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Error in print

The figures 1 and 3 have been interchanged.

Abstract.

An observed influence of the interplanetary magnetic sector structure on the geomagnetic variations in the polar cap appears to be due to the component of the interplanetary magnetic field near the ecliptic perpendicular to the earth-sun direction. This suggests that the observed effect on the ground originates in the front of the magnetosphere.

A clear correspondence between the sector polarity of the interplanetary magnetic field and the geomagnetic variations in the polar cap has been found to exist by Svalgaard (1968) and by Mansurov (1969). For a positive polarity of the interplanetary magnetic field (a direction away from the sun) the vertical component, Z, of the magnetic field at Thule (INVL, invariant latitude, = 86.8°N) is depressed during several hours around magnetic noon and the horizontal component, H, at Godhavn (INVL = 77.5°N) is increased. Correspondingly a negative sector polarity gives rise to an increase of the Z-component at Thule and a decrease of the H-component at Godhavn. This correlation between the interplanetary magnetic field and the geomagnetic field in the polar cap is so distinct that it has been possible to infer the sector polarity from the geomagnetic field variations at the polar cap observatories Thule and Godhavn (Friis-Christensen et al., 1971), (Svalgaard, 1972).

But a more detailed examination of the observed relationship (Friis-Christensen, 1971) revealed a few cases in which the geomagnetic variations at Thule and Godhavn apparently disagreed with the sector polarity. Especially May 29th and June 21st in 1968 showed evidence of being situated in a sector of opposite polarity to the one observed by spacecraft (Wilcox and Colburn, 1970). As these days occurred around shifts in the sector polarity a possibility of a time delay was at first looked for. The fact, however, that the shift in the type of daily variation of the geomagnetic field in the polar cap did occur nearly a day earlier than indicated by the spacecraft measurements made this assumption very unrealistic. Therefore a closer examination of the interplanetary magnetic field variations around the days showing inconsistency with geomagnetic variations was performed.

A few words might be mentioned here of the coordinate system to which the interplanetary field is referred in the following. A geocentric solar magnetospheric system (GSM) has been used in which the X-axis points towards the sun from the earth. The Y-axis is perpendicular to the X-axis and to the earth's magnetic dipole so that the X-Z plane contains the dipole axis. The Z-axis is positive in the northward direction. The Y-axis is pointing towards the dusk. In this coordinate system the components of the interplanetary magnetic field are called BXM, BYM, and BZM.

The interplanetary magnetic field may be found in any direction but the most frequent direction is near the ecliptic along the Archimedes spiral which forms an angle of 45^o with the sun-earth direction (Wilcox and Ness, 1965). The occasional deviations from the average direction of the interplanetary magnetic field make it possible to get further information about the relationship between the interplanetary magnetic field and the geomagnetic variations in the polar cap. For the normal direction of the interplanetary magnetic field in an away sector (positive polarity) the X-component, BXM is negative and BYM is positive, whereas in a toward sector (negative polarity) BXM is positive and BYM is negative.

In Fig. 1 is shown the variation of the interplanetary magnetic field vector on May 28-30, 1968. The vectors indicate hourly mean values of the vector component of the interplanetary field in the X-Y plane. The corresponding hourly mean values of the Z-component at Thule are shown as well. The sector boundary between a towards sector and an away sector is obviously situated around 04^h-05^h UT on May 30th. May 29th seemed to have the wrong polarity inferred from the geomagnetic variations at Thule. A depression of the Z-component at Thule is observed on May 29th accompanied by a very distinct deviation from the Archimedes spiral of the direction of the interplanetary magnetic field. The same abnormal direction of the interplanetary field was also existing during the negative perturbation of Z at Thule on June 21st which is shown in Fig. 2. Thus, it seems likely that the negative perturbation of the Z-component at Thule which is characteristic for an away sector is related to the component of the interplanetary field in the magnetic equator perpendicular to the sun-earth direction rather than to the component along the sun-earth direction or the component along the Archimedes spiral. When the component BYM is positive the Z-component at Thule is depressed in the day hours.

The suggestion that the variation of BYM is reflected in the geomagnetic variations in the polar cap is further illustrated by the variation of BYM also shown in Fig. 1 and Fig. 2. Notice that in the figures the positive axis of BYM is downwards which gives an idea of the very close relationship between BYM and Z at Thule. Apparently a time delay of about 1 hour exists between variations in BYM and in Z at Thule.

During the months of June, July and August of the year 1969 hourly mean values of the vertical intensity, Z, at Thule and of the interplanetary magnetic field were compared. The hourly average values of Z at Thule at 15^h-16^h UT were plotted against the corresponding hourly average values of BYM, BXM, and BZM in the Figs. 3a, 3b, and 3c. A very high correlation between BYM and the Z-component at Thule is observed. As a time delay of about an hour is intimated in the Figs. 1 and 2, the hourly mean values of Z at Thule at 16^h-17^h UT were used in comparison with the components of the interplanetary magnetic field at 15^h-16^h UT in the Figs. 4a, 4b, 4c, and it appears that the correlation between BYM and Thule Z in Fig. 4a is still greater than in Fig. 3a. Only one single points seems not to fit into this pattern, the value at July 22nd. The value of Z at Thule at 16^h-17^h UT is here 56550 gammas, about 300 gammas above the value expected from the figure. At 15^h-16^h UT, however, the value is 56266 gammas indicating that the time delay of an hour is not always valid. This is not surprising because the unit of time used in this analysis is one hour, of the same order of magnitude as the proposed delay. Fig. 5a and Fig 5b show similar correlations as in Fig. 4a between the value of Thule Z at 10^h-11^h UT and 13^h-14^h UT versus BYM at 09^h-10^h UT and 12^h-13^h UT. It is noticeable that near local magnetic noon at Thule, namely 13^h-14^h UT, a relation $Z_{TH} = -k \cdot BYM + Z_o$ seems to be valid where Z_o denotes the Z component at Thule for BYM = 0, and k is a constant. At 10^h-11^h UT, however, this relation is less obvious for BYM > 0 whereas at 16^h-17^h UT the relation is less obvious for BYM < 0.

As the number of cases of an abnormal direction of the interplanetary magnetic field is small, the fact that it is the Y-component that is the cause of the observed geomagnetic variations at Thule and not the polarity of the interplanetary magnetic field does not obviously appear from the comparison between an inferred sector structure and observations by spacecraft in 1969 by Friis-Christensen et al. (1971). In the months of June, July, and August of 1969 the following cases of discrepancy throughout a whole UT-day occurred:

		June 11		July 4		August 5
Inferred polarity:		+		+		+
Observed polarity:		-		-		-
BYM:	07^h-17^h:	+	14^h-17^h:	+	11^h-24^h:	+

It is clear that all of these cases of apparent inconsistency may find an explanation by the assumption that thr Y-component of the interplanetary magnetic field causes the geomagnetic variations in the polar cap dealt with in this work.

Thus it is probable that the previously found influence of the sector polarity on the geomagnetic variations in the polar cap merely is a consequence of the existing preferred directions of the interplanetary magnetic field along the Archimedes spiral. This implies a statistically very high correlation between the polarity and the Y-component of the interplanetary field.

The clear evidence of the influence of the Y-component of the interplanetary magnetic field on polar cap geomagnetic variations demonstrated in this work seems to indicate a mechanism having its origin in the front of the magnetosphere in the cusp region. Fig. 6 sketches the formation of merging points at the flanks of the magnetosphere. A positive Y-component of the interplanetary field will be in favour of a formation of a merging point displaced towards the dusk whereas a negative Y-component will imply a merging point displaced towards the dawn. This is in good agreement with the time of maximum increase of Z at Thule at negative polarity of the interplanetary field generally occurring around 13^h UT while the maximum decrease of Z at Thule at positive polarity is situated at 16^h UT (Friis-Christensen, 1971). Also this is in agreement with the result if Fig. 4 a and Fig. 5a indicating a greater proportionality factor k in the relation $Z_{TH}-Z_o = -k \cdot BYM$ at 16^h-17^h UT for $BYM > 0$ and at 10^h-11^h UT for $BYM < 0$.

In a reconnection model based upon merging of interplanetary and geomagnetic field lines (Wilhjelm and Friis-Christensen, 1972) the observed geomagnetic effects in the polar cap are explained as caused by the penetration of an electric field at the dayside polar cusp.

Acknowledgement.

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F I G U R E S

Fig. 1.

Hourly mean values of the vector component of the interplanetary magnetic field in the X-Y plane, the vertical intensity, Z, of the geomagnetic field at Thule (invariant latitude = $86.8^{o}N$) and of the eastward component, BYM, of the interplanetary magnetic field during May 28-30, 1968.

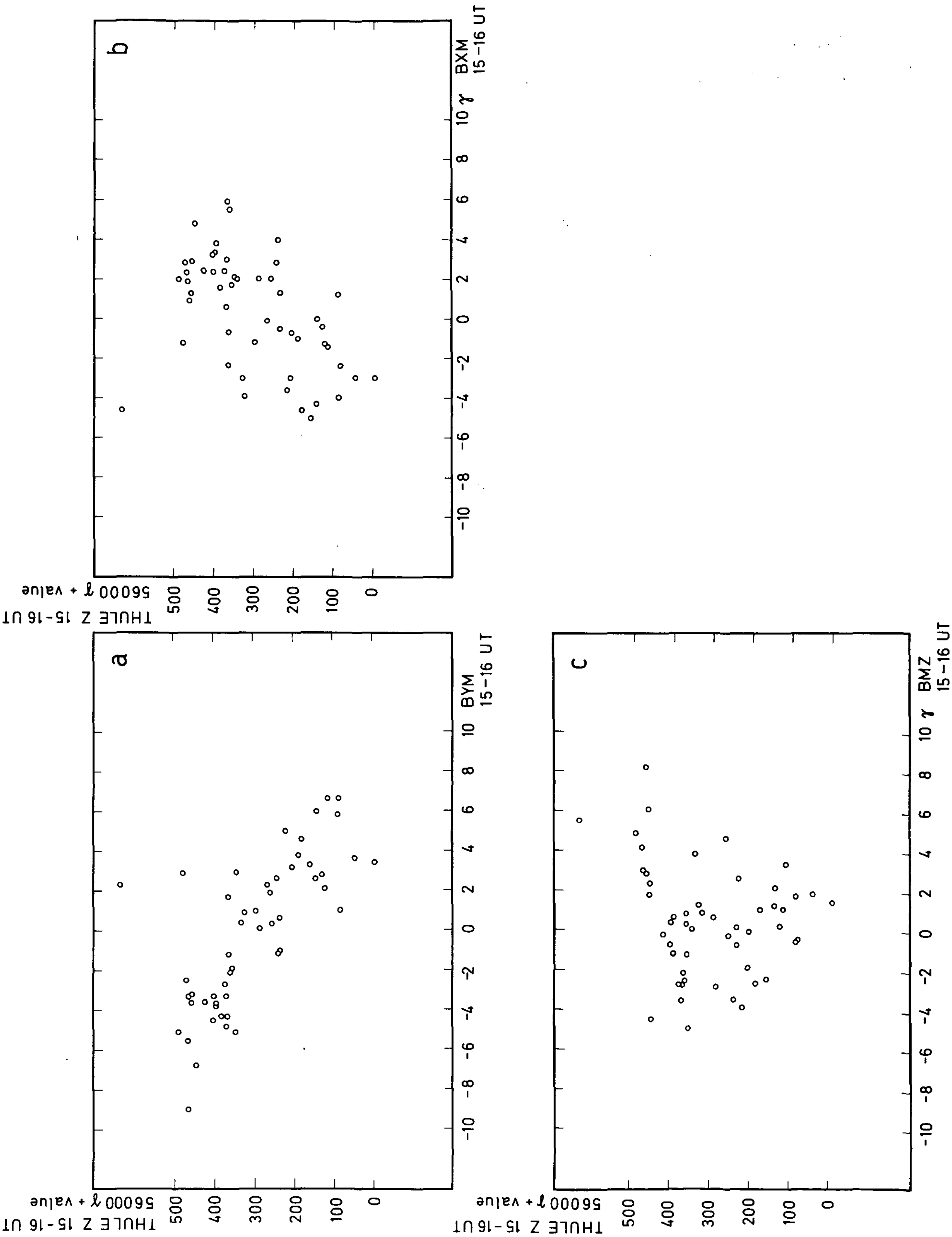

a
b
c
THULE Z 15-16 UT
56000 γ + value
BYM 15-16 UT
BXM 15-16 UT
10 γ BMZ 15-16 UT

Fig. 2.

Same as Fig. 1 for June 20-22, 1968.

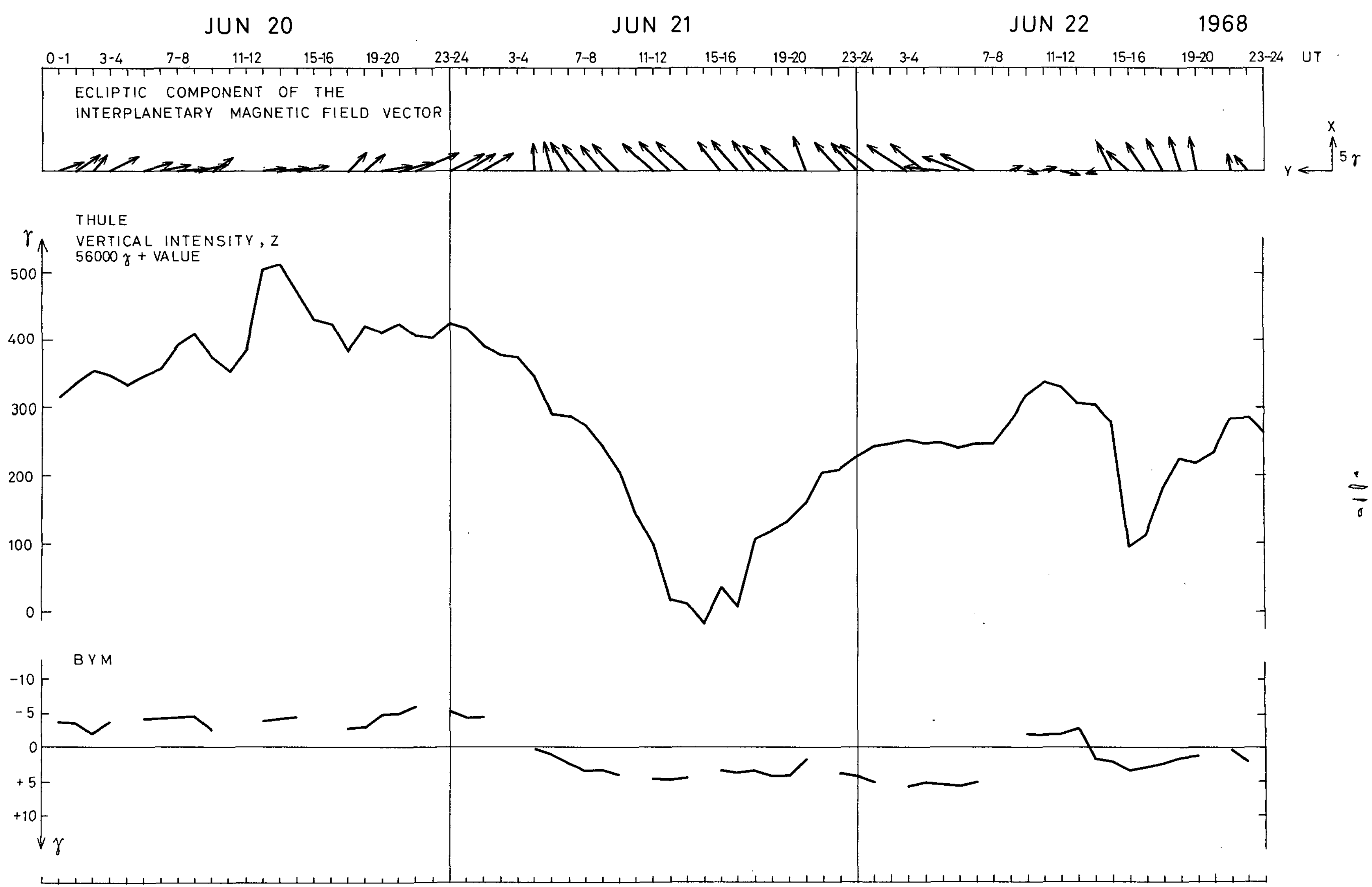

JUN 20
JUN 21
JUN 22
1968
0-1
3-4
7-8
11-12
15-16
19-20
23-24
UT
ECLIPTIC COMPONENT OF THE
INTERPLANETARY MAGNETIC FIELD VECTOR
X
Y
5 γ
THULE
VERTICAL INTENSITY, Z
56000 γ + VALUE
γ
500
400
300
200
100
0
BYM
-10
-5
+5
+10

Fig. 3.

Plot of hourly mean values of Thule Z at 15^h-16^hUT against hourly mean values of the components of the interplanetary magnetic field at 15^h-16^h UT during June, July, and August of o969.

a) Eastward component BYM.

b) Sunward component BXM.

c) North-South component BZM.

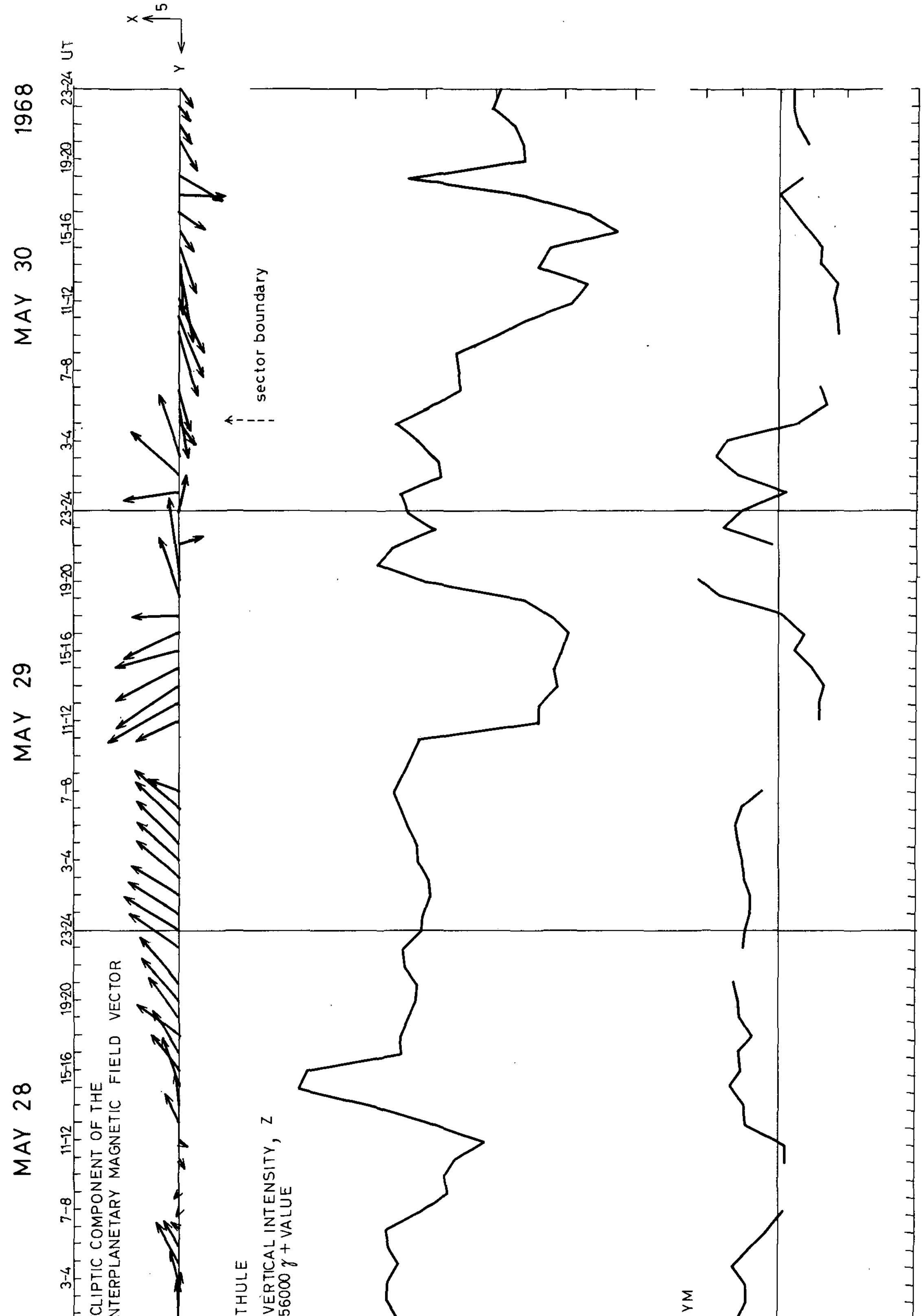
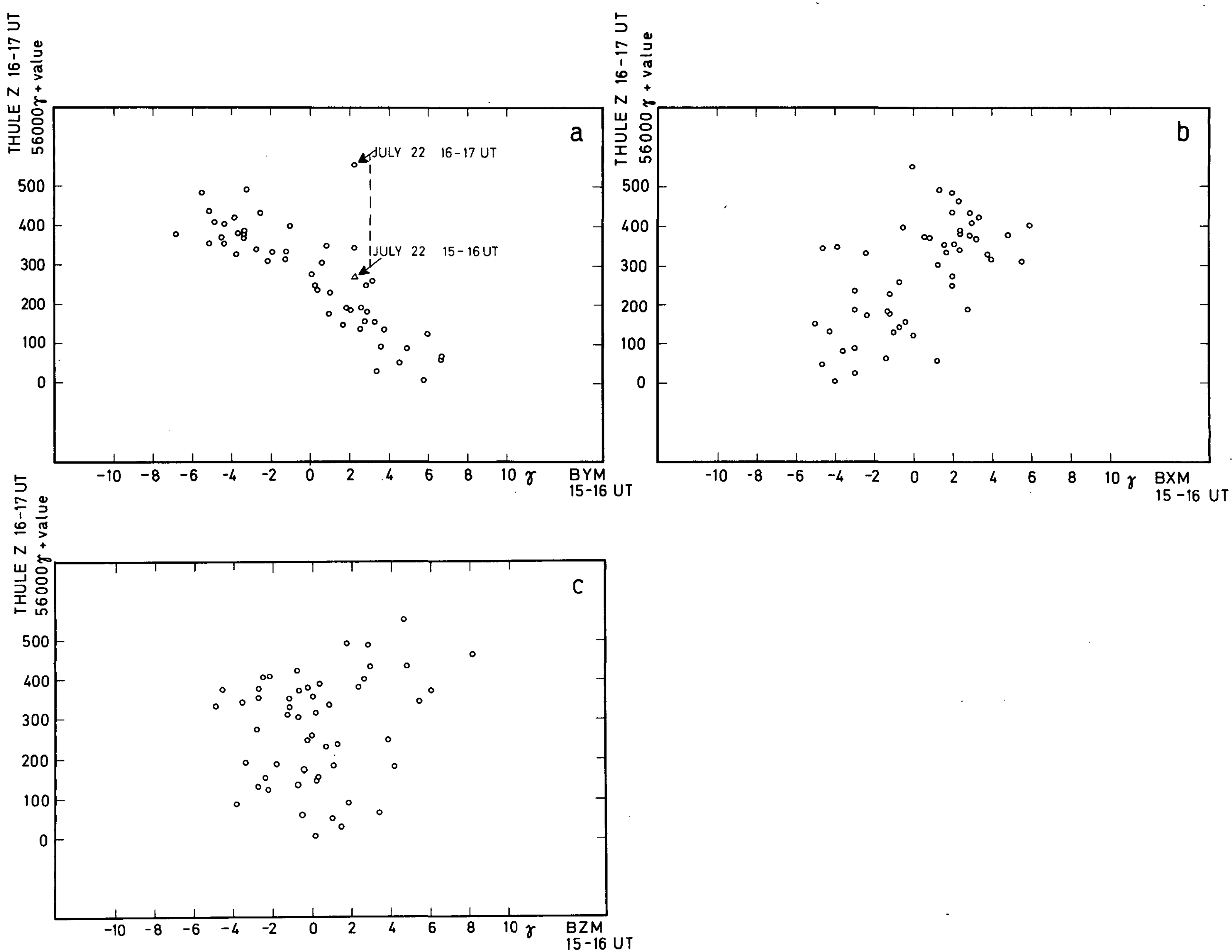

MAY 28
MAY 29
MAY 30
1968
ECLIPTIC COMPONENT OF THE
INTERPLANETARY MAGNETIC FIELD VECTOR
X
5 γ
Y
UT
0-1
3-4
7-8
11-12
15-16
19-20
23-24
sector boundary
THULE
VERTICAL INTENSITY, Z
56000 γ + VALUE
BYM
γ
500
400
300
200
100
0
-10
-5
0
+5
+10
γ

Fig. 4.

Same as Fig. 3 except that the values of the interplanetary magnetic field at 15^h-16^h UT are compared with the values of Thule Z one hour later i.e. 16^h-17^h UT.


a
b
c
THULE Z 16-17 UT
56000γ + value
JULY 22 16-17 UT
JULY 22 15-16 UT
BYM
15-16 UT
BXM
15-16 UT
BZM
15-16 UT
-10 -8 -6 -4 -2 0 2 4 6 8 10 γ
0 100 200 300 400 500

15

Fig. 5.

a) Plot of Thule Z at 10^h-11^h UT against BYM at 09^h-10^h UT.

b) Plot of Thule Z at 13^h-14^h UT against BYM at 12^h-13^h UT.

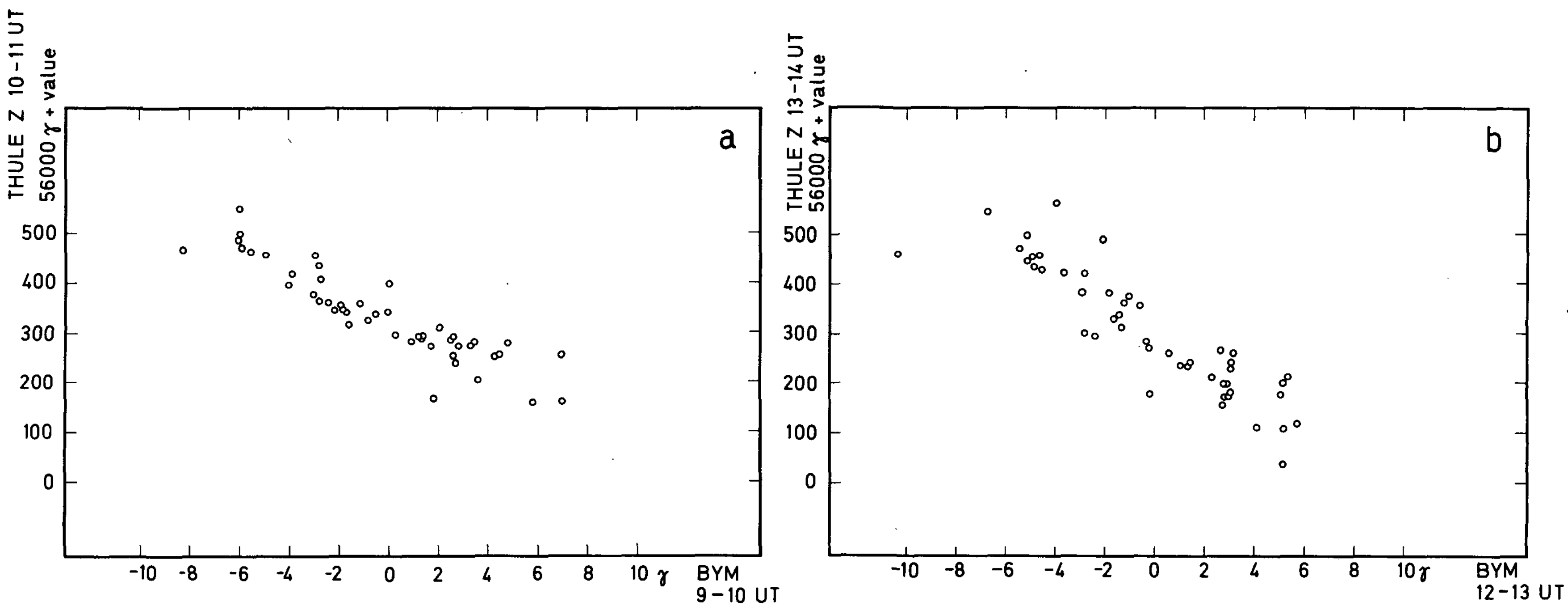
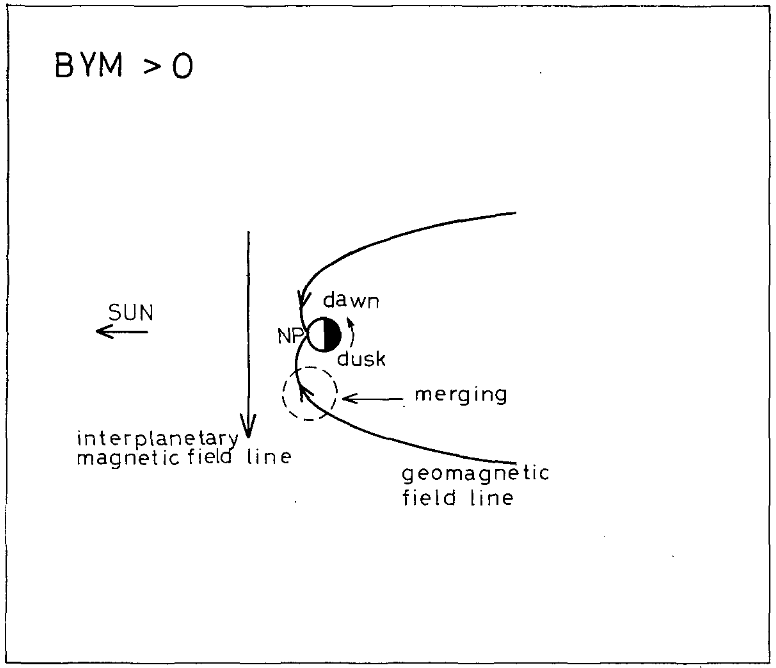
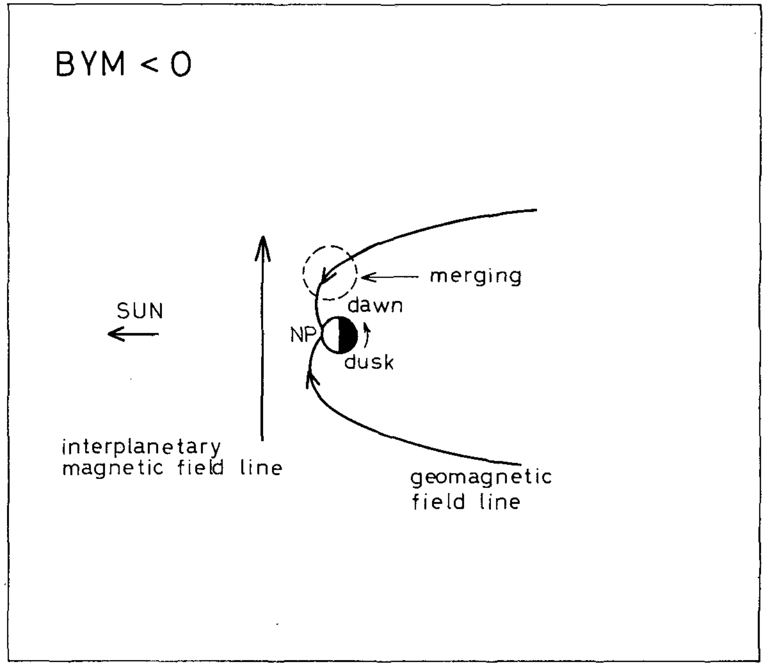

THULE Z 10-11 UT
56000 γ + value
500
400
300
200
100
0
a
-10 -8 -6 -4 -2 0 2 4 6 8 10 γ
BYM
9-10 UT
THULE Z 13-14 UT
56000 γ + value
500
400
300
200
100
0
b
-10 -8 -6 -4 -2 0 2 4 6 8 10 γ
BYM
12-13 UT

Fig. 6.

Projection on the ecliptic of geomagnetic field lines in the dayside northern polar cusp indicating a possibility of merging on a geomagnetic field line situated shortly after magnetic noon in the case of an eastward interplanetary magnetic field and shortly before magnetic noon in the case of a westward interplanetary magnetic field.


BYM > 0
SUN
interplanetary magnetic field line
NP
dawn
dusk
merging
geomagnetic field line


BYM < 0
SUN
interplanetary magnetic field line
NP
dawn
dusk
merging
geomagnetic field line

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