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Long-term Modulation of Cosmic Ray Intensity in Statistical Relation with Coronal Mass Ejections and Solar Flare Index Parameters

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Abstract
We have studied statistically correlative analysis of long-term modulation of cosmic ray intensity (CRI) with coronal mass ejections and solar flare index for the period of 1997 to 2010 (23rd and 24th solar cycle). Inverse correlation has been found between solar activity parameters cosmic ray intensity (CRI), coronal mass ejections, solar flare index. Negative correlation with correlation coefficient -0.83 has been found between cosmic ray intensity and coronal mass ejections. Negative correlation with correlation coefficient -0.70 has been found between cosmic ray intensity and solar flare index number.
Keywords: Cosmic Ray Intensity, Coronal Mass Ejections and Solar Flare Index.

Introduction

The cosmic ray intensity (CRI) as it is observed from Earth and in Earth's orbit, exhibits an approximate 11-year variation anti correlated with solar activity, with perhaps some time lag, firstly studied by Forbush [1]. Many research groups have tried to express this long-term variation of the galactic cosmic ray intensity through means of appropriate solar indices and geophysical parameters. The modulation of galactic cosmic rays in the heliosphere using theoretical as well as empirical approaches is successful and advanced rapidly [2]. However, an adequate description of the effect of the heliosphere on cosmic rays still does not appear to be a simple task. To be adequate, theoretical models should consider the complex shape and dynamics of the heliospheric current sheet, the heliolatitudinal distribution of the solar wind velocity, boundaries between fast and slow solar wind streams, various sporadic and recurrent structures, and the role of the termination shock and the heliopause. Exarhos and Moussas [3] tried to estimate the magnetic field at the heliospheric termination shock and to study the effects of its temporal variation on the galactic cosmic ray long-term modulation starting from the Parker's model and using in-ecliptic measurements from different Spacecrafts at 1 AU near the Earth. Morishita and Sakukibara [4] tried to estimate the size of the heliosphere derived from the long-term modulation of neutron monitor intensities. Particular consideration of the cosmic ray modulation is given to the correlation of long term cosmic ray variations with different solar-heliospheric parameters and to existing empirical models of cosmic ray intensity, as it is described in the review paper by [5]. An empirical relation based on solar and interplanetary parameters was presented by [6] in order to describe the long-term modulation of cosmic ray intensity during the last solar cycle. Emphasis was given to the different behaviour of the heliospheric parameters compared with the solar ones regarding interesting properties of the cosmic ray intensity modulation.
More recently, an effort has begun to find a relation between the CR modulation and the interplanetary magnetic field (IMF), with which it has been suggested to be highly associated [7]. A relationship between cosmic-ray intensity variations and IMF intensity exists for short time intervals during Forbush effects [8] and in the distant heliosphere [9].The IMF configurations that can produce Forbush decreases in three categories and show that we cannot ignore the importance of the IMF, as it is also strongly related to cosmic-ray fluctuations [10]. From this point of view we can use the IMF instead of, or coexisting with, geomagnetic index values. Furthermore, the heliospheric current sheet (HCS) results in adrift (mostly in the radial direction), which facilitates CR access to the inner heliosphere. It is of interest the study of the HCS tilt effect on cosmic-ray modulation. The heliospheric current sheet and other solar-heliospheric parameters successfully describe the long-term variations of cosmic rays in the past two solar cycles, especially in the epochs of solar maxima [11]. Additionally, since 1996, with the assistance of the LASCO coronagraphs onboard the SOHO spacecraft, there is a better but still incomplete understanding of and more data concerning coronal mass ejections (CMEs), and many authors have started taking into consideration the possible effect that the CMEs may have on cosmic-ray modulation.

Data Analysis

In this work yearly data of Oulu, kiel and Moscow super neutron monitor will be used to determine different phases of cosmic ray intensity. The data of coronal mass ejections (CMEs) will be taken from SOHO large angle

spectrometric, coronagraph (SOHO / LASCO) and extreme ultraviolet imaging telescope (SOHO/EIT) data. The data of X-ray solar flares, solar geophysical data report U.S. Department of commerce NOAA monthly issue and solar STP data (http://www.ngdc.noaa.gov/stp/solar/solardata services.html.) have been used.

Result and Discussion

In this study we have statistically correlative analysis between long term modulation of cosmic ray intensity (CRI) and CMEs, cosmic ray intensity (CRI) and solar flare index has been performed for the period of 1997 to 2010. Inverse correlation has been found between cosmic ray intensity and solar activity parameters CMEs and solar flare index. Negative correlation with correlation coefficient -0.83 has been found between cosmic ray intensity and coronal mass ejections (shown in figure-1). Negative correlation with correlation coefficient -0.70 has been found between cosmic ray intensity and solar flare index (shown in figure-2).

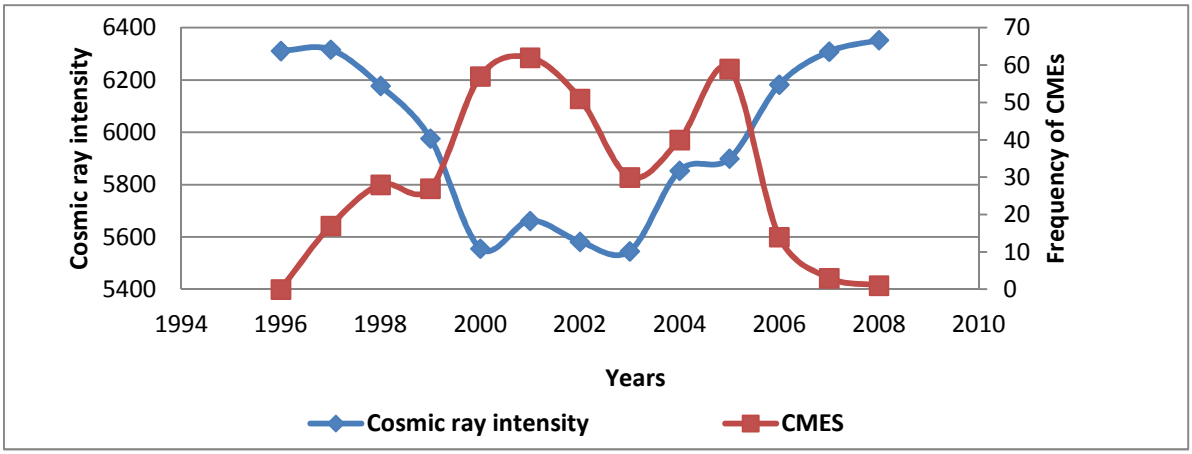

Figure-1 Shows the scatter plot between long-term cosmic ray intensity and frequency of CMEs.

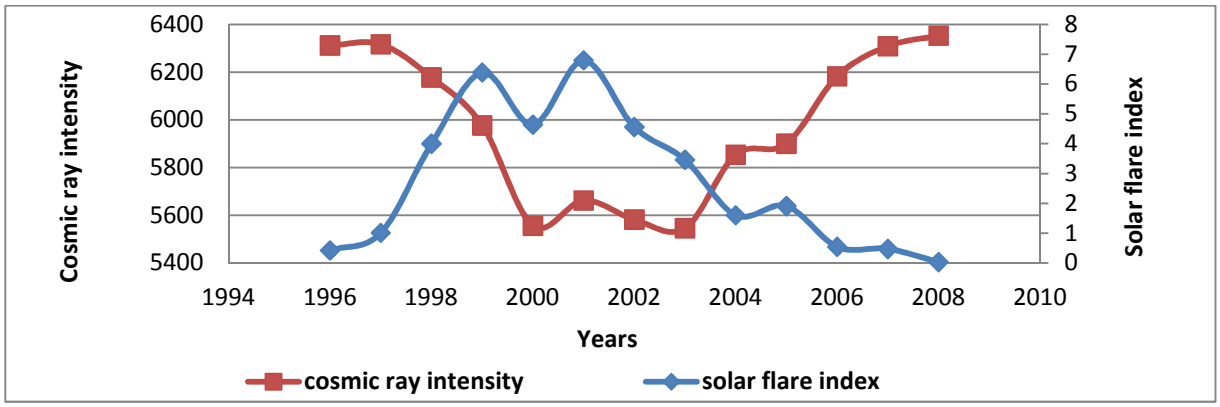

Figure-2 Shows the scatter plot between long-term cosmic ray intensity and solar flare index.

Conclusion

On the basic of observational results and discussions we have surmised important conclusion, which are as follows:

Negative correlation has been found between cosmic ray intensity (CRI) and coronal mass ejections. We have also found negative correlation between cosmic ray intensity (CRI) and solar flare index. From the results it is concluded that cosmic ray intensity (CRI) inverse correlated with Coronal Mass Ejections and solar flare index.

References

[1] S. Forbush, Journal of Geophysical Research, vol. 59, no. 4, p. 525, 1954.
[2] M. S. Potgieter, Space Science Reviews, vol. 83, no. 1-2, pp. 147–158, 1998.
[3] G. Exarhos and X. Moussas, Solar Physics, vol. 187, no. 1, pp. 157–175,1999.
[4] I. Morishita and S. Sakukibara, in Proceedings of the 26th International Cosmic Ray Conference (ICRC ’99), p. 87, 1999.

[5] A. Belov, Space Science Reviews, vol. 93, pp. 79–105, 2000.
[6] E. Paouris, H. Mavromichalaki, A. Belov, R. Gushchina, and V. Yanke, Solar Physics, vol. 280, pp. 255–271, 2012.
[7] H.V. Cane, Wibberenz, G., Richardson, I.G., & Von Rosenvinge, T.T., 15 Geophys. Res. 26(5), 565, 1999.
[8] H. V. Cane, J. Geophys. Res., vol. 98, pp. 3509-3512, 1993.
[9] L. F. Burlaga,, F. B. McDonald, and N. F. Ness, J. Geophys. Res. 98, 1–11, 1993.
[10] K. Kudela,, Storini, M., Hofer, M. Y. & Belov, A., Space Sci. Rev., 93, 153, 2000.
[11] A. V. Belov,, E. A. Eroshenko, V. A. Oleneva, and V. G. Yanke, paper presented at 27th International Cosmic Ray Conference, Int. Union of Pure and Appl. Phys., Hamburg, Germany,2001.

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