

A SEARCH FOR THE SOLAR ROOTS OF THE MOST DISTURBED INTERPLANETARY FIELD INTERVALS OF SOLAR CYCLE 21

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ABSTRACT

During the course of the Pioneer Venus Orbiter mission, fairly continuous interplanetary plasma and magnetic field data were obtained which span the interval from prior to the last solar maximum to the current solar minimum recovery. Within this nearly complete solar cycle interval, several periods of exceptional disturbance of the interplanetary field stand out. We have examined the available solar data to determine what features, if any, distinguish these periods. Neither flare nor coronal mass ejection reports show particularly unusual behavior. However, these periods appear to occur in conjunction with marked changes in the interplanetary sector structure. This suggests that heliospheric current sheet reconfiguration is an indicator of the level of interplanetary disturbance distinct from the more traditional solar activity data.

INTRODUCTION

The Pioneer Venus Orbiter (PVO), which has been orbiting Venus at .7 AU since December 1978, has provided an exceptionally continuous record of interplanetary conditions spanning the better part of the last solar cycle. One advantage of the 0.7 AU data over 1 AU data is that the interaction regions between corotating solar wind streams are not as well developed at 0.7 AU as at 1 AU so that transient disturbances stand out. This feature allows us to explore some aspects of the long term behavior of the interplanetary medium that are not apparent at larger heliocentric distances. In this paper, the PVO interplanetary magnetic field data are used to identify periods of extraordinary interplanetary disturbance at 0.7 AU. Solar data and local plasma data are examined in an attempt to determine the cause of the interplanetary activity. It is found that some of these disturbed intervals with durations of one to two apparent solar rotations show a clearer relationship to the evolutionary trends of the heliospheric current sheet than to the usual indicators of solar activity.

OBSERVATIONS

For the purpose of this study, the Pioneer Venus magnetometer data for 1978-1984 were averaged over 10 minutes and plotted in apparent solar rotation (~28 day) segments. These plots were scanned to qualitatively determine which 28 day periods were exceptionally disturbed. Similar plots of plasma data from the Pioneer Venus Orbiter Plasma Analyzer were used for information on the contemporaneous solar wind velocity and density. Solar data from Solar Geophysical Data /1/ for the same period were compiled to construct time series of flare occurrences and coronal mass ejections. Ha synoptic charts and magnetic field synoptic charts were also examined to determine the surface distributions of flares, coronal holes and magnetic polarity. Although these data pertain to the sun as seen by the earth, it is considered that since periods of a solar rotation are under analysis here, the general state of the surface and general level of activity seen from Venus would not be very different.

Figure 1a shows the total field magnitudes for four solar rotations selected as the most disturbed examples of the 0.7 AU interplanetary magnetic data. For contrast, Figure 1b shows four exceptionally quiet periods of 28 day duration. The difference in these data intervals is notable. (Most other intervals fall on the quiet side of the range of disturbance, and may be punctuated by a few isolated transients.) To illustrate the extent to which solar flare activity appears to be responsible for the level of disturbance, plots of the same 28 day intervals of solar flare occurrence data are displayed in Figure 2. Similar plots of coronal mass ejection occurrences are given in Figure 3. It is notable that with the possible exception of the flare data for the earliest "disturbed" interval in January 1982, there is no great contrast between the disturbed and quiet rotation flare or coronal mass ejection occurrence rate. Moreover, examination of the locations of the flaring regions

suggested that there was no significant overall difference in the latitude distribution of the flares.

Further examination indicated that there was one additional aspect of the magnetic data that distinguished the disturbed intervals from the quiet intervals. At 0.7 AU, the heliospheric sector structure is clearly seen in the radial component of the interplanetary magnetic field. In Figure 4, this component is plotted for several solar rotations surrounding the disturbed intervals. Note that, in all three cases (two of the disturbed rotations-January and February 1982-were contiguous), there was a transition between 2-sector and 4-sector structure at the time of the disturbed solar rotation(s). The direction of this transition does not seem to matter. The quiet intervals show a constant sector structure.

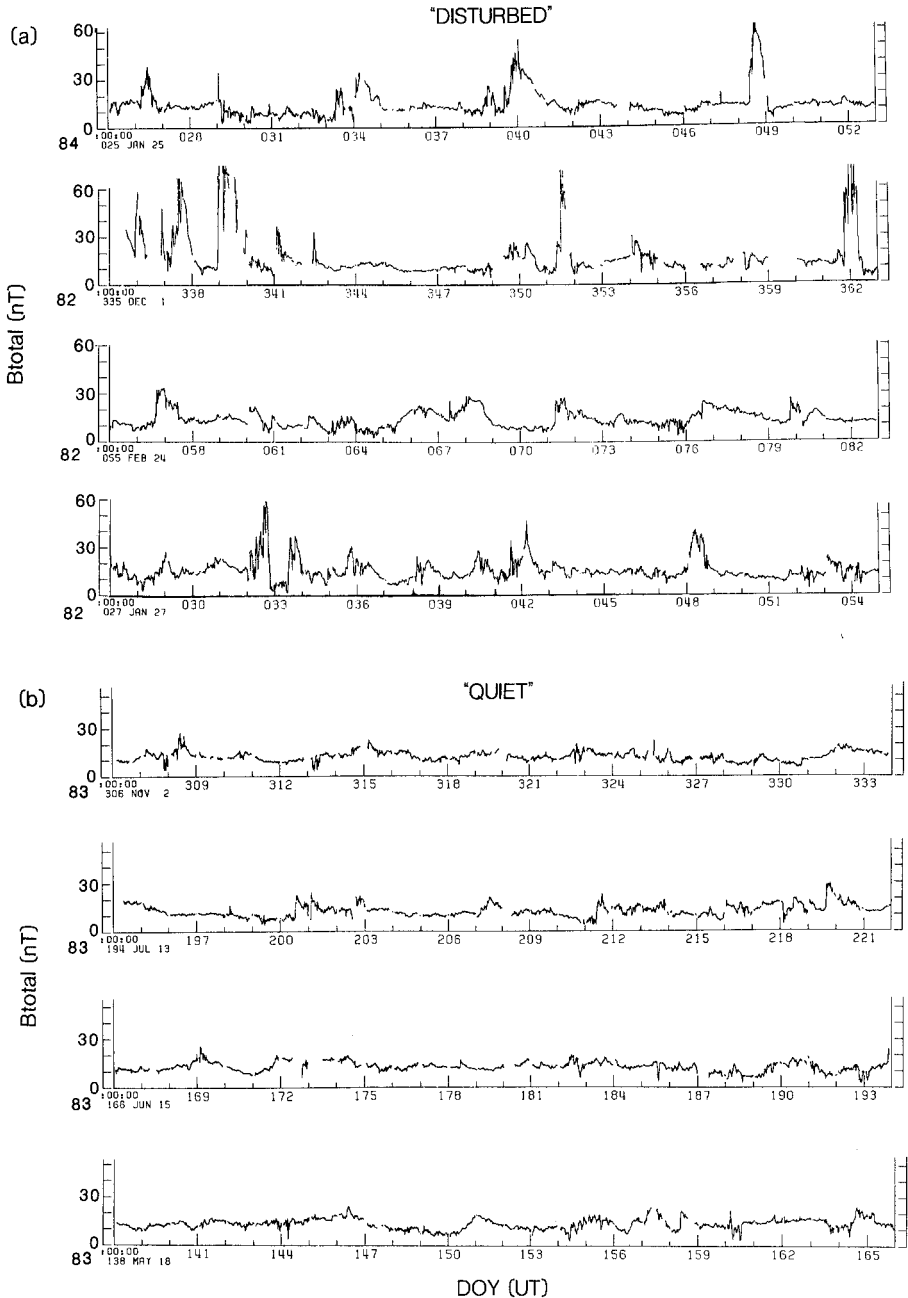


Fig. 1. (a) Examples of particularly disturbed 28-day intervals of PVO magnetometer interplanetary magnetic field magnitude data (10 min. averages).

(b) Examples of particularly quiet 28-day intervals.

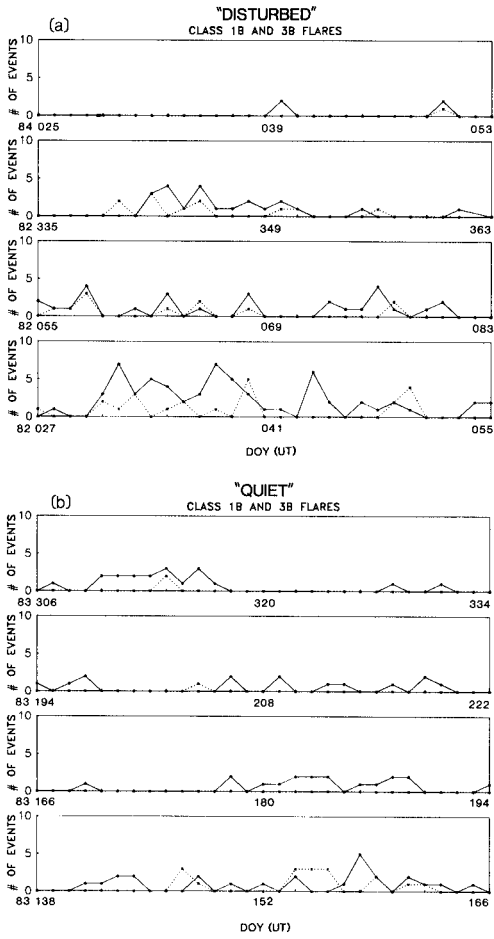


Fig. 2. (a) Flare occurrence data corresponding to the intervals in Fig. 1a. (b) Same as Fig. 2a but for the intervals in Fig. 1b.

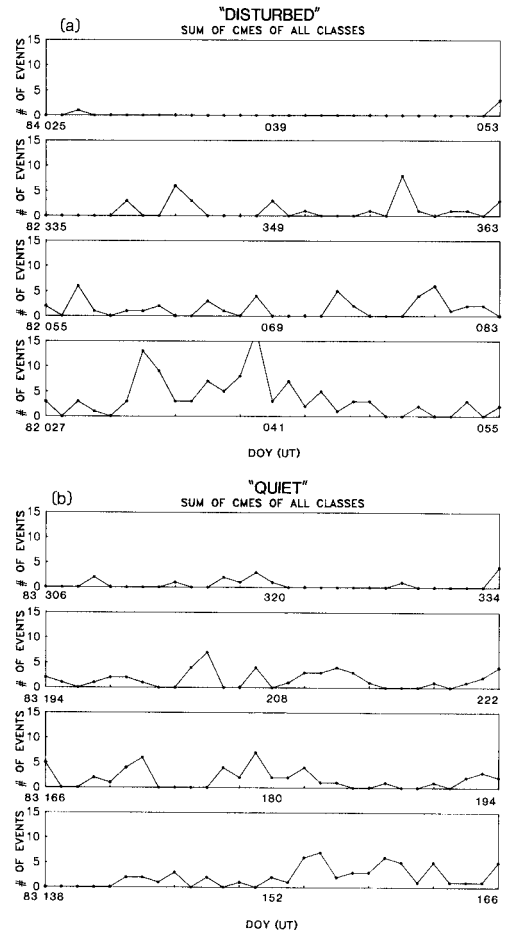


Fig. 3. (a) Coronal mass ejection occurrence data corresponding to the intervals in Fig. 1a. (b) Same as Fig. 3a but for the intervals in Fig. 2b.

DISCUSSION

It is worthwhile at this point to consider what may be transpiring in the course of a change between 2 and 4 sector interplanetary field patterns. Plots of the heliospheric current sheet projected on the source surface were constructed by Hoeksema et al. /2/ for the years 1978-82. These plots show that the current sheet can "switch" patterns over only a solar rotation instead of evolving slowly from one state to the other. It thus seems reasonable to expect that the transition period must be accomplished by a fairly rapid reconfiguration of coronal holes and the attendant transients in the interplanetary medium as stream interaction regions are produced not by rotation, as at 1 AU, but by changes in the geometries of the source regions. These transients are more akin to flare transients than to corotating stream phenomena because they should be signatures of a similar sort of "snowplow" effect on the slower solar wind in front of a newly emerging high speed stream or a rarefaction behind a slowing stream.

This picture is supported by both the solar wind plasma and solar surface data. Figure 5 shows the plasma velocity data spanning the disturbed intervals in Figure 1a. There is a clear transition in the velocity in a given heliolongitude range from low speed to high speed solar wind or vice versa. The 10830Å coronal hole data, obtained from Solar Geophysical Data, are reproduced in Figure 6 for the Carrington rotations that include the periods of interest. These show the extent to which the coronal holes (presumably the sources of the high speed solar wind) have reconfigured during the active intervals. The flare occurrence rate appears to behave largely independently of the coronal hole or sector structure changes although flaring regions are sometimes seen to be the sites of locally altered magnetic field polarity.

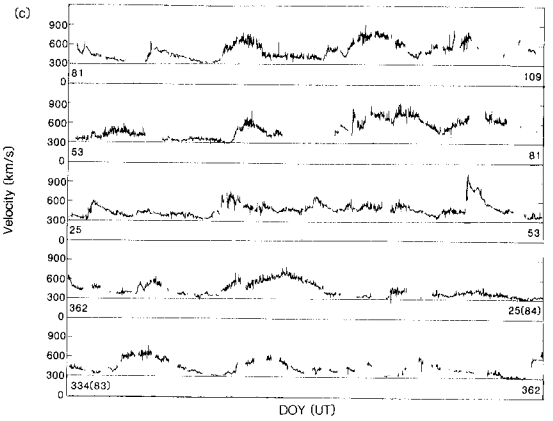
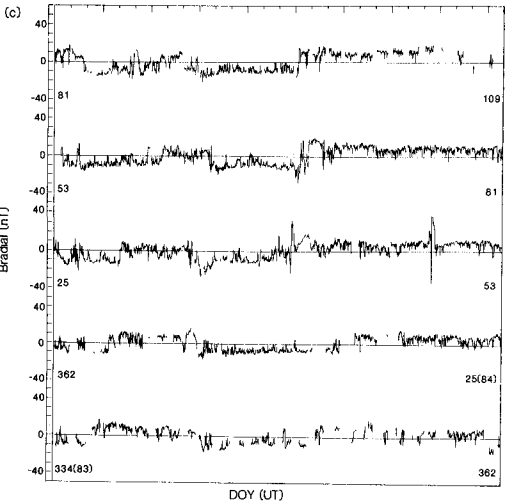
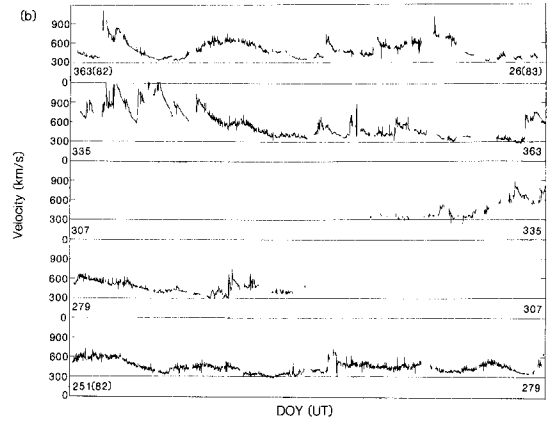
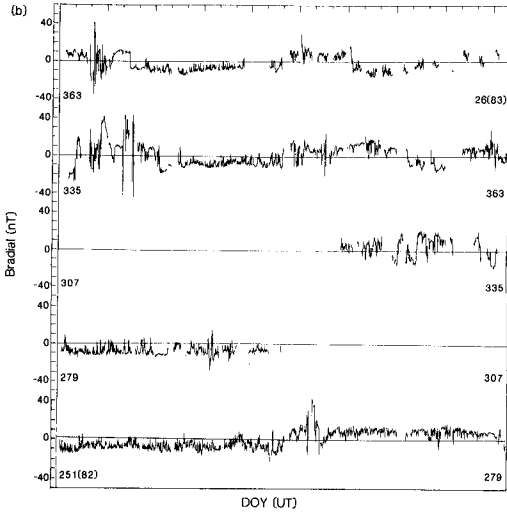
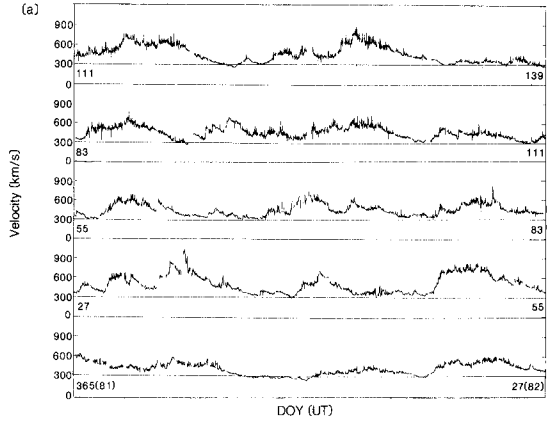
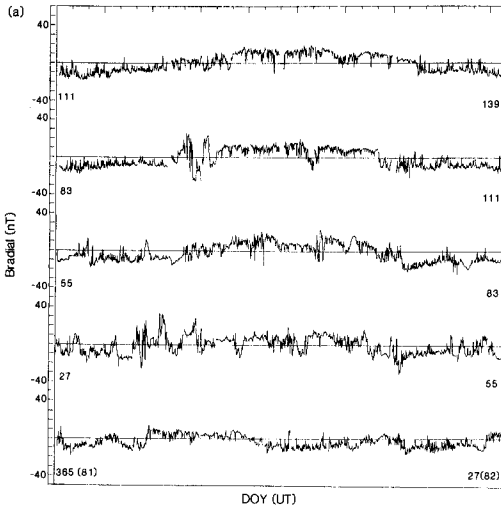


Fig. 4. Radial interplanetary magnetic field (10 min. average) time series for 28-day intervals surrounding the active periods shown in Fig. 1a.

Fig. 5. Solar wind velocity data surrounding the active periods shown in Fig. 1a.

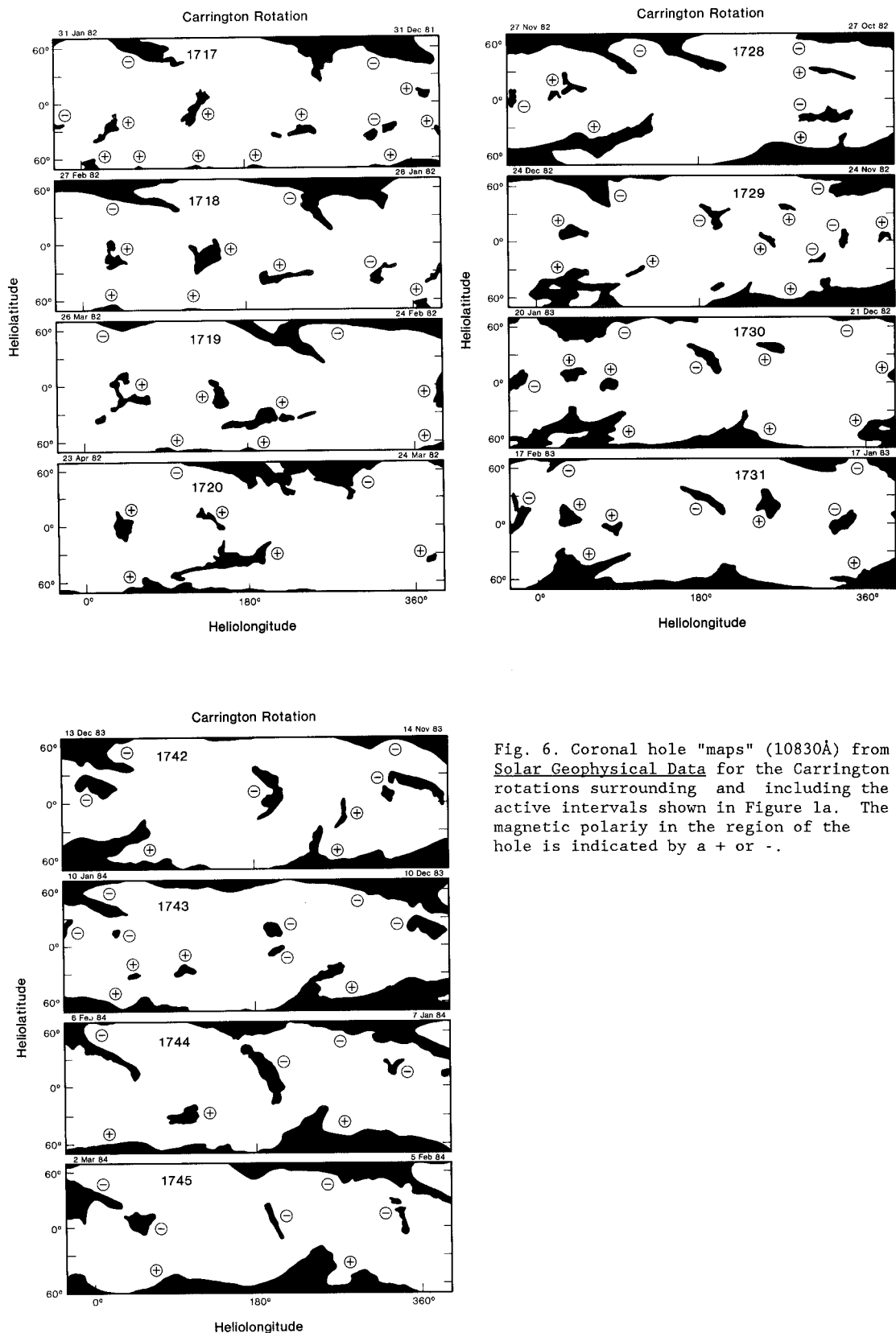


Fig. 6. Coronal hole "maps" (10830Å) from Solar Geophysical Data for the Carrington rotations surrounding and including the active intervals shown in Figure 1a. The magnetic polarity in the region of the hole is indicated by a + or -.

CONCLUSIONS

Examination of interplanetary magnetic field data obtained by the Pioneer Venus Orbiter at .7 AU for intervals of an apparent solar rotation (28 days) and contemporaneous solar activity data indicates that particularly disturbed periods are distinguished by a change in the heliospheric sector structure rather than by enhanced solar activity (although the latter are not always exclusive). The behavior of the solar wind velocity and the solar coronal hole patterns supports the idea that transient changes in stream structure associated with the coronal hole reconfiguration causes the observed persistently high level of interplanetary monitoring programs and studies of disturbances in the solar wind.

ACKNOWLEDGEMENTS

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