Temporal modulations of the longitudinal four-peaked structure of the equatorial ionosphere by planetary waves

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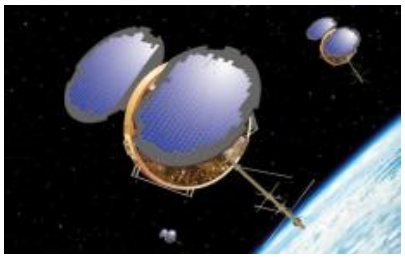
Objective: Ionosphere variations forced by lower atmosphere

- We focused on the global-scale wavenumber-4 longitudinal structure of the equatorial ionosphere and its day-to-day modulations.
- We looked for signatures of tides and planetary waves in the ionosphere; and we found correspondence of planetary waves in the MLT region and the ionosphere variations.
- We studied the interaction between the tide and longer-period planetary waves and the effects on the ionosphere.

Data

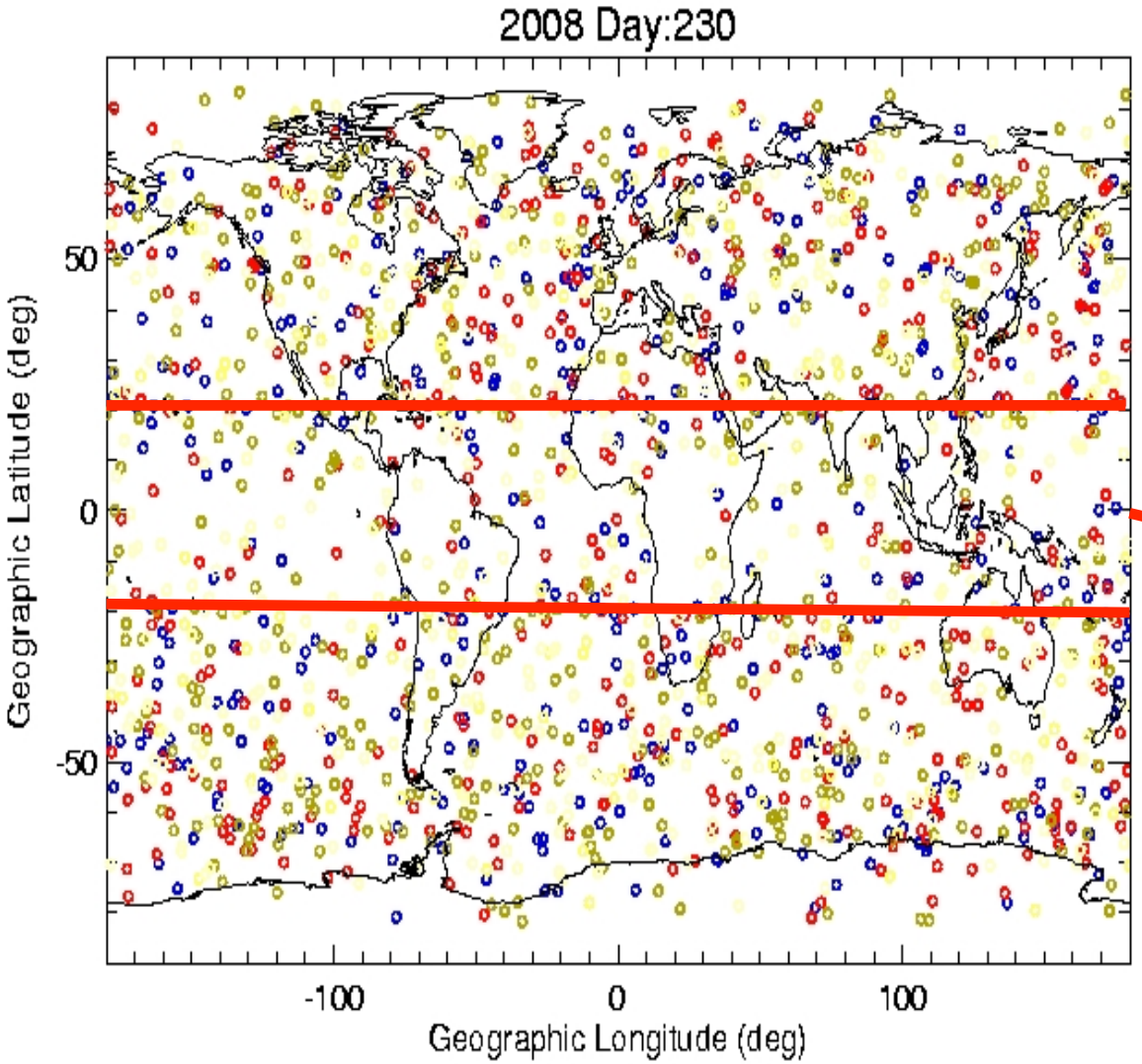
- Space-borne COSMIC electron density profiles for the ionosphere.
- Simultaneous neutral wind observations for the MLT region by ground-based meteor radar.



COSMIC (Constellation Observing System for Meteorology Ionosphere & Climate)

- A revolutionary collaboration of Taiwan and the United States [*Cheng et al., 2006; Schreiner et al., 2007]!*
- COSMIC is a six satellite constellation.
  - It uses GPS radio occultation technique to retrieve electron density profiles.
  - It measures the properties of atmosphere and ionosphere including hmF2 (height of F2 layer) and TEC.
  - It was launched in April 2006; separated into different orbits evenly spaced in late 2007.
  - Multiple satellites cover the globe and for a wide range of local times in one single day.

COSMIC 1-day sampling

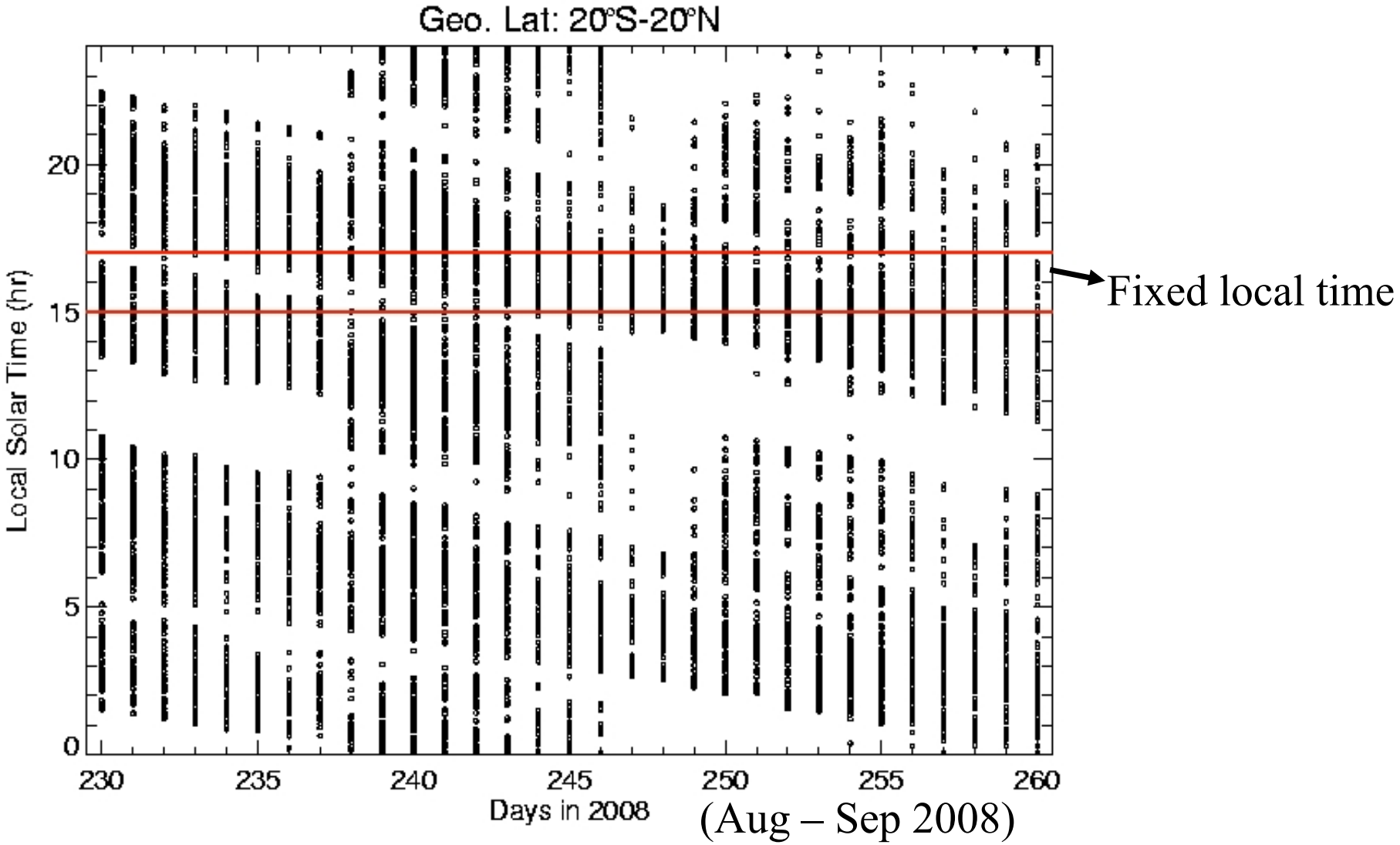


COSMIC can provide 2000 electron density profiles per day.

Its sampling is irregular.

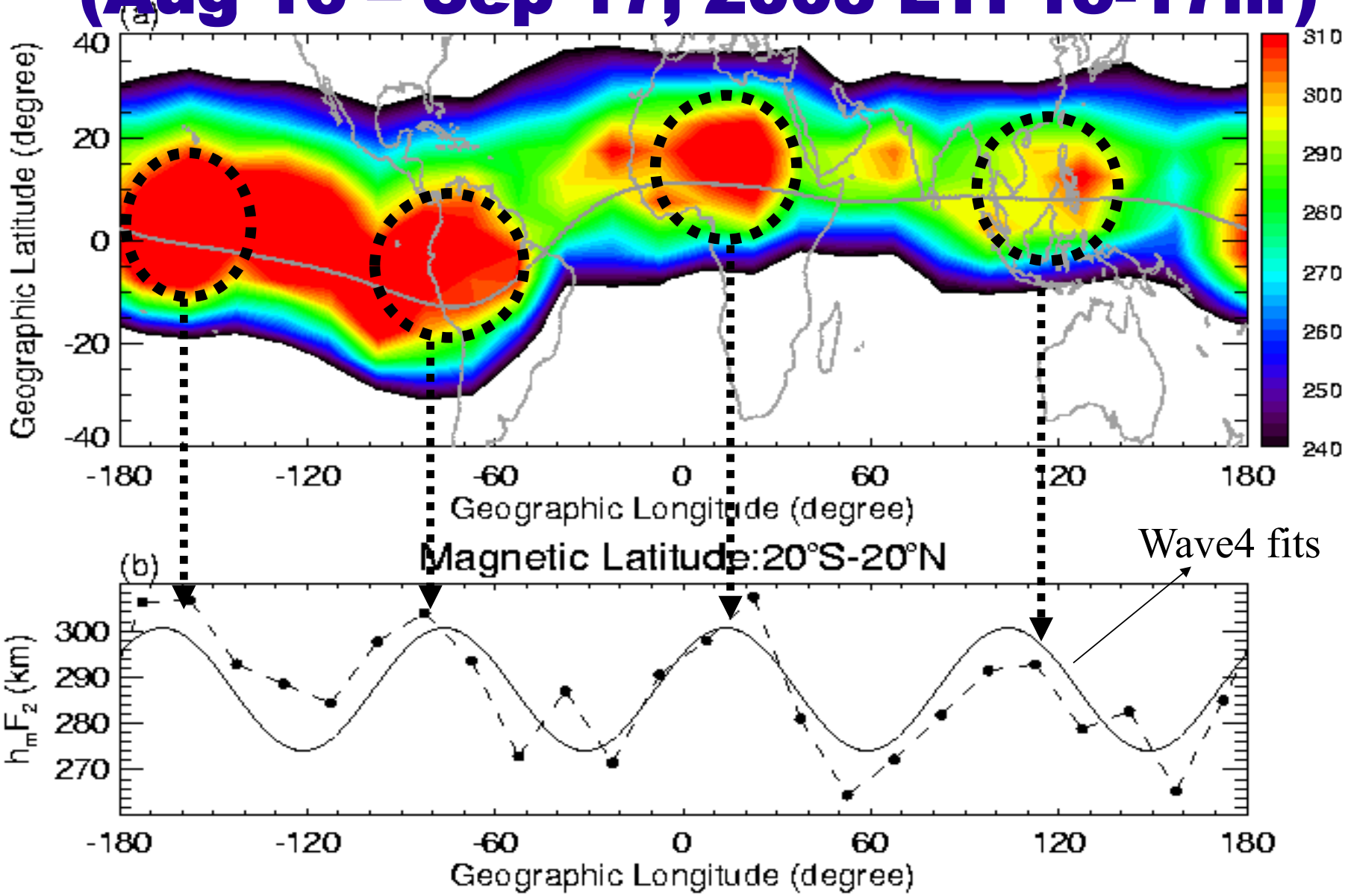
less sampling at the equator

Local time distribution of samples from COSMIC over 30 days at magnetic equator



(Aug – Sep 2008)

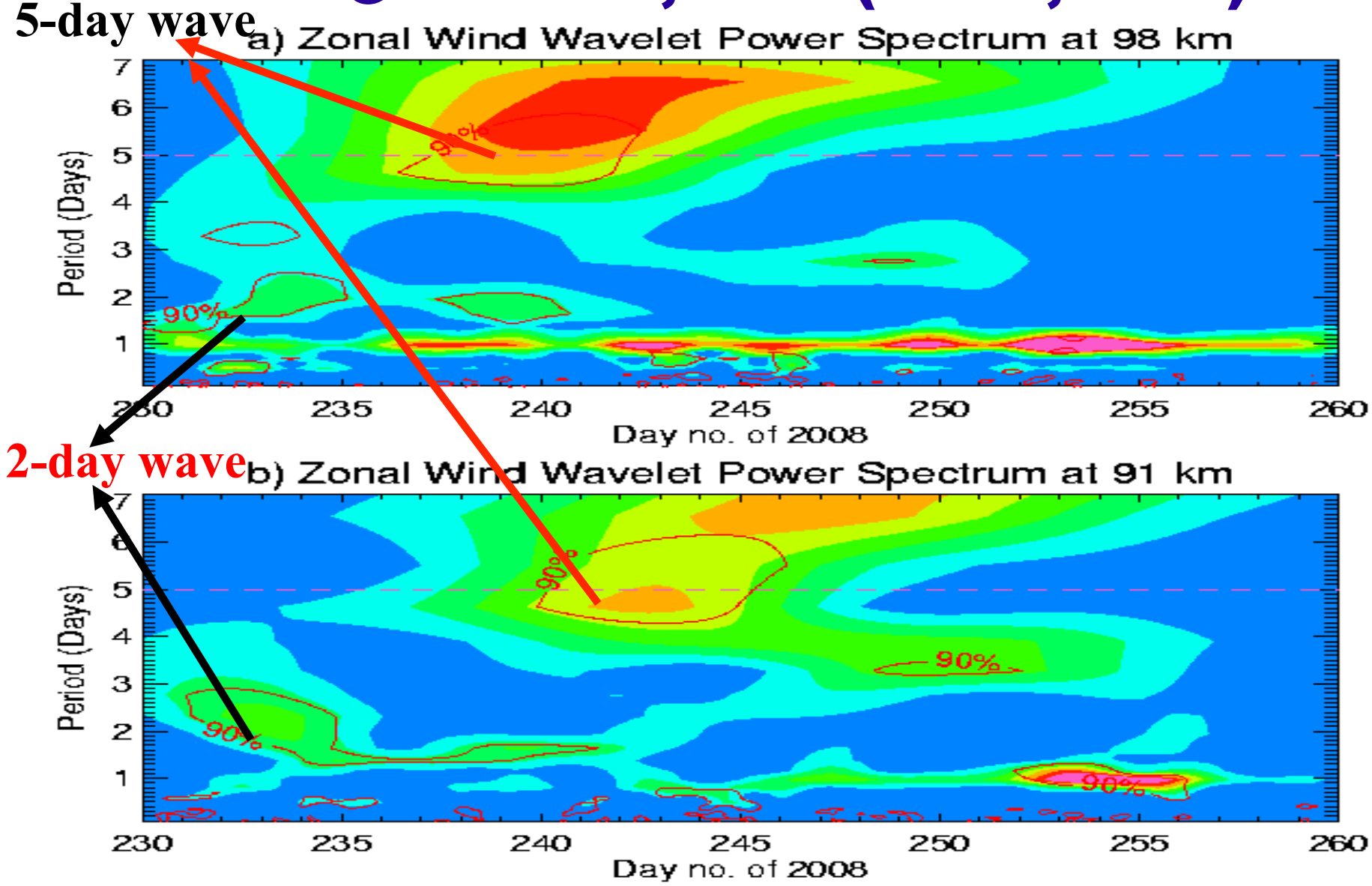
hmF2 four-peaked wave4 structure (Aug 16 – Sep 17, 2008 LT: 15-17hr)



Does the hmF2 wave-4 structure have a temporal periodicity on the order of days?

- The longitudinal structure of hmF2 is dominated by four-peaks at the equator.
- We want to search periodicity in this structure on the order of days.
- Some studies found evidence of the interaction between tides and longer period planetary waves in the ionosphere [e.g. Pancheva et al., 2006; Immel et al., 2009].

Wavelet spectra of MLT winds by SkiYMET radar @ Thumba, India(8.5°N, 77°E)

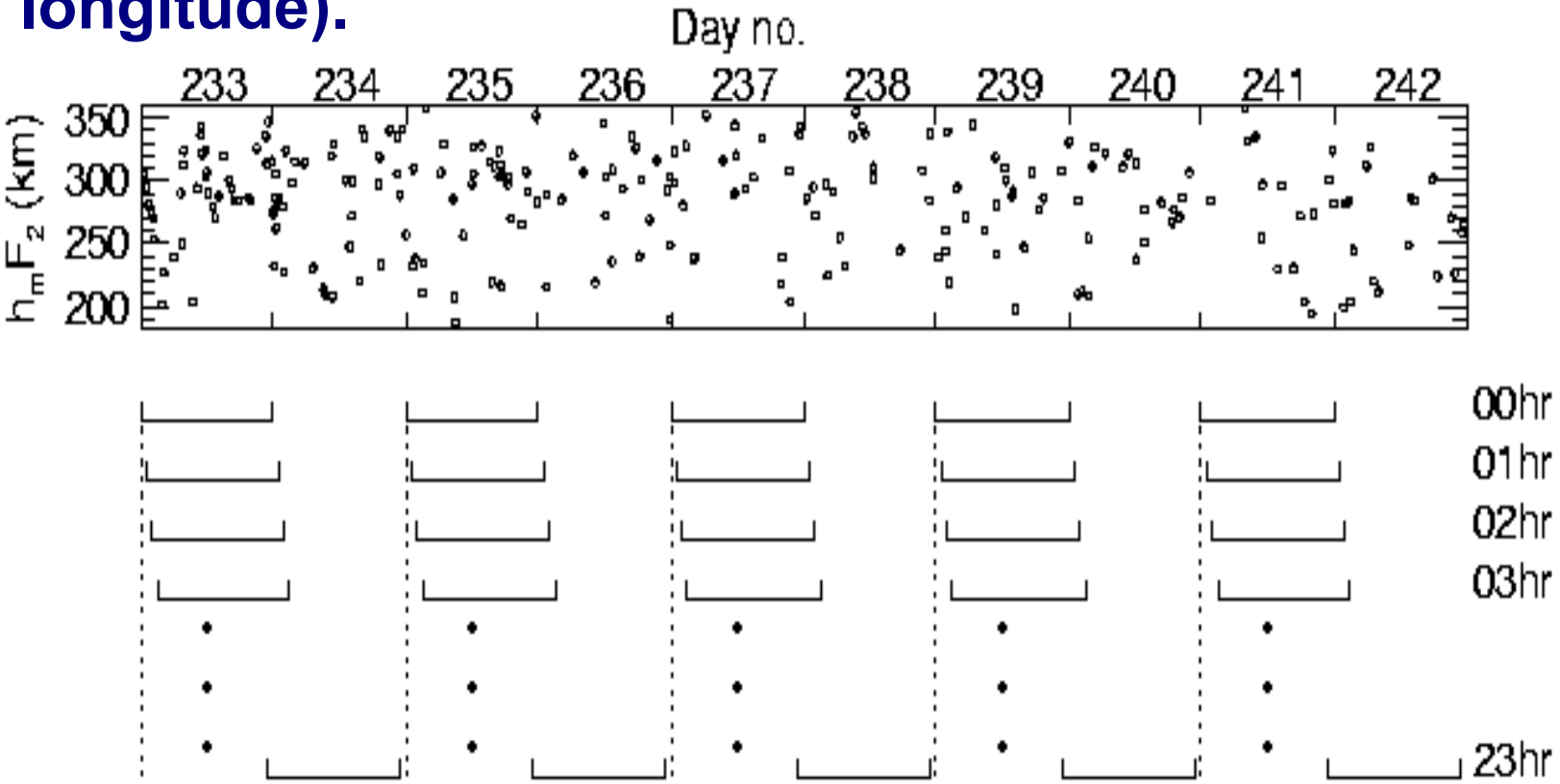


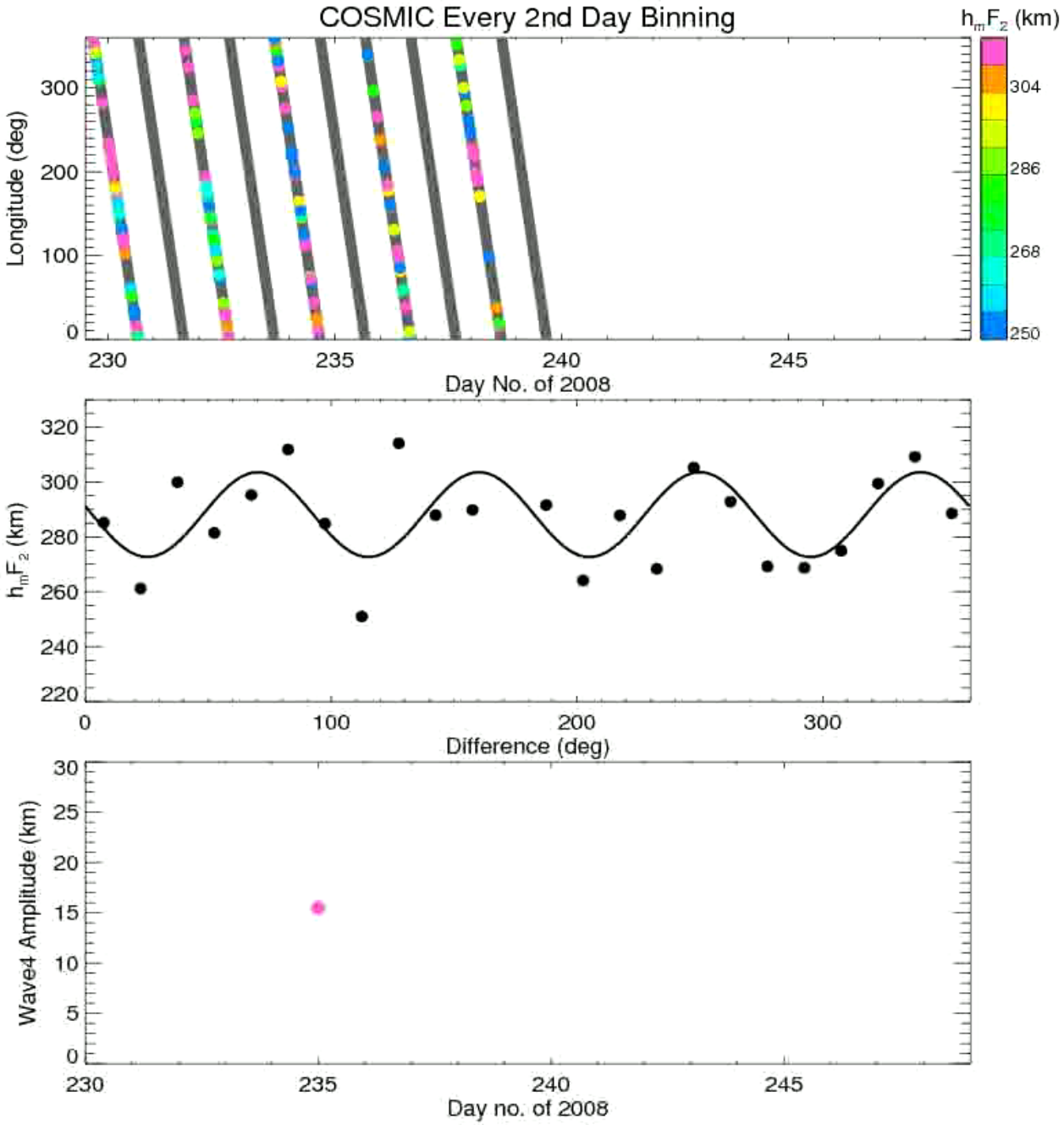
Let's concentrate on the 2-day periodicity.

- We have shown the 5-day modulation of the four-peaked ionospheric structure [*Liu et al.*, JGR, 2010; CEDAR 2009].
- Now the question is whether the 2-day wave in the MLT region is ALSO accompanied by a related signature in the ionosphere?
- We'll look for the 2-day modulation of the hmF2 four-peaked wave4 structure.

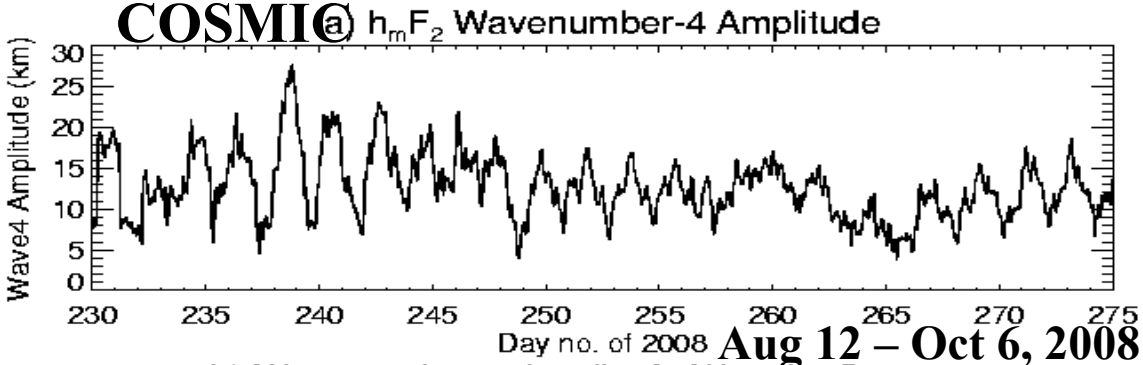
COSMIC hmF2 binning

- To improve sampling, the COSMIC data at 15-16 hr LT in Aug-Oct 2008 are binned by every 2nd day within a 10-day running window stepped by 1 hr (15° longitude).



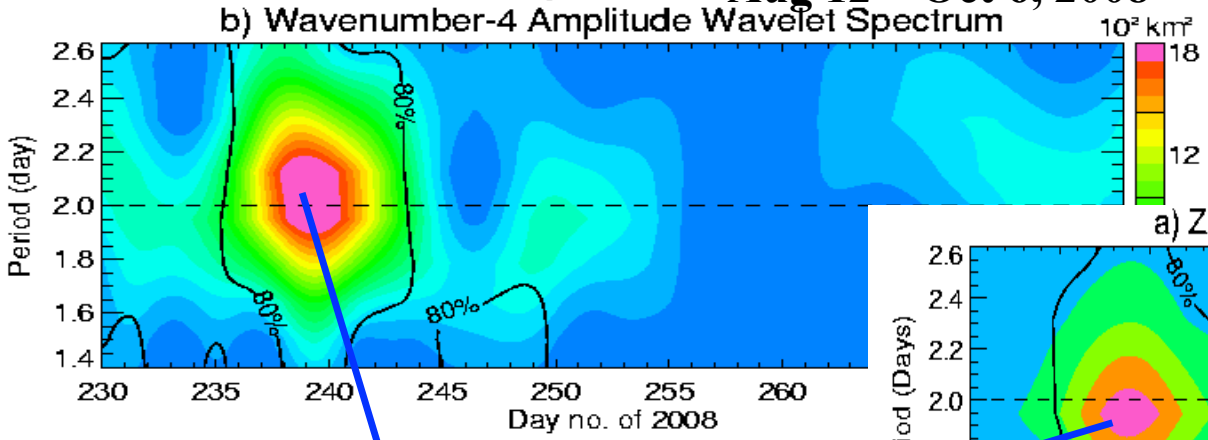

COSMIC Every 2nd Day Binning
h_mF_2 (km)
304
286
268
250
Longitude (deg)
0
100
200
300
230
235
240
245
Day No. of 2008
h_mF_2 (km)
220
240
260
280
300
320
0
100
200
300
Difference (deg)
Wave4 Amplitude (km)
0
5
10
15
20
25
30
230
235
240
245
Day no. of 2008

COSMIC

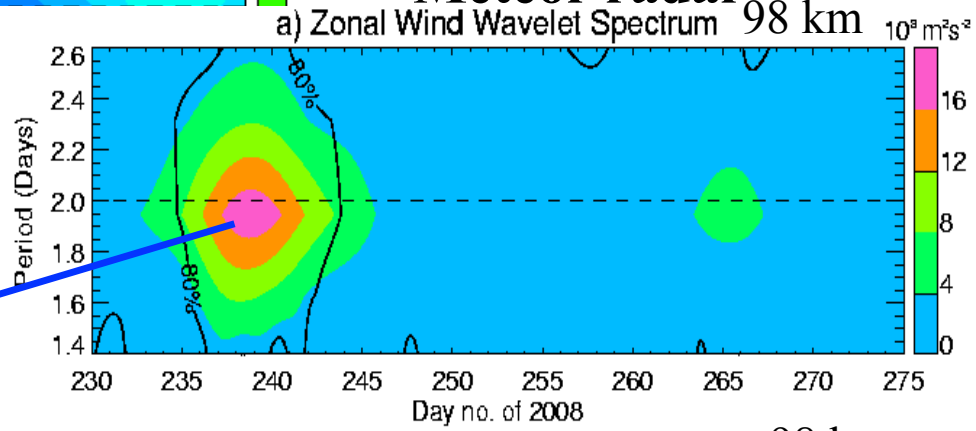


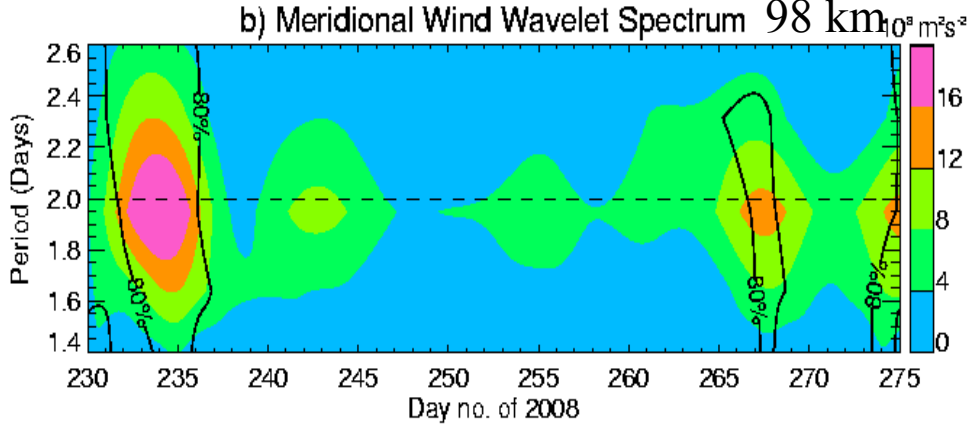
Aug 12 – Oct 6, 2008

Wavelet Spectrum



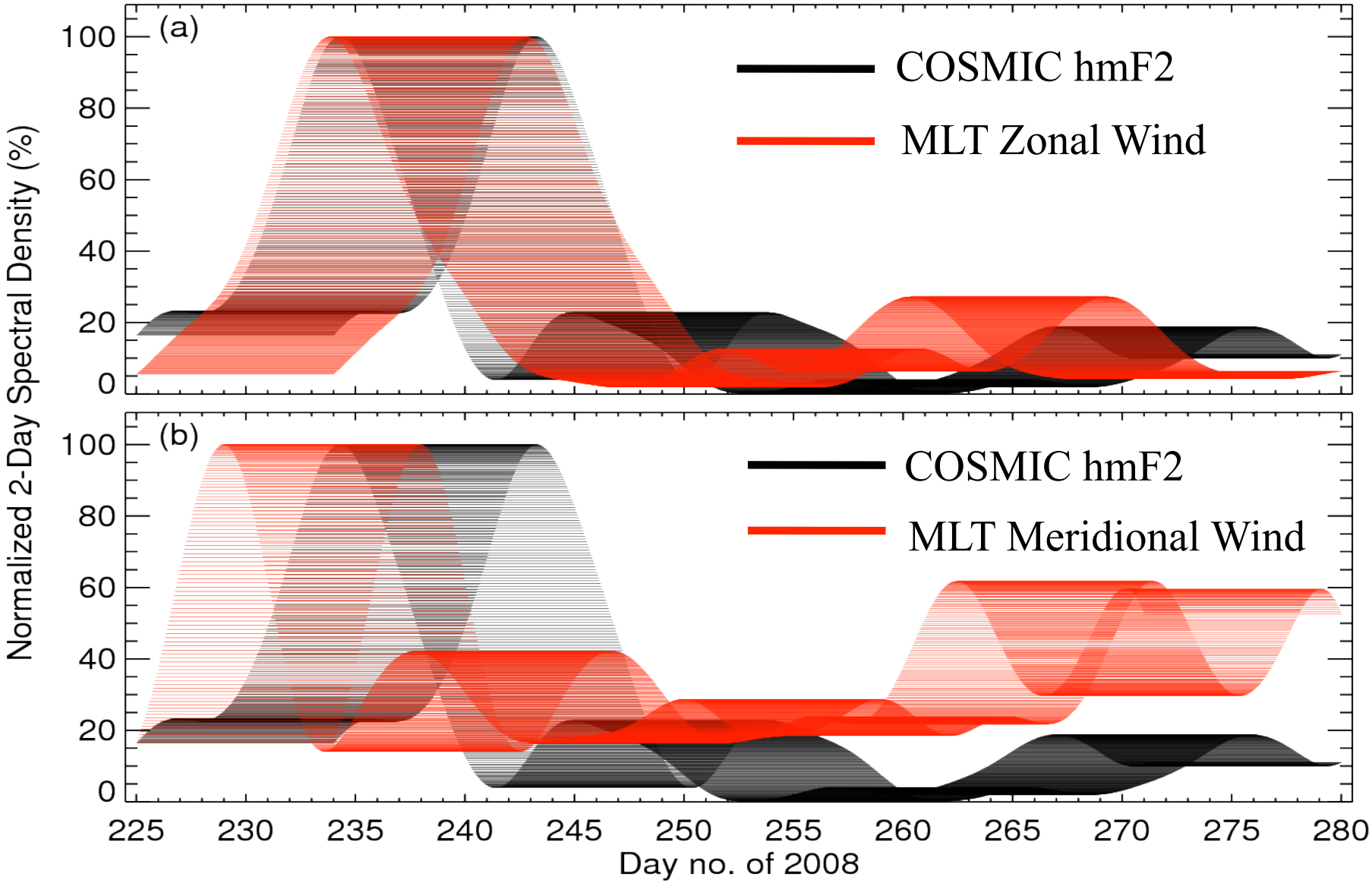
Meteor radar





2-day periodicity occurs on same days

Correspondence: hmF2 & MLT wind



Discussion

- *hmF2 four-peaked longitudinal structure is likely forced by the DE3 tide [e.g. Immel et al., 2006].*
- *Periodic variations (period >1 day) of the ionosphere could be caused by planetary waves [e.g. Chen, 1992; Forbes et al., 1997; Pancheva et al., 2002, 2006, 2008].*
- *The hmF2 four-peaked structure is subjected to a 2-day modulation. This could result from the effects involving both the DE3 tide and the 2-day wave.*

Summary

- We found a correspondence of the 2-day variation of the four-peaked longitudinal structure in hmF2 and the 2-day wave in the MLT region.
- The zonal wind component of the 2-day wave corresponds better to F2 layer changes.
- We believe the 2-day modulation of the longitudinal structure in the equatorial ionosphere is produced by the interaction of DE3 and the 2-day wave.

Many thanks to NSF and CEDAR for supporting this research!