Analysis of the Equatorial Theromosphere Anomaly Using Dusk-Time GOCE Orbit Data

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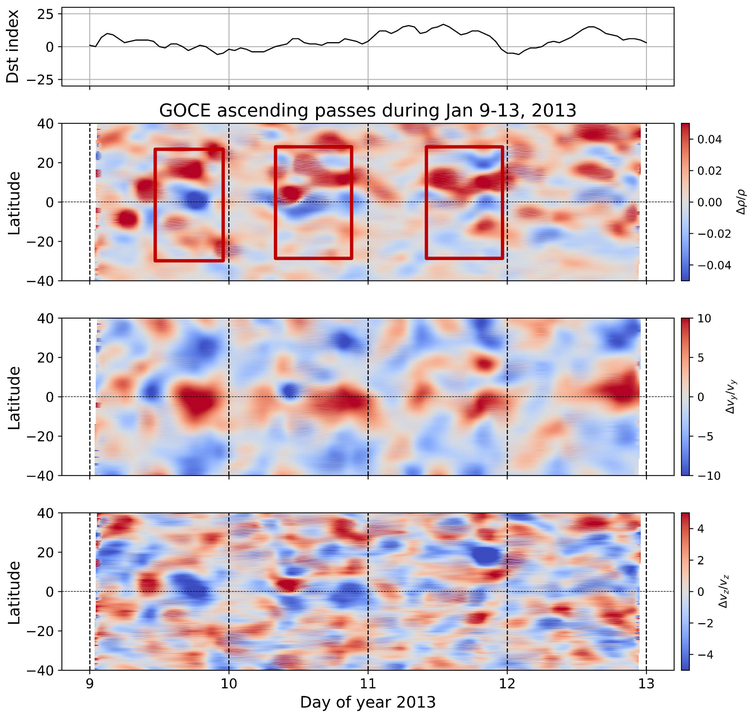
Introduction

- The Equatorial Thermosphere Anomaly (ETA) is characterized by neutral density crests at $15^\circ - 20^\circ$ magnetic latitude at each hemisphere and a density trough at the equator.
- These density variations associated with ETA can cause a significant impact on satellite drag and provide insights into I-T coupling at low latitudes.
- **In this study, we identify ETA peaks by analyzing accelerometer-derived neutral density data along the dusk-side orbits of the Gravity field and Ocean Circulation Explorer (GOCE) satellite.**
- The seasonal and longitudinal distributions of the ETA peaks have been analyzed using GOCE density data from 2010 to 2013.

GOCE Density Data on Jan 7-12, 2013

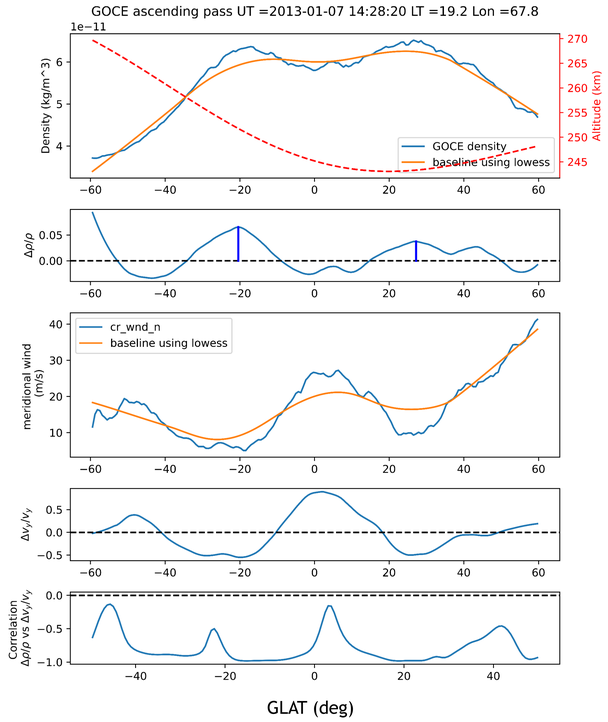
- **Thermosphere anomaly cases are observed in GOCE dusk-side passes during January 9-13, 2013, as shown below.**



- Mean altitude = 258 km, Local time ≈ 17:00.
- Anomaly peaks are observed at $15^\circ - 20^\circ$ geographic latitudes on each hemisphere, mostly in the South American sector (2nd panel).
- Higher velocity of meridional wind at the density trough locations (3rd panel).
- Variations in the vertical wind velocity at low latitudes are correlated with ETA density structures (4th panel).

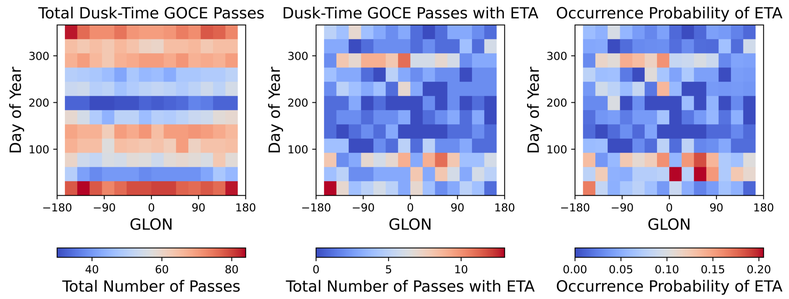
Detection of Neutral Anomalies in GOCE Data

- Days with absolute DsT index value < 30 are selected.
- The density data (ρ) is detrended using a Locally Weighted Scatterplot Smoothing (LOWESS) method. **An example case is shown below.**



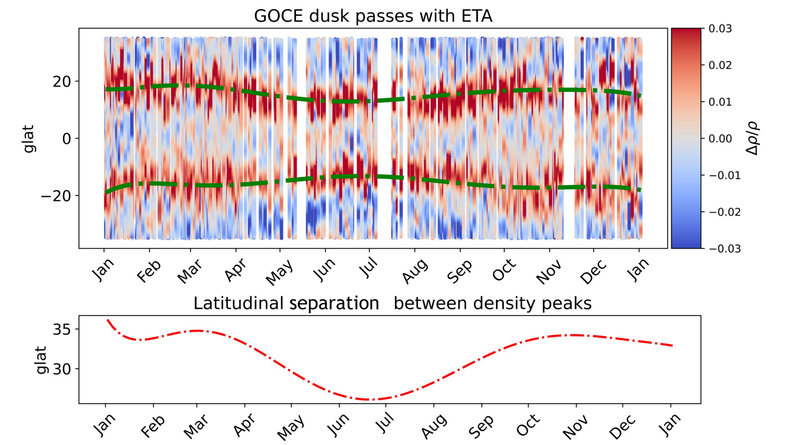
- The passes with density peaks with perturbation $(\Delta\rho)$ > 3% wrt background at both hemispheres, located between $10^\circ - 25^\circ$ glat are identified as passes with ETA (1st panel (ρ) and 2nd panel $(\Delta\rho/\rho)$).
- The detrending for the meridional wind velocity (v_y) here uses a degree 3 polynomial (3rd panel (v_y) and 4th panel $(\Delta v_y/v_y)$).
- A strong anti-correlation between density and meridional wind velocity is observed in most cases (5th panel).
- **GOCE ascending passes during 2010-2013 are analyzed using this detection process to find the longitudinal and seasonal distribution of ETA peaks. 520 passes were identified with ETA.**

Longitudinal and Seasonal Dependence



$$\textit{Occurrence probability} = \frac{number\ of\ passes\ with\ ETA}{total\ number\ of\ passes}$$

- Maximum ETA occurrence observed during the equinoxes, lowest occurrence during northern summer (June-July).
- Higher ETA occurrence in African sector (0° to 75° lon) during March equinox and in South Atlantic/American sector (-60° to -85° lon) during September equinox.



- **1st panel:** Perturbation density over background $(\Delta\rho/\rho)$ plotted for all selected passes with ETA from 2010-2013 wrt day of year.
- **2nd panel:** The latitudinal separation between the density peaks is highest during the equinoxes (up to 35° glat) while its lowest during northern summer ($\sim 25^\circ$ glat).

CONCLUSION

1. Analyzing GOCE dusk-time passes from 2010 to 2013 reveals occurrences of the equatorial thermosphere anomaly at 250-270 km, highlighting the significant role of meridional and vertical neutral winds.
2. The seasonal variation in ETA occurrence and the location of density peaks resemble EIAs, suggesting that ETA formation depends on ion-neutral drag from low-latitude vertical ion drift.
3. Further model-based studies are required to understand the role of ion drift and neutral winds in the formation of ETA structures.

CONTACT

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