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A Possible Correlation Between Maxima of the Far Ultraviolet Solar Irradiance and Central Meridian Passages of Solar Magnetic Sector Boundaries

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The question of the possible existence of a causal relationship between solar activity and meteorological phenomena has been the subject of many investigations. Recently there have been a series of papers reporting a connection between passages of solar magnetic field sector boundaries past Earth and certain meteorological phenomena. That work with ample references to past work has been reported in detail by Wilcox (1975) elsewhere in the proceedings of this symposium.

It is the purpose of this work to describe the relationship that has been observed between enhancements in the far UV solar irradiance and the position of the solar magnetic sector boundaries. The UV observations have been made with the Monitor of Ultraviolet Solar Energy (MUSE) experiments, which were launched aboard Nimbus 3 in April 1969 and Nimbus 4 in April 1970. The Nimbus 4 experiment is still operating. A summary of the circumstances of observed and well-defined sector boundaries is contained in the work by Wilcox (1975).

The MUSE experiment has been described in detail by Heath (1973); it consists of five broadband photometers that respond to solar radiation from 115 to 300 nm. Since the instrument was flown on the Sun-synchronous Nimbus 3 and 4 satellites, it has been possible to observe the intrinsic variability of the Sun as a UV variable star. The persistent regions of solar variability that are related to the rotation of long-lived active regions are shown in figure 1. Each point gives the solar longitude of the central meridian for the day number when the UV solar irradiance (principally, H Lyman-alpha) was observed to be a maximum. The different symbols simply indicate the different active regions by virtue of their clustering about preferred solar longitudes. The nature of these curves is outside the scope of this paper and is used only to illustrate the fact that there are two very long lived regions of UV activity that were separated by about 180° in solar longitude in 1969.

Figure 2 shows the polarity of the interplanetary magnetic field as observed by spacecraft orbiting Earth (Wilcox and Colburn, 1972). Because there is a delay of about 4½ days between the time a sector boundary is at central meridian on the Sun and the time at which the solar wind carries it past Earth (Wilcox, 1968), the sector boundaries shown in figure 2 should be shifted backward by about 4½ days to give the time at which they were near central meridian on the Sun. When this is done, one notes that the ultraviolet peaks marked with circles are very close to the time when an away/toward boundary

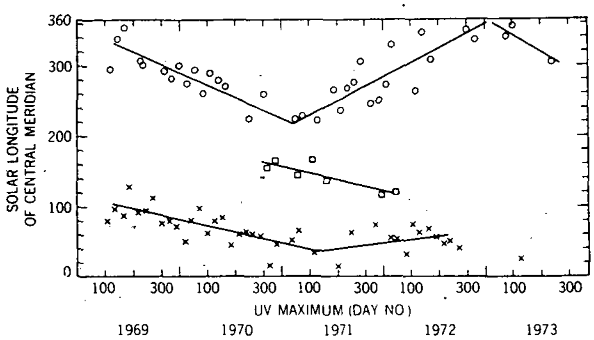

Figure 1.—Carrington solar longitude of the central meridian on days of observed UV maximums in irradiance. The different symbols represent regions on the basis of groupings in longitude.

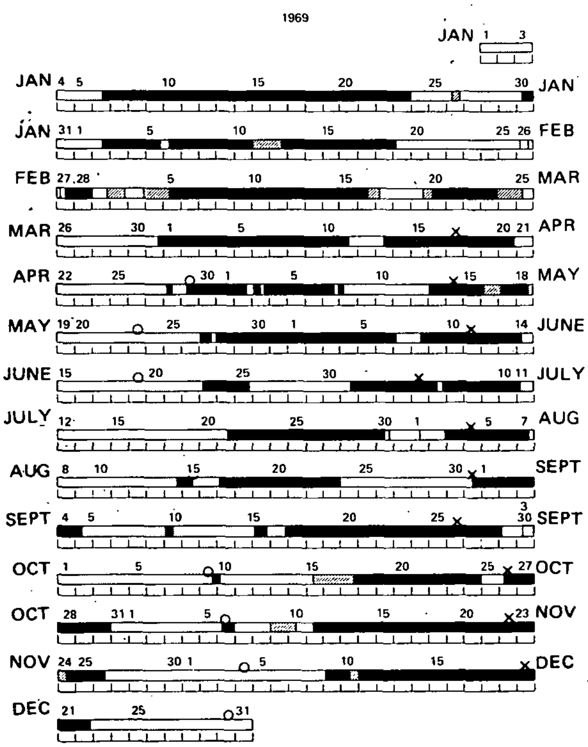

Figure 2.—Representation of the sectors of the large-scale photospheric magnetic field carried radially outward by the solar wind as it sweeps by Earth. The shaded regions represent the field directed away from the Sun and the black regions represent the field directed toward the Sun. The times of solar UV enhancements are indicated with the symbols of figure 1. The sector boundaries were near central meridian on the Sun about 4½ days before the times shown in the figure at which the boundaries were observed by spacecraft orbiting Earth.

was near central meridian, and the UV peaks marked with **X**'s are very close to the time when a toward/away boundary was near central meridian.

This relation is quantitatively displayed in figure 3, which shows a histogram of the time in days of the UV peaks with respect to the time at which a sector boundary was near central meridian. A clustering of the UV peaks near the sector boundaries is evident. We reserve judgment on the small difference between away/toward and toward/away boundaries until more observations have been analyzed.

Increases in the solar UV above the minimum during a solar rotation that were observed with the MUSE experiment in 1969 were typically 25 percent at H Lyman-alpha, 5 percent at 175 nm, and 1 percent at 295 nm. In terms of the equivalent width of the photometer channels, this would correspond to increases above the minimum during a solar rotation of 1.6 ergs/cm^2 · s at H Lyman-alpha, 1.0 erg/cm^2 · s at 175 nm, and 230 ergs/cm^2 · s at 295 nm. In other words, variations per solar rotation are typically greater than the annual variation below 175 nm and less than above 175 nm. This representative increase associated with the solar rotation of UV active regions should be considered when examining possible physical causes to explain the observed correlations between passages of the solar magnetic sector boundaries past Earth and meteorological phenomena.

In summary, satellite observations of the Sun over almost 5 yr have shown that principally two UV active longitudes have persisted over a significant portion of this observational period. A comparison between the position of solar magnetic sector boundaries and UV enhancements of the Sun seems to show, at least during the year 1969, that the UV maxima tend to occur near the times when a solar sector boundary is near central meridian. An estimate of the magnitude of the variable UV solar energy input into the atmosphere resulting from the rotation of active solar longitudes is that for wavelengths less than 175 nm and down to H Lyman-alpha it exceeds the annual variation, whereas at longer wavelengths it is less. The total observed peak-to-peak variation in the UV irradiance from 120 to 300

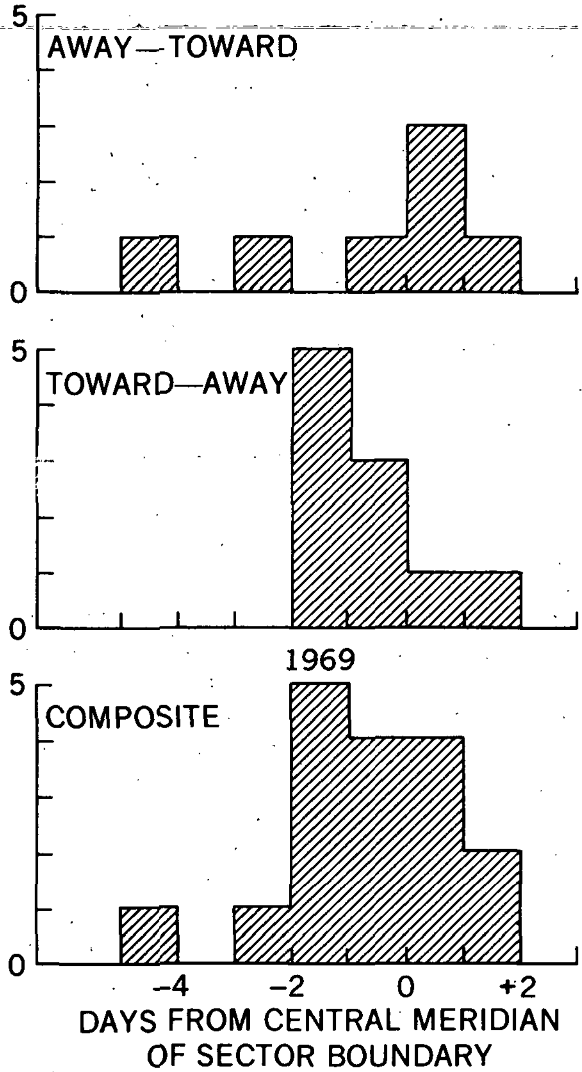

FIGURE 3.—Histogram of the time delay in days between an observed UV solar enhancement (UV max) and a corresponding central meridian passage of the solar magnetic field sector boundary.

nm over a solar rotation is typically at least 230 ergs/cm^2 · s.

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DISCUSSION

LONDON: The Nimbus 3 observations showed, for some of the filtered measurements in the UV, a fairly pronounced solar rotation period in the shorter wave UV. Was there a similar solar rotation period in the Nimbus 4 observations? And, if the UV is related to magnetic sector fluctuations, should there not then be a semirotation period in the variation rather than a solar rotation period? Should there not be a 14-day rather than a 27-day period?

HEATH: The variations are similar both on Nimbus 3 and 4 and, at times when you have the two active regions, they are separated by about 180° in solar longitude.

QUESTION: As I remember, what was shown in the Nimbus 3 results was a full solar rotation period in the fluctuation, not a 14-day, but on the order of 27 days.

HEATH: Two curves in figure 1 represent the two very long-lived active regions, and they are about 180° apart in solar longitude, so there is UV enhancement essentially twice per solar rotation.

RASOOL: What were these enhancements?

HEATH: In the case of Lyman-alpha, typical variation in 1969 was the order of enhancement of 25 percent above the normal background during that solar rotation. In the case of 1750 Å, it was of the order of 5 to 6 percent enhancement over one solar rotation; that is, per each active region. If there were two, you would have two peaks of that magnitude, and, for the longest wavelength, 2900 Å, it was only during the very high period of solar activity during the spring of 1969 that we saw an enhancement of the order of 1 percent at 2900 Å.

RASOOL: How is this related to your statement about the order of magnitude increase at 2900 Å?

HEATH: If I use the same sensor that gives these data and I compare the absolute values of the solar radiance derived from the rocket flight in 1966 at solar minimum with the satellite data beginning in 1969 at solar maximum and continuing into 1970, then the difference is about an order of magnitude at 2900 Å and also at 1750 Å but not at Lyman-alpha.