

Global distribution of ionospheric scintillation and irregularities measured using GPS receivers onboard the FORMOSAT-3/COSMIC satellites

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Outline



- **Motivation of the study**

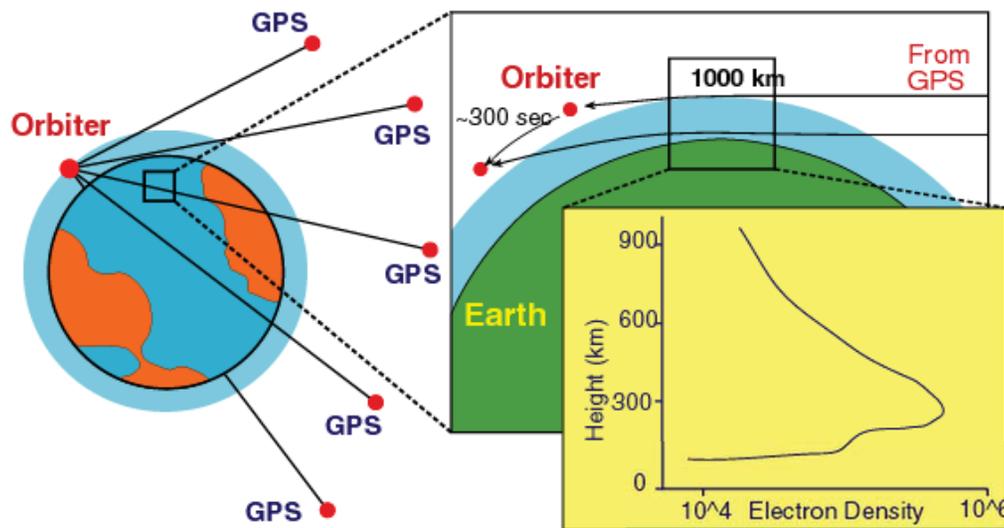
- To characterize and classify scintillation measurements made using GPS receivers onboard COSMIC satellites
- **Clarify** statistical results derived from COSMIC scintillation data seen in some presentations

- **Analysis**

- COSMIC 1-sec S_4 measurements, a proxy for amplitude scintillation measurements
- Global measurements made from all COSMIC satellites in October, 2009
- S_4 profiles, n_e profiles, and $S_{4,max}$
- LAT, LON, LT, and ALT distribution; F and E regions
- Amplitude scintillation occurrence rate

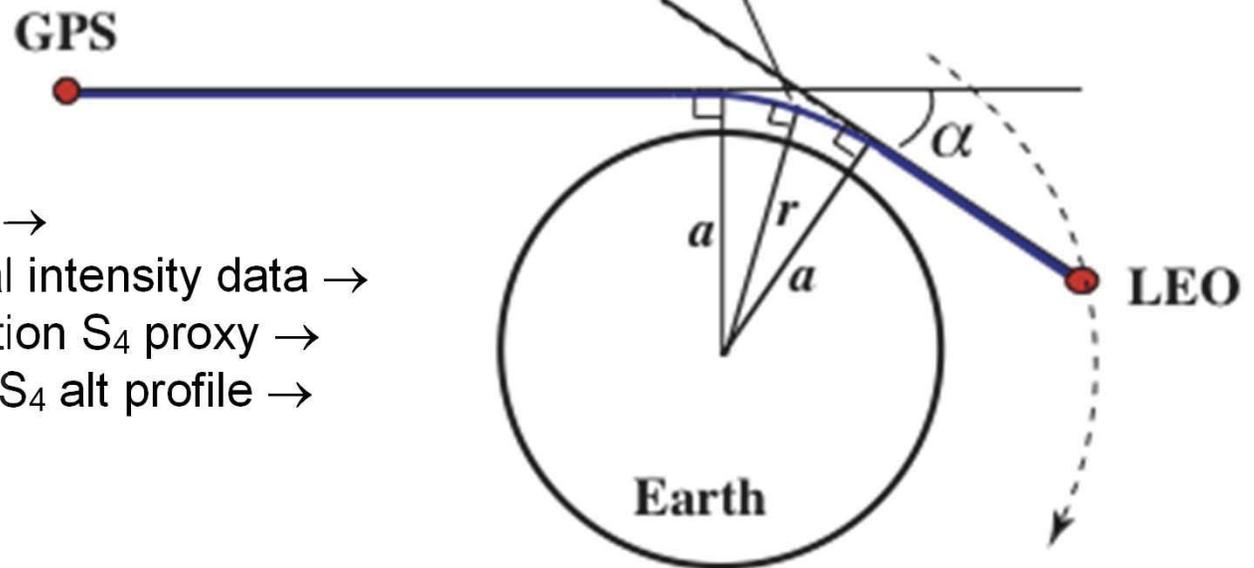
- **Summary**

Ionospheric Measurements from GPS Radio Occultations

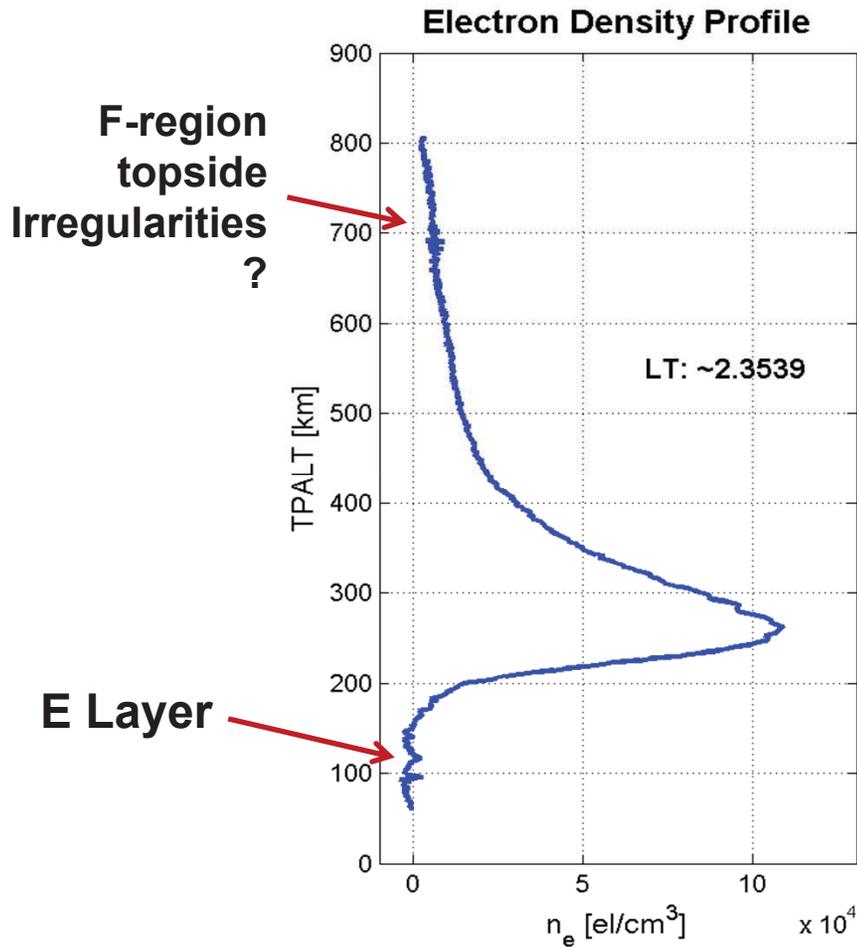


- Time sequence of TEC derived from GPS occulting signals →
- Abel inversion →
- Electron density profile →
- Peak density n_m and height h_m

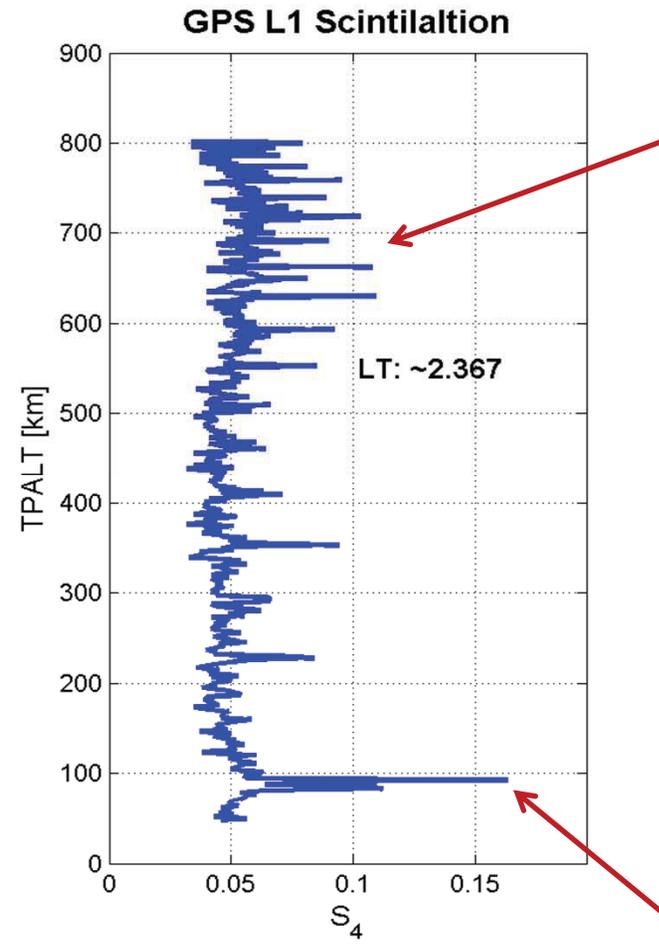
- 50-Hz L1 C/A SNR data →
- 1-sec approximate signal intensity data →
- 1-sec amplitude scintillation S_4 proxy →
- Time sequence of S_4 → S_4 alt profile →
- $S_{4,max}$ for the profile



Measured S4 Index and Retrieved Ne Profile

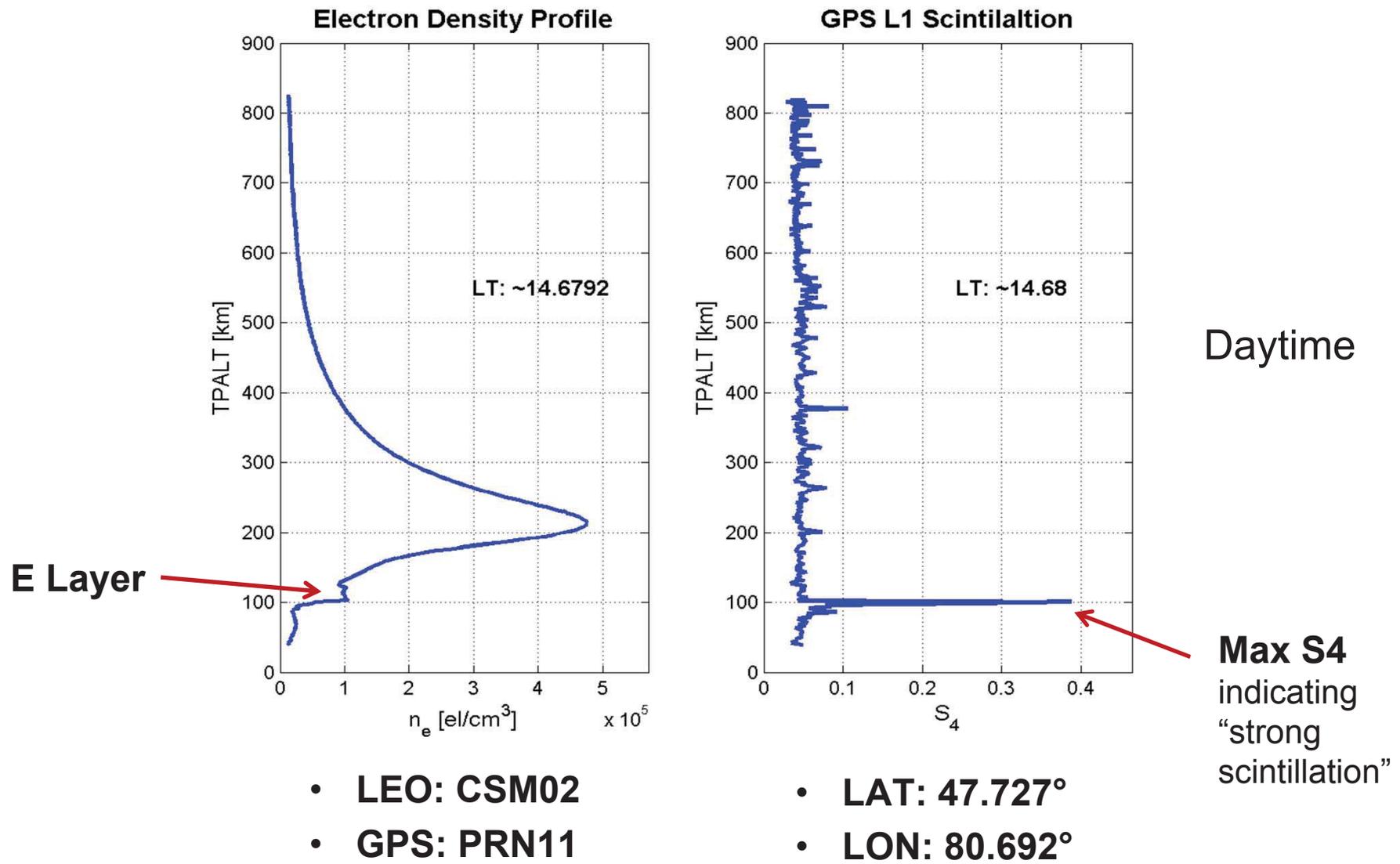


- LEO: CSM02
- GPS: PRN11

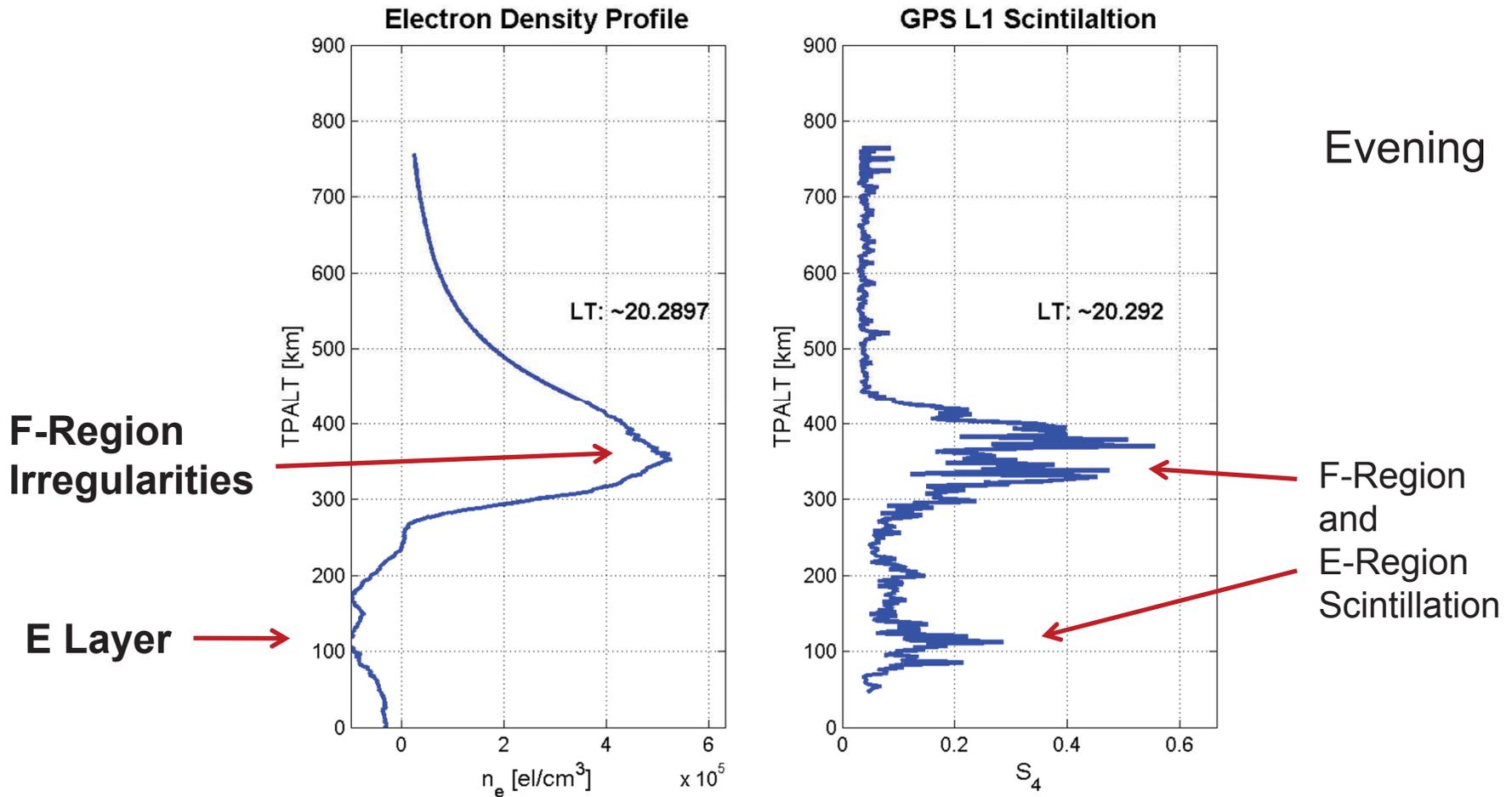


- LAT: -42.519°
- LON: 168.043°

Strong Scintillation Associated with Layering



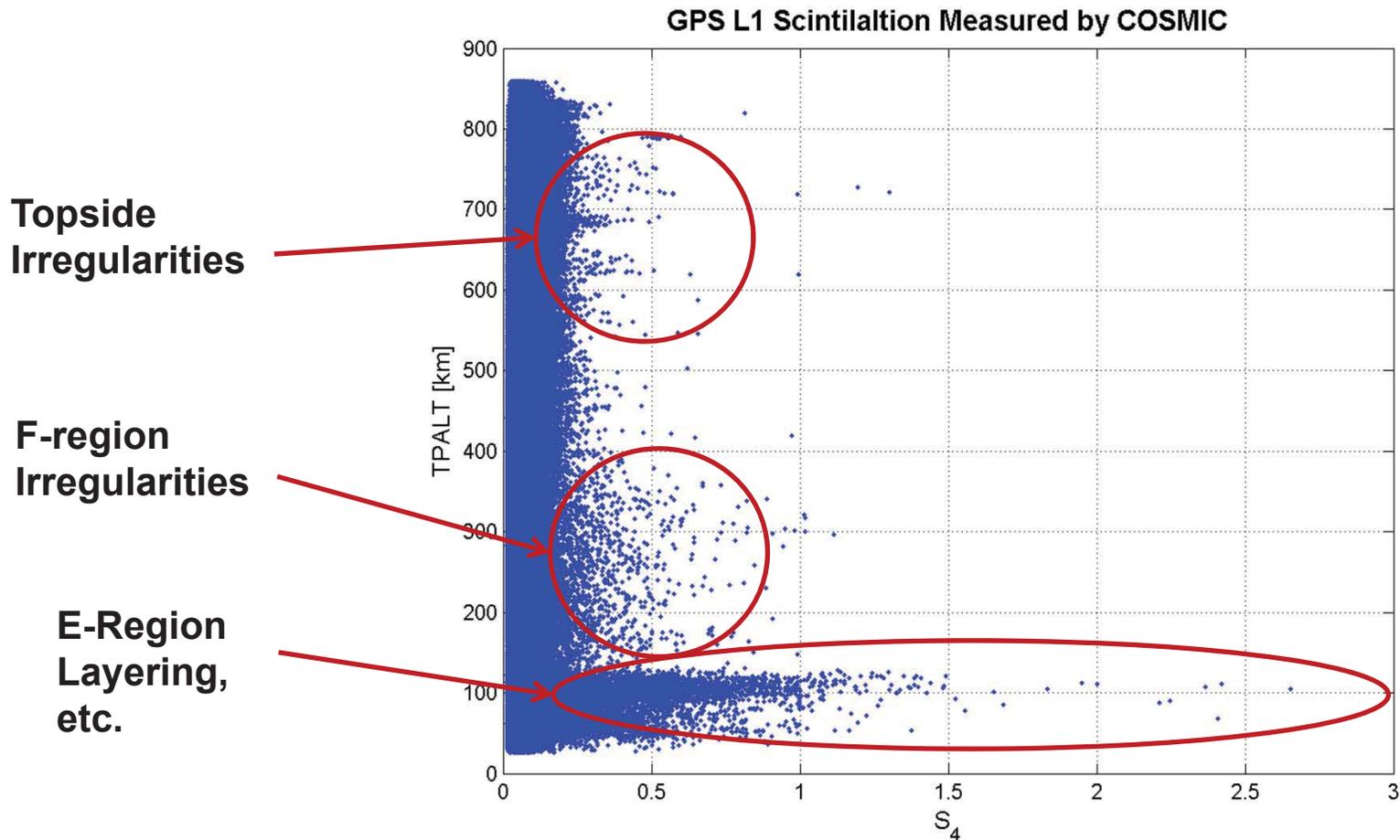
Strong Scintillation Associated with Layering



- **LEO: CSM04**
- **GPS: PRN19**

- **LAT: -4.086°**
- **LON: 37.336°**

Ionospheric Scintillation Associated with Various Inhomogeneities



- LEO's: CSM01-06
- GPS's: All
- 2009.274
- Global, all time

Data Presentation



- **$S_{4,max}$ and its corresponding tangent point altitude (TPALT)**

- Occulting radio links: elevation angle $\leq 0^\circ$
- Tangent point: the point along the radio link where the distance to the center of the Earth is closest
- Maximum S_4 in an occultation profile
- TPALT: altitude of the tangent point

- **Data binning**

- $15^\circ \times 5^\circ$ (LON \times LAT)
- 1 hour $\times 5^\circ$ (LT \times LAT)

- **Median($S_{4,max}$)**

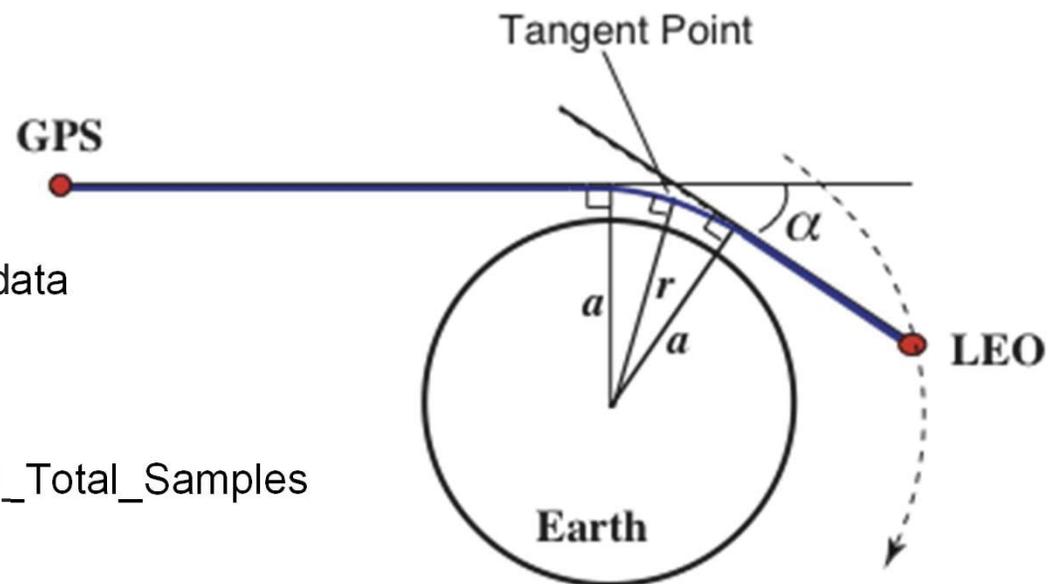
- The median value of all $S_{4,max}$ data falling in each bin

- **Occurrence Rate**

- $N_Events(S_{4,max} \geq S_{4,max0}) / N_Total_Samples$

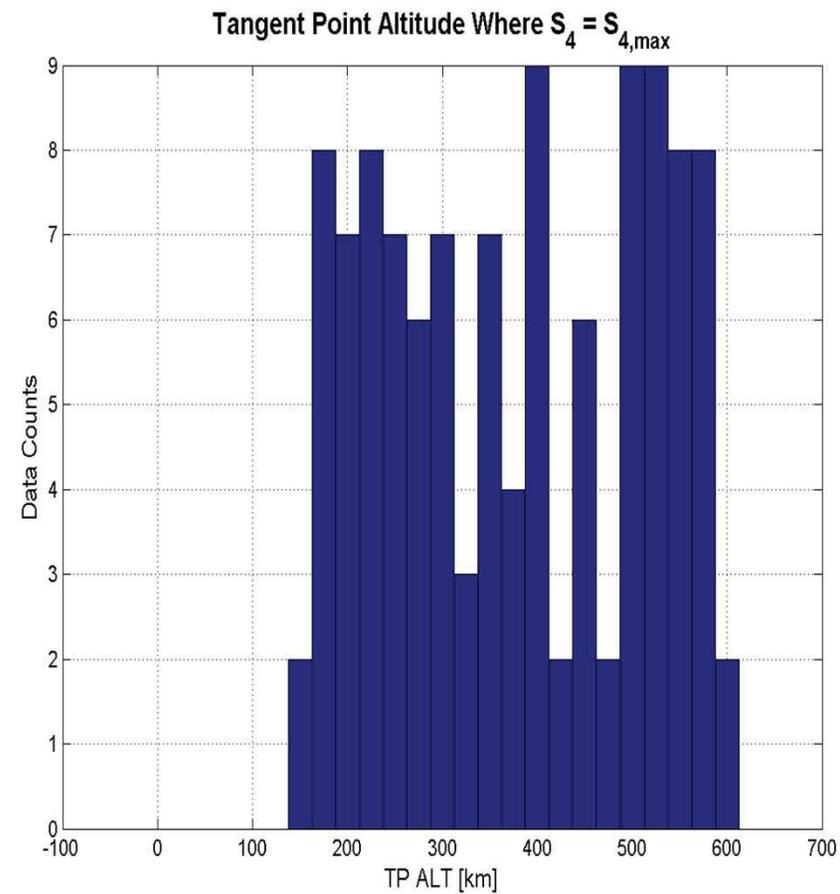
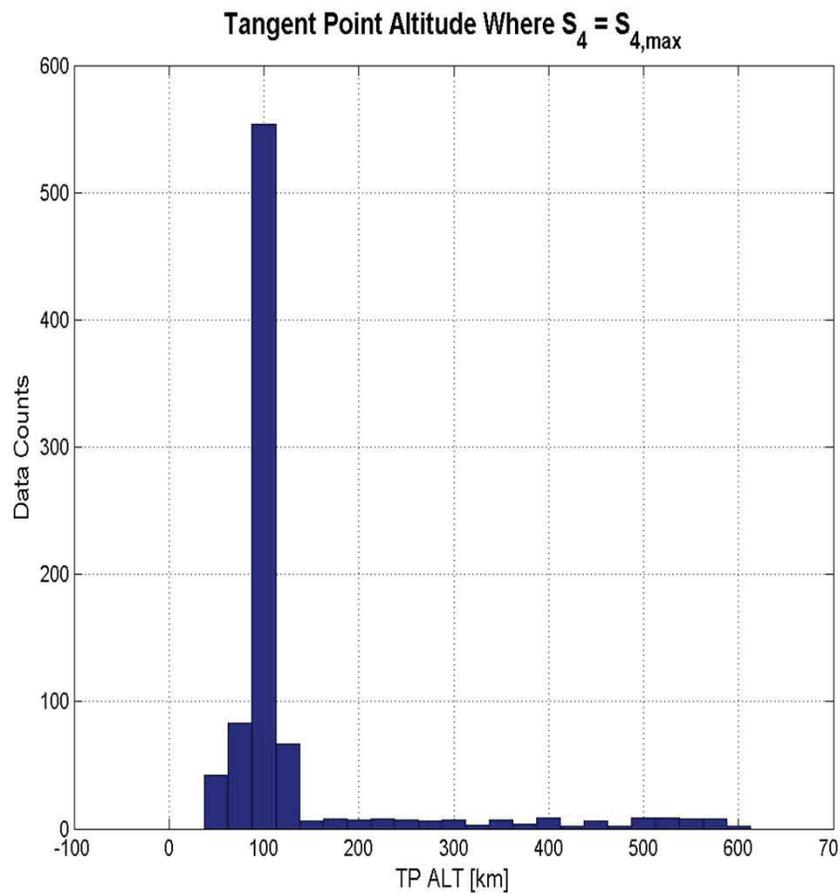
- **ALT range**

- 0 – 600 km (all regions)
- 150 – 600 km (F region)
- 80 – 150 km (E region)





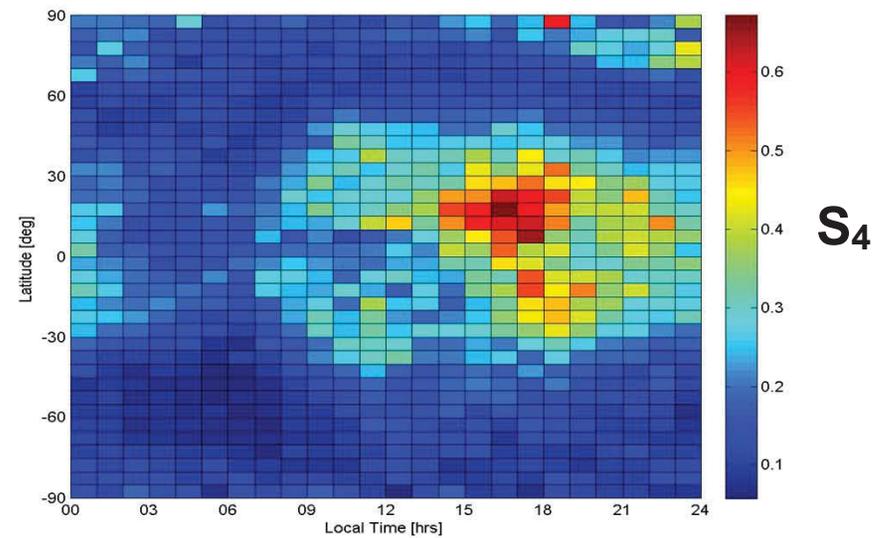
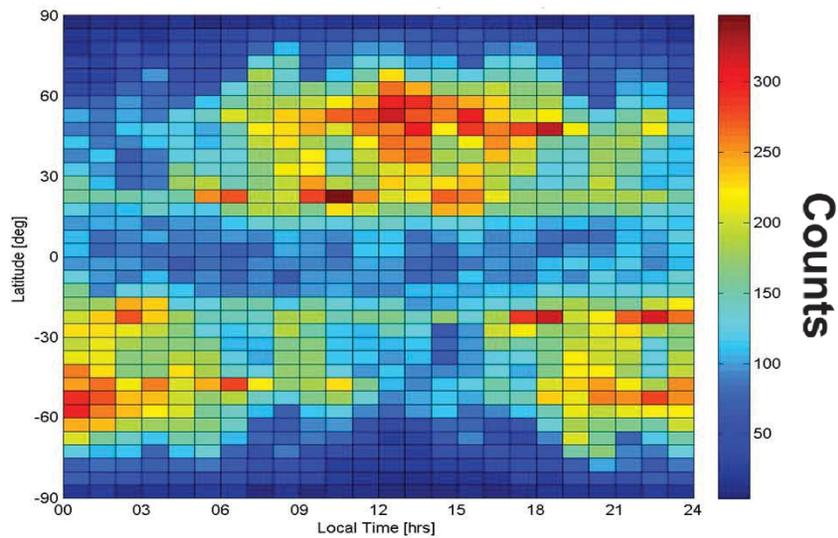
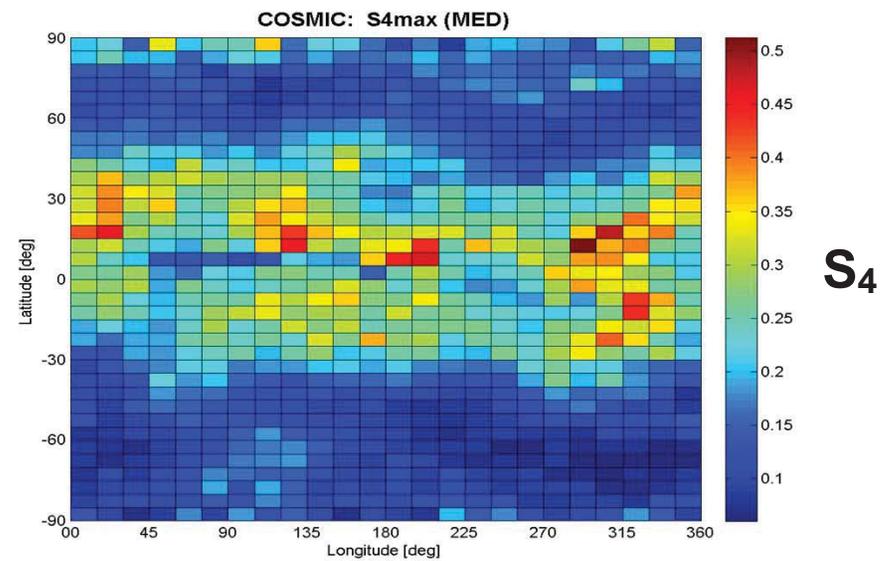
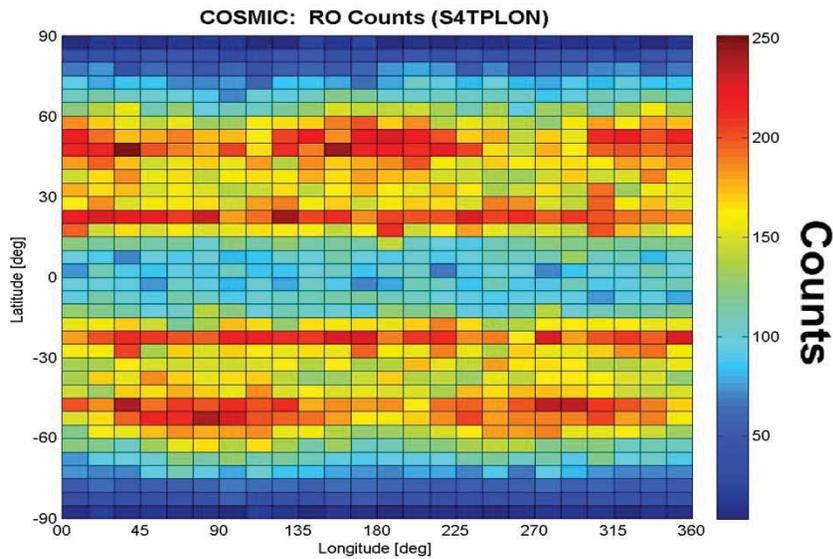
Altitude Distribution of E- and F-Region Scintillation



- A medium value of $S_{4,max}$ is obtained for each $15^\circ \times 5^\circ$ (LON \times LAT) bin.
- Its corresponding tangent point altitude is then taken into account in the histograms.

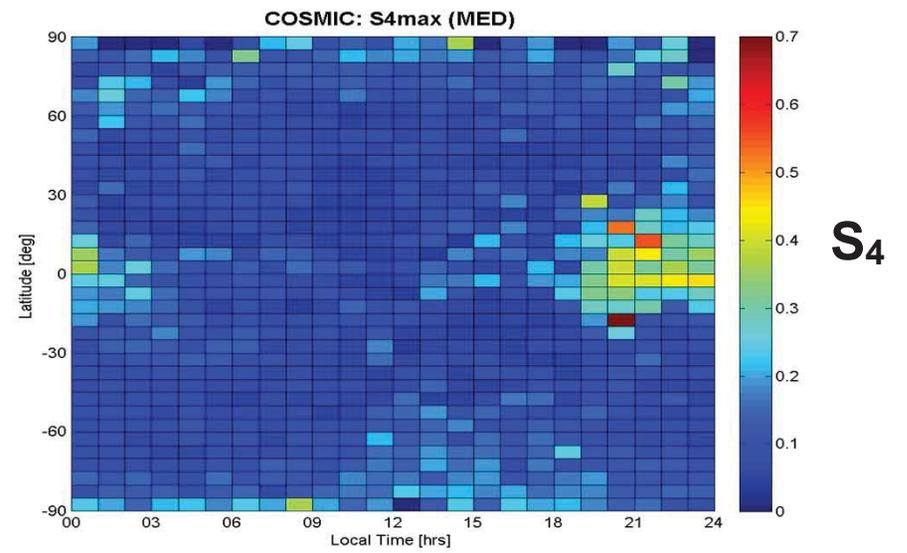
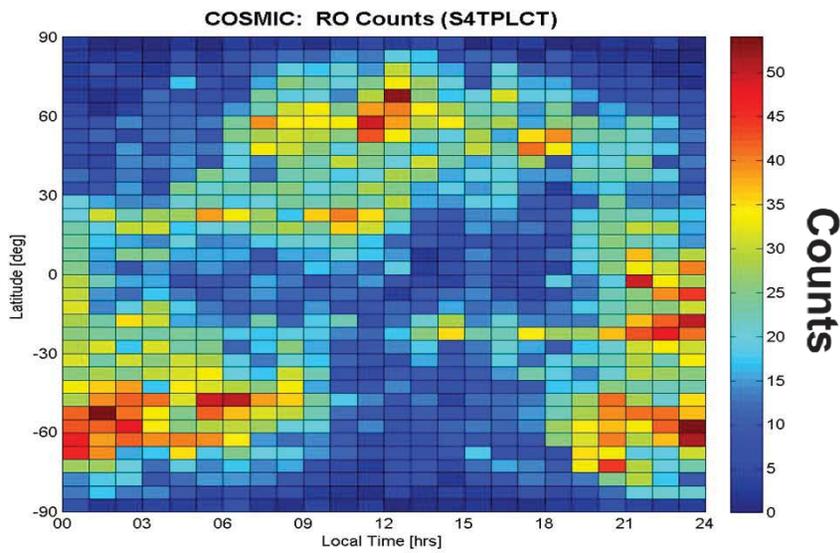
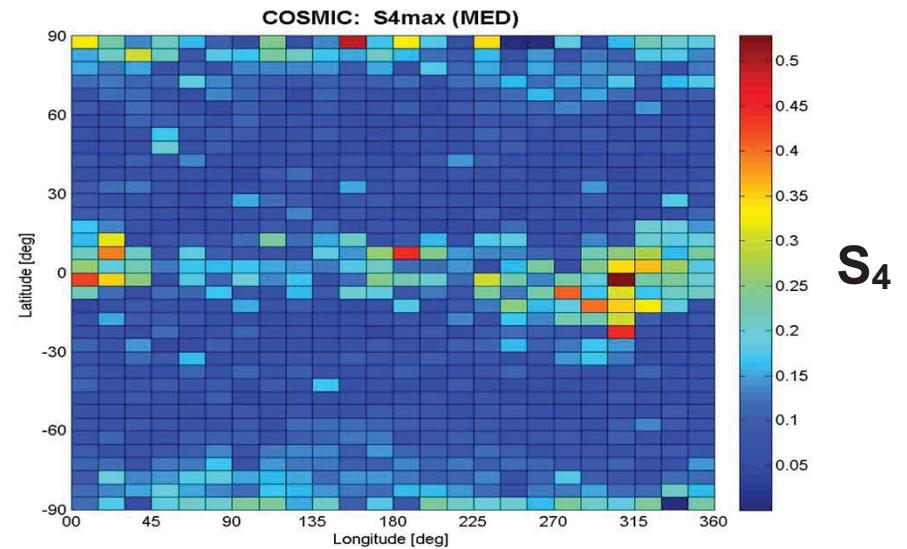
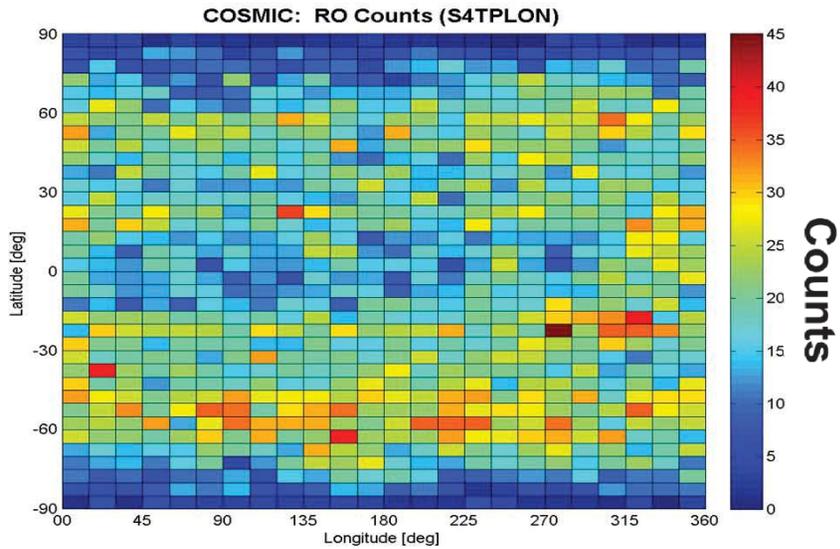
Global Distribution of Amplitude Scintillation

Altitude Range: 0~600 km October 2009



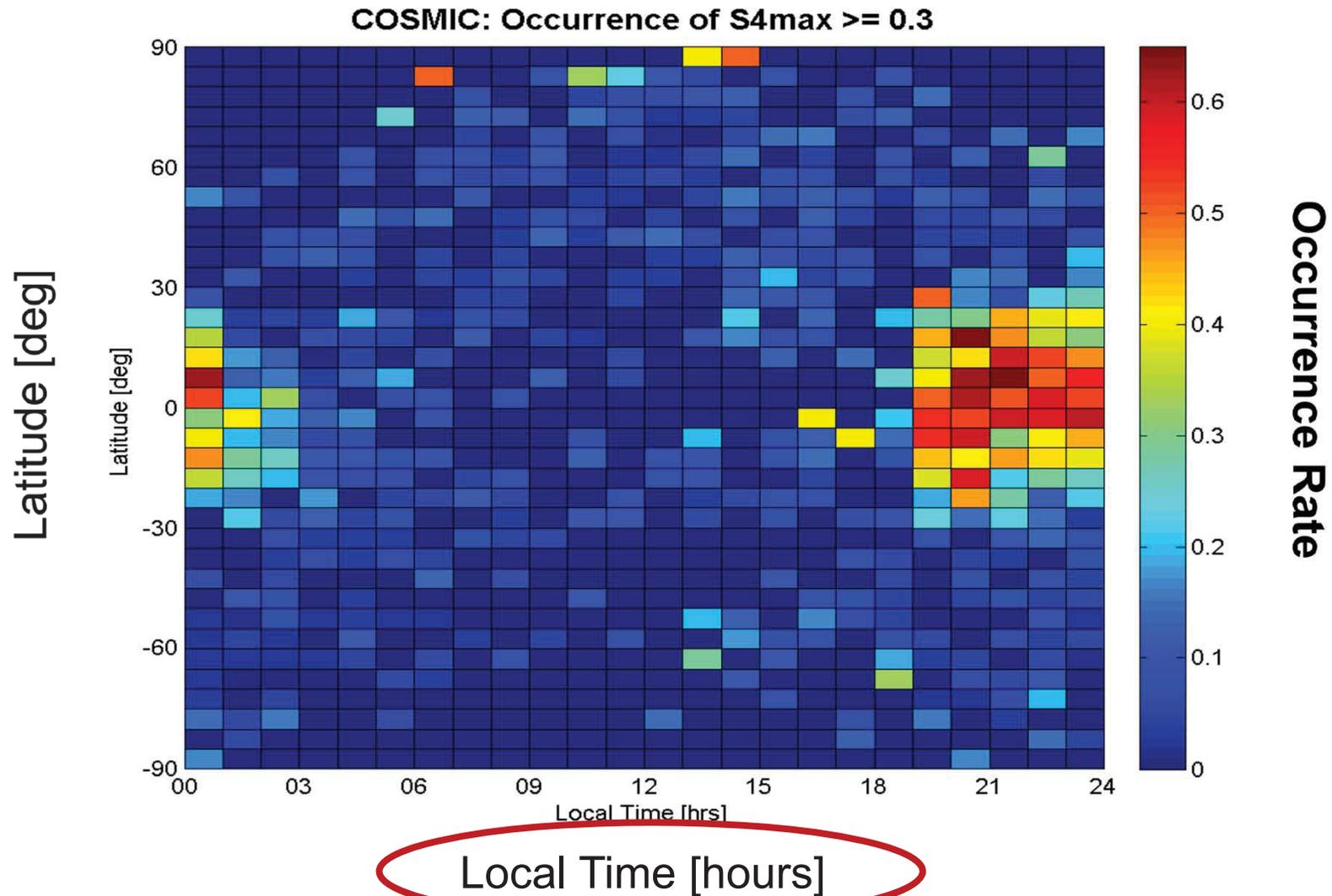
Global Distribution of Amplitude Scintillation

Altitude Range: 150~600 km October 2009



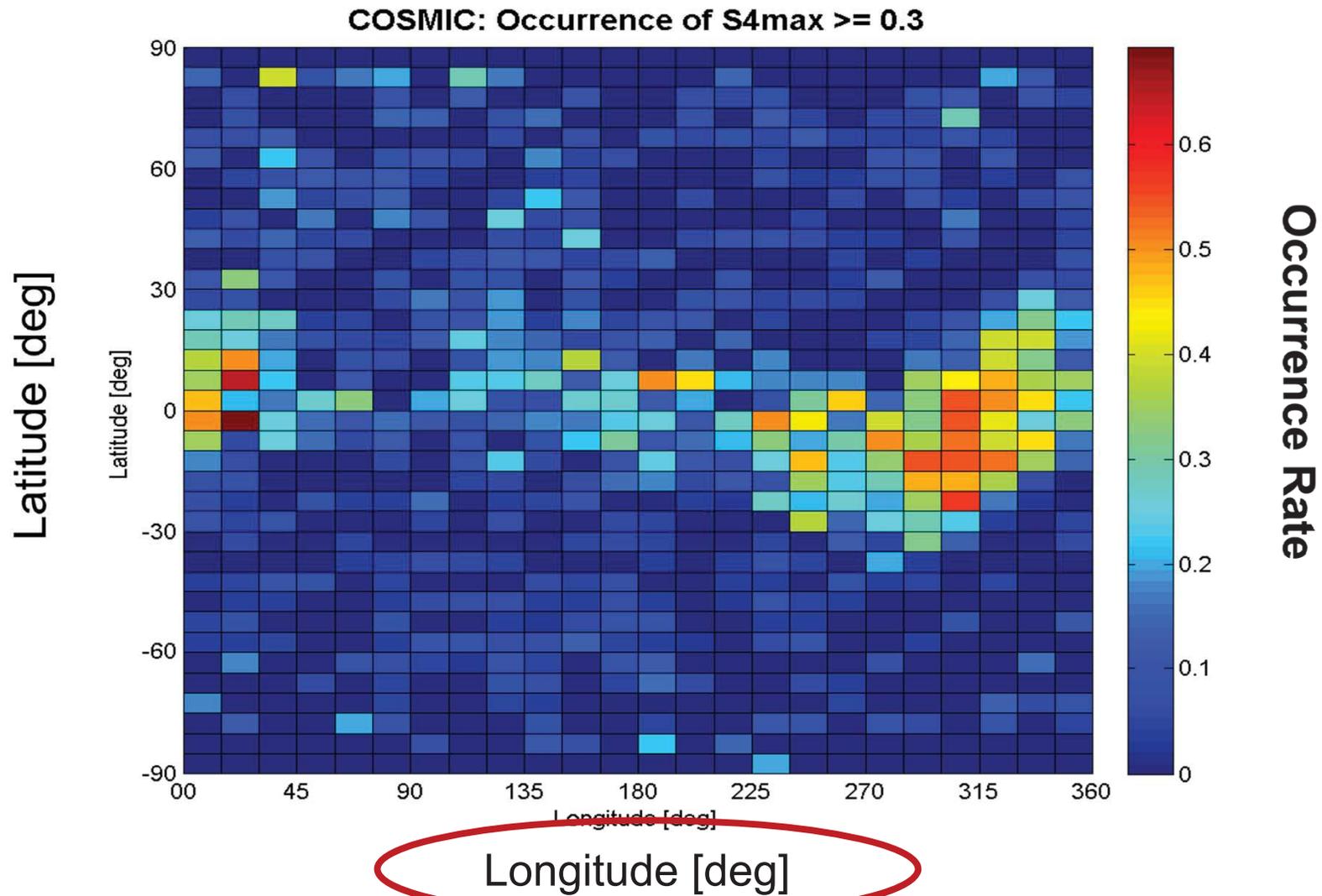
Global Occurrence of Amplitude Scintillation

Altitude Range: 150~600 km October 2009



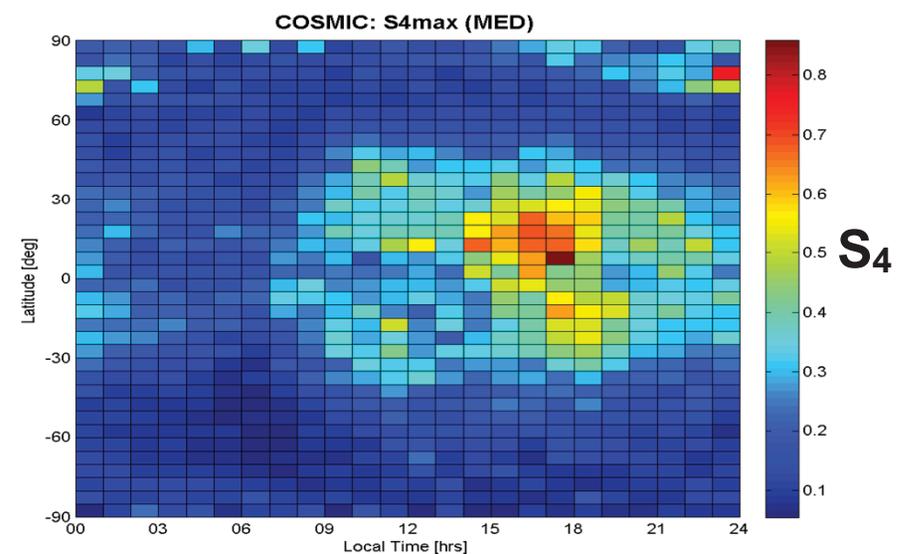
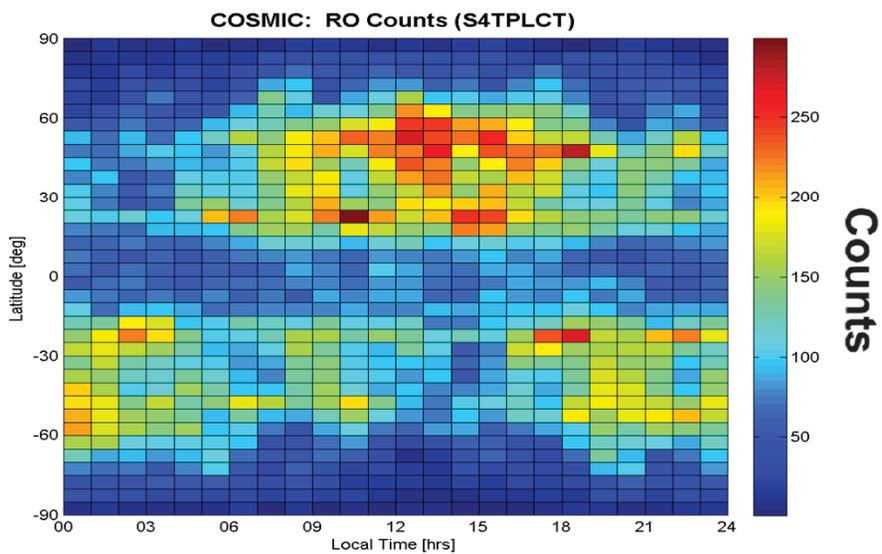
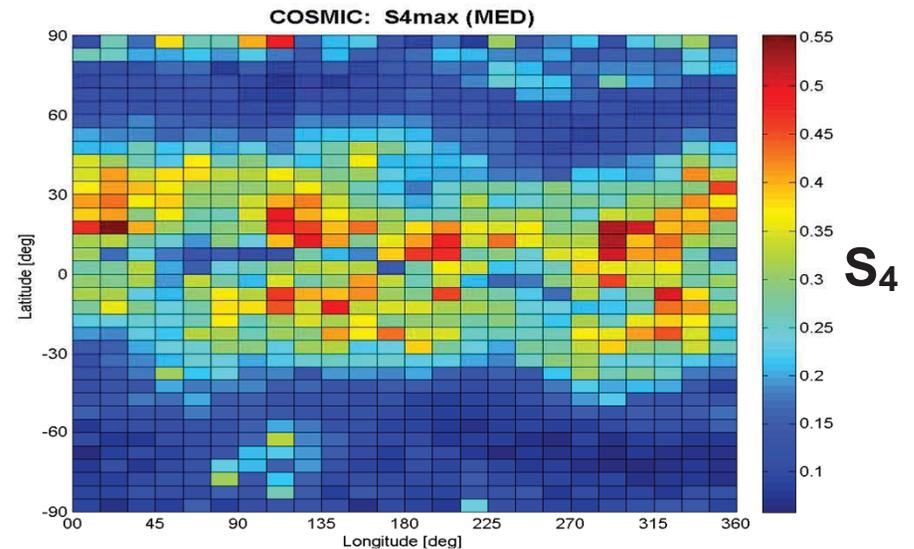
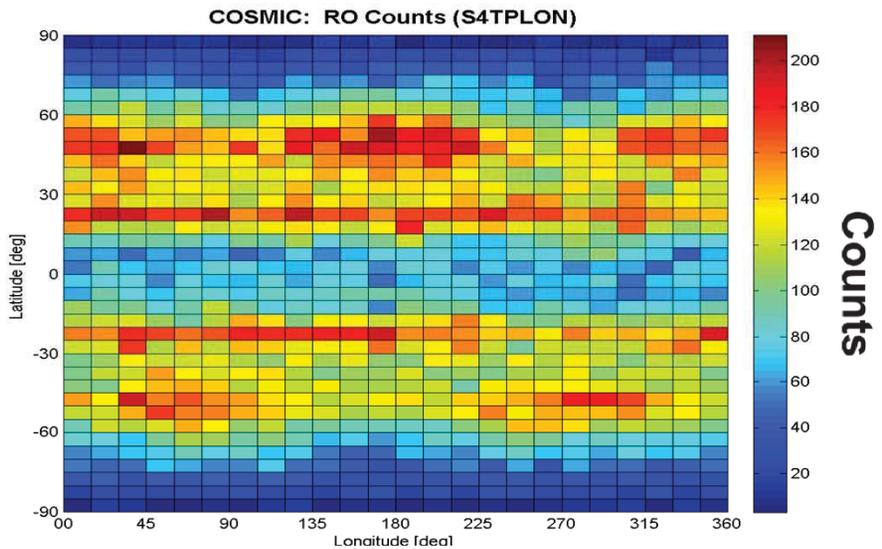
Global Occurrence of Amplitude Scintillation

Altitude Range: 150~600 km October 2009



Global Distribution of Amplitude Scintillation

Altitude Range: 80~150 km October 2009



Summary



- **Amplitude scintillation measured using occulting radio signals must be characterized according to altitude regions where different ionospheric phenomena occur**
- **The concerned phenomena include**
 - E-region density changes or layering in a narrow altitude range, which usually do not cause scintillation in ground-based GPS observations
 - F-region ionospheric irregularities that also cause scintillation in ground-based GPS observations
- **In a scintillation statistical analysis, one should avoid inter-contamination between the F- and E-region phenomena**
- **The results of this analysis show**
 - F-region scintillation follows the scintillation characteristics obtained from ground-based measurements
 - E-region scintillation is a good indicator of E-layer and thus can be applied to E-layer studies
 - Primarily occur at middle and low latitudes, besides auroral-related variations,
 - Diurnal variation pattern, maximizing between 15 and 19 pm and minimum at dawn