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Study of GLE with Solar Energetic particle emission and solar wind

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Abstract: A ground level enhancement (GLE) is the sharp increase of small duration in counting rate of ground-based cosmic rays detectors caused by accelerated charged particles from the sun to the energies sufficiently high to be recorded at Earth.

Keywords: GLE, Solar Energetic particle emission (like proton flux) and solar wind.

I. Introduction

Solar output variations are changes in amount of radiant energy of energetic particles emitted by our sun [1-3]. There are periodic components to these variations, the principal one being the 11-year solar cycle (or sunspot cycle), as well as fluctuations which are aperiodic [4-6].

II. Data and Method

In this analysis we derive the results using long term and short term records of neutron monitor intensity. The ground level enhancement (GLEs) are directly associated with the solar output variation. To know the cause that causes cosmic ray ground level enhancement we used short term variational data of cosmic ray detectors. The anomalous variations within the solar cycle are investigated and relevant associated parameters are identified to understand the observed characteristics of the variations. In solar cycle 23 a total of 16 GLE events are recorded in this work we observe the recent two GLE events (i.e. event no. 14 & 15 in 2005 & event no. 16 in 2006).

III. Observational Results

Ground level enhancement (GLE) events represent the largest class of solar energetic particle (SEP) events that require acceleration process to produce $\geq$ GeV ions in order to produce showers of secondary particles in the earth's atmosphere with sufficient intensity to be detected by ground-level neutron monitor, above the background of cosmic rays. The GLE events are associated with solar flares and coronal mass ejections (CMEs). Proton fluxes are caused by flare-accelerated particles in lower corona. Coronal mass ejections (CMEs) are observed in all recently detected (GLEs). Thus we can say that flares and CMEs are both necessary conditions for a GLE event fig 1 shows the scatter plot of proton flux & cosmic ray intensity counting rate in GLE event 1 of 2005. The correlation coefficient $r = -0.292$ fig. 2 shows the scatter plot of proton flux ($PF > 10 \text{ MeV}$) and cosmic ray intensity counting rate (KIEL). in GLE event no. 1 of 2005 and the correlation coefficient is $r = 0.002$ fig. 3 shows scatter plot of solar wind with C.R.I. (KIEL). counting rate for GLE event no. 1 of 2005 and the correlation coefficient is $r = 0.302$ fig. 4 shows scatter plot of 5 min. short term variation of CRI (KIEL) & proton flux $> 30 \text{ MeV/cm}^2 \text{ sec-ster}$ in GLE event no. 2 of 2005 and correlation coefficient is $r = 0.450$ fig. 4 shows scatter plot of 5 min short term variation CRI (KIEL) & proton flux $> 10 \text{ MeV/cm}^2 \text{ sec. ster}$ in GLE event no.2 of 2005 and correlation coefficient $r = 0.275$. It is observed from above scatter plot the correlation coefficient is better in GLE events of year 2005.

IV. Discussion

On the basis of observational results and discussion, the following conclusions are drawn. Ground level enhancement (GLE) events represent the largest class of solar energetic particle (SEP) events that require acceleration process to produce $\geq 1 \text{ GeV}$ ions in order to produce showers of secondary particles in earth's atmosphere with sufficient intensity to be detected by ground -level neutron monitors, above the background of cosmic rays. The solar energetic particle (SEP) emission which includes proton fluxes of energies $> 10 \text{ MeV/cm}^2 \text{-sec-ster}$ to $30 \text{ MeV/cm}^2 \text{-sec-ster}$ and solar wind resulted in ground level enhancement (GLE) events in 2005. The sudden increase in proton fluxes of energies $> 30 \text{ MeV/cm}^2 \text{-sec-ster}$ caused the CRI counting rate increase in 2006 which gave rise of GLE event on 13 Dec. 2006. All recent GLE events are associated with solar energetic particle

(SEP) emission, coronal mass ejections (CMEs), proton fluxes and solar flares, thus we conclude that solar energetic particle emission, solar flare and CMEs are necessary conditions for GLE events.

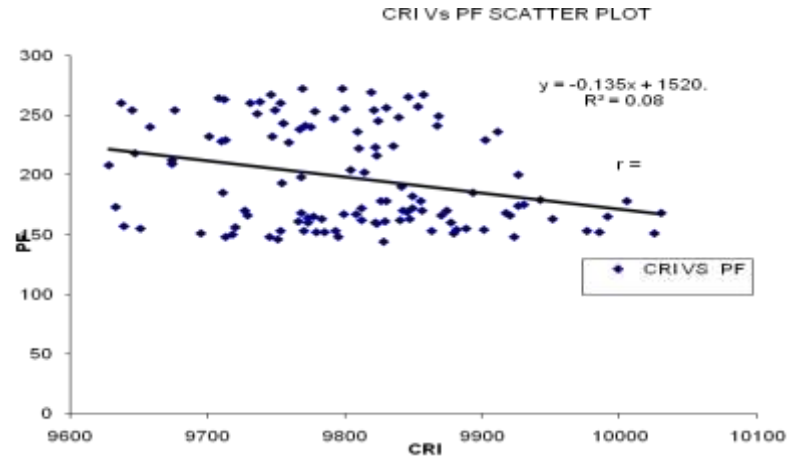


Figure 1: Showing scatter plot of short term (5 min.) CRI counting rate variation in GLE 1. of 17 Jan 2005 with prton flux

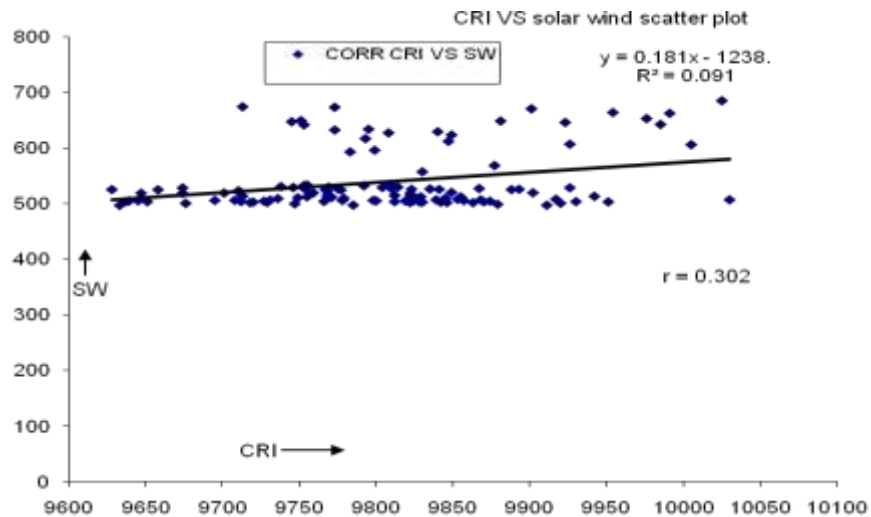


Figure 2: Shows scatter plot of solar wind with C.R.I. (KIEL)

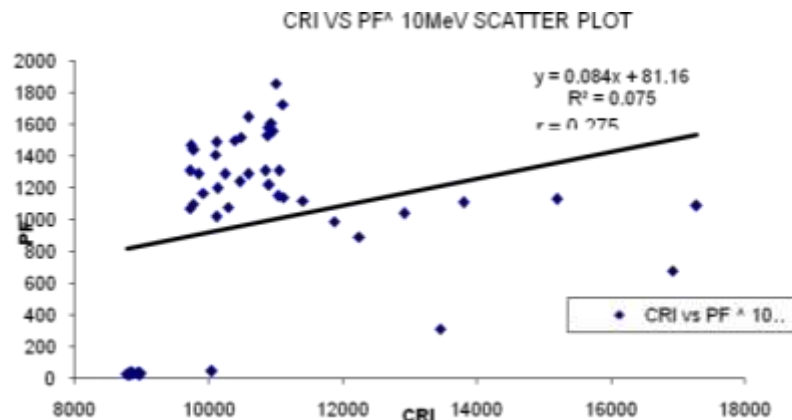


Figure 3: Showing scatter plot of short term (5 min.) CRI counting rate variation in GLE 2. of 20 Jan. 2005

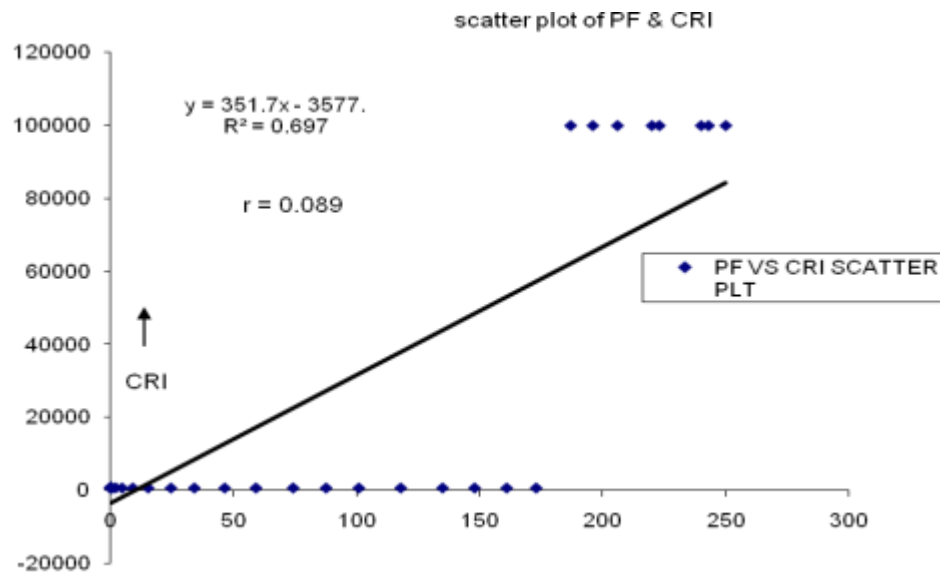


Figure 4: Showing scatter plot of short term (5 min.) CRI counting rate variation in GLE 1. of 13 december 2006 with prton flux.

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