Quiet-time variability of the ionosphere and thermosphere using data from GOLD and ICON

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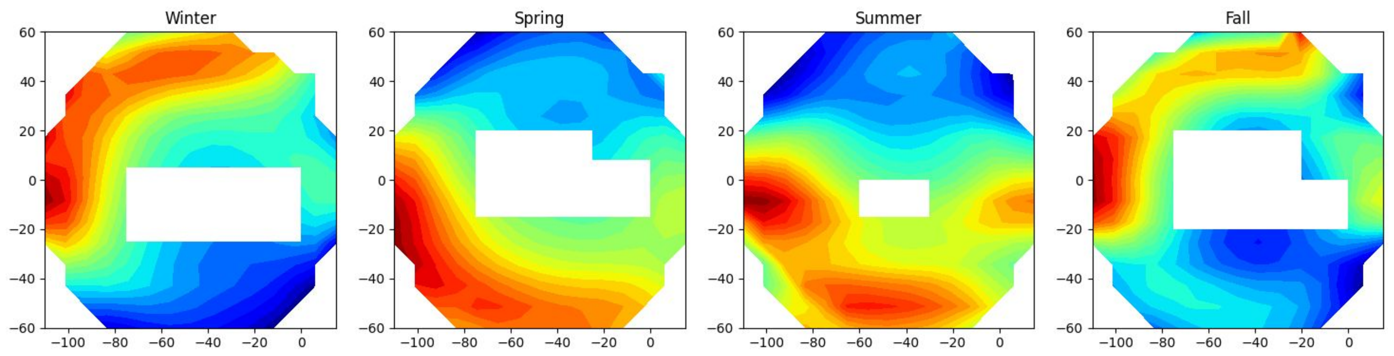
Introduction

During quiet times, large scale atmospheric waves propagating from below and in-situ generated tides dictate variability in the ionosphere-thermosphere (IT) environment. In order to characterize the role that these forcings play in IT variability, we study the properties of the IT region during quiet times when lower atmosphere forcing should be dominant over solar geomagnetic forcing. We use data from the Global-scale Observations of the Limb and Disk (GOLD) and the Ionospheric Connection Explorer (ICON) satellites to characterize the quiet-time (Kp < 2.7) variability of the IT environment. We find strong seasonal, longitudinal, and local time dependencies in short- and long-term IT variability.

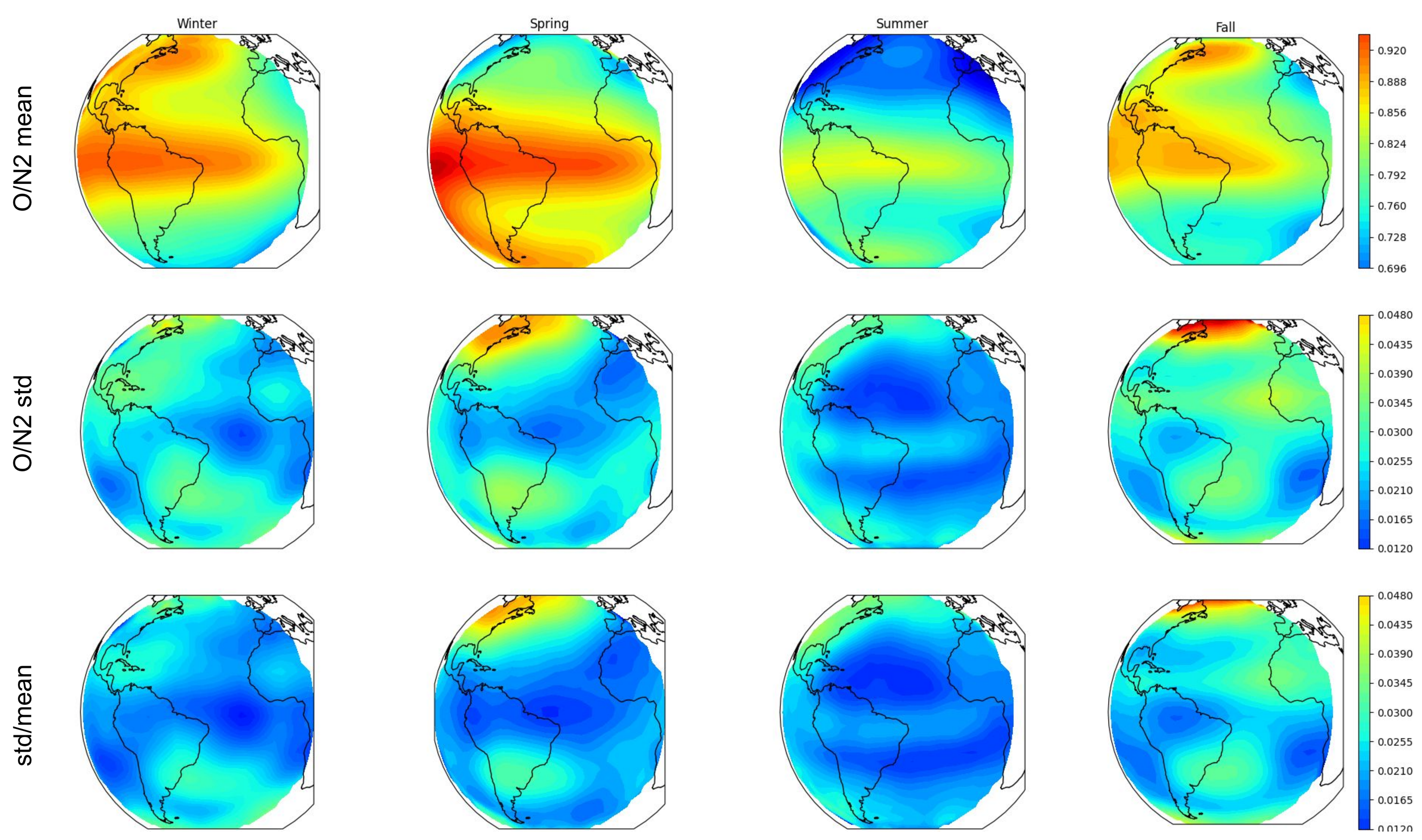
O/N2 Global Distribution

We use data from 2020 quiet time conditions at UT ~14:30 - 15:00. We define quiet conditions as days with Kp < 2.7 and the two days following a storm day. We also omit DOY 78 to 86 and 222 to 226 account for recalibration events.



- Figure 1: global quiet time, mean global O/N2 distribution observed by GOLD. Data quality is low at the equator as a result of a latitudinal bias which arises from issues with flat field corrections in GOLD.
- The hemispheric distribution of O/N2 is consistent with observations made by GUVI (e.g. Luan et al, 2017)

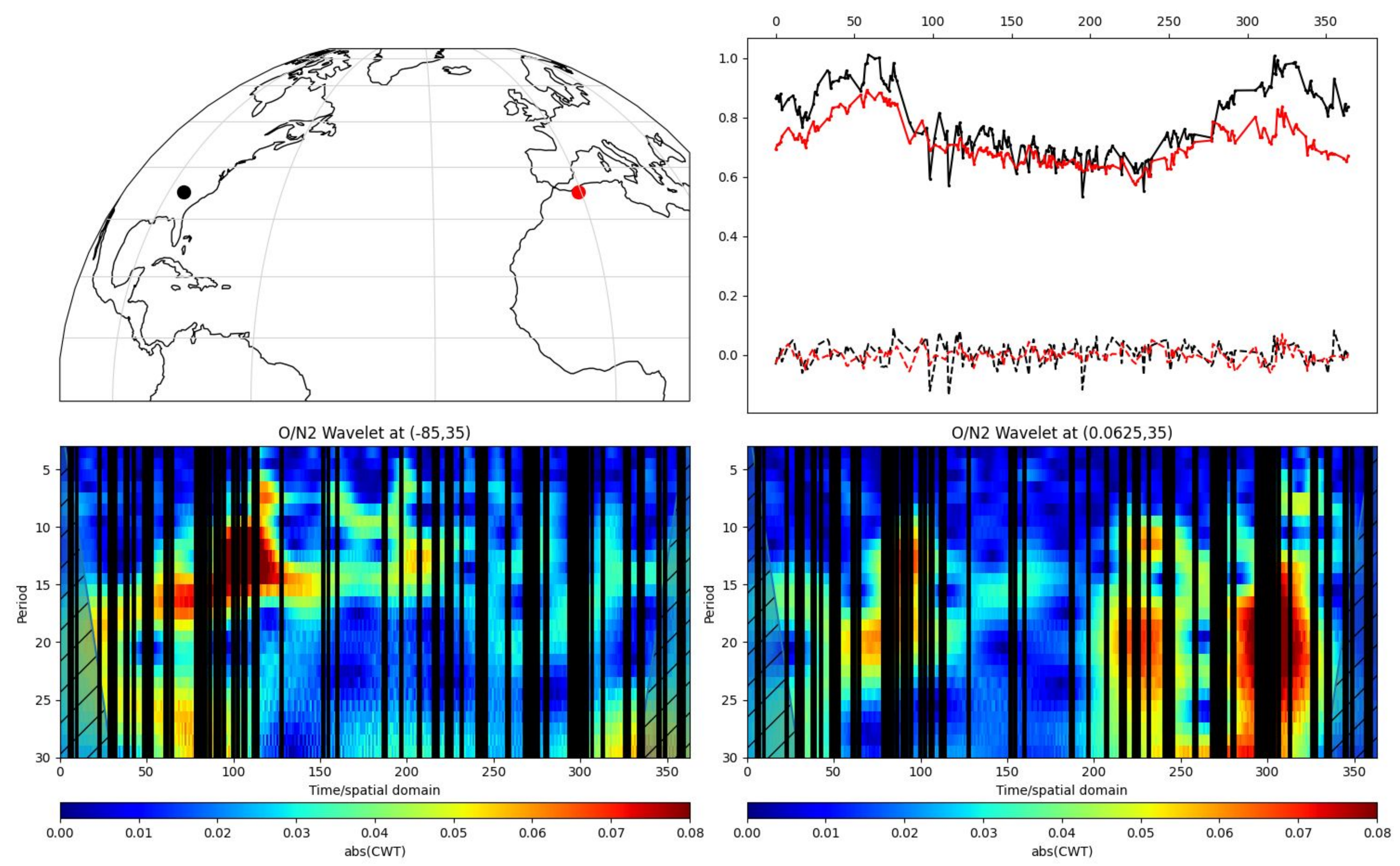
O/N2 Global Variability



- First row of figure 2: mean global mean O/N2 distribution with a higher uncertainty threshold than that of figure 1.
- Second row: absolute standard deviation of O/N2 as a proxy for variability. Standard deviations are calculated after fitting and subtracting annual and semi-annual harmonics to account for the detector's latitude bias.
- Third row: the relative standard deviation.

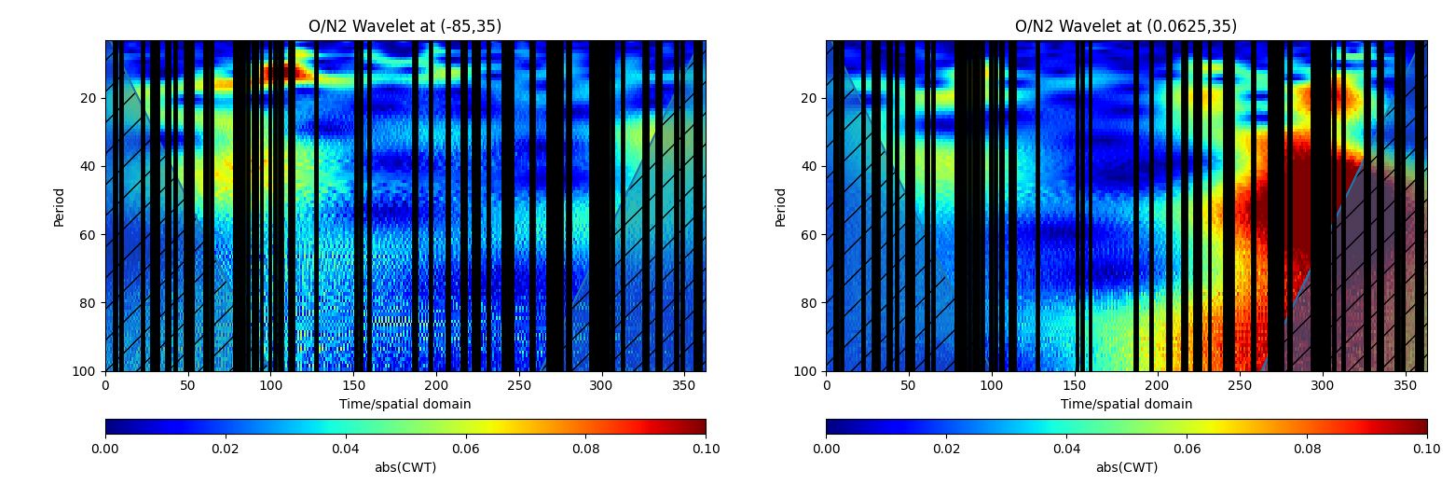
- Mean O/N2 peaks at high latitudes in winter hemispheres and is minimum at high latitudes in summer hemispheres.
- O/N2 variability peaks at high and mid latitudes in both winter and summer hemispheres
- Enhanced variability near the South Atlantic Anomaly

O/N2 Global Variability (cont.)



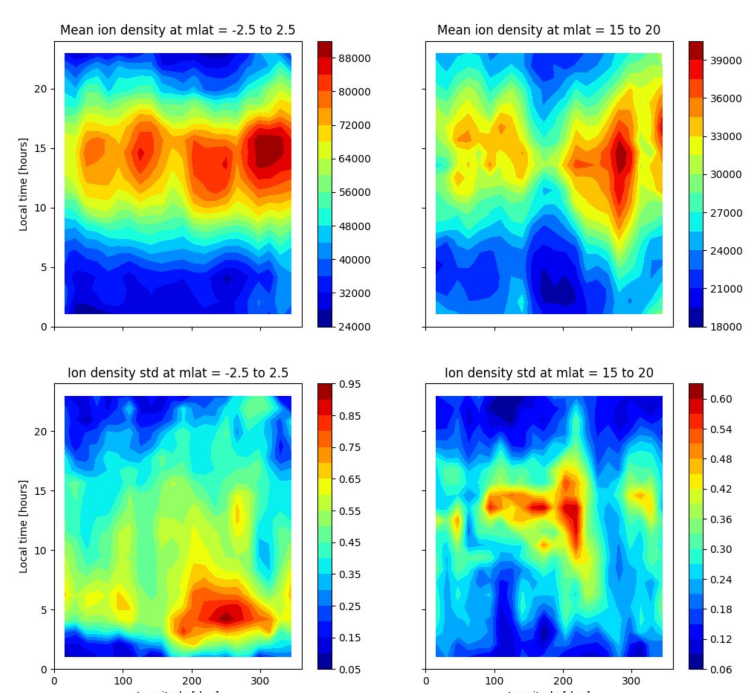
- Figure 3: raw, quiet time O/N2 before (solid lines in the upper right panel) and after annual and semi-annual fit subtraction for a point inside (black) and outside (red) the high O/N2 region seen in Figures 1 and 2.
- Bottom two panels: wavelets at the corresponding regions, with storm days blacked out.

- O/N2 longitudinal structure: persistently higher near the winter hemisphere nighttime terminator
- Stronger, short-term (5 - 10 day) variability in the region with higher O/N2

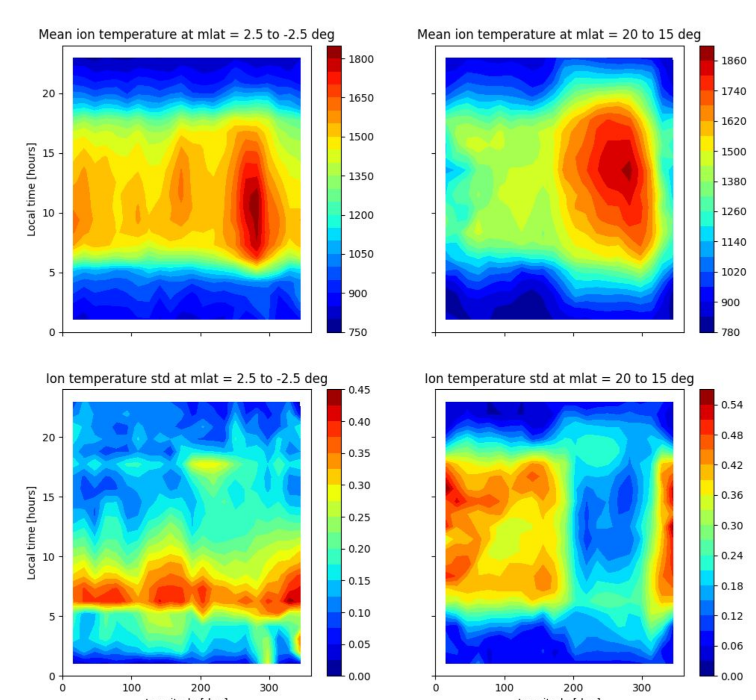


- Figure 4: a "zoom out" Figure 3

Ion Density and Temperature Variability

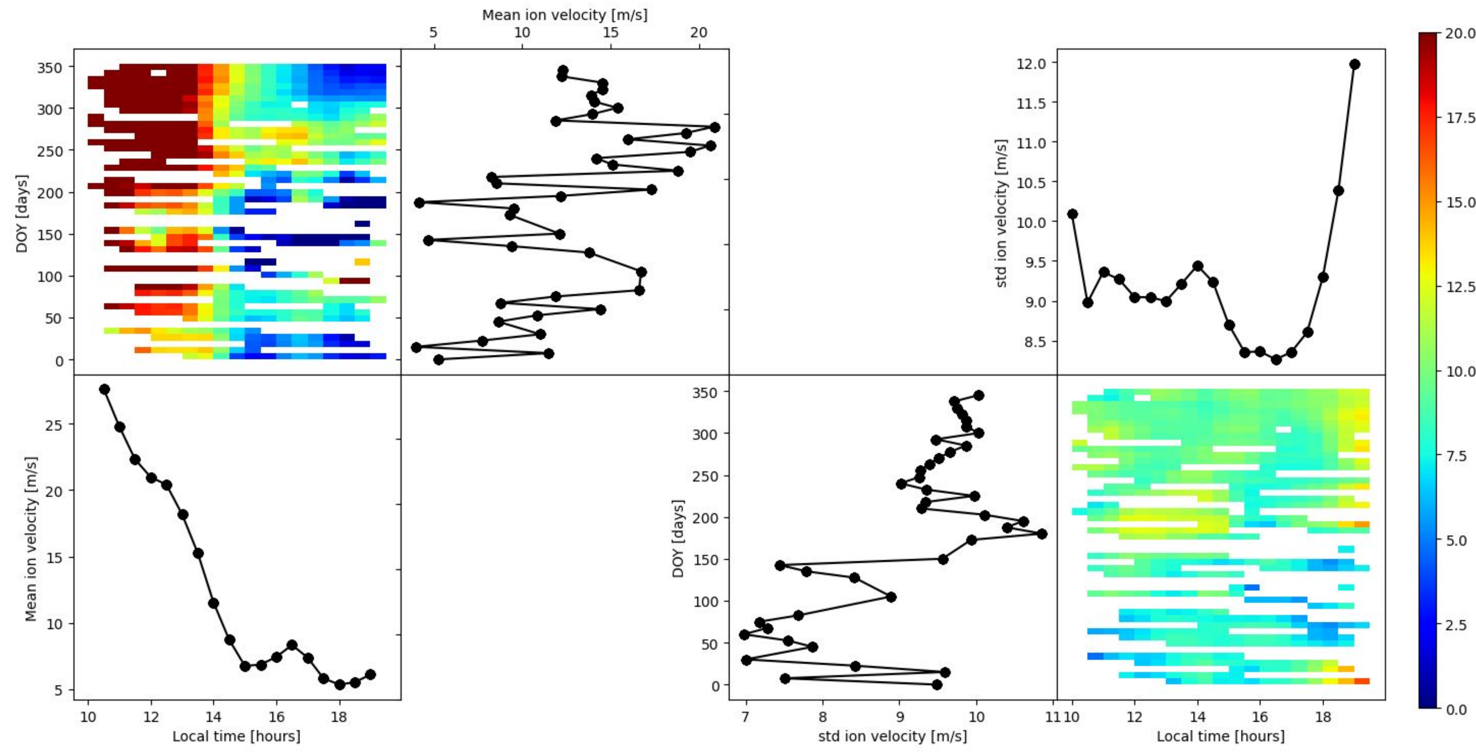


- Figure 5: mean, equatorial ion density and the variability of ion density.
- Clear wave 4 structure in ion density at the equator
- Contributions from other wave numbers distort the wave structure at higher latitudes

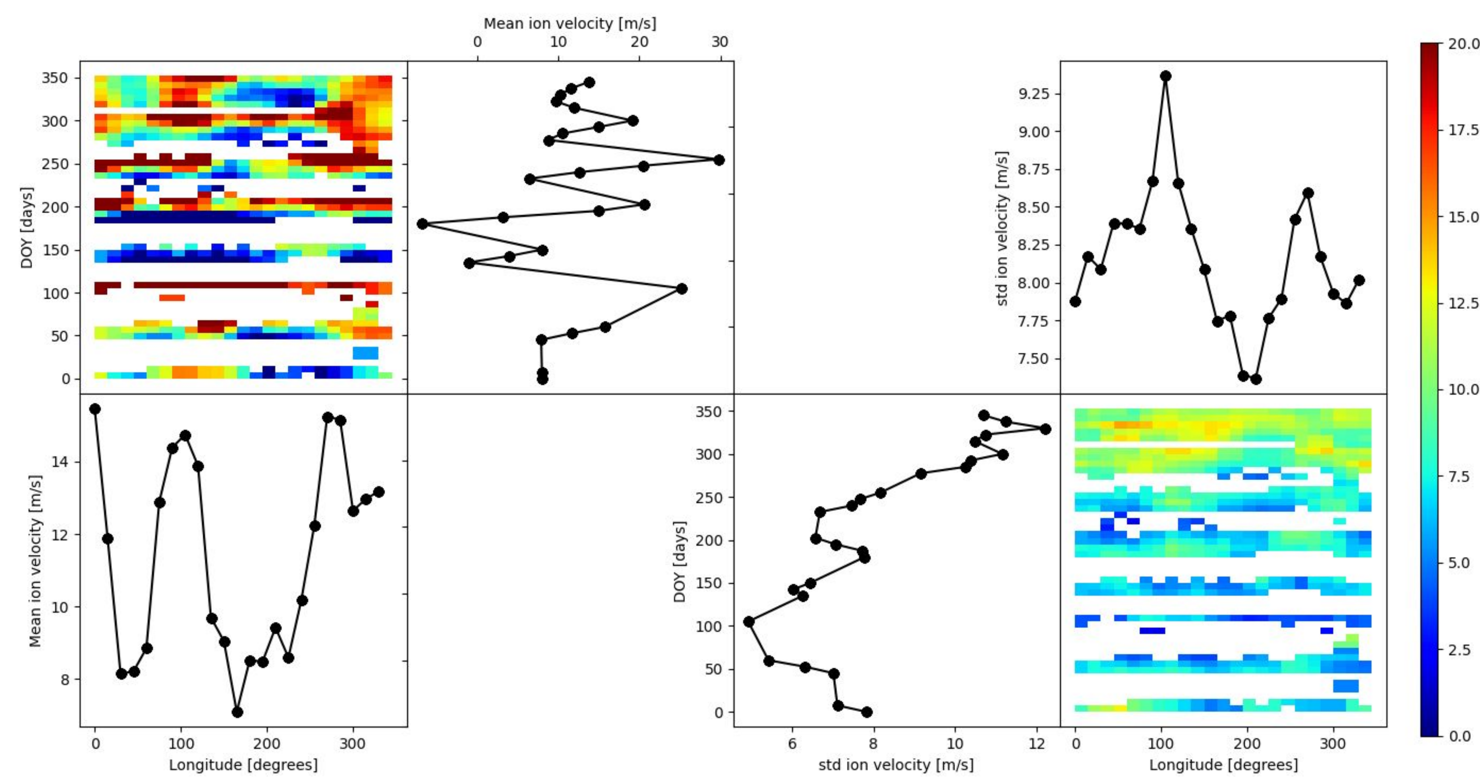


- Figure 6: mean, equatorial ion temperature and the relative variability of ion temperature.
- Variability peaks at dawn dusk, the dusk-time variability peak is stronger at higher latitudes
- Both ion temperature and density exhibit strong LT dependence and longitudinal structure

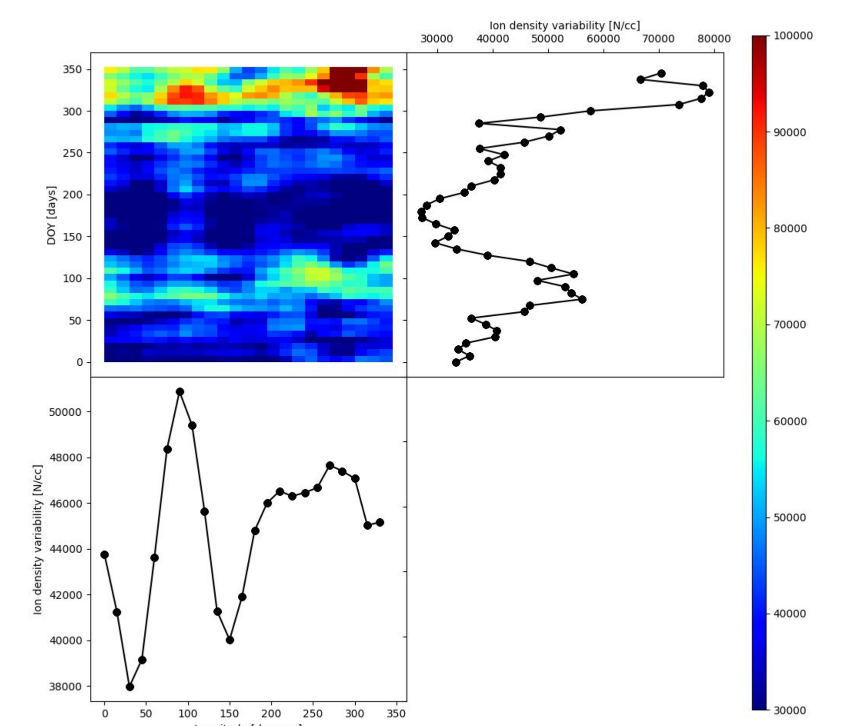
Ion Wind and Density Variability



- Figure 7: daytime, equatorial meridional ionized wind speeds as a function of local time and day of year
- Day time meridional wind speed is almost always positive
- Meridional wind speed decreases smoothly with local time from 10 - 18 with a small enhancement at ~ LT = 16h
- Meridional wind speed variability peaks at dusk, similar peaks can be seen in ion density and temperature
- Meridional wind speed variability is highest during the winter time
- Possible springtime peak in meridional ion wind variability



- Figure 8: daytime, equatorial meridional wind speeds as a function of local time and day of year



- In Figure 8, a strong wave 3/4 signal can be seen, particularly in the winter where data coverage is high
- Figure 9: ion density variability as a function of day of year and longitude
- Ion density variability peaks in the spring and late fall/early winter
- Strong peak at 100 degrees longitude

Conclusions

- O/N2 variability exhibits peaks at high latitudes in both winter and summer hemispheres and may be influenced by the South Atlantic Anomaly
- There is strong seasonal, longitudinal, and local time dependence in ion temperature, ion density, ion winds, and the O/N2 ratio.

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