Magnetometeorology: Relationships Between the Weather and Earth's Magnetic Field

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A comparison of meteorological pressures and the strength of Earth's magnetic field suggests that the magnetic field exerts, through some unknown process, a controlling influence on the average pressure in the troposphere at high latitudes (King, 1974). For example, the contour pattern showing the average height of the 500-mb level in the northern hemisphere during winter and the contours of constant magnetic field strength are very similar. There are two regions in the northern hemisphere where low pressure is associated with high magnetic intensity, whereas there is only one such region in the southern hemisphere. Figure 1 shows a comparison of the longitudinal variations at 60° N of averaged 500-mb data and magnetic intensity data. The similarity between the two curves is striking except that the magnetic B curve is displaced about 25° toward the west. Certain features of the "permanent" atmospheric pressure system appear to have moved westward during some decades of the present century, and this movement may be associated with the westward drift of the nondipole component of Earth's magnetic field. No attempt has been made, however, to correct the curves presented in figure 1 to allow for this drift; in any case, the "phase" of the meteorological variation depends on the height and latitude to which it relates and further curves such as those in figure 1 may well reveal the origin of the magnetic-field-dependent "driving force" on the atmosphere.

If Earth's magnetic field influences meteorological phenomena, long-term changes in the geomagnetic field should produce corresponding changes in climate. Figure 2 shows, in the upper section, the variation of the magnetic inclination at Paris since about 700 A.D. The lower section shows 50-yr averages of the temperatures prevailing in central England since about 900 A.D. These two sets of data exhibit similar variations. The "Little Ice Age" (Lamb, 1966) that occurred in Britain during the period 1550 to 1850 A.D. is clearly associated with an epoch of high magnetic

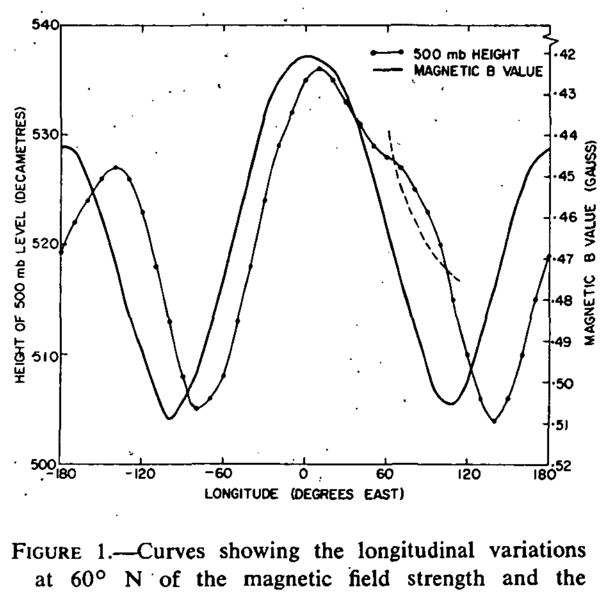

FIGURE 1.—Curves showing the longitudinal variations at 60° N of the magnetic field strength and the height of the 500-mb level. The short broken curve draws attention to some of the pressure data that may be anomalously high (King, 1974). The magnetic data relate to 1965 and the meteorological data to the epoch 1918 to 1958.

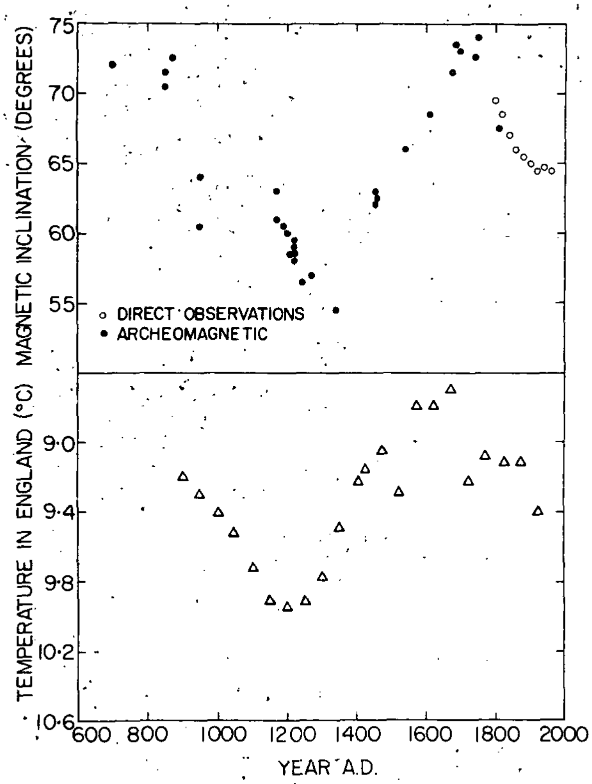

FIGURE 2.—Upper section: magnetic inclination at Paris since 700 A.D. (after Thellier, 1970). Lower section: average temperature in central England since 900 A.D. (after Lamb, 1966).

inclination. More work obviously needs to be done to determine the extent to which climatological changes are associated with magnetic field changes.

One possible way in which Earth's magnetic field may affect the weather is by its controlling influence on the precipitation of charged particles from the magnetosphere. In this context it is worth noting (King, 1973) that contours showing the average height of the 850-mb surface in July over the Canadian Arctic region during the period 1964 to 1972 are nearly parallel to contours of constant invariant latitude. The southeastern area of this region is, however, dominated by a ridge of high pressure that occurs at invariant latitudes between 76° and 79°; these are the latitudes at which solar wind particles penetrate into the atmosphere most easily, having gained access to the magnetosphere through the northern magnetospheric "cleft." While the single comparison described certainly does not prove that meteorological pressures can be affected by precipitated charged particles, it does point to the need for further studies of this kind.

It is well known that physical processes occurring in the magnetosphere and ionosphere vary with solar activity and many authors have conjectured that certain features of the weather vary during the solar cycle. It is interesting, for example, that the length of the annual "growing season" (defined as the portion of the year during which the air temperature at 1.25 m above ground exceeds 5.6° C) at Eskdalemuir (55° N, 03° W) in Scotland appears to have been influenced by changes of solar radiation associated with the solar cycle during the period from 1916 to 1969 (King, 1973). This conclusion is based on an apparent association between the length of the growing season and the yearly mean sunspot number: on the average, the growing season is about 25 days longer near sunspot maximum than near sunspot minimum. A detailed comparison of the growing season and the solar data reveals the geophysically interesting fact that the growing season tends to be longest about a year after sunspot maximum.

Starr and Oort (1973) have made a comprehensive study of meteorological temperatures, using about 10 million individual measurements of temperature, to derive the average temperature of the bulk of the atmospheric mass in the northern hemisphere for each of the 60 months between May 1958 and April 1963. If the mean seasonal variation is subtracted from the monthly values to yield the residual temperatures, it is found that the spatially averaged temperature fell by about 0.60° C during the 5 years. A comparison of the temperatures with the monthly mean sunspot numbers during the same period suggests that the declining temperature trend may be associated with the decline in solar activity. This suggestion is supported by the fact that smoothed variations of temperature and sunspot number are both relatively flat during the first and last years of the 5-year period. Alternatively, it appears that Earth's magnetic dipole is moving slowly into the northern hemisphere (Nagata, 1965) and the magnetic field is, on the average, gradually increasing there; this behavior may lead, in some unknown way, to the decrease of northern hemisphere meteorological temperatures.

Many attempts have been made in the past to relate changes in solar radiation to meteorological phenomena; similarly, many different explanations have been offered for climatic changes. We fully appreciate the pitfalls that abound in this area of research and are also cognizant of the speculative nature of the suggestion that spatial and temporal variations of Earth's magnetic field may be associated with climatic changes. Nevertheless, we believe that the evidence presently available is sufficient to warrant further investigations in the field of magnetometeorology.

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