PROPOSED MECHANISM TO EXPLAIN A SEMI-ANNUAL VARIATION IN THE WINDS IN THE POLAR MESOSPHERE

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As this is a meeting on proposed mechanisms of solar-terrestrial relations, I would like to review one hypothesis that was proposed to explain a property of the long-term variations of the stratospheric winds. This has been published, but may be of interest to those who are not familiar with it (Belmont and Dartt, 1973; Belmont et al. 1974a, 1974b).

Figure 1, shows the amplitude of the semi-annual variation of the wind, as a function of altitude and latitude. It has a normal tropical semi-annual variation which has been well-known since the middle 1960's. The arctic center at high latitudes and high altitudes is not yet well recognized. It extends up into the lower thermosphere but only the lower fringe of it can be seen here; it seems to be quite separate from the tropical one, both in phase and in amplitude distribution. It has its maximum at the equinoxes, but there is no explanation to date as to what causes it, except an hypothesis. The first reaction when this was published was that the semi-annual variation was not real, that it couldn't be; that it was just poor data because it was on the upper fringe of the reach of rocket data, and true, there weren't very many observations. This covered a period from 1960 to 1971. About 1978, the analysis was updated by consolidating all available data to produce Figure 2, in which the polar center was much reduced. There was a tendency to say our critics were right and that the initial version was simply due to poor data; there really was no polar semi-annual variation after all. However, the period of data that went into each analysis reflected, relatively, periods of solar maximum and solar minimum. The number of observations of rocket data increases in time, except since 1979 when it has decreased rapidly. But in these earlier years, each year's number of rocket observations was far greater than in previous years. So though the period of the first data group was 1960 to 1971, it reflected mainly the latest observations from the rather moderate solar maximum of 1969. When the data period was extended through 1976, the results really reflected solar minimum.

To check that, the data were separated according to solar minimum and solar maximum. In 1961 to 1966, during solar minimum, the amplitude is weak at high latitudes, but for the period 1967 to 1970 it is strong. And then, during the period of the most recent solar minimum, 1971 to 1976, it disappeared again (Figure 3, Nastrom and Belmont, 1980).

The checked rocket data are not available for several years after the observations are made, so the strength of the polar semi-annual variation during this last solar maximum, from 1978-80, cannot yet be verified.

Now the question is: "what causes it?" The hypothesis we advanced was suggested by the fact that the equinoctial phase of the semi-annual variation of the wind coincides with the equinoctial phase of the semi-annual variation of geomagnetic activity. Other things being equal, it seems reasonable to say that therefore there should be more geomagnetic storms and particle precipitation during the equinoxes, than at other times of the year. If that is acceptable, then that should lead to semi-annual disassociation of O_2 or N_2, and affect the formation of ozone at lower altitudes, thereby changing the heat distribution and the winds. This is now a hypothesis that others have also invoked. Hypotheses involving atmospheric chemistry at high levels are very hard to verify until estimated trace species concentrations, realistic reaction rates, absorption coefficients and radiation rates can all be confirmed. We are presently examining ozone profiles observed by Nimbus 4 to see if the semi-annual variation in ozone exists at these latitudes on a global scale. It was already found near 18 km over North America in ozonesonde data (Wilcox et al., 1977).

An eleven-year solar effect may be seen not only in the semi-annual variation, but also in the annual and the quasi-biennial variations. Figure 4 (Nastrom and Belmont, 1980) shows the period of the quasi-biennial oscillation on one scale and the 10.7 cm solar flux on an inverted scale; the correlation is reasonably good. They are out of phase, with a lag of about 24 months. This lag has its maximum at around 30 km, and if one extrapolates the QBO phase upward at the usual descent rate of the QBO of one kilometer per month, it would imply that the QBO would be in phase with the sun at near 50 km which is a region that might easily be affected by particles. Work is continuing by examining particle precipitation directly for evidence of semi-annual and QBO periods.

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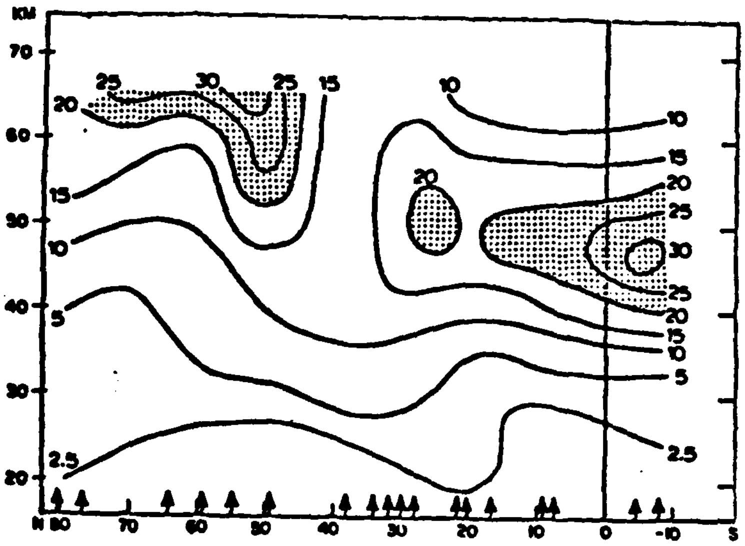

Figure 1. Amplitude of the semiannual oscillation in zonal wind speed from rocketsonde data, 1960-1971, as given by Belmont and Dartt (1973). Arrows depict rocket station locations.

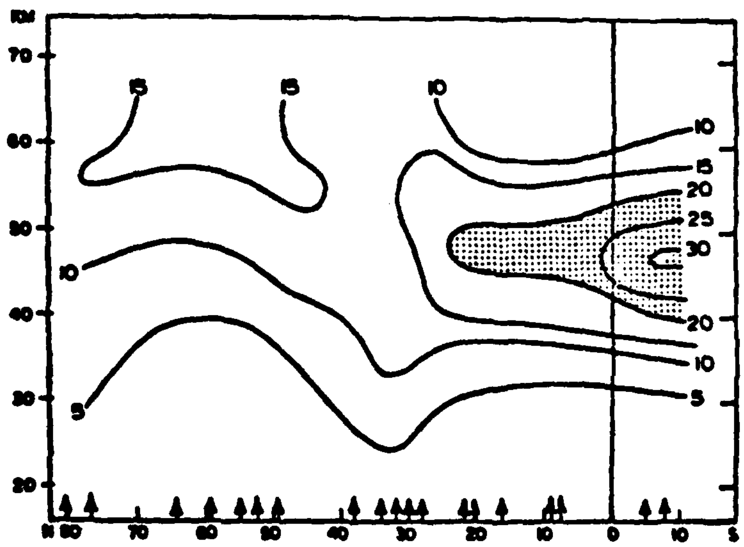

Figure 2. As in Figure 1., except for 1960-1976 (some data through 1978)

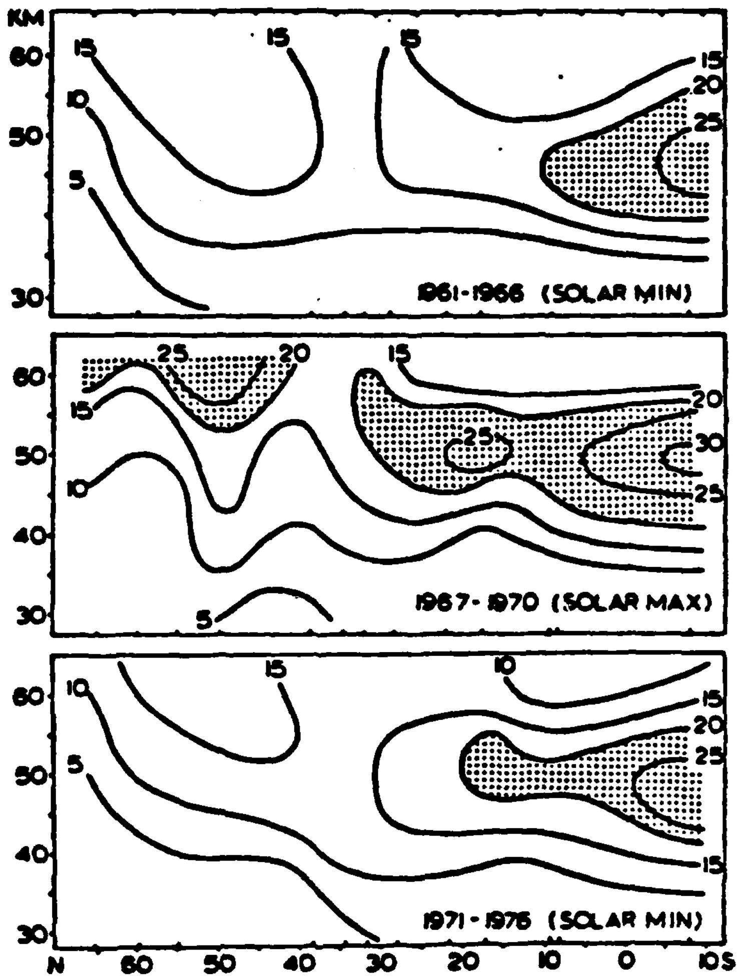

Figure 3. As in Figure 1., except for periods of solar activity minimum (1961-66, 1971-76) and maximum (1967-70)

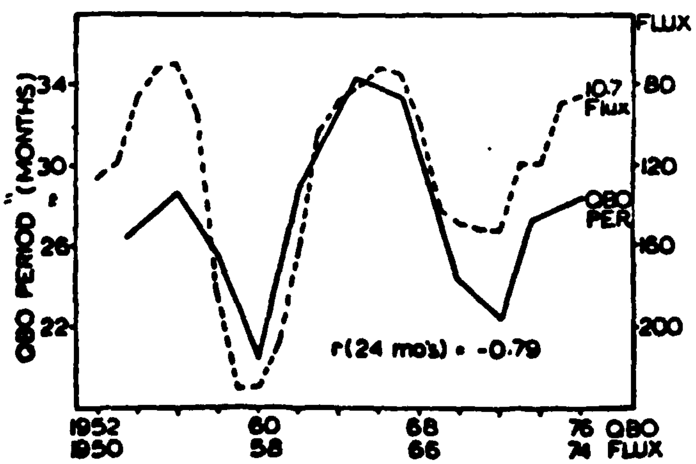

Figure 4. QBO period at 30 mb at 9° N (measured from the beginning of one westerly phase to the beginning of the next westerly phase) compared with yearly mean Solar activity.