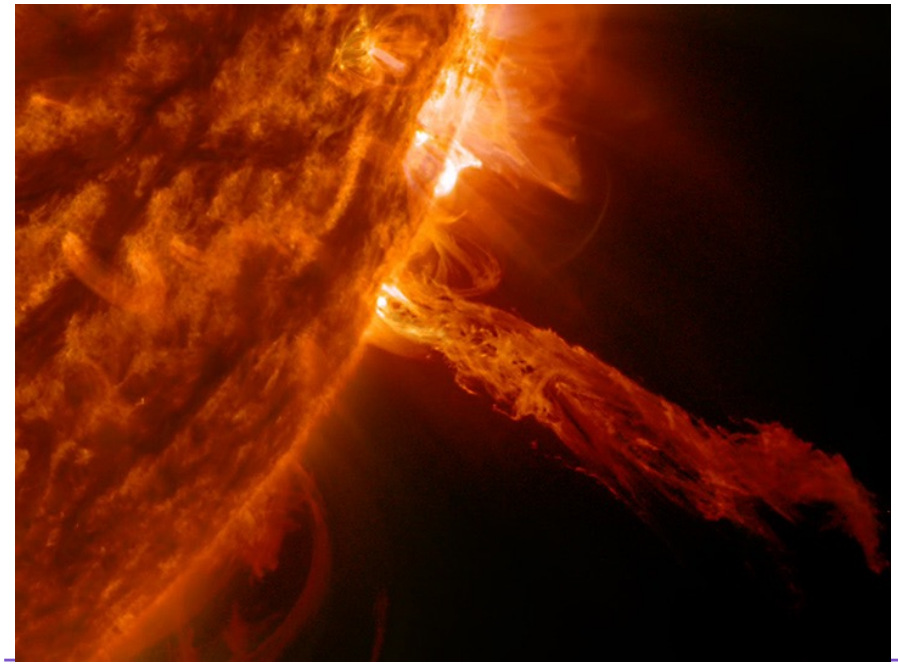
- Flow energy (together with Earth's rotation):
water power, wind power, tides,...



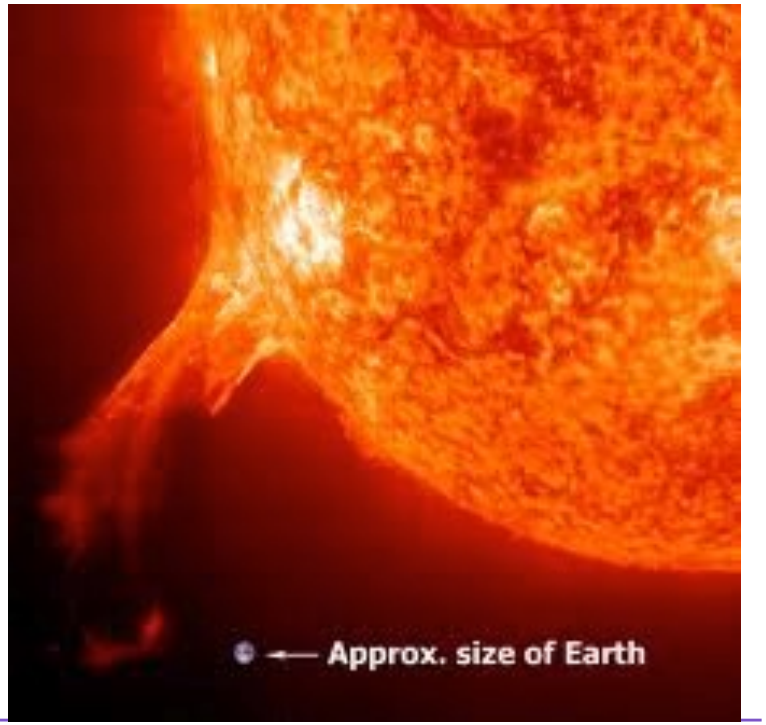
(The only major energy form not related to Sun is nuclear energy).

Solar storms from the Sun

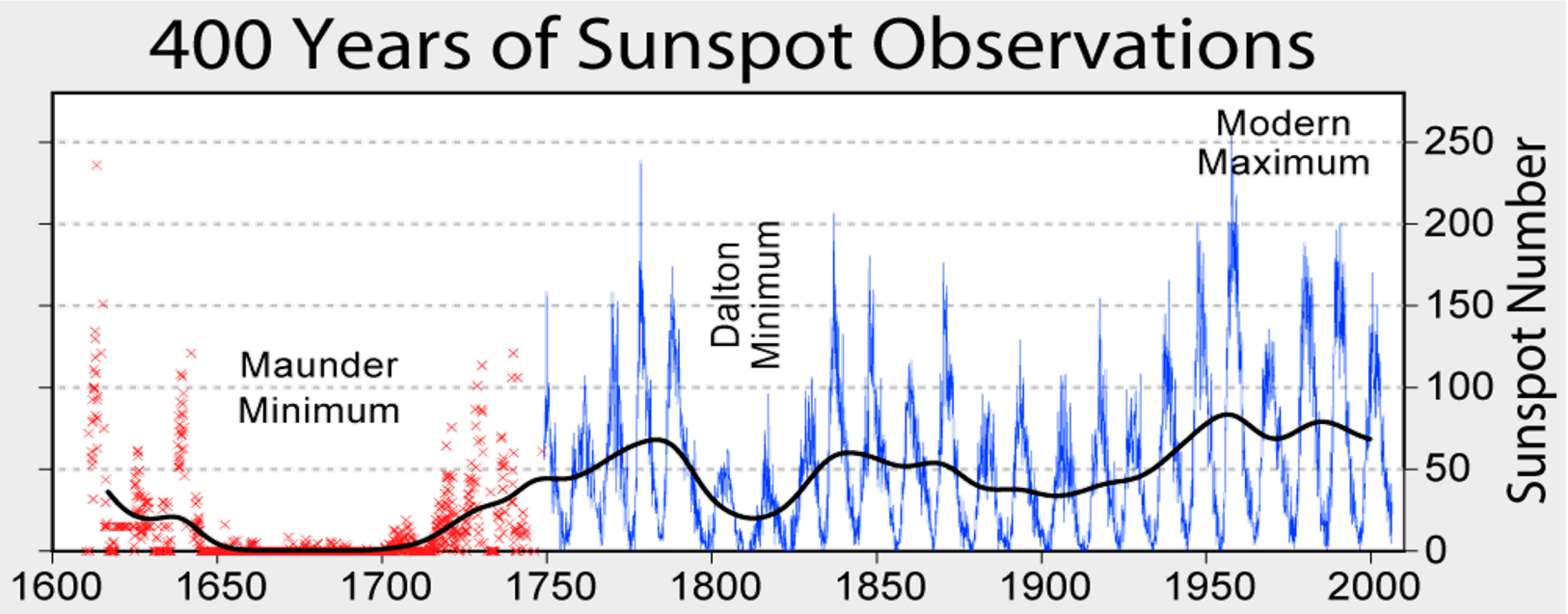
"Once a day burst",
that did not erupt towards the Earth.



Plasma cloud that was released towards the Earth.



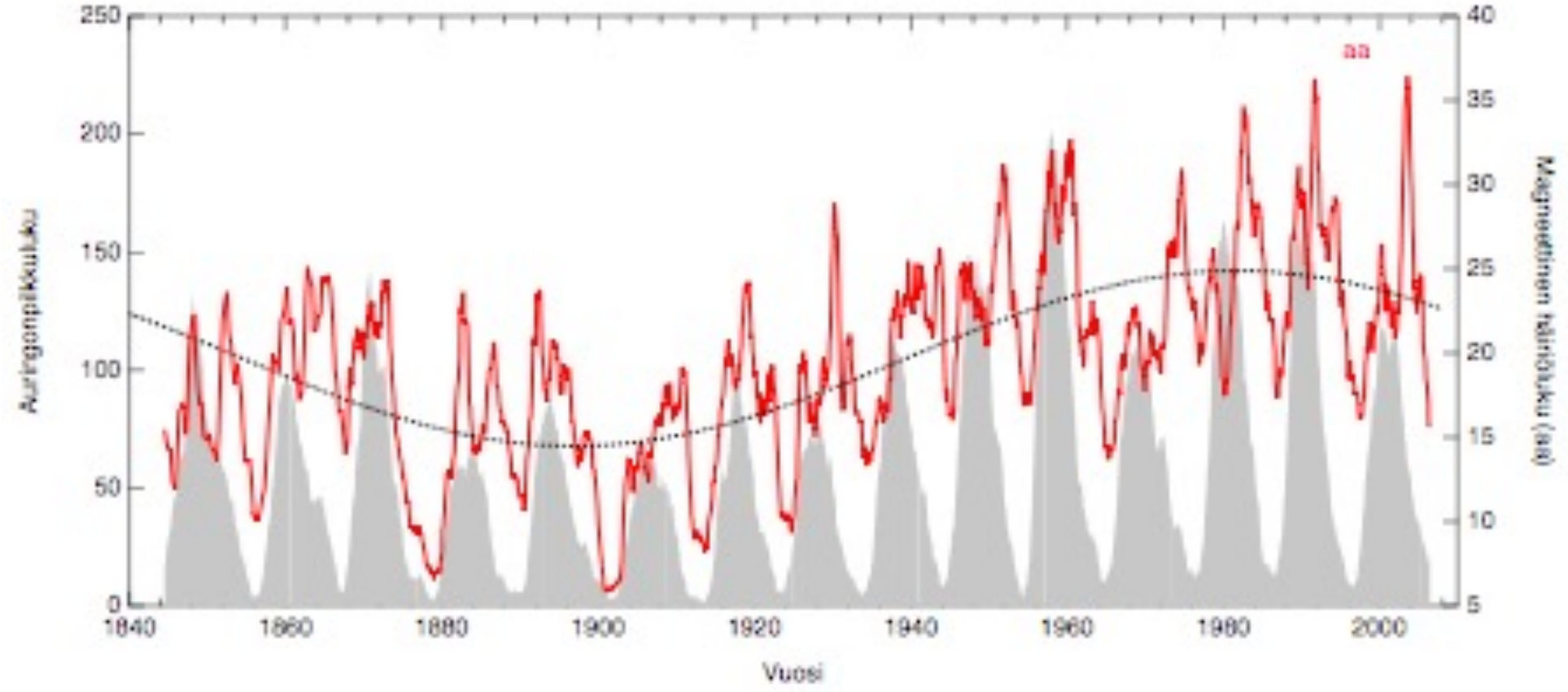
Measures of solar activity



Last 100 -150 years

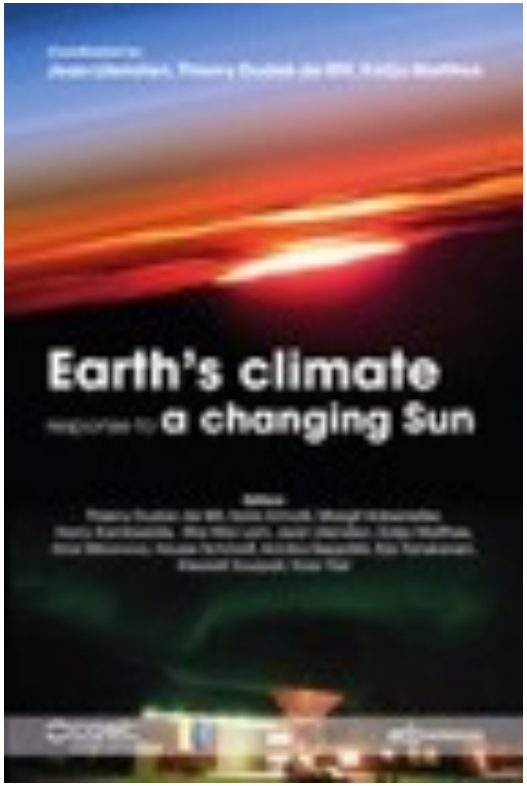
Solar storms modulate the ionosphere

Sunspot number is shown by a grey shading while
the strength of the ground magnetic field (and ionospheric currents) is shown by red.



Solar storms modulate the atmosphere

- Solar effects on atmosphere and climate are still very poorly understood, BUT …



Solar originated disturbances are known to modulate the North Atlantic anomaly and thus alter the winter-time temperatures (Maliniemi et al. 2014-2016).

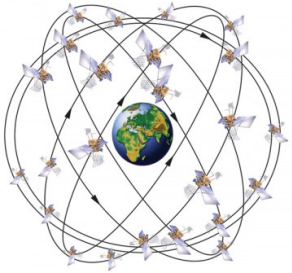
Solar storms affect the infrastructure

- Destroyed, malfunctioning and lost “zombie” satellites
- Re-routing of polar flights
- Power blackouts and lost electricity
- Problems to oil drilling
- GPS errors of tens of meters (big problem to automatic cars)
- Errors in time signals e.g. Metsähovi case
- Increased drag of space debris to ionosphere (GOCE satellite 21.10.2012, ENVISAT, Hubble space telescope)

- 30% increased cancer risk for pilots in polar flights
- Biological effects to humans in space station

- Toronto stock market closed for 3 h due to the solar storm effects in Aug 1989
- Ghost phone calls, problems to elevators and traffic lights

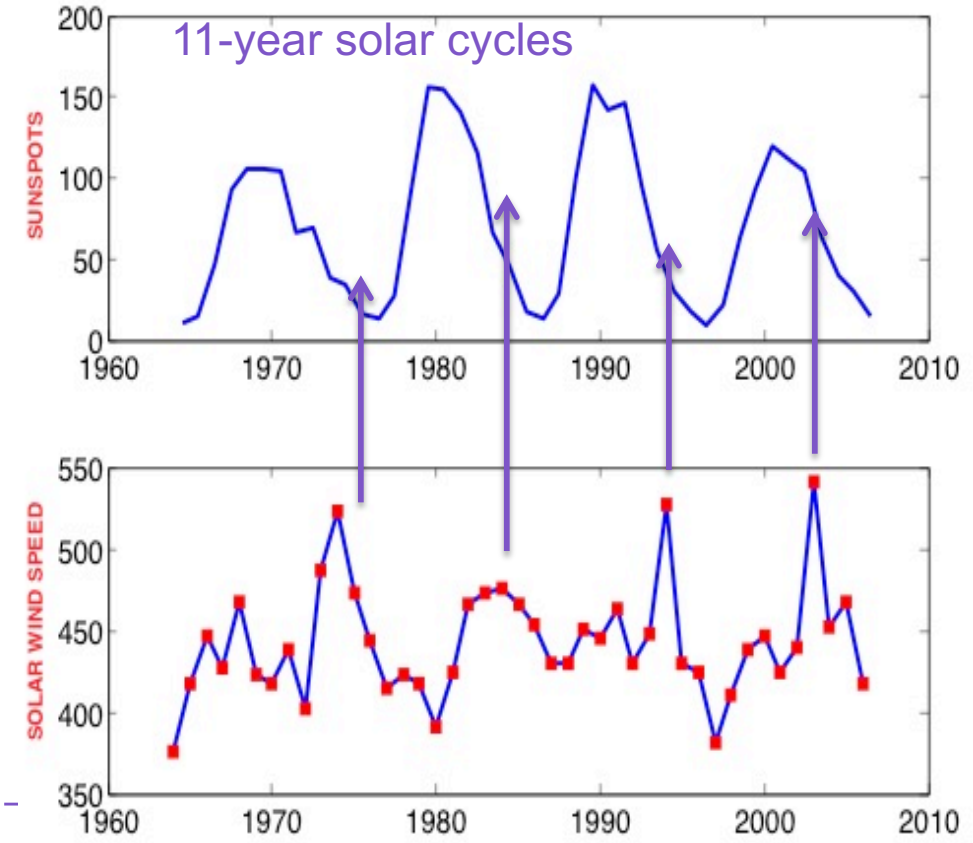



Solar wind (SW)

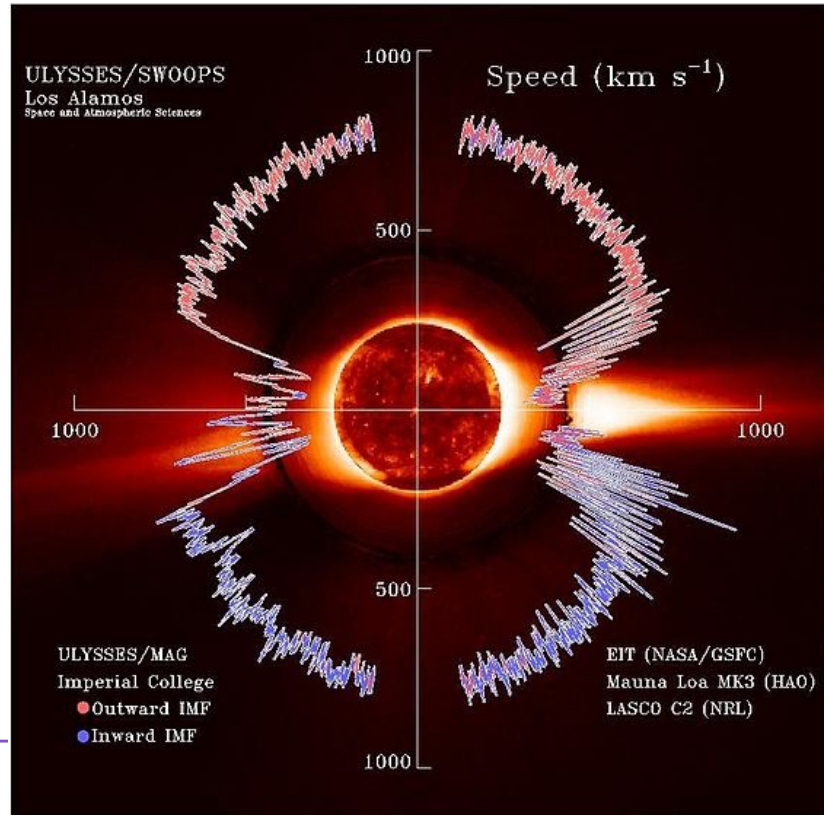
= A stream of changed particles released from the upper atmosphere of the Sun.

Consist of mostly electrons and protons where interplanetary magnetic field is embedded.



SW speed maximum in declining phase.

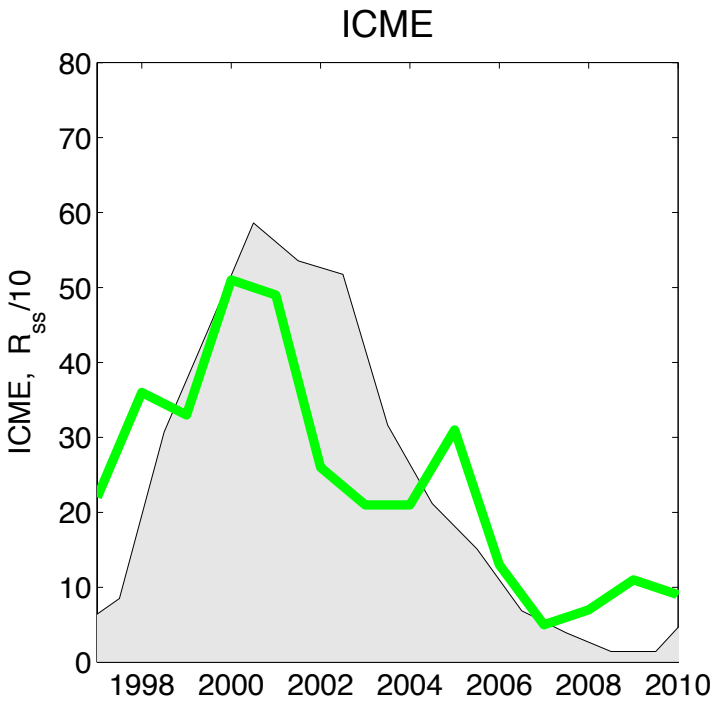
Fast wind (> 600 km/s) close to the poles.

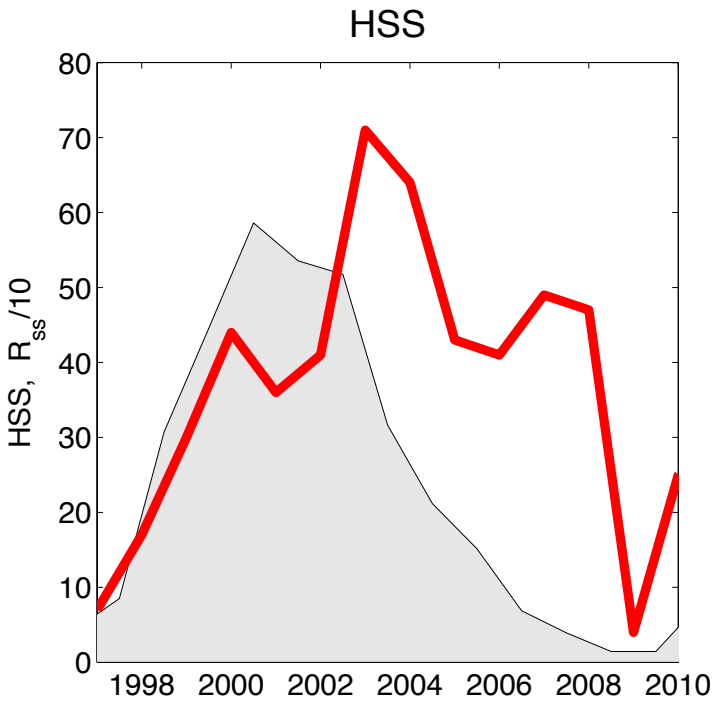


Slow solar wind (< 400 km/s) at equator.

Solar wind transients

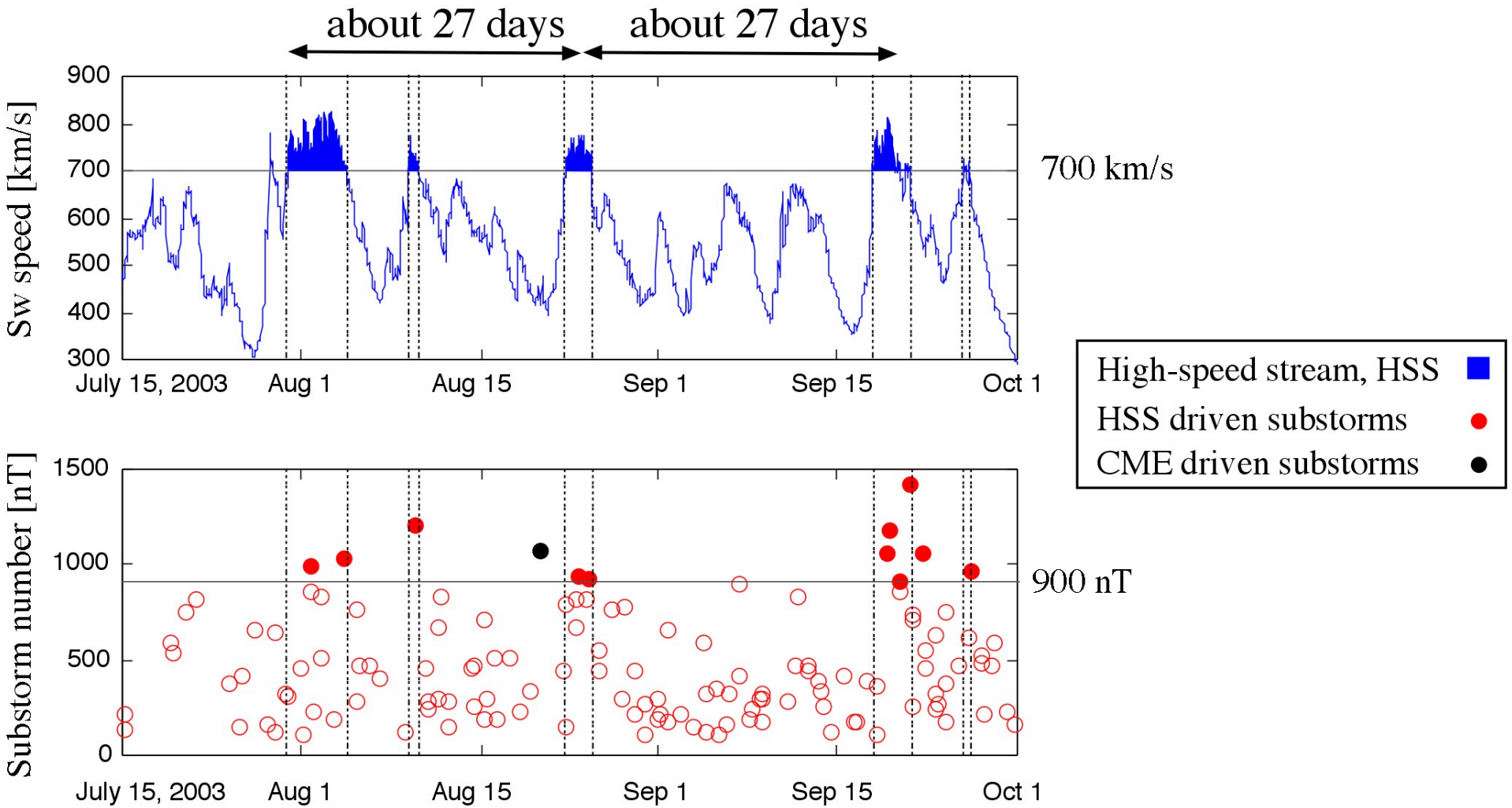
- Solar wind transient exist on top of the continuous solar wind flow:
  - High-speed stream (HSS)
  - Interplanetary coronal mass ejections (ICMEs)
  - Co-rotating interaction regions (GICs)
- Each of them affect differently to the geomagnetic activity.



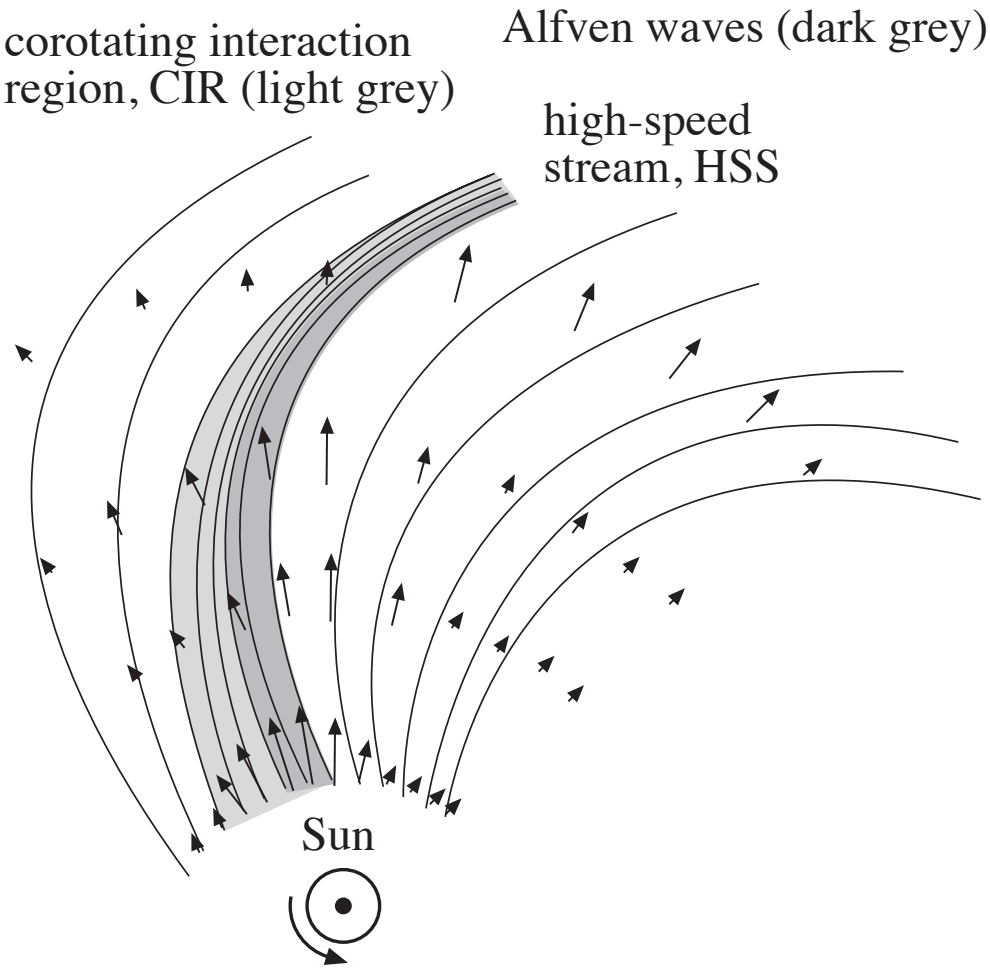


Sunspot number with grey shading.

High-speed stream



Origin of high-speed streams



Interplanetary coronal mass ejection

Proton density enhanced, magnetic field, speed increased and temperature increased.