International Journal of Physics and Applications

E-ISSN: 2664-7583
P-ISSN: 2664-7575
IJOS 2023; 5(1): 20-23

www.physicsjournal.in
Received: 03-01-2023
Accepted: 16-03-2023

Kalpana Singh
Institute of Technology & Management Bakshi Ka Talab, Lucknow, Uttar Pradesh, India

Anoop Kumar Singh
Department of Geology, University of Lucknow, Lucknow Uttar Pradesh, India

Corresponding Author:
Kalpana Singh
Institute of Technology & Management Bakshi Ka Talab, Lucknow, Uttar Pradesh, India

Occurrences of different types of Solar Flares with Sunspot number during solar cycle 23-25

Kalpana Singh and Anoop Kumar Singh

DOI: https://doi.org/10.33545/26647575.2023.v5.i2a.73

Abstract
In this study, we analyzed different types (C, M, and X classes) of X-ray solar flares occurring in sunspot groups. We have made an attempt to study the occurrence of (X, M ,C & B)- class flares and Sunspot number during the period 1996 - 2023, the occurrence of total number of (X, M, C & B) class flares are 92, 203, 105 and 06 respectively. This review focuses on recent observations in EUV, soft and hard X-rays, white light, and radio waves. The number of sunspots seen on the surface of the sun, changes from year to year. This rise and fall in sunspot counts is a cycle. The sunspot cycle begins at a maximum and increases as the interior magnetic field becomes increasingly distorted as sunspot activity increases the distance between the equator of the sun and the newly formed bipolar group decreases. Sunspot maximum is recognized by containing numerous sunspots with the latest pair being near 12 and 8 degrees solar latitude north to south.

Keywords: Sunspot number, (X, M, C & B) class flares

1. Introduction

A flare is defined as a sudden, rapid and intense variation in brightness. A solar flare occurs when magnetic energy that has built up in the solar atmosphere is suddenly released. Radiation is emitted across virtually the entire electromagnetic spectrum, from radio - waves at the long wavelength end, through optical emission to X-rays and gamma rays at the short wavelength end. The amount of energy released is the flood of X – rays emitted during a solar flare greatly increases the number of charged particles in the ionosphere. Sunspots are strong magnetic-field concentrations in the solar atmosphere. They appear dark in white-light images because of their low temperature, which is due to suppressed convection in the magnetized plasma regions that leads to lower energy flux into a sunspot as compared to their surroundings. Sunspots are transient phenomenon with a lifetime that can vary from a few days to a few weeks or even months. Complexity of the magnetic fields and the degree of their non-potentiality are responsible for occurrence of solar flares, which are manifested as sudden increase of chromospheric and coronal (as well as photospheric in the case of strong flares) brightening observed on the solar disc over a wide range of solar spectra (Švestka 1966). Flares are indirectly associated with accelerated high-energy particles, coronal mass ejections (CMEs), and geomagnetic storms. Solar material heated to millions of degrees overcomes the resistance of the solar coronal magnetic fields and escapes into interplanetary space during an eruption. The typical amount of energy released during a solar flare can range between 1027 and 1032 erg depending on the flare type (e.g. Fletcher *et al*. 2011). Flares reach their brightness peak in a very short time and then fade gradually away (Singh, 2012) [48]. They affect all the outer layers of the solar atmosphere (photosphere, chromosphere, and corona), as well as the near-space environment and ground-based infrastructures (pipelines and electricity grids, etc.) on the Earth. During these events, electrons, protons, and heavy ions can be accelerated up to speeds close to the speed of light and the magnetic energy is released in all ranges of the electromagnetic spectrum. It is known that faster CMEs are typically associated with more powerful solar flares (Moon *et al*. 2002) [23]. If a CME erupts in the Earthward direction it can produce a strong geomagnetic storm, which may have destructive effect on the Earth and near-space environment infrastructure, such as pipelines, electronic systems, GPS and navigation, satellites, etc. In general, strong flare activity mostly occurs in complex sunspot groups. This causes the level of the ionosphere to shift the pattern of long range radio communication. New Results from the Spectral Observations of Solar Coronal Type II Radio

New Results from the Spectral Observations of Solar Coronal Type II Radio Bursts (Ramesh, R. *et al*., 2022; Singh *et al*., 2017a, b, 2023a, b; Tripathi *et al*., 2013) [28, 43].

2. Selection Criteria & Data analysis

Most solar flares occur in or closed to growing or disturbed active regions, with the largest flare often associated with gamma and delta spot groups. Solar flare can often be grouped into two classes, compact and major compact flares which are usually smaller and more frequent than major flares. Major flares often cover large areas of the sun and cause pelage brightening expanding outward across the solar disk. Flares seen on the solar disk frequently show two areas of emission on either side of magnetic inversion line, because energy released anywhere in the flare tube will rapidly heat surface at its footprints where it meets the surface. The solar active region and associated processes produce a host of phenomena such as emission of soft thermal and hard non – thermal X – ray and different types of bursts in radio region, characterized by different frequency time evolution. Association of radio burst with solar cycle has been discussed in the literature (Gupta *et al*., 2006) In the present study we have analyzed the radio bursts (II type) and their relationship with solar flare occurred during solar cycle 23, 24 & 25. The radio bursts data has been taken from the GOES satellite which is supported by National Geophysical Data Center (NGDC) ftp://ftp:ngdc.noaa.gov/. For the present study we have considered the monthly observed different types (II type) of radio bursts and X class & M class solar flare data from the various reporting stations published in the solar geophysical data. The white-light CME is observed by the Large Angle Spectrometric Coronagraph (LASCO, Brueckner *et al*. 1995) [3] on board the Solar and Heliospheric Observatory (SOHO) and the Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI, Howard *et al*. 2008) on board the Solar Terrestrial Relations Observatory (STEREO). The combined SOHO and STEREO images help us track the CME from the Sun to Earth. We use OMNI data (https://omniweb.gsfc.nasa.gov/) to describe the plasma and magnetic properties of the interplanetary CME.

3. Results and Discussion

The occurrences of total number of X and M class flares have the significant association with the general level of solar activity during solar cycle 23 which shows the positive correlation between the solar cycle 23. Whereas the occurrences of X & M class are not well defined during solar cycle 24 & 25 which shows the indistinct behavior and do not exactly follow the phase of solar cycle. (fig.1 & fig. 2) Singh *et al*., 2017a, b, 2023a,b.

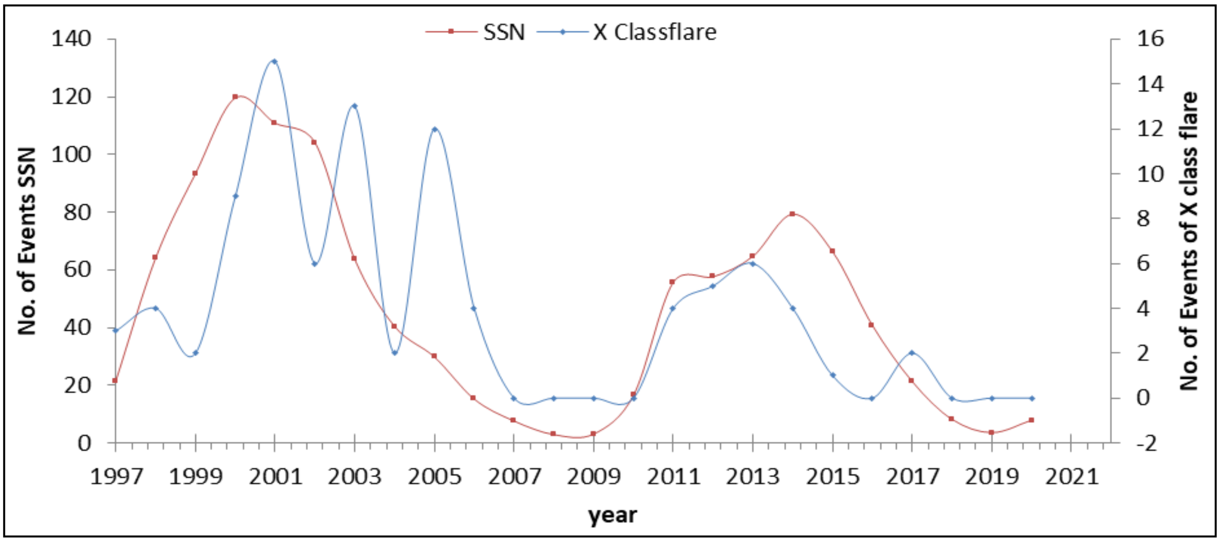

Fig 1: Shows the occurrences of total number of X class flares during solar cycle 23, 24 & Current solar cycle 25.

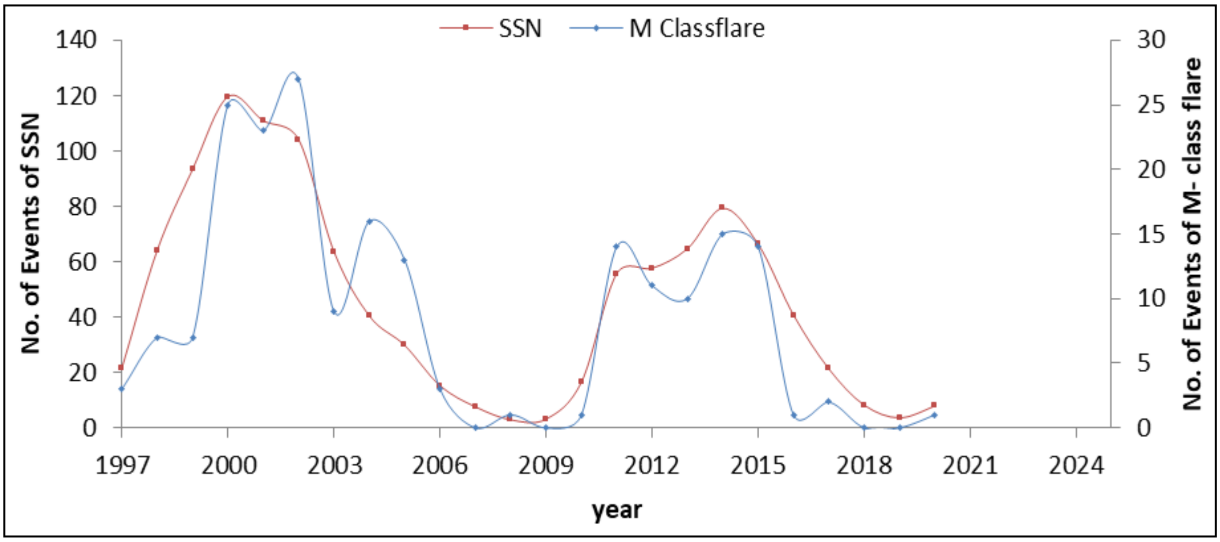

Fig 2: Shows the occurrences of total number of M - class flares during solar cycle 23, 24 & Current solar cycle 25.

The occurrences of total number of C and B class flares have the significant association during solar cycle 23 & 24 which positively follow the general level of solar activity and show the distinct behavior. Whereas the occurrences of C & B class flares are not well defined during current cycle, which shows the indistinct behavior and do not exactly follow the phase of solar cycle 25. (fig.3 & fig. 4).

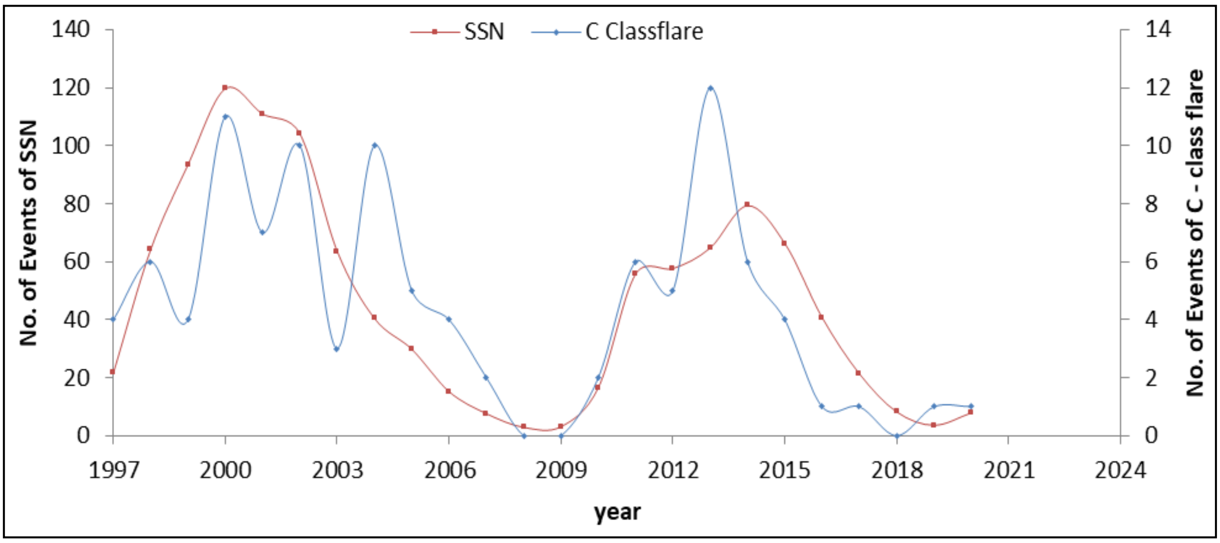

Fig 3: Shows the occurrences of total number of C - class flares during solar cycle 23, 24 & Current solar cycle 25.

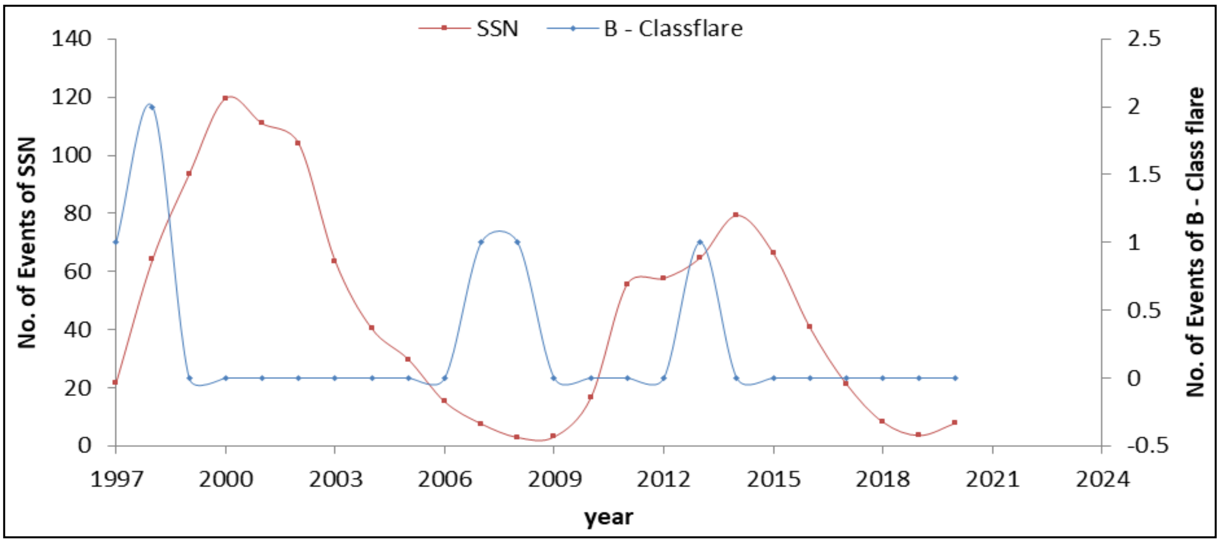

Fig 4: Shows the occurrences of total number of B - class flares during solar cycle 23, 24 & Current solar cycle 25.

4. Conclusions

It is found that the results indicate that the disturbances observed in space near earth are dominated by the level of solar activity in general and the complex and intense magnetic field behavior of solar active regions in particular on the solar surface. Due to the peculiar behavior of particular solar active regions some time disturbances shows deviation from general level of solar activity cycle.

5. References

1. Alissandrakis CE, Nindos A, Patsourakos S, Hillaris AAA. c2021;654:A112.
2. Aurass H., in Coronal Physics from Radio and Space Observations, ed. G. Trottet, Vol. 483 (Berlin: Springer), 1997;483:135.
3. Brueckner GE, Howard RA, Koomen MJ, *et al*. SoPh, 1995;162:357.
4. Cho KS, Bong SC, Kim YH, Moon YJ, *et al*., A&A, 2008;491:873.
5. Cho KS, Moon YJ, Dryer M, *et al*. JGRA. 2005;110:A12101.
6. Claßen HT, Aurass H. A&A. 2002;384:1098
7. Cliver EW, Webb DF, Howard RA. SoPh, 1999;187:89.
8. Cunha-Silva RD, Fernandes FCR, Selhorst CL. A&A, 2015;578:A38.
9. Gopalswamy N. in Solar Eruptions and Energetic Particles, ed.N. Gopalswamy, R. Mewaldt, & J. Torsti,. (New York: Wiley), 2006;165:207
10. Gopalswamy N, Aguilar-Rodriguez E, Yashiro S, *et al*. JGRA. 2005;110:A12S07.
11. Gopalswamy N, Thompson WT, Davila JM, *et al*. SoPh, 2009;259:227
12. Gopalswamy N, Xie H, Mäkelä P, Yashiro S, Akiyama S. AdSpR. 2013;51:1981.
13. Hariharan K, Ramesh R, Kathiravan C. SoPh. 2015;290:2479.
14. Klassen A, Aurass H, Klein KL, Hofmann A, Mann G. A&A. 1999;343:287.
15. Kouloumvakos A, Patsourakos S, Hillaris A, *et al*. SoPh, 2014;289:2123.

16. Kumari A, Ramesh R, Kathiravan C, Gopalswamy N. ApJ. 2017a;843:10.
17. Kumari A, Ramesh R, Kathiravan C, Wang TJ, Gopalswamy N. ApJ, 2019;881:24.
18. Lara A, Gopalswamy N, Nunes S, Muñoz G, Yashiro S. GeoRL, 2003;30:8016.
19. Lin J, Mancuso S, Vourlidas A. ApJ. 2006;649:1110
20. Magdalenić J, Marqué C, Zhukov AN, Vršnak B, Žic T. ApJ. 2010;718:266.
21. Maia D, Pick M, Vourlidas A, Howard R. ApJL. 2000;528:L49.
22. Mann G, Classen T, Aurass H. A&A. 1995;295:775
23. Moon YJ, Choe GS, Wang H, Park YD, Gopalswamy N, Yang G, Yashiro S. ApJ. 2002;581:694
24. Nindos A, Alissandrakis CE, Hillaris A, Preka-Papadema P. A&A. 2011;531:A31.
25. Nindos A, Aurass H, Klein KL, Trottet G. SoPh. 2008;253:3.
26. Pal M, Kumar P, Rani A, Thakur N, Singh K, Mishra AP, Singh S. ISSN: 11775653 (P), 11775661 (O) Publication. 2023;13(3):202317430
27. Pick M, Vilmer N. A&ARv. 2008;16:1.
28. Ramesh R, Anna Lakshmi AM, Kathiravan C, Gopalswamy N, Umapathy S. ApJ, 2012a;752:107
29. Ramesh R, Kathiravan C, Natarajan SS. The Astrophysical Journal. 2022;926:8:5.
30. Ramesh R, Kathiravan C, Sreeja SK, Gopalswamy N. Ap J, 2010b;712:188.
31. Shanmugaraju A, Moon YJ, Cho KS, Dryer M, Umapathy S. 2006.
32. Shanmugaraju A, Moon YJ, Dryer M, Umapathy S. SoPh. 2003;215:161
33. Sheeley NR, Jr., Howard RA, Michels DJ. *et al.*, JGR, 1985;90:163.
34. Singh K, Singh S, Singh AK, Mishra AP. International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181. 2019;8(11):397-401
35. Singh K, Singh S, Singh AK, Mishra AP. International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181, 2019;8(11):374-378.
36. Singh K, Mishra AP. 1050, SH1.4, during; c2011. p. 125-131. DOI:10.7529/ICRC2011/V10/1050
37. Singh K, Tripathi R, Mishra AP. 2010;208:012068. doi:10.1088/1742-6596/208/1/012068
38. Singh S, Pandey A, Singh K, Mishra AP. (Article Id:27702290) ISSN :2051-6851, International journal of Physics and Astronomy. 2013;26:1103-1110.
39. Singh S, Pal M, Kumar P, Ran A, Thakur N, Singh K, Mishra AP. 38th International Cosmic Ray Conference (ICRC2023) and Nagoya, Japan; c2023.
40. Singh S, Pandey AC, Singh K, Mishra AP. International Journal of Pure and Applied Physics. ISSN0973-1776. 2017;13(1):35-43.
41. Singh S, Singh K, Vasishth A, Panday AC, Shabir SA, Mishra AP. IJSRSET. 2017;3:456-460.
42. Subramanian KR, Ebenezer E. A&A. 2006;451:683
43. Tripathi OP, Verma PL, Singh K, AARJMD ISSN: 2319-2801. 2013;I(16):204-210
44. Vršnak B, Cliver EW. SoPh. 2008;253:215.
45. Vršnak B, Aurass H, Magdalenić J, Gopalswamy N. A&A. 2001;377:321.
46. Zucca P, Carley EP, Bloomfield DS, Gallagher PT. A&A. 2014a;564:A47
47. Zucca P, Pick M, Demoulin P, *et al*. ApJ, 2014b;795:68
48. Singh K. Hand Book of Sun and Associated Phenomena. LAP LAMBERT Academic, Publishing Germany, ISBN-10: 3846514500 | ISBN-13: 978-3846514504; c2012.

v