

Evidence of tropospheric 90-day oscillations in the thermosphere

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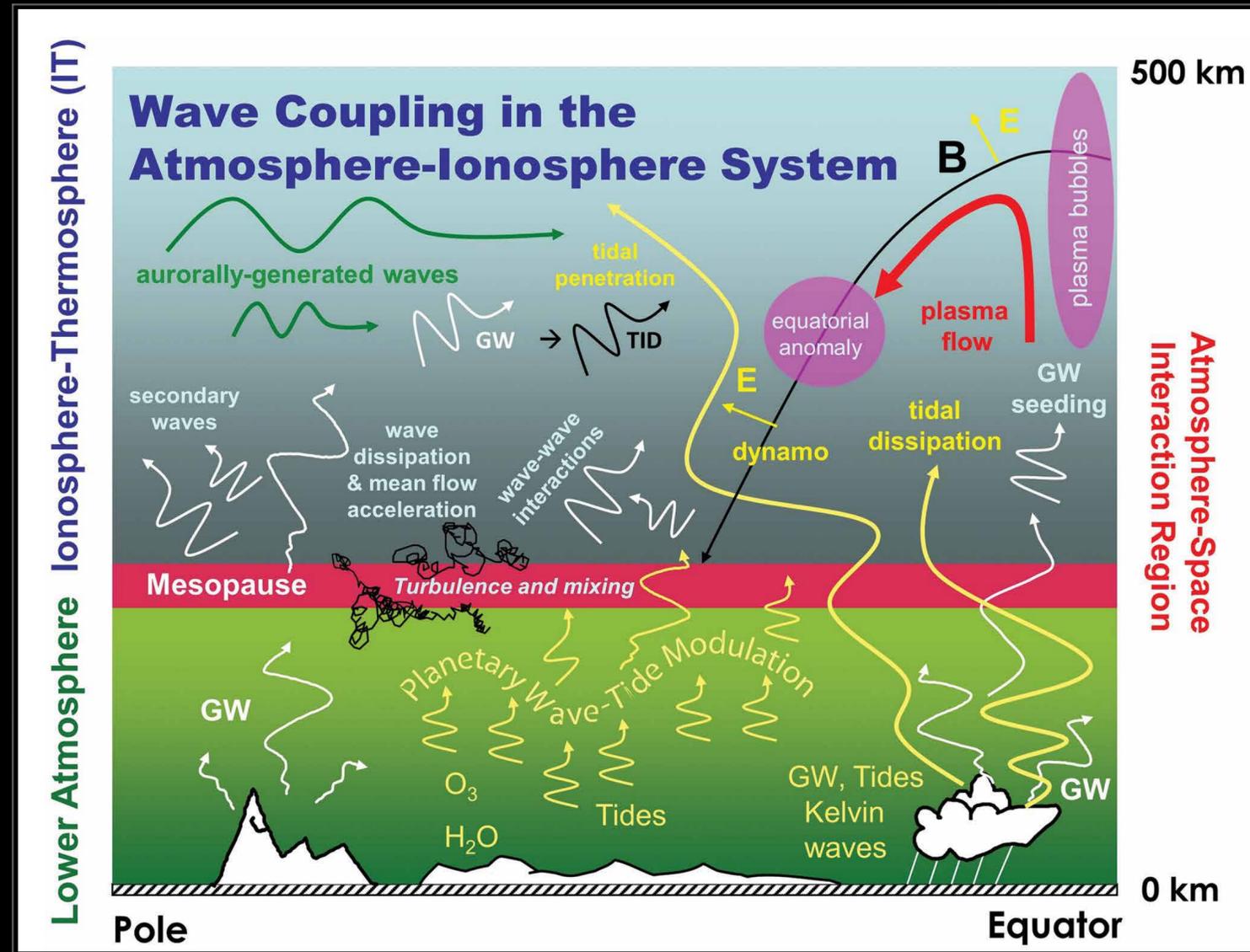
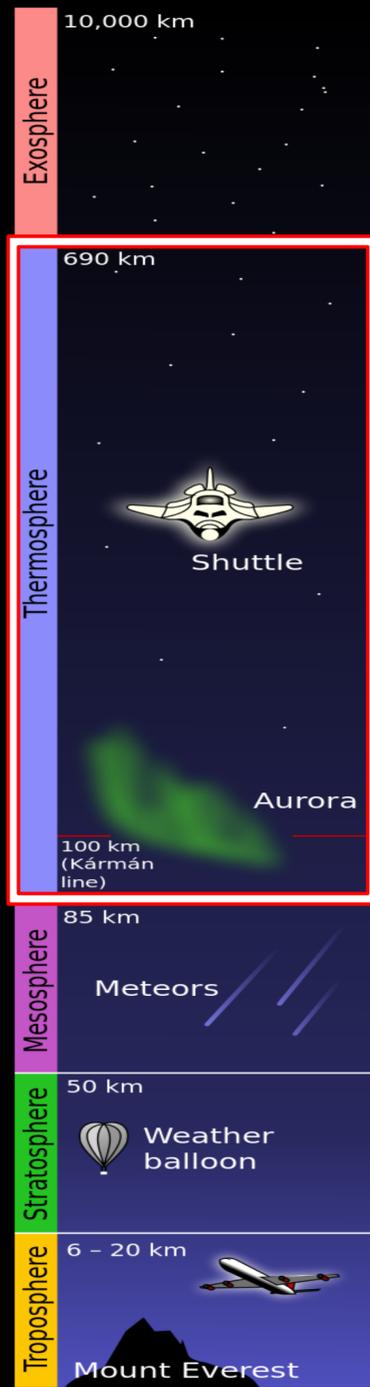


* Gasperini, F., Hagan, M. E., & Zhao, Y. (2017). Evidence of tropospheric 90 day oscillations in the thermosphere, *Geophysical Research Letters*, 44, 10,125-10,133.

OUTLINE

- Background
- Satellite Observations and Modeling
- Evidence of 90-day Oscillations in the Thermosphere
- Link to Tropospheric Convection
- Summary

Sources of Thermospheric Variability



Solar and Space Physics Decadal Survey, National Academy of Sciences, 2012 (Jeff Forbes).

Dissipation of Upward Propagating Waves

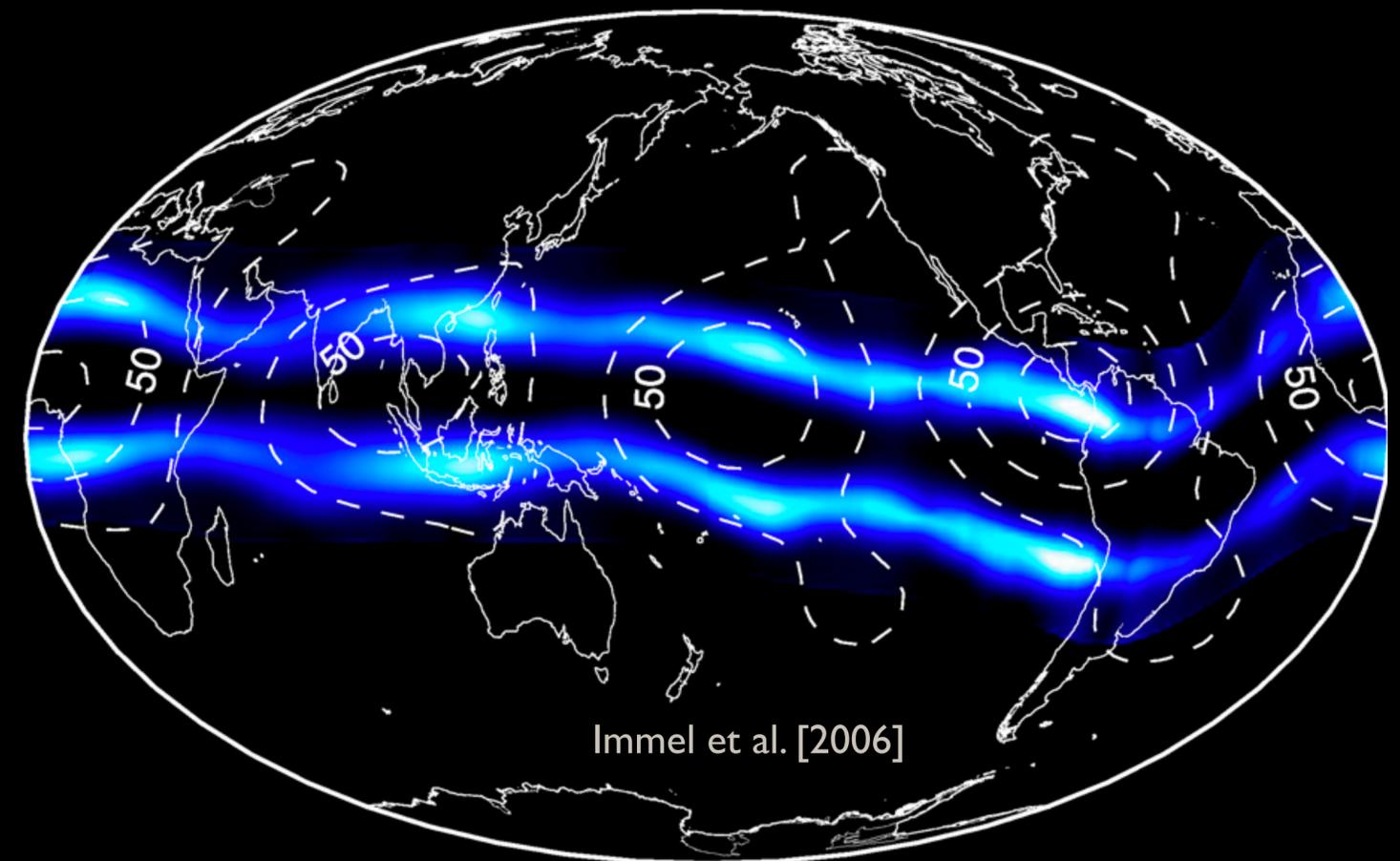


Sources from BELOW

DE3 tide

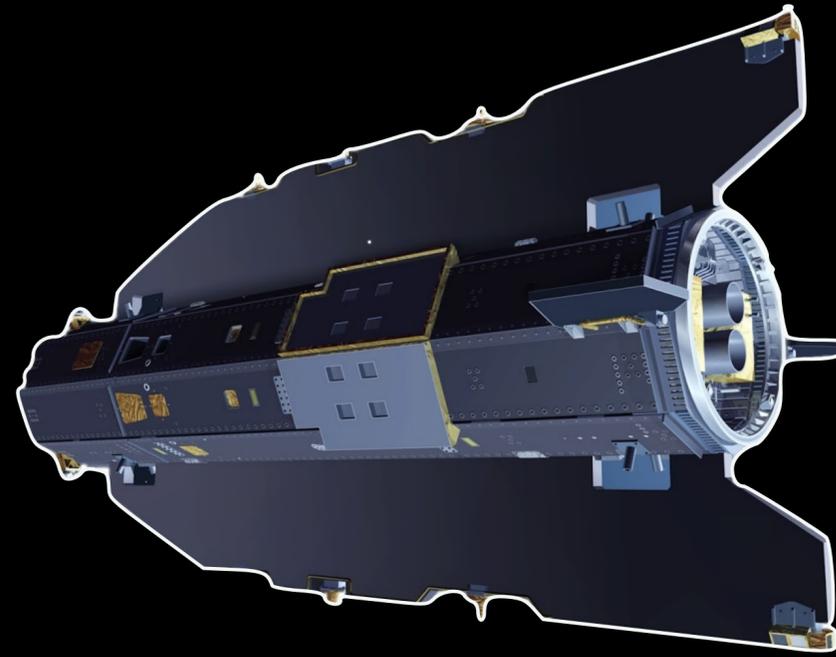
i.e. Diurnal Eastward propagating wavenumber 3 tide

- Excited in the tropical troposphere by latent heat release in deep convective clouds
- Significant source of variability in the ionosphere and thermosphere
- Large contributor to the ionospheric 4-cell (or *wave-4*) structure



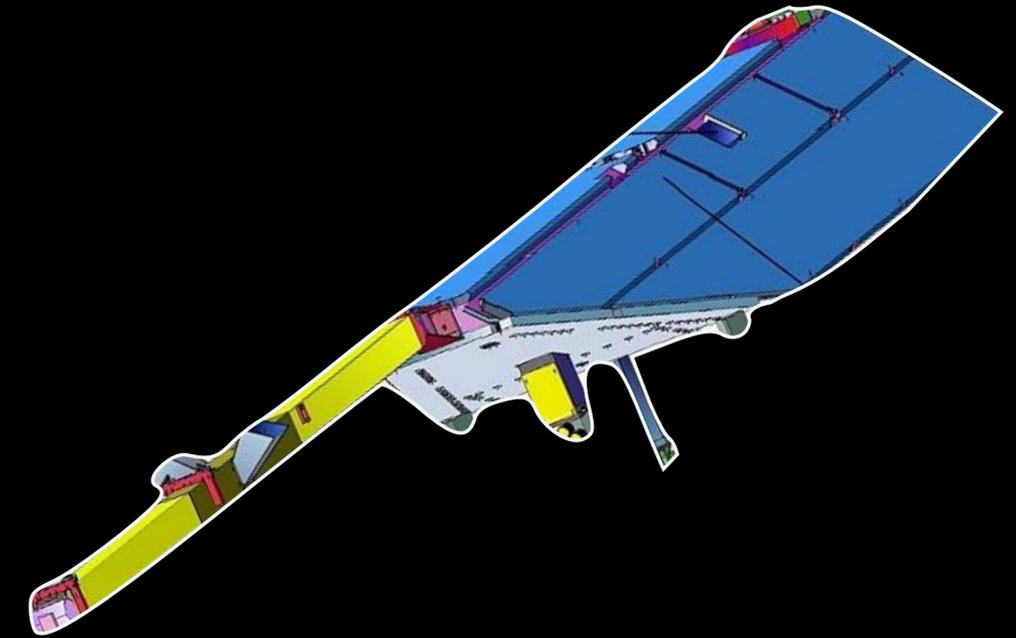
GOCE

Gravity Field and Steady-State Ocean Circulation Explorer



CHAMP

CHALLENGING Minisatellite Payload



LIFETIME

Mar 09 – Nov 13

Jul 00 – Sept 10

ORBIT

near-circular 260 km dawn-dusk
with $i=96.7^\circ$ (sun-synchronous)

near-circular 450-300 km
with $i=87^\circ$ (slowly precessing)

COVERAGE

Global

Global

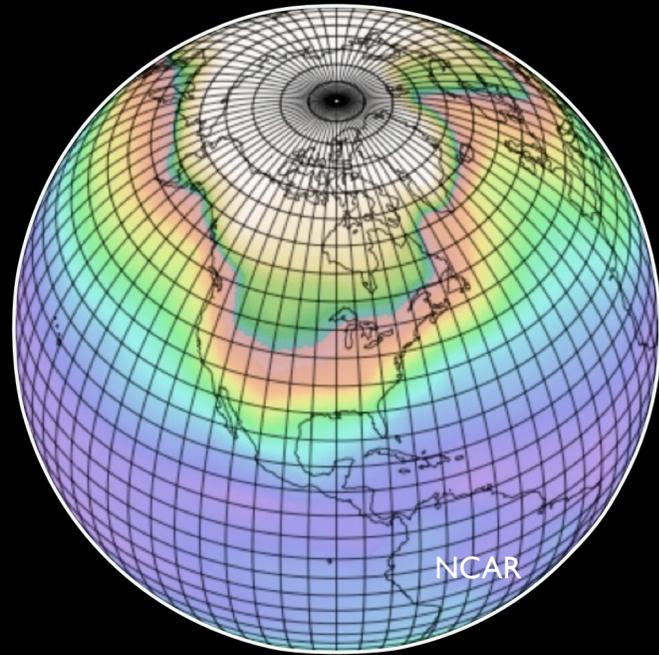
DATA

Cross-track (east-west) winds from
accelerometer data

Cross-track (east-west) winds from
accelerometer data

TIME-GCM

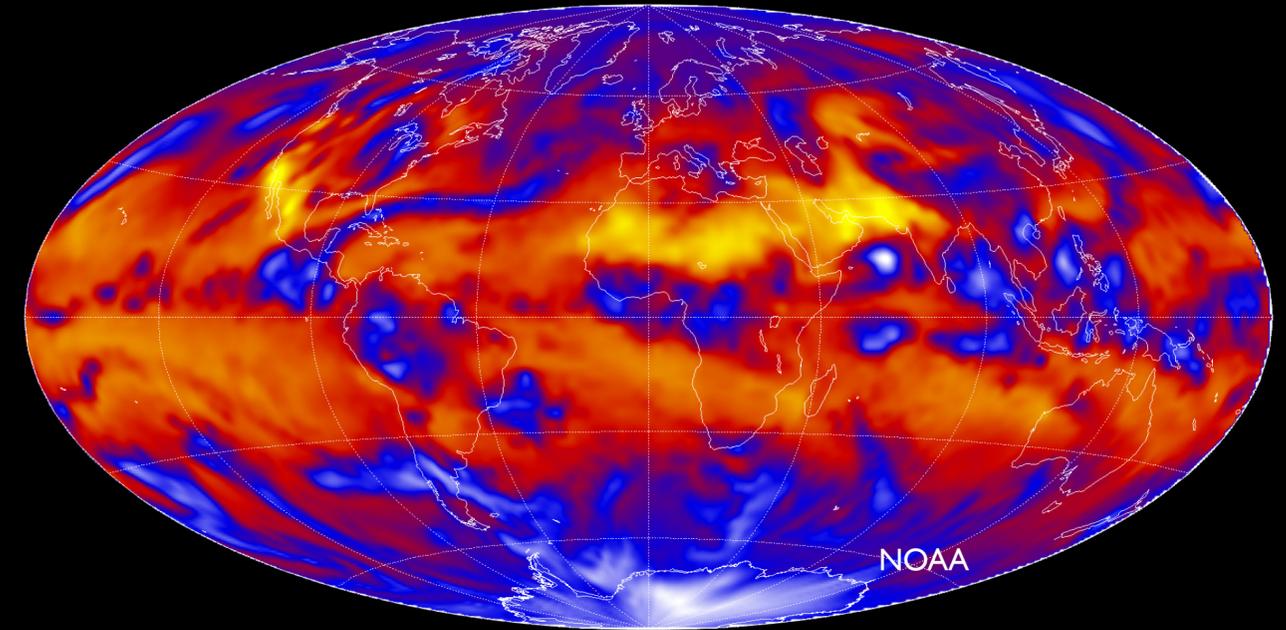
Thermosphere Ionosphere Mesosphere Electrodynamics
General Circulation Model



- Global time-dependent model developed by NCAR.
- F10.7 and Kp indices used to represent solar radiative and high-latitude forcing.
- Grid: 2.5°x2.5°, 30-500 km, 1-min time step.
- Lower boundary set with MERRA reanalysis data that provides realistic wave forcing.
- The focus here is on zonal winds during 2009-2010.

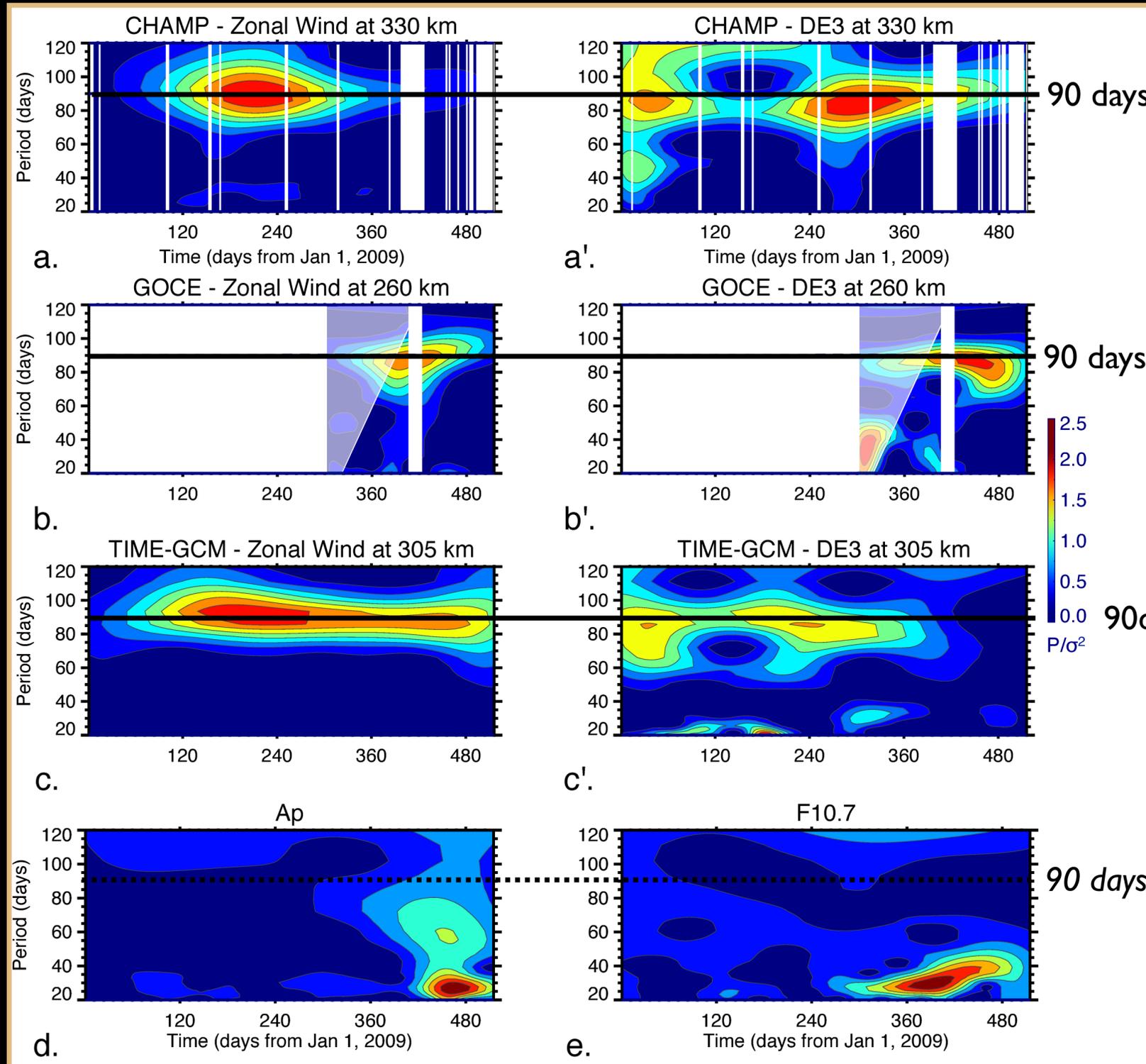
OLR

Outgoing Longwave Radiation



- Infrared radiation emitted from Earth and its atmosphere to space.
- Measured by radiometers onboard NOAA's polar orbiting satellites.
- Serves as proxy for tropospheric convection, because convective cloud tops are cold and thus emit little long-wave radiation.

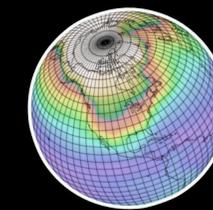
Evidence of 90-day oscillations in the thermosphere



330 km



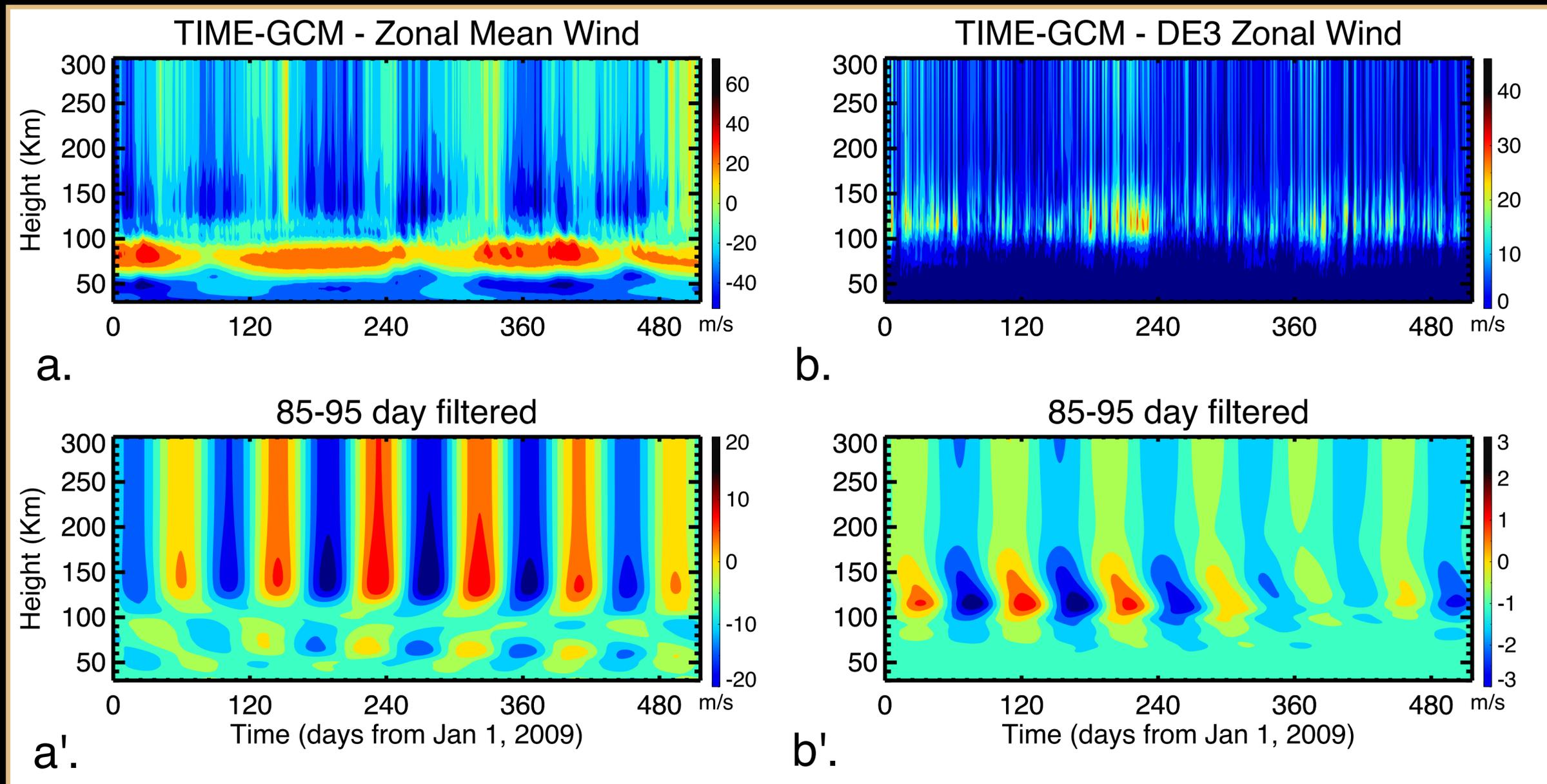
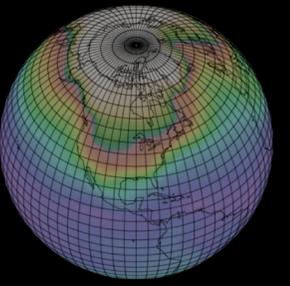
260 km



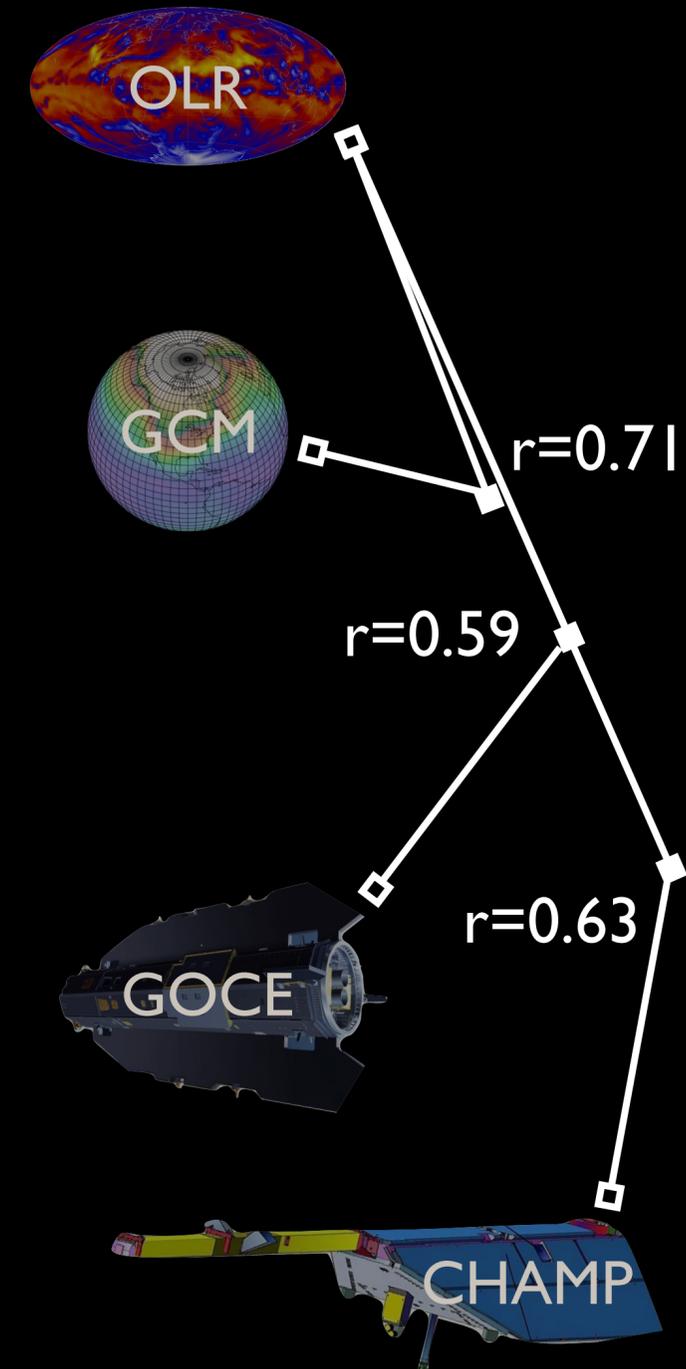
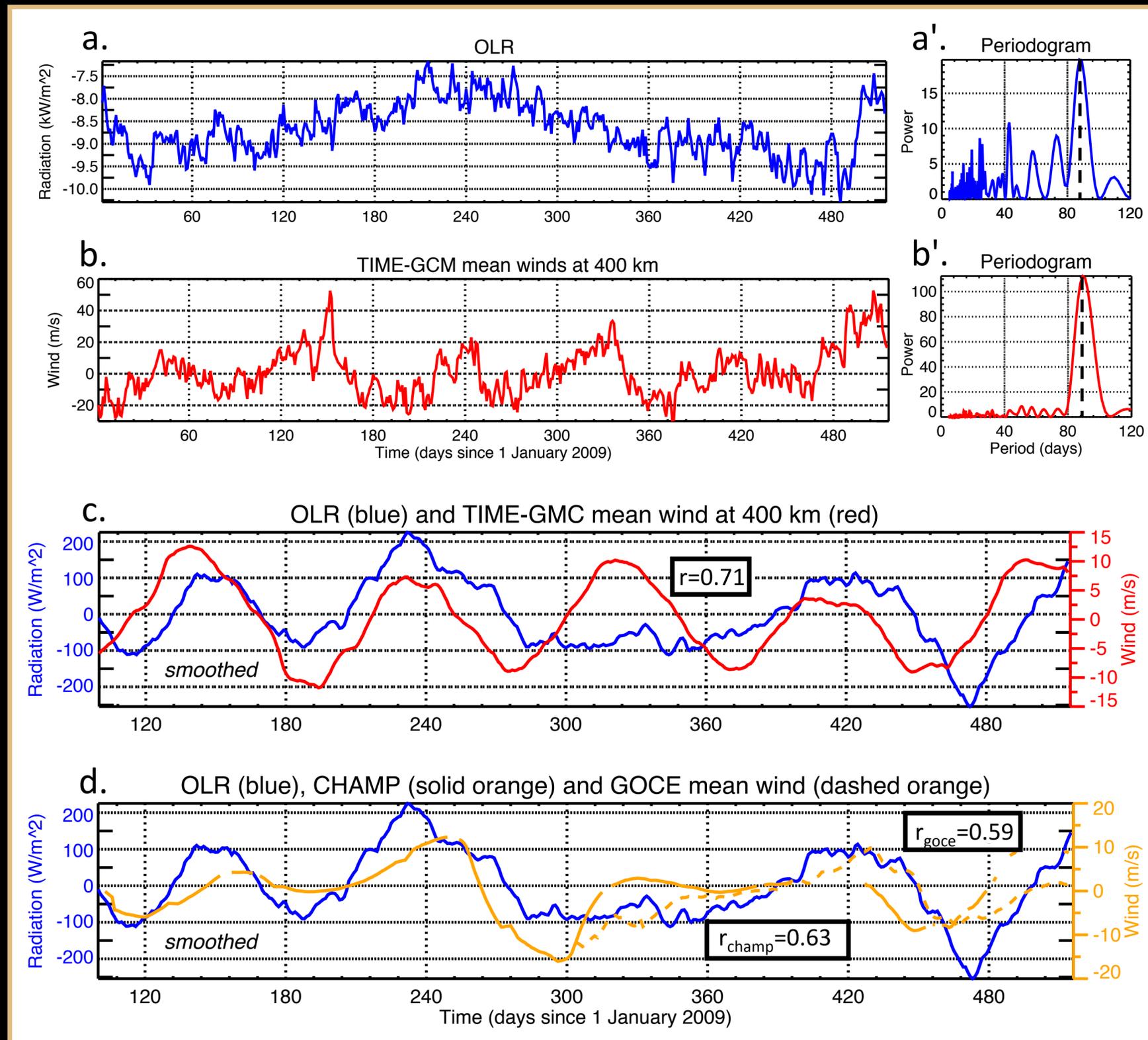
305 km

The 90-day oscillation does not appear to be connected to solar or geomagnetic forcing

Vertical structure



Link to Tropospheric Convection



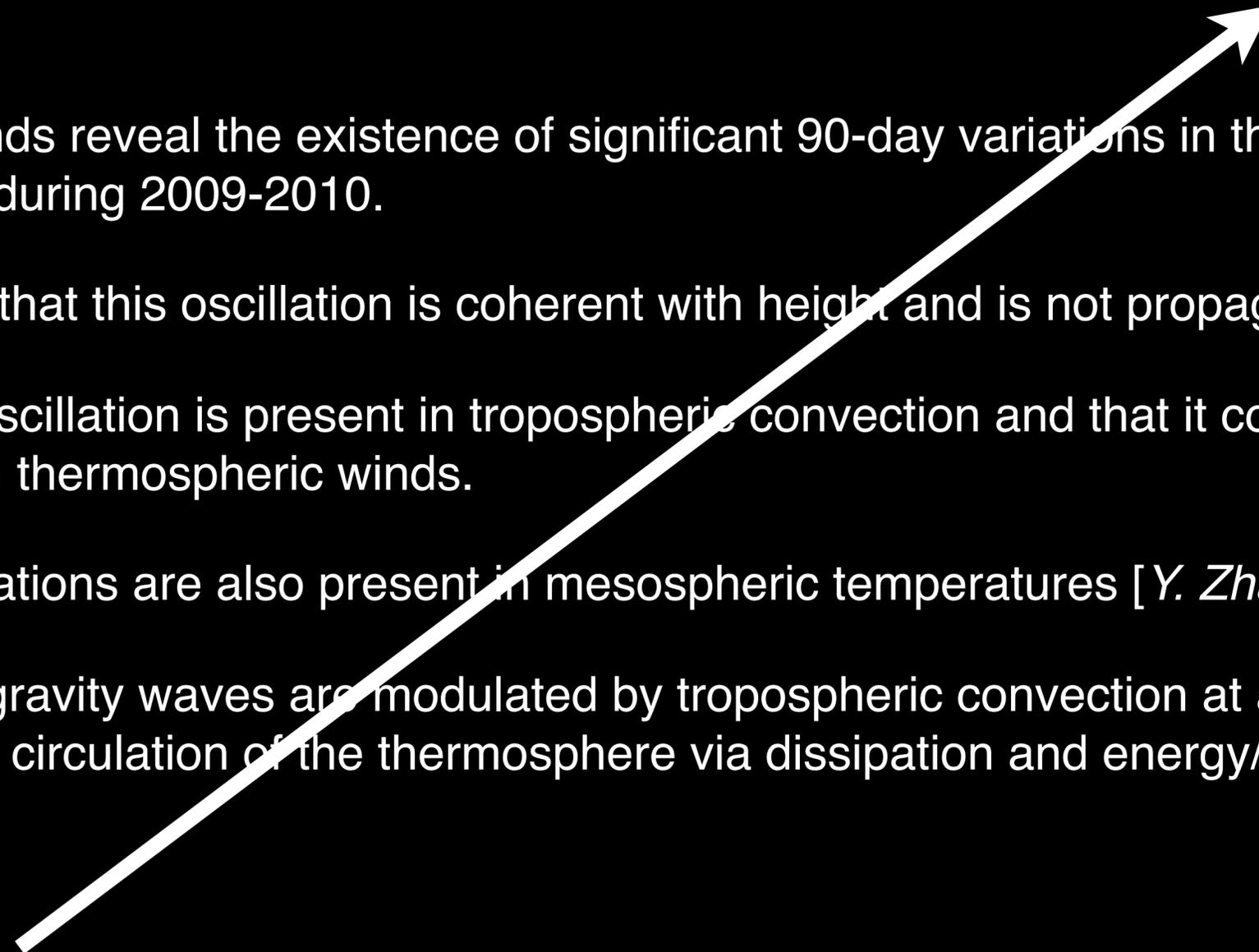
Summary

Thermosphere

- CHAMP and GOCE cross-track winds reveal the existence of significant 90-day variations in the thermospheric mean winds (± 20 m/s) and DE3 (± 3 m/s) during 2009-2010.
- MERRA/TIME-GCM demonstrates that this oscillation is coherent with height and is not propagating from below.
- OLR reveals that the same 90-day oscillation is present in tropospheric convection and that it correlates with observed ($r=0.59-0.63$) and modeled ($r=0.71$) thermospheric winds.
- Similar (but localized) 90-day oscillations are also present in mesospheric temperatures [*Y. Zhao*].
- Our results suggest that tides and gravity waves are modulated by tropospheric convection at a period of 90 days and transfer this periodicity to the mean circulation of the thermosphere via dissipation and energy/momentum deposition.



Troposphere



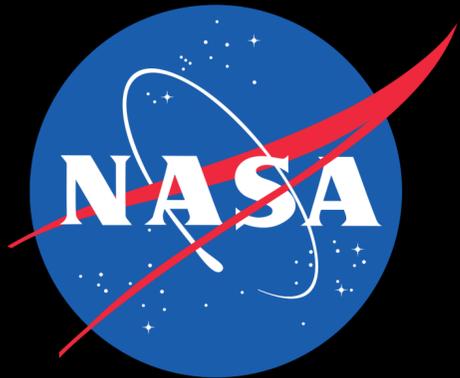
Outstanding Questions

Q1: How frequent, prevalent, and persistent are correlations between 30-100 day variations in the troposphere, mesosphere, and thermosphere in the past 15 years?

Q2: How well does WACCM-X 2.0 capture the observed intra-seasonal variability from the mesosphere up to the thermosphere?

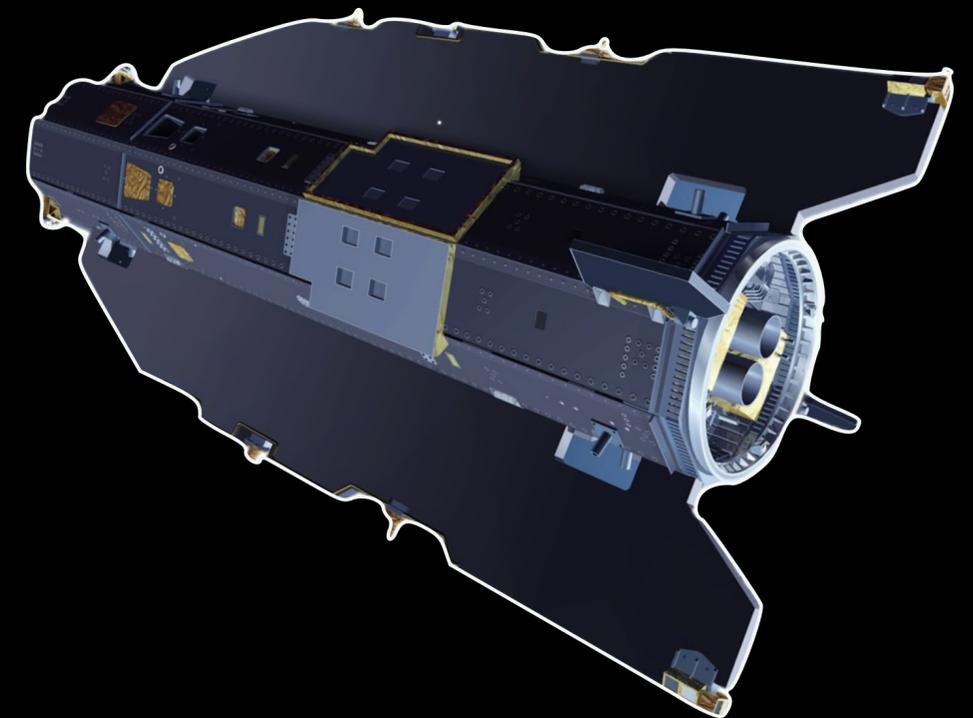
Q3: What plausible roles do large-scale upward propagating waves play in dynamically coupling tropical tropospheric intra-seasonal variability into the thermosphere?

ACKNOWLEDGEMENTS



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Questions?
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