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The Nano Level Analysis Of Solar Cycle Impact On Severe Geomagnetic Storm (Dst≤-250nt)

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The Sun's magnetically dynamic nature perturbs Earth's geomagnetic field through solar cycle variability. This study investigates the nano-scale temporal dynamics of severe geomagnetic storms (SGMS; Dst≤-250nT) during solar cycles 19-24 (1957-2019). Our analysis reveals a significant correlation between SGMS occurrence and the solar cycle peak, with 91.66% of events occurring within a 4-year window centered on the peak (1 year before to 3 years after). Solar cycles 19-23 exhibit SGMS occurrence rates of 92.85%, 100%, 75%, 100%, and 85.71%, respectively, within this critical period. Notably, solar cycle 24 showed no SGMS. This nano-scale perspective underscores the vulnerability of Work Involving Magnetic Fields (WIMF) – including satellite operations, global positioning systems, directional drilling, power grid management, and radio communication to geomagnetically induced disruptions during this sensitive 4-year interval.

Keywords: SGMS, WIMF, SSN.

Introduction:

The connection between the Sun and Earth is very strong. When sun spot number changes, the Earth's magnetic field is also disturbed and geomagnetic storms generated. A severe geomagnetic storm (Dst≤-250) is a major solar-terrestrial connection event. A severe geomagnetic storm greatly affects satellite, navigation, and GPS. Echer E. el at. [1] studied intense geomagnetic storm and analyzed their relation with interplanetary parameter for space weather forecasting. Gonzalez W.D. et al.[2] this study provided connection between solar cycles and intense geomagnetic storm from 1965 to 1985. G. Le et al. [7] analyze solar cycle distribution of great geomagnetic storm after statistical analysis from 1957 to 2005 it was shown that 83% of great geomagnetic storm occur two year before and three year after the solar peak. Le G. et al. [8] statistical analysis of the major geomagnetic storm from 1957 to 2006 the results obtained to show that, 82% of geomagnetic storms occur at Dst≤ - 100 nT level , about 12% are great GMS ,and about 6% are SGMS. It was also observed that 27% of geomagnetic storm occur during ascending phases of the SC and 73% of GMS occur during descending phase of the SC. Gonzalez et al. [3] examine the distribution of super geomagnetic storm throughout solar cycle, the summary of this paper suggests that super geomagnetic storms occur in all phases of the solar cycle but are more frequent around the solar maximum and during initial descending phase. Rodger C.J. et al.[9], this paper gives historical data of super geomagnetic storm of the last 50 years from 1965 to 2015. It is clear that solar cycle disrupt the geomagnetic field here we referred to the solar earth connection when high intensity and super geomagnetic storm occur the magnetic field based systems on the earth are affected. Gupta et al.[5] solar- terrestrial events and solar cycle phases were studied in this paper during 1956 to 1963, these events occur in the ascending and descending phases except at solar peak. Zang et al. [11] study the Solar terrestrial connection and GMSs are influenced by the combined impact of solar wind and IMF parameter. Katus R. M. et al. [6] in this paper investigate effect of geomagnetic storm on space based function.

In present study we analyzed severe geomagnetic storm data collected from 1957 to 2019 this period cover solar cycle 19-24. After statistical analysis we provide the period between one year before and the three year after the peak of the solar cycle is important and sensitive for satellite launching, GPS, power system, navigation, compass use, magnetic survey, and radio communication. This is the purpose of the paper.

Data Analysis:

In this paper, severe geomagnetic storms are analyzed for the period 1957 to 2019, this period covers solar cycles 19, 20, 21, 22, 23, and 24.Dst value are obtained from the world data centre at Kyoto university database (http://wdc.kugi.kyoto-u.ac.jp/dstdir/).

Table (1) : Severe Geomagnetic Storm (SGMS Dst≤-250) During 1957-2019

Solar Cycle 19 (Jan.1957-Oct.1964) Peak Time Mar.1958

Date	**Time(UT)**	**Dst value (nT)**
22 Jan .1957	23UT	-250
02 Mar.1957	08UT	-255
05 Sep. 1957	04UT	-324
13 Sep. 1957	11UT	-427
23 Sep. 1957	08UT	-303
11 Feb. 1958	12UT	-426
08 Jul. 1958	23UT	-330
04 Sep. 1958	23UT	-302
15 Jul. 1959	20UT	-429
01 Apr.1960	19UT	-327
30 Apr.1960	19UT	-325
07 Oct. 1960	01UT	-287
13 Nov. 1960	10UT	-339
28 Oct. 1961	19UT	-272
Solar Cycle 20 (Oct.1964-	**Jun.1976) Peak Time – Nov.1968**	
25 May 1967	25 (24UT)	-312
26 May 1967	26 (05UT)	-387

08 Mar.1970	08 (23UT)	-284
09 Mar.1970	09 (01UT)	-258
Solar Cycle 21 (Jun.1976-Sep.1986) Peak Time –Dec.1979		
13 Apr.1981	13 (07UT)	-311
14 Jul.1982	14 (02UT)	-325
06 Sep.1982	06 (12UT)	-289
09 Feb.1986	09 (01UT)	-307
Solar Cycle 22 (Sep.1986-May.1996) Peak Time –Jul.1989		
13 Mar. 1989	13 (24UT)	-472
14 Mar. 1989	14 (02UT)	-589
19 Sep.1989	19 (05UT)	-255
21 Oct.1989	21 (17UT)	-268
17 Nov. 1989	17 (23UT)	-266
10 Apr. 1990	10 (19UT)	-281
24 Mar. 1991	24 (24UT)	-281
25 Mar. 1991	25 (01UT)	-298
29 Oct. 1991	29 (08UT)	-254
08 Nov.1991	08 (24UT)	-280
09 Nov.1991	09 (02UT)	-354
10 May.1992	10 (15UT)	-288
Solar Cycle 23 (May 1996-Dec.2008) Peak Time- Apr.2000		
06 Apr. 2000	06 (23UT)	-287
07 Apr. 2000	07 (01UT)	-288
15 Jul. 2000	15 (22UT)	-289
16 Jul. 2000	16 (01UT)	-301
31 Mar. 2001	31 (09UT)	-387
11 Apr. 2001	11 (24UT)	-271
06 Nov. 2001	06 (07UT)	-292
29 Oct. 2003	29 (24UT)	-350
30 Oct. 2003	30 (23UT)	-383
31 Oct. 2003	31 (01UT)	-307
20 Nov. 2003	20 (21UT)	-422
21 Nov.2003	21 (01UT)	-309
08 Nov. 2004	08 (07UT)	-374
10 Nov. 2004	10 (11UT)	-263

Table (2) Number of SGMS for period between one year before and three years after the peak of the SC ,for remaining period and whole period.

Time period	Number of SGMS (Dst≤-250nT)	Ratio

Period between one year before and three year after the peak of SC.	44	91.66%
The remaining period from above	04	08.33%
The whole period (Total)	48	-

Table (3) SGMS (Dst≤-250nT) for different Solar Cycles 19, 20, 21, 22, 23, and 24

Number of SGMS → Number of SC ↓	For period between one year before and three year after the peak of SC.	For period except between one year before and three year after the peak of SC.	For whole period	Ratio for 4 year window
19	13	01	14	92.9%
20	04	00	04	100%
21	03	01	04	75.0%
22	12	00	12	100%
23	12	02	14	85.7%
24	00	00	00	--

Table (4) Number of SGMS in different Months

Month	For period between one year before and three year after the peak of SC.(P4)	For period except between one year before and three year after the peak of SC.(Pe)
Jan	01	00
Feb	02	01
March	08	00
April	07	00
May	03	00
Jun	00	00
July	05	00
Aug	00	00
Sep.	06	00
Oct.	07	00

Nov.	09	02
Dec.	00	00

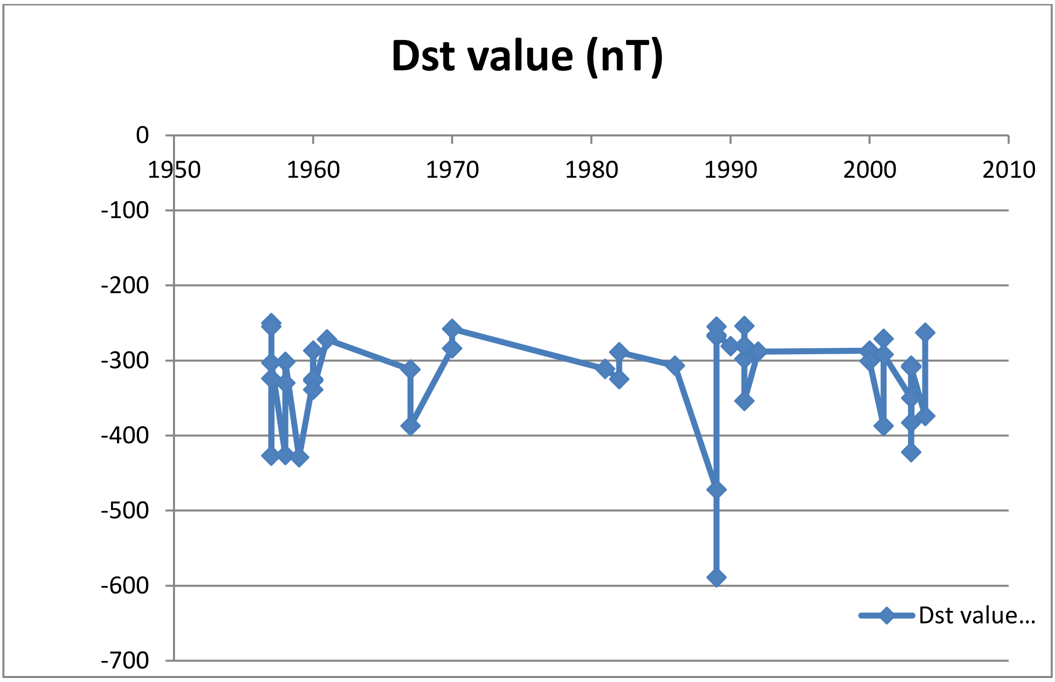

Figure [1] Change in Severe Geomagnetic Storm (SGMS Dst≤-250) During 1957-2019

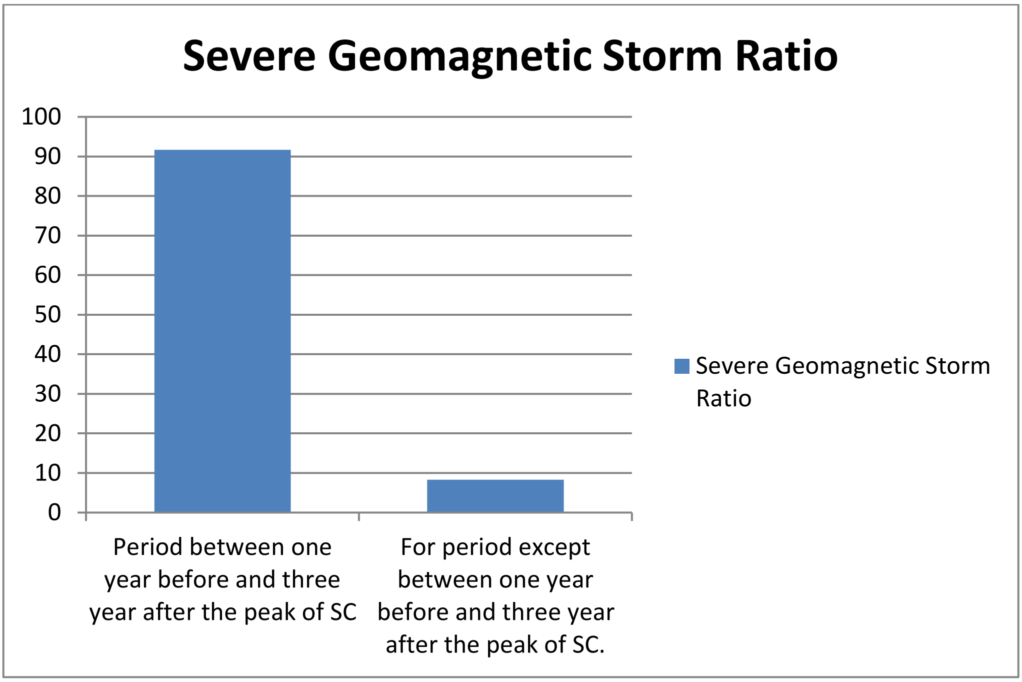

Figure [2] SGMSs Ratio for Period between one year before and three year after the peak of SC, and the remaining period from above.

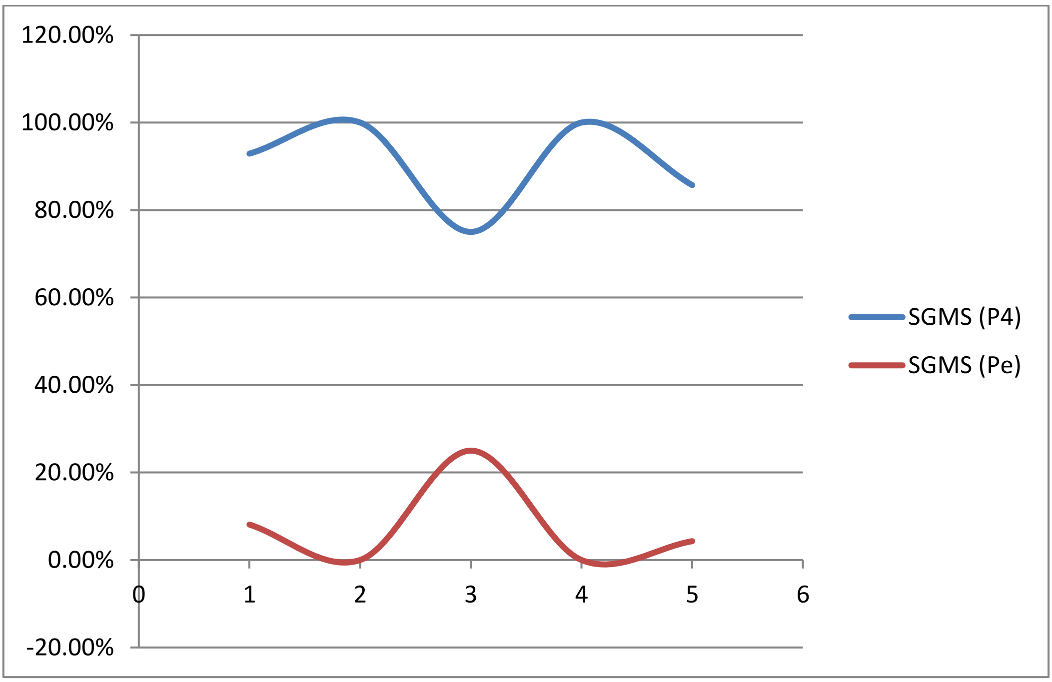

Figure [3] For Solar Cycle 19-23 SGMS [period between one year before and three years after the peak of SC (P4)] and SGMS [Excluding above period (Pe)].

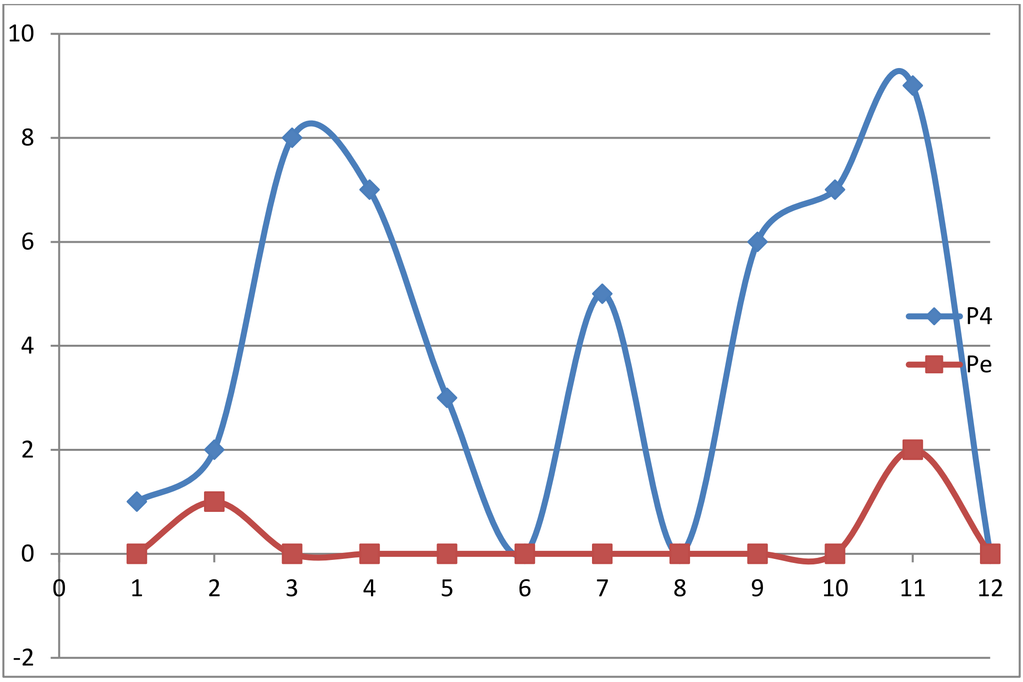

Figure [4] SGMS Change in different Months for period between one year before and three years after the peak of SC (P4)] and excluding above period (Pe).

Table 1 shows the total number of severe geomagnetic storms generated between Solar Cycles 19 to 24, which is 48. Out of these, 44 (91.66%) severe geomagnetic storms occur in the 4 years around the Solar Cycle and only 04 (8.33%) severe geomagnetic storms occur in the remaining period. Table 2 shows the severe geomagnetic storms generated in the 4-year period around the Solar Cycle for Solar Cycles 19 to 24. Their ratio is 92.9%, 100%, 75%, 100%, 85.7% respectively. In Table Third, analysis of severe geomagnetic storm in different months from Solar Cycle 19 to 24 has been done. In the 4 year period around the Solar Cycle, the most severe geomagnetic storms occur in March (08), April (07), July (05), September (06), October (07) and November (09). No severe geomagnetic storm occurs in January, August and December. Except this 4 year period, for the remaining period only 01 severe geomagnetic storm occurs in February, 02 in November and no severe geomagnetic storm occurs in the remaining months.

Result and Discussion:

(1) A total of 48 severe geomagnetic storms have been received during the period 1957 to 2019. Out of which 44 severe geomagnetic storms i.e. 91.66% have occurred between the

period one year before and three years after the peak of the solar cycle. Only 04 geomagnetic storms i.e. 8.33% have occurred in the remaining periods.

(2) In Solar Cycles 19, 20, 21, 22, 23 and 24, about 99.85%, 100%, 75%, 100% and 85.71% respectively severe geomagnetic storms(Dst≤-250)are received between the period one year before and three years after the peak . It is clear that the maximum number of severe geomagnetic storms (Dst≤-250nT) are experienced during the period of one year before and three years after the peak of the solar cycle, i.e., the four year period around the peak of solar cycle.

(3) In the 4 year period around the Solar Cycle, the most severe geomagnetic storms occur in March (08), April (07), July (05), September (06), October (07) and November (09). No severe geomagnetic storm occurs in January, August and December. Except this 4 year period, for the remaining period only 01 severe geomagnetic storm occurs in February, 02 in November and no severe geomagnetic storm occurs in the remaining months.

Conclusion:

In this research paper, statistical analysis of SGMS (Dst≤-250nT) was done for the long period 1957 to 2019 which covers solar cycle 19 to 24. It was found that about 91.66 % SGMS (Dst≤-250nT) are obtained in the period 1 year before and 3 years after the peak of the solar cycle, it means that this period is sensitive and affects the results for WIMF such as satellite launching, global positioning system, power grid system, radio communication, etc. Hence, extra caution is required in this period.

Acknowledgement:

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Reference:

[1] Eicher,E., Gonzalez,W.D., Tsurutani,B.T.Gonzalez,A.L.C. (2008). Interplanetary conditions causing intense geomagnetic storms (Dst≤-100nT) during solar cycle 23(1996-2006).J. Geophys.Res.113,A05221doi:10.1029/2007JA012744.
[2] Gonzalez,W.D.Gonzalez,A.L.C.Tsurutani,B.T. (1990) Planet.Space Sci.38,181.
[3] Gonzalez,W D.,Joselyn,J.A.,Kamide,Y.Kroehl,H.W.,Rostoker,G., Tsurutani,B T.,Vasyliunas,V.M. (1994). what is geomagnetic storms? J.Geophys.Res.99,5771.
[4] Gonzalez, W.D.,Echer,E., Gonzalez,A.L.C., et al. (2011). Extreme geomagnetic storms,recent Gleissberg cycles and space era-superintense storms. J. Atmos.Sol.-Terr. Phys. 73, 1447-1453.
[5] Gupta,M.K.D.,Basu,D.(1965) Journal of Atmospheric and Terrestrial Physics, 27,1029.
[6] Katus,R.M. and Liemohn,M.W. (2017): The effects geomagnetic storms on the Earth´s magnetosphere J. of Geophys Research:Space Phy. Vol. 122(10), 10,223-10,234. doi: 10.1002/2017JA024555.
[7] Le, G., Cai, Z., Wang, H., Zhu, Y. (2012). Solar cycle distribution of great geomagnetic storms. Astrophys Space Sci.151-156.

[8] Le, G., Cai, Z., Wang, H.,Yin,Z.,Li,P. (2013). Solar cycle distribution of major geomagnetic storms. Research in Astron. Astrophys.vol. 13 No. 6, 739-748.
[9] Rodger, C. J., et al. (2017). Super geomagnetic storm historical record of last 50 years. Journal of Geophysical Research: Space Physics, 122(1), 931-941. doi: 10.1002/2016JA023665
[10] Raghuwanshi,D (2024). Solar Cycle Influence on Super Geomagnetic Storm (Dst≤-300nT) : A Quarter-Day Analysis . J. Nanotechnology Perceptions 20 No. S9 (2024) 469–477
[11] Zhang, J., et al. (2007). solar and interplanetary sources of major geomagnetic Storms(Dst≤-100nT) during 1996 - 2005. J. Geophys. Result. 112, A10102doi:10.1029/2007JA012321.