IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Comparative Study Of Different Solar Parameters With Sunspot Numbers

Moushmi Jaiswal* M.L. Chouhan* Ravi Katare*

***Department of Physics, Government Model Science College, Jabalpur, India**

Abstract

Based on the monthly data of various solar parameters, e.g. sunspot numbers (SSN), sunspot area, grouped solar flares (GSF) index, SFI for the last four cycles (19 to 22) as well as for the present cycle 23. We have found that on monthly average basis, the SSN are highly co-related with other solar parameters. We have seen that the progression of solar cycle from 20 to 23 the slope of the regression line between SSN and GSF or SFI decreases continuously. However, no such unidirectional change is observed in the corelation coefficient.

Key points: Sunspot numbers (SSN); Sunspot area (photosphere); Ground solar flares (GSF); Solar flare Index; Solar cycles.

Introduction

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 important measuring devices to study the Sun and its continuously varying outputs, which modulate cosmic rays, as well as produce disturbances in geomagnetic field. Infact, in the last few decades, various indices have been standardised representing various facts of the solar phenomena occurring in the photosphere, chromosphere and corona. Recent parameters are easily available to the researchers in the form of well defined indices for the investigation of Solar Terrestrial Relationship (STR). The standard way of representing the solar activity is through the variation of sunspot numbers, which vary with 11 years periodicity.

The first solar cycle, officially recorded known as Solar Cycle 1, began in March 1775 when astronomers started systematically tracking sunspots and solar activity.

On average each Solar Cycle lasts about 11 years. We are currently in Solar Cycle 25, which started in December, 2019 and is expected to continue until around 2030. In the mean time, with the availability of larger database and correlation studies, it has been recognised that the sunspot number and the 10.7cm solar flux are highly correlated even on monthly average basis. Now since many solar indices are available, we have investigated their variability for various solar cycles. They have also compared the results in between the solar cycles to advocate that while using the available solar indices. It would be pertinent to choose the proper solar index., which is most likely to be of relevance for the solar phenomena under investigation, or alternatively use only sunspot number.

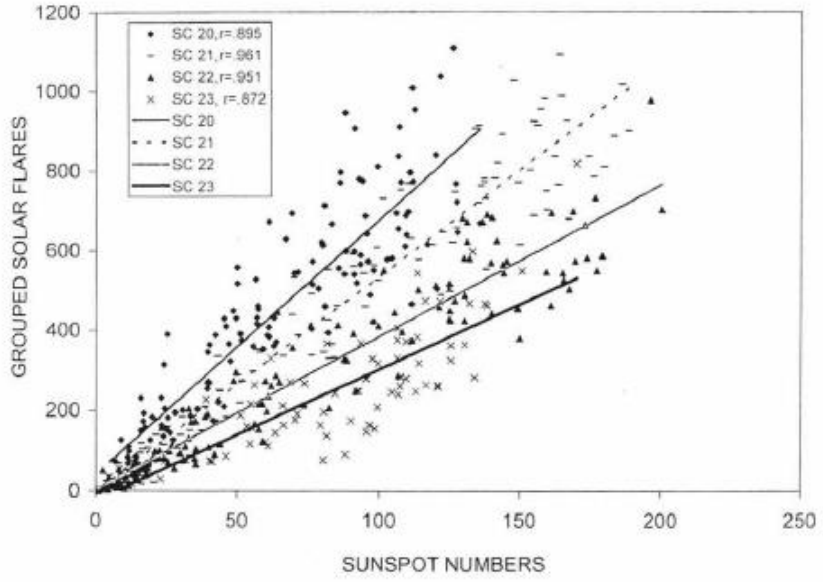

Fig. 1—Shows the cross-plot between monthly sunspot numbers and grouped solar flare for the solar cycles 20 to 23. Significant different behaviour of regression lines for different cycles is clearly apparent.

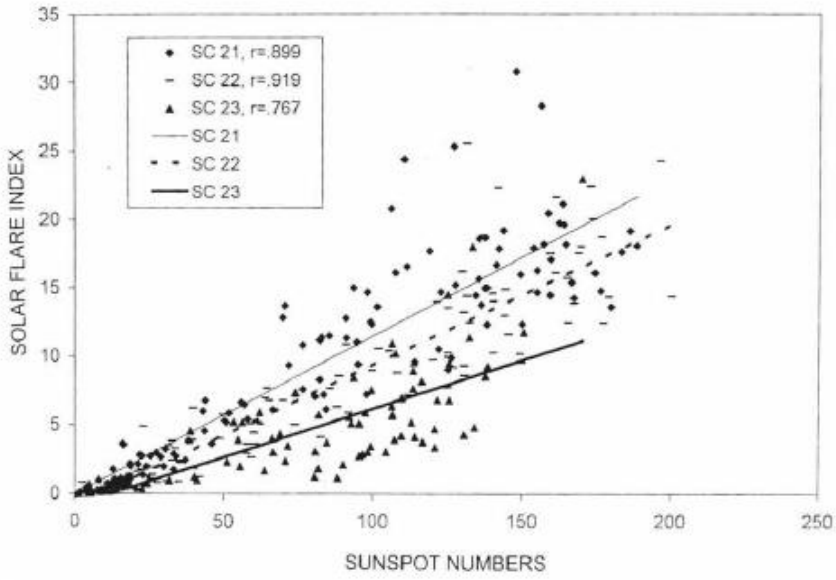

Fig. 2—Shows the cross-plot between monthly sunspot numbers and solar flare index for the solar cycles 21 to 23. Significant different behaviour of regression lines for different cycles is clearly apparent.

Collection of Data

Most of the solar indices (SSN, GSF, SFI, 10.7cm flux, and GSN)have been taken from the website of NOAA (https://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 is available at https://science.noaa.gov/ssl/pad/solar/greenwch/sunspot_are.txt.

Results and Discussions

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 10.7cm 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 other indices have also been used for various investigations of STR. 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 parameter for different studies in STR. 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 (data only up to Dec. 2003) and cycle 23-0.962. Except for solar cycle 23 (limited data for 8 years only), for all other solar cycles, the correlation coefficient is >0.97. Detailed study of all the cross-plots between SSN (R_2) and 10.7-cm solar flux (cycle 19 to 23) it is obvious that for any STR studies either R, or 10.7-cm flux can 'be used, as either of them will yield the same result, because R, and 10.7-cm flux are very highly correlated). The correlation coefficient for the individual solar cycles 19 to 23, the authors have also calculated (and plotted) the regression lines individually for all the solar cycles. It is found that the regression lines between SSN and 10.7-cm flux generally overlap for all the solar cycles. further signifying that on monthly average basis the two indices are indistinguishable. The correlative study between the SSN and Total Sunspot Area (now 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. 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 daily flare index I, has also been defined for the purpose of STR by Sawyer's, by the relationship $I_t = (0.76 \Sigma A_c^2/T^*)$. Here A represents the flare area in millionths of solar disk and T* the effective observing time in minutes. The other three solar indices (10.7-cm solar flux, sunspot area and grouped sunspot numbers). Nevertheless, here again the correlation coefficients are 0.87 or more, with the highest value being 0.96 for solar cycle 21. However, it is observed that the regression lines are significantly different from each other, distinctly different from that for earlier mentioned indices.

We see the regression line for cycle 20 signifies that for the same SSN (100), GSF is high (551), whereas the cycle 23 signifies that for the same sunspot number (100), now the GSF is very significantly low (208). This result has an important implication in the study of STR, which necessitates for the choice of relevant solar index. We use the solar index (SFI), which is available from solar cycle 21, even though yields high correlation coefficient during solar cycle 21 and 22 e 0.90), yields a low correlation coefficient of 0.77 for solar cycle 23, whose data are available only for the interval 1996-2002. Here again it can be emphasized that for any terrestrial relationships, SFI or SSN can be used on monthly average basis, until and unless there are specific reasons to use GSF or SFI.

Results

The results of the analysis presented in Figs 1 and 2 signifies that with the advancement from solar cycle 20 to 23 the effective slope of the regression lines between SSN and GSF/SFI show continuous shift to lower values (ie. the relationship becomes weaker or softer), though their correlations are quite significant in all the solar cycles. The progression of weaker relationship is not understood presently, particularly when no progressive change is found in their correlation coefficient. However, in future studies this fact seems to be quite important in understanding the choice of solar parameter for studies of terrestrial phenomena. Moreover, it is also necessary to give sufficient reasons for the proper choice of one or the other solar index for any STR studies.

References

1. http://www.dxlc.com/solar/cycle1.html
2. Dorman IV & Dorman L. I., Solar wind properties obtained from the study of 11-year cosmic ray cycle, J Geophys Res (USA). 72 (1967) 1513.
3. Pomerantz M A & Duggal S P. Cosmic ray solar diurnal anisotropy, Space Sci Rev (Netherlands). 12 (1971) 75.
4. Rao U R, Solar modulation of galactic cosmic radiation. Space Sci Rev (Netherlands), 12 (1972) 719.
5. Webber W R & Lockwood J A.. Characteristics of the 22-year modulation of cosmic rays as seen by neutron monitors. J Geophys Res (USA). 93 (1988) 8735.

6. Chattopadhyay R. Midya SK & De U K. Statistical study on the temporal correlation of different solar parameters with Ol 6300 A line intensity over Calcutta and its implications. Indian J Radio & Space Phys. 32 (2003) 135

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

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

9. Valdes-Galicia J F & Caballero-Lopez R A. 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. 2003. p.4107.

10. Storini M, Jakimiec M. Antalova A & Sykora J. 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, 1999, p.151.

11. Dodson H W, Hedeman E R & Mohler O C. Comparison of activity in solar cycles 18.19 and 20. Revs Geophys and Space Phys (USA), 12 (1974) 329.

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

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

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

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

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

17. Shrivastava P K. Tiwari R K & Nigam S K. Coronal index of solar activity and cosmic ray intensity variations. Indian J Phys, 75B (2001) 11.