

Thermosphere Extension of the Quasi 6-day Wave Observed by the TIMED Satellite

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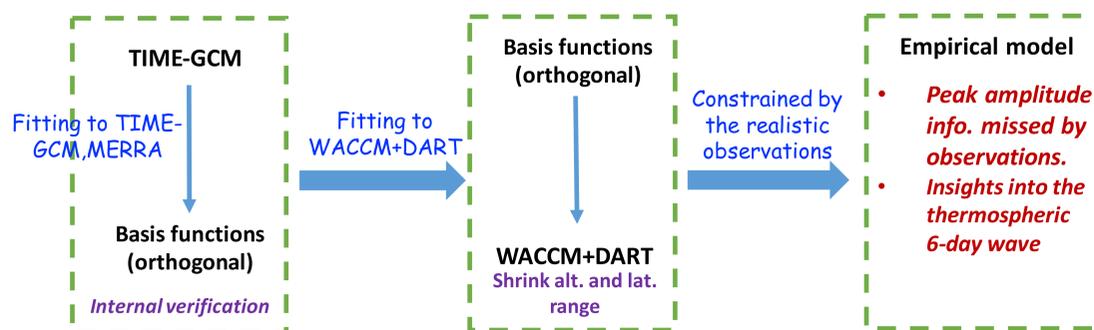
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1. Abstract

The quasi 6 day wave, westward propagating with a period of 5-7 days and zonal wavenumber 1, is one of the most prevailing and recurrent phenomenon in the MLT region. It has been well established that the quasi 6 day wave plays a significant role in the low and middle atmospheric neutral dynamics, as well as upward coupling with the Thermosphere/Ionosphere. However, due to the limit of current satellite-based observations, a global pattern of the quasi 6 day wave has not yet been derived, particularly in the thermosphere. This motivates us to develop an empirical model based on the most recent satellite observations to characterize the nature of the quasi 6 day wave from the stratosphere up to the thermosphere.

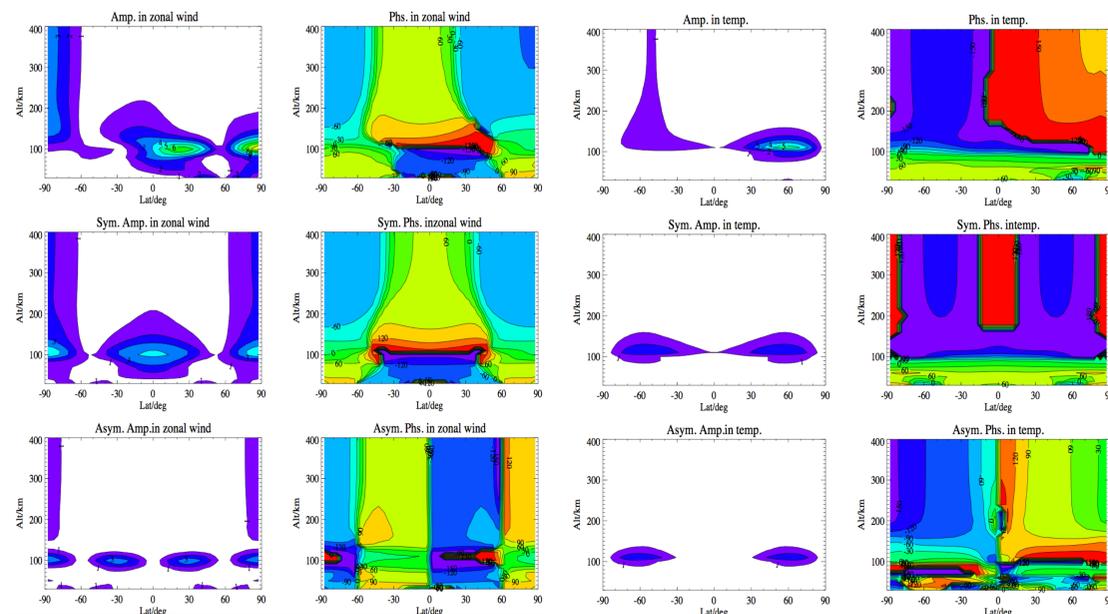
2. Data and methodology

- TIME-GCM: -90S-90N & 30-400 km
- WACCM+DART: -90S-90N & 0-145 km (Courtesy of Nick Pedatella)
- SABER temp. and TIDI winds: -90S-90N & 20-110 km/80- 105 km



✓ The flow chart heads to the observation-based empirical model of the quasi 6 day wave.

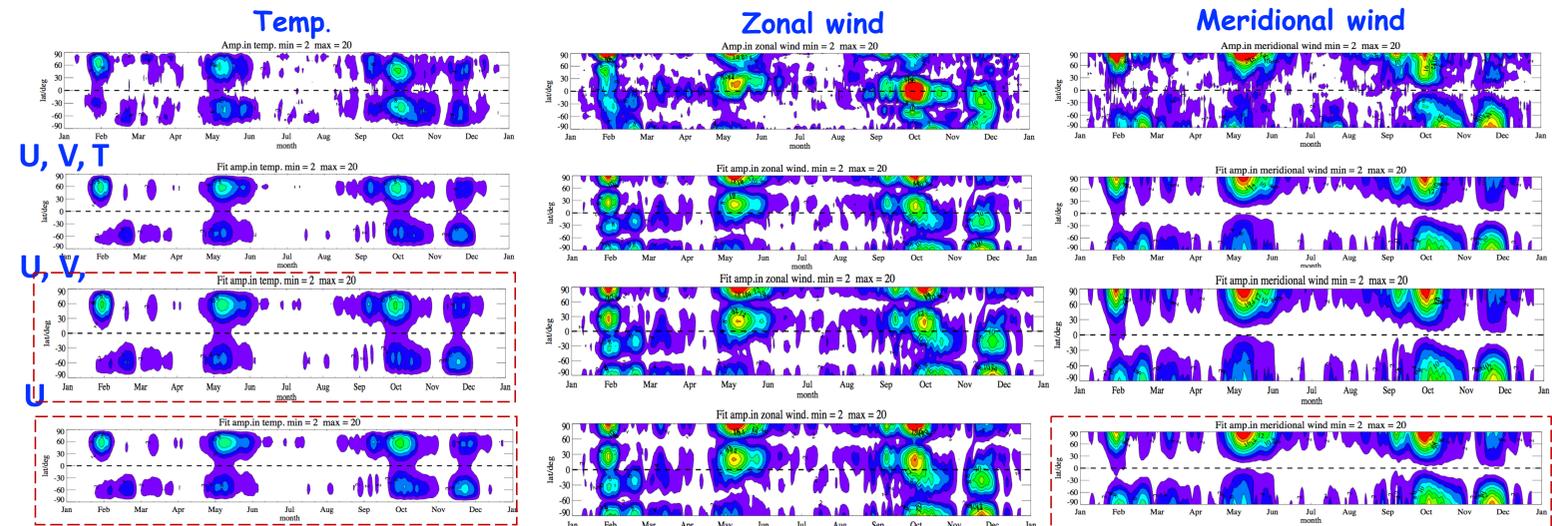
3. Basis functions



The amplitude and phase of the TIME-GCM simulated quasi 6 day wave as a function of altitude and latitude in zonal wind (left two columns) and temperature (right two columns) under the post-vernal equinox condition.

- ✓ The quasi 6 day wave simulated by TIME-GCM is decomposed into the symmetric and antisymmetric components, which are mathematically orthogonal and thus could be used as a set of basis functions.
- ✓ The quasi 6 day wave under post-vernal equinox condition, characterized by the asymmetric structure about the equator, is well-suited for computing the basis functions.
- ✓ Post-vernal equinox corresponds to the time of the strongest wave activity.

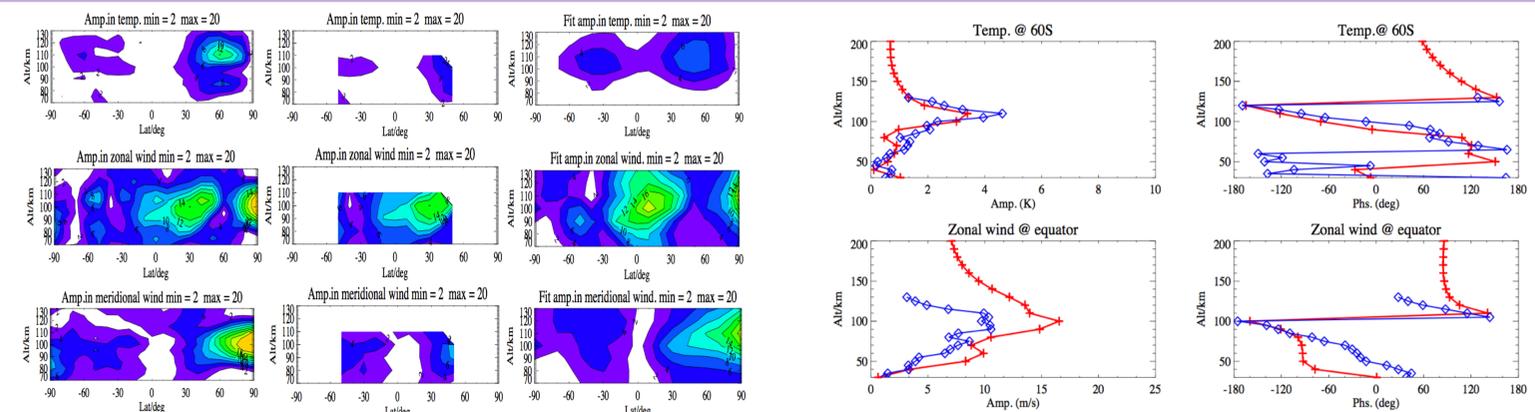
4. Verification with the TIME-GCM MERRA simulations for year 2009



(From left to right) The TIME-GCM simulated quasi 6 day wave in temp, zonal wind, and meridional wind for 2009 by forcing the model lower boundary with the MERRA reanalysis data (first row). The basis functions are fit to the time series of (U, V, T) (second row), (U, V) (third row) and (U) (fourth row).

- ✓ The fit results are consistent among the cases, except for slightly smaller magnitudes in the (U, V, T) case.
- ✓ The empirical model demonstrates an excellent prediction capability (red boxes) of the quasi 6 day wave in the unknown fields.

5. Thermosphere extension by fitting the basis functions to the WACCM+DART simulations



(Left column) The WACCM+ DART quasi 6 day wave amplitudes in temp (first row), zonal wind (second row), and meridional wind (third row). (Middle column) It is same as the left, but for the amplitudes in the 50S-50N latitude and 70-110 km altitude region. (Right column) It is the reconstructed amplitudes of the quasi 6 day by fitting the basis functions to the amplitudes in the middle column.

The quasi 6 day wave amplitude (left panel) and phase (right panel) in temp. (top panel) and zonal wind (bottom panel) in the height of 30 - 200 km. Blue and red lines denote the the results from WACCM+DART and fitting, respectively.

- ✓ The basis functions are fit to the quasi 6 day wave within the 50S-50N latitude and 70-110 km altitude region simulated by the WACCM+DART. The quasi 6 day wave is reasonably reproduced in the region of 90S-90N and 30-130 km.
- ✓ The thermosphere extension of the quasi 6 day wave displays a coherent vertical structure in both the amplitude and phase compared with that below 130 km simulated in the WACCM+DART.

6. Conclusions

- ✓ Using a set of basis functions constrained by observations, we can derive an empirical model of the quasi 6-day wave that includes information missing in observations of the wave (e.g., peak height and latitude).
- ✓ The empirical model provides new insights into the thermospheric quasi 6-day wave that are beyond the capability of current satellite observations.