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INTRODUCTION

Schieldge and Siscoe (1970) and Kawasaki et al (1971) have studied the occurrence of negative bays triggered by storm sudden commencements (SSC's). Both groups concluded that the probability for simultaneous events increases with increasing SSC amplitude and is independent of Kp. Schieldge and Siscoe (1970) also noted higher probabilities when the low-latitude magnetic H component in the pre-midnight sector was depressed. Kawasaki et al (1971) found that SSC's triggered negative bays with a high probability (49%) in the IGY but with a very low probability (4%) in the IQSY. They noted that, although the IQSY SSC's had smaller amplitudes, the amplitude effect could not explain the large difference since in the IGY small SSC's ($< 10\gamma$) triggered substorms with a high probability. Kawasaki et al (1971) noted further that the probability of simultaneous SSC and substorm events bore no clear relation either to the type of discontinuity in the interplanetary magnetic field ($\vec{B}_{IMF}$) or to the direction of the current vector associated with the discontinuity. On this basis they concluded that the direction of the interplanetary magnetic field is not an important parameter for SSC-triggered substorms.

It is noted here that, whereas Kawasaki et al (1971) considered only the change in $\vec{B}_{IMF}$ direction across the discontinuities, the results of Arnoldy (1971) and Foster et al (1971) suggest that the direction of $\vec{B}_{IMF}$ for a period of time preceding the SSC may be of more importance. The purpose of this study is to examine the possible relationship between the latitude of $\vec{B}_{IMF}$ for a period prior to SSC's and the probability of SSC-triggered negative bays.

RESULTS

The 36 SSC's discussed by Taylor (1969) and Kawasaki et al (1971) were examined in this study. Of these SSC's, which occurred during the period June 1965 - January 1967, 10 clearly produced simultaneous negative bays. Examination of available high-latitude magnetograms indicated that the other 26 SSC's did not produce simultaneous negative bays, although lack of complete longitude coverage always limits the accuracy in such determinations. All 36 SSC's, however, were associated with $\vec{B}_{IMF}$ discontinuities which were observed by Explorer 28 and analyzed by Taylor (1969). Since no plasma data is available from Explorer 28, only $\vec{B}_{IMF}$ data are considered in this study.

The findings of Arnoldy (1971), Foster et al (1971) and Tsurutani and Meng (1972) indicate that a period of southward $\vec{B}_{IMF}$ ranging from < 15 to 80 minutes will produce substorms with a high probability in the absence of SSC's. The fact that SSC's often trigger simultaneous substorm breakups indicates that if a southward $\vec{B}_{IMF}$ is important it need not persist for as long a period as required for a non-SSC breakup. For this reason, the direction of $\vec{B}_{IMF}$ during approximately one-half hour prior to the SSC was examined for possible correlation with SSC-produced negative bays. The actual time used was approximately 33 minutes. That is, the six values of the 5.46-minute average vector magnetic field measurements which preceded the detection of the SSC by Explorer 28 were combined to give an average Z component in geocentric solar magnetospheric (GSM) coordinates and an average magnitude $<B_{IMF}>$.

Following Kawasaki et al (1971), the magnitudes of the SSC's were obtained by averaging the magnitudes at Tashkent, San Juan and Honolulu, thereby averaging out any large local time asymmetries. In Figure 1 the results are plotted as follows: (1) The average of the six 5.46-minute average Z components of $\vec{B}_{IMF}$ which preceded the SSC is plotted on the vertical axis; (2) The SSC magnitude is plotted on the horizontal axis; (3) Squares and triangles indicate SSC's which produced simultaneous negative bays, circles those which did not trigger negative bays; (4) Small circles and squares indicate $\langle B_{IMF} \rangle < 6\gamma$, large circles and inverted triangles $\langle B_{IMF} \rangle$ 6-9γ, and normal triangles $\langle B_{IMF} \rangle > 9\gamma$. For the 36 SSC's considered Figure 1 shows that: (1) No substorms were triggered by SSC's smaller than 10γ, (2) All SSC's larger than 10γ which were preceded by at least a half-hour of southward $\vec{B}_{IMF}$ averaging greater than 1γ triggered simultaneous negative bays, and (3) No negative bays were triggered by SSC's larger than 10γ which were not preceded by either a half-hour of southward $\vec{B}_{IMF}$ averaging greater than 1γ or an average $\vec{B}_{IMF}$ magnitude greater than 9γ.

Note also in Figure 1 that all five SSC's which were preceded by a half-hour of average $\vec{B}_{IMF}$ magnitude greater than 9γ triggered simultaneous negative bays and that one of these SSC's was not preceded by a southward $\vec{B}_{IMF}$ in GSM coordinates. Data for this SSC are presented in Figure 2. The magnitude and GSM latitude of the interplanetary magnetic field is shown along with magnetograms from Great Whale River, Fort Churchill and Meanook. M's along the magnetogram traces denote midnight magnetic local time. The SSC and simultaneous breakup at approximately 0802 hrs. are most evident in the Great Whale River trace. Note, however, the

2-3 hours of enhanced negative activity which preceded the SSC at Great Whale and Churchill. The magnetic deflections at these stations are consistent with what is seen during the growth phase of magnetospheric substorms (McPherron, 1970). The growth phase has been linked rather convincingly with erosion of magnetic flux from the dayside magnetosphere to the tail (see Aubry et al, 1970; McPherron, 1971; Burch, 1972) which is associated with a GSM southward component of $\vec{B}_{IMF}$. In this one case, on 7 January 1967, there was no GSM southward component of $\vec{B}_{IMF}$ for four hours preceding the SSC. There was, however, a rather large $\vec{B}_{IMF}$ magnitude of approximately 13γ and a nearly horizontal $\vec{B}_{IMF}$ direction. It appears then that such conditions can produce a growth phase and that a GSM southward component of $\vec{B}_{IMF}$ is not an absolute necessity for erosion of dayside magnetic flux, at least for reasonably high field magnitudes.

SUMMARY

A study of 36 SSC's in the period June 1965 - January 1967 indicates that, for the cases considered, sufficient conditions for the triggering of simultaneous polar magnetic substorm breakups were (1) An SSC amplitude greater than 10γ, and (2) An average GSM Z component of interplanetary magnetic field less than - 1γ over a period of at least one-half hour preceding the SSC. All events satisfying these conditions produced simultaneous negative bay onsets. However, one SSC which was not preceded by a period of southward $\vec{B}_{IMF}$ also triggered a simultaneous negative bay. This event was associated with a nearly horizontal interplanetary

magnetic field of higher magnitude than any of the other events which did not satisfy conditions (1) and (2) above. Detailed consideration of this event indicates that a substorm growth phase preceded the SSC and that magnetospheric conditions were therefore similar to those expected for southward interplanetary magnetic fields of lower magnitudes.

It is concluded that: (1) In agreement with Schieldge and Siscoe (1970) and Kawsaki et al (1971), the SSC amplitude is important in determing whether a simultaneous negative bay will be triggered, and (2) Contrary to the conclusion of Kawasaki et al (1971), the direction and magnitude of the interplanetary magnetic field play key roles in the SSC-triggered substorm process. More specifically, interplanetary magnetic field conditions which are associated with substorm growth phases appear to be necessary for the triggering of substorms by SSC's. These conditions are: (1) A GSM southward component of $\vec{B}_{IMF}$ or (2) a nearly horizontal $\vec{B}_{IMF}$ coupled with high $\vec{B}_{IMF}$ magnitudes. Therefore, the triggering of negative bays by SSC's appears to require that the magnetosphere be in a state similar to that required for non-SSC negative bays. This finding is consistent with the model of Parks et al (1971) in which the negative bay is triggered by the SSC-produced magnetospheric compression when high electron fluxes near the critical flux limit for pitch angle scattering are present in the outer zone. In their model the anisotropy toward large pitch angles is increased by the betatron action resulting from the compression. Precipitation and an enhanced electrojet result. However, the existence of electron fluxes near the stable trapping limit implies that the magnetosphere is in a metastable state. The present study indicates that this state is in fact the substorm growth phase.

Finally, the observation of Schieldge and Siscoe (1970) that the probability of SSC-triggered negative bays was higher when the low-latitude H component was depressed in the premidnight sector agrees well with the above results. That is, Schieldge and Siscoe attributed the behavior of the H component to the development of an asymmetric ring current which has been noted by McPherron (1970) to be a part of the substorm growth phase.

ACKNOWLEGMENTS

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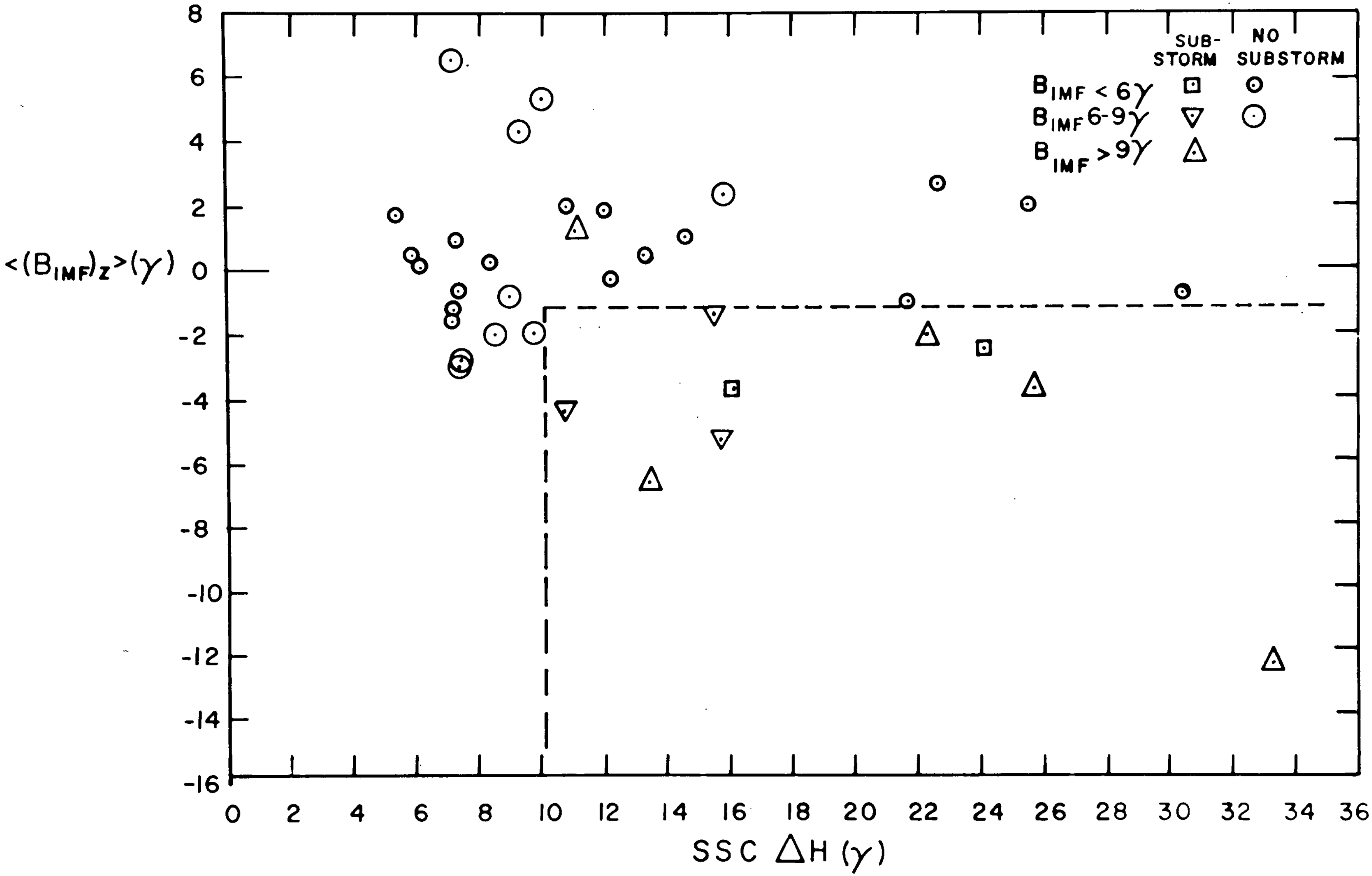
FIGURE CAPTIONS

Figure 1. A plot showing conditions in the interplanetary magnetic field associated with each of the 36 SSC's studied. The average of the six 5.46-minute average GSM Z components of $\vec{B}_{IMF}$ which preceded each SSC is plotted on the vertical axis. The SSC magnitudes (averaged from Tashkent, Honolulu and San Juan) are plotted on the horizontal axis. Squares and triangles indicate SSC's which produced simultaneous negative bays, circles those which did not trigger negative bays.

Figure 2. Ground and interplanetary magnetic field data for the SSC on 7 January 1967 which produced a simultaneous negative bay onset but was not preceded by a period of southward $\vec{B}_{IMF}$ in GSM coordinates. The magnitude and GSM latitude of $\vec{B}_{IMF}$ is shown along with nightside ground magnetograms. M's along the magnetogram traces denote midnight magnetic local time.



8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
$<(B_{IMF})_z>(\gamma)$
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
SSC ΔH (γ)
SUB-STORM
NO SUBSTORM
$B_{IMF} < 6\gamma$
B_{IMF} 6-9γ
$B_{IMF} > 9\gamma$

FIGURE 1

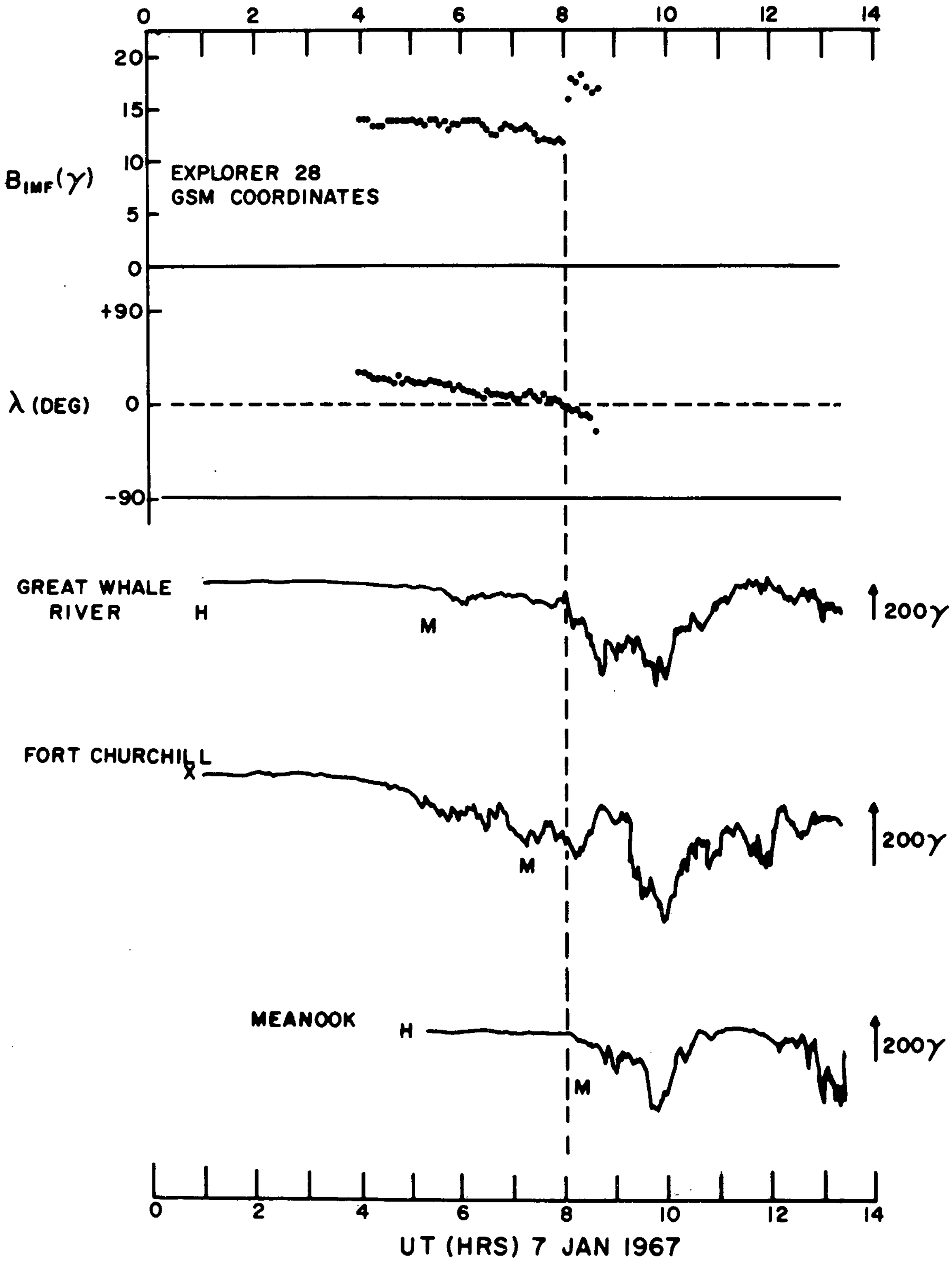


FIGURE 2

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