

# The Low-Latitude Ionospheric Sensor: Recent Scientific Results

Cesar E. Valladares  
University of Texas at Dallas

[cev160230@utdallas.edu](mailto:cev160230@utdallas.edu)

<http://lisn.igp.gob.pe>



# **Outline**

**New insights on the occurrence of near-midnight TEC enhancements that develop after sunset at low latitudes on 30% of the days [Valladares and Chau, 2012].**

**Tropical Ionization Anomaly [Valladares and Eccles, 2016, under review].**

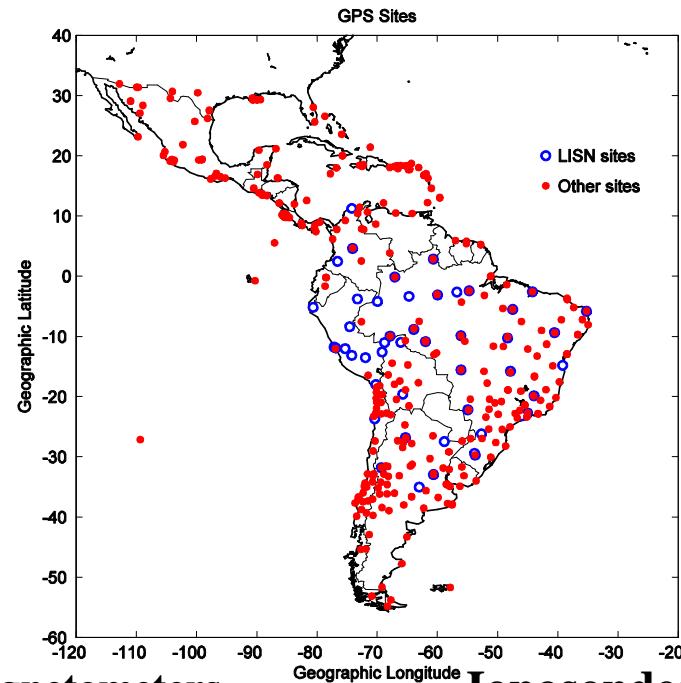
**Study of the association of primary and secondary gravity waves with tropical storm Irene [Valladares et al., 2017]**

**Observations of Conjugate MSTIDs using Networks of GPS Receivers in the American Sector. [Valladares and Sheehan, 2016].**

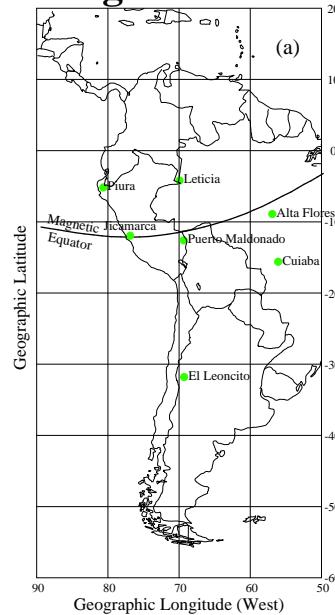
**During two large magnetic storms that occurred during the northern hemisphere summer solstice, a pronounced TEC enhancement was observed in addition to the storm enhanced density (SED) [Valladares et al., 2016].**

**Plasma bubbles observed with SWARM constellation and C/NOFS satellite on December 10, 2013. The bubble velocity field. 3D view of plasma bubbles.**

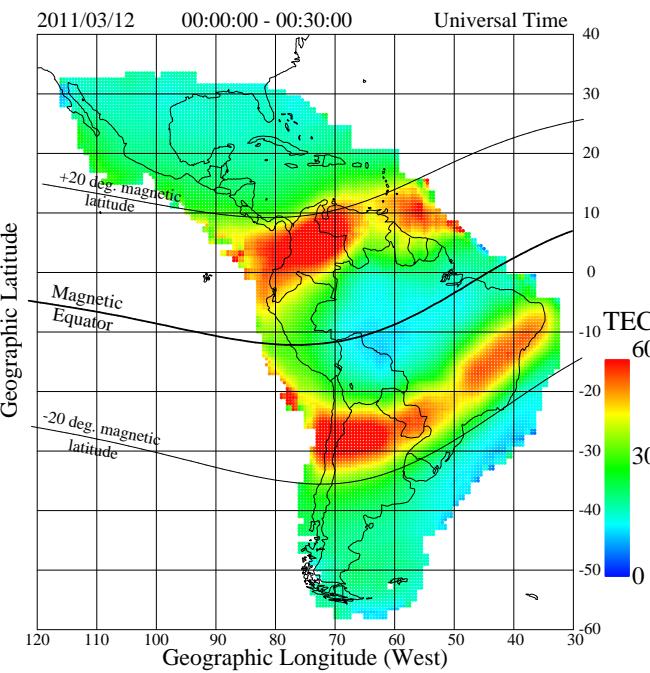
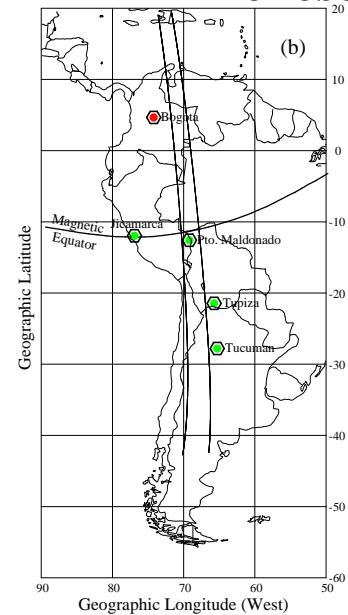
# LISN instruments and basic measurements



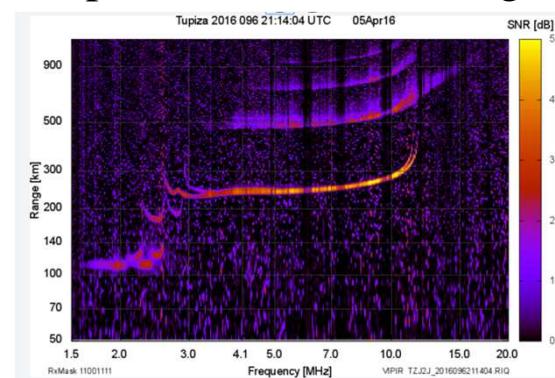
Magnetometers



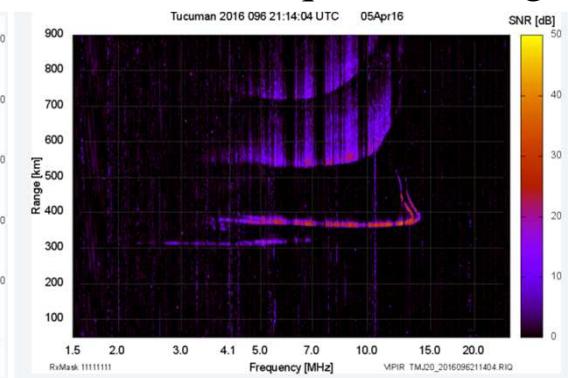
Ionomanders



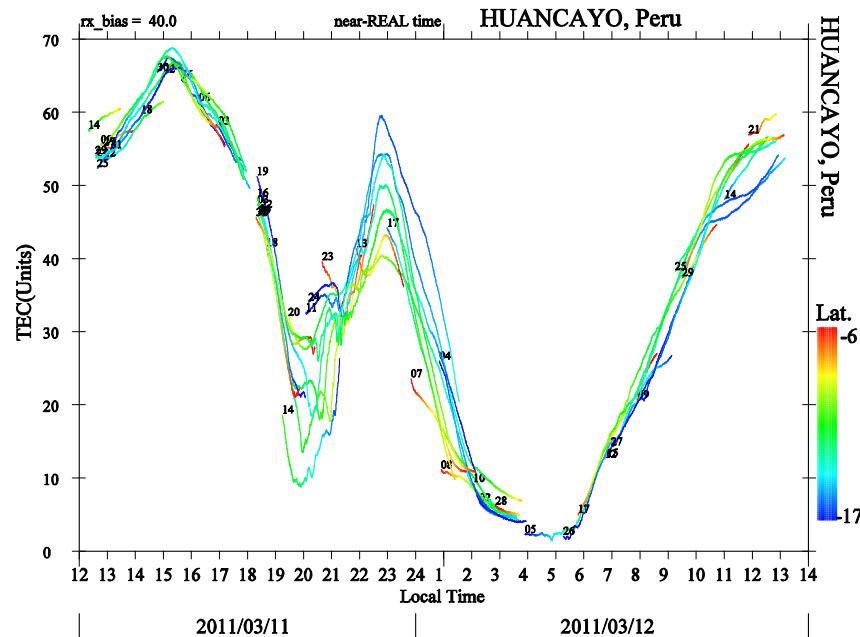
Tupiza: vertical sounding



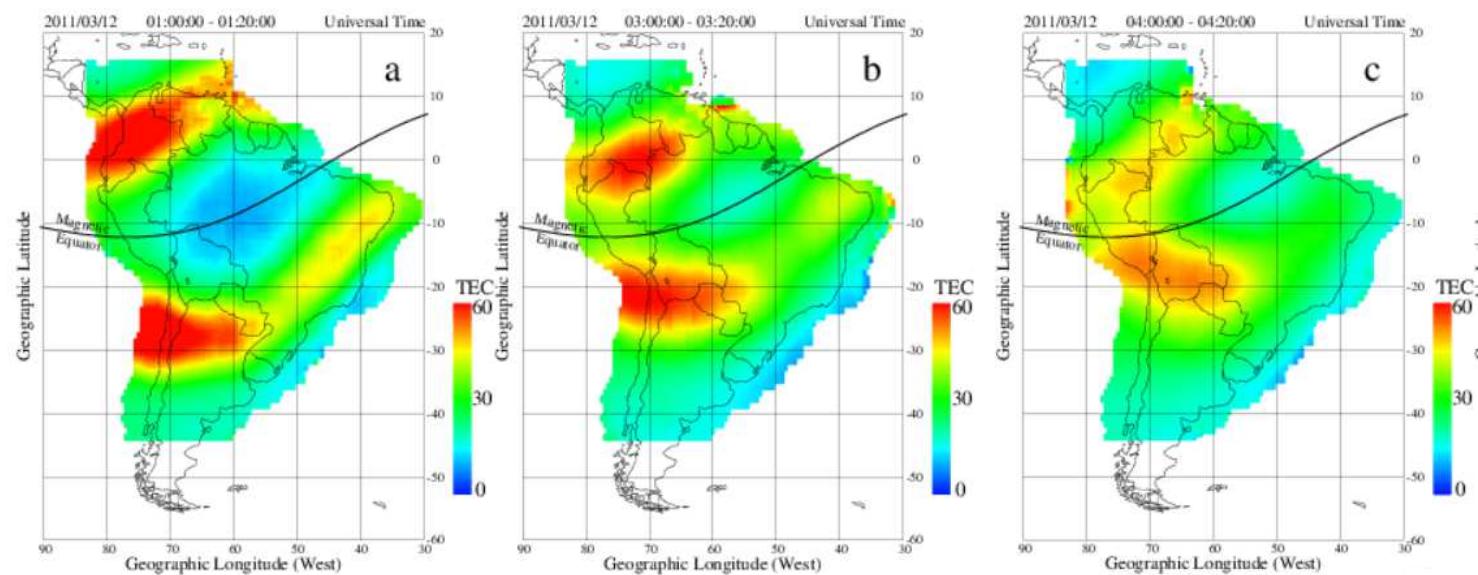
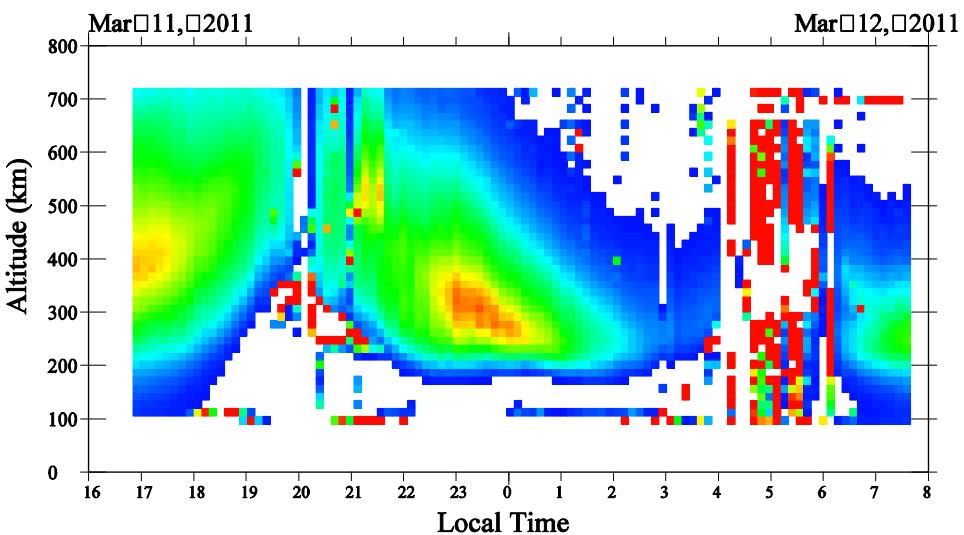
Tucuman: oblique sounding



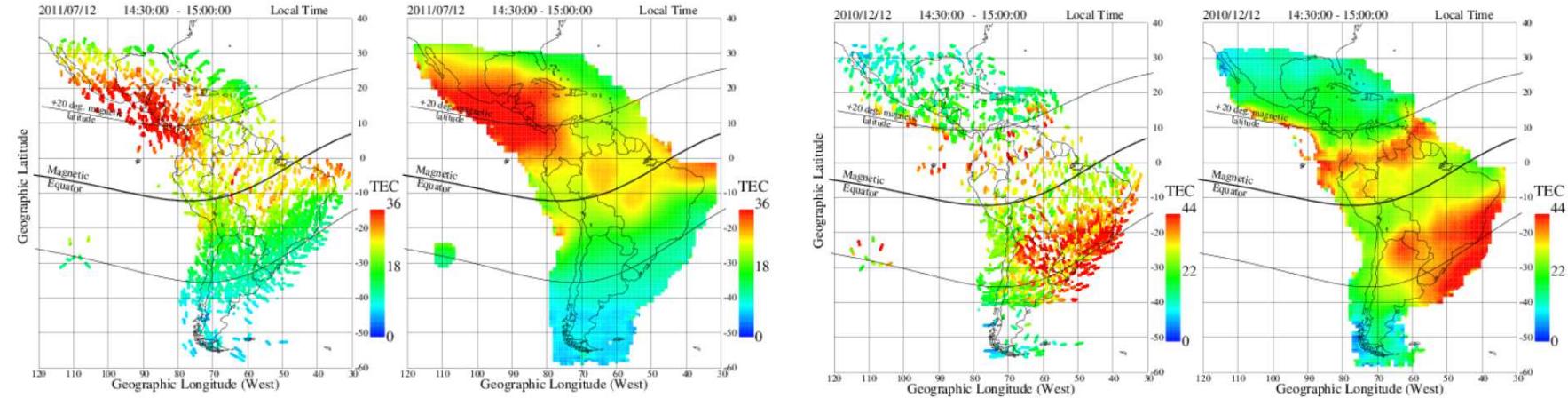
## Largest Near-Midnight TEC Enhancement



## Jicamarca Density Profiles

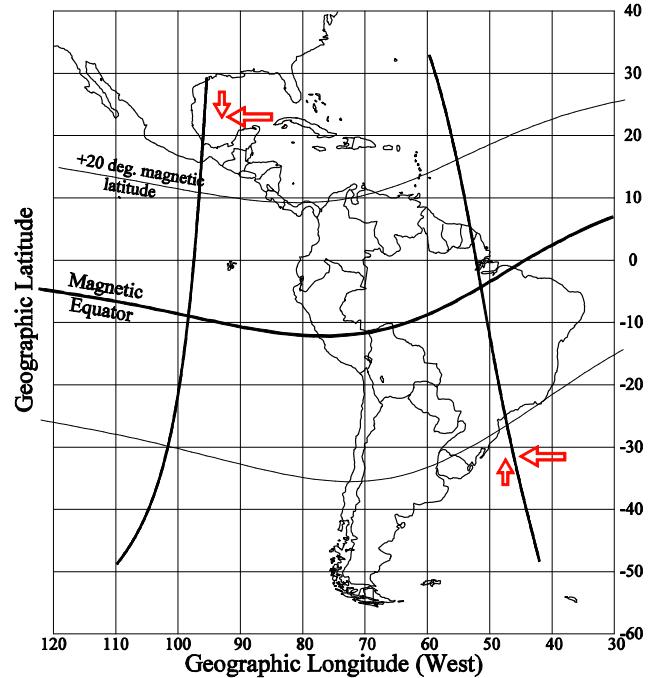


## Tropical Ionization Anomaly (TIA)

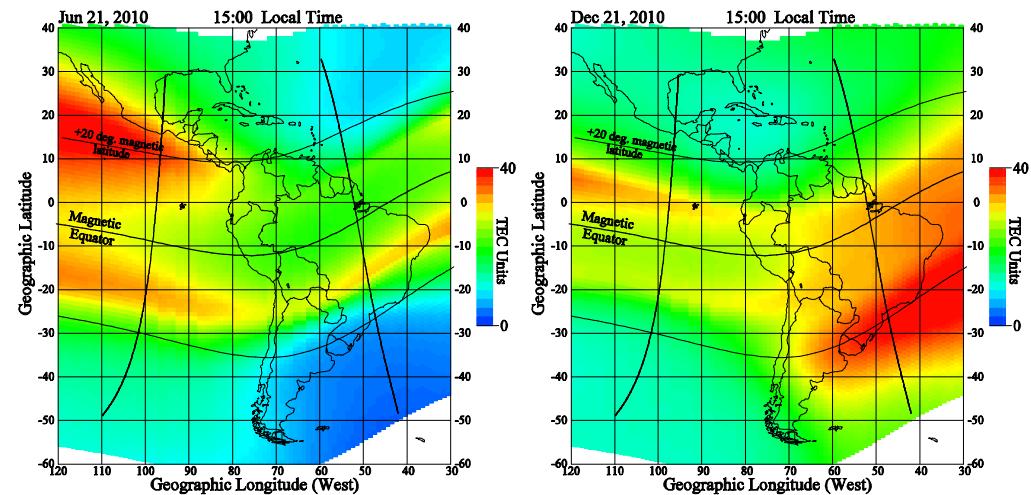


Large-scale TEC enhancement observed during June solstice    Observed over South America during December solstice

### Wind system associated with TIA

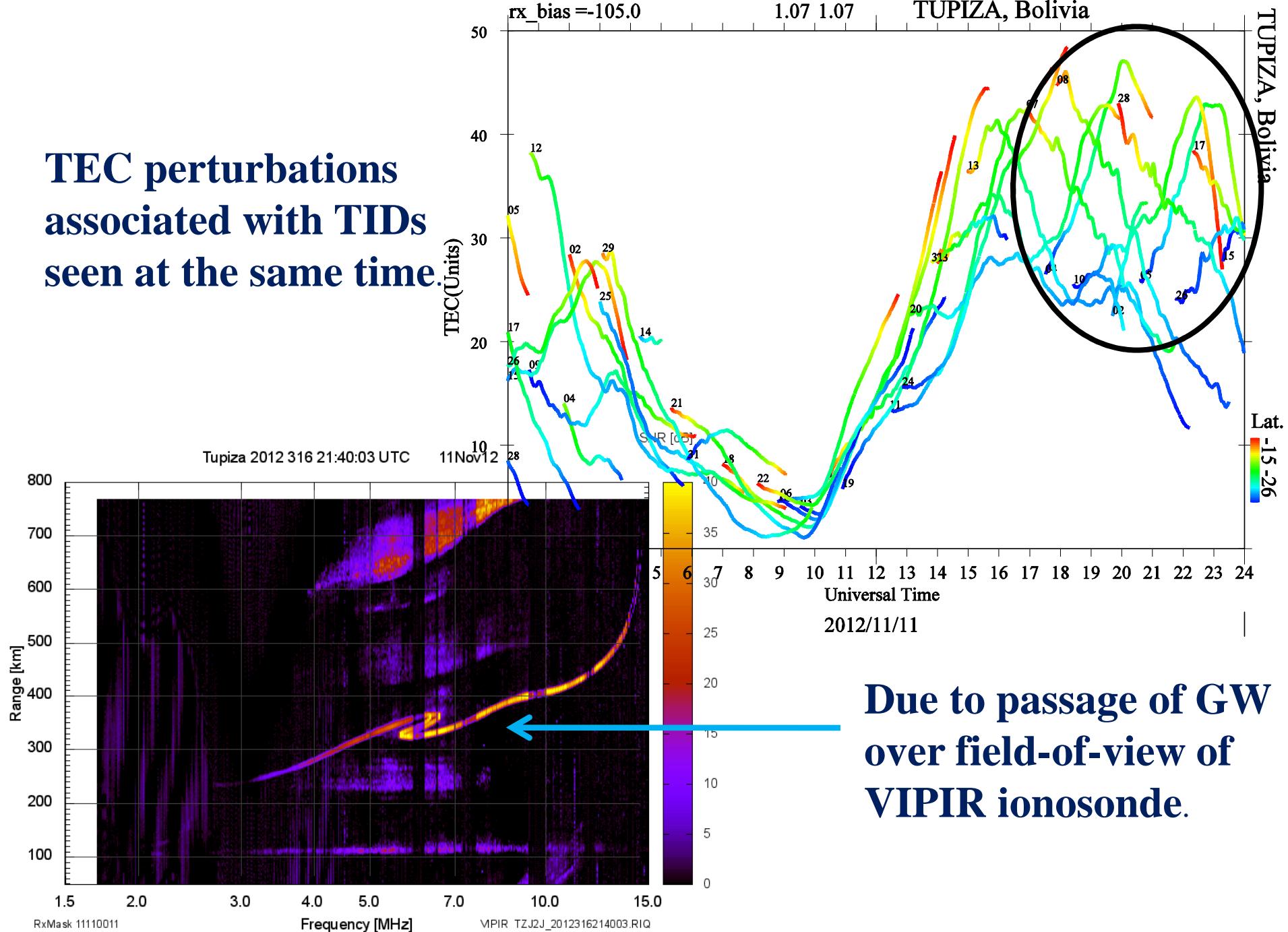


Decays at 18 LT when zonal wind reverses. Appear at longitudes with significant declination.

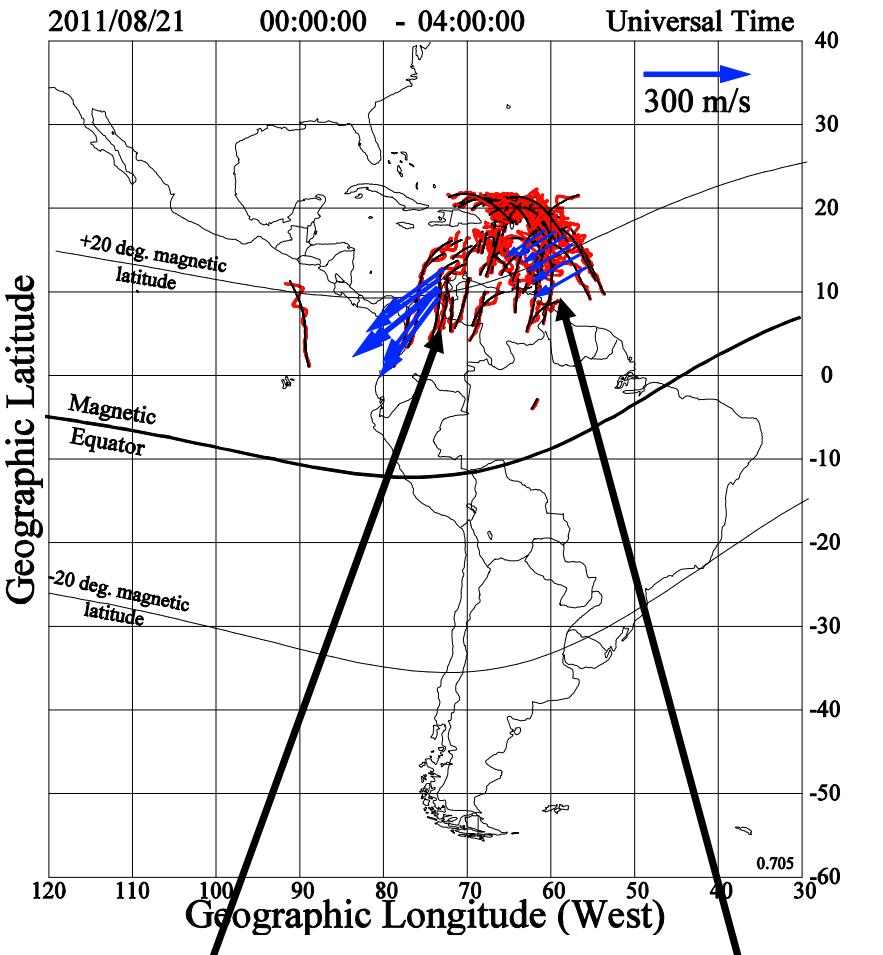
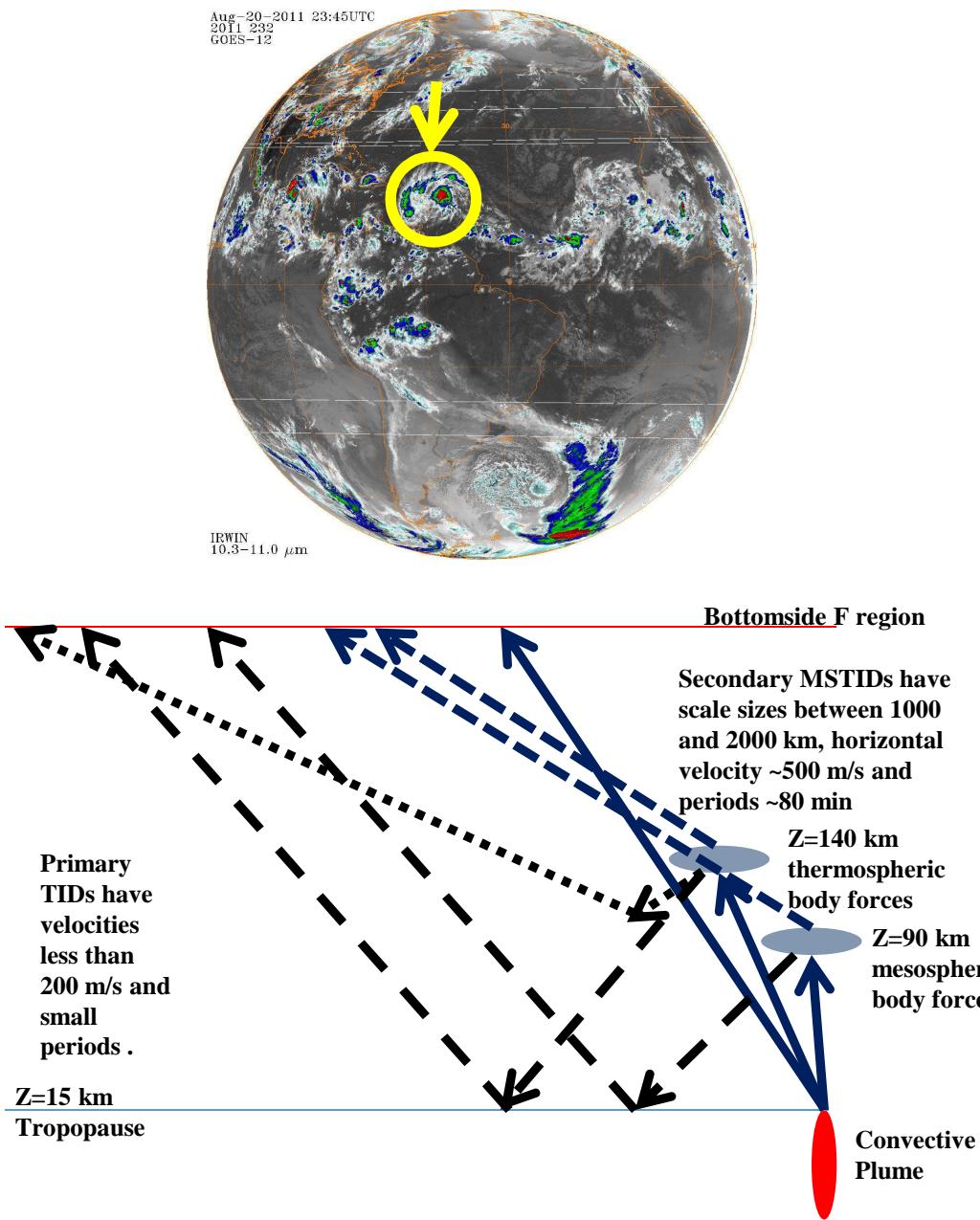


TEC results of the numerical model LLIONS using 90 planes along parallel field lines. Any complete model of the ionosphere should include these large-scale features.

# TEC perturbations associated with TIDs seen at the same time



# TIDs associated with Tropical storm Irene (August 20-21, 2011)

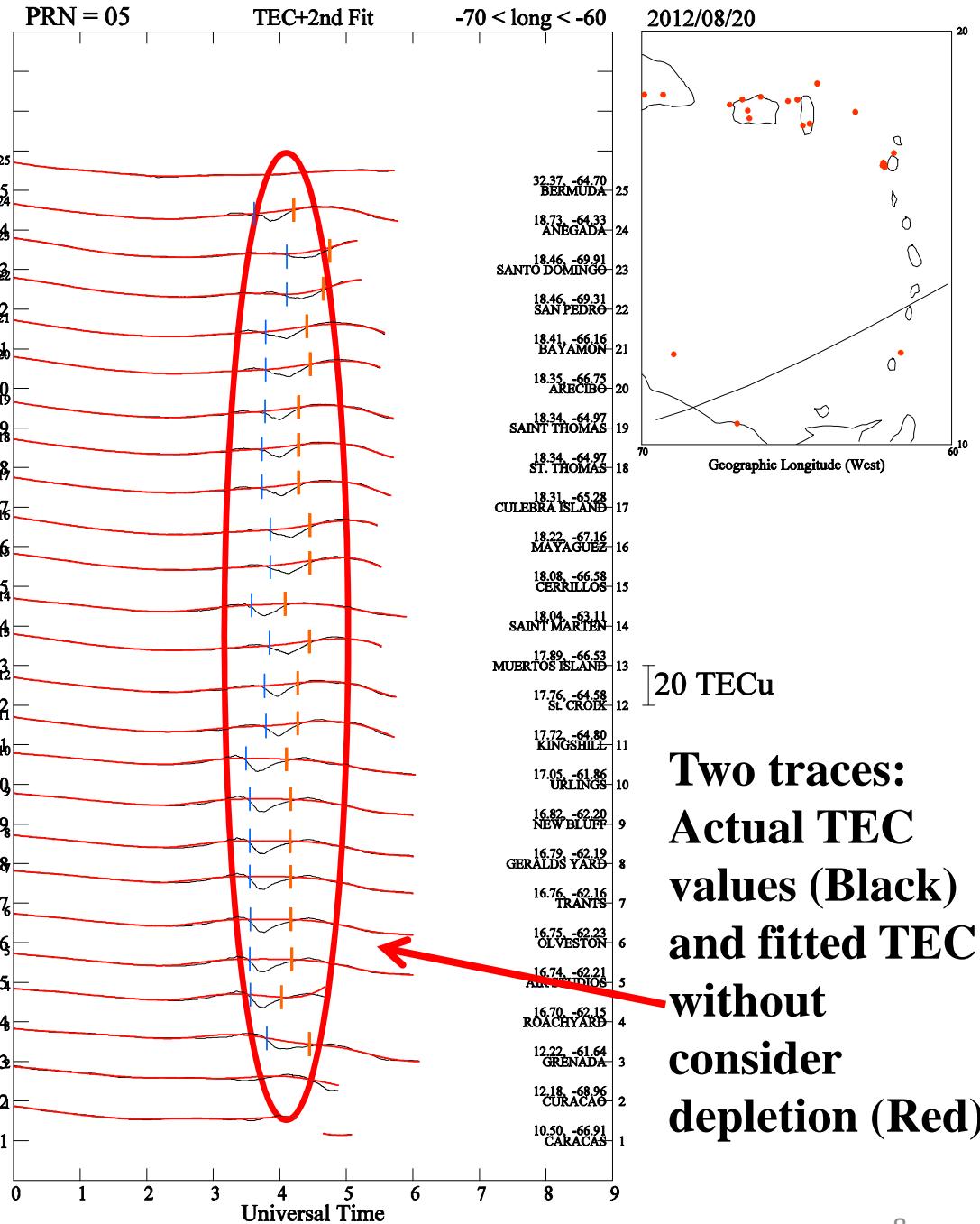
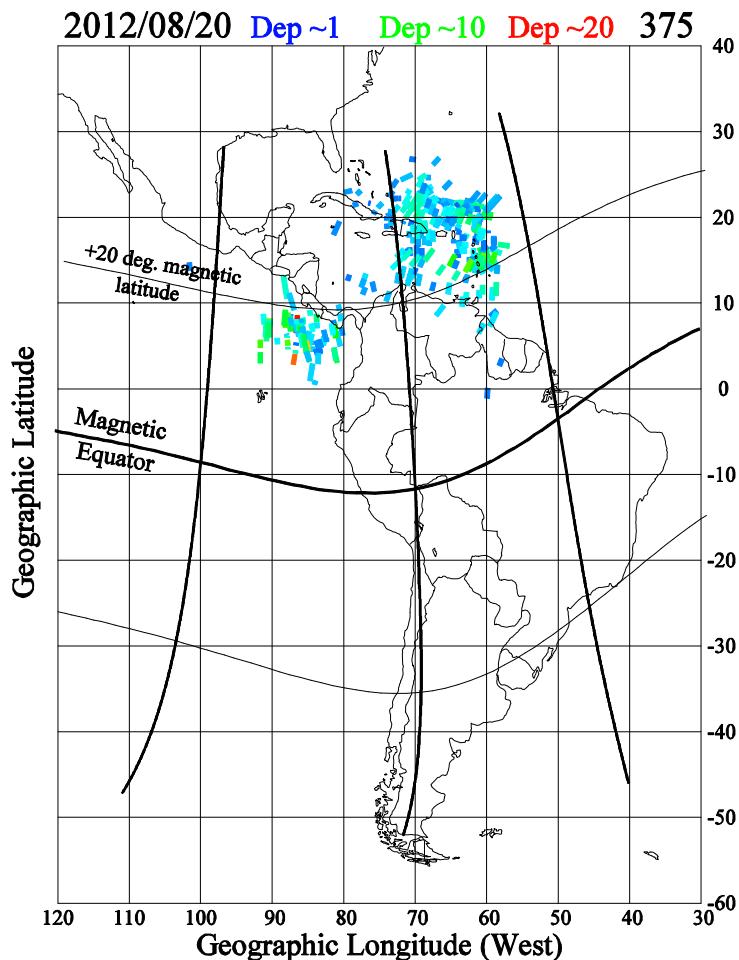


**Due to Secondary GWs**  
**Due to Primary GWs**

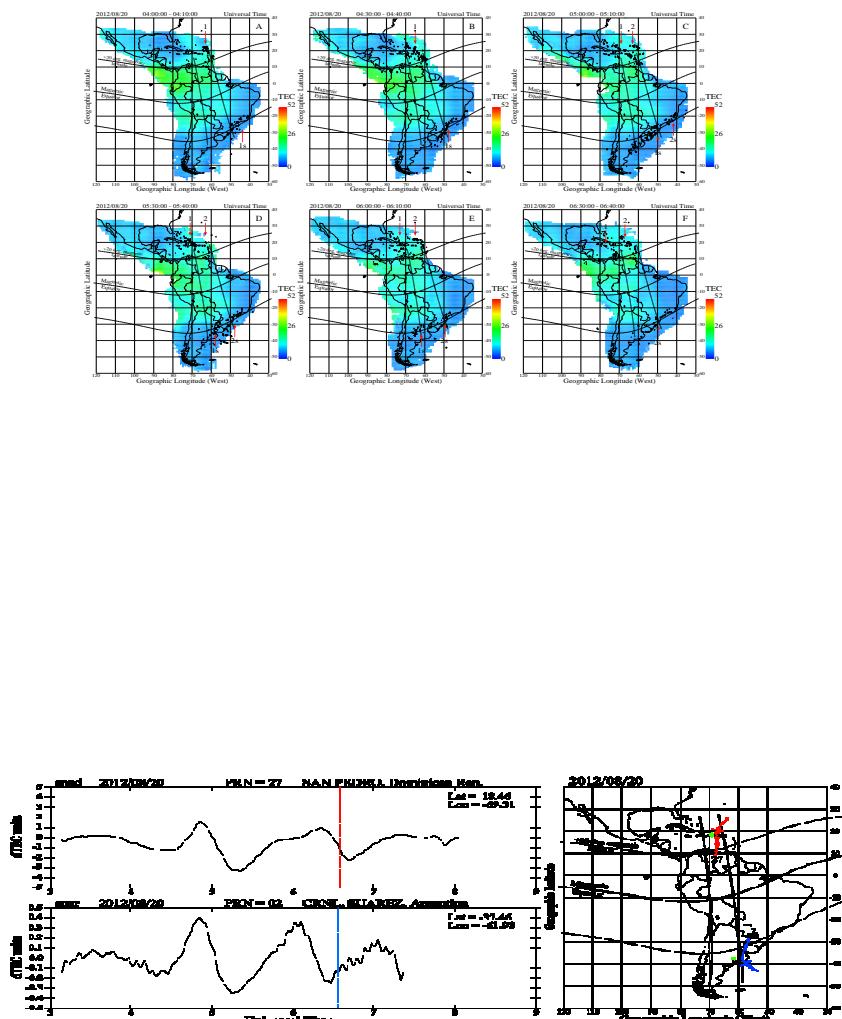
Investigation to correlate existence of  
TIDs and tropospheric phenomena.

## Medium-scale TIDs

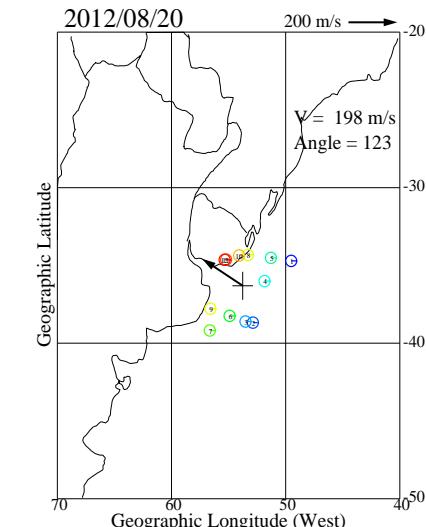
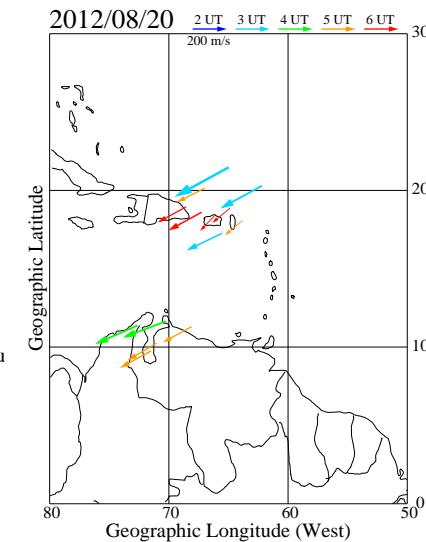
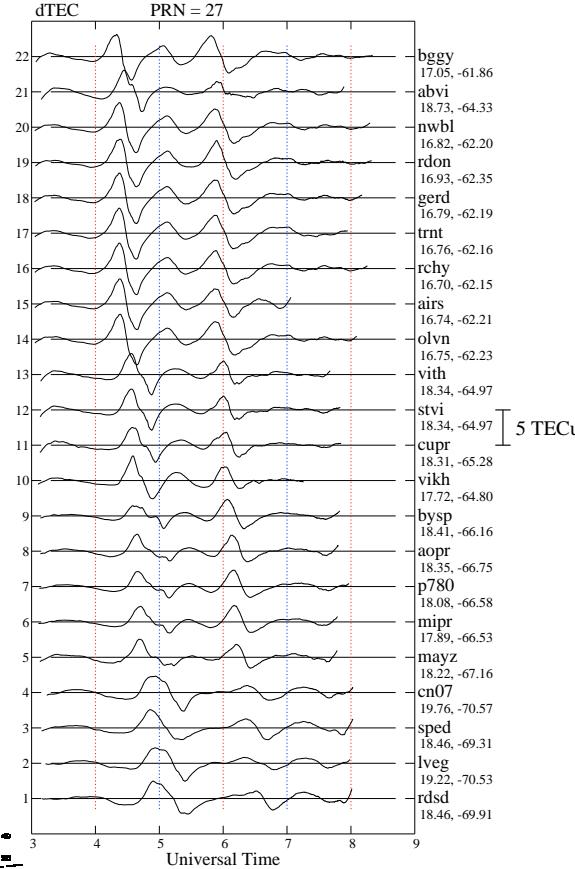
We used a computer program that automatically detects TEC depletions with a depth larger than 1 TEC unit.



# Medium-scale Traveling ionospheric disturbance (MSTIDs), Electro-buoyancy waves

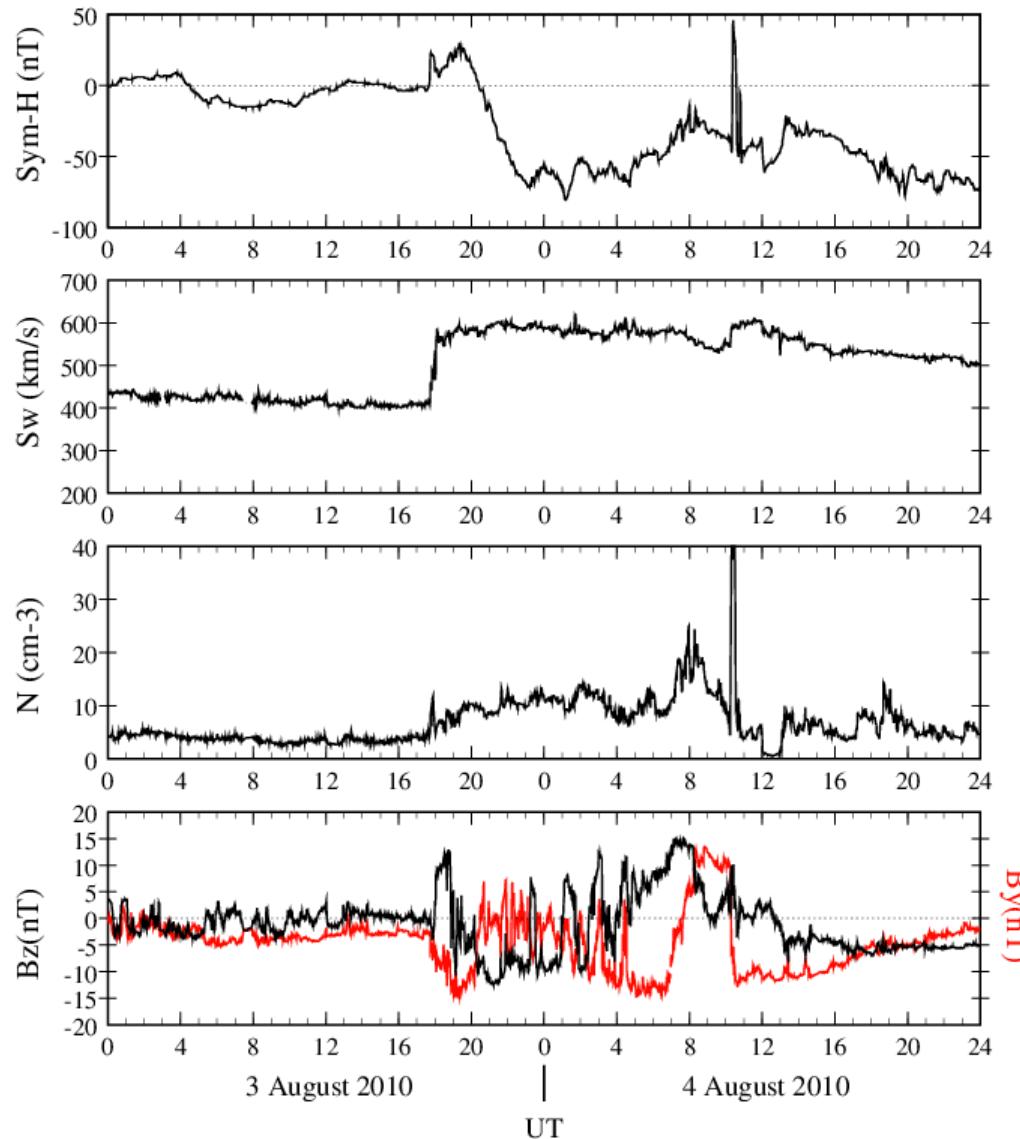


Similar structures observed in the northern and southern hemispheres. However, their amplitudes are ten times smaller at the South.



**Measurements of conjugate structures (MSTIDs) that develop in the American sector (~20 cases per year) between 2010 and now.**

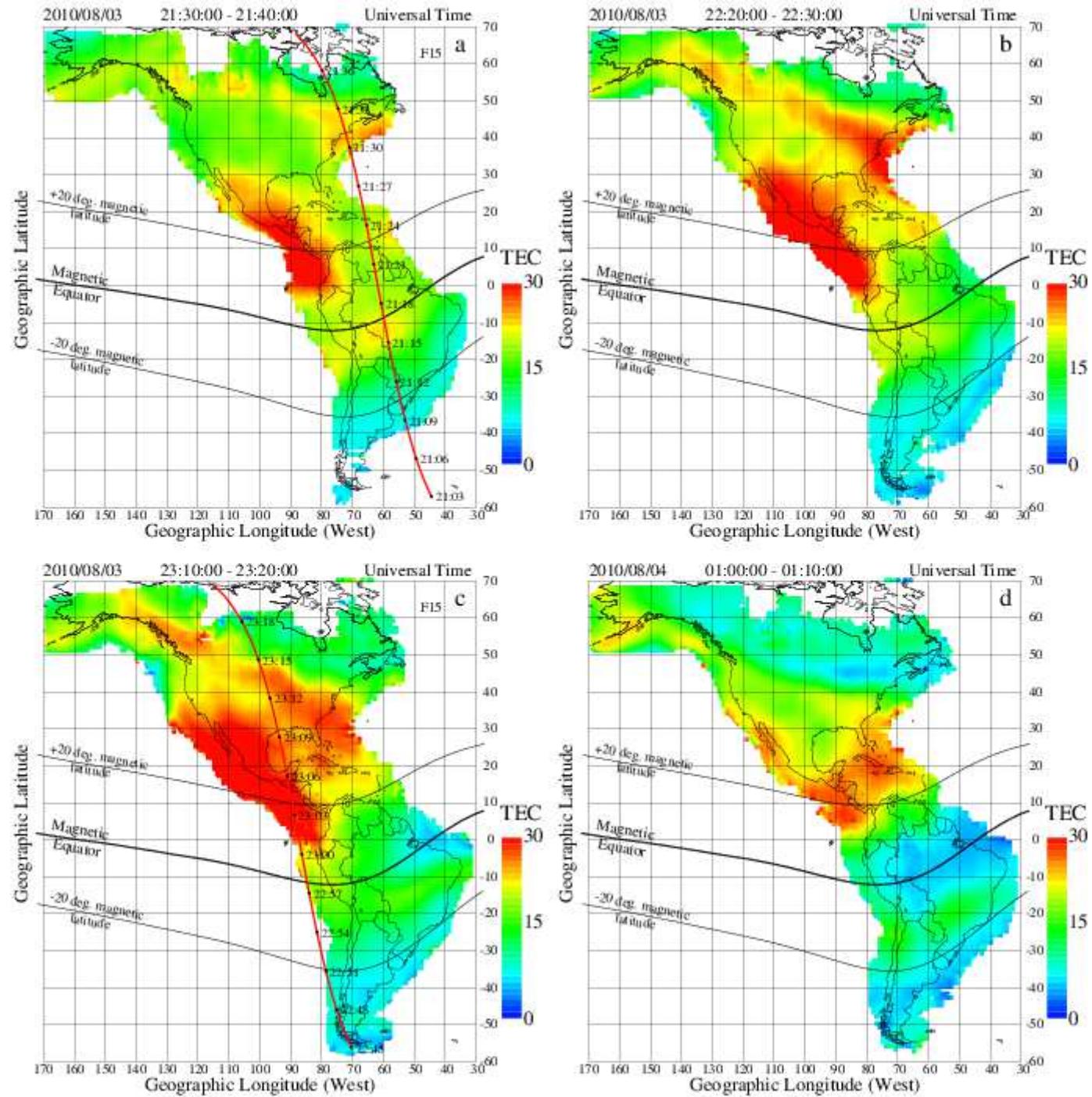
## Magnetic Storm



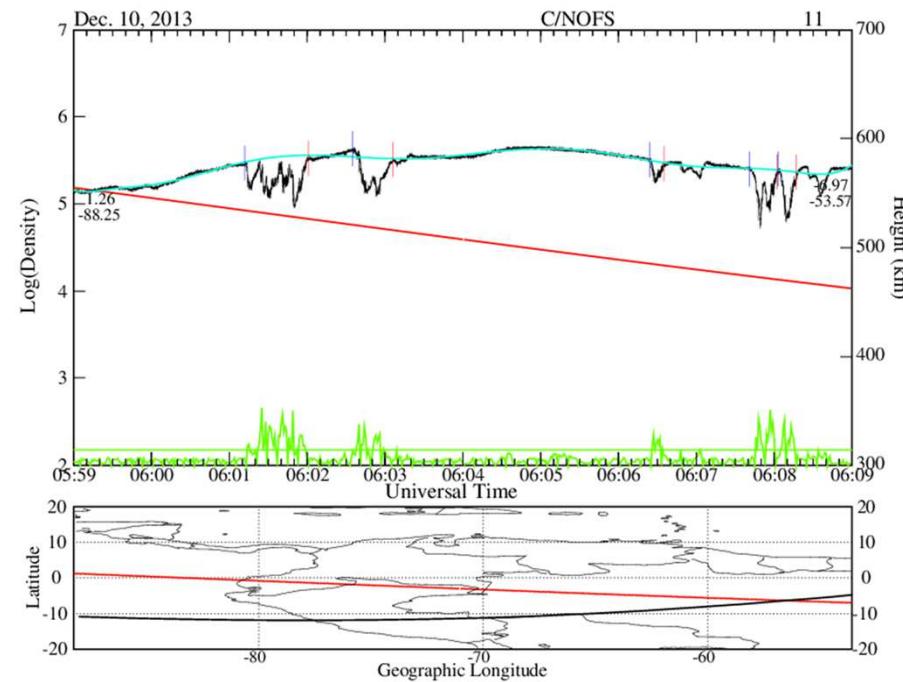
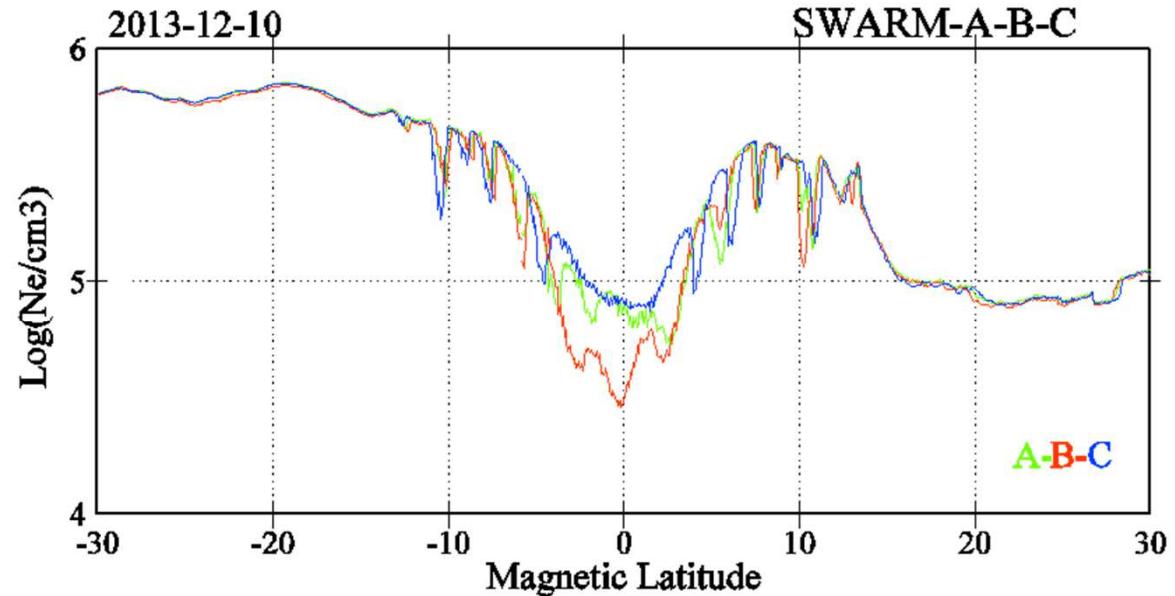
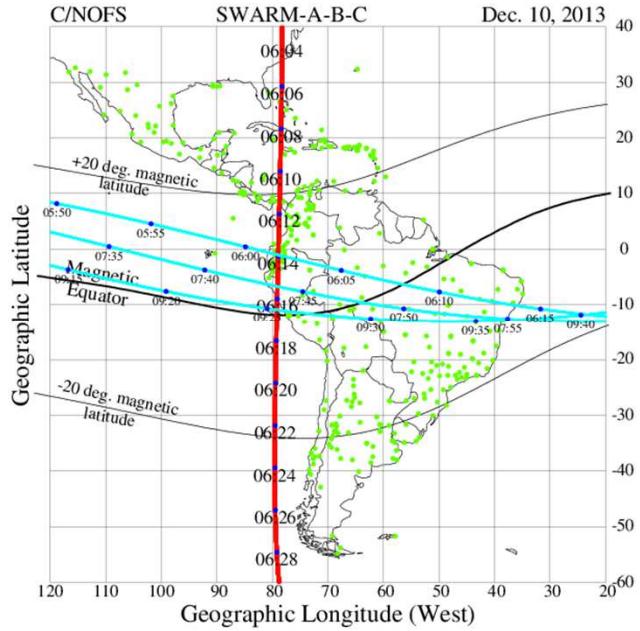
From top to bottom, the 1-minute Sym-H index (nT), the solar wind velocity (km/s), the solar wind proton density (cm<sup>-3</sup>) and the IMF  $B_z$  and  $B_y$  components (nT) displayed in black and red for August 3-4, 2010.

## Magnetic Storm

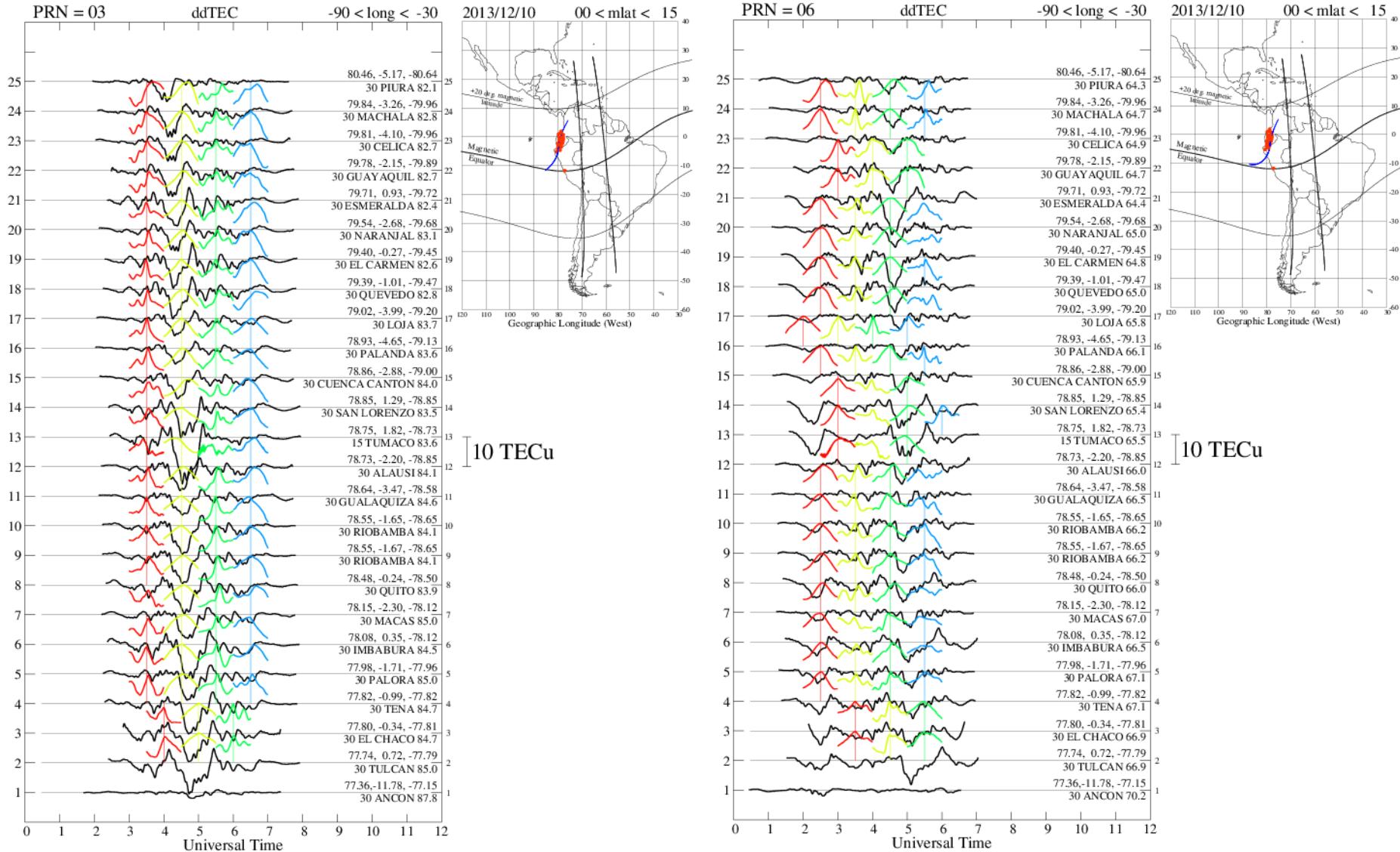
Total electron content measured in North, Central and South America and the Caribbean region. The four frames correspond to the following times: (a) 21:30-21:40 UT, (b) 22:20-22:30 UT, (c) 23:10-23:20 UT, and (d) 01:00-01:10 UT. Frames a and c show the trajectory of two consecutive passes of DMSP-F15.



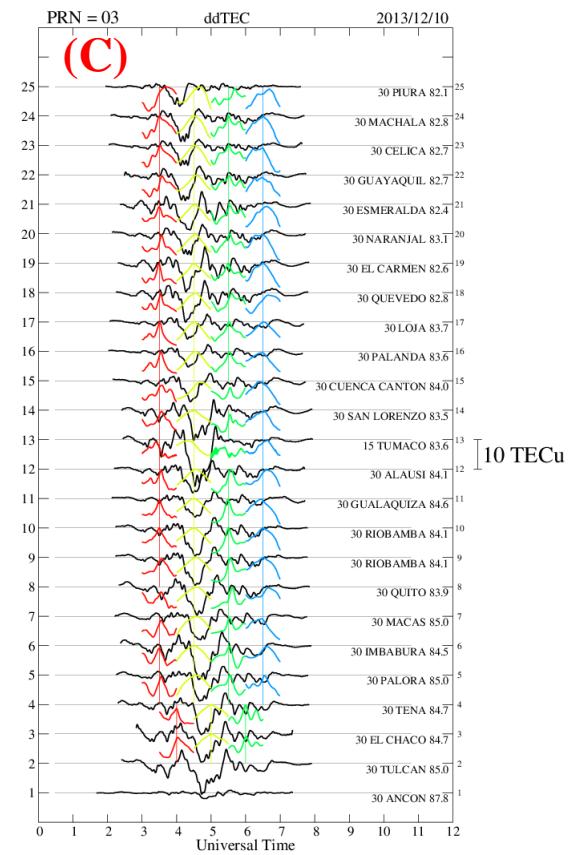
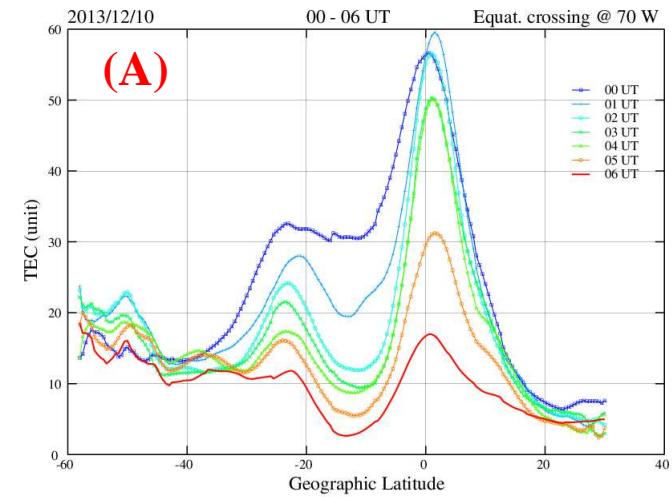
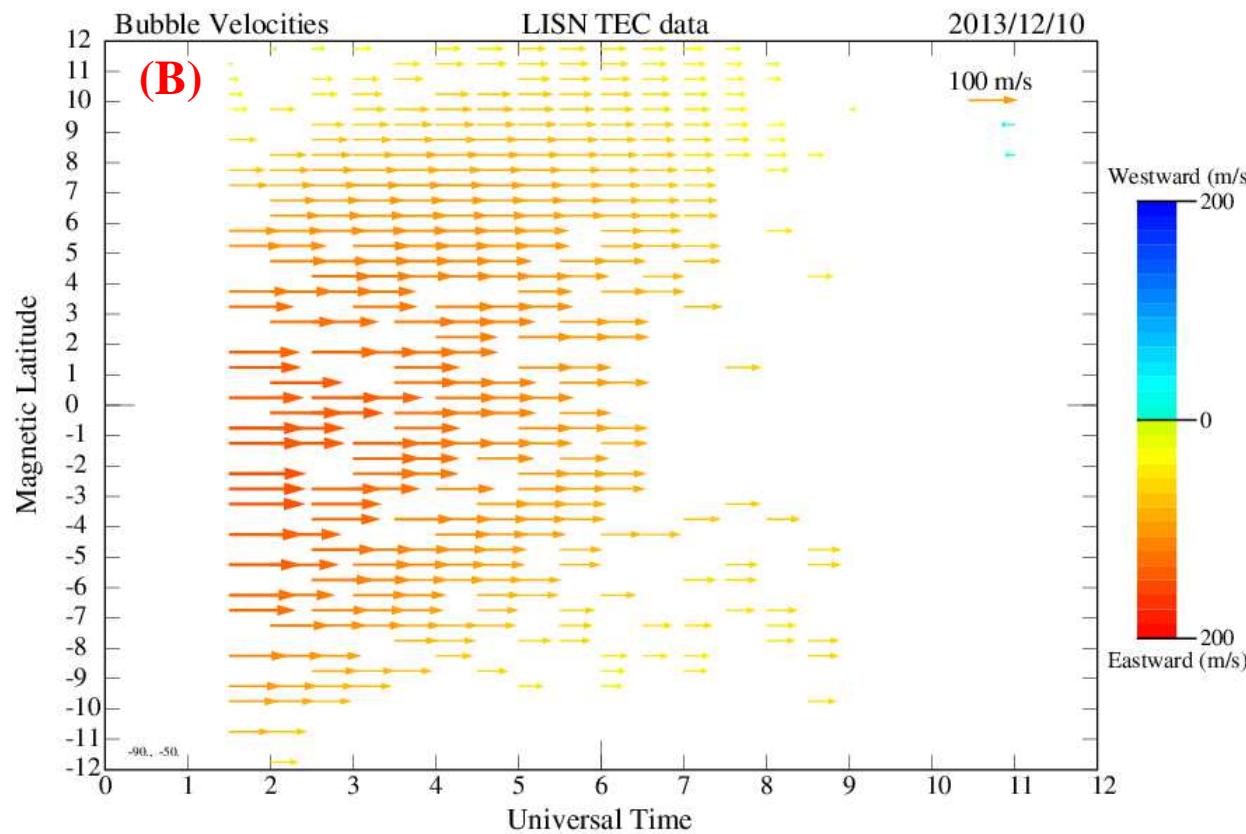
# Investigation of Equatorial Plasma Bubbles



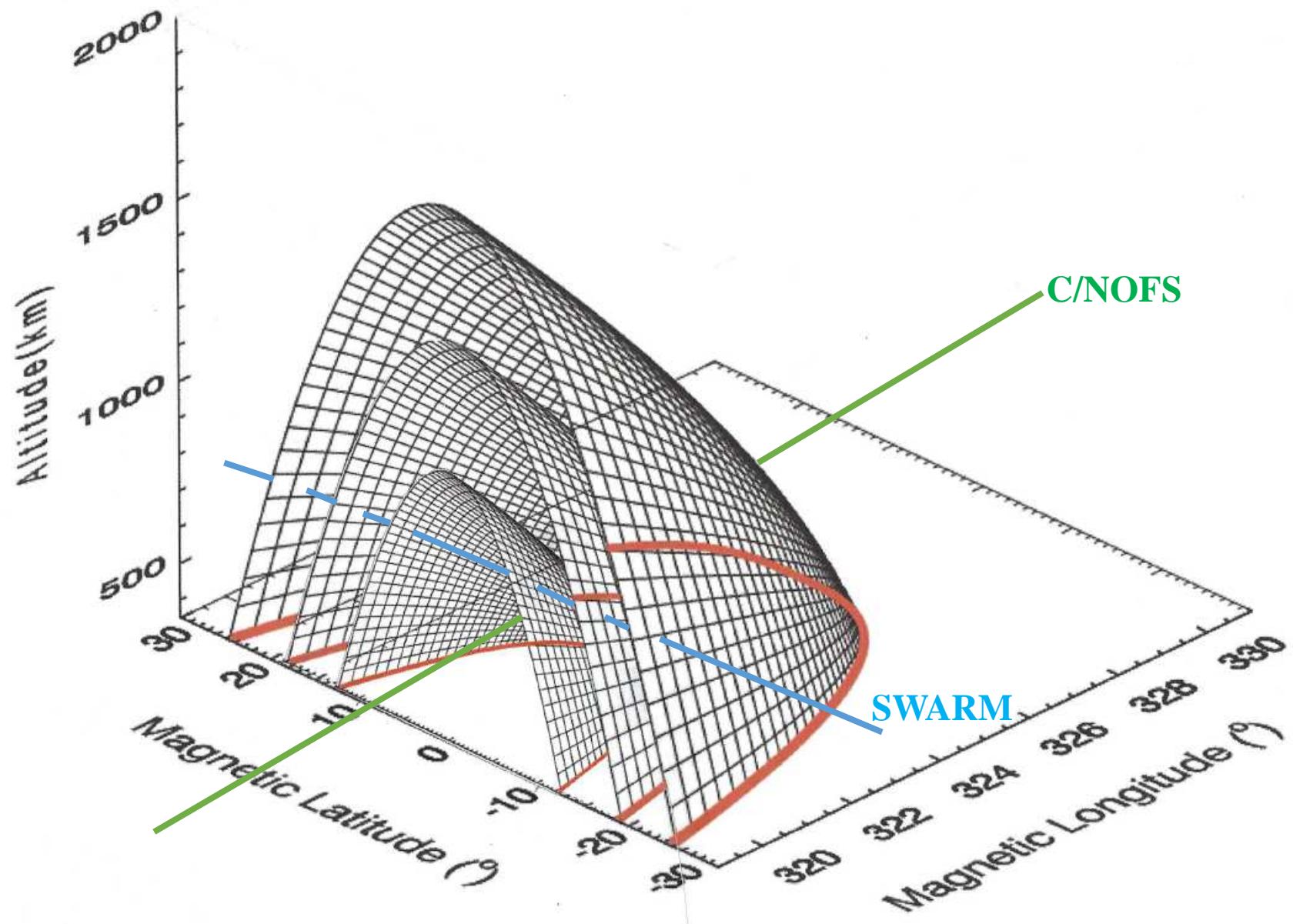
## TEC perturbation from PRN = 03, 06 recorded on December 10, 2013



Analysis of TEC depletions to calculate the drift velocity of plasma bubbles using the LISN TEC data corresponding to December 10, 2013. **(A)** TEC latitudinal profiles showing the anomaly lasting until 06 UT at  $70^{\circ}$  W. **(B)** cross-correlations of adjacent stations aligned from West to East in magnetic coordinates. **(C)** Velocity field based on all stations in South and Central America.



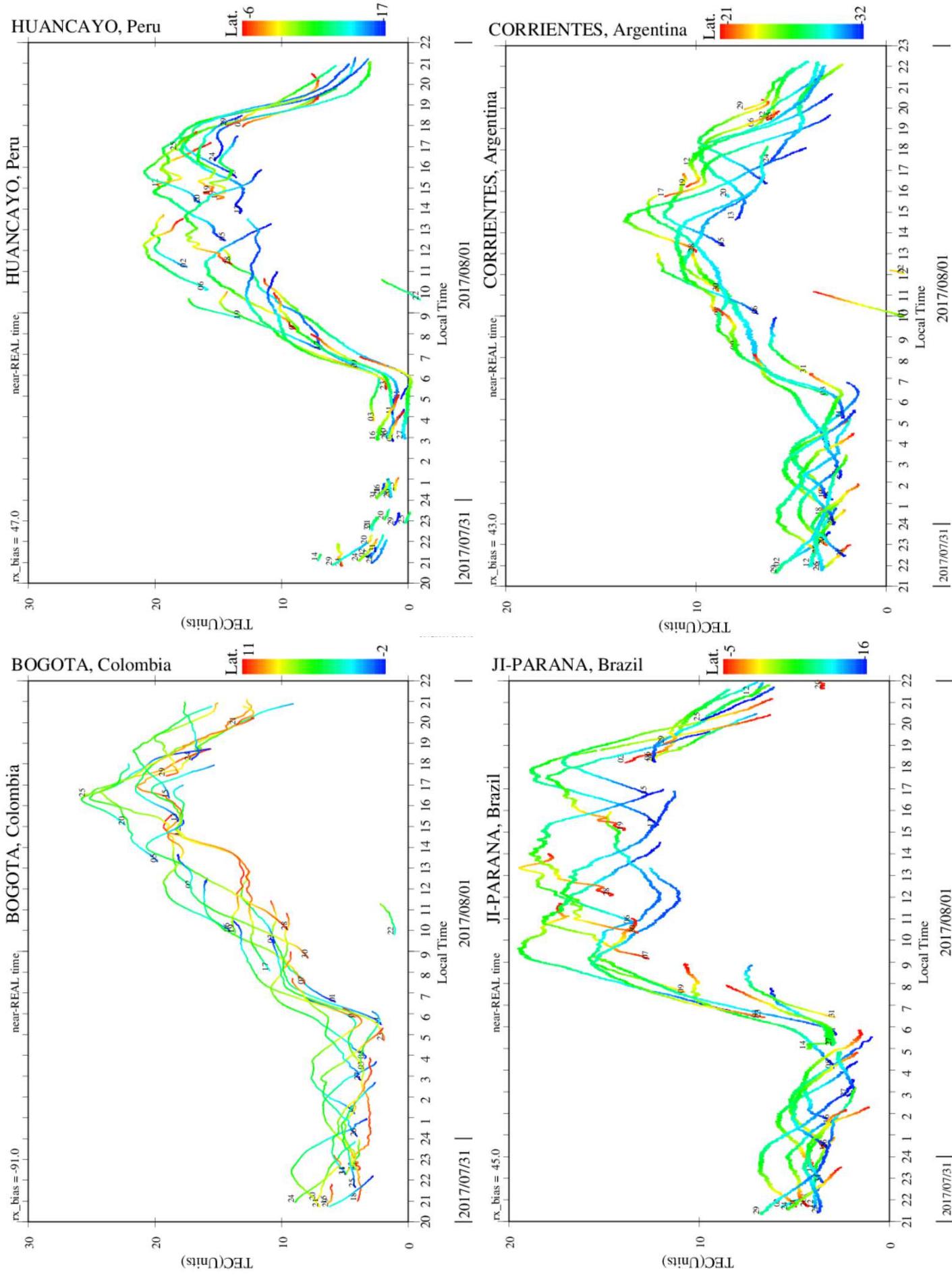
3-D model of bubbles for Dec 10, 2013  
Based on Kil et al.



## Conclusions

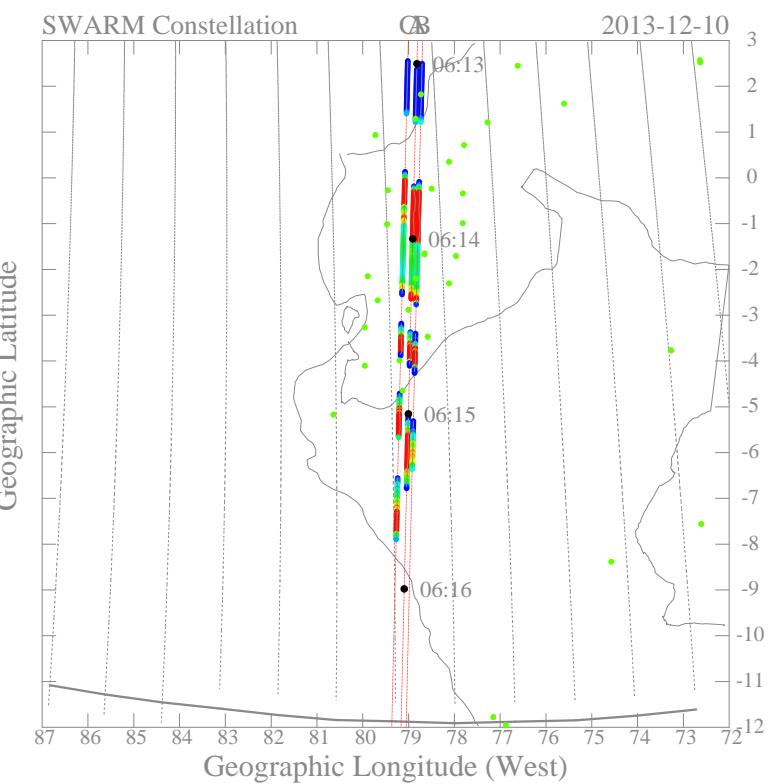
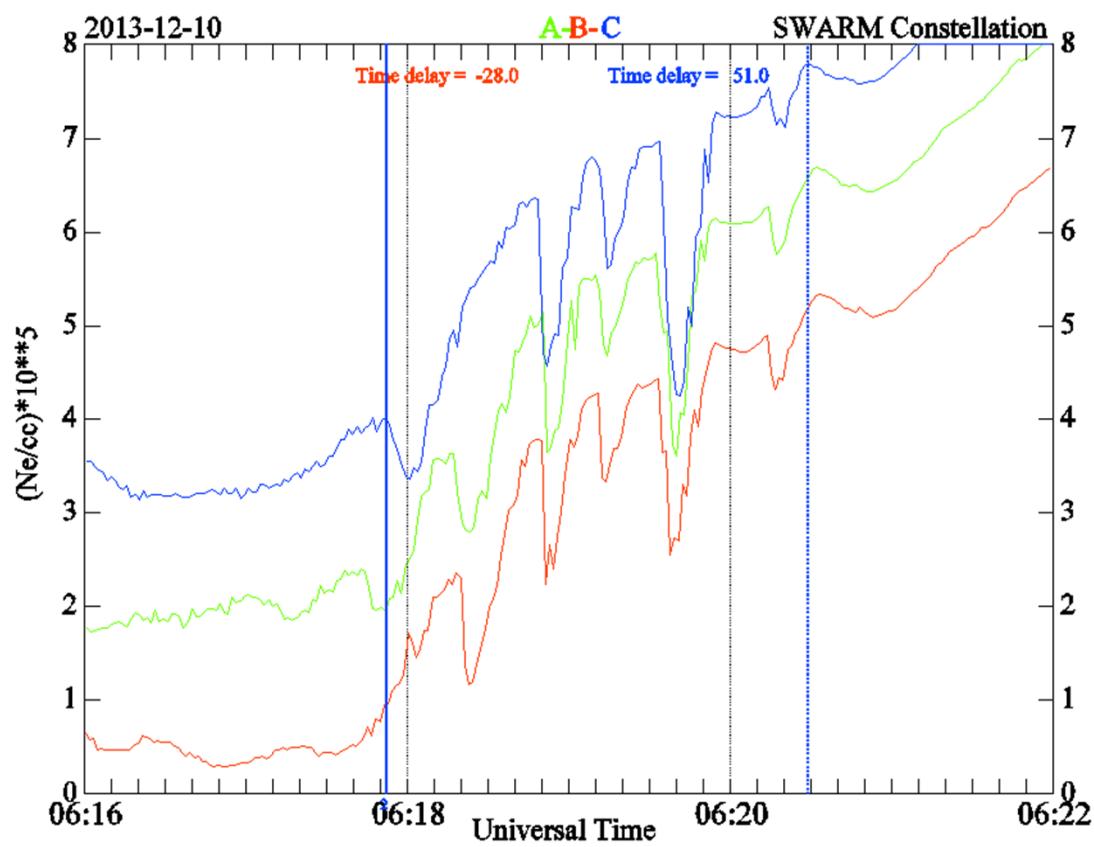
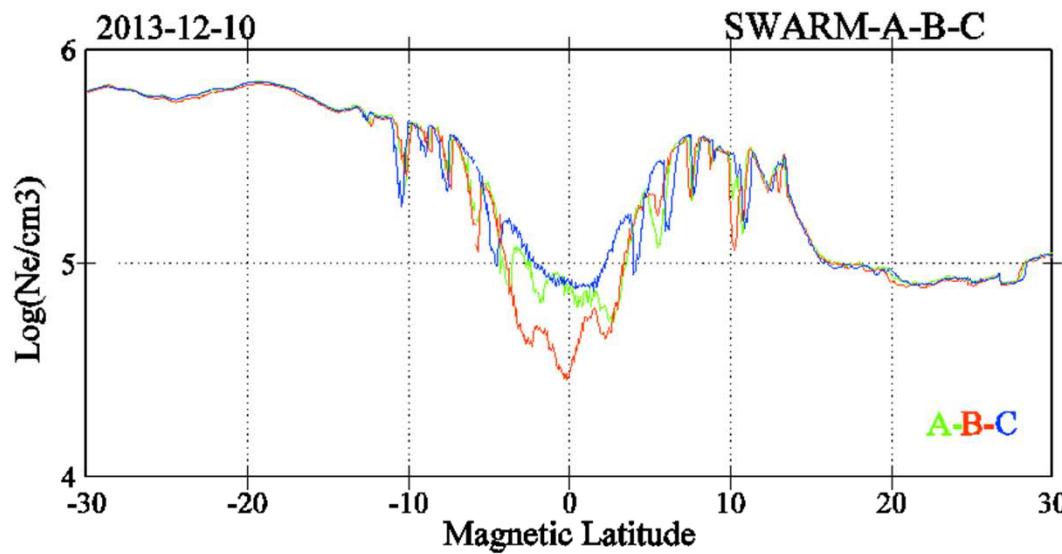
**The LISN distributed observatory provides near-real time observables in a continuous fashion (24/7). Our initial task was to upload maps of Tec and scintillations. We are in the process of moving into delivering processed parameters, such as maps of TIDs, conjugate MSTIDs, TEC depletions. A more complete display of the bubble will require real-time measurement of satellite data.**

A new processing algorithm has been designed to determine the Bubble velocity field. The velocity has been calculated using hundreds of GPS/GNSS receivers that exist in South and Central America and the Caribbean region. The bubble velocity field can be used to trace backward/forward in time measurement of plasma bubbles conducted with satellites/cubesats.

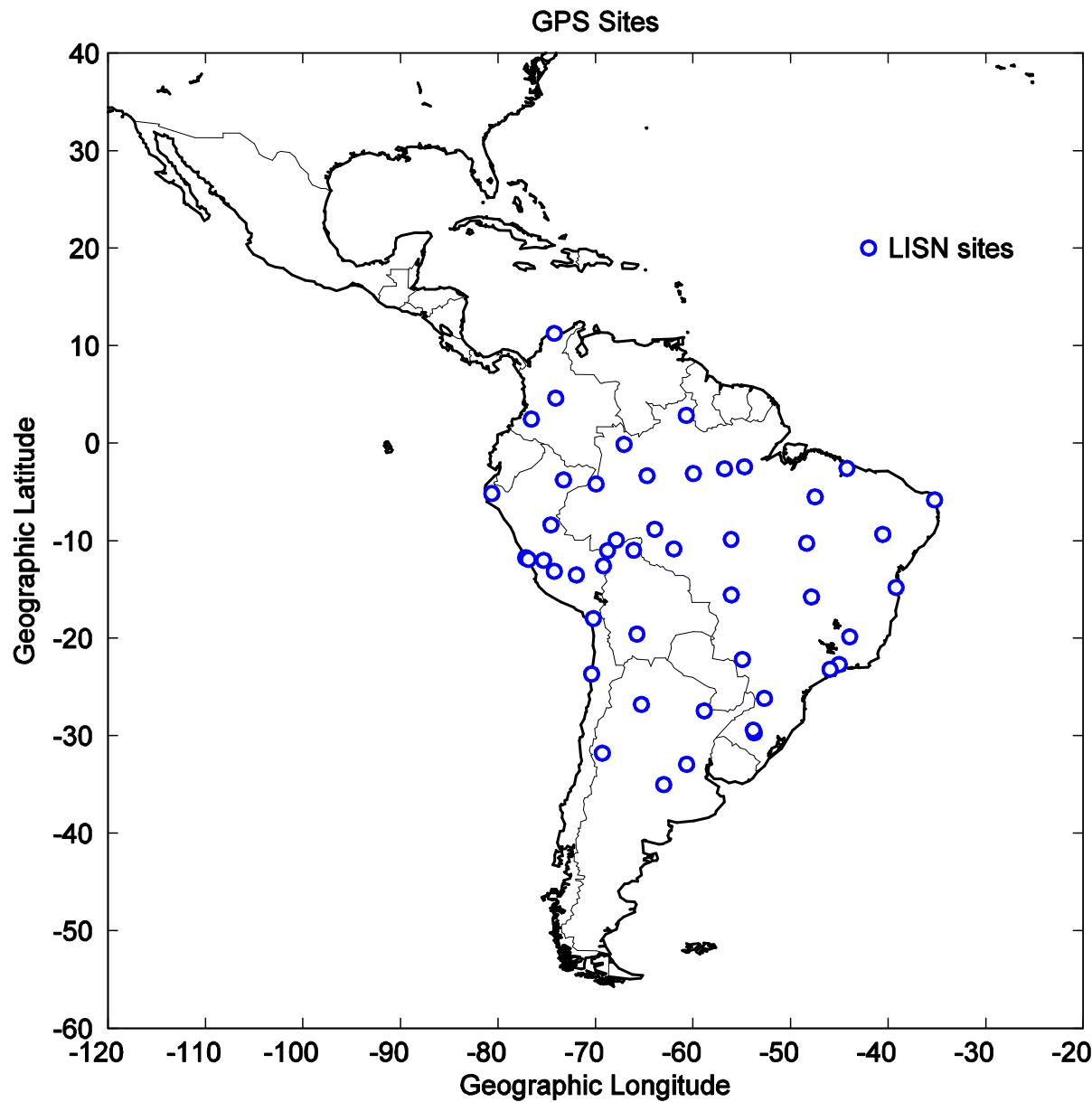




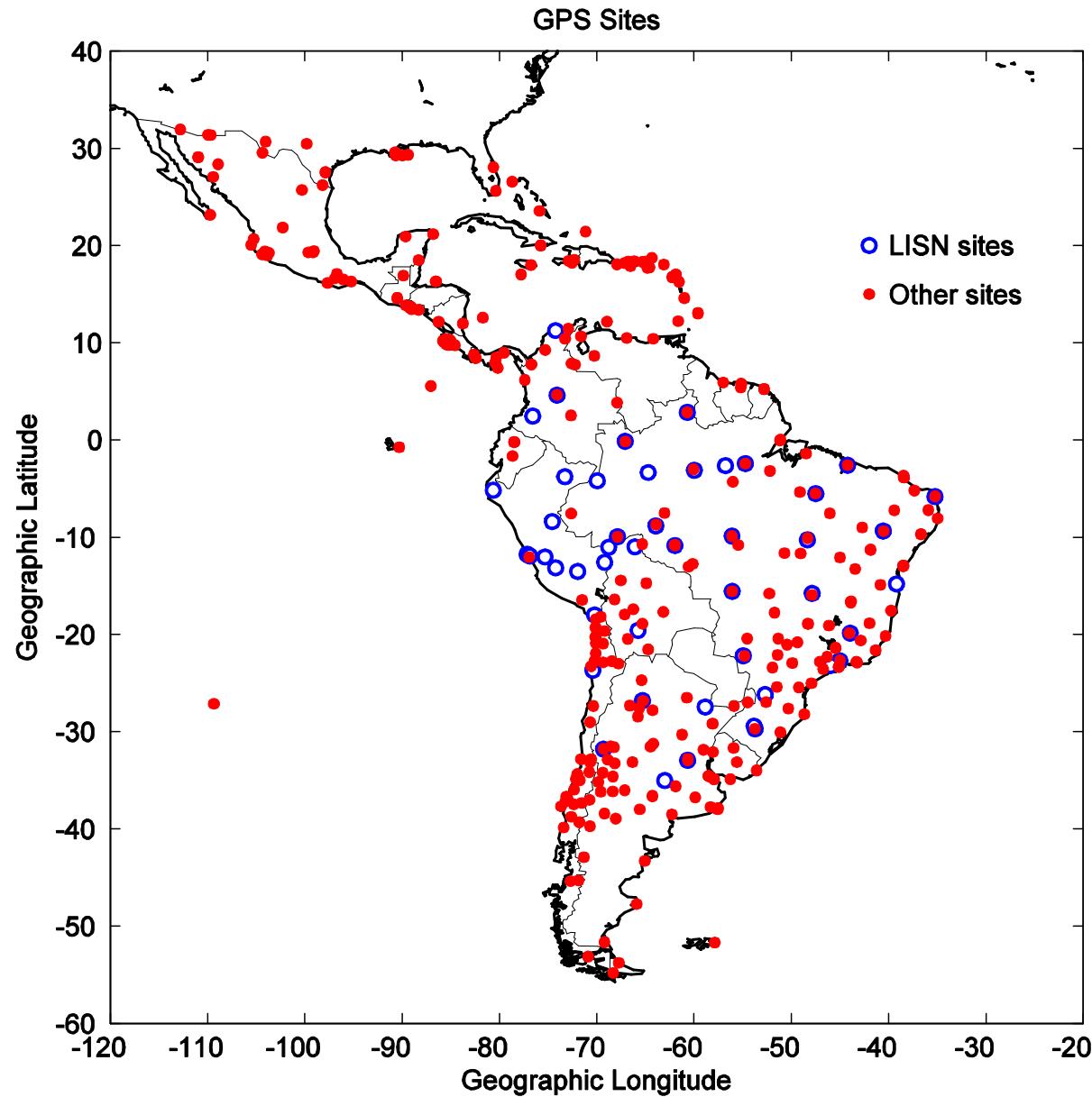


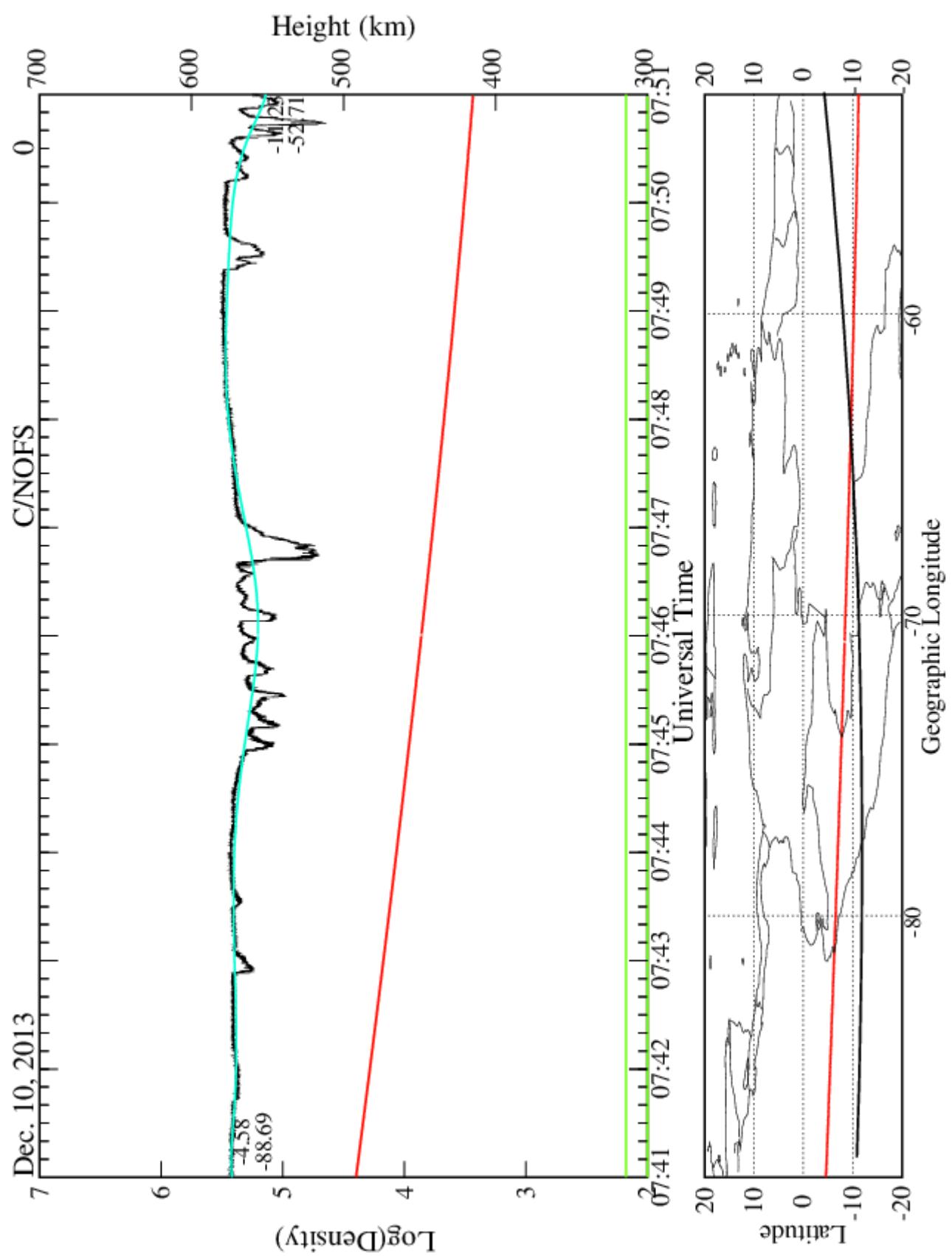


# LISN GPS Stations

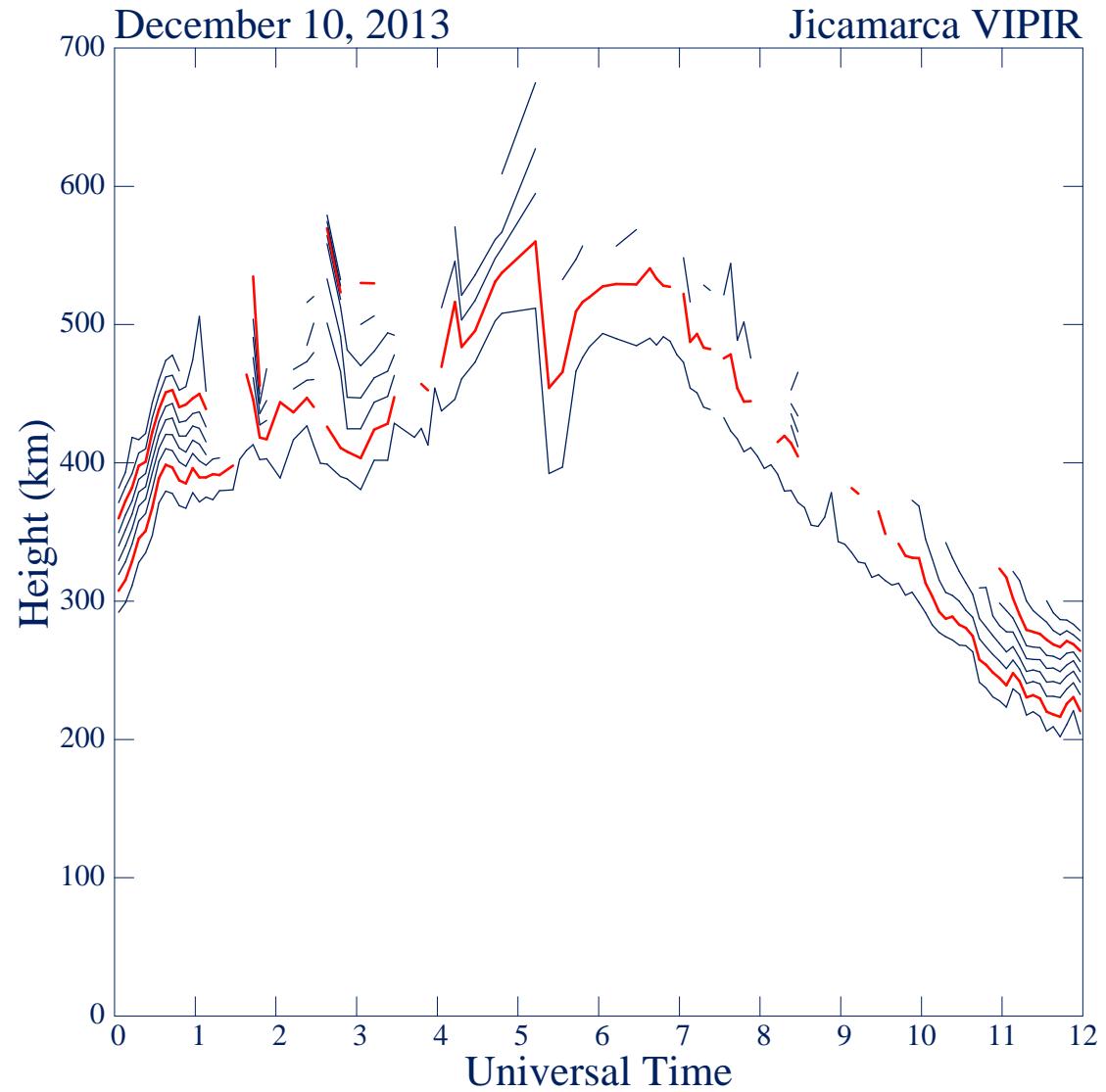
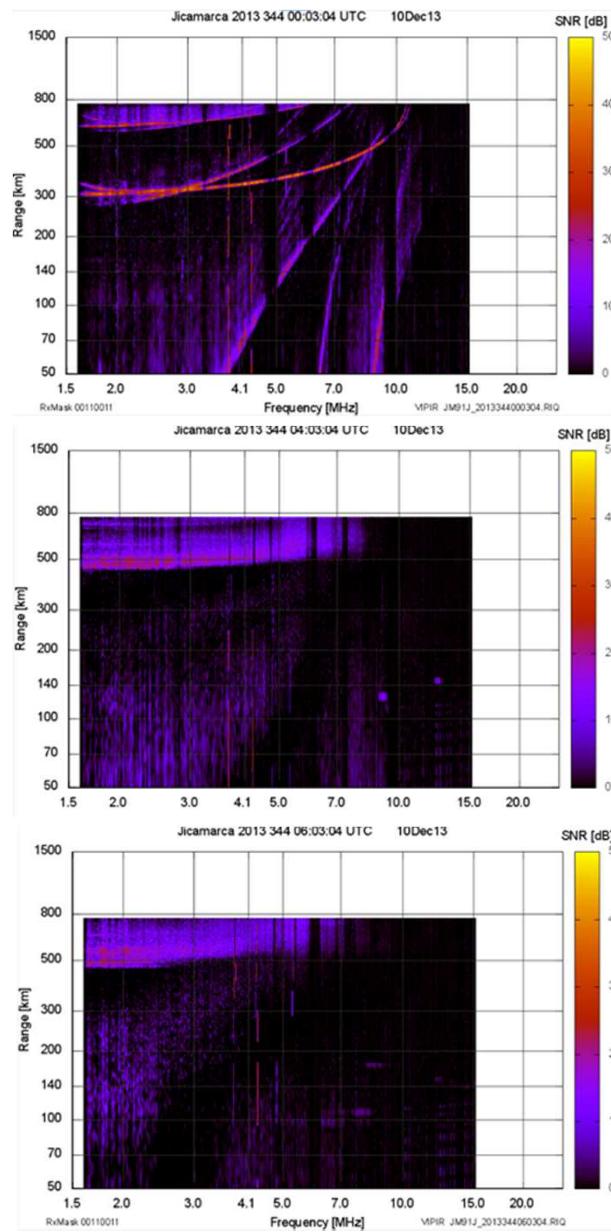


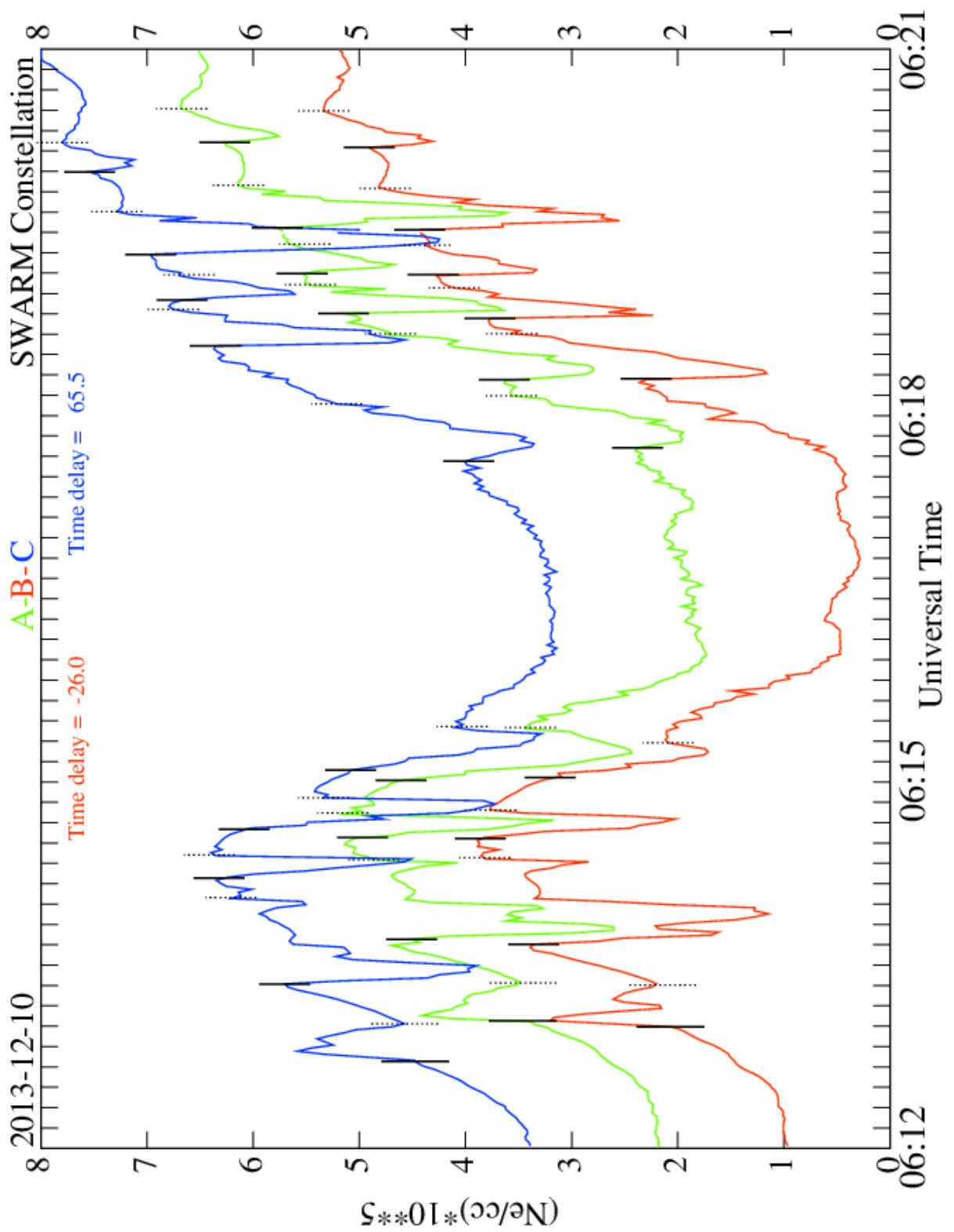
## LISN and other GPS Stations in South and Central Americas





# Ionograms and hand-scaled densities using VIPIR ionosonde





## TEC perturbation from PRN = 03, 06 recorded on December 10, 2013

