EPSC Abstracts
Vol. 7 EPSC2012-825-1 2012
European Planetary Science Congress 2012

Thermal Tides as Revealed by Mars Climate Sounder

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Abstract

The extensive spatial and seasonal coverage provided by Mars Climate Sounder allows us to document the seasonal variation of temperature and cloud structure over the course of the two-plus Mars years. Nightside and dayside observations (at 3am and 3pm, respectively) enable the identification of nonmigrating thermal tides and provide much more detail on the migrating diurnal tide, previously characterized by [1]. Mars GCM simulations are also presented to better interpret the tide observations. Prior work [2,6] has suggested a coupling between the tides and water ice clouds, whereby the tides shape the temperature response and cloud radiative effects amplify the tide forcing. The MCS observations and MGCM modeling provide further support for this claim.

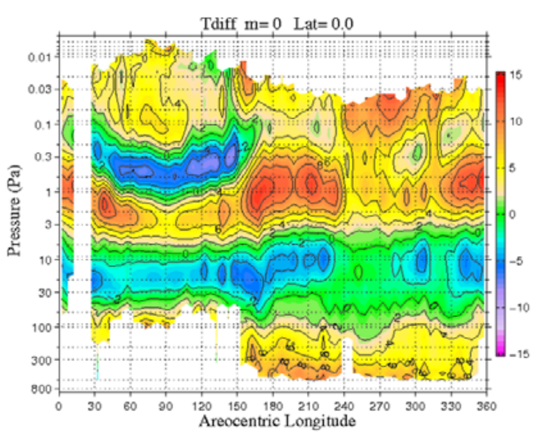

Figure 1. Composite seasonal cycle of the equatorial migrating diurnal tide field represented by zonally averaged T_{diff}.

1. Introduction

The tides can be examined in MCS temperature retrievals by an analysis of gridded fields of $T_{diff} = (T_{3pm}-T_{3am})/2$. Nonmigrating diurnal tides can be identified by the presence of zonal structure in the T_{diff} field. Given the relative absence of stationary waves in the tropical temperature field, nonmigrating tides can also be identified using T_{3am} data only.

2. Results

The equatorial migrating tide is shown in Figure 1. The result is consistent with a vertically propagating tide, with the phase fixed by the 3am/3pm observation time. The maximum tide amplitudes in the equinoctial seasons are in good agreement with MGCM simulations. Figure 2 shows the longitudinal structure present in the equatorial T_{3am} field. The field is dominated by features with zonal waves 2-4 and relatively long vertical wavelengths. These are found to reflects a mix of eastward propagating diurnal period Kelvin waves [1] and westward propagating tides with shorter vertical wavelengths. The latitude/height structures of these waves are in general agreement with MGCM simulations. The seasonal variation in tropical temperature structure at 1 Pa (~60 km) is shown in Figure 3. Nonmigrating tide amplitudes are typically stronger during the NH summer season than in other seasons. The full T_{3am} field corresponding to the bottom 40 km of Figure 3 is shown in Figure 4.

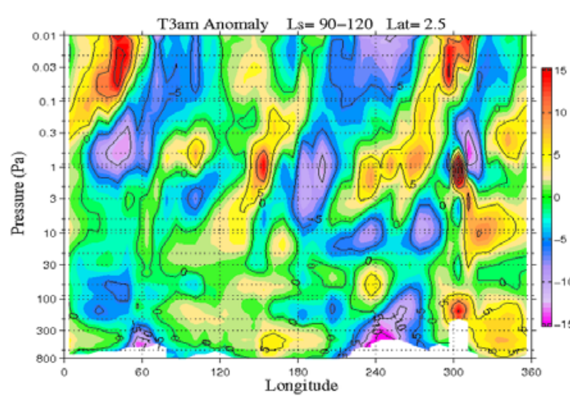

Figure 2. Anomaly field constructed from equatorial T_{3am} during the NH summer solstice season.

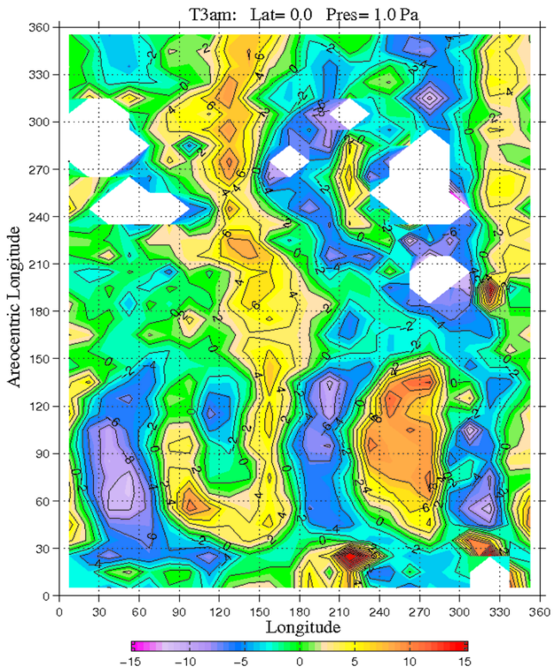

Figure 3. Longitude-time plot of the T_{3am} equatorial (5°S-5°N) temperature anomaly field at 1 Pa.

As discussed in [6], there is a close relationship between ice clouds and temperature. MGCM simulations [2,6] indicate that the prominent temperature inversion in the Tharsis region is consequence of an enhanced tide response forced by cloud radiative cooling. This is particularly notable in the cold near-surface temperature anomalies over Arabia and Tharsis (Figures 2 and 4). The seasonal variation of the zonal wave 2 pattern in low level temperature that is summarized in Figure 5 is closely correlated with the evolution of ice cloud opacity that peaks shortly after NH summer solstice. The cold air temperature anomalies are also strongly correlated with anomalously warm MCS surface temperatures that were interpreted [5,6] as reflecting the presence of enhanced IR radiation from thick nighttime water ice clouds. We will show how these observations can serve to constrain MGCM simulations of radiatively active water ice clouds.

3. References

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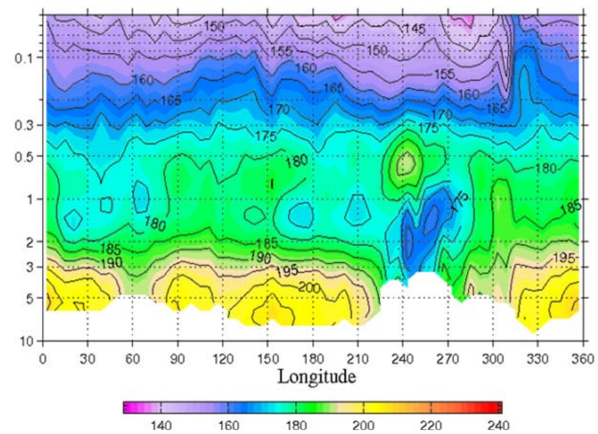

Figure 4. Longitude/pressure section of equatorial temperature for L_s= 110-120°. Pressure in hPa.

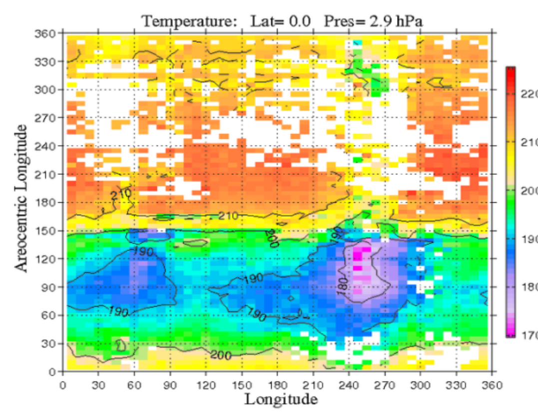

Figure 5. Evolution of equatorial T_{3am} at 290 Pa.