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Dependence of Cosmic Rays Intensity on Solar and Solar Wind Plasma Parameters During 1997-2008

KEYWORDS: Cosmic Ray Intensity. Sun spot Numbers Solar Fare Index, Solar WindVelocity Interplanetary Magnetic Fields

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ABSTRACT *We have studied the relation between yearly average of cosmic ray intensity and sunspot numbers, solar flare index, solar wind velocity and interplanetary magnetic fields observed during the period of 1997-2008. We have inferred that the yearly average of cosmic ray intensity is well correlated with yearly average of sunspot numbers, solar flare index, solar wind velocity, and interplanetary magnetic fields. We have obtained negative correlation with correlation coefficient-0.80 between yearly average of sun spot numbers and cosmic ray intensity .-0.67 between yearly average of solar flare index number and cosmic ray intermsity.-053 between yearly average of solar wind velocity and cosmic ray intensity and -0.86 between yearly average of interplanetary magnetic fields and cosmic ray intensity.*

1-Introduction

The cosmic-ray intensity, as is observed from Earth and in Earth's orbit, exhibits anapproximate11-year variation ant correlated with solar activity, with perhaps some time lag, a fact that was firstly studied by Forbush (1958) and by many subsequent researchers(Pomerantz and Dugal, 1974; Perko and Fisk,1983). Many research groups have tried to express this long-term variation of the galactic CR intensity through means of appropriate solar indices and geophysical parameters, such as the sunspot number by Nagashima and Morishita (1980a), solar flares by Hatton (1980) and the geomagnetic index by Chirkov and Kuzmin (1979). Other authors such as Nagashima and Morishita (1980b) took into account the contribution of more than one parameter (solar or geophysical) in the modulation process.Mavromichalaki and Petropoulos (1984) found an empirical relation between the modulated CR intensity during the 20th solar cycle and a combination of the relative sunspot number, the number of proton events and the geomagnetic index Ap, that was later improved by Mavromichalaki and Petropoulos (1987). Exarhos and Moussas (1999a) 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 Parker's model and using in-ecliptic measurements from different spacecraftat 1 AU near the Earth. Morishita and Sakakibara (1999) tried to estimate the size of the heliosphere derived from the long-term modulation of neutron monitor intensities. Usoskin etal. (2002), using a reconstruction of the open solar magnetic flux from sunspot data as an input to a spherically symmetric quasi-steady state model of the helio sphere, calculated the expected intensity of galactic cosmic rays at Earth's orbit. This calculated cosmic-ray intensity is in good agreement with the neutron monitor measurements during the past 50 years. 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(Cane et al., 1999; Belov, 2000. Belov et al.(2001) have shown that the tilt of 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. Many authors have started taking into consideration the possible effect that the CMEs may have on cosmic-ray modulation. Thus, Cane (2000) suggests that CMEs "do not appearto play a major role in long term modulation", whereas others such as Cliver and Ling (2001) suggest that CMEs do play a role in long-term cosmic-ray modulation. In this investigation we have tried to the possible relationship between cosmic ray intensity and solar and solar wind parameters observed during the period of 1997-2008.

2-Experimental data

In this work yearly data of sunspot number, solar flare index, solar wind plasma velocity, interplanetary magnetic fields, and cosmic ray intensity count rates over the period of 1997 to 2008 have been used to determine possible correlation between these parameters. Monthly and hourly data of oulu super neutron monitors over the period 1998-2008 have been used to determine long term variation in cosmic ray intensity. To determine disturbances in solar wind plasma parameters, hourly data of solar wind plasma velocity density temperature average interplanetary magnetic field has been used these data has also been taken from omni web data(http;//omniweb.gsfc.nasa.gov/form/dxi.html)).. 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/solardataservices.html.) have been used.

Table-1 Yearly average of cosmic ray intensity, sunspot numbers ,solar wind velocity and interplanetary magnetic fields.

Years	Cosmic Ray Intensity	Solar flare index	Sunspot numbers	Solar wind Velocity	IMF
1997	6317	1.01	21.5	366.77	5.4
1998	6178	4	64.3	409.82	6.88
1999	5977	6.39	93.3	437.71	6.83
2000	5556	4.64	119.6	444.69	7.07

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2001	5662	6.8	111	425.14	6.9
2002	5582	4.56	104	439.77	7.5
2003	5546	3.46	63.7	532.34	7.44
2004	5854	1.6	40.4	451.1	6.53
2005	5900	1.91	29.8	470.3	6.25
2006	6183	0.54	15.2	428.51	5.04
2007	6309	0.47	7.5	440.15	4.49
2008	6353	0.03	2.9	448.18	4.25

3-Method of analysis and results
In this study, correlative analysis between sunspot numbers (SSN),solar flare index,solar wind velocity, interplanetary magnetic fields and cosmic ray intensity (CRI) has been performed for the period of1977-2008.In this study statistical method of correlation has been used. The correlation is one of the most common and most useful statistics. A correlation is a single number that describes the degree of relationship between two variables. Correlation coefficient, symbolized as r, is a numerical summary of a bivariate relationship and can range from –1.00 to +1.00. Any r that is positive indicates a direct or positive relationship between two measured variables. Negative r indicates indirect or inverse relationship.

The formula for the correlation is

$$r = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\left[N\sum X^2 - (\sum X)^2\right]\left[N\sum Y^2 - (\sum Y)^2\right]}}$$

Where:

N= number of pairs of scores, $\sum x$ = sum of the products of paired scores, $\sum X$ = sum of x scores, $\sum Y$ = sum of y scores, $\sum X^2$ = sum of squared scores, $\sum Y^2$ = sum of squared score

The scale of correlation coefficient is
.8 to 1.0 or -.8 to -1.0 (very large relationship)
.6 to .8 or -.6 to-.8 (large relationship)
.4 to .6 or -.4 to -.6 (good medium relationship)
.2 to .4 or .2 to -.4(weak relationship)
.0 to .2or .0to -.2 (weak or no relationship)

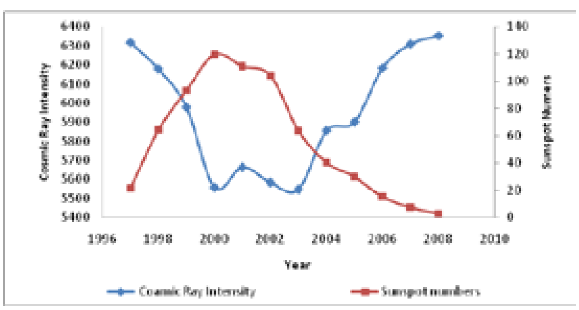

Fig-1-Shows variation of cosmic ray intensity with sun spot number during the period of 1997-2008.

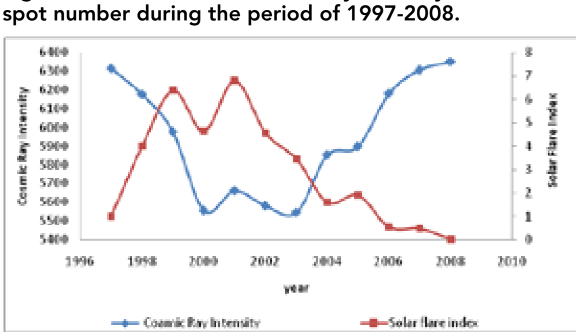

Fig-2-Shows variation of cosmic ray intensity with solar flare index during the period of 1997-2008.

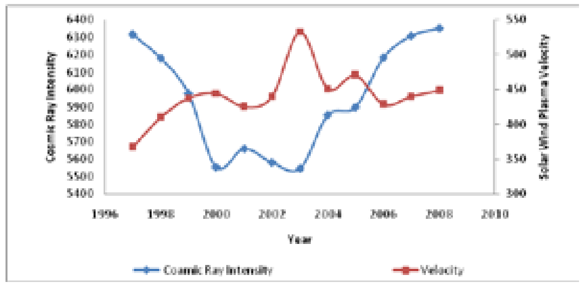

Fig-3-Shows variation of cosmic ray intensity with solar wind plasma velocity during the period of 1997-2008.

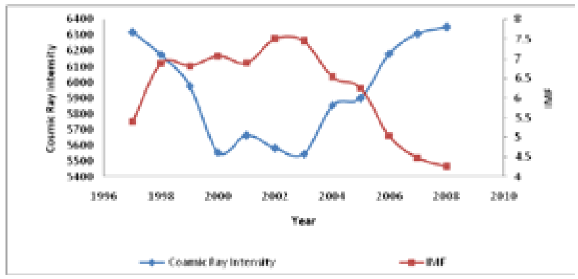

Fig-4-Shows variation of cosmic ray intensity with interplanetary magnetic field during the period of 1997-2008.

Main Results
Very large negative correlation with correlation coefficient -0.80 has been found between sunspot number and cosmic ray intensity

Large negative correlation with correlation coefficient -0.67 has been found between solar flare index number and cosmic ray intensity.

Good medium negative correlation with correlation coefficient -0.53 has been found between solar wind velocity and cosmic ray intensity.

Negative correlation with correlation coefficient -0.86 has been found interplanetary magnetic fields and cosmic ray intensity.

4-Conclusions Conclusion
The long term study confirms results of number of previous observations on links between cosmic ray intensity and solar and solar wind parameters (Pomerantz and Dugal, 1974; Perko and Fisk, Cane et al.,1999; Belov,2000. Belov et al.(2001). Results of this study are also shows that there is strong relationship between sunspot numbers, solar flare index, solar wind velocity, interplanetary magnetic fields and cosmic ray intensity. The significant correlation with correlation coefficient -0.80, -0.67,- 0.53,-0.86 between yearly average of sunspot number ,solar flare index, solar wind velocity and interplanetary magnetic fields [Fig,1,2,3,4]confirms the relationship of solar and solar wind parameters with cosmic ray intensity.

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