

Signatures of the Madden-Julian oscillation in the thermosphere?

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Abstract

- Terrestrial weather is known to greatly impact the mean state of the thermosphere via the dissipation of gravity waves (GW) and solar tides.

- Using thermospheric cross-track wind measurements from the CHAMP and GOCE satellites, a MERRA/TIME-GCM simulation, and Outgoing Long-wave Radiation (OLR) data, we demonstrate¹:

- The existence of a prominent global-scale 90-day oscillation in the thermospheric mean zonal winds and in the diurnal eastward-propagating wavenumber 3 tide (DE3) during 2009-2010.
- Its connection to variability in tropospheric convective activity, possibly associated with the Madden-Julian oscillation (MJO).

1. 90-day Oscillation at 300 km

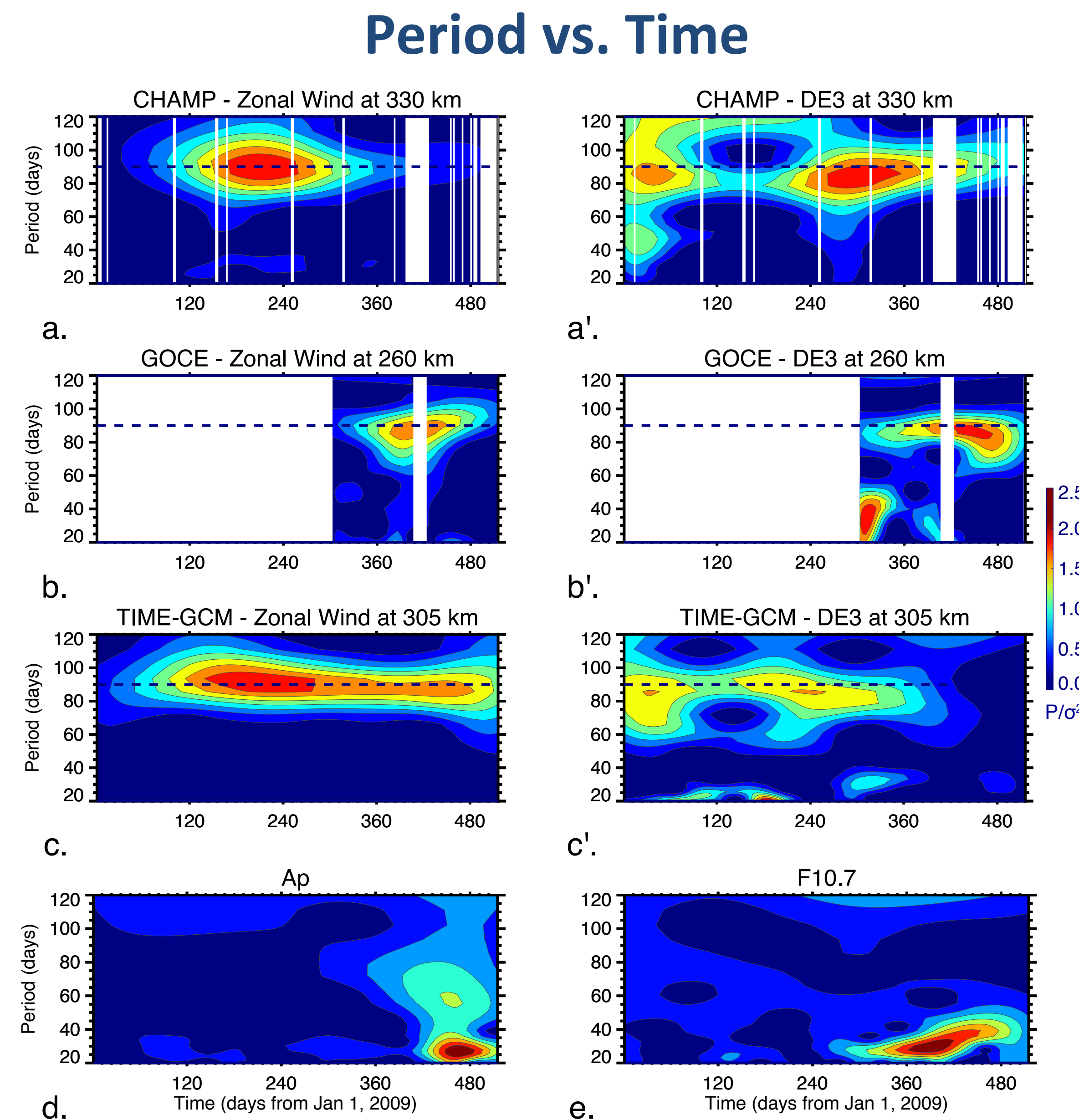


Fig. 1 Wavelet of thermospheric mean zonal winds and DE3 from CHAMP (a,a'), GOCE (b,b'), TIME-GCM (c,c'). (d) (e) show the Ap, F10.7 wavelets.

Height vs. Time

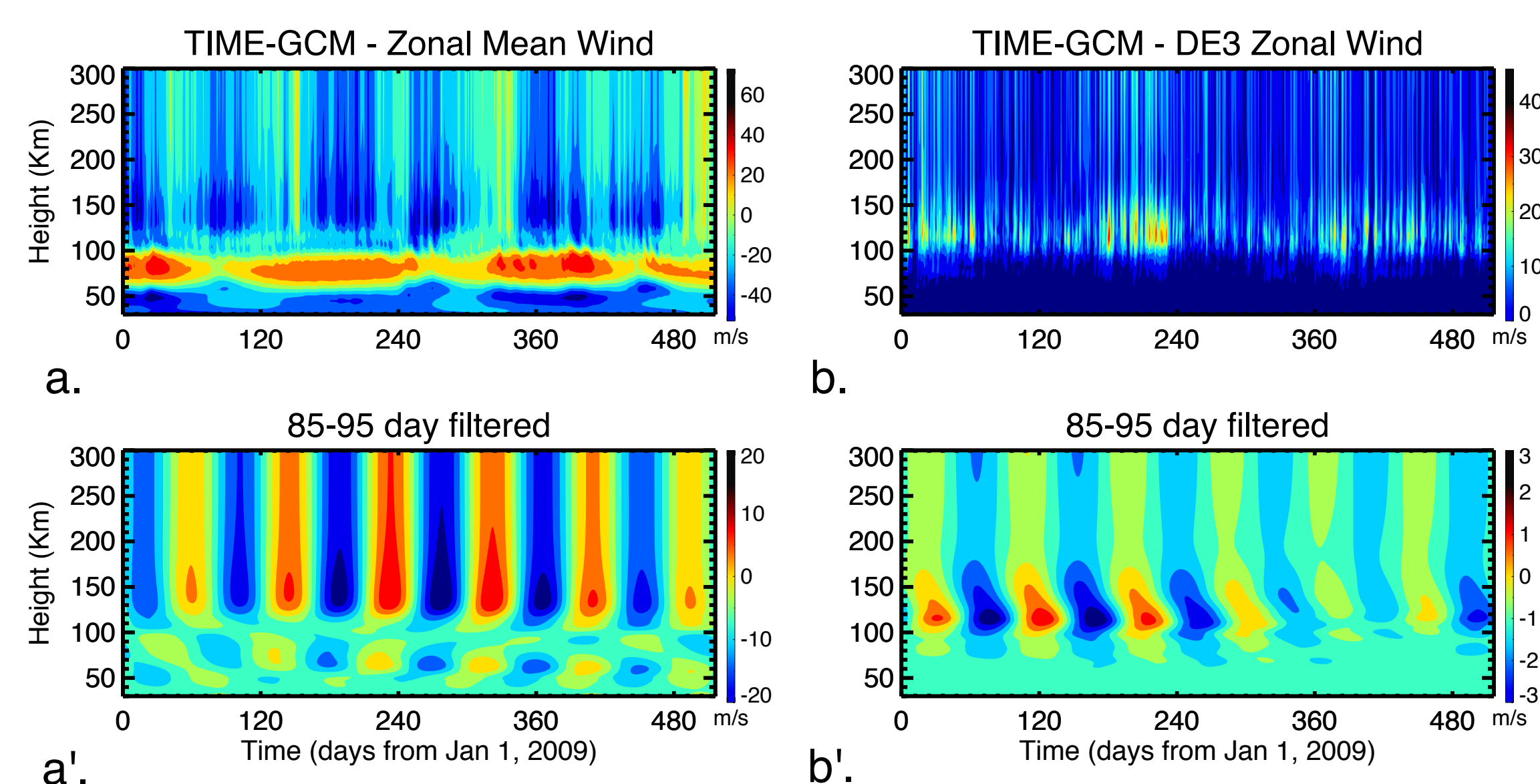


Fig. 2 TIME-GCM zonal mean wind and DE3 wind amplitudes before (a, b) and after (a', b') a 85-95 day filter is applied.

2. Connection to Tropospheric Convection

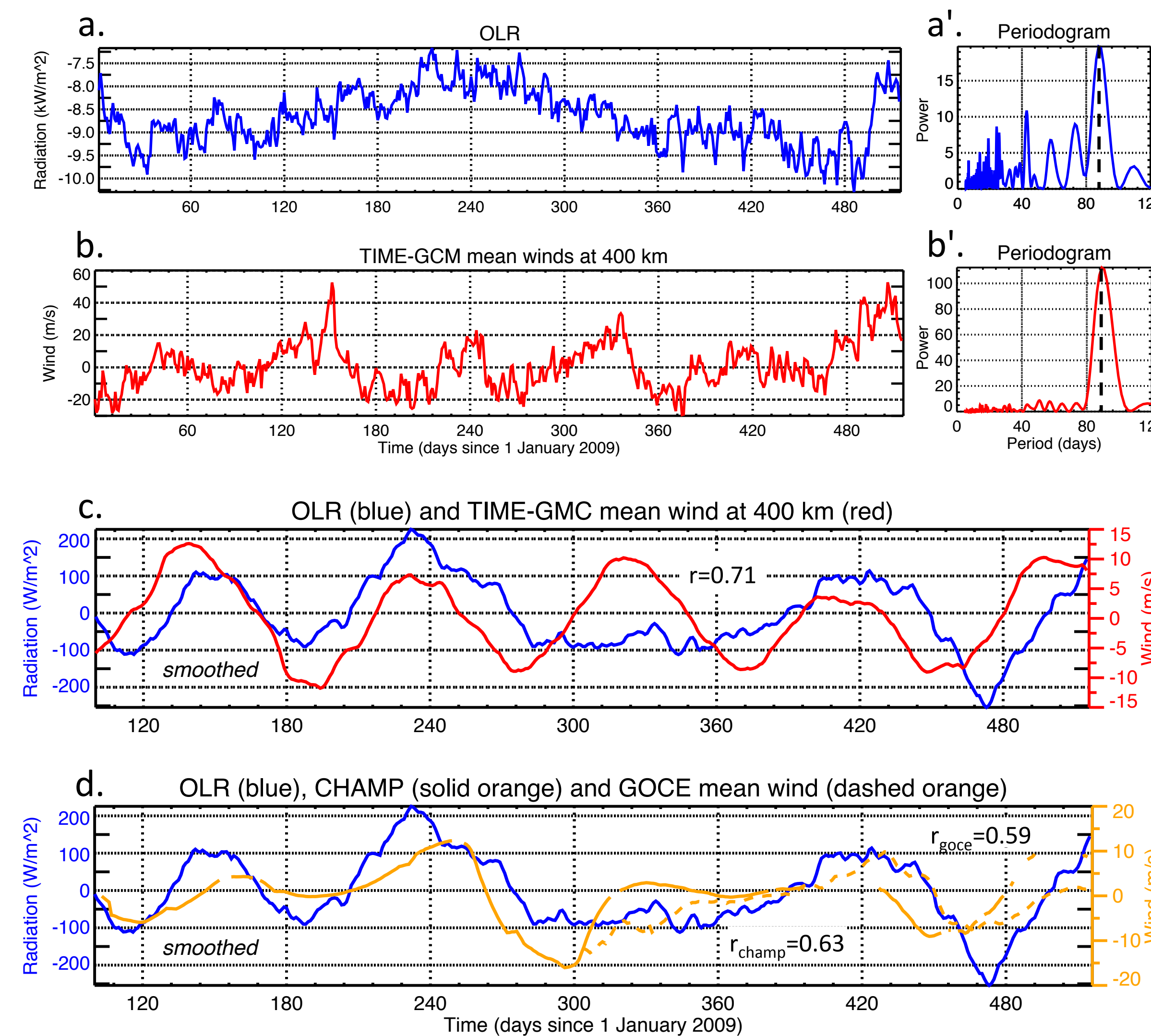


Fig. 3 Time series of OLR (a) and TIME-GCM mean zonal winds (b) with periodograms. (c), (d) show 30-day running means of 90-day residuals.

- A strong and persistent 90-day oscillation is found in both thermospheric mean zonal winds (Figs 1-2) and OLR (Fig 3a).
- OLR is a common proxy for tropospheric convective activity.
- Correlation analysis demonstrates a connection between the 90-day oscillation in the thermospheric mean wind and tropospheric convection ($r=0.71$, model-OLR).
- A plausible explanation for the 90-day variation in tropospheric convection is the MJO, a major tropical tropospheric disturbance with a period of 30-100 days.

90-day in tropospheric OLR

90-day in thermospheric mean winds

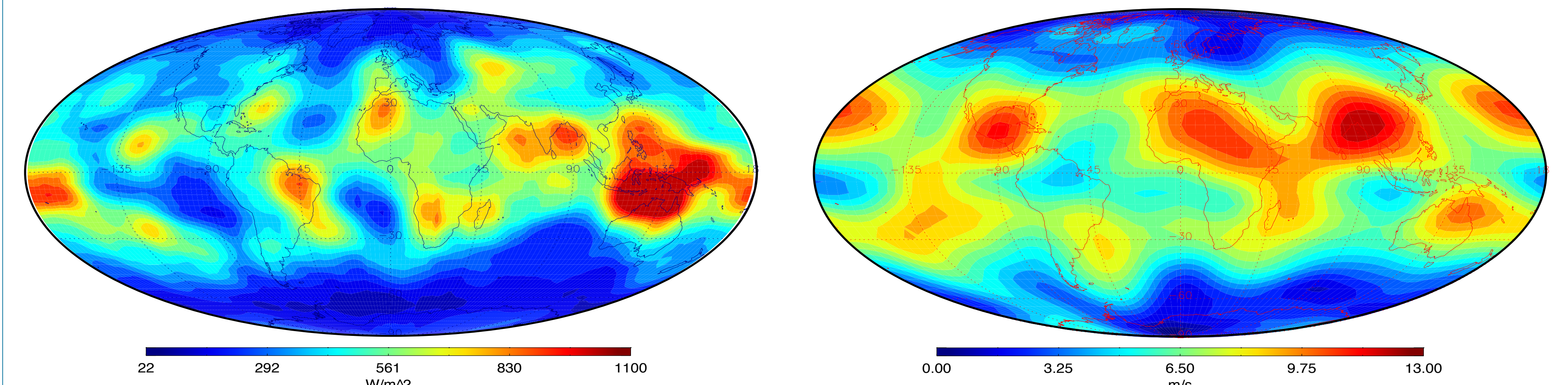


Fig. 4 Latitude-longitude map of 85/95-day filtered diurnal-mean OLR (left) and model mean zonal winds at 400 km (right). Winds and OLR display distinct latitude-longitude structures with most variability concentrated near the tropics.

❖ Our results suggest that GW and tides modulated by 90-day oscillations in tropospheric convection may transfer this periodicity to the mean circulation of the thermosphere via dissipation and energy/momentum deposition.

¹ Gasperini, F., and M. Hagan (2017), Evidence of tropospheric 90-day oscillations in the thermosphere, *Geophys. Res. Lett.*, 2017GL074461 (submitted).