Plasma blob observed by ground-based radio and optical Techniques in the F-region – A case study on 27-28 August 1987

[1]Alexandre A. Pimenta,[1] Danielle C.M. Amorim, [1] Aline A. de Almeida, [1]Cristiano S. Machado

[1]National Institute for Space Research (INPE) – Av. dos Astronautas 1758, Sao Jose dos Campos, SP, Brazil – pimenta@laser.inpe.br, danielle@laser.inpe.br, aline@laser.inpe.br, cristiano@laser.inpe.br

Abstract

An interesting case of plasma blob event was observed on August 27-28, 1987 over Cachoeira Paulista (22.7ºS, 45.0ºW; magnetic latitude 13.25ºS, declination 20ºW) showing localized plasma density enhanced by a factor of, approximately, 2 above the background level. The F-region parameters were obtained from a Digisonde 256, which provide a good idea of the ionospheric behavior during the event. On this night, geomagnetic activity was moderately disturbed with Dst > -70 nT. Complementary data was obtained from an all-sky imager operating on a routine basis at the same site. All-sky images were used to map the spatial extension and temporal location of plasma blob that showed, typically, east-west and north-south extensions of 320-350km and of 360-380km, respectively. In this paper, important features from this observation is presented and discussed.

1. Introduction

Discrete F-region electron density enhancements or plasma blobs, with densities increased by a factor of two, or more, above the background density, have been measured in "situ" by satellite in the tropical F-region (e.g. [1-3]). Using data from the Hinotori satellite, with altitude of 650 km, [1] reported the first observations of localized regions of plasma density enhancements in addition to plasma depletions in the nightside tropical F-region. They showed that these electron density enhanced regions have similar east-west scale sizes as the plasma depletions and that, within these regions, the plasma density is enhanced by a factor of, approximately, 2 above the background level. In addition, their statistical study showed that the occurrence probabilities of the plasma depletions and plasma blobs appear to be complementary to each other. [2] and [3], using data from ROCSAT-1 (observations at ~ 600km altitude), DMSP (observations at ~ 800km altitude) satellites, and KOMPSAT-1 (observations at ~ 685km altitude) and DMSP satellites, respectively, also detected plasma blobs in association with large-scale plasma depletions. On the other hand, [4], using all-sky images in the OI 630 nm emission, were the first to report ground-based observations of blobs in the tropical region and their association with equatorial spread-F plasma depletions. Recently, [5] using the CNOFS/CINDI data shows that bubbles and blobs can be independent phenomena. In this paper we report a case of plasma blob in the tropical region using simultaneous radio and optical techniques and confirm that the plasma bubble is not a prerequisite condition for the appearance of blobs. Furthermore, we suggest possible mechanism for the plasma blob generation.

2. Measurement technique and observations

A Digisonde 256 (DGS256) located at Cachoeira Paulista was used to obtain vertical sounding data of the ionosphere on August 27-28, 1987. The Digisonde can be operated in a number of modes, and during the event reported here was at vertical incidence. The vertical ionograms were automatically scaled by using the ARTIST inversion algorithm to obtain the true height profile and subsequently were checked manually and rescaled where necessary to remove obvious errors. The ionospheric parameters (Figure 1), around 26:50 LT, registered abrupt increases in foF2 (peak electron density), whereas both the base height (h'F) and F-layer peak height (hmF2) decreased to an altitude of 220 km and 300 km, respectively, which is the typical altitude range of the OI 630 nm airglow emission. Both of these effects (larger foF2 and lower hmF2) enhance the airglow. We believe that the bright region which appears in Figure 2 can be related with the so-called ''blob'' reported by [4] and [6] showed that during the occurrence of blobs, the localized plasma density enhanced by a factor of, approximately, 2 above the background level.

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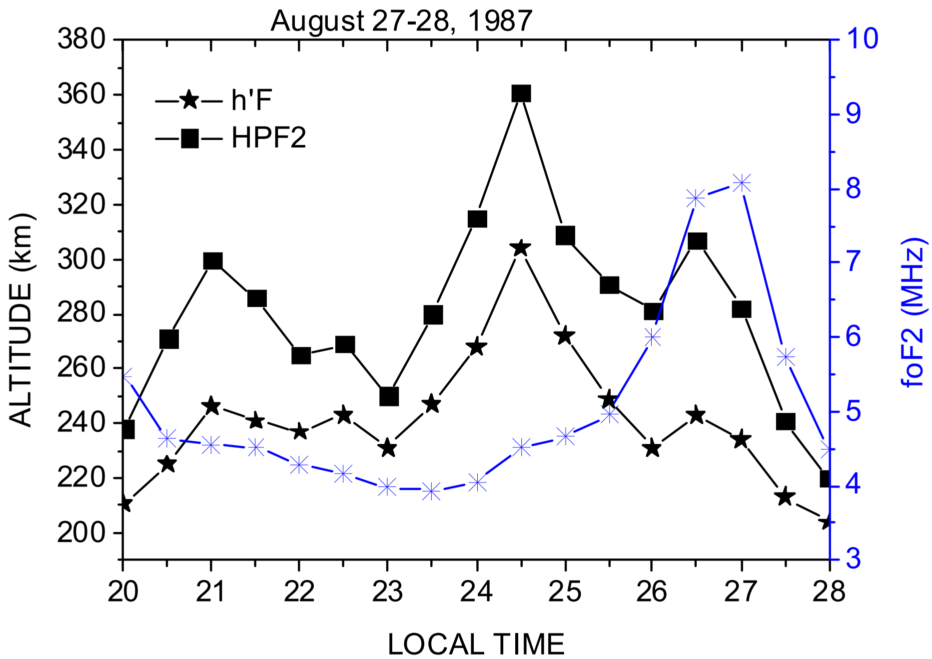

Figure 1 – Digisonde observations of F-layer peak height (hmF2), base height (h'F) and foF2 on 18–19 July 1998 showing the plasma blob occurrence around 27 LT (blue line).

The all-sky imaging technique offers a unique capability to characterize, simultaneously, the morphology of blobs over regions spanning several million square kilometers. Observations of the OI 630 nm nightglow emission, using monochromatic wide-angle imager, have been carried out at Cachoeira Paulista (22.7°S, 45ºW), Brazil, from October 1998 to September 2000. The OI 630 nm emission is produced in the bottomside of the F-region (250-300km) by the O_2^+ dissociative recombination process and is widely used to monitor important F-region ionospheric processes. Full details of the ground-based all-sky imaging system used in this study have been presented earlier [7]. On August 27-28, 1987, geomagnetic activity was moderately disturbed, with Dst > -70 nT. Figure 2 shows the field of view of this system together with other relevant information. The major chemical reactions that generate the OI630.0 nm airglow emission in the F-region are as follows:

$$O^+ + O_2 \rightarrow O_2^+ + O \tag{1}$$

$$O_2^+ + e \rightarrow O + O^*(^1D) \tag{2}$$

$$O^*(^1D) \rightarrow O + h\nu(630nm) \tag{3}$$

It is considered that production of O(¹D) by dissociative recombination of NO^+ is unimportant (Dalgarno and Walker, 1964). Therefore, the production of the OI 630.0 nm emission depends on the molecular oxygen density $[O_2]$ and the oxygen ion density $[O^+]$. The oxygen ion density $[O^+]$ is approximately equal to the electron density in the F-region. The height of the F- layer peak electron density occurs around 350-400 km, while the molecular oxygen density $[O_2]$ increases with decreasing height. Thus, the 630.0 nm emission peak occurs in the bottomside of the F-region around 220-300 km. When the F-layer moves downward, the OI 630.0 nm emission is enhanced, so that the OI630.0 nm emission intensity is a sensitive indicator of F-region vertical motions and plasma density variations.

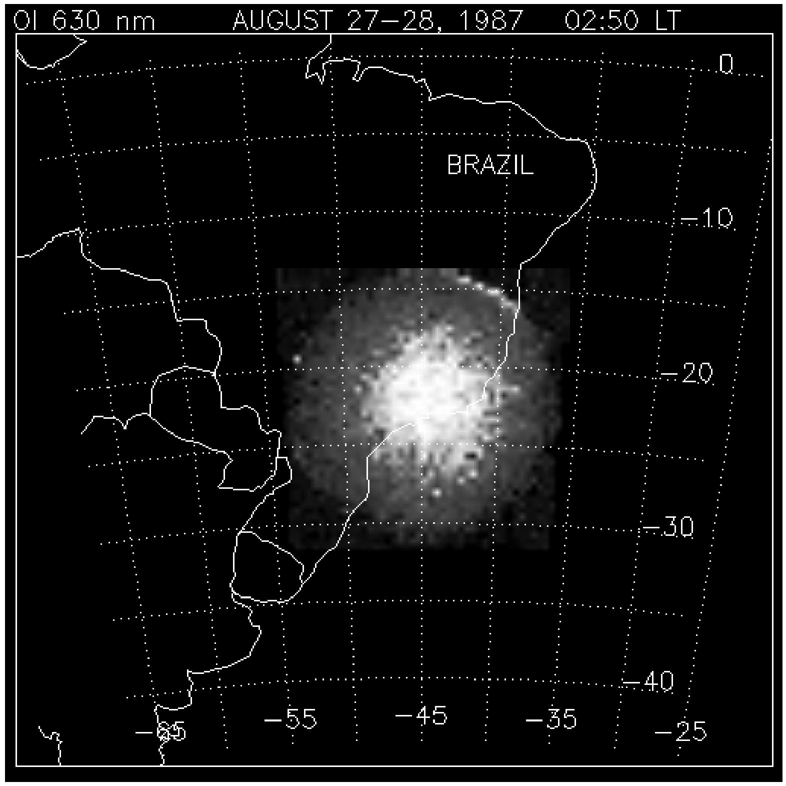

Figure 2 - Location of the OI 630.0 nm emission all-sky imager at Cachoeira Paulista with it respective field of view (considering an emission height at 250 km). Unusual airglow OI 630 nm emission enhancements or blob is associated with intensity enhancements produced through the O_2^+ dissociative recombination process.

3. Summary

In summary, our observations from ground-based radio and optical measurements, have shown the occurrence of a localized ionospheric plasma density enhancement, similar to the satellite observations reported by [5]. Within these density enhancements structures, the plasma density may be increased, by more than twice above the background density. The plasma blob showed, typically, east-west and north-south extensions of 320-350km and of 360-380km, respectively. We conclude that bubbles need not be a prerequisite condition for the appearance of blobs.

4. References

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