Effects of thermal tides on the mean structure of Mars' lower thermosphere

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Vertically propagating tides produce variations of up-to 30% in density and 20 K in temperature fields in Mars' thermosphere. This local variability is invisible in the background fields and doesn't affect the zonal and temporal averages. A general circulation model of Mars' atmosphere is used to elucidate the effects of solar thermal tides on the zonal mean density, temperature and wind structure of Mars' atmosphere between 90 and 160 km. The effects are substantial, and amount to order 10-40%, 10-30 K and 50-150 ms^{-1}, respectively (see Figure 1), at these altitudes under low dust conditions, thus being equal or larger than induced amplitudes. By depositing their momentum, the largest tides produce a net effect that weakens westward winds and strengthens eastward ones (see Figure 2). The change in horizontal winds also alters the meridional circulation and the vertical velocities which in turn modify the thermal structure through adiabatic heating and cooling. The thermospheric polar regions in the winter hemisphere are significantly cooler which indicates a weakening of the winter polar warming by tides. The collapsing of the atmosphere in colder regions and expansion in warmer ones due to the thermal effect of tides produce an average density deviation of nearly 50% near 160 km altitude. Nearly all of the above effects on large scale atmospheric structure are due to tides originating in the lower atmosphere.

References

Moudden, Y., and J. M. Forbes, Topographic Connections with Density Waves in Mars' Aerobraking Regime, *J. Geophys. Res.*, doi:10.1029/2008JE003107, 2008.

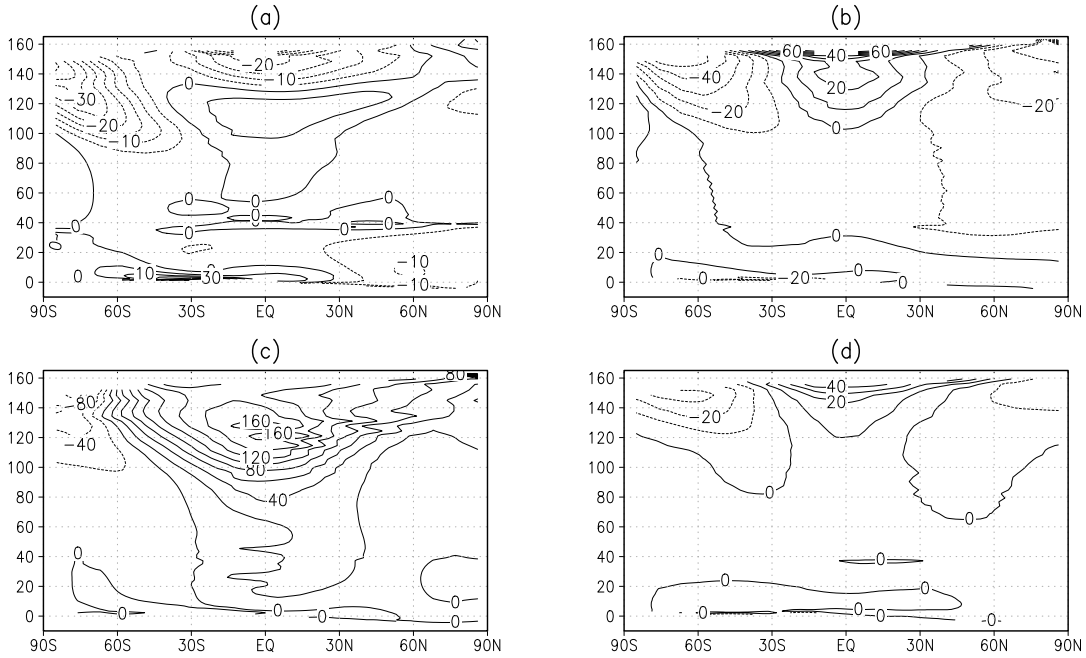

Figure 1: Difference fields illistrating the contributions of non-migrating and migrating thermal tides to (a) zonal mean temperature, (b) zonal mean total mass density, (c) zonal mean zonal winds and (d) of only non-migrating tides to zonal mean total mass densities, for low dust conditions ($\tau = 0.1$).

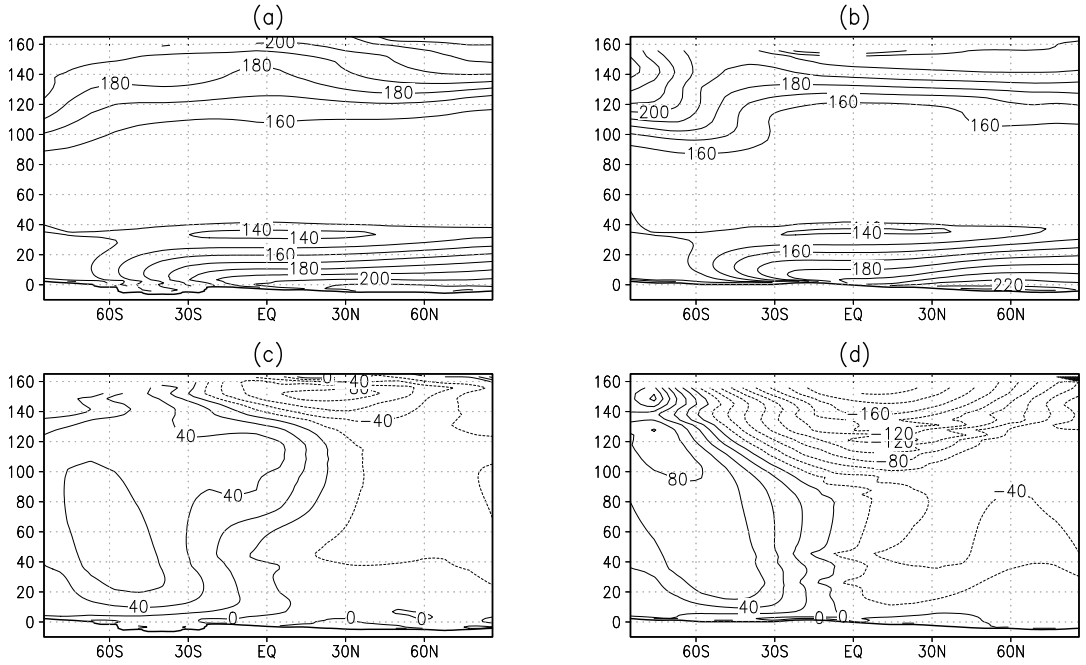

Figure 2: Zonal mean temperatures (top) and zonal winds (bottom) with diurnal cycle and full surface topography (left) and with no diurnal cycle and smooth surface (right) for low dust optical depth $\tau = 0.1$. The differences between the left and right panels indicate the influence of both migrating and non-migrating tides on the zonal mean temperature and wind structure of Mars atmosphere for low dust conditions.