SIMULATION OF THERMAL TIDES IN THE MIDDLE ATMOSPHERE OF MARS. E. Chassefiere, F. Vial, F. Jegou, F. Forget, F. Hourdin, and E. Lellouch, Universite Pierre et Marie Curie.

Measurements on the dynamics on Mars middle atmosphere (at 40-70 km) have been obtained from ground-based millimeter-wave observations. Specifically, inspection of Doppler shifts on strong rotational lines of CO mapped on the martian disk allows one to reconstruct the global wind field around 50 km. Such measurements have been already conducted with large single dish antennas (Lellouch et al. 1991 ; Theodore et al, 1993), indicating for the first time the gross structure of the middle atmosphere circulation near Southern Solstice and Equinox. They are now being extended to interferometric observations, with a 5-fold improvement in spatial resolution. Information is also available on the temperature field up to 70 km altitude. Such measurements, which can be obtained on a regular basis, allow one to monitor the dynamical state of the middle atmosphere, providing insight in the coupling processes between the middle and upper atmosphere.

One of the most striking, still unexplained, feature observed by millimeter-wave observation is a strong, global, retrograde jet at low and mid-latitudes near equinox (Gillet and lellouch, 1994). No convincing explanation of this phenomenon presently exists, although moderately negative zonal winds in the equatorial middle atmosphere of Mars are in some cases exhibited by existing General Circulation Models of the Mars atmosphere (Forget et al., 1999). One possible explanation could be the effect of zonal acceleration induced by tides at mesospheric levels. As already shown by Zurek (1976), the strong thermal forcing of Mars surface and low dusty atmosphere results in global pressure, temperature and wind oscillations which vertically propagate up to the middle Martian atmosphere where, due to their exponential growth, they may greatly influence the general circulation. The goal of this study is to evaluate the role of thermal tides in Mars mesospheric circulation through the combined use of the General Circulation Model developed at LMD (Hourdin et al, 1993) and a specific model developed for analyzing the role of tides in the dynamics of the terrestrial mesosphere (Vial and Teitelbaum, 1986).

In the tidal model, dissipation is taken into account through average Rayleigh friction and Newtonian cooling coefficients. Assuming that the middle atmosphere is clear, and because heat is absorbed at the surface, or in the low dusty atmospheric layer (below 15 km altitude), forcing may be neglected at altitudes of interest, and tidal waves may be supposed to propagate freely through the middle atmosphere. Complex Hough functions are calculated. The general solution is represented as the product of a complex exponential factor associated with zonal propagation, a linear combination of Hough functions describing latitudinal variations, and the exponential solution of the vertical structure equation. The values of zonal numbers and frequencies relevant to Mars, which must take into account the effect of the topographic forcing, have been selected in a first step according to other existing studies (Zurek, 1976 ; Hamilton and Wilson, 1996). In a final stage, they will be fixed according to the results of the analysis of the GCM fields in terms of Hough modes, as explained hereafter. The main modes of interest, efficiently propagating up to middle atmospheric levels, are selected according to their equivalent depth and dissipation time.

The wind and temperature fields derived from the GCM in equinoxial conditions, at 40-70 km altitude, are analyzed through a Fourier analysis of longitude/ time series, followed by a latitudinal decomposition of resulting functions on the basis of the Hough functions. In this way, it is possible to assess the way thermal tides are reproduced in the GCM, as well to identify dominant modes. Ultimately, this study will allow to check the self-consistency of the GCM (with and without diurnal cycle) and the Tidal Model, which will be used as a diagnostic tool. The previous comparison allows to fix in a realistic way the amplitude of the tidal perturbation, which depends on the thermal forcing at the bottom of the atmosphere (not modelled in the present approach). By using the formalism of Vial and Teitelbaum (1986), it is then possible to calculate the zonal acceleration and heating rate induced by tides. A preliminary estimate of the negative acceleration due to momentum deposition is 5 10-5 m s-2 at low latitudes. Zonal acceleration results in the formation of a dynamical cell, in the meridional plane, extending from equator to 30 degrees latitude, superimposed on the background main circulation pattern. The typical values of the associated vertical and meridional winds are a few mm/s and a few tens cm/s, respectively.

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