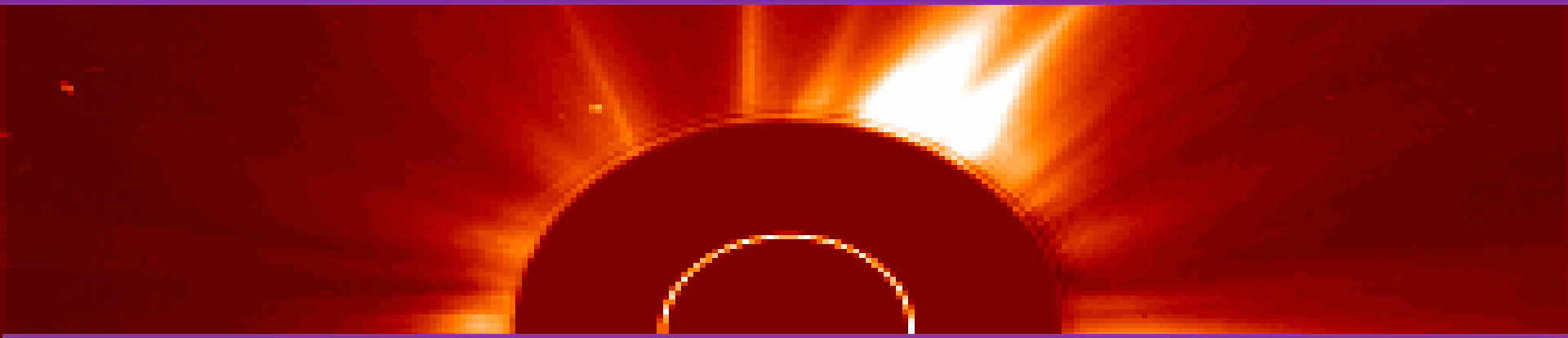
# Longitudinal Variability of Nightside Equatorial Electrodynamics?

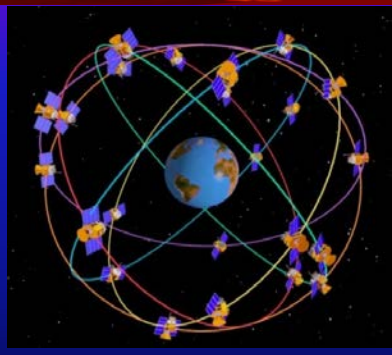


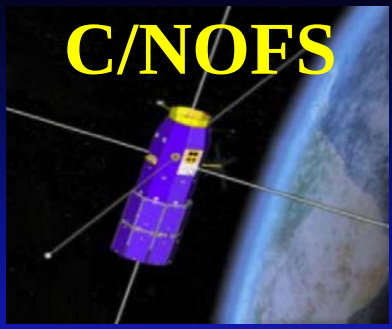

## Endawoke Yizengaw and AMBER Team

**Institute for Scientific Research, Boston College, USA**

# Outline

- Motivation
  - What controls the longitudinal, local time, and seasonal variability of density irregularities?
- Equatorial electrodynamics?
- One-to-one correlation between irregularities and vertical drift
- Future Direction: **Can we use magnetometer to estimate the nightside drifts?**

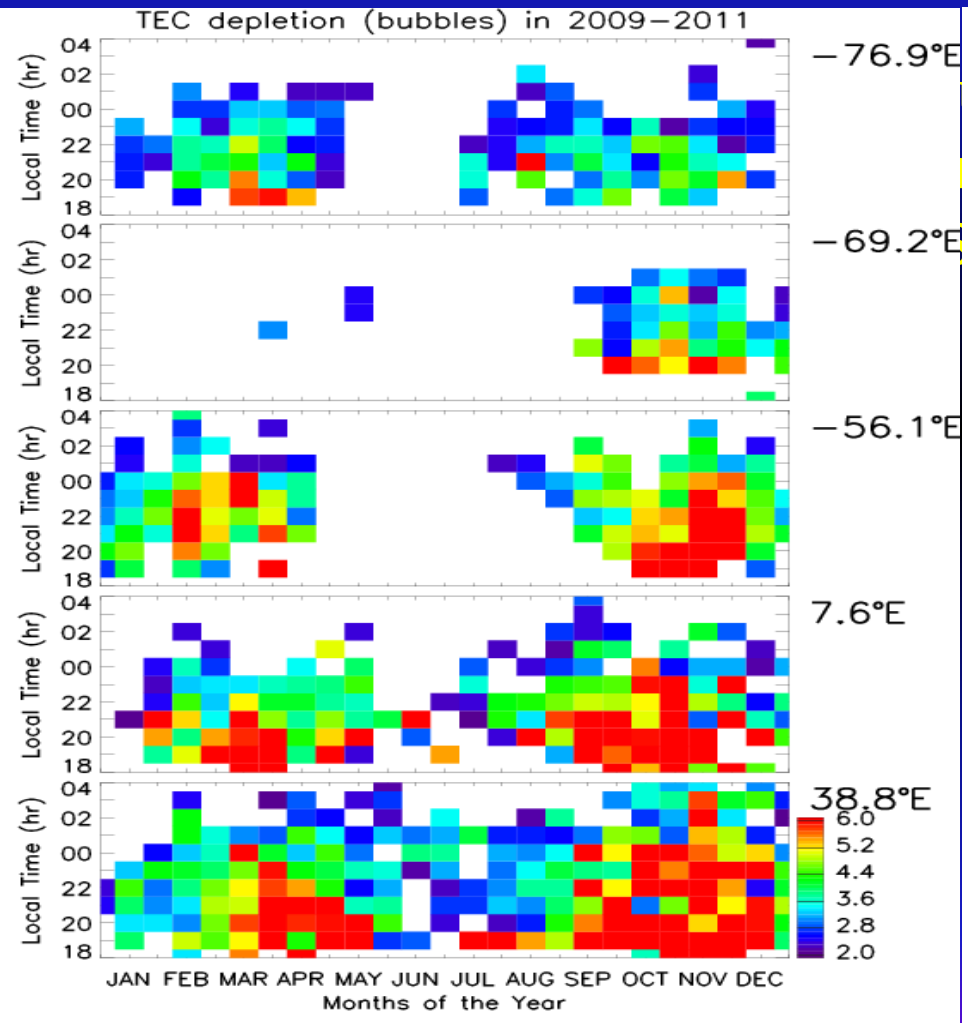




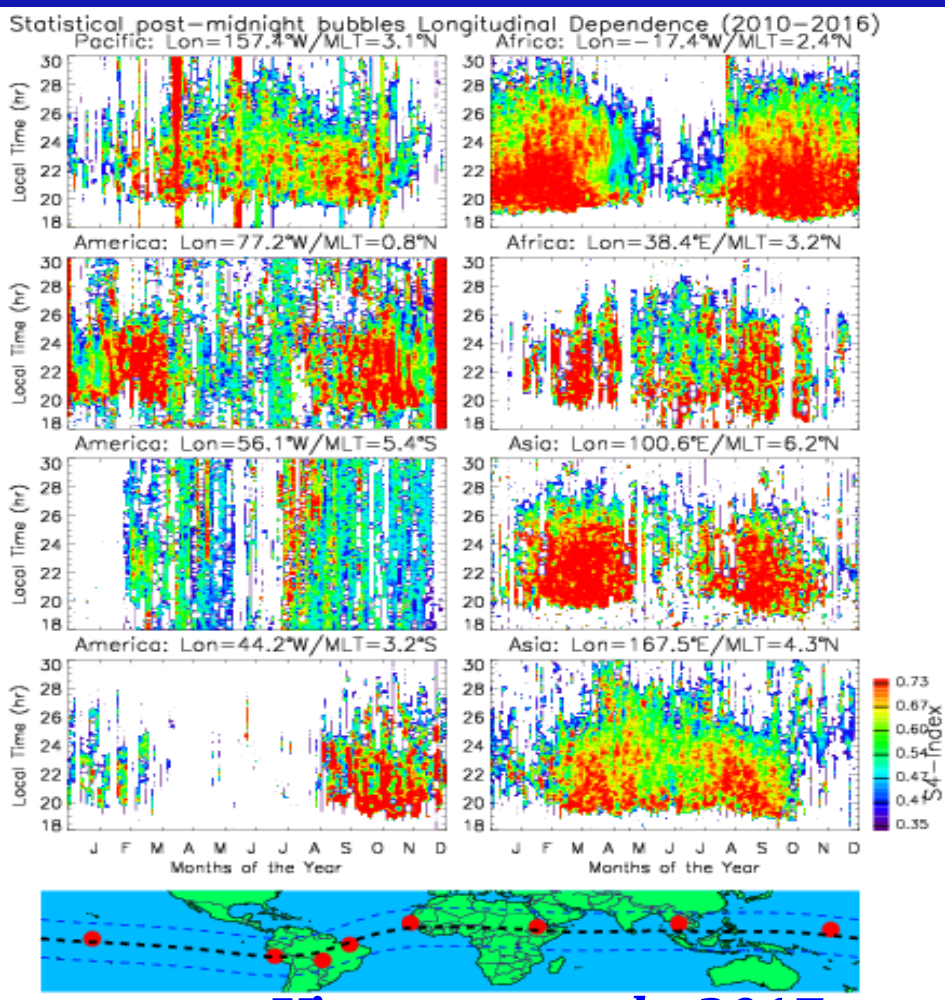
# What controls the longitudinal, Local Time and Seasonal variability of ionospheric irregularities?

## Bubbles extracted from TEC



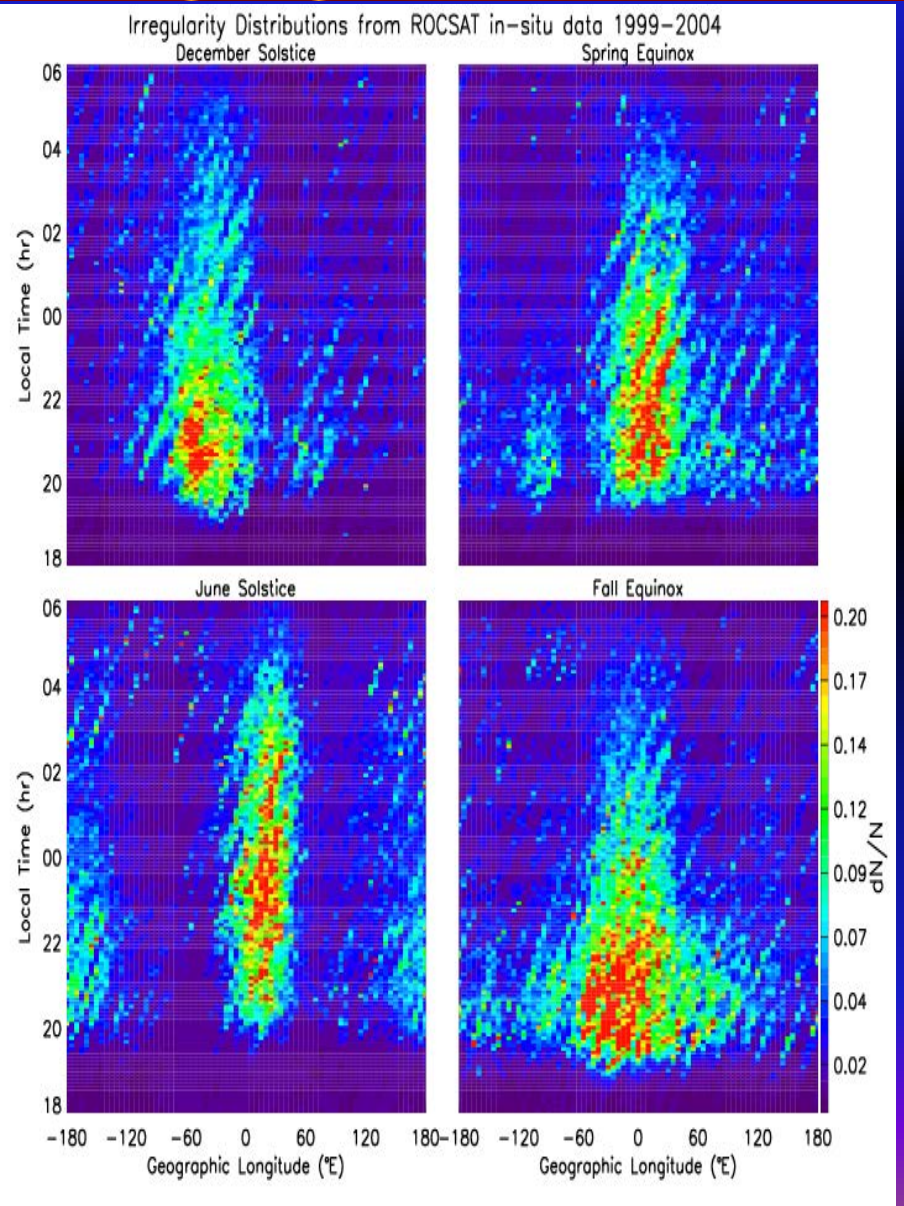

*Yizengaw et al., AG, 2014*

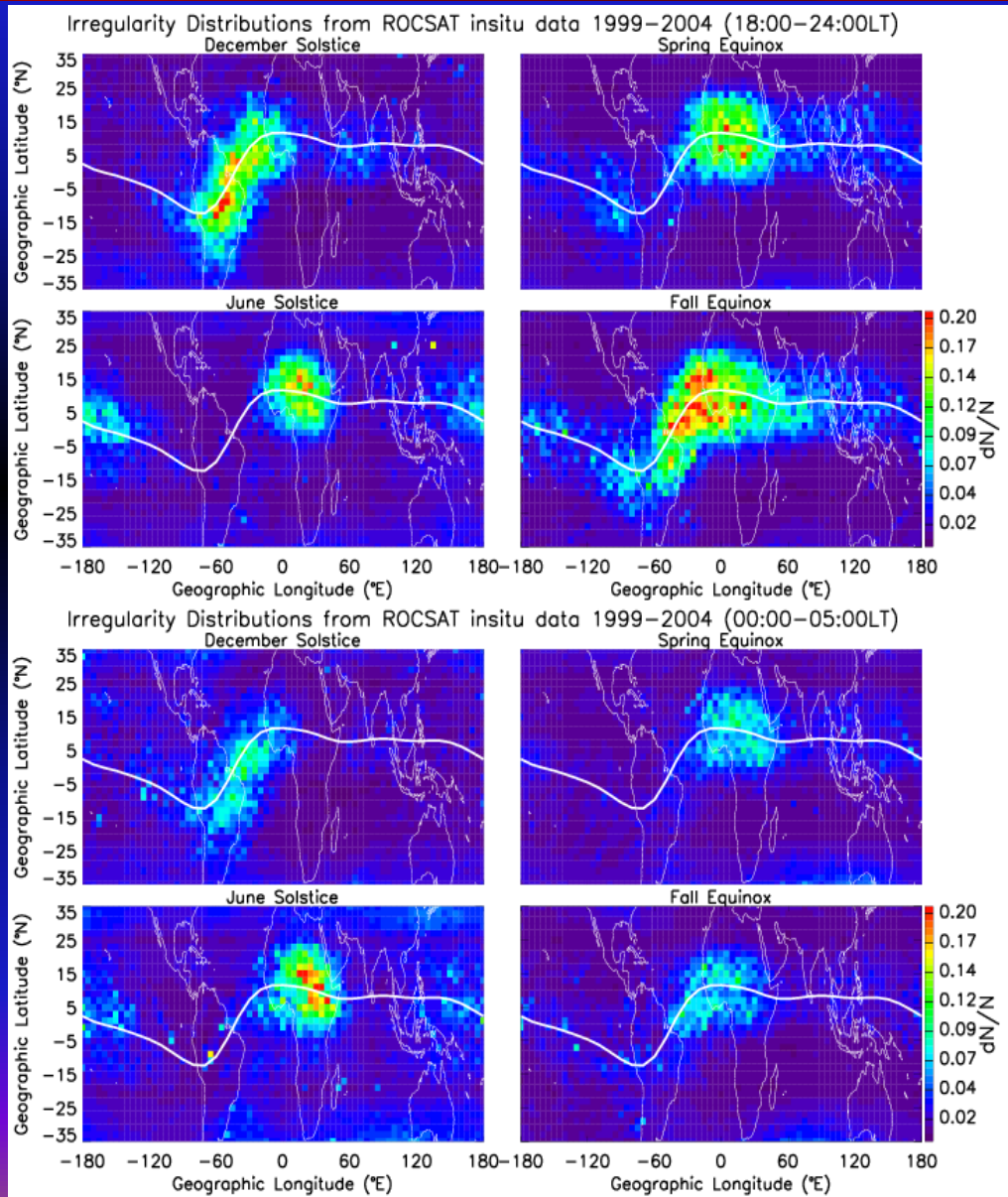
## Scintillations from UHF receivers



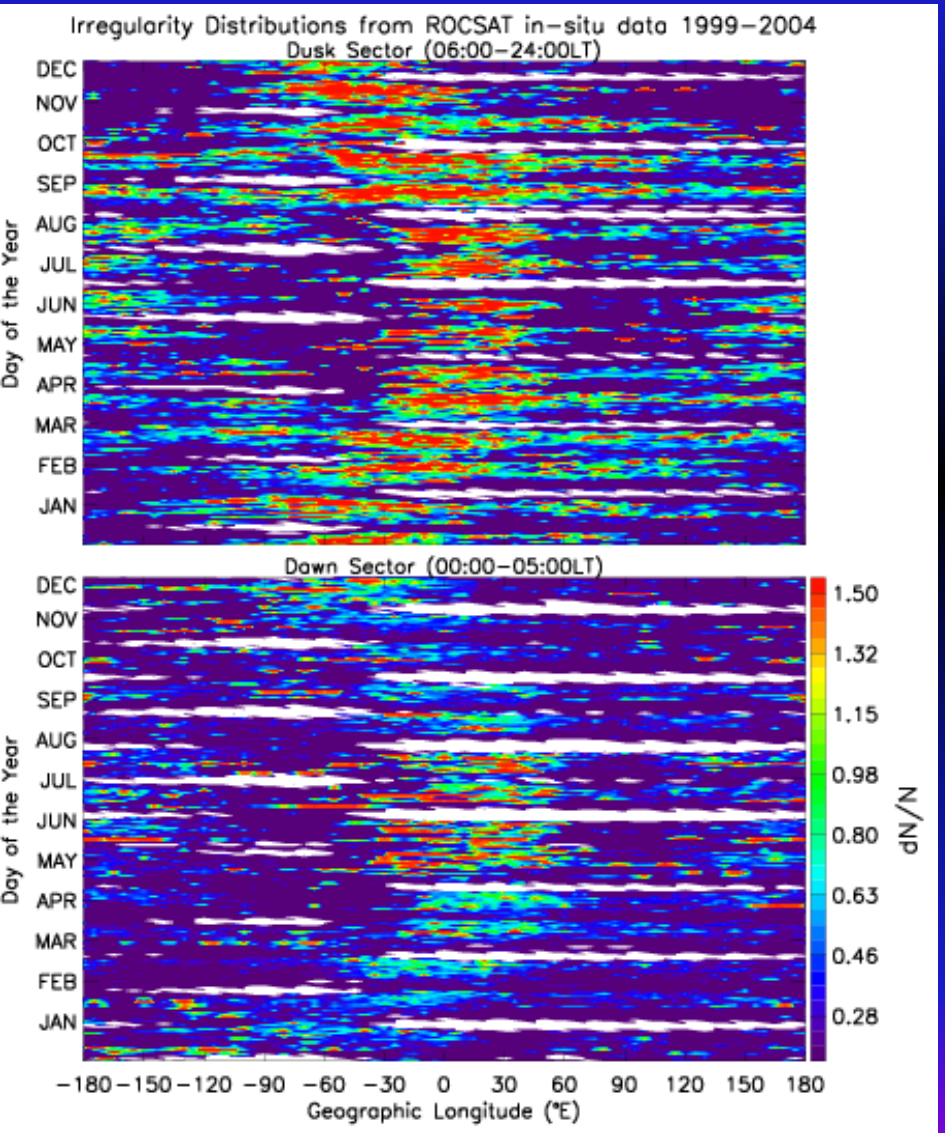

*Yizengaw et al., 2017*

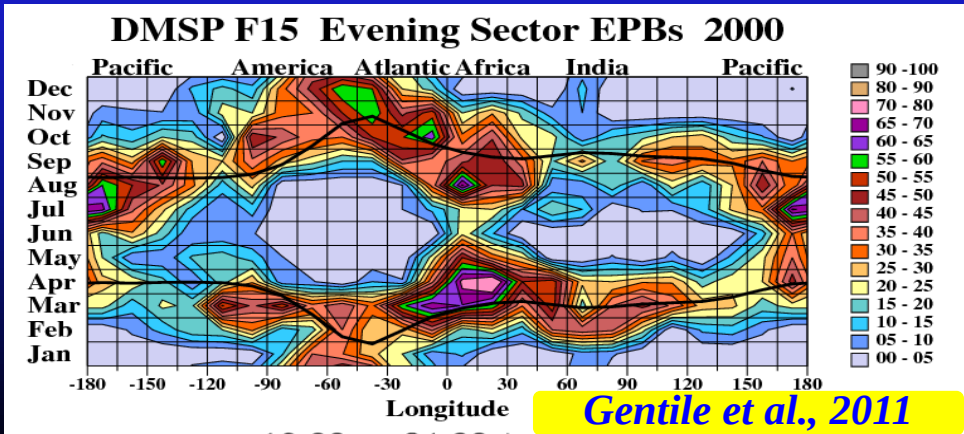
# Longitudinal and seasonal variability of ionospheric irregularities from ROCSAT



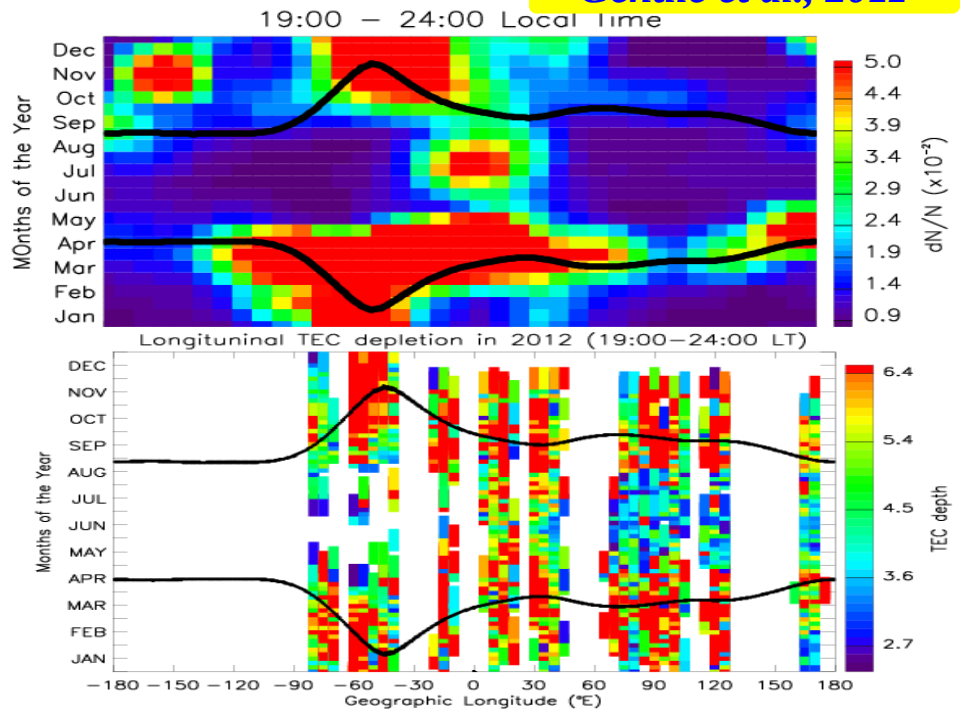



# Multi-instrument observations of Longitudinal and seasonal variability of irregularities



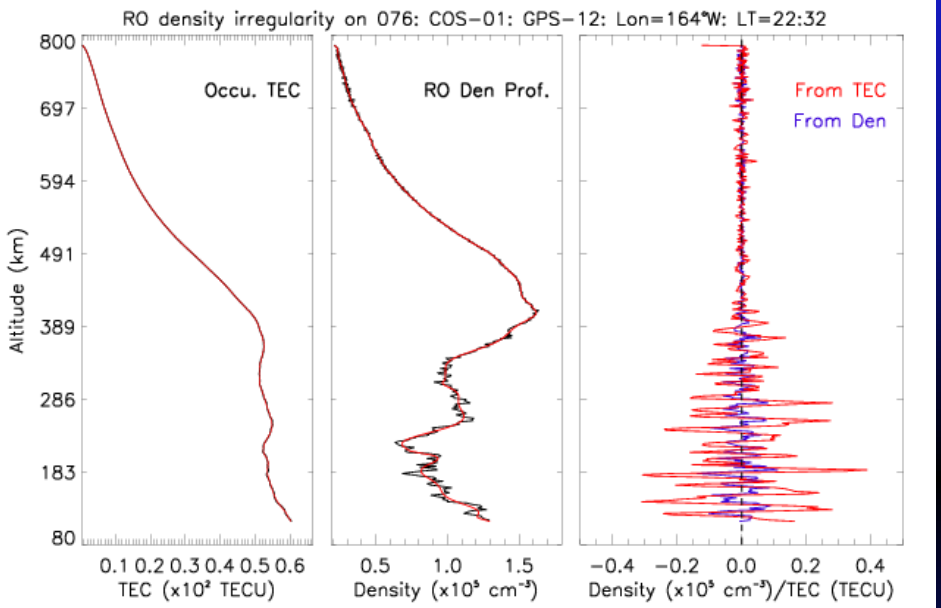



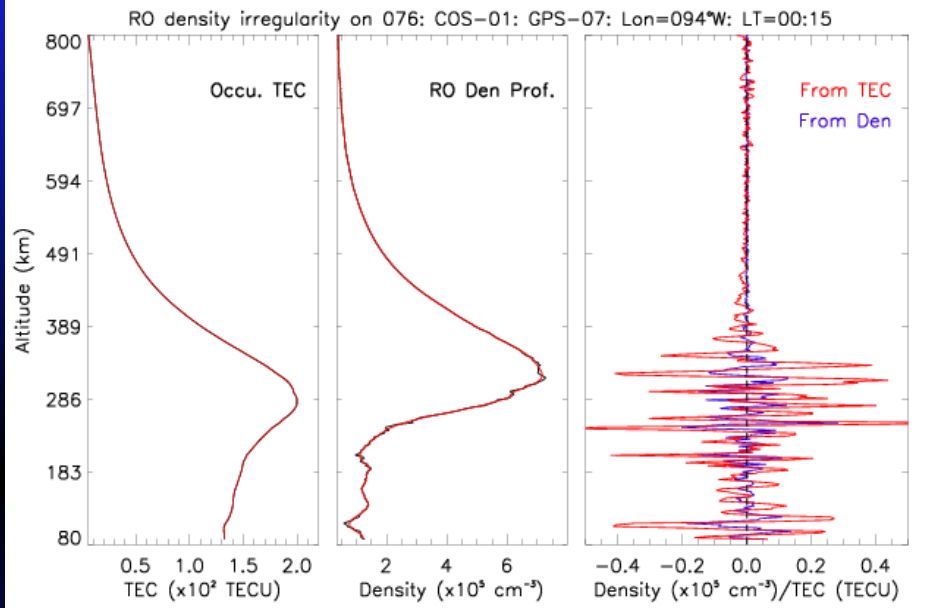

*Gentile et al., 2011*

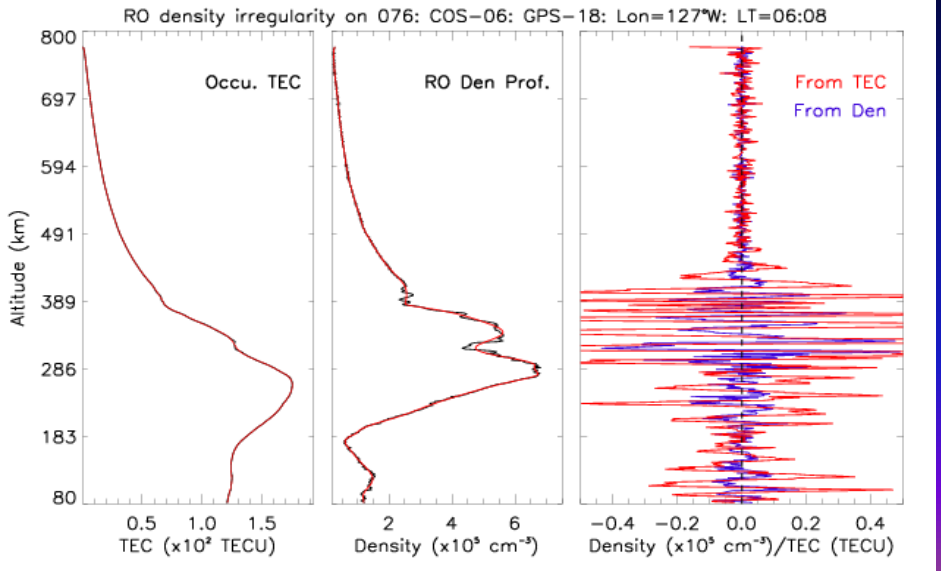


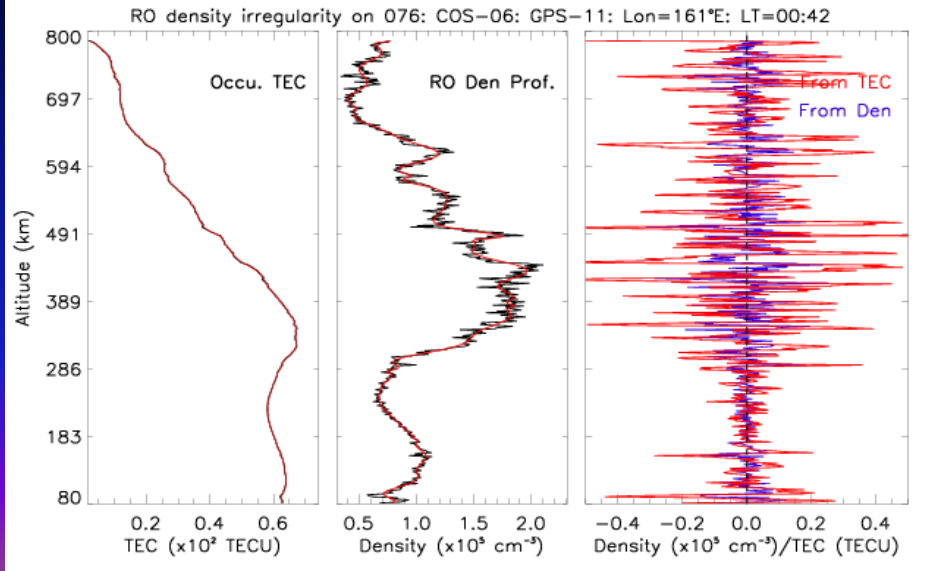

*Yizengaw et al., 2014*

# Altitudinal, Longitudinal and seasonal structures of irregularities: Utilizing COSMIC data



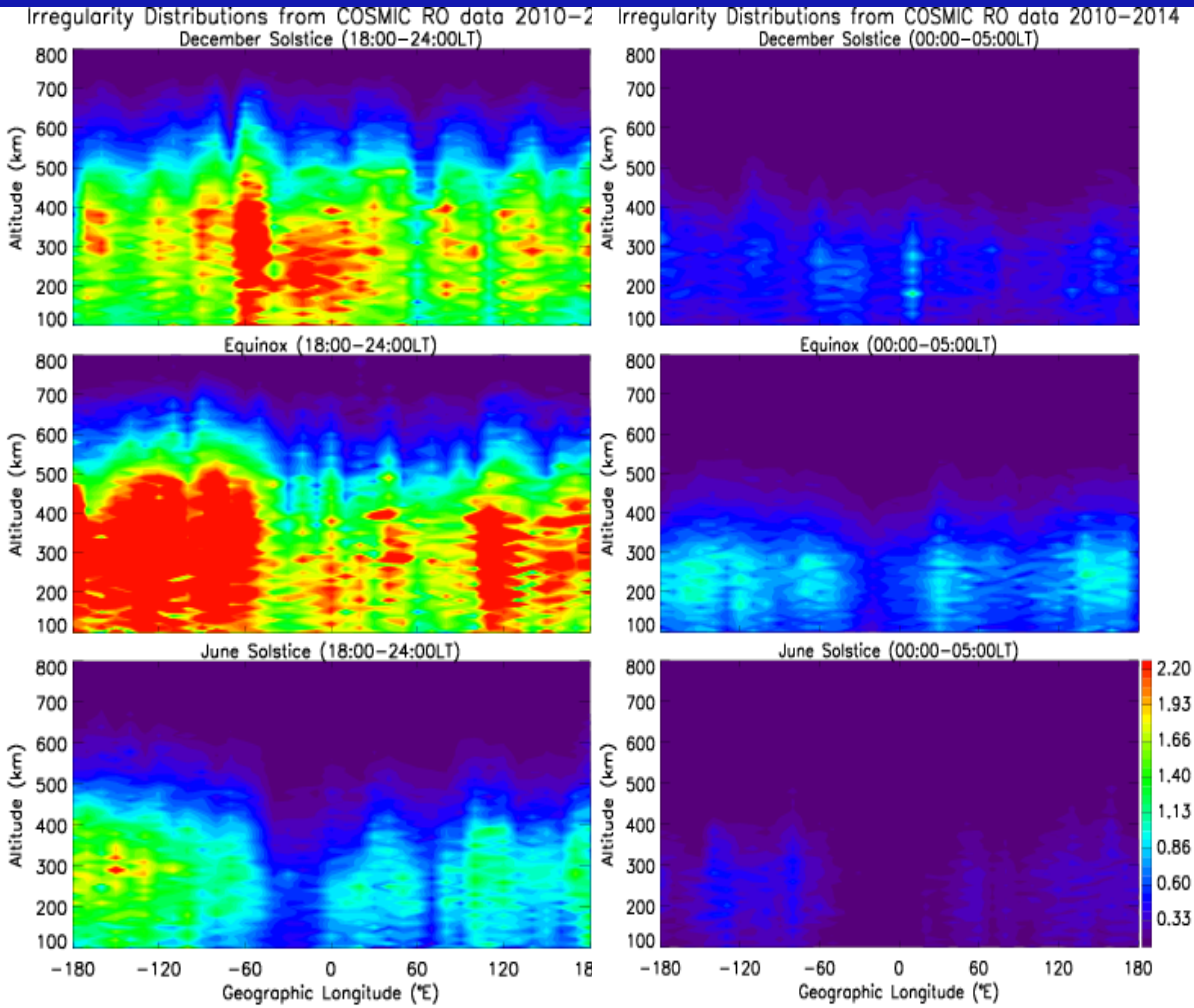



# Altitudinal, Longitudinal and seasonal structures of irregularities: Utilizing COSMIC data

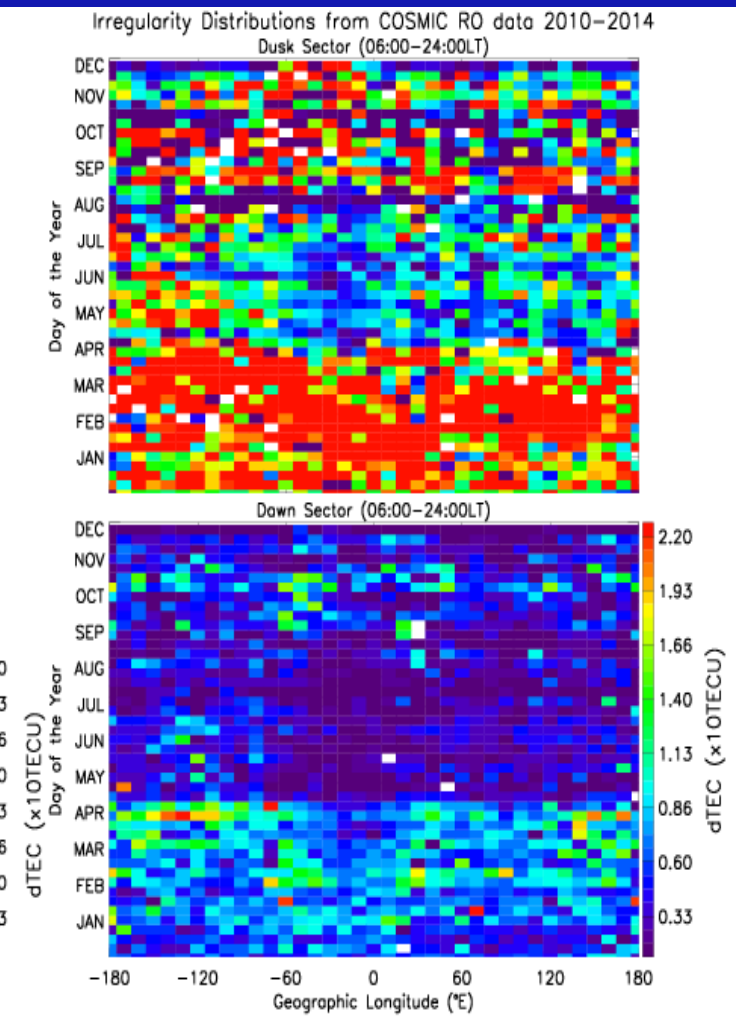
*Lat = -15° to 15°N*

*Lat = -15° to 15°N; Alt = 200-300km*



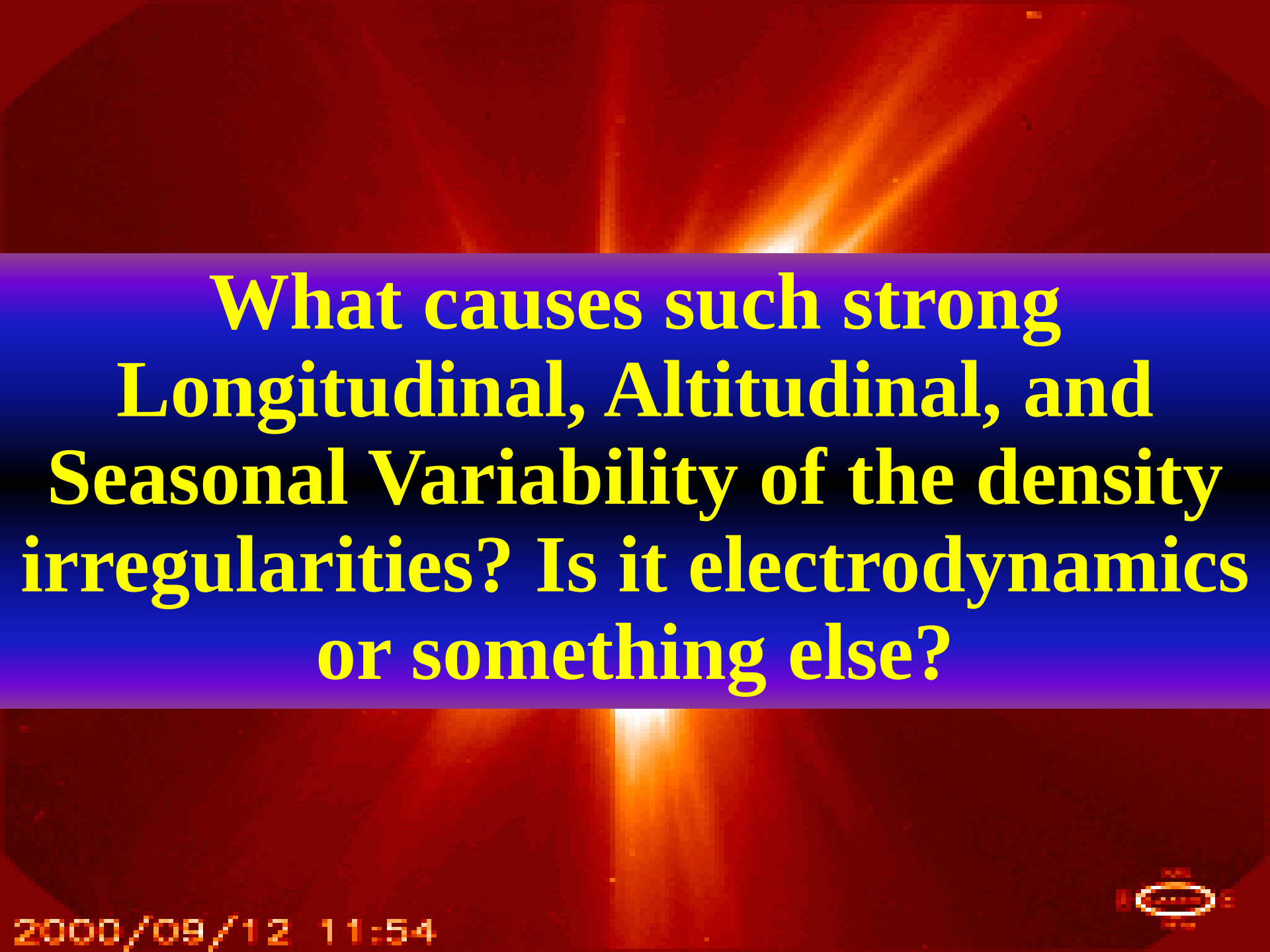




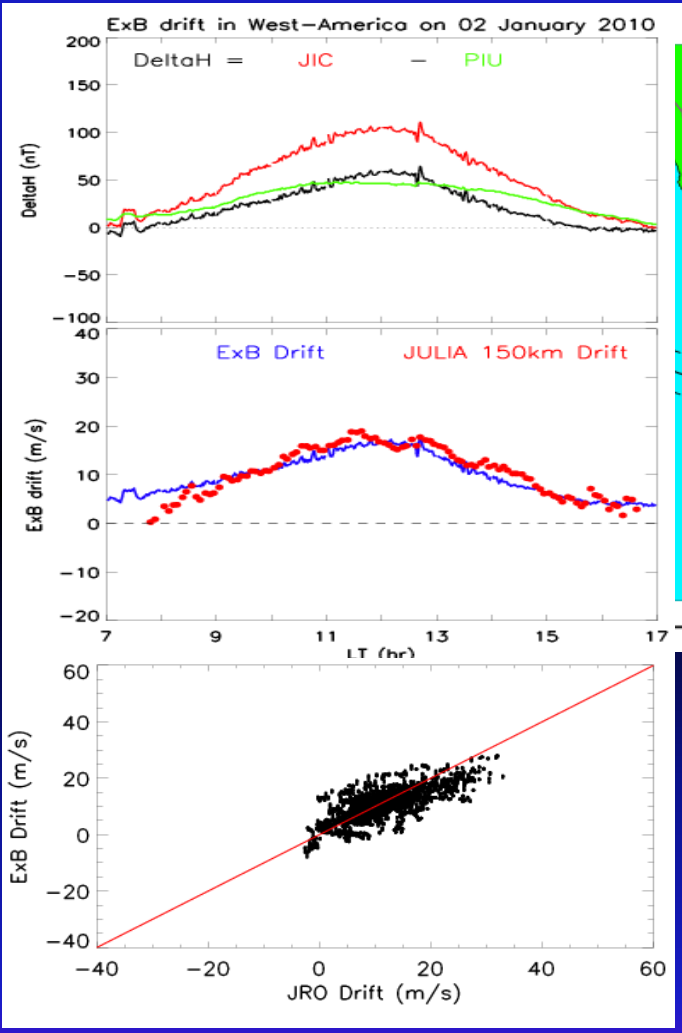


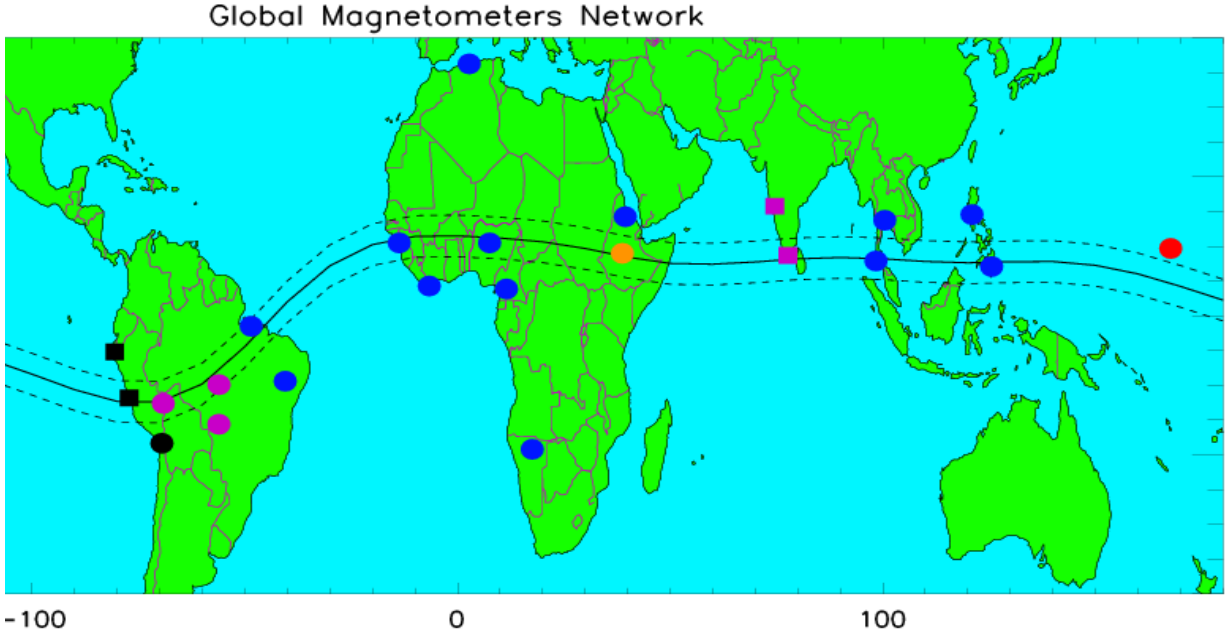

✈ **What controls these variability of irregularities distributions?**

**What causes such strong Longitudinal, Altitudinal, and Seasonal Variability of the density irregularities? Is it electrodynamics or something else?**



# Equatorial Electrodynamics: Dayside




- **Magnetometer at off the equator**

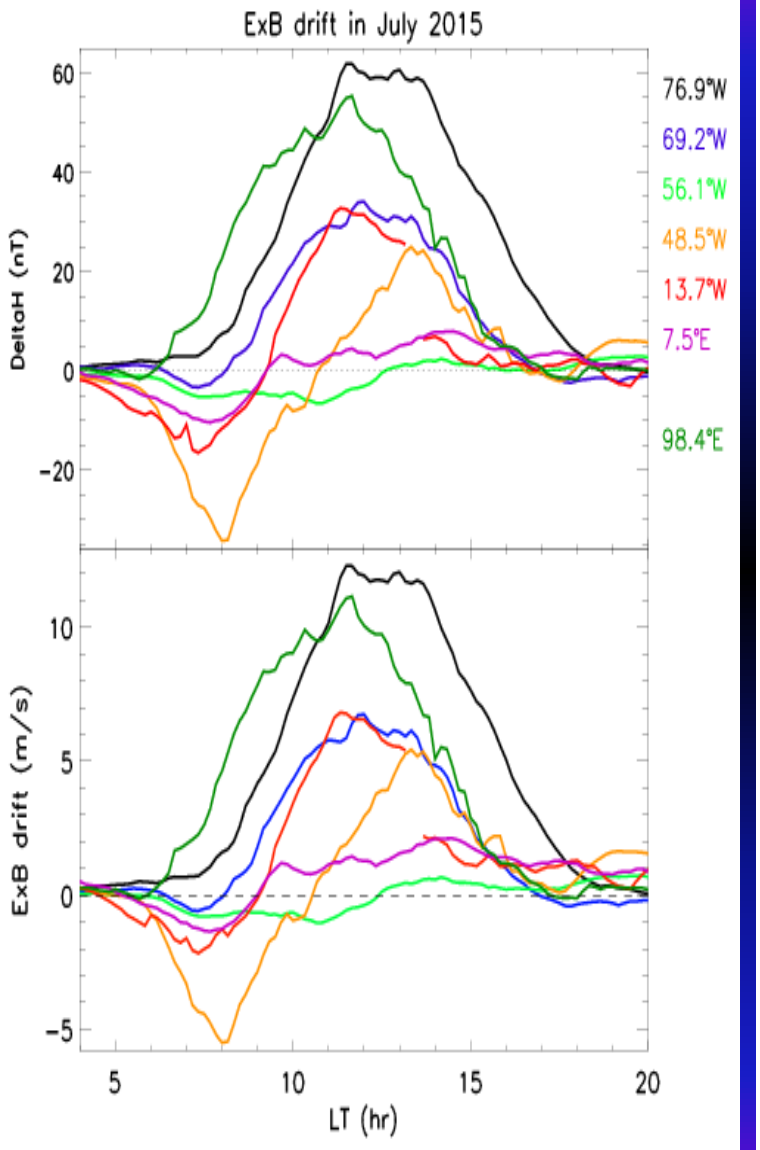
$$B_{Obs} = B_{main} + B_{SQ} + B_{FAC} + B_{RC} + B_{MP}$$

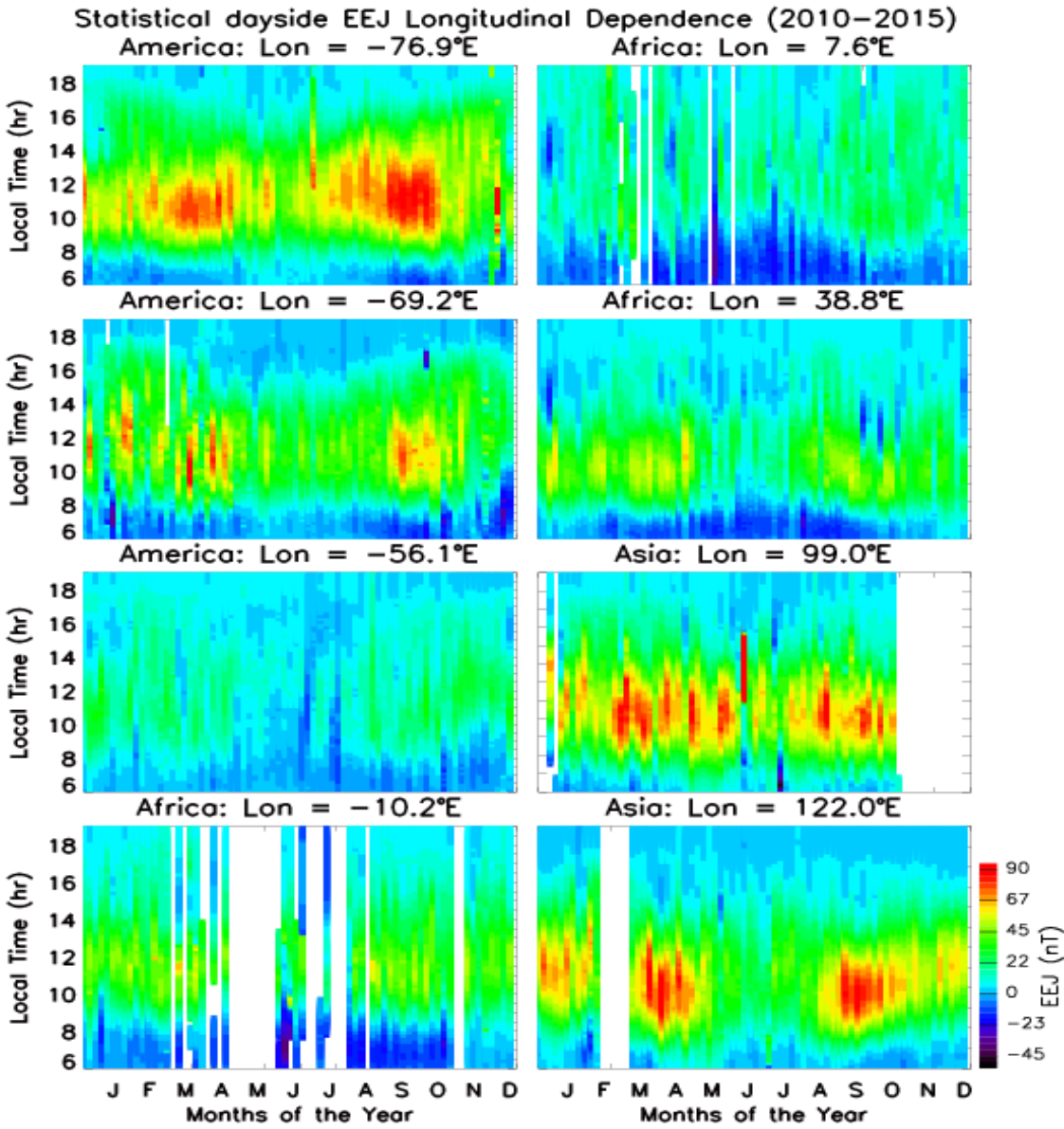
- **Magnetometer at the equator**

$$B_{Obs} = B_{main} + B_{SQ} + B_{FAC} + B_{RC} + \mathbf{B_{EJ}} + B_{MP}$$

- **Problem:** Does EEJ current or Equatorial Electrodynamics in general show longitudinal and seasonal dependence?

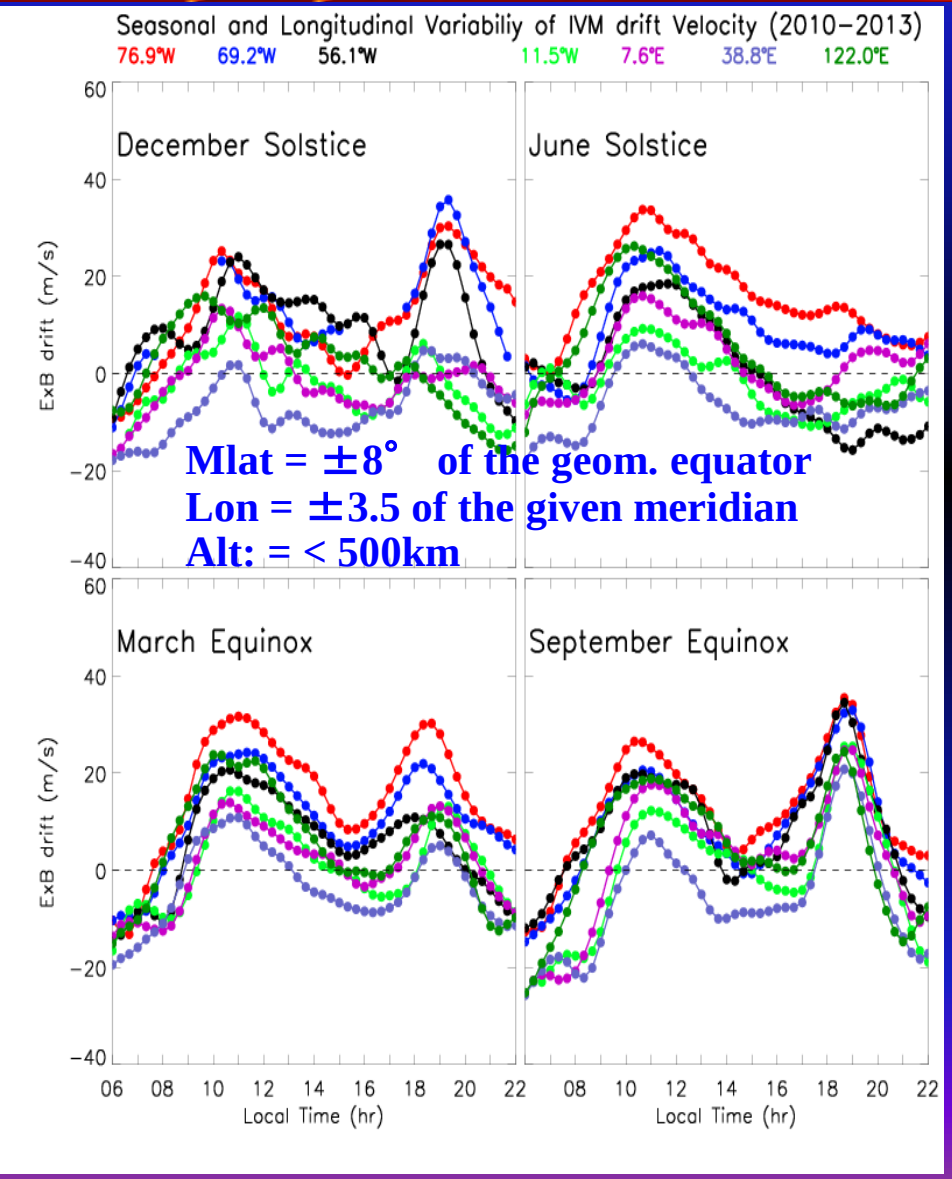
# Longitudinal variability of dayside drift

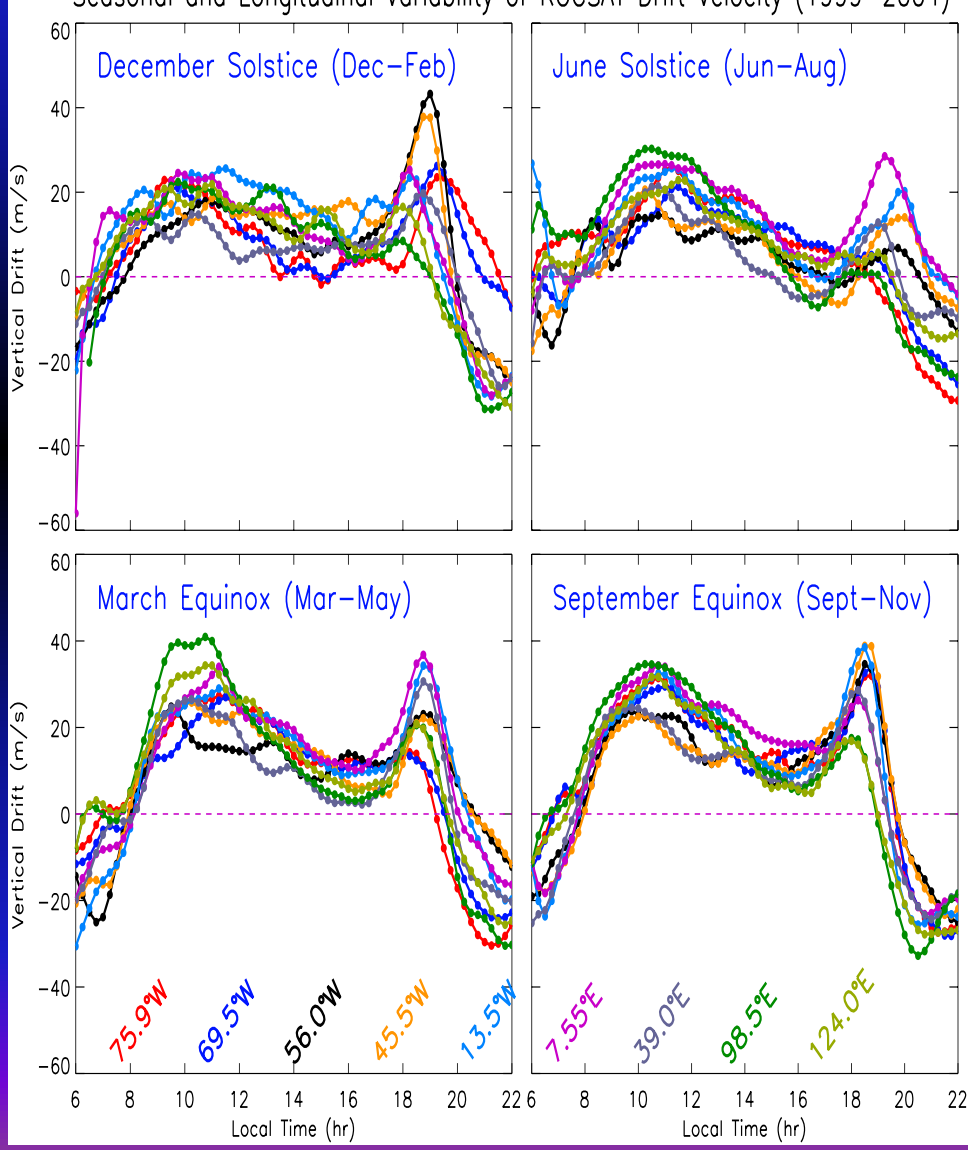



*Yizengaw et al., AG, 2014*

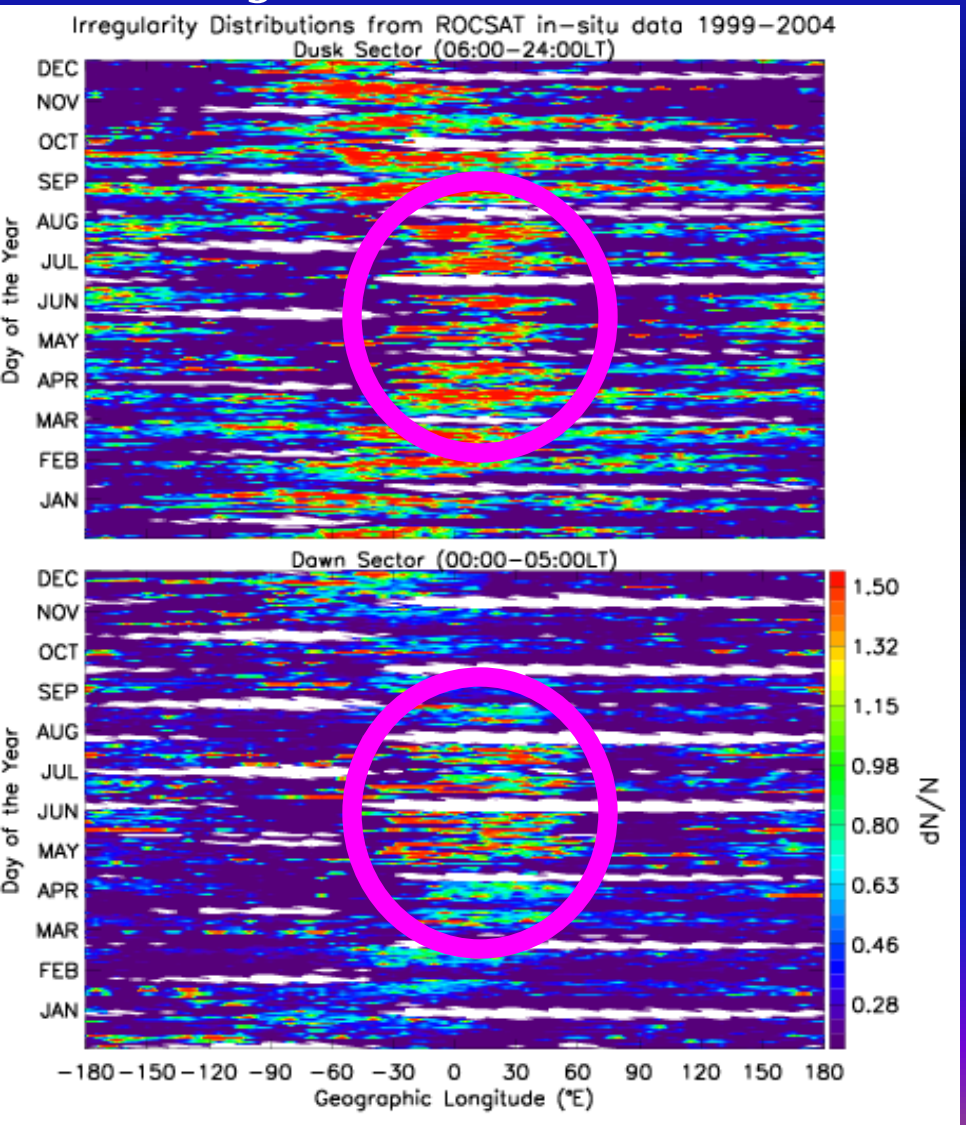
# Longitudinal variability of day and night side drifts



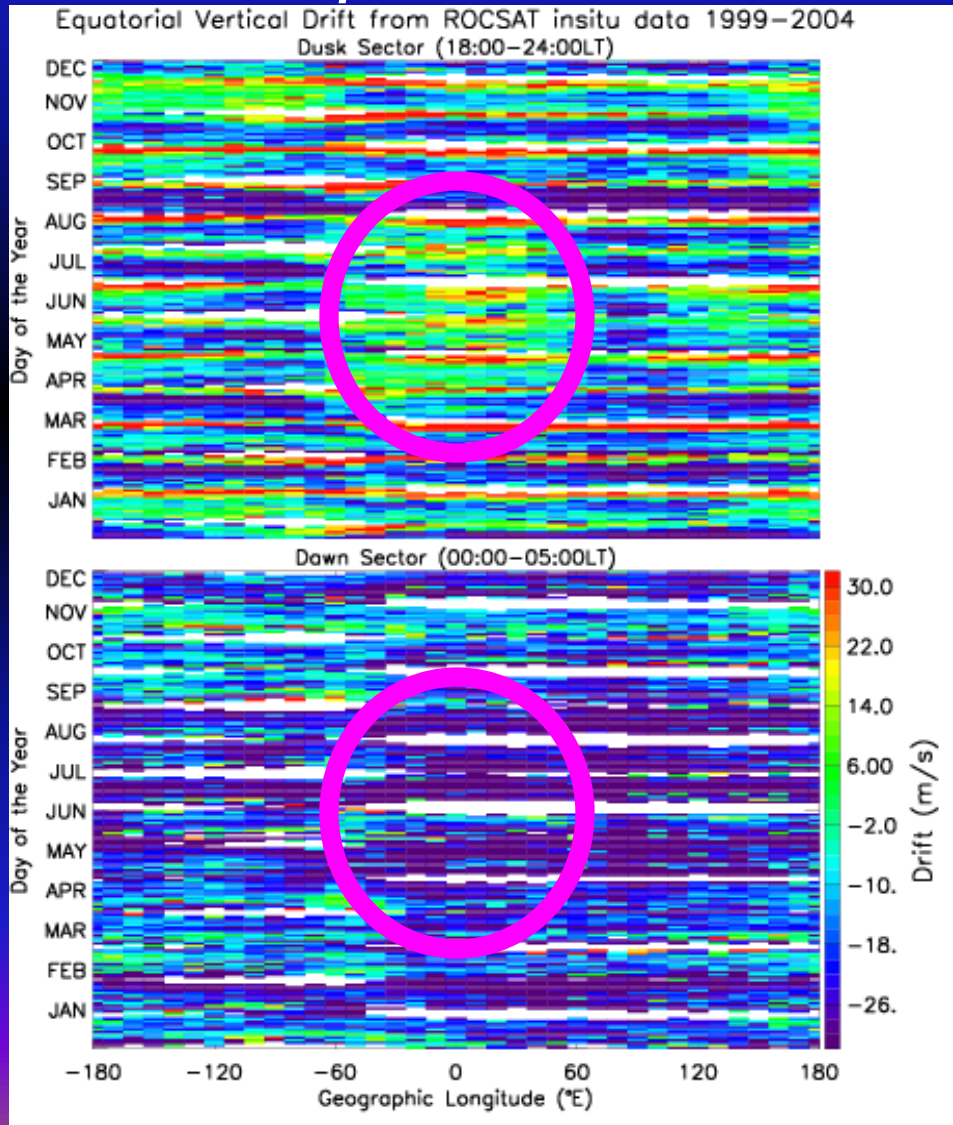



# One-to-one correlation between Longitudinal and Seasonal variability of drifts and irregularities

*Irregularities at ROCSAT alt.*

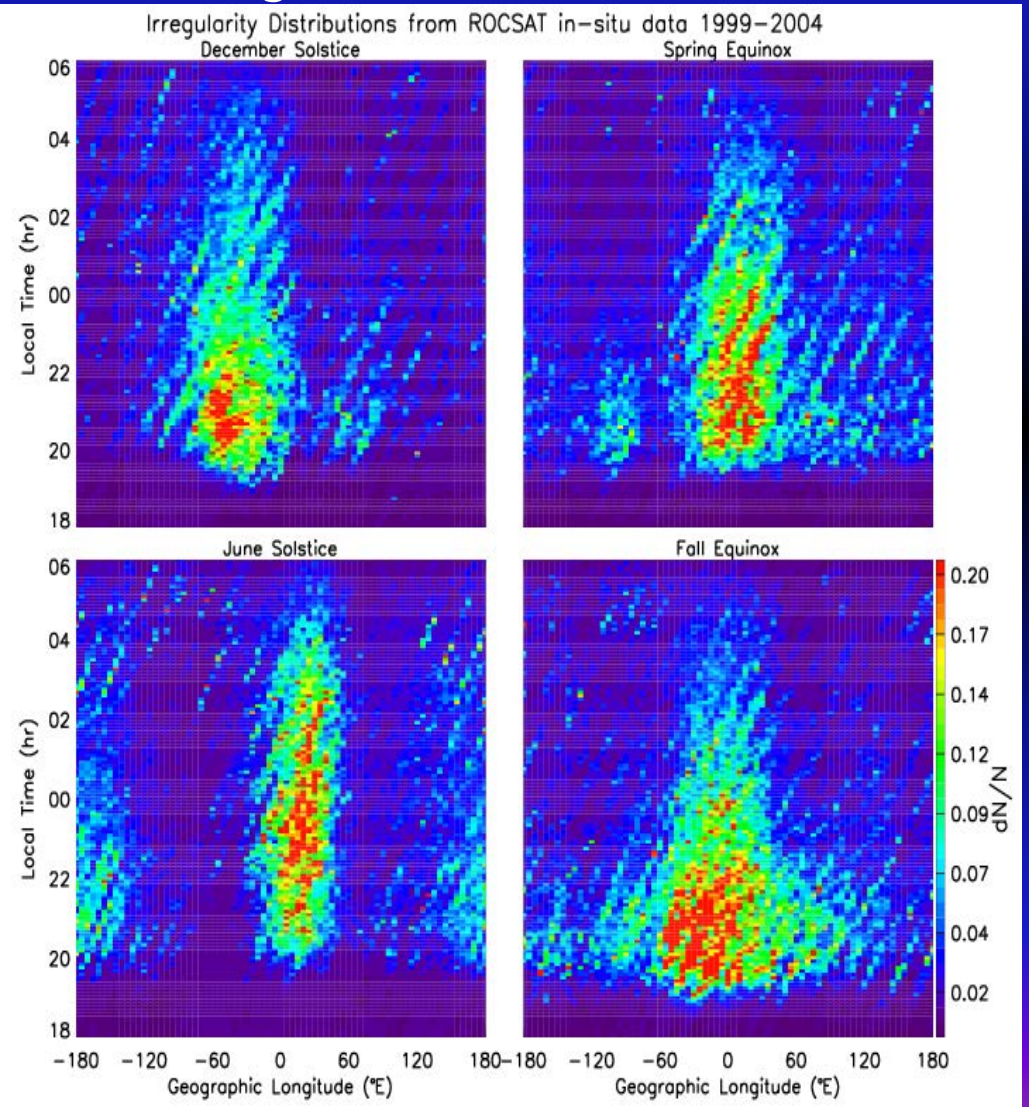



*Drift at ROCSAT alt*

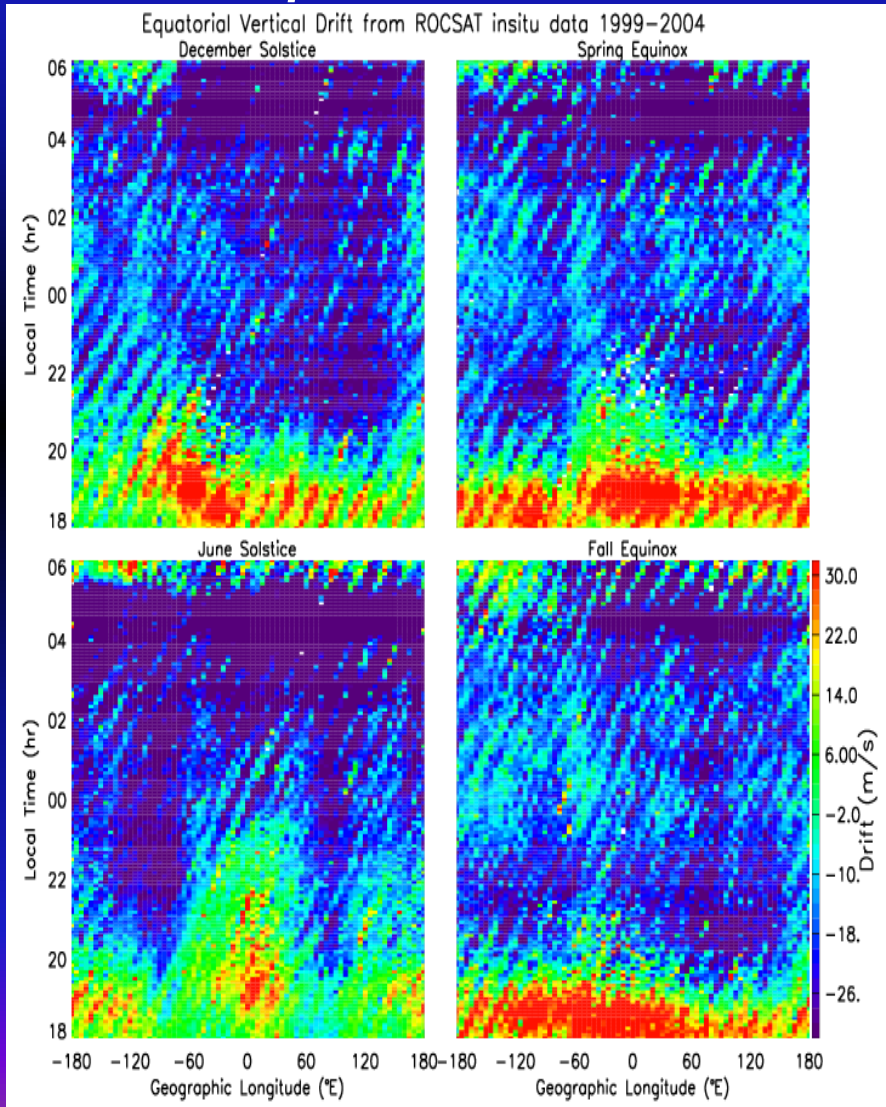


# One-to-one correlation between Longitudinal, Local time and Seasonal variability of drifts and irregularities

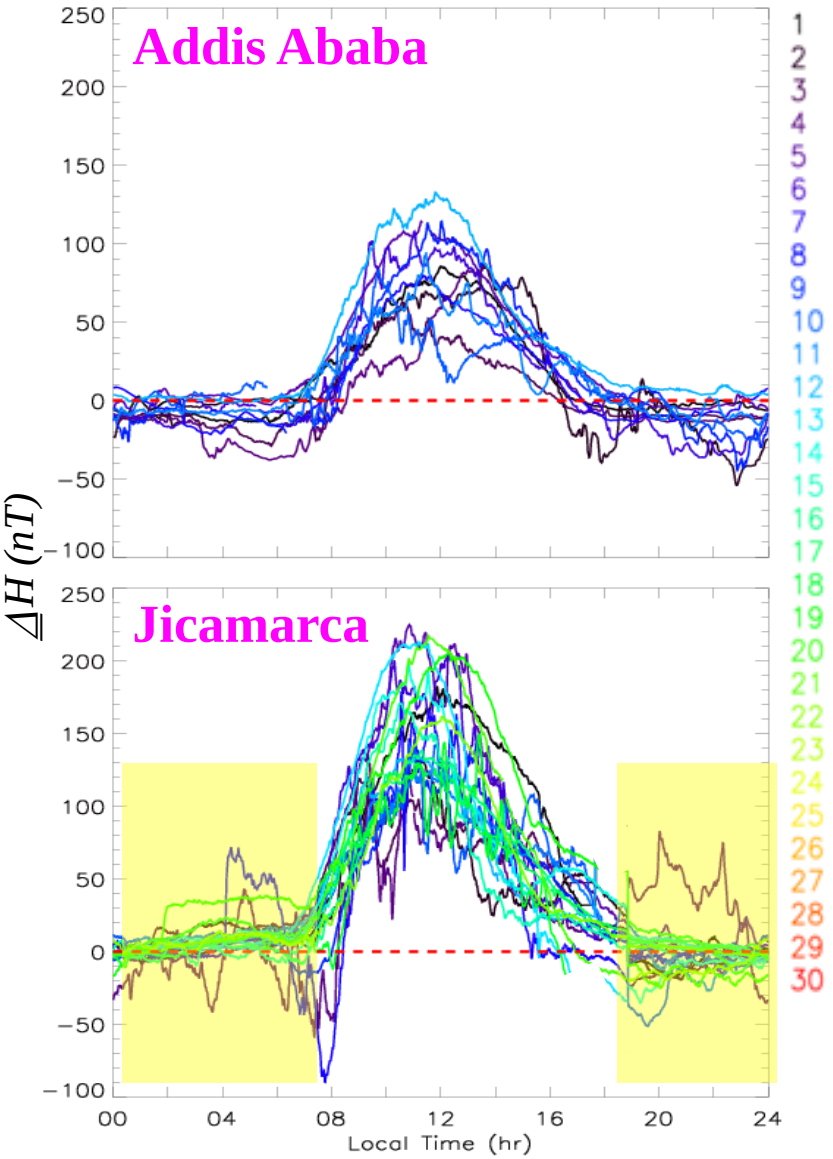
*Irregularities at ROCSAT alt.*

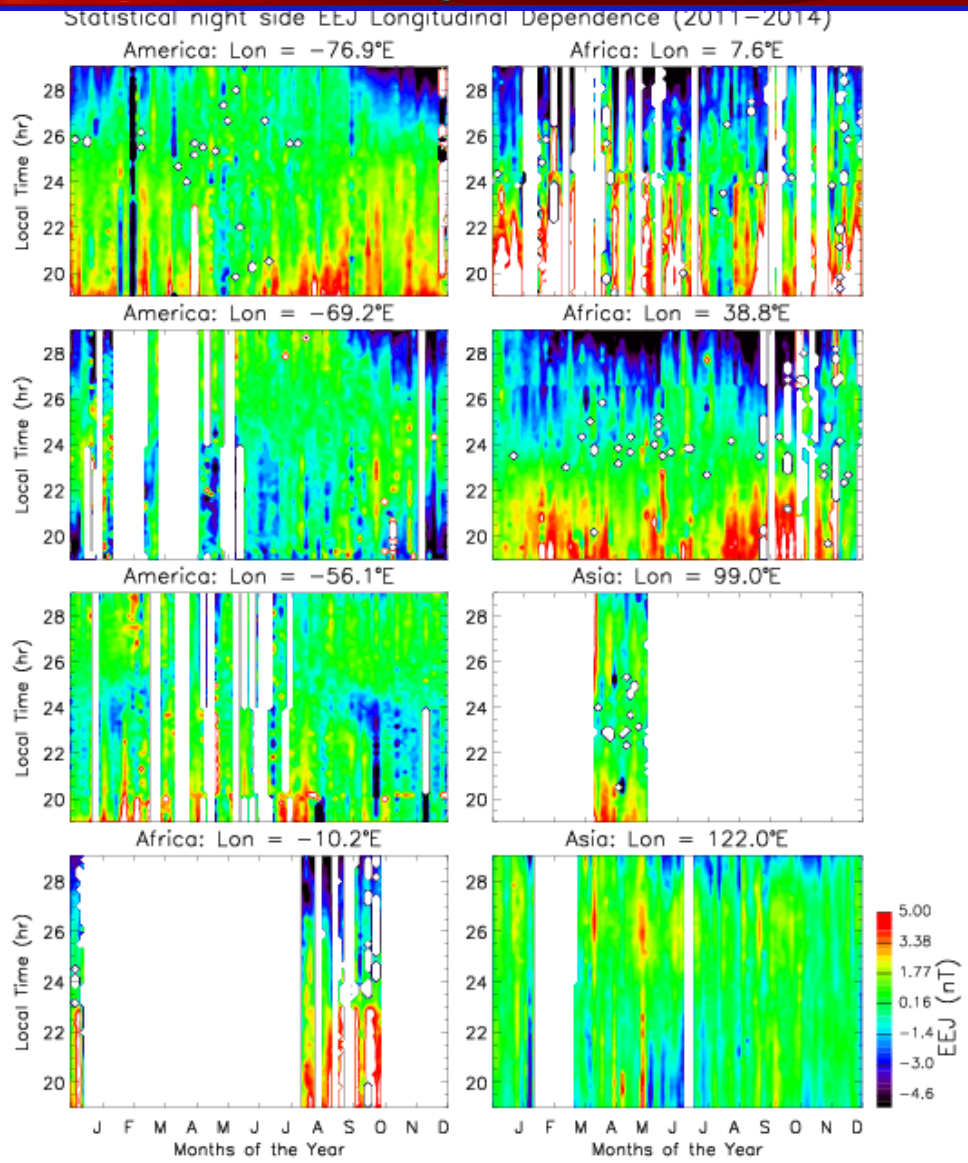



*Drift at ROCSAT alt*

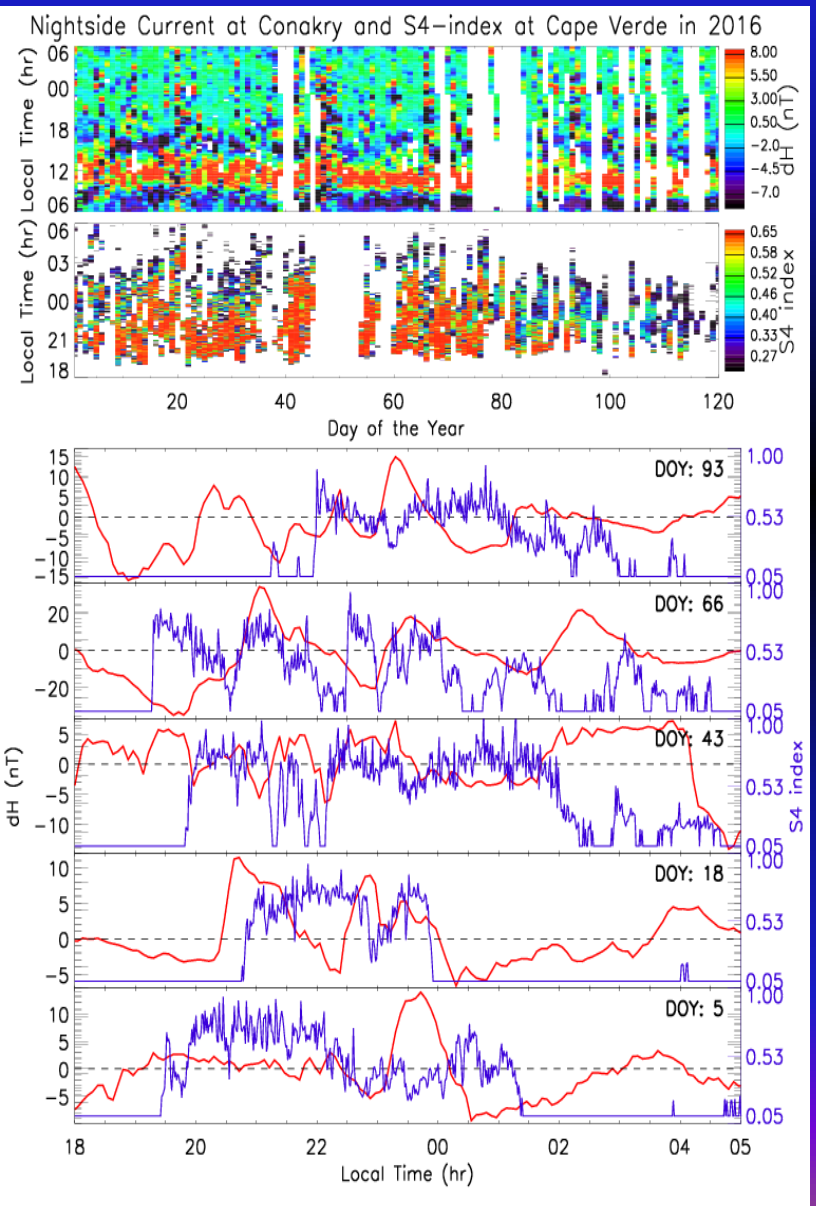


# Does Mag data useful to detect the day-to-day variability of nightside electrodynamics?

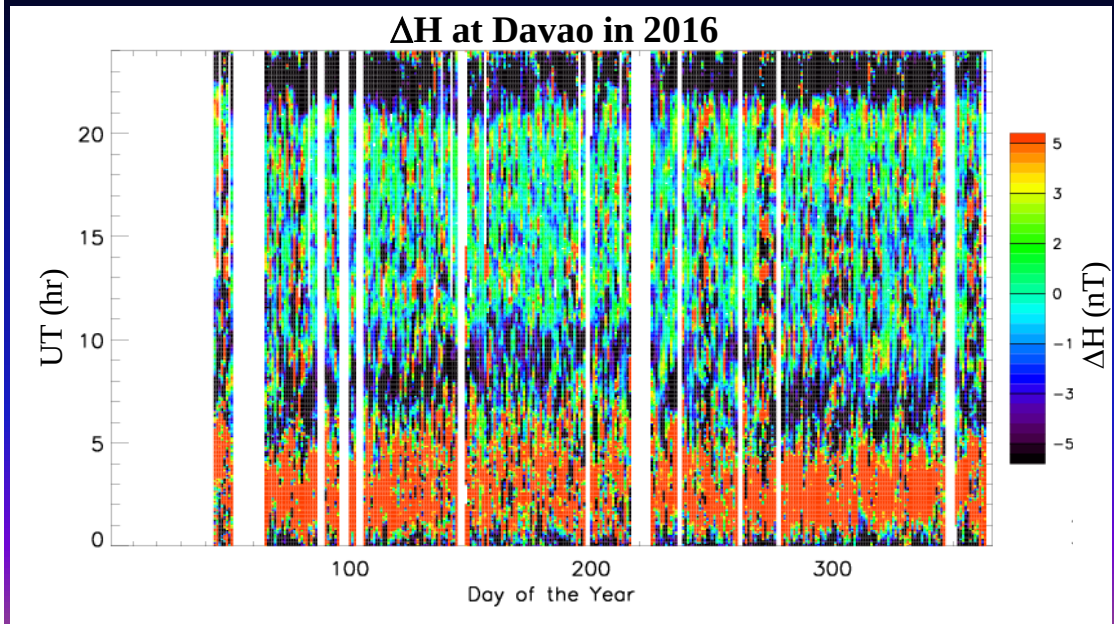


# Does Mag data useful for day-to-day variability of nightside electrodynamics?

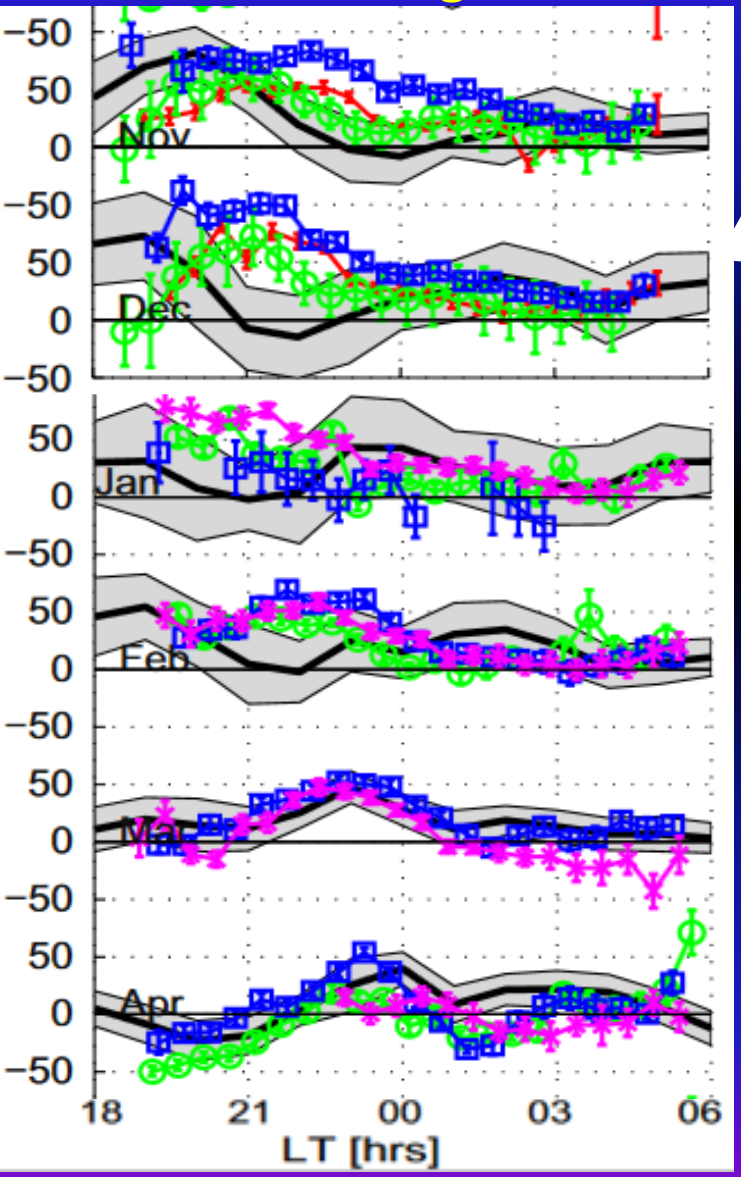



- To reduce the ring current contribution and to removes the gradual drift of the background field, a 4 hours running mean is subtracted from the *H*-values.
- The residual (*ΔH*) variations indicates the east-west current or electric field variations during dayside and nightside.



# Meridional wind Longitudinal Variability

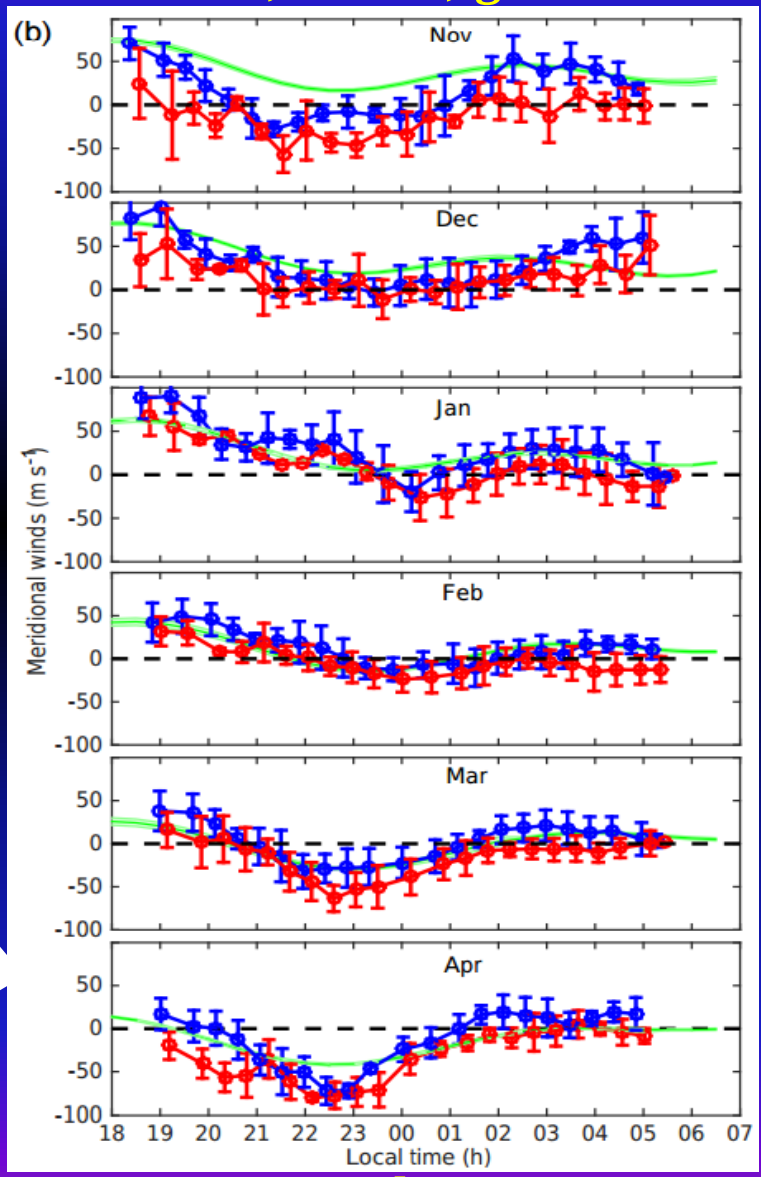
**Brazil 7°S, 39°W; geom: 5.8°S**




**2009 2010**
**2011 2012**
**WAM model**

**2015 - 2016**
**South direction**
**North direction**
**HWM14 model**

**East-Africa 11.6°N, 37.4°E; geom: 3.7°N**

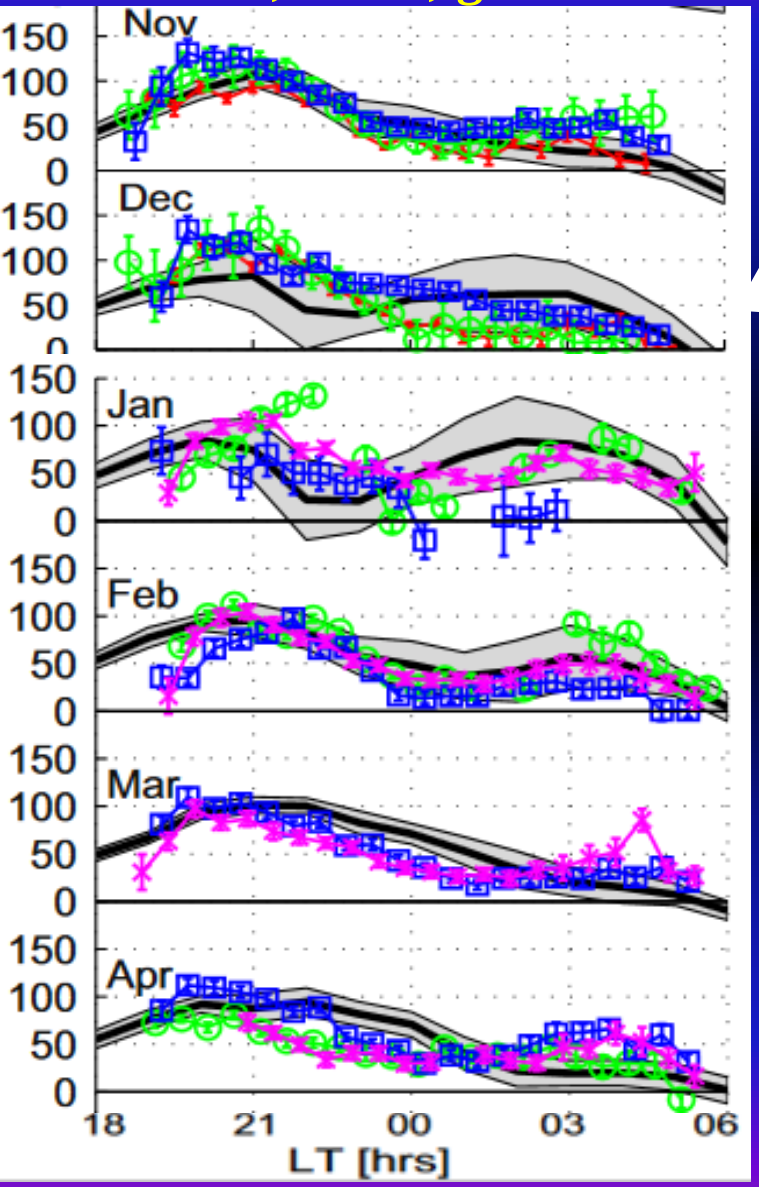



*Meriwether et al., JASTP, 2013*

*Tesema et al., AG, 2017*

# Zonal wind Longitudinal Variability

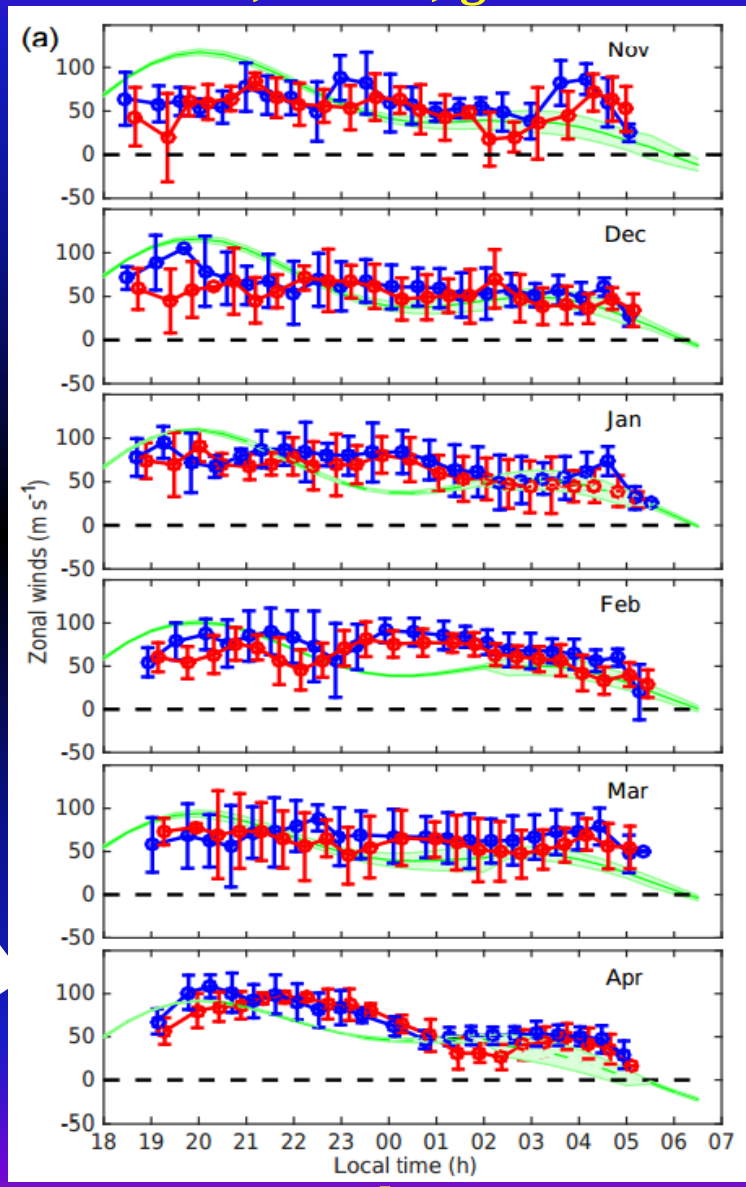
**Brazil 7°S, 39°W; geom: 5.8°S**




**2009 2010**
**2011 2012**
**WAM model**

**2015 - 2016**
**West direction**
**East direction**
**HWM14 model**

**East-Africa 11.6°N, 37.4°E; geom: 3.7°N**



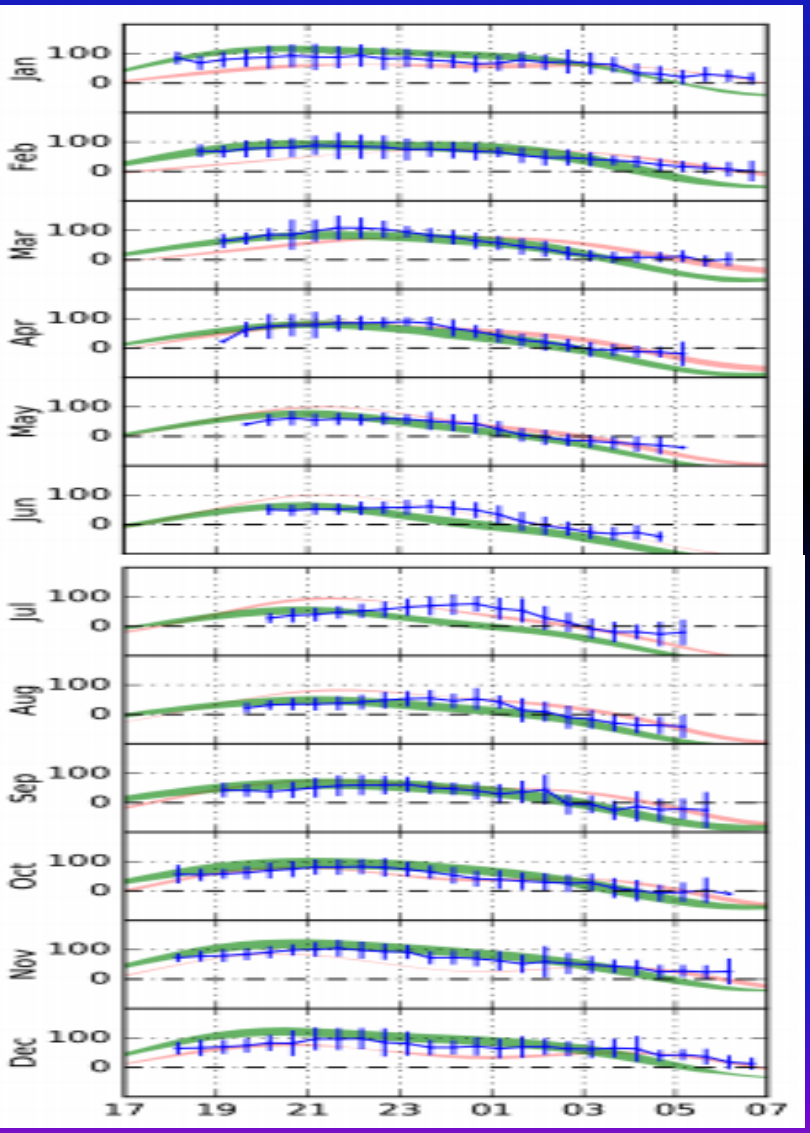

*Meriwether et al., JASTP, 2013*

*Tesema et al., AG, 2017*

# Zonal and Meridional winds in Morocco

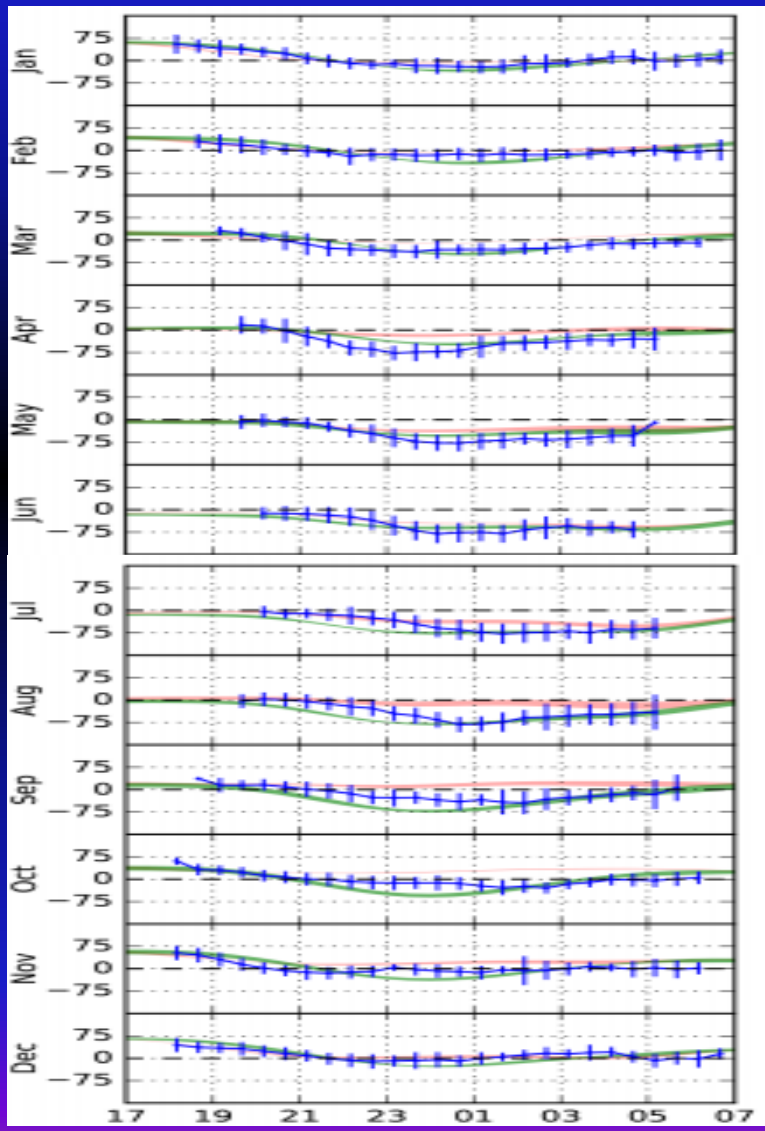
## Atlas Mountains, Morocco 31.2°N, 7.9°E; geom: 22.8°N

**Zonal Wind**



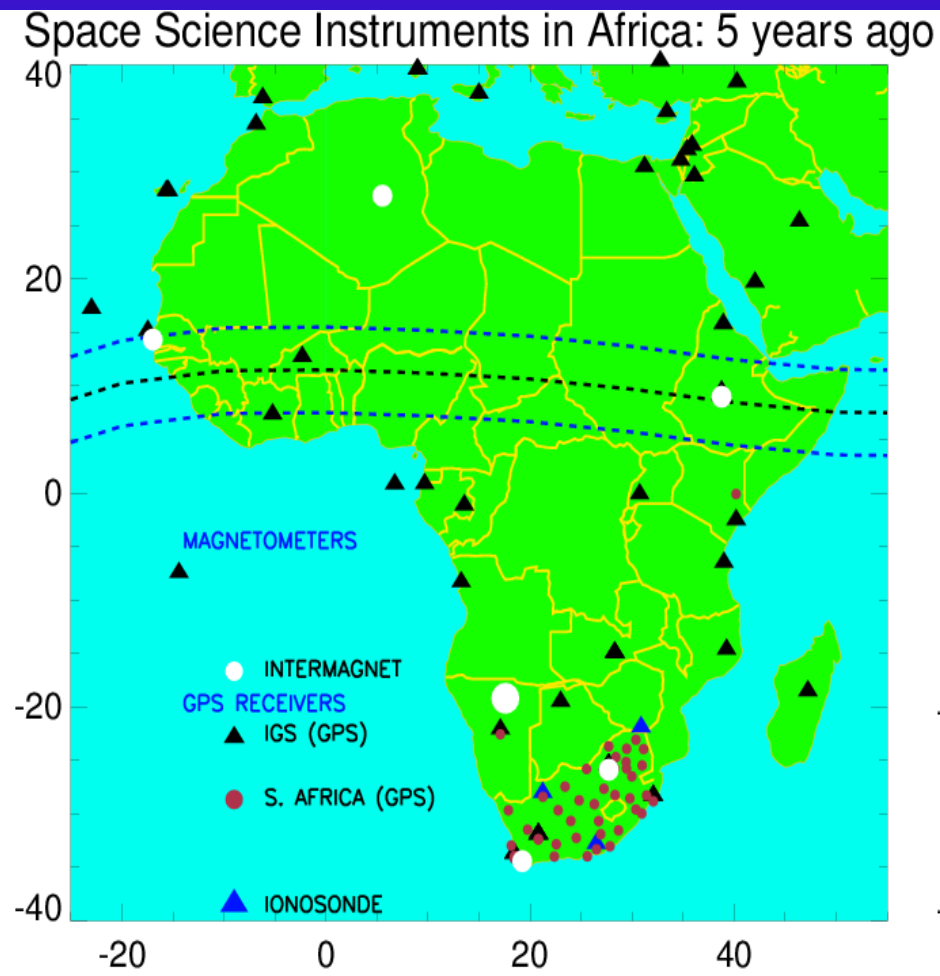

**Data**
**HWM07**
**&**
**HWM14**
**models**

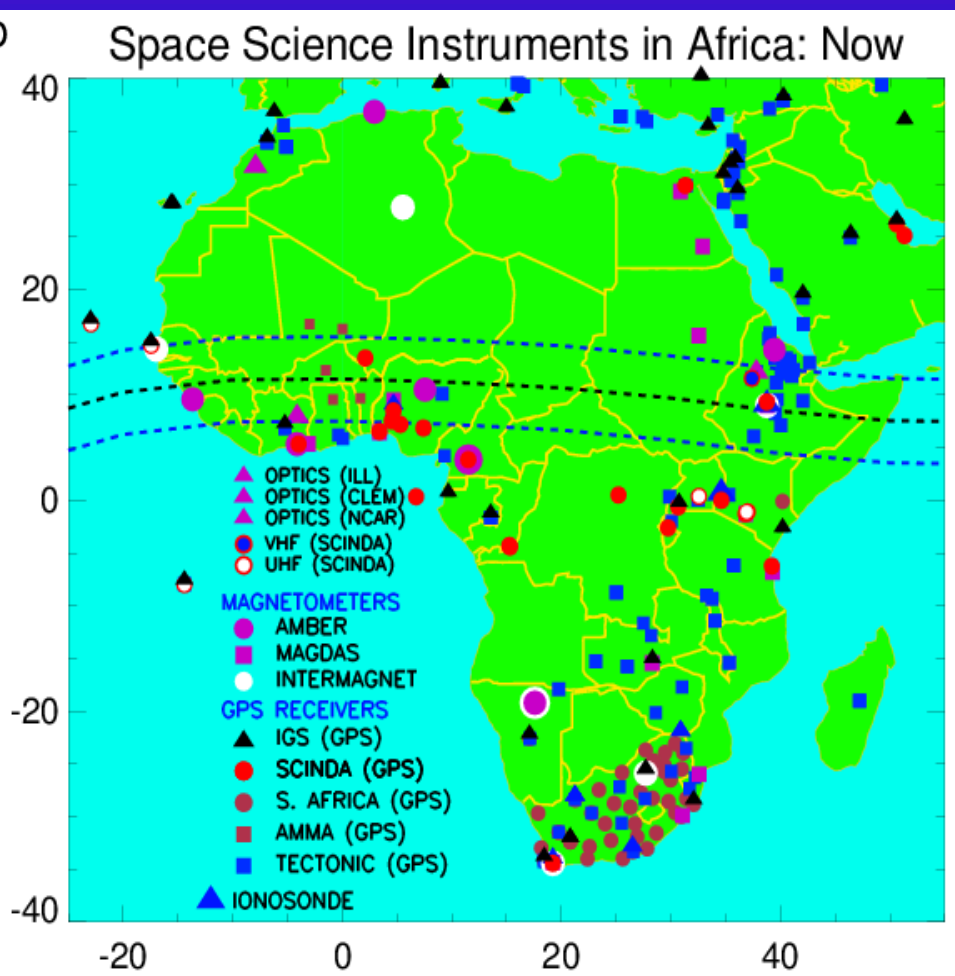
**Meridional Wind**




*Kaab et al., AG, 2017*

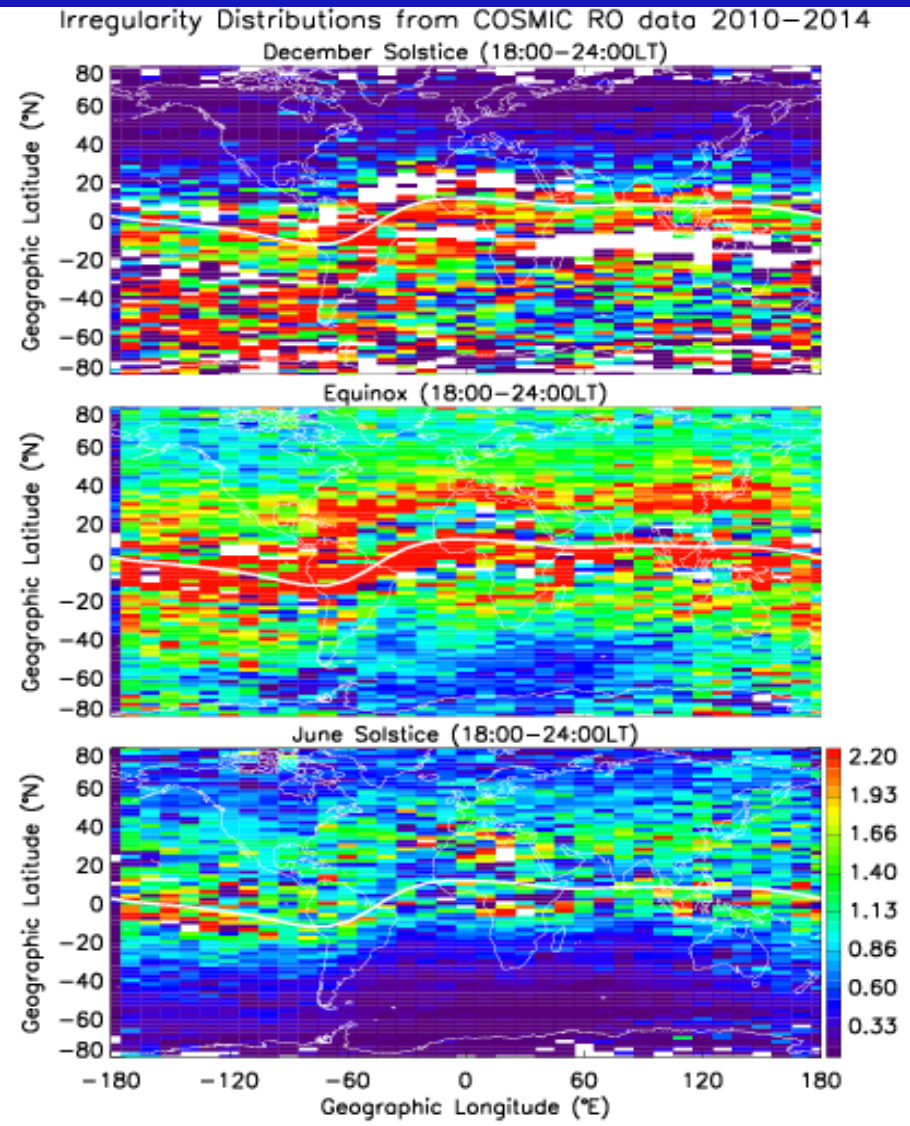
# General Instrumentation in Africa

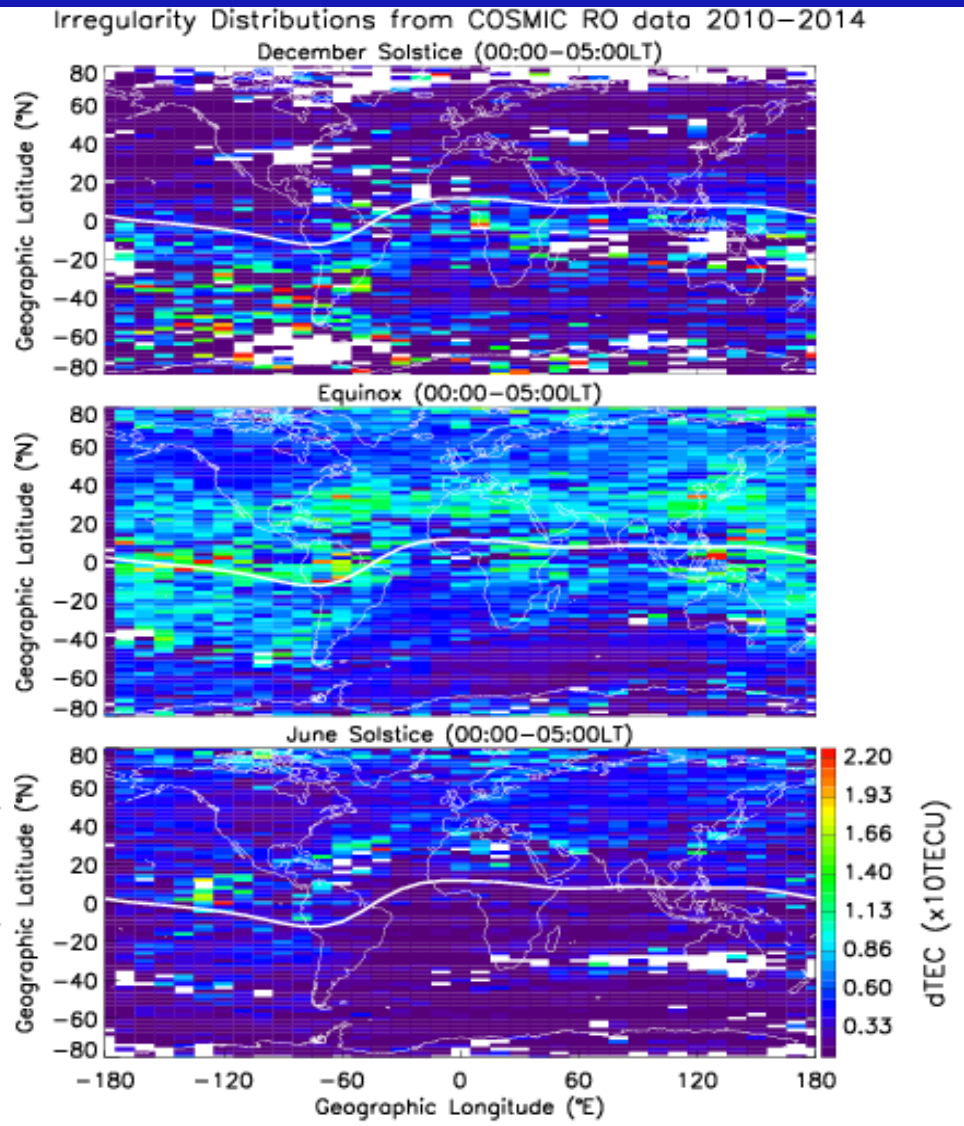


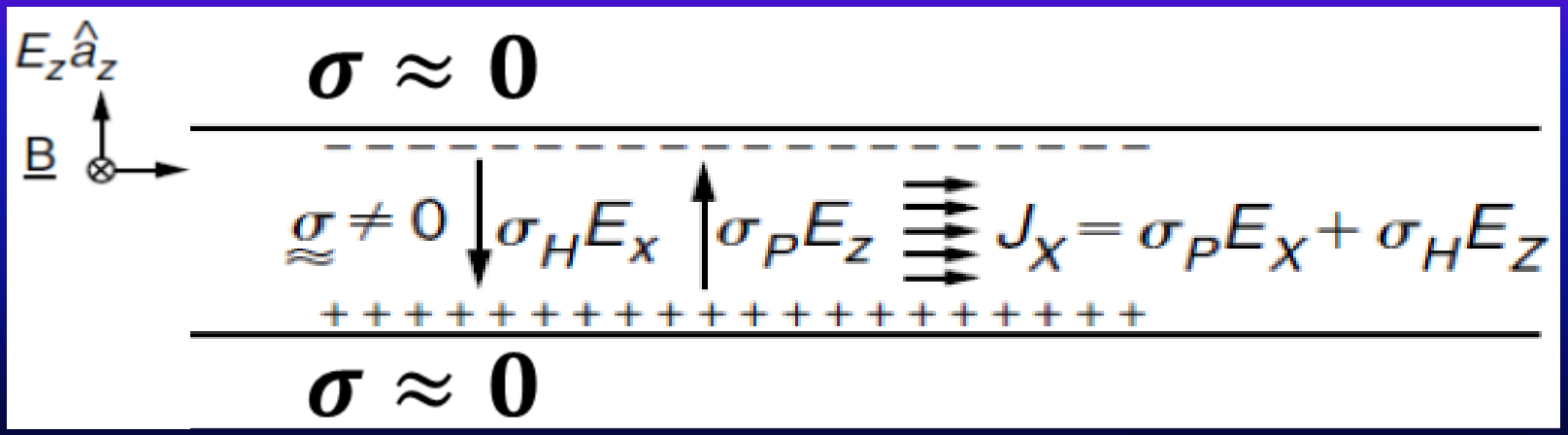

**In 2007** **In 2015**

# Thank You!


Irregularity Distributions from COSMIC RO data 2010–2014
December Solstice (18:00–24:00LT)
Equinox (18:00–24:00LT)
June Solstice (18:00–24:00LT)
Geographic Latitude (°N)
80
60
40
20
0
−20
−40
−60
−80
−180
−120
−60
0
60
120
180
Geographic Longitude (°E)
dTEC (x10TECU)
2.20
1.93
1.66
1.40
1.13
0.86
0.60
0.33


Irregularity Distributions from COSMIC RO data 2010–2014
December Solstice (00:00–05:00LT)
Equinox (00:00–05:00LT)
June Solstice (00:00–05:00LT)
Geographic Latitude (°N)
80
60
40
20
0
−20
−40
−60
−80
−180
−120
−60
0
60
120
180
Geographic Longitude (°E)
dTEC (x10TECU)
2.20
1.93
1.66
1.40
1.13
0.86
0.60
0.33

# Equatorial Electrojet (EEJ) ~ Equatorial Drift




$$J_Z = -\sigma_H E_X + \sigma_P E_Z = 0 \quad \rightarrow \quad E_Z = \frac{\sigma_H}{\sigma_P} E_X$$

$$J_X = \sigma_P E_X + \sigma_H \left( \frac{\sigma_H}{\sigma_P} E_X \right)$$

$$J_X = \left( \sigma_P + \frac{\sigma_H^{\,2}}{\sigma_P} \right) E_X = \sigma_C E_X \quad \rightarrow \quad \text{EEJ current}$$

→ **EEJ current, which is generated by Hall & Pederson conductivities in the vicinity of geomagnetic equator (±3°), is proportional to vertical drifts and can be estimated using magnetometer data.**