F REGION HEIGHT BEHAVIOR OVER CACHOEIRA PAULISTA, BRAZIL, USING DIGISONDE DATA

R. T. Medeiros[1], I. S Batista, E. R. de Paula, M. A. Abdu

Instituto Nacional de Pesquisas Espaciais
Cx. Postal 515, São José dos Campos, SP 12201-970, Brazil

ABSTRACT

In March 1990 a Digisonde has been installed in Cachoeira Paulista (22.5°S, 45°W), a low latitude station over Brazil. The data from April 1990 to January 1993 has been analyzed in order to study the virtual (h'F) and the true (hmF) heights of the F region. Both h'F and hmF show a consistent pre-dawn maximum occurring around 0800 UT (0500 LT) that is more pronounced from April to August. From September to December we observe two pre-dawn maxima occurring between 0000 UT and 0800 UT. The earlier maximum becomes more important during the local summer months. In spite of this very general characteristics we have observed a peculiar behavior during disturbed periods. On April 29 and 30, 1990, two disturbed days with ΣKp equal to 32o and 24+ respectively, the F layer height showed a much more pronounced maxima around 0800 UT. The maximum in hmF (corresponding to the frequency of 5 MHz), that was around 300 km during the quiet days, increased to 370 and 395 km on the disturbed days. Another peculiar behavior was observed during the development of the main phase of the magnetic storm on June 12, 1990 when the hmF increased to 350 km around 2230 UT (the mean value is around 230 km during winter months). In both of these cases, spread F was observed over Cachoeira Paulista simultaneously with the uplift of the layer. It is well known that spread F over low latitude stations such as Cachoeira Paulista is generally correlated with the development of plasma bubbles that are generated over equatorial stations and extend to the low latitudes through the magnetic field lines. However, in the April 1990 case, spread F was not observed over Fortaleza (4°S, 38°W), an station located near the magnetic equator and at the same longitude sector, but eastward of Cachoeira Paulista. In the June 1990 spread F was observed over Fortaleza (FZ), but nearly simultaneously with the event over Cachoeira Paulista (CP). The effects of electric fields and thermospheric winds in the generation of the disturbed behavior of the F region height are discussed.

INTRODUCTION

The equatorial and low-latitude F region have been extensively studied in the last two decades. The study of the low-latitude F region electrodynamic have had a good development mainly due to the existence of several techniques which can provide good experimental results, for instance, VHF radars, in situ rocket and satellite measurements [1]. Investigations using ionosondes have provided means of studying the morphological and dynamic characteristic of the undisturbed F region as well as the global changes that occur on it during magnetic activities [2-7].

All the previous studies using ionosondes have used the h'F parameter to investigate the variability of the F region height. With the advent of the digital ionosondes it became possible to use hmF even on those studies that deals with a big amount of data. The Digisonde data from CP, from April 1990 to January 1993, have been analyzed in order to study the equatorial and low-latitude F region dynamics. The parameters used in this work were the

[1] On leave from Universidade Federal do Rio Grande do Norte

virtual (h'F) and the true (hmF) heights of the F region (we have used the true height corresponding to the frequency of 5 MHz).

RESULTS

The diurnal variation of h'F over FZ and CP has been extensively studied [2-7]. It is well known that near sunset the F layer over FZ rises under the action of an **ExB** drift, that is intensified due to the F region dynamo [6]. This sunset uplift of the layer is more pronounced during summer and equinoxes than during the winter season, and it is also dependent on the solar activity. The analysis of hmF over CP has shown a consistent maximum occurring between midnight and down. When we distinguish between quiet and magnetically disturbed periods, the hmF has a much more defined pattern, as we can see from Figure 1. During quiet time the maximum in hmF occurs around 22-23 UT (post-sunset maximum) while during disturbed periods the maximum that occurs around 0700 UT is much more pronounced than the one that occurs after sunset. This is a common feature during all the analyzed period. In Figure 1 we can also identify another maxima occurring around 0200 UT.

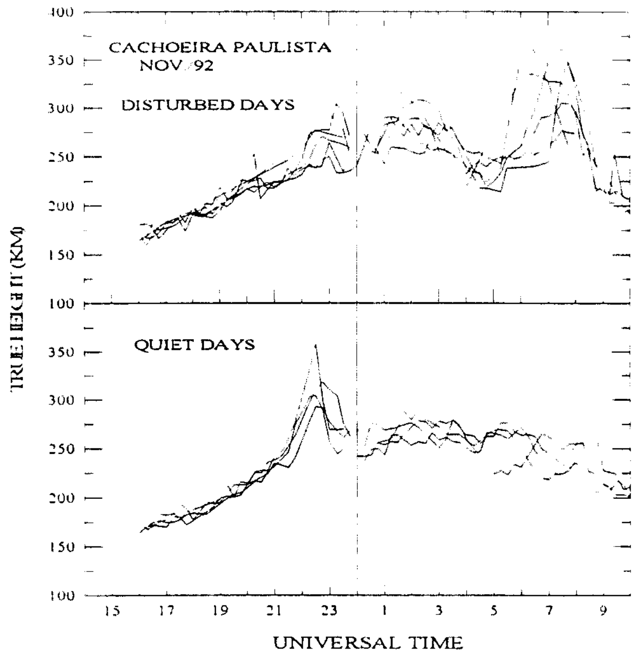

Fig. 1. True height variation over Cachoeira Paulista for November 1992

Figure 2 shows hmF over CP and h'F over FZ for the night of June 12, 1990. The letters R and M, on the figure, stand for range spread F and mixed (both range and frequency spread F type). We can see that spread F started nearly simultaneously at the two stations, just after the post-sunset rise of the layer. After 0000 UT the layer rises, but the movement is not simultaneous at the two stations. We observe that over FZ the layer rises just after 0000 UT and again around 0600 UT while over CP we observe two pronounced rises around 0300 UT and 0600 UT.

Another peculiar behavior during disturbed periods occurred on April 29 and 30, 1990 (Figure 3) when ΣKp was equal to 32o and 24+, respectively. Figure 3 shows that on April 29 and 30 the hmF maxima around 0800 UT over CP is much higher than the month average. The maximum in hmF, that was below 300 km, increased to 370 and 395 km on the two days, respectively. Simultaneously with the uplift of the layer, spread F was observed over CP on the two nights. In the same figure we can see h'F over Fortaleza for April 29. In this case the rise of the layer (after ~0600 UT)) was almost simultaneous over the two stations. Spread F was observed over CP but not over FZ.

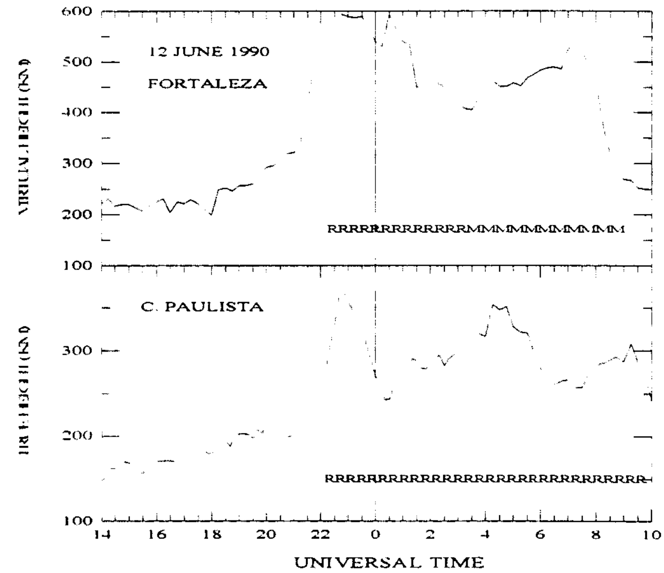

Fig 2. Virtual height variation over Fortaleza and true height over Cachoeira Paulista for June 12-13, 1990. R and M stand for range spread F and mixed (both range and frequency spread F), respectively.

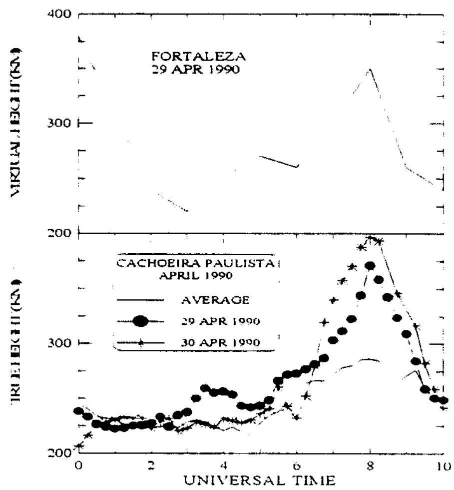

Fig. 3. Virtual height over Fortaleza and true height over Cachoeira Paulista.

DISCUSSIONS OF THE RESULTS AND CONCLUSION

The F region rises observed over CP between 0000 UT and 0800 UT, during disturbed periods, cold be caused either by disturbances electric fields that penetrate from high to low latitudes during magnetic substorms, or by enhanced meridional winds that could occur during disturbed periods, as well. The effect of an eastward electric field on the F layer height should be an almost simultaneous rise of the layer over CP and FZ, as the one that is observed on April 28 (Figure 3), although, in this case, we should expect spread F over the two stations.

From Figure 2 we can see that spread F occurred during all the night over CP and FZ on June 12-13, 1990. It is well known that the probability of occurrence of spread F over CP during the winter months is very low [7]. From Figure 2 we can see that the time delay between the beginning of spread F over FZ and over CP is very small. A plasma bubble developed at equatorial latitudes takes at least half an hour to develop and, consequently extend to low latitudes. So we cannot justify this case using equatorial plasma bubble development over the equator that extended to low latitudes. The equatorial spread F occurrence is correlated with **E**x**B** drift and to the F region bottomside height [8]. If the **ExB** drift reaches a value around 40 ms^{-1} and the F region bottomside height is above 300 km then the Rayleigh Taylor instability growth rate accelerates the irregularity generation process. So the irregularities can be generated above the equatorial F region if both these conditions are satisfied, independently of the season and of the time during the night. In order to explain the spread F occurrence above CP independently of its occurrence over FZ, it is necessary to suppose the existence of another process generating the low latitude spread F, maybe the same one that occurs at equatorial latitude, acting at low latitude now.

The rises of the layer between 0000 UT and 0800 UT over FZ and CP on June 13, 1990 are the most complex to be explained. They could not be explained as due to electric field penetration because they are not simultaneous at the two stations. The effect of an enhanced meridional thermospheric wind could have effect over CP but its effect over FZ should be almost zero due to the very small dip angle (~4^{o}) over that region. The effect over FZ could be explained by the disturbance dynamo [1,8] that is also generated by a disturbed thermospheric wind (zonal component). So the anomalous behavior observed on June 13 could be best explained by the presence of a disturbed thermospheric wind.

BIBLIOGRAPHY

1. Fejer, B. G. Low latitude electrodynamic plasma drifts: A review, *J. Atmos. Terr. Phys.*, *35*, 677 - 693, 1991.
2. Abdu, M. A.; Batista, I. S ; Bittencourt, J. A. Some characteristics of spread F at the magnetic equatorial station Fortaleza, *J. Geophys. Res.*, 86, 6836-6841, 1981.
3. Abdu, M. A.; Medeiros, R. T.; Sobral, J. H. A. Equatorial spread F instability conditions as determined from spaced ionograms, *Geophys. Res. Lett.*, *9*, 692-695, 1982.
4. Abdu, M. A.; Medeiros, R. T.; Bittencourt, J. A.; Batista, I. S. Vertical ionization drift velocities and range type spread F in the evening equatorial ionosphere, *J. Geophys. Res.*, *88*, 399-402, 1983.
5. Abdu, M. A.; Batista, I. S.; Sobral, J. H. A. A new aspect of magnetic declination control of equatorial spread F and F region dynamo, *J. Geophys. Res.*, *97*, 14897-14904, 1992.
6. Batista, I. S.; Abdu, M. A., Bittencourt, J. A. Equatorial F region vertical plasma drift: Seasonal and longitudinal asymmetries in American sector, *J. Geophys. Res.*, *91*, 12055-12064, 1986.
7. Medeiros, R. T. F region ionospheric irregularity study on the equatorial ionosphere, over Fortaleza, Natal and Cachoeira Paulista, MsC. Thesis, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, SP, Brazil, 1981.
8. Kelley, M. C.; Maruyama, T. A diagnostic model for equatorial spread F 2. The effect of magnetic activity, *J. Geophys. Res.*, *97*, 1271-1277, 1992.