IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

STUDY OF GEOMAGNETIC ACTIVITY EFFECT ON FOF2 AT LOW, MID AND HIGH LATITUDE

[1]Madhuri Singh, [2] Akanksha Shekhar Sharma, [3]Sanjay Rathore, [4]Kalpana Maski, [5] S.K. Vijay

[1]Department of Physics ,SIRT Bhopal

[2]P.G. College Devas

[3]Satya Sai University Sehore

[4]Regional Institute of Education ,NCERT Bhopal

[5]Govt. Maharani Laxmi Bai Girls P.G. College ,Bhopal

Abstract:This study examines the impact of geomagnetic activity on the ionospheric parameter of FoF2 at various latitude zones (low, mid, and high), including Sodankyla (67.40°N, 26.59°E), Mawson (67.60°S, 62.87°E), Canberra (35.28°S, 149.13°E), Beijing (39.91°N, 116.41°E), Chongqing (29.43°N, 106.92°E), and Darwin (12.46°S, 130.844°E) over the course of 2008–2014. In addition to discussing the average behaviour of foF2 during light, moderate, and violent storms, the research of observed changes in foF2 and the geomagnetic indicators AE(Auroral Electro jet index), Kp (K- Index), Bz(Interplanetary magnetic field) and Dst(Disturbed Storm Time) has been conducted. We found that storm location and latitude, in addition to storm severity and duration, all influence the ionospheric impacts. it is also observed that the occurrence of severe storms is smaller than moderate storms for the period of study. During the magnetic disturbance the notice that normalized deviation is drop for all latitude and negative phase isobserved.

Index Terms - Geomagnetic activity, normalized deviation, AE(Auroral Electrojet index), Kp (K- Index), Bz(Interplanetary magnetic field) and Dst(Disturbed Storm Time).

I. INTRODUCTION

The magnetospheric and ionospheric current systems are controlled by the dynamic pressure of the solar wind and the strength and orientation of the interplanetary magnetic field. Any changes to these parameters will alter the magnetosphere-ionosphere current system, causing a shift in the magnetic field near the Earth's surface, known as geomagnetic activity.

The F2 layer's morphology is far more complicated than the F1 layer's. A simple physical model cannot explain the critical frequency foF2 or the height at which it occurs. The critical frequency is much easier to measure than the peak density height, and fluctuations in foF2 give some insight into what's going on in the F2 layer as a whole. The following are the most common reasons for ionospheric F-layer variability: (i) solar ionising radiation (solar rotation, variations in the solar cycle, active region development and decay); (ii) neutral atmosphere (planetary waves, surface phenomena such as earthquakes and volcanoes, acoustic and gravity waves); (iii) electrodynamics (dynamo effects at low latitudes, penetration of magnetospheric electric fields, electric fields from lightning and sprites); (iv)Geomagnetic activity (magnetic storms and sub storms, IMF/solar wind sector structure, energetic particle precipitation, Joule heating, and solar wind).

The ionosphere is a crucial component of Earth's space weather. Day-to-day ionospheric variability is coupled with strong connectivity to regions below (e.g., through gravity and planetary waves), as explored by Rishbeth and Mendillo, (2001) (e.g., through solar and geomagnetic activity). As a result, comprehending ionospheric density variations is difficult. Recent research has looked into the ionosphere's day-to-day variability as a result of planetary wave activity (e.g., Aburjania et al., 2003, 2004; Altadill and Apostolov, 2003; Lastovicka et al., 2003; Lastovicka and Sauli, 1999; Voiculescu and Ignat, 2003; Haldoupis et al., 2004). At mid latitudes, the planetary waves in the F area displayed variations with periods of 2, 5, 10, and 16 days (Lastovicka et al., 2003). At least 20–30% of the planetary waves with periods of 2–3, 5–6 days, as well as 65–70% of the 10- and 16-day periods, were associated with changes in geomagnetic activity (Altadill et al., 2003). These findings show that geomagnetic activity plays a significant role in the ionosphere's short-term fluctuations.

II. Data and Method of analysis

In the present work, we have analyzed hourly values of the critical frequency (foF2) parameter are taken over different latitude zones (low ,mid and high) Sodankyla(67.40°N, 26.59°E), Mawson (67.60°S, 62.87°E), Canberra (35.28°S, 149.13°E), Beijing (39.91°N, 116.41°E), Chongqing (29.43°N,106.92°E) and Darwin (12.46°S, 130.844°E), . Hourly values of the critical frequency (foF2) parameter are collected from UK Solar System Data Centre website (https://www.ukssdc.ac.uk/cgi_bin/wdcc1/secure/iono_data.pl) from the year 2008 to 2014, which is a low solar activity period, of 24th solar cycle.

Values of geomagnetic indices i.e. AE, Kp, Bz, and Dst are collected from Omniweb (https://omniweb.gsfc.nasa.gov/form/dx1.html). During the period considered in the present work, total 99 storms (low-61, moderate-25, and severe-13) are selected for study, on the basis of Dst index. With Dst≤-100nT considered as severe storms, Dst between - 70nT and -100nT considered as moderate storms and Dst≥-70nT considered as low storms. he normalised deviations of the critical frequency foF2 from the reference, which is used to signify the F2 region response to a geomagnetic activity, are a convenient way to explain the F2 region response to ionospheric storms.It is given by

D(foF2) = foF2-(foF2)ave /(foF2)ave

Therefore, the data being studied consists of D (foF2) of corresponding hourly values of foF2. The average foF2 value for that hour determined from the quiet days serves as the reference for each hour. If two storms occurred on the same day then they are not considered. In the present work we have considered the storm time, sudden storm commencement (SSC) as 0 hour and 48 hours prior to the SSC and 48 hours after the SSC were analyze for foF2.

III. Results

In the present work considered 99 storm at Sodankyla (67.40°N, 26.59°E), 83 storms at Mawson (67.60°S, 62.87°E), 97 storms at Darwin (12.46°S, 130.844°E), 86 storms at Canberra (35.28°S, 149.13°E), 88 storms at Chongqing (29.43°N,106.92°E) and Beijing(39.91°N, 116.41°E) were considered due to unavailability of data during the storm period . Details of the storm considered in the study for different season and according to the strength of storm are given in the table.

TABLE .1

	Sodankyla(67.40°N, 26.59°E)	Mawson (67.60°S, 62.87°E)	Canberra (35.28°S, 149.13°E)	Beijing (39.91°N, 116.41°E)	Chongqing (29.43°N,106.92°E)	Darwin (12.46°S, 130.844°E)
Dst≥-70nT	**61**	**50**	**61**	**53**	**53**	**60**
70nT Dst≥-100nT	**25**	**21**	**24**	**22**	**22**	**24**
Dst≤-100nT	**13**	**12**	**11**	**13**	**13**	**13**
Total	**99**	**83**	**86**	**88**	**88**	**97**

3.1 Average behaviour of foF2 during weak storm at all low, mid and high latitude station

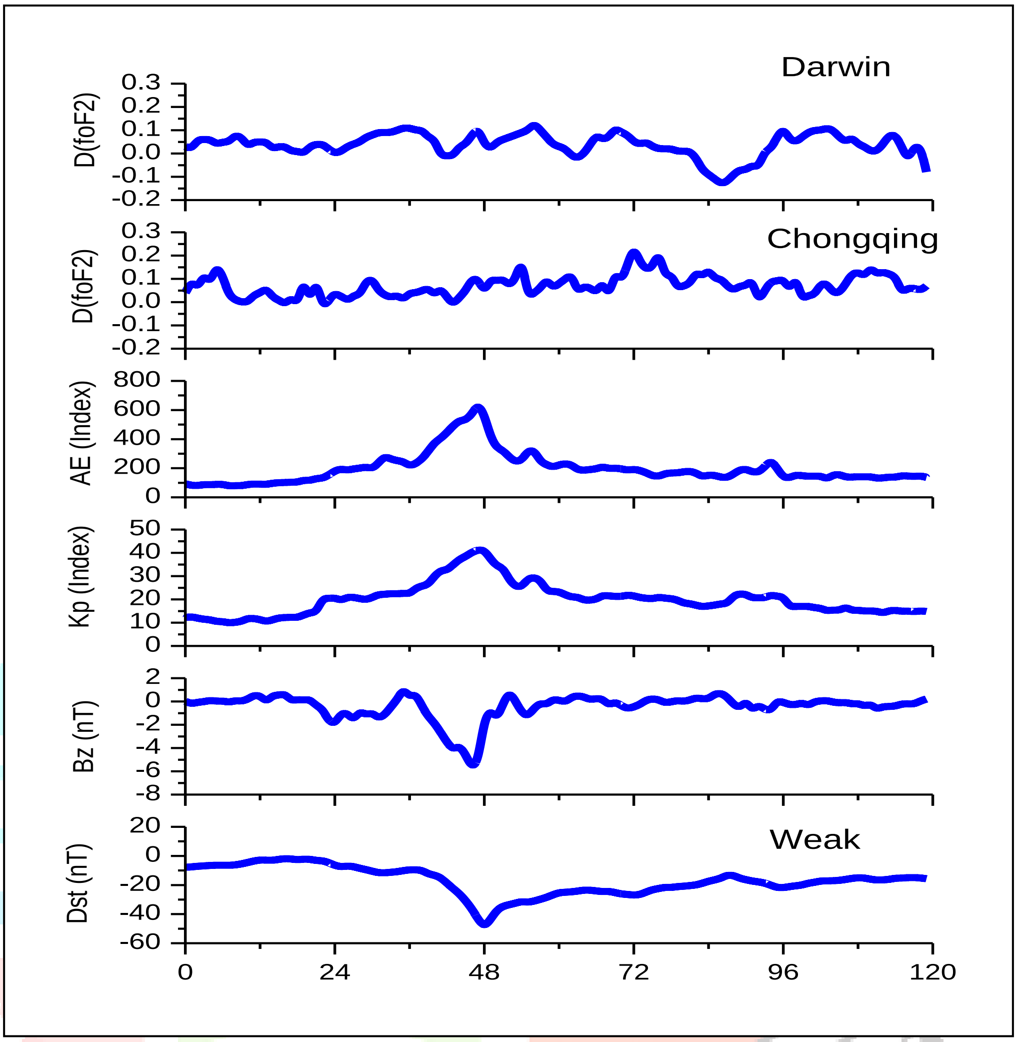
Figures (3.1.1), (3.1.2), and (3.1.3) depict the variation in foF2 normalised deviation from January 2008 to December 2014. During moderate storm 61 storms were occurred at Sodankyla, 50 storms occurred at Mawson, 53 storms were occurred at Beijing, 53 storms occurred at Chongqing, 61 storms were occurred at the Canberra, and 60storms were occurred at the Darwin.

It is seen from figure (3.1.1) depicts that for low latitude location Chongqing and Darwin the normalized deviation of foF2 [D (foF2)] shows positive phase effect storm. At Chongqing shows the positive deviation 0.22 of foF2 after SSC where as positive deviation 0.19 of foF2 obtained during the main phase of time. For Darwin show positive deviation 0.13 of foF2 during the main phase of storm. The D (foF2) shows negative deviation -0.13 after SSC and positive deviation 0.11 of foF2 in the recovery phase of time.

Figure (3.1.2) depicts that for mid latitude location at Canberra shows the negative deviation -0.11 of foF2 after SSC and recovery phase of time it is show positive deviation 0.06 of foF2. However positive deviation 0.7 of foF2 obtained during the main phase of time. For Beijing show positive deviation 0.14 of foF2 during the main phase of storm .The D (foF2) shows 0.1 decrement after SSC and also in recovery time.

Figure (3.1.3)) at Sodankyla the D(foF2) show negative phase of effect storm which is show deviation -0.13 after SSC (Sudden Storm Commencement) however the positive deviation 0.21 obtained in the main phase of storm and the recovery phase of storm the normalized deviation of foF2 shows 0.34 increment. At Mawson, D(foF2) shows the negative phase effect after SSC (sudden storm commencement). The negative deviation -0.2 of foF2 obtained after SSC and get positive deviation 0.11 of foF2 in the recovery phase of time. However the positive deviation 0.14 gets in the main phase of storm.

The lowest panel of the graph shows the average of Dst, Kp and AE respectively .It is noted from the figure that the fluctuation observed in Kp follows the variation of Dst index, Kp value reaches 41.17 nt when Dst has more negative for weak storm and its reaches 49.60nT.



Hours (UT)

Figure 3.1.1: Variation of normalizeddeviation of foF2 [D (foF2)] for (Dst≥-70nT) at low latitude station for the period January 2008-December 2014

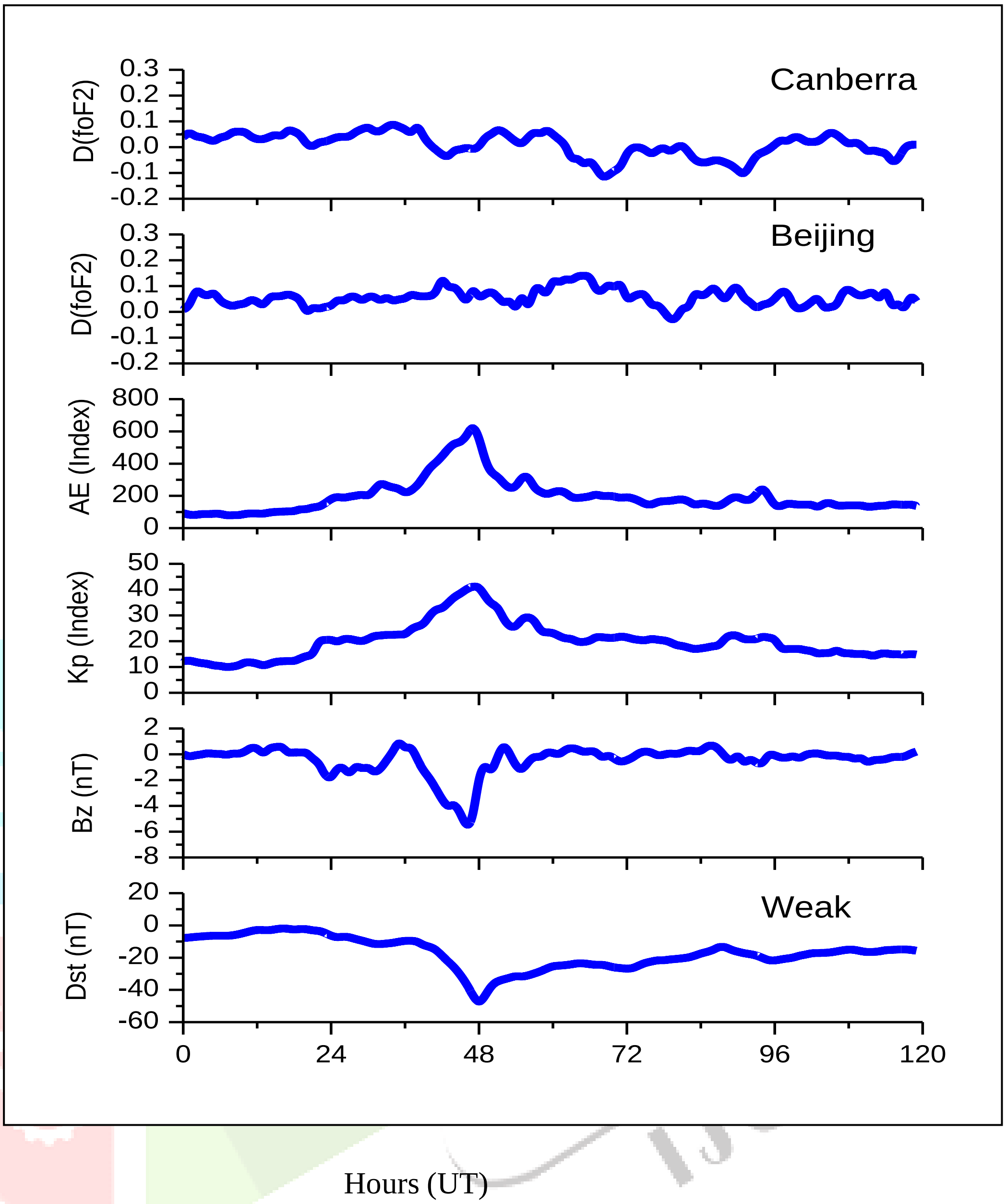
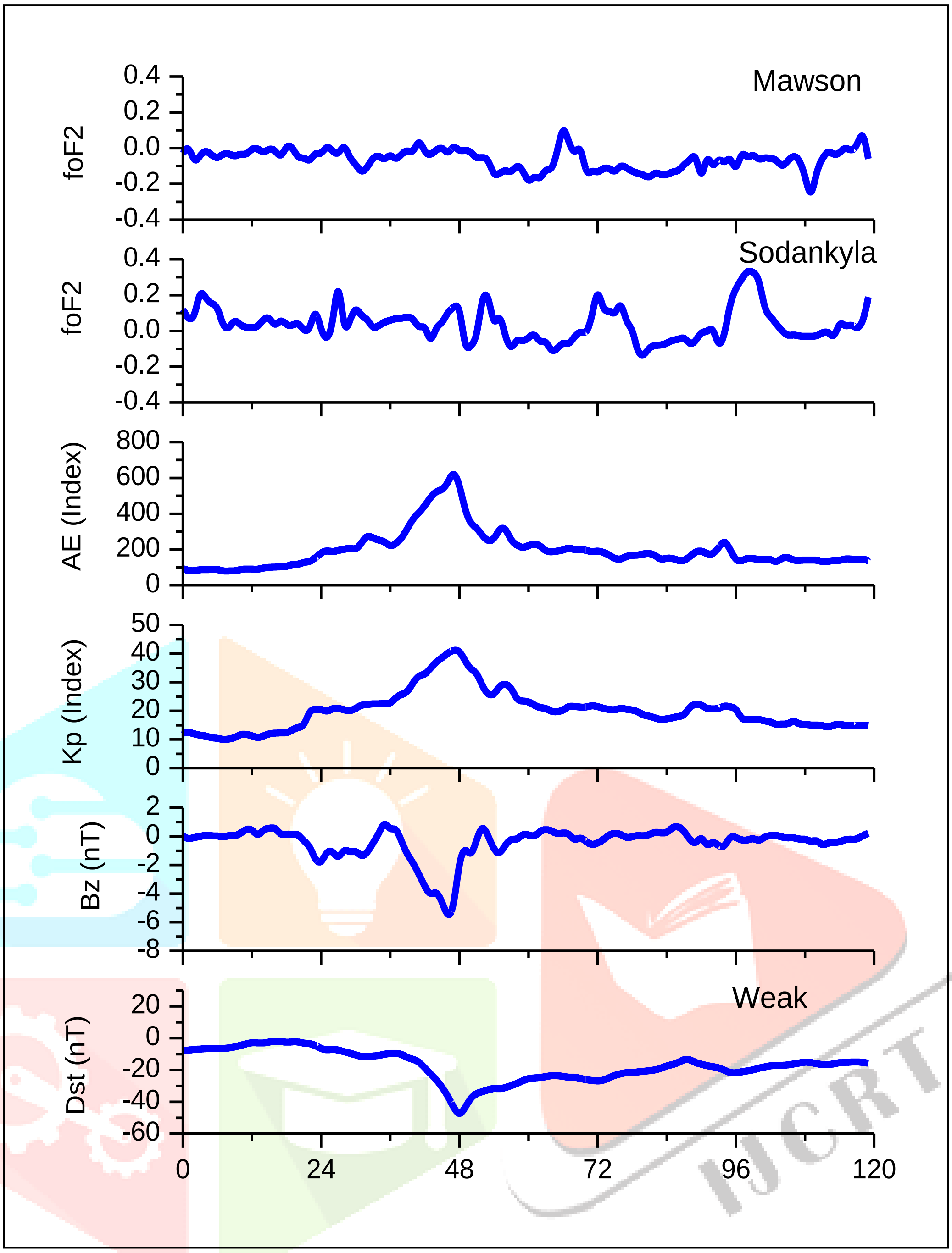


Figure 3.1.2: Variation of normalizeddeviation of foF2 [D (foF2)] for (Dst≥-70nT) at mid latitude station for the period January 2008-December 2014



Hours (UT)

Figure 3.1.3: Variation of normalized deviation of foF2 [D (foF2)] for (Dst≥-70nT) at high latitude station for the period January 2008-December 2014

3.2 Average behaviour of foF2 during moderate storm at all low, mid and high latitude station

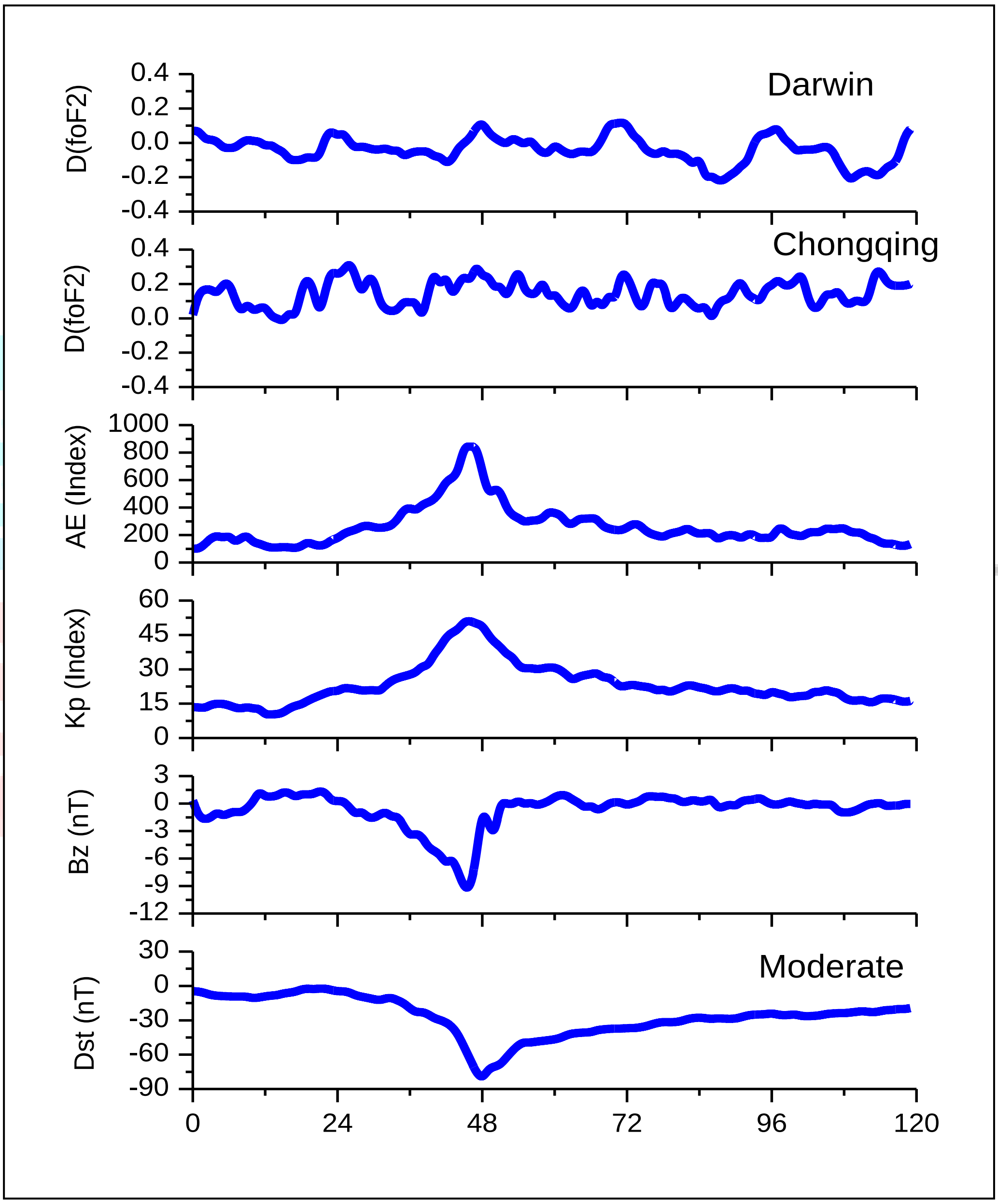
Figure (3.2.1), (3.2.2) and (3.2.3) shows the moderate storm variation of normalized deviation of foF2 [D (foF2)] from January 2008 to December 2014. During moderate storm 25 storms were occurred at Sodankyla, 21 storms occurred at Mawson, 22 storms were occurred at Beijing, 53 storms occurred at Chongqing and 24 storms were occurred at the Darwin and Canberra.

In figure (3.2.1) depicts that for low latitude location Chongqing the D (foF2) shows positive phase of storm after SSC. The positive deviation 0.29 of foF2 after SSC however positive deviation 0.32 of foF2 obtained in the main phase of storm. At Darwin the main phase of storm shows the positive deviation 0.12 of foF2. It is show negative deviation -0.22 of foF2 after SSC. Positive deviation 0.9 obtained in the recovery phase of time and again it is decreases -0.21.

Figure (3.2.2) show that at mid latitude location Canberra the D (foF2) shows the negative deviation -0.24 of foF2 after just SSC and in the recovery phase of time it is slightly increases deviation 0.05 and again decreases deviation -0.23 of foF2. At Beijing the main phase of storm shows the positive deviation 0.28 of foF2 and during recovery phase of time it is show positive deviation 0.29 of foF2.

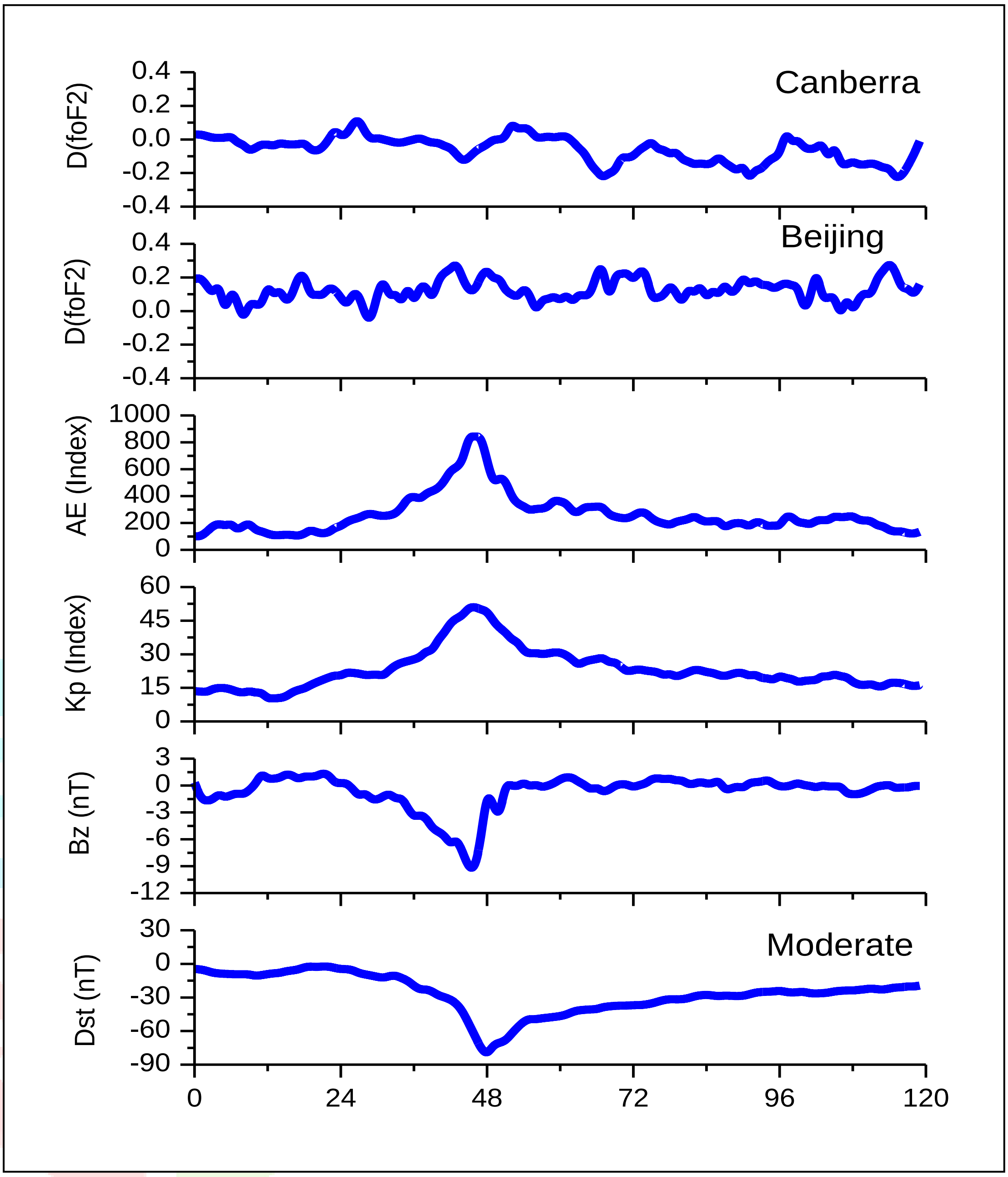
Figure (3.2.3) depicts that for high latitude location at Sodankyla the positive deviation 0.34 of foF2 after SSC. However the D (foF2) shows positive deviation 0.49 during the main phase of storm. At Mawson the normalized deviation of foF2 shows negative deviation -0.31 of foF2 after SSC. However negative deviation -0.34 of foF2 obtained in the main phase of storm. However negative deviation -23.47 of foF2 obtained in the main phase of storm.

The lowest panel of the graph shows the average of Dst, Kp and AE respectively .It is noted from the figure that the fluctuation observed in Kp follows the variation of Dst index. Kp value reaches 49.28 nt when Dst has more negative for has -81.69 for moderate storm.



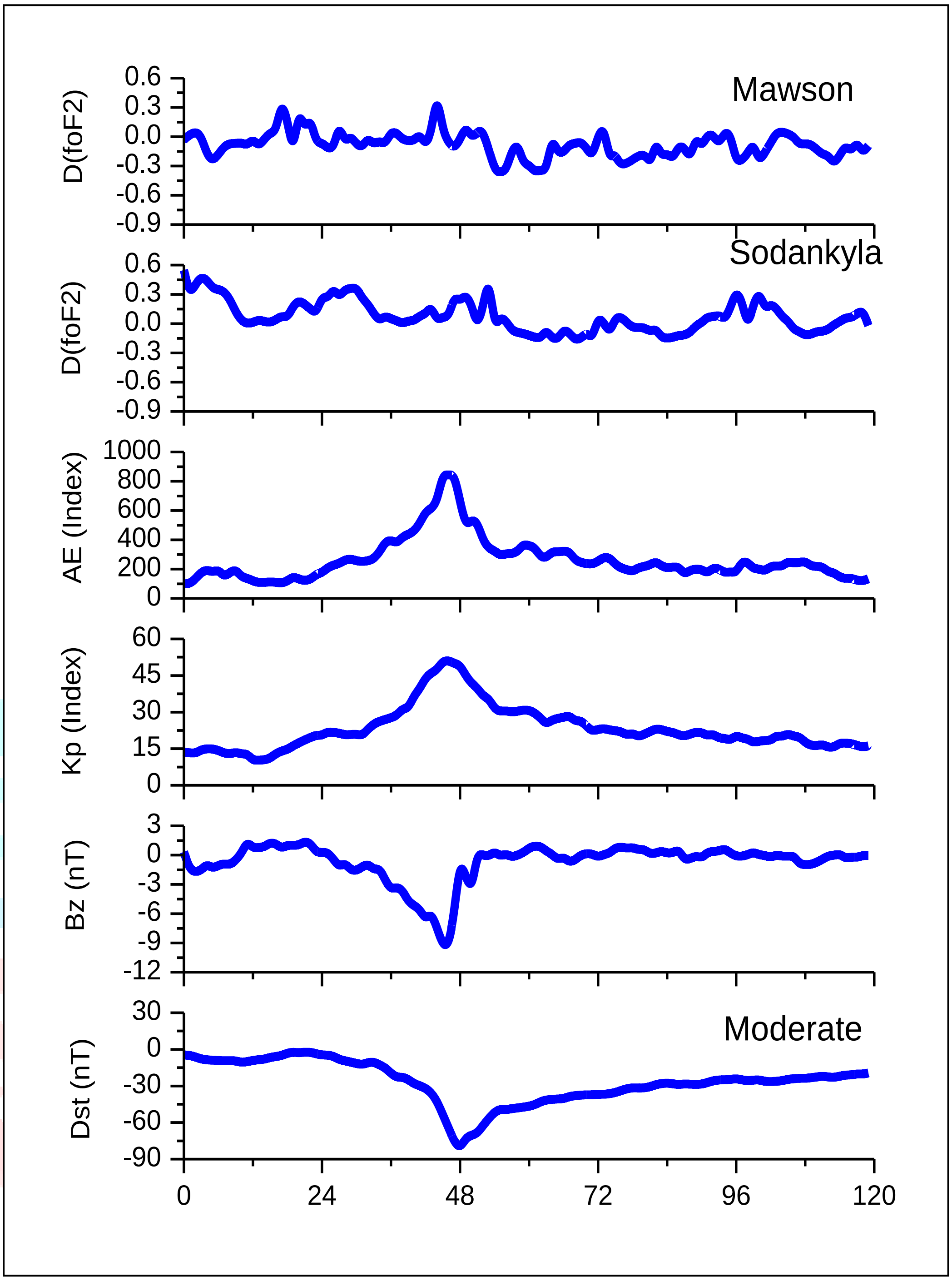
Hours (UT)

Figure 3.2.1: Variation of normalized deviation of foF2 [D (foF2)] for (Dst≥-70nT) at low latitude station for the period January 2008-December 2014



Hours (UT)

Figure 3.2.2: Variation of normalizeddeviation of foF2 [D (foF2)] for (Dst≥-70nT) at mid latitude station for the period January 2008-December 2014



Hours (UT)

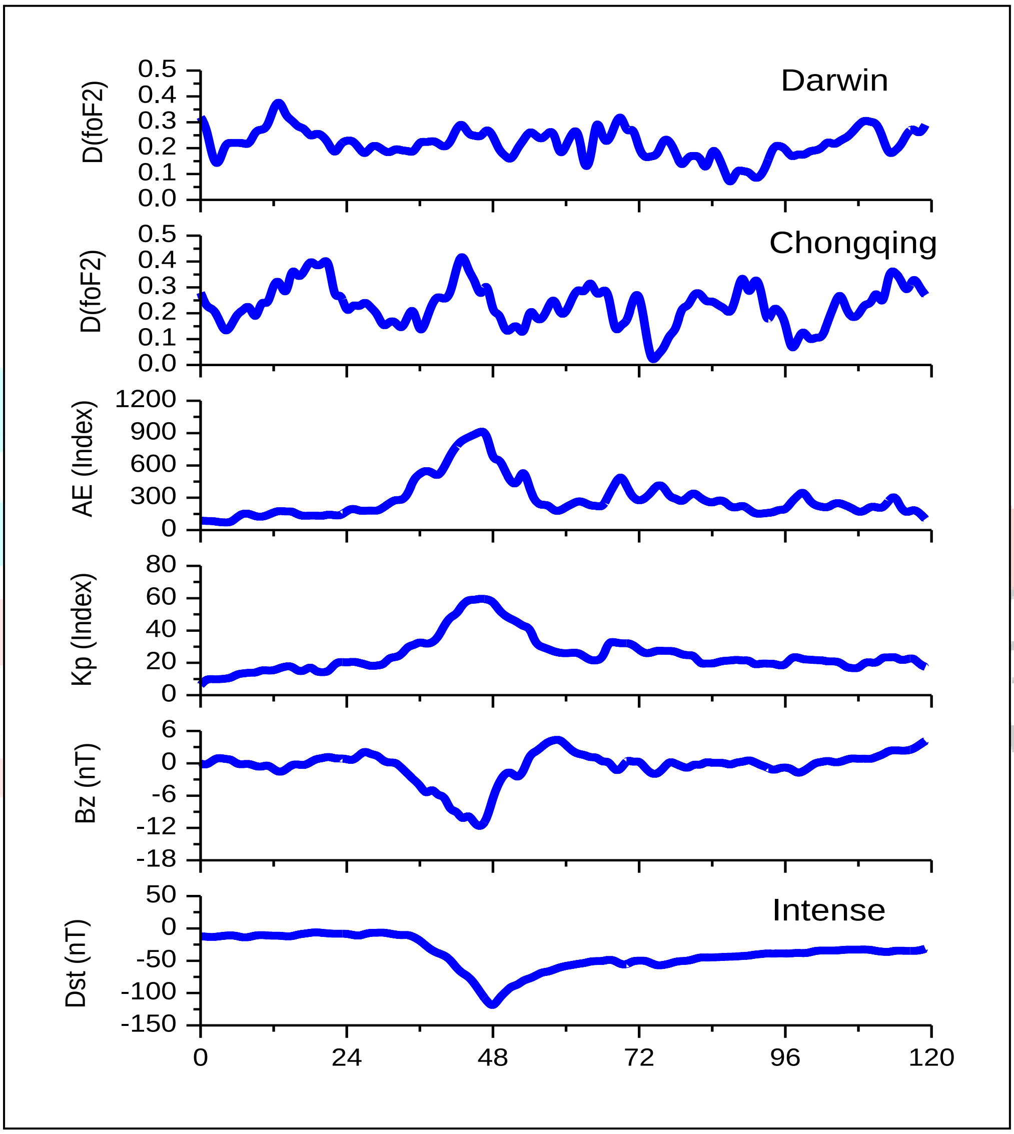
Figure 3.2.3: Variation of normalizeddeviation of foF2 [D (foF2)] for (Dst≥-70nT) at high latitude station for the period January 2008-December 2014

3.3 Average behavior of foF2 during intense storm at all low, mid and high latitude station

Figure (3.3.1), (3.3.2) and (3.3.2) shows the intense storm variation of normalized deviation of foF2 [D (foF2)] from January 2008 to December 2014. During severe storm 13 and 12 storms occurred at high latitude location Sodankyla and Mawson respectively. 11 storms were occurred at Canberra, 13 storms occurred at Beijing, 13 storms were occurred at Darwin and Canberra.
It is seen from figure (3.3.1) shows that at low latitude location Darwin the D (foF2) shows the decrement 0.31of foF2 after SSC in the recovery phase of time where as positive deviation 0.34 of foF2 obtained during the main phase of time. For Chongqing show positive deviation 0.37 of foF2 during the main phase of storm. The D (foF2) shows negative deviation 0.34 after SSC.
Figure (3.3.2) shows that positive phase effect at mid latitude location Canberra and Beijing the D (foF2). At Canberra the negative deviation -0.31 of foF2 after SSC and recovery phase of time get positive

deviation 0.11 of foF2. However the D (foF2) shows positive deviation 0.38 in the main phase of storm. At Beijing shows the negative deviation 0.34 of foF2 after SSC and recovery phase of time get positive deviation 0.33 of foF2. However it is show positive deviation 0.46 of foF2 in the main phase of storm.
Figure (1.3.3) shows that at high latitude location Mawson the positive deviation 0.35 of foF2 obtained in the main phase of storm and negative deviation -0.21 of foF2 after SSC and the D (foF2) show positive deviation 0.21 in the recovery phase of time. For Sodankyla negative deviation -0.36 of foF2 after SSC and recovery phase of time get positive deviation 0.45 of foF2. However positive deviation 0.35 of foF2 obtained in the main phase of storm.

The lowest panel of the graph shows the average of Dst, Kp and AE respectively .It is noted from the figure that the fluctuation observed in Kp follows the variation of Dst index. Kp value reaches 58.17 nt when Dst has more negative. The peak value of Dst with a value of -122.21 nT hours for severe storm.



Hours (UT)

Figure 3.3.1: Variation of normalized deviation of foF2 [D (foF2)] for (Dst≤-100nT) at low latitude station for the period January 2008-December 2014

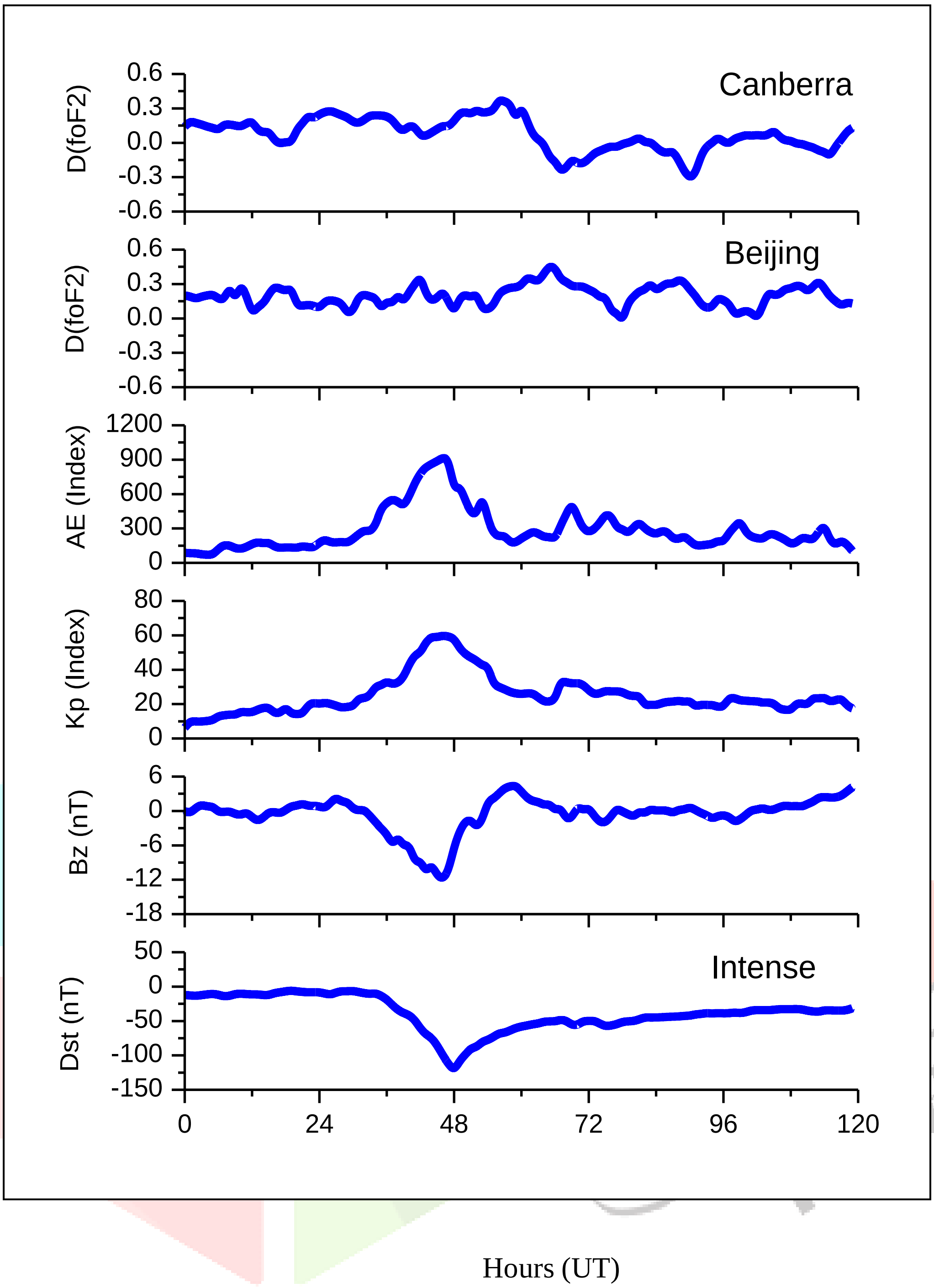


Figure 3.3.2: Variation of normalized deviation of foF2 [D (foF2)] for (Dst≤-100nT) at mid latitude station for the period January 2008-December 2014

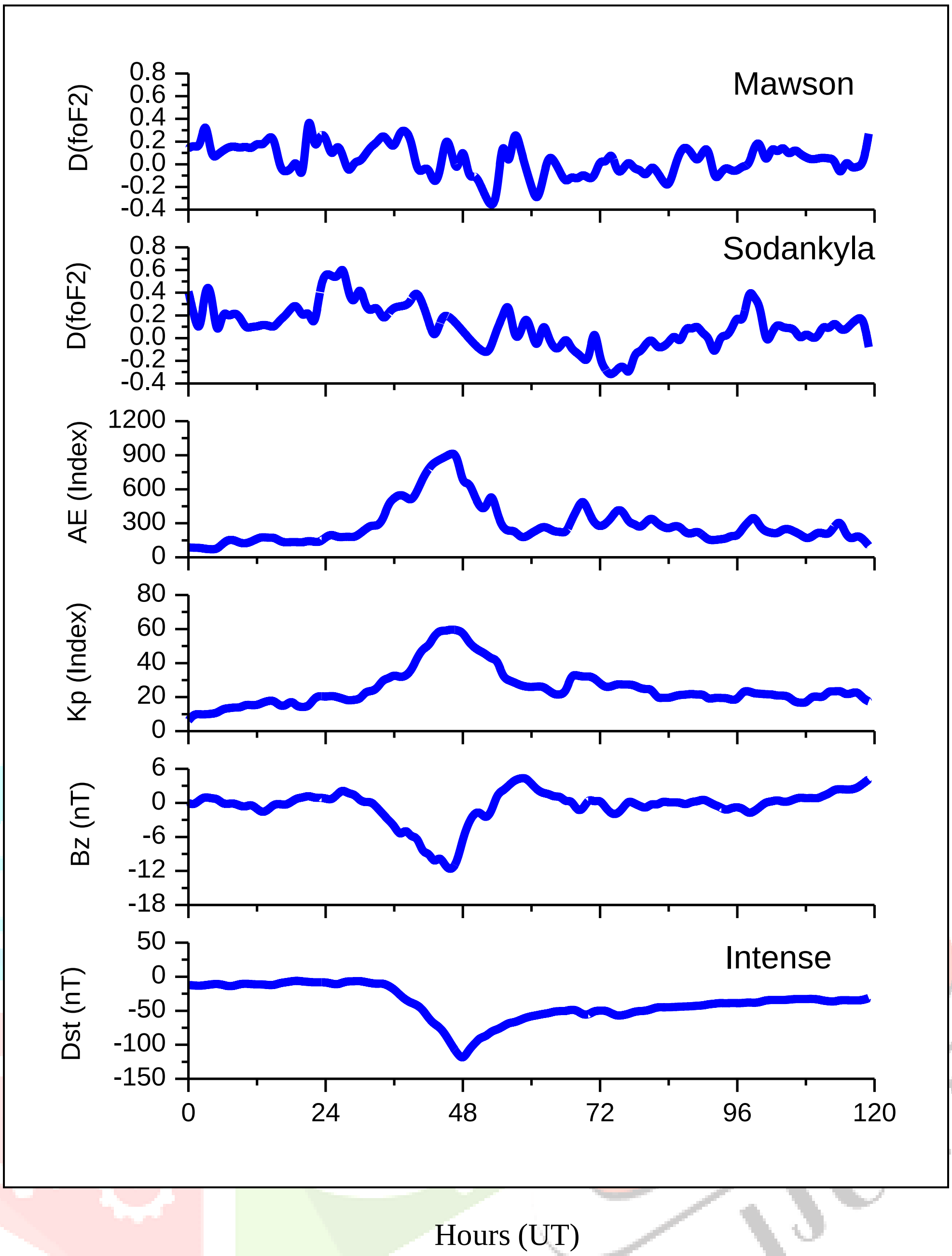


Figure 3.3.3: Variation of normalized deviation of foF2 [D (foF2)] for (Dst≤-100nT) at high latitude station for the period January 2008-December 2014

Discussion:

The most noteworthy phenomenon during geomagnetic disturbances is the simultaneous huge enhancement of foF2. The main cause of ionospheric critical frequency variations is thought to be atmospheric winds. The ionosphere at equatorial latitudes is very dynamic, posing serious hazards to communication and navigation systems, particularly on days when the magnetic field is disturbed (Kumar and Gwal 2000; Basu et al. 2002). At equatorial latitudes, ionospheric holes are one of the most spectacular disruption effects (Prolss, 2006). A dramatic decline in electron density to shallow values characterises these holes. The strength of a magnetic storm is traditionally indicated by geomagnetic indices, such as the disturbance storm time (Dst), the planetary K (Kp) index, and so on (Akala et al., 2010).

Short-term eastward penetration electric fields that drive an upward plasma drift or equator ward propagating TADs that push the plasma upward along magnetic field lines are believed to be responsible for short-term favourable storm impacts; both process move the plasma to high latitudes of slow molecular recombination and lead to large electron densities in the F2 region (e.g., Prölss, 1993; Bauske and Prolss, 1997). Long-term positive storm effects are thought to be caused by three major mechanisms: changes in neutral composition caused by the convergence of neutral winds, and upward motion of the ionosphere caused by eastward electric fields or equatorward neutral winds. Burns et al. 1995; Fuller-Rowell et al., 1996) found that downward neutral winds at low latitudes have a tendency to increase O/N2, which causes an increase in the O+ production rate and a decrease in the recombination rate as well as an increase in the ionospheric F2 region peak electron density (NmF2) and ionospheric total electron content (TEC). Depending on geophysical conditions such as season, local time, and interplanetary magnetic field (IMF) conditions, the dominant mechanism that produces positive storm effects may vary both for each storm and within individual storms. Our findings are in line with those for the average behaviour of weak storm at low and high latitude show a positive phase effect while mid-latitude shows a negative phase effect of the storm.

There have been numerous classifications offered for the influence of perturbations on the F-region of the ionosphere. However, none of them can claim to have explained all storm occurrences using the proposed method. This is owing to the phenomenon's variability, and the fact that many different processes are operating at the same time. The reaction of the region of the F2 to geomagnetic disturbances is complex, with both negative phase and positive phase. When there are magnetic disturbances, the positive phase is usually noticed near equatorial latitude. However, during major disturbances, some of the negative phase has been detected Adeniyi was the one who discovered it (1986). Our findings are in line with those for moderate storm the normalized standard deviation of foF2 show negative phase effect at low and high latitude while mid latitude show positive storm effect of storm.

Polar and high latitude regions, namely in the zone of Joule heating, have strong electric fields during storms. Due to the magnetic field geometry, they do not produce vertical drifts as at low latitudes, but they are able to influence the F2-region behavior via the recombination coefficient (Mansilla et al., 2016). The rate of the O+ + N2 reaction, which provide an important reaction in the loss of ionization, depends strongly on the electric field, and thus an increase of the field should lead to a negative effect (Schunk et al., 1975; Dalinov et al., 2001).Our findings are in line with those for intense storm low, mid and high latitude shows negative phase effect of storm after storm.

Conclusion:

In this present work investigated the responses of high, mid and low latitude ionospheric foF2 to geomagnetic activities based on the foF2 data from six different locations Chongqing, Beijing and Sodankyla, Drawin, Canberra ,Mawson . It has been studied in the present work the storm wise average behavior. The conclusions can be drawn as follows:

1. The occurrence of severe storms is smaller than moderate storms for the period of study.
2. Average behaviour of weak storm at low and high latitude show positive phase effect while mid latitude show negative phase effect of storm.
3. In moderate storm the normalized standard deviation of foF2 show negative phase effect at high and low latitude while mid latitude show positive phase effect of storm.
4. For intense storm all latitude shows negative phase effect of storm.
5. The peak value of Dst with a value for weak storm reaches -49.60nT, and -81.69n for moderate storm where as the value of Dst reaches -122.21nT for severe storm.

ACKNOWLEDGMENT

The author (Madhuri Singh) would like to thanks UK Solar System Data Centre website (https://www.ukssdc.ac.uk/cgi bin/wdcc1/secure/iono_data.pl) for providing data of ionospheric parameter of foF2 and from Omniweb (https://omniweb.gsfc.nasa.gov/form/dx1.html) for providing geomagnetic values.

REFERENCES

[1] Adeniyi, J.O., 1986 "Magnetic storm effects on the morphology of the equatorial F2-layer" Journal of Atmospheric and Terrestrial Physics, vol. 48, pp. 695–702.

[2] Aburjania, G. D., Chargazia, K. Z., Jandieri, G. V., Khantadze, A. G., and Kharshiladze, O. A., 2004"On the new modes of planetary-scale electromagnetic waves in the ionosphere", Ann. Geophys., 22, 1203–1211, doi:10.5194/angeo-22-1203.

[3] Akala A.O., Oyeymi E.O., Somoye E.O., Adeloye A.B., And Adewale A.O., 2010 "Ionospheric Fof2 Variability at Equatorial and Low latitudes During Low ,Moderate and high solar activity ", Adv. Space Res., Vol. 40, pp. 124-129.

[4] Altadill, D., and E. M. Apostolov, 2003"Time and scale size of planetary wave signatures in the ionospheric F region: Role of the geomagnetic activity and mesosphere/lower thermosphere winds", J. Geophys. Res., 108(A11), 1403.

[5] Altadill, D., Apostolov, E. M., Jacobi, C., & Mitchell, N. J..2003 "Six-day westward propagating wave in the maximum electron density of the ionosphere". Annales Geophysicae, 21, pp. 1577– 1588.

[6] BauskeR. and PrölssG. W., 1997 "Modeling the ionospheric response to traveling atmospheric disturbances", Volume102, IssueA7 pp. 14555-14562.

[7] Burns,A.G., T.L.Killeen, G.R.Carignan, R. G. Roble ,1995 "Large enhancement in the O/N2 ratio in the evening sector of the winter hemisphere during geomagnetic storms", J. Geophys. Res., Space Phys,. 100(48), pp.14661– 14671.

[8] Burns,A.G., T.L.Killeen, W.Deng, G.R.Carignan, R. G. Roble , 1995"Geomagnetic storm effects in the low- to middle-latitude upper thermosphere", J. Geophys. Res., 100, pp. 14,673– 14,691.

[9] Basu S., Groves K.M., Basu S , Sultan PJ, 2002 " Specification and forecasting of sckntillations in communication / navigation links: current and future plans," J. Atmos Solar Terr Phys 64 (16), pp. 1745-1754.

[10] Danilov AD, Lastovicka J,. 2001 "Effects of geomagnetic storms on the ionosphere and atmosphere", Int J of Geomag and Aero 2: 209-24.

[11] Fuller-Rowell, T. J., Codrescu, M. V., Moffett, R. J., Quegan, S., Rishbeth, H., 1996 "Response of the thermosphere and ionosphere to geomagnetic storms", Journal of Geophysical Research, 101, pp. 2343-2353.

[12] Haldoupis C., D. Pancheva, N.J. Mitchell, , 2004 " A study of tidal and planetary wave periodicities present in mid- latitude sporadic E layers". J. Geophys. Res. 109, A02302.

[13] Kumar Sushil, AK Gwal , 2000 "VHF ionospheric scintillations near the equatorial anomaly crest: solar and magnetic activity effects" Journal of Atmospheric and Solar-Terrestrial Physics 62 (3), pp.157-167.

[14] Lastovicka, J., Krizan, P., Sauli, P., & Novotna, D., "Persistence of the planetary wave type oscillations in foF2 over Europe". Annales de Geophysique, pp. 1543–1552, 2003.

[15] Laštovička J. and Šauli P., " Are planetary wave type oscillations in the F2 region caused by planetary wave modulation of upward propagating tides?", Adv. Space Res., 24, 1473−1476, 1999.

[16] Mansilla GA, Zossi MM. , 1993 "Some ionospheric storm effects at an Antarctic station", Adv Space Res 57, pp. 1319-27, 2016.

Pro¨lss, G.W., " Common origin of positive ionospheric storms at middle latitudes and the geomagnetic activity effect at low latitudes", J. Geophys. Res., 98, 5981.

[17] Voiculescu,M, M Ignat, 2003 “Vertical motion of ionization induced by the linear interaction of tides with planetary waves”, Ann. Geophys., 21, 1521–1529.