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A Case Study of Comparison of High and Low Solar Active Spread -F Occurrence during Equinoctial Months over a Low Latitude Station Visakhapatnam

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Abstract: ***A case study of comparison of equinoctial months (March, April, September, October) of a high solar active year 2001 (Rz =110.9) and a low solar active year 2007 (Rz =7.6) at a low latitude station Waltair (17.7^{o}N, 83.3oE).***

Keywords: Ionosphere, Ionograms,Solar activity,Spread F, Equinoctial months.

1. Introduction

The phenomenon of equatorial spread-F on ionograms was found as diffuse traces by Booker and Wells. Krishna Murthy found that the occurrence of ESF over topside is followed by the ESF bottom side with about two hours time delay, in addition to that different aspects of occurrence range and frequency spread-F was observed on ionograms. (Perkins, 1973) introduced the concept of bottom side F-region instabilities presumed to lead to mid-latitude spread-F. Spread-F was originally defined in terms of multiple highly disturbed F-region traces on ionograms. Woodman and LaHoz [1976] observed these F region irregularities associated with the range spread in reflected frequencies seen in radar data. Since then, the term equatorial spread F (ESF) has ballooned to encompass instabilities ranging 7 orders of magnitude in size, from centimeters to hundreds of kilometers.

The presence of diffuse traces is a commonly noticeable feature on night-time ionograms at locations in a belt of width of about 400 centered on the geomagnetic equator (Wright, 1959); (Shimazaki, 1959) and is referred to as equatorial spread-F (ESF). It has been well-known that the onset of ESF is closely related to the vertical uplift of F-region that conspicuously occurs in the postsunset equatorial ionosphere (Farley et aI., 1970; Skinner and Kelleher, 1971)VHF radar backscatter observations demonstrated that in the vicinity of dip equator, the F-region plasma drifts upward (downward) during day (night) under the influence of the eastward (westward) electric field associated with the E-region dynamo, and the reversal in drift direction from upward to downward (downward to upward) Occurs around sunset (sunrise) (Woodman, 1970; Farley et al., 1970). Further, the daytime upward vertical drift (V) undergoes a short-lived enhancement in the evening hours before reversing to downward, particularly during high sunspot activity years (Woodman et al., 1977; Fejer et al., 1979). Build-up of polarization electric fields in the F -region (F – region dynamo effect) due to the sudden decrease of E-region conductivity at sunset is considered to be responsible for the enhancement in the eastward electric field (Rishbeth, 1971; HeeIis et al., 1974). The recent finding of a dependence of the peak amplitude (Vzp) and width of the prereversal peak in Vz on the duration of sunset between the conjugate E-regions over the equatorial stations, Fortaleza and Jicamarca by Abdu et al. (1981 a) lends support to this understanding.

The equatorial F -region rises in height accompanied by steepening of electron density gradient son its underside following sunset, due to chemical recombination and electrodynamics effects associated with the enhancement of the eastward electric field.

Such physical conditions render the steep plasma density gradients on the bottomside unstable to either collisional Rayleigh-Taylor (R-T) instability (Dungey, 1956; Haerendel, 1974; Hudson and Kennel 197~ or EXB gradient drift instability (Martyn, 1959; Simon, 1963). The initial perturbations in plasma density necessary to trigger the R-T or EXB instability are widely attributed to internal gravity waves (Rottger, 1973, 1976, 1978; Booker, 1979). The subsequent growth~ under favorable altitude and gradient conditions, of irregularities leads to the formation of depletions in plasma density on the bottom side which then rise non linearly into the topside (Ossakow et al., 1979). These depletions are referred to variedly in the literature as holes, bubbles and plumes depending on experimental technique adopted to detect their signatures.ESF as seen on ionograms is considered to be due to secondary plasma instabilities on the walls of the plasma bubble (Woodman and La Hoz, 1976; Tsunoda, 1980).

2. Data Base

The present study is a case study of comparing the equinoctial months in a high solar active period over a low solar active period over a low latitude station Visakhapatnam Waltair which is in a southern hemisphere. The ionograms were carefully checked and those showing the presence of a spread –F the graphs were shown for 00 to

24 hours. On X-axis the time is in hours is plotted and height and frequency on Y-axis respectively.

3. Results and Discussions

(Candido et al., 2011) presented new results about Spread F over a Brazilian low-latitude site, the spread-F events analyzed presented some special features they occur around midnight and post midnight hours, and Candido et al. [2008] performed a statistical analysis of these disturbances and verified an occurrence peak during June solstice. Its signature and climatology features are very similar to midlatitude Spread F/TIDs, extensively studied for other longitudinal sectors [Bowman, 2001; Bowman and Mortimer, 2002]. These earlier reports about TIDs have pointed out as their signatures the rise of F-layer accompanied by depletions in foF2. Also, they can produce Spread F. Additionally, an inverse relation between midlatitude MSTIDs and geomagnetic activity was recently studied by Seker et al. [2011]. They verified that MSTIDs occur principally under low values of geomagnetic parameters such as Kp, Ap, and Dst, agreeing with the previous results

Based on the presently known studies (e.g.Hoang et al), the interconnected ionosphere – thermosphere system factor controlling the ESF development are the evening F-region height and the vertical plasma drift due to the PRE that are controlled by the thermospheric zonal wind (eastward in the evening)and the gradient in the E-region conductivity near sunset(Pezzopane et al 2013).

The present work continues the search for underlying Spread-F phenomenon in the high and low solar active period of equinoctial months and is compared with previous investigations and sustains few results equal to them.

Though several days have been found in the observation only selected dates have been presented in the present discussion. The occurrence of post midnight is mainly observed in all the four months in our study both range and frequency spread –F is observed in most of the occasions. The phenomenon of spread-F is observed between 18.00LT and 02:00LT and also during a few hours in the morning times. When the solar flux has reached very low values (<70 SFU). In the Brazilian sector the occurrence of Spread F is known to be associated with equatorial plasma bubbles (EPBs) and is observed mainly between September and March.

On this basis, we figured out the high and low solar active period, in Figure 1 it is observed that the occurrence of spread F in the year 2001 showed the highest duration of Spread F during the month of September, the classification of spread based on duration that is equal to two or greater than two and less than or equal to one, the duration of more than 2 hours is observed in September and October than in March and April a similar comparison is done in a low solar active period which showed the similar results (the result of Mar,Oct 2007 has very less events so is neglected.

The K-index quantifies disturbances in the horizontal component of earth's magnetic field with an integer in the range 0-9 with 1 being calm and 5 or more indicating a geomagnetic storm. It is derived from the maximum fluctuations of horizontal components observed on a magnetometer during a three-hour interval. The planetary 3-hour-range index Kp is the mean standardized K-index from 13 geomagnetic observatories between 44 degrees and 60 degrees Northern or Southern geomagnetic latitude. Figure 2 is the index of Kp which shows the activity of Kp is more in April compared to the others.

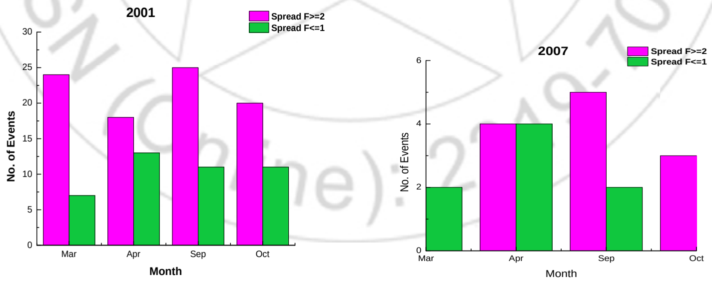

Figure 1: No of events of Spread-F during the year 2001and 2007

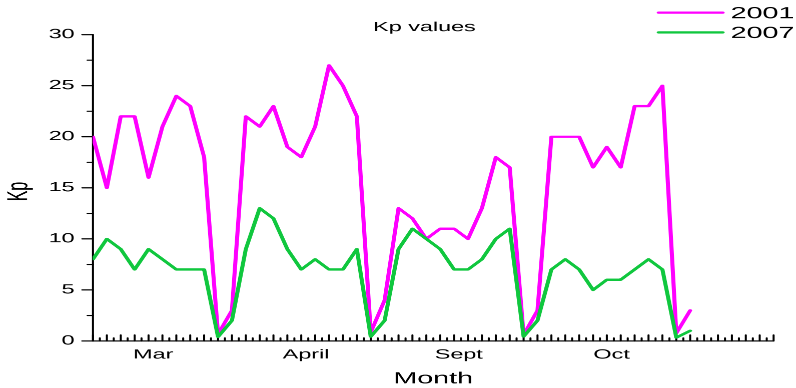

Figure 2: ∑Kp values for the year 2001 and 2007

On observed days of 29th may 2001 and 28th September 2001 the observations of about five parameters have been shown using origin graph the spread F occurrence for March was observed around 2 to 5 hrs and for 28th Sep it is about 2hrs in the morning and around 18:00hrs to 20:00 hrs at night. A simultaneous observation from theory is observed the uplift of height of F regio .(Figure 3)

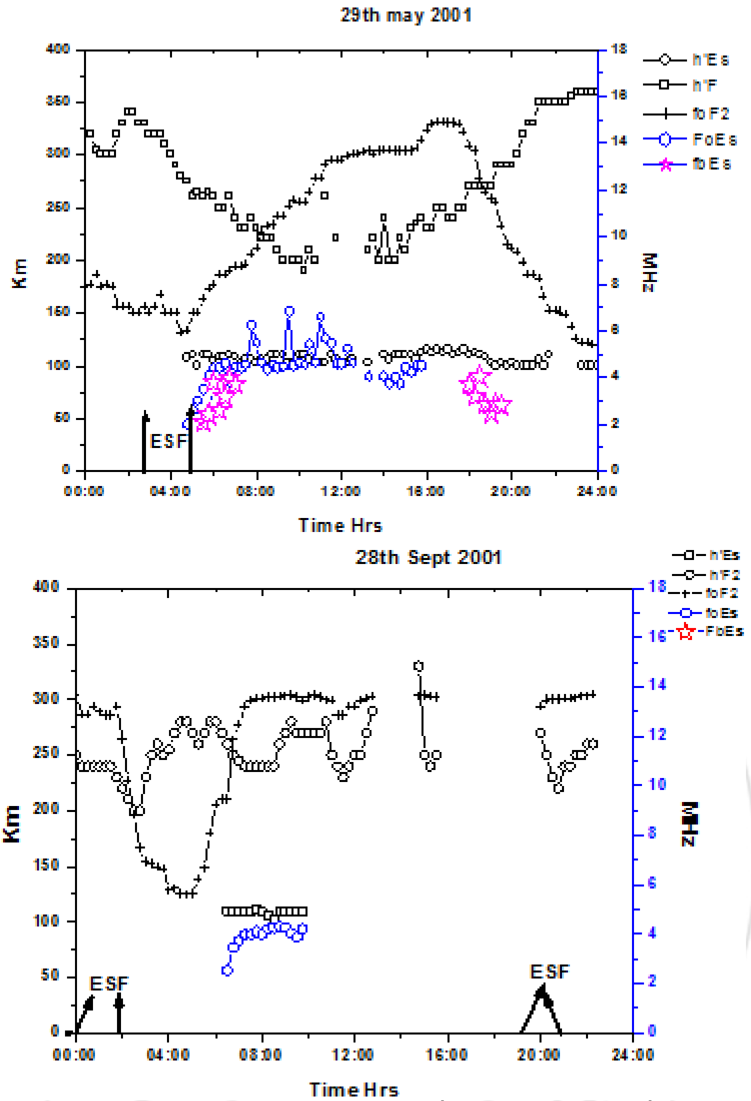

Figure 3: Example of presence of Spread F on 29th May 2001 and 28th September 2001

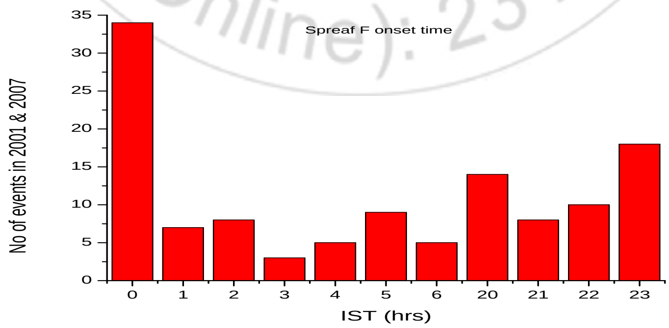

Figure 4: Onset time for spread F during the years 2001 and 2007

from Figure 4 we have presented the onset time for Spread F for both the years 2001 and 2007 here the spread F observation is observed mostly at 00:00 hrs IST and least occurred around 3:00hrs IST .

4. Conclusions

1) A case study of comparison of Equinoctial months for Spread F observations of a high solar active period 2001 and a low solar active period 2007 was presented.
2) We have found that in both the cases the month of September showed a maximum occurrences for Spread F .In 2001 after September March showed the second

maximum for Spread F while in 2007 the spread F occurrence is observed in April while in March and October the observed events are very less countable to two or three and so not presented and one of the reason for this less occurrence of spread F events might be the low solar activity of sun form the Kp index of 2007 we observe the same during the Months of March and October

3) The spread F onset time is also mostly at midnight hours and uplift of F region height is observed which is one of the signature of Spread f occurrence.
4) A relavant science for future work of comparison of about a solar cycle is under investigation.

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References

[1] Abdu, M. A., and I. S. Batista, Sporadic E layer phenomena in the Brazilian geomagnetic anomaly: Evidence for a regular particle ionization source, *J. Atmos. Terr. Phys, 39, 723–731, 1977.*
[2] Andrew W. Stephan,1,2 Marlene Colerico,3 Michael Mendillo,3 Bodo W. Reinisch,4 and David Anderson: Suppression of equatorial spread F by sporadic E , *Journal Of Geophysical Research, VOL. 107, NO. A2, 1021,10.1029/2001JA000162, 2002.*
[3] Batista, P. P., B. R. Clemesha, I. S. Batista, and D. M. Simonich, Characteristics of the sporadic sodium layers observed at 23_S, *J. Geophys. Res. 94, 15,349– 15,358, 1989.*
[4] Bowman, G. G.: Some aspects of mid-latitude spread Es and its relationship with spread F, *Planet. Space Sci., 33, 9, 1081–1089, 1985.*
[5] Bowman, G. G. (196Oa), some aspects of sporadic-E at midlatitudes. *Planet Space Sci. 2, l95.*
[6] Bowman, G. G. (1968), Movements of ionospheric irregularities and gravity waves. *J. atmos. terr. Phys. 30,721.*
[7] Bowman. G. G. (196Ob), Further studies of "spread-F" at Brisbane, I-Experimental. *Planet. Space.science.2, 133.*
[8] Bowman, G. G. (1981)**,** The nature of ionospheric spread-F Irregularities in mid-latitude regions. *J. atmos. terr. Phys. 43, 65.*
[9] Bowman, G. G., and G. S. Dunne, Some initial results on mid-latitude spread-F irregularities using a directional ionosonde, *J. Atmos. Terr. Phys., 43, 1295–1307, 1981.*
[10] Barnes, R. I.: An investigation into the horizontal structure of spread-Es , *J. tmos. Terr. Phys., 54, 3/4, 391–399, 1992.*
[11] Clarke, R. H. (1965) M.Sc. Thesis, University of Queensland, Brisbane, Australia.
[12] Haldoupis, C., Kelley, M. C., Hussey, G. C., and Shalimov, S. Role of unstable sporadic-E layers in the generation of midlatitude spread-F, *J. Geophys. Res., 108, doi:10.1029/2003JA009956, 2003.*
[13] Inez S. Batista, M.A. Abdu, A.J. Carrasco, B.W. Reinisch, E.R. de Paula,
[14] N.J. Schuch, F. Bertoni, Equatorial spread F and sporadic E-layer connections during the Brazilian Conjugate Point Equatorial Experiment (COPEX), *Journal of Atmospheric and Solar-Terrestrial Physics 70 (2008) 1133–1143.*
[15] Kelley, M. C., and S. Fukao, Turbulent upwelling of the midlatitude ionosphere. 2. Theoretical framework, *J. Geophys. Res.*, *96*, 3747, 1991.
[16] Kelley, M. C., Haldoupis, C., Nicolls, M. J.,Makela, J. J., Belehaki,A., Shalimov, S., and Wong, V. K.: Case studies of coupling between the E and F regions during unstable sporadic-E conditions**,***J. Geophys. Res., 108, doi:10.1029/2003JA009955, 2003.*
[17] Mc Nicol,R. W. E., Webster,H.C.andBowman,G.G.(1956) A study of "spread-F" ionospheric echoes at night at BrisbaneI range spreading (experimental), *Aust. J. Phys. 9,247.*
[18] Mathews, J. D.: Sporadic E: current views and recent progress, *J.Atmos. and Solar-Terr. Phys., 60, 4, 413–435, 1998.*
[19] Mendillo, M., B. Lin, and J. Aarons, The application of GPS observation
[20] to equatorial aeronomy, *Radio Sci., 35, 885–904, 2000.*
[21] Perkins, F.W., 1973. Spread F and ionospheric currents. *Journal of Geophysical Research 78, 218–226.*
[22] Reinisch, B. W., Modern Ionosondes, in Modern Ionospheric Science, edited
[23] by H. Kohl, R. Ru¨ster, and K. Schlegel, pp. 440 – 458, *Europea Geophysical Society, Katlenberg-Lindau, Germany, 1996.*
[24] Whitehead, J. D.: Recent work on mid-latitude and equatorial sporadic-E, *J. Atmos. Terr. Phys., 51, 5, 401–424, 1989.3.*
[25] Woodman, R. F., and C. LaHoz, Radar observations of F region equatorial irregularities, *J. Geophys. Res., 81, 5447–5466, 1976.*
[26] M.Pezzopane et.al; Low-latitude euuinocital spread-f occurrence at different longtitude sectors undr low solar activity,*Ann.Geophys*.,31,153-162,2013.