

Solar cycle

Introduction

The main periodicity in the Sun's activity is the 11-year cycle called the solar cycle. The period is not constant, but varies between about 9.5 and 12.5 years; for discussion about the periodicity determination, see Mursula and Ulich (1998). During the cycle, changes occur in the Sun's internal magnetic field and in the surface disturbance level. It has been agreed that a cycle starts from an activity minimum. The solar cycle 1986.8-1996.4 is labelled to be #22; the "first" one was the 1755-1766 cycle.

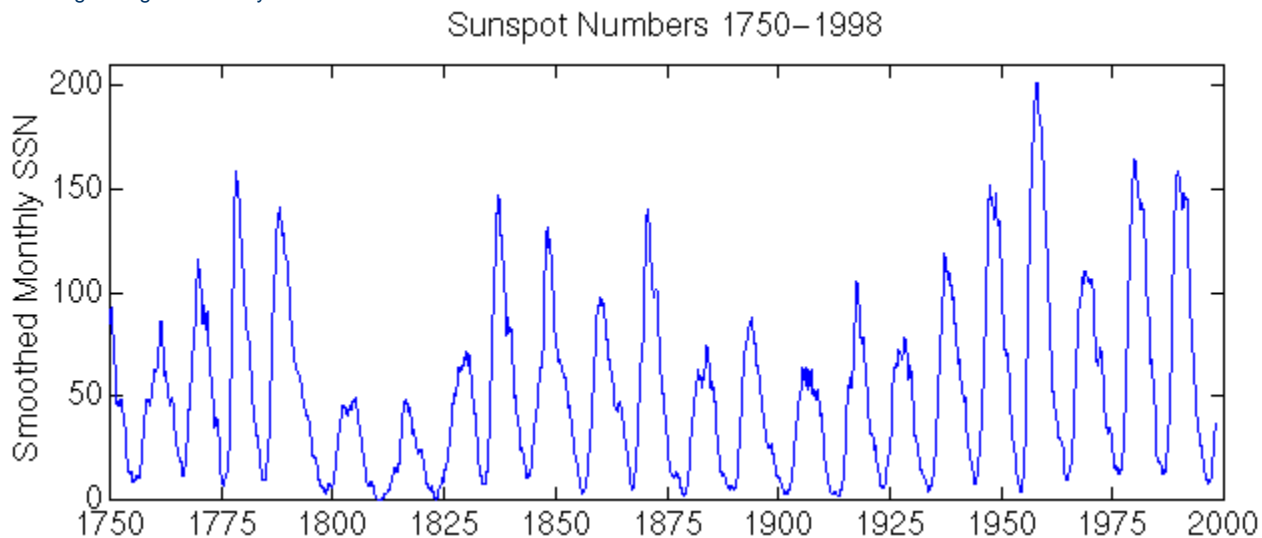
Solar magnetic field

At the beginning of a cycle the solar magnetic field resembles a dipole which axis is aligned with Sun's rotation axis. In this configuration the helmet streamers form a continuous belt about the Sun's equator and **coronal holes** are found near the poles. The situation is not very different from Earth's magnetotail geometry (see **magnetosphere**): closed field lines at low altitude equator, a current sheet at higher altitude equator, and open field lines at higher latitudes. During the following 5-6 years towards the maximum this nice configuration is totally destroyed, leaving the Sun, magnetically, in a disorganized state with streamers and holes scattered all over different latitudes. During the latter part of the cycle the dipole field is restored. At the beginning the dipole tilt can be large, but as the minimum epoch approaches and the dipole grows in strength, it also orients itself more with the Sun's rotation axis.

When a new dipole is reformed, it has an opposite orientation (polarity) than the old one: this creates a 22-year cycle for the Sun, the so-called double-solar-cycle (DSC). Also the **sunspot** pairs reflect this change.

Sunspot number and latitude

The 11-year periodicity in the Sun's activity was first observed in the sunspot number (see the figure below). The sunspot number - and Sun's activity - is at maximum in the middle of a cycle, when the Sun's internal magnetic field is most chaotic. Although the total energy output of the Sun - solar constant - is only about 0.1 % greater at maximum years than at minimum years, the 11/22 year variability is reflected - via **solar wind** - in the **geomagnetic activity**.



Sunspots display the 11-year cycle also in their latitude. At the beginning of a cycle new spots start to appear at about $\pm 45^\circ$ latitude. As the cycle evolves, the spots move towards the Sun's equator, reaching latitudes of about $\pm 5^\circ$ at the end of the cycle. Plots showing this feature are called "butterfly diagrams" (Maunder, 1904).

Other variables

Both **CMEs** and **flares** are more typical during the solar maximum than minimum times. Solar radio emissions follow solar activity through the solar cycle (see F10.7). Solar wind/IMF controlled **cosmic ray** intensity shows a clear 11-year periodicity, with a 22-year effect in the recovery phase.

References

- Mursula, K. and Th. Ulich, A new method to determine the solar cycle length, *Geophys. Res. Lett.*, 25, 1837-1840, 1998.

See also [Wikipedia on solar cycle](#).