Statistical Influences of Sun Spot Numbers and Solar Radio Fluxes on Geomagnetic Field during the Period 1986-2008

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Abstract: ***Geomagnetic field is highly affected by solar activities e.g. sun spot numbers (SSN). Sun spot numbers are dark and irregular spots which are usually appear in groups on the sun's photosphere and disappear after a few days or week. Sun spot appear dark; since the temperature of sun spot is less as compare to photosphere temperature i.e. we can say that the sun spot numbers are cooler than the surrounding surface of sun (i.e. photosphere).During the period of solar cycle 22 and 23; We have been studied total 383 magnitude of geomagnetic storms (Dst ≤ -50 nT) out of them 251 are moderate, 106 are intense and 26 are severe. From this study we have determined positive correlation between sun spot numbers and total number of magnitude of geomagnetic storms with correlation coefficient 0.68 (0.40,0.80 and 0.65 respectively) between sun spot number and number of magnitude of geomagnetic storms (moderate, intense and severe) and obtained a good correlation for intense and severe geomagnetic storms with sun spot numbers. Also, we have determined positive correlation between solar radio flux and total number of magnitude of geomagnetic storms with correlation coefficient 0.66 (0.38, 0.77 and 0.69 respectively) between solar radio flux and number of magnitude of geomagnetic storms (moderate, intense and severe) and obtained a good correlation for intense and severe geomagnetic storms with solar radio flux. Also we have been found that a very good correlation 0.99 between yearly average sun spot numbers and yearly average solar radio flux.***

Keywords: Geomagnetic Field, Disturbance storm time (Dst), Sunspot Number, Solar Radio Flux.

1. Introduction

The geomagnetic storms are characterized by prolonged depression of the horizontal component of geomagnetic field in the mid to low latitudes in the range of several tens to several hundred nT that lasts from one half to several days. It is defined by changes in dst index. Geomagnetic field is highly affected by solar activities. Sun spot numbers are dark and irregular spots which are usually appear in groups on the sun's photosphere and disappear after a few days or week. Sun spot appear dark; since the temperature of sun spot is less as compare to photosphere temperature i.e. we can say that the sun spot numbers are cooler than the surrounding surface of sun (i.e. photosphere). Solar radio flux is taken from F10.7 which is often expressed in SFU or solar flux units. It represents a measurement of diffuse, non-radiative heating of the coronal plasma trapped by magnetic fields over active regions, and is an excellent indicator of overall solar activity levels. The solar F10.7 cm record extends back to 1947, and is the longest direct record of solar activity available, other than sunspot-related quantities. In this investigation we have identified 383 magnitude of geomagnetic storms associated with disturbance storm time (Dst) which is decreases more than -50 nT; which are observed during 1986-2008, which is a duration of 22nd and 23rd solar cycle. Sun spot and solar radio flux are taken by 27 days average data of Omni data set and converted into yearly average value.

2. Experimental Data

In this investigation hourly Dst indices of geomagnetic field have been used over the period of 1986 to 2008 to determine onset time, maximum depression time and magnitude of geomagnetic storms. This data has been taken from the NSSDC Omni web data system which been created in late 1994 for enhanced access to the near earth solar wind, magnetic field and plasma data of Omni data set, which consists of one hour resolution near earth, solar wind magnetic field and plasma data, energetic proton fluxes and geomagnetic and solar activity indices. To determine the sun spot number and solar radio flux we have used 27 days data from Omni data set and convert it into yearly average sun spot numbers and yearly average solar radio flux.

3. Observations

We have studied the solar activities cycle from 1986 through 2008 which contains two cycle 22 and 23.It is mostly found that the a solar cycle has around 11years solar activities which is playing a important role with sun-earth connection. Solar activity is directly related to space weather and geomagnetic activity does rise and fall along with the solar activity. We have studied sun spot numbers during the period (1986-1996) of solar cycle 22, solar cycle contains two peak values in 1989 and 1991, while in the period (1996-2008) of solar cycle 23, it contains only one peak value in 2000, where sunspot number is in peak position, so these periods (1989-1991) and 2000 are called maximum phase of solar cycle. So, the maximum phase of solar cycle 22 and 23 have been measured during the year 1989-1991and 2000 whereas 1986-1988, 1992-1996-1999 and 2001-2008 are the periods of minimum phase of sun spot number. This is shown in figure 1.

We have studied solar radio flux during the period (1986-1996) of solar cycle 22, solar cycle contains two peak values in 1989 and 1991, while in the period (1996-2008) of solar cycle 23, it contains only one peak value in 2001, where solar radio flux is in peak position, so these periods (1989-

1991) and 2000-2001 are called maximum phase of solar cycle. So, the maximum phase of solar cycle 22 and 23 have been measured during the year 1989-1991and 2000-2001 whereas 1986-1988, 1992-1996-1999 and 2002-2008 are the periods of minimum phase of solar radio flux. This is shown in figure 2.

In the current study, we have used Dst indices of Omni web data system to determine the number of magnitude of geomagnetic storms with various criterion during solar cycle 22 and 23. For the statistical study of geomagnetic storms we have observed 383 magnitude of geomagnetic storms out of them some are moderate, intense and severe with Dst ≤ -50 nT, are occurred during 1986 to 2008. On the basis of above criterion of geomagnetic field disturbances during the period of 1986-2008, we have determined 383 magnitudes of geomagnetic storms. Out of them 251 are moderate geomagnetic storms, 106 are intense geomagnetic storms and 26 are severe geomagnetic storms. According to Loewe and Prolss, geomagnetic storms with respect to their Dst magnitude can be categories in four parts. A geomagnetic storm can be weak (Dst > -50nT), moderate (-100nT < Dst ≤ -50nT), intense (Dst ≤ -100nT), and severe (Dst ≤ -200 nT). Figure 1 gives the yearly averaged sunspot number and figure 2 gives the yearly averaged solar radio flux and figure 3 gives the total number of magnitude of geomagnetic storms <= -50 nT per year. Here, we have analyzed about 383 geomagnetic storms occurred during the period of 1986-2008. The number of geomagnetic storms observed in each year along with the sunspot number is shown in figure 1 and figure 3.

Table 1: gives the Yearly Average Sun spot numbers and Number of magnitude of Geomagnetic storms with classification during the period of 1986-2008.

Year	*Solar Radio Flux*	*Sun Spot Number*	*Moderate GMs*	*Intense GMs*	*Severe GMs*	*Total GMs*
1986	74	13	9	4	1	14
1987	86	31	7	1	0	8
1988	145	104	8	6	0	14
1989	213	157	12	12	4	28
1990	190	141	11	7	1	19
1991	209	147	13	6	4	23
1992	149	94	19	8	1	28
1993	109	54	20	5	0	25
1994	83	27	6	3	1	10
1995	77	17	16	3	0	19
1996	72	8	6	0	0	6
1997	82	22	16	4	0	20
1998	120	67	15	9	1	25
1999	155	94	11	4	1	16
2000	181	121	16	8	3	27
2001	183	111	10	5	3	18
2002	177	103	12	6	0	18
2003	128	63	15	4	2	21
2004	106	40	7	5	2	14
2005	91	29	11	4	2	17
2006	80	15	6	2	0	8
2007	73	7	3	0	0	3
2008	69	3	2	0	0	2

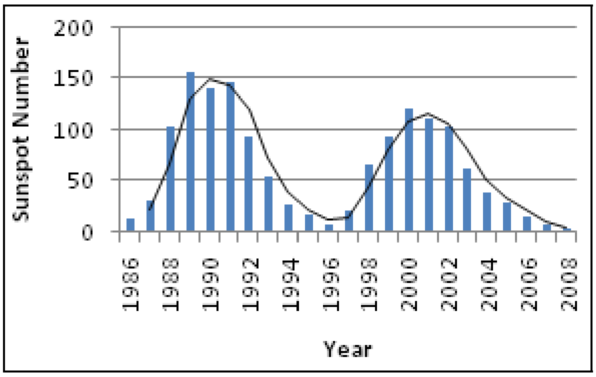

Figure 1: Shows increasing and decreasing yearly average SSNs during cycle 22 and 23

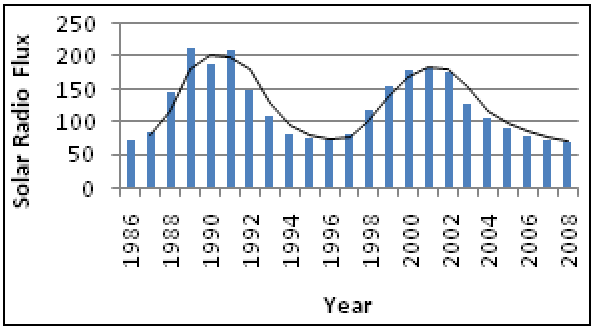

Figure 2: Shows increasing and decreasing yearly average Solar Radio Flux during cycle 22 and 23

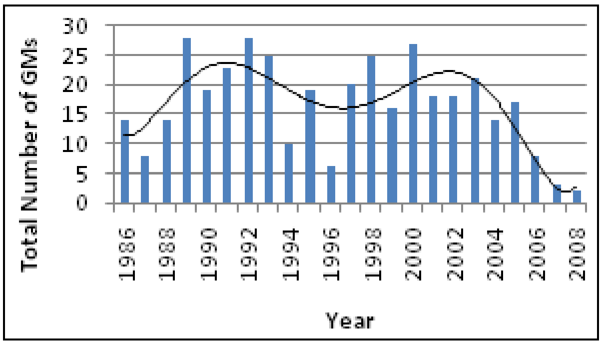

Figure 3: Shows yearly total number of magnitude of Geomagnetic Storms during cycle 22 and 23

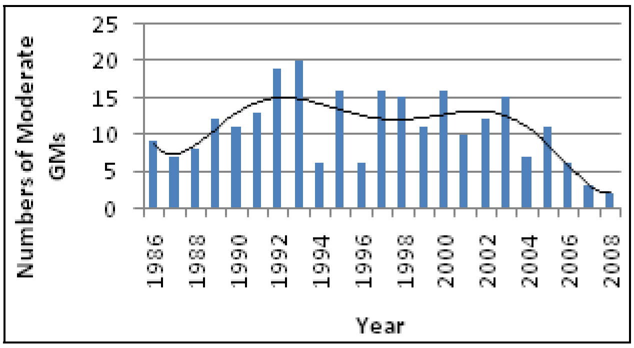

Figure 4: Shows yearly number of magnitude of Moderate Geomagnetic Storms during cycle 22 and 23

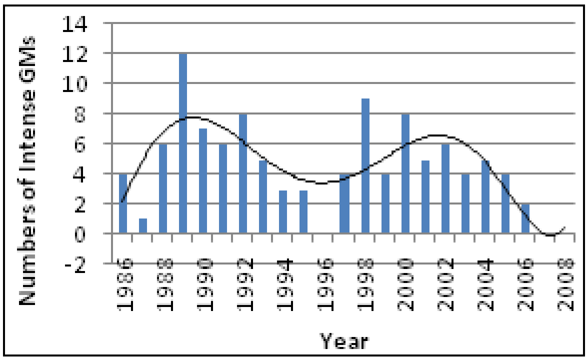

Figure 5: Shows yearly number of magnitude of Intense Geomagnetic Storms during cycle 22 and 23

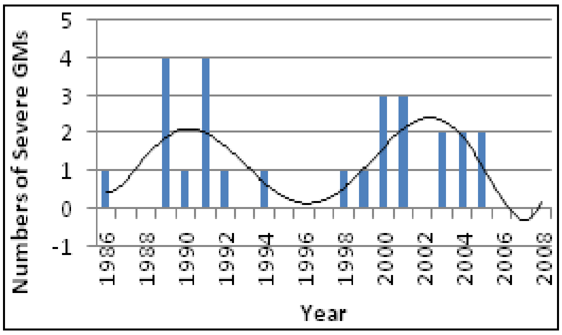

Figure 6: Shows yearly number of magnitude of Severe Geomagnetic Storms during cycle 22 and 23

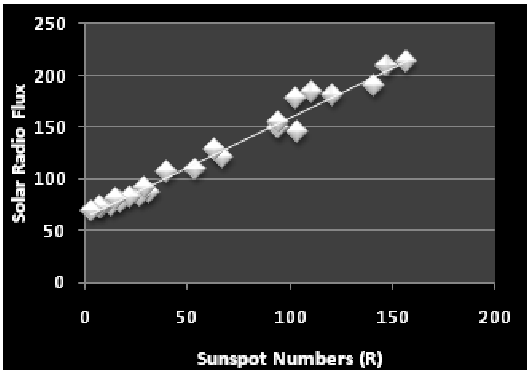

Figure 7: Shows Scatter plot between Sun Spot Number and Solar Radio Flux during cycle 22 and 23

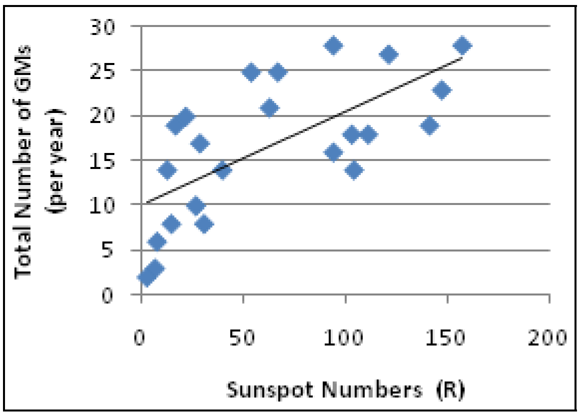

Figure 8: Shows Scatter plot between Sun Spot Number and total Number of Geomagnetic Storms during cycle 22 and 23

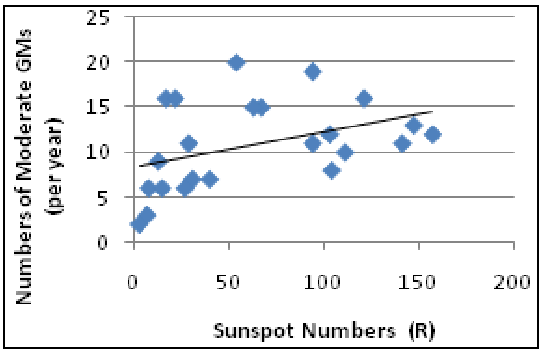

Figure 9: Shows Scatter plot between Sun Spot Number and Number of Moderate Geomagnetic Storms during cycle 22 and 23

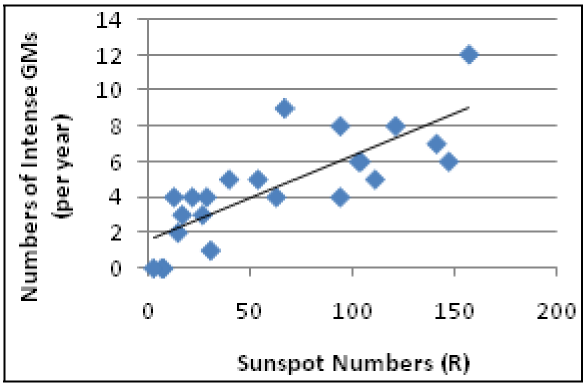

Figure 10: Shows Scatter plot between Sun Spot Number and Number of Intense Geomagnetic Storms during cycle 22 and 23

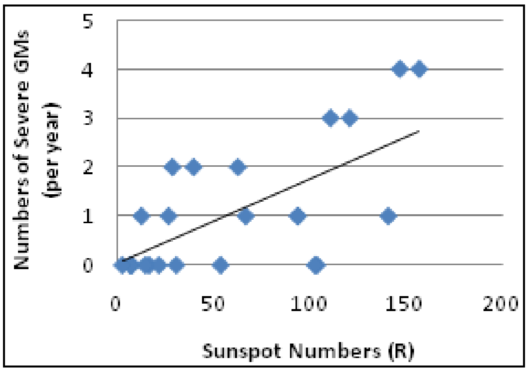

Figure 11: Shows Scatter plot between Sun Spot Number and Number of Severe Geomagnetic Storms during cycle 22 and 23

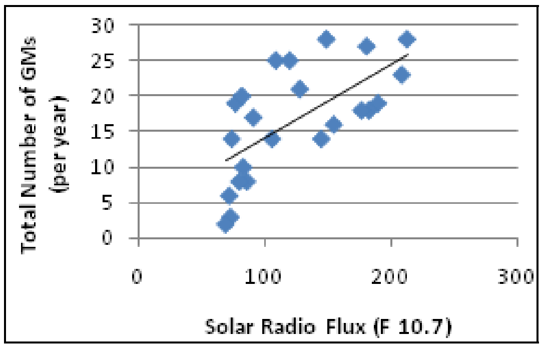

Figure 12: Shows Scatter plot between Solar Radio Flux and total Number of Geomagnetic Storms during cycle 22 and 23

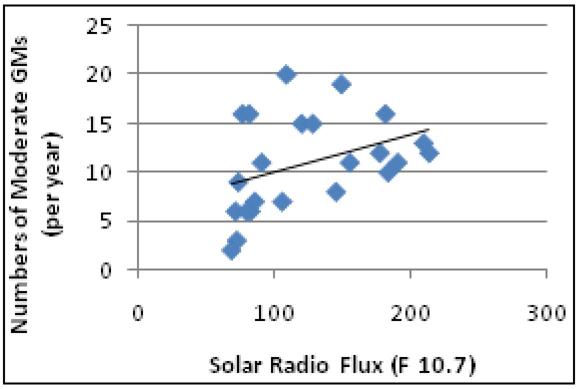

Figure 13: Shows Scatter plot between Solar Radio Flux and Number of Moderate Geomagnetic Storms during cycle 22 and 23

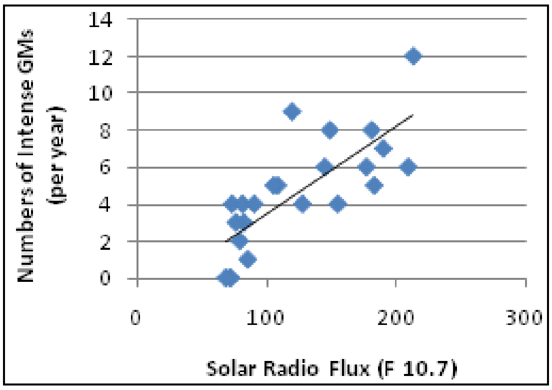

Figure 14: Shows Scatter plot between Solar Radio Flux and Number of Intense Geomagnetic Storms during cycle 22 and 23

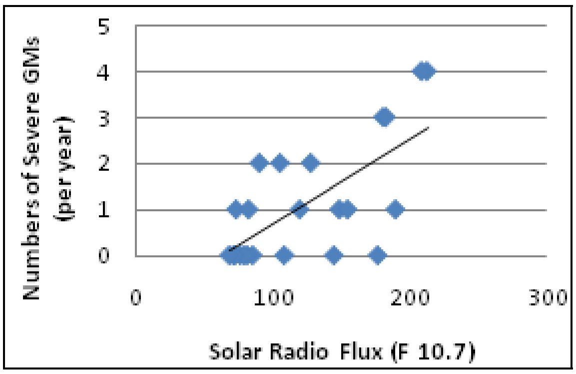

Figure 15: Shows Scatter plot between Solar Radio Flux and Number of Severe Geomagnetic Storms during cycle 22 and 23

4. Results

After the analysis and observation of solar activities and geomagnetic field disturbances during the period of 1986 - 2008, we have obtained 383 magnitudes of geomagnetic storms. Out of them 251 are moderate geomagnetic storms, 106 are intense geomagnetic storms and 26 are severe geomagnetic storms. From the figures we can say that solar activities (like sun spot numbers and solar radio flux) and geomagnetic storms are dependent. From the above study we have been found that the positive correlation 0.68 between yearly average sun spot number and total number of magnitude of geomagnetic storms, 0.40 between yearly average sun spot number and number of moderate geomagnetic storms, 0.80 between yearly average sun spot number and number of intense geomagnetic storms, 0.65 between yearly average sun spot number and number of severe geomagnetic storms.

From the above study we have been found that the positive correlation 0.66 between yearly average Solar radio flux and total number of magnitude of geomagnetic storms, 0.38 between yearly average Solar radio flux and number of moderate geomagnetic storms, 0.77 between yearly average Solar radio flux and number of intense geomagnetic storms, 0.69 between yearly average Solar radio flux and number of severe geomagnetic storms. Also we have been found that a very good correlation 0.99 between yearly average sun spot numbers and yearly average solar radio flux.

5. Conclusion

From the observations and graphical representation we have conclude that The both side of peak value of solar cycle 22 and 23 rising and decline phase of sun spot cycle obtained which is called minimum phase of solar cycle. Which is clearly follow the phase of sun spots cycle. It is also found that maximum numbers of geomagnetic storms have occurred in year 1989 and 1992 during solar cycle 22 while year 1989 and 1991 are the maxima of the solar cycle 22. Similarly, the maximum numbers of geomagnetic storms have occurred in year 2000 during solar cycle 23 which is also a maximum phase of sun spot number during solar cycle 23. Which is exactly follow the phase of solar cycle. It is also clear that intense and severe geomagnetic storms are more effective as compared to moderate geomagnetic storms since majority of intense and severe geomagnetic storm occur during the maximum phase of sunspot. So we can say that the sun spot numbers and solar radio flux are effective on geomagnetic field disturbances because with the change in solar cycle number of magnitude of geomagnetic storms changes.

6. Acknowledgement

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References

[1] Rathore B.S., Kaushik S.C., Firoz K. A., Gupta D. C., Shrivastava A. K., Parashar K.K., and Bhaduriya R.M., "A Correlative Study of Geomagnetic Storms Associated with Solar Wind and IMF Features During Solar Cycle 23" International Journal of Applied Physics and Mathematics, Vol. 1, No. 2, September 2011, 149-154

[2] Tripathi O. P., Verma P.L.," Solar Features and Solar Wind Plasma Parameters with Geomagnetic Storms During The Period of 2002-2006" IJAR, Volume: 3, Issue: 5, May 2013

[3] J. A. Joselyn and P. S. McIntosh, "Disappearing solar filaments: A useful predictor of geomagnetic activity," J. Geophys. Res., 86, 4555, 1981

[4] S.I. Akasofu, "Solar-wind disturbances and the solar wind-magnetosphere energy coupling function," Space Sci. Rev., 34, 173-183, 1983

[5] Shea, M. A and D. F. Smart (1990), A summary of major solar events, solar physics, 127, 297-320

[6] Lakhina G.S., "solar wind-magnetosphere-ionosphere coupling and chaotic dynamics", Surveys in Geophysics, Vol 15, No.6/Nov, pp 703-754 DOI: 10.1007/ BF00666091, 1994.

[7] W. D. Gonzalez, J. A. Joselyn, Y. Kamide, H. W. Kroehl, G. Rostoker, B. T. Tsurutani, V. M. Vasyliunas, "What is A Geomagnetic Storm?," J. Geophys. Res., 99, 5771-5792, 1994

[8] C. A. Loewe and G.W. Prolss, "Classification and mean behaviour of magnetic storms," J. Geophys. Res. 102, 14209, 1997

[9] Kaushik, S.C. and Shrivastava, P.K., Influence of magnetic clouds on interplanetary features, Indian Journal of Physics, 74 B (2), 2000, 159 - 162.

[10] Kaushik, S.C., A study of intense geomagnetic storms and their associated solar and interplanetary causes, Coronal and stellar mass ejections, Proc. IAU Symposium, Cambridge University Press, 2005, p. 454.

[11] Mishra S.K., Tiwari D.P. and Kaushik S. C., Forbush decrease event and associated geomagnetic field variation during space radiation storm, International Journal of Modern Physics – A, 20, No. 29, 2005, 6717.

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