Large Scale Plasma Bubbles Observed by GPS TEC Mapping over South America

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Abstract (Font: Arial Bold, 9)

The equatorial ionosphere could be monitored successfully by mapping total electron contents (TEC) retrieved from the phase delay of the GNSS radio waves. The data obtained by ground-based GNSS receiving network RBMC/IBGE, LISN, IGS and RAMSAC were used. It was possible to monitor spatial and temporal variation of TEC by two-dimensional form with 100 – 500 km of spatial resolution and 10 minutes time resolution. During the period of December 2013 to March 2014, periodic spacing plasma depletion forms (bubbles) were observed along the longitudinal extension with the separation of 800 – 1000 km. Salient features of the observed plasma bubbles and the importance to space weather application will be discussed.

1. INTRODUCTION

In South American continent, there are 4 main GNSS receiver networks, RBMC, IGS, RAMSAC and LISN. Using in total more than 140 ground receivers we could plot TEC values making a TECMAP over the whole South America. The purpose of this work is to demonstrate plasma bubbles observed by TECMAP, and their periodic spacing structures. In order to validate the TECMAP for detection of the bubbles, OI 630 nm airglow imaging technique was also used.

2. OBSERVATION

The TEC values were calculated by using pseudrange (P1 and P2) and phase difference between the GNSS carrier waves (L1 and L2). Spatial resolution of the map is dependent on the density of ground receiver, which is 100-200 km (Central part of Brazil), 300-500 km (Northern part of Brazil) and ~1000 km over Amazon region. Temporal resolution is 10 minutes. Although, continuous data sampling made it possible to monitor the ionosphere by 24 hours/7 days.

Figure 1 shows GPS based TEC Observation points over South America on the night of December 24-25, 2013, at 01:20 UT. The total number of TEC observation point (ionospheric pierce points) was ~ 460. The color shade presents TECu from 1 (purple) to 80(red). The TECMAP depicts large latitudinal and longitudinal variations of TEC along the magnetic equator. The green to yellow belt is the Post-Sunset Equatorial Anomaly. Also seen are TEC depletions inside of the Anomaly, those are plasma bubbles.

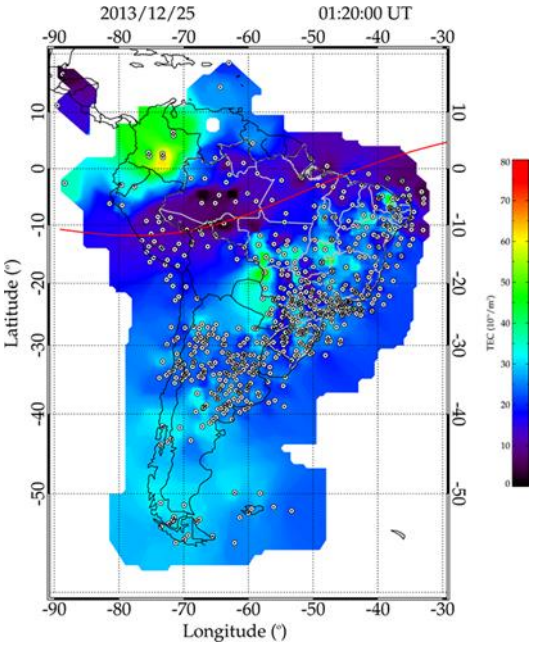

Fig. 1. TEC Mapping over South America with ionospheric pierce point of observation.

3. RESULTS:

Figure 2 shows periodic spacing (~560 km) plasma bubbles observed on the night of February 14 to 15, 2014, at 23:30, 01:00 and 02:00 UT. At 02:00 UT, 6 bubbles extended over 4000 km in Longitude were observed.

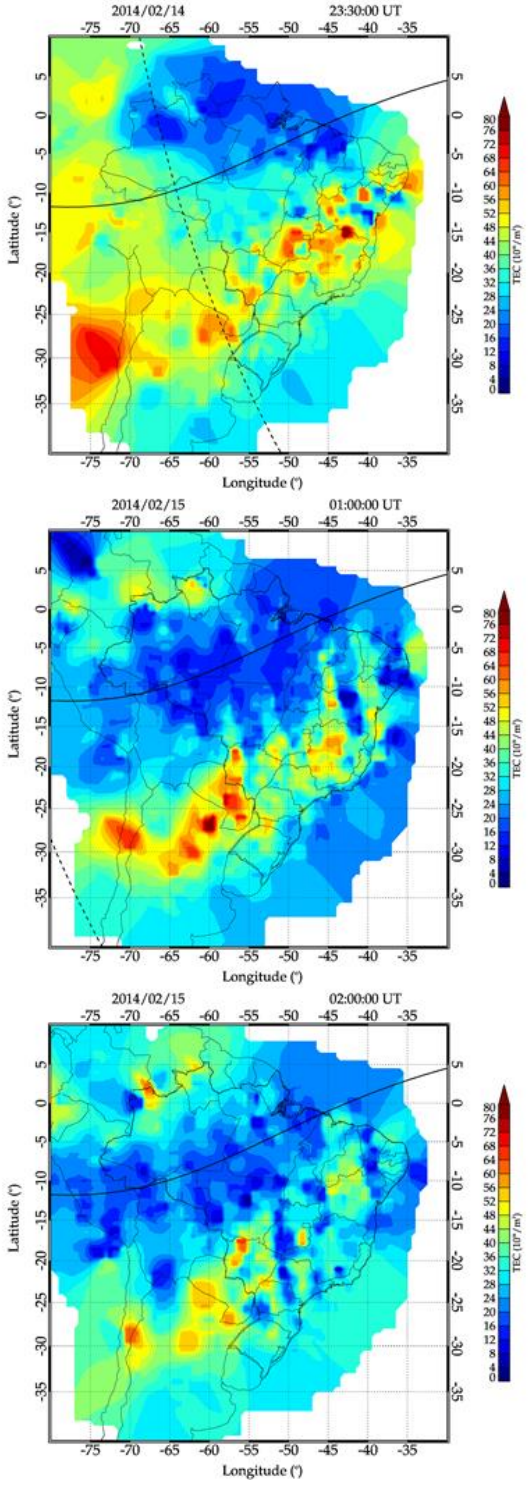

Fig. 2. Periodic spacing (~560 km) plasma bubbles observed on the night of February 14 to 15, 2014, at 23:30 (top), 01:00 (middle) and 02:00 UT(down).

Figure 2 shows a typical example of periodic spacing plasma bubbles. On this evening, the plasma bubbles were started on 23:00 UT with a distance of around 600-800 km. At 02:00 UT, 6 bubbles were extended along the longitude covering almost whole continent. We observed the similar bubble formations during the December to February period. The periodic form of plasma bubbles may suggests a seeding process related to the solar terminator.

The large depletion of TEC with an amplitude of 10 to 50 TECu from inside to outside of the bubble, for example, causes an approximately 1 to 5 m of the error range in the GNSS positioning system if no ionospheric error correction was performed. Several bubble events observed during the December 2013 to February 2014 will be presented and discussed.

Conclusions

Periodic spacing bubbles were observed during the December solstice season. They appeared after 01:00 UT, with an interval of 600 to 900 km, extending by more than 4000 km in longitude. Their latitudinal extensions are longer than ~2500 km in the southern hemisphere.

Acknowledgments

The GPS data used in this work were provided by the GPS receiver networks in the South America. We thank these providers:

* IBGE website, http://www.ibge.gov.br/home/geociencias/geodesia/rbmc/rbmc_est.shtm

* IGS website,< http://www.igs.org>,

*LISN website: <http://lisn.igp.gob.pe>,

*RAMSAC Website : http://www.ign.gob.ar/NuestrasActividades/Geodesia/Ramsac