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COMPARISON OF SSC MAGNITUDES AT MAGSAT ALTITUDES (325-550 km) AND AT GROUND LOCATIONS

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Abstract. A comparison of the total ssc magnitudes at MAGSAT altitudes (325-550 km) and at ground observatories indicated equality, implying virtually no ionospheric contribution and instead, a predominantly magnetospheric origin, at dusk and dawn hours.

Introduction

When blobs of interplanetary plasma encounter the earth, the magnetosphere is compressed, and the resulting hydromagnetic waves produce storm sudden commencement (ssc) at ground. The ssc characteristics can be considerably modified by ionospheric currents. For example, ssc magnitudes can be larger by factors as large as 3 or more in the equatorial electrojet region during daytime [see Kane, 1978, and references therein]. At other latitudes too, ionospheric contributions may exist. If so, ssc magnitudes observed at ground would be different from those observed at locations above the ionosphere. It would be of interest to see whether at MAGSAT altitudes (325-550 km, mainly above the ionospheric F region) the ssc magnitudes are the same as at ground, especially in the low-latitude and equatorial region, where complications are fewer as compared to the polar and auroral region. For a particular event (ssc at 0738 UT on November 30, 1979), Araki et al. [1982] claimed that the negative impulse observed in the D component provided the first experimental evidence of the global ionospheric current system for the preliminary reverse impulse (PRI) of ssc. We will not deal with this finer aspect but will concentrate on the total magnitude of the increase of the H component (positive deviation, from initial level) of ssc in low latitudes for several events that occurred during the period November 1979 to April 1980. Since MAGSAT moves fast in latitude, the decay of ssc will not be studied.

Observations

Table 1 lists the ssc's for the period November 1979 to April 1980 for which MAGSAT data were available. The relevant MAGSAT passes are indicated. Amongst these, only those given a serial number had the ssc within a geographical latitude range ±35°, and these are the events studied in the present analysis. Event 8B occurred at 39°N latitude and is included to illustrate how such events (commencing outside the ±35° latitude range, but the satellite entering this range within a few minutes) look.

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From the MAGSAT investigator B tapes supplied to us, the X, Y, and Z components were available, and the H component was obtained as $H=(X^2+Y^2)^{1/2}$. Similarly, the MAGSAT (4/81) model values XMD, YMD, and ZMD were also available, and $HMD = (XMD^2+YMD^2)^{1/2}$ was obtained. The residual $\Delta H = H-HMD$ was used for analysis.

During any pass, the ΔH values show a latitudinal distribution which may be affected by ground anomalies. To estimate this effect, quiet day passes in 5° longitude belts were averaged. From the disturbed day passes (events in Table 1), the quiet day average latitude distribution for the longitude belt appropriate to the disturbed day pass was subtracted. Figure 1 illustrates this procedure for event 6, i.e., the ssc on January 13, 1980. The upper nine plots (rows 1-9) show the geographic latitude variation of ΔH for nine quiet day passes for the longitude belt

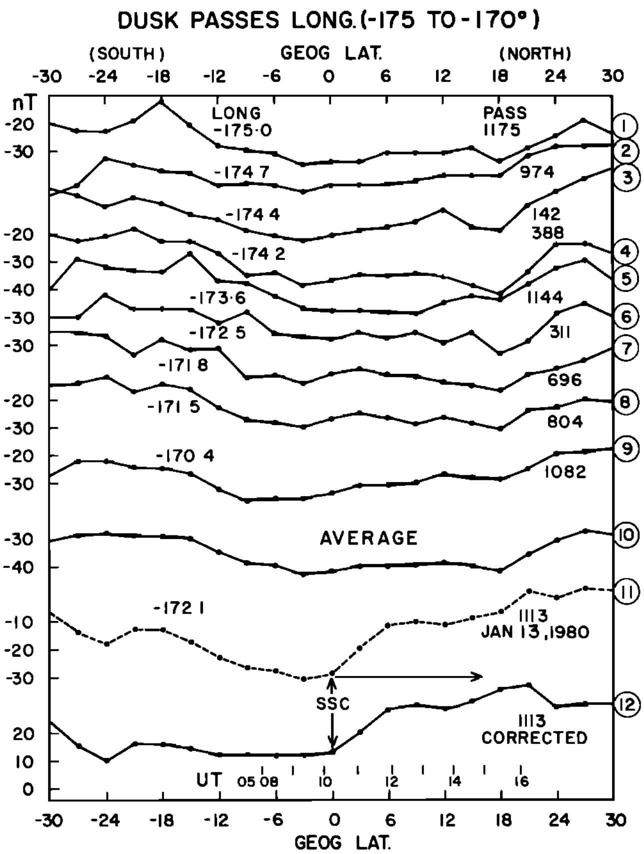

Fig. 1. Quiet day dusk passes having their equatorial crossing longitudes in the range 175°W to 170°W (rows 1-9), their average (row 10), the disturbed days pass 1113 (event 6) on January 13, 1980 (row 11), and its corrected form (pass 1113 minus average) (row 12).

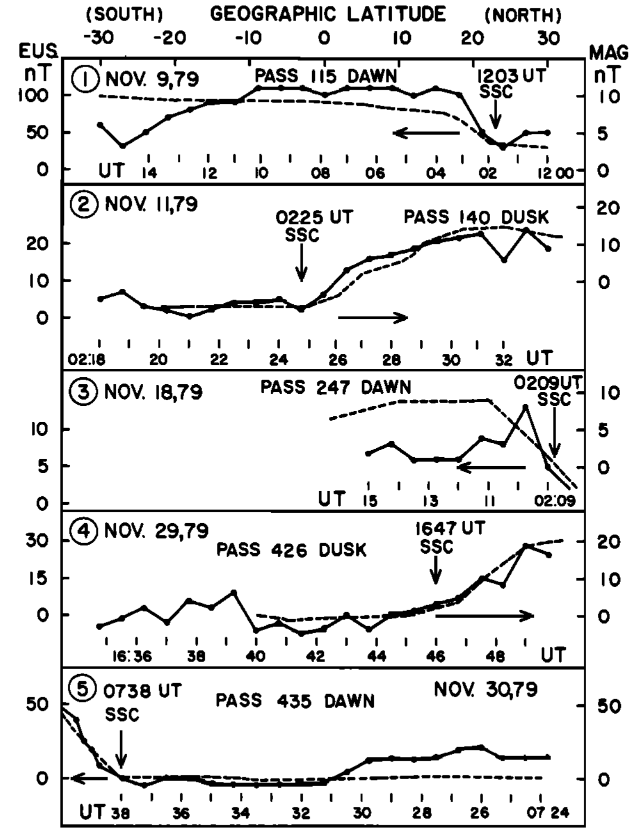

Fig. 2a

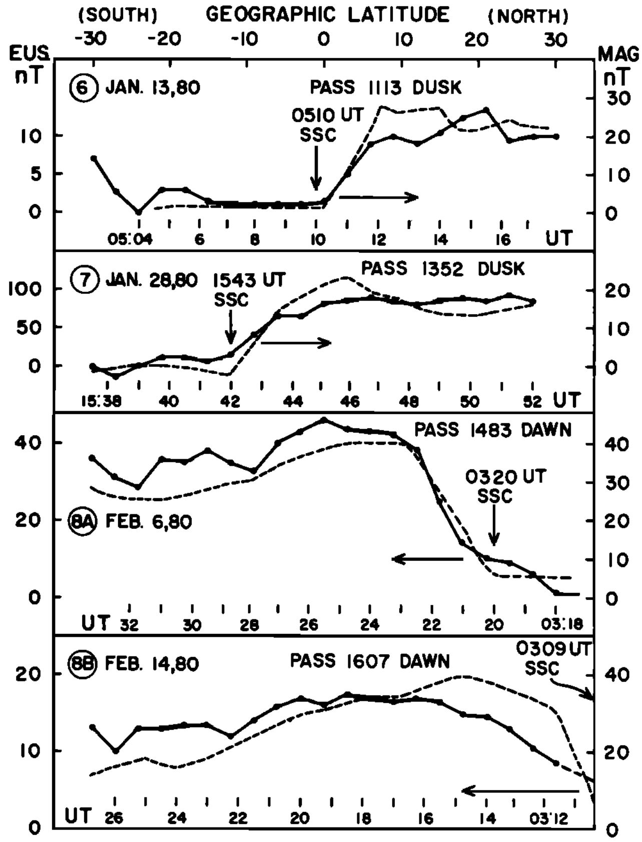

Fig. 2b

Fig. 2. The geographic latitude variation of corrected ΔH at MAGSAT (solid lines) and for Eusébio (4°S, 38°W, dip -3.5°) (dashed lines) for the various events: (a) events 1, 2, 3, 4, 5, (b) events 6, 7, 8A, 8B, (c) events 9, 10, 11, 12.

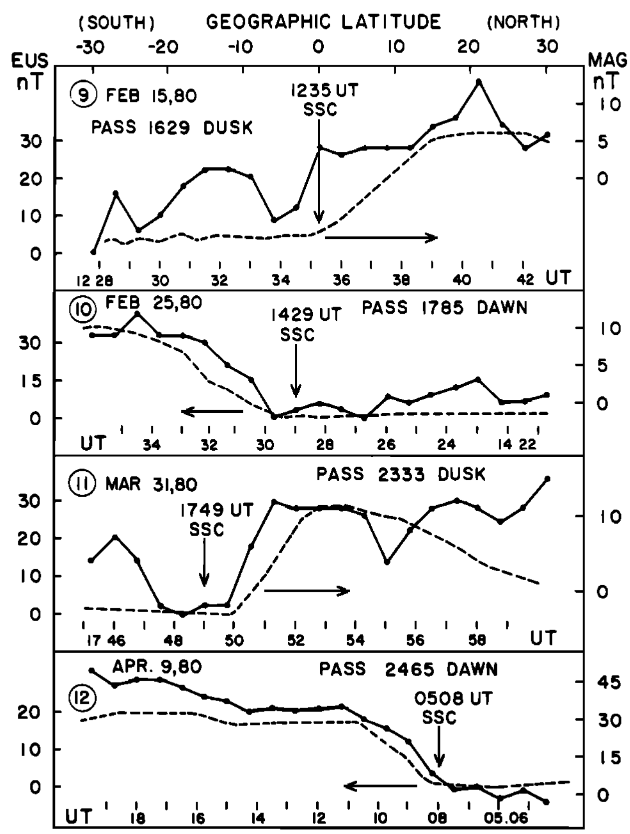

Fig. 2c

170°-175°W. The tenth plot (row 10) is their average. The eleventh plot (row 11) is pass 1113, which contains the ssc event 6. When the average is subtracted from pass 1113, the residual is the corrected 1113, shown at the bottom of Figure 1 (row 12). Here, one can easily recognize the ssc at about 0510 UT, when the satellite was at about 0°N and moved northward and the H value attained a maximum of ~25 nT at about 21°N (above the base level at 0°N). Thus the ssc magnitude for this event was ~25 nT at MAGSAT altitude and occurred in the latitude range 0°-21°N, which is mentioned in the last column of Table 1.

Figures 2a-2c show the geographical latitude profiles of the ΔH thus corrected for all the events (solid lines). Thus the top plot (solid line) in Figure 2b for event 6 of January 13, 1980, in the same as row 12 of Figure 1. The vertical arrows show the occurrence of ssc. The UT scale is marked for each event separately. For a rough comparison, the H plot for the equatorial electrojet location Eusébio, Fortaleza 4°S, 38°W, dip -3.5°) in Brazil, is also shown (dashed lines). It must be remembered that the geographical latitude scale is valid for MAGSAT only while the UT scale is applicable for both MAGSAT and Eusébio. Thus the MAGSAT plots show a space-time evolution of ssc at different longitudes, while the Eusébio plots show only the time evolution at

TABLE 1. Details of Passes During Which ssc Occurred

Serial Nº	Date	Julian Day	Pass	Type	ssc, UT	Pass Equatorial Longitude	ssc Latitude (Geographic)
x	Nov. 7, 1979	44184	86	Dusk	1347	+58.5	55°S
1	Nov. 9, 1979	44186	115	Dawn	1203	-93.0	24°N-18°N
2	Nov. 11, 1979	44188	140	Dusk	0225	-127.6	3°S-18°N
3	Nov. 18, 1979	44195	247	Dawn	0209	+54.3	33°N-27°N
4	Nov. 29, 1979	44206	426	Dusk	1647	+17.0	6°N-30°N
5	Nov. 30, 1979	44207	435	Dawn	0738	-25.1	27°S-35°S
x	Jan. 11, 1980	44249	1084	Dusk	0758	+143.1	47°S
6	Jan. 13, 1980	44251	1113	Dusk	0510	-172.0	0°N-21°N
x	Jan. 17, 1980	44255	1175	Dusk	0512	-174.9	35°S
x	Jan. 25, 1980	44263	1302	Dawn	1109	+111.1	31°S
7	Jan. 28, 1980	44266	1352	Dusk	1543	+28.5	15°S-6°N
8A	Feb. 6, 1980	44275	1483	Dawn	0320	+33.0	30°N-0°N
8B	Feb. 14, 1980	44283	1607	Dawn	0309	+34.3	40°N-12°N
9	Feb. 15, 1980	44284	1629	Dusk	1235	+75.3	12°N-18°N
10	Feb. 25, 1980	44294	1785	Dawn	1429	-133.3	6°S-24°S
x	March 19, 1980	44317	2138	Dusk	0617	+172.3	55°N
x	March 30, 1980	44328	2321	Dawn	2354	+79.3	74°N
11	March 31, 1980	44329	2333	Dusk	1749	-5.6	12°S-6°S
x	April 6, 1980	44335	2422	Dawn	1059	-86.4	62°N
12	April 9, 1980	44338	2465	Dawn	0508	+4.4	18°N-24°S
x	April 22, 1980	44351	2666	Dusk	0037	-99.4	90°N

Dusk passes are northbound (south to north), and dawn passes are southbound (north to south).

TABLE 2. Details of Ground Locations

Station	Symbol	Geographic Coordinates Latitude	Longitude	Computed Dip
Bangui	BAN	4°N	19°E	-14.7
Hermanus	HER	34°S	19°E	-65.8
Addis Ababa	ABA	9°N	39°E	-0.4
Alibag	ALI	18°N	73°E	+23.0
Jaipur	JAI	27°N	76°E	+39.0
Trivandrum	TRI	8°N	77°E	-1.6
Annamalainagar	ANN	11°N	79°E	+5.2
Hyderabad	HYD	17°N	79°E	+19.7
Tangerang	TAN	6°S	107°E	-33.0
Gnangara	GNA	32°S	116°E	-66.4
Davao	DAV	7°N	126°E	-1.8
Toolangi	TOO	38°S	145°E	-68.4
Guam	GUA	14°N	146°E	+12.3
Port Moresby	PMB	9°S	147°E	-32.8
Wake Island	WIS	19°N	167°W	+27.2
Midway Island	MIS	28°N	177°W	+42.7
Honolulu	HON	21°N	158°W	+39.2
Tahiti	TAH	18°S	150°W	-30.2
Tucson	TUC	32°N	111°W	+59.1
Boulder	BOU	40°N	105°W	+68.3
Huancayo	HUA	12°S	75°W	+1.3
Fuquene	FUQ	5°N	73°W	+33.3
San Juan	SAN	18°N	66°W	+50.7
Trelew	TRE	43°S	65°W	-40.7
Eusébio	EUS	4°S	38°W	-3.5
M'Bour	MBO	14°N	17°W	+16.0

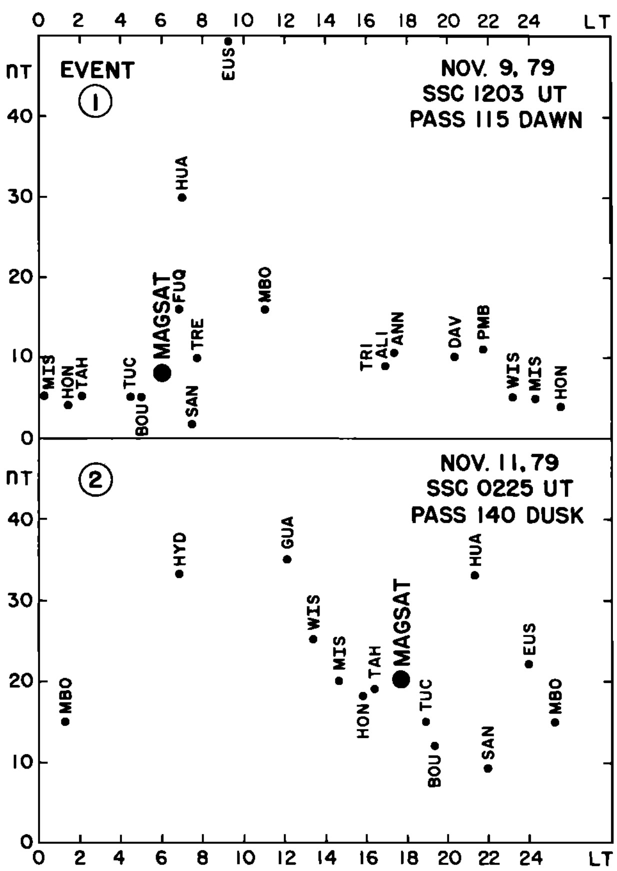

Fig. 3. The magnitudes of ssc for events 1 and 2 at MAGSAT (big solid circle) and at several ground locations, plotted versus local time (LT).

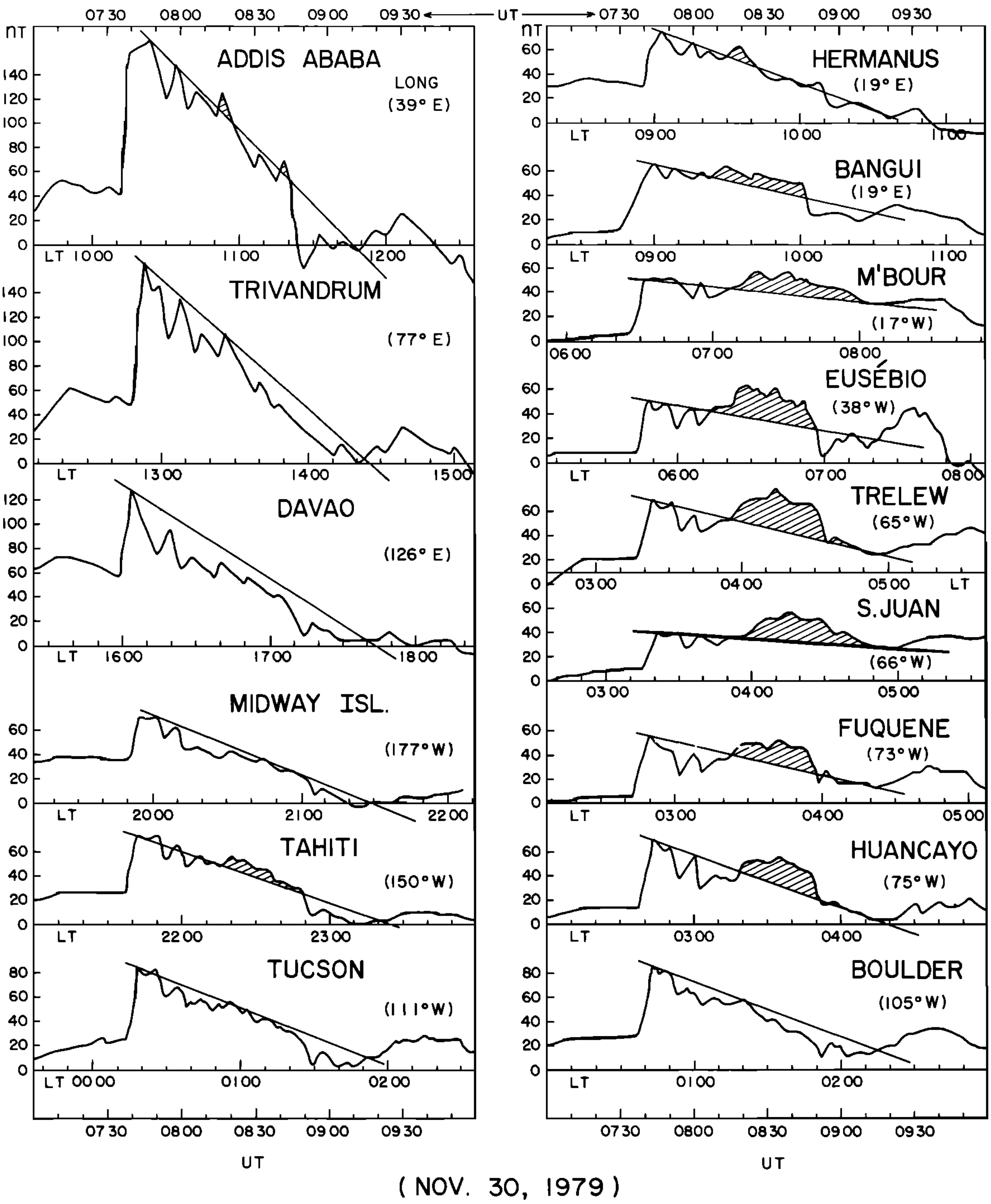

Fig. 4. Plot of H at several locations for the period 0700-1000 UT on November 30, 1979, when an ssc occurred at 0738 UT (event 5). The shaded portions indicate excess H at some locations (15°W to 75°W) at about 0830 UT.

a particular location only. In almost all cases, the profiles at the two locations are similar, but the magnitudes are not always the same (scale on left is for Eusébio, and scale on right is for MAGSAT). This is mainly because whereas MAGSAT local time was always dusk or dawn, Eusébio was at varying local times and because during daytime the Eusébio (equatorial electrojet) magnitudes of ssc are expected to be larger than those at MAGSAT. However, in what follows, Eusébio magnitude of ssc is compared with MAGSAT only if and when MAGSAT passed over Eusébio, during dusk or dawn (event 5). Otherwise, MAGSAT is compared with other locations.

Table 2 gives the coordinates of the various low- and mid-latitude locations fro which data were used and includes the equatorial electrojet locations Addis Ababa, Trivandrum (or Annamalainagar), Davao, Huancayo, and Eusébio, to illustrate that during daytime the ssc magnitudes at these locations are larger than those at other locations.

Figure 3 (upper half) shows a plot of ssc magnitudes for event 1, i.e., the ssc at 1203 UT on November 9, 1979. The MAGSAT magnitude is shown by the large solid circle in the dawn portion. For Boulder, Tucson, etc., for which the ssc occurred before dawn, the magnitudes were about 5 nT. For MAGSAT at dawn, the value was about 8 nT. For Fuquene the magnitude was about 16 nT at about 0700 LT. For Trelew it was about 10 nT at about 0800 LT. For Huancayo the amplitude was 30 nT at about 0700 LT. For Eusébio the amplitude was about 50 nT at about 0900 LT. Thus MAGSAT amplitude fits rather well in a rising trend from a predawn level of about 5 nT to a postdawn level of about 10-15 nT at nonequatorial locations and much higher values for the electrojet region. Figure 3 (lower half) shows similar results for event 2, i.e., ssc at 0225 UT on November 11, 1979. In the various events the following patterns were noticed:

1. The postdawn (predusk) magnitudes were slightly larger than the predawn (postdusk) magnitudes for ground locations.
2. MAGSAT values were in between (examples are events 1, 2, 3, 8B, 9, and 10).
3. In cases where ground locations had ssc at dawn or dusk, MAGSAT values were either equal to or, in some cases, slightly larger than the values at ground locations (examples of equality are events 4, 5, and 7; examples of MAGSAT larger are events 6, 8A, 11, and 12).

According to Hermance]1982], a contribution from the ionospheric E region, combined with the induction effect in the conducting earth, should give slightly smaller magnitudes at MAGSAT altitudes (above the E region). The accuracy of ground observations is quite good, and the magnitudes are probably accurate to within ±1 nT. For MAGSAT, because of the corrections needed for ground anomalies as illustrated in Figure 1, we estimate an accuracy of about ±3 nT. Thus, within this accuracy, it seems to us that the MAGSAT magnitudes are roughly the same as at ground, indicating no ionospheric effects at dusk or dawn. Also, the postdawn (or predusk) increase observed at ground locations is also probably not an ionospheric effect but represents the DS component of ssc, mostly of magnetospheric origin. The equatorial electrojet region enhancement of ssc is, of course, a clearly ionospheric modification [Jacobs and Watanabe, 1963].

For most of the events mentioned above, the MAGSAT magnitudes are only about 20 nT or less except for event 5, where MAGSAT magnitude was about 45 nT, event 8A (MAGSAT 38 nT), and event 12 (MAGSAT 28 nT). Unfortunately, for event 5, MAGSAT was at 27°S when the ssc occurred and then moved away southward, attaining maximum ssc magnitude at about 40°S [Araki et al., 1982], and its further evolution was in the auroral region. However, we noticed a peculiar asymmetry in the local time evolution of this ssc as observed at ground. Figure 4 shows the plot of H at several locations around the globe for 0700-1000 UT on November 30, 1979, when the ssc occurred at 0738 UT (event 5). For many locations the ssc occurred during daytime, and hence the initial rise is large, especially at the electrojet locations. However, if a straight line is drawn connecting the high point at about 0740 UT to the low point 1 1/2 hours later (0915 UT), there are enhanced H values (shaded in Figure 4) at about 0830 UT but only at certain locations, namely, those in the longitude zone 15°-75°W, where the local time was at dawn or earlier. Thus, ionospheric effects are ruled out, and the enhanced H seems to be a clear case of a DS component of ssc, mostly of magnetospheric origin. For event 12 of April 9, 1980, we observed a similar longitudinal asymmetry. The event had an ssc at 0508 UT, and for Eusébio the H values continued to be high for 1 hour (0510-0610 UT, i.e., 0240-0340 LT), while for Huancayo the values were high only for half an hour (0510-0540 UT, i.e., 0010-0040 LT) and later dropped rapidly below the initial level.

Conclusions

This comparison of ground and MAGSAT observations indicates that the ssc magnitudes are similar, indicating a predominantly magnetospheric origin and virtually no ionospheric contribution, at dusk and dawn hours.

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