

# Solar Fingerprint in the Geomagnetic Storms

D. K. Tripathi<sup>1</sup> and A. B. Bhattacharya<sup>2\*</sup>

Department of Physics, Narula Institute of Technology, Kolkata, India<sup>1</sup>

Department of Physics, University of Kalyani, Kalyani, India<sup>2</sup>

**ABSTRACT:** The Geomagnetic storm is the disturbance created in the interplanetary space. In this paper the linkage between the geomagnetic storm and average number of sunspot is found by analyzing the data from 1957 to 2009. A high degree of correlation is found between these two phenomena. Also the variation of geomagnetic storm with sunspot number is studied as per solar cycle.

**KEYWORDS:** Geomagnetic storm, sunspot, coronal mass ejections, interplanetary field.

## I. INTRODUCTION

The reconnection of southward magnetic field component of an interplanetary structure with earth's magnetic field due to which solar wind energy enters the magnetosphere is termed as geomagnetic storm [1]. The magnetic field of the Sun also enters to the interplanetary space and is known as interplanetary magnetic field (IMF). The intensity and orientation of the magnetic field associated with solar wind is due to the interaction between slow and fast solar wind coming from solar corona which results in co-rotating interaction region [2-5]. The coronal mass ejection (CME) and co-rotating interaction regions (CIR) are the two possible causes of geomagnetic storms. The geomagnetic storms are generally measured by ring current disturbance storm time (Dst) index. Dst denotes the average change in the horizontal component of earth's magnetic field due to the geomagnetic storm at four low latitude stations [1]. A storm is characterized as weak if  $Dst < -50nT$ , moderate if  $-100nT < Dst < -50nT$ , Intense if  $Dst \geq -100nT$  and severe if  $Dst \geq -200nT$  [6]. As solar variability is measured by number of sunspot, we tried to find some possible linkage between international sunspot number and Dst.

## II. DATA SELECTION

The hourly Dst data is considered from 1957 to 2009. To investigate any link the yearly average of Dst and average number of sunspot is taken. In solar cycle vs Dst analysis, the Dst data is taken from the date cycle started to the date of the completion of the cycle. The yearly average for this analysis does not means average throughout the year, it means the average from or up to that month of the year and yearly mean of average number of sunspot consists of yearly average from or up to the month the cycle extends.

## III. ANALYSES AND RESULTS

Solar cycle 23 showed some special features of slow and prolonged decline phase [7-9]. We have investigated the geomagnetic storms occurred during it. Table I presents the number and types of geomagnetic storm occurred during solar cycle 23.

TABLE I  
LIST OF STORMS OF SOLAR CYCLE 23

Year	Number of moderate storms	Number of intense storms	Number of severe storms
1996	1	1	0
1997	12	06	0
1998	13	07	02
1999	15	04	01

**International Journal of Innovative Research in Science, Engineering and Technology**

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

**National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)**

**On 15<sup>th</sup> to 16<sup>th</sup> February, Organized by**

**Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.**

2000	16	08	04
2001	07	10	03
2002	21	13	0
2003	18	04	02
2004	10	06	01
2005	20	07	02
2006	03	02	0
2007	02	0	0
2008( Up to Jan)	0	0	0

The maximum number of storms occurred in the year 2002 whereas maximum number of severe storms occurred in the year 2000. To see any possible linkage between the occurrence of geomagnetic storm and solar variability the 52 years data of Dst and sunspot number are potted as scatter diagram in Fig.1.

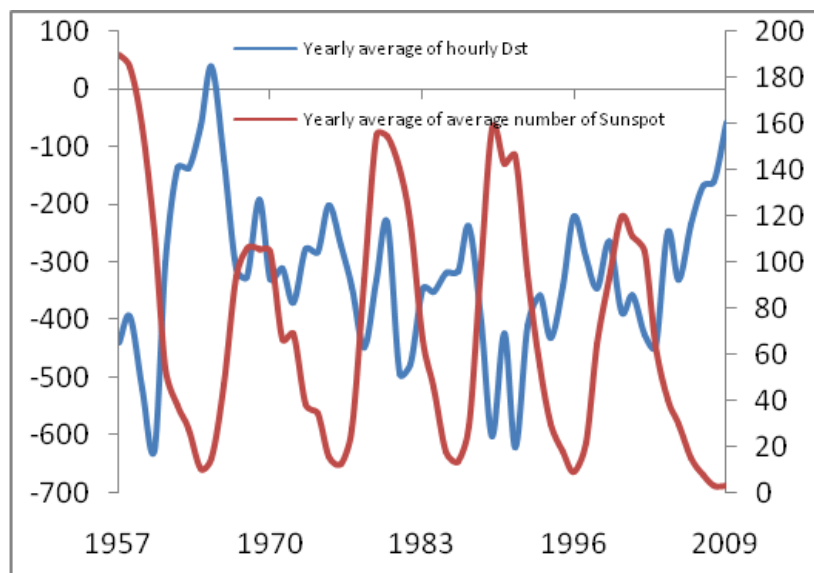


Fig. 1 Yearly average of hourly Dst vs yearly average of average number of sunspot.

Fig.1 indicates the yearly average of hourly Dst is varying in the same manner as the yearly mean of average number of sunspot but there is some time lag between the two. The correlation coefficient is found as 0.65 which shows the strong linkage between these quantities. For critical scrutiny the yearly mean of average number of sunspot is plotted against the yearly sum of hourly Dst in Fig. 2.

**International Journal of Innovative Research in Science, Engineering and Technology**

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

**National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)**

**On 15<sup>th</sup> to 16<sup>th</sup> February, Organized by**

**Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.**

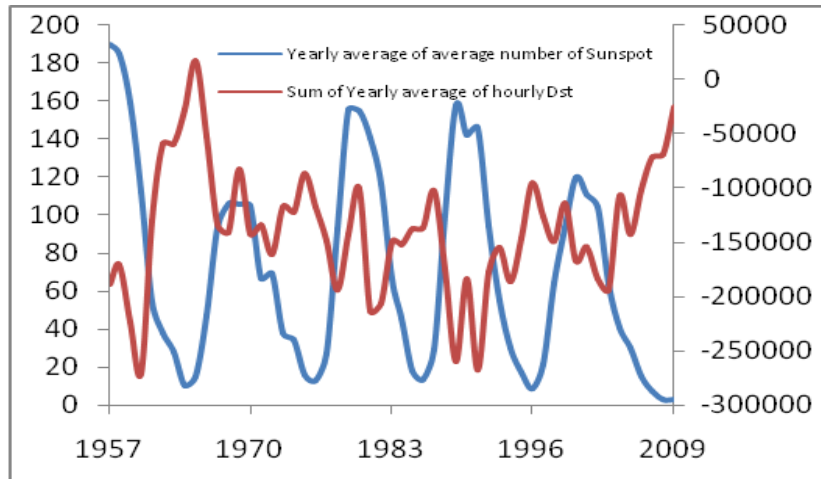


Fig. 2 Yearly mean of average number of sunspot Vs yearly sum of hourly Dst.

The Fig. 2 also shows the same trend variation of Dst with sunspot number. The correlation coefficient between these two quantities is also found as 0.65. The whole data series is divided into the five eleven years time span to see any variation. The result obtained is tabulated in Table II.

Table II  
DURATION vs. KIND OF VARIATION OF THE TWO INDICES

Duration	Kind of Variation
1957-1967	Same but with a time lag
1968-1978	Same but with a time lag
1979-1989	Same but with a time lag
1990-2000	Same but with a time lag
2001-2009	Same but with a time lag

Table II reveals that there is solar influence on geomagnetic storm as yearly average of hourly Dst varies exactly in the same manner as the yearly mean of the average number of sunspot but with some time lag. To verify it with solar cycle we have plotted the Dst and international sunspot number of a particular cycle from date to date and analysed the variation in Table III. A scatter plot of 22<sup>nd</sup> solar cycle which shows the variability of the two quantities is shown in Figure 3.

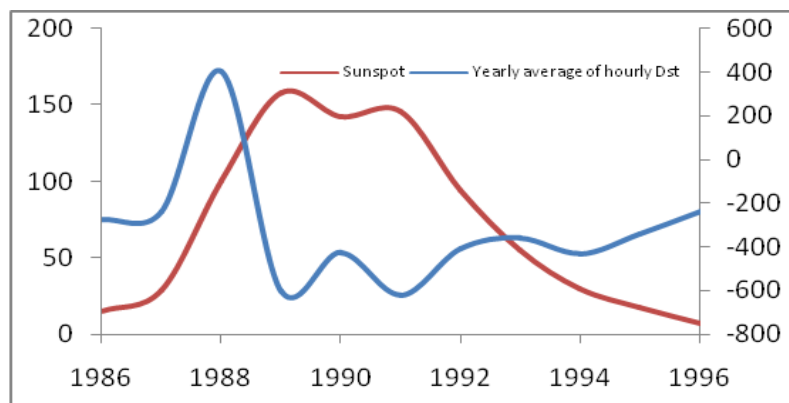


Fig. 3 Variation of yearly average of hourly Dst with yearly average of average number of sunspot.

Table III  
SOLAR CYCLES AND THE VARIATION OF THE Dst AND INTERNATIONAL SUNSPOT NUMBER

Number of Solar Cycle	Duration	Response
19 <sup>th</sup>	4/1954 - 10/1964	Dst shows the same trend variation but with time lag
20 <sup>th</sup>	10/1964 - 6/1974	Dst shows the same trend variation but with time lag
21 <sup>st</sup>	6/1996 - 9/1986	Dst shows the same trend variation but with time lag
22 <sup>nd</sup>	9/1986 - 5/1996	Dst shows the same trend variation but with time lag
23 <sup>rd</sup>	5/1996 - 01/2008	Dst shows the same trend variation but with time lag

#### IV. CONCLUSION

The analysis suggests that there is strong linkage between yearly average of hourly Dst and yearly mean of average number of sunspot which in turn shows that the geomagnetic storm is due to the coronal mass ejection, solar flare effect or any type of change in the magnetic field of the sun [1]. The correlation coefficient between these two quantities is found as 0.65. The low value of correlation coefficient is due to Dst data.

#### ACKNOWLEDGMENT

The hourly Dst index is taken from [http://wdc.kugi.kyoto-u.ac.jp/dst\\_final/index.html](http://wdc.kugi.kyoto-u.ac.jp/dst_final/index.html) and average number of sunspot is taken from [http://solarscience.msfc.nasa.gov/greenwch/spot\\_num.txt](http://solarscience.msfc.nasa.gov/greenwch/spot_num.txt).

#### REFERENCES

- [1] N. Gopalswamy, "CME link to the geomagnetic storms," in *Proc. IAU Symposium No 264*, 2009, p. 119.
- [2] S.I. Akasofu, "Solar-wind disturbances and the solar wind-magnetosphere energy coupling function", *Space Sci. Rev.*, Vol. 34, pp. 173-183, 1983.
- [3] S.C. Kaushik and P.K. Shrivastava, "Influence of magnetic clouds on interplanetary features, *Indian Journal of Physics*", Vol. 74 B (2), pp. 159-162, 2000.
- [4] M. A. Shea and D. F. Smart, "A summary of major solar events", *Solar physics*, Vol. 127, pp. 297-320, 1990.
- [5] B. S. Rathore, S. C. Kaushik, K. A. Firoz, D. C. Gupta, A. K. Shrivastava, K. K. Parashar and R. M. Bhaduriya, "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(2), pp. 149-154, September 2011.
- [6] C. A. Loewe and G. W. Pross, "Classification and mean behavior of magnetic storms", *Journal of Geophysical Research*, Vol. 102 (A7), pp.14209-14213, JULY 1, 1997.
- [7] S. C. Kaushik, "Highly geo-effective solar transients and their associated geomagnetic activities", *Journal of Earth Science Research*, Vol. 1, PP. 35-42, Aug 2013.
- [8] S. K. Pandey and S. C. Dubey, "Characteristic features of large geomagnetic storms observed during solar cycle 23", *Indian Journal of radio and Space Physics*, Vol. 38, pp. 305-312, December 2009.
- [9] E. Echer, W. D. Gonzalez and B. T. Tsurutani, "Interplanetary conditions leading to superintense geomagnetic storms (Dst  $\leq$  -250 nT) during solar cycle 23", *Geophysical Research Letters*, Vol. 35, L06S03, doi:10.1029/2007GL031755,2008.

#### BIOGRAPHY



Dr. D. K. Tripathi obtained M. Sc. and B.Ed. degree from Dr. R. M. L. Avadh University, Faizabad and Ph. D. degree from University of Kalyani, W.B. He is presently an Assistant Professor in the Department of Physics, Narula Institute of Technology. He has published 20 research papers in different international and national journals and symposium. His area of research are radio physics, atmospheric physics, astrophysics and communication electronics.