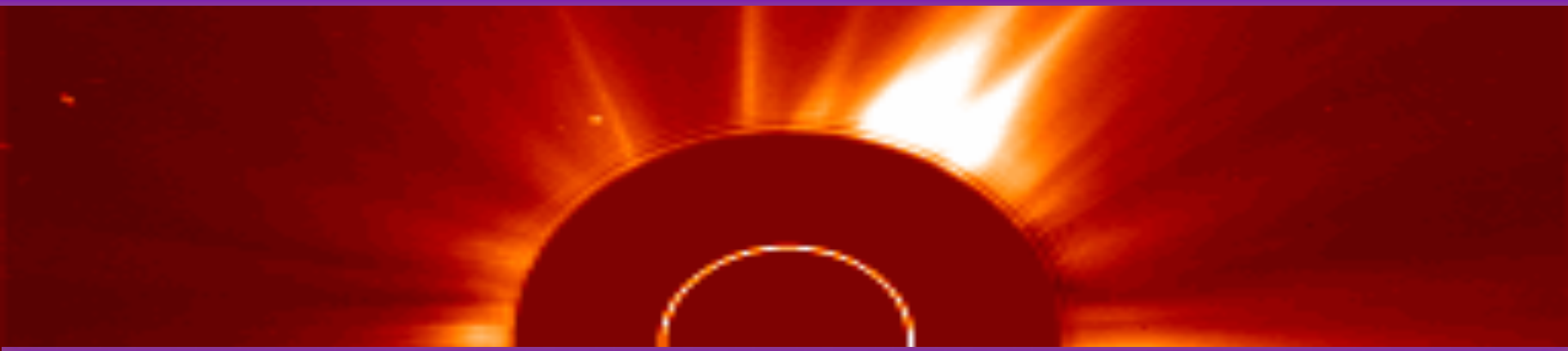
Longitudinal Variability of Scintillation and Equatorial Electrodynamics



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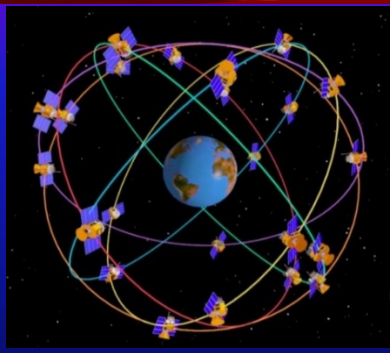
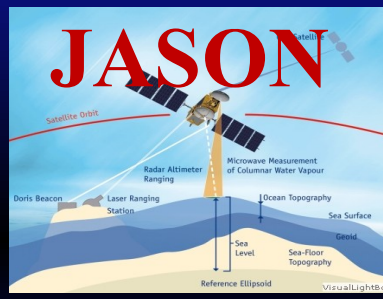
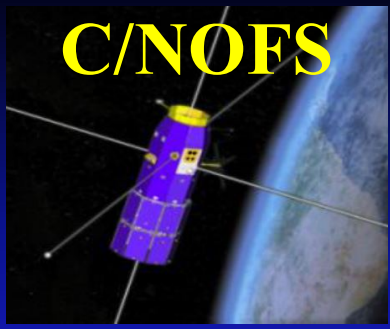
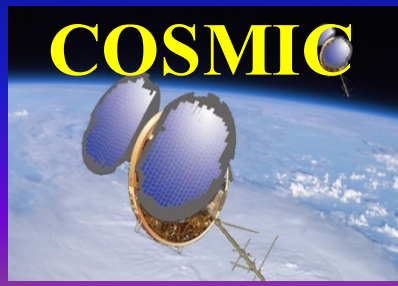
Outline

- Motivation
  - What controls the longitudinal, local time, and seasonal variability of density irregularities?
  - Scintillation/bubbles longitudinal distributions
  - Longitudinal Equatorial electrodynamics
- Existing modelling capability in reproducing bubbles/scintillation distributions



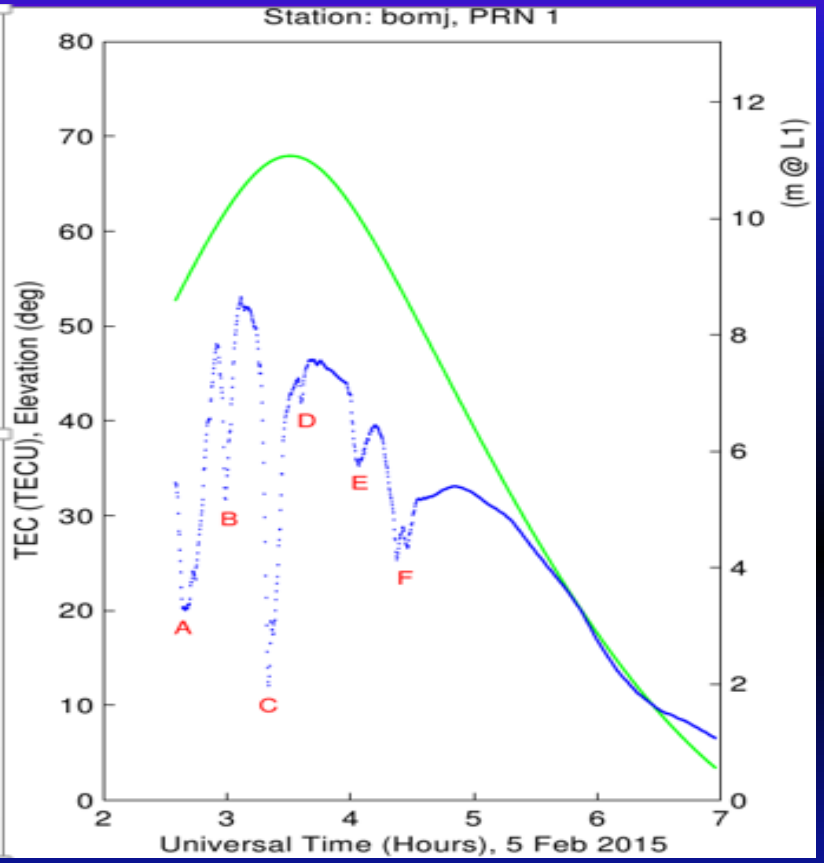






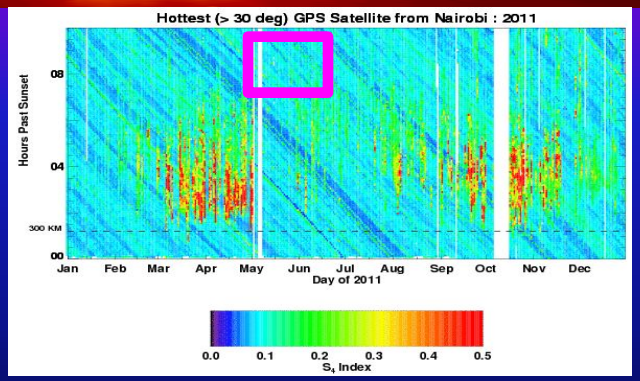
Bubble detection with GPS and UHF radar

Bubbles extracted from TEC



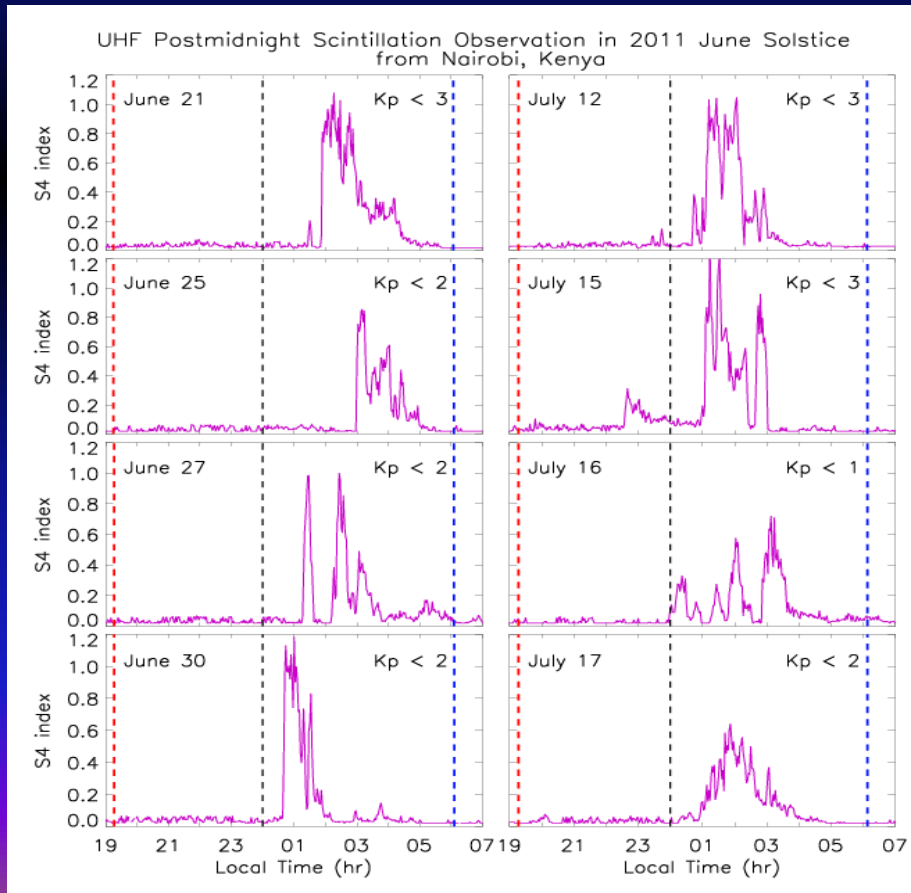
Bubble detection technique from the ground-based GPS TEC observations (*Seemala and Valladares*, 2011)

Yizengaw et al., GRL, 2013



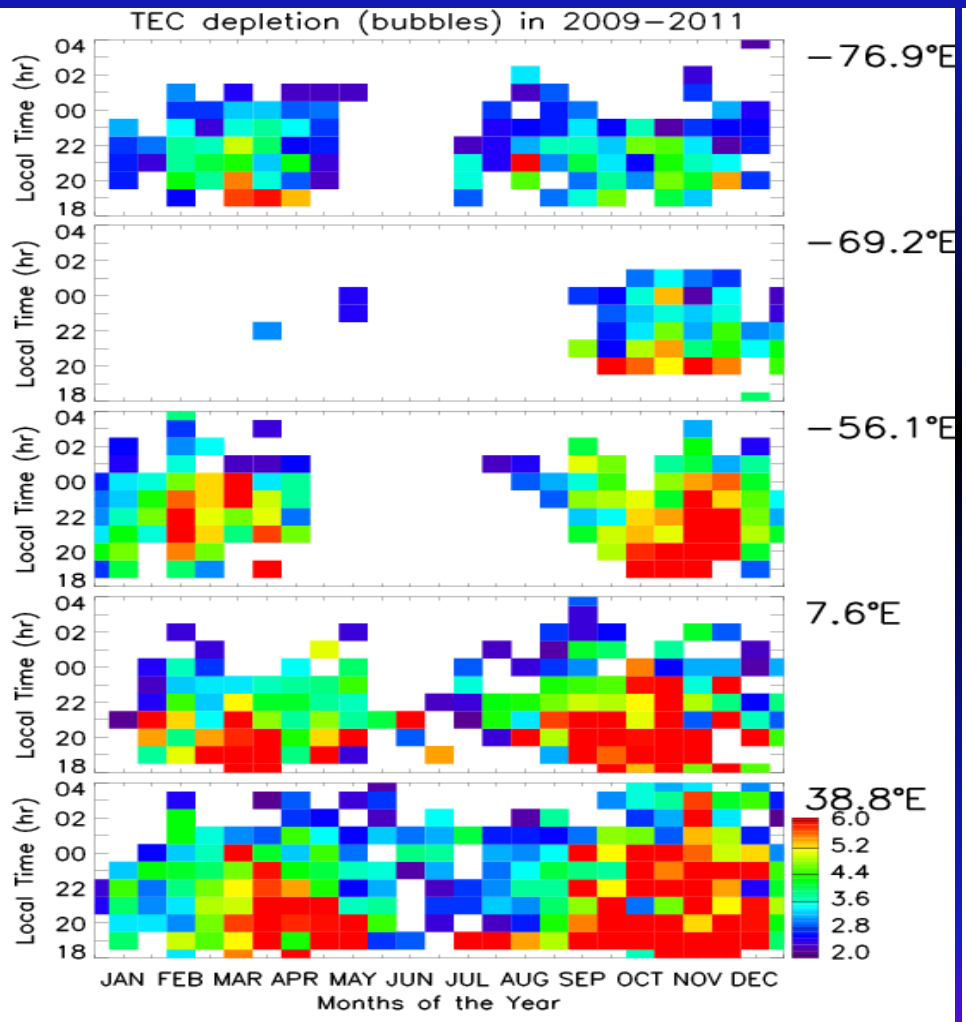
Sometime GPS show no scintillation but doesn't mean no bubbles/structures

250 MHz scintillation observations

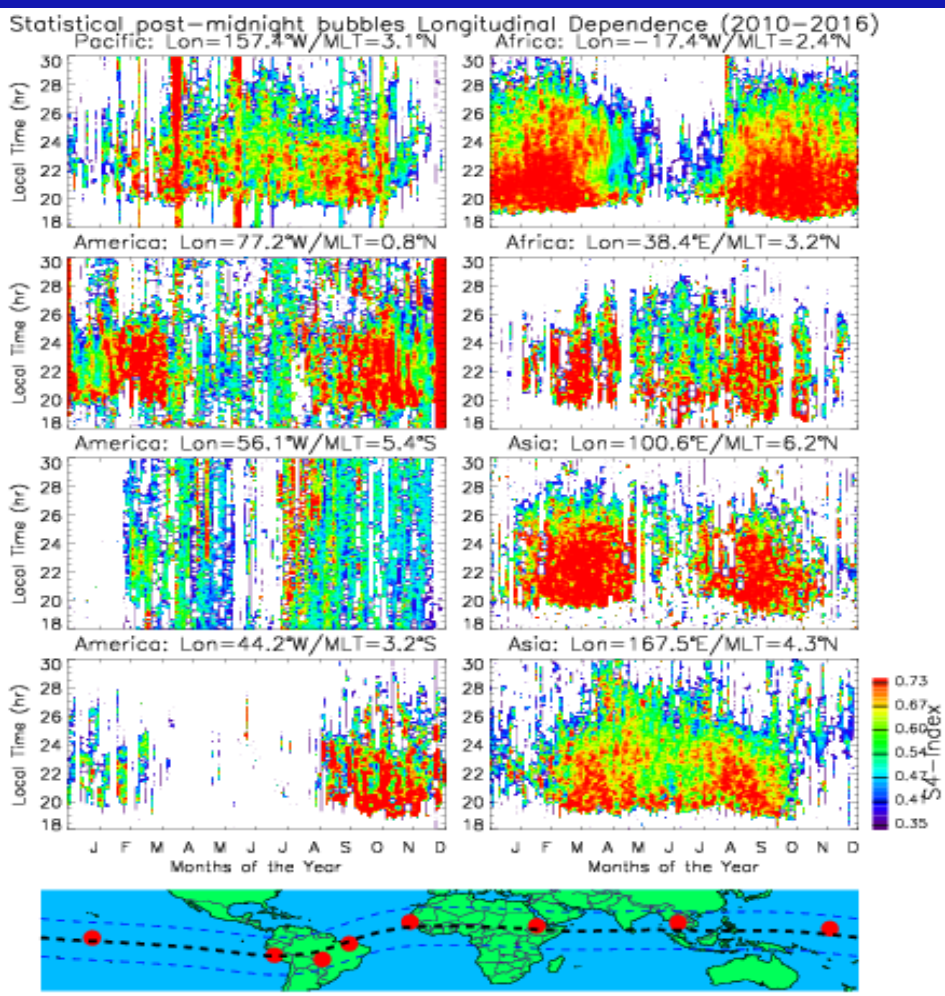


Longitudinal, Local Time and Seasonal variability of ionospheric irregularities: from the ground

Bubbles extracted from TEC



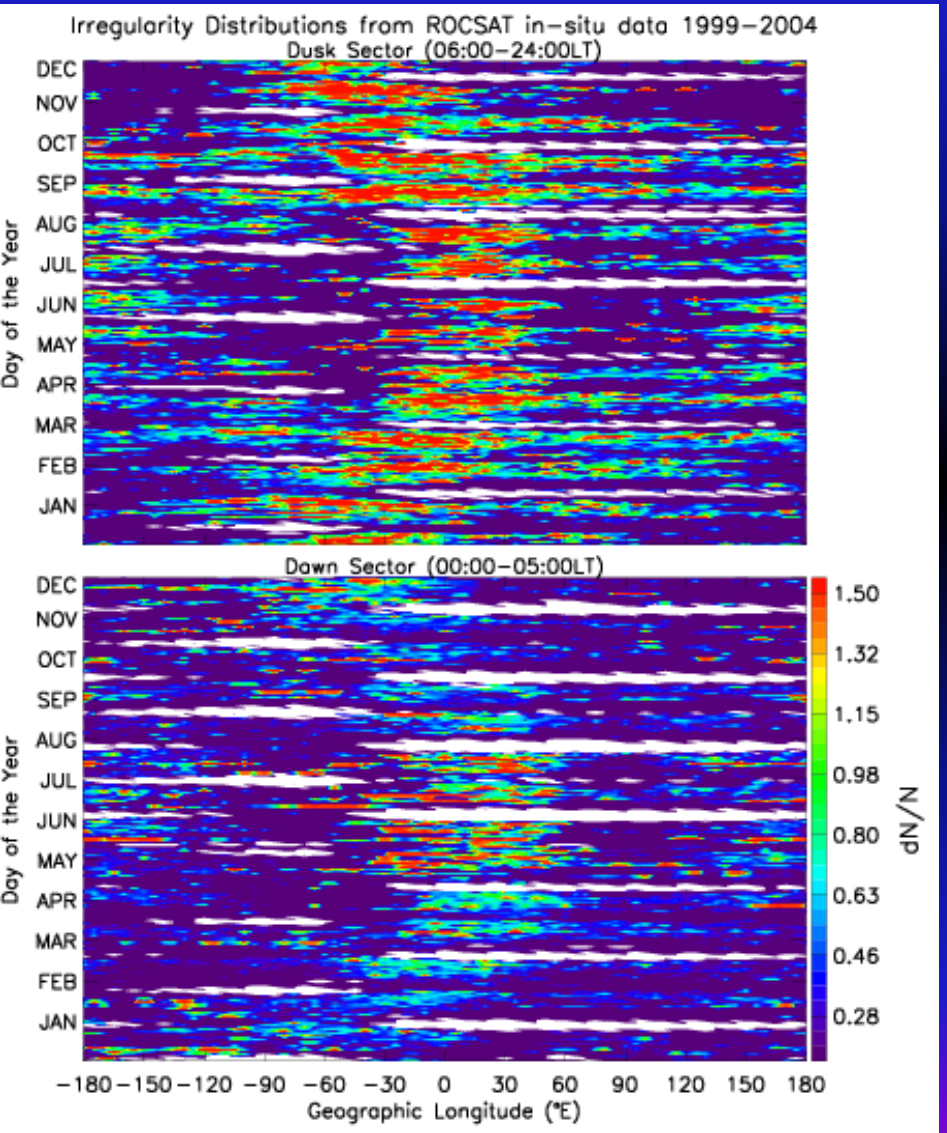
Scintillations from UHF receivers

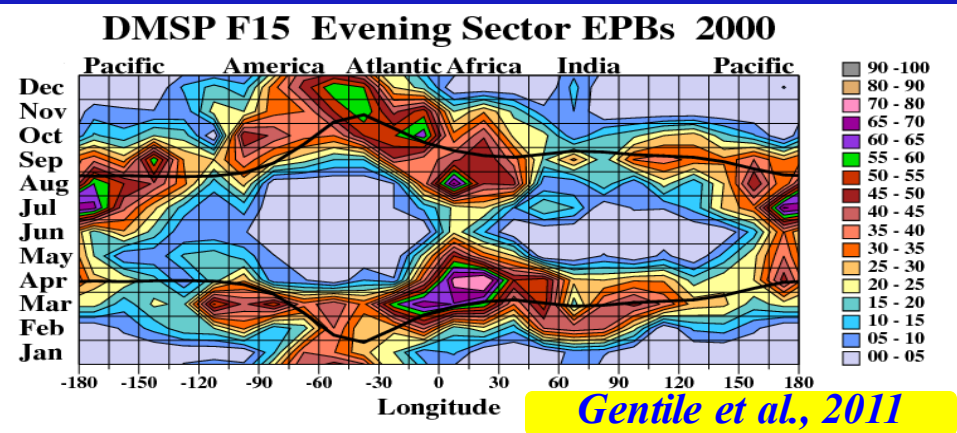


Yizengaw et al., AG, 2014

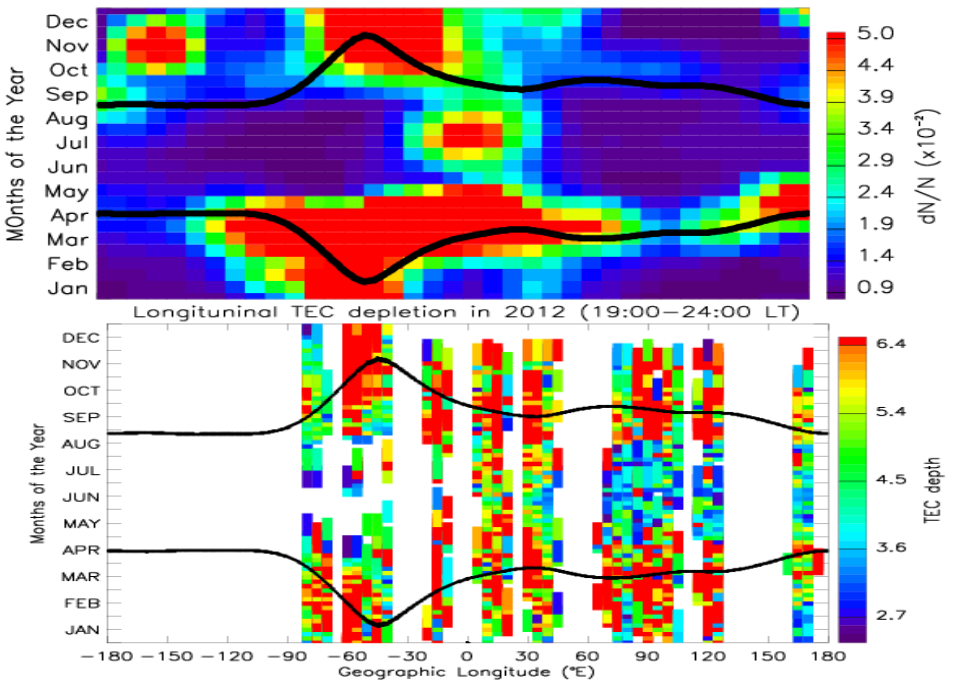
Yizengaw et al., 2017

Multi-instrument observations of Longitudinal and seasonal variability of irregularities



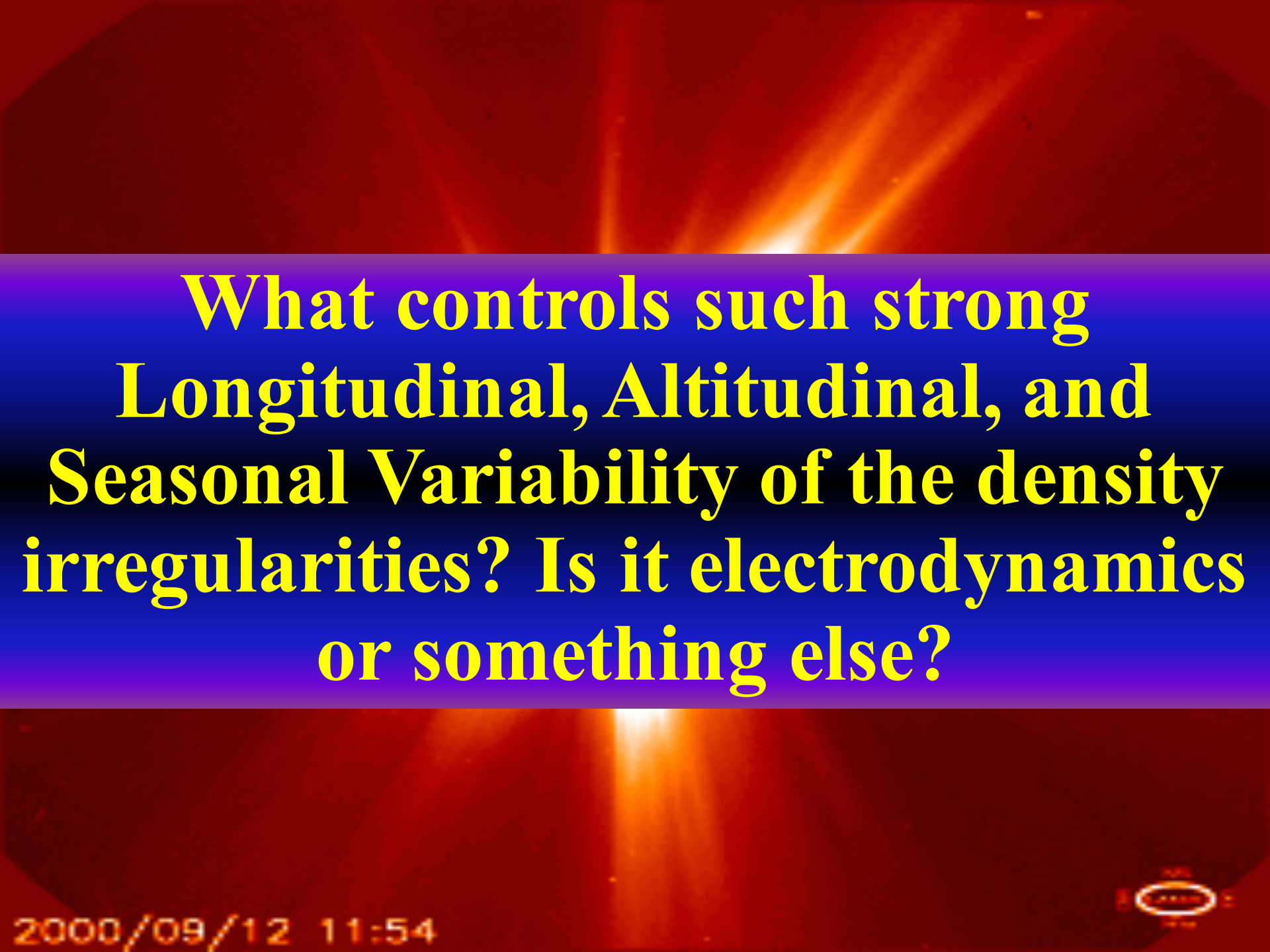


Gentile et al., 2011

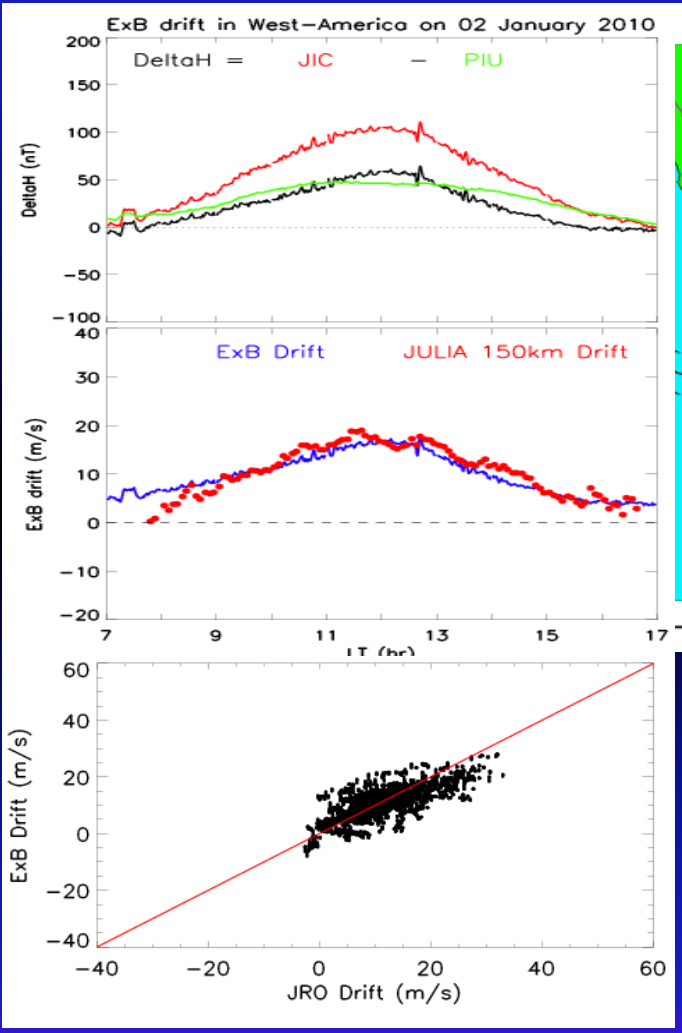


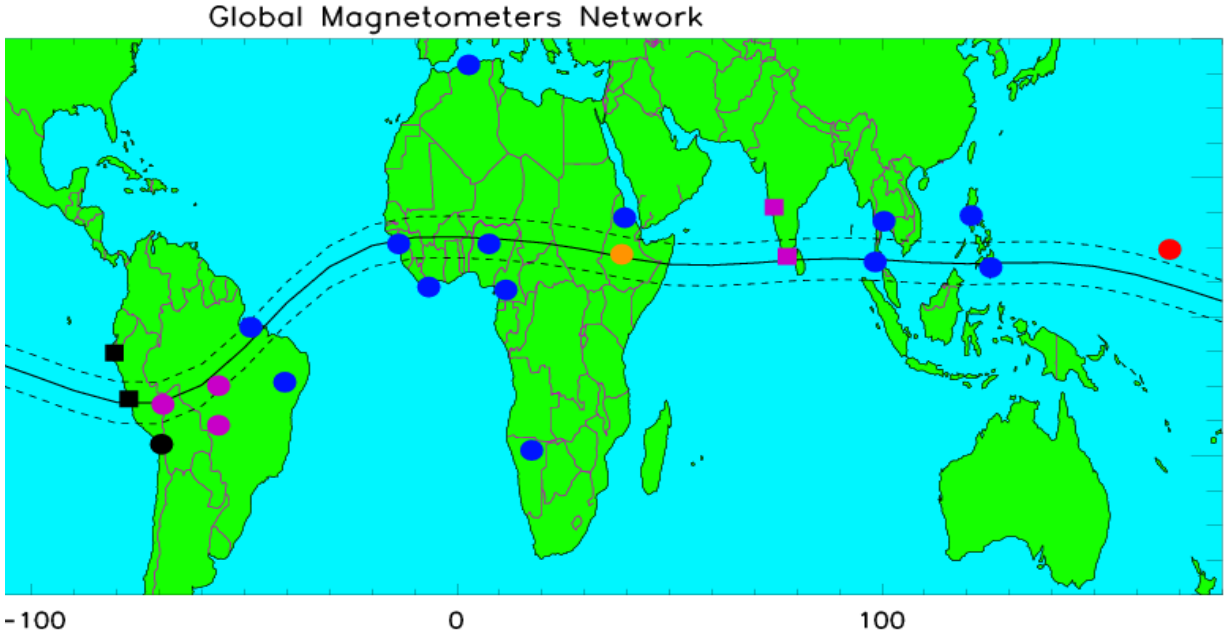
Yizengaw et al., 2014

What controls 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**

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

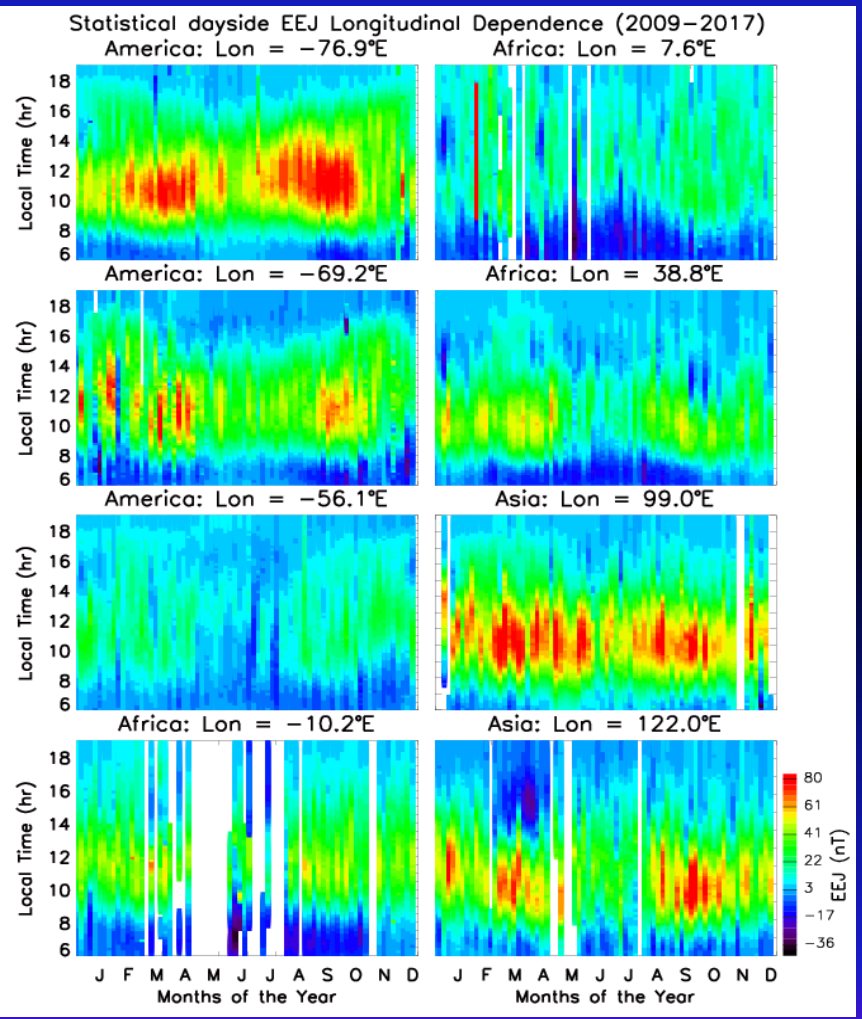
- **Magnetometer at the equator**

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

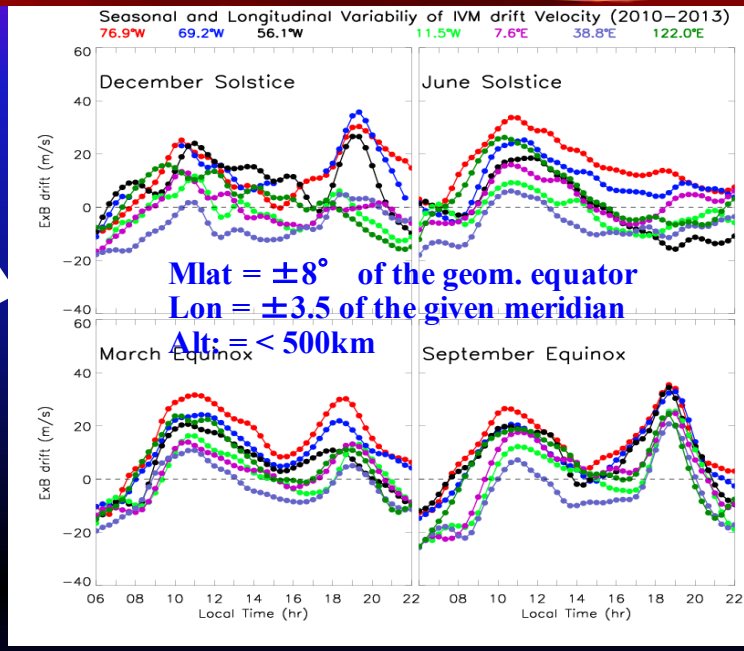
- **Problem:** Does EEJ current or Equatorial Electrodynamics in general show longitudinal and seasonal dependence?

Longitudinal variability of day and night side drift

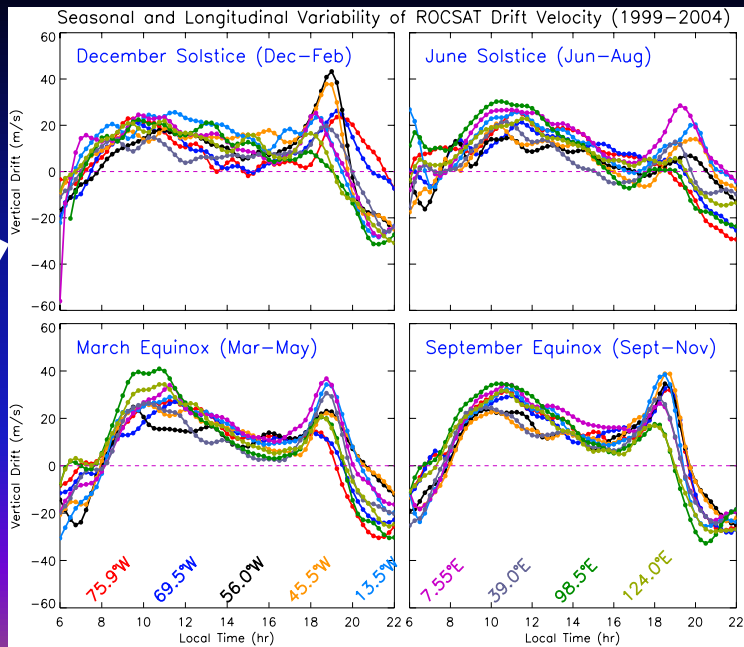
Dayside EEJ/drift from magnetometer observations



Day and nightside drifts from C/NOFS IVM



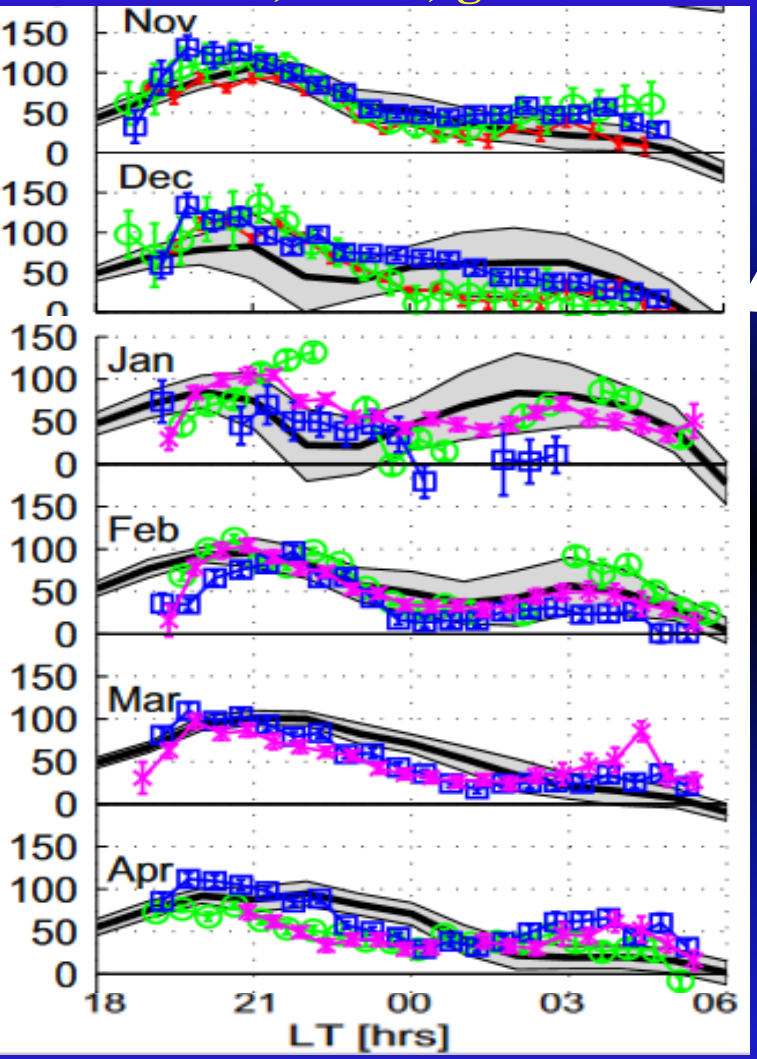
Day and nightside drifts from ROCSAT



In general, the day and nightside drifts show stronger in the American and Asian sectors but weaker in the African sector, which is opposite to bubble longitudinal distribution

Does the wind play role? Zonal wind Longitudinal Variability

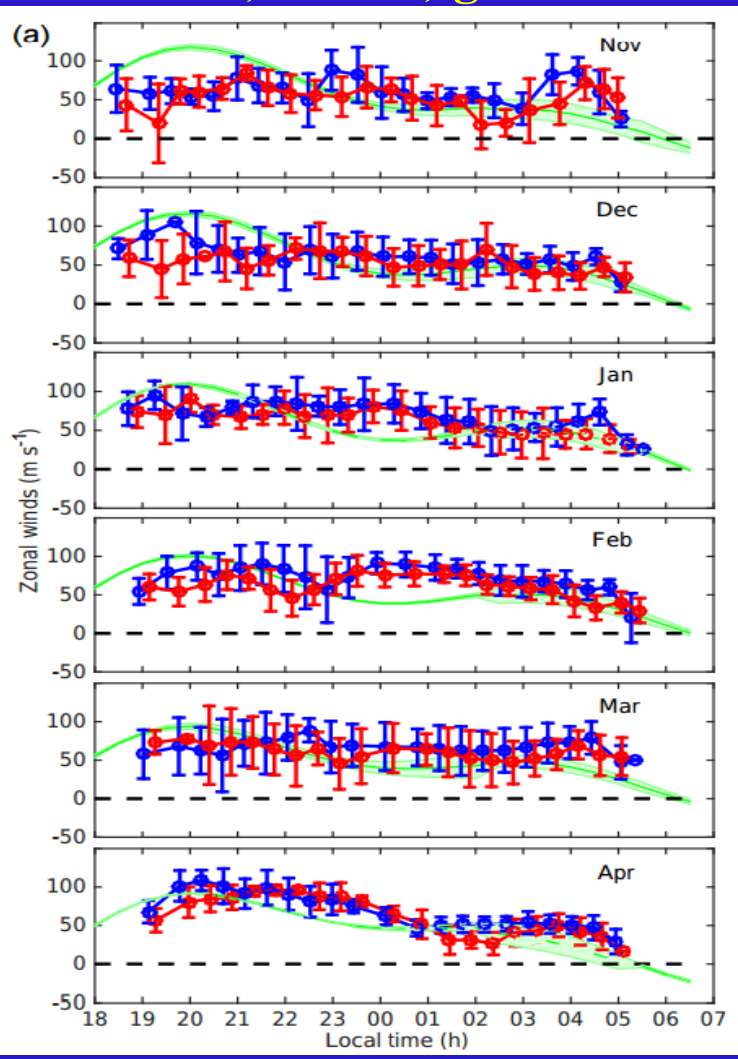
Brazil 7°S, 39°W; geom: 5.8°S



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

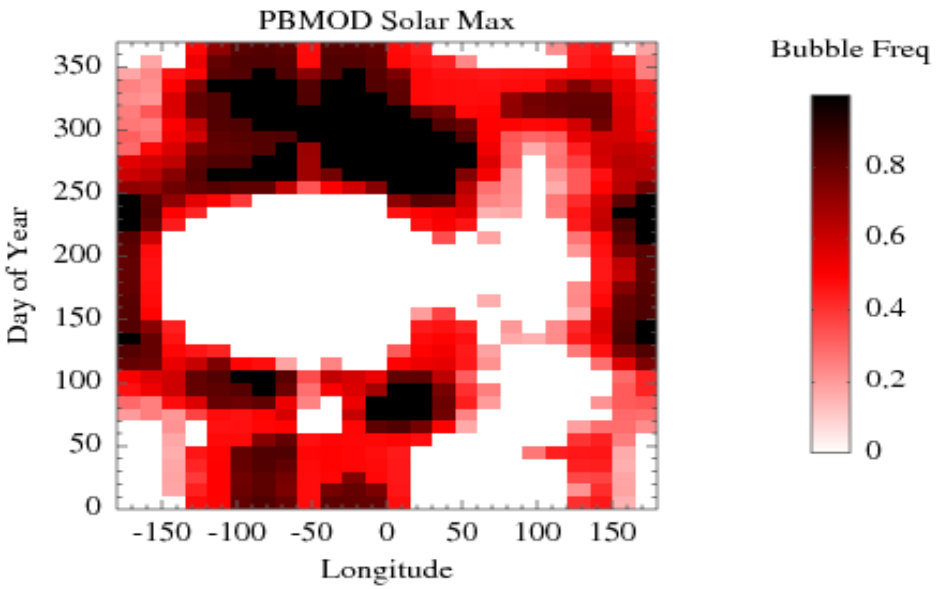


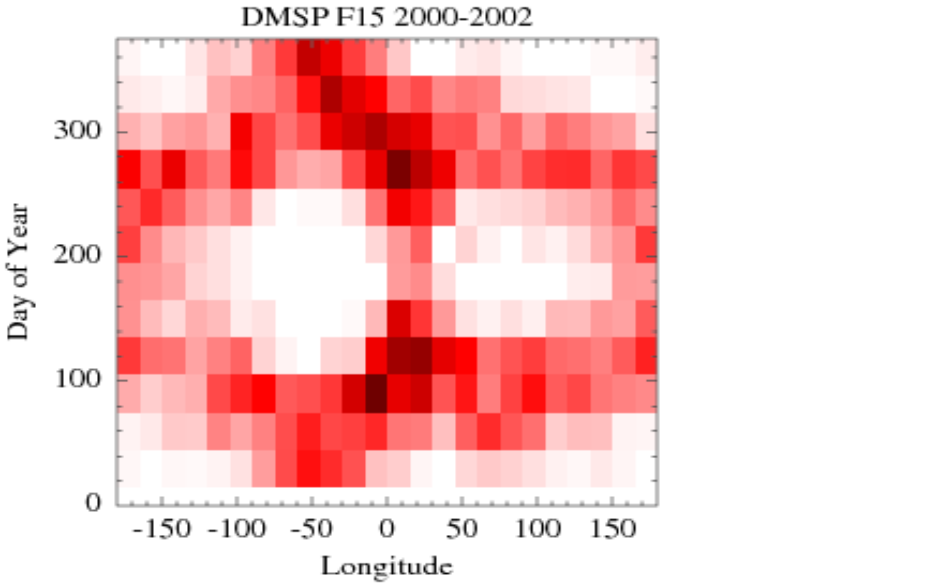
Meriwether et al., JASTP, 2013

Tesema et al., AG, 2017

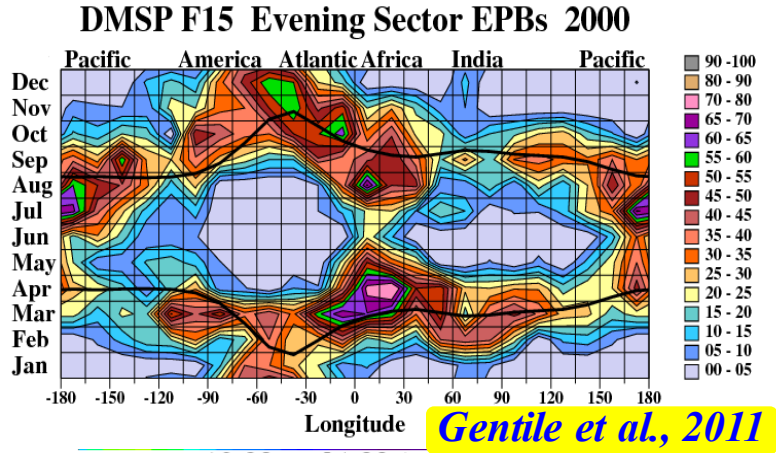
No big difference in zonal wind magnitude between Africa and American sectors, though the time of observations not at the same year

Modelling capabilities: Climatology bubbles comparisons

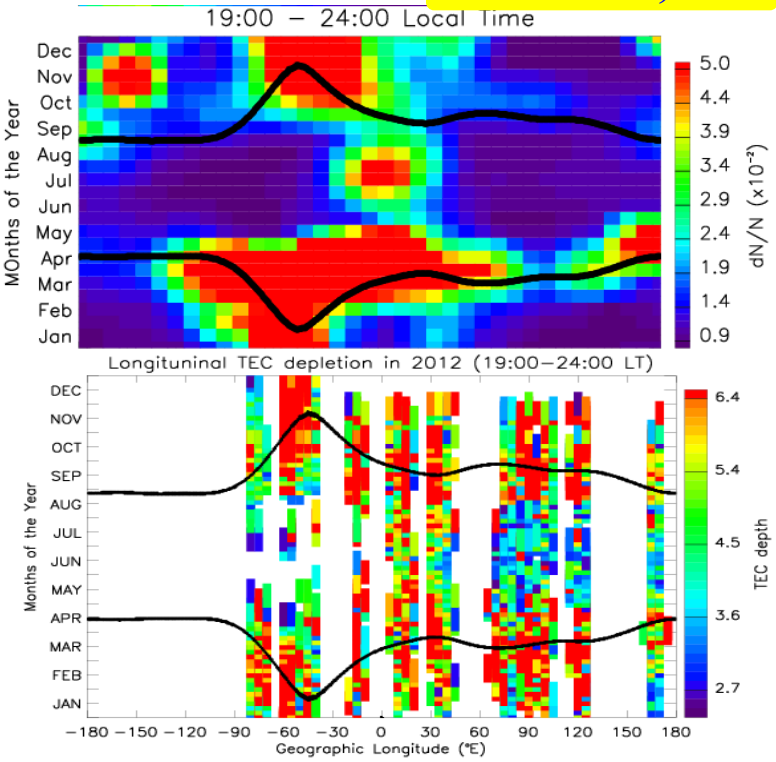




Retterer et al.



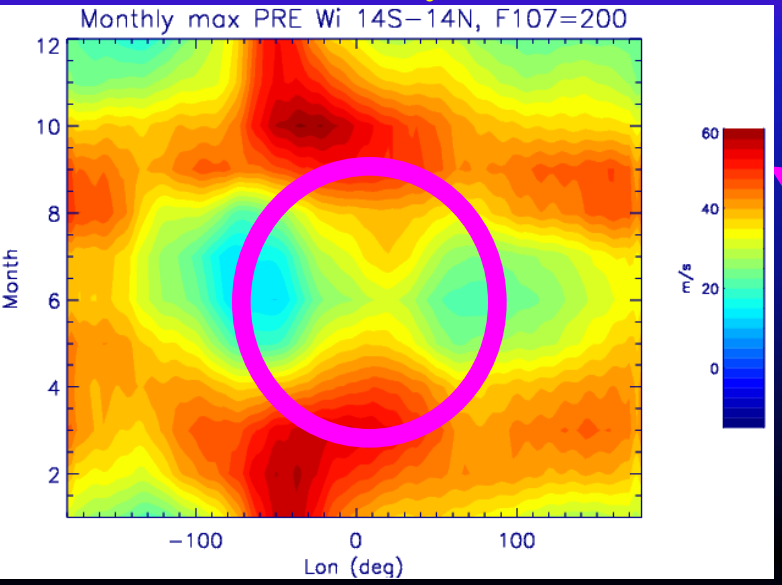
Gentile et al., 2011



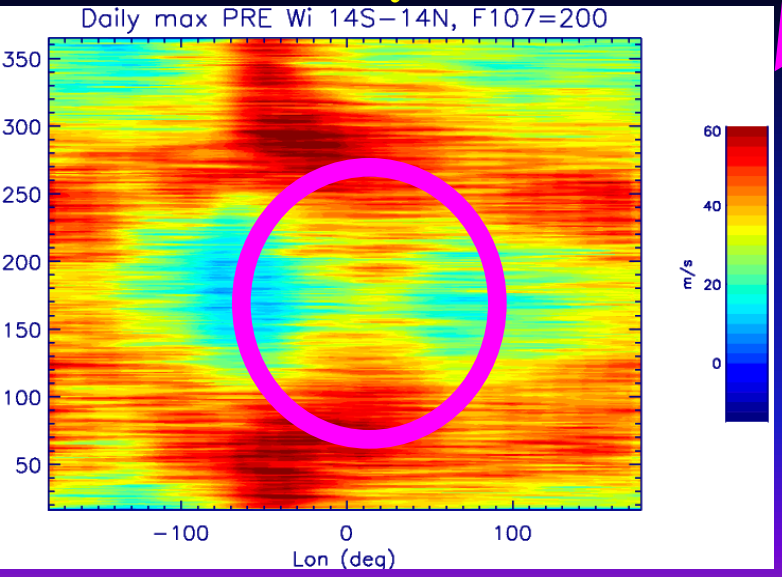
Yizengaw et al., 2014

Modelling capabilities: Climatology drifts comparisons

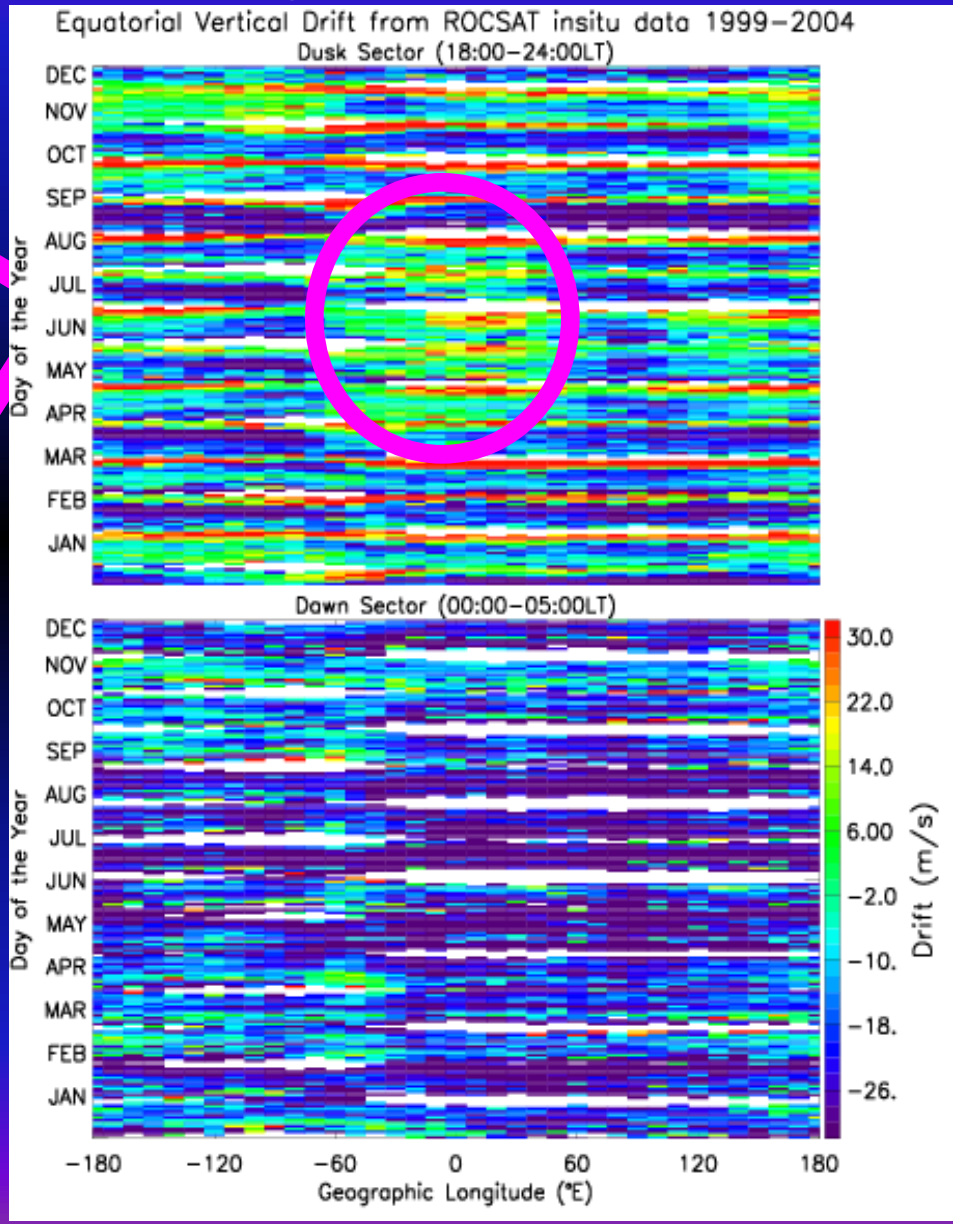
Solar Max: Monthly PRE maximum



Solar Max: Daily PRE maximum



Drift at ROCSAT alt



Liu et al.

Summary

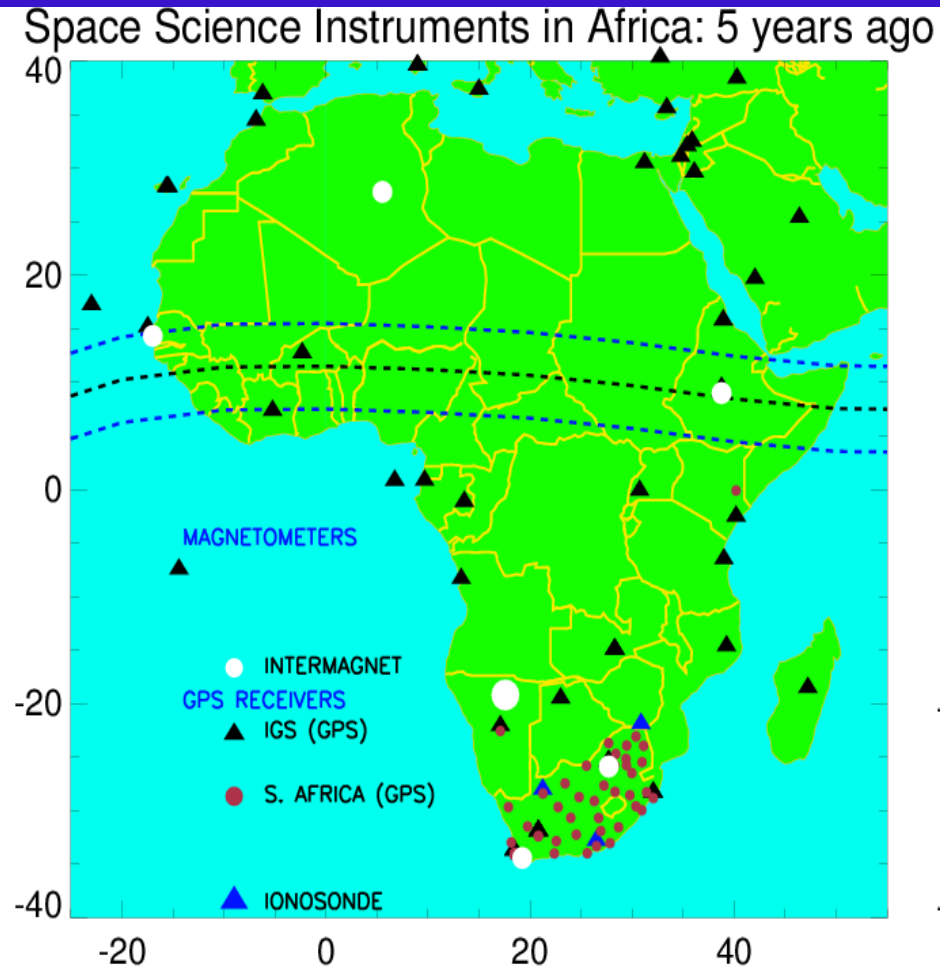
- The magnitude and direction of the vertical drift (both dayside and evening sector) show significant longitudinal differences but stronger in the American and Asian than African sectors, which is opposite to the longitudinal bubble distributions.

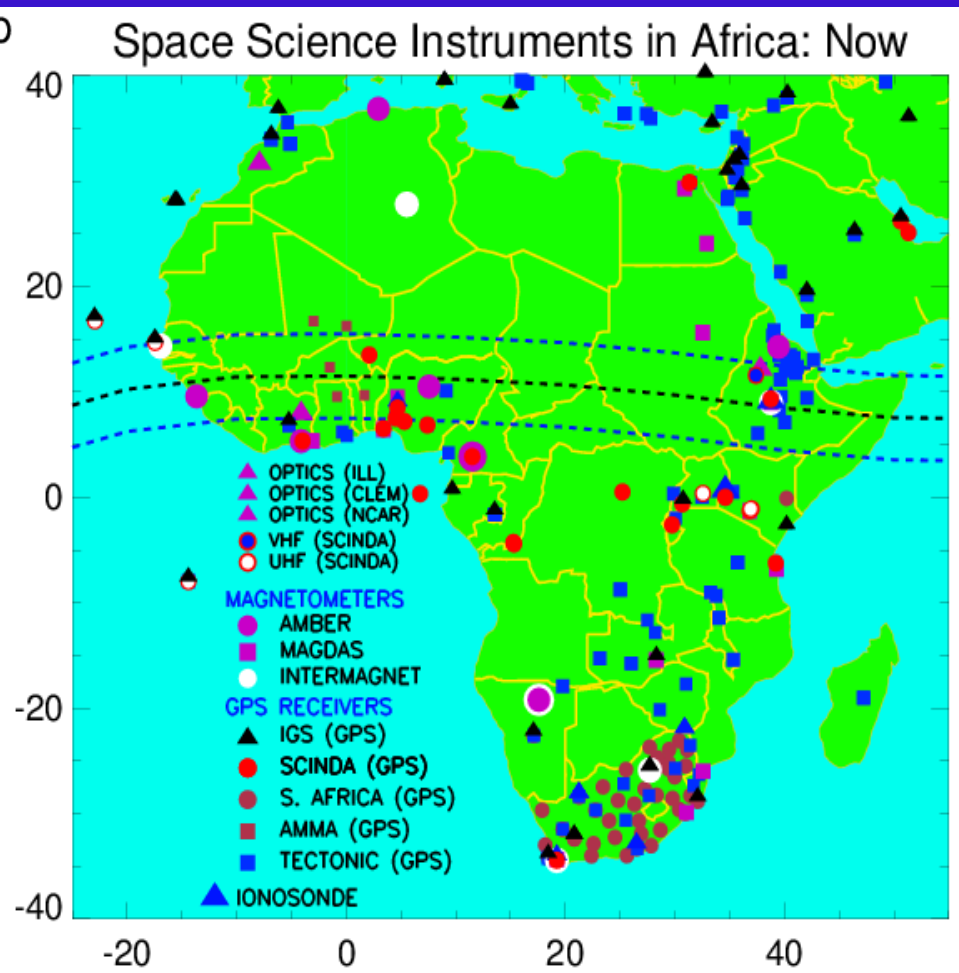
- On the other hand both ground- and space-based observations show clear longitudinal and seasonal variability of the bubble distribution, stronger in the African sectors.

- Strength and weakness of the current model performances
  - Reproduce the climatology scintillation distributions fairly well
  - Have problem in reproducing the day-to-day variability

- Way forward to improve current model prediction capability
  - Fair estimation of the drivers is essential
  - More ground-based observations are required

General Instrumentation in Africa





In 2007 **In 2015**

Thank You!

Longitudinal, Local Time and Seasonal variability of ionospheric irregularities: from ROCSAT