Day to Day Variability of Ionospheric Parameters at Mid Latitude for Conjugate Locations

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Abstract: *F_2-region variability of ionospheric parameters ITEC and foF2 at mid latitude location from January 2009 to December 2013 are being studied. For this diurnal, seasonal, monthly and annual variability has been considered. In the present study we have taken variability of both the parameters during quiet as well as disturbed days. The data and analysis method are classified in to three seasons including equinox (March, April, September, and October), winter (January, February, November and December) and summer (May, June, July and August). In this paper we observed that at Athens (38^0 N-24^0 E) variation of ITEC and foF2 is maximum during month of April and at Grahmstown (33^0 S-27^0 E) both the parameters shows the maximum variation during month of October. Which clearly indicate the presence of equinoxial an7amoly in both the hemisphere at mid latitude.*

Keyword: *Mid latitude, Critical frequency, Ionospheric disturbances, Variability*

I. INTRODUCTION

Earlier research has shown that the ionosphere is highly variable in space and time, according to geographical location (polar, auroral zones, mid latitudes and equatorial region) and to certain solar related ionospheric disturbance (Licilla, et al., 2011). The morphologicsl feature of TEC at low and equatorial latitudes have been extensively studied especially outside the African continent (Chauhan et al., 2011)

Several statistical studies have been made on the variability of foF2 and TEC (Forbes ,et al., 2000; Aggarwal ,et al., 2012).The greatest involvement to the TEC from the F layer disturbance of the ionosphere is not only influenced by the significant changes in the solar and geomagnetic variations but also from the neutral wind effect. It has been shown that the prediction of one of the parmeters TEC/foF2 is possible if another one foF2/TEC is known (Houminer & Soicher ,et al., 1996).

Ionosphere displays both a background state (climatology) and a disturbed state (weather). These variations cover a wide range of timescales, which range from operational time scales of hours and days up to solar cycles and even long-term trends studied by (Rishbeth,et al.,1998). Among these variabilities with different time scales, day-to-day variability is one of the most regularly investigated recently for both scientific and applicable reasons found by (Forbes et al., 2000; Fuller-Rowell et al., 2000; Mendillo et al., 2002; Rishbeth and Mendillo, 2001).

Venkatesh et al., (2011) studied the diurnal, day to day, seasonal and latitudinal variation of TEC, NmF2, slab thickness (Ʈ) and neutral temperatures (Tn) over the three different Indian stations The ionospheric electron content (IEC), maximum electron density and ionospheric slab thickness (Ʈ) are the parameters used to observe the temporal and spatial behaviour of the ionosphere.

Regular studies on the day-to-day and hour-to-hour variability of the critical frequency of the *F*-region, *foF*2 and of the Total Electron Content, TEC, have shown that these perturbations, with negative and positive response, depend on local time, season and location (Kouris *et al.*, 1998, 1999, 2002, 2006; Rawer *et al.*, 2003; Fotiadis *et al.*, 2004). Regarding variations of *foF*2 in the time interval of an hour have been reported by many authors (Kouris *et al.*, 2000; Fotiadis *et al.*, 2001; Zolesi *et al.*, 2001; Buresova and Lasˇtovic ˇka, 2001) showing that a deviation of *foF*2 around 12% (positive or negative) with respect to the hourly daily value considered at the standard hour time is always present. This ionospheric variability within-the-hour or otherwise "ionospheric density noise" can be estimated from the variation of the relative deviations of 5-min daily *foF*2 measurements with respect to the standard hour daily value of *foF*2 measured at the corresponding standard hour. The diurnal variation of these 5-min relative deviations shows clearly that in certain hours and under particular circumstances, values of variability greater than 12% (in absolute value) of the related hourly daily value can occur (Kouris *et al.*, 2000; Buresova and Lasˇtovicˇka, 2001; Fotiadis *et al.*, 2001).

The study of day-to-day variability of IEC of scientific interest and importance as looking towards its forecast capabilities .the day-to-day variability is best describes by the ratio of aviation of daily value of IEC from monthly median to the monthly median value. Klobuchar, et al., (1983) showed that the standard deviation from the monthly mean value is around 20-25% during day time and during night time it is higher than that for day time in solar maximum period (1968-1969), however the complete value of IEC during day time is higher than that for night time. Kane, et al., (1982) has studied the change in IEC at mid latitude and concluded that the change in IEC value at all three locations were not always similar. Dabas et al., (1984). Suggested that the main factors responsible for day-to-day variability at low latitudes (Indian sector) is equatorial electro jet strength and it is not influenced by solar or magnetic activity. Similar result were also shown for low and mid latitude stations, (R G Rastogi et al.,1987; Aravindan and Iyer.,1990).

It was observed that at mid latitudes, foF2 shows nearly a linear relationship with sunspot number, though this relation is nonlinear for low latitude Sethi et al., (2002). At middle latitudes, storm enhanced plasma densities (SEDs) are frequently observed during periods of enhanced geomagnetic activity. These bands of largely improved density structures, caused by storm-time electric fields which transport plasma from low to middle latitudes Foster et al., (2002).

II. DATA AND METHOD OF ANALYSIS:

Analysis is based on hourly values foF2 and ITEC of two Ionosonde Mid Latitude station Athens (38^0 N-24^0 E) and Grahamstown (33^0 S-27^0 E). Both the locations are the conjugate. Hourly value of ITEC and foF2 collected from the site NGDC space physics Interactive data Resource(SPIDR)[http//ngdc.noaa.gov/]from January 2009 to December 2013for Mid Latitude zone Athens (38^0 N-24^0 E) and Grahamstown (33^0 S-27^0 E).The average of hourly ITEC and foF2 values are determined to represent the day to day variability. Day to day variability is calculated separately for each day, month and seasons of the year. Quiet days and disturbed days during the period of consideration are taken from World Data Centre Kyoto, Japan. Seasonal variations were observed by using data from four month for each season Winter, Summer and Equinox. There is unavailability of data for Mid Latitude zone Grahamstown (33^0 S-27^0 E) from May 2012 to December 2012.

III. RESULTS

DIURNAL VARIATION OF ITEC AND FOF2:

Figure- 2.1 represent the diurnal variation of ITEC and foF2 from January 2009 to December 2013 for two mid latitude conjugate points Athens (38^0 N-24^0 E) and Grahamstown (33^0 S-27^0 E). It is observed that variations of ITEC at Athens (38^0 N-24^0 E) decreases at around 0400-0600 hours LT and that increases around 1200-1500hours LT. ITEC shows the maximum peak at 1300 hours LT, and foF2 also shows the similar behaviour while at Grahamstown (33^0 S-27^0 E) value of ITEC is maximum during 1200 hours LT. besides value of foF2 remain same.

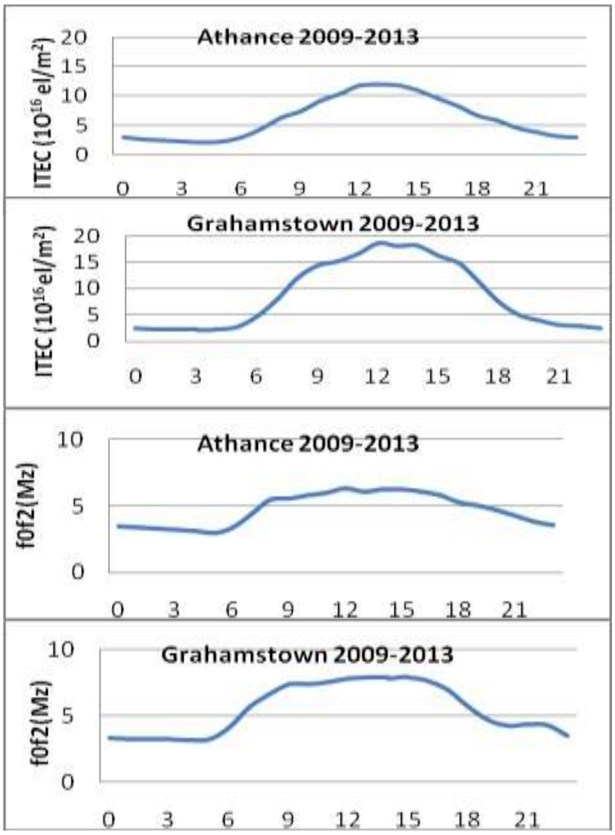

Figure-2.1 Diurnal Variation of ITEC and foF2 hour (LT)

MONTHLY VARIATION OF ITEC AND FOF2 PARAMETERS:

Figure-2.2 represent the monthly variation of ITEC and foF2 respectively, it is observed that the variation of ITEC is maximum during month of April at Athens (38^0 N-24^0 E) and foF2 also shows similar behaviour. At Grahamstown (33^0S-27^0E) ITEC maximum during month of October, although variation of foF2 shows not much enhancement in the month of October as compared to the other months of the year.

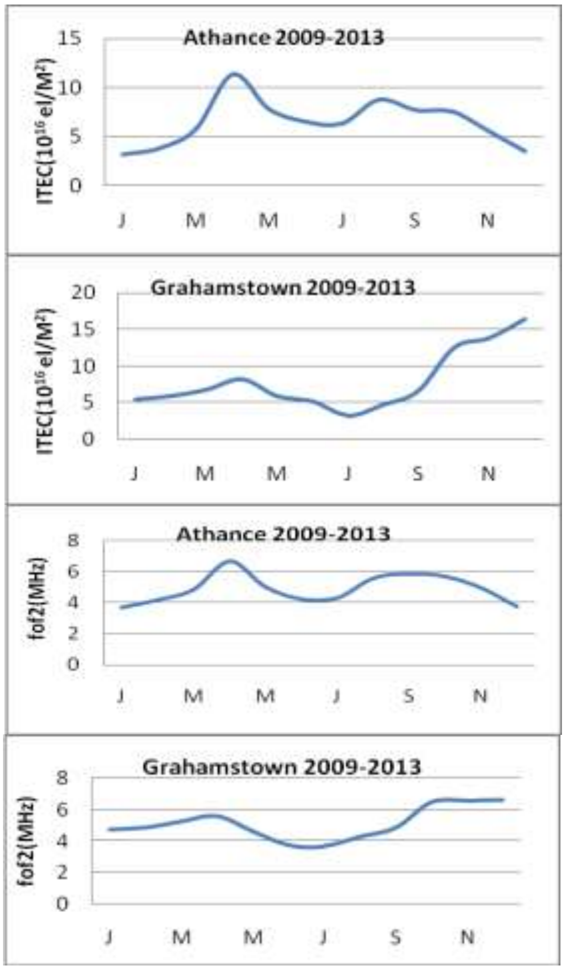

Figure-2.2 Monthly variation of ITEC and foF2 hours(LT)

SEASONAL VARIATION OF ITEC AND FOF2:

Figure-2.3 shows the seasonal variation of ITEC and foF2 respectively. It observed that at Athens (38^0 N-24^0 E) variation of both parameters ITEC and foF2 is maximum during equinoxial month, but at Grahamstown (33^0 S-27^0 E) ITEC shows maximum variation during winter whereas foF2 shows maximum variation during equinox.

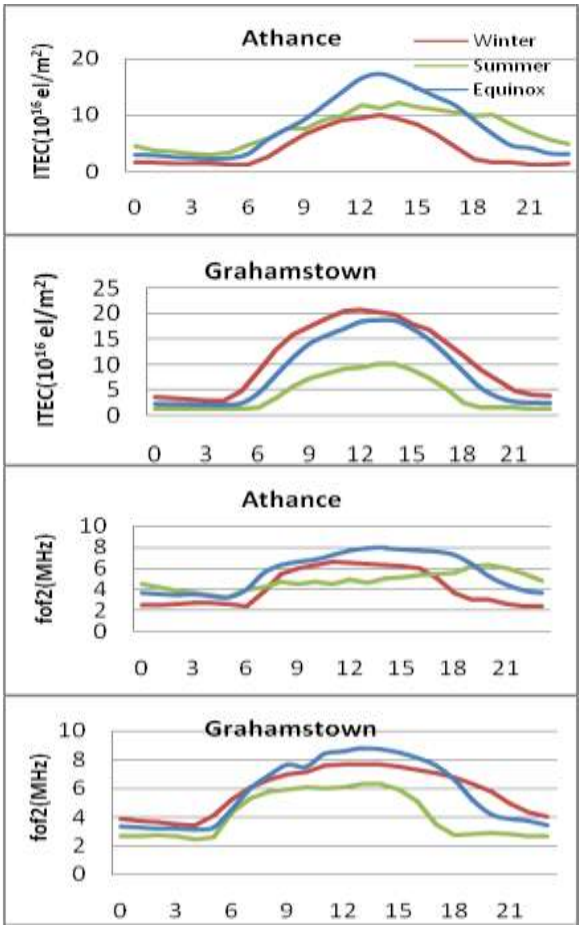

Figure-2.3 Seasonal variation of ITEC and foF2 hours(LT)

DIURNAL VARIATION OF ITEC AND FOF2 DURING QUIET AND DISTURBED DAYS:

Figure-2.4 shows the diurnal variation of ITEC and foF2 respectively during quiet and disturbed days. It is observed from the figure that variation of ITEC is maximum during quiet days for Athens (38^0 N-24^0 E) at around 1200-1300 hours LT. Although at Grahamstown (33^0 S-27^0 E) variation of ITEC shows a maximum value during quiet days around 1400 hours LT. It is also analysed from the figure that the variation of foF2 at Athens (38^0 N-24^0 E) is maximum during disturbed days at around 1200-1300 hours LT. while at Grahamstown (33^0 S-27^0 E) variation of foF2 maximum during disturbed days but around 1300-1400 hours LT.

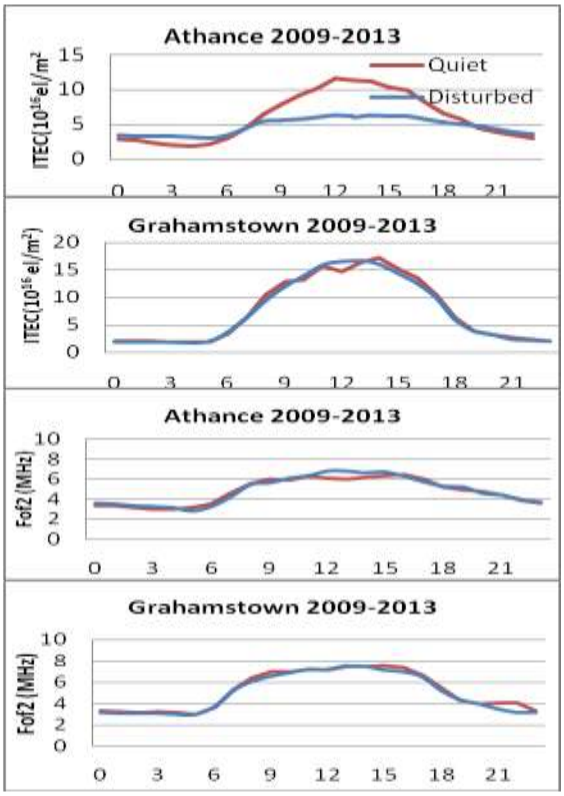

Figure-2.4 Diurnal variation of ITEC and foF2 during quit and disturbed days hours(LT)

SEASONAL VARIATION OF ITEC AND FOF2 DURING QUIET AND DISTURBED DAYS:

Figure-2.5 shows the seasonal variation of ITEC during quiet and disturbed days. It is observed that at Athens (38^0 N-24^0 E) value of ITEC from the duration of equinoxial months sharp peak during disturbed days, at around 1300 hours LT. While at Grahamstown (33^0 S-27^0 E) ITEC shows a peak during 1200 hours LT.

During summer months at Athens (38^0 N-24^0 E) ITEC shows a sharp peak during disturbed days and at around 1200 hours LT. Also at Grahamstown (33^0 S-27^0 E) ITEC shows peak during 1300-1400 hours LT. whereas during winter months variation of ITEC at Athens (38^0 N-24^0 E) shows a maximum variation during disturbed days at around 1200-1400 hours LT, and at Grahamstown (33^0 S-27^0 E) ITEC shows maximum variation in quiet days at around 1100 hours LT.

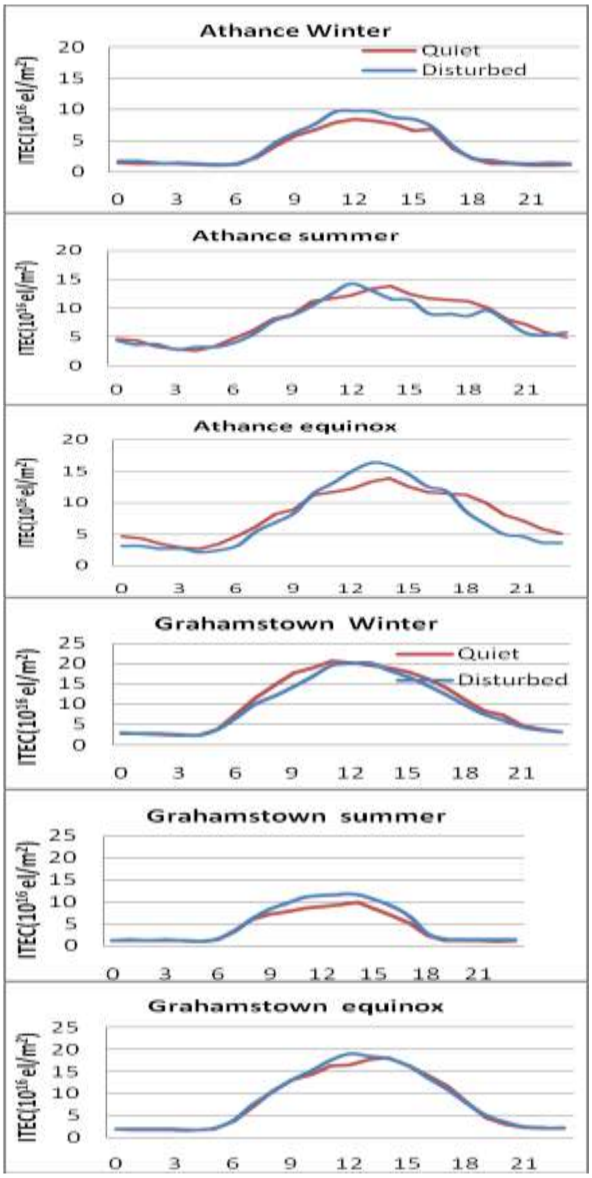

Figure-2.5 Variation of ITEC during quiet and disturbed hours (LT)

Figure-2.6 shows the seasonal variation of foF2 during quiet and disturbed days it is clear from the graph that variation of foF2 during equinoxial months shows a sharp peak during disturbed days at around 1300 hours LT. Athens (38^0 N-24^0 E) and Grahamstown (33^0 S-27^0) shows a similar behaviour. For summer months at Athens (38^0 N-24^0 E) shows a sharp increase in foF2 during quiet days at around 2000-2100 hours LT. Whereas at Grahamstown (33^0 S-27^0) foF2 shows maximum variation during disturbed days at around 1400 hours LT. although during winter season Athens (38^0 N-24^0 E) shows maximum variation is throughout disturbed days around 1100 hours LT. whereas Grahamstown (33^0 S-27^0) whereas at Grahamstown (33^0 S-27^0) foF2 shows maximum variation during quiet days at similar hours.

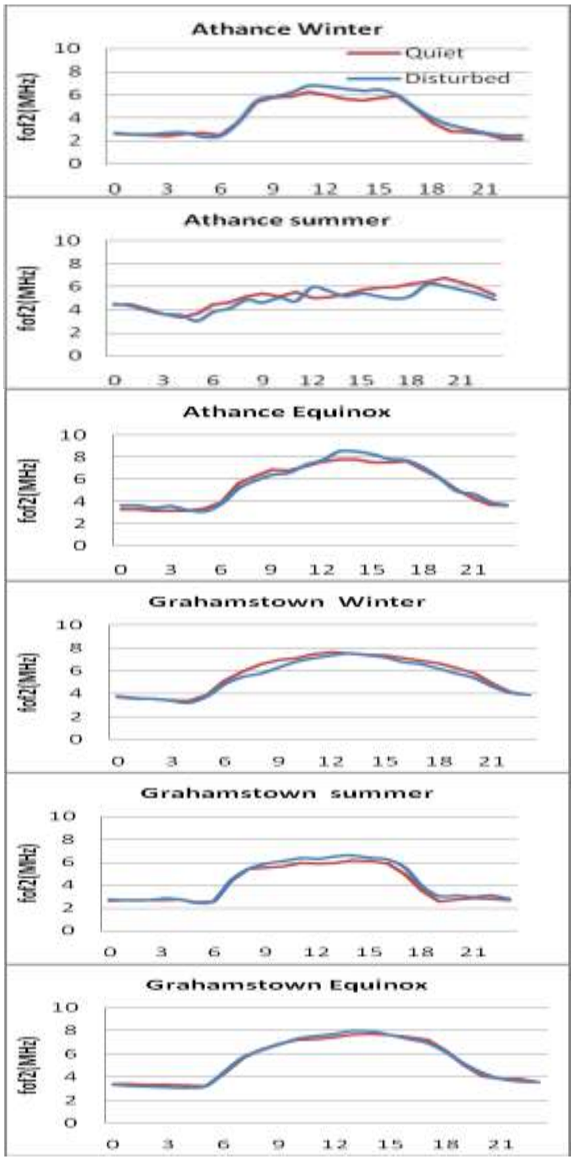

Figure-2.6 Seasonal variation of foF2 during quiet and disturbed day hours (LT)

IV. DISCUSSION:

Balaji et al., (2012) studied the gradual increase in TEC to a maximum values at peak hours of the day at equatorial and low latitudes has been attributed to the solar extreme ultraviolet (EUV) drift. In our study the seasonal variation at Northern hemisphere, variation of both Parameters ITEC and fof2 is maximum during Equinoxial month, but at southern hemisphere, winter as well as in equinoxial month is shows maximum variations. Oron et al., (2013) studied the variation in TEC at Kampala, an African equatorial station, during 2010 and 2011. The daily average TEC values were seen to be highest during the months of March, April, September and October (equinoctial months), while lower TEC values occurred during the solstice months.

Gupta et al.,(2001) studied the diurnal variation of seasonal mean of IEC on quit days shows a secondary peak similar to daytime peak in equinox and winter in higher solar activity. They also studied the effect of season, solar and magnetic activity on ionospheric electron content, the day time maximum of IEC has been averaged on a seasonal basis in each of two solar cycle 21 and 22, they found that the value of daytime IEC undergoes significant chance in low solar activity, the winter IEC is lower compared to summer and equinox IEC.

The local time and seasonal variations in the ionospheric F layer variabilities are statistically obtained by Araujo-Pradere et al., (2005) ; Risbeth and Mendillo (2001) analyzing global ionosondes observations. They suggested that the greater variabilities at night, especially in winter, is partly due to the lower electron density, partly due to the lack of the strong photochemical control that exists in the daytime F2-layer, but occurs largely because the auroral sources of magnetic activity become stronger and move to lower latitudes at night. This effect is improved in the winter when nights are long.

Bhawre et al., (2015) investigated the dependence of foF2 on the solar activity. Four solar activity indices namely flare index, relative sunspot number, solar flux at 10.7 cm, and CMEs occurrence indexes were correlated with foF2 data of Syowa, Antarctica. These indices give a good scene to study the solar activity variability in the ionosphere. The individual variation of critical frequency foF2 and solar indices verified the dependency of foF2 on the solar cycle variability but this variation was different during the months, which depended on the solar activity and polar ionospheric behavior. The solar indices and critical frequency foF2 vary synchronously with each other during the rising and falling phases of solar cycle.

Dabas et al., (2006) reported that the short and long terms variations in the observed daytime foF2 values are found to be unrelated to the solar and magnetic activity changes most of the time. The short as well as long term (seasonal/annual) variations in foF2 around the dip equator stations are found to be mainly controlled by the EEJ strength variations during the high sunspot period. It has also been suggested that from equatorial and low latitude location, electrojet strength is a useful parameter for the prediction of day-to-day changes in the ionosphere as well as latitudinal distribution of plasma. Rastogi & Rajaran(1971) have also suggested that a strong electrojet should lead to a stronger E×B drift and ionization anomaly.

Smita et al., (2004) studied the seasonal variation of day-today variability parameter for Sagamore hill during 1985 and 1986. During 1985 it is higher for winter month while lower for summer months and during 1986 it is higher for equinoxial months while lower for summer months.

The day-to-day variability in TEC is greater than in foF2 and exhibits its higher values during the nighttime hours Kouris et al., (2008). The upper and the lower limits of TEC variability have an average value over Europe (35o-60oN) circa 0.30 (in absolute value) for 90% of the monthly time during the daytime, but they are higher during nighttime reaching an average value of 0.40 Kouris et al., (2006a). However, it should be noted that levels of TEC variability greater than 0.50 occur in each month but only for a few hours, and fall mostly between the values of 0.50 and 0.80 although they can reach values up to 1.20 and even higher. These last ones are rare and not smooth and occur mainly during winter and equinoxes and after midnight, and in any location Kouris et al., (2008), illustrates the frequencies that the levels 0.50 or 0.80 (in absolute value) of TEC variability are exceeded during 1999 and 2000 at different locations Kouris et al., (2008). It is apparent that a very disturbed state occurs mostly in equinoxes including February and November, and that the variability depends on the solar activity and the location.

Chandra et al., (2009) have examined the day-to-day variability in the critical frequency of F-layer (foF2) over Ahmadabad. They showed that while the daytime deviations are of same orders during different seasons the night-time, deviation are slightest during equinoxes. The day time values of foF2 are mainly controlled by the equatorial electrodynamics and the following expansion of equatorial ionization anomaly the higher values during night-time seen to be due to the variability in the thermospheric neutral temperature and winds. However, from the seasonal and solar activity stand- point post-sunset September equinox maximum and June solstice maximum variability was observed at all the stations for all seasons (Akala et al., 2010).

Chauhan et al., (2011).Studied diurnal and seasonal variation of TEC at Agra in India observed that the mean TEC varies from pre-dawn minimum to an afternoon maximum and then decreases. The low values are observed in winter, while high values were observed in equinox and summer months, and there was an absence of winter anomaly. Anju nagar et al., (2015) found that the diurnal observation revealed that foF2 is more susceptible to variability during night than the daytime having two maxima during the day, a little before (after) the sunrise (sunset) between .20 and .40 (normally).

Sardar et al., (2012) Reported that the diurnal, monthly, seasonal and latitudinal variations of NmF2 over six different locations Chilton, Port_Stanley, Athens, Sanvito, Kwajelin and Learmonth during low to moderate solar activity indicates a significant latitudinal variation in the equivalent slab thickness with higher daytime values for all the latitudes. They conclude that the maximum electron density of F2-layer (NmF2) at all the stations more or less show analogous nature of variation.

Saranya et al.(2015) examine the variability of foF2 and TEC over Waltair and Delhi, the data of two month, namely April and July 2004 are considered. The percentage of variability is calculated for the two individual parameters, foF2 and TEC. At both the stations for the month of April and July the variability shows positive and negative values, which indicate the increase and decrease in daily value with respect to monthly mean values. They observed that variability is high during both the months at two different stations. They also observed that the variability of foF2 lies almost within the range of the TEC. The variability between foF2 and TEC from hour-to-hour of each day lies within the inter quartile range of 40.

Retish et al.,(2016) measure up to the diurnal variability of the ionospheric foF2 at high and mid latitude stations, Soyawa and Bhopal, they found that a typical diurnal peak is observed at mid latitude station during all the months of the year while at high latitude station the diurnal peak exists only during some months. Moreover at mid latitude the time of occurrence of diurnal peak is almost same while at high latitude a time shift in the occurrence of the diurnal peaks is clearly evident. The peak values of foF2 are comparatively much higher at high latitude than at mid latitude. The monthly variability of foF2 at mid-latitude and high latitude are almost opposite but the variability at both the stations follows a standard and well defined pattern. The seasonal variability almost follows a similar pattern at both the stations. The value of foF2 is lowest during winter season at both the stations while highest during equinox season at mid latitude and during summer season at high latitude.

V. CONCLUSION

The results presented in this study provide a comprehensive picture of the diurnal, monthly, seasonal and latitudinal variations of ITEC and foF2 over mid latitude conjugate station Athens (38^0 N-24^0 E) and Grahmstown (33^0 S-27^0 E).

In the diurnal variations, ITEC and foF2 shows a similar behavior for Athens and Grahmstown, variation of ITEC is maximum during quiet days. The variation of foF2 at both the locations maximum during disturbed days. For the seasonal variation at Athens variation of both the Parameters ITEC and fof2 is maximum during equinoxial month, but at Grahmstown ITEC is maximum in winter whereas foF2 is maximum in equinoxial month are approximately same as the results obtained by Oronal et al., (2013).

In the monthly variation of ITEC and foF2 is maximum during the month of April at Athens, Whereas at Grahmstown both the parameter shows the maximum variation during month of October.

In the seasonal variation for quiet and disturbed days at Athens value of ITEC for the Equinoxial month sharp peak during disturbed days while foF2 shows similar behavior.

During summer months Athens as well as Grahmstown shows maximum variation of ITEC during disturbed days, whereas Athens foF2 shows maximum variation during quiet days while Grahmstown shows similar behavior.

During winter Variation of both the parameters ITEC and foF2 at Athens shows maximum peak during disturbed days, whereas at Grahamstown ITEC shows maximum variation during quiet days While foF2 shows maximum peak during disturbed days.

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REFERENCES

1. Aggarwal M, Joshi H P, Iyer K N, Kwak Y-S, Lee J J, Chandra H And Cho K S, Day To Day Variability Of Equatorial Anomaly In Gps-Tec During Low Solar Activity Period, Adv Space Res (Uk), Pp1709-172049(2012).
2. Akala A.O., Oyeymi E.O., Somoye E.O., Adeloye A.B., And Adewale A.O., "Variability Of Fof2 In The African Equatorial Ionsphere", Adv. Space Res., Vol. 45, No. 11, Pp. 1311-1314,2010.Doi:10.1016/J.Asr.2010.0.003.
3. Anju Nagar, Mishra S D, Vijay S. K. " Day To Day Variability Of Low Latitude F-Region Ionosphere During Low Solar Activity" International Journal Of Astrophysics And Space Science, 3(3): 30-41,2015.
4. Araujo-Pradere E.A., T.J. Fuller Rowell, Codrescu M.V., And Bilitza D, "Characteristics Of The Ionospheric Variability As A Function Of Season, Latitude, Local Time, And Geomagnetic Activity", Radio Sci., Vol.40, No. 5,Pp.m Doi: 10.1029/2004rs003179, 2005.
5. Aravindan P., Iyer K. N., Day to day variability in ionosphere electron content at low latitudes, planet space sci., vol. 38, no.6,pp.743-750.1990. Doi:10.1016/0032-0633(90)90033-M.
6. Balaji O S, Adeniyi J O, Redicella S M & Doherty P H, Variability Of Total Electron Content Over An Equatorial West African Station During Low Solar Activity , Radio Sci.(Usa),47 (2012).Doi: 10.1029/2011rs004812.
7. Bhare P , Kishor K., Dongra S.K. Purohit P K, Abdul M, Khatarkar P K, Atulakr R, " Characterstics Of Ionosphere Fof2 And Solar Indices During The 23rd Solr Cycle Over High Latitude Station. Syowa , Antarctica, American Journal Of Climate Change 4 408-416, 2015.
8. Buresova, D. And J. Las ˇTovic ˇKa Changes In The F1 Region Electron Density During Geomagnetic Storms At Low Solar Activity, J. Atmos. Solar-Terr. Phys., 63, 537-544(2001).
9. Chandra H, Sharma S, And Aung S.W., "Day To Day Variability In The Critical Frequency Of F2 Layer Over The Anomaly Crest Region, Ahmedabad", J. Ind. Geophys.Union, Vol. 13, No. 4, Pp. 217-226, 2009.
10. Chouhan V, Singh O P & Birbal S, Diurnal And Seasonal Variation Of Gps-Tec During A Low Solar Activity Period As Observed At A Low Latitude Station Agra, Indian J Radio Space Physics, 40, 26 (2011).
11. Dabas R.S, Bhuyan P.K., Tyag T.R Bharadwaj R.K.,.Lal J.B, "Day To Day Changes In Ionospheric Electron Content At Low Latitudes", Radio Sci., Vol. 19, No. 3, Pp.746-7491984, .Doi: 10.1029/Rs019i003p00749.
12. Dabas R.S., Sharma N., Pillai M.G.K. And Gwal, A.K. "Day To Day Variability Of Equatorial And Low Latitude F-Region Ionosphere In The Indian Zone", J. Atmos. Terr. Phys., Vol. 68, No. 11, Pp. 1269-1277, 2006,.Doi:10.1016/J.Astp.2006.03.009.
13. Forbes, J. M., Palo, S. E., And Zhang, X. L.: Variability Of The Ionosphere, J. Atmo. Sol. Terr. Phys., 62, 685–693, 2000.
14. Foster J. C., Erickson P. J., Coster A. J., Goldstein J., Rich F. J. "Ionospheric Signatures Of Plasmaspheric Tails". Geophys. Res. Lett., 29(13), Doi:10.1029/2002gl015067, 2002.
15. Fotiadis, D.N., S.S. Kouris And B. Zolesi Prelim- Inary Results On The Within-The-Hour Ionospheric Vari- Ability, Phys. Chem. Earth (C), 26 (5), 315-318, 2001.
16. Fotiadis, D.N., S.S. Kouris, V. Romano And B. Zolesi Climatology Of Ionospheric F-Region Distur- Bances, Ann. Geophysics, 47 (4), 1311-1323, 2004.
17. Fuller-Rowell, T. J., Codrescu, M., And Wilkinson, P.: Quantitative Modeling Of The Ionospheric Response To Geomagnetic Activity, Ann. Geophys., 18, 766–781, 2000.
18. Gupta J.K. And Singh L " Long Term Ionospheric Electron Content Variations Over Delhi. Ann. Geophys-Sicae Vol-18, 1635-1644, 2001.
19. Houminer Z And Soicher H, Improved Short –Term Predictions Of Fof2 Using Gps Time Delay Measurement , Radio Sci(Usa),31(5) Pp1099-1108, 1996.
20. Kane R P, Ann. Geophysics 38 145, 1982.
21. Klubuchar J A Proc. Of The International Symp. On Beacon Satellite Studies Of The Earths Environment (New Delhi) India P3, 1983.
22. Kouris, S. S., Bradley, P. A., & Dominici, P., Angeo, 16, 1039,1998.
23. Kouris, S.S. And D.N. Fotiadis Ionospheric Vari- Ability: A Comparative Statistical Study, Adv. Space Res. 29 (6), 977-985, 2002.
24. Kouris, S.S., B. Zolesi, D.N. Fotiadis And C. Bianchi On The Variability Within-The-Hour And From Hour-To-

Hour Of The F-Region Characteristics Above Rome, Phys. Chem. Earth (C), 25 (4), 347-351, 2000.

25. Kouris, S.S., D.N. Fotiadis And B. Zolesi Specifica- Tions Of The F-Region Variations For Quiet And Disturbed Conditions, Phys. Chem. Earth (C), 24 (4), 321-327, 1999.
26. Kouris, S.S., K.V. Polimeris And Lj. R. Cander (2006a): Specifications Of Tec Variability, Adv. Space Res., 37, 983-1004.
27. Kouris, S.S., K.V. Polimeris, Lj. R. Cander And L. Cirao- Lo Solar And Latitude Dependence Of Tec And Slab Thickness, J. Atmos. Solar-Terr. Phys., 70, 1351- 1365, 2008, Doi:10.1016/J.Jastp.2008.03.009.
28. Lucilla A Wernik A W, Materassi M, Spogli L,Bougard B& Monico J F G, Low Latitude Scintillation: A Comparison Of Modeling And Observations Within The Cigala Project : Ieee Pro (Ieee, Italy), 2011, Doi: 10.1109/Ursigass.2011.
29. Mendillo, M., Rishbetha, H., Roble. R. G., And Wroten, J.: Mod- Elling F2-Layer Seasonal Trends And Day-To-Day Variability Driven By Coupling With The Lower Atmosphere, J. Atmos. Sol. Terr. Phys., 64, 1911–1931, 2002
30. Oron S, Ujanga F M D, And Senyonga T J S, Ionospheric Tec Variations During The Ascending Solar Activity Phase At An Equatorial Station, Uganda, Indian Journal Of Radio & Space Physics Vol 42(2) Pp 7-17, 2013.
31. Rastogi R G And S J Alex Atmos. Terr. Phys. 49 1133, 1987.
32. Rawer, K., S.S. Kouris And D.N. Fotiadis Vari- Ability Of F2 Parameters Depending On Modip, Adv. Space Res., 31 (3), 537-541, 2003.
33. Rishbeth, H. And Mendillo, M.: Patterns Of F2-Layer Variability, J. Atmo. Sol. Terr. Phys., 63, 1661–1680, 2001.
34. Rishbeth, H., "How The Thermospheric Composition Affects The Ionospheric F2-Layer " J. Atmos. Terr. Phys., 60, 1385-1402, 1998.
35. Ritesh Yadav ., "Comparative Study Of High And Mid Latitude Fof2 During Low Solar Activity", International Journal Of Innovative Research, Engineering And Technology ., Vol. 5, Pp 2347-6710[5], 2016.
36. Sarayna P L Prasad D S V, Niranjan K, Rama Rao P V S, Short Term Variability In Fof2 And Tec Over Low Latitude Indian Stations, Indian Journal Of Radio & Space Physics Vol (44)(3) Pp 14-27, 2015.
37. Sethi N. K., Geol M. K., Mahajan K. K., "Solar Cycle Variations Of Fof2 From Igy To 1990", Ann. Geophys., 20, Pp. 1677-1685, 2002.
38. Smita Dubey , Rasmi Wahi , Kalpna Maski, S K Vijay And A K Gwal, Day To Day Variability Of Iec At Mid Latitude During Sunspot Minimum, Ann. J Phys. 78b(2),229-232, 2004.
39. Sradar N, Singh A.K. , Nagar A, Mishra S D And Vijay S.K. " Study Of Longitudinal Variation Of Ionospheric Parameters –A Detailed Report. J. Ind. Geophys . Union Vol-16 No. 3, Pp 113-133, 2012.
40. 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 Thethermosphere In The Indian Low Latitude Sector, Ann. Geophys., 29, 1635-1645, 2011.
41. Zolesi, B., Kouris S.S., Fotiadis D.N. And Scotto C. Evaluation Of The Ionospheric Noise And Vari- Ability Within-The-Hour By 5 Min Ionospheric Sound- Ings, Phys. Chem. Earth (C), 26 (5), 359-362, 2001.