Comparative study of the ionospheric characteristics of two low latitude Brazilian stations

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This paper was prepared for presentation at the 9th International Congress of the Brazilian Geophysical Society held in Salvador, Brazil, 11-14 September 2005.

Abstract

We present, in this paper, a comparative study of ionospheric parameters obtained by two digital ionosondes located at the Brazilian stations of Palmas (10.17°S, 48.20°W) and São José dos Campos (23.21°S, 45.86°W), during periods of geomagnetically quiet days of the equinoctial months of September, October and November 2003. It is suggested that some of the differences between the ionosphere behaviors over those locations to be related to seasonality and some to geographic and geomagnetic configurations.

Introduction

Digital ionosondes are instruments that, due to its versatility and reasonable low maintaining costs have been widely used in ionosphere research around the world. Several ionospheric parameters are provided from ionograms registered by those instruments.

A large set of measurements have been carried out in a systematic basis by two Brazilian scientific research groups in cooperation. One of them, located at the city of Palmas (PAL), Brazil, and recently named as Centro de Física Espacial e Atmosférica from Centro Universitário Luterano de Palmas (CEULP) (Center for Space and Atmospheric Physics, Palmas Lutheran University Center), and the other is Grupo de Pesquisa de Física Atmosférica e Astronomia from Universidade do Vale do Paraíba (Atmospheric Physics and Astronomy Research Group, University of Paraíba Valley), at the city of São José dos Campos (SJC). In Figure 1 it is shown the geographic and geomagnetic location of the three stations managed by those two research groups. Besides PAL and SJC, there is another station at the city of Manaus (MAN) (3.1°S, 60.0°W).

Table 1 – Stations geographic location

Station	Latitude	Longitude	Dip
PAL	10.17°S	48.20°W	-10.98°
SJC	23.21°S	45.86°W	-32.41°
MAN	3.10°S	60.00°W	12.65°

Each one of the stations has a CADI currently operating. PAL and SJC have all-sky imager photometers and in a near future GPS systems will be operating to take total electron content and scintillation measurements at all the three stations.

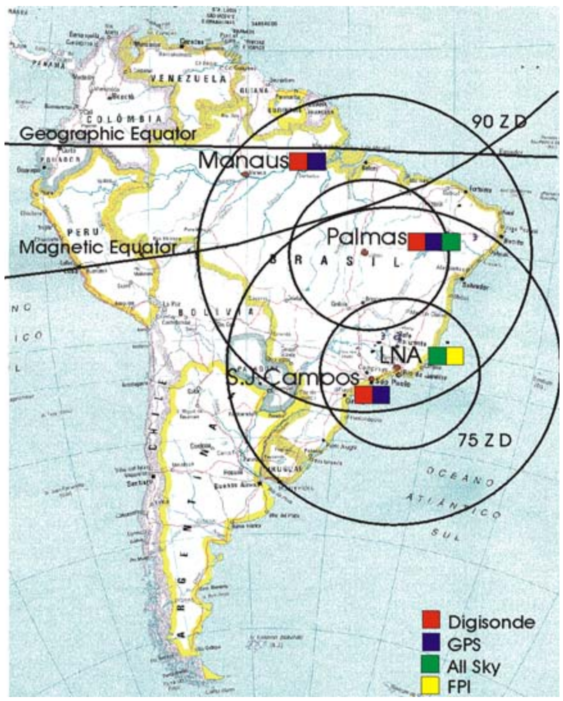

Figure 1 – Map showing geographic and geomagnetic location of the stations.

Method

We have used data obtained with two Canadian Advanced Digital Ionosondes (CADI) (Grant et al., 1995), one located at PAL and other at SJC. In our analysis we have chosen the magnetically quietest days of the months of September, October and November 2003. The choice for comparative study on the ionosphere behavior over those two stations, during quiet days is interesting in the sense that we can observe the behavior pattern of the ionospheric characteristics in usually smooth conditions, which is quite different of the behavior during magnetically disturbed periods (Bertoni, 2005; Lima et al., 2004; Becker-Guedes et al., 2004; Fejer, 2002; Fuller-Rowell et al., 2002; Abdu et al., 1997; Batista et al., 1991; Mazaudier e Venkateswaran, 1990; Blanc e Richmond, 1980), in which up and down displacements of the F-region ionospheric plasma bulge may be related to perturbation electric fields arising from prompt penetration from high to low magnetic latitudes, and disturbance winds dynamo action driven by Joule heating due to increased energy and momentum deposition into the high latitude thermosphere-ionosphere system.

The following ionospheric parameters were processed and analyzed: F-region critical frequency, virtual height of electronic density peak and minimum virtual height (respectively, foF2, hpF2 and h`F). They are presented in the next section.

Results

In the Figures 2, 3 and 4, panels display the ionospheric parameters foF2, hpF2 and h`F registered at PAL and SJC for the equinoctial months of September, October and November 2003. As already mentioned, we have scaled magnetically quiet day ionograms of those months and with simultaneous measurements at the two stations.

Table 2 – Magnetically quiet days of the observation period (year 2003)

September	28	14	29	07	30
October	11	10	12	23	4K
November	28	27	29	5K	8A

Source: http://www.gfz-potsdam.de/pb2/pb23/GeoMag/niemegk/kp_index/quietdst/qs20000x.html

Not all the days from Table 2 had simultaneous measurements in both locations. Only the month of November 2003 had the complete set of 5 quietest days of measurements. September had 4 days (28, 29, 07 and 30), and October, just 2 days (23 and 4K).

Ionosphere behavior patterns are different at those two locations, as expected. Geomagnetic characteristics, such as magnetic declination and inclination angles play an important role in controlling the ionosphere (e.g. Abdu et al., 1981; Batista et al., 1986). An interesting feature is the small pre-reversal peak of SJC relative to PAL, evidenced by the curves of hpF2 and h`F, during the month of September and its increasing values along the successive observation months. In other words, we can notice what seems to be the influence of the seasonality over the pre-reversal peak behavior of SJC and its lesser importance over the same ionospheric characteristic for PAL. Such influence of the seasonality appears to be present because higher values reached by hpF2 and h`F at SJC are in November, which is close to the solstice summer in the south hemisphere.

In the Figure 2 (right panel), it is observable that in September, spread-F events in range and frequency occurred over SJC, usually at late night/pre-sunrise times (between 06 (~03) and 09UT (~06LT)), exhibiting moderate to weak intensity. Spread-F events are evidenced by the gap in the curves of foF2 and hpF2, because the difficulties to scale the ionograms, so diffuse are their traces. Spread-F occurred everyday of the observed periods over PAL, (see Figures 2, 3 and 4, left panels), usually between 00 (~21) and 02UT (23LT) and, between ~23 (~20) and 24UT (21LT).

In the subsequent months of October and November (Figures 3 and 4), one can observe the intensification of spread-F occurrence over SJC, earlier in the night, between 00 (~21LT) and ~02UT (~23LT) and only two days (October 4, and November 28) with pre-sunrise spread-F. There are no data available between approximately 1330 and 1500UT on October 4 at PAL (Figure 3).

Another noticeable feature is the increasing values of hpF2, between 09 and 12UT, characterizing a positive vertical ionospheric drift velocity at that time range, while the parameter h`F shows the opposite behavior, exhibiting decreasing values. This differential displacement of the F-region in which the bottom side of the F-region moves down and the denser plasma of higher altitudes, including the electronic density peak, moves up, reaches the highest amplitudes, within the period observed in this work, in the month of November.

Conclusions

Preliminary studies on the ionospheric characteristics from two Brazilian stations (Palmas and São José dos Campos), during the quietest days of September, October and November 2003, show us, as expected, different ionospheric behaviors. Such differences can be related to the different geographic and geomagnetic configurations from one location to another. Also, this small sample of days seems to show the effect of seasonality. Further analyses are necessary in order to explain some characteristic structures observed in the current results.

Acknowledgments

To Dr. J. R. Abalde by the map in the Figure 1.

References

Abdu, M. A. Outstanding problems in the equatorial ionosphere-thermosphere electrodynamics relevant to spread F. Journal of Atmospheric and Solar-Terrestrial Physics**,** 63: (9) 869-884 2001.

Abdu, M. A. Major phenomena of the equatorial ionosphere-thermosphere system under disturbed conditions. J. Solar-Terr. Phys., 59, 13, 1505, 1997.

Abdu, M. A., Bittencourt, J. A., Batista, I. S. Magnetic declination control of the equatorial F region dynamo electric field development and spread-F. J. Geophys. Res., 86 (A13), 11443-11446, 1981.

Batista, I. S.; de Paula, E. R.; Abdu, M. A.; Trivedi, N. B.; Greenspan, M. E. Ionospheric effects of the March 13, 1989, magnetic storm at low and equatorial latitudes. J. of Geophys. Res., 96, A8, 13943, 1991.

Becker-Guedes, F., Sahai, Y., Fagundes, P. R., Lima, W. L. C., Pillat, V. G., Abalde, J. R., Bittencourt, J. A. Geomagnetic storm and spread-F. Ann. Geophys., 22, 1-9, 2004.

Bertoni, F.; Batista I. S.; Abdu, M. A.; Reinisch, B. W.; Kherani, E. A. A comparison of ionospheric vertical drift velocities measured by Digisonde and Incoherent Scatter Radar at the magnetic equator. J. of Atmos. and Solar-Terr. Phys., 2005. (submitted)

Blanc, M., Richmond, A. D. The ionospheric disturbance dynamo. J. of Geophys. Res., 85, 1669, 1980.

Fejer, B. G. Low latitude storm time ionospheric electrodynamics. J. of Atmos. and Solar-Terr. Phys., 64, 1401, 2002.

Fagundes, P.R., Bittencourt, J.A., Sahai, Y., Takahashi, H. and Teixeira, N. R. Plasma drifts inferred from thermospheric neutral parameters during geomagnetic storms at 23°S. J. of Atmos. and Solar-Terr. Phys., 60, 1303-1311, 1998.

Fuller-Rowell, T. J., Millward, G. H., Richmond, A. D., Codrescu, M. V. Storm-time changes in the upper atmosphere at low latitudes. J. Atmos. and Solar-Terr. Phys. 64, 1383, 2002.

Grant, I.F.; MacDougall, J.W.; Ruohoniemi, J.M.; Bristow, W.A.; Sofko, G.J.; Koehler, J.A.; Danskin, D. and Andre, D. Comparison of plasma flow velocities determined by the ionosonde Doppler drift technique, SuperDARN radars, and patch motion. R. Sci., 30, 1537, 1995.

Lima, W. L. C., Becker-Guedes, F., Sahai, Y., Fagundes, P. R., Abalde, J. R., Crowley, G., Bittencourt, J. A. Response of the equatorial and low-latitude ionosphere during the space weather events of April 2002. Ann. Geophys., 22, 3211-3219, 2004.

Mazaudier, C., Venkateswaran, S. V. Delayed ionospheric effects of the geomagnetic storms of March 22, 1979 studied by the sixth coordinated data analysis workshop (CDAW-6). Ann. Geophys., 8, 7-8, 511, 1990.

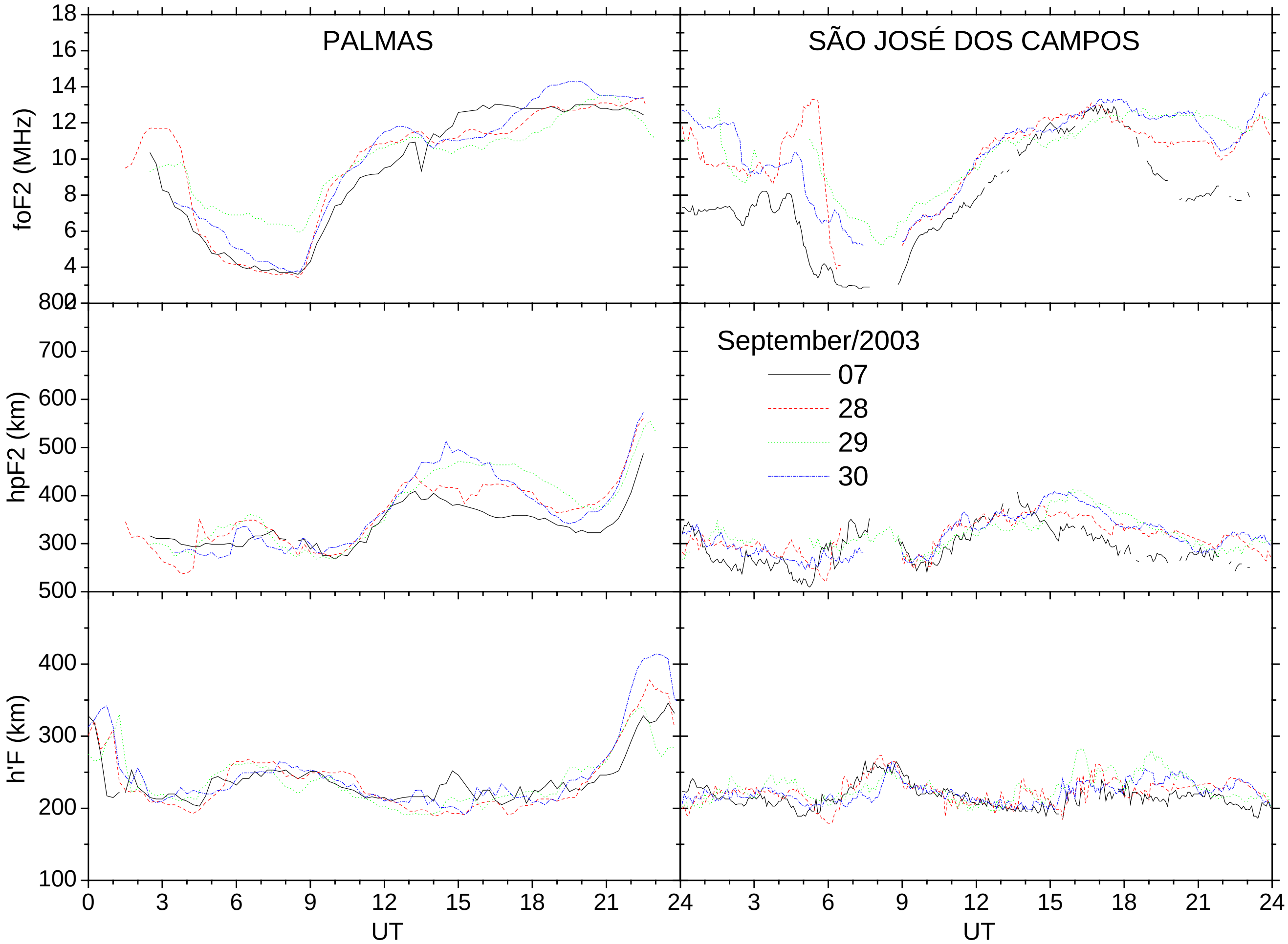

Figure 2 - Panels displaying ionospheric parameters foF2 (top side), hpF2 (intermediate) and h`F (bottom side) for data from Palmas (left) and São José dos Campos (right), registered on September 2003.

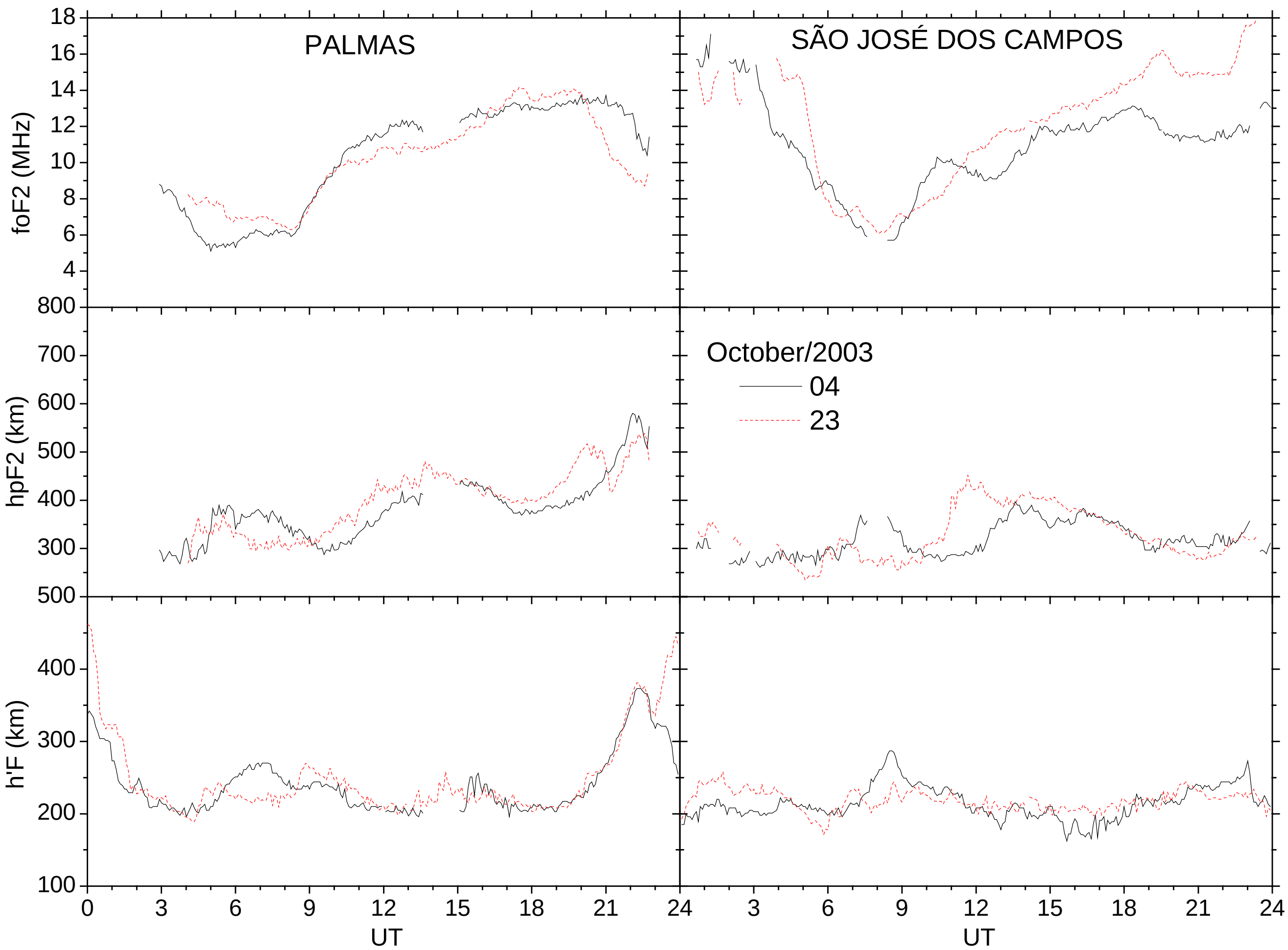

Figure 2 – Same ionospheric parameters and locations, but for October 2003.

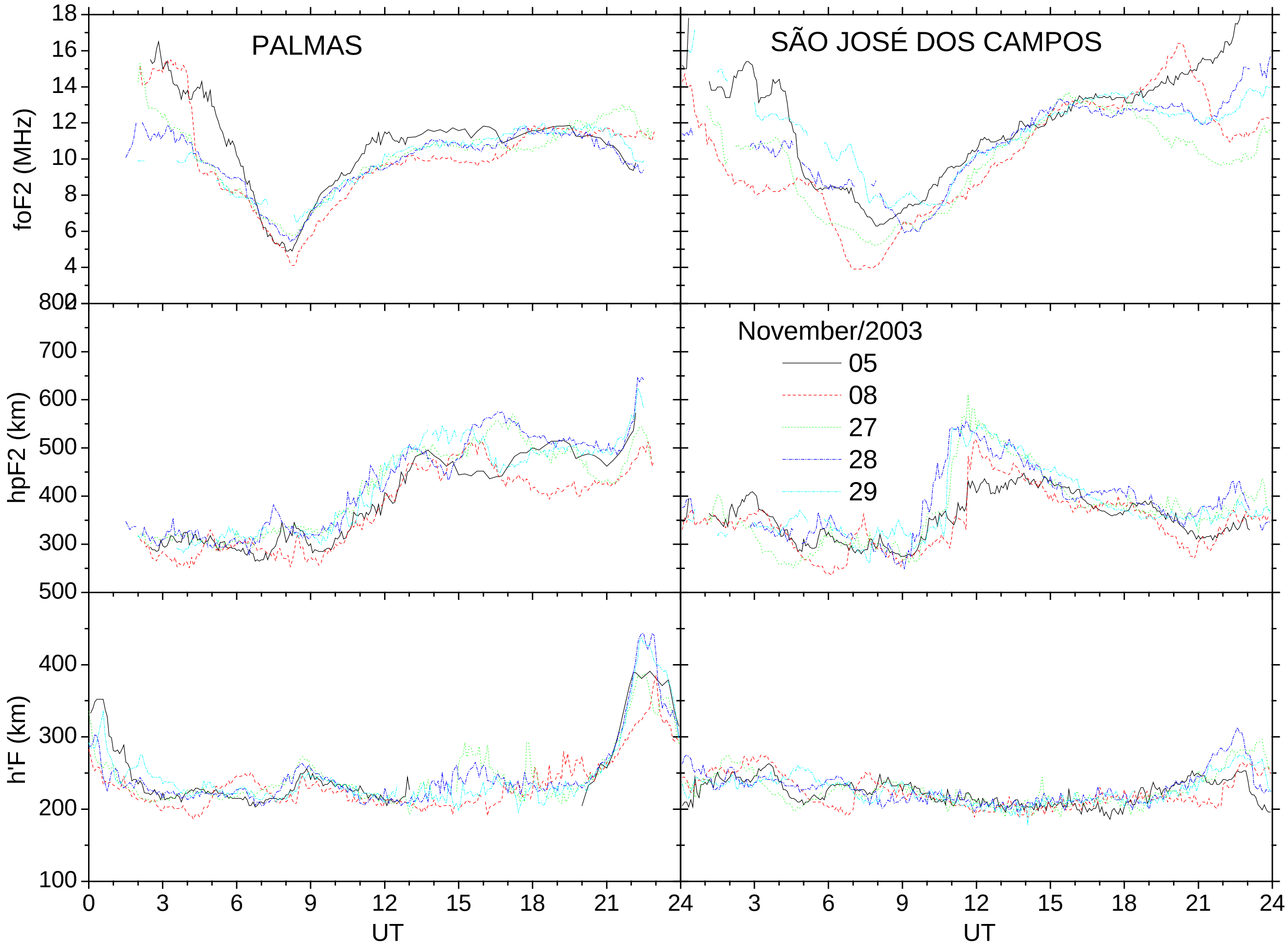

Figure 4 – Same ionospheric parameters and locations, but for November 20