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Distribution of Solar flares around the sun and their association with Coronal Mass Ejections and Forbush Decreases during the period of 2000 to 2010

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ABSTRACT: The Coronal Mass Ejections (CMEs) generally occur in large numbers during the period of high solar activity carry large amount of plasma and contain high magnetic field having the capability to produce interplanetary disturbances. Many early studies indicated that Coronal Mass Ejections are usually associated with a decrease in Cosmic Ray Intensity (CRI) called Forbush Decrease (Fds). A statistical analysis has been made to obtain the relationship between Coronal Mass Ejections and Forbush Decreases for the period of 2000 to 2010 covering the solar cycle 23 and recent period of solar cycle 24. Solar flares in association with Coronal Mass Ejections occurring in Northern hemisphere are found to be more effective in producing Forbush Decrease (Fds) events in Cosmic Ray Intensity (CRI). For the period 2000 to 2010 Coronal Mass Ejections (CMEs) and Forbush Decreases (Fd) associated solar flares are equally distributed in Eastern and Western hemisphere.

Key words: Solar flares, Coronal Mass Ejection, Forbush decrease.

I. INTRODUCTION

Solar flares play an important role in the study of cosmic ray modulation as they release vast amount of matter and radiations in a short time. Distribution of solar flare on the sun and their association with decrease of Cosmic Ray Intensity (CRI), called Forbush decrease (Fds) has been studies by several authors [3,4,8,9]. Recently it has been reported that Coronal Mass Ejections, not solar flare alone may produce cosmic ray intensity variation [10]. In this analysis we calculated the relation between solar flare, Coronal Mass Ejections and Forbush Decrease for the period 2000 to 2010.

The majority of transient decreases in the galactic cosmic ray intensity have been generally connected with solar flares. Result of our analysis suggests that these Coronal Mass Ejections produce geomagnetic disturbances.

Coronal Mass Ejection (CME) was first discovered in 1971 using the seventh Orbiting Solar Observatory (OSO-7) coronagraph [13].

Based on the observations from the Large Angle and Spectrometric Coronagraph (LASCO) on board the Solar and Heliospheric Observatory (SOHO) mission, characteristic features of Coronal Mass Ejections heave been studied. Coronal Mass Ejections are dynamics large scale events in the solar corona that expels plasma and magnetic field through the solar wind [7].

The Coronal Mass Ejections initiated by the solar flare was emitted at very high speed and was directed towards the Earth and resulting Forbush Decrease occurred in cosmic ray intensity [2].

II. DATA AND METHOD OF ANALYSIS

For the purpose of this study, we have selected most of the solar flares during the interval 2000-2010 with optical importance ≥ 1. The selection was made from the routine list published in solar Geophysical Data Book. The data of Coronal Mass Ejections were taken from SOHO/ LASCO. Only those solar flares have been considered which are found to be associated in time either with Coronal Mass Ejection alone or with both Coronal Mass Ejections and Forbush Decreases.

Coronal Mass Ejections and Forbush Decrease (Fds) considered to associated with a flare if it occurs between +1 to 3 days after because it is expected that the event near the earth will occur with certain delay compared to the time of the flare due to the finite time taken by the solar wind and the associated magnetic field to propagate to the earth neighborhood. We have identified 128 solar flares with optical importance ≥1 and associated with Forbush Decrease and Coronal Mass Ejections.

III. RESULT AND DISCUSSION

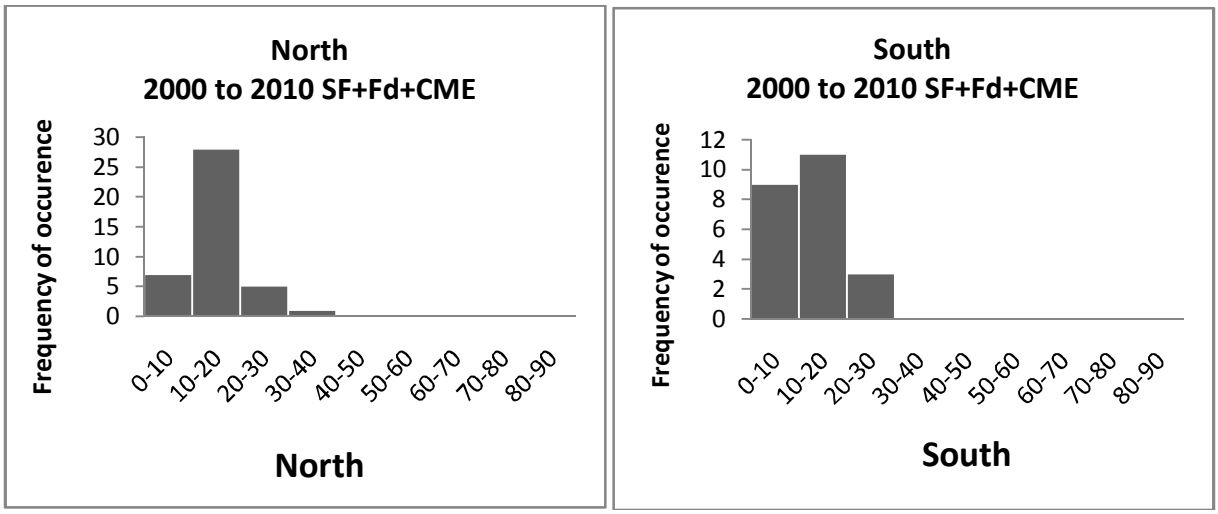
The Galactic Cosmic Ray Intensity recorded at Earth has an 11 year variation opposite to that of the sunspot number. The Cosmic ray intensity has its minimum of the maximum of sunspot cycle.

Sunspots are known to produce solar flares and other short/long term phenomena on the surface of the Sun, which in turn propagate their energy through solar wind and interplanetary magnetic field to long distances in the heliosphere. These in turn produce modulation in cosmic rays.

The Cosmic Ray Intensity monitored at neutron monitor energies is found to vary with an 11 year cycle [12, 5]. This solar modulation takes place as galactic cosmic rays pass through the region around the Sun.

Recently, Shrivastava (2003) reported that the flares occurring between 15° to 30° North and between 0° to 30° East are most effective in producing Forbush Decrease events [9]. In the present analysis we are a slightly different approach from the earlier authors [14,11].

Fig.1 shows the frequency of occurrence of solar flare with helio- latitude in interval of 10°. Figure shows the solar flare latitudinal frequency distribution of flares associated with Forbush Decrease (Fds) as well as Coronal Mass Ejections during the period 2000 to 2010. It is noted that the number of flares occurring 10° to 20° North and between 0° to 30° South are more effective in producing Forbush Decrease as well as Coronal Mass Ejections. We have again plotted longitudinal frequency distribution for those solar flares which are associated with Forbush Decreases and Coronal Mass Ejections as shown in Fig. 2.

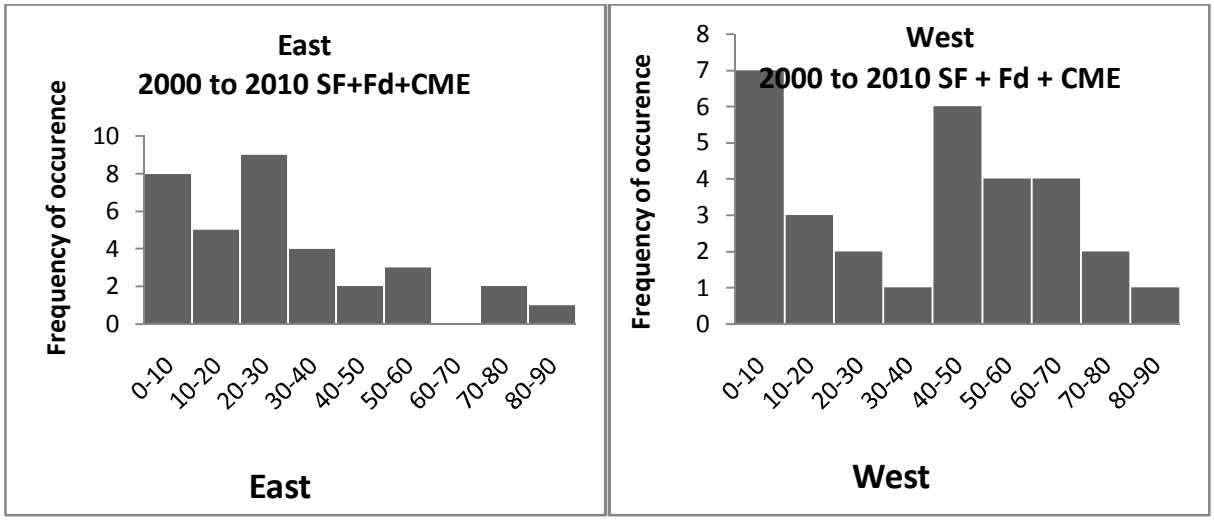


Helio-Latitude

Fig. 1. Shows the frequency of occurrence of solar flares associated with CMEs and Fdswith helio-latitude in interval of 10^{o} for the period of 2000 to 2010.

It is now observed that almost equal numbers of solar flares are found in Eastern and Western hemisphere in the case of solar flares associated with Forbush Decrease and Coronal Mass Ejections for the period 2000 to 2010.

These events have generally been understood to be due to the shielding of cosmic ray particles by the shock fronts produced by an intense solar flare. (Dryer 1974), (Nishida 1982) has reported a quantitative correlation between Forbush Decrease and passage of shock fronts followed by disturbance represented by enhanced by solar wind velocity and reduced field aligned diffusion coefficients [6,1].



Helio-Longitude

Fig. 2. Shows the frequency of occurrence of solar flares associated with CMEs and Fdswith helio-longitude in interval of 10^o for the period of 2000 to 2010.

IV. CONCLUSIONS

(i) Solar flares in association with Coronal Mass Ejections and Forbush Decrease are found to be equally distributed in the Eastern and Western hemisphere for the period 2000 to 2010.
(ii) Solar flares in association with Coronal Mass Ejectionsin the Northern Hemisphere are found to be more effective in producing Forbush Decrease events in Cosmic ray.
(iii) A large number of solar flares are in association with Coronal Mass Ejections and Forbush Decrease occurring in the zone 10^0North and 30^0 South.
(iv) Coronal Mass Ejections produce significant decrease in cosmic ray intensity.
(v) Coronal Mass Ejections produce transient decrease particularly in maximum solar activity period.
(vi) Coronal Mass Ejections are found responsible in geomagnetic disturbances.

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