INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD
ISSN(O): 2455-0620 [Impact Factor: 9.47]
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value : 86.87
Volume - 10, Issue - 5, May - 2024

DOIs:10.2015/IJIRMF/202405019 --:-- Research Paper / Article / Review

Study Of Ground Level Enhancement On 17 May 2012 Associated with Solar Output

[1] **Sandeep Kumar Tiwari,** [2] **Devendra Sharma,** [3] **Laxmi Tripathi**
[1]Research Scholar, Department of Physics, Govt PG College Satna, Madhya Pradesh India
[2]Facuty, Department of Physics, Govt Model Science College Rewa, Madhya Pradesh India
[3] Facuty, Department of Physics, Govt Model Science College Rewa, Madhya Pradesh India

Email – [1] sandeeprewa210@gmail.com

Abstract: *In the Sun, particles mostly protons (positively charged) with energies up to several hundred (MeV) are escaped during periods of intense flare activity. These particles are solar cosmic radiation, which are very small particles move at nearly the speed of light through space. The flare and coronal mass ejection (CME) may also cause a sharp rise in the cosmic ray intensity (CRI) at the Earth atmosphere. There are indications that the most energetic events occurred in the minimum phase of solar activity. When cosmic rays enter the Earth's atmosphere they collide with atoms and molecules, as the Sun's magnetic field became weak the cosmic rays are flooding into the solar system from deep space, causing health risks to space travellers. Sudden increases in the cosmic ray intensity called Ground level enhancements (GLEs) are measured or recorded on Earth' sea level by neutron monitor (NM). The main objective of this research is to find the relation between cosmic ray and the GLE events and other solar activity parameters during 12 May 2012 on solar cycle (24). In this work satellite data of GLE based on ground level station Oulu NM (ONM) are taken is situated in north Finland at the height of 15m above sea level in the geographic coordinates (65.05°N; 25.47°E). We Found GLE event increasing (~15%) is most common near solar maximum but occur around sunspot maximum (116) throughout the cycle. Solar cycle 24 is poor of number of GLE, the flare associated with shockwave in GLE 71 increase cosmic ray intensity.*

Key Words: *Cosmic ray, CME, GLE, Solar cycle 24.*

1. INTRODUCTION:

From the Sun, during the period of high solar activity (solar disturbance time) or when there is intense flare activity the positively charged particles protons with high energies reach to several hundred (MeV) are ejected, these particles are termed solar cosmic rays (SCR). There is, in addition to this solar source a galactic cosmic radiation (GCR), which is plainly not of solar origin and a steady background of high-energy radiation. The cosmic rays consist of electrons, neutrons and atomic nuclei, which have been accelerated to very high speed [1]. The astrophysical origin of cosmic rays is from, primary particles such as electrons, protons and helium. The cosmic ray's elemental composition provides information on chemical fractionation in the source region as well as some insight into the nature of this region and of the propagation of cosmic rays in interstellar space, the variation of the charge and mass composition with energy, their energy spectra can be related to the acceleration process and to particle transport in the galaxy [2]. Several attempts and Studies were conducted by scientists to improve data taking from neutron monitor (NM) for ground stations and for several and different regions, Bütikofer and Flückiger in 1999 propose a technique which compensates for this effect and improves the reliability of pressure corrected NM data [3]. Mishev et al (2013) provide a new study of variation cosmic ray sea-level (NM) on different temporal and spatial scales by adding theoretical yield function that is investigated with experimental data [4]. Mishev et al in (2019) found a great significant correlation between neutron monitor peak count rate and the maximum effective dose rate increase during GLEs is observed propose to use the maximal count rate increase as a proxy for assessment of the effective dose at flight altitude during strong solar particle events [5]. Mishev et al. (2020) provide a new yield function of the standard sea-level NM, isotropic flux of cosmic ray (CR) particles, and extended here to different altitudes of the atmospheric depths from sea level up to 500 g/cm2 [6]. Mishev and Usoskin in 2019 and 2020 used data from NM to analysis ground level enhancement (GLE) event for space weather applications. Their study revealed that the effect of space weather change is related to global NM network which is a useful tool for estimation namely the exposure of aircrew due to galactic and solar cosmic ray origin. The derived spectra and angular distributions will be integrated into the GLE database [7, 8]. Many researchers studied the relationship between cosmic rays and solar activity through the parameters GLE, coronal mass ejection (CME), and others Firoz et al. 2010 et al. [9]; Firoz 2011 et al. [10]; Firoz et al. 2014 [11], Firoz et al. 2019b [12] and Firoz et al. 2019 [13] their study show that the production of a GLE need harder energetic particle fluxes having strong cast above the background emission due to galactic cosmic rays (GCR). Statistical analysis has shown that a conjunction between CME driven interplanetary shock and flare are likely to be the cause of GLEs, but CMEs alone probably does not cause GLEs. The variation of the GLEs may depend on the magnitude of the solar energetic particle, intensity of the flare and CME pushed out. Yu Balabin in 2013 presents the analysis of solar cycle 24, which started at 2009 and the GLE71 on May 17, 2012 has become the first event of this cycle [14]. They found that there is a poor correlation between the numbers of GLEs and the amplitude of the solar cycle [15]. The solar energetic particles (SEPs) are the dominant source of ionization in Earth's upper atmosphere and a major source of natural radiation on the Earth's surface. The magnitude of the SEP flux intensity increase specifies the enhancement of the radiation level, which can cause damage to satellite electronics and also pose a radiation hazard to astronauts and air crews [13]. When relativistic solar protons (RSPs) reach the Earth surface, the interaction between (RSPs) and Earth's atmosphere will lead to enhance the cosmic ray intensity which is referred to ground level events (GLEs) [15]. GLE appears in the cosmic-ray temporal profile conspicuously as a sudden, sharp, and short lived [12]. For each solar cycle a few times detection of SCR particles by ground-based detectors on average are occurs. Each GLE has its own typical spectrum, amplitude, duration, and spatial distribution of flux. The worldwide network of neutron monitors (NMs) using the geomagnetic field as a giant magnetic spectrometer enables to determinate the characteristics of the SCRs near Earth during a GLE in the energy range ~500 MeV to ~15 GeV [16]. While the energetic particle fluxes comprise softer and harder spectra, the softer phase representing in MeV energetic particle fluxes refers to the solar energetic particle (SEP) event, and the harder phase representing in GeV energetic particle fluxes refers to the GLE event [17]. GLE events are subset of large SEP events (~15% of events identified by Space Weather Prediction Centre with particularly hard spectra, making them a substantial space weather hazard to space-based instrumentation and exposed astronauts. Large solar flare is associated with a GLEs, the flare may not be related to the production of the protons high energy which produce the GLE that affects the Earth atmosphere. The cosmic ray intensity intensifies to a sharp increase due to the propagation process of the accelerated higher energy particles, then the sharp rise of cosmic ray intensity returns to the background level when the acceleration of particles ends, this process measured at the ground by neutron monitors takes tens of minutes to hours. Flare and CME also cause a sharp rise in the cosmic ray intensity at the Earth's atmosphere. The aim of this research we try to find the correlation between cosmic ray and the GLE events and other solar activity parameters17 May 2012.

2. Data Source and Methodology :

We analysed the data of cosmic ray intensity (CRI) registered by ONM (see http://cosmicrays.oulu.fi/) for 17 May 2012 (solar cycle 24). The station (ONM) is situated in north Finland at the height of (15m) above Earth's sea level in the geographic coordinates of (65.05°N) latitude and (25.47°E) longitude, the local vertical geomagnetic cut off rigidity is almost (0.8 GV). It is a standard consisting of three units with each of three counters (uncorrected counter rate (in counts/ min), barometric pressure (in mb) and corrected count rate (in counts/min). For this study data of CRI from the ONM stations preferred, because its data has high resolution for a long time period and correct reliable. Solar Feature data have been taken form https://omniweb.gsfc.nasa.gov/form/dx1.html and CME data has been taken from CME Catalogue https://cdaw.gsfc.nasa.gov/CME_list/. By using Applying different statistical method we found some important results.

3. Result and Discussion:

In this paper we investigate the effect of GLE event on Southward component Bz along with solar wind velocity on cosmic ray intensity (CRI) during following time intervals when the GLE amplitude was >= 5% recorded by OULU neutron monitor station: 16-17 may 2012. We have searched for the solar sources responsible for above events by tracking back the smoothed monthly mean sunspot numbers (SMMSNs), daily total sunspot number, also determine solar flare associated CME, and, some days before the onset of GLE. This was the first GLE (~15%) event of maximum phase of 24th solar cycle. It originated location (N12 W83) which unleashed X-ray flare of class M5.1on 17 May 2012 at 1:45 UT. Associated the flare a CME was with high-speed of 1582 km/sec, SSN equals 116. On 17 May 2012, the fast CME shock waves featured by sudden jump in cosmic ray intensity (CRI), and almost all parameter that chosen gradually increased Bz solar wind proton density, Dst except Kp index which is gradually increased. From figure (2), it is noticed that SW velocity groundling decline from 378 Km/sec at start the event to 357 Km/sec at the end of event, Bz value fallen to -2.9 nT at the peak of event, the value of Kp had fast regression. Thus, due to interplanetary Coronal mass

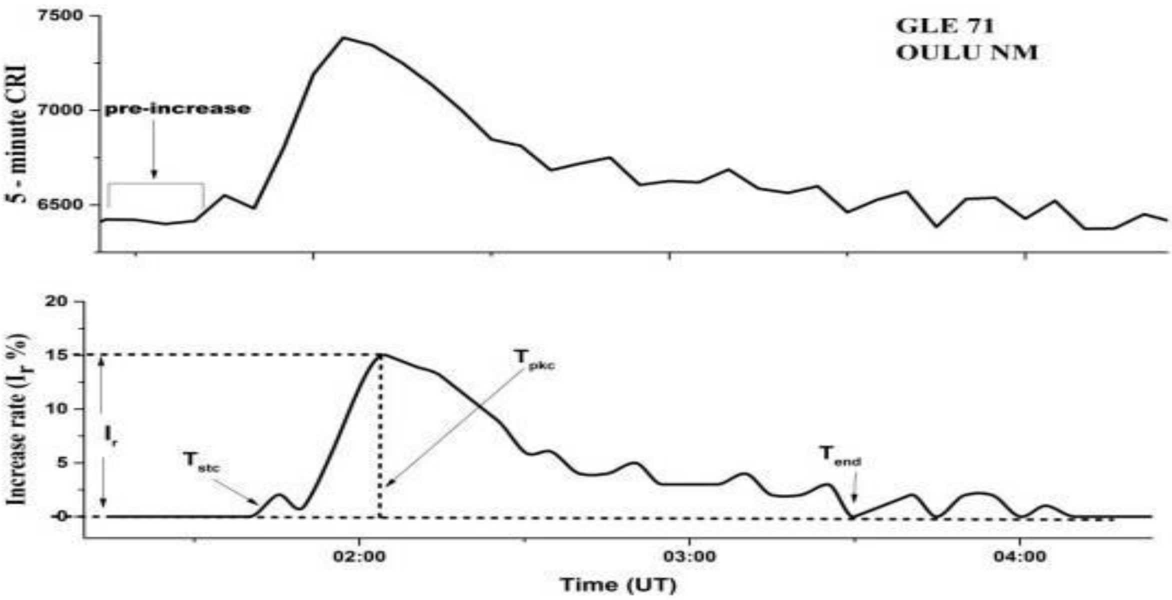

Figure 1 Show the increase rate of CRI data from ONM which Indicate the Onset time T_{stc} Peak time T_{pkc} and GLE end Time T_{end}

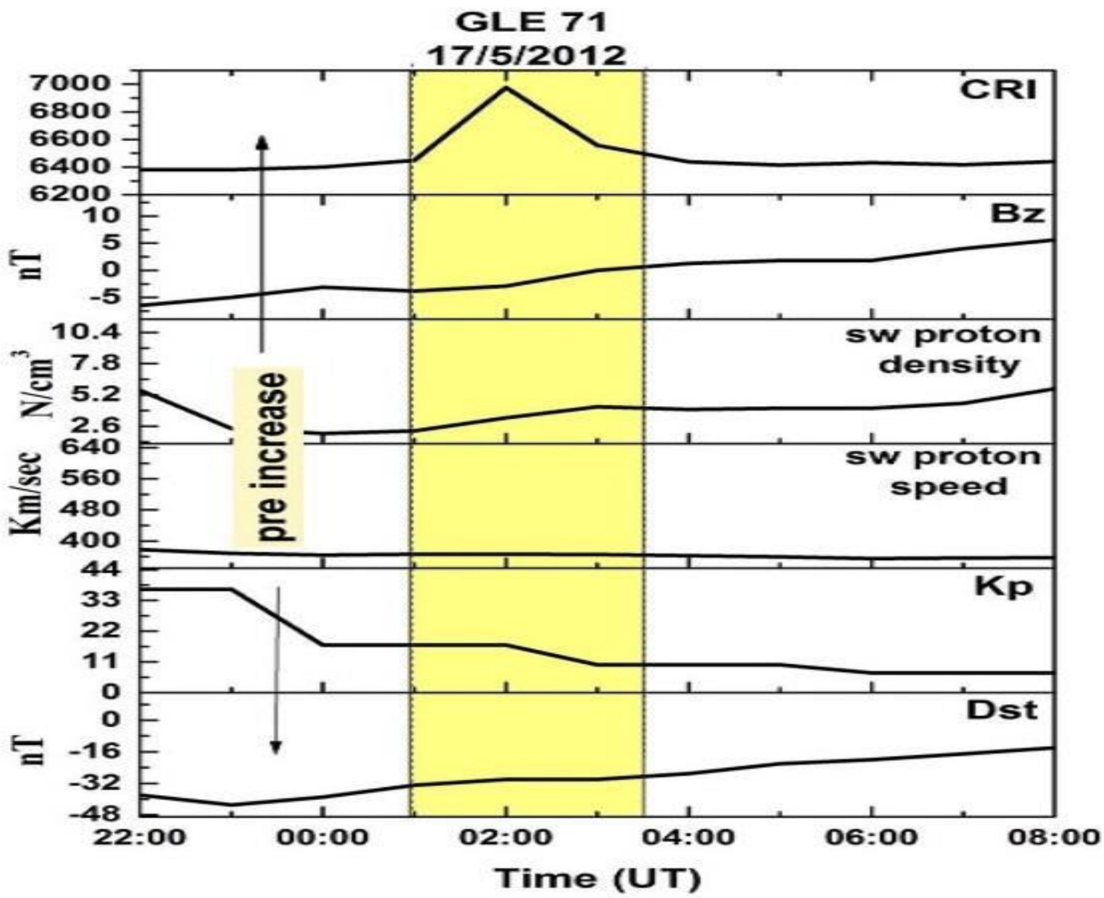

Figure 2 (from top to bottom) CRI, southward component Bz, solar wind density, solar wind speed, Kp and Dst indices, (all hourly averaged) plots from 10 to 11 September 2017. Vertical line marks the duration of GLE event

ejections (ICME) impacting on slow solar wind there was a sheath upstream of ICME led by a fast forward shock causing GLE. On other hand Solar wind proton density groundling increase to 5.5 and continue increasing after the end of event because the ionization that resulting from increased number of particles entering the Earth's ionosphere during the GLE and reconnection need time to remove the effect.

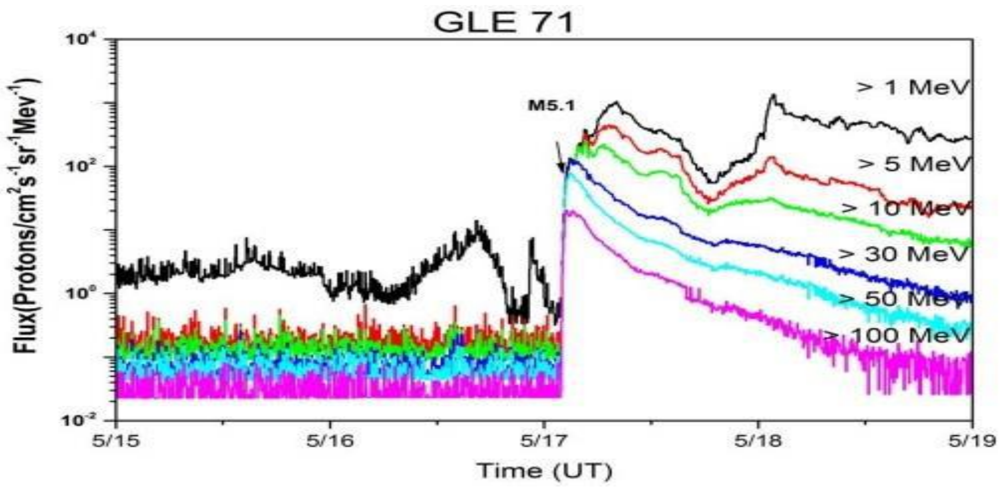

Figure 3 Five-minute averaged integral proton fluxes (in pfu = protons/ cm2 ·s·1sr-1) as measured by a GOES satellite for each of the energy thresholds >1, >5, >10, >50, and >100 MeV, from 15 -19 May 2012. Vertical arrows indicate analysed of solar event with M5.1 flare.

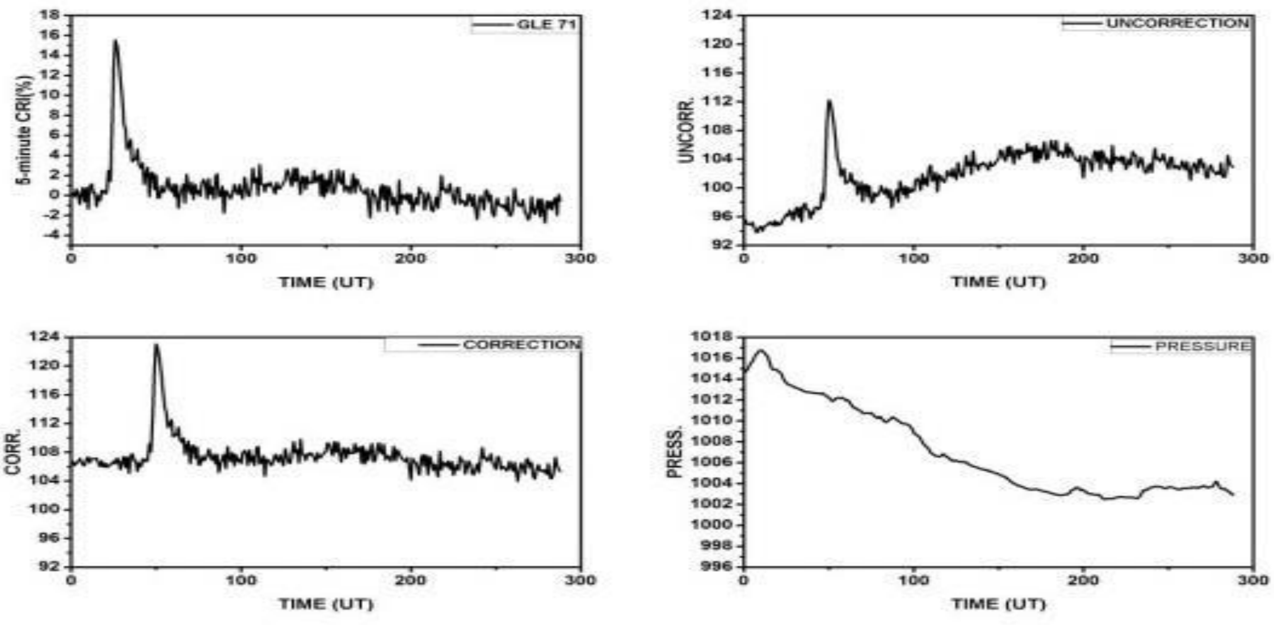

Figure 4 ground level enhancement 71 (a) increasing (b) uncorrected pressure (c) corrected pressure (d) pressure for event GL71.

4. CONCLUSION: In the present analysis we examined Ground level enchainment event on 17 May 2012 in association with solar interplanetary and geomagnetic parameters to find the causes of large increase in cosmic ray neutron monitor counts at the Earth. It is found that the initiation of GLE is linked to the appearance of active regions on solar disk which is erupted fast CMEs associated by strong flares. The effects of GLE event preceded by large CRI variations, sudden rise in solar wind density and Bz, increase in cosmic ray flux and decrease in geomagnetic activity the Dst and decrease in geomagnetic activity the kp. This paper summarizes the extreme solar activity and its implications via GLE events during the maximum and declining phase of the solar cycle 24 on 17 May 2012. We have compiled and compared the properties of GLE which has the potential of yielding a lot of information for space weather applications. The solar cycle effect is not much significant in case of very large GLE event. It is seen that high duration of increasing in intensity of GLE have occurred in the descending phase of solar cycle. We can say that large GLE event increasing (~15%) is most common near solar maximum but occur around sunspot maximum (116) throughout the cycle. Solar cycle 24 is poor of number of GLE, the flare associated with shockwave in GLE 71 increase cosmic ray intensity.

REFERENCES:

1. Hansjörg Schlaepfer, (2003); "Cosmic Rays", International Space Science Institute, SPATIUM Published by the Association Pro ISISI.
2. Frank B. Mc.Donald and Vladimir S. Ptuskin, 2001; Galactic Cosmic Rays, The Century of Space Science, Kluwer Academic Publishers; pp. 677–697.
3. Bütikofer R., and Flückiger E. O., (1999) "Pressure Correction of GLE Measurements in Turbulent Winds", 26th International Cosmic Ray Conference (ICRC26), August 17-25, p. 395, Salt Lake City, Utah. 4. Mishev A. L., Usoskin I. G., and Kovaltsov G. A., 2013 "Neutron monitor yield function: New improved computations", Journal of Geophysical Research: Space Physics, Vol. 118, pp. 2783– 2788.
4. Mishev A., Usoskin I., Tuohino S. and Ibragimov A., (2019) "The upgraded GLE database includes assessment of radiation exposure at flight altitudes", 26th Extended European Cosmic Ray Symposium, IOP Conf. Series: Journal of Physics: Conf. Series 1181 (2019)12061.
5. Mishev A. L., Sergey A. Koldobskiy, Gennady A. Kovaltsov, Agnieszka G., and Ilya G. Usoskin. (2020) "Updated Neutron-Monitor Yield Function: Bridging Between In Situ and Ground-Based Cosmic Ray Measurements", JGR Space Physics, Research Article.
6. Mishev A., and Usoskin I., (2019) "Analysis of sub-GLE and GLE events using NM data: space weather applications", 26th Extended European Cosmic Ray Symposium, IOP Conf. Series: Journal of Physics: Conf. Series 1181 (2019)12006.
7. Mishev A. L. and Usoskin I. G., (2020) "Current status and possible extension of the global neutron monitor network", arXiv: 2005.12621v1 [physics.space-ph] 26 May 2020.
8. Firoz K. A., Cho K. S., Hwang J., Phani Kumar D. V., Lee J. J., Oh S. Y., Kaushik S. C., Kudela K., Rybanský M. and Dorman L. I., (2010), "Characteristics of ground- level enhancement associated solar flares, coronal mass ejections, and solar energetic particles", Journal Geophysics Research, 115, (12pp), A09105.
9. Firoz K. A., Hwang J., Dorotovič I., Pintér T., and Subhash C. Kaushik, (2011) "Relationship of ground level enhancements with solar, interplanetary and geophysical parameters", Astrophys Space Sci, 331, pp. 469–484.
10. Firoz K. A., Zhang Q. M., Gan W. Q., Li Y. P., Rodr´ıguez-Pacheco J., Moon Y.-J., Kudela K., Park Y.-D., and Dorman L. I. (2014) "An interpretation of GLE71 concurrent CME driven shockwave", The Astrophysical Journal Supplement Series, 213:24 (14pp
11. Firoz K. A., Gan W. Q., Li Y. P., Rodríguez-Pacheco J., and Kudela K., (2019) "On the Possible Mechanism of GLE Initiation" The Astrophysical Journal, 872, 178, 13pp, February 20
12. Firoz K. A., Gan W. Q., Moon Y. J., Rodríguez-Pacheco J., and Li Y. P., (2019b) "On the Relation between Flare and CME during GLE-SEP and Non-GLE-SEP Events", The Astrophysical Journal, 883(91).
13. Yu. V. Balabin, Germanenko A. V., Vashenyuk E. V., and Gvozdevsky B. B., (2013) "The first GLE of the new 24th solar cycle", In: Proceedings 33rd International Cosmic Ray Conference (ICRC), Rio de Janeiro, Brazil, Polar Geophysical institute, Apatity, Russia, “Physics of Auroral Phenomena”, Proc. XXXVI Annual Seminar, Apatity, pp. 103 - 105.
14. Le G., and Liu G., (2020) "The Properties of Source Locations and Solar Cycle Distribution of GLEs during 1942–2017", Sol Phys 295, 35.
15. Bütikofer R., Lückiger E., Alabin Y., and Belov N., (2013) "The reliability of GLE analysis based on neutron monitor data – a critical review", In Proc. of 33rd international cosmic ray conference, Rio de Janeiro, Brazil, 2-9 July, 0863.
16. Augusto C. R. A., Navia C. E., de Oliveira M. N., Nepomuceno A. A., Fauth A. C., Kopenkin V., and Sinzi T., (2018) "Relativistic proton levels from region AR2673 (GLE #72) and the heliospheric current sheet as a Sun-Earth magnetic connection", Publications of the Astronomical Society of the Pacific, 131:024401 (14pp).
17. Augusto C. R. A., Kopenkin V., Navia C. E., Felicio A. C. S., Freire F., Pinto A. C. S., et al., (2018) "Was the GLE on May 17, 2012 linked with the M5.1-class flare the first in the 24th solar cycle?", Astroph. SR, (9pp).