The LMD Venus General Circulation Model: Improvements and Questions

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The General Circulation Model developed at the Laboratoire de Meteorologie Dynamique for the atmosphere of Venus has made significant progress over the last couple of years. This model includes a specific radiative transfer module that allows the consistent computation of the temperature structure, which is a major difference compared to other models using more simple temperature forcings.

The first results obtained with this model have been recently published (Lebonnois *et al.* 2010, JGR Planets, *in press*). The modeled circulation shows superrotation above 40km, but not below, indicating that despite the fact that the transfer of angular momentum from below to within the clouds is effective, the acceleration of the deepest layers of the atmosphere is not obtained. The mechanism for the transfer of angular momentum shows an equilibrium between transport by the mean meridional circulation and transport by waves (Gierasch mechanism). However, the role of thermal tides in this transport is shown, dominantly as a vertical transport in equatorial regions, that helps maintain the cloud equatorial superrotation.

Our more recent simulations have focused on improving the circulation in the deep atmosphere. The role of the boundary layer has been tested, though the circulation is not strongly affected by the use of different boundary layer schemes. The impact of initial conditions has been tested, and surprisingly it modifies strongly the circulation obtained after a couple of hundred Venus days. When the atmosphere is initialized with superrotating winds, an equilibrium is established between the atmosphere and the surface, but the total atmospheric angular momentum depends on the initial state, at least on these timescales (10^9 s). This raises many questions, especially about the mechanism initially pumping momentum in the atmosphere.

In these simulations, the circulation and temperatures are quite realistic compared to observations, though the wind shear between below and within the clouds is too high. The temperature contrast in the cloud between equator and high latitudes is close to observations, but the warm core of the vortex is not reproduced. As well as the zonal wind, the meridional structure in the clouds depends on the initial state. The dominant waves present in these simulations are diurnal and semi-diurnal tides, and waves with periods around 4 to 5 Earth days. The role of the thermal tides in the angular momentum budget is confirmed. We will also present the transport of pseudo-chemical tracers, shaped to mimic the behaviour of CO and OCS. Their latitudinal variations will be discussed and linked to the meridional circulation.