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A study on severe geomagnetic storms and earth's magnetic field H variations, Sunspots and formation of cyclone

M.V.Subramanian* and S.Jagadesan
PG & Research Department of physics, H.H. The Rajah's College, Pudukkottai. Tamilnadu.

ABSTRACT
For our study, we have selected ten severe geomagnetic storms. Which occurred during the years 1994 to 2015. Here great geomagnetic storm of Dst index from -422 nT to -17 nT are taken. These storms are significant not only because of the extremely high magnetic activity but also due to their great impact on the geomagnetosphere. We have studied the relation between severe geomagnetic storms with Earth's magnetic field in horizontal component (H constant) and also studied the relation between Dst index with sunspots number. The H constant data from Kyoto data centre and Dst index, Ap index, Kp index from OMNI data centre. We have found that the Dst is at very lowest level in this storm period, Ap index Kp index are increased in severe geomagnetic storm period and H Constant is at very lowest level in storm period. We have found that geomagnetic storms were induced to form the cyclones within 29 days. The Sunspots numbers are increased to induce to geomagnetic storm within 5 – 15 days.
Keywords: H constant, Dst index, Ap index, Kp index, Sunspot number and Cyclone.

I. INTRODUCTION

Solar output in terms of solar plasma and magnetic field ejected out into interplanetary medium consequently create the perturbation in the geomagnetic field. When these plasma and fields reach the Earth's atmosphere, they produce extra ionization in the sunlit part of the Earth and exhibits peculiar storm time charges in the observed geomagnetic field. Solar wind plasma constantly flowing out of the sun throughout interplanetary space at typical speeds of the order of 400–500 km/s, carrying the Sun's magnetic field frozen into it (Brandt, 1970). Superposed on this ambient plasma, there are transient injections of material, often faster than the solar wind and also carrying strong magnetic field, known as coronal mass ejections. Earth's magnetic field, shields Earth from a variety of interplanetary structures and forms the cavity known as magnetosphere. If the solar wind magnetic field is such that its direction points anti–parallel to Earth's magnetic field, energy can be injected into the magnetosphere, increasing the equatorial ring current, causing geomagnetic storms. Large geomagnetic storms are usually caused by structures in the solar wind having specific features, long durations of strong southward interplanetary magnetic field (IMF) impinging on the Earth's magnetosphere. These features are effective in causing geomagnetic disturbances and are said to be geo effective (Chen, 1996; Chen et al., 1996).

Large geomagnetic storms can cause deleterious effects on space and ground based installations. The variation of Earth's magnetic field, usually expressed through magneto grams,

shows the time variation of declination (D), vertical component (Z) and horizontal component (H). However, for global quantitative representation, various geomagnetic indices have been introduced [R. Tripathi and A. P. Mishra.,2006].

Within 24 – 48 hours of a solar flare or intense solar activity, a plasma cloud of electrons and protons ejected from an active solar region, together with an embedded magnetic field, arrives at the earth. If the direction of the interplanetary magnetic field is favorable, and if the solar plasma has sufficient energy density, field and particle energy enters the earth's environment and perturbs its electromagnetic state. it is the H component which best reflects the storm signature on the geomagnetic field, and the effect is most prominent at the equator. The first onslaught of the solar plasma on the earth's magnetopause manifests as a shock wave which leaves its signature on the ground geomagnetic field as a sharp rise in H called the storm sudden commencement [Grija rajaram, 1998].

Geomagnetic storms are disturbances in the geomagnetic field and in the magnetosphere that have been studied for more than 200 years (e.g. von Humboldt 1808; Chapman and Bartels,1940; Rostoker and Falthammar1967; Gonzalez and Tsurutani,1987; Gonzalez etal.,1994, 2007; Tsurutani etal.,1988, 1997, 2006a, 2006b; Echer and Gonzalez,2004; Gonzalez and Echer,2005; Guarnieri etal.,2006; Echer etal.,2005a, 2008).

Geomagnetic storms are usually defined by ground-based, low-latitude geo- magnetic field horizontal component (H) variations. The magnetic variations are proxies (and indirect measures) for disturbances in the plasma populations and current systems present in the magnetosphere (Dessler and Parker,1959; Sckopke, 1966). It is well known that the primary inter planetary cause of geomagnetic storms is the presence of a southward interplanetary magnetic field structure in the solar wind (Rostoker and Falthammar1967; Hirshberg and Colburn,1969; Gonzalez and Tsurutani1987; Tsurutani and Gonzalez,1987; Tsurutani etal.,1988; Gonzalez et al.1994, 1994; Echer etal.,2005a, 2005b). This magnetic field orientation allows magnetic reconnection (Dungey, 1961; Gonzalez and Mozer,1974; Akasofu, 1981) and energy transfer from the solar wind to the Earth's magnetosphere.

Geomagnetic storms are characterized by enhanced particle fluxes in the radiation belts. These enhanced fluxes can be indirectly measured by decreases in the Earth's magnetic field horizontal component caused by the diamagnetic effect generated by the azimuthal circulation of the ring current particles. A standard measure of this is the Dst index, which is approximately proportional to the total kinetic energy of 20–200 KeV particles flowing westwardly (as viewed from the northern hemisphere) in the region of ~ 2– 6 terrestrial radii(R_E), during the storm's main and recovery phases. The inner edge of the ring current is located at $4R_E$ or less from the Earth's surface during intense storms. For lesser intensity storms, the ring current is located further away from the Earth (Gonzalez etal.,1994; Daglis and Thorne,1999; Echer etal.,2005a).

The Dst index is derived from hourly averages of the horizontal component of the geo-magnetic field, usually recorded at four or six low-latitude observatories. Dst is the average of the H fields after the average solar quiet variation and the permanent magnetic field have been subtracted from the disturbed one (Sugiura, 1964).

The various magnetic fields, more notably its shot-term components, is due to disturbances in the earth's electromagnetic environment caused by solar activity. The degree of disturbance in the magnetic field is indicated by what are called indices of geomagnetic activity. These are essentially indices of energy coupling between the environments of the sun and earth. There have been several such indices devised for research and application purpose. The more prominent of these are Dst, Ap, kp, Cp and AE index based on geomagnetic pulsation [Grija rajaram, 1998].

The Kp scale is essentially a logarithmic one. It is often necessary to have a linear scale for assessing the level of magnetic activity, especially for correlating with other geophysical phenomena. This is provided by Ap index (index of planetary amplitude), which is derived from the Kp index. [Grija rajaram, 1998].

The aim of the study presented in this paper is to analyze various characteristics of severe geomagnetic storms days and their association with different horizontal component (H), Ap index, Kp index and Dst index. We have studied the relation between sunspots numbers and geomagnetic storm and also relation between geomagnetic storm and formation of cyclone.

II. SELECTION CRITERIA AND DATA ANALYSIS

Severe geomagnetic storms that occurred during 1994–2015, have been compiled. In the present study, we have analyzed in detail all those large geomagnetic storms (ten) (https://www.spaceweatherlive.com/en/auroral-activity/top-50-geomagnetic-storms) which are associated with Dst decreases of less than –100nT and are observed during the period 1994 –2015. The hourly values of geomagnetic Ap index, Dst index, kp index, has been obtained by OMNI data services. The hourly values of Earth's magnetic field in horizontal component (H) have been measured by Kyoto data centre. Station name, station code, latitude and longitude details (Table 1).

III. RESULTS AND DISCUSSION

The characteristic features of all those severe geomagnetic storms, which are compiled in Table 3, are described here. In the following section we have discussed some of the great events, illustrating various features of H constant, Ap index, Dst index and kp index. The Correlation between sunspots number, cyclone and geomagnetic field are shown in table2.

August 27 (year 1998) geomagnetic storm

The variations of geomagnetic parameters are shown in a figure 1, for the period of 26 to 28 August, 1998. The geomagnetic storm day was 27^{th} August at 22 hours. The Earth magnetic field was measured in six stations. The stations were Alibag, Chengdu, Chichijima, Pondicherry, Tirunelveli and Ujjain. In Alibag, H constant variation was 389nT. Followed by Chengdu was 175nT, Chichijima was 517nT, Pondicherry was 422nT, Tirunelveli was 382nT and Ujjain was -31nT.

The Ap index was at peak level at 179nT seen in the Figure 9. The Kp index was at peak level at 80nT. The Dst index was very lowest level at -155nT.

We found that with a gap of 8 – 25 days after the geomagnetic storm induced atmospheric sea level pressure and formed the cyclone. Five cyclones in Atlantic region were formed. The Sunspots number 12th was 159 as seen in the Figure 17. After 15 days geomagnetic storms was formed. The sunspots number increased to induce the geomagnetic storm.

July 15 (year 2000) geomagnetic storm

Figure 2 shows the variation of various interplanetary geomagnetic parameters, for the period of 14 to 16 July 2000 and storm day was 15th July 2000 at 22 hours. Earth magnetic field was observed in five stations. The stations were Alibag, chichijima, Moscow, Ujjain and Visakhapatnam. In Alibag, H constant variation was 255nT. In chichijima, H constant variation was 432nT. After Moscow was -458nT, Ujjain was -165nT and Visakhapatnam was 450nT.

We found that the Ap index was peak level at 400nT seen in the Figure 10. The Kp index was at peak level at 90nT. The Dst index was at the very lowest level at -301nT.

We found that after geomagnetic storm induced atmospheric sea level pressure. Six cyclones in Atlantic region were formed, three cyclones in pacific region were formed and seven cyclones in west north pacific region were formed. The cyclone formed after occurred the geomagnetic storm between 2 - 28 days. At the days sunspots number seen in the Figure 18. July 10th was 309 and peak value, after five days geomagnetic storms were formed. The sunspots number increased to induce the geomagnetic storm.

March 31 (year 2001) geomagnetic storm

The variations of geomagnetic parameters shown in figure 3, for the period of March 30 to April 1, 2001. The Earth magnetic field was 31th March at 09 hours. The Storm was measured in nine stations. The stations were Alibag, Chengdu, Chichijima, Moscow, Nagpur, Pondicherry, Tirunelveli, Ujjain and Visakhapatnam. In Alibag, H constant variation was 291nT. Followed by Chengdu was -54nT, Chichijima was 273nT, Moscow was -151nT, Nagpur was 200nT, Pondicherry was 437nT, Tirunelveli was 198nT, Ujjain was -147nT and Visakhapatnam was 304nT.

The Ap index was peak level at 300nT as seen in the Figure 11. The Kp index was peak level at 87nT. The Dst index was at very lowest level at -387nT.

We found that with a gap of 17 days after occurred the geomagnetic storm induced atmospheric sea level pressure. One cyclone in pacific region was formed.

The Sunspots number 16th was 352 as seen in the Figure 19. After 15 days, geomagnetic storms were formed. The sunspots number increased to induce the geomagnetic storm.

November 06 (year 2001) geomagnetic storm

The variation of geomagnetic parameters shown in a figure 4, for the period of 5th to 7th November, 2001. The geomagnetic storm day was 6th November at 5 hours. Earth magnetic field was measured in five stations. The stations were chichijima, Nagpur, Pondicherry, Tirunelveli and Visakhapatnam. In chichijima, H constant variation was 545nT. Followed by Nagpur was 246nT Pondicherry was 407nT, Tirunelveli was 478nT and Visakhapatnam was 482nT.

The Ap index was peak level at 300nT seen in the Figure 12. The Kp index was peak level at 87nT. The Dst index was very lowest level at -281nT.

We found that after the geomagnetic storm disturbed atmospheric sea level pressure and formed the cyclone, one cyclone in Atlantic region was formed, one cyclone in pacific region was formed and four cyclones in west north pacific region were formed. The cyclone formed occurrence of the geomagnetic storm between 10 - 28 days. The sunspots numbers are gradually increased as seen in the Figure 20. The sunspots number increased to induce the geomagnetic storm.

October 29 &30 (year 2003) geomagnetic storm

Figure 5 was a geomagnetic H constant variation from the 28th to 31th of October (2003). Geomagnetic storm day was 29th and 30th October 2003. Earth magnetic Field was observed in four stations. The stations were Alibag, Moscow, Pondicherry and Visakhapatnam. In 29th alibag, H constant variation was 331nT at 23 hours. Followed by Moscow was -351nT, Pondicherry was 491nT and Visakhapatnam was 415nT.

On 30th Alibag was 204nT seen in the Figure 13. Moscow was -374nT. Pondicherry was 369nT and Visakhapatnam was 291nT. The Ap index was peak level at 300nT. The Kp index was peak level at 87nT.

On October 29th, The Dst index was at very lowest level at -39nT and October 30th was -17nT.

We found that with a gap of six days after occurred the geomagnetic storm induced atmospheric sea level pressure, a cyclone in Atlantic region was formed at Dec 4, 2003. On those days sunspots number are gradually increased seen in the Figure 21.

November 20 (year 2003) geomagnetic storm

Figure 6 shows the variation of various interplanetary geomagnetic parameters, for the period of 19 to 21 July, 2003 and storm day was 20th July at 20 hours. The Earth magnetic field was observed in three stations. The stations were Alibag, Moscow, and Tirunelveli. In Alibag, H constant variation was -39nT. In Moscow, H

constant variation was -324nT and Tirunelveli was -165nT.
The Ap index was at peak level at 300nT as seen in the Figure 14. The Kp index was at peak level at 87nT. The Dst index was at very lowest level at -422nT.

We found that with a gap of 14 days after occurred the geomagnetic storm induced atmospheric sea level pressure. The geomagnetic storm was induced to form low pressure level and formed cyclone. One cyclone in Atlantic region was formed. The Sunspots number was gradually increased as seen in the Figure 22. The sunspots number increased to induce the geomagnetic storm.

July 25 & 27 (year 2004) geomagnetic storm

Figure 7 was similar to Figure 6 but for the period of 24–28 July, 2004, and it shows the storm days, 25th and 27th October, 2004. Earth magnetic field was measured in five stations. The stations were chichijima, Nagpur, Pondicherry, Tirunelveli and Visakhapatnam. On 25th chichijima, H constant variation was 369nT at 23 hours. Followed by Nagpur was 326nT, Pondicherry was 551nT Tirunelveli was 585nT and Visakhapatnam was 488nT.

On 27th chichijima, H constant variation was 366nT. Nagpur was 248nT, Pondicherry was 456nT Tirunelveli was 505nT and Visakhapatnam was 413nT. The Ap index was peak level at 300nT seen in the Figure 15. The Kp index was at peak level at 87nT.
On July 25th, the Dst index was at very lowest level at-136nT and October 27th was -170nT.
We found that after occurred the geomagnetic storm induced atmospheric sea level pressure, six cyclones in Atlantic region were formed, three cyclones in pacific region were formed and seven cyclones in west north pacific region were formed. The cyclone formed occurrence of the geomagnetic storm between 4 – 10 days.
On those days sunspots number peak value seen in the Figure 23, 14th was 148 and 19th was 164, after 5 – 15 days the induced geomagnetic storm was produced. The sunspots number increased to induce the geomagnetic storm.

November 10 (year 2004) geomagnetic storm

The variation of geomagnetic parameters shown in a figure 8, for the period of 9th to 11th November, 2004. The geomagnetic storm day was 10th November at 22 hours. The Earth magnetic field was measured in five stations. The stations were chichijima, Moscow, Nagpur, Tirunelveli and Visakhapatnam. In chichijima, H constant variation was 199nT. Followed by Moscow was -45nT, Nagpur was 167nT, Tirunelveli was 438nT and Visakhapatnam was 333nT.

We found that the Ap index was at peak level at 300nT as seen in the Figure 16. The Kp index was peak level at 87nT. The Dst index was very lowest level at -368nT.
We found that after occurred the geomagnetic storms disturbed atmospheric sea level pressure. Four cyclones in pacific region were formed. Four cyclones in west north pacific were formed. The cyclone formed after the geomagnetic storm between 4 - 29 days. The geomagnetic storm induced to form cyclone.
The sunspots number 2nd was 119 as seen in the Figure 24 and peak value after eight days geomagnetic storms were formed. The sunspots number increased to induce the geomagnetic storm.

Table 1: List of stations used with codes and coordinates

S.No	Station name	Station code	latitude	longitude
1	Alibag	ABG	18.6	72.9
2	Chengdu	CDP	31.0	103.7
3	chichijima	CBI	27.1	142.1
4	Moscow	MOS	55.4	37.1
5	Nagpur	NGP	21.2	79.1
6	Pondicherry	PND	11.9	79.9
7	Tirunelveli	TIR	8.7	77.8
8	Visakhapatnam	VSK	17.6	83.3
9	Ujjain	UJJ	23.2	75.8

Table 1: List of Date of severe geomagnetic storm, sunspot Number and Cyclone.

S. No	**severe geomagnetic storm Date**	**peak value sunspot Number Date**	**formation of Cyclone Date**	**Difference between SGMS date and cyclone formation date**
1	29/10/2003	gradually increased	Nov 16, Nov 18, Nov 24	8, 18, 24
2	31/03/2001	16/03/2001	Apr 17	17
3	30/10/2003	gradually increased	Same as day	Same as day

4	27/07/2004	19/07/2004	Jul 31, Aug 02, Aug 03, Aug 06, Aug 09, Aug 13, Aug 17, Aug 18, Aug 19, Aug 23, Aug 24.	4, 6, 7, 9, 12, 16, 20, 21, 22, 27, 28
5	15/07/2000	10/07/2000	Jul 17, Jul 23, Jul 24, Jul 26, Jul 27, Jul 31, Aug 03, Aug 05, Aug 09, Aug 10, Aug 13.	2, 8, 9, 11, 12,16, 18, 20, 24, 25, 28
6	10/11/2004	02/11/2004	Nov14, Nov 22, Nov 27, Nov 28, Dec 09.	4, 12, 17, 18, 29
7	25/07/2004	14/07/2004	27/07/2004	2 days
8	20/11/2003	gradually increased	Dec 04.	14
9	27/08/1998	12/08/2004	Oct 05, 22.	8, 25
10	06/11/2001	gradually increased	Nov 16, 18, 24, Dec 04.	10, 12, 18, 28

Table 3: Severe Geomagnetic Storms days, Dst index, Ap index, Kp index.

S. No	Date of severe geomagnetic storm	Dst (nT)	Ap (nT)	Kp (nT)
1	29/10/2003	-039	300	84
2	31/03/2001	-387	300	87
3	30/10/2003	-017	300	84
4	27/07/2004	-170	300	87
5	15/07/2000	-301	400	90
6	10/11/2004	-368	300	87
7	25/07/2004	-136	300	87
8	20/11/2003	-422	300	87
9	27/08/1998	-155	179	80
10	06/11/2001	-288	300	87

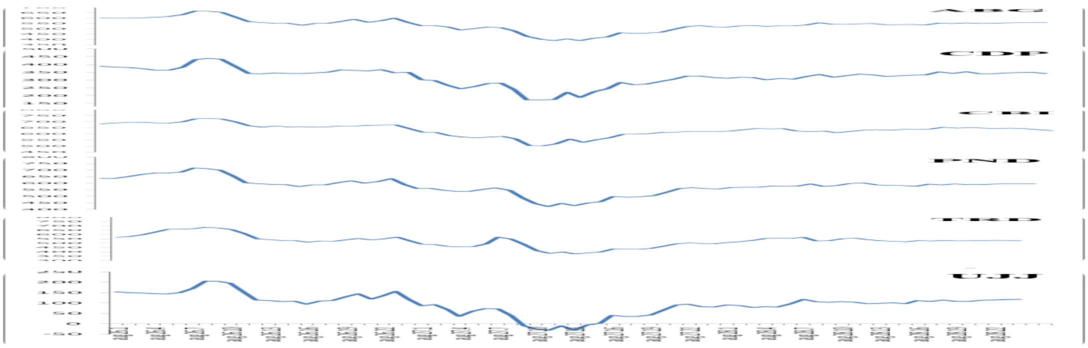

Figure 1: The Earth's magnetic field in horizontal (H) component variation from 26th to 28th August 1998.

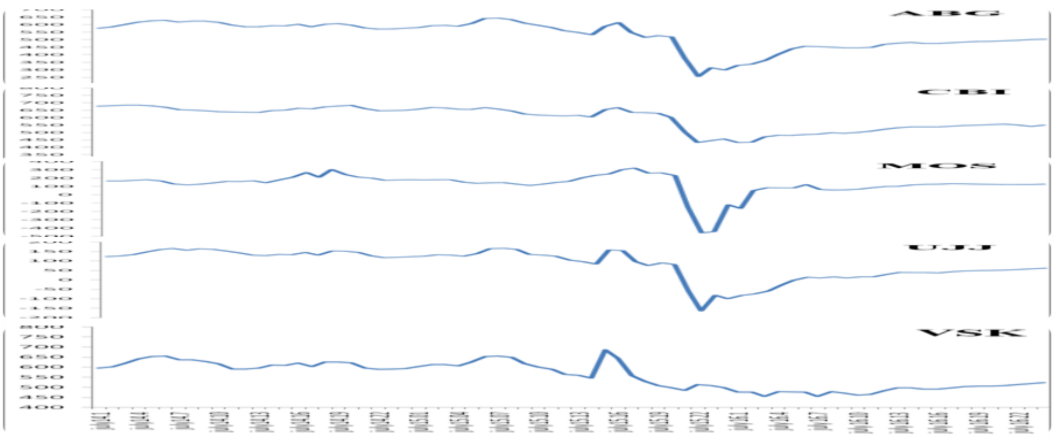

Figure 2: The Earth's magnetic field in horizontal (H) component variation from 14th to 16th July 2000.

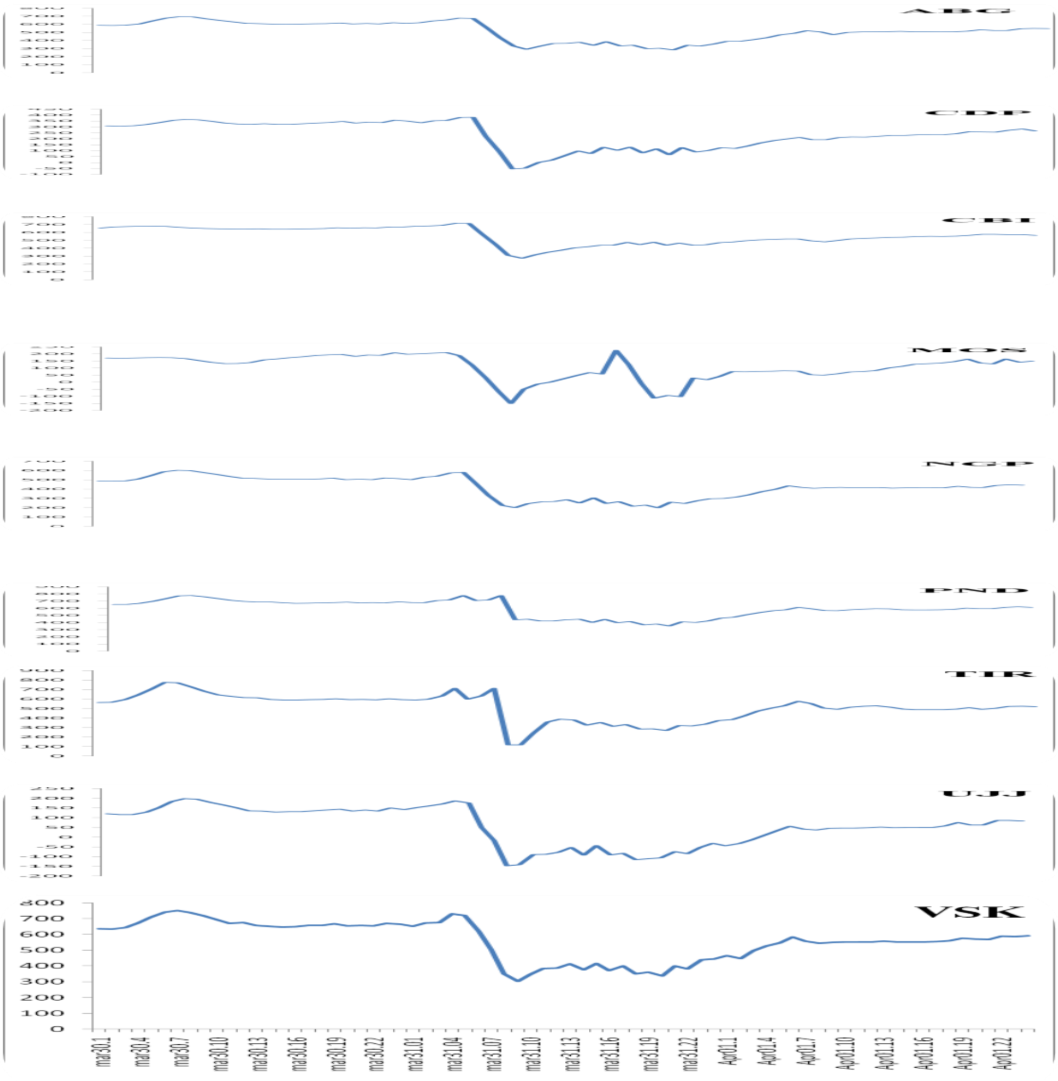

Figure 3: The Earth's magnetic field in horizontal (H) component variation from March 30th to April 1st 2001.

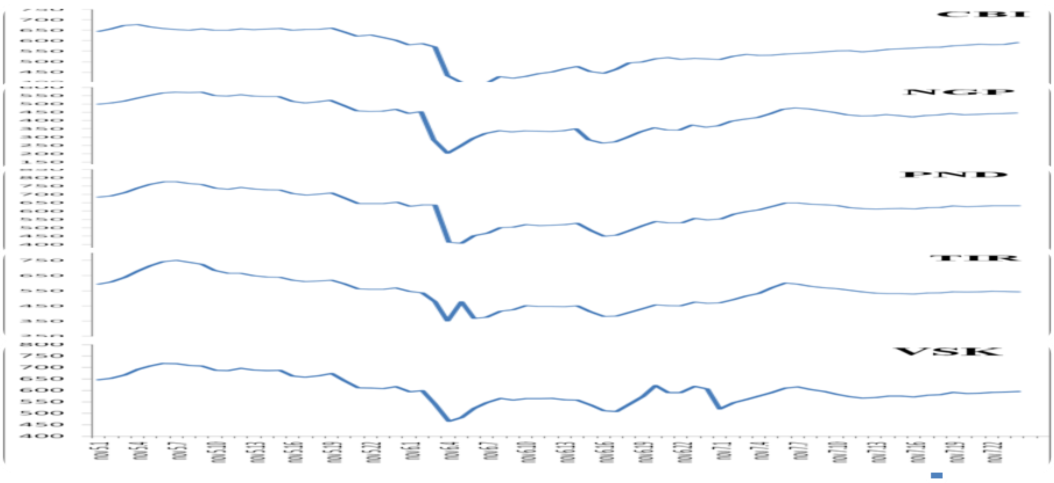

Figure 4: The Earth's magnetic field in horizontal (H) component variation from 5th to 7th November 2001.

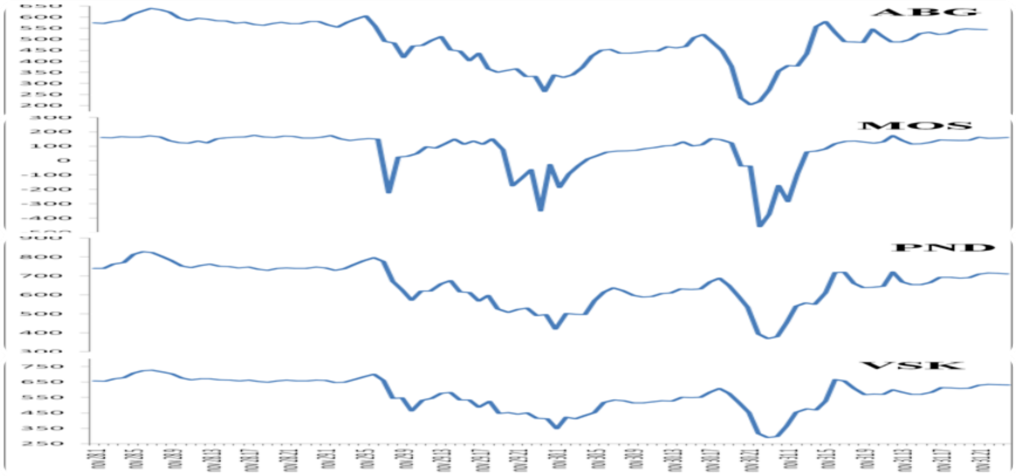

Figure 5: The Earth's magnetic field in horizontal (H) component variation from 28th to 31th October 2003.

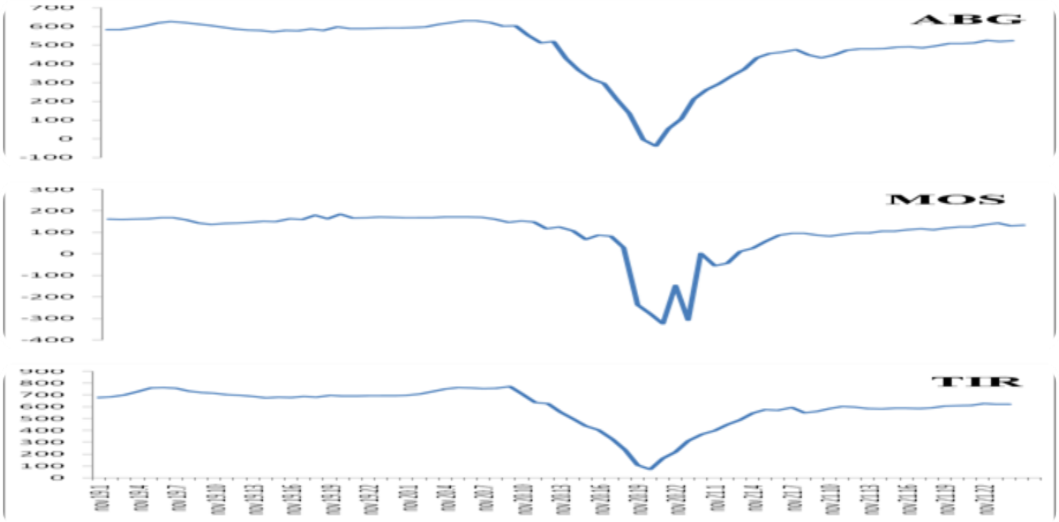

Figure 6: The Earth's magnetic field in horizontal (H) component variation from 19th to 22th November 2003.

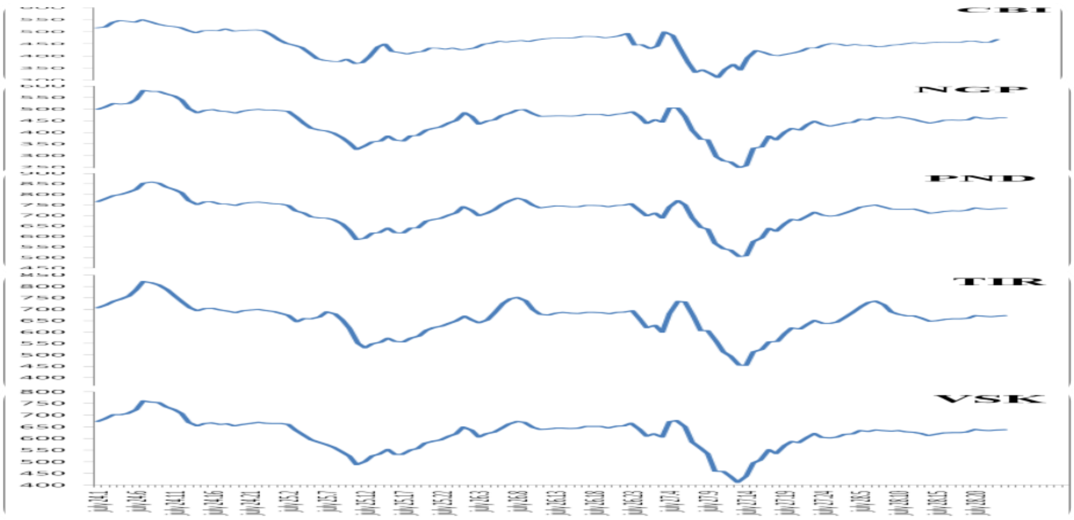

Figure 7: The Earth's magnetic field on horizontal (H) component variation from 24th to 28th July 2004.

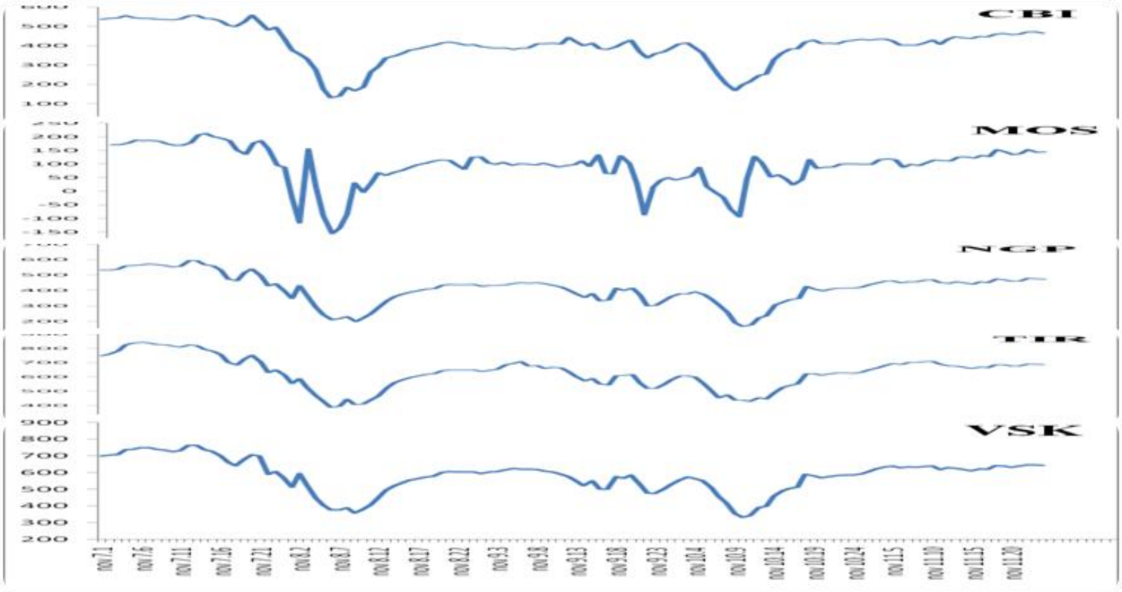

Figure 8: The Earth's magnetic field in horizontal (H) component variation from 7th to 11th November 2004.

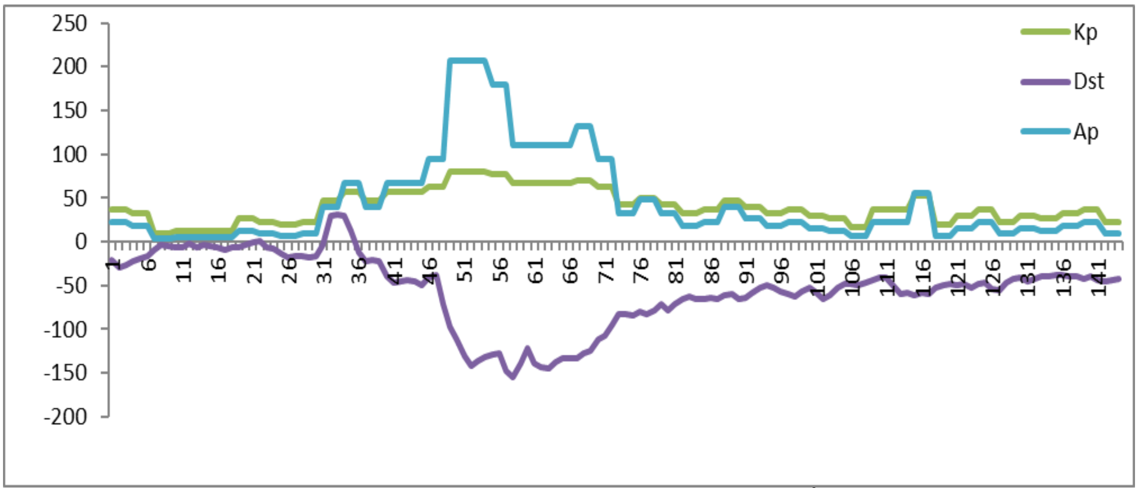

Figure 9: The Kp index Ap index Dst index variation on 27th August 1998.

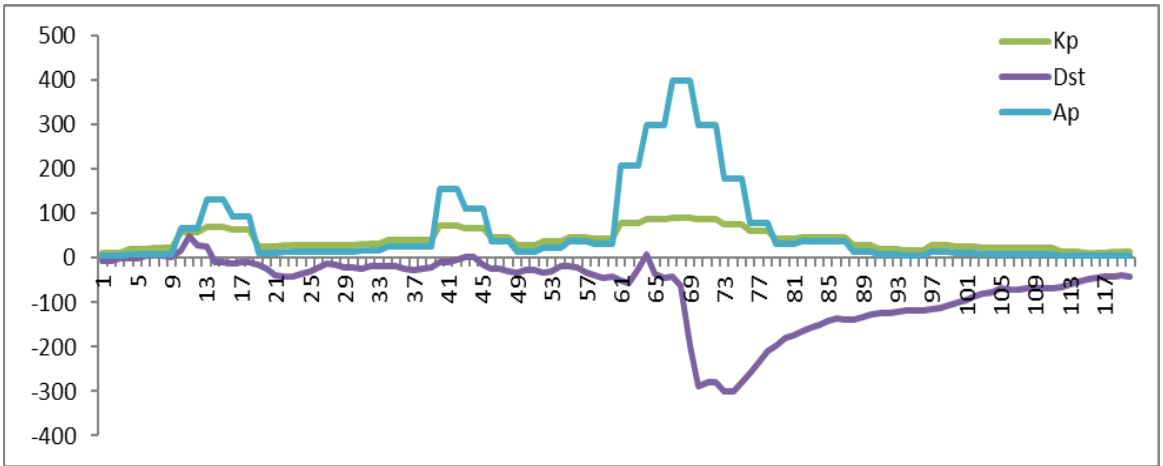

Figure 10: The Kp index Ap index Dst index variation on 15th July 2000.

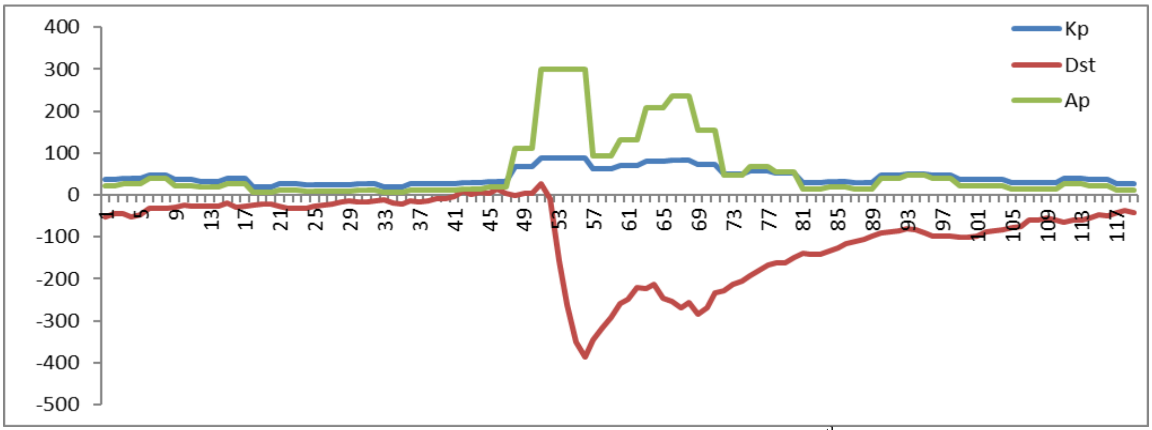

Figure 11: The Kp index Ap index Dst index variation on 31th March 2001.

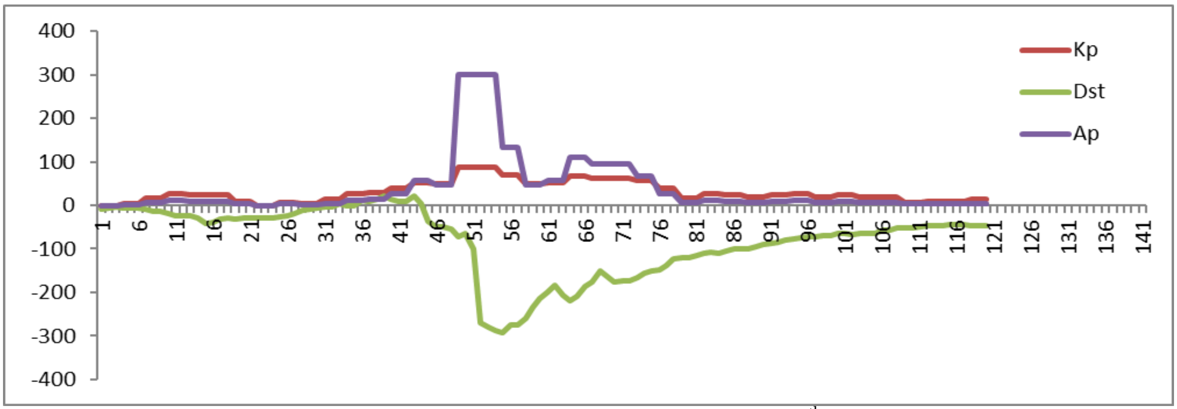

Figure 12: The Kp index Ap index Dst index variation on 6th November 2001.

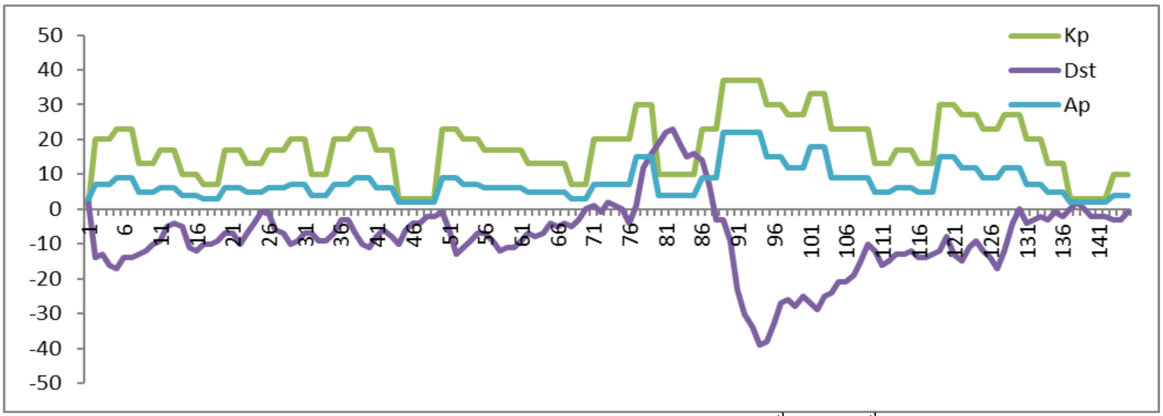

Figure 13: The Kp index Ap index Dst index variation on 28th and 30th October 2003.

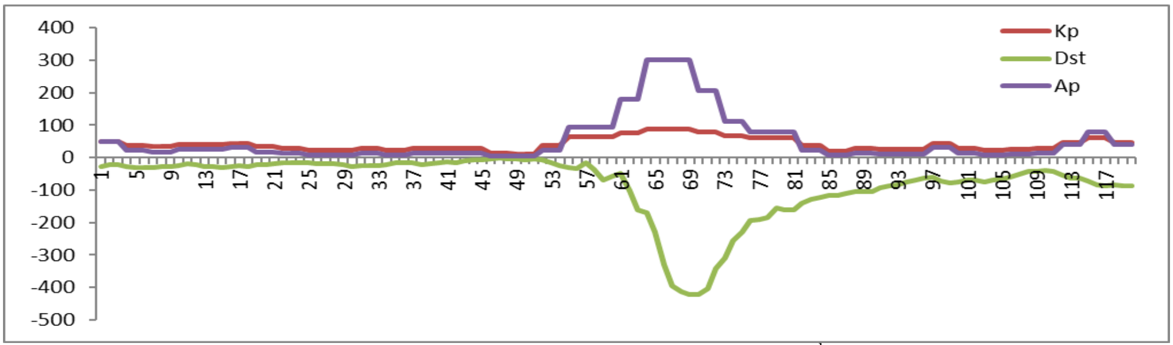

Figure 14: The Kp index Ap index Dst index variation on 20th November 2003.

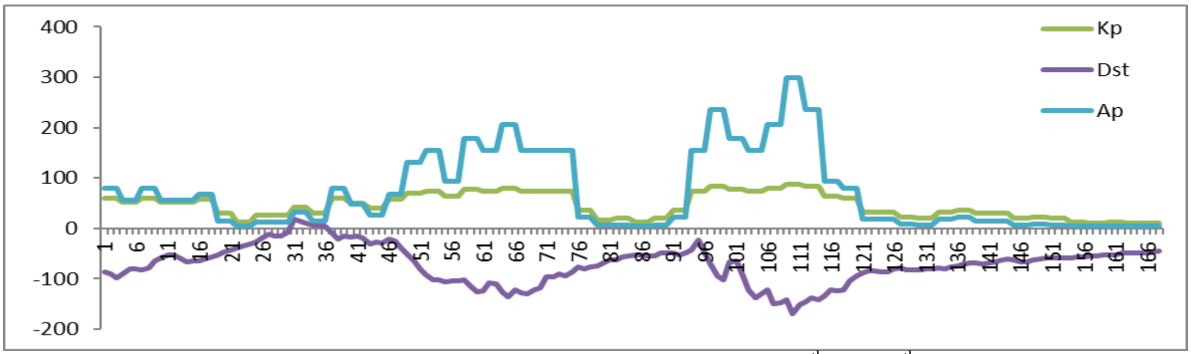

Figure 15: The Kp index Ap index Dst index variation on 25th and 27th July 2004.

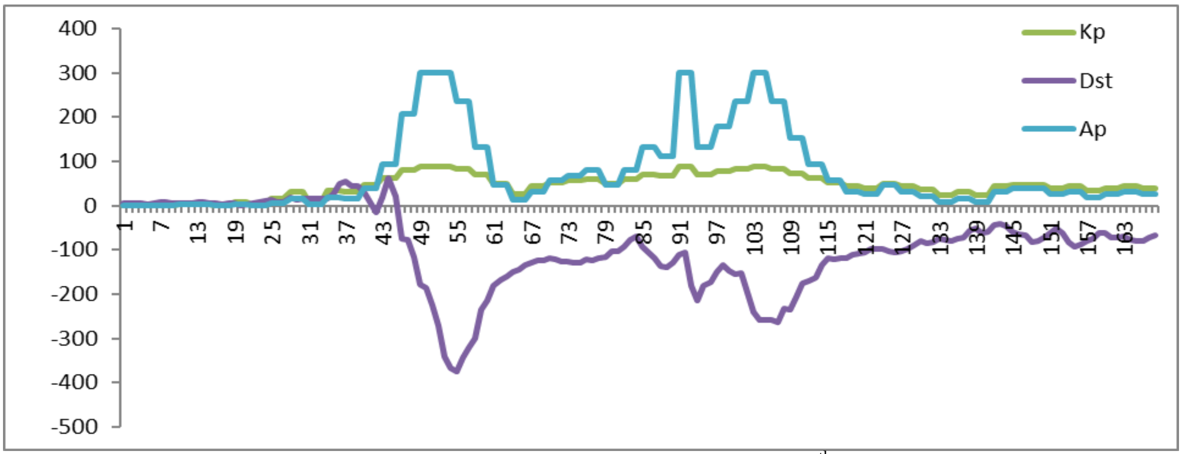

Figure 16: The Kp index Ap index Dst index variation on 10th November 2004.

Figure 17: Sunspots Number variation on 27th August 1998.

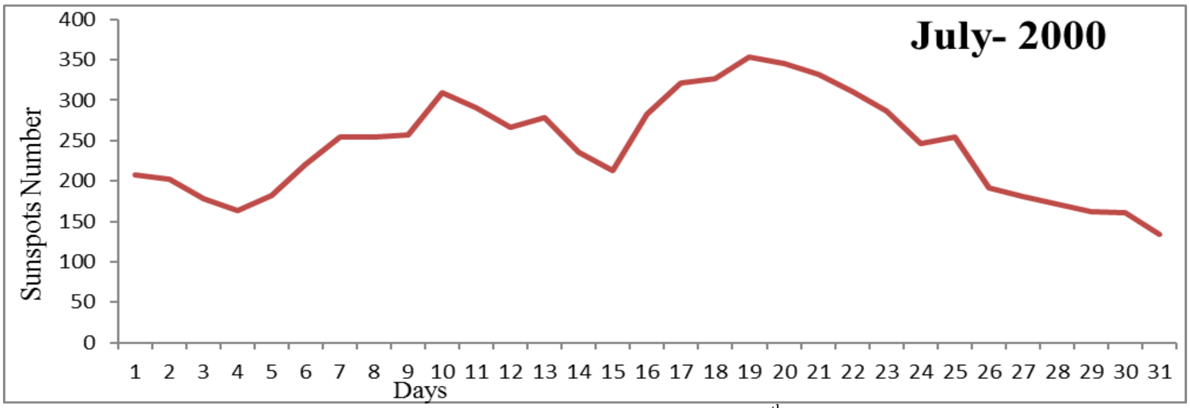

Figure 18: Sunspots Number variation on 15th July 2000.

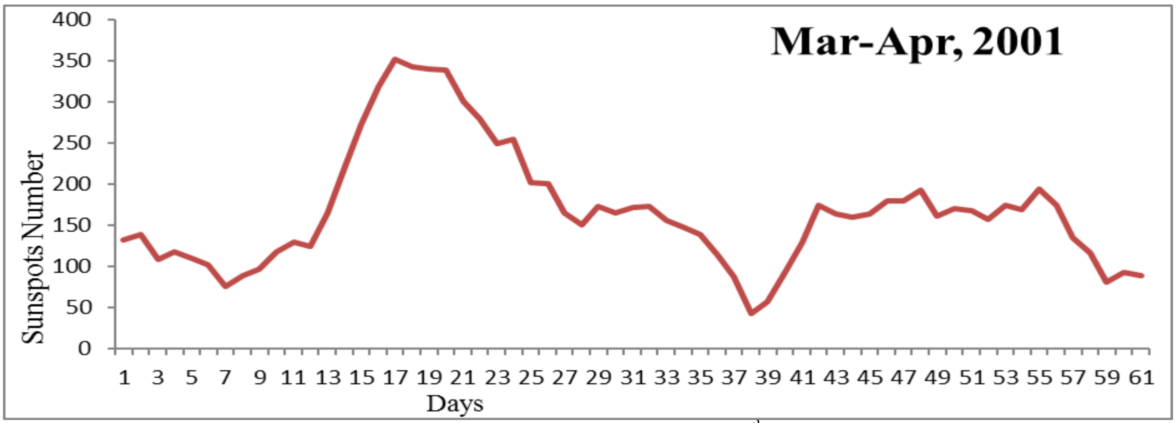

Figure 19: Sunspots Number variation on 31th March 2001.

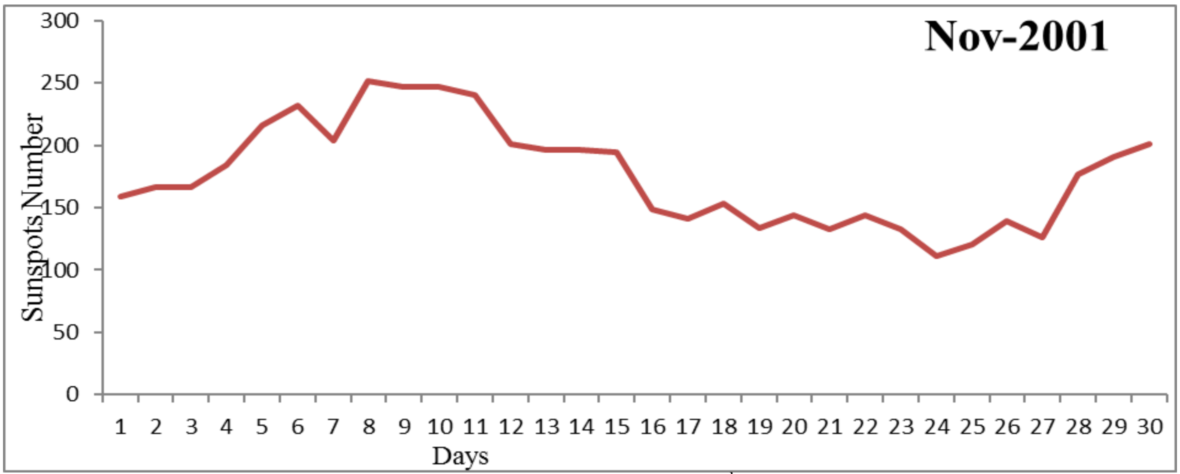

Figure 20: Sunspots Number variation on 6th November 2001.

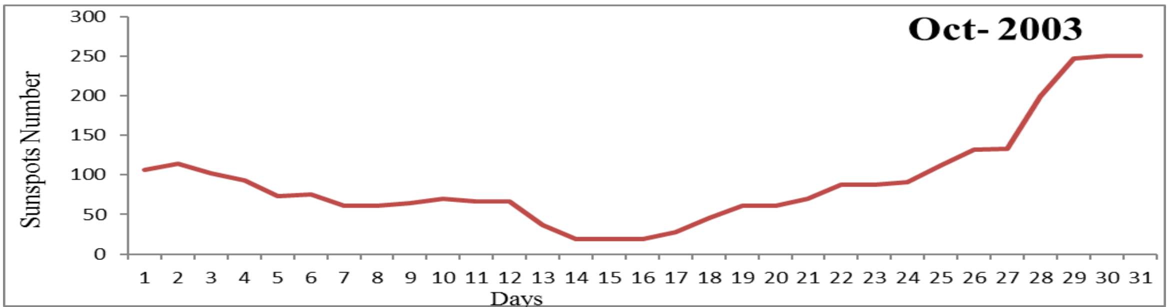

Figure 21: Sunspots Number variation on 29th and 30th October 2003.

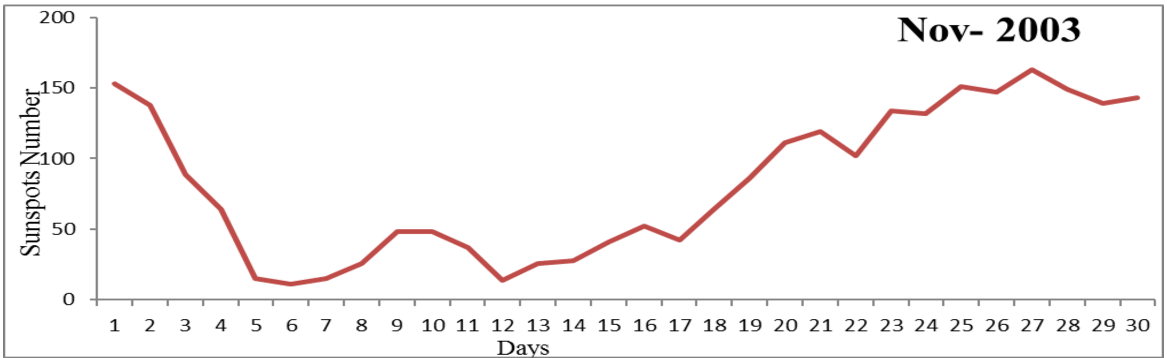

Figure 22: Sunspots Number variation on 20th November 2003.

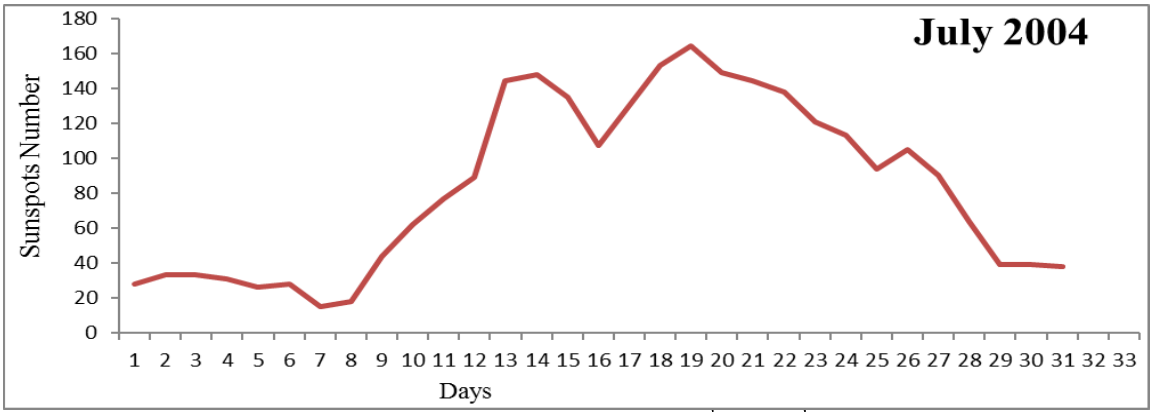

Figure 23: Sunspots Number variation on 25th and 27th July 2004.

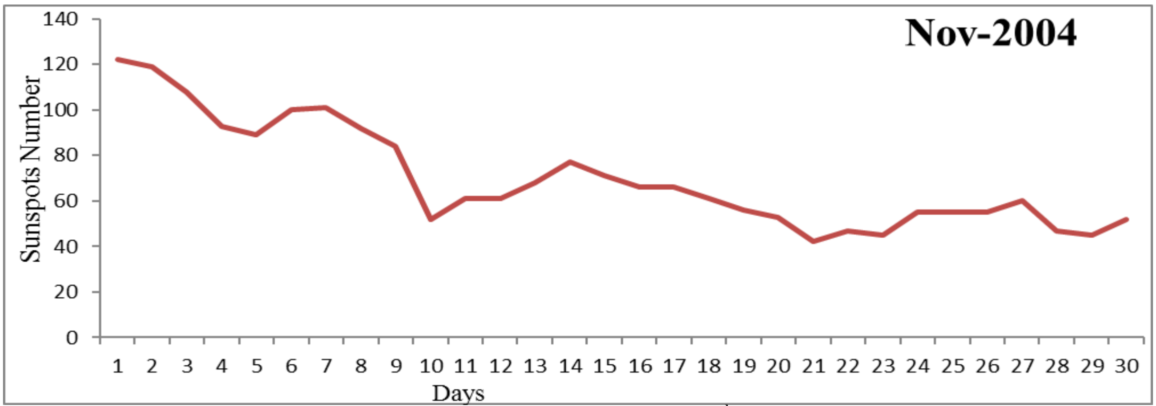

Figure 24: Sunspots Number variation on 10th November 2004.

IV. CONCLUSION

A solar flare or intense solar activity, a plasma cloud of electrons and protons ejected from an active solar region, together with an embedded magnetic field, arrives at the earth. If the direction of the interplanetary magnetic field is favorable, and if the solar plasma has sufficient energy density, field and particle energy enters the earth's environment and perturbs its electromagnetic state. It is the H component which best reflects the storm signature on the geomagnetic field, and the effect is most prominent at the equator. The first onslaught of the solar plasma on the earth's magnetopause manifests as a shock wave which leaves its signature on the ground geomagnetic field as a sharp rise in H called the storm sudden commencement [Grija rajaram, 1998].

The various magnetic fields, more notably its shot-term components, is due to disturbances in the earth's electromagnetic environment caused by solar activity. The degree of disturbance in the magnetic field is indicated by what are called indices of geomagnetic activity. These are essentially indices of energy coupling between the environments of the sun and earth [Grija rajaram, 1998].

We have analyzed the relationship between severe geomagnetic storms and Earth's magnetic field in horizontal component (H constant). Also we have found the relation between geomagnetic storm and sunspots number, we have found that Earth's magnetic field in horizontal component (H constant) was induced by geomagnetic storm. In the following days, H constant value is at very lowest level in geomagnetic storm period. We have found that Dst index also is at the very lowest level (Negative value) in geomagnetic storm days. The Ap index and Kp index are at the highest level in geomagnetic storm days. The geomagnetic storms induced Cyclones were formed after geomagnetic storm within 29 days. The Sunspots number increased to induced geomagnetic storms.

We have selected ten severe geomagnetic storm events taken for analysis; they indicate various solar and interplanetary characteristics changes and their corresponding Earth's magnetic field effects changes these changes also change Earth's atmosphere. For each event, peak Dst values as well as date and time of their occurrences, Kp index, Ap index are presented. The event of 20th November, 2003 with the Dst magnitude was -422 nT and it was the highest geomagnetic storm of the period 1994 to 2015. The event of 15th July, 2000 with the Ap index was 400 nT with the highest storm in the period. The event of 15th July, 2000 with the Kp index was 90 nT with the highest storm in the period. The event of 15th July, 2000 with the Sunspots Number was 353 with the highest number of sunspots of the period in between 1994 to 2015. The sunspots number was highest number (353) induced the Geomagnetic storm.

- On October 29 &30 (year 2003), we found that with a gap of six days after occurrence of the geomagnetic storm induced atmospheric sea level pressure and cyclone formed, a cyclone in Atlantic region was formed on Dec 4, 2003. On those days sunspots number were gradually increased. The sunspots number induced the interplanetary magnetic field and also Geomagnetic storms were induced.
- On July 25 & 27 (year 2004), we found that after occurrence of the geomagnetic storm induced atmospheric sea level pressure and form the cyclone. We found six cyclones in Atlantic region were formed, three cyclones in Pacific region were formed and seven cyclones in West North Pacific region were formed. A cyclone was formed after occurrence of the geomagnetic storm within 10 days. On those days sunspots number peak value, 14^{th} was 148 and 19^{th} was 164, the sunspots number induced to form after 5 – 15 days geomagnetic storm.
- On July 15 (year 2000), we found that occurrence of the geomagnetic storm induced atmospheric sea level atmospheric pressure and form cyclone, Six cyclones in Atlantic region were formed, three cyclones in Pacific region were formed and seven cyclones in West North Pacific region were formed. The cyclone formed occurrence of the geomagnetic storm within 28 days. At that days sunspots number was July 10^{th} 309 and it was peak value, the sunspots number gradually increased to induce interplanetary magnetic field and after five days geomagnetic storms were formed.
- On November 10 (year 2004), we found that after occurrence of the geomagnetic storms induced the atmospheric sea level pressure and form the cyclone, Four cyclones in Pacific region were formed. Four cyclones in West North Pacific were formed. Cyclone was formed occurrence of the geomagnetic storm within 29 days. The sunspots number 2^{nd} was 119 it was peak value the sunspots number induced interplanetary magnetic field and after eight days geomagnetic storms were formed.
- On November 20 (year 2003), we found that with a gap of 14 days after occurrence of the geomagnetic storm induced the atmospheric sea level atmospheric pressure and form the cyclone, One cyclone in Atlantic region was formed. The Sunspots number was gradually increased to induce the Geomagnetic storms.
- On August 27 (year 1998), we found that with a gap of 8 – 25 days occurrence of the geomagnetic storm induced the atmospheric sea level pressure and form the cyclone, Five cyclones in Atlantic region were formed. The Sunspots number 12^{th} was 159. The sunspots number increased to induce after 15 days geomagnetic storms were formed.
- On November 06 (year 2001), we found that after occurrence of the geomagnetic storm induced the atmospheric sea level pressure and form the cyclone, one cyclone in Atlantic region was formed, one cyclone in Pacific region was formed and four cyclones in West North Pacific region were formed. The cyclones were formed occurrence of the geomagnetic storm between 10 - 28 days. The sunspots numbers are gradually increased to induced interplanetary magnetic field and form Geomagnetic storms.
- On March 31 (year 2001), we found that with a gap of 17 days occurrence of the geomagnetic storm induced atmospheric sea level pressure and the cyclone was formed, One cyclone in Pacific region was formed. The Sunspots number 16^{th} was 352. After 15 days, the sunspots number gradually increased to induced interplanetary magnetic field and geomagnetic storms were formed.

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