## Sun, Weather, and Climate. ,NASA Special Publication 426, 1978

The physical basis of the sector structure can be understood in terms of a phenomenological model suggested by Schultz (1973) and by Svalgaard et al. (1974). A large-scale current sheet separating the positive and negative sectors imposes a warping of the heliomagnetic equator; thus, relatively speaking, the Earth is sometimes above that equator and sometimes below it as the Sun rotates. When the extension of the tilt in the current sheet (sector boundary) rotates by the Earth, the IMF polarity is observed to reverse. The model has also been used to explain long-term variations in cosmic ray intensity (Svalgaard and Wilcox, 1976).

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Before proceeding to the analysis itself, it may be illuminating to consider the basic concept of vorticity. One may define vorticity as the circulation per unit area, where circulation in turn is defined as the line integral of the velocity of a stream traveling along a closed path in a fluid (Svalgaard, 1973). The absolute vorticity as used by Roberts and Olson (1973a,b), Svalgaard (1973), and Wilcox et al. (1973a,b) is the sum of the relative vorticity of the atmospheric airflow relative to the Earth's surface, and the vorticity of the Earth itself. The magnitude of the latter term is simply twice the angular velocity of the Earth's component of rotation about an axis normal to the surface.

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Now, it can be shown (Svalgaard, 1973) that for a rotating air column in the atmosphere the absolute vorticity is conserved for that volume of air. The distribution of absolute vorticity over the Earth's surface is very irregular, with numerous centers of high separated by areas of low absolute vorticity. The highs move across the Earth's surface with weather systems (e.g., circumpolar jet streams) while conserving their value of absolute vorticity. When the pressure decreases in one of these centers, its area increases to conserve the volume, and the area covered by the high vorticity expands accordingly.

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Significant systematic variations were found in response to MSB crossings. For example, at high latitudes the pressure-level heights increased a few days after boundary passage, and at middle latitudes they decreased. This is the same as saying that the pressure at a constant height increases in high latitudes and decreases in middle latitudes after a MSB passage.

To illustrate these variations, Svalgaard (1973) used the height difference $\Delta h$ between levels of constant pressure in the 40°–50° belt (middle latitude) and 60°–70° belt (high latitude) averaged over all longitudes in the northern hemisphere. The results, based on a superposed epoch analysis of 54 MSB crossings during the winters of 1964–1970, are given in figure 4.12. Several features in this figure are noteworthy. For example, at all levels investigated the height difference decreased from about day 0 to a minimum approximately 4 days later, then increased again over the next day or two. Also, there was a consistent increase in $\Delta h$ from 4 or 5 days prior to day 0 to a maximum reached on day 0 at the 30-mb level, but 1 to 2 days earlier at successively lower altitudes. The decrease in $\Delta h$ thus began on day 0 at 30 mb, but 1 to 2 days *before* MSB crossing at the greater pressure levels, and minimum $\Delta h$ was reached soonest at the lowest altitude (850-mb level).

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The semipermanent low-pressure centers north of 40°N near southern Greenland and Iceland in the Atlantic Ocean, and just south of the Aleutians and stretching into the Gulf of Alaska on the Pacific side, seem to be closer to the pole in years of low sunspot activity and move toward the equator in high sunspot years. Storm tracks likewise seem to migrate equatorward as annual sunspot activity increases; this may be due to alterations of the latitudinal temperature gradient and planetary wave pressure structure.

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