TOWARDS A GLOBAL MODEL OF THE MARTIAN ATMOSPHERE

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Introduction: In an effort to continuously improve the capabilities of the Martian atmospheric predictions at LMD, the GCM has been extended into thermospheric heights thus creating the first model to self-consistently couple the lower and upper regions of the Martian atmosphere. The behaviour of the Martian thermosphere is strongly influenced by lower atmospheric processes and has complex dynamics. Such a fully coupled model will certainly aid in the preparation of future missions and on the analysis of future high altitude data, as well as serve as a base for the simulation of ionospheric processes, escape, etc.

Above approximately 120 km, the atmosphere ceases to be well-mixed and the different chemical species decrease with their individual scale heights. This is a result of the dominance of molecular diffusion in this region, where it becomes a more efficient process than eddy mixing, in contrast to lower atmospheric heights where the reverse is the case. The heat balance of the thermosphere is controlled by UV and Extreme UV solar radiation absorption and thermal conduction that tends to smooth the gradients induced by the solar heating. With all these various processes at work, the thermosphere is expected to reach a disctinctive thermal structure and circulation from what is found at lower regions of the atmosphere.

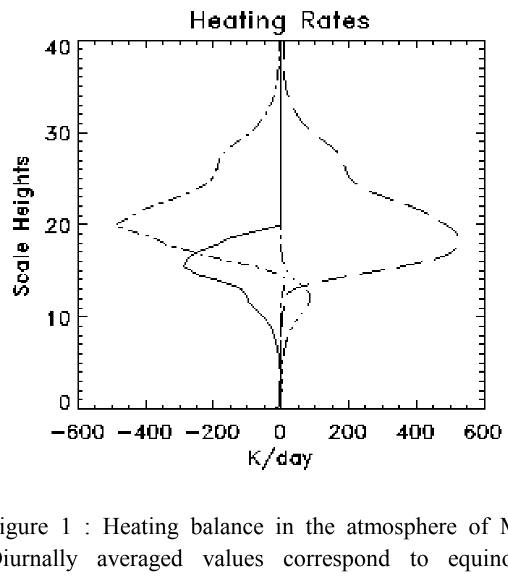

Figure 1 : Heating balance in the atmosphere of Mars. Diurnally averaged values correspond to equinoctial (Ls=0), solar minimum conditions at the equator.

LMD GCM: The Mars LMD GCM has evolved from a terrestrial climate model. With the support of CNES and ESA, and in collaboration with the University of Oxford and the Instituto de Astrofisica de Andalucia (Granada), the model has been constantly improved [1] and extended vertically, with a model top reaching 120 km recently (see Forget et al., this issue).In particular, the energetics of the simulations include the radiative effects of airborne dust and CO_2, taking into account non-LTE effects.

Thermospheric Extension: The model now reaches a height of approximately 250 km and includes the effects of thermal conduction, molecular viscosity and EUV absorption which are relevant processes at high altitudes as was mentioned above. This latter heating process is parameterized to account for the contributions of carbon dioxide and molecular and atomic oxygen absorption in the thermosphere.

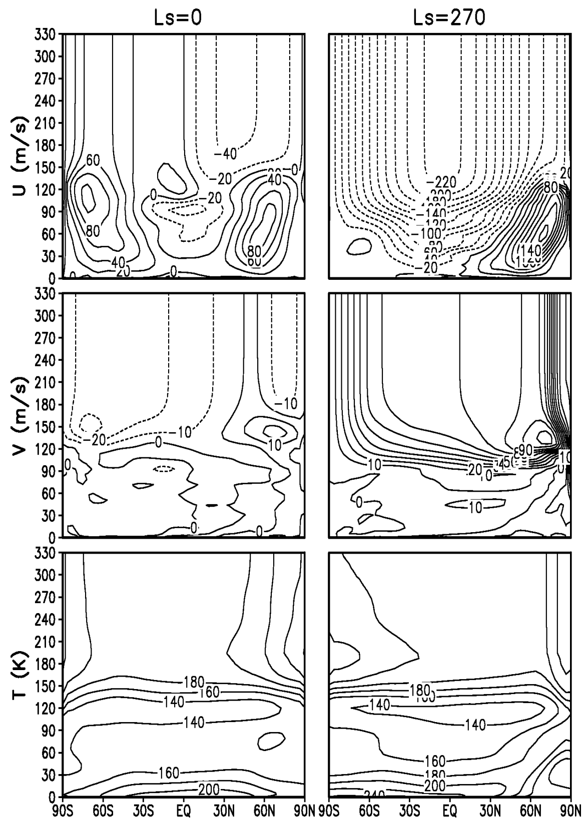

Figure 2 : Zonal mean winds and temperature for equinox (Ls=0) and solstice (Ls=270).

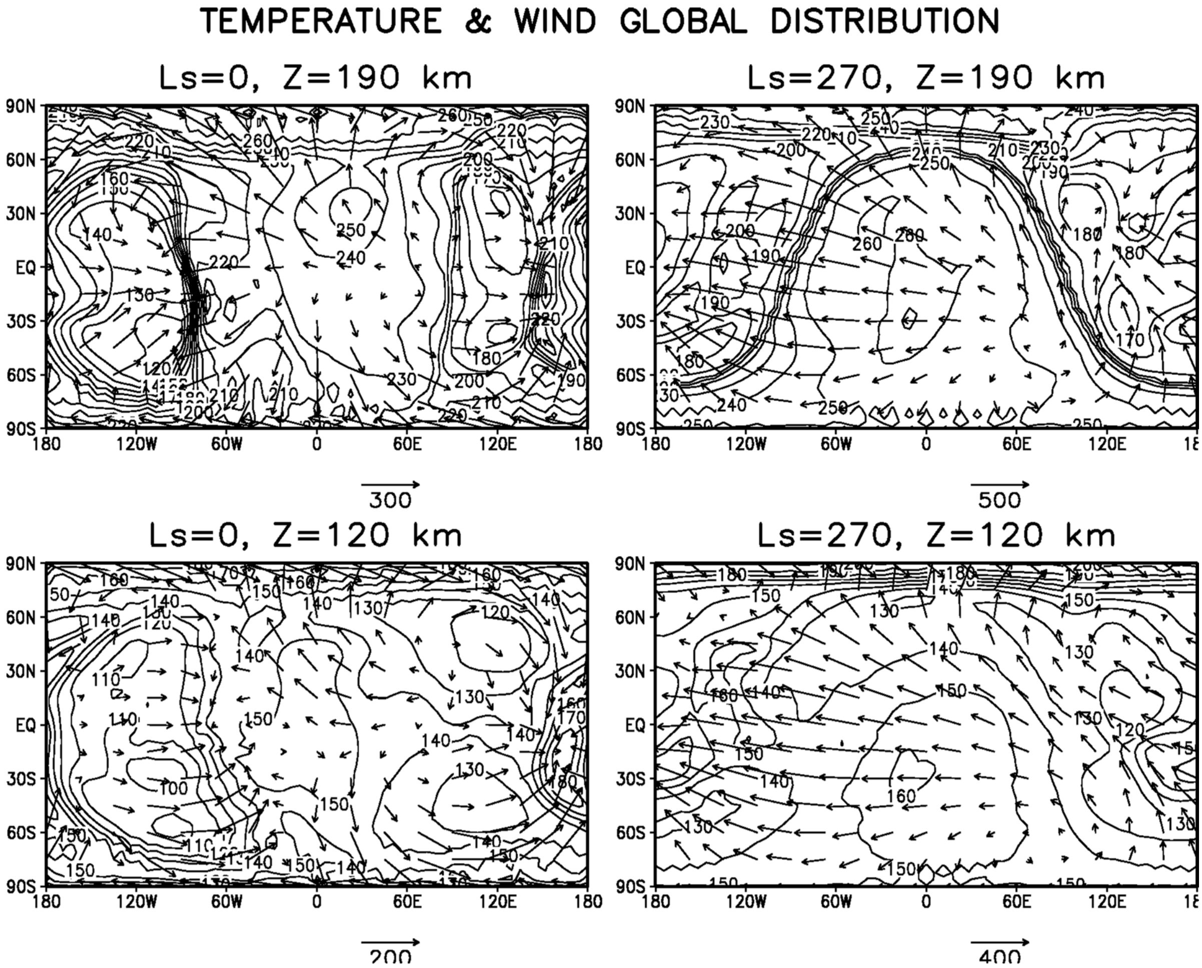

Figure 3 : Global temperature and wind distributions for two seasons and two altitudes (120 km, bottom; 190 km, top) for UT=12.

First Results: The extended GCM runs with a resolution of 64x48x58 or 5.5x3.5 degrees and height layers ranging from a few meters at the surface to 10 km in the thermosphere. The solar heating was calculated for solar medium conditions, corresponding to an F10.7 value of 109.5. Diurnally av eraged thermospheric heating balances are depicted in Figure 1.

As can be seen, EUV heating is the major source at thermospheric heights, with molecular conduction having a cooling effect by transporting the absorbed heat downward where cooling by the 15 µm CO_2 band becomes important, below approximately 160 km.

Zonal mean temperatures and winds obtained with the extended thermospheric model are shown in Figure 2 for equinox (Ls=0) and solstice (Ls=270) conditions. Figure 3 depicts temperature and wind distribution at two altitudes (~ 120 and 190 km) for UT=12 for the previous two seasons. These plots clearly portray the different nature of the circulation for the two seasons and stress its importance in the structure of the temperature distribution.

Conclusions: A thermospheric extension has been included in the LMD Mars GCM, that includes all the energetics of the region. The results show the general circulation pattern induced with a distinct character between high and low thermospheric heights.

The LMD GCM is the first model to be able to simulate the atmosphere of Mars from the ground up to the thermosphere self-consistently. This full coupling of the various atmospheric regions yields an excellent tool to study the effects and their extent of different atmospheric processes in different atmospheric regions, enhancing our understanding of the feedbacks that are at work and that determine the global structure of the Mars atmosphere.

References: [1] Forget, F., et al. (1999) *J. Geophys. Res.*, 104, 24155-24176.

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