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STRUCTURE OF THE HELIOMAGNETOSPHERE IN FEBRUARY–MARCH 1986

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Abstract

The time interval from January to March 1986 is remembered by many people for several reasons. Comet Halley approached the sun and the earth for the first time in 76 years, and a very large flares on the sun occurred in February 1986. Many kinds of instruments were aimed at these remarkable phenomena. Several spacecraft were also launched for exploring the comet, and many interesting phenomena were observed. Japan's interplanetary spacecraft "Sakigake" observed the interaction region between the solar wind and the comet. In addition to this observation, "Sakigake" provided us with background parameters of the solar wind about the heliomagnetosphere during this time. The result shows that at least three corotating high-speed streams existed near the solar equatorial plane. Two of them caused recurrent geomagnetic activity in Feb. – March 1986.

1. Solar wind parameters in the first half of 1986

Spacecraft "Sakigake" has successfully measured the solar wind plasma, since it was launched on January 8, 1985 (Itoh and Hirao, 1986). The solar wind detector on board the spacecraft employs a retarding potential trap to measure several parameters (bulk speed, proton number density, proton temperature and plasma flow direction) of the solar wind by utilizing the spacecraft spin (Oyama et al., 1984, 1986). Figure 1 shows the solar wind parameters obtained from December 1985 to May 1986. In the top panel, high-speed streams recurrently appeared every 27 days (corresponding to one solar rotation), although that observation was not performed in the interval from December 31, 1985 to January 5, 1986. It is interesting to note that no high-speed streams of faster than 500 km/sec were observed for a long time after March 6, 1986; the next high-speed stream appeared on

April 14, 39 days after the last appearance. The periodicity of 27 days seems to have been destroyed during this interval.

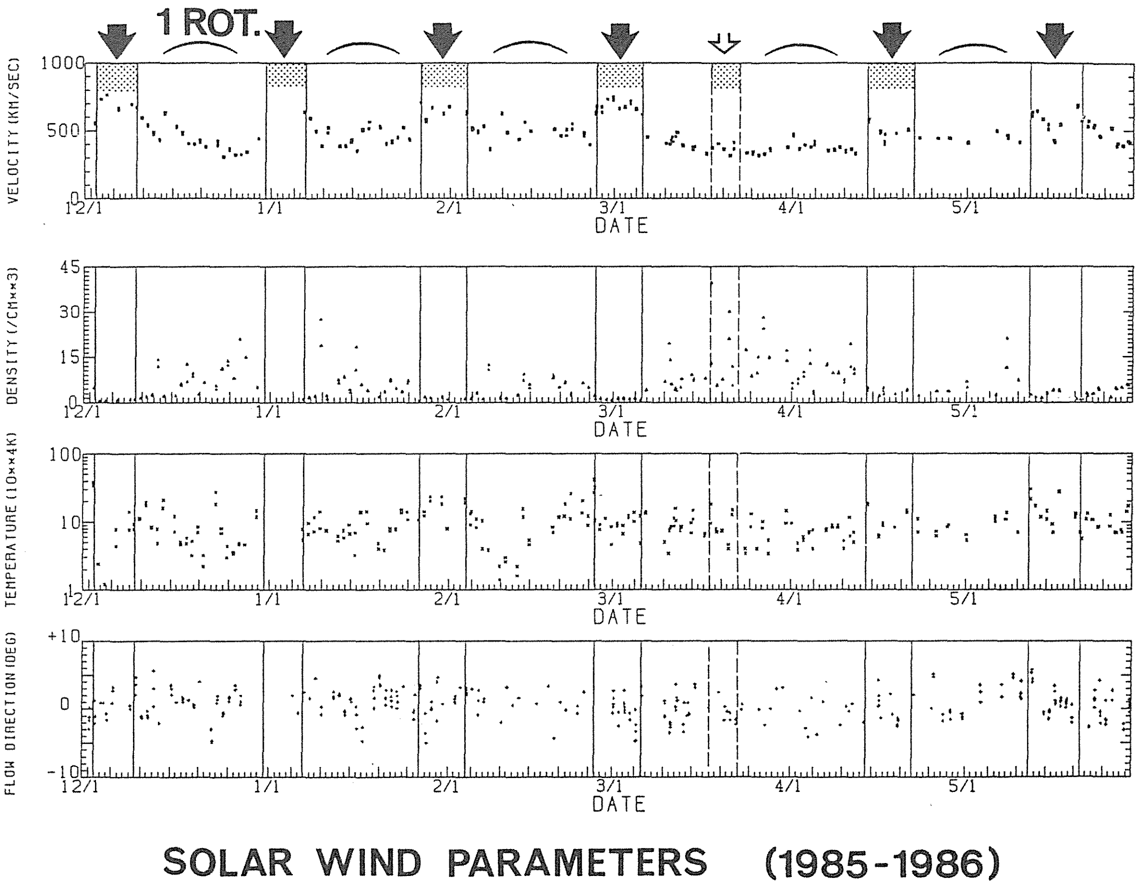

Fig. 1. Solar wind parameters (the bulk speed in km/s, the proton number density in cm^{-3}, the proton temperature in kelvin and the flow direction of plasma in degree) obtained by "Sakigake" in the interval from December 1985 to May 1986. The negative sign in the flow angle means the wind flows from the right-hand side when we see the sunward side on "Sakigake" and *vice versa*.

2. Solar wind structure in the first half of 1986

Next, we map source regions of high-speed streams on the solar source surface using solar wind speed data obtained by Sakigake. To do this, we assume that the solar wind speed is constant between the source surface and "Sakigake." We also assume the radially flowing solar wind. Figure 2 shows the resultant map for the ranges of the carrington longitude of 0° ~ 360° and the latitude of 20° ~ +20°. Three shaded areas denote high-speed streams. Among them, Region 1 (Lat. 0° ~ 10°, Lon. 270° ~ 360° and 0° ~ 20°) extends from the equatorial region to the northern hemisphere, and widens as it moves north. Region 2 (Lon. 160° ~ 260°, Lat. −10° ~ −3°) is located in the middle longitudes, and the average speed is higher than that of Region 1. Region 3 (Lon. 20° ~ 45°, Lat. −10° ~ −7°) is smaller than other two regions. The locus of the "Sakigake" projected onto the source surface is also shown in Figure 2.

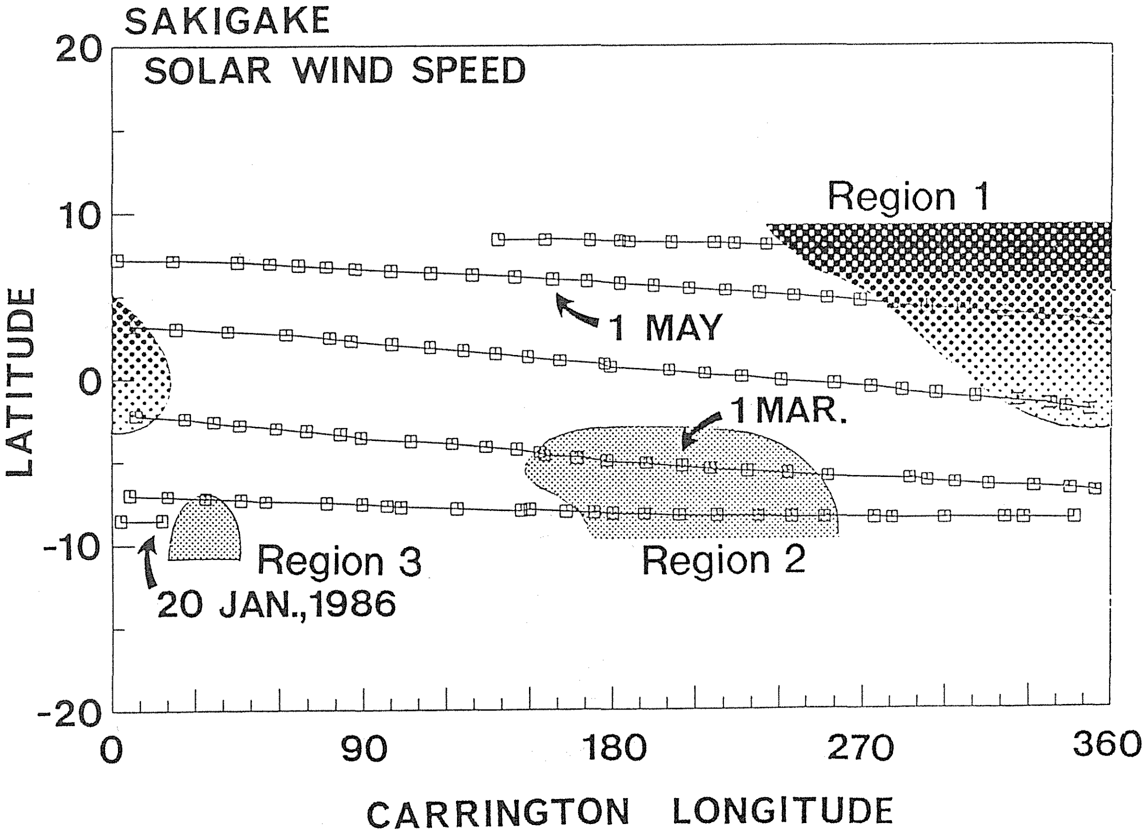

Fig. 2. Two-dimensional distributions of the source regions of high-speed streams on the source surface inferred from "Sakigake" observations in the interval from January 20 to May 31, 1986. Shaded areas denote high-speed source regions.

3. Geomagnetic activity

We also examine the periodicity in the geomagnetic activity in order to see the effect of the solar wind upon the activity in the interval in question. Figure 3 shows the K_p indices from February through May 1986. Arrows indicate effective streams, which cause high geomagnetic activity, in each Bartels rotation. A periodicity of geomagnetic activity was seen in the interval from February 1 through April 7, then it disappeared after April 8. A map of effective regions (sources of effective streams) on the source surface shown in Figure 4 is constructed by using the same method employed in construction of Figure 2. To do this, we use solar wind speeds obtained by "Sakigake" in previous solar rotaions when the latitude of sub-solar point of the spacecraft was similar to that of the earth. This figure shows that three effective regions exist on the source surface. According to comparison between Figure 2 and Figure 3, not all effective regions correspond to the source regions of the high-speed streams, because there exists no effective region corresponding to Region 3. One reason for this inconsistency will be the difference in the magnitude of the B_z component of the interplanetary magnetic field which governs the degree of geomagnetic activity. The locus of the Earth projected onto the source surface is also shown in Figure 4.

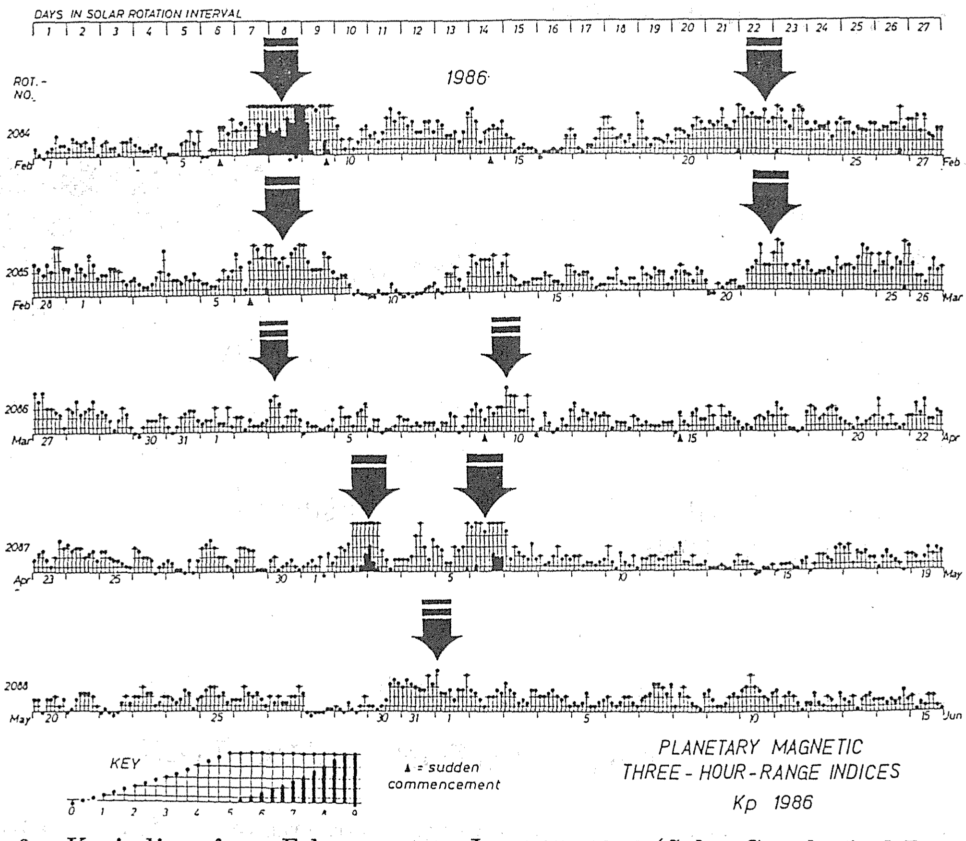

Fig. 3. K_P indices from February 1 to June 15, 1986 (Solar-Geophysical Data, Part I, Nos. 499 ~ 502, U.S. Department of Commerce, Boulder, CO 80303).

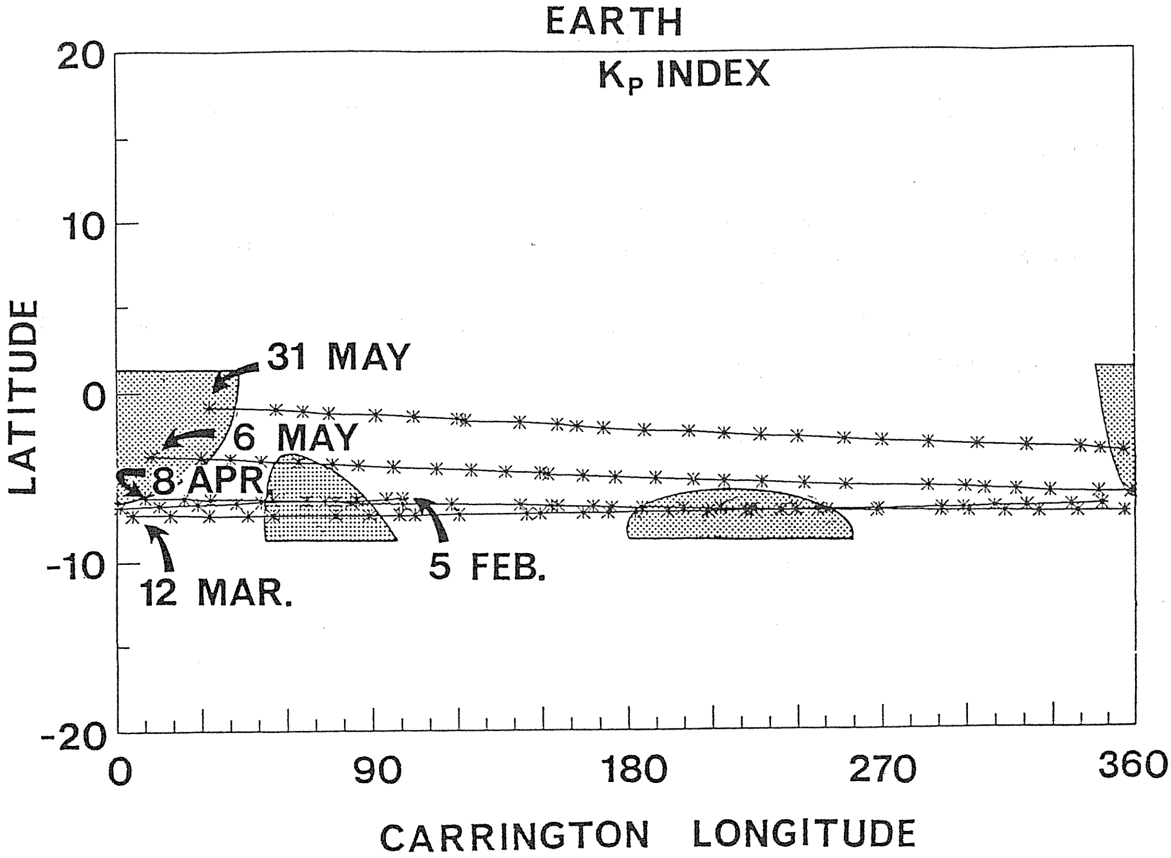

Fig. 4. Schematic representation of effective regions (the shaded areas) derived from K_p indices in the interval from February 5 to May 31, 1986.

4. Periodic variations in solar wind parameters

We apply the maximum entropy spectral analysis method on solar wind data obtained by Sakigake to examine the periodicity in the time variations of solar wind parameters. It is seen that the periodicity in two solar wind parameters (the bulk speed and the proton number density) disappeared in March 1986. The disappearance reflects the special geometry of solar wind stream structures in March 1986; as shown in Figure 2, the trajectory of Sakigake did not intersect with high-speed streams in the interval.

References

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