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Effect of the IMF Sector Structure on the Mid-latitude S_q

by

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Abstract

The geomagnetic hourly value data at Memambetsu, Kakioka and Kanoya during 16 years have been statistically analyzed to confirm the effect of the interplanetary magnetic field (IMF) sector structure on the daily variation in the middle latitude.

It has been shown that the IMF sector structure has a small but clear effect on the focus latitude and intensity of S_q variation, but little effect on the mean absolute level of S_q. Some other features of the effect have also been examined.

The interplanetary magnetic field (IMF) sector structure has a clear effect on the geomagnetic field in the polar-cap region. The daily variation of H or Z component in this region shows binary features associated with the polarity of the IMF sector structure (Svalgaard 1972). This effect is now well established and is used to infer inversely the sector structure from the polar-cap magnetic data (Svalgaard 1972). Such effect in the middle and low latitudes was examined by Matsushita et al. (1973). They and one of them (Matsushita 1975) showed that the focus of the S_q current system shifts poleward (equatorward) associated with the away (toward) sector polarity. The present author (Shiraki 1975) also obtained the same conclusion on the relation between the shift of S_q focus and the IMF sector structure. However, as these results were obtained from small sample of days, an examination using long period of data is necessary to confirm the effect. Such examination is the purpose of this brief report.

Data used are hourly mean values of three components D, H and Z at three stations, Memambetsu (43°55′N, 144°12′E), Kakioka (36°14′N, 140°11′E) and Kanoya (31°25′N, 130°53′E), for the interval 1958-1973. To examine the effect of the IMF sector structure on S_q, the international quiet days (five days per month) were divided into two groups, depending on whether the polarity of the IMF sector structure was away from or toward the sun. Thereafter average daily variations of three components at three stations were computed for each group. Polarities of the sector structure were those inferred by Svalgaard (1972, private communication 1974) from the geomagnetic data in the polar-cap region. The accuracy of the inferred sector structure is disputable (Campbell and Matsushita 1973), however, they may be adequately used for the statistical study. The total number of days used are 560 days and 388 days for away and toward polarities, respectively.

The results are shown in Figure 1. The difference between the average daily variation for the away polarity, S_q^{A}, and that for the toward polarity, S_q^{T}, is small compared with S_q^{A} or S_q^{T} itself. Therefore the difference between S_q^{A} and S_q^{T}, indicated by δS_q, is shown in the figure but S_q^{A} or S_q^{T} itself is not shown. The scale of S_q is fivefold of that of δS_q. In the computation of S_q^{A}, S_q^{T}, δS_q or S_q, daily mean value was used as the reference level, but it was not included in the figure.

Small but clear effect of IMF sector structure on S_q is seen from Figure 1. The shape and magnitude of δS_q at three stations are nearly equal for each component. The ratio of the magnitudes of S_q and δS_q (computed from their ranges) is about 8.5. The shapes of δS_q for D and H components are different from those of S_q.

Though δS_q is not S_q-like variation, it is included in S_q^{A} or S_q^{T}. Therefore it

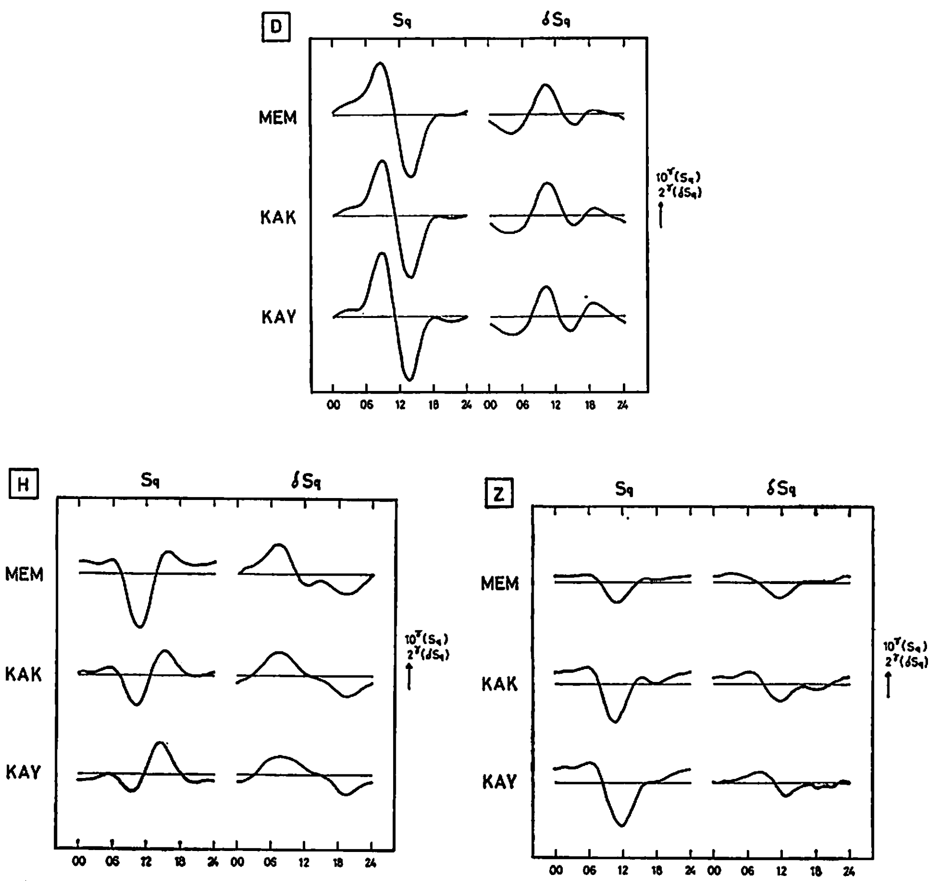

Figure 1. The effect of the IMF sector structure on S_q variations for D, H and Z components at Memambetsu, Kakioka and Kanoya.

causes the difference of the focus latitude and the intensity of the equivalent current system between $S_q{}^A$ and $S_q{}^T$. Estimated focus latitudes for $S_q{}^A$ and $S_q{}^T$ using H component by the method described in the previous papers (Shiraki 1973, 1974) are about 35°N and 34°N in geographic latitude, respectively. Though their difference is not so large as one presented by Matsushita (1975), the direction of the shift is the same, that is, the focus shifts poleward (equatorward) associated with the away (toward) sector polarity. These results are consistent with that obtained by the present auther (Shiraki 1975) from the correlation study on the day-to-day changes of S_q focus latitude and the IMF sector structure. Considering the range of D component as the measure of intensity of S_q current system, the intensity for the away sector polarity is larger by about five percent than that for the toward sector polarity.

Similar patterns of δS_q as Figure 1 were obtained for the subdivision of data into three seasons (winter, equinoxes and summer). However, the magnitude of the variation changes with seasons; the maximum occurs at equinoxes. For another subdivision of data by the annual mean sunspot number into two groups (quiet and active), similar patterns of δS_q were also seen for both groups, though the magnitude for active group is greater than that for quiet group. Table 1 shows ranges of S_q and δS_q at Kakioka for the above subdivisions.

Table 1. Ranges of S_q and δS_q at Kakioka. Unit is gamma.

		All	Season			Solar activity	
			w	e	s	q	a
D	S_q	46	28	53	65	39	54
	δS_q	3.9	3.2	8.8	3.7	3.5	6.4
H	S_q	22	13	31	26	19	25
	δS_q	3.5	2.7	5.3	3.9	2.8	4.1
Z	S_q	22	19	24	26	18	25
	δS_q	2.3	2.3	4.5	1.9	1.7	4.2

Matsushita et al. (1973) found a clear effect of IMF sector structure on the mean absolute value of H component in middle and low latitudes. However the result from the present analysis is negative for this effect. Table 2 shows the shift of daily mean

Table 2. Shift of the daily mean values from $S_q{}^T$ to $S_q{}^A$. Unit for D component is minute of arc in west and those for H and Z components are gamma.

	Memambetsu	Kakioka	Kanoya
D	0.27	−0.22	−1.29
H	5.0	4.8	8.2
Z	31.4	26.6	21.6

values from $S_q{}^T$ to $S_q{}^A$ for three components at three stations. For H component the sense of the shift is consistent with the result shown by Matsushita et al. However, the magnitudes of the shift at three stations are nearly proportional to the magnitudes

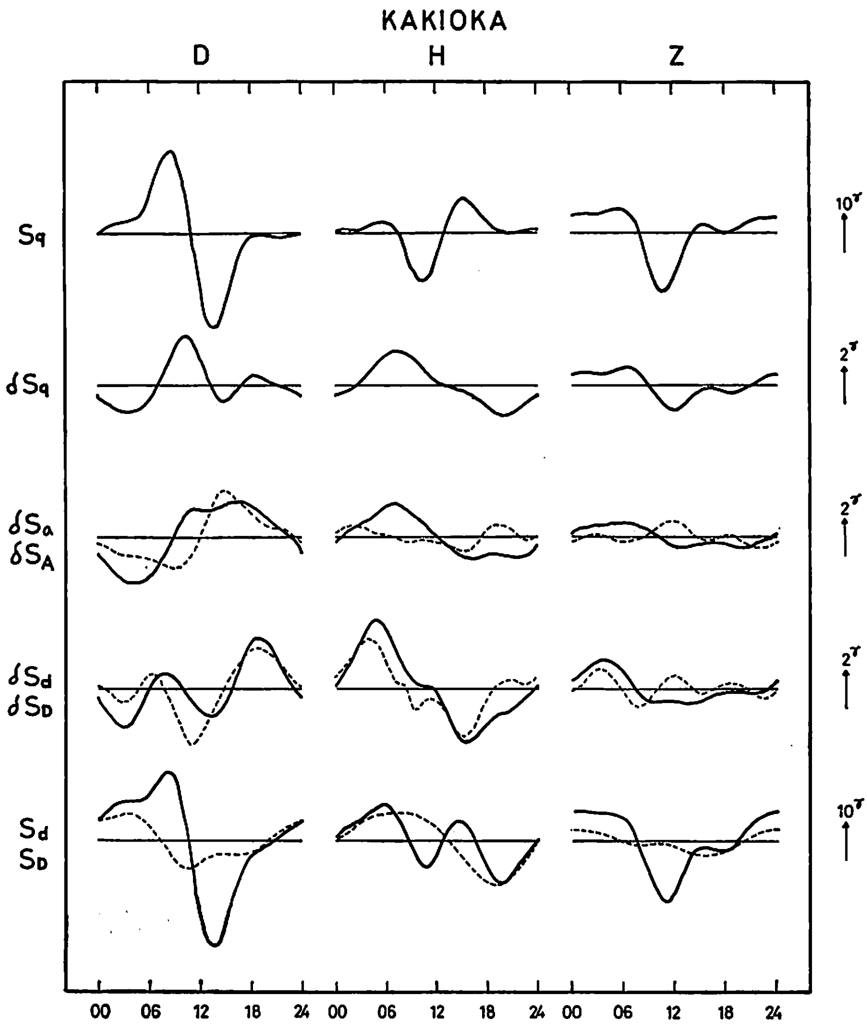

Figure 2. The effect of the IMF sector structure on the daily variations for quiet days, all days and disturbed dasturbed days at Kakioka. S_q, δS_q, δS_a, δS_d and S_d are shown by solid curves and δS_A, δS_D, and S_D are shown by broken curves.

of the mean secular change at three stations. The shift of the daily mean values may be explained by the combination of the non-uniform distribution of away and toward polarity days with the secular change. Results for D and Z components may support the above statement. Svalgaard (1975) also showed a similar conclusion that the sector polarity does not control the daily mean values of the H component.

In addition to the above-described effect of the IMF sector structure on quiet days, the effect on disturbed days was also examined. For this purpose δS_a from all days (2959 and 2760 days for away and toward polarities) and δS_d from international disturbed days (410 and 524 days for away and toward polarities) were computed similarly as δS_q. Figure 2 shows δS_a and δS_d at Kakioka together with δS_q and S_q in Figure 1. The lowest part of the figure shows S_d, which is the average of $S_d{}^A$ and $S_d{}^T$. In addition to them, $\delta S_A(=\delta S_a-\delta S_q)$, $\delta S_D(=\delta S_d-\delta S_q)$ and $S_D(=S_d-S_q)$ are superposed on δS_a, δS_d and S_d, respectively, by the broken curves. It is seen from this figure that the patterns of δS_a and δS_d are similar to that of δS_q for H component. However for D component δS_q, δS_a and δS_d do not show variations similar to each other, and the patterns of δS_q and δS_D seem to be in antiphase. Comparing δS_q and S_D, the shape of δS_q for H component is similar to that of S_D, and for D component δS_q and S_D are in opposite phase.

As described above it was confirmed that the IMF sector structure has a small but clear effect on S_q variation in the middle latitude, which is seen as the change of the focus latitude and intensity, but it has little effect on the mean absolute level of S_q. Some other features of the effect were also examined. This effect may be explained by the ionospheric electric current produced by the change of the magnetospheric convection together with the field-aligned current associated with the interaction of the ionosphere and magnetosphere. For the discussion of the physical mechanism of the effect, the features such as seasonal change of δS_q or similarlity of δS_q and S_D may be important. It is necessary to clarify further the effect in different latitudes and longitudes in a similar manner.

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IMF セクター構造と中緯度の地磁気日変化

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概 要

われわれの三つの観測所，柿岡，女満別および鹿屋の資料から，中緯度の地磁気日変化に対する惑星空間磁場（IMF）のセクター構造の影響を調べた。三地点における 1958 年～1973 年の地磁気三成分（偏角，水平成分および鉛直成分）の統計解析から，地磁気日変化の等価電流系の中心緯度や強さに小さいがはっきりした IMF セクター構造の影響のみられることが明らかにされた。