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Impact of Solar Variability on Cosmic Rays and Geomagnetic field During Solar Cycle 23 And 24

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Abstract - Cosmic rays are very energetic spaceborne particles that collide with Earth's atmosphere. This research examines the observed findings and the effects of solar variability on cosmic rays and the geomagnetic field from 1996 to 2015. Two types of cosmic ray modulation have been identified: periodic and sporadic. Sporadic categories include Forbush decline, transitory drop, and ground level enhancement (GLE). Galactic cosmic ray variation is also known as long-term variation, while Forbush reduction is short-term variation. Long-term variations in cosmic ray intensity exhibit an 11-year cycle with one peak every cycle. Solar activity and cosmic ray intensity are inversely correlated.

Keywords - Forbush Decreases, Cosmic Rays, Geomagnetic, Solar Cycle 23 And 24

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INTRODUCTION

Following a coronal mass ejection (CME), there is a sudden drop in the reported galactic cosmic ray intensity known as a Forbush decline. It happens because certain galactic cosmic rays are deflected away from Earth by the magnetic field of the plasma solar wind. The American physicist Scott E. Forbush, who investigated cosmic rays in the 1930s and 1940s, is remembered by the moniker Forbush decline. Since detailed records of solar sunspot activity started in 1755, there have been 23 solar cycles. Solar cycle 23 was the 23rd of those cycles. 12.3 years passed during the solar cycle, which started in August 1996 and ended in December 2008. The initial low was 11.2, while the highest averaged sunspot number throughout the solar cycle was 180.3 (November 2001). There was a total of 817 days without any sunspots during the lowest transit of solar cycle 23 to cycle 24. It was rather active when compared to the previous solar cycles.

High-energy particles or clusters of particles—often protons or atomic nuclei—that travel across space at almost the speed of light are known as cosmic rays. They come from the Sun, other parts of the galaxy besides the Solar System, and faraway galaxies. Some of the secondary particles created by cosmic ray impacts with Earth's atmosphere make it to the surface, while the majority are diverted out into space by the magnetosphere or heliosphere.

Victor Hess made the 1912 discovery of cosmic rays via balloon experiments, for which he was given the 1936 Nobel Prize in Physics. Since the first satellites were launched in the late 1950s, it has been feasible to study cosmic rays directly, particularly at lower energy. On satellites and spacecraft, particle detectors used in nuclear and high-energy physics are employed to study cosmic rays. A major portion of primary cosmic rays are thought to come from star supernova explosions, according to data from the Fermi Space Telescope (2013). (Better source is required) According to data from the blazar TXS 0506+056's detection of neutrinos and gamma rays in 2018, active galactic nuclei also seem to emit cosmic rays.

A geomagnetic storm, often referred to as a magnetic storm, is a transient disruption of the Earth's magnetosphere brought on by an interaction between the Earth's magnetic field and a shock wave from the solar wind. A solar coronal mass ejection (CME) or (much less severely) a co-rotating interaction region (CIR), a fast-moving stream of solar wind coming from a coronal hole, may be the disruption that causes the magnetic storm. With the solar cycle, the frequency of geomagnetic storms rises and falls. Geomagnetic storms are more frequent at solar maximum, and most of them are caused by CMEs.

LITERATURE REVIEW

Shalaby, S. et.al (2023). From 2008 through 2021, six significant Forbush drop (FD) episodes of solar cycles 24 and 25 were detected by five neutron monitoring sites located in Rome, Moscow, Fort Smith, Oulu, and Thule. On November 3, 2021, July 15, 2017, September 6, 2017, June 21, 2015, September 11, 2014, and March 7, 2012, these occurrences were noted. In an attempt to understand the potential reasons that contributed to the occurrence of the big FD, an inquiry has been conducted. Numerous severe solar and planetary occurrences were examined throughout the inquiry. Sunspot counts, the disturbance storm time (DST) index, and the Ap index are a few of them. We also looked at the solar wind's speed, density, temperature, and BZ component of the interplanetary magnetic field (IMF). The DST index has a dramatic decline during the event time that is comparable to the Forbush reduction. Prior to the start of the FD, there were more sunspots, which suggests that this phenomenon may be related to the occurrence of solar flares, which further affect the variance in cosmic rays. It was discovered that there was a considerable southerly BZ drop, a rapid rise in solar wind temperature and speed, and that no major FD showed any evidence of density impact.

Мелкумян, Анаид et.al (2019). In solar cycles 23 and 24 (as well as in the maxima of these cycles and the lowest between them), it has been compared between recurring (related with high-speed streams from coronal holes) and sporadic (produced by interplanetary coronal mass ejections, or ICMEs) Forbush declines (FDs). We were able to use statistical approaches because the Forbush Effects and Interplanetary Disturbances database, which was constructed and maintained in IZMIRAN, supplied a significant number of events (about 1700 solitary FDs, 350 recurrent FDs, and 207 random FDs picked with high confidence). The findings showed that recurrent FDs predominated at the lowest between cycles whereas sporadic FDs predominated in the maxima of cycles. Particularly at the maxima of the cycles, FD characteristics (magnitude, decline rate, and anisotropy) are higher for random events than for recurring ones. For sporadic events, FD magnitude is larger at peaks than minima, and it hardly varies for recurring ones. In general, recurring events have higher solar wind velocities than sporadic ones; recurrent FDs have higher velocities in the minimums while sporadic FDs have higher velocities in the maximum. In the maxima, the magnetic field is stronger for random FDs than recurrent ones, and in the lowest, it is about equal for both kinds of events. The magnetic field of ICMEs is less now than it was in the last solar cycle. Both kinds of events had shorter primary phases of FDs in their maxima; in cycle 23's maximum, sporadic FDs developed noticeably more quickly than recurring ones.

Papailiou, M. et.al (2020). The many solar sources connected to them are one of the causes of the vast range of Forbush reductions. The numerous aspects and traits of Forbush declines are investigated in this study, with a focus on big Forbush drops and their connection to solar sources. This study started with a broader selection of events from the Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio wave Propagation of the Russian Academy of Sciences, which was then focused on a subset of large Forbush decreases. The occurrences under examination were divided into three subcategories based on the helio-longitude of the solar source: western (21 helio-longitude), eastern (60 helio-longitude), and central (20 helio-longitude). The chosen incidents occur between 1967 and 2017. The aforementioned Forbush declines were examined using the "Global Survey Method" combined with information on solar flares, solar-wind speed, geomagnetic indices (KP AND DST), and the interplanetary magnetic field. The temporal profiles for the chosen events were shown using the superimposed epoch approach. Interesting findings on the characteristics of cosmic-ray declines in relation to the helio-longitude of the solar sources are revealed by this thorough research. Large Forbush decreases are associated with increased geomagnetic activity and increased anisotropy, including anisotropy be, regardless of the helio-longitude of the solar source. In particular, Forbush decreases related to central or eastern solar sources are more frequently observed, have a greater magnitude, and present a slower development than Forbush decreases related to western sources, which are rarer, have a smaller magnitude, and have a shorter lifespan.

Kharayat, Hema et.al (2016). We look at how the interplanetary magnetic field (IMF, (Formula provided.)) and geomagnetic storms (GS) over the years 1997 to 2006 (Solar Cycle 23) are related to cosmic ray intensity (CRI). To do this, we used the superposed-epoch approach to perform a Chree analysis. On GS incidence days, CRI experiences a brief reduction that follows a pattern like that of the disturbance storm-time index (DST). We further demonstrate that when IMF rises, the CRI declines. There is a one-day or less lag between the rise in IMF and the fall in CRI. Additionally, a rise in IMF (Formula given) is seen along with a fall in DST index. The sunspot number is not shown to be linked with IMF, DST index, or CRI over the time period under study, however IMF and DST index are strongly anti-correlated to one another. It is discovered that the IMF is a useful parameter combination for causing GS and Forbush drop. Additionally, we discovered symmetric and asymmetric declines in CRI for Solar Cycle 23. For the purpose of researching the consequences of space weather, CRI reductions may be of assistance.

Mathpal, et.al (2018). In this study, we use their daily mean average to examine the relationships between cosmic ray intensity (CRI) and various solar wind parameters, including solar wind speed V, plasma proton temperature, and density, geomagnetic storms (GSs), averaged planetary A-index (Ap index), and sun spot number (SSN), for the years 2009 to 2016 (solar cycle 24). We use the analytical approach of the superposed-epoch method to determine the relationship between CRI and other solar wind metrics, including GSs, IMF B, Ap index, and SSN. According to our observations, CRI declines as IMF B rises. Additionally, the time-lag study using the correlation coefficient approach revealed a 0-to-2-day lag between the rise in IMF B and the decline in CRI. Additionally, we demonstrate that during the majority of Solar Cycle 24 the CRI is shown to decline in a way comparable to the disturbance storm time (DST index). CRI and DST index show a strong and favorable association. CRI and IMF have a worse anti-correlation than CRI and Ap index. CRI and SSN have a strong positive correlation. Plasma proton temperature and plasma proton density are not CR-effective factors, although solar wind metrics such as solar wind speed V are. While CRI and SSN exhibit unique behavior for the two cycles, the specified parameters, such as DST index, Ap index, IMF B, and solar wind parameters, such as solar wind speed V, plasma proton temperature, and plasma proton density, exhibit rather erratic changes for solar cycles 23 and 24.

STUDY OF SOLAR VARIABILITY ON COSMIC RAY

Researchers have looked at the effects of solar variability on cosmic rays and the geomagnetic field using data from ground-based detectors, primarily the global grid of super neutron monitors, in conjunction with a variety of solar, interplanetary, and geophysical parameters. Solar terrestrial connection describes the interrelationship between these variables. Long-term galactic cosmic ray fluctuations are an unresolved issue in cosmic ray investigations, in addition to short-term changes in CRI. Numerous studies have shown that the 11-year solar cycle of Sun spot activity modulates cosmic ray flux, with cosmic ray intensity changing over the solar cycle in anticorrelation with Sun spot activity with a time lag of 1-2 years. Cosmic ray intensity reaches a maximum during quiet period of solar cycle & minimum near peak of solar activity. Neutron Monitor count rates have a substantial correlation with the tilt angle of the neutral current sheet at the beginning of the current modulation cycle.

In a paradigm that includes drifts and diffusion, investigated modulating cosmic rays via corotating interaction areas. In an effort to improve the association between cosmic ray strength and solar activity, used the spherical harmonics of the solar magnetic fields. demonstrated that the average cosmic ray intensity exhibits an apparent 11-year anticorrelation to solar activity. The research of features of the 11-year type has been greatly aided by the persistent recoding of cosmic beam power throughout past decades by technologies for neutron screen. the strongest declines in long-term variety seem to follow significant Forbush declines that last for a time, followed by equivalent fast declines that further reduce overall force. In response to the extreme inversion of the Sun's attractive field that took place between 1969 and 1970 hypothesized the existence of a 22-year tweak. Many workers have described a few studies to explain long-distance cosmic beam power variation taking into account certain time-slack in between sunspot numbers.

On the basis of a novel balancing parameter, an effort has been made to clarify long-distance management of astronomical beam strength on the basis of the combined influence of a few interplanetary highlights, actual investigations have been conducted to clarify the long-distance Cosmic beam strength They come to the conclusion that a massive structure fueled by the sun is responsible for an 11-year cycle in cosmic beam force diversity. The instrument of the 22-year type is associated with the inversion of the Sun's dipole field, they suggested that high power states, in which the sun's and the galaxy's attractive fields are parallel to one another, would promote the entry of cosmic beam particles into the heliosphere.

However, it has since developed so that galactic cosmic beams are in opposition to Sun spot numbers (SSN), with their strongest force occurring at the base of the Sun spot cycle. The association of long-haul enormous beam power diversity with SSN & tilt point (TA) has been studied They have observed that the Sun spot numbers and tilt edge are strongly correlated, and the cosmic beam force has an antagonistic relationship with them. Although the idea of a long-distance adjustment system for a galactic inestimable beam has been widely discussed for more over 50 years, both conceptually and tentatively. However, long-term balance is still an issue that has to be resolved in studies on cosmic beam management. As a result, we have made an effort to identify the issue with the use of observational data obtained via precise quantifiable analysis. Information used in this inquiry was acquired from neutron screen stations with low, middle, and high cutoff inflexibility.

ASSOCIATION OF COSMIC RAYS WITH SOLAR & INTERPLANETARY PARAMETERS

Cosmic rays have been linked to a number of solar parameters, including Sunspot numbers (Rz), Solar flux (>2800 MHz), Index (Ap), Solar electro jet index (Ae), Interplanetary Magnetic field (B), Solar wind velocity (V) & V.B for Solar cycles 23 & 24. These stations include Beijing, Oulu, and Moscow. The solar-terrestrial interaction also contributes significantly to the understanding of the galactic cosmic rays' 11- and 22-year variations.

CORRELATIVE STUDY OF SUNSPOT NUMBERS &COSMIC RAY INTENSITY VARIATION

It has been discovered that cosmic ray strength varies with the solar cycle (sunspot numbers Rz), with maximum intensity occurring around seven months following sunspot minima. However, not every solar cycle is affected by this phenomenon. The interval between the solar cycle and the cosmic ray cycle varies depending on the solar cycle. Additionally, it fluctuates throughout different solar cycle phases. Numerous previous studies have examined the temporal fluctuation of cosmic ray strength and sunspot counts. They deduced an inverse relationship between the strength of cosmic rays and the number of sunspots. According to Forbush (1958), the change in cosmic ray intensity lags solar activity by 6 to 12 months. In this study, we displayed the annual estimates of CRI from three different neutron screens located in Beijing, Oulu, and Moscow. In this study, Wolf Sunspot Numbers

(SSN), which encompass solar cycles 23 and 24, were used as a sunlight-based parameter from 1996 to 2015. According to this analysis, the sun-oriented cycle throughout the full period from 1996 to 2015 is clearly followed by an incalculable beam power. However, timescale slack differs somewhat from different sun-oriented cycles.

For the sunlight-based cycles 23 and 24, a correlative analysis of astronomical beam force (CRI) and sunspot counts (Rz) has been conducted. In a correlative analysis, the annual mean benefits of the super-neutron screens in Beijing, Oulu, and Moscow were used. For continuing time periods, hostile to correlative behavior between infinite beams and sunspot counts is confirmed. (1996-2015). In a correlative analysis using annual mean estimates of sunspot numbers (Rz) and infinite beam force, relationship coefficients for the period 1996 to 2015—which spans the 22nd and 24th solar cycles—have been found. A negative coefficient of connection is thought to exist. We created a cross-plot between the sunspot number (Rz) and huge beam power (CRI) from 1996 to 2015.We then used correlation coefficient to show that the form of the curve for an even solar cycle is similar to that of the next even solar cycle, and that of an odd solar cycle is similar to that of the following odd solar cycle.

ASSOCIATION OF FORBUSH DECREASE WITH CORONAL MASS EJECTIONS AND SOLAR FLARES

Periodic ejections of magnetized coronal plasma are known as coronal mass ejections (CMEs). they are propelled by the release of energy carried by magnetic fields adumbrated by CME post-eruption. Flares, which speed up huge particles (solar cosmic rays), are often included with very intense CMEs. A small percentage of CMEs propagate towards Earth and are known as "halo" CMEs because of how they look in coronagraph photographs. These earth-directed CMEs grow and spread across interplanetary space, becoming what are known as interplanetary CMEs (ICMEs). Forbush et al. (2006) and Gopalswamy (2007). There is evidence that many succeeding CMEs often combine to generate a single complex ICME, albeit the exact link between CMEs and ICMEs is not entirely known. Fast CMEs often move at super-Alfvenic speeds in the solar wind, driving shocks in front of them.

Large geomagnetic storms are commonly triggered by shocks generated by halo CMEs It is generally known that CMEs and their near-earth analogues play a part in the Forbush reductions that occur on Earth Because CMEs are massive magnetized plasma structures, their spread into the heliosphere has significant ramifications. Geomagnetic storms are expected to result from Earth-directed CMEs interacting with the magnetosphere. Solar energetic particles (SEPs) are accelerated by shocks caused by CMEs. Gosling (1993) had highlighted the crucial role CMEs played in intensifying geomagnetic storms. When a direct link between CMEs and their extraterrestrial equivalents (ICMEs) was discovered, this became even more obvious the commencement of a SEP event is accompanied by a number of related phenomena, the most conspicuous of which, for all but the smallest occurrences, is a CME. However, flares are also connected to prompt events that come from the disk. Flare emissions are strong and persistent in virtually all of the greatest events, indicating that there may be a connection between these emissions and the first energetic particles.

ASSOCIATION OF FORBUSH DECREASE WITH INTERPLANETARY SHOCKS & MAGNETIC CLOUDS

Numerous researchers have looked at the impact that large-scale interplanetary shocks play in Forbush reductions Forbush drops seemed to be caused by the area of strong fields in interplanetary space. Interplanetary magnetic loops/clouds with ordered field topology that have been ejected from solar regions, interplanetary shocks with comparably ordered field structure, turbulent fields around shocks, or tangential discontinuities are some examples of these locations. Forbush declines are thought to be caused by magnetic clouds that are preceded by shocks According to Badruddin et al. (1991), cosmic ray drops begin right away when the earth experiences a shock. Interplanetary (IP) shocks are primarily caused by coronal mass ejections (CMEs) and their interplanetary counterparts (ICMEs).

Stream interaction regions (SIR), which arise when a rapid solar wind stream passes across a sluggish stream, are another potential source of IP shocks Due to its function in particle acceleration and as a source of geomagnetic storms investigation of IP shocks is crucial. Although energetic storm particles (ESPs) are sometimes linked to shock passages, they are often recognized as rapid changes in solar wind plasma properties (Bryant et al., 1962; Rao et al., 1967). Numerous writers have sometimes explored the acceleration of ESPs in ICME-driven (transient) interplanetary shocks We have shown that 47% of shocks are forward shocks and 68% of FDS are related with I.P. shocks.

Relationship between interplanetary magnetic field and solar wind velocity during the Forbush decline The Sun is a variable star that emits energetic particles, electromagnetic radiation, and mass in the form of transitory and ongoing events. Beyond Pluto's orbit solar wind is plasma that carries the sun's magnetic field across interplanetary space, producing the heliosphere. Whether or whether they contain inherent magnetic fields, the ionosphere, or a neutral atmosphere, entities buried in the heliosphere respond to the influence of solar activity in accordance with its properties. The solar wind is "the medium" via which all solar disturbances are propagating towards Earth and has a significant influence in the structure and dynamics of the heliosphere. Numerous research examined the existence of two different high-speed solar wind streams and their impact on the strength of cosmic rays.

Satellites and spacecraft study the fast solar wind streams that linger for many days. These HSSWS cause considerable fluctuations in cosmic ray intensity as well as geomagnetic disruptions. It has been discovered that two different high-speed solar wind streams, flare generated streams (FGS) and corotating streams (CS), are equally efficient in reducing cosmic ray intensity. there is a tight relationship between cosmic ray intensity declines seen in high-speed solar flare streams and Forbush decreases, whose amplitudes are not directly connected to an increase in solar wind speed. investigated the effect of high-speed solar wind streams and the IMF on the reduction of cosmic rays and its relationship to other interplanetary and geomagnetic parameters.

FDS and solar wind velocity are connected, and it is possible to detect a steady increase in solar wind velocity prior to the commencement of FDS. The size of FDS cannot, however, be solely determined by the solar wind parameters, as is evident. Forbush decreases of considerable size, on the other hand, correlate to magnetic storms because solar wind disturbances have the ability to produce magnetic storms that inevitably impact cosmic rays. It is clear that HSSW velocity ranges between 400 and 450 km/Sec occur more often. We can also see from these numbers that there are a lot of FDS during the 400-450 Km/Sec HSSW stream periods.

STUDY OF INDIVIDUAL EVENTS OF FORBUSH DECREASE AS ASSOCIATED WITH SOLAR, INTERPLANETARY & GEO MAGNETIC PARAMETERS

In addition to studying the average behavior of several Forbush decline events of galactic cosmic ray intensity, large-magnitude (10%) individual occurrences also reflect a variety of causes. In earlier research of Forbush drop, Agrawal et al. (1972) suggested that massive solar flares and shocks may have a role in causing significant FD occurrences. Numerous researchers have witnessed and examined a small number of distinct FDS occurrences According to recent research by Shrivastava et al. (2011), strong solar flares that occur in the Sun's western hemisphere in conjunction with halo coronal mass ejections result in a significant number of FD occurrences.

We only included FDS in this study that had declined by more than 10%. Forbush dips (FDS) episodes were identified using the count rates of the Oulu neutron monitor, which is located in northern Finland (65.05oN, 25.47oE), during solar cycle 23 (1996–2007). Use of the Omni online data site is for extraterrestrial parameters. Data on CMEs were gathered from observations made using the SOHO LASCO CME catalog The Solar Geophysical Data Book (NOAA/NESDIS/NGDC-STP, Boulder) was used to collect the data on solar flares.

EFFECTS OF MAGNETIC CLOUDS ON GEOMAGNETIC FIELDS VARIATIONS

An enormous interplanetary structure known as the magnetic clouds event was created by transient solar wind ejections. Several scientists periodically look at how magnetic clouds affect the geomagnetic field and cosmic rays investigated the impact of a magnetic cloud event on the geomagnetic field and cosmic rays under three different circumstances. They have come to the conclusion that magnetic clouds connected to the turban shock cause significant drops in cosmic ray intensity and changes in the geomagnetic field. According to many studies the southern component of the interplanetary magnetic field and geomagnetic activity are related. We used 3 and 5 magnetic cloud occurrences from the years 2006 and 2007 for this investigation. A three-stage super EPOCS research approach has been used to examine the short-term impact of magnetic cloud occurrences on geomagnetic activity.

This research was conducted in both 2006 and 2007. On the arrival time of magnetic cloud occurrences, zero days are taken. DST values for both years show significant drops. It shows a dramatic improvement in the earth's geomagnetic field as a result of the action of magnetic clouds. We have selected a few magnetic cloud episodes for additional investigation so that we can see how they relate to interplanetary and geomagnetic indices. The magnetic cloud occurrences on May 21, 2007, and November 19, 2007, were selected for this investigation. These indicators' daily values are displayed 5 days before and 10 days after magnetic cloud occurrences. DST readings on a daily basis have been used to gauge the severity of geomagnetic disturbances. As can be predicted, during times of high plasma speed & high plasma temperature, proton density is noticeably low. After 0 days, IMF BZ moves toward the south. Four to five days after the start of magnetic cloud episodes, plasma speed is still high. DST value drops are a result of intense geomagnetic activity during magnetic cloud episodes.

CONCLUSIONS

Long-term variations in cosmic ray intensity exhibit an 11-year cycle with one peak every cycle. Solar activity and cosmic ray intensity are inversely correlated. The long-term profile of the CRI at different epochs of low and high stiffness value is somewhat greater at A>0 epochs than at A0 epochs. long-term yearly mean profile Cosmic ray intensity (CRI) and solar wind speed (V) exhibit anti-correlation with correlation coefficients (r) of -0.64 in Oulu and -0.323 in Beijing. According to our research, V and CRI are not positively connected.

The annual mean fluctuation of the interplanetary magnetic field (B) and the long-term profile of high-speed solar wind streams exhibit a positive link with a correlation coefficient (r) of 0.33. Despite the fact that there is little correlation between these variables, these variables exhibit comparable patterns. The annual mean fluctuation of the geomagnetic disturbance index (Ap) and the long-term profile of high-speed solar wind streams exhibit a positive link with a correlation coefficient (r) of 0.76. IMF B, solar wind velocity, and geomagnetic activity all rise in response to magnetic cloud episodes.

REFERENCES

1. Shalaby, S. & Darwish, A. & Ayman, Aly & Hanfi, M. & Ambrosino, Fabrizio & Alqahtani, Mohammed & Elshoukrofy, Abeer. (2023). Analysis of a significant Forbush depression of solar cycles 24 and 25 (2008–2021). The European Physical Journal Plus. 138. 10.1140/epjp/s13360-023-04426-y.
2. Мелкумян, Анаид & Melkumyan, Anaid & Белов, Анатолий & Belov, Anatoliy & Абунина, Мария & Abunina, Maria & Абунин, Артем & Abunin, Artem & Ерошенко, Евгения & Eroshenko, Evgeniya & Оленева, Виктория & Oleneva, Viktoria & Янке, Виктор & Yanke, Viktor. (2019). Recurrent and sporadic Forbush decreases during solar cycles 23–24. Solar-Terrestrial Physics. 5. 28-34. 10.12737/stp-51201904.
3. Papailiou, M. & Abunina, Maria & Belov, A. & Eroshenko, E. & Yanke, Victor & Mavromichalaki, H. (2020). Large Forbush Decreases and their Solar Sources: Features and Characteristics. Solar Physics. 295. 10.1007/s11207-020-01735-8.
4. Kharayat, Hema & Prasad, Lalan & Mathpal, Rajesh & Garia, Suman & Bhatt, Beena. (2016). Study of Cosmic Ray Intensity in Relation to the Interplanetary Magnetic Field and Geomagnetic Storms for Solar Cycle 23. Solar Physics. 291. 603-611. 10.1007/s11207-016-0852-y.
5. Mathpal, & Prasad, Lalan & Pokharia, Meena & Bhoj, Chandrashekhar. (2018). Study of cosmic ray intensity in relation to the interplanetary magnetic field and geomagnetic storms for solar cycle 24. Astrophysics and Space Science. 363. 10.1007/s10509-018-3390-2.
6. Melkumyan A A, Belov A V, Abunina M A, Abunin A A, Eroshenko E A, Oleneva V A and Yanke V G 2018 Geomagn. Aeron. 58 154–168
7. Belov A, Eroshenko E, Yanke V, Oleneva V, Abunin A, Abunina M, Papaioannou A and Mavromichalaki H 2018 Sol. Phys. 293 68
8. Yang, S., Zhang, J., Zhu, X., & Song, Q. (2017). Block-induced complex structures building the flare-productive solar active region 12673. Astrophysical Journal Letters, 849(2), L21. https://doi.org/10.3847/2041-8213/aa9476
9. Yermolaev, Y. I., Lodkina, I. G., Nikolaeva, M. Y., & Yermolaev, M. Y. (2014). Influence of the interplanetary driver type on the durations of the main and recovery phases of magnetic storms. Journal of Geophysical Research: Space Physics, 119, 8126–8136. https://doi.org/ 10.1002/2014JA019826
10. Webb, D. F., & Howard, T. A. (2012). Coronal mass ejections: Observations. Living Reviews of Solar Physics, 9(3). https://doi.org/10.12942/lrsp-2012-3
11. Yan, X. L., Wang, J. C., Pan, G. M., Kong, D. F., Xue, Z. K., Yang, L. H., et al. (2018). Successive X-class flares and coronal mass ejections driven by shearing motion and sunspot rotation in active region NOAA 12673. Astrophysical Journal, 856(1), 79. https://doi.org/10.3847/ 1538-4357/aab153
12. Raghav, A., Bhaskar, A., Lotekar, A., Vichare, G., & Yadav, V. (2014). Quantitative understanding of Forbush decrease drivers based on shock-only and CME-only models using global signature of February 14, 1978 event. Journal of Cosmology and Astroparticle Physics, 2014(10), 074. https://doi.org/10.1088/1475-7516/2014/10/074
13. Raghav, A., Shaikh, Z., Bhaskar, A., Datar, G., & Vichare, G. (2017). Forbush decrease: A new perspective with classification. Solar Physics, 292(8), 99.
14. Lingri, D., Mavromichalaki, H., Belov, A., Eroshenko, E., Yanke, V., Abunin, A., & Abunina, M. (2016). Solar activity parameters and associated Forbush decreases during the minimum between cycles 23 and 24 and the ascending phase of cycle 24. Solar Physics, 291(3), 1025–1041.
15. Luhmann, J. G., Mays, M. L., Li, Y., Lee, C. O., Bain, H., Odstrcil, D., et al. (2018). Shock connectivity and the late cycle 24 solar energetic particle events in July and September 2017. Space Weather, 16, 557–568. https://doi.org/10.1029/2018SW001860

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