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太陽の磁気活動とその地球環境への影響
Solar Magnetic Activity and Their Influence on the Earth's Environment

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The Sun affects the environment of the Earth in diverse ways. In a time scale of a few days, XUV emission and energetic particles from solar flares and disturbances in the solar wind (coronal mass ejections) cause various phenomena in the ionosphere and the magnetosphere. In a time scale of 2-4 weeks, the rotation of the Sun modulates its irradiance and solar wind properties. In a time scale of 11-year solar cycle, total and spectral irradiance changes in phase with the sunspot number. In this presentation I will pick up new results obtained with the Hinode mission and other ground-based instruments.

Hinode, launched on 23 September 2006, is a Japan-US-UK joint mission with contributions for downlink connections from ESA. The three primary instruments on Hinode are

(1) solar optical telescope/magnetograph (SOT),
(2) soft X-ray telescope (XRT), and
(3) extreme ultraviolet imaging spectrometer (EIS).

Ulysses spacecraft showed in 1998 that fast and steady solar wind comes from polar regions, and slow and variable solar wind comes from low-latitude regions. Since low-latitude regions are basically characterized by closed magnetic field lines by the presence of active regions with bipolar magnetic field configuration, it was not clear how the solar wind could flow out of the regions. However, Hinode/XRT discovered continuous outflow from the edges of active regions. Later, EIS observations confirmed the outflow by its Doppler shift. Now this outflow is believed to be the long-sought source of the slow solar wind.

The fast solar wind originates from polar regions which are basically unipolar. Since quiet-sun magnetic field of 10 gauss or less was known to consist of intense flux tubes with a kilo-gauss field strength occupying 1% of the area, the same might be expected for polar fields. Hinode/SOT showed clearly with its high spatial resolution observations of vector magnetic fields that it is the case. Hinode/SOT observations also track the polar field reversal with an unprecedented accuracy. The time delay of the south pole reversal compared with the north pole is seen in Hinode/SOT polar field observations as well as other indices, and is speculated to be related to an unusually low activity of the present solar cycle.

Coronal mass ejections (CMEs) are the major source of geomagnetic disturbances. How such an ejection of plasma cloud takes place is explained by several models. In one scenario, a solar magnetic configuration evolves by supplies of magnetic flux and magnetic helicity from below the surface. The accumulation of magnetic helicity leads to abrupt instability of magnetic configuration, leading to a CME. Magnetic helicity is distributed basically anti-symmetrically with respect to the equator, but anomaly is often observed. Long-term observations of magnetic helicity by ground-based instruments and high accuracy measurements of helicity by Hinode/SOT are providing interesting information on the nature of magnetic field generation in the solar convection zone.

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