Interplanetary transients causing moderately severe geomagnetic storms

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Abstract

Eight moderately severe (MS) type geomagnetic storms (GMSs) are identified and investigated statistically during the period 1978–80. The interplanetary magnetic field (IMF), B, proton density, D_P and proton temperature, T_P are enhanced ahead of magnetic clouds that are preceded by a shock, while strong magnetic field density and low T_P are southward Bz is a dominant parameter for producing MS type GMSs, whereas B_{av}, Sunspot numbers (SSNs) and V also play a significant role for development of MS type geomagnetic storms. Generally the value of Ap index increases, acquiring maximum value on the day of maximum activity. In 50% events the decrease in CR intensity starts few hours earlier than the arrival of shock associated magnetic cloud at earth, while in 25% events, it starts at the time of occurrence of MS type GMSs at earth with no cloud event at earth.

1. Introduction

A geomagnetic storm is global disturbance of earth's magnetic field and usually occurs in response to abnormal conditions in the IMF and solar wind which are caused by variety of emission from the sun (Akasofu and Chapman, 1963). The solar output in term of particle and field ejected out into interplanetary medium influences the geomagnetic field conditions (Kahler, 1992; Gosling, 1993). It has been observed that the coronal mass ejections (CMES) play an important role in interplanetary disturbances and may be responsible for non-recurrent geomagnetic storms (Gosling, 1993; Crooker, 1994). Numerous studies have reported correlation between various indices of geomagnetic activity and many functions of solar wind velocity, V; southward component of IMF, Bz; T_P; solar wind density; N and other parameters (Gonzelez, et al, 1989, Tsurutani et al, 1992). Recently, It is observed that the geomagnetic activity during the declining phase of solar activity is highly related to high values of the product of **V** and IMF strength **B** i.e. **V** X **B** leading to geomagnetic disturbances causing GMSs (Sabbah, 2000). These geomagnetic disturbances are observed and represented by different geomagnetic indices A_E, A_P, K_P and equatorial index Dst etc. Geomagnetic disturbances are driven by the interaction of solar wind with

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Table 1. List of MS type geomagnetic storms during the period 1978 – 80.

Date,Time of GMSs	Range of D,H,Z	SCA of D,H,Z	Cloud Begin	Cloud Ending	Cloud duration (Hrs)	Storm duration (Hrs)
12.11.78, 1st hr	8.1,338,75	-1.1,20,9	15th hr.,13.11.78	12th hr,14.1178	21	43
09.03.79, 8th hr	6,299,65	-1.0,39,10	24th hr, 9.03.79	15th hr,10.03.79	15	50
22.03.79, 8th hr	7,383,73	.1,67,19	19th hr, 22.03.79	10th hr,23.03.79	15	26
13.08.79, 6th hr	9.8,280,108	-1.4,59,11	12th hr, 13.08.79	10th hr,14.8.79.	22	28
20.08.79, 6th hr	10.5,260,71	1.4,77,22	11th hr, 20.08.79	10th hr,21.08.79	23	37
15.03.79, 6th hr	4.5,259,53	-0.4,27,6	No cloud			15
07.10.79, 4th hr	6.7,288,66	-0.7,.36,10	No cloud			23
13.01.80, 5th hr	-1.1,42,13	4.2,263,75	No cloud			38

magnetosphere and the strength of this interaction depends on the solar wind parameters. Although, there has been substantial growth in our knowledge of solar and interplanetary causes of GMSs, there are still unanswered questions that must be addressed and solved to predict the occurrence of GMSs (Tsurutani and Gonzalez, 1995). In this paper an analysis of MS type GMSs has been presented and an attempt has been made to understand the association of MS type GMSs with various interplanetary and solar features.

2. Data Analysis

Eight MS type GMSs with $250\gamma < \mathrm{H} < 400\gamma$ and are identified during the period 1978–80 using cosmic ray intensity data recorded with ground based neutron monitor, SWP and IMF parameters (Couzens and King, 1986, 1989, 1994).

3. Results and Discussion

Eight MS type GMSs are identified during the period and are listed in table 1. In table 1, the range and sudden commencement amplitude (SCA) of D, H, Z have been taken in minute, gamma, gamma respectively. Out of eight events, four events are associated with shock associated cloud (SAC) 1 type, while one event is associated with SAC-2 type magnetic cloud. Three events are not associated with either SAC-1 type or SAC-2 type magnetic clouds. Generally, it is observed that the value of A_p index, D_P, T_P, V increases at the time of storm from its earlier value. This result is consistent with Kumar and Yadav (2002) result. All events are associated with 5nT $<B_{av}<$16.2nT. Three events are associated with $-3.9\mathrm{NT} < B_Z < -2.5\mathrm{nT}$ and five events are associated with 1.5 nT $<B_z<$9.5 nT whereas 7th Oct, 1979 event is having $B_z = -3.9\mathrm{nT}$, which shows that not only large negative value of B_z is responsible for the GMSs but B_{av} also contribute significantly (Kane, 1977, Sabbah, 2000). It may also be inferred from here that some time the higher value of B_{av} seems to be more effective parameter as compared to that magnitude of southward B_z component. For MS storms, it is argued that the events with not only the amplitude of B_z but also the duration of the negative B_z have definite contribution for the development of the magnetic storm (Gonzalez and Tsurutani, 1987, Gonzalez et al, 1989, Tsurutani et

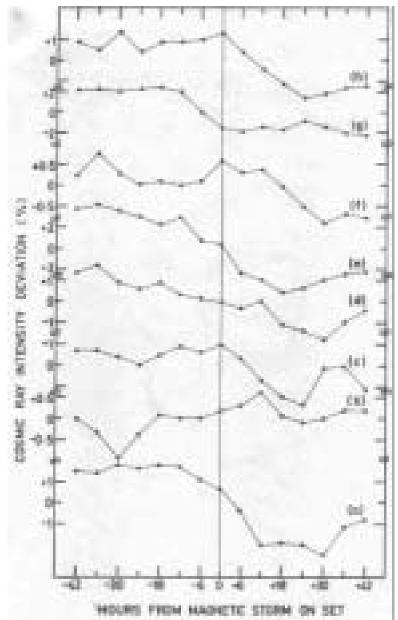

Fig. 1. The variation of cosmic ray intensity plotted using super epoch analysis, 0-Hr is an SSC hour.

al, 1992). Cosmic ray intensity data recorded with Deep River neutron monitor has been subjected to super epoch analysis and sudden storm commencement (SSC) observation hour at earth has been taken as the epoch hr. which is shown in Fig 1. The decrease in CR intensity starts few Hrs earlier than the arrival of magnetic cloud at earth with shock associated events as shown in Fig 1(a, c, d & e) (Duggal et al, 1983; Badruddin et al, 1986). On the other hand, the decrease in CR intensity starts at the time of magnetic storm at earth with no cloud event as shown in Fig 1 (f & h). Shock associated cloud events seem to be associated with Forbush type decreases. This type of decrease is caused by the entry of earth into a loop or tongue of IMF lines which are freshly ejected from the sun. The duration of initial phase of shock associated cloud events, lies between 5 to 15 Hrs while in case of no cloud events it lies between 3 to 7 Hrs. Main phase of shock associated events, it lie between 4 to 12 hrs, while with no clouds events it lies between 2 to 5 hours. Thus we conclude that duration of main phase is always less than that of initial phase (Yadav, 2001). Longevity of magnetic storm of shock associated cloud events it lies between 26 to 50 Hrs while in case of no cloud events, it lies between 15 to 39 hours. Four events are associated with solar flares, two events are associated with disappearing filaments (DFs). However, five events are associated with magnetic clouds, four events are associated with eruptive streams (ES) type events while two events are with co-rotating interaction region (CIR) type events separately. All events are associated with moderately large SSNs which lie between 97.9 to 186.2. It is observed that GMSs are more associated with solar flare which is consistent with Garcia and

Dryer (1987) and Kumar & Yadav (2002) result and inconsistent with Hewish & Bravo (1986) and Webb (1995) result. During the investigation of events, it has been observed that not only B_z component of IMF is an important parameter but other parameters like sunspot number, Bav and V also significant. This result agrees with Sabbah (2000), Kumar and Yadav (2001). Moreover, the value of Bz component is 4.3 nT (20^{th} Aug, 1979 event) on the SSC time but shock has higher V (551Km/Sec) which seems to be associated with large number of SSNs.

4. Conclusions

From statistical analysis of data presented in the forgoing section, the following conclusions have been drawn :

(i) Generally the value of Ap index, solar wind velocity (V), proton temperature (Tp) and proton density (Dp) increases its earlier value at the time of SSC and acquires optimum value at or after the occurrence of SSC at earth in few hrs duration.

(ii) MS type GMSs are more associated with solar flares.

(iii) It is observed that Geomagnetic activity is related to Bav, V, and SSNs significantly.

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