
*International Journal Of*

**Recent Scientific Research**

**ISSN: 0976-3031**

**Volume: 7(3) March -2016**


# CORRELATIVE STUDY OF DIFFERENT SOLAR PARAMETERS


**Mishra V K and Mishra A.P**



THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 7, Issue, 3, pp. 9666-9669, March, 2016

International Journal of Recent Scientific Research

RESEARCH ARTICLE

# CORRELATIVE STUDY OF DIFFERENT SOLAR PARAMETERS

**Mishra V K * and Mishra A.P**

Department of Physics, A P S University, Rewa (M P) 486 003

**ARTICLE INFO**

***Article History:***

Received 16th December, 2015
Received in revised form 24th January, 2016
Accepted 23rd February, 2016
Published online 28th March, 2016

***Keywords:***

Sunspot number; Sunspot area; Grouped solar flares; Solar flare index; Solar cycles

**ABSTRACT**

Based on the monthly data of various solar parameters e.g. sunspot numbers (SSN),Solar flux (10.7 cm), sunspot area (SA), grouped solar flares (GSF) and solar flare index (SFI) for the solar cycle 21 to the present cycle 24 (up to year 2015), a detailed correlative study has been performed. It has been found that, on monthly average basis, the SSN are highly correlated with other solar parameters (except SFI) and hence, SSN can be safely used as a solar parameter for any correlative study, until and unless there are some specific reasons to use other easily available solar parameters (or indices). As for as correlation coefficient is concerned, SSN and SFI shows distinctly different behaviour during cycles 23 and 24. Moreover, it has been found that with the progression of solar cycle, from cycle 22 to 24 the slope of the regression line between SSN and GSF or SFI decreases continuously. However, no such unidirectional change is observed in the correlation coefficient.



## INTRODUCTION

The aim of the present study is to extend the earlier study performed by Mishra, *et.al*, (2005) for the last solar cycle 23 and present solar cycle 24. The field of Solar Terrestrial Physics (STP) has greatly advanced in the last 40 years, since the start of the *in-situ* measurements by satellites and deep space probes. Nevertheless, the sun has been continuously observed by using ground-based detectors, which are still very important measuring devices to study the sun and its continuously varying outputs, which modulate cosmic rays, as well as produce disturbances in geomagnetic field. As such, the continuous measurement of the solar variability has been found to be of great importance. In fact, in the last few decades, various indices have been standardized representing various facets of the solar phenomena occurring on the photosphere, chromosphere and corona (Mishra *et al.*, 2005). Currently many solar parameters are easily available to the researchers in the form of well-defined indices for the investigation of Solar-Terrestrial Relationships (STR). These are Sunspot Numbers (SSN), 10.7-cm Solar Flux (or 2800 MHz radio emission), Grouped Solar Flares (GSF), Solar Flare Index (SFI), Sunspot Area, Grouped Sunspot Numbers (GSN) and Coronal Index (CI). Amongst these, the Sunspot Numbers ($R_z$) and 10.7-cm (2800 MHz) Solar Flux are available for a long period of time from the year 1610 and 1947, respectively. The standard way of representing the solar activity is through the variation of sunspot numbers, which in general has an 11-year periodicity. Initially, almost all the investigators have generally used the sunspot number as a representative solar index for various studies in their investigations associating phenomena between the sun and the earth (Dorman and Dorman, 1967; Pomerantz and Duggal, 1971; Rao, 1972; Webber and Lockwood, 1988). Later on, with the availability of other solar indices, either the sunspot number or some other solar indices (arbitrarily) have been used, mostly without assigning any physical reason for the choice of a particular index or the combination of solar indices (Chattopadhyay *et al.*, 2003; Sabbah *et al.*, 2003; David *et al.*, 2002; Valdes and Caballero, 2003; Storini *et.al.*, 1999; Dodson *et al.*, 1974)

In the mean time, with the availability of larger database and correlation studies, it has been recognised that the sunspot number and 10.7-cm solar flux are very highly correlated even on monthly average basis (David *et al.*, 2002). In fact, when the correlation coefficient is ≥ 0.95, between $R_z$ and 10.7-cm solar flux, it would be sufficient to use either of the two solar indices and the use of both will not serve any extra purpose. Nevertheless, still many investigators prefer to use both of these solar indices (monthly or yearly averages) for their correlation studies of the terrestrial phenomena under investigation, though the results expected are bound to be the same (Chattopadhyay *et al.*, 2003; David *et al.*, 2002; Valdes

**Corresponding author:* **Mishra V K**
Department of Physics, A P S University, Rewa (M P) 486 003

and Caballero, 2003). Further, tilt-angle of heliospheric neutral current sheet has also been as solar parameter in the modulation studies of cosmic rays (Gupta, *et al.*, 2006a; Gupta, *et al.*, 2006b; Gupta *et al.*, 2014). Recently, coronal index (CI) of solar activity alongwith SSN has been used to study the long-term modulation of cosmic ray intensity (Mishra and Mishra, 2016).

Earlier it had been found that the slope of regression lines between SSN and SFI/GSF continuously decreased from solar cycles 20 to 23, though their correlations were quite significant in all the solar cycles (Mishra *et al.*, 2005; Gupta *et al.*, 2007). Now the data of various solar parameters is available for complete solar cycle 23 as well as for present solar cycle 24 (up to 2015). Thus it would be pertinent re-examine the results for present solar cycle 24 in comparison to previous solar cycles to choose the proper solar index, which is most likely to be of relevance for the phenomena under investigation, or alternatively use only sunspot number.

## COLLECTION OF DATA

Most of the solar indices (SSN, GSF, SFI, 10.7-cm Solar Flux and GSN) have been taken from the website of NOAA (fttp://fttp.ngdc.noaa.gov/STP/ SOLAR_DATA/….html) available in public domain. Many of these have also been available for long periods of time at much acclaimed solar geophysical data (monthly publication of NOAA). The sunspot area data are available at http://science.noaa.gov/ssl/ pad/solar/greenwch/sunspot_area.txt.

## RESULTS AND DISCUSSION

For most of the studies in the field of STR, initially the sunspot numbers were used, as these were available for a long period of time. Later on, with the availability of 10.7-cm flux, this index has also been used for STR studies, particularly for ionospheric studies. However, in the last 20 years many other solar indices have also been routinely published in the solar geophysical data and hence these and other indices have also been used for various investigations of STR (Kumar and Yadav, 2002; Gupta *et al.*, 2006c; Gupta *et al.*, 2006d). In fact, now the situation has further improved with the availability of data on solar indices through the internet and hence it is pertinent to investigate the relationships amongst these solar indices and stress to define the best-suited solar parameter for different studies in STR. For this purpose, the authors have used the monthly averages of the solar indices mentioned earlier.

The cross-correlations between sunspot number and 10.7-cm solar flux yield very high correlations, which have been found to be for solar cycle 19- 0.994, 20- 0.974, 21- 0.980, 22- 0.981, cycle 23- 0.972 and cycle 24- 0.950 (data only up to Dec. 2015). Except for solar cycle 24 (limited data for 7 years only), for all other solar cycles, the correlation coefficient is > 0.97. From the detailed correlative study between SSN ($R_z$) and 10.7-cm solar flux (cycle 19 to 24) it is obvious that for any STR studies either $R_z$ or 10.7-cm flux can be used, as either of them will yield the same result, because $R_z$ and 10.7-cm flux are very highly correlated.. As such, for investigating the relationships with other solar indices, only sunspot numbers (SSN) have been used.

It was reported that the correlative study between the SSN and Total Sunspot Area (instead of 10.7-cm solar flux) on monthly average basis for solar cycles 19 to 23 yields correlation coefficient > 0.90 in all the cases, with the highest value of 0.97 for solar cycle 19 (Mishra *et al.*, 2005). In the present study, it has been found that the correlation coefficient between SSN and Total Sunspot Area is again high and almost equal for solar cycles 23 and 24 (r = 0.92). As such, it is further advocated that even the use of sunspot area as the solar index will not yield any different result than using sunspot number in the studies of any terrestrial or interplanetary phenomena. Similar conclusions can be drawn from the correlative studies between SSN and the grouped sunspot numbers (GSN). For further study, GSF and SFI have generally been used. The grouped solar flares (GSF) are routinely generated without giving any weightage to the importance and duration of the solar flares, whereas the calculation of the solar flare index (SFI) takes care of these two factors. The SFI was first introduced in 1952 by including $Q = i.t$, to quantify the daily flare activity over 24-hours per day (Kleczek, 1952). Here $i$ represents the intensity scale and $t$ the duration (in minutes) of the flare. It is expected that this relationship gives roughly the total energy emitted by the flares (Kleczek, 1952; Mishra and Tiwari, 2003, Mishra *et al.*, 2006)). The daily flare index $I_f$ has also been defined for the purpose of STR by Sawyer (1967), by the relationship $I_f = (0.76\ \Sigma\ A_d^2/T^*)$. Here $A_d$ represents the flare area in millionths of solar disk and $T^*$ the effective observing time in minutes. Since these -$I_f$ values (equally good) are not available in public domain or published routinely, the authors have restricted themselves to only those indices, which are published or available in public domain.

The cross-plots between SSN and GSF for the solar cycles 21 to 24 (up to March 2009 only) are illustrated in Figure 1. Here it is noticed that the correlation coefficient is not as high as was found for the other three solar indices (10.7-cm solar flux, sunspot area and grouped sunspot numbers). Nevertheless, here again the correlation coefficients are 0.89 or more, with the highest value being 0.96 for solar cycle 21. Here it is observed that correlation coefficients are almost similar for solar cycles 21 and 22 (0.96 and 0.94), whereas it is almost equal for solar cycles 23 and 24(r=0.89). However, it is observed that the regression lines are significantly different from each other. It is also observed that the slope of regression lines is continuously decreasing from cycles 21 to 24.

The use of another solar index (SFI), which is available from solar cycle 21, even though yields high correlation coefficient during solar cycle 21 and 22 (≥ 0.90), but yields a low correlation coefficients during cycles 23 (r=0.77) and 24 ((r=0.64). The cross plot between SSN and SFI is depicted in Figure 2. The data of SFI for solar cycle 24 are available only for the interval 2008-2014. As such, here again it can be emphasized that for any terrestrial relationships, SFI or SSN can be used on monthly average basis during cycles 21 and 22, until and unless there are specific reasons to use GSF or SFI, but during solar cycles 23 and 24 the use of SSN or SFI may yield the different result for any STR studies as the correlation coefficients are ≤ 0.77. However, it may be noted that amongst GSF and SFI, the latter is a better representative of the solar output and its variation (Mishra and Tiwari, 2003).

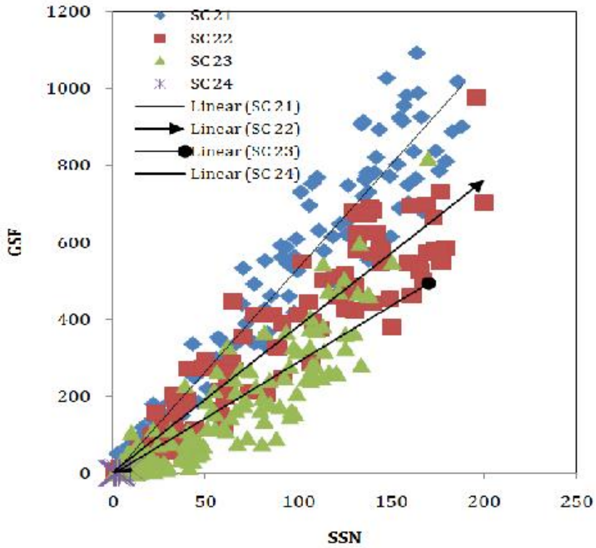


**Figure 1** Shows the cross-plot between monthly sunspot numbers and grouped solar flare for the solar cycles 21 to 24. Significant different behaviour of regression lines for different cycles is clearly apparent.

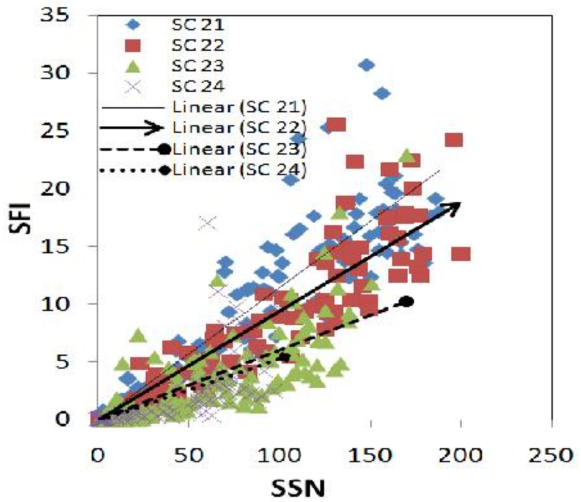


**Figure 2** Shows the cross-plot between monthly sunspot numbers and solar flare index for the solar cycles 21 to 24. Significant different behaviour of regression lines for different cycles is clearly apparent.

Badruddin *et al*., (1983) have also found a different trend of regression lines, when they investigated the solar cycle relationships between SSN and major flare occurrence frequency by choosing flares of higher importance only, on yearly basis. As such, the results of the analysis presented in Figure 1 signifies that with the advancement from solar cycle 21 to 24 the effective slope of the regression lines between SSN and GSF show continuous shift to lower values (i.e. the relationship becomes weaker or softer), though their correlations are quite significant in all the solar cycles. Similar trend of regression lines in the relationship between SSN and SFI has also been found (Figure 2) but the correlation coefficients are significantly different (less) during cycles 23 and 24. The progression of weaker relationship is not understood presently, particularly when no progressive change is found in the correlation coefficient between SSN-GSF, while correlation coefficient between SSN-SFI is significantly low during cycles 23 and 24. However, in future studies this fact seems to be quite important in understanding the choice of solar parameter for studies of terrestrial phenomena.

## CONCLUSIONS

Based on the observational similar results discussed as above following conclusions are drawn.

1. Sunspot numbers (SSN) are highly correlated with Solar Flux (S.F.-10.7 c.m.) and Total sunspot area. Therefore for any correlative study either sunspot number or 10.7 c.m. solar flux or total sunspot area may be used, as either of them will yield the same result.
2. The correlation coefficients between SSN and GSF are almost similar for solar cycles 21 and 22 (0.96 and 0.94), whereas almost equal for solar cycles 23 and 24 (r = .89). However, it is observed that the regression lines are significantly different from each other and slope of regression lines has been found to be continuously decreased from cycles 21 to 24.
3. The correlation coefficient between SSN and another solar index SFI, has been found to be high during solar cycles 21 and 22 (≥ 0.90), but it is significantly different and low during cycles 23 (r = 0.77) and 24 (r= 0.64). However, it is again observed that the regression lines are significantly different from each other and slope of regression lines has been found to be continuously decreased from cycles 21 to 24.
4. Thus, it can be emphasized that for any terrestrial relationships, SFI or SSN can be used on monthly average basis during cycles 21 and 22, but during solar cycles 23 and 24 the use of SSN or SFI may yield the different result for any STR studies as the correlation coefficients are ≤ .077


#### Acknowledgement

The authors are highly grateful to NOAA for providing most of the solar indices data (SSN, GSF, SFI, 10.7-cm Solar Flux and GSN) through their website (fttp://fttp.ngdc.noaa.gov/STP/SOLAR_DATA/….html) available in public domain. The authors are also thankful to the authorities of website http://science.noaa.gov/ssl/pad/solar/greenwch/sunspot_area.txt for providing sunspot area data.


## References


Badruddin, Yadav R. S. and Yadav N. R. (1983) On the major solar flare activity in solar cycles 19, 20 & 21 (1955-79), *Indian J. Radio & Space Phys.* 12 : 124

Chattopadhyay R., Midya S. K. & De U. K. (2003) Statistical study on the temporal correlation of different solar parameters with OI 6300 Å line intensity over Calcutta and its implications, *Indian J Radio & Space Phys*, 32:135.

David H., Hathway Rabert M., Wilson and Edvin J. Reichmann (2002) Grouped sunspot numbers; Sunspot cycle characteristics, *Solar Phys (Netherlands)*, 211:357.

Dodson H. W. Hedeman E. R. and Mohler O. C. (1974) Comparison of activity in solar cycles 18, 19 and 20, *Revs Geophys. and Space Phys. (USA)*, 12:329.

Dorman I. V. and Dorman L. I. (1967) Solar wind properties obtained from the study of 11-year cosmic ray cycle, *J Geophys Res (USA)*, 72: 1513.

Gupta, M., Mishra, V.K. and Mishra, A.P. (2006a) Cosmic ray intensity variations associated with sunspot numbers and tilt angle, *Indian J.Phys.*. 80(7): 697-701

Gupta, M., Mishra, V.K. and Mishra, A.P. (2006b) Correlation of long-term cosmic ray intensity variations with sunspot numbers and tilt angle, *J. Astrophys. Astr*. 27: 455-464

Gupta, M., Mishra, V.K. and Mishra, A.P. (2006c) Long-term modulation of cosmic ray intensity in relation to sunspot numbers and tilt angle, *Indian J. Radio & Space Phys.*, *35*: 387-395

Gupta, M., Mishra, V.K. and Mishra, A.P. (2006d) Study of cosmic ray intensity variations in relation to solar activity for sunspot cycles 19-23, *Indian J. Radio & Space Phys*. 35 : 167-173

Gupta, M., Mishra, V.K. and Mishra, A.P. (2007) Solar activity parameters and their interrelationship: continuous decrease in flare activity from cycles 20 to 23, *J Geophys Res*. 112: A05105, doi: 10.1029/2006 JA012076

Gupta, M., Narang, S.R. Mishra, V.K. and Mishra, A.P. (2014) Correlative Study of Solar Activity and Cosmic Ray Intensity Variations during Present Solar Cycle 24 in Comparison to Previous Solar Cycles, *International Journal of Engineering Technology, Management and Applied Sciences*. 2(6): 103-115

Kleczek J., Catalogue of activity of chromospheric flares, *Publ Inst Centr Astron (Prague)*, no. 22 (1952).

Kumar Santosh and Yadav M. P. (2002) Solar causes of geomagnetic storms, *Indian J. Radio & Space Phys.* 31: 190.

Mishra V. K. and Tiwari D. P. (2003) Long-term association of solar activity and cosmic ray intensity for solar cycles 21 and 22, *Indian J Radio & Space Phys*, 32:65.

Mishra, V.K., Tiwari, D.P., Tiwari, C.M. and Agrawal, S.P. (2005) Comparative study of different solar parameters with sunspot numbers. *Indian J. Radio & Space Phys.*, 34: 13-16

Mishra, V.K. and Mishra, A.P. (2016) Coronal Index of Solar Activity and Long-Term variation of Cosmic Rays, *International Journal of Science, Engineering and Technology Research,* 5(2) : 390-394

Mishra, A.P., Gupta, M. And Mishra, V.K. (2006) Cosmic ray intensity variations in relation with solar flare index and sunspot numbers, *Solar Phys*. 239: 475-491

Pomerantz M. A. and Duggal S. P. (1971) Cosmic ray solar diurnal anisotropy, *Space Sci Rev (Netherlands),* 12: 75.

Rao U. R. (1972) Solar modulation of galactic cosmic radiation, *Space Sci Rev (Netherlands)*, 12 : 719.

Sabbah I., Kudela K., Al Jasar H. K. and Rybansky M. (2003) Dependence of the cosmic ray intensity upon solar coronal hole area, *Geophys Res Abst (EGU)*, 5: 08367.

Sawyer C. B. (1967) A daily index of solar flare activity, *J Geophys. Res. (USA)*, 72: 385.

Storini M., Jakimiec M., Antalova A. and Sykora J. (1999) Cosmic ray modulation versus corona variability during the maximum phase of the 11-year cycle, *Proceedings of 26th International Cosmic Ray Conference*, held at Salt Lake city, Utah, Vol.7, p.151.

Valdes-Galicia J. F. and Caballero-Lopez R. A. (2003) Rigidity dependence and correlations with solar parameters of galactic cosmic ray intensity as seen by neutron monitors, *Proceedings of 28th International Cosmic Ray Conference*, held at Tsukuban, Japan, SH 3.4, p.4107.

Webber W. R. and Lockwood J. A. (1988) Characteristics of the 22-year modulation of cosmic rays as seen by neutron monitors, *J Geophys Res (USA)*, 93: 8735.


*******


**How to cite this article:**

Mishra V K and Mishra A.P.2016, Correlative Study of Different Solar Parameters. *Int J Recent Sci Res.* 7(3), pp. 9666-9669.

ISSN 0976-3031

9 770976 303009 >