Solar wind and geomagnetic activity

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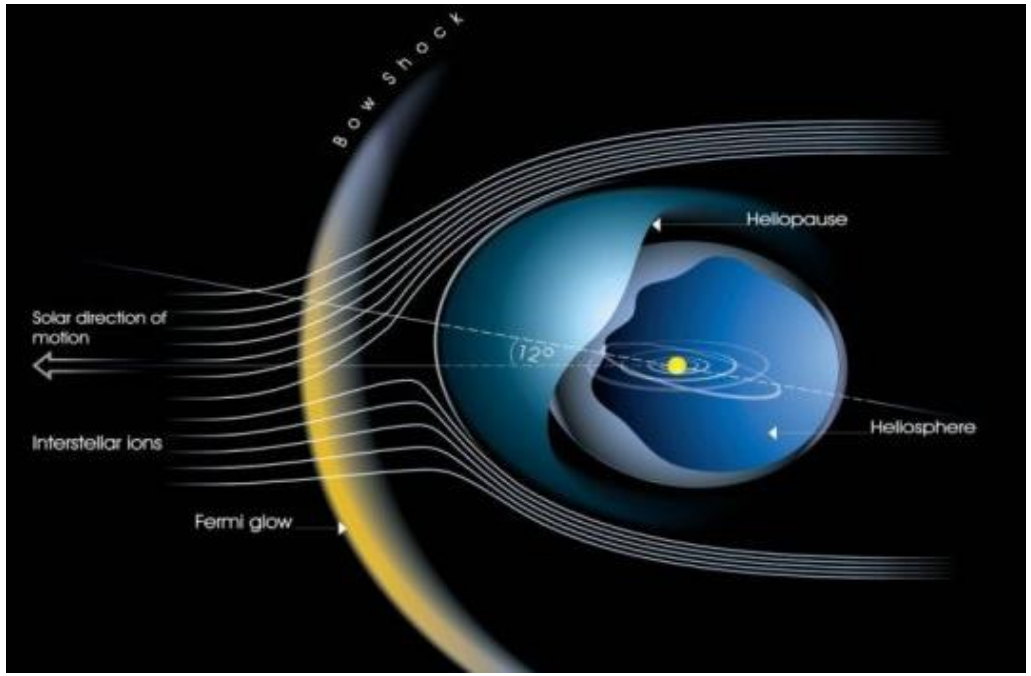
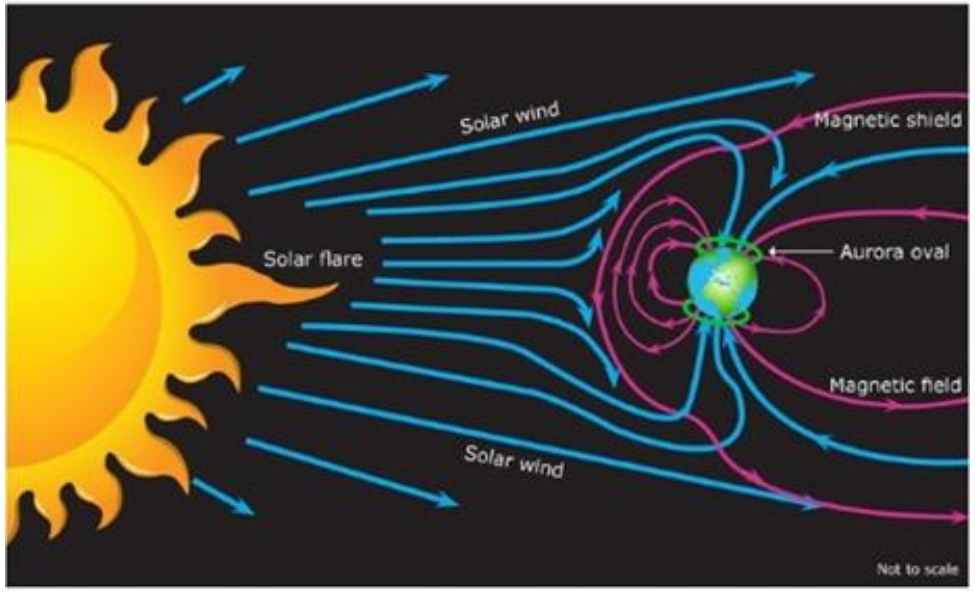
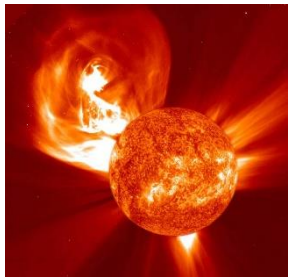
solar wind

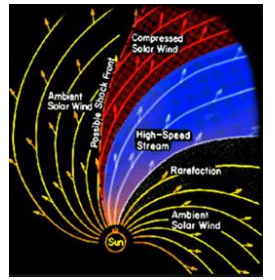
The solar corona (the outermost part of the solar atmosphere) is not in hydrostatic equilibrium and is constantly expanding until it meets the interstellar matter





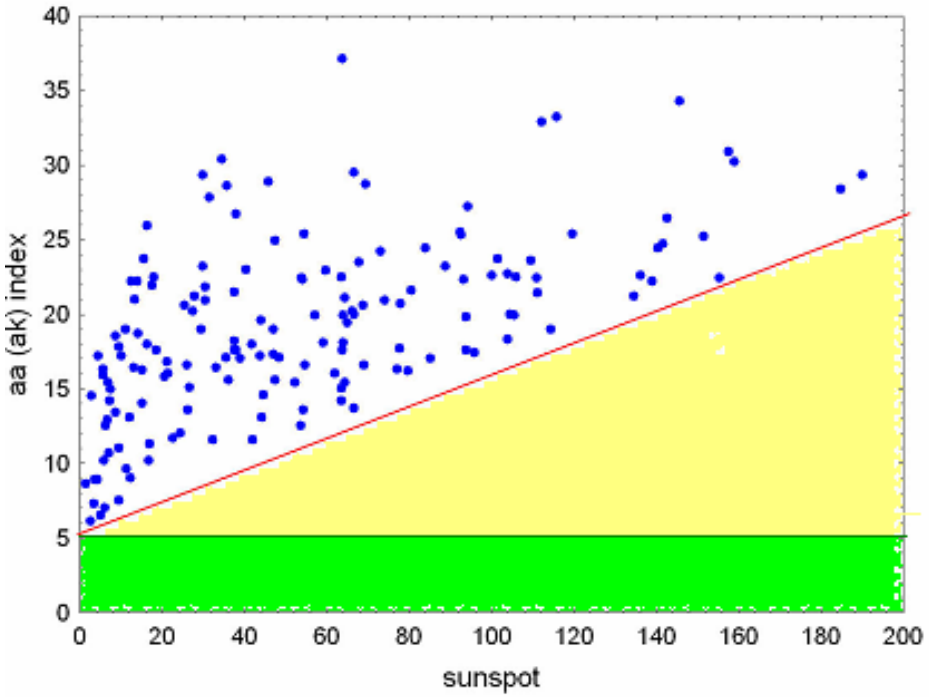
On top of this background solar wind, transient events ride as **coronal mass ejections** and **high speed solar wind** flows from solar coronal holes





The solar wind has 3 components:

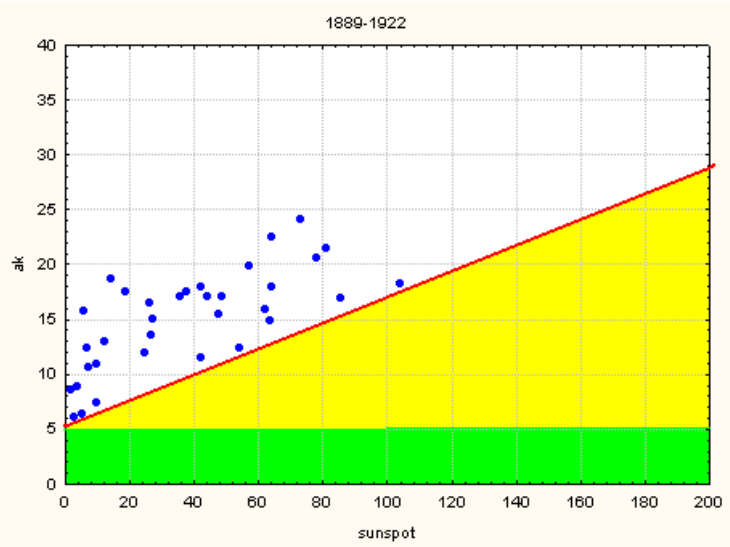
- Slow (background) solar wind
- Coronal mass ejections
- High speed solar wind streams

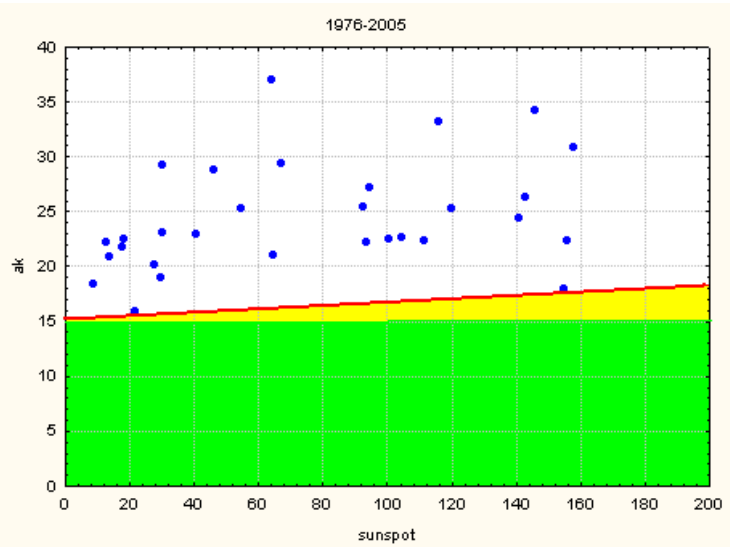


Respectively, the geomagnetic activity has three components:

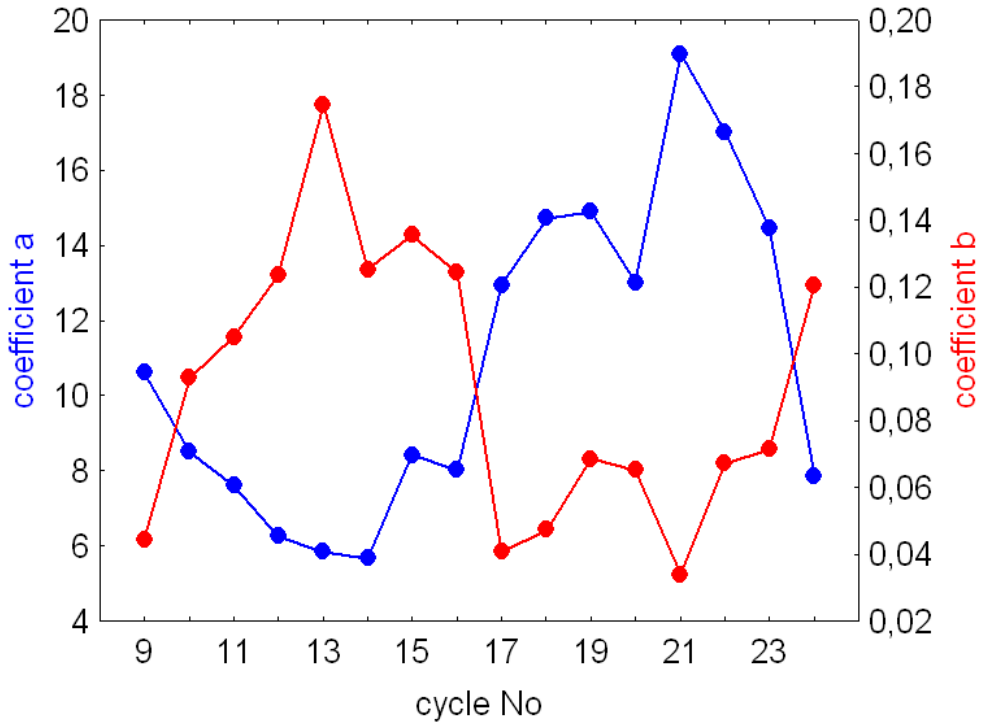
- "floor" of geomagnetic activity – the level under which geomagnetic activity cannot fall even in the absence of any CMEs and HSS
- CME-related geomagnetic activity
- HSS-related geomagnetic activity

The three components of geomagnetic activity are different in different periods

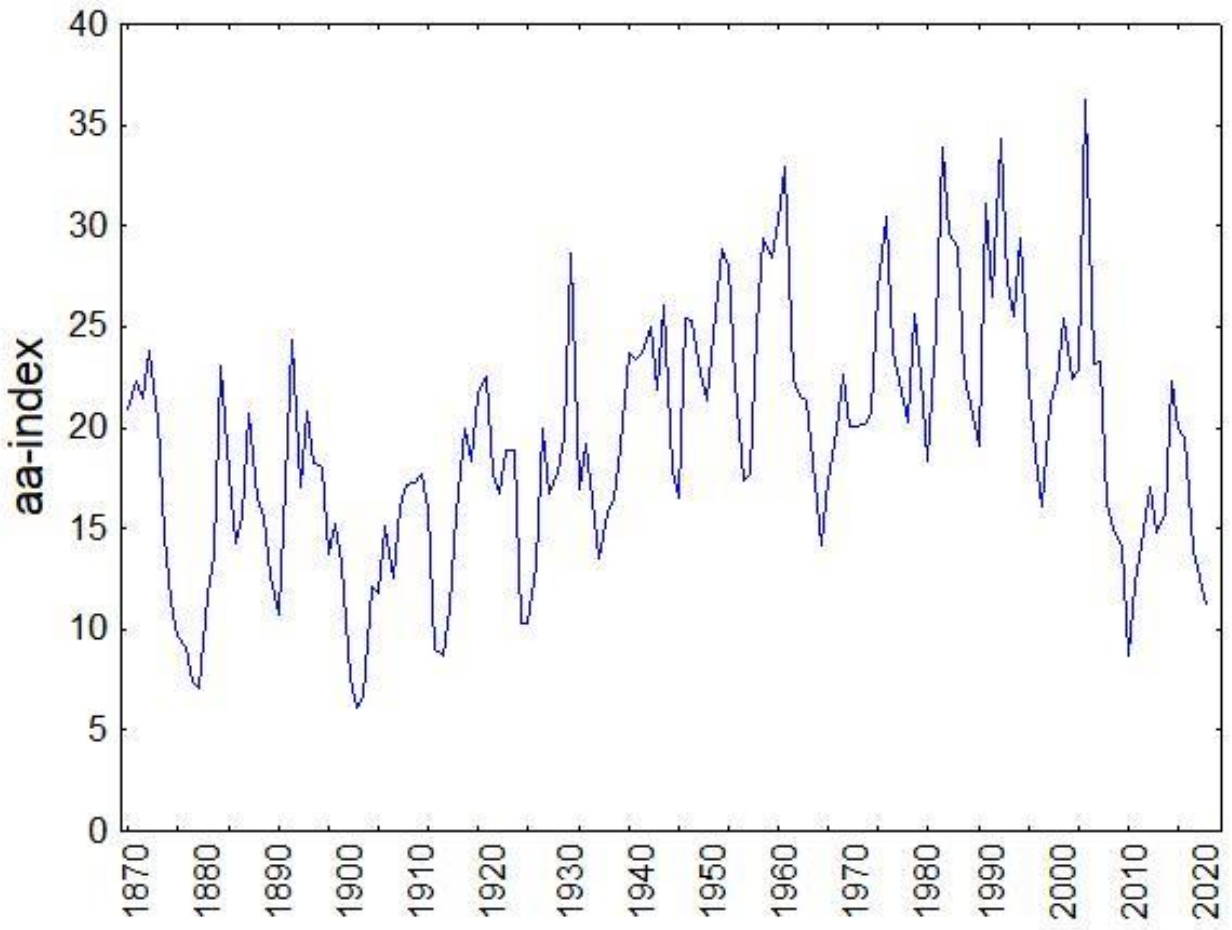




and have long-term cyclic variations



The geomagnetic activity has been decreasing since the 1990s



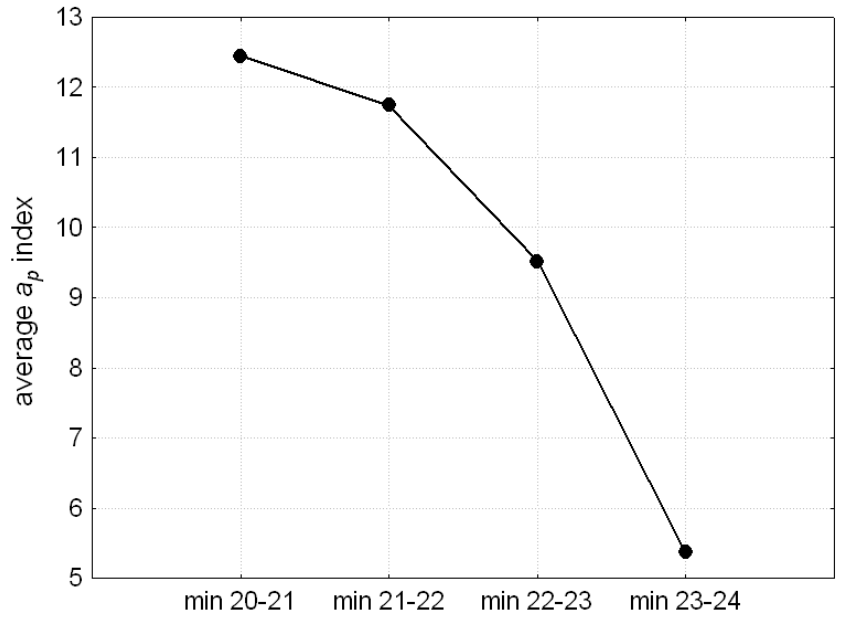
especially its minimum values

We study the recent minima for which there are *in situ* measurements of the solar wind

- $\pm$ 12 months around sunspot minimum
- Identify times when the Earth is under the influence of CMEs and HSS
- CME: low T, low plasma β, high B
- HSS: jump in V, high V, high T, low N
- Slow solar wind: no CME, no HSS, V<450 km/s

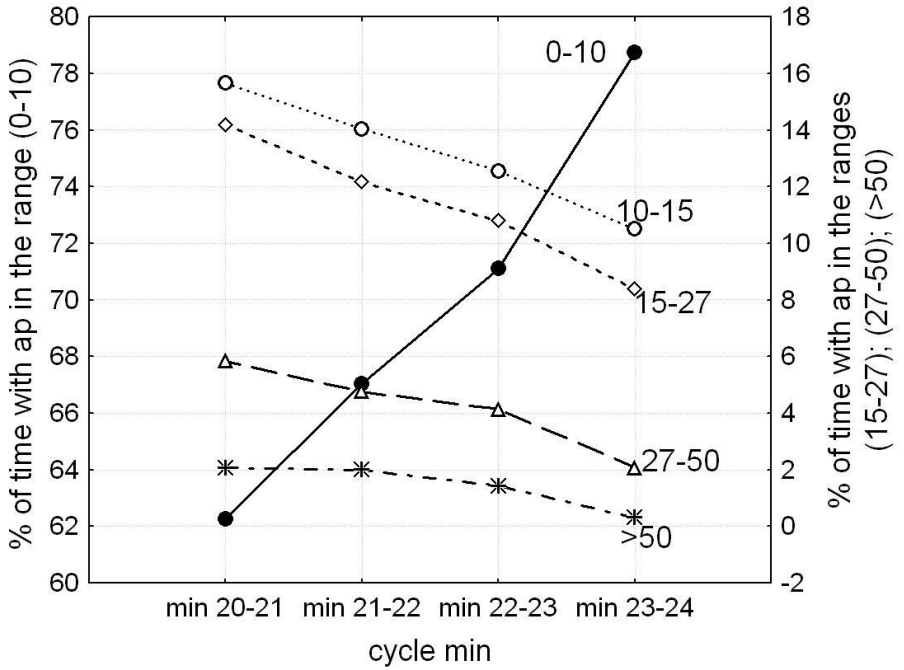
The overall geomagnetic activity has been decreasing in the previous 4 sunspot minima

average ap index

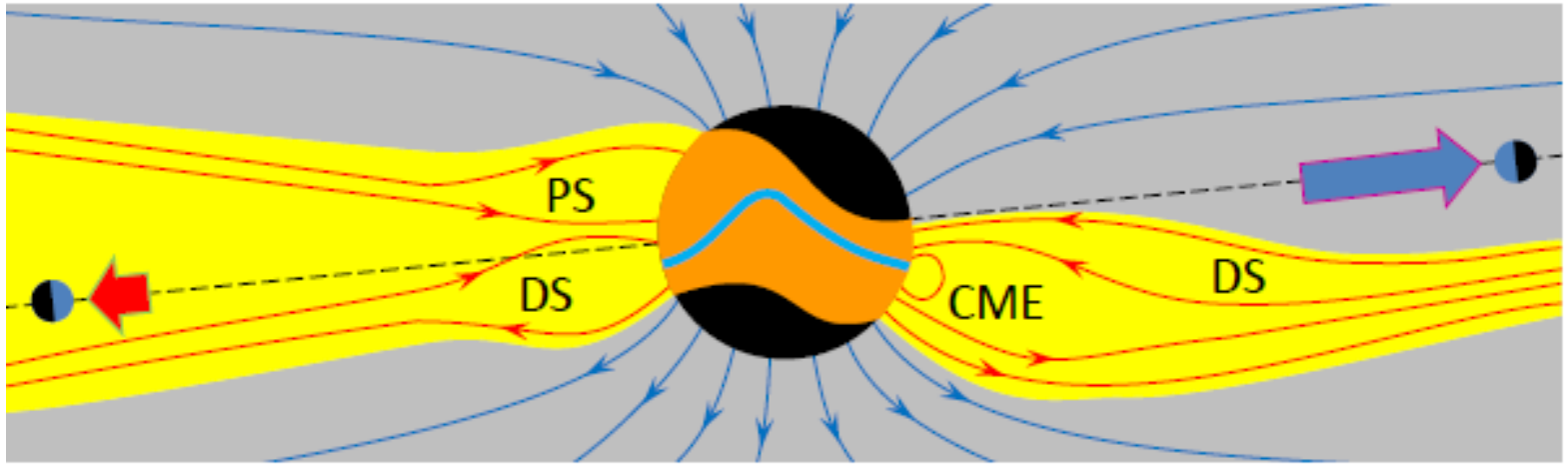


Increasing fraction of time with very low ap

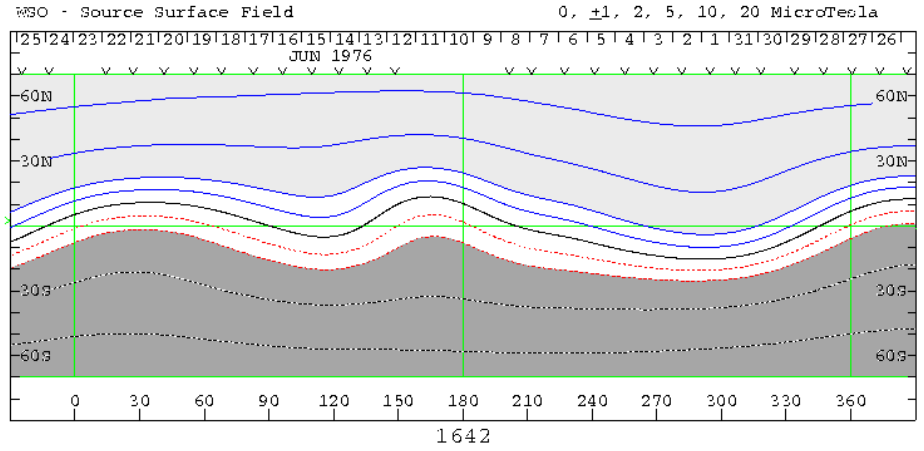
Decreasing duration of intervals with high and even moderate ap

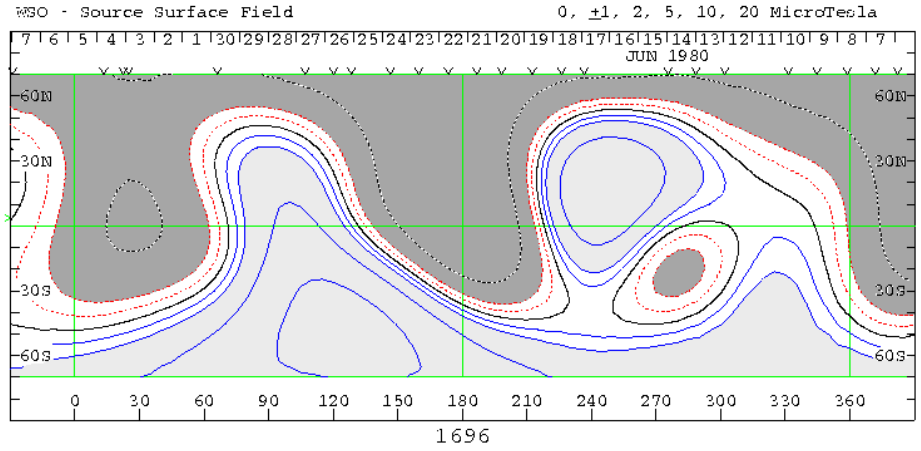


The present paradigm: the annual number of geomagnetically “quiet” and “very quiet” days is determined by the time the Earth spends in slow solar wing from the solar streamer belt (*Simon and Legrand, 1987*)

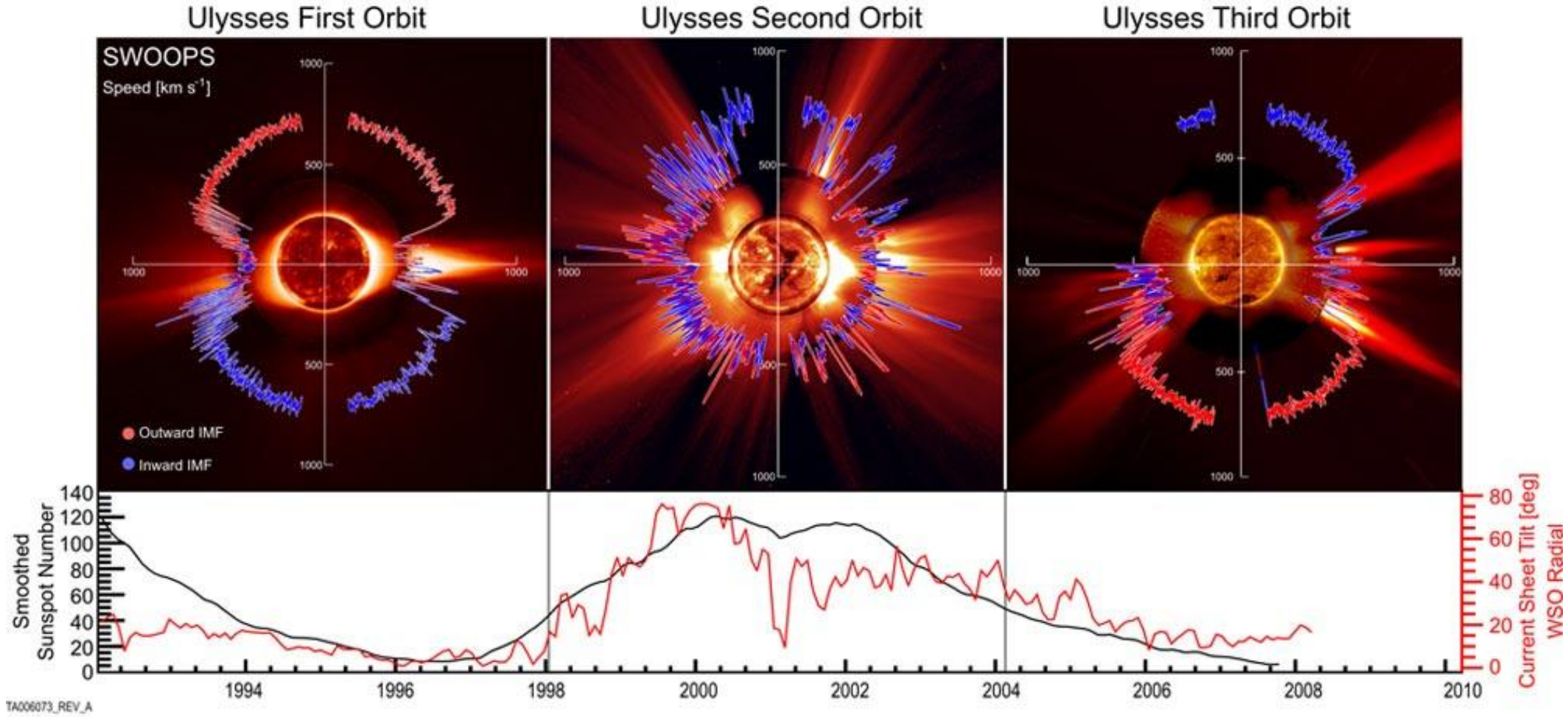


The solar streamer belt’s projection in the interplanetary space is the heliospheric current sheet

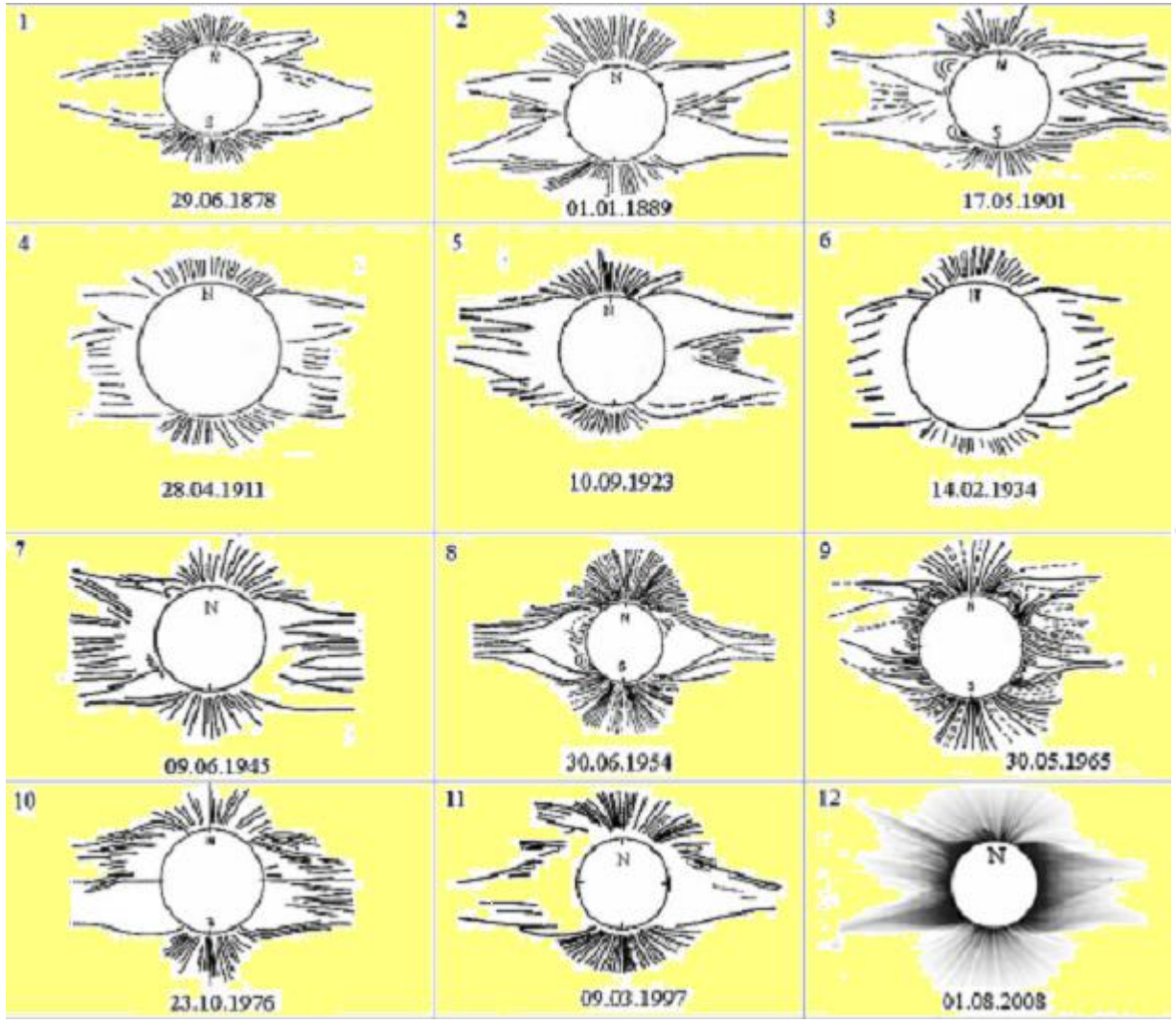


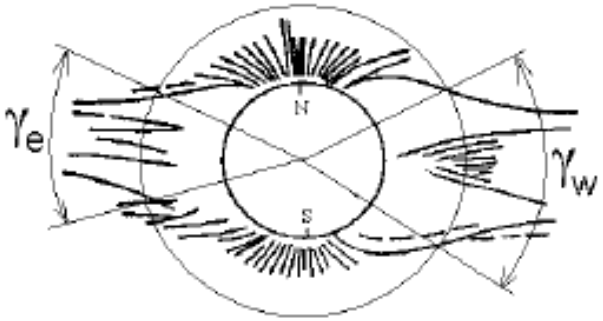


In sunspot minimum the heliospheric current sheet is in the ecliptic plane

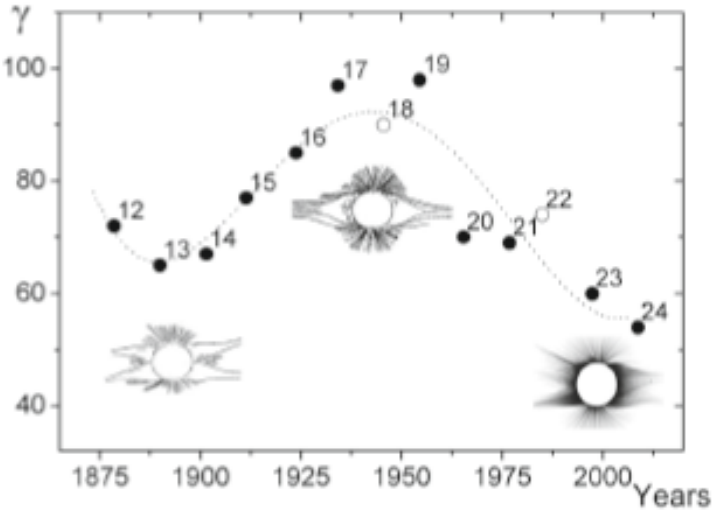


The streamed belt thickness from solar eclipse observations during sunspot minimum



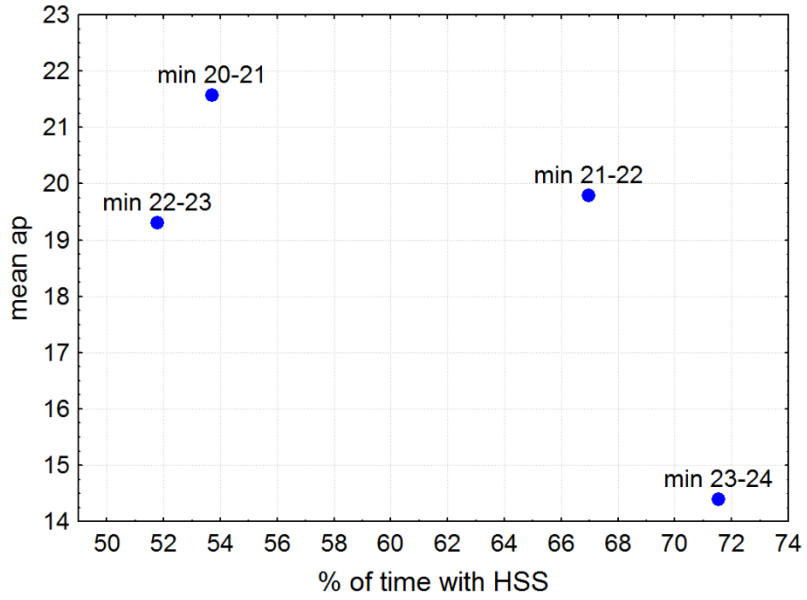


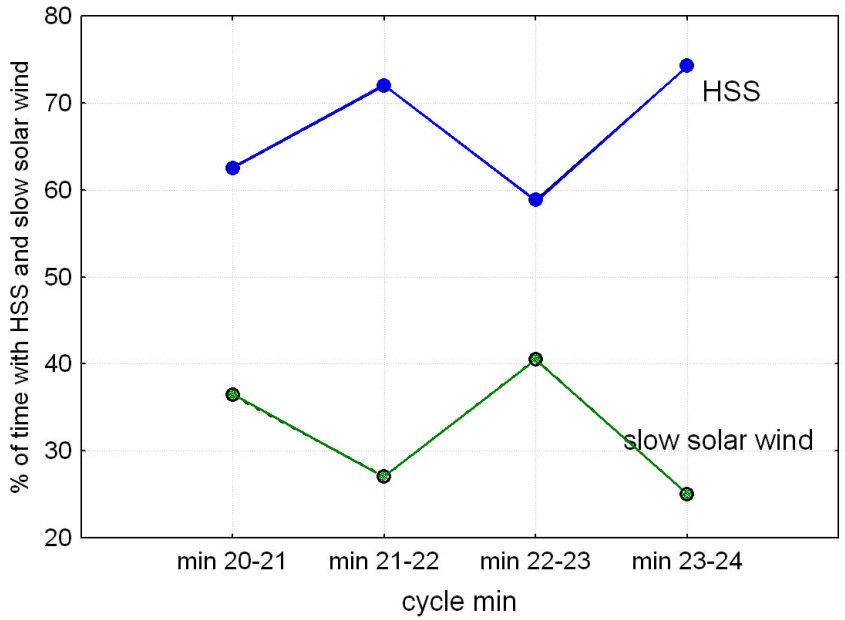
$$\gamma = 180 - (\gamma_W + \gamma_E).$$



Tlatov (2010)

A surprising result





No clear trend in the time spent by the Earth in HSS

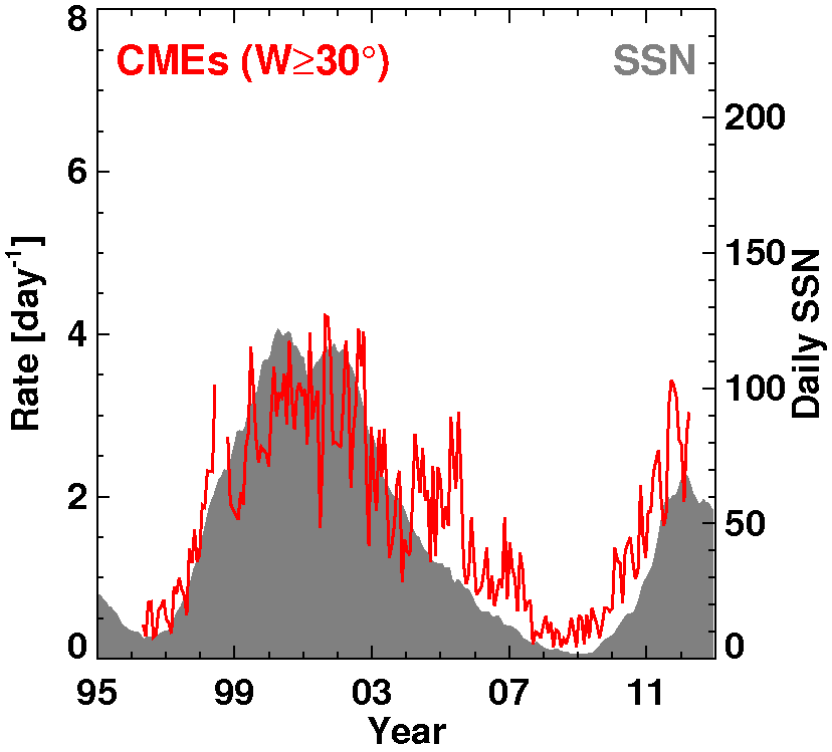
No trend in the portion of time spent inside and outside the heliosheet

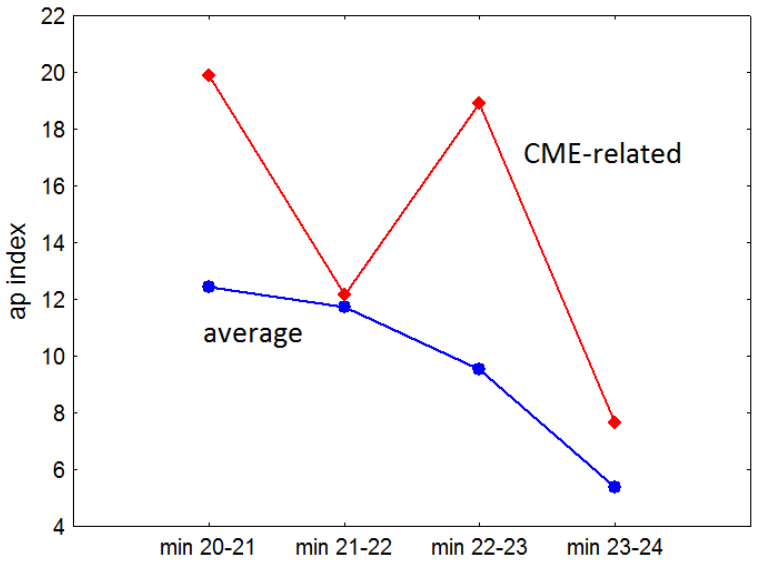
Other possible sources of the geomagnetic floor variability

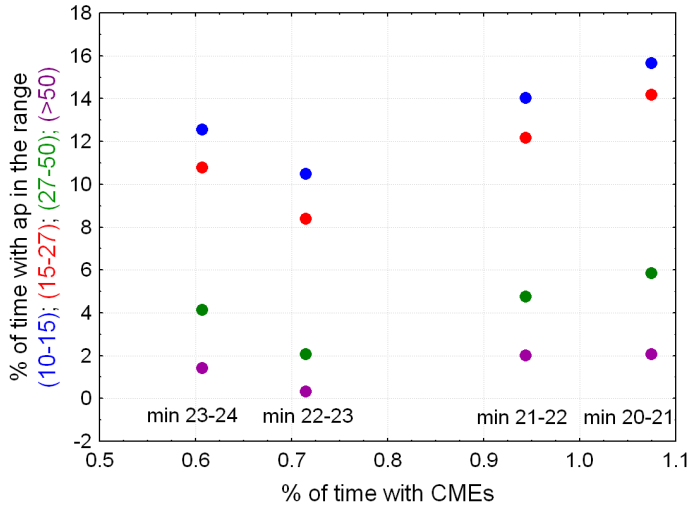
- variations of the number and/or parameters of coronal mass ejections and/or high speed solar wind streams

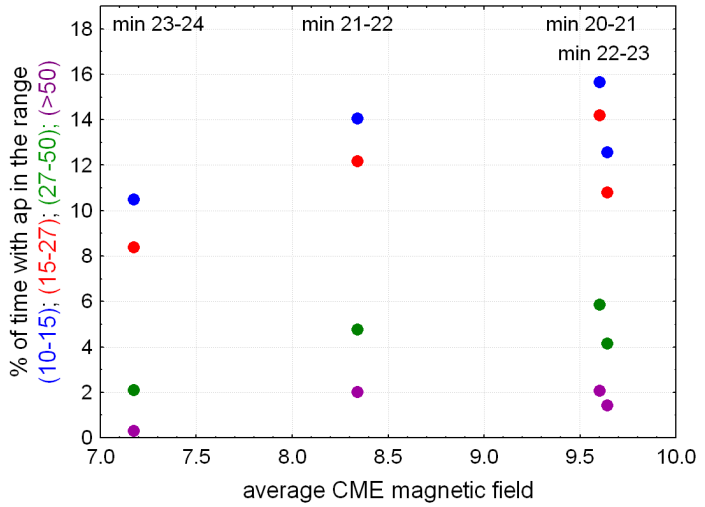
- variations of the parameters of the slow solar wind from the heliospheric current sheet

Possible effects of the number and/or parameters of CMEs





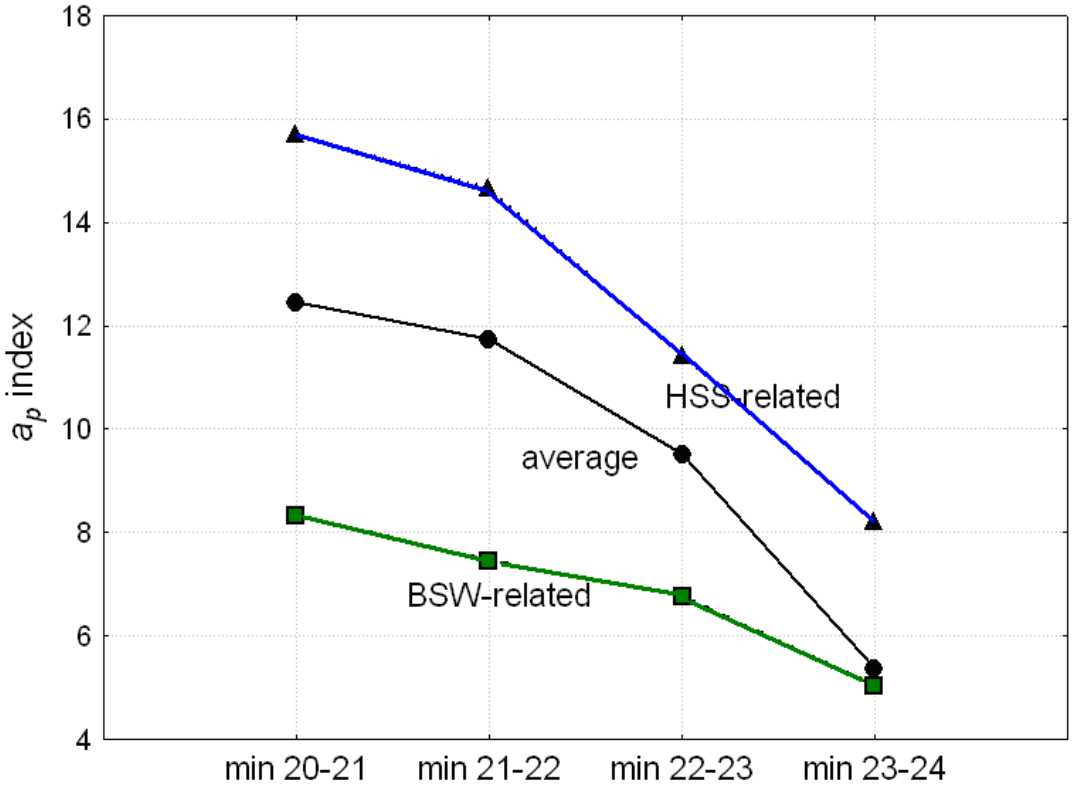




The number of CMEs follows the sunspot cycle and is very low (up to ~1%) during sunspot minimum

No dependence on the time spent with CMEs or on CME's magnetic field

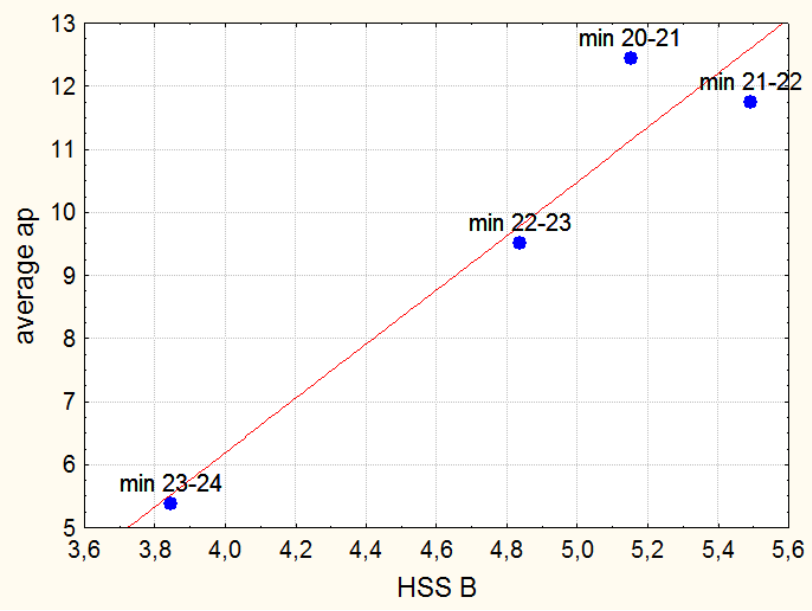
Possible effects of the parameters of HSS and slow solar wind



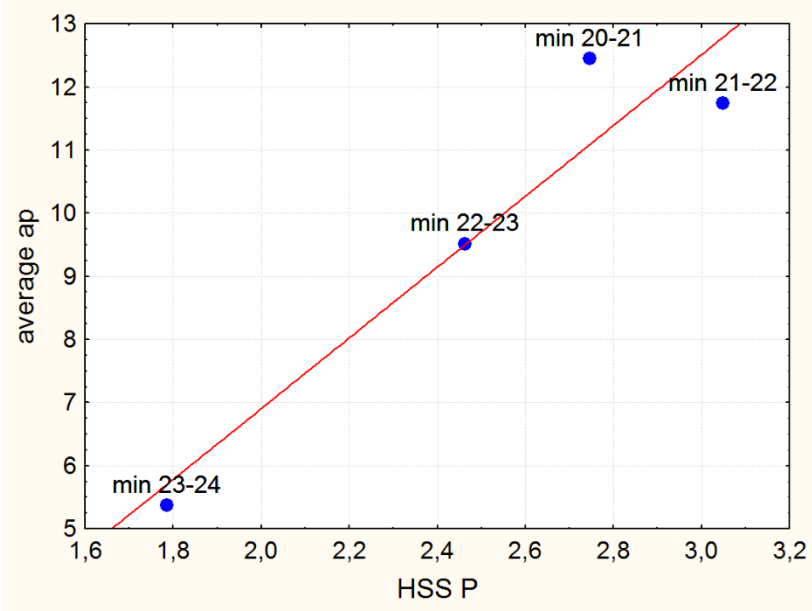
The geoeffectiveness of both the high speed wind outside the heliosheet and the slow solar wind inside the heliosheet decreases

HSS and geomagnetic activity in sunspot minimum

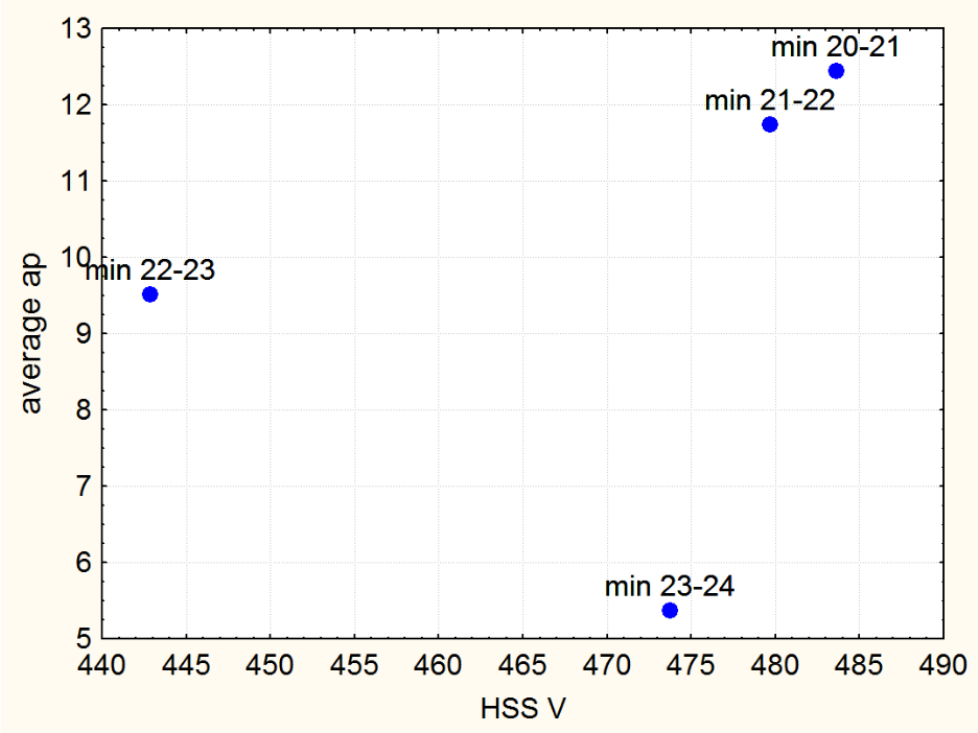
Decreasing HSS magnetic field and ap



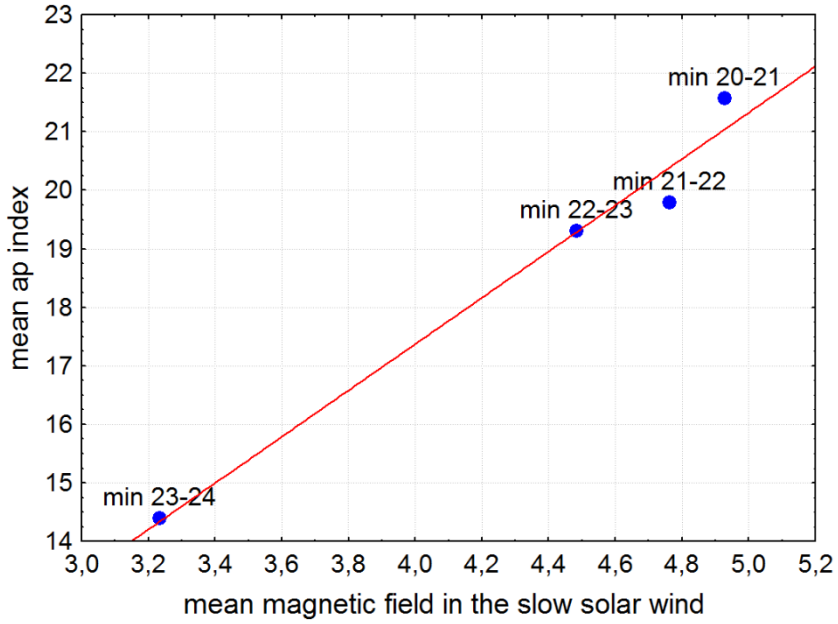
Decreasing HSS pressure and ap

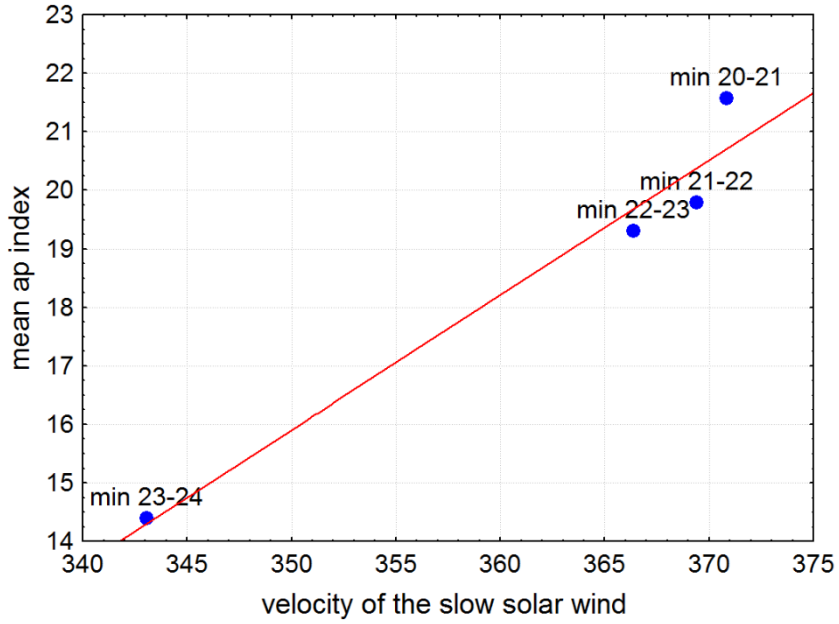


No clear trend and dependence on HSS velocity



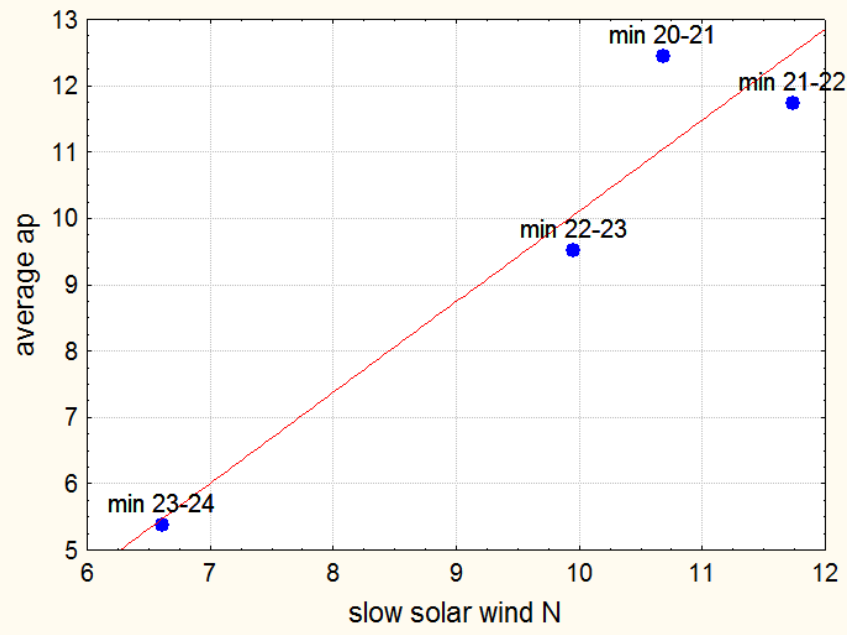
B and V of the slow solar wind are decreasing in the last 4 sunspot minima

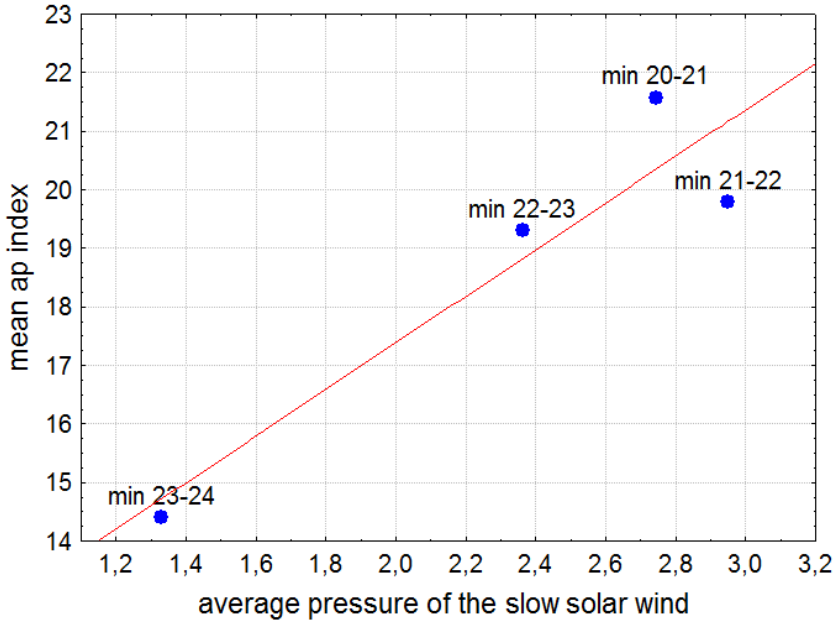




And so is geomagnetic activity

Density and pressure of the slow solar wind are decreasing



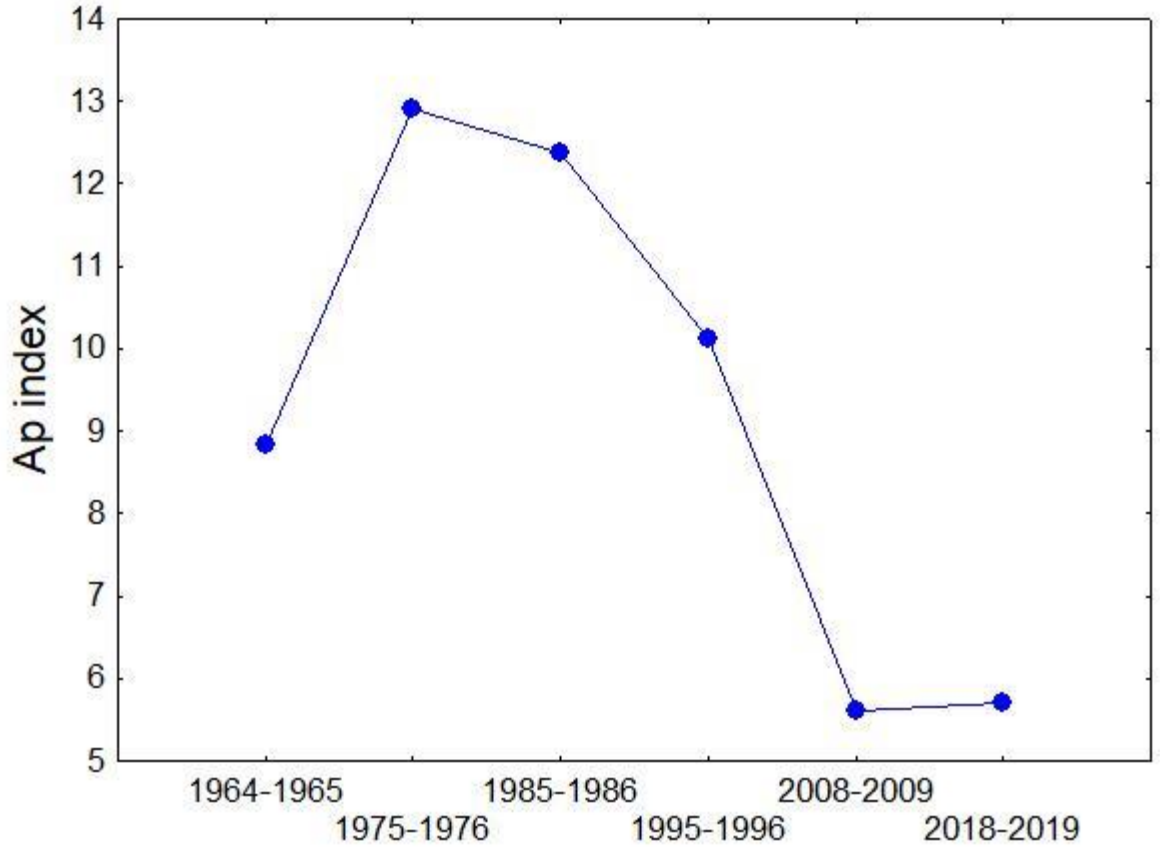


And so is geomagnetic activity
(exception min 20-21)

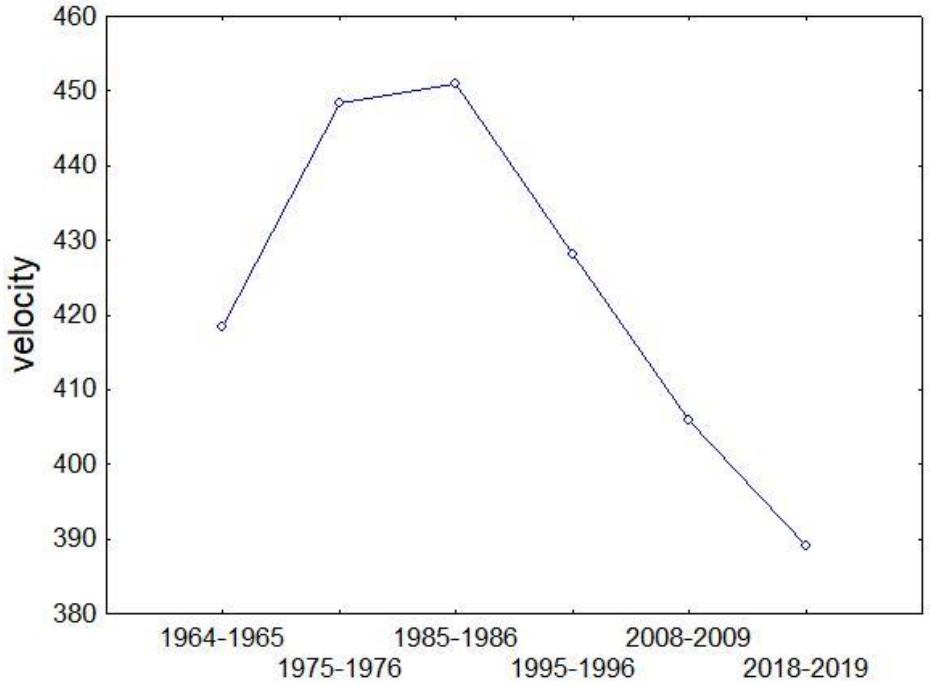
Conclusion 1

- The geomagnetic activity in sunspot cycle minimum is mostly determined **not** by the time spent by the Earth in the slow solar wind and HSS but by the magnetic field and plasma pressure of the solar wind both inside the heliosheet and from superradially expanding high latitude coronal holes

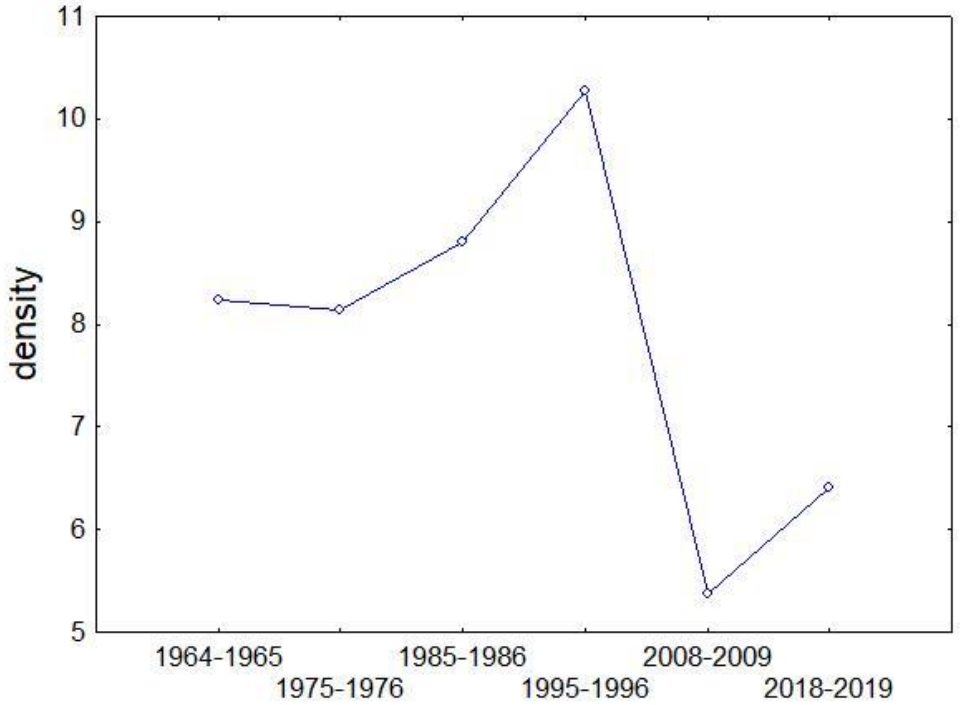
What about the last sunspot minimum?



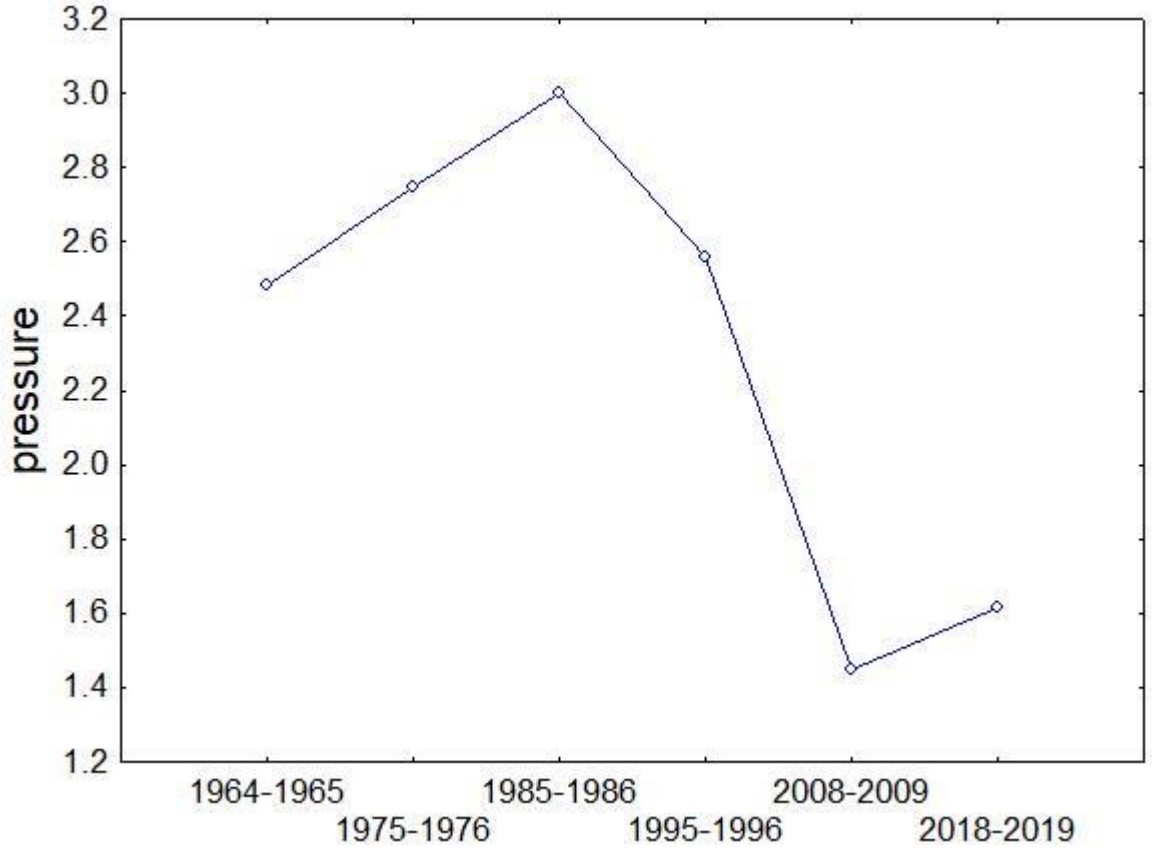
The decrease in geomagnetic activity has stopped

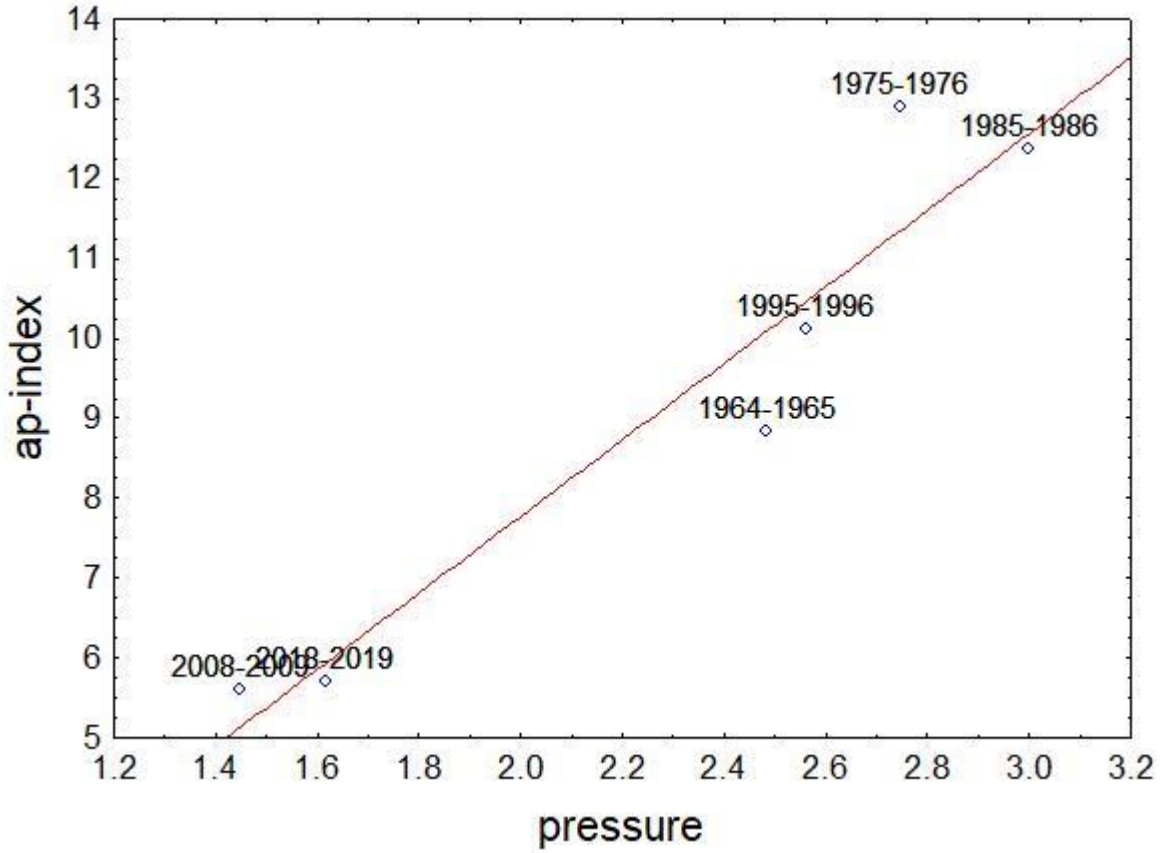


The decrease in solar wind velocity continues, however the density is increasing



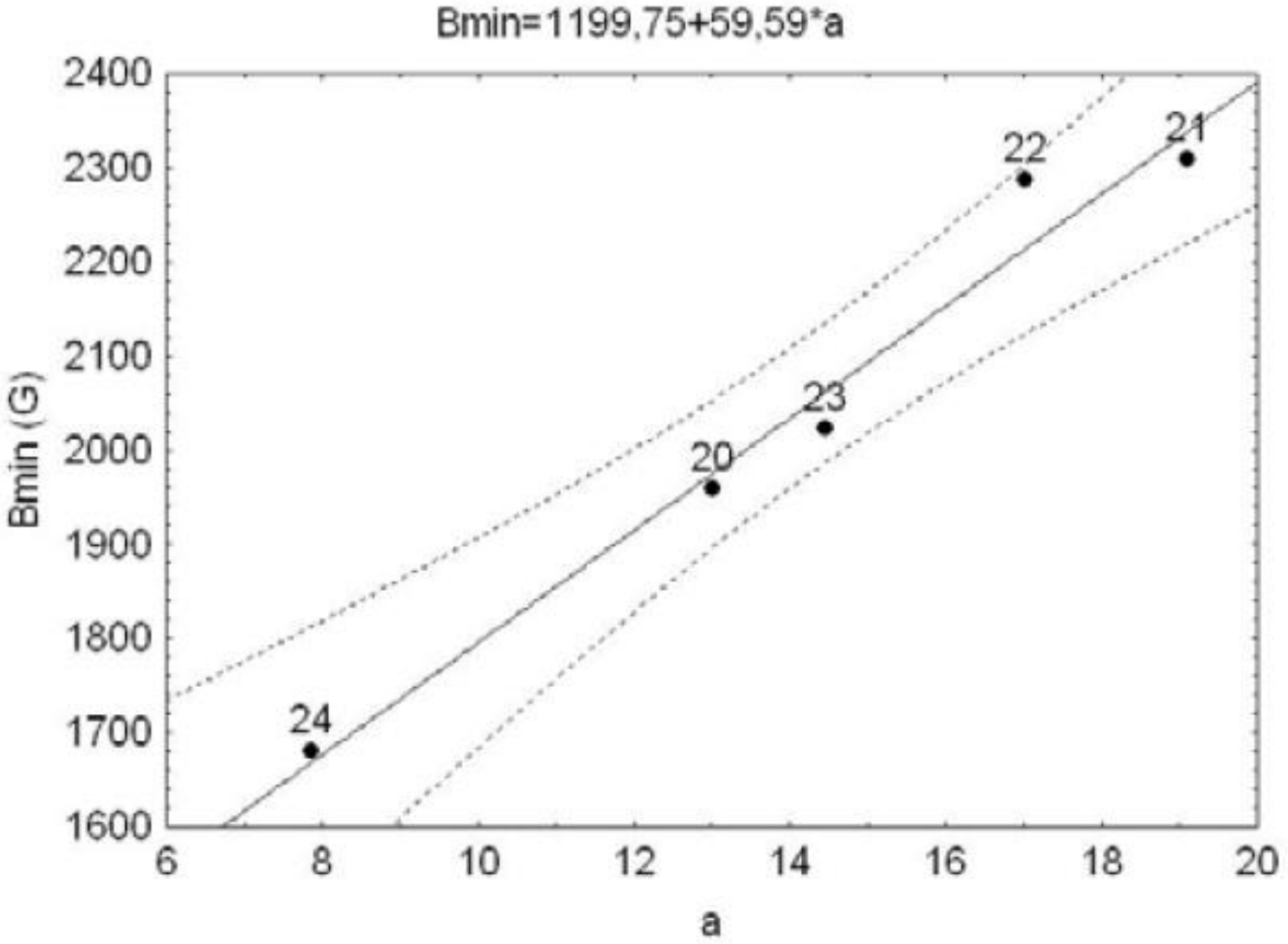
As a result the solar wind pressure increases



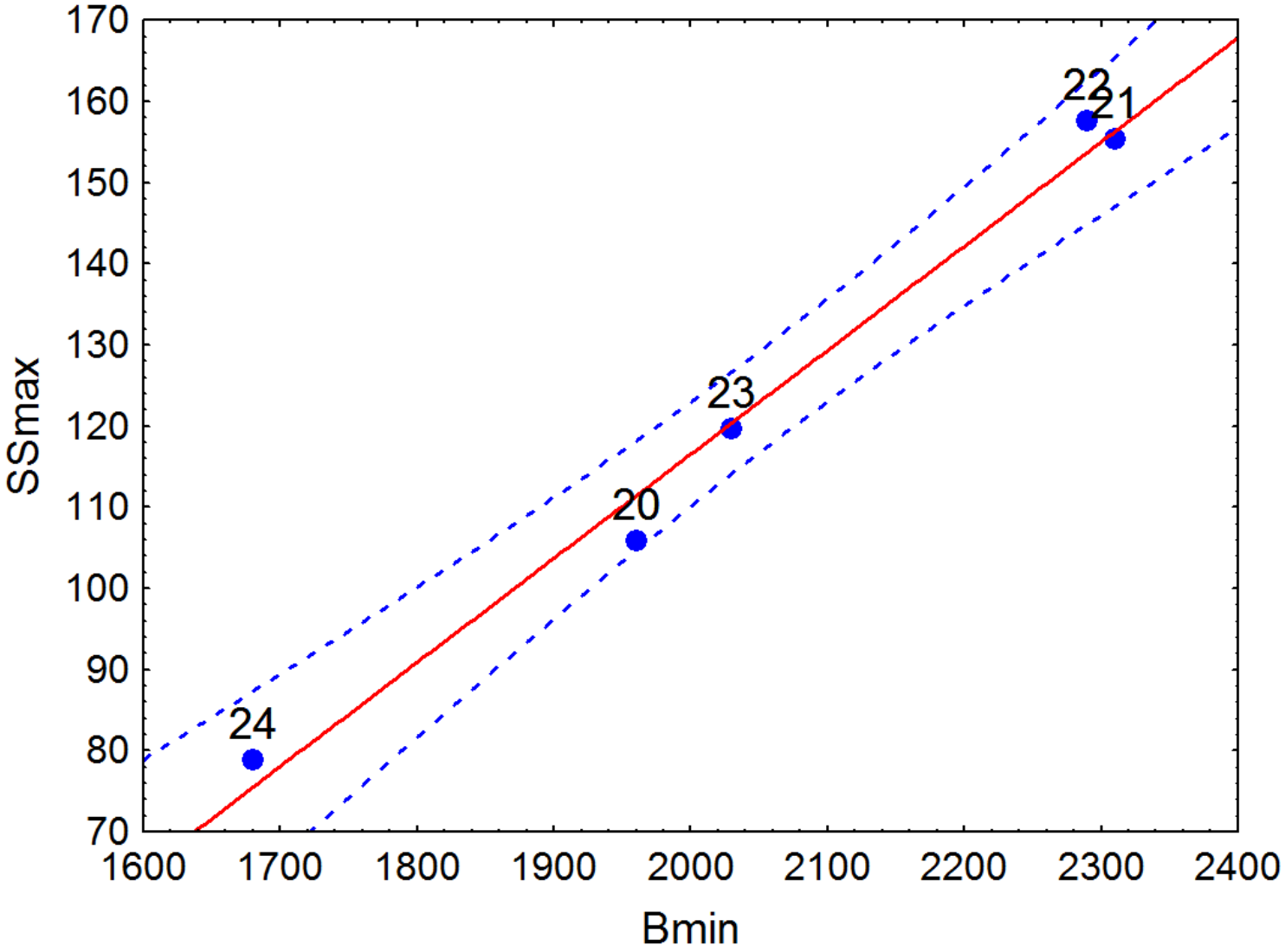


and so does the geomagnetic activity

Correlation between the geomagnetic activity in sunspot minimum and the sunspot magnetic field in cycle minimum



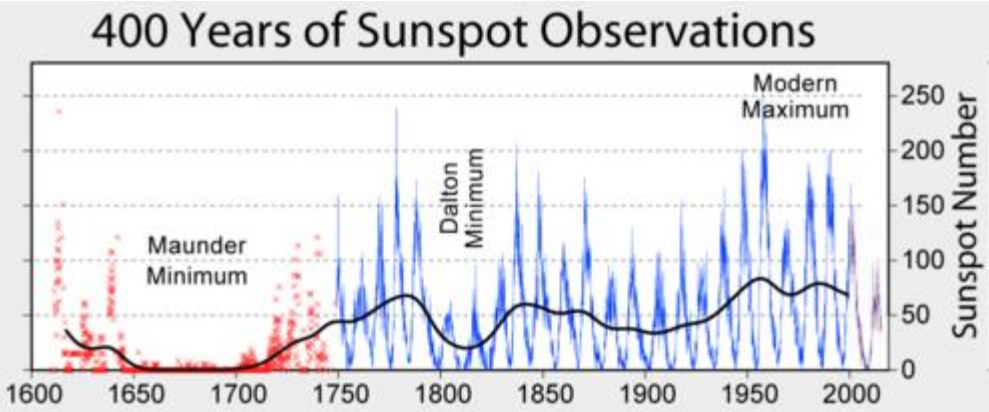
Strong correlation between sunspot magnetic field in cycle minimum and amplitude of the next cycle



Conclusion 2

The decrease in solar activity seems to have come to an end.

Most probably the Sun is in a secular solar minimum and is not entering a Maunder-type Grand minimum.



Thank you for your attention