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GEOPHYSICAL PAPERS

Sector Structure of the Interplanetary Magnetic Field and Daily Variation of the Geomagnetic Field at High Latitudes

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R-6 August 1968

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Introduction

It is wellknown that the agitation of the magnetic field is very high in the polar cap. The agitation is most prominent in the daylight hours and persists even when the field outside the polar cap is very quiet.

It is the purpose of this note to draw the attention to the existence of two distinct types of perturbations existing over the polar cap. In a paper under preparation a much more detailed investigation of the types will be reported. A given type of perturbation is usually persistent during several days causing a distinct type of diurnal variation of the geomagnetic field components. Furthermore, it is noted that the shift from one type to the other is strongly correlated to a change in the overall direction of the interplanetary magnetic field vector. In essence one type of daily variation is observed when the interplanetary magnetic field is directed towards the sun, while the other type occurs when the field direction is predominantly away from the sun.

The daily variation of the geomagnetic field at high latitudes

Inspection of magnetograms from high-latitude stations demonstrates the fact that regular daily variations do exist. Very often the effect of the usually proposed uniform return current sheet over the polar cap is directly seen as a 24-hour sine wave in the records of the horizontal components. At very high latitudes the return current sheet will exert only very small daily variations of the vertical force Z. The Z-records therefore are generally least affected by the return current from the auroral electrojet(s).

Systematic study of Z-records from high-latitude stations in both hemispheres have revealed some interesting results. The most striking is that at the time, where the daytime-agitation has its maximum, one may find a pronounced positive Z-perturbation on some days, while on other days one observes a broad negative perturbation of the Z-component. The duration of the perturbations is usually 8-12 hours. Fig. 1 shows the Z-variation at Thule (corr. geomagn. lat. 86°8N) on July 2o, 196o. The undisturbed level is indicated by a broken line. The figure shows an example of the positive Z-perturbation between 11h and 19h UT. The time of maximum of the day-agitation is about 15h UT.

Fig. 2 shows an example of a negative disturbance in Z. The appearence of the magnetograms is so different that we may speak of two different types of variation. It must be stressed that the examples given are not the findings of a careful selection, and many other examples may equally well be presented. We denote the positive perturbation as being of type C while the negative perturbation is called type A disturbance (type B is reserved for mixed types which sometimes occur. At Godhavn (corr. geomagn. lat. 77°5) the difference between the two types manifests itself in the H-records (the sense of the perturbation is opposite to that of the Z-perturbation).

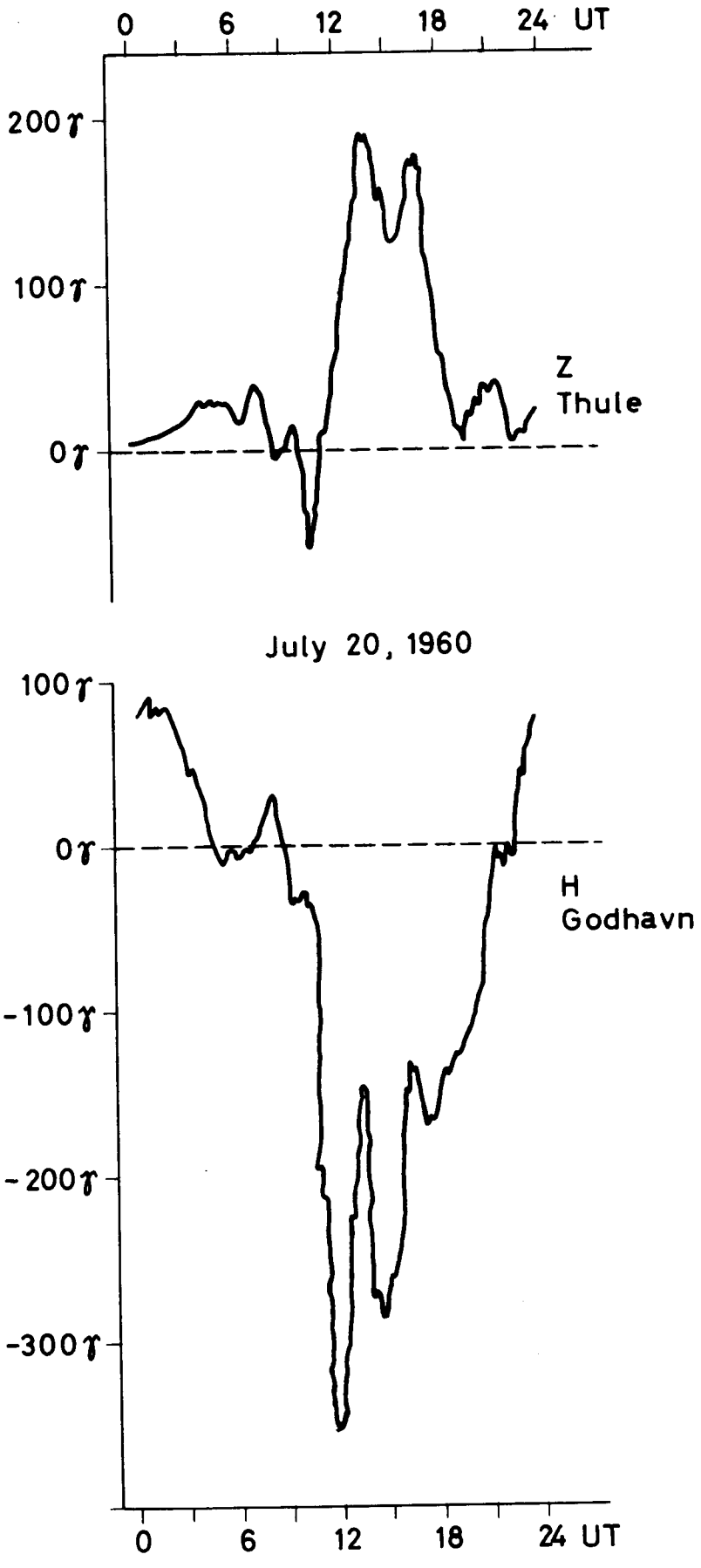

FIG. 1 Type C variation.
The undisturbed level is indicated by broken lines.

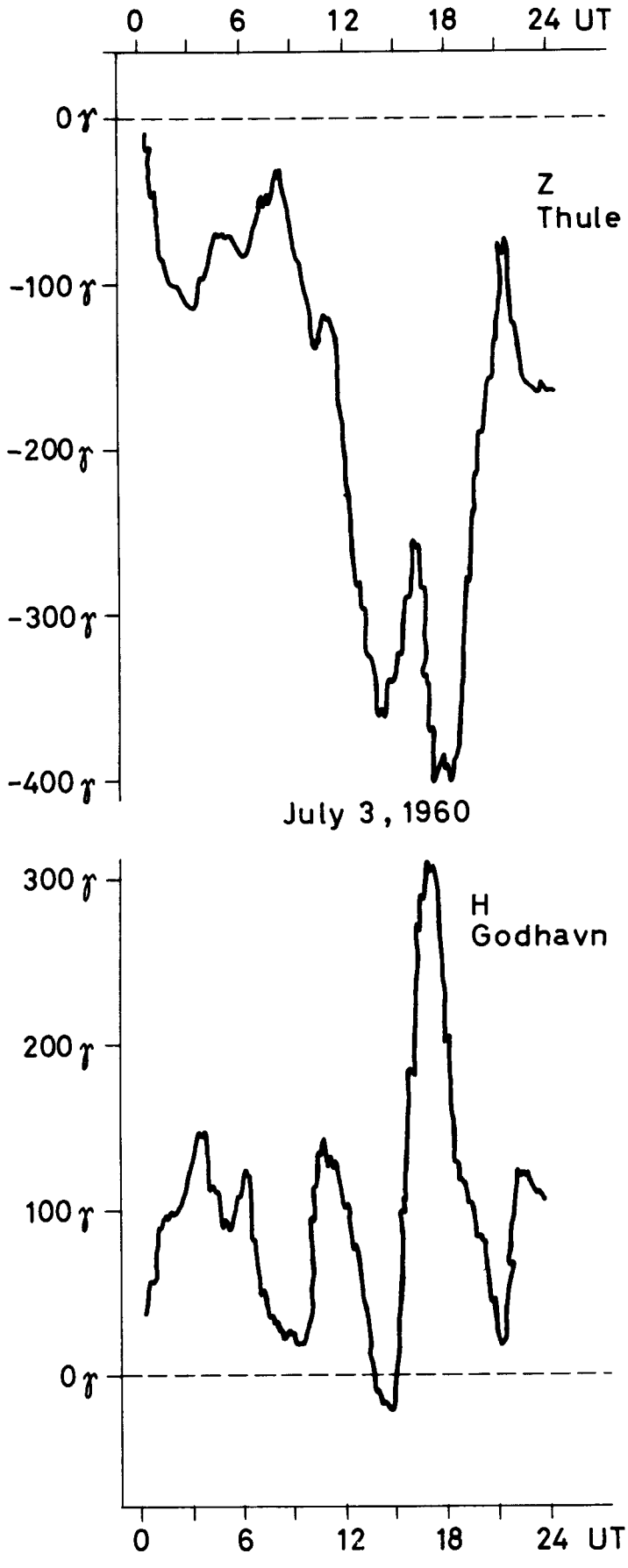

FIG. 2 Type A variation.
The undisturbed level is indicated by broken lines.

As seen from Fig. 3 (and from any collection of records from Thule and Vostok) the two types occur on the same days at both Thule and Vostok (inv. lat. -85° S). In fact, a given type occurs at all polar stations in both hemispheres at the same time. The time of the day where the perturbations are observed is the time of maximum of the daytime-agitation.

We conclude that two different types of daytime-perturbation exist. For each GMT-day it is generally possible to classify it as being either an A-day or a C-day according to the dominant type of high-latitude daytime-perturbation.

This classification has been carried out for some years (1932-33, 1947-49, and 1957-65). At the present, work is being done in order to extend the classification to cover all available data; this means at least some 4o years. Fig. 4 shows the result for the IQSY. From the data given it is evident that:

1) days having the same type tend to occur in groups.

2) the groups show a 27-29 days recurrence tendency, thus indicating a solar origin of the cause of the different types of day-agitation.

In order to test if the occurrence of a given type is dependent on the world wide disturbance level, the percentages of days of each type which are international disturbed or quiet days were calculated. Using records from the periods 1932-33, 1947-49, and 1957-6o we found:

Total number of A-days:				977
including	164	Q-days	= 16.8 o/o	
and	161	D-days	= 16.5 o/o	
Total number of C-days	(including some days of mixed type)			1586
whereof	255	Q-days	= 16.1 o/o	
and	256	D-days	= 16.2 o/o	

Since 16.4 o/o of all days are Q-days and other 16.4 o/o are D-days we conclude that over a long period there is no correlation between the type of the day-perturbation and the world wide disturbance level.

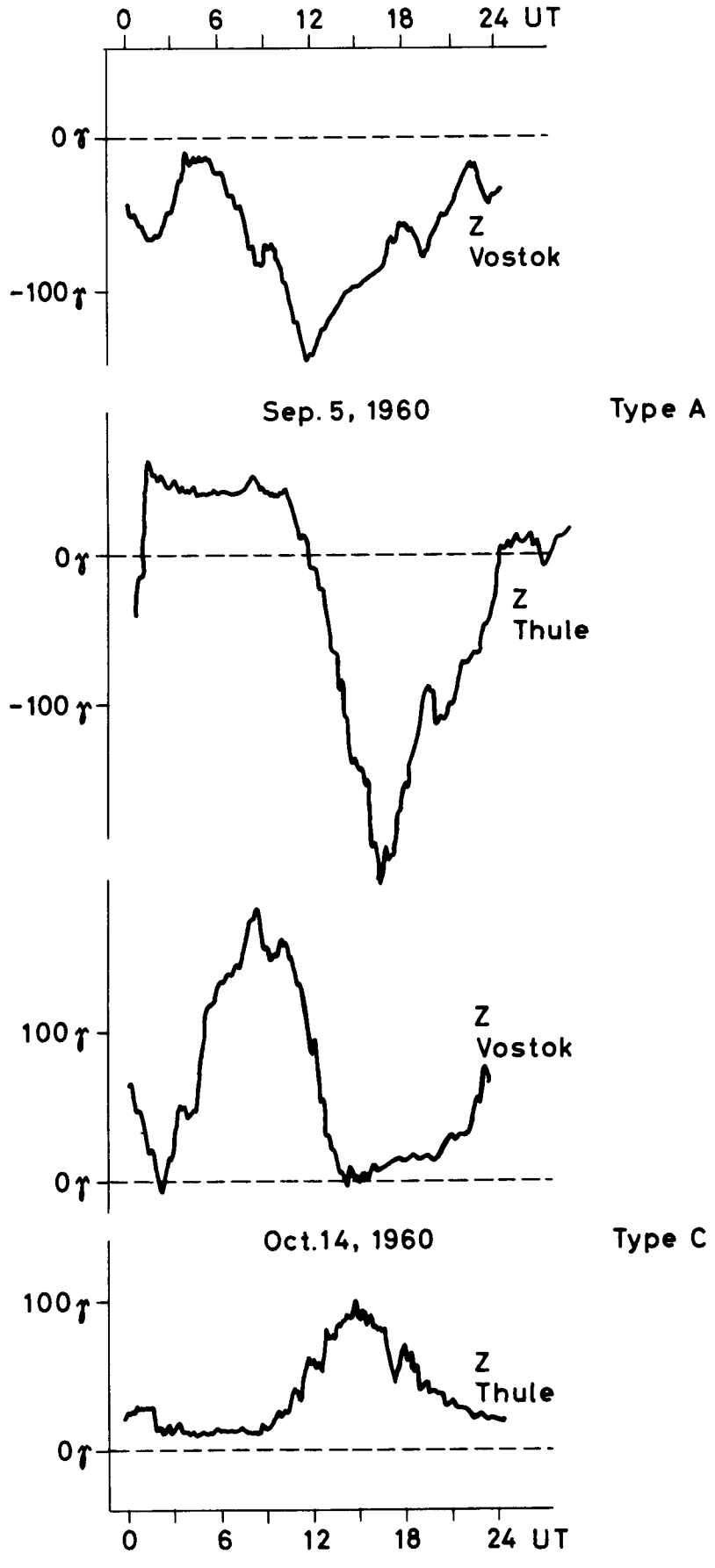

FIG. 3 Simultaneous occurrence of types in both hemispheres.

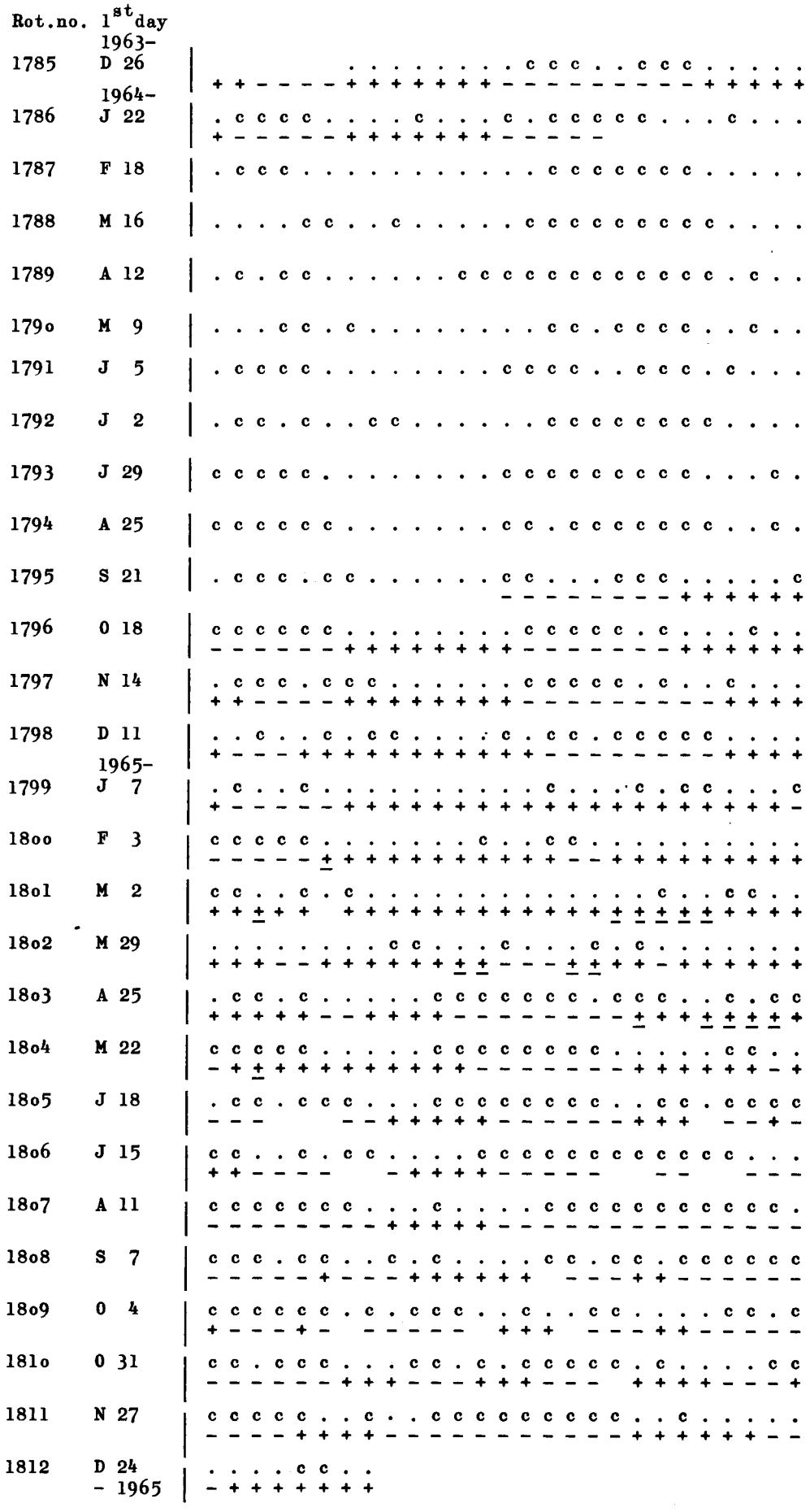

FIG. 4. Observed sector structure (+ means away from the sun and - means towards the sun) compared with A/C classification as derived from Canadian IQSY stations; the dot (.) indicates type A variation and the c indicates type C variation of Z. The data are ordered in sun rotation periods.

Interplanetary sector structure

The work of NESS, WILCOX, COLEMAN, and FAIRFIELD (NESS and WILCOX 1967) has shown that the interplanetary magnetic field exhibits a sector structure. This sector structure is defined as the property that for several consecutive days the sense of the field is either predominantly toward the sun or predominantly away from the sun. A remarkable feature of the type-classification introduced above is that on a day belonging to an away-sector the daily variation of the geomagnetic field at high latitudes will be of type A, while type C variations dominate when the interplanetary field is directed towards the sun. This observation is important for several reasons:

1) it provides a convenient way to determine the sector structure at any time from ground-based measurements.

2) it makes possible a study of the long-term behaviour of the sector structure because regular registration of the high latitude geomagnetic field has been carried out during most of this century, and

3) it shows that the geomagnetic field in high latitudes, and in turn the configuration of the magnetosphere, is highly influenced by the interplanetary magnetic field. The close correlation between the type of daytime-perturbation and the sense of the interplanetary magnetic field seems to indicate that the magnetosphere is open as suggested by DUNGEY.

Fig. 4 compares the observed sector structure (IMP 2, Mariner 4, IMP 3) as given by NESS and WILCOX (loc.cit.) with the type-classification based on data from the Canadian stations Resolute Bay, Alert and Mould Bay during IQSY.

Note in Fig. 4 that the death of the old solar cycle and the beginning of the next cycle is seen to take place during the sun rotations no. 1799 to 1801.

Conclusion

It seems that the state of the high-latitude geomagnetic field is heavily influenced by the sense of the interplanetary magnetic field vector. This favours an open magnetosphere. It seems possible to determine with fair accuracy the sector structure of the interplanetary field from ground-based observation of the daytime perturbation of the geomagnetic field.

Reference

Ness N.F. and Wilcox J.M., 1967, Solar Physics 2, 351.