Responses to the Comment and/or Suggestions from Referee 1

Manuscript 'On developing a new ionospheric plasma index for the Brazilian equatorial F region irregularities' by Resende et al. submitted to the Annales Geophysicae.

We would like to acknowledge the comments given by the referee. We have carried out a revision of the manuscript taking into account all the referee's comments and suggestions.

Comment:

1. The authors have investigated time delay of the peak of the upward velocity of the F layer movement and onset of the spread F. This reviewer believes that it is worth studying, but the authors need to mention the followings. The observations carried out in this study is the observation just above the ionosonde. By the only one point observation, it is impossible to distinguish between temporal and spatial variations of the spread F or plasma bubble. In most cases, plasma bubbles occur around sunset terminator and move eastward at the same velocity as the ambient plasma in the ionosphere. By the observation at a single point, it is impossible to identify where and when the plasma bubble is generated. For an example, we consider the case that spread F is observed by an ionosonde 1 hour after the upward velocity of the F layer movement reaches a peak. Plasma bubble may be generated above the ionosonde 1 hour after the peak of the upward velocity of the F layer. The other possibility that the plasma bubble is generated at west of the ionosonde site, moves eastward, and reaches the ionosonde site 1 hour after the peak of the upward velocity of the F layer. Satellite trace in the ionogram arises from radio wave reflection from the oblique direction, indicating plasma bubble does not exist just above the ionosonde, but apart from the ionosonde.

Our response:

Thanks to the reviewer for highlight this point. However, the digisonde can make vertical and oblique soundings, which allow us to study a considerable portion of the ionosphere. The digital beam forming is done taking four complex amplitudes observed in a particular Doppler line of the spectrum on four receive antennas and forming seven beams shown in the figure below. There is one bam overhead at 0° zenith angle and six oblique beams cantered at North and South directions and each 60° in between (Reinisch et al., 2009, doi: 10.1029/2008RS004115).

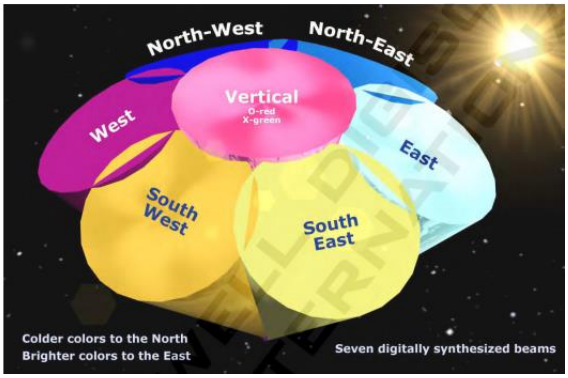

Figure 1. Seven beams for the angle of arrival measurd in ionogram mode. Source: Technical Manual Operation and Maintenance of Digisonde.

A spatial range of ~3480 km is obtained at 250 km altitude. Therefore, the digisonde can make measurements up to ~3480 km away from the point just above it. The ordinary and extraordinary traces as well as the vertical and oblique soundings can be identified by the colours in the ionograms. Also, the digisonde can monitor the ionosphere continuality with a temporal resolution of 10 minutes. So, we can monitor the ionosphere since the pre-reversion peak up to spread f onset time with good precision (Abdu et al., 2009; doi: 10.5194/angeo-27-2607-2009). Moreover, the error is not significant in terms of the spread F occurrence, as the main purpose for the Space Weather program. Finally, we understand that satellite traces are necessary precursor to the occurrence of an spread F trace on the ionograms as point out by Cabrera et al. 2010 (doi: 10.5194/angeo-28-1133-2010). However, the onset time of the spread f was considered when the digisonde echoes were clear diffuse. In order to clarify these points, we include some information about the temporal error in this manuscript (page 18).

2. P. 11, l. 1: "U^P" is not zonal wind. It is the Pedersen conductivity-weighted neutral wind perpendicular to the magnetic field in the magnetic meridian plane.

Our response:
We modify this part accordingly.

3. P. 14, ll. 15-17, "In addition, the formation of these irregularities ...": It is better to change to "the post-midnight plasma bubbles could be caused by atmospheric gravity wave seeding of the Rayleigh-Taylor instability and/or increase in growth rate of the Rayleigh-Taylor instability due to the F-layer uplift, .

Our response:
We modify this part accordingly.

4. P. 14, ll. 17-18, "In both cases, there is a decrease...":
This explanation of applicable to only latter case, that is the increase in growth rate of the Rayleigh-Taylor instability due to the F-layer uplift. Gravity wave does affect the ion-neutral collision frequency. On the other hand, when the F-layer is uplifted, the F layer exists at higher altitude, where the ion-neutral collision frequency is low.

Our response:
The reviewer is right. We remove this last phrase to avoid some confusion in the text.

Minor comments:

1. P. 14, l. 16, "an abrupt uplift": "abrupt" is not needed. Only "uplift of the F layer" is.

Our response:

Done.

2. P. 14, l. 17, "In both cases, ...": When the F layer is uplifted

Our response:

This phrase was removed in this new version of Manuscript.

3. P. 16, l. 8: what is "um"?

Our response:

We modify this part accordingly.

4. P. 17, l. 13: "shown" --> "have shown"

Our response:

Done.

Thanks to the reviewer for pointed this fact. We included the symbol equals where we consider the threshold in table.

5. It is better to use "December solstice" and "June solstice instead of "summer" and "winter" because plasma bubbles occur around equator and exist simultaneously in both northern and southern hemispheres.

Our response:

In this case, we prefer to use the summer and winter, since the magnetic equator is located in the Brazilian sector in the southern hemisphere.

6. Reference list: Change the order of the references to "Barros et al., 2018", "Basu et al. 1996", and "Batista et al. 1986 and 1996".

Our response:

Done.

Finally, we would like to take this opportunity to thank the reviewer for kindly evaluating our paper helping to greatly improve its quality.