SPACE SCIENCES LABORATORY

ASYMMETRY IN GEOMAGNETIC RESPONSE TO THE POLARITY OF THE INTERPLANETARY MAGNETIC FIELD

John M. Wilcox

Technical Report

ONR Contract Nonr 3656(26), Project NR 021 101
NASA Grants NsG 243 and NGR 05-003-230
NSF Grant GA 1319

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UNIVERSITY OF CALIFORNIA, BERKELEY

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Asymmetry in Geomagnetic Response to the Polarity of the Interplanetary Magnetic Field*

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Several recent investigations have demonstrated the enhanced geomagnetic effectiveness of a southward component in the interplanetary magnetic field (see Rostoker and Fälthammar (1967) and Schatten and Wilcox (1967) for discussions of these investigations). This raises the possibility of a differing geomagnetic response to interplanetary magnetic field sectors with polarity toward the sun or away from the sun. A recent communication (Siebert, 1968) has indeed found such an effect during the three solar rotations observed by the IMP-1 satellite in the K indices of several geomagnetic observatories located in the northern and southern hemispheres. The present analysis, which was started independently, confirms and extends these results.

There is an obvious topological symmetry between a), geomagnetic field lines from the northern hemisphere and interplanetary magnetic field lines associated with an away sector, and b), geomagnetic field lines from the southern hemisphere and interplanetary field lines in a toward sector. In each of these two cases the geomagnetic field lines are of the proper polarity to be connected to the interplanetary field lines. In both of these cases the interplanetary and geomagnetic field lines near the geo-

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magnetic tail region tend to be oppositely directed, resulting in an enhanced possibility for reconnection.

Mayaud (1967) has recently described some new geomagnetic indices which are somewhat similar to the Bartels K_p indices but are prepared separately for the northern and southern hemispheres. K_n and K_s are prepared using observatories just equatorward of the auroral zones, and an attempt is made to preserve longitudinal symmetry. (For a detailed description of the preparation of K_n and K_s and some differences between them and K_p see Mayaud, 1967.)

The interplanetary magnetic sector pattern observed by IMP-1 near the start of 1964 was almost identical to the sector pattern observed near the end of 1964 by IMP-2 and Mariner 4. The patterns of recurring geomagnetic activity through the year 1964 strongly suggest that this four-sector pattern was essentially unchanged throughout the year. A more detailed discussion in support of this interpolation has been given by Wilcox (1968). In the present investigation we assume that the four-sector pattern of the interplanetary magnetic field was essentially unchanged through the year 1964, and compute the average difference $\overline{K_n - K_s}$ during away sectors and during toward sectors. For the entire year the average difference $\overline{K_n - K_s}$ during away sectors was 0.38 ± 0.02, and the average difference $\overline{K_n - K_s}$ during toward sectors was 0.29 ± 0.02. (In estimating the errors the conservation property (Chapman and Bartels, 1940) of the geomagnetic indices was included.) Thus during away sectors there appears to have been a small but significant enhancement of geomagnetic activity in the northern hemisphere as compared with the south, and vice versa for toward sectors.

This effect is also shown in an analysis in which the year 1964 is divided into the individual Bartels 27-day rotations. In each such rotation the average difference $\overline{K_n - K_s}$ is computed for away sectors and for toward sectors, and the results are shown in Figure 1. The predominant effect in Figure 1 is the seasonal variation in which the excess of geomagnetic activity in the northern hemisphere as compared with the southern hemisphere reaches a maximum during northern summer months. This effect has already been pointed out by Mayaud (1967). Figure 1 also shows a small but rather consistent tendency for $\overline{K_n - K_s}$ to be larger during away sectors as compared with toward sectors. The effect related to interplanetary magnetic field polarity is approximately an order of magnitude smaller than the seasonal effect in these geomagnetic indices.

Schatten and Wilcox (1967) found that during the observations of IMP-3 in the latter half of 1965 the average value of K_p was consistently larger in away sectors as compared with toward sectors. Siebert (1968) has suggested that this might be related to the fact that 11 of the 12 K_p observatories are situated in the northern hemisphere. The analysis described in the present note for $\overline{K_n - K_s}$ was repeated for K_p. The average value of K_p in away sectors during 1964 was 1.82 ± 0.10, and in toward sectors was 1.89 ± 0.10, so that there was little if any signicant difference. During the IMP-3 observations in 1965 the larger geomagnetic activity was associated with newly-formed away sectors, and it seems likely that the dynamics of sector birth and evolution may be a principal cause of the effect found by Schatten and Wilcox.

Acknowledgements. I am indebted to P. N. Mayaud for the K_n and K_s indices during the year 1964 and for a discussion of these indices. Discussions with K. H. Schatten are much appreciated.

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Figure Captions

Fig. 1. The average difference $\overline{K_n - K_s}$ computed during each of the Bartels rotations in 1964. Results obtained during away sectors are indicated with plus signs and results obtained during toward sectors are indicated with minus signs.

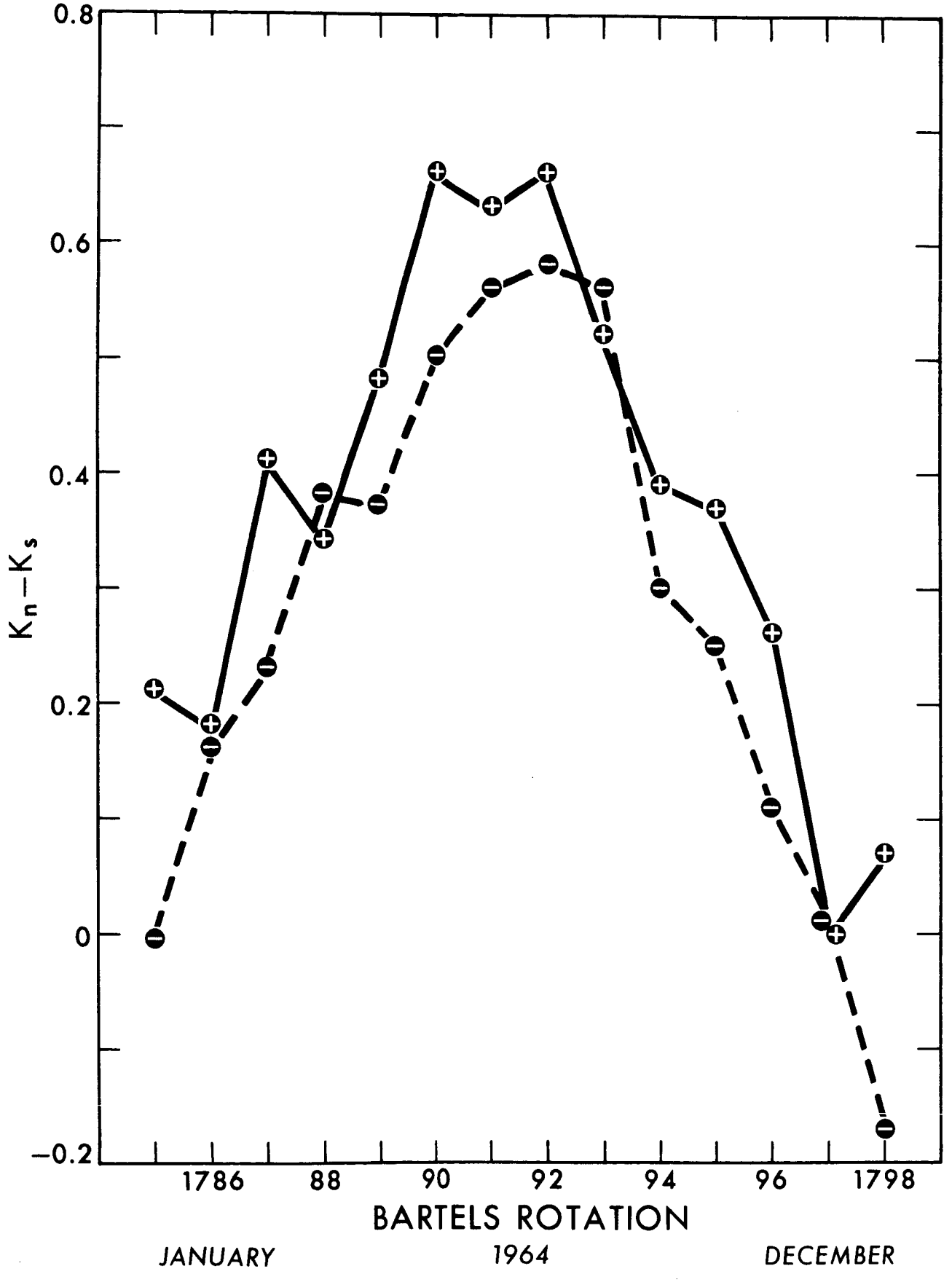
0.8
0.6
0.4
0.2
0
−0.2
$K_n - K_s$
1786
88
90
92
94
96
1798
BARTELS ROTATION
JANUARY
1964
DECEMBER

Figure 1

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13. ABSTRACT

The difference between northern and southern hemispheric geomagnetic activity is investigated as a function of the sector polarity pattern of the interplanetary magnetic field. It is found for the year 1964 that sectors with field directed away from the sun are associated with slightly enhanced northern hemisphere activity, and toward sectors are associated with slightly enhanced southern hemisphere activity. (U)

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