Imaging the global vertical density structure from the ground and space

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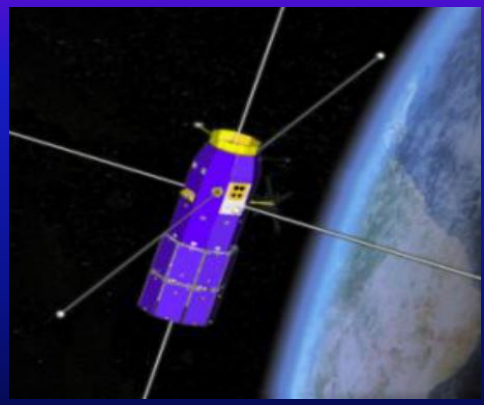
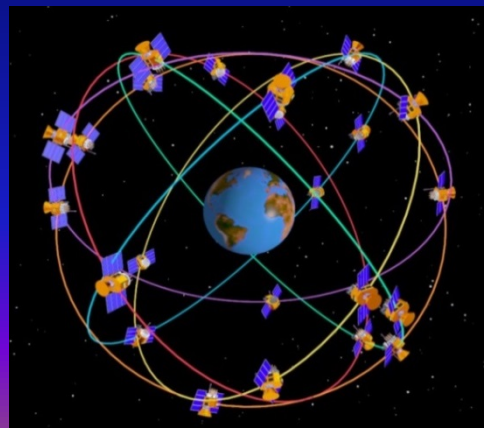
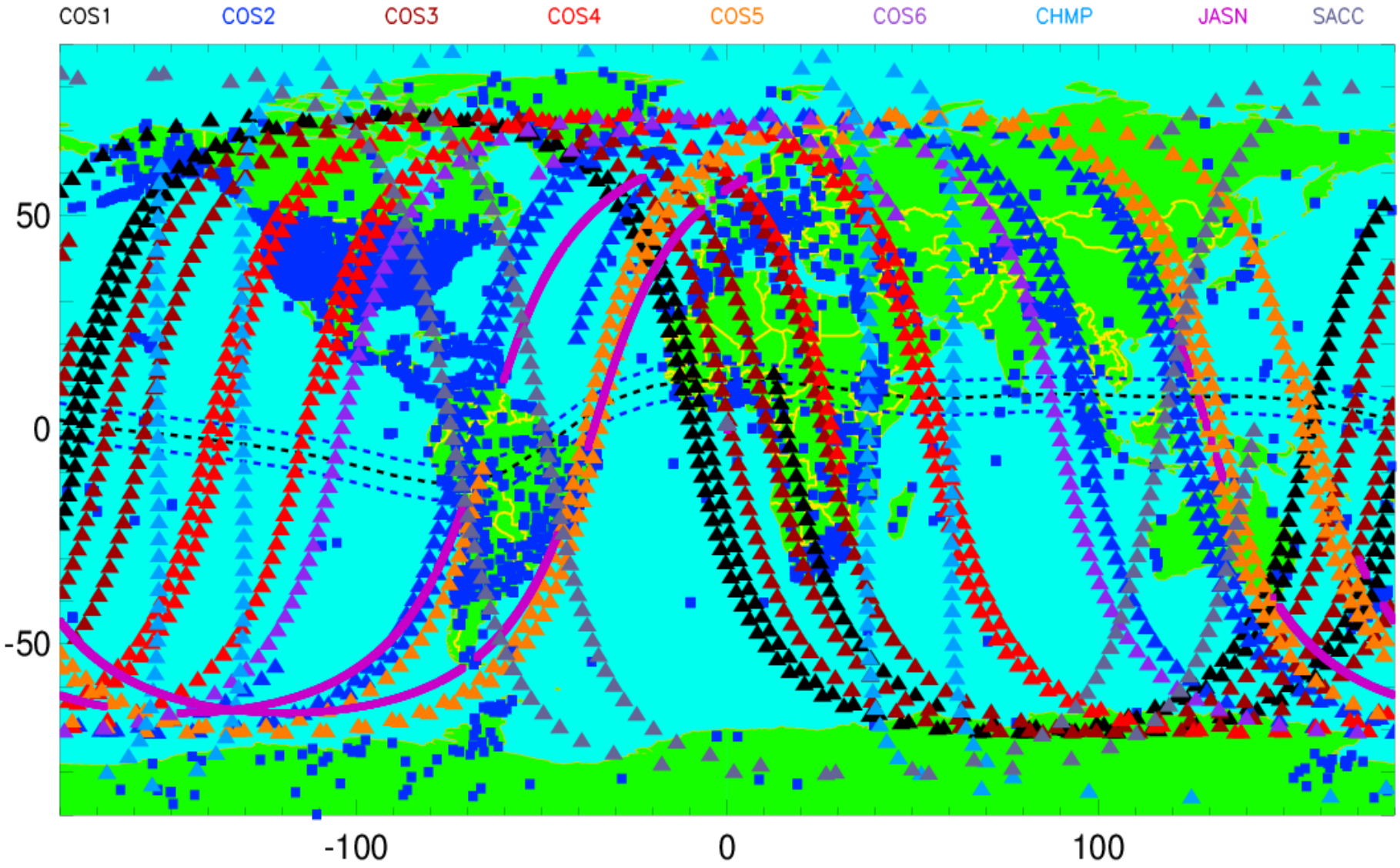
Outline

- Global Data Coverage
- Occultation density and its validation with different data sets
- Topside tomographic reconstruction
- Desired Future LEO Satellites' Data

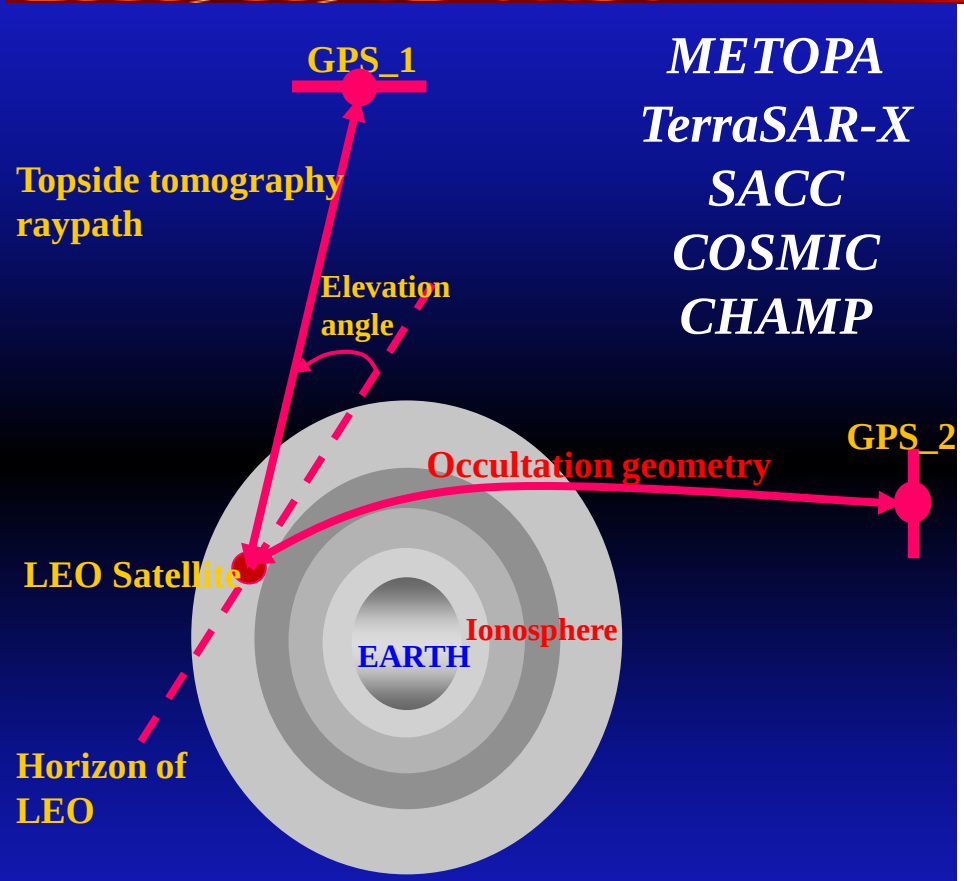




Global Ground- and Space-based GPS data coverage

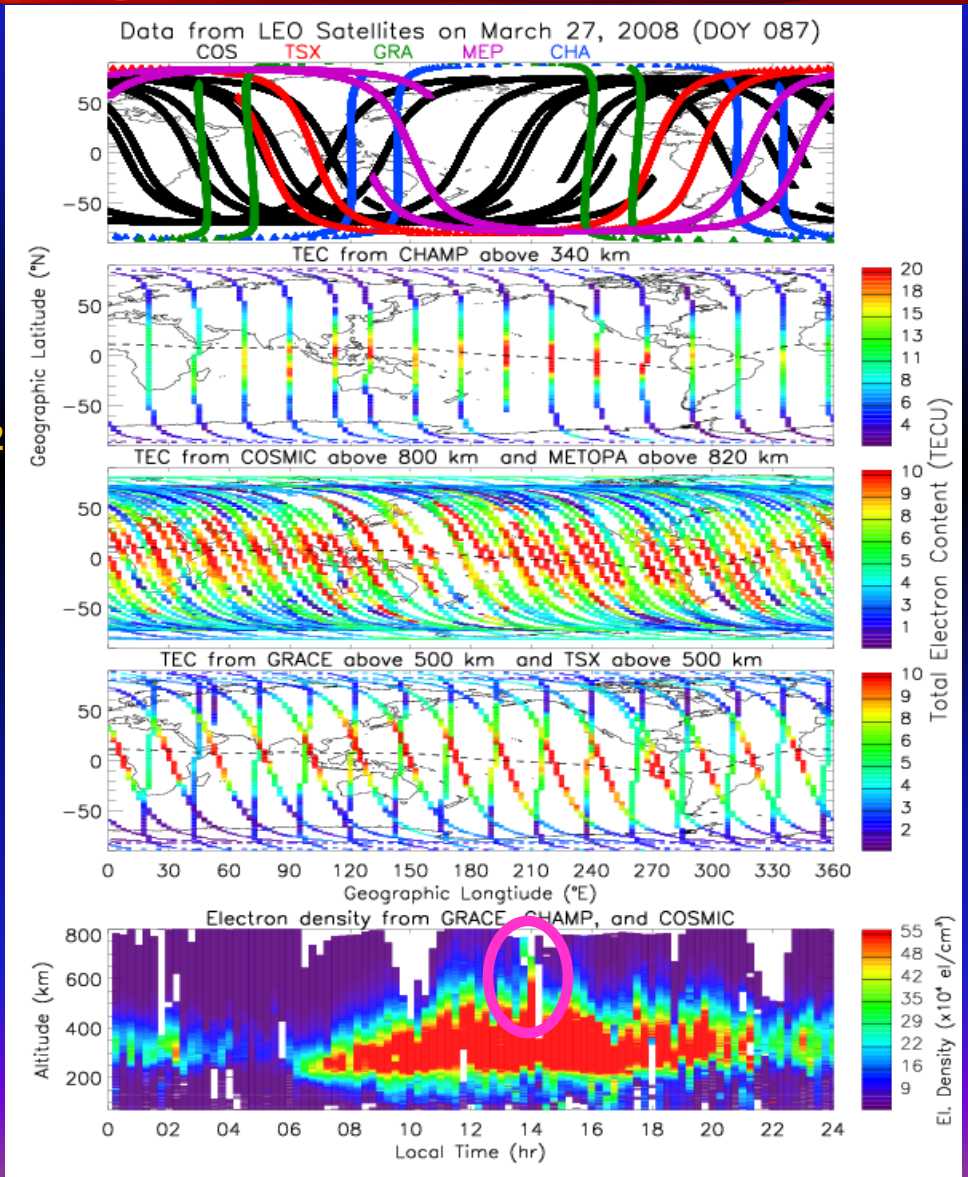


The two most important type of LEO GPS observations

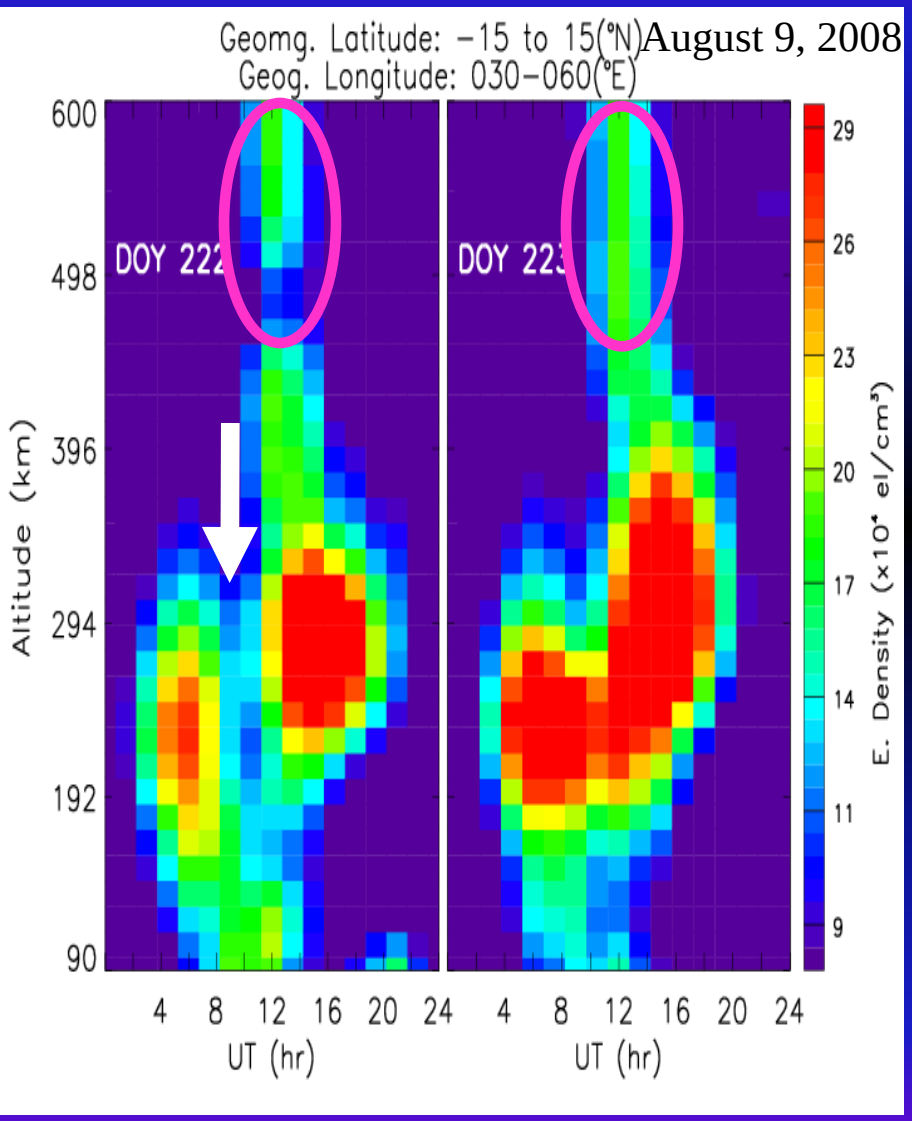


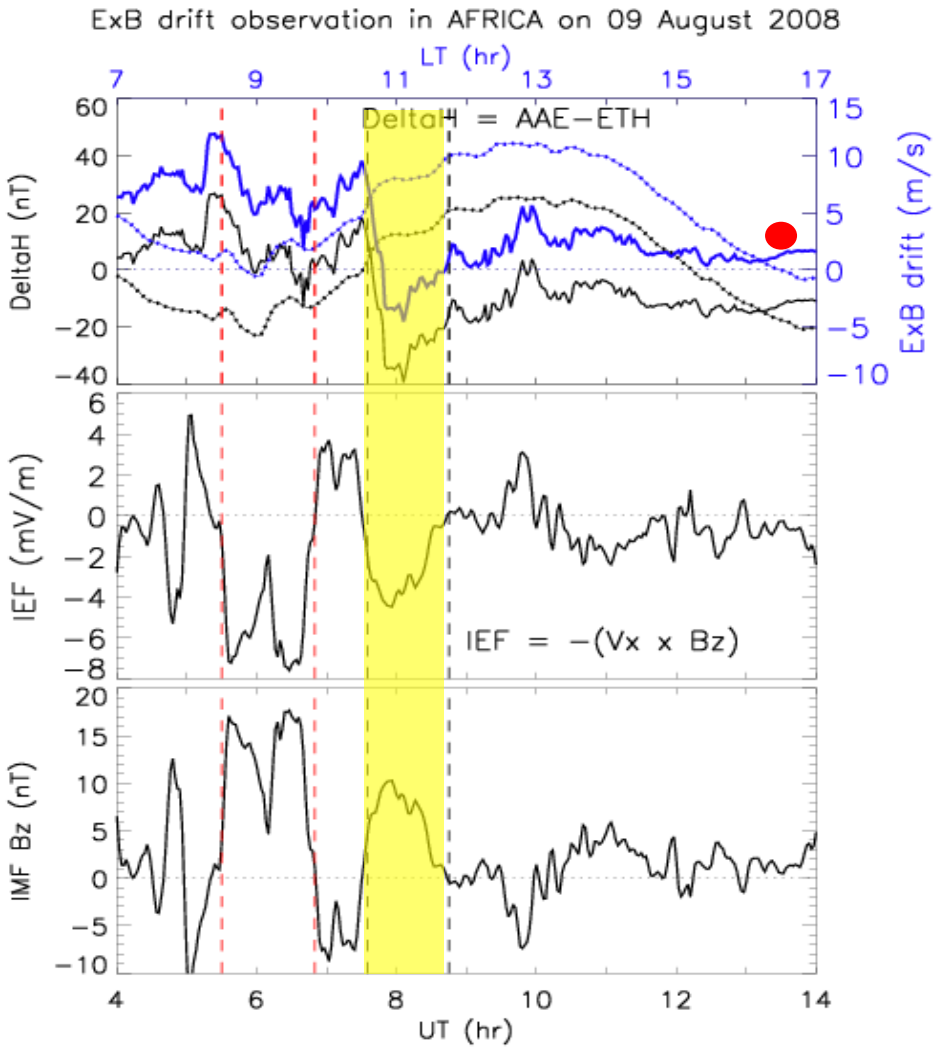
METOPA
TerraSAR-X
SACC
COSMIC
CHAMP

Yizengaw and Carter, 2016



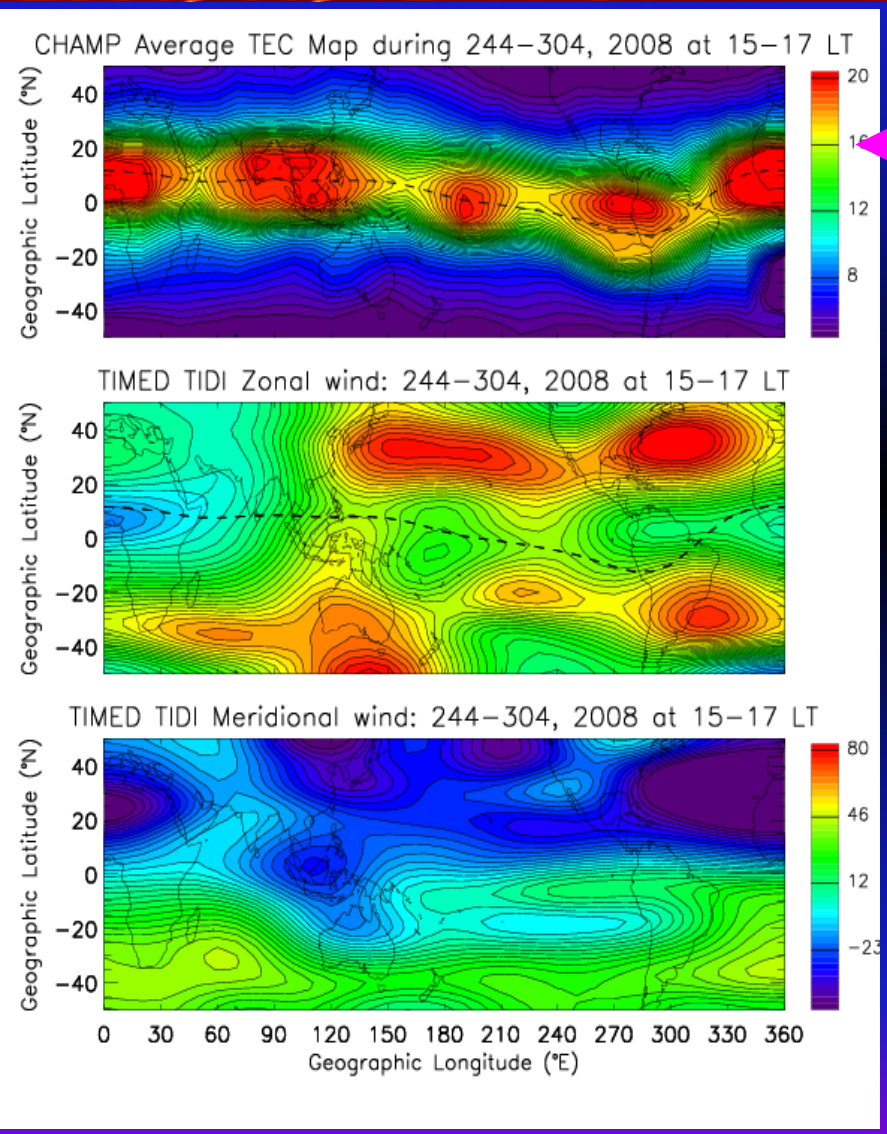
LEO GPS Occultation Data

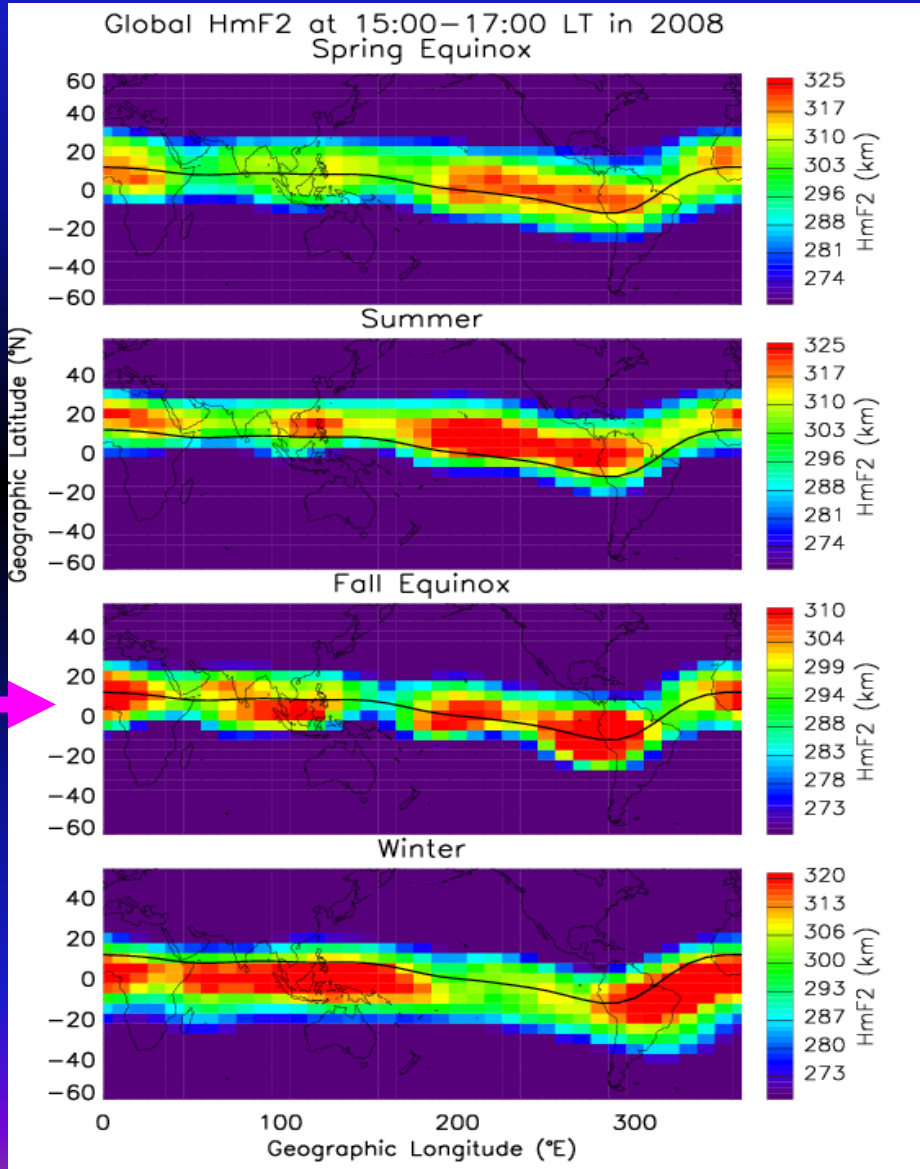




Yizengaw et al., JASTP, 2011

Global Statistical Studies using LEO Occultation





Yizengaw, JGR, 2012

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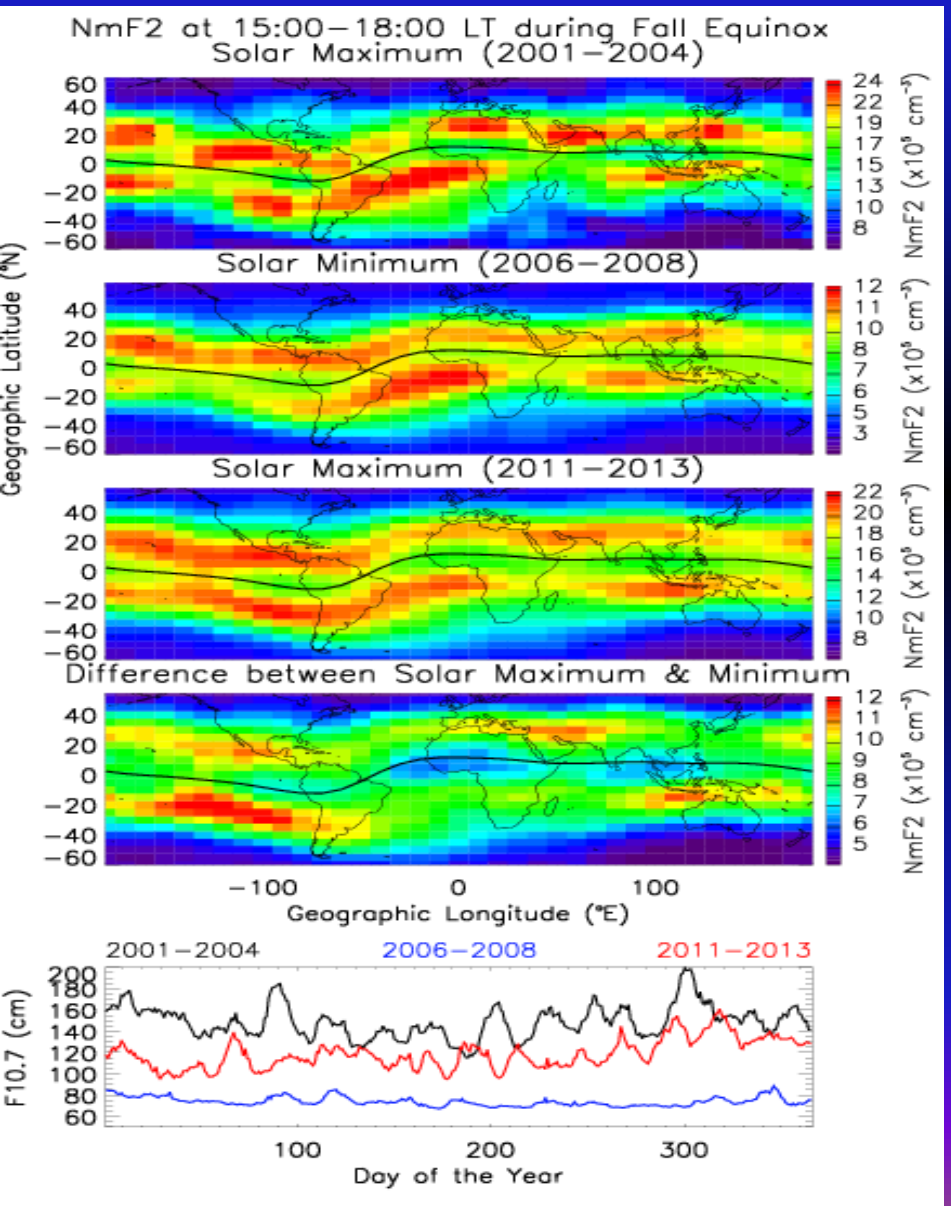
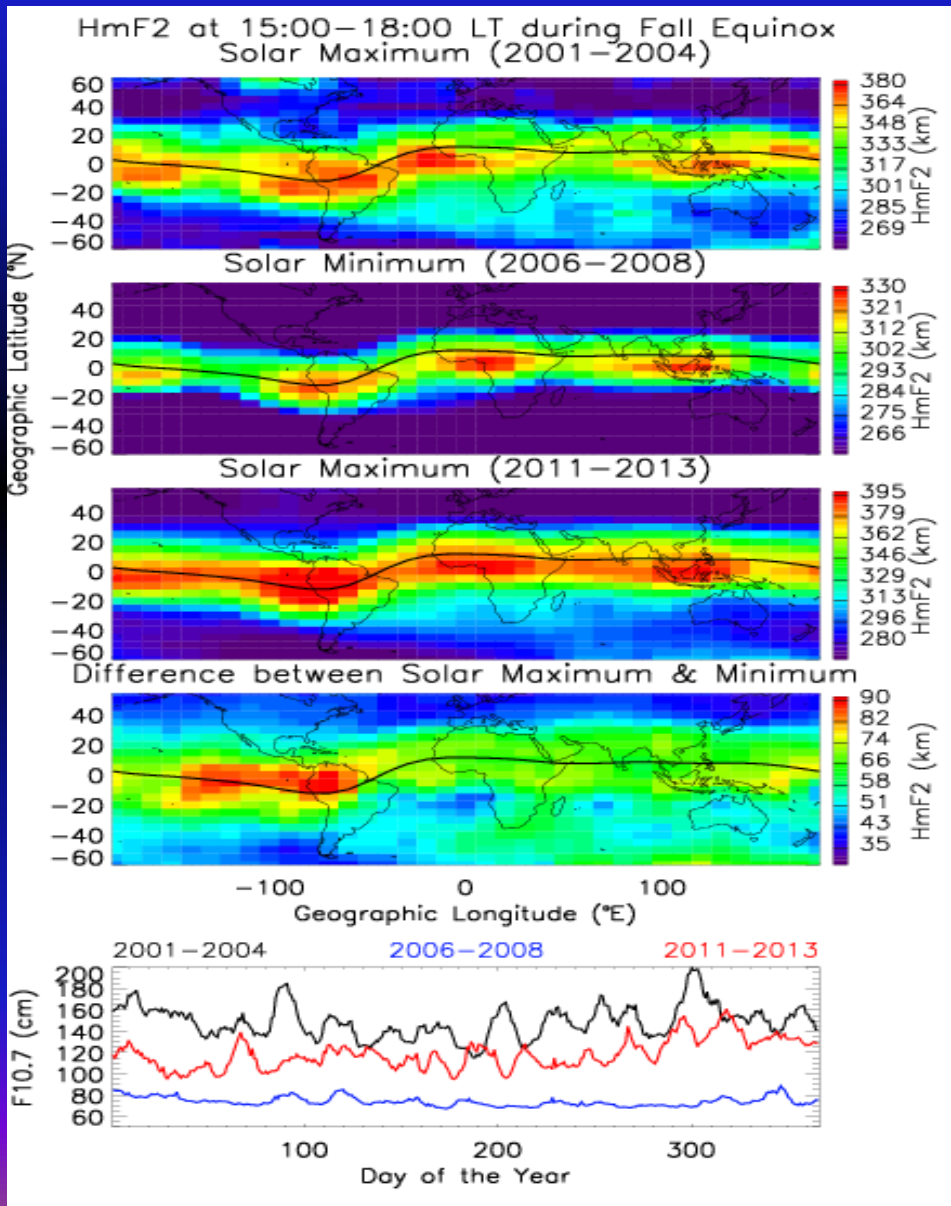
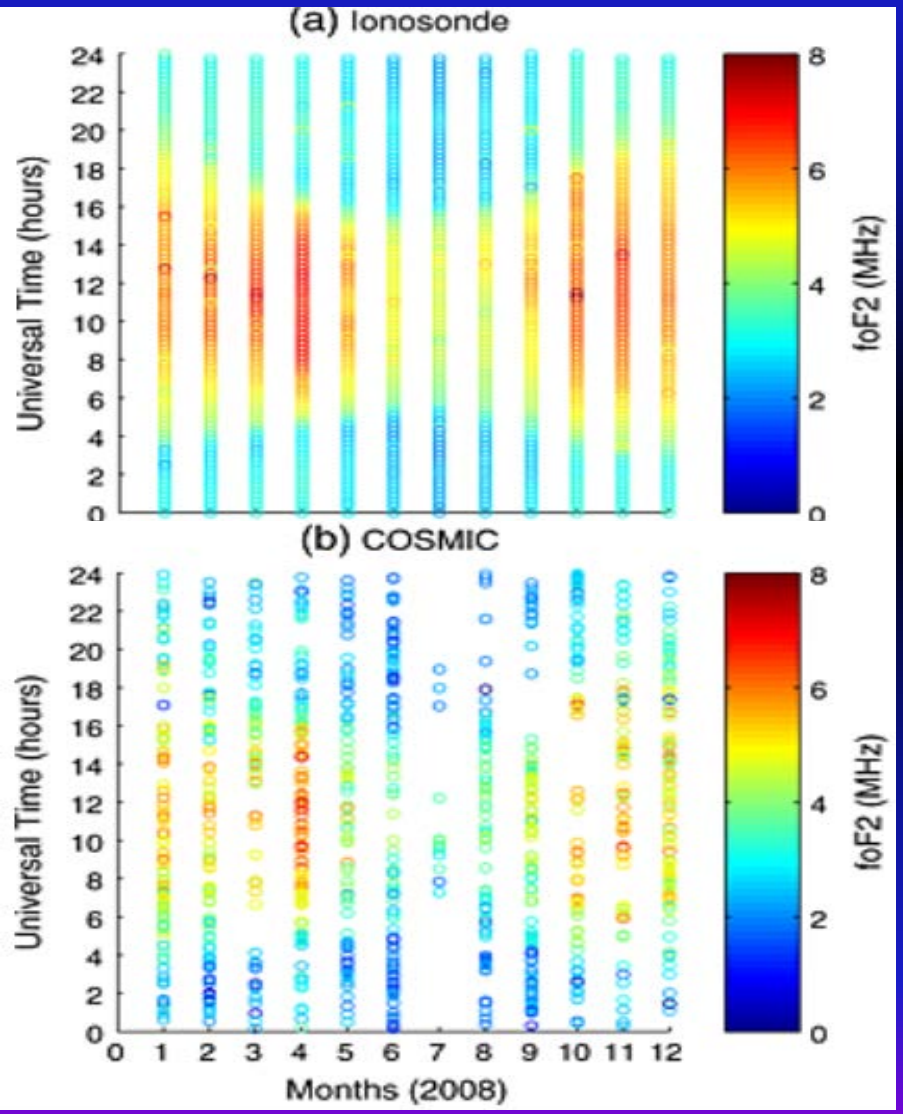
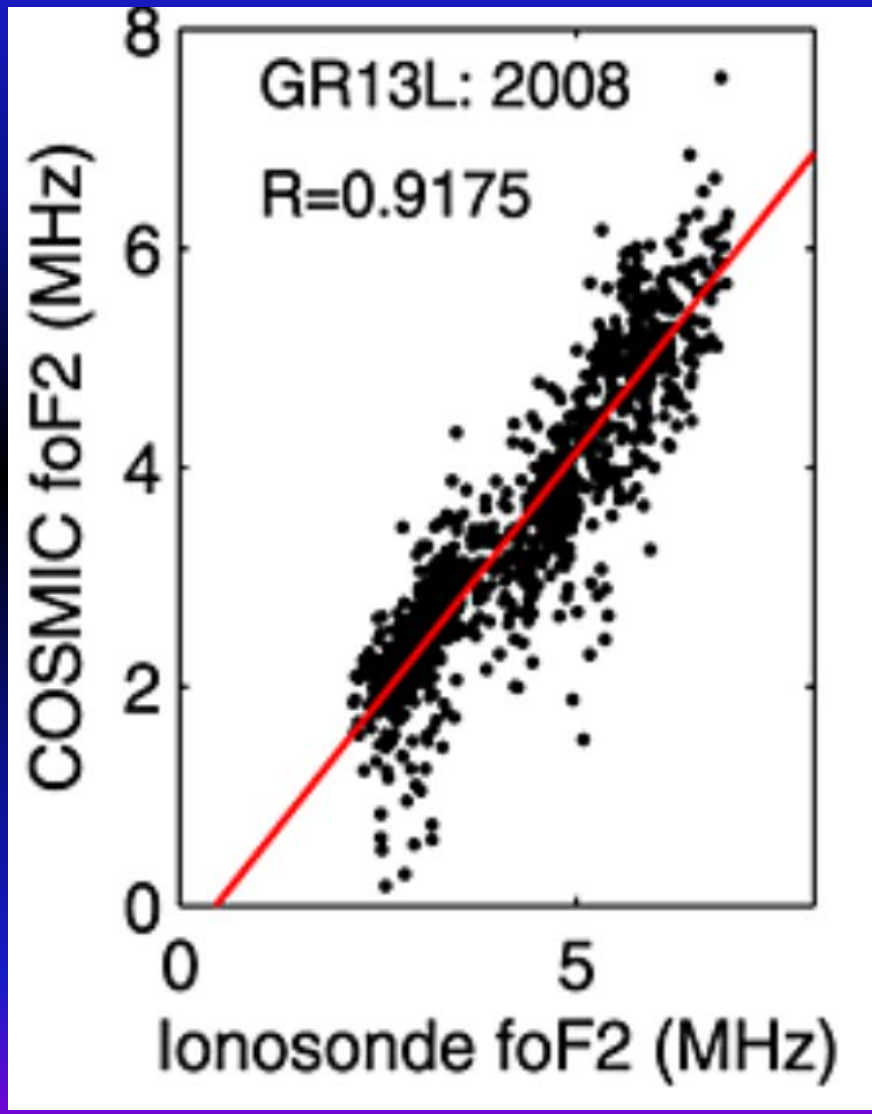




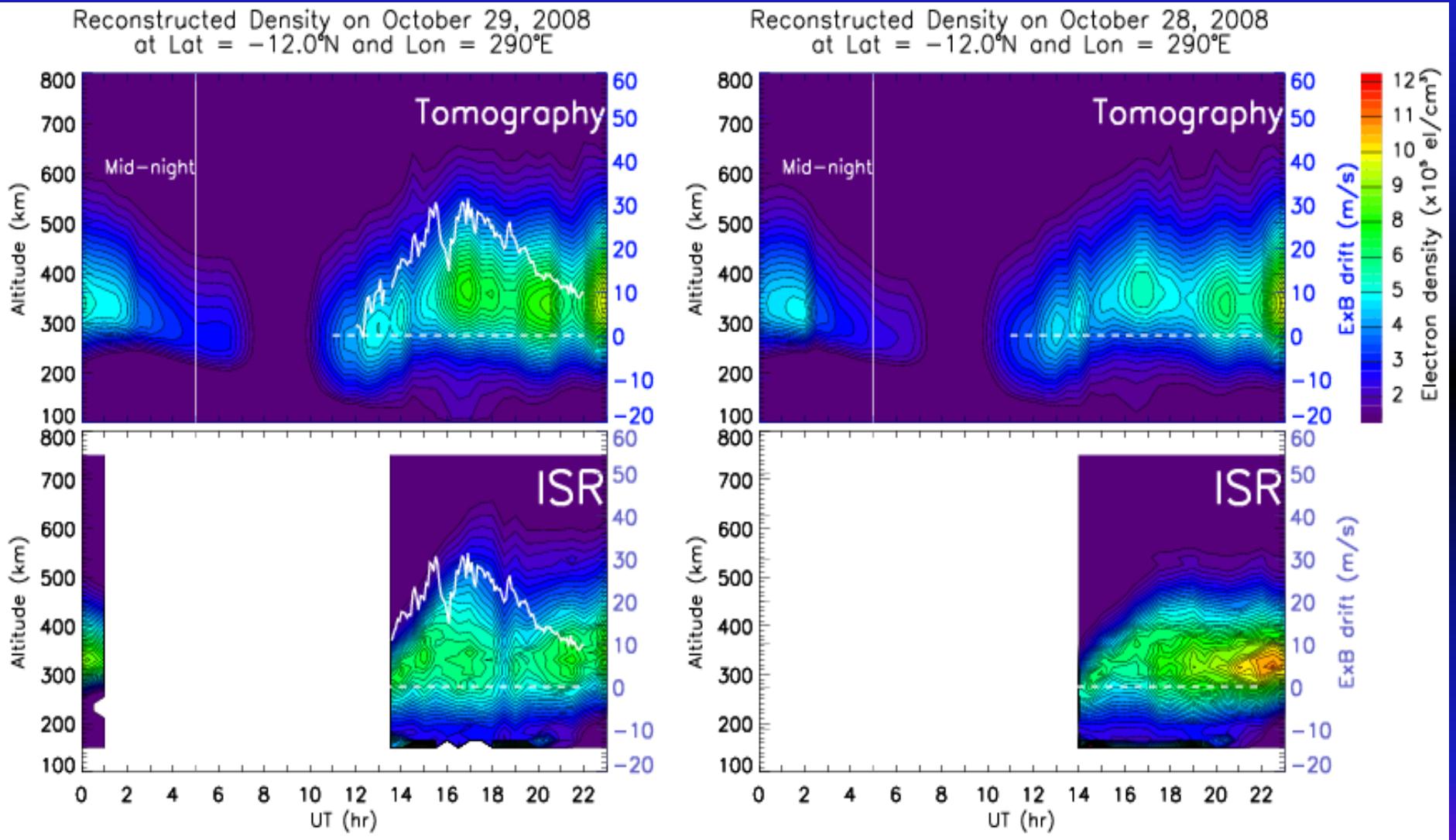
Validation of LEO Occultation Profiles with Ionosonde Measurements





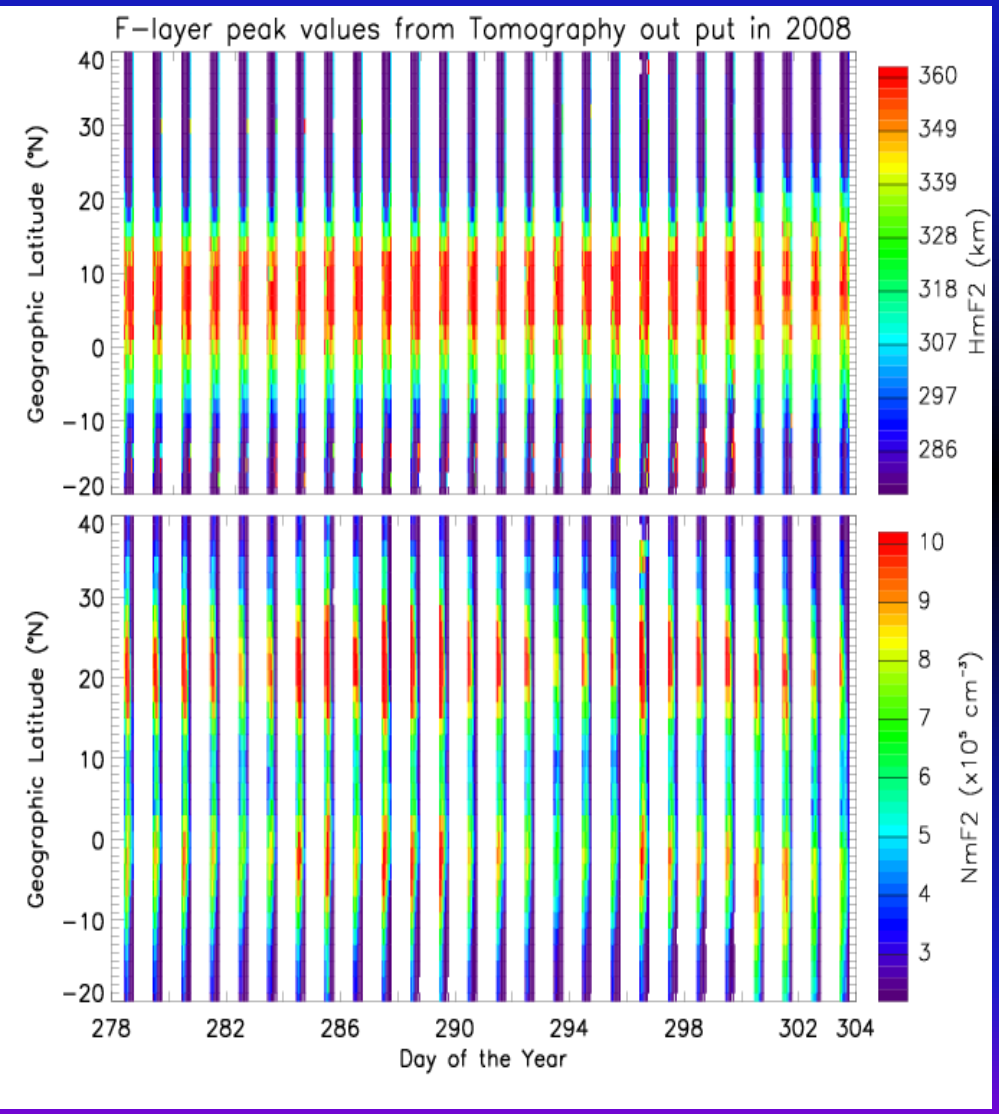
Habarulema and Yizengaw et al., JGR, 2014

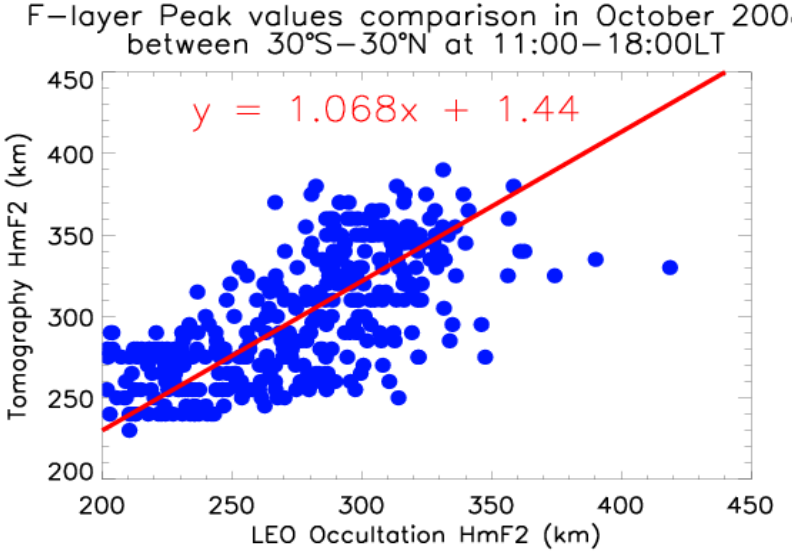
Validation of LEO Occultation Profiles with ground-based tomography results

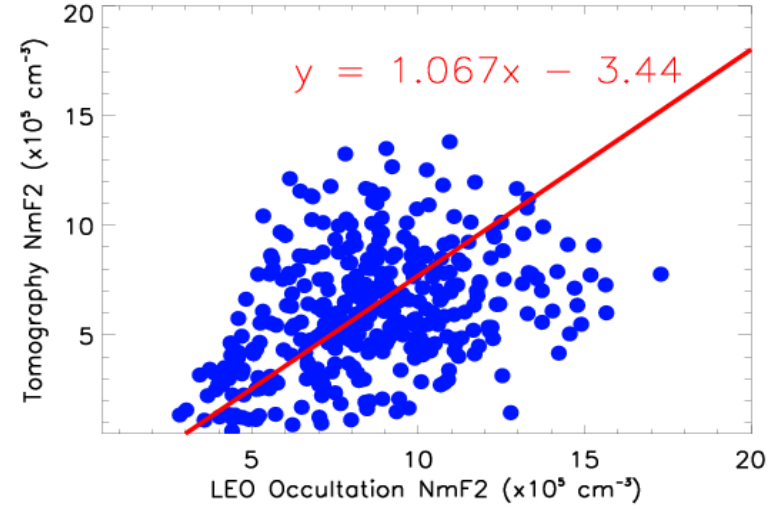


Yizengaw et al., JGR, 2012

Comparison of F-layer peaks from Ground-based Tomography and LEO Occultation

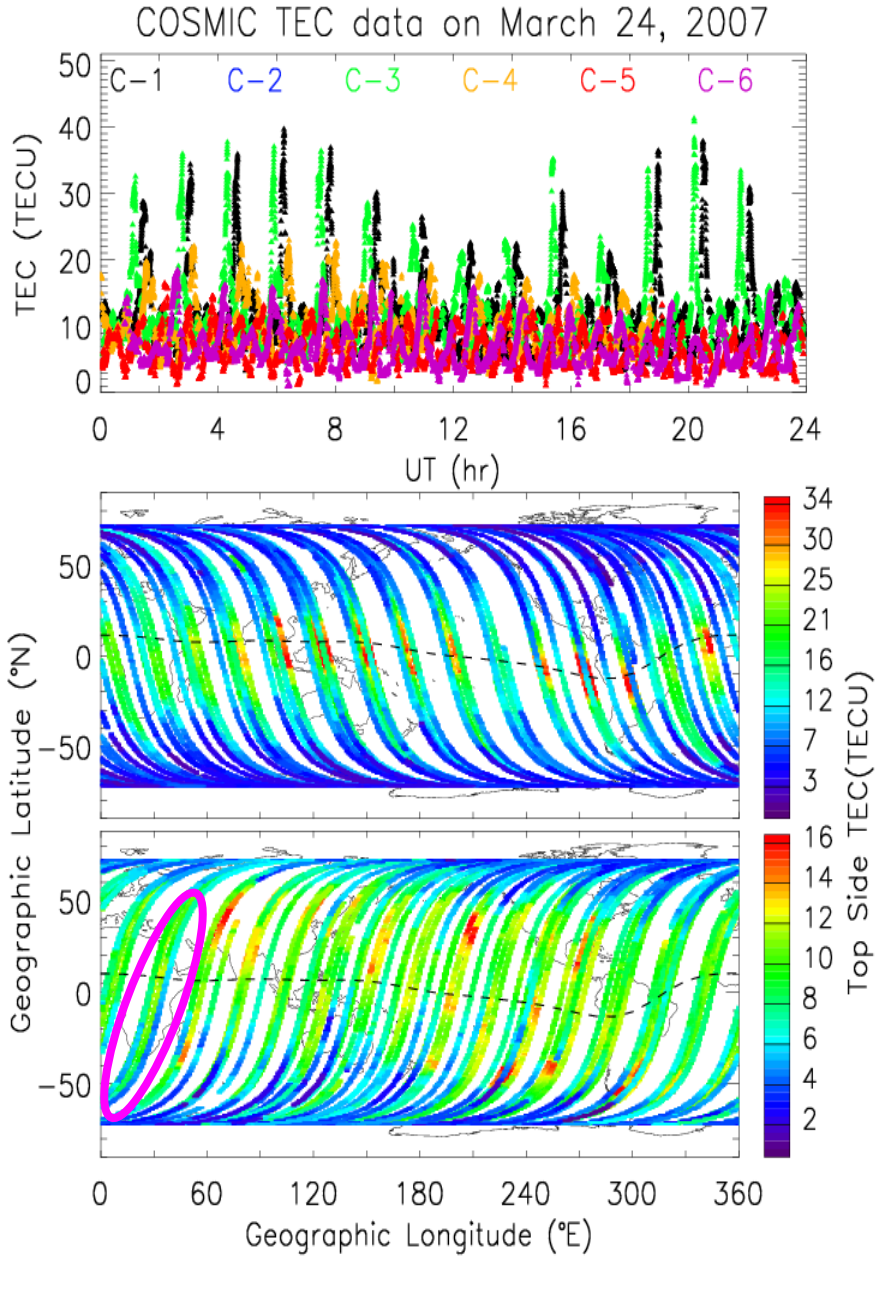


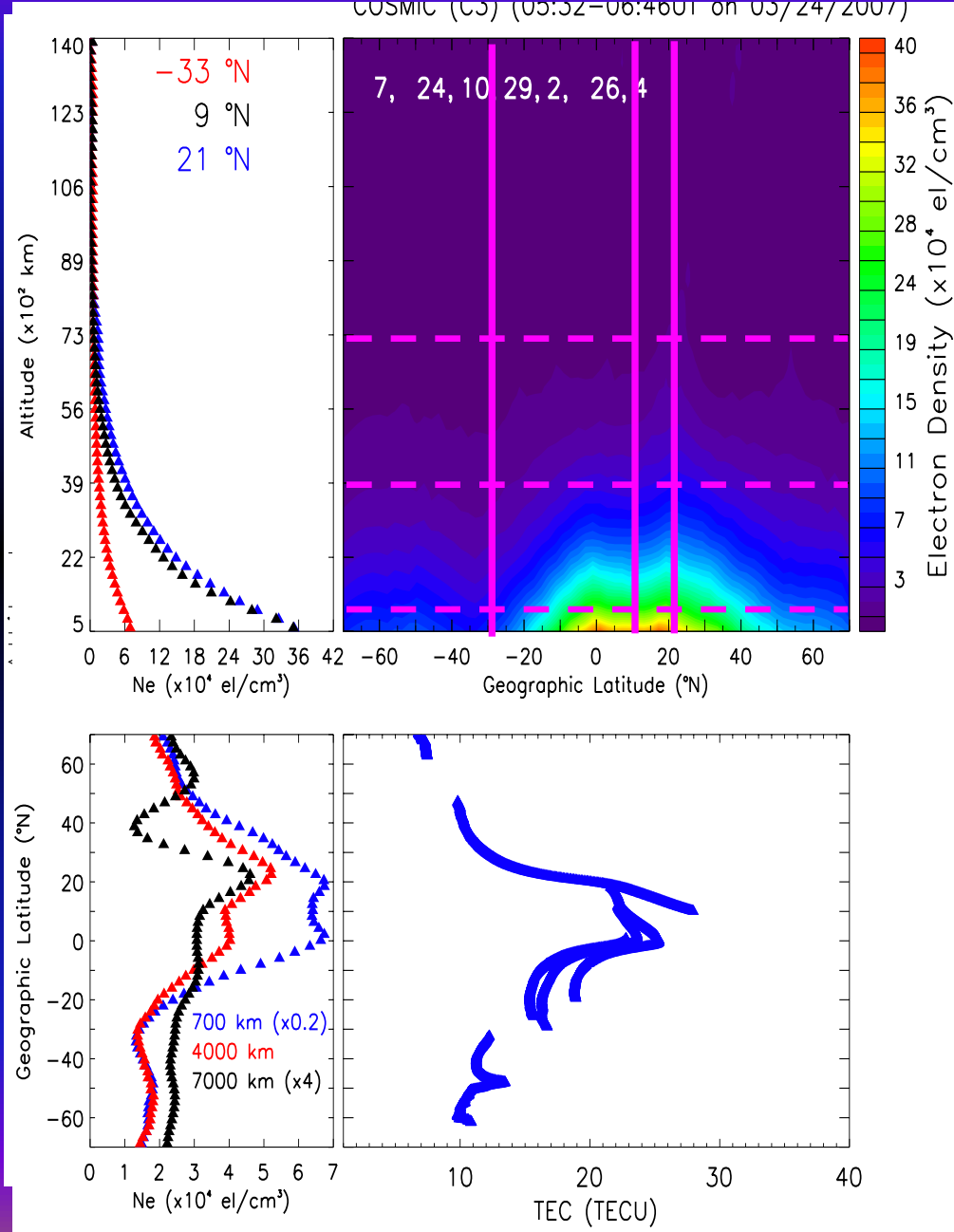




Yizengaw and Carter, 2016

Tomographic Application on Topside LEO TEC





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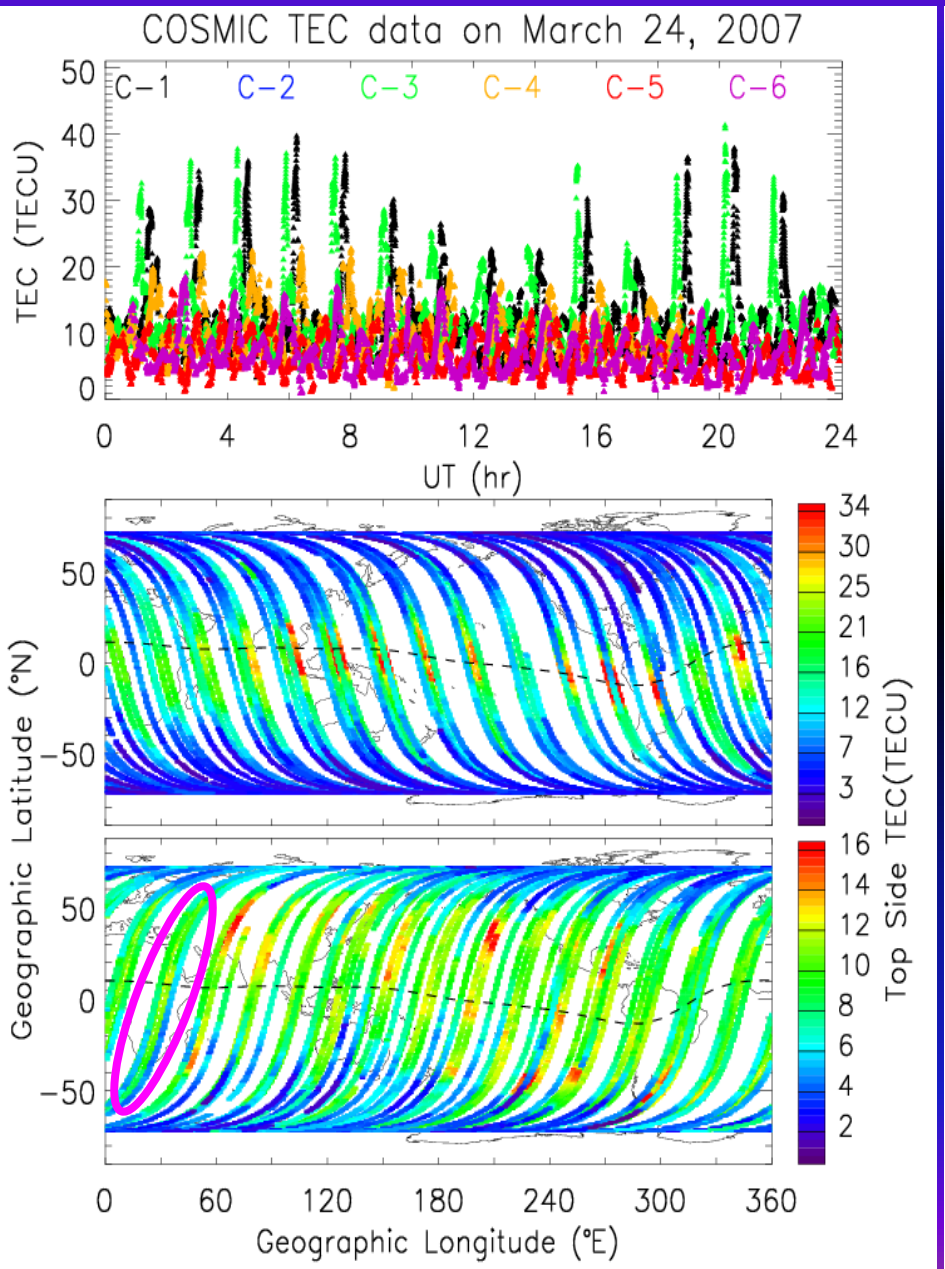

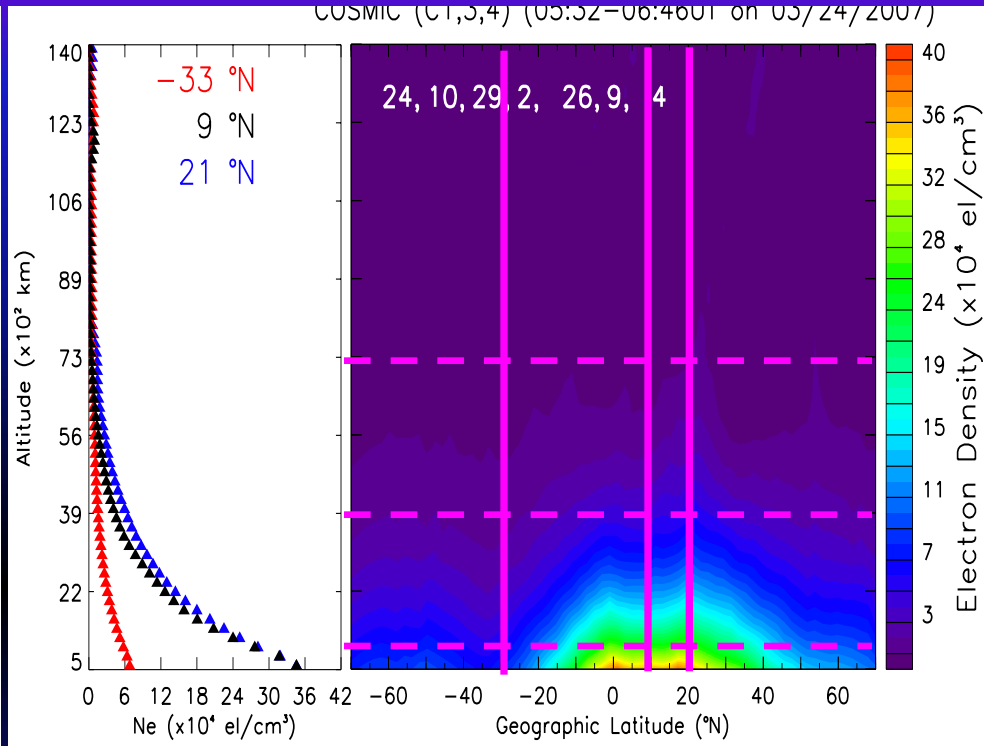

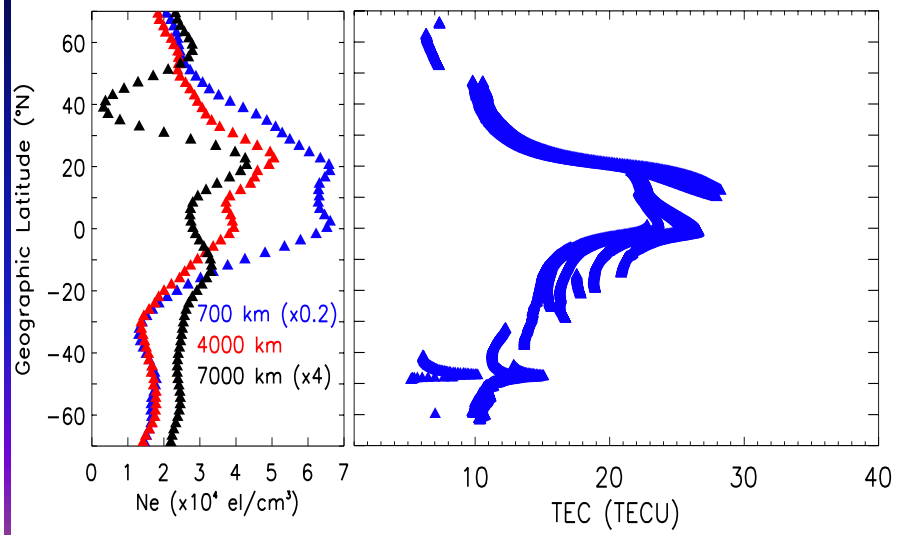

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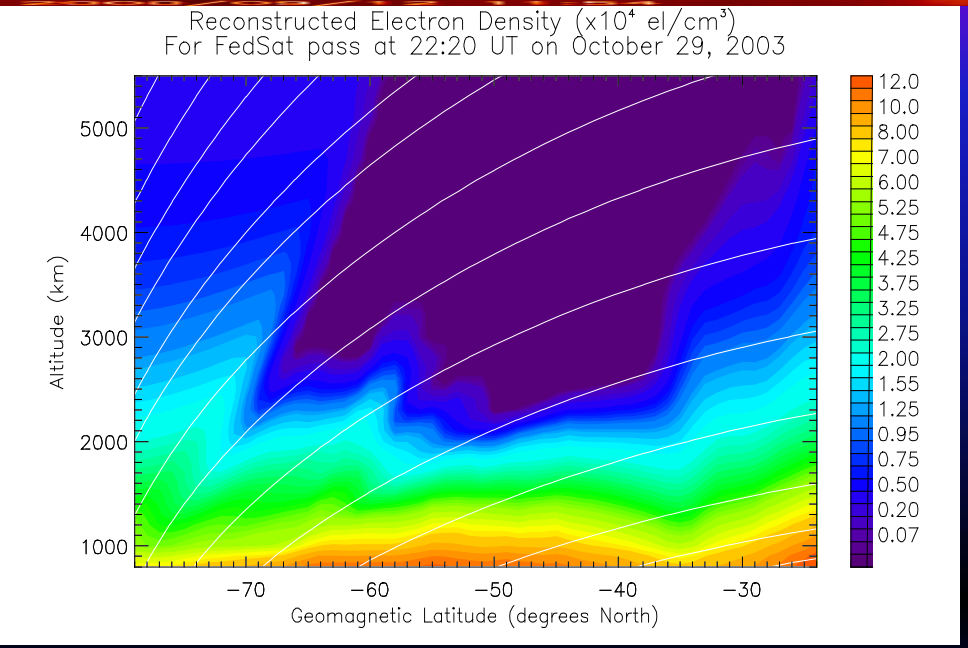
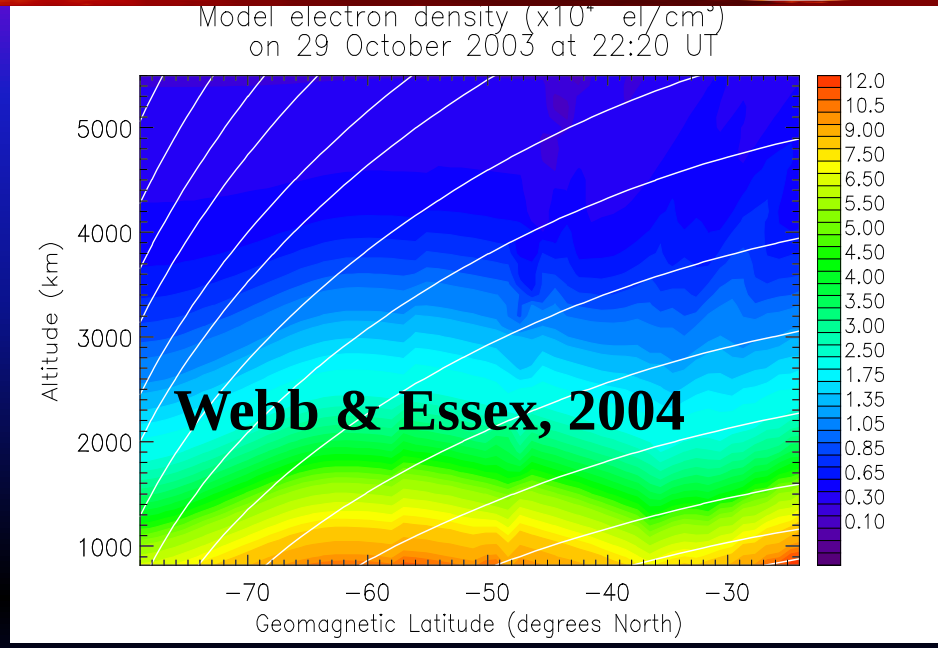
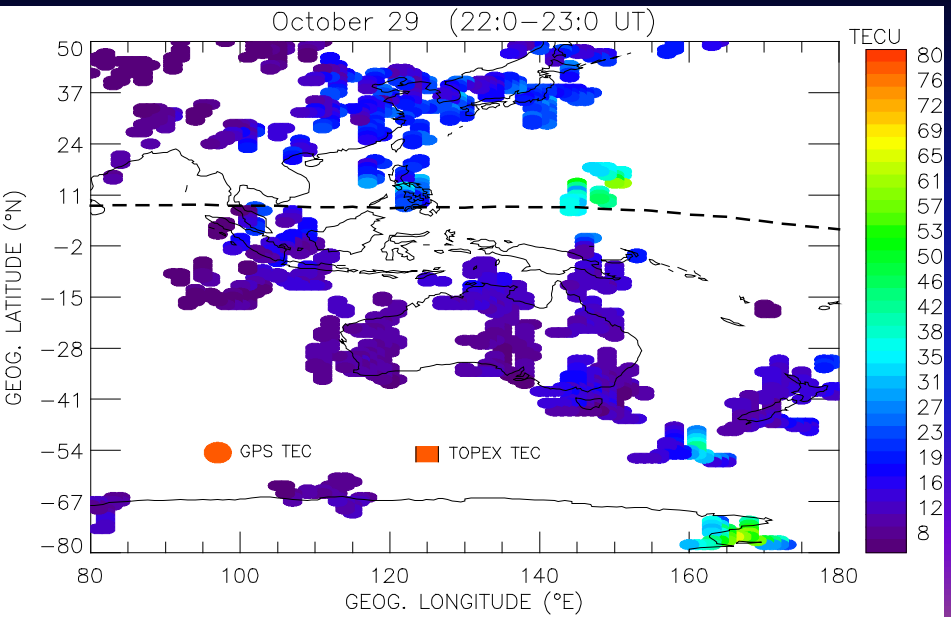
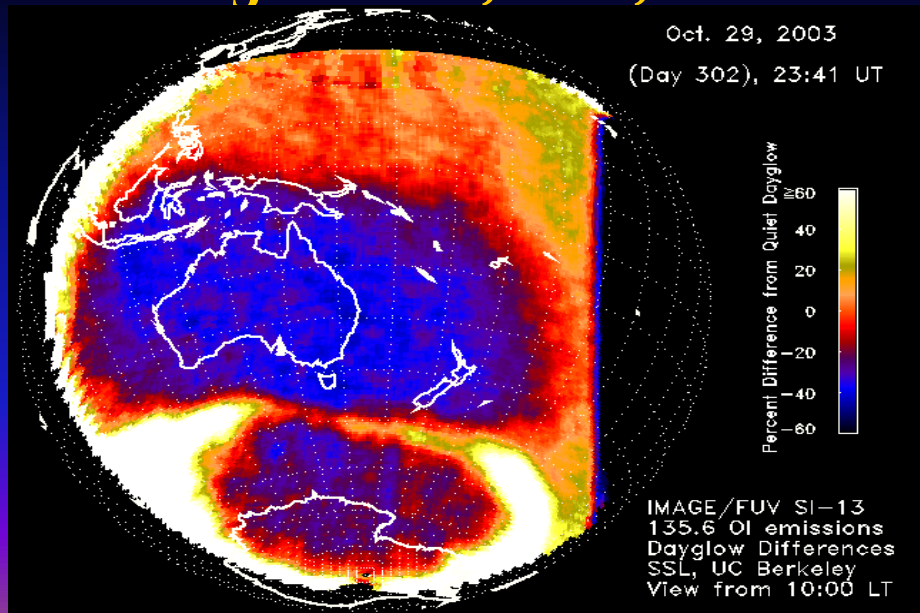


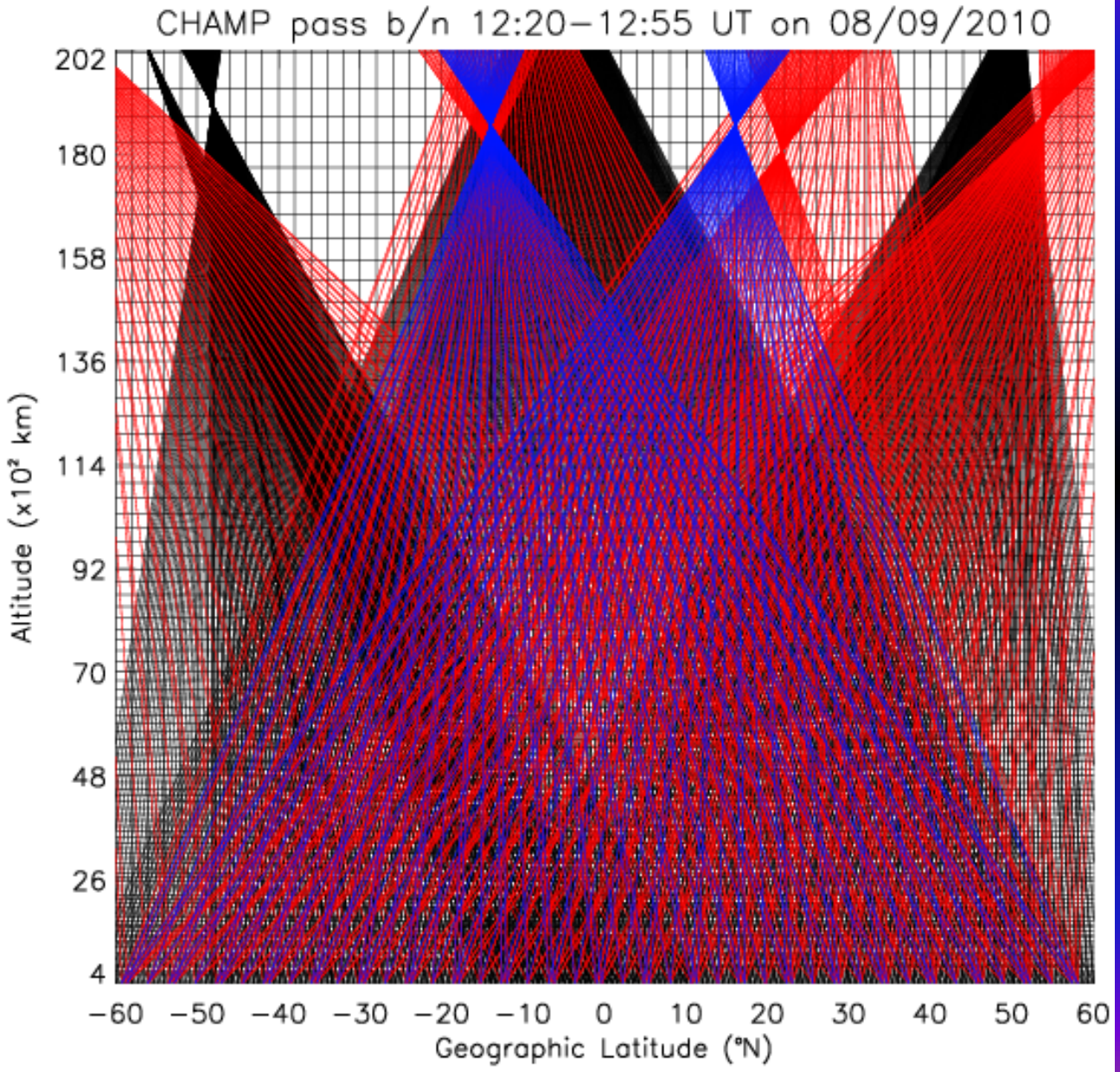




Yizengaw et al., JGR, 2005



Desired Future LEO Satellites' Data



GPS

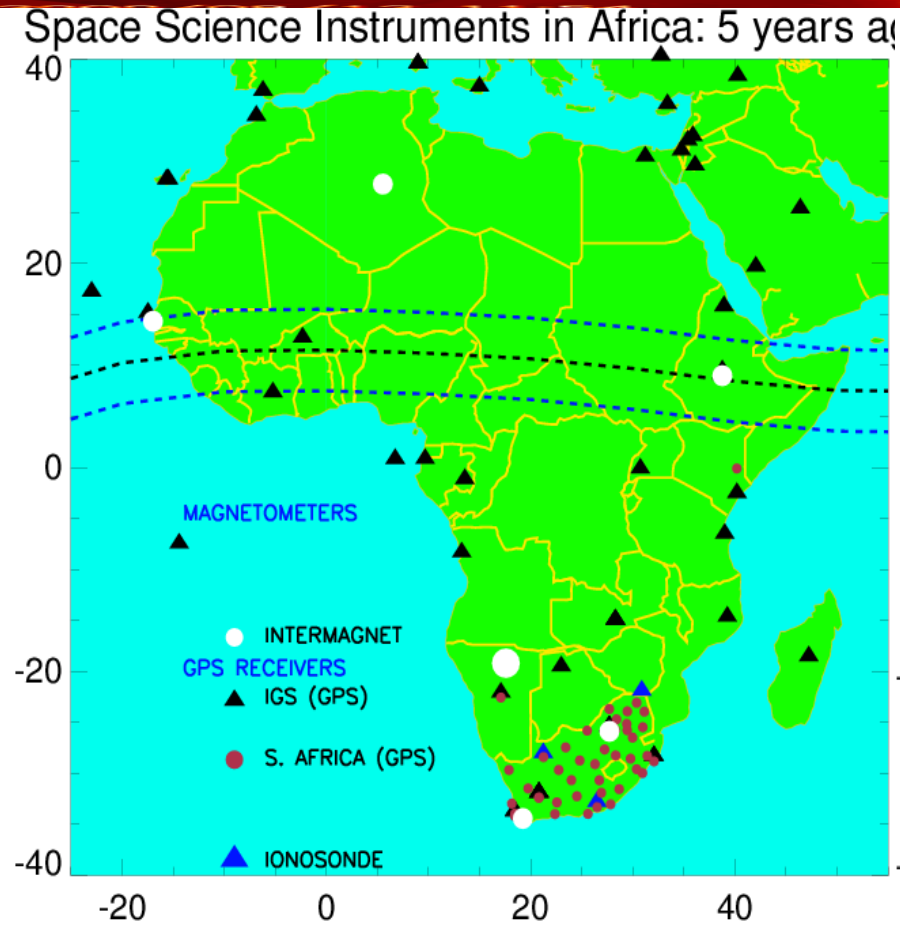
GPS+GLON

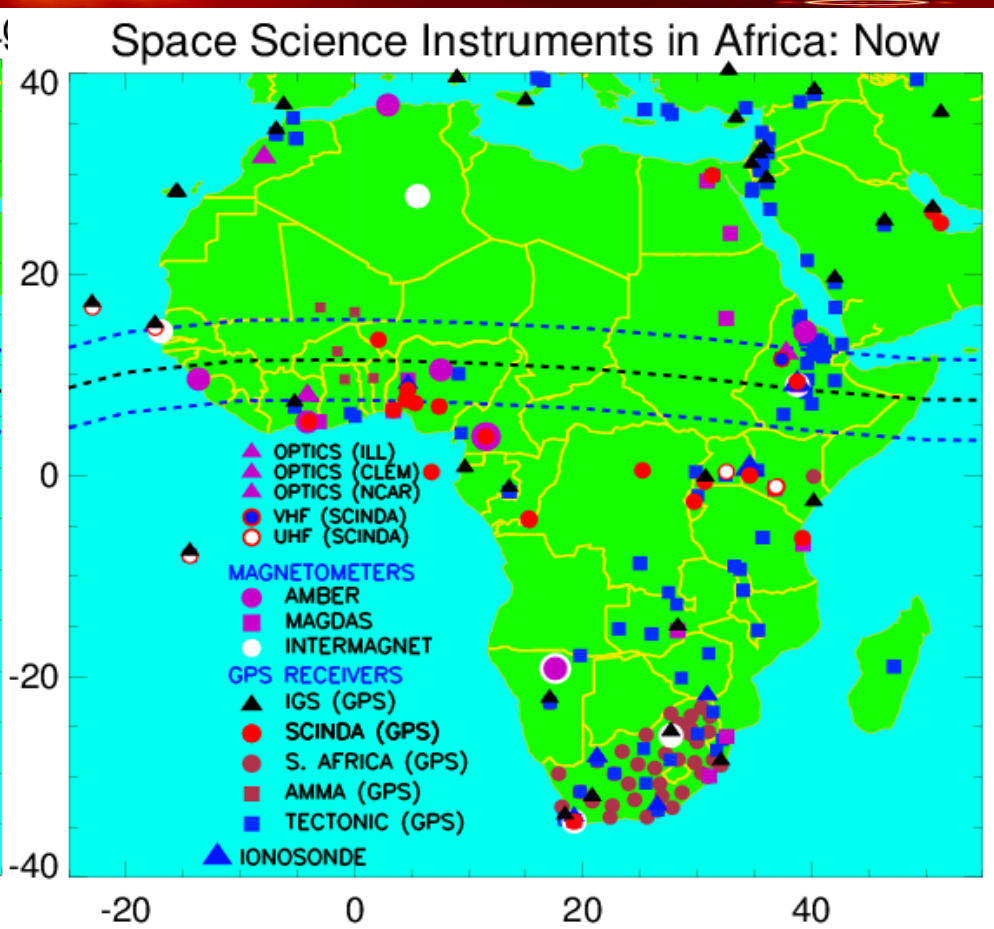
GPS+GLON+GAL

Summary and Conclusion

- There is no doubt that the LEO GPS data provide significant contribution to the mitigation effort of the space weather impact on communication and navigation systems.
- Topside tomographic imaging technique gives us good opportunity to view the detail structure of topside ionosphere and plasmasphere which can not be possible from the ground due to F-region density dominance.
- Having multi-channel GPS receivers onboard future LEO satellites will allow us to obtain significantly high resolution global ionospheric structure, which is very important to understand the space weather impact on our communication and navigation systems.

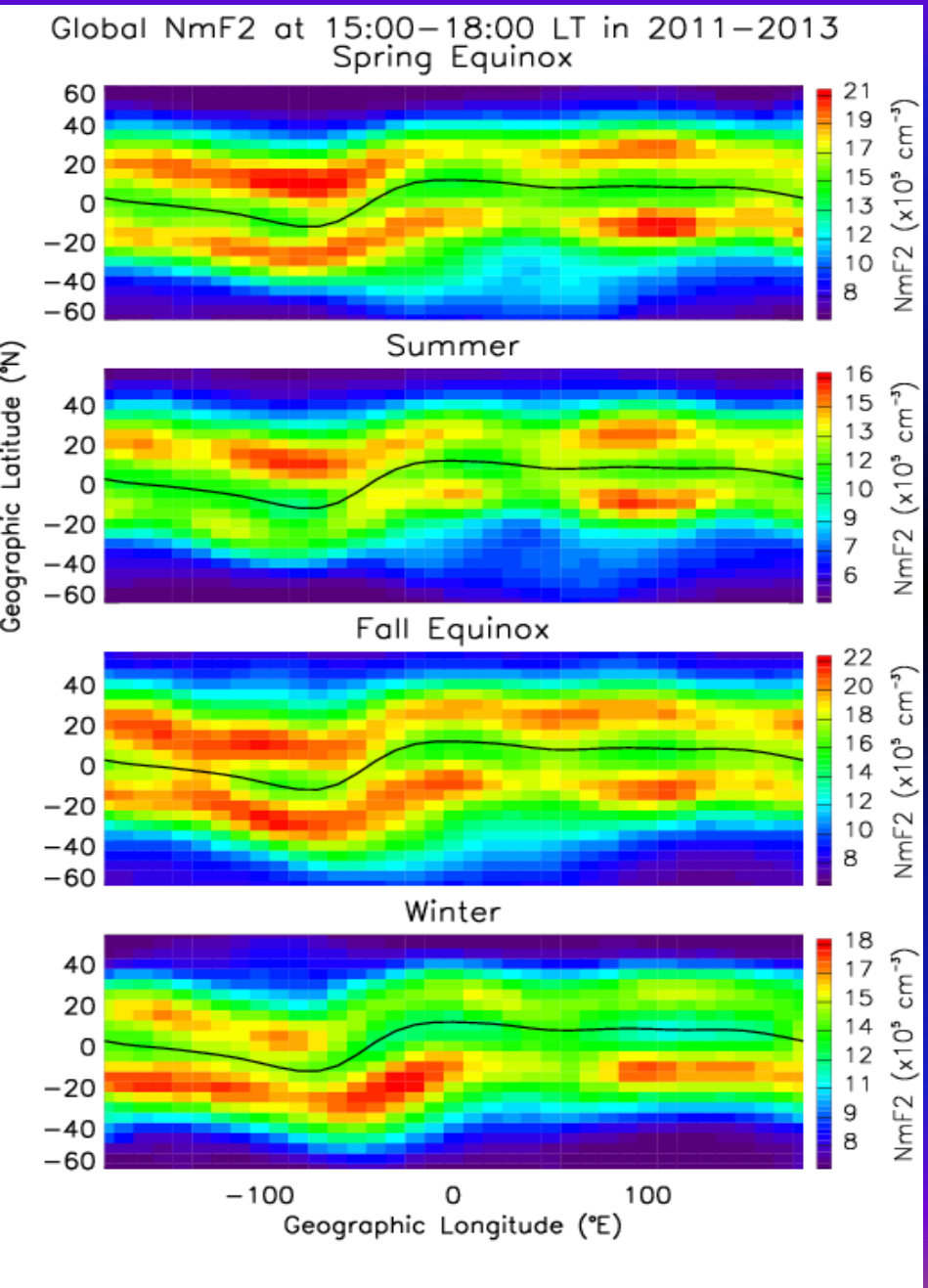
General Instrumentation in Africa

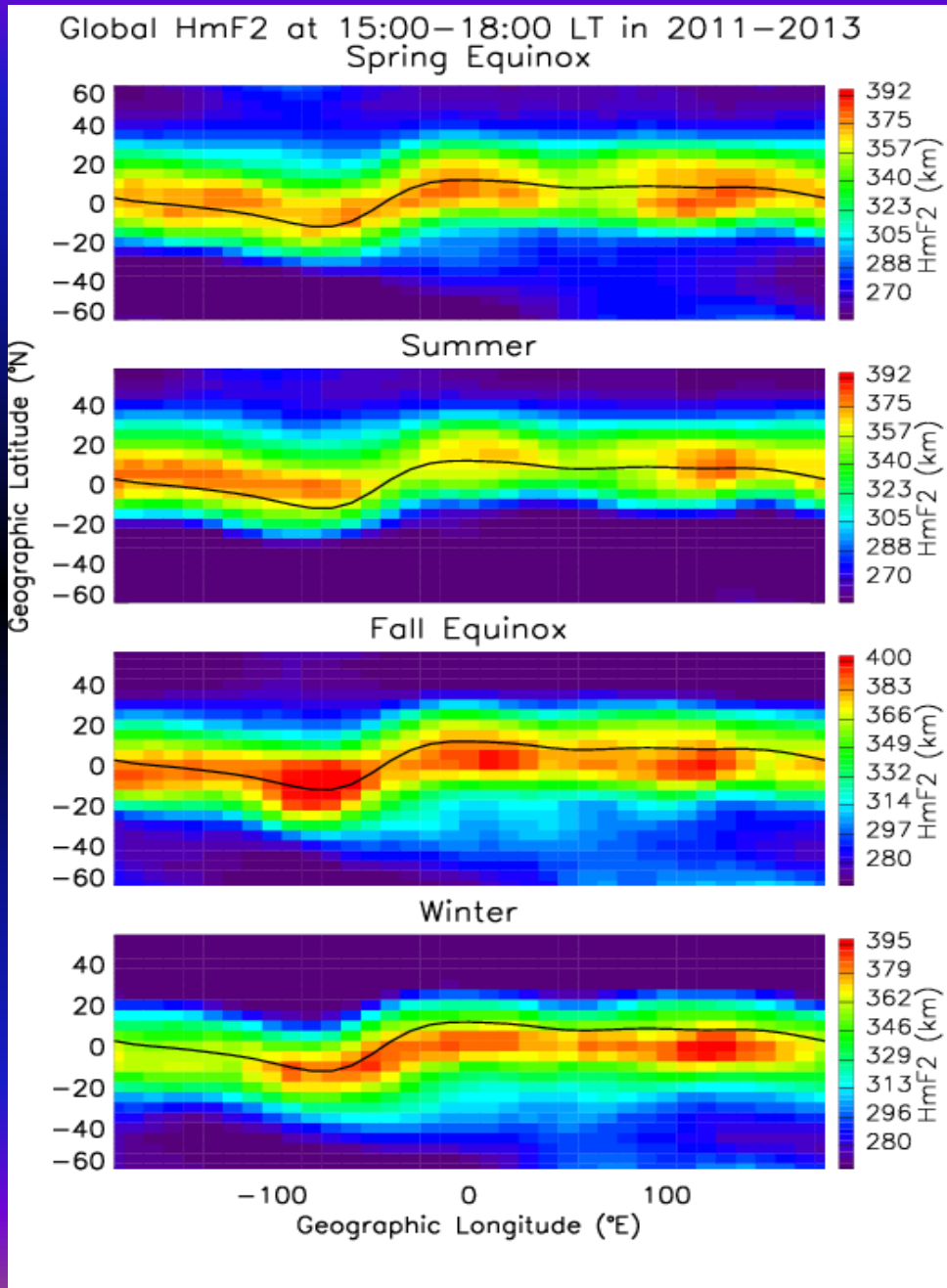




Eight Years ago **This Now!**

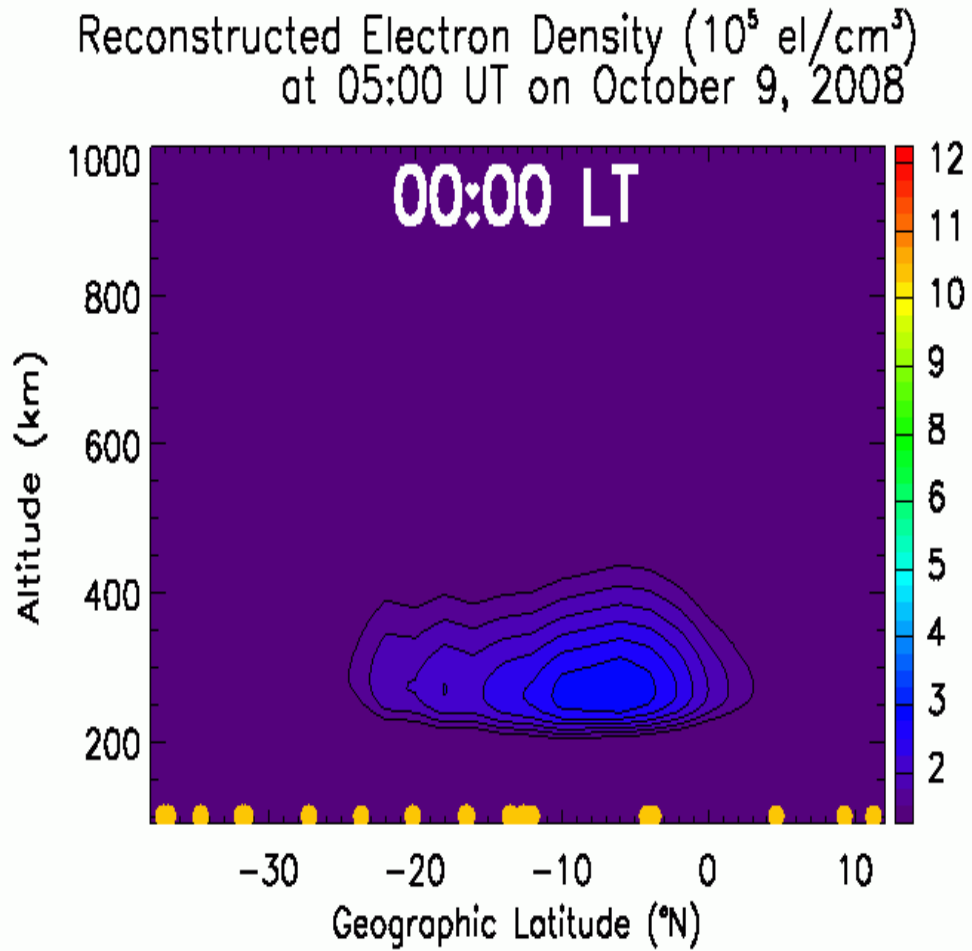
Thank you!


Global NmF2 at 15:00–18:00 LT in 2011–2013
Spring Equinox
Summer
Fall Equinox
Winter
Geographic Latitude (°N)
Geographic Longitude (°E)
NmF2 (x10⁵ cm⁻³)

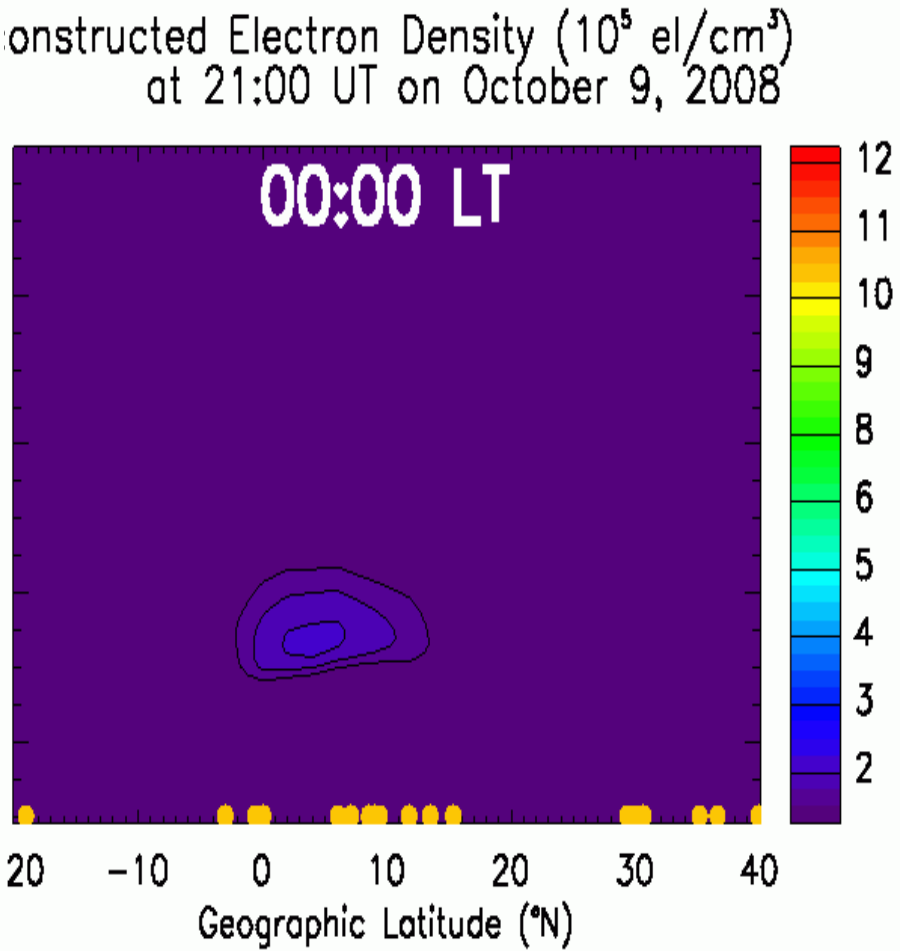

Global HmF2 at 15:00–18:00 LT in 2011–2013
Spring Equinox
Summer
Fall Equinox
Winter
Geographic Latitude (°N)
Geographic Longitude (°E)
HmF2 (km)

Tomographically reconstructed density profiles

West America



East Africa



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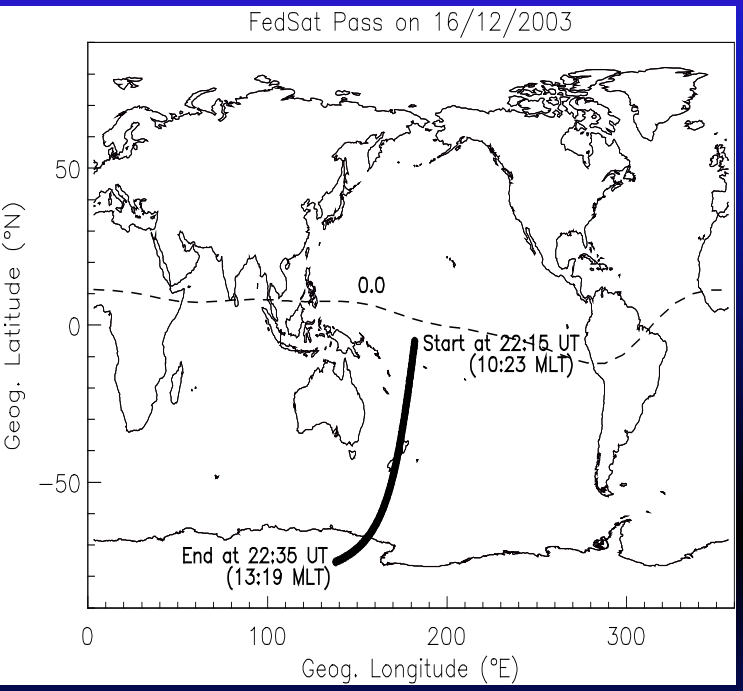
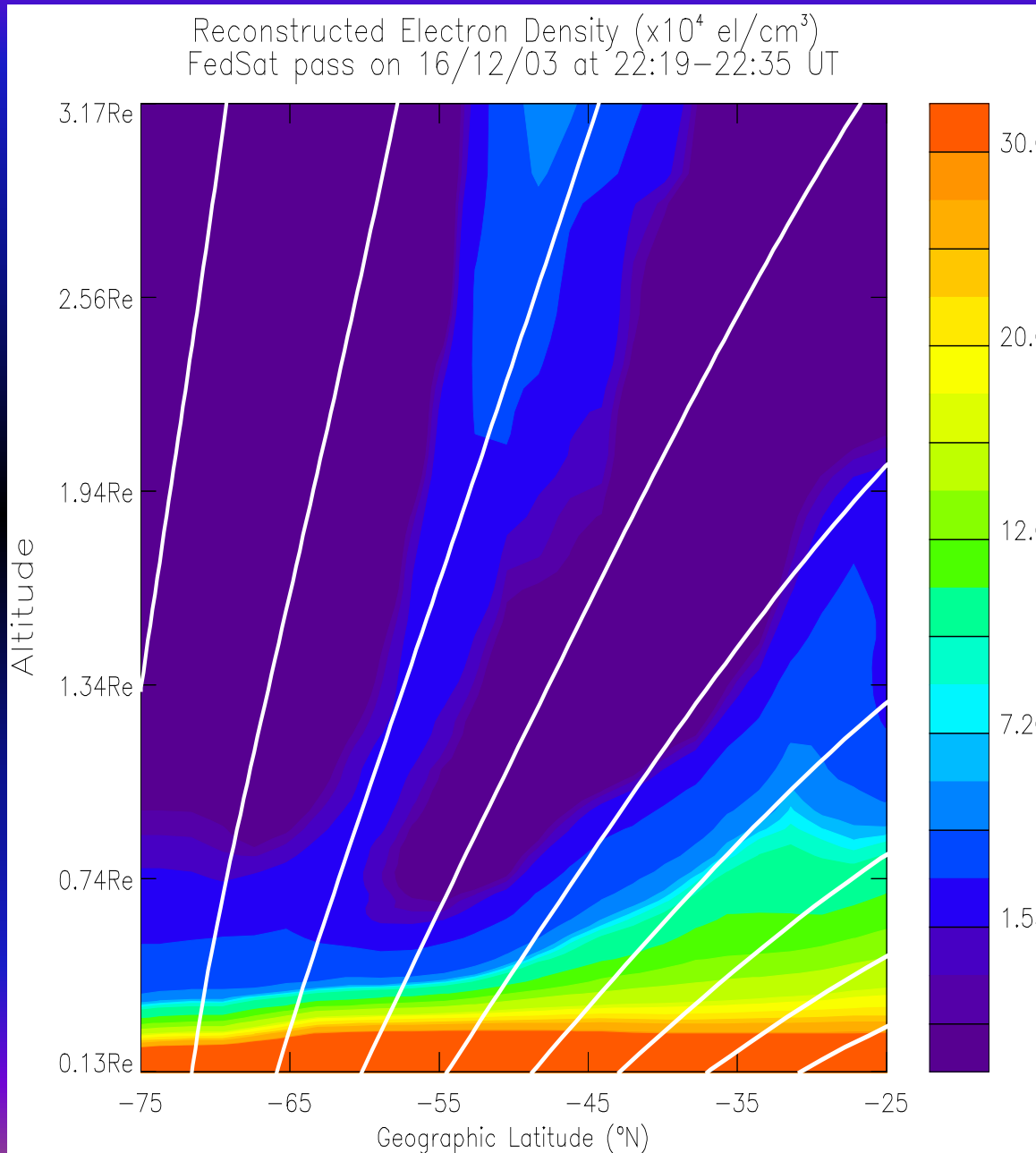


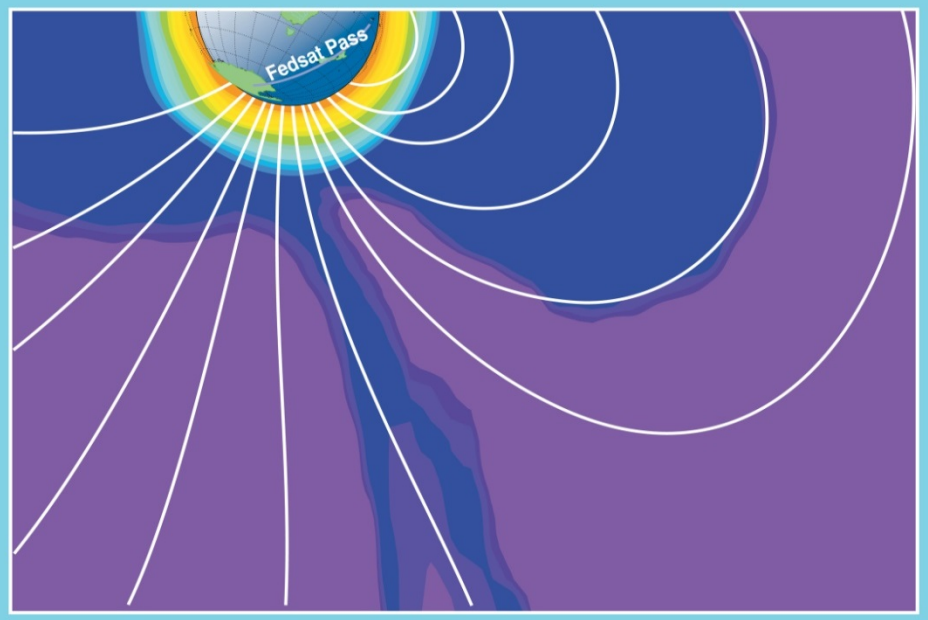
Yizengaw et al., GRL, 2006

Tomographically imaged ion outflow: from its source to its sink region.



Geophysical Research Letters

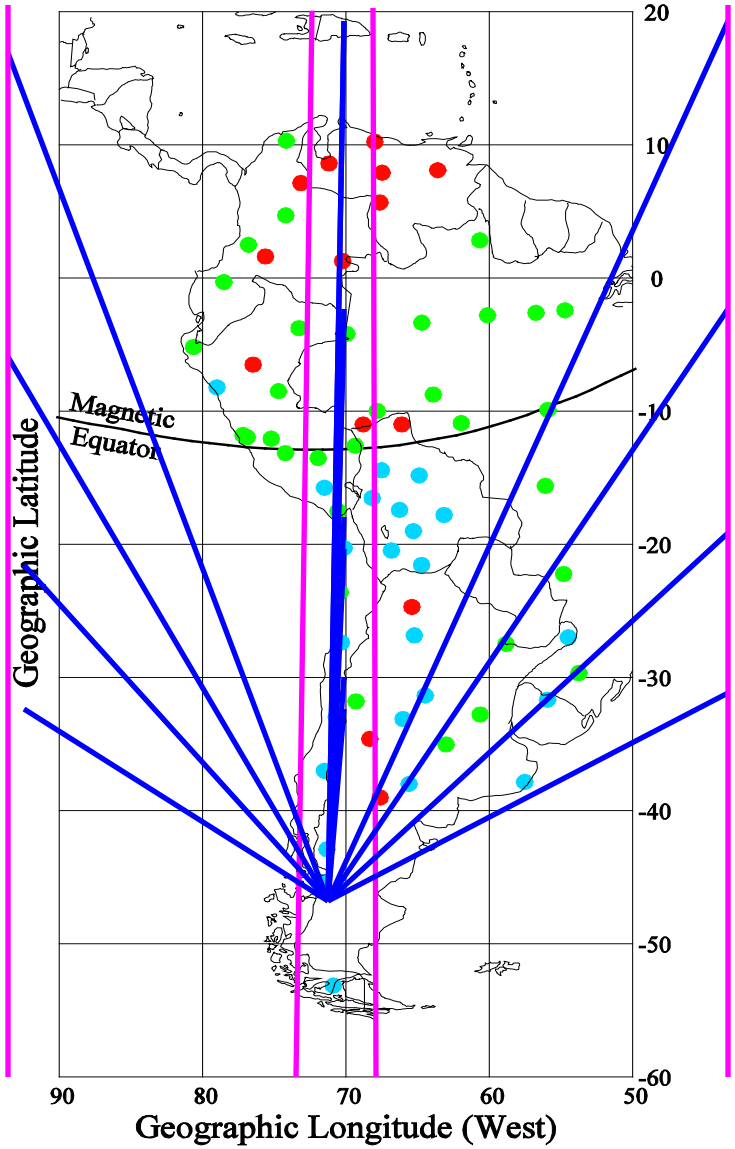
28 OCTOBER 2006
Volume 33 Number 20
American Geophysical Union



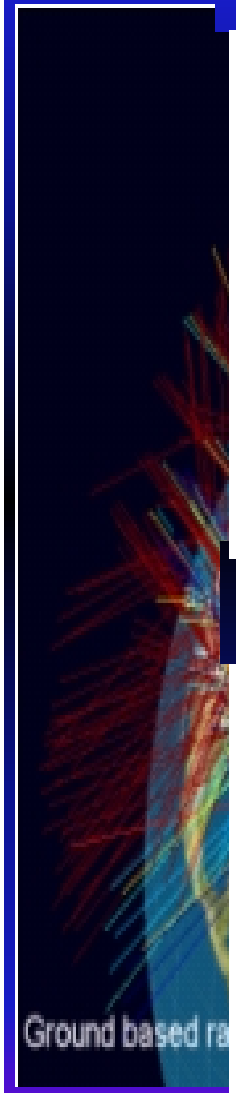
Yizengaw et al., GRL, 2006

First tomographic image of ionospheric outflows • Detailed analyses of the October 2005 Pakistan earthquake • China's surface temperatures to increase despite decrease in insolation

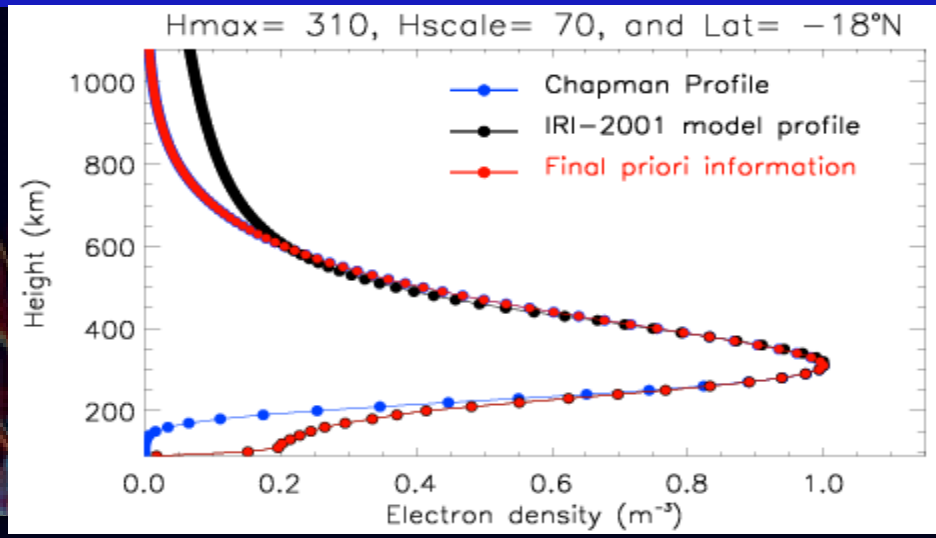
Resource for Tomography



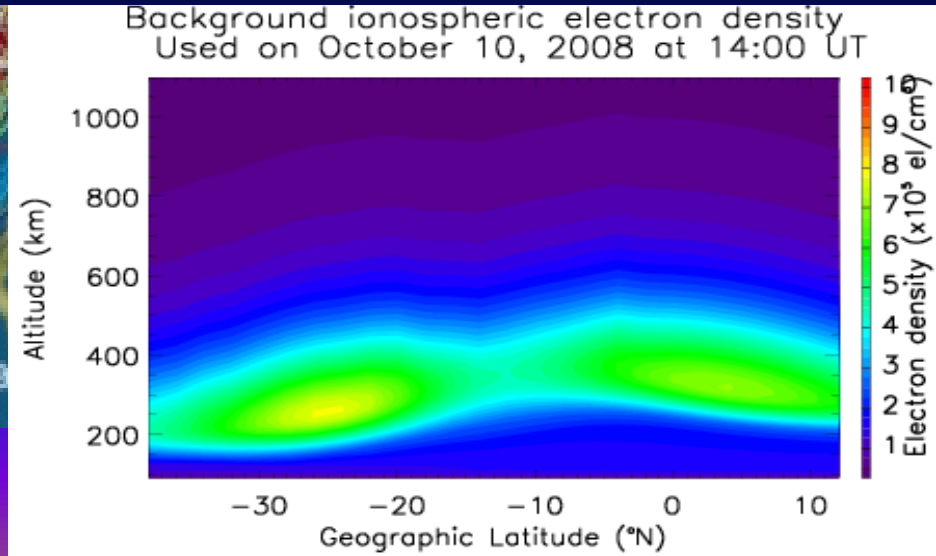
Courtesy to Valladares



Harmonic background profiles



Background profiles



CIT Inversion technique

Q Divide the imaging region in to number of pixels

$$TEC_i = \int_{p_i} N_e ds = \sum_{j=1}^{N} d_{ij} n_j + E$$

$$TEC_{guess} = \sum_{j=1}^{N} d_{ij} (n_{gs})_j$$