Comparison of Space and Ground-based observations of equatorial electron density irregularities

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Outline :

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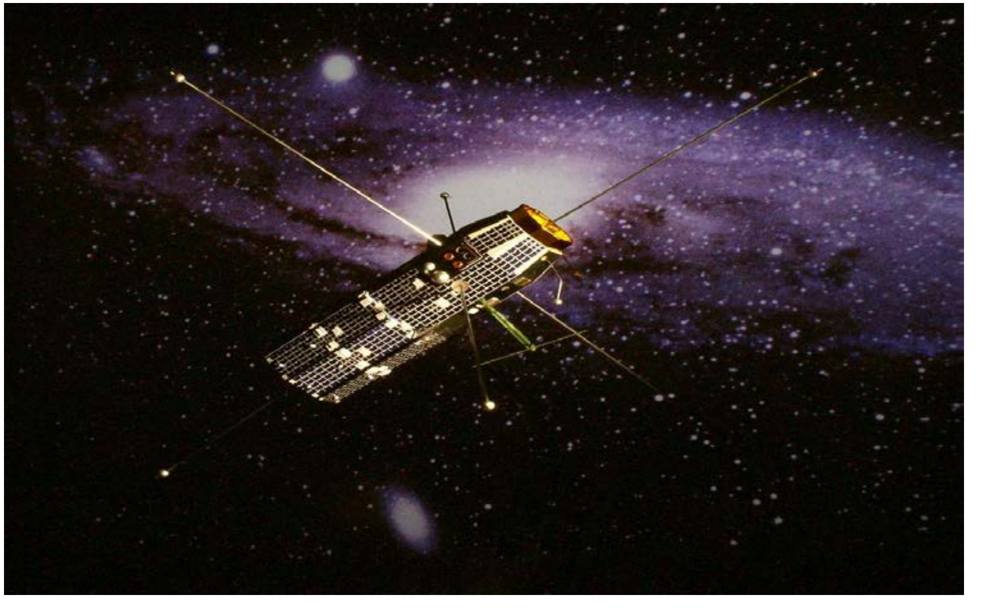


Motivation

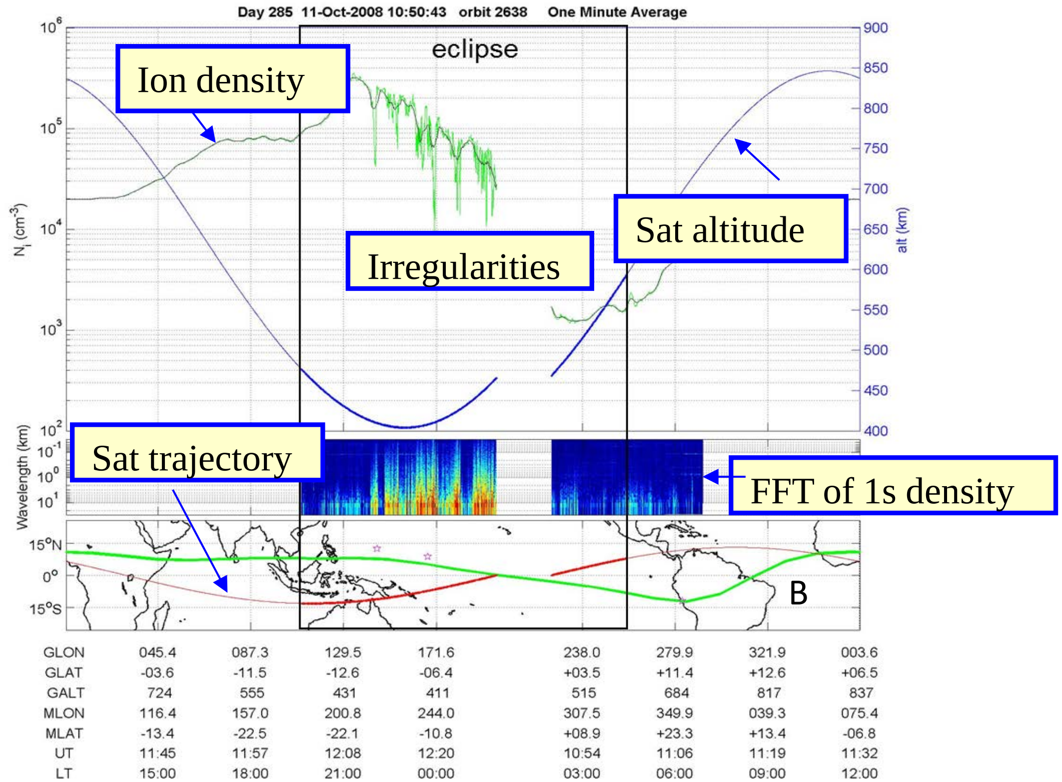
- Our goal is to understand the spatial distribution of equatorial irregularities as a function of solar flux.
- The assumed mapping of large-scale electric fields along magnetic field lines suggests that the meridional extent of spread F structures can be estimated from the altitude distribution of equatorial bubbles.
- An initial examination of bubble altitudes revealed a surprising absence of bubbles above about 700 km during 2011-2014.
- To test the consistency of these findings we compare the in situ results with ground-based scintillation observations.

PLP Observations from C/NOFS

C/NOFS sampled all altitudes between 400 – 850 km every orbit

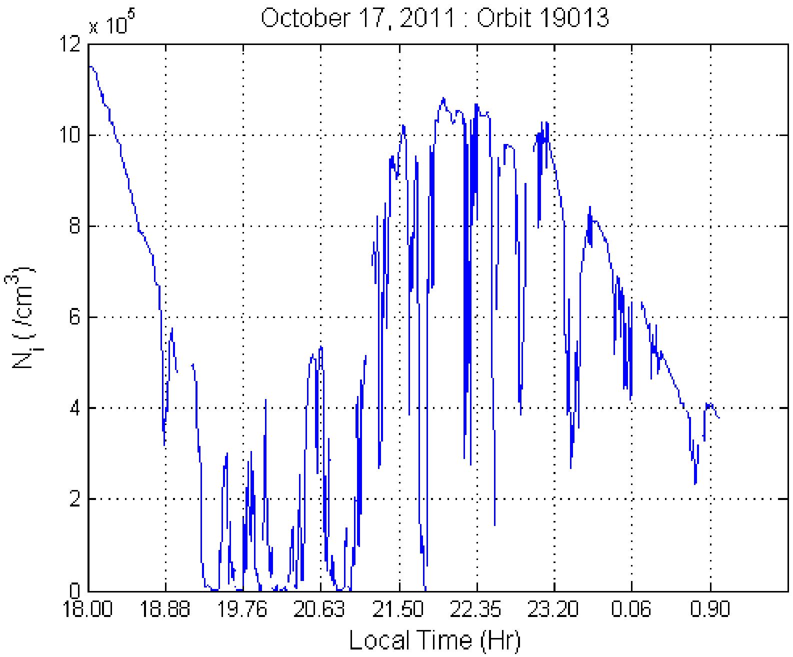
C/NOFS Mission Parameters:

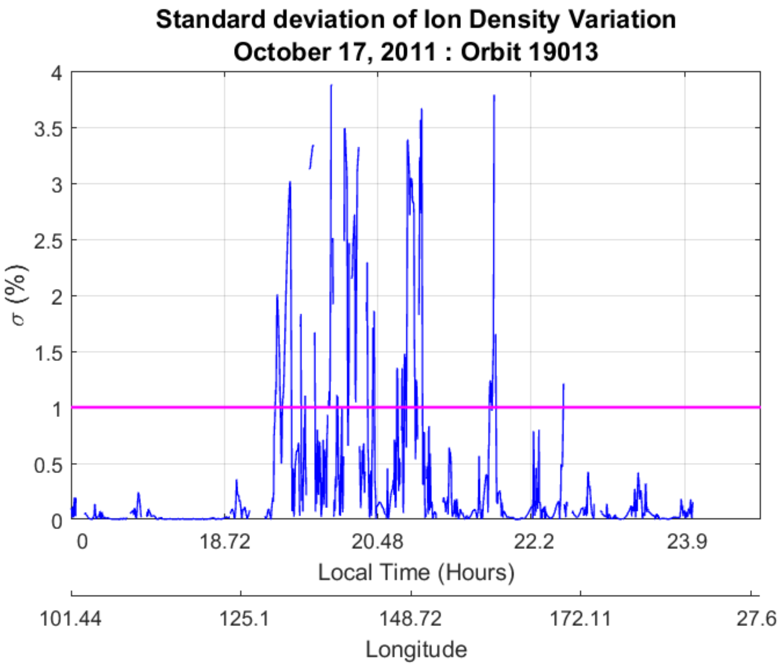
- Perigee – 400 km
- Apogee – 850 km
- Inclination – 13 degrees
- Period – 97.3 minutes
- Six sensor payload measures
  - Ion density
  - Vector E-field
  - Neutral wind
  - Temperature
- Ground-based instruments
- Models (PBMOD)



Orbital parameters well-suited to analysis of altitude characteristics

Irregularity Detection Methodology



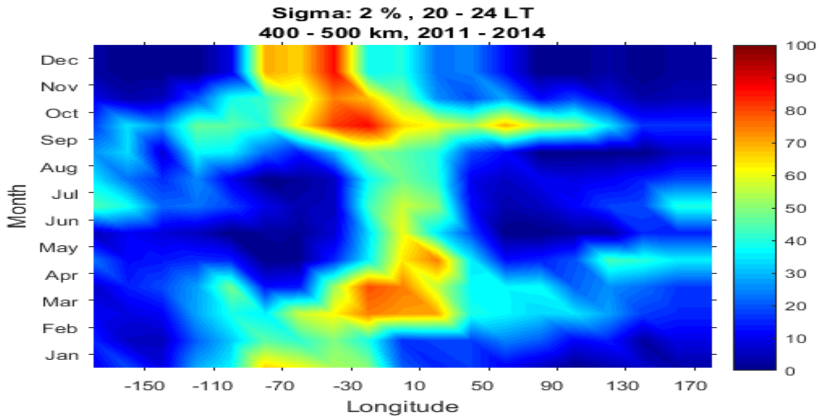


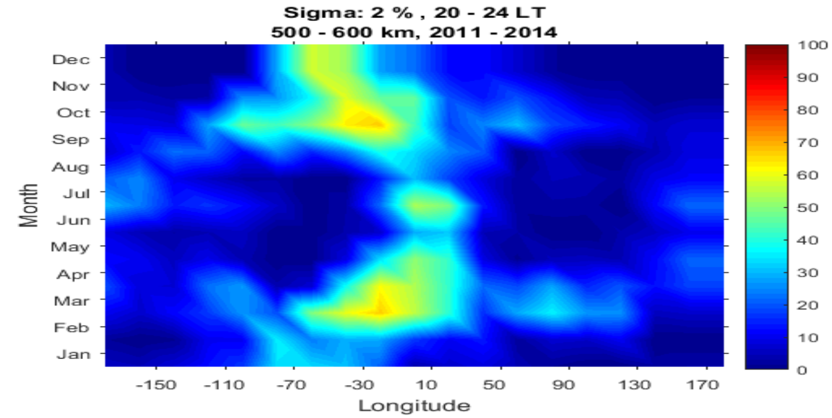
We define an irregularity parameter, σ as follows:

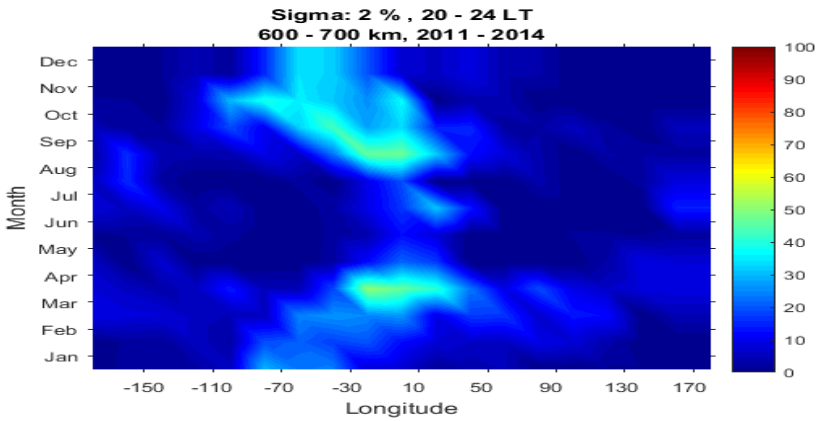
$$\sigma\ (\%) = 100\ \times\ \frac{\left[\frac{1}{11}\sum_{i=1}^{11}\left(\log N_{\mathrm{i}} - \log N_{0i}\right)^{2}\right]^{1/2}}{\frac{1}{11}\sum_{i=1}^{11}\log N_{0i}}$$

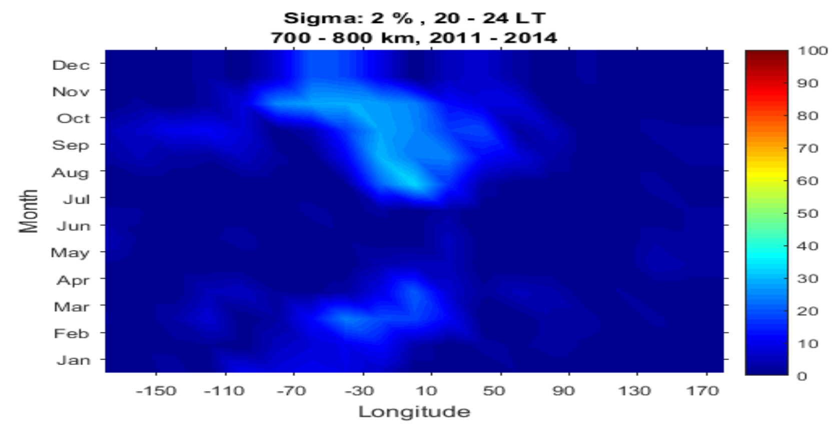
The above equation represents the standard deviation of ion density variations in logarithmic scale divided by the mean of ion density in logarithmic scale.

CNOFS Observations Solar Cycle 24



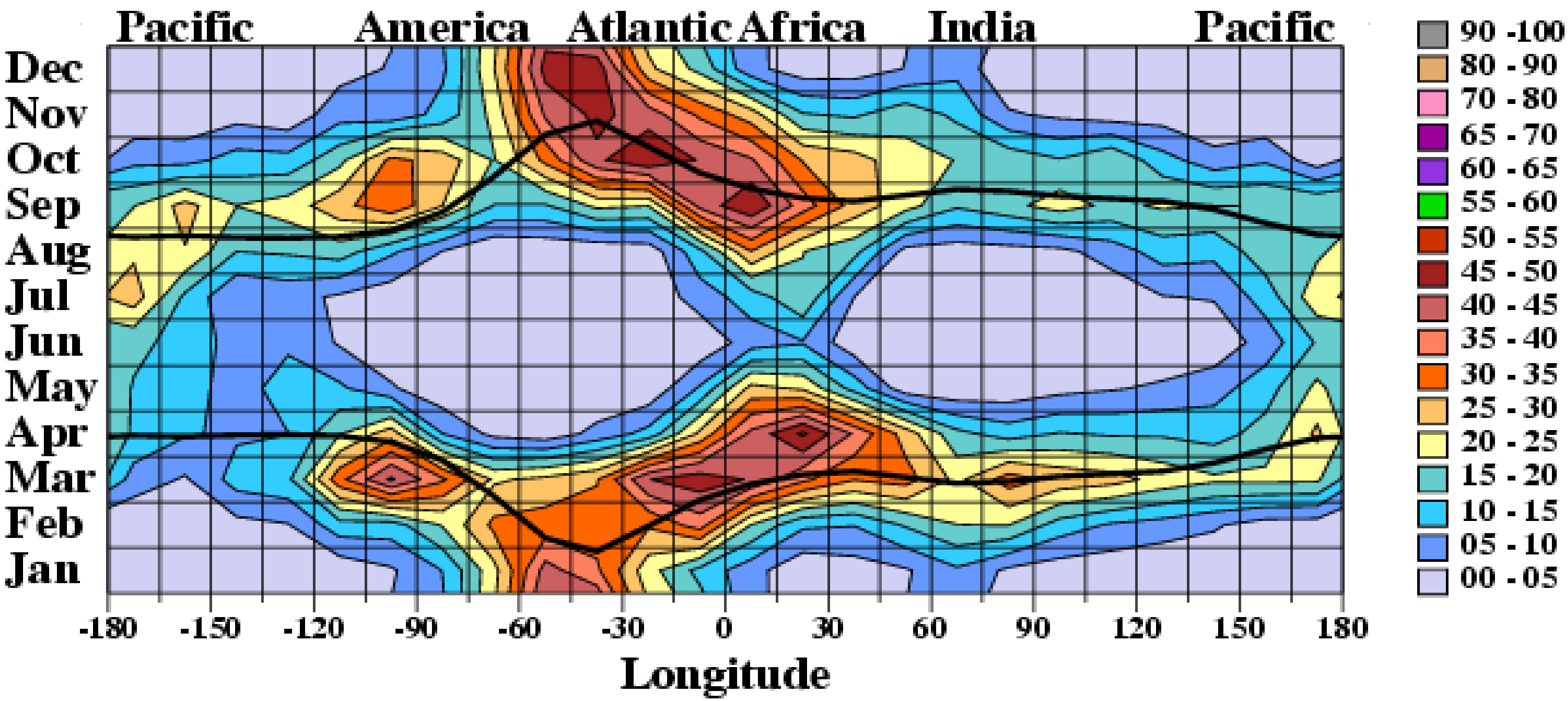






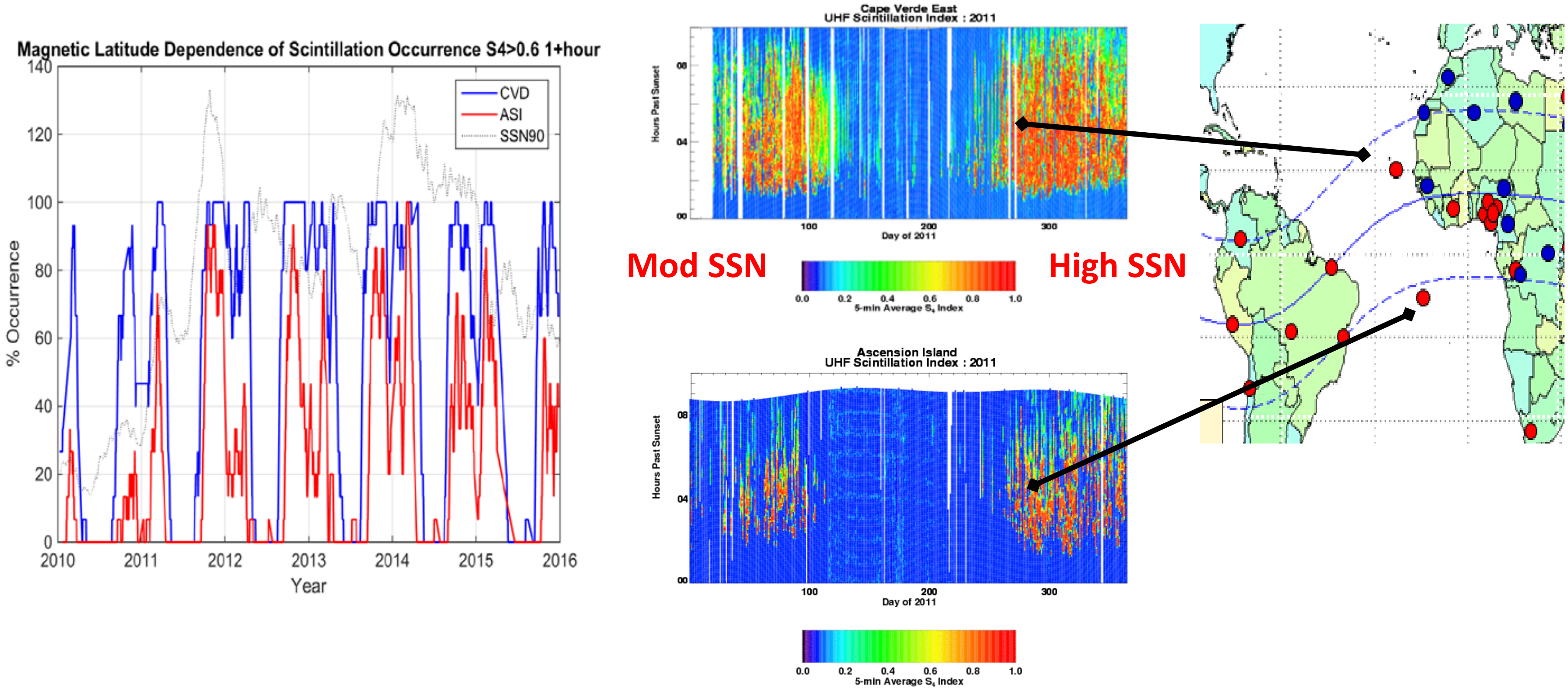
- Consistent with other studies, the occurrence probability is generally high in equinoctial months and low around June solstice, maximizes in the longitude sector from 280°E to 30°E.
- But the occurrence of bubbles above 700 km is considerably lower than was previously observed with DMSP

DMSP Observations Solar Cycle 23



- Peak occurrence rates ≥ 50 % observed during active periods in the American-African longitude sectors at the DMSP altitude of ~830 km, considerably higher than was observed with the C/NOFS PLP during the 2011-2014 period – is this due to the lower solar flux in solar cycle 24 relative to solar cycle 23?

Ground based Observations



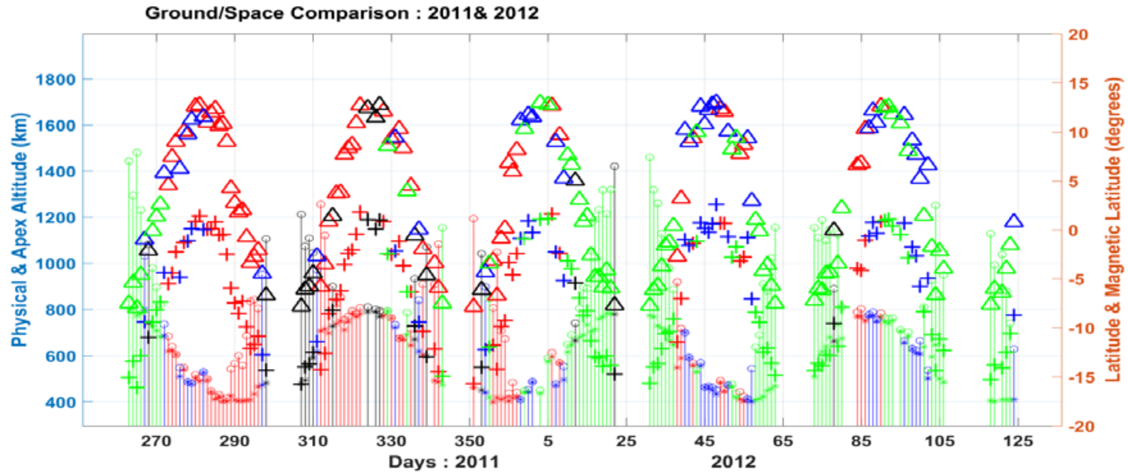
- Ground-based VHF measurements show that scintillation occurrence at Ascension Island (-17° Mlat) reached 50-80% during the peak seasons between 2011-2015
- Occurrence frequency of C/NOFS PLP observations are much lower
- The apex altitude of the magnetic field at 250 km above Ascension is more than 1000 km, so why don't we see these bubbles with C/NOFS??

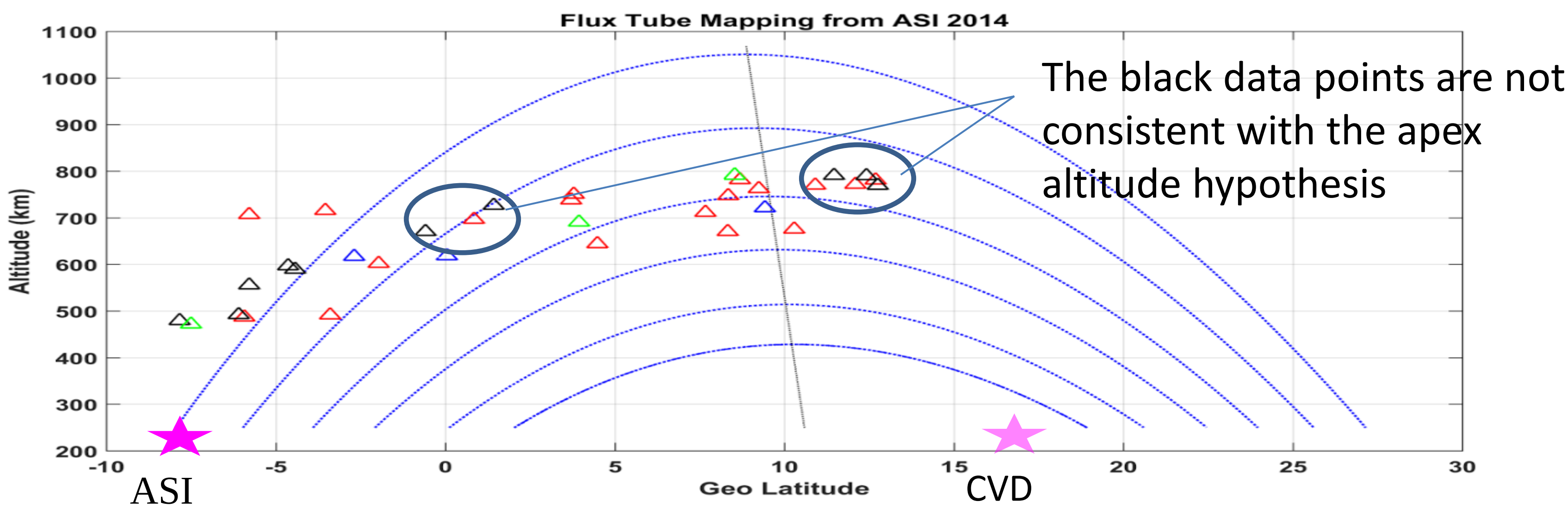
Ground-based Comparison Approach

- To compare the ground scintillation and space-based irregularity observations we map the C/NOFS in situ observations into the magnetic field geometry at Ascension Island and Cape Verde
- We expect to see in situ irregularities whenever scintillation is observed on the ground and the satellite is sampling below the apex altitude of the F-region field lines above the site
- Data are plotted as functions of physical and apex altitude and geographic and geomagnetic latitude.

Flux Tube Mapping : Ascension Island

Color Key	S4 > 0.6	σ > 1%
Red	YES	YES
Black	YES	NO
Blue	NO	YES
Green	NO	NO

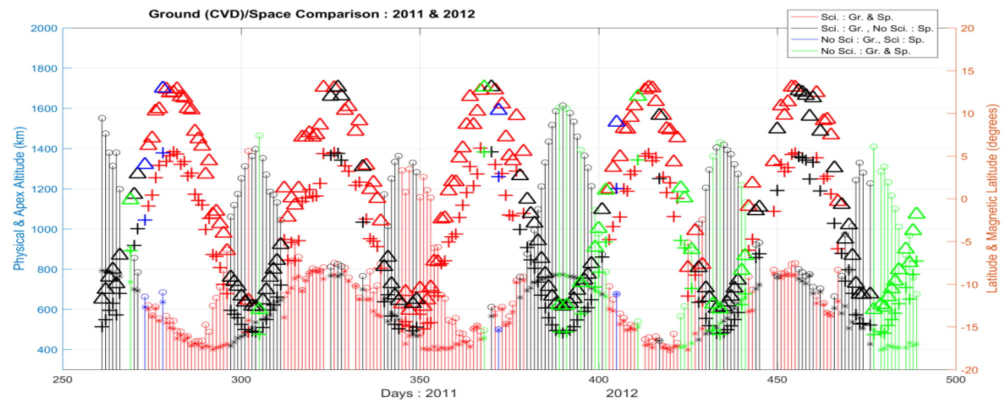


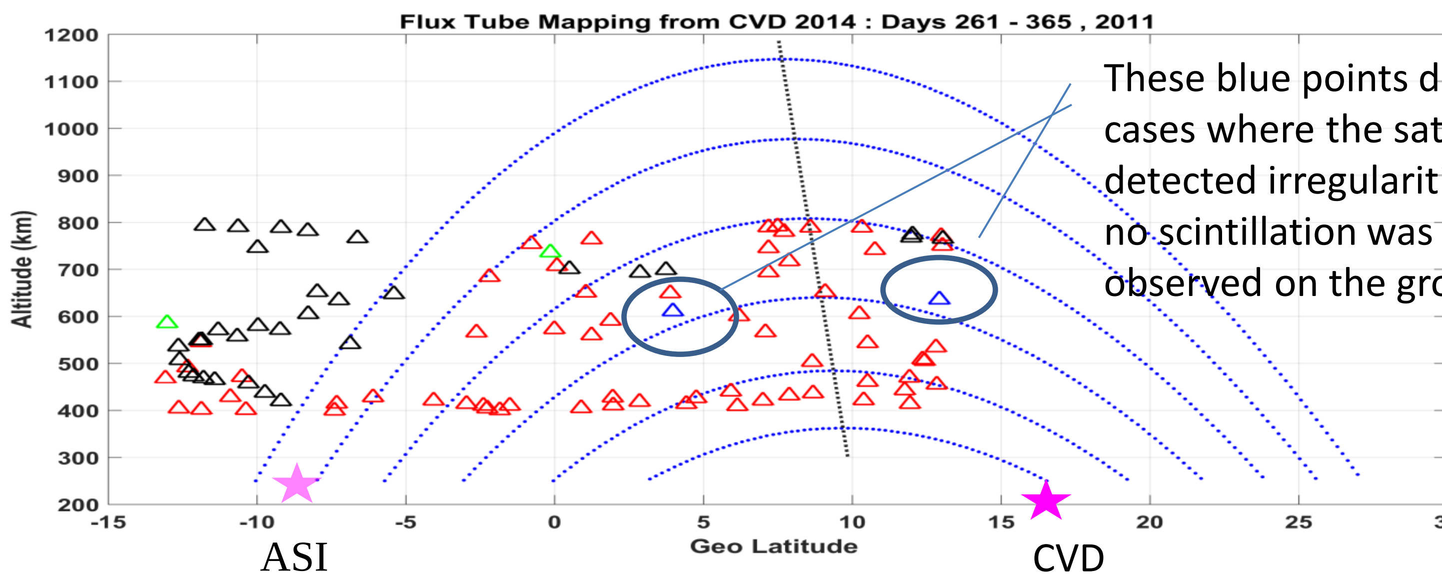


- Example shows the distribution of points from 2011 days 307-343
- The black points inside the circle need more analysis.

Flux Tube Mapping : Cape Verde Island

Color Key	S4 > 0.6	σ > 1%
Red	YES	YES
Black	YES	NO
Blue	NO	YES
Green	NO	NO

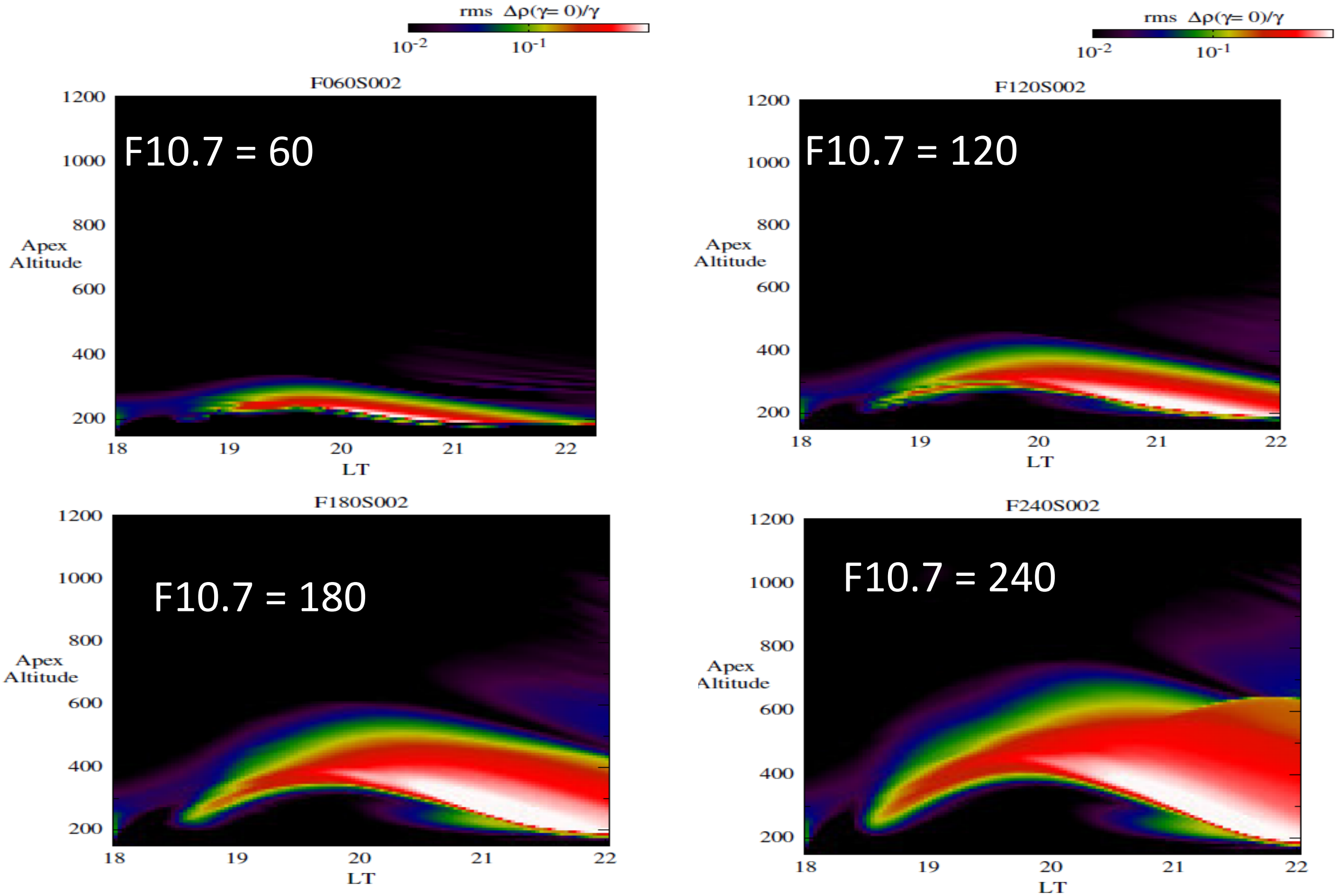




These blue points denote cases where the satellite detected irregularities but no scintillation was observed on the ground.

- Example shows the distribution of points from 2011 days 261-365
- The blue points inside the circle need more analysis.

Modeling: PBMOD



- PBMOD indicates that the bubble height increases with increasing solar flux

Conclusions and Future Work

- The C/NOFS bubble occurrence statistics are consistent with previous work related to this topic (Huang, et al. 2012, Gentile et al., 2006).
- Results from observations and modeling confirm the increase of apex altitude as solar flux increases; quantitative comparisons require improved modeling.
- C/NOFS occurrence rates for altitudes above 700 km are far lower than ground-based observations of scintillation at Ascension Island.
- The apex altitude of the F-region at Ascension is over 1000 km suggesting that more bubbles should reach these altitudes.
- Comparisons with the ground-based observations indicate that bubbles do not necessarily need to reach the expected apex altitude for a given site—suggests possible cross-field expansion of bubbles
- More analysis is needed before reaching unambiguous conclusions.