Original Research Article

Day to day variability of NmF2 during 23rd and 24th high solar activity period at low latitude station

Anita Agrawal[*], Kalpana Maski[**], S. K. Vijay[***], S. D. Mishra[****]

[*]Research Scholar, Barkatullah University Bhopal, Madhya Pradesh, INDIA.
[**]Regional Institute of Education, NCERT Bhopal, Madhya Pradesh, INDIA.
[***]Rashtriya Uchhatar Shiksha Abhiyan Bhopal, Madhya Pradesh, INDIA.
[****]Atal Bihari Vajpayee Hindi Vishwavidyalaya Bhopal, Madhya Pradesh, INDIA.
Email: anitagrwl3@gmail.com

Abstract This paper presents the study of day to day variability of NmF2 during 23rd and 24th high solar activity period at low latitude station Jicamarca (12^{o}S, 76.90^{o}W). Jicamarca (12^{0}S, 76.90 ^{0}W) is an American station located near the dip equator. To study day to day variability of ionosphere, we have used the ionosonde measurements for NmF2 of F2 layer. The NmF2 is an important and most widely used parameter for studying the ionospheric variability. The variability of ionosphere through NmF2 has been studied annual diurnal. Hourly data for the year 2002 (High solar activity period for 23rd solar cycle) and 2014 (High solar activity period for 24th solar cycle) of NmF2 are analyzed to study the diurnal variation. There are two maxima during the day time, the value of NmF2 is greater vary during the day time than night. The study shows that the value of NmF2 is significantly more in 23rd high solar activity period than 24th high solar activity period.

Key Words: Diurnal variation, High Solar Activity Period, Ionosphere, Low Latitude Station, Variability of NmF2.

[*]**Address for Correspondence:**
Dr. Anita Agrawal, Research Scholar, Barkatullah University Bhopal, Madhya Pradesh, INDIA.
Email: anitagrwl3@gmail.com

Access this article online	
Quick Response Code:	Website: www.statperson.com
	Accessed Date: 26 March 2018

INTRODUCTION

The day-to-day variability is the variability from one day to the next at a given hour. The study of the variability of the ionosphere parameters is a very significant means of studying the variation of the equatorial ionosphere. The ionospheric F2-layer is most efficient layer for long-distance high frequency (HF) radio communication. The regular solar daily variation of the geomagnetic field was first explained by Stewart in1882. They explained the existence of current in the upper atmosphere due to movement of the conductive air across the lines of the force of earth magnetic field caused by the solar heating. The factors that control the ionospheric variability are electric fields, currents, plasma drifts, instabilities, and plasma structuring. They influence variability due to upward propagating waves from their sources in the lower atmosphere, which include- planetary waves, Kelvin waves, their interactions with tidal modes resulting in electric field generation by *E*- and *F*- layer dynamo, and gravity waves; We have focused the study on low latitude. The low latitude is a complex area of the ionosphere. Solar and magnetospheric disturbances that cause penetration electric fields, disturbance winds, and disturbance dynamo electric field that prevail over low latitudes. An In situ measurement of plasma density in the F region of ionosphere gives useful information about the location of the EIA, its spatial and temporal extent, and variability with the season and solar cycle Larger variability occurs at shorter wavelengths. The variability of the solar activity initiates enormous variations in the neutral density and temperature, ion and electron densities and, neutral winds, and electric fields in the ionosphere. Knowledge of the ionosphereic parameters such as IEC, ionospheric F2 peak density NmF2, its peak height hmF2, or in some cases the whole electron density profile Ne (h), is of great importance for ionospheric forecasting and ionospheric propagation studies. Practical importance of space weather studies includes knowledge of impact of ionospheric variability on trans-ionospheric radio propagation (Zhang *et al*., 2004). The earth's ionosphere is formed due to photoionization of neutral atmosphere by solar radiation and exhibits latitudinal, longitudinal, altitudinal as well as diurnal and seasonal. Sardar *et al* (2012) have studied latitude variation of NmF2 at six location Chilton,Port-stanley, Athence, Sanvito, Kwajelin, and Learmonth and found that variation of NmF2 is maximum during day time hours at all latitude. Onori E. O. (2016) presents the effect of longitude on the relative variability (VR) of the maximum electron density of the F2 region (NmF2) during High Solar Activity (HSA). Data from six equatorial stations located from west to east of the Greenwich Meridian (GM) are used for this study. Ionospheric stations in the neighborhood of GM are found to have lowest post midnight NmF2 VR, while the stations west of GM are found to have the lowest pre-midnight NmF2 VR. Large daytime NmF2 VR is found in stations close to GM. Longitudinal influence is observed in the hour of occurrence of post-midnight peak of NmF2. While post-midnight NmF2 VR in stations close to GM occurred between 05 - 07 hours, post-midnight NmF2 VR of stations east of GM occur earlier that is between 02 – 04 hours. In all six stations considered, the variability of NmF2 is generally greater at Huancayo (78%) and Vanimo (70%) than other stations in the neighborhood and east of GM due to their longitudinal differences. Venkatesh *et al*., (2011) studied the diurnal, day to day, seasonal and latitudinal variation of TEC, NmF2, slab thickness (t) and neutral temperatures (Tn) over the three different Indian stations. Their result shows that the maximum electron density of the F2-layer (NmF2) at all the three stations more or less show similar nature of variation with much lower values during most of the day-time compared to those of TEC. The ionospheric electron content (IEC), maximum electron density and ionospheric slab thickness (t) are the parameters used to monitor the temporal and spatial behavior of the ionosphere. Gwal A.K (2012) paper presented the variation in NmF2 (Maximum electron density of F2 layer) parameter by correlation method at the time of strong seismic activity. They used Ionosonde data which installed at different locations for analysis purpose. They used two ionosonde receivers, where one is in the earthquake preparation zone and the other is outside of it. By correlation technique they calculate Auto Correlation Coefficient and Cross-Correlation Coefficient. Results of the study showed the anomaly in Correlation Coefficients related to NmF2 parameter few days before the seismic event. This fact can be regarded as precursory phenomena. The anomaly in the F-layer density may be interpreted as a result of associated seismic electric field generated by internal gravity waves. It may be due to the inflow of energy from the earth and then propagated upward, which disturb the F region of ionosphere. This study may be beneficial for prediction of earthquake. AOgwala, (2015) have studied of the Maximum Electron Density of the F2 layer (NmF2) in the ionosphere over the African, Asian and American sectors. Mean NmF2 and NmF2 coefficient of variability (CV) of three ionosonde stations namely Dakar (14.8°N, 17.4°, 16.1°N dip) in the African sector, Manila (14.7°N, 121.1°E, 14.2°N dip) in the Asian sector and Huancayo (12°S, 75.3°W, 1.9°N dip) in the American sector were used for this study during three epochs of solar cycle: 1982, year of high solar activity (HSA) with monthly average sunspot number, Rz12 (115.9), 1983, year of moderate solar activity (MSA) with monthly average sunspot number, Rz12 (68.7) and 1986, year of low solar activity (LSA) with monthly average sunspot number, Rz12 (13.4). Results obtained show that pre- and post-noon peaks bothering the noon bite-out were present in the diurnal curves of mean NmF2 for the three stations. Morning peaks were predominant during HSA while afternoon peaks were predominant during MSA and LSA. NmF2 CV is characterized by pre- and post-midnight peaks in all the three stations. The results reveal diurnal, seasonal, solar cycle and longitudinal influences of mean NmF2. Y. Chen *et al* (2012) have examined equinoctial asymmetry in solar activity variations of NmF2 and TEC. They observed that with solar activity increasing, the equinoctial asymmetry of noontime NmF2 increases at middle latitudes but decreases or changes little at low latitudes, while the equinoctial asymmetry of TEC increases at all latitudes. The latitudinal feature of the equinoctial asymmetry at high solar activity is different from that at low solar activity. The increase rate of NmF2 with P at March equinox (ME) is higher than that at September equinox (SE) at middle latitudes, but the latter is higher than the former at the EIA crest latitudes, and the difference between them is small at the EIA trough latitudes. They explained above reason that ionospheric equinoctial asymmetry may originate from the equinoctial differences in the thermosphere and ionospheric dynamics processes, these equinoctial differences also should result in discrepant variations of electron density with solar activity between the two equinoxes.

Data and Method: Hourly values of the critical frequency (foF2) parameter are taken over Jicamarca (12^0S, 76.9^0W; dip 0.28^0). Jicamarca is an ionospheric station along the anomaly trough in the American sector. Hourly values of the critical frequency (foF2) parameter are collected from the site NGDC Space Physics Interactive data Resource (SPIDR) website (http://spidr.ngdc.noaa.gov) during period (2002 and 2014).

The NmF2 values were derived from the foF2 data using the relation in equation

NmF2 = 1.24 x 10^{10} (foF2)2 (i)

Where NmF2 is given in m-3 and foF2 in MH

RESULT

Annual Diurnal Variation of NmF2: Figure 1 shows annual variation of NmF2, in which the average mean value of is NmF2 at Y-axis and local time is at X-axis for low latitude station Jicamarca (12°S, 76.90°W). Figure 1 (a) shows the annual variation of NmF2 for high solar activity period in the year 2002. Fig.1 (b) shows the annual variation of NmF2 for high solar activity period in the year 2014. From figure 1(a) it can be seen that the NmF2 gets change with the increase of time. According to local time it remains down in the night and reaching minimum of whole day at LT 5:00 next get sharply increase when sun rises up until arriving at the first maximum at LT 9:00 and reaches second maximum at LT15:00 after going through only little drop. Finally become lower and lower in the night, entering next cycle. We found two maximum periods from LT 9: 00 to LT 15: 00with only small variation, which means that the ions in the ionosphere undergo a period of high ionization. From figure 1(b) it can be seen that the NmF2 gets change with the increase of time. According to local time it remains down in the night and reaching minimum of whole day at LT 4:00 next get sharply increase when sun rises up until arriving at the first maximum at LT 8:00 and reaches second maximum at LT15:00 after going through only little drop. Finally become lower and lower in the night, entering next cycle. We found two maximum periods from LT 9: 00 to LT 15: 00with only small variation. The annual variation of NmF2 for year 2002 is more than 2014.

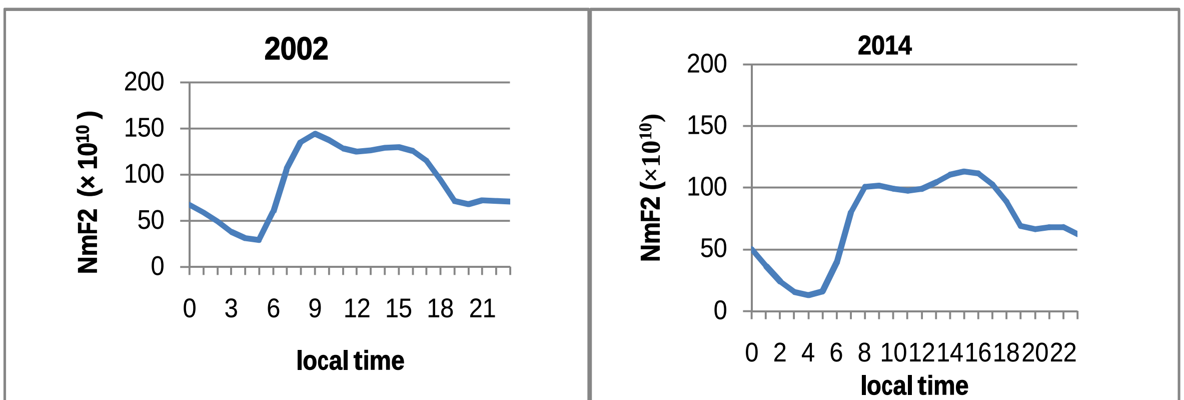

Figure 1: Annual Diurnal Variation of NmF2 during 23rd and 24th solar cycle for year 2002 and 2014 at Jicamarca (12°S, 76.90°W)

DISCUSSION

The present study allows us to investigate the morphology of day to day variability of NmF2 during 23rd and 24th high solar activity period at low latitude station Jicamarca (12°S, 76.90°W). Jicamarca (12°S, 76.90 °W) is an American station located near the dip equator. The result presented here provides the complete picture of day to day variability of NmF2 at low latitude station. We found that two maximum periods from graph of diurnal and seasonal variation of NmF2 with only small variation. In 2002 annual diurnal variation the value of NmF2 starts increases from 5: LT and reaches to maximum 9: LT and little drop then again increases up to 15: LT, In 2014 the value of NmF2 started increase from 4: LT and reaches to maximum 9: LT and little drops then again increases up to 15: LT. In 2002 first maxima is greater than second. But In 2014 first maxima is little smaller than second. In 2002 first maxima is significant greater than 2014. Diurnal variation of NmF2 for year 2002 is more than 2014. There are many cause of ionosphere variability in the ionospheric plasma.

1. Solar radiation is main cause of ionospheric electron density to vary diurnal attitudinally, seasonally and over 11year cycle of solar activity.
2. The composition of the thermosphere which affect the recombination rate.
3. Thermosphere wind which cause the transport the plasma along the magnetic field line thus raising and lowering the ionosphere.

The vertical drift is upward during the daytime and increases in velocity from around 0400 up till around 900 LT with a wide peak around 1500 LT. We can say that during day time electrons move up and away from the equator in which case the electrons depletion during the daytime peaks around midday, this condition allows for the formation of a maximum electron density before noon and a minimum around midday. Generally, depressions were observed nearly after the daytime peak till around 1700 LT. After the maximum upward vertical drift was reached, the drift velocity takes a downward pattern and reach minimum before the post-sunset increase begins again. This shows a reduction in the depletion of electron density after noontime. Since the decrease in reduction begins some hours before sunset, when ionization production is still taking place, then one should expect the formation of a post noon peak in the electron density. This is smallest in summer. At night time, the vertical drift is first characterized by an upward enhancement; it is called the evening time pre-reversal vertical enhancement (PRE) around 1900 LT, then by a downward reversal. The PRE phenomenon is mainly driven by eastward electric fields and can change the height of the ionosphere. The diurnal variation of NmF2 is determined by production, loss and transport processes. In the low latitude ionosphere the transport of electrons due to ExB drift determine particular shape of the diurnal pattern of NmF2. the stations located between the equatorial anomalies crests, some features of the diurnal pattern can be explained in terms of the ExB drift velocity variation. Although the meridional wind in these cases would play a major role, not find any clear connection between wind and NmF2, taking into account that a pole ward wind would produce a decrease in NmF2 and an equator ward wind, increase in NmF2 (" www.researchgate.net 2017). Solar activity and seasonal dependences of the plasma density distribution around sunset are due to the changes in the PRE vertical drift with solar activity level and season and neutral winds are also important for the plasma density distribution. Yiding Chen (2009) investigated the solar activity dependence of the topside ionosphere with ROCSAT-1 observations. The distribution of the plasma density at 600 km altitude shows features with considerable local time, season, and solar activity differences. In the daytime, plasma density peaks around the dip equator. Photoionization, recombination, and dynamics processes play important roles in the F2 peak region, while dynamics processes dominate in the topside ionosphere. During daytime, equatorial vertical drift drives the plasma to higher altitudes in the dip equator region. That enhances the peak(s) in the latitudinal distribution of plasma density in the topside ionosphere. As a result, the strength of the peak depends on the vertical drift and the plasma density in the F2 peak region. Stronger vertical drift should induce the peak in the topside plasma density to be more distinct. The plasma density in the F2 peak region will change when there are changes in neutral atmosphere and solar radiations. Because of the effect of the equatorial vertical drift, it is likely that the topside plasma density in the dip equator region shows stronger enhancement as compared with the case in the absence of the equatorial vertical drift. Liu *et al*. (2006b) observed inconsistency of the change rates of solar EUV intensity and NmF2, if the solar activity effects of neutral compositions and chemical and dynamical processes are consistently taken into account. Zhao *et al*. (2005) investigated the changes in topside ion compositions under different solar activities. Lighter ions (H+ and He+) dominate at 840 km altitude at low solar period. With increasing solar activity, the main ions are gradually taken over by O+. It means the upper transition height, the altitude with equivalent number density of lighter ions and O+, moves towards higher altitudes under high solar activities. (Liu libo2012). The topside ionosphere is mainly composed of ions O+, H+ and He+. The abundances of these ions are dominated by transport and chemical processes (Chandra and Rangaswamy, 1976; West *et al.*, 1997; Zaho *et al.*, 2005). The plasma distribution of the equatorial and mid-latitude ionosphere is subject to a number of transport processes involving thermospheric neutral winds, EXB drifts, and fieldaligned diffusions (Venkatraman and Heelis, 2000).

CONCLUSIONS

The outcome in present study gives complete picture of day to day variability of NmF2 which is an important parameter of F2 layer of ionosphere. The main results are:

- There are two maxima during the day time, the value of NmF2 is greater vary during the day time than night.
- We compare the day to day variability of NmF2 during high solar activity period 23rd and 24th solar cycle. The value NmF2 is greater in 2002 of 23rd solar cycle than 2014 of 24th solar cycle. The Sun is much less active in Solar Cycle 24, resulting in significantly weaker ionization of the atmosphere.

REFERENCES

1. Gwal AK, Jain Santosh, Panda Gopal, Gujar Y. S. Raghuwanshi S. and Vijay S. K., "Study of Ionospheric Perturbations during Strong Seismic Activity by Correlation Technique using NmF2 Data" Res. J. Recent Sci vol. 1(1), 2-9, Jan (2012) www.isca.in
2. Liu, L., Wan, W., Ning, B., Pirog, O.M., and Kurkin, V. I. "solar activity variation of the ionosphere peak electron density, " Geophy.Res.A08304, 2006b
3. Ogwala E. O. Somoye, E. O. Onori, "Characterizing the Maximum Electron Density of the F2 Layer (NmF2) in

the Equatorial Ionosphere " Physics Journal, Vol.1, No.2, Sep. 2015, Pub. Date: Sep. 1, 2015

4. Onori E. O., Somoye E. O., Ogungbe A. S., Ogwala A.(2016) "Longitudinal Influence of NmF2 Variability on the Equatorial Ionosphere During High Solar Activity" Physics Journal Vol. 1, No. 3, 2015-16, pp. 388-392
5. Nuzhat Sardar, Mishra S.D. Vijay S K, Singh K Anup and Anju Nagar, Union July (2012) "Study of Latitudinal variation of Ionospheric parameters". J. Ind.Geophys. Vol.16 pp.113-133.
6. Venkatesh, K., Rama Rao, P.V.S, Prasad, D.S.V.V.D, Niranjan, K., and Savanya, P.L, "Study of TEC, slab thickness and neutral temperature of the Study of Latitudinal variation of Ionospheric parameters - A Detailed report thermosphere in the Indian low latitude sector," Ann. Geophys., 29, 1635-1645, 2011
7. Venkatraman, S. and Heelis, R.," Inter hemispheric Plasma flows in the equatorial topside ionosphere, J. Geophys. Res., 105(A8), 18464, 2000."
8. Y. Chen,, L. Liu, W. Wan, and Z. Ren "Equinoctial asymmetry in solar activity variations of NmF2 and TEC" Ann. Geophys., 30, 613–622, 2012 www.ann-geophys.net/30/613/201 doi:10.5194/angeo-30-613-2012
9. Yiding Chen, Libo Liu, Weixing Wan, Xinan Yue, and Shin-Yi Su "Solar activity dependence of the topside ionosphere at low latitudes" JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, A08306, doi:10.1029/2008JA013957, 2009
10. Zhang, M.L., Shi, J.K., Wang, X., Radicella, S.M. (2004) "Ionospheric variability at low latitude station" Hainan, China. Advances in Space Research, 34 (2004) 1860-1868
11. Zaho, B., Wan, W., Liu, L., Yue, X., and Venkatramn, S. Stastistical characteristics of the total ion density in the topside ionosphere during the period 1996-2004 using empirical orthogonal function (EOF) analysis," Ann. Geophy., 23, 3615,2005
12. ("www.researchgate.net 2017)
13. http://www.aiscience.org/journal/
14. www.isca.in

Source of Support: None Declared
Conflict of Interest: None Declared