Magnetism & Applications
Monday 5.6.2023

MSc. Reko Hynönen
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Thesis worker, Aalto University

Prof. Eija Tanskanen
Director, Sodankylä Geophysical Observatory

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Grading and tasks

- **Participation in the lectures:**

+ 1 p per lecture (including this)

+ 1 p if you ask a question (once per lecture,
+ bonus point per lecturer if more than one)

Total of 8 p + 8 p (+ bonus) (unless a lecture gets cancelled, then it's 2 p fewer)

If you didn't already, join the course in Sisu/Peppi, open until Tue 6.6. *

* or contact Reko

- **Project**

+ max. 20 p for the presentation

+ max. 40 p for the final report

Total of 60 p

→ Presentation is recommended

→ Report is **mandatory** for passing the course

½ max. points grants grade 1, gradual increase up to 5 from there

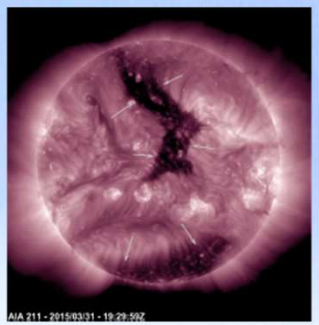
Schedule and topics

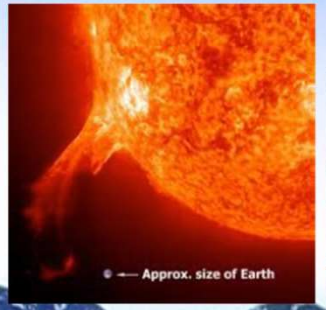
Mon 5.6.	Introduction lecture Basics of the Sun-Earth coupling, R Hynönen
Tue 6.6.	Geo- ja space observations, R Hynönen
Sun 11.6. DL	Research report **topic** delivery deadline
Mon 12.6.	Project topic preview (R Hynönen) VLF waves, Jyrki Manninen Sunspots and solar magnetism, Shabnam Nikbakhsh
Tue 13.6.	...Pending...
Mon 19.6.	...Pending... Report writing, R Hynönen
Tue 20.6.	Electric Sail Physics and Technology, Pyry Peitso / Auroral Propulsions
Mon 26.6.	...Pending...
Tue 27.6.	Poster presentations virtually
Fri 30.6. or Sun 9.7.	Final research report delivery at 23:59

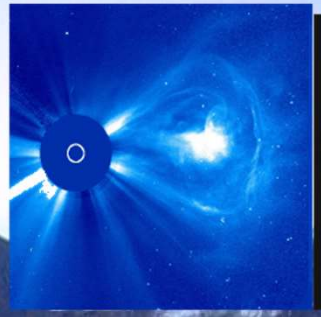
Zoom link to the lecture: https://oulu.zoom.us/j/62286510953

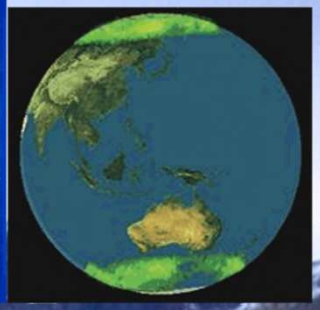
The Sun-Earth magnetic coupling

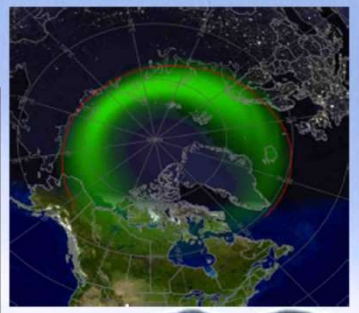
Goal is to examine and begin to understand geomagnetic activity and its drivers from above and below in time-scales of seconds, hours, decades, and centuries and beyond.











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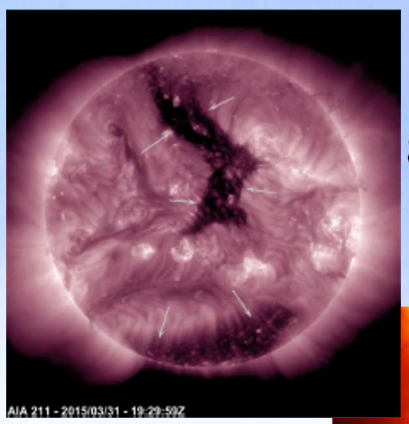
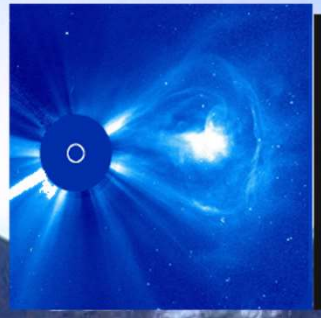
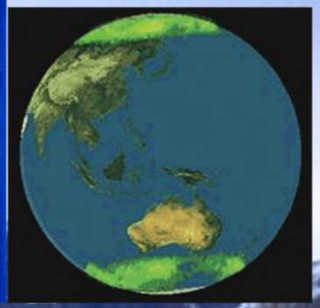
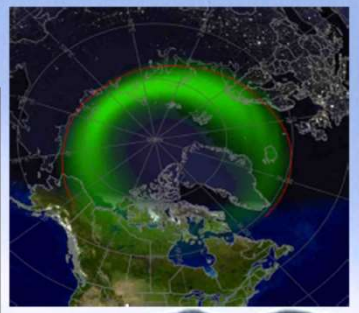
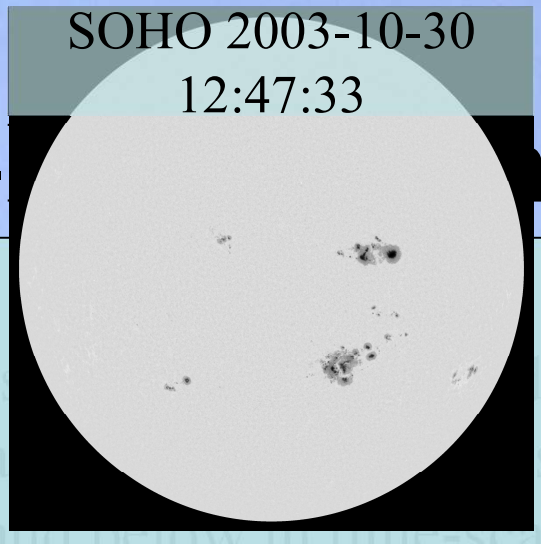


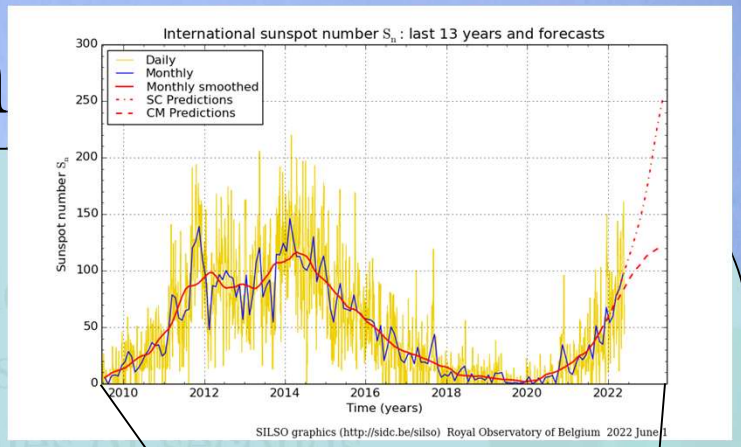


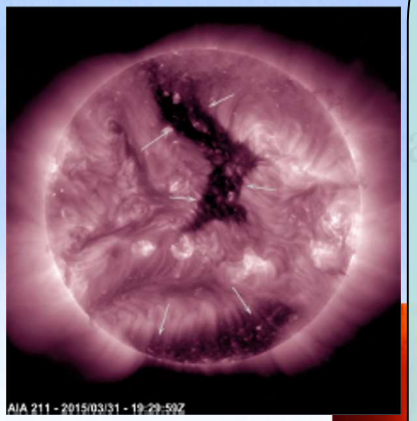


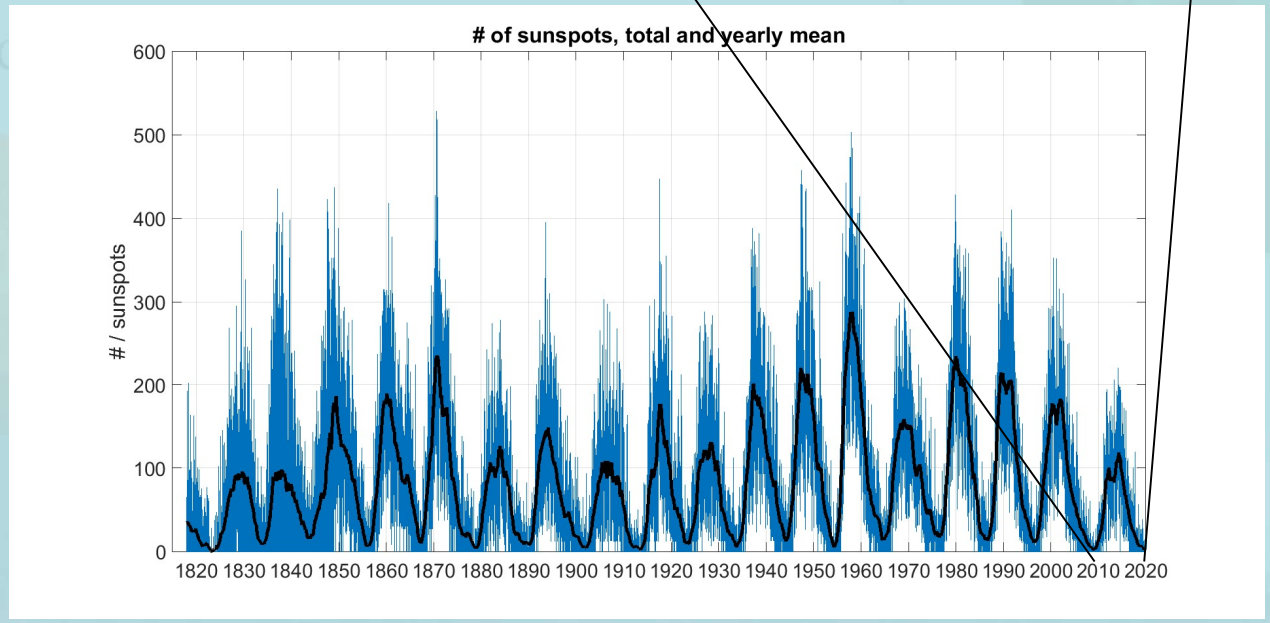


The Sun-





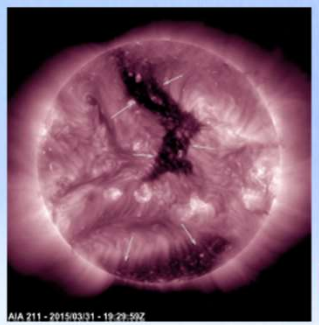


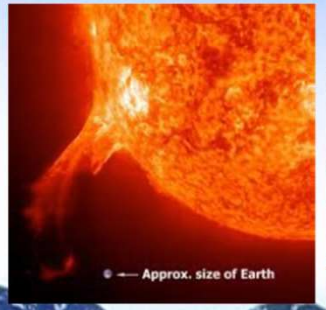


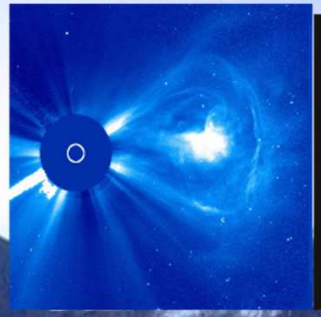
SILSO data base
sidc.be/silso

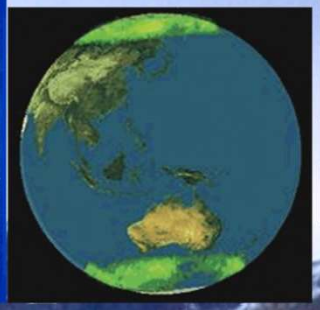
The Sun-Earth magnetic coupling

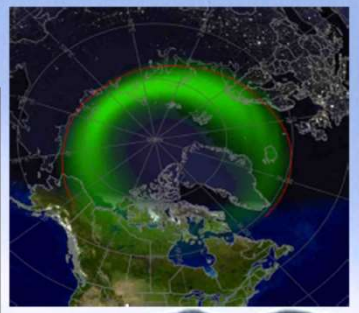
Goal is to examine and understand better geomagnetic activity and its drivers from above and below in time-scales of seconds, hours, decades, and centuries and beyond.





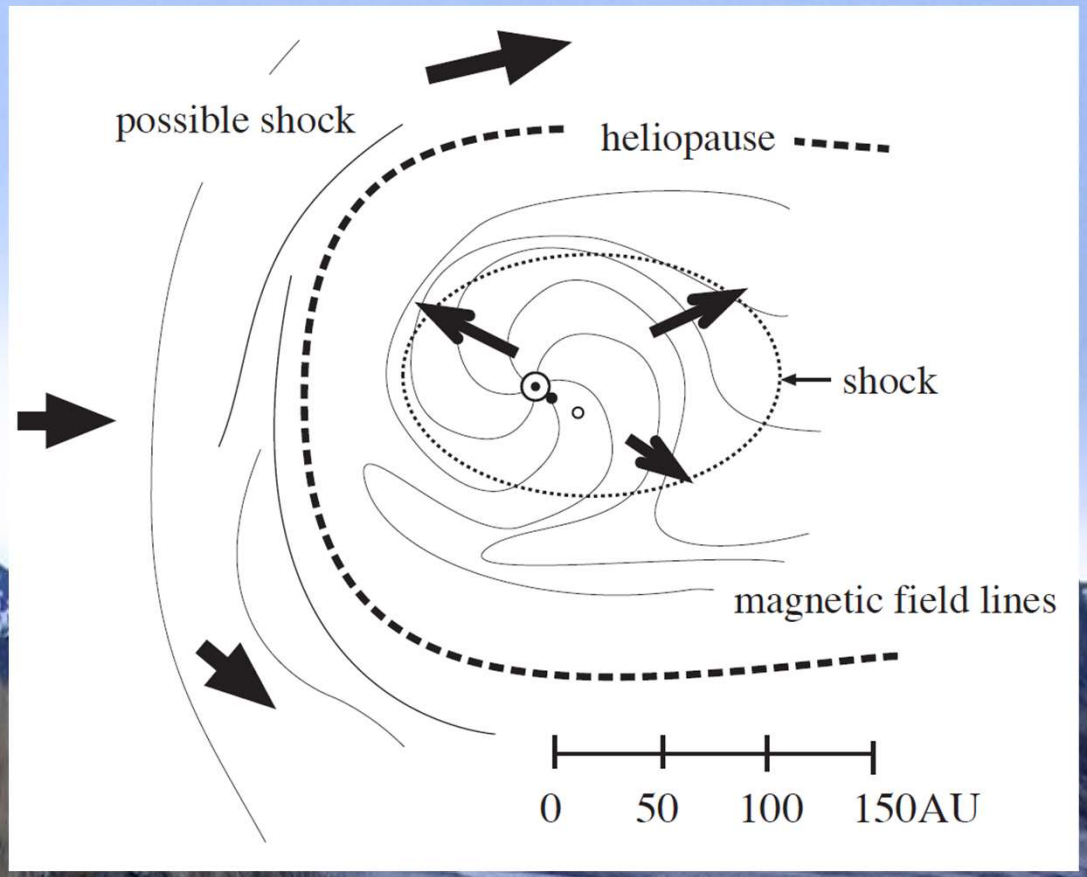






Magnetism in heliosphere and beyond

Magnetic forces act in many spatial scales from nanometers to light years.



Heliosphere

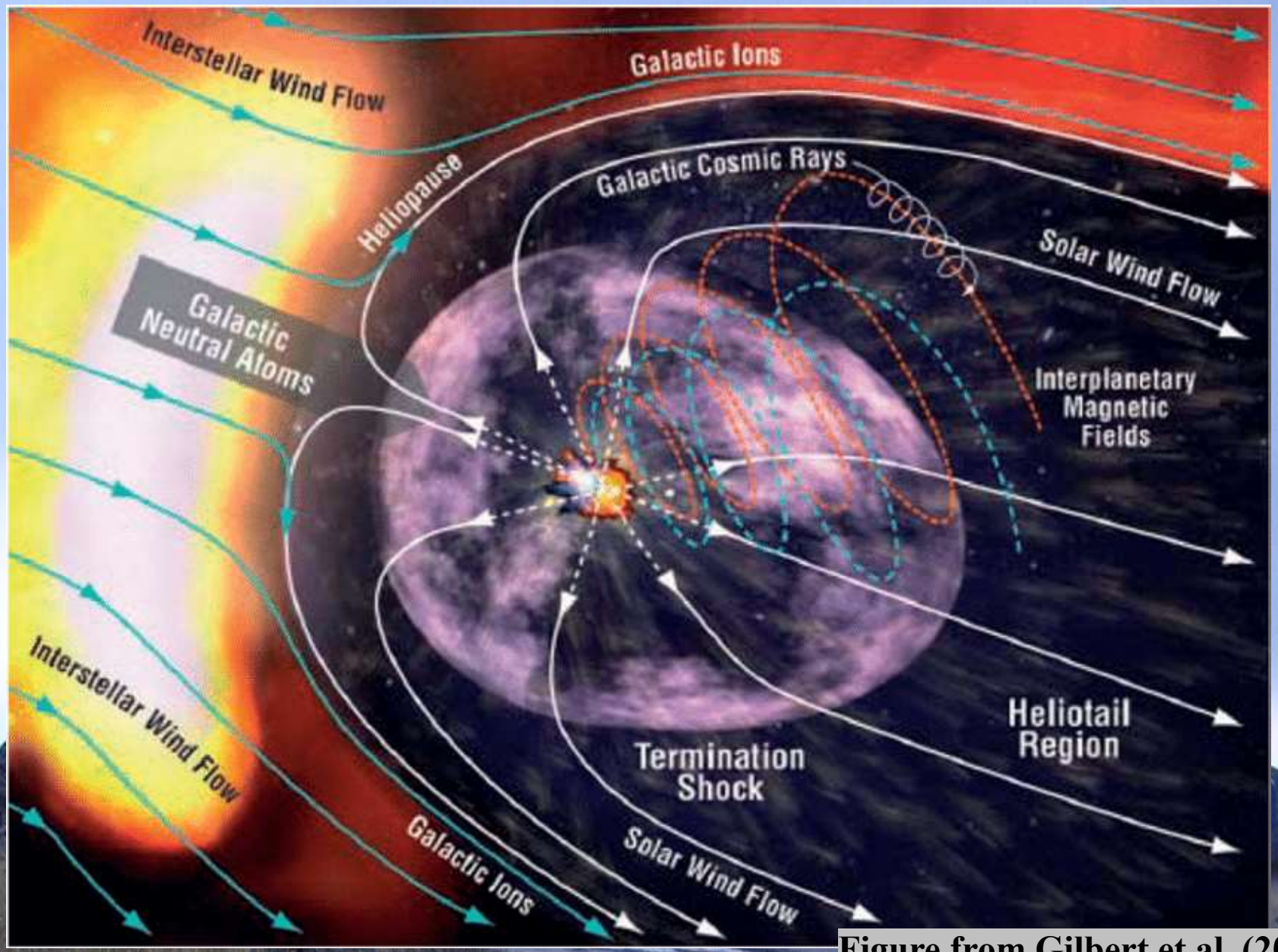
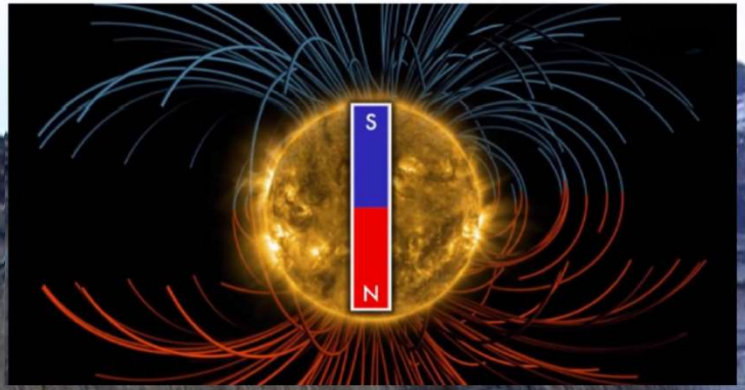


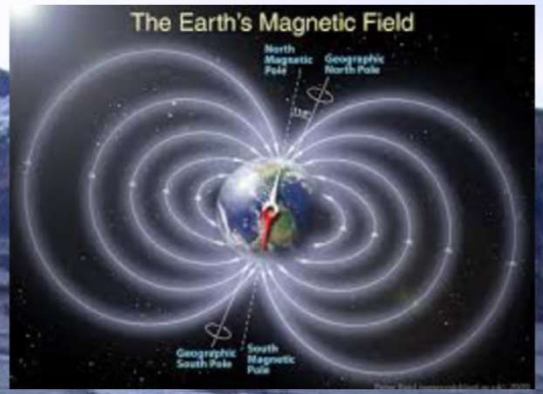
Figure from Gilbert et al. (2009)

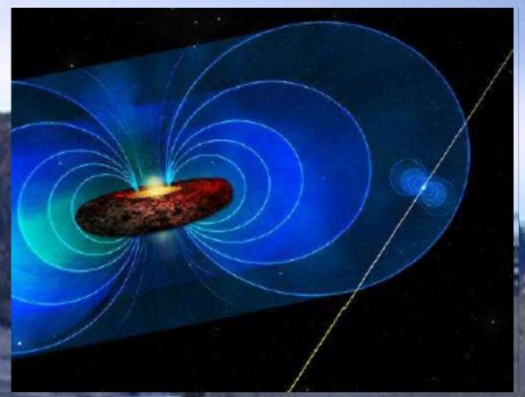
The Earth is a magnet.
The Sun is a magnet.
The Milky Way is a magnet.

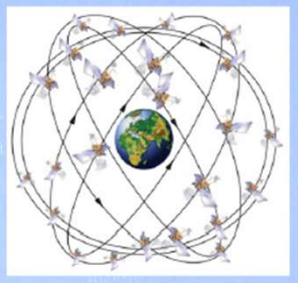
We live in an electromagnetic world almost without noticing the forces that have an influence on us, on our environment and on the basic functions of our society.

Our lives and homes are filled with devices used every day, which are based on magnetic forces, including cars, computers, microwave ovens, credit cards and cell phones.









Telecommunication

Satellite safety

Space safety

Aviation, navigation

Transportation

Electric cars

IMPACT

Nuclear power safety

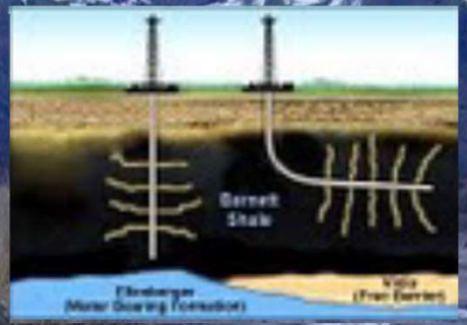
Energy supply

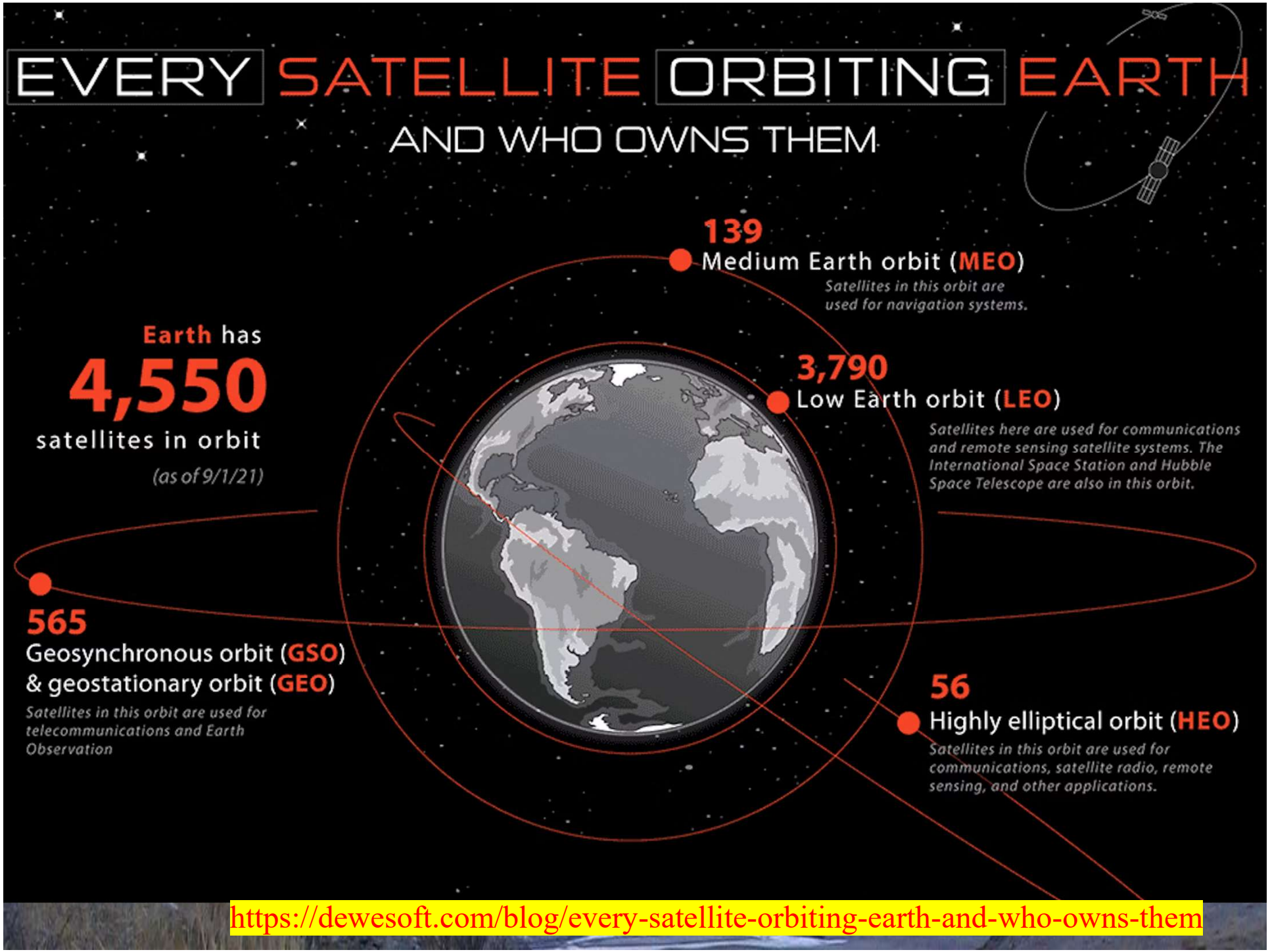
Electricity

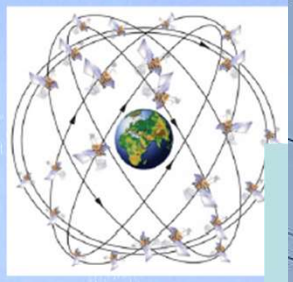
Food and water supply

Synchronized data systems

Oil drilling, mining

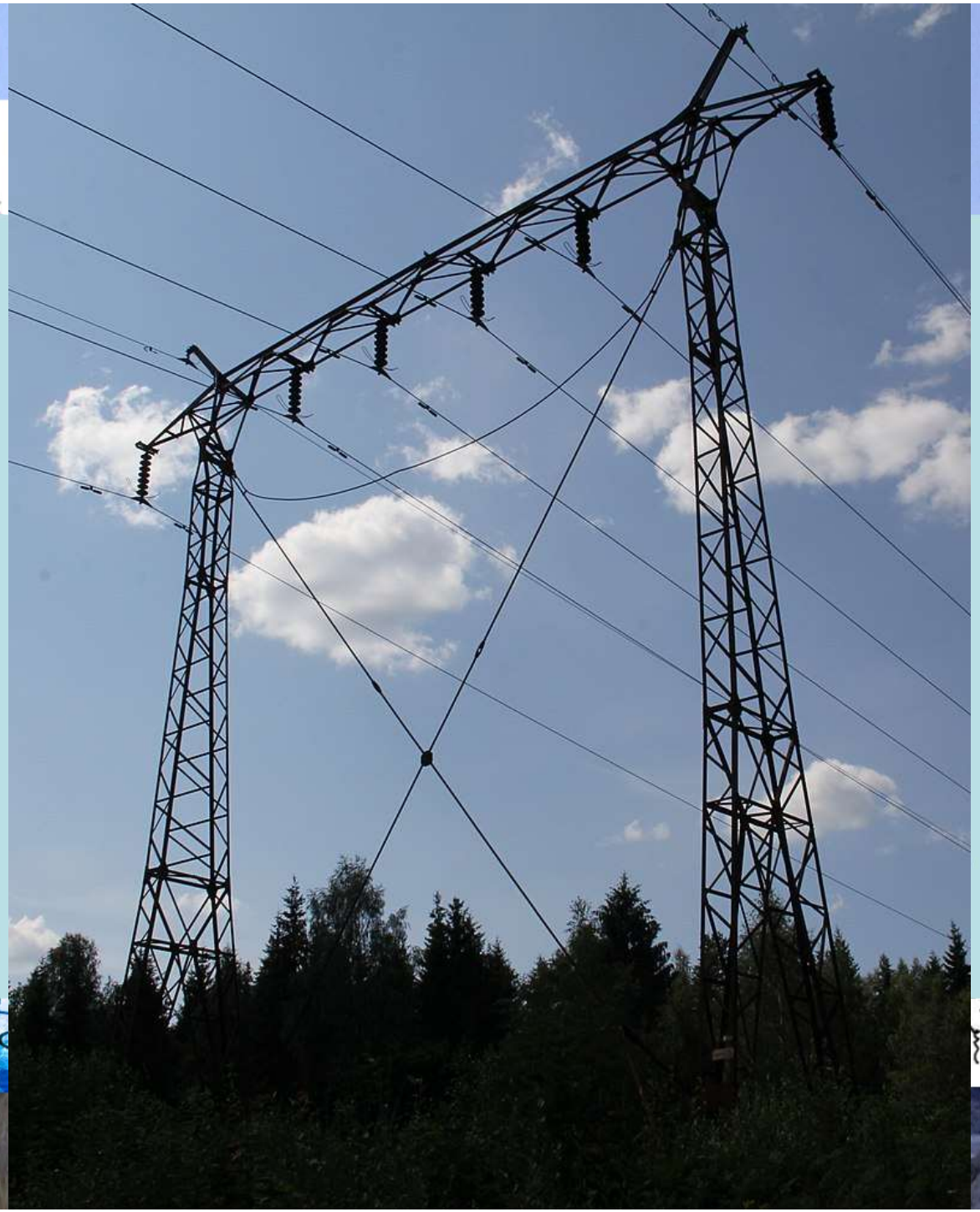


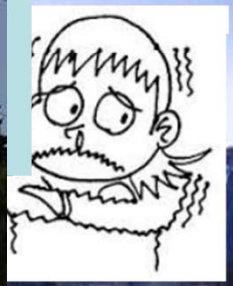

EVERY SATELLITE ORBITING EARTH
AND WHO OWNS THEM
Earth has
4,550
satellites in orbit
(as of 9/1/21)
139
Medium Earth orbit (MEO)
Satellites in this orbit are used for navigation systems.
3,790
Low Earth orbit (LEO)
Satellites here are used for communications and remote sensing satellite systems. The International Space Station and Hubble Space Telescope are also in this orbit.
565
Geosynchronous orbit (GSO) & geostationary orbit (GEO)
Satellites in this orbit are used for telecommunications and Earth Observation
56
Highly elliptical orbit (HEO)
Satellites in this orbit are used for communications, satellite radio, remote sensing, and other applications.
https://dewesoft.com/blog/every-satellite-orbiting-earth-and-who-owns-them



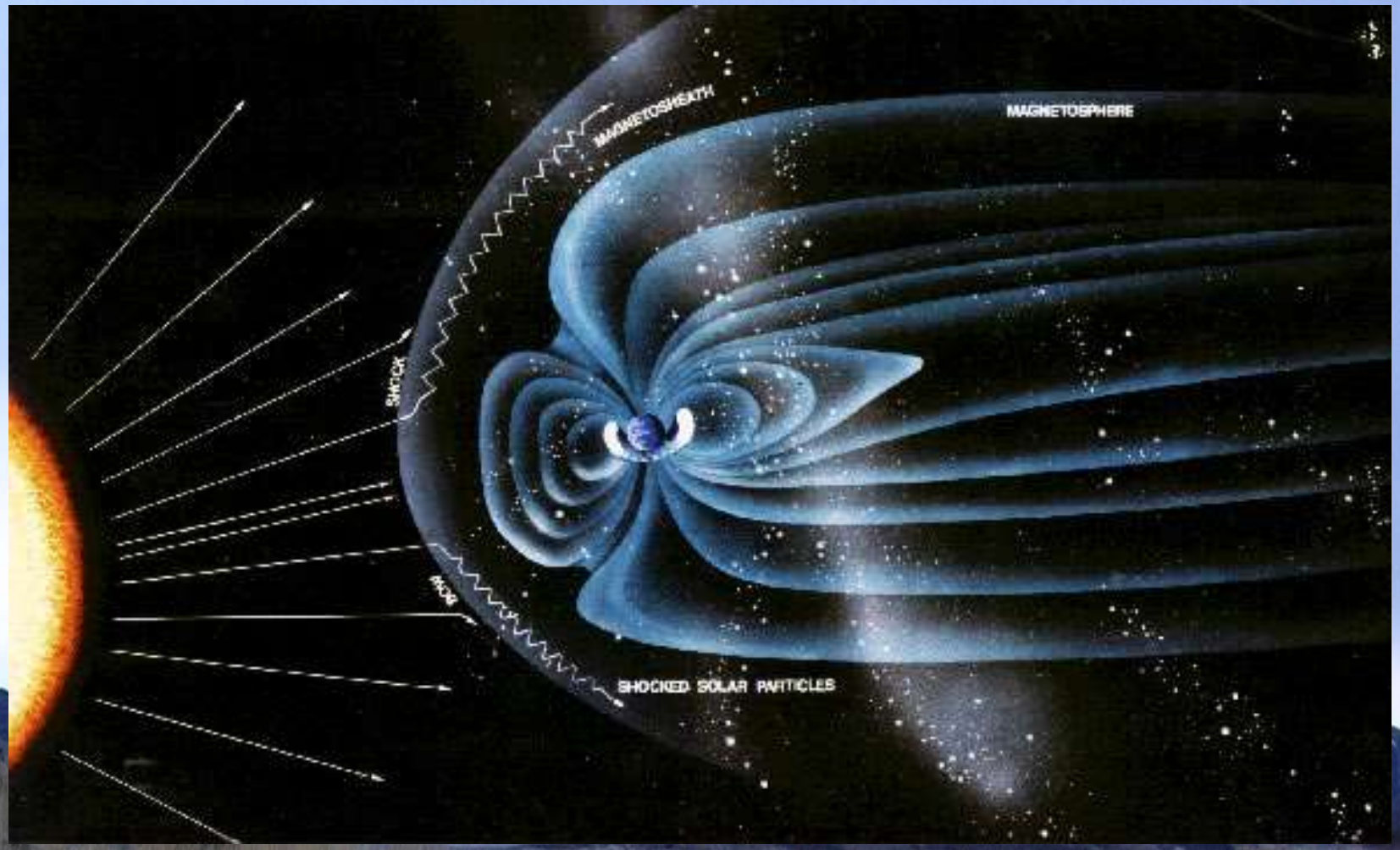
Telecor

Synchro





Sun-Earth magnetic coupling



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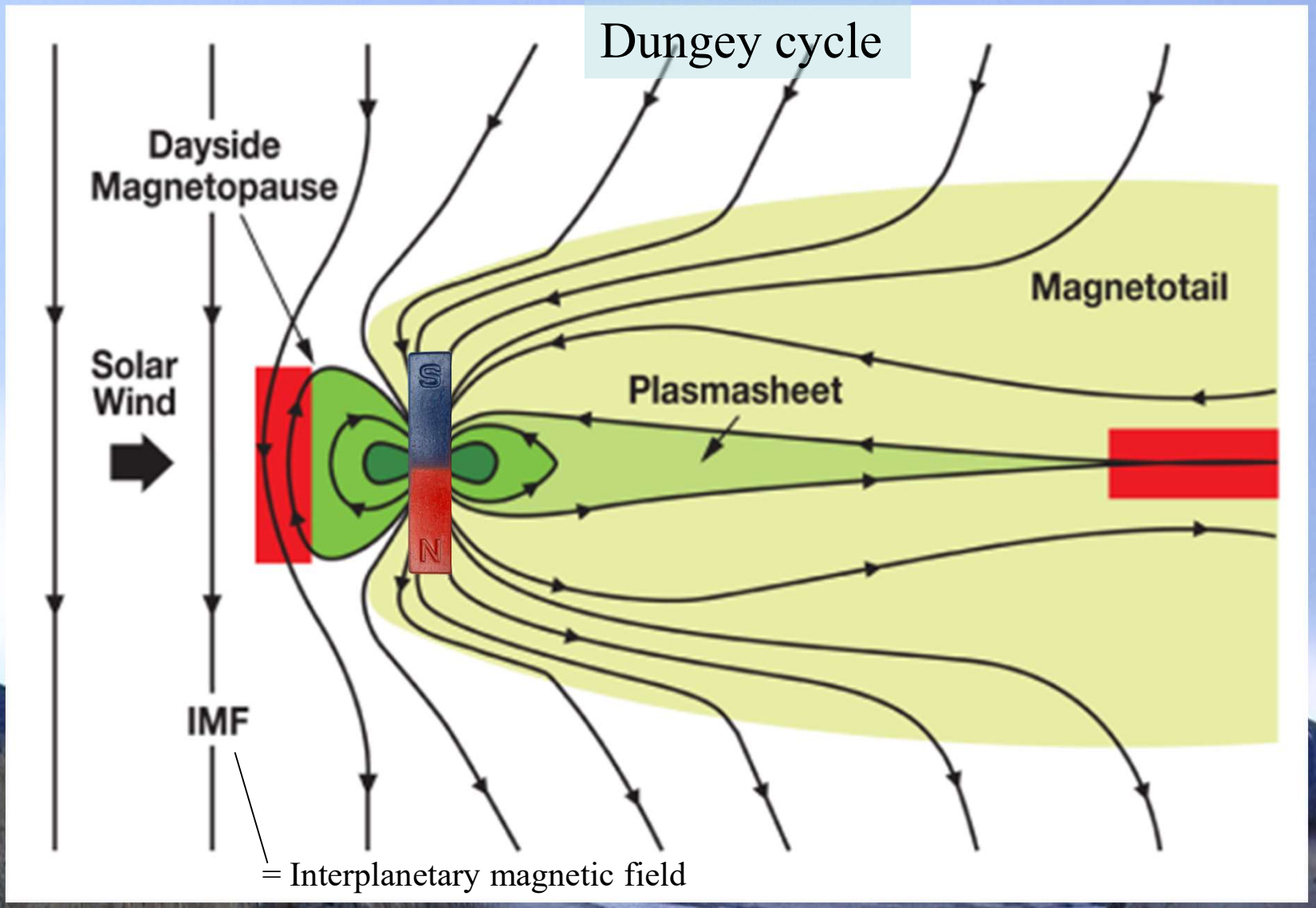
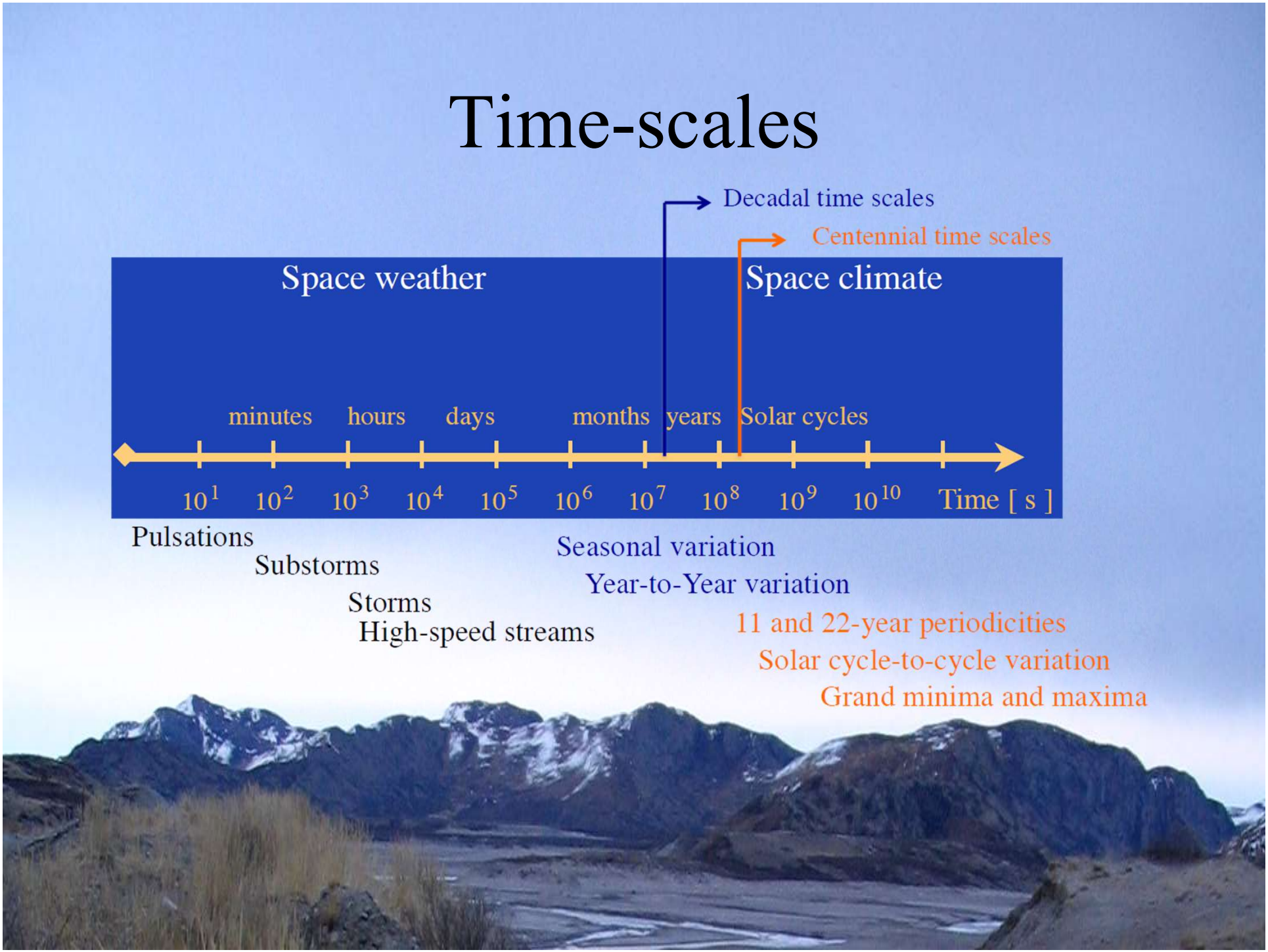
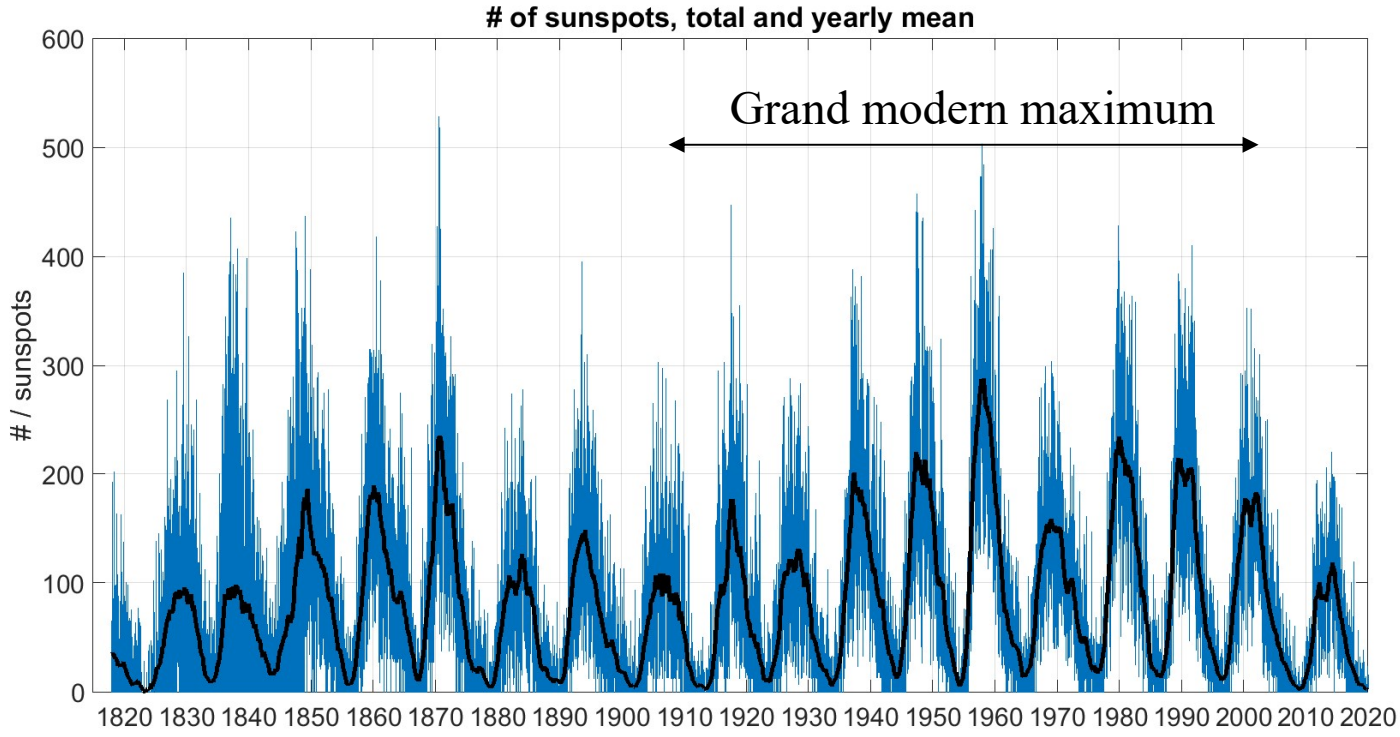


Time-scales


Decadal time scales
Centennial time scales
Space weather
Space climate
minutes
hours
days
months
years
Solar cycles
10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^{10}
Time [s]
Pulsations
Substorms
Storms
High-speed streams
Seasonal variation
Year-to-Year variation
11 and 22-year periodicities
Solar cycle-to-cycle variation
Grand minima and maxima

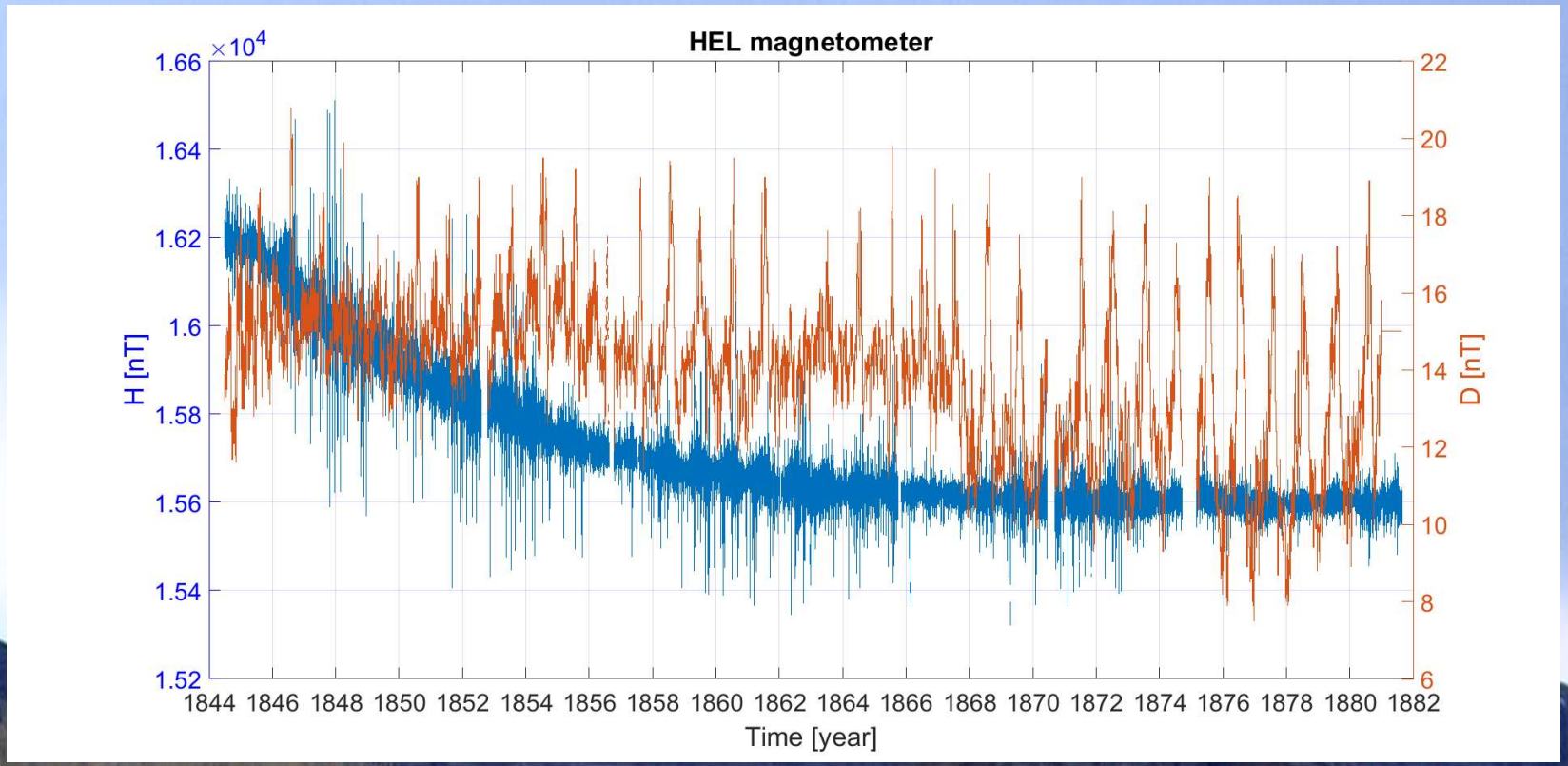
Sunspots



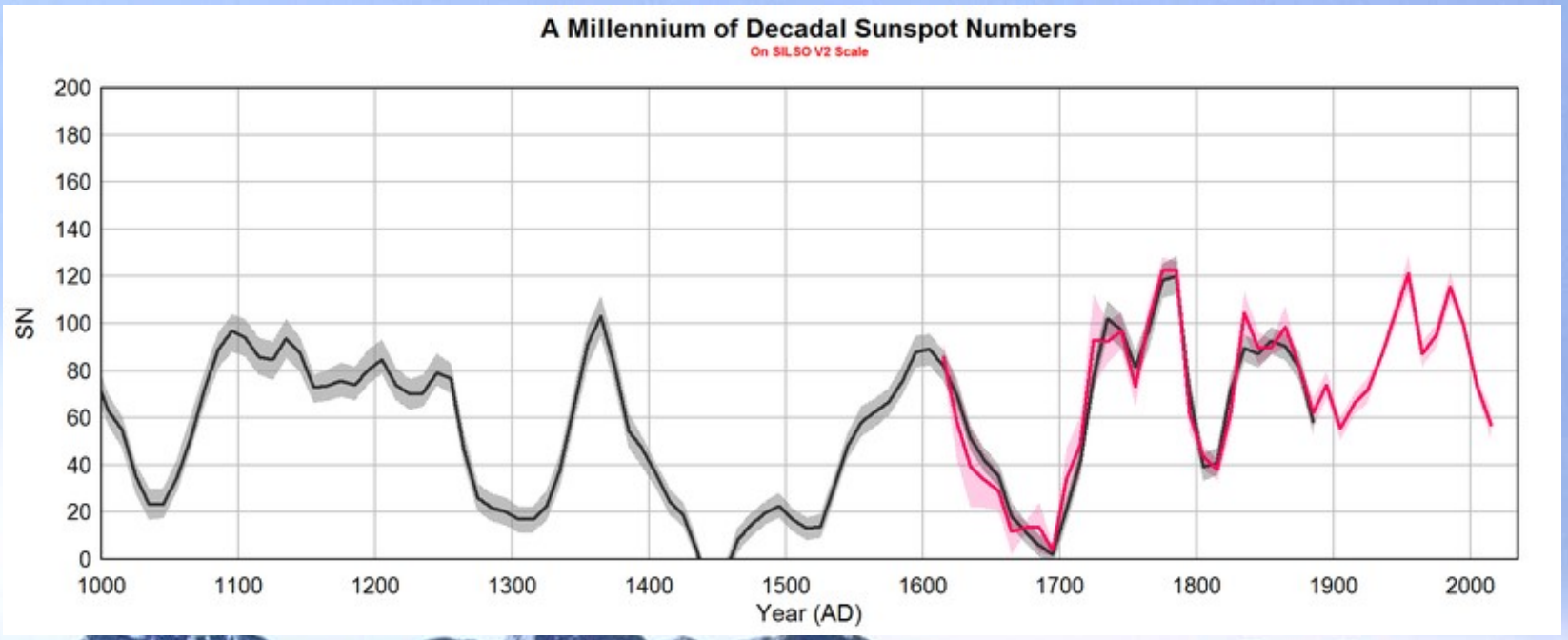
SILSO data base
sidc.be/silso

Scientific quality geomagnetic data

Recorded in Finland since 1844



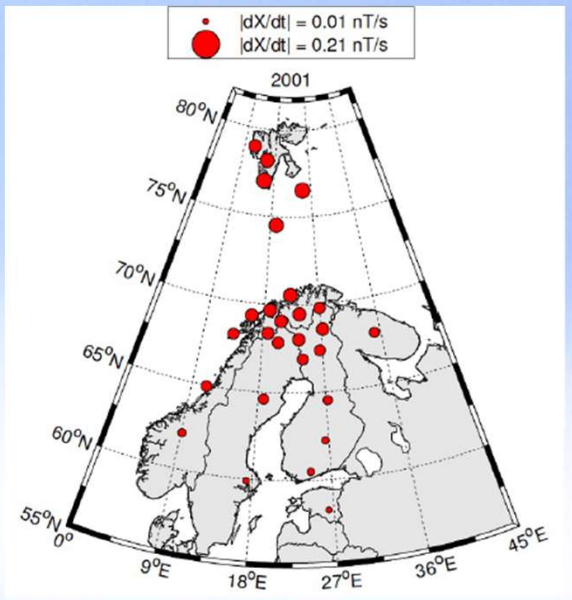
Reconstructed time series



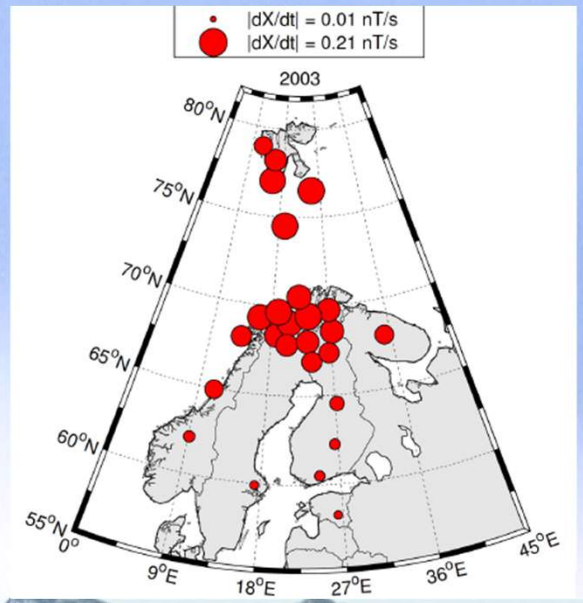
Svalgaard (2018)
https://doi.org/10.48550/arXiv.1810.11952

High-latitude geomagnetic activity

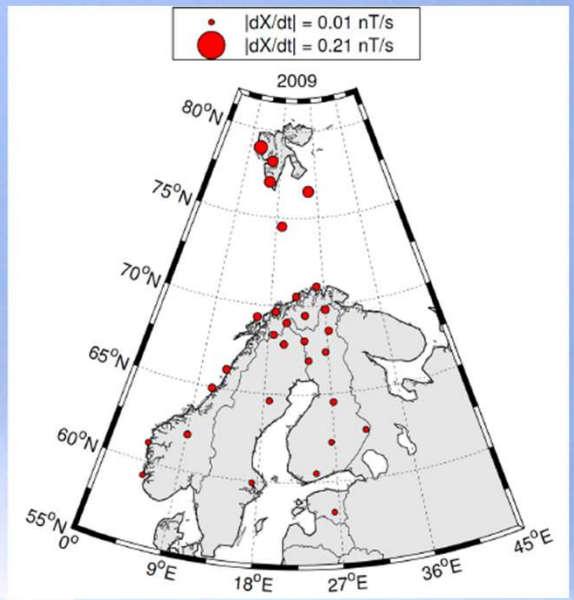
Largest geomagnetic disturbances in high-latitudes between 65° and 75° geom. lat. during declining solar cycle phase. (Tanskanen et al., 2002; 2005; 2011 & Tanskanen, 2009.)



Solar maximum



Declining solar cycle phase



Solar minimum

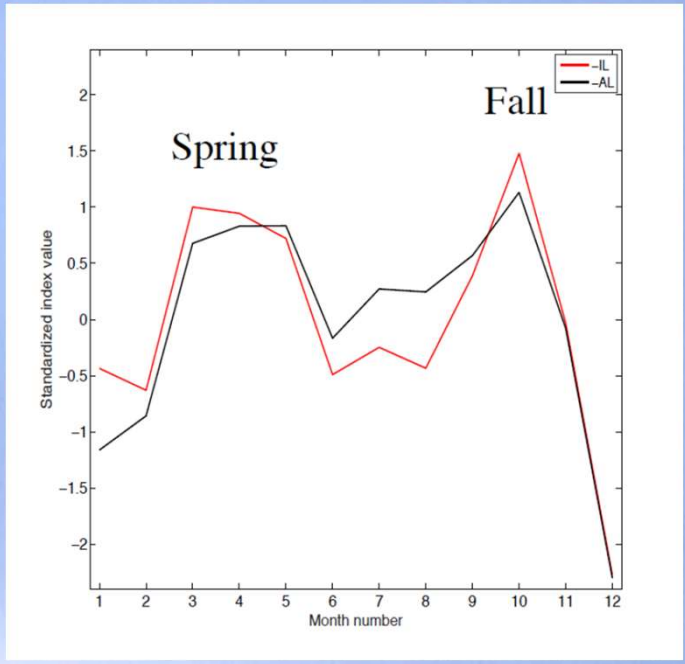
Seasonal variation

Old paradigm:

- Geomagnetic activity maximizes in spring and fall.

New paradigm:

- Geomagnetic activity can maximize at any solar cycle phase depending on the state of the Sun.



"While mechanisms leading to the classical two-equinox maxima pattern are in operation, the long-term change of solar wind speed tends to mask the effect of these mechanisms for individual years."