

Geomagnetic Storm Response of Global Thermospheric Density from CHAMP Accelerometer Measurements



***J.M. Forbes¹, G. Lu², X. Zhang¹, E. Sutton¹,
S. Nerem¹, A.D. Richmond², R.G. Roble²,
and S. Bruinsma³,***

**¹Department of Aerospace Engineering Sciences, UCB 429,
University of Colorado, Boulder, CO 80309-0429**

**²High Altitude Observatory, National Center for
Atmospheric Research, P.O. Box 3000, Boulder, CO,
80307**

**³Department of Terrestrial and Planetary Geodesy, Centre
National d'Etudes Spatiales, 18, Avenue E. Belin,
31401 Toulouse, France**

***1. Latitude vs. time response of total mass density
at 410 km during the October & November 2003
storms:***

- CHAMP Accelerometer and MSISE90***
- Waves & Traveling Atmospheric Disturbances
(TADs)***

2. TADs during April 16-22, 2002; CHAMP & TIEGCM

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CHAMP Mission



- **CHAMP (CHALLENGING Minisatellite Payload) is a German small satellite mission for geoscientific and atmospheric research and applications, managed by GFZ**
- **Launch: July 15, 2000, Russian COSMOS launch vehicle**
- **Initial orbit: almost circular (454 km), 87° inclination**
- **Design lifetime: 5 years**
- **LST precession: 5.44 min/day
24-hour coverage per
133 days**

STAR Accelerometer



- The STAR accelerometer sensor is provided by the Centre National d'Etudes Spatiales (CNES) and was manufactured by the Office National d'Etudes et de Recherches Aerospatiales (ONERA).

- Accuracy: $3 \times 10^{-9} \text{ ms}^{-2}$ in-track and cross-track;
 3×10^{-8} radial

radial: not capable of deriving vertical winds

cross-track: possible cross-track winds

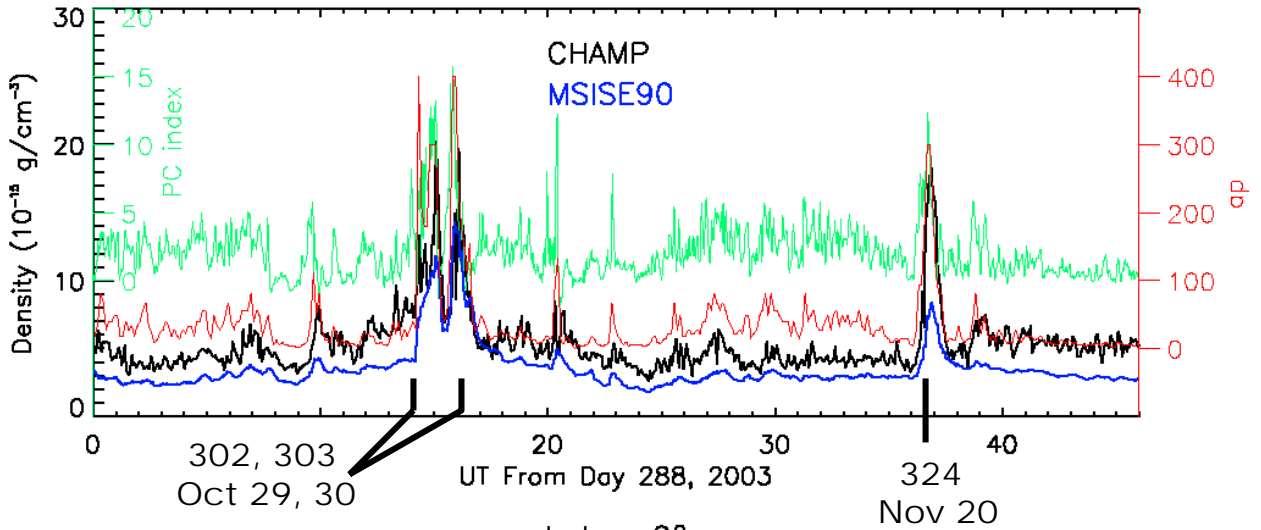
in-track: $\frac{1}{2} C_D \frac{A}{M} \rho \left(V_s - V_A \right)^2$

$$V_A = 100 \text{ m}^{-\text{s}} \Rightarrow 2.5\% \text{ error in } \rho$$

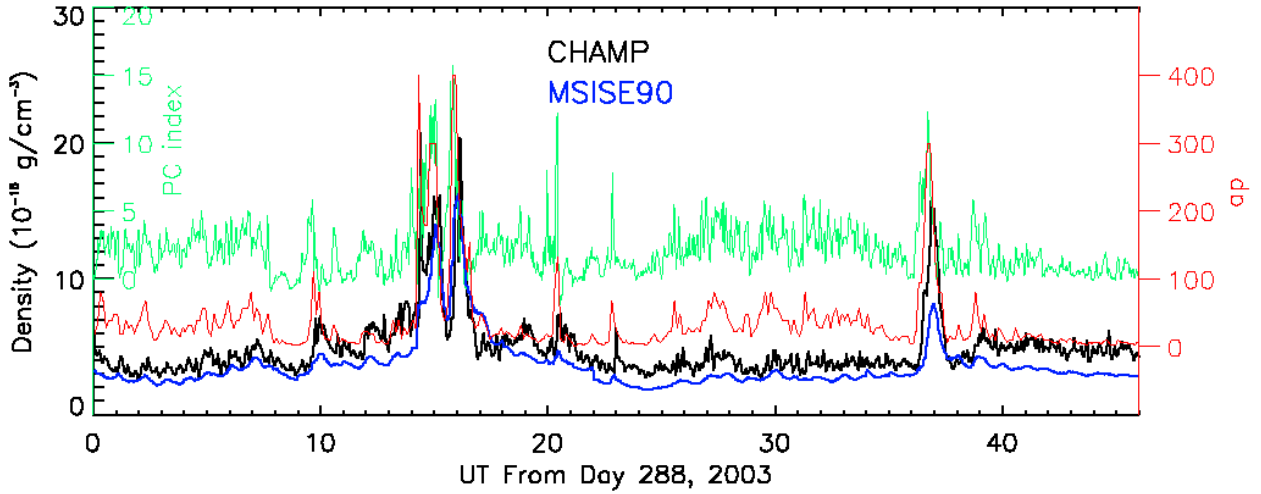
$$V_A = 1000 \text{ m}^{-\text{s}} \Rightarrow 25\% \text{ error in } \rho$$

CHAMP density at 400Km, Ascending (LST~24:00)

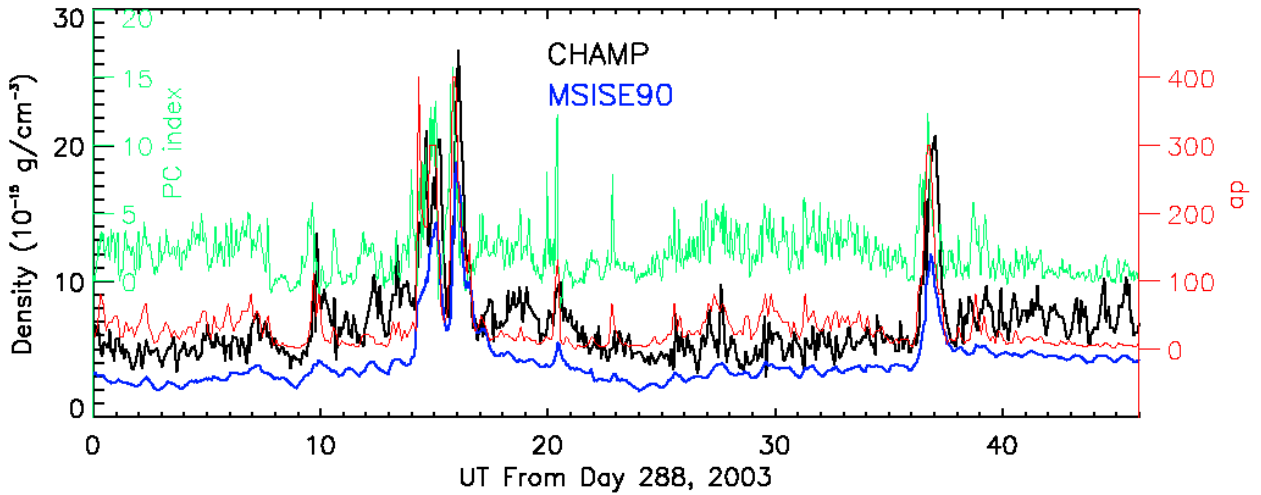
Lat = 60°



Lat = 0°

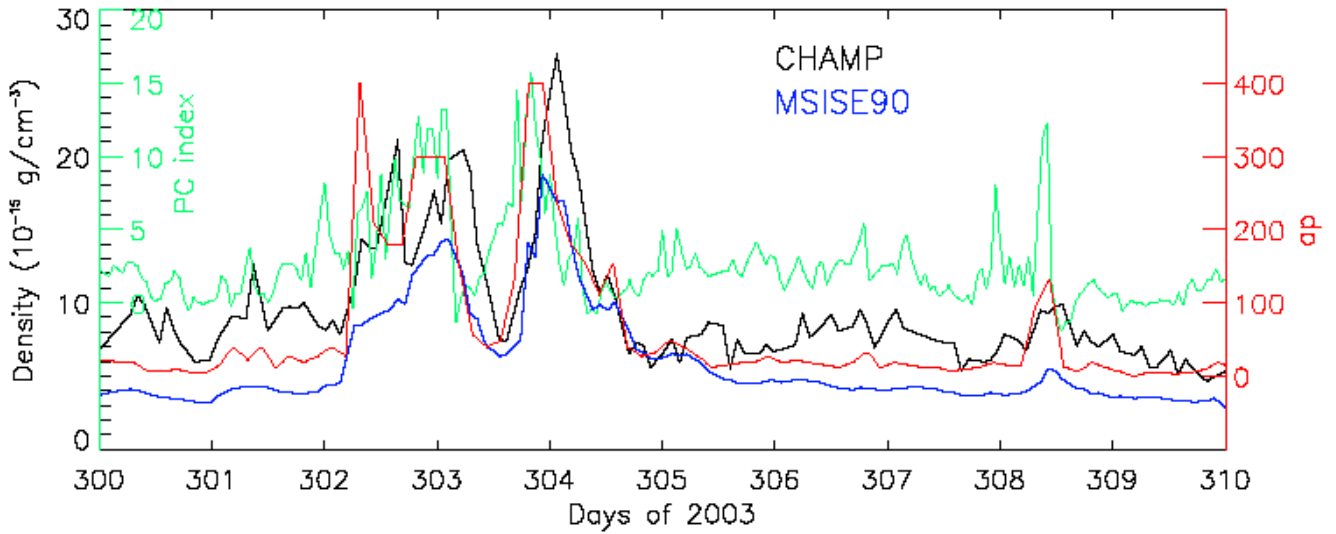


Lat = -60°

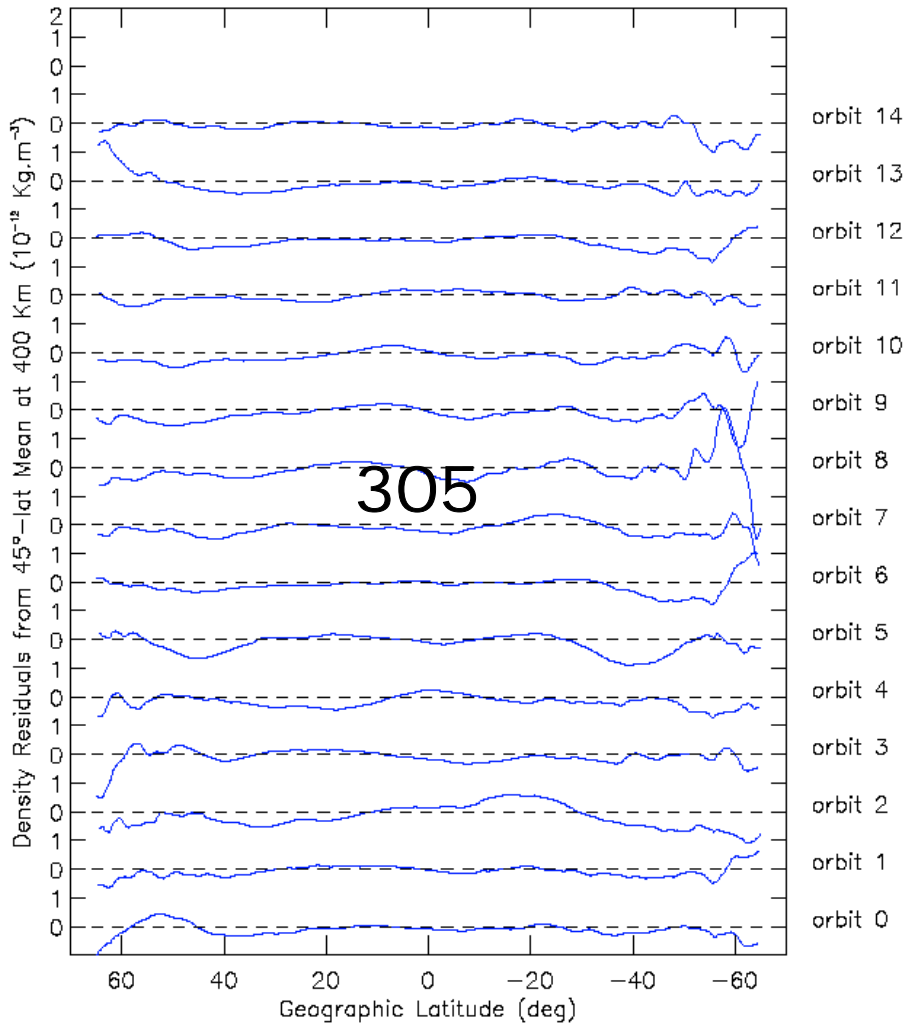


CHAMP density at 400Km, Ascending (LST~24:00)

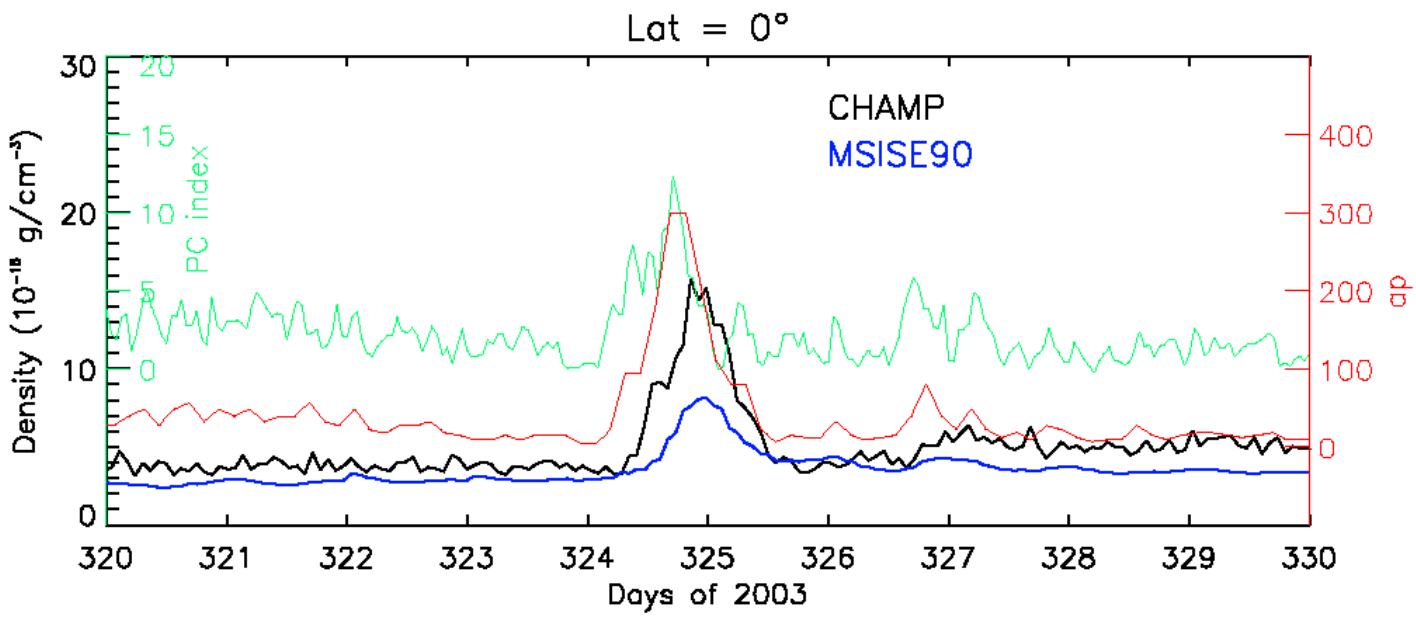
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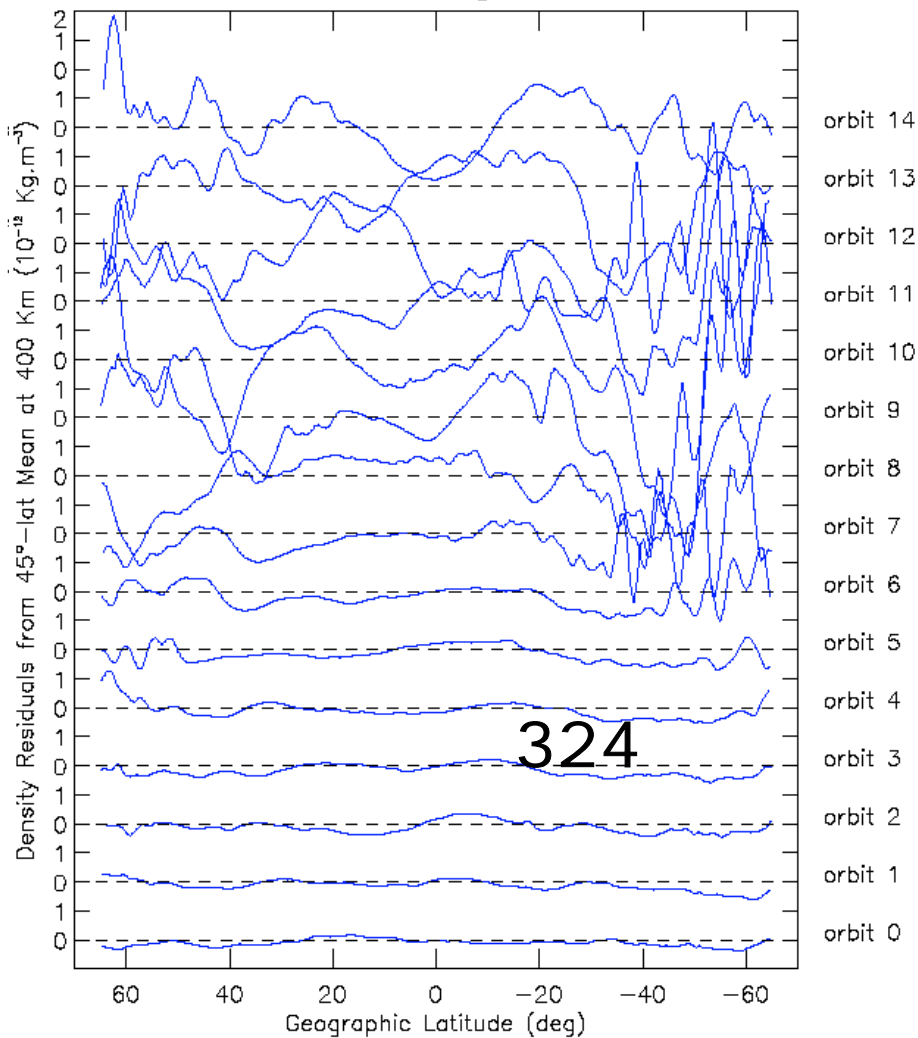
Wave Structures from the CHAMP/STAR Accelerometer
305, 2003, Night Time



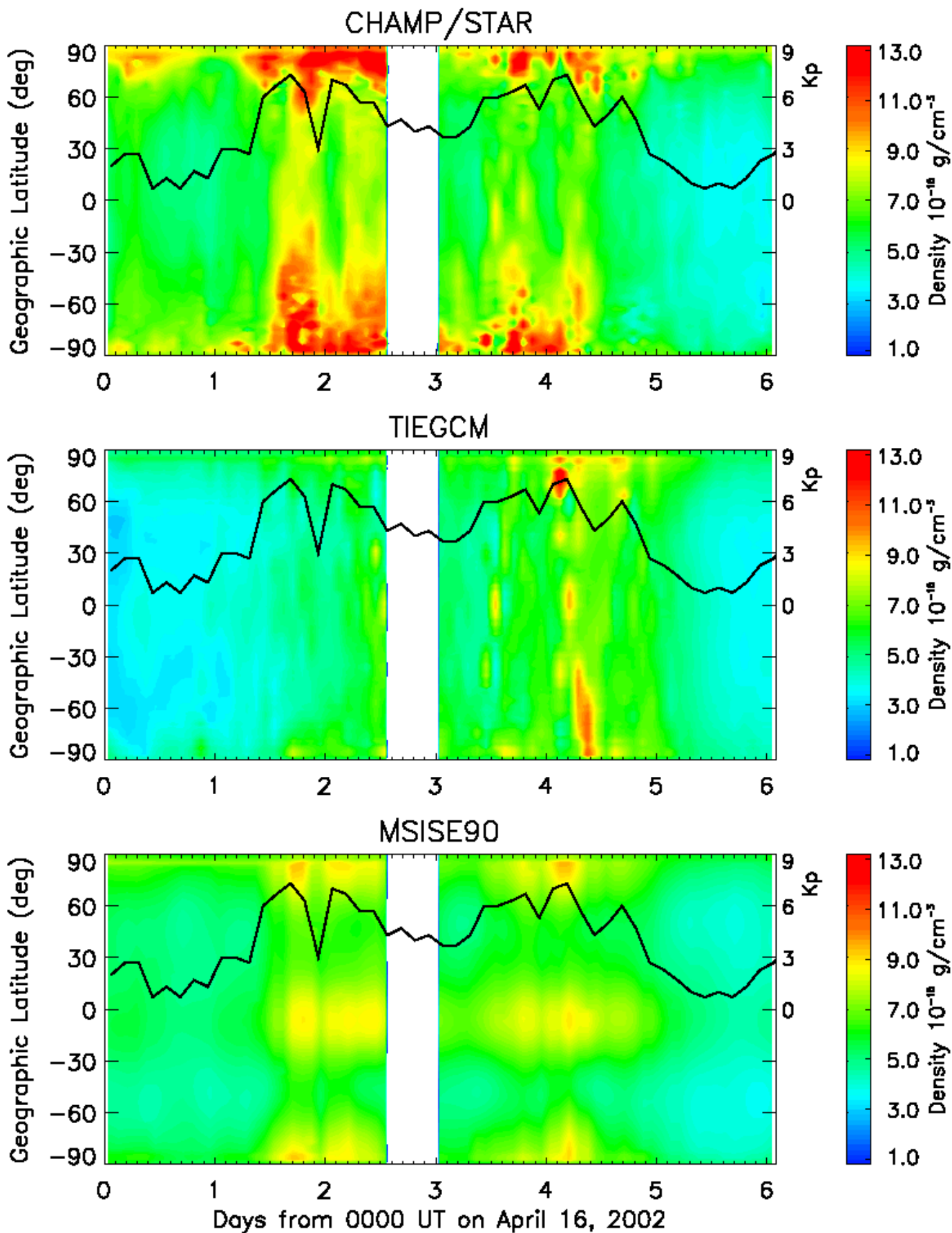
CHAMP density at 400Km, Ascending (LST~24:00)

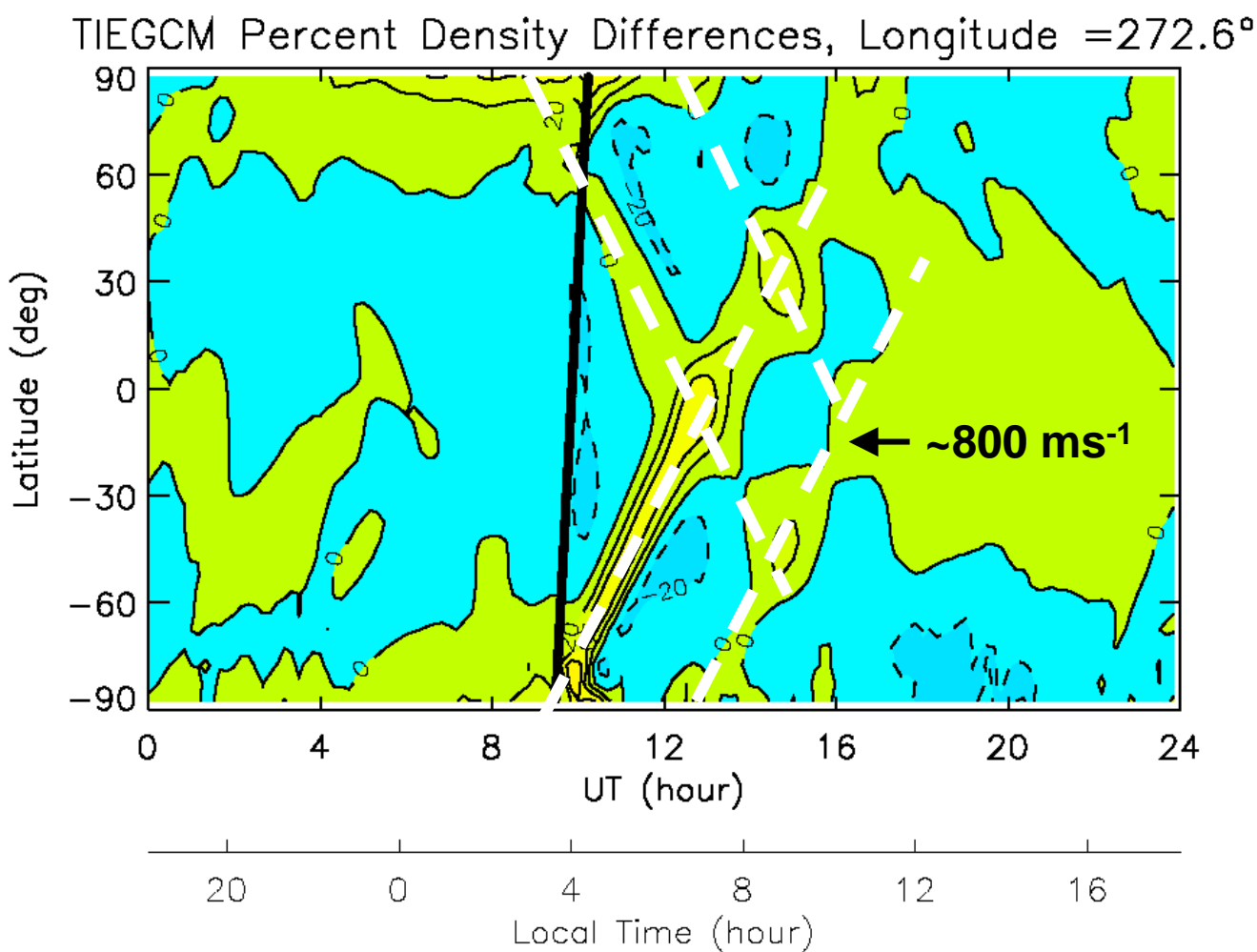
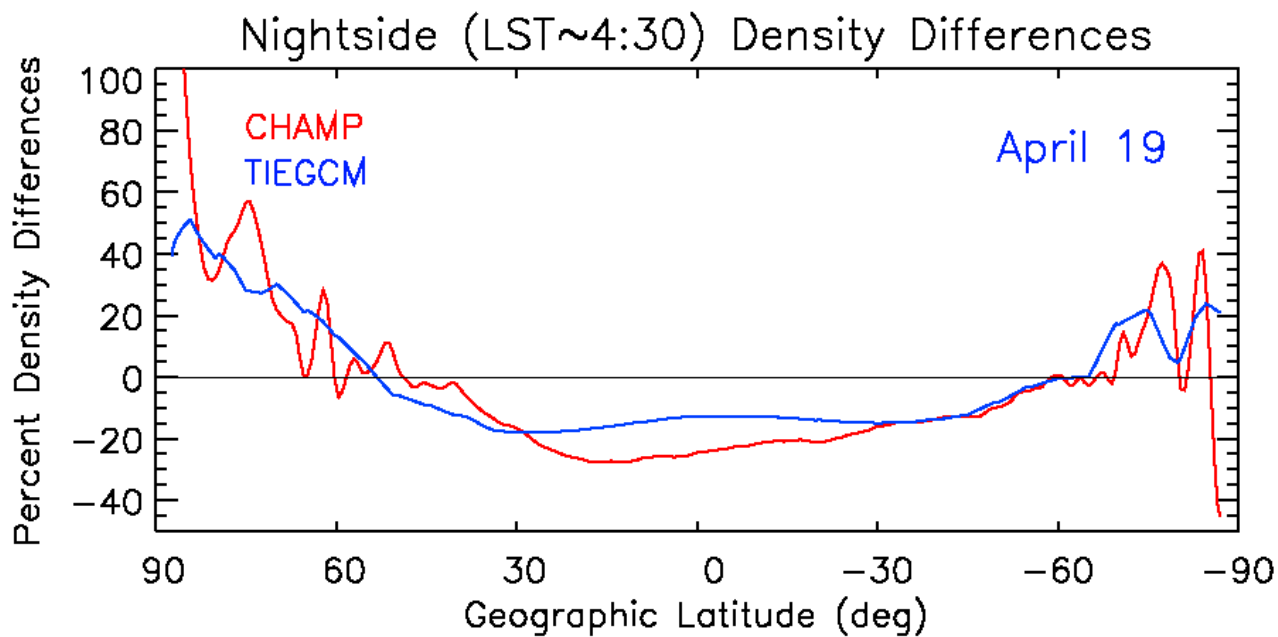


Wave Structures from the CHAMP/STAR Accelerometer
324, 2003, Night Time

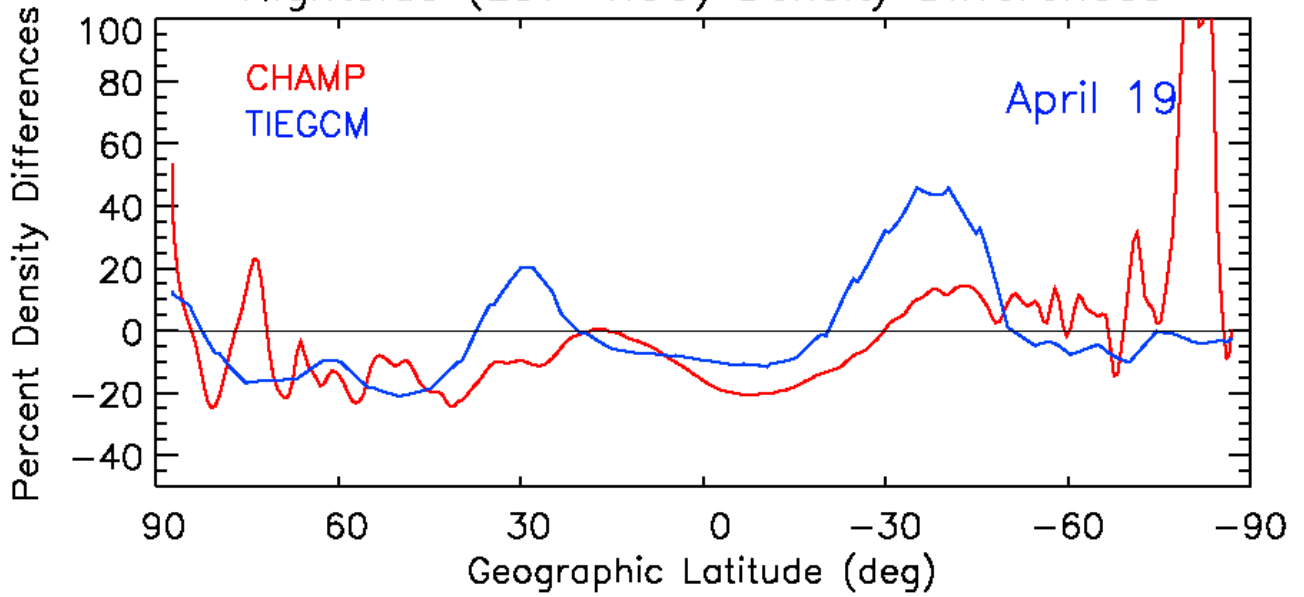


Total Mass Densities at 410 Km, Nightside: $\overline{LST}=04:36$

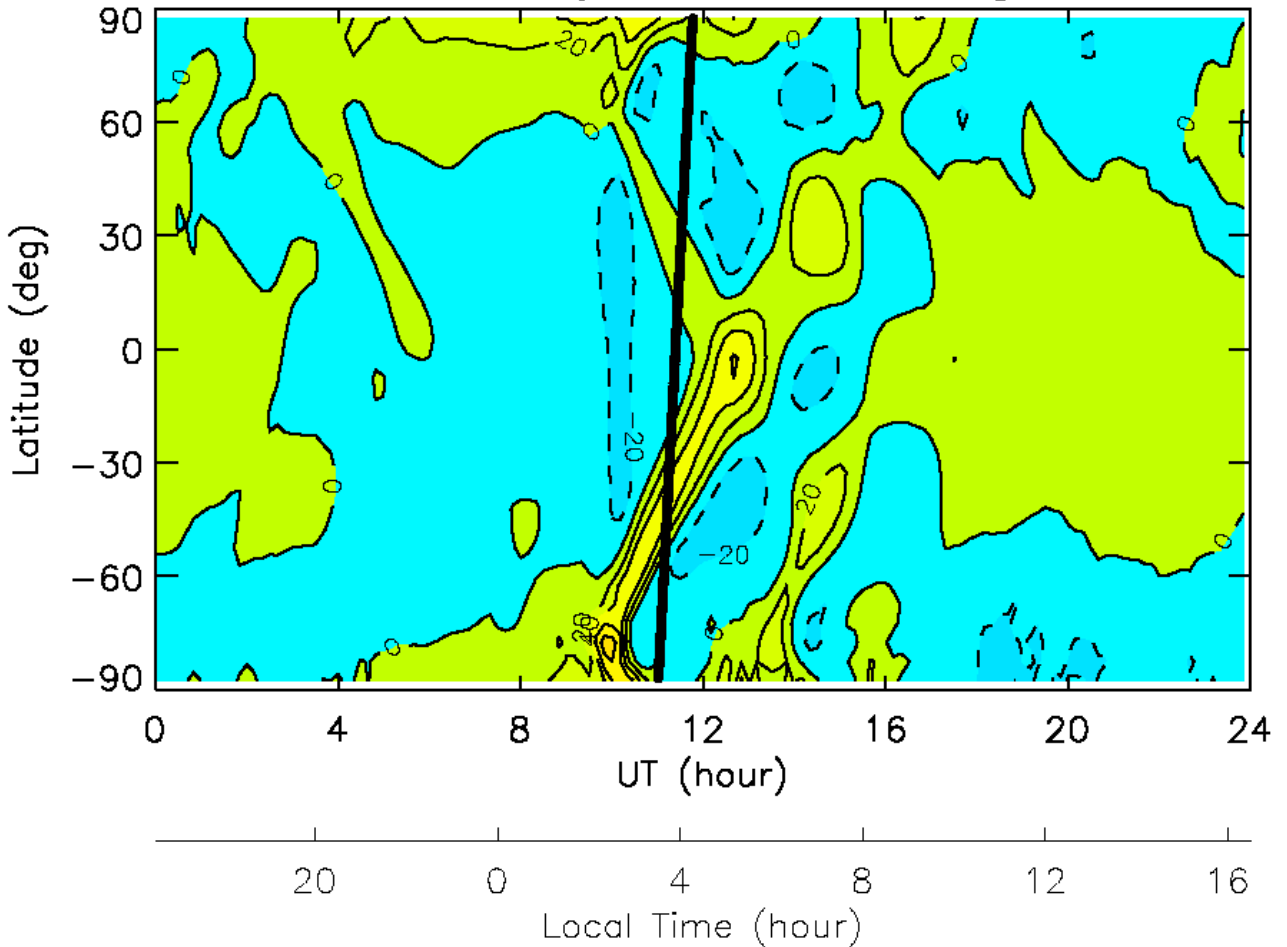




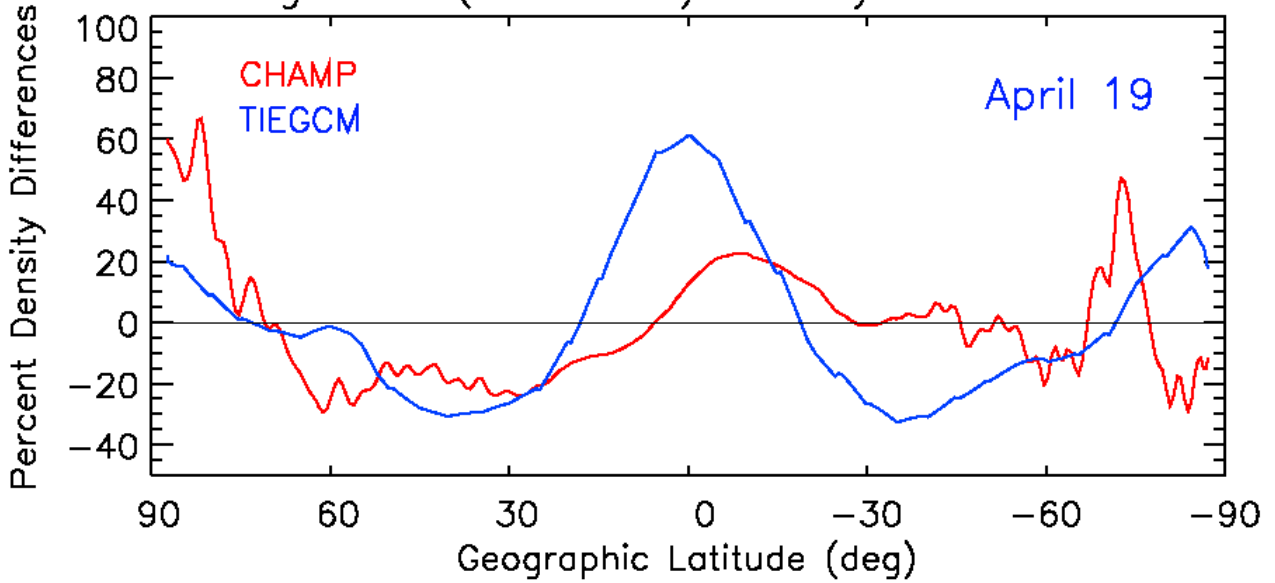
Nightside (LST~4:30) Density Differences



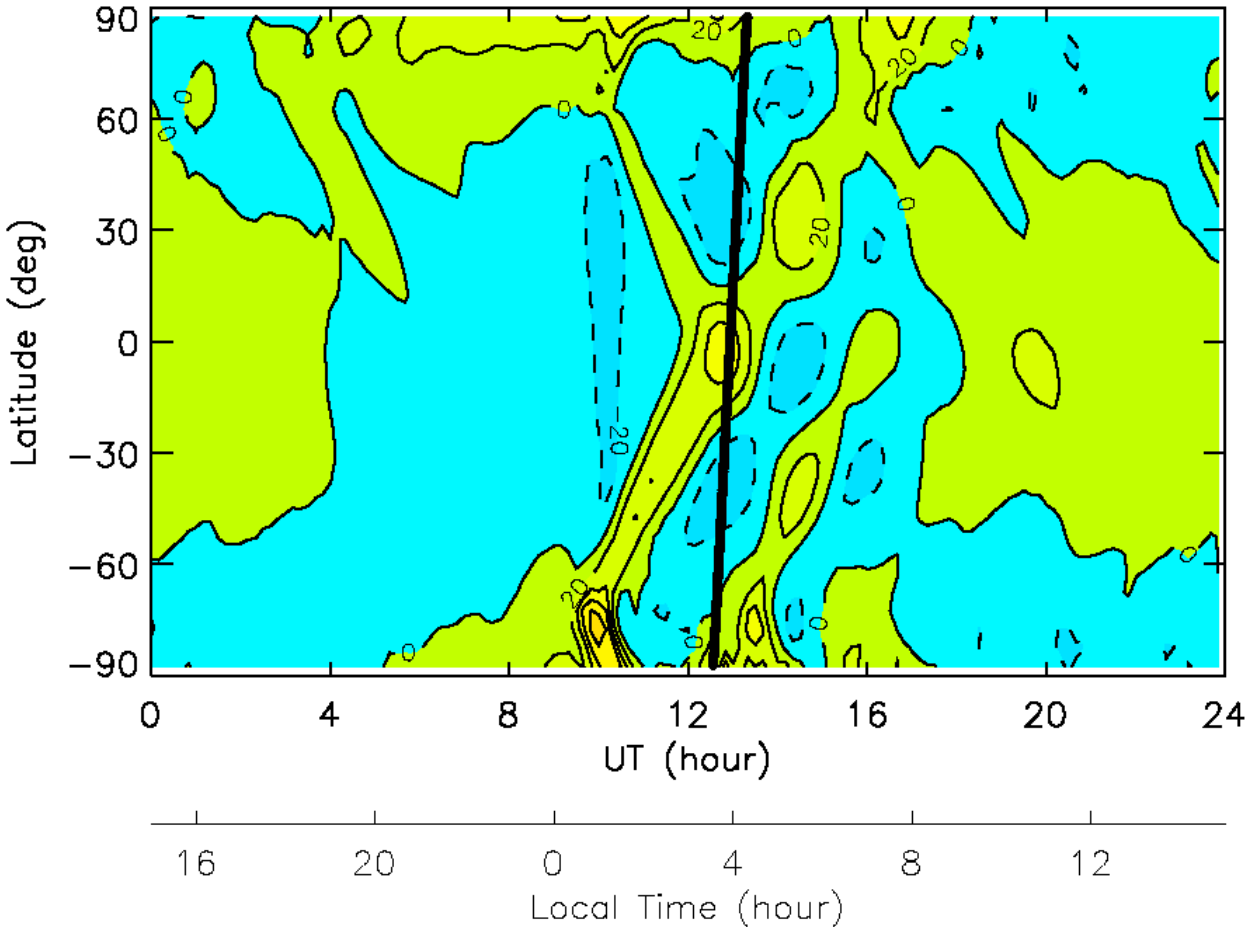
TIEGCM Percent Density Differences, Longitude = 249.3°



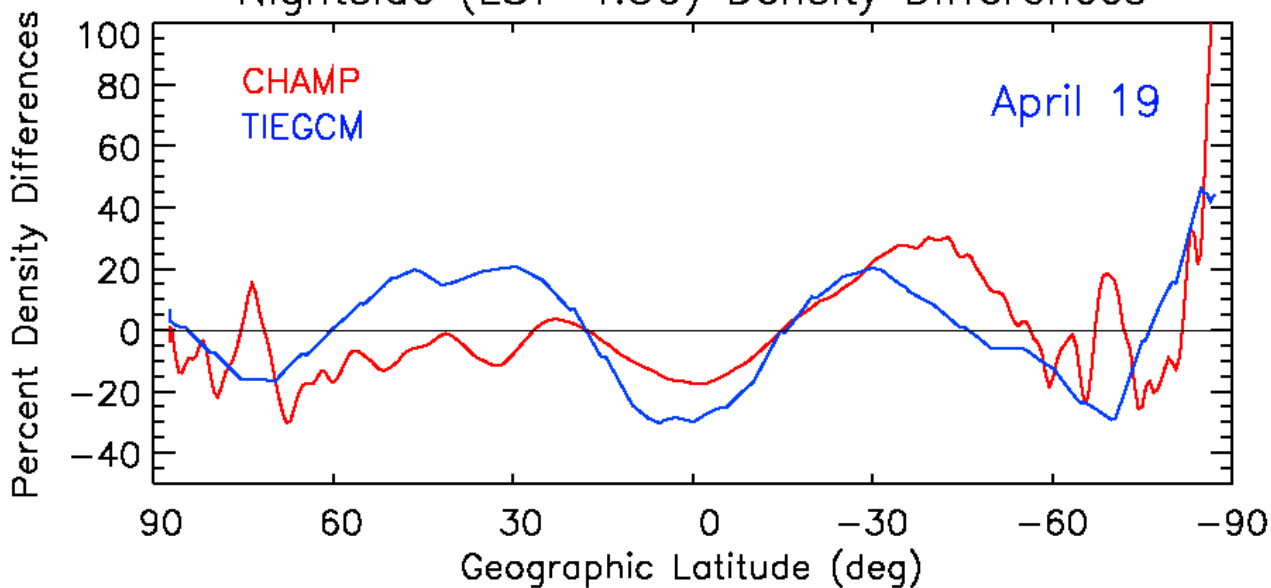
Nightside (LST~4:30) Density Differences



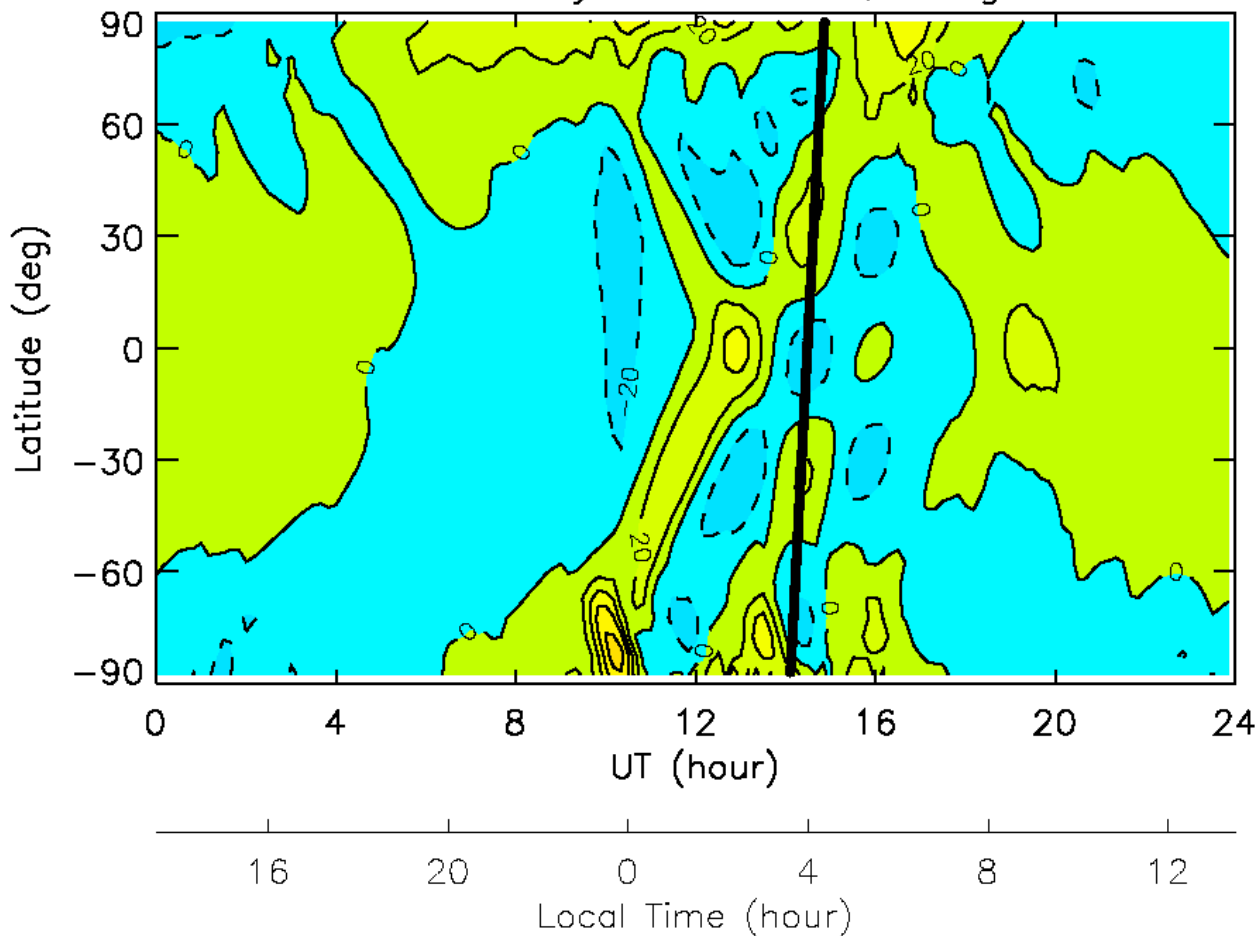
TIEGCM Percent Density Differences, Longitude = 226.1°



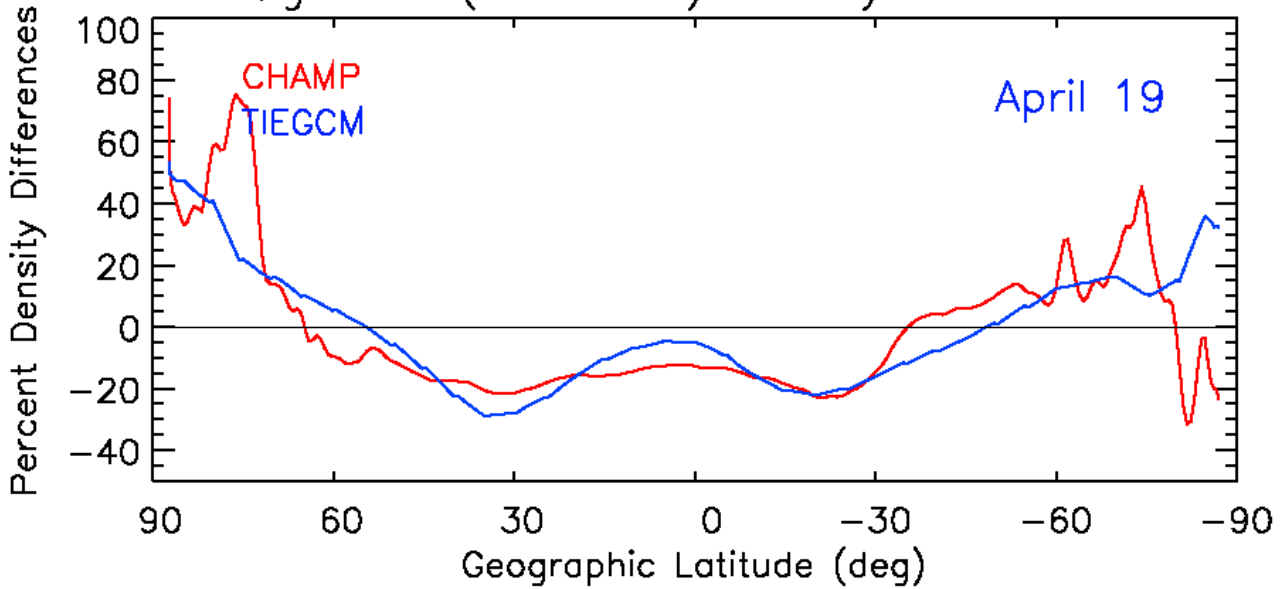
Nightside (LST~4:30) Density Differences



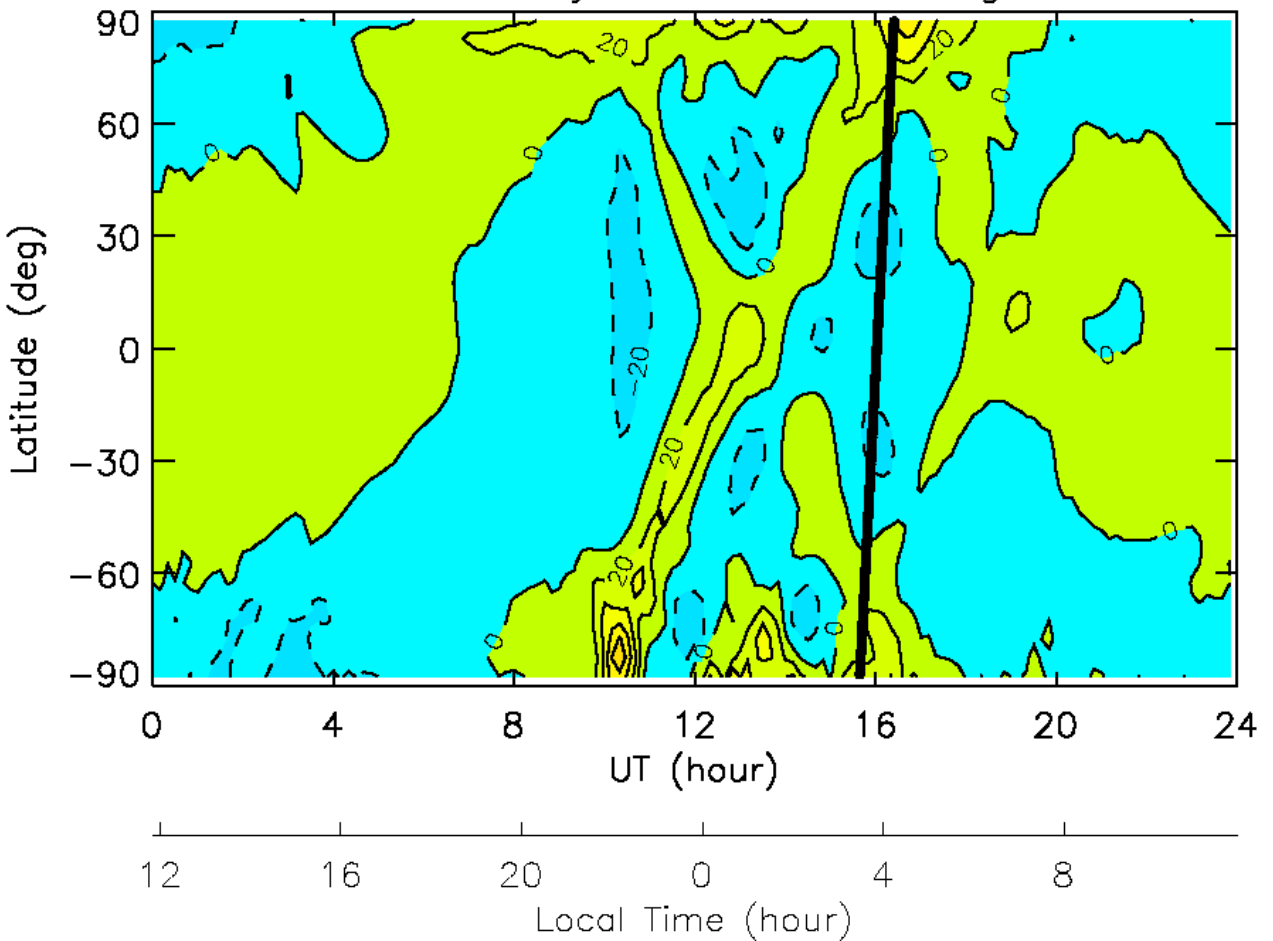
TIEGCM Percent Density Differences, Longitude = 202.8°

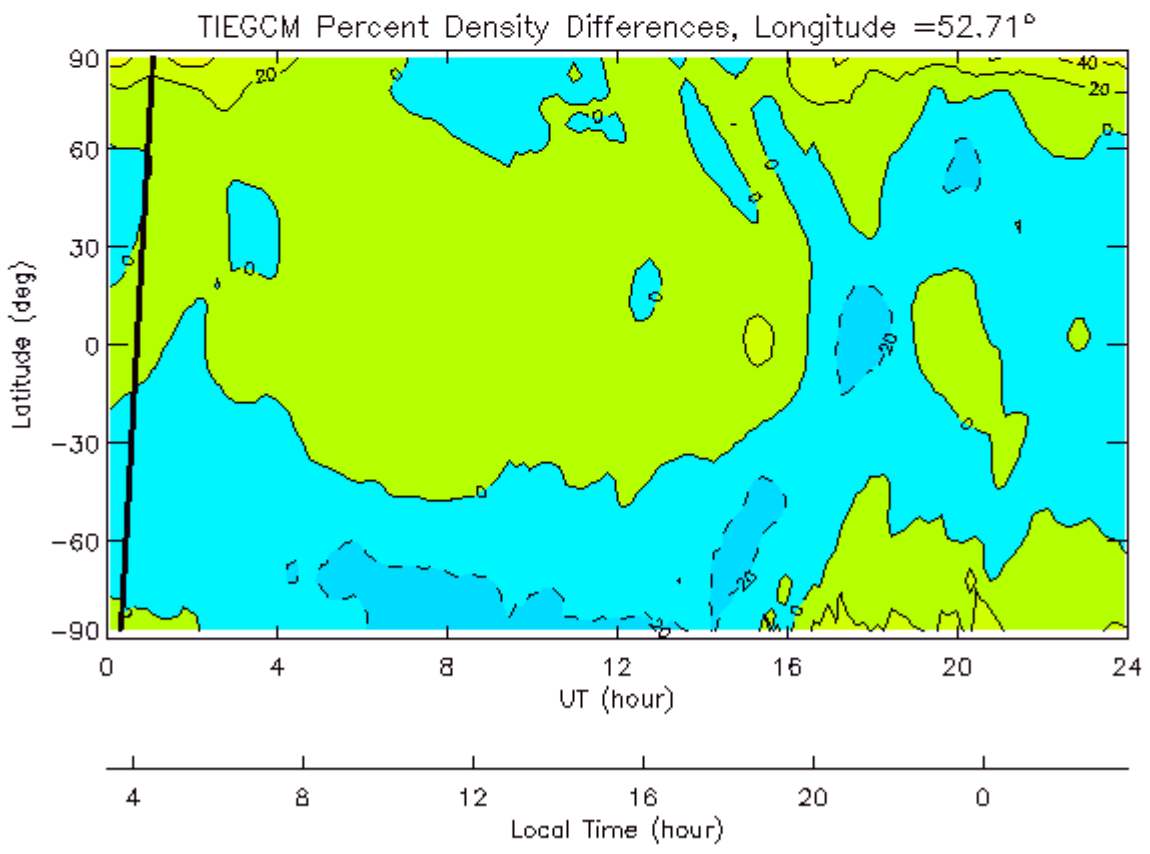
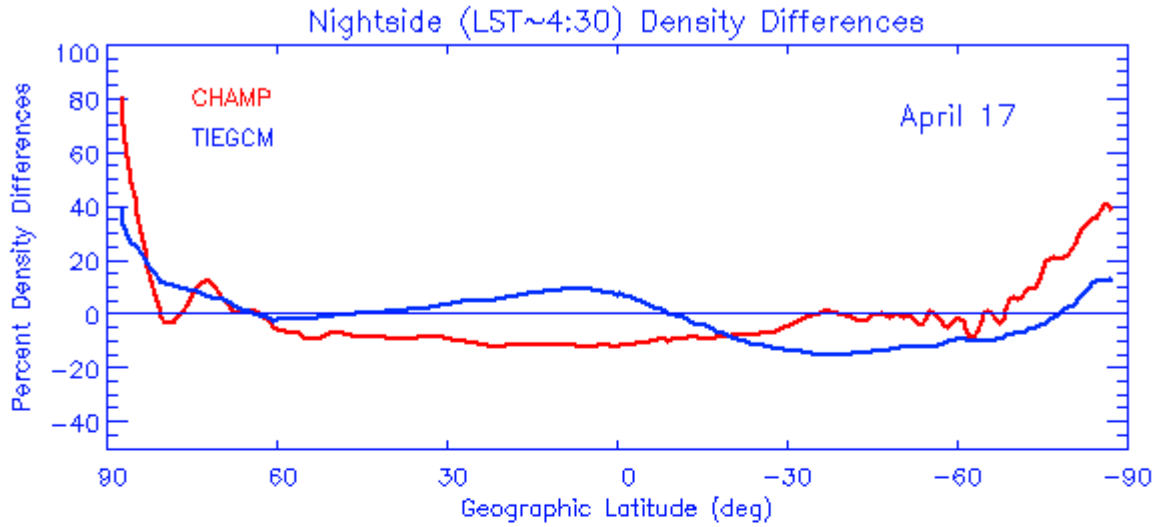


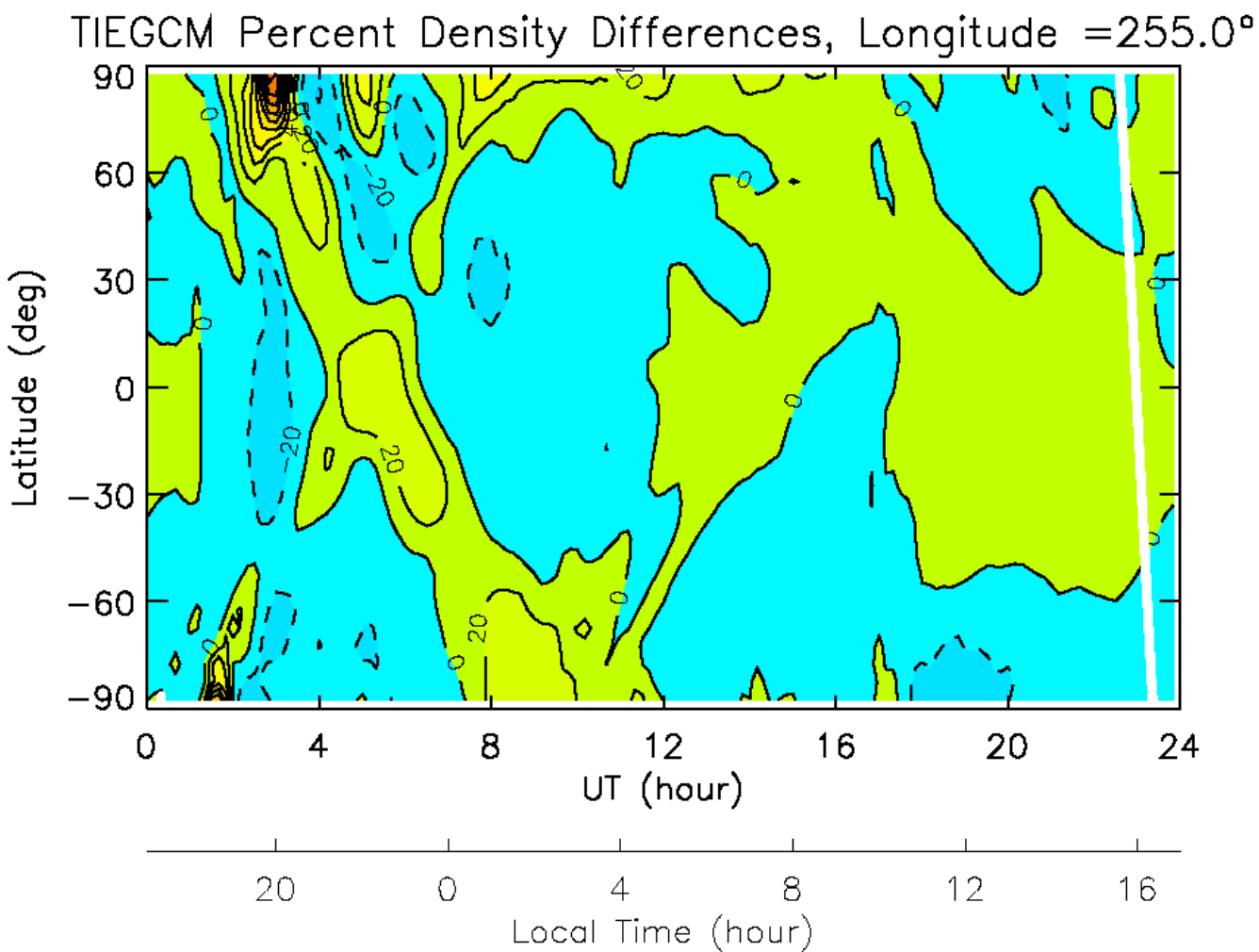
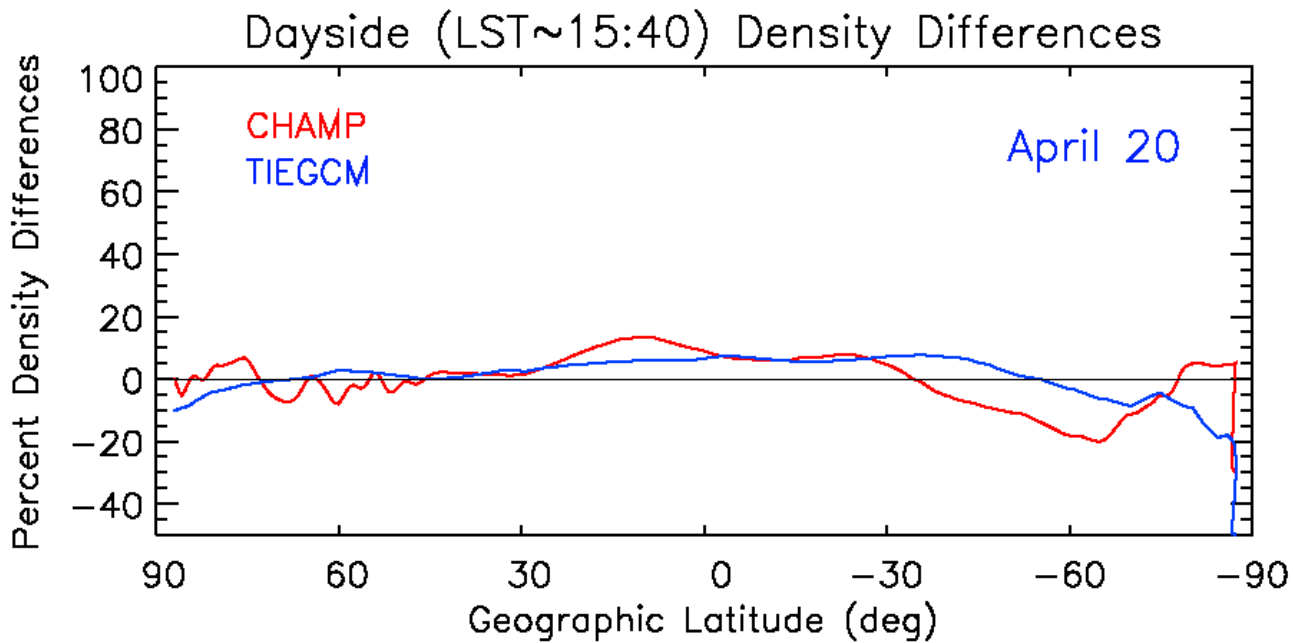
Nightside (LST~4:30) Density Differences



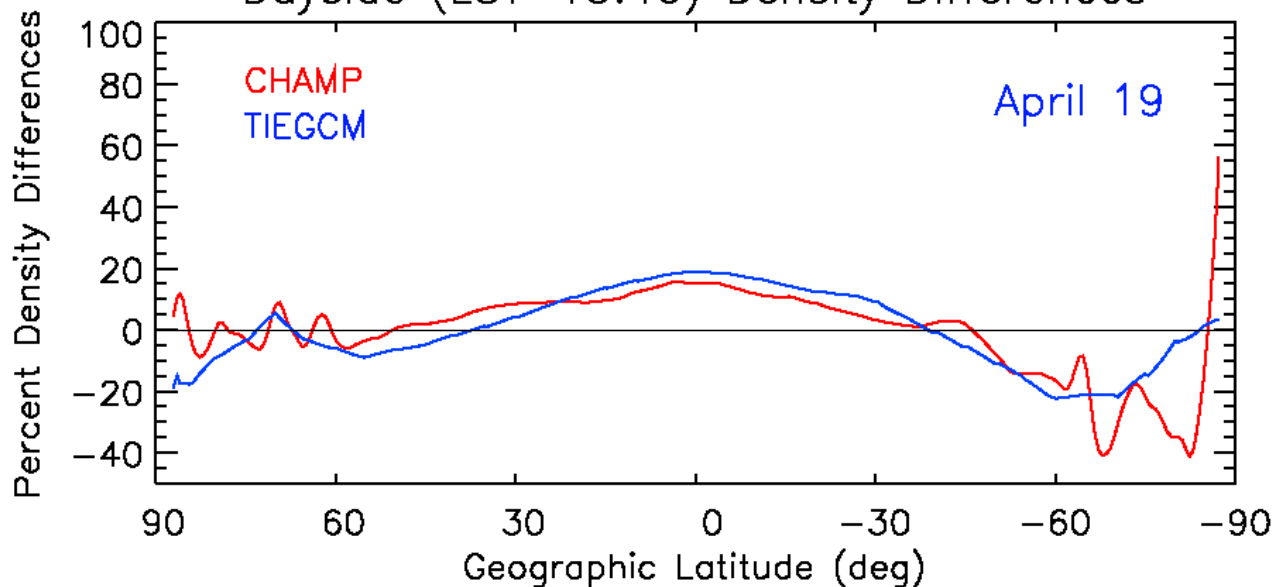
TIEGCM Percent Density Differences, Longitude = 179.6°



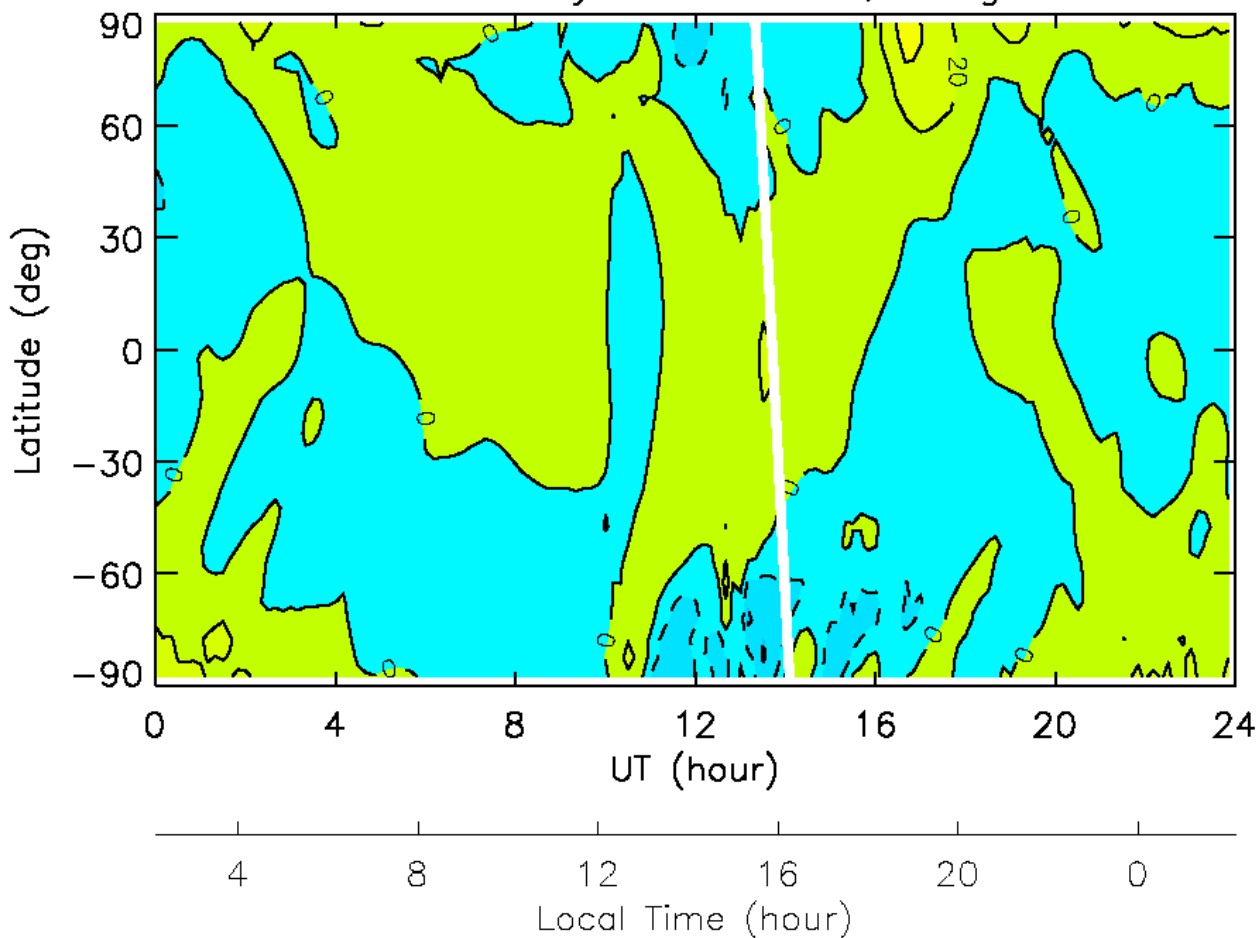


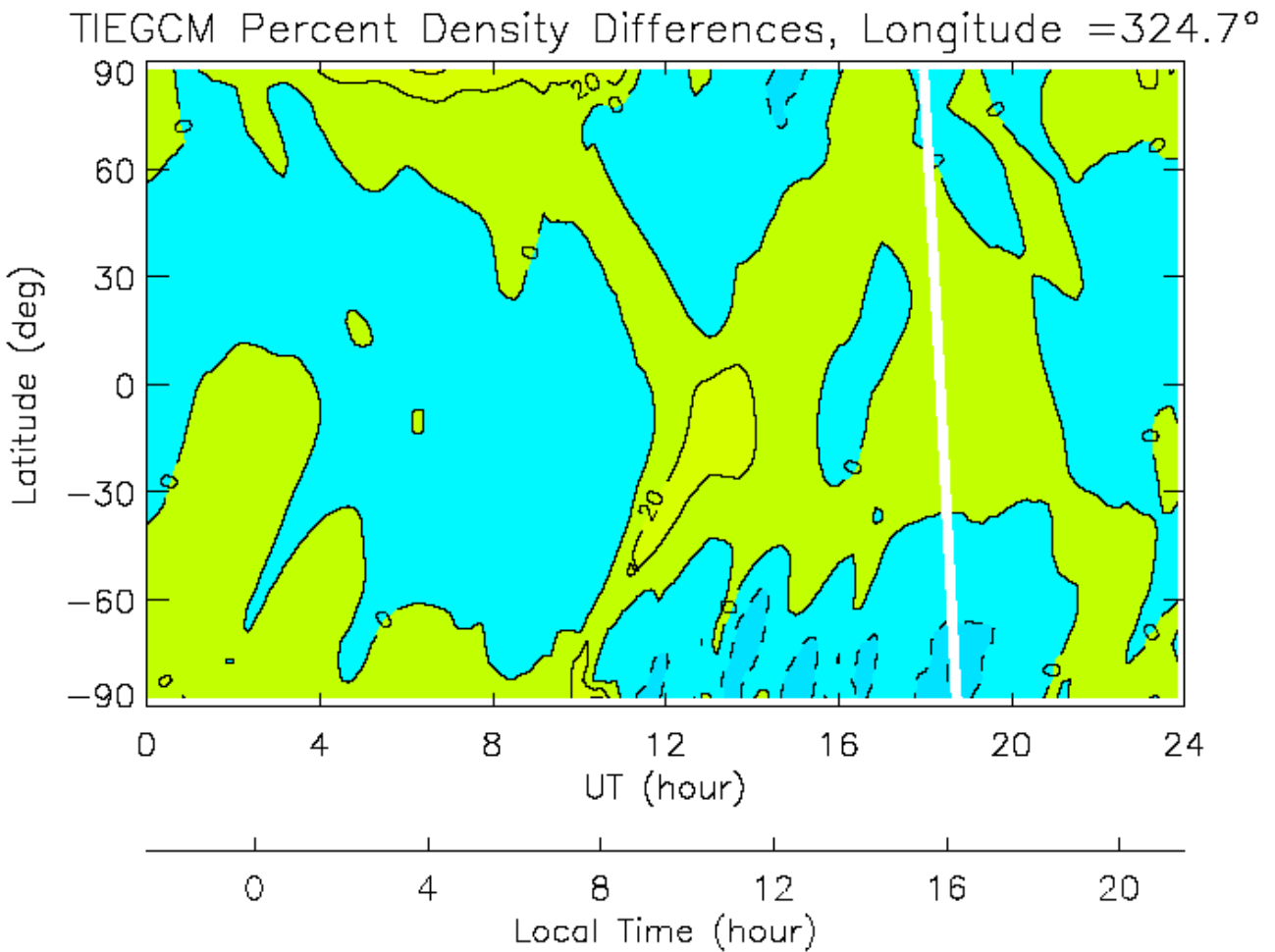
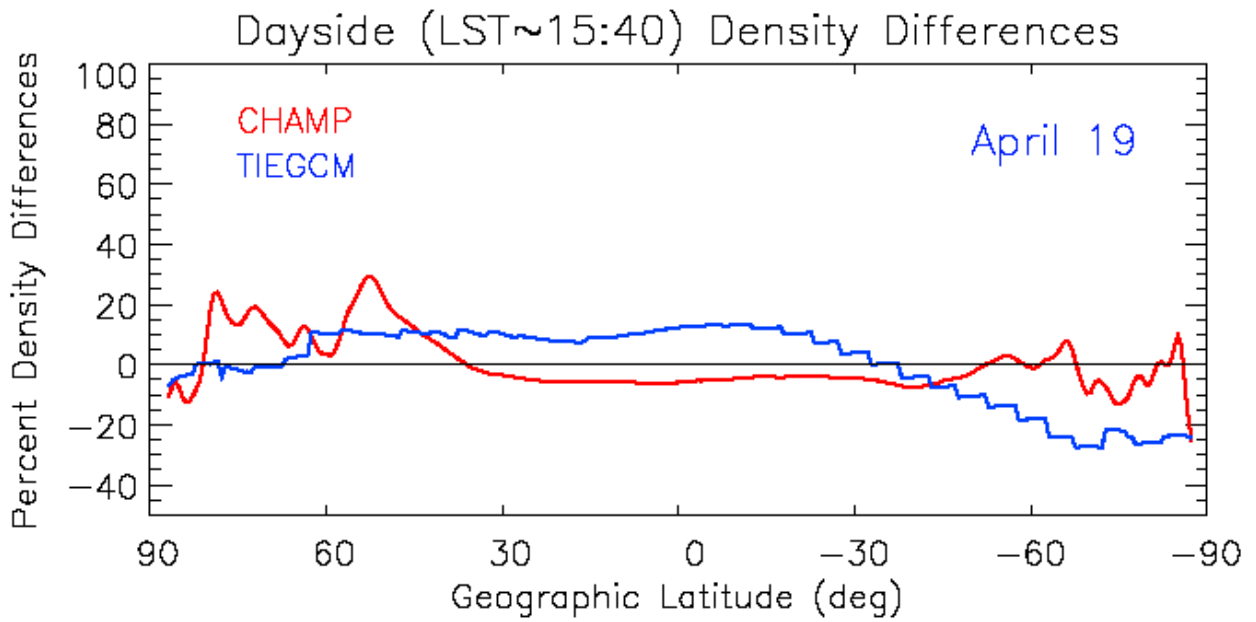


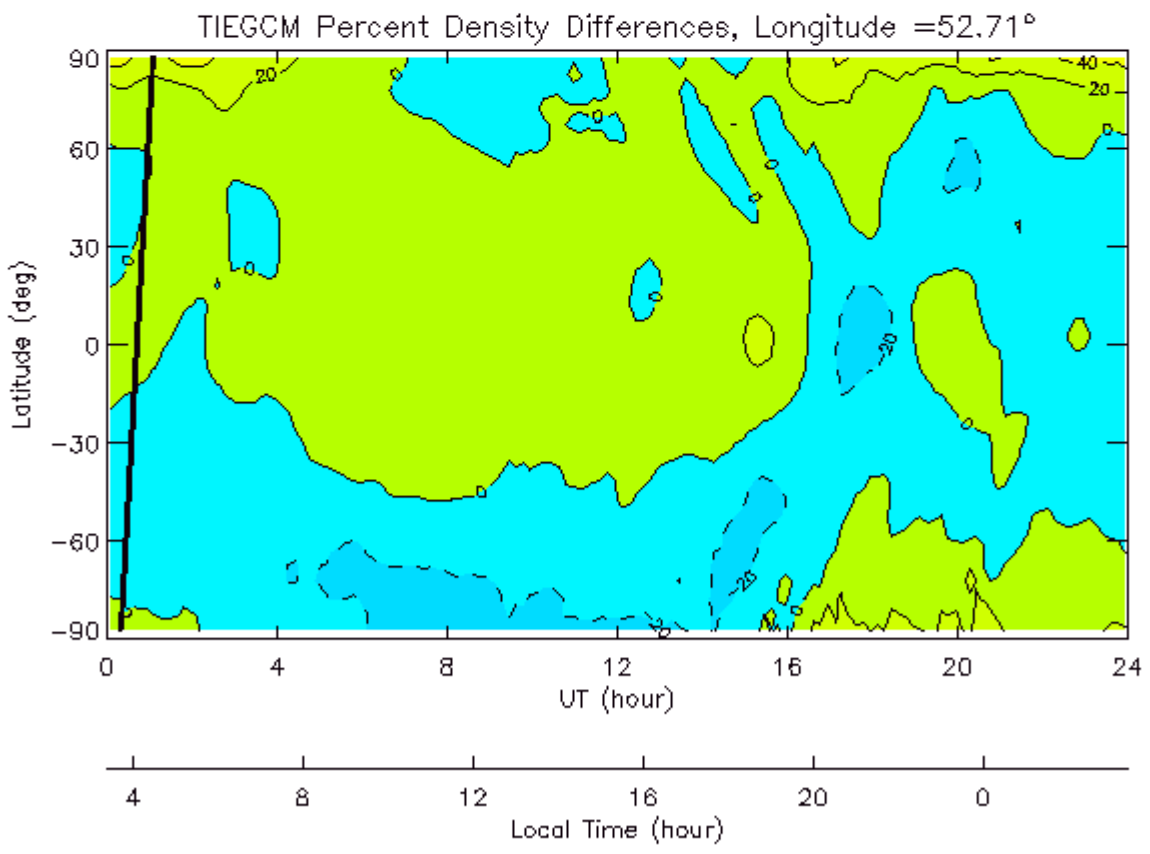
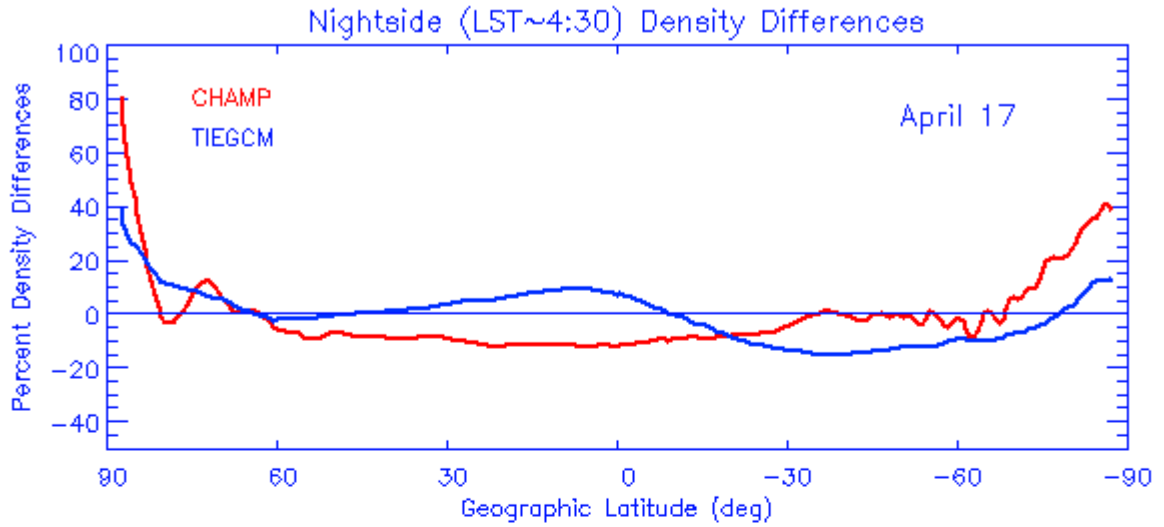
Dayside (LST~15:40) Density Differences



TIEGCM Percent Density Differences, Longitude = 34.48°







General Conclusions and Observations

- *Density perturbations near 410 km due to geomagnetic disturbances can approach 400%.*
- *The effects are global, but differ between day and night.*
- *To what extent is the response dependent on pre-conditioning or specific properties of the solar wind?*
- *Empirical models underestimate the density response.*
- *Waves and large-scale traveling atmospheric disturbances comprise an important component of the thermospheric response:*
 - *The TADs bear similarity with those simulated in the TIEGCM.*
 - *To what extent are net momentum and heat transported by the waves?*

Future Efforts

- *Relate density response characteristics to specific properties of the solar wind, i.e., epsilon parameter, dynamic pressure, B_z/B_y , etc. (many storms). Is a predictive capability possible?*
- *Quantify the wave characteristics -- spectra, variances, etc.*
- *Neutral winds from the cross-track accelerometer.*