Study of the Effect of Geomagnetic Storm on Low Latitude Station in the Low Solar activity Period during 24^{th} Solar Cycle

Bhanupriya[1], Madhuri Singh[2], Akansha Shekhar Sharma[3], Kalpana Maski[4], S K Vijay[5]
[1,2]Research Scholar Barkatullah University Bhopal
[3]Assistant Professor, Government Science College, Dewas
[4]Assistant Professor, Regional College, Bhopal
[5]Professor, Government MLB College , Bhopal

***Abstract* - The current study investigated the effect of a geomagnetic storm on the ionospheric parameter NmF2 at low latitude stations Cocos Is (12.1642◦S, 96.8710◦E), Brisbane (27.47S,153.02E), and Darwin (12.47S,130.85E) during the 24th solar cycle's low solar activity period. The observed variations in NmF2, geomagnetic indices Dst (Disturbed Storm Time), Kp (K-Index), Ap (A-Index), and Bz were analysed using technology (Interplanetary magnetic field). All three stations have a drop in normalised deviation (DNmF2) during the magnetic disturbance, with Cocos Is experiencing a negative phase.**

***Index Terms* - Low Latitude, Geomagnetic Storm, Solar Cycle, NmF2.**

I.INTRODUCTION

When the Earth's magnetic field captures ionized particles ejected by the sun's coronal mass ejections or coronal holes, Geomagnetic storms occur. The reconnection process occurs when the arriving solar wind plasma has a southerly field. When the terrestrial ring current changes, the magnetic field at the Earth's surface weakens. Ionization increases and de- creases during geomagnetic storms referred to as positive and negative ionospheric storms. According to [1], thermospheric disturbance gravity waves greatly influence the propagation of negative and positive ionospheric storms.

According to [2] the thermospheric incident storm has a substantial impact on the behavior of the ionosphere during geomagnetic storms, recasting the neutral air winds and composition, resulting in a change in rates of production and loss of ionization; this implies a link between the ionospheric storm and the matching thermospheric storm. Furthermore, [3] observed that positive storm effects result from the downwelling of neutral atomic oxygen and uplifting of the F- layer due to winds.

The negative storm in foF2 and total electron content (TEC) develops in a formation disturbance region that travels to lower latitudes in summer than in winter and prefers the night and morning due to the local temporal fluctuation neutral winds. Depending on the station coordinates, local time effects, and specific other criteria, the reaction of the ionosphere as seen at different ionospheric stations may be somewhat distinct during the storm period [3-7].

According to [8], the dusk effect increases electron density and total electron content (TEC) in the mid-latitude ionospheric F-region during magnetic storms; this is due to an eastward electric field boosting the F-layer and merging in the east- west direction, which is perhaps responsible for the dusk effect [9].

[10] explore whether eastward prompt penetration electric fields (PPEFs) during the dominant stage have effects at equatorial and low-mid latitudes that are opposed to those at higher latitudes [11]. According to the physical mechanism of positive ionospheric storms at low and mid-latitudes, [12] examines that positive storm are anticipated to fall regularly from 20◦ to 30◦ magnetic latitudes and during the morning-noon dawn of geomagnetic storms [11]. [13] used a geomagnetic storm to study the mid-latitude differences between positive and negative ionospheric storm impacts.

At low latitude and equatorial areas, ExB drifts are impacted by fast penetration of magnetospheric convection electric fields and long-lived dynamo electric fields from disturbed neutral winds and storm-relevant replacement in ionospheric conductivity, according to [14]. Low latitude ionospheric plasma concentrations, electric fields, and currents are highly disordered during the intensified geomagnetic event. Magnetic disruption at the equator's dayside is frequently induced by dayside diffusion of the convection electric field and is associated with disturbances at high latitudes [15, 16].

The disruption dynamo and direct penetration of the high latitude electric field to lower latitudes play essential roles in reshaping the storm time equatorial ionosphere and thermosphere. As a result, statistical analyses and empirical models of storm time equatorial electric fields are created [17, 18]. For example, [19] studied the F-region reactions over the low latitude Australian area using four storms during the high solar activity period.

We analyse and discuss the variations in NmF2 in the ionosphere at the Australian area during solar cycle 24 in the geomagnetic storm that appeared on January 05, 2015, at 6.16 UT with Dst- index reaching -99 nT at 11:00 U.T. in this work.

II. DATA AND METHOD OF ANALYSIS

In this paper, the behaviour of the NmF2 of the F2 layer during a geomagnetic storm get investigated. To represent the ionospheric Response of NmF2 over the geomagnetic storm, we consider that period 05-07 Jan 2015 occurred at 6.16 UT, with hourly values of Dst, Kp, Ap, and Bz. We consider the hourly data of NmF2 from the low latitude Australian region (Cocos Is (12.1642◦S, 96.8710◦E), Brisbane (27.47S,153.02E) and Darwin (12.47S,130.85E)). The data of NmF2 is obtained through FoF2 by using the formula.

NmF2 = 1.24 × (foF2 in Mhz)2 × 1010 per cubic meter

FoF2 data were obtained through the U.K. Solar System

Data Centre (UKSSD) website (https://www.ukssdc.) for 2015.

This study's geomagnetic index and solar wind data represented hourly values of the magnetic index Dst, Kp index, and interplanetary magnetic field component Bz. These statistics were taken from the NSSDC OMNI Web of the National Space Science Centre NSSDC OMNI Web services (http://nssdc.gsfc.nasa.gov/omniweb).

The F2 region response to geomagnetic storms is conve- niently described in terms of D(NmF2) i.e., the normalized deviations of NmF2

D(NmF2) = NmF2-(NmF2)ave /(NmF2)ave x100%

The D(NmF2) variations are described in terms of percent- age in peak electron density.

III. RESULTS

The storm was intense with minimum Dst –99nT. This Sudden Storm Commencement (SSC) appeared at 06.16 UT (54 hours) on January 07, 2015. The change in NmF2 values of all the three stations from January 05 to 09, 2015, is shown in Figure-1. According to fig-1, in graph 1 for Cocos Is, the values of DNmF2 become negative -24% at 11 UT (58 hours) after 4 hours of SSC. In graph 2 for Brisbane, the values of DnmF2 become 2.57% at 09 UT (56 hours) after 2 hours of SSC. Finally, in graph 3 for Darwin, the values of DnmF2 become 0.06% at 11 UT (58 hours) after 4 hours of SSC.

The corresponding Dst, Kp, Ap, and Bz graphs are shown in figure-2. In figure 2, the first graph shows Dst; according to the graph, in storm time, the Dst becomes negative -21nT after 2hours, i.e., at 08 UT (56 hours). The second graph shows the Kp index; according to the graph, the Kp becomes highest 63 at the same time. The third graph shows the Ap index; according to the graph, the Ap index becomes 94 at the same time. The fourth graph shows Bz, which becomes -17.4 at 09 UT (57 hours). There is a slight drop in Dst in the recovery phase at 14 UT (62 hours).

IV. DISCUSSION

According to [20] et al., massive (or severe) storms have a Dst extreme of -100 nT, ordinary storms have a Dst extreme of -50 to -100 nT, and dull storms have a Dst extreme of -30 to -50 nT. The storm was an average storm

Fig. 1. The graph shows the normalized deviation of NmF2 for all three stations of the Australian region. The first graph shows the deviation in Cocos Is, the second is in Brisbane, and the third is in Darwin.

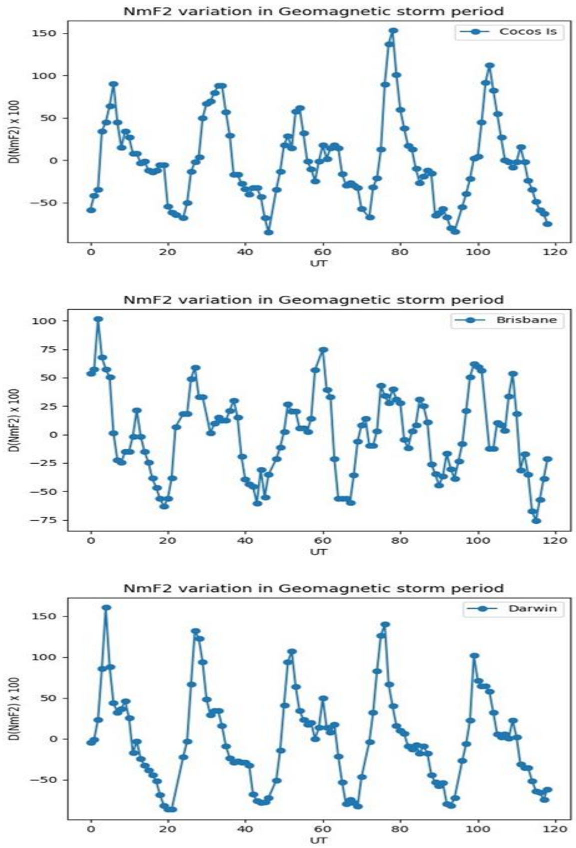
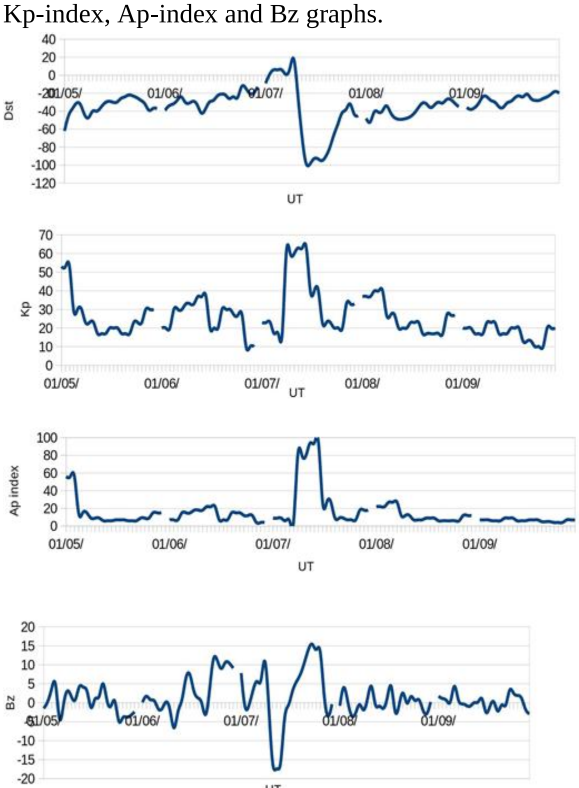


Fig. 2. The graph shows the corresponding Dst-index, Kp-index, Ap-index and Bz graphs.



based on these characteristics. [21] and [22] discovered that interplanetary phenomena govern interplanetary events that trigger intense magnetic storms. When the IMF stream is oriented in the negative z-direction, geomagnetic activity increases [23]. TID (Travelling Ionospheric Disturbances) are formed at high latitude and migrate to the equatorial direction, according to [24] and [25].

[26] discovered that during the early phase of a storm at high and mid-latitudes on the dayside, there is a lack of positive ionospheric storm impacts and a negative storm, and the presence of an excessive positive phase at a low latitude station. [27] discovered that the F2 region diminishes (negative storm impacts) at high latitudes while increasing (positive storm effects) at low latitudes; our results show the same for low latitudes. [28], discovered that the concentration of electrons at the highest height of the F2-layer is precisely proportional to the [O]/[N2] ratio.

According to [29], the thermospheric heat affects the thermospheric composition during a geomagnetic storm, which causes the negative phase. The thermospheric heat creates its motion, which moves the air from the equator to lower latitudes at the F2 -layer peaks [30]. The heated gas with a low [O]/[N2] ratio has a high temperature traveling through the thermosphere. [31] discovered that the linear recombination coefficient height increases with increasing temperature in the F-area, and therefore, the electron concentration decreases. As a result, the negative phase in the heated thermospheric gas is caused by two factors: lower [O]/[N2] and increased recombination owing to increased temperature [32]. The prompt penetration of electric field (PPEFs) effect in the equatorial/low-latitude ionosphere could be related to solar/magnetospheric source electric fields [33-36] or magnetospheric dynamical procedure, such as substorms [34]. In both circumstances, there is a chance to develop an eastward electric field, which boosts the F layer to higher altitudes where recombination is significantly lower, increasing F layer electron density/TEC [37]. According to [19], the positive phase in intense magnetic storms occurred in 2000 at Darwin, a low latitude station.

V. CONCLUSIONS

Based on the data provided above, we concluded that positive storms occur in low latitudes due to geomagnetic storms. As a result, the storm is moderate, with a Dst of -99. The connection between Bz, Kp, Ap, and DNmF2.

REFERENCES

[1] J. Liu, B. Zhao, and L. Liu, "Time delay and duration of ionospheric total electron content responses to geomagnetic disturbances" Ann. Geophys vol. 28, pp. 798-805, 2010.

[2] M.1, Buonsanto,"Tonospheric storms-A review," Space Science Reviews, vol. 88, n0. 3/4, pp. 563-601, 1999.

[3] RP. Kane, "lonospheric foF2 anomalies during some intense geomagnetic storms," Ann. Geophys, vl. 23, pp. 2487-2499, 2005.

[4] AD. Danilov. "F2region response to geomagnetic disturbances" Atmos. Sol-Terr. Phys, vol 63. pp. 441449. 2001.

[5] AO. Akala. EO. Oyeyemi, EO. Somoye, A. B. Adcloye, and A.O. 'Adele, "Variability of foF2 in the African equatorial ionosphere" AdSpace Res, vol. 45, pp. 604-613, 2010.

[6] Vijayalekshmi, N. Balan, S. Ram, J. ¥. L. W. Wei, Y, B. Zhao, G. Guozhu, and W. Wan, "Statistics of geomagnetic storms and ionospheric storms at low and mid-lattudes in two solar cycles." Al1,11328, vol. 16, pp. 748-761, 2000.

[7] BO. Adebesin, S.O. Ikubanni, S.J. Adebiyi, and B. W. Joshua, ionospheric disturbance of March 9, 2012 and comparison with IRI-model, 2012.

[8] BO. Adebesin, S.O. Ikupanni J O Ojadiran, J.S. Kayode, "An investigation into the geomagnetic and ionospheric Response daring a magnetic activity at high and mid-latitude," Advances in Applied Science Research, vol. 3. no. 1, pp. 146-185, 2012.

[9] C-S. Huang. J.C. Foster, L:P. Goncharenko, PJ. Erickson, W. Rideout and A. Coster, "A strong postive phase of ionospheric storms observed by the Millstone Hill incoherent scatter radar and global GPS network, J Geophys Res (USA). vol. 110, pp. 6303-6303, 2005.

[10] I, S. Batista, E. D. Paula, M. A. Abdu, N. Trivedi, and M. Greenspan "Ionosphere effects of the March 13, 1989, magnetic storm at low and equatorial latitudes" J. Geophys. Res, vl. 96, pp. 943-956, 1991.

[11] N. Balan, K. Shiokawa, ¥. Otsuka, T: Kikuchi, D. V.Lekshmi, S. Kawa-mura, M. Yamamoto, and G. J. Bailey, "A physical mechanism of positive ionospheric storms at low and mid-latitudes through observations and modeling." Geophys. Res, vol. 115, pp. 2304-2304, 2010.

[12] V. 'Chukwuma, "Interplanetary phenomenon, geomagnetic and iono-spheric Response associated with the storm of" Acta Geophys Pol(Poland), vol. 51, pp. 459-472, 1989.

[13] B.J. Adekoya, V. U. Chukwuma, N-O. Bakare, and T. W. David, "On the elfects of geomagnetic storms and prestorm phenomena on low and middle latitude ionospheric F2 layer." Astrophys Space Sci, vol 340, 2012.

[14] BG. Fejer ERD. Paula, S. A. Gonzalez, and RF. Woodman, "Average vertical and zonal F region plasma drifts over Jicamarea.Journal of Geophysical Research, vol. 97, no. AB, pp. 13901-13906, 1997.

[15] radar." J. Geophys. Res, vol. 10, pp. 17 161-17 173, 1996.

[16] T. Kikuchi, M. Pinnock, A. Rodger, H. Lh T Kitamura, H.Tachihara, IM. Watanabe, N. Sato, and M. Ruohoniemi, "Global evolution of substorm-associated D_P. 2 current system observed by SuperDARN and magnetometers." Advances in Space Research, 2000a.

[17] B. G. Fejer and L. Scherliess, "Empirical models of storm time equatorial zonal electric Held," J. Geophys. Res, vol. 102, no. A11, pp. 47-71,1997.

[18] A. D. Richmond, "ionospheric electrodynamics," in Handbook of Atmospheric Electrodynamics, H. Volland, Bd, vol. 2. CRC Press, pp. 249-290, 1995.

[19] G. Khoobchandani S. D Mishra, and S K Vijay "Variability of foF2 at Low Laitude daring High, Moderate and Low Solar Activity." International Journal of Engineering Trends and Technology. 2017.

[20] W. D. Gonzalez, J. A. Joselyn, Y. Kamide, H. W. Kroehl, G. Rostker, B.T Touruani, and V. Vasyliunes, "What is geomagnetic storm," Journal of Geophysical Research, vol. 99, pp. 5771-5792, 1994.

[21] LE Vieira W.D. Gonzalez, A. L. C.D. Gonzalez, and A. Lago, "A study of magnetic storms development in two or more steps and its association with the polarity of magnetic clouds.

J. Atmos. Sol. TerraPhys, vol. 63, pp. 457-461, 2001.

[22] W. D. Gonzalez, BLT. Tsurutani, and A. L. C. D. Gonzalez, “Inter-planetary origin of geomagnetic storms,” Space Sei. Rev, vol. 88, pp. 520-562, 1999.

[23] Chaman-Lal, “Sun-Earth geometry, geomagnetic activity, and planetary P2 layer ion density: Part I: Signatures of magnetic recomnecton,” Journal of Atmospheric and Solar-Terresivial Physics, vol. 62, 80, pp. 3-16. 2001.

[24] de. Abreu, “Hemispheric asymmetries inthe ionospheric response ‘observed in the American sector during an intense geomagnetic storm.” J. Geophys. Res, vol 11S, pp. 12312-12312, 2010.

[25] W.L.C. Lima, F. Becker-Guedes, Y. Sahai, P.R. Pagundes, JR. Abalde, G. Crowley, and J. A. Bitencour, “Response of the equatorial and low laltitude ionosphere during the space weather events of.” Aun. Geophys, vol. 22, no. 9, pp. 3211-8219, 2002.

[26] B-O. Adebesin, “A study of intense magnetic storms development (using Dst signature) and its association with magnetic clouds” Afr Re. Phys vol. 2, no, OOLT, pp. 143-158, 2008.

[27] G.B. Burns, B. A. Tinsley. A. V. Frank-Kamenetsky, and E. A. Bering, “Interplanetary magnetic eld and atmospheric electric circuit influences ‘on ground-level pressure at Vostok" J. Geophys Res, vo. 112, pp. 4103 4103, 2007.

[28] Rishbeth, H., and D. W. Barron, Equilibrium electron distribution in the ionosphericF2 layer, J. Atmos. Sol. Terr. Phys., 18, 234, 1960.

[29] M. J. Seaton, “A possible explanation of the drop in F-region critical ‘densities accompanying major ionospheric storms," J. Amos. Terr. Phys,vol. 8, pp. 122-124, 1956.

[30] R.A. Duncan, “F-egion seasonal and magnetic storm behavior” Journal of Atmospheric and Terrestrial Physics, Vol. 31, pp. 59-10, 1969.

[31] A.V. Mikhailov. M. G. Skloblin, and M. Forster, ‘Daytime F2 layer Positive storm elfect at middle and lower latitudes.” Ann. Geophys, vol. 13, pp. 532-532, 1995.

[32] A.V. Mikhailov and M- Forster, “Day-to-day thermosphere parameter variation as deduced from Millstone Hill incoherent scatter radar ‘observations during March 16-22, 1990 magnetic storm period:” Ann Geophys, vol 15, pp. 1429-1439, 1997.

[33] Wei, Y., B. Zhao, G. Guozhu, and W. Wan, Electric field penetration into Earth’s ionosphere: A brief review for 2000–2013, Sci. Bull., 60(8), 748–761, doi:10.1007/s11434-015-0749-4, 2015.

[34] C. S. Huang, “Statistical analysis of dayside equatorial imospheric electric fields and elecrojet currents produced by magnetospheric substorms during sawiooth evens." J. Geophys. Res, vol. 117,pp. 2316-2316, 2012.

[35] BG. Fejer, J. W. Jensen, and S. Y. Su, “Seasonal and longitudinal dependence of equatorial disturbance vertical plasma drifts” Geophys, ‘Res, Lett, vol. 35. pp. 20 106-20 106, 2008.

[36] C. S. Huang and K. Yumoto, “Quantification and hemispheric asym-metry of low-latitude geomagnetic disturbances caused by solar wind pressure enhancements.” J. Geophys. Res, vol. 111, pp. 9316-9316, 2006.

[37] PR. Fagundes, LP. Goncharenko, A.J. D. Abreu, K. Venkatesh M, Pezzopane, Rlesus, M. Gende, A. J. Coster, and V. G. Pilla “Ionospheric Response to the 2009 sudden stratospheric warming over the equatorial, low, and middle latitudes in the South American sector.” J. Geophys. Res. Space Physies, vol. 120, pp. 7889-7902, 2015.