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TOTAL ELECTRON CONTENT MONITORING UNDER QUIET AND DISTURBED CONDITIONS OVER SOUTH AMERICA REGION: RECENT DATA

PATRICIA M. DE SIQUEIRA*, EURICO R. DE PAULA* AND YUICHI OTSUKA†

*Aeronomy Division
Instituto Nacional de Pesquisas Espaciais (INPE)
Av. dos Astronautas, 1758 Jd. da Granja, São José dos Campos, SP Brazil
e-mail: patricia.mara@dae.inpe.br, eurico@dae.inpe.br, web page: http://www.inpe.br

†Solar-Terrestrial Environment Laboratory
Nagoya University, 3-13 Honohara, Toyokawa, Aichi 442-8507, Japan.

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1 INTRODUCTION

The Total Electron Content (TEC) is being extensively used to monitor the ionospheric behavior under geomagnetically quiet and disturbed conditions. The complex effects of magnetospheric convection in ionospheric electric fields and currents from middle to low latitudes during geomagnetic disturbances were documented in several studies. Under disturbed conditions the two main sources of electric fields, which are responsible for changes in the plasma drifts and for current perturbations are the short-lived prompt penetration electric fields (PPEFs) and the longer lasting ionospheric disturbance dynamo (DD) electric fields. Detected TEC perturbations and modifications are closely related to space weather characterizing quantities such as solar radio emission, solar wind and geomagnetic activity indices. In this work we will show the advances in TEC monitoring over South America using the expanded RBMC/IBGE GPS receivers network. TEC maps were performed using the Nagoya-TECMAP model[1] for quiet conditions ($Kp \leq 3$) and different seasons. Also TEC maps were calculated to show the effects of a geomagnetic storm occurred in September 2012.

2 METHODOLOGY

The TEC maps were calculated using the program developed at the University of Nagoya, Japan[1], called Nagoya-TECMAP program in this work. The code has a least squares fitting procedure to remove instrumental biases inherent in the GPS satellite and receiver. Two-dimensional maps of absolute vertical TEC are derived with time resolution of 10 minutes and spatial resolution of $1.0° \times 1.0°$ in latitude and longitude. The Nagoya-TECMAP program allows the calculation of TEC maps with up to $0.15° \times 0.15°$ grid and is very useful for dense GPS receivers network. Over the South America this program is running with a good performance by using data from the expanded RBMC/IBGE (Brazil) network, the RAMSAC (Argentina) network and IGS stations placed at this region.

3 SEASONAL FEATURES

TEC characteristics are showed in Figure 3.1 for different seasons. For all the maps the Kp ≤ 3 and F10.7 solar flux was ~ 70 solar flux units in 2009, ~80 in 2010 and ~ 100 in 2011. All maps are showed at 21:00 UT which corresponds to 18:00 LT at Brazilian region (prereversal enhancement hours) and 16:00 LT at Peruvian region. It is clear from Figure 3.1 the improvement of the GPS receivers coverage from 2009 (a.1 to a.4) to 2011 (c.1 to c.4). This improvement allows much better monitoring of the ionospheric disturbances over South America region. Well known seasonal features of ionospheric behavior can be identified in Figure 3.1, as lower TEC during the winter (a.2, b.2 and c.2), higher TEC during the summer (a.3, b.3 and c.3) and pronounced Equatorial Ionization Anomaly during the (March) equinox (a.1 and b.1). More pronounced EIA during the equinox compared to the summer at prereversal enhancement hours can be explained by the higher equinoctial vertical drifts[2].

4 STORM-TIME TOTAL ELECTRON CONTENT

During geomagnetic storms the low-latitude ionosphere exhibits characteristics modulated by Prompt Penetration Electric Fields (PPEF) and Disturbance Dynamo (DD) mechanism which act in the expansion/contraction of the EIA. The prompt effects of a geomagnetic storm are usually a expansion and enhancement of TEC over the EIA crests in the diurnal side due to the PPEF. On the other hand, the long lasting features of low-latitude ionosphere during a geomagnetic storm are related to the suppression of EIA due to DD mechanism. These features are shown in Figure 4.1 which presents TEC maps calculated for the geomagnetic storm occurred in September 30, 2012 starting at ~ 12:00 UT. The Dst index reached ~ -130 nT at 03:00 UT on October, 1. TEC maps of September, 29 are shown as quiet time reference (a.1 to a.4). TEC maps from b.1 to b.4 show enhanced TEC and c.1 to c.4 shows the TEC recovering.

5 CONCLUSIONS

The expansion of GPS receivers networks at South America region allows better understanding of the phenomena related to TEC modulations during quiet and disturbed times. Climatological studies using these new data are going to be performed, as case studies considering geomagnetic disturbed conditions. Longitudinal differences are going to be explored considering equatorial and low latitude GPS stations located in Brazil and the west side of South America due to the high difference in the declination angle that characterizes both locations. Also, other computer programs such as NOAA US-TEC will be used to calculate TEC maps and to compare with the Nagoya-TECMAP results.

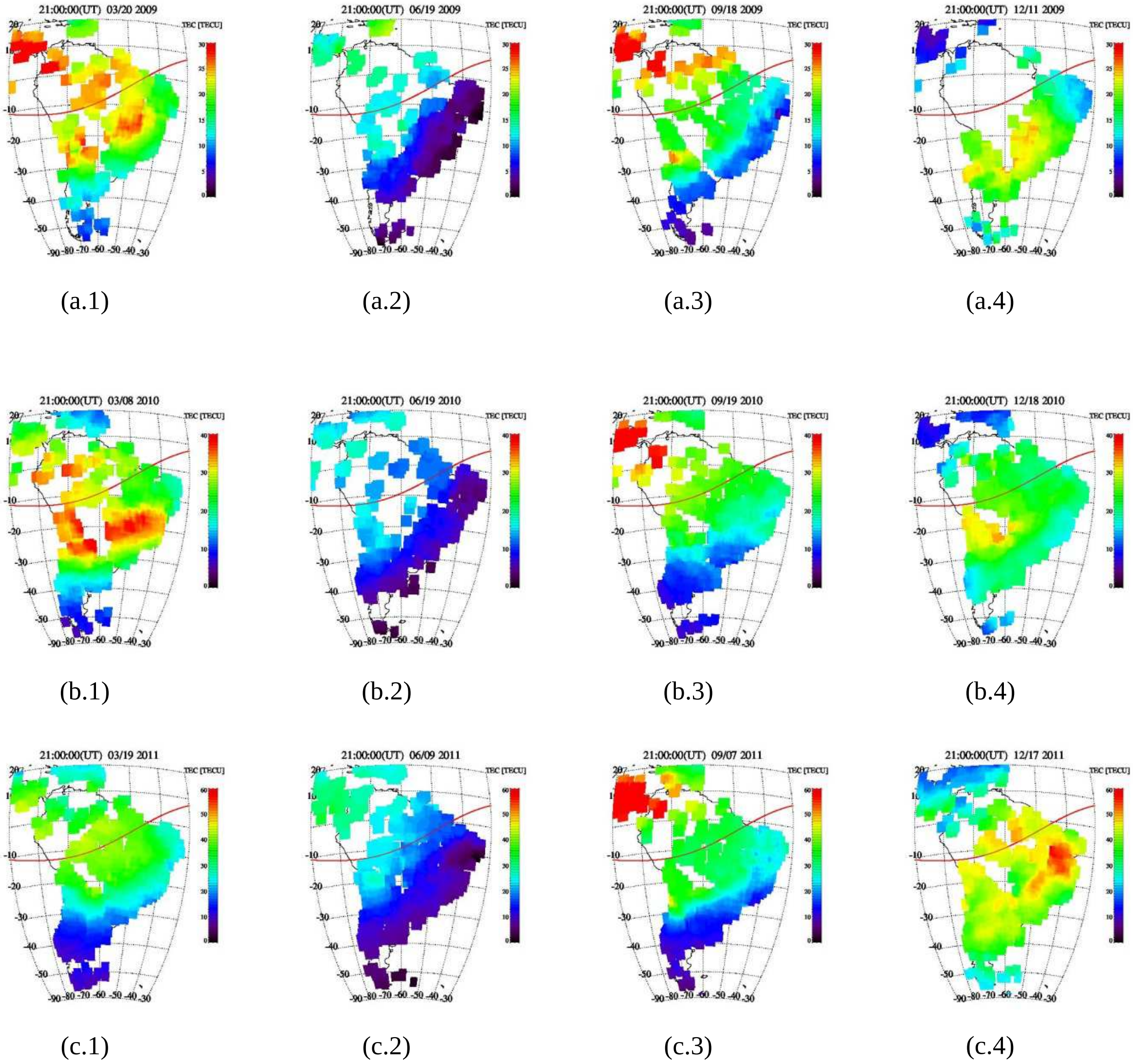

Figure 3.1. TEC maps for 2009 (a.1 to a.4), 2010 (b.1 to b.4) and 2011 (c.1 to c.4) showing: the coverage improvement of the GPS receivers over the South America region and its impact on the TEC calculation; well known seasonal features considering a period of low solar activity.

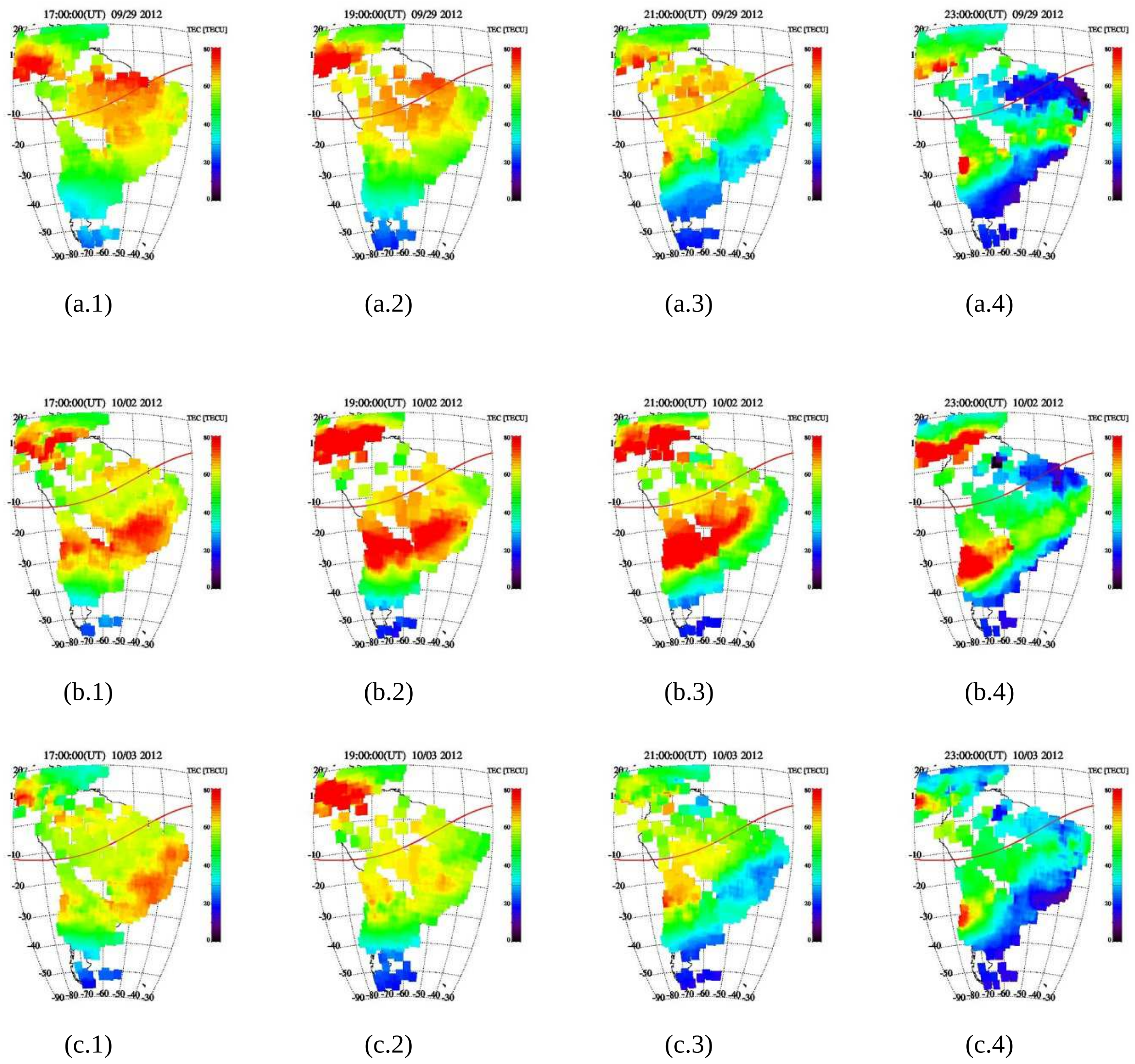

Figure 4.1. TEC maps calculated for the geomagnetic storm occurred in September 30 - October 1, 2012.

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