EPSC Abstracts
Vol. 6, EPSC-DPS2011-958, 2011
EPSC-DPS Joint Meeting 2011

Temperatures in the Martian mesosphere/thermosphere given by a General Circulation Model

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Abstract

In this work we analyze the temperature of the upper atmosphere of Mars using a state-of-the-art ground-to-exosphere GCM. The results will be compared with different recent datasets that have provided important information about the Martian upper atmosphere.

1. Introduction

The temperature of the upper atmosphere of Mars (between about 40 and 180 km of altitude from the surface) is determined by the influence of the solar radiation (UV solar flux in the thermosphere, NIR solar absorption in the mesosphere), the atmospheric emissions (in particular CO_2 15 μm non-thermal emission) and the coupling with the lower atmosphere [1]. The temperature in this atmospheric region strongly affects the atmospheric escape, that determines the long-term evolution of the whole atmosphere [2]. A good knowledge of the temperature of the upper atmosphere is also important for the design of aerobraking maneouvers of possible future missions to Mars, such as ExoMars [3].

2. The LMD-MGCM

The LMD-MGCM [4] has been extended up to the thermosphere in the frame of a collaboration between the LMD and the IAA and is now a ground-to-exosphere GCM [1]. It includes the most important physical processes for the upper atmosphere of Mars, such as the absorption of UV solar radiation, the NIR thermal balance (including Non-LTE effects), photochemistry, molecular diffusion and thermal conduction. The effects of the atmospheric circulation and the coupling with the lower atmosphere are naturally included in the model. This makes this model an ideal tool for the study of the temperature, density and composition of this atmospheric region.

A recent update to the model is the implementation of a new parameterization of the Non-LTE NIR thermal balance which improves over a previous Non-LTE scheme. The new parameterization includes the effects of variable atomic oxygen concentrations on the CO_2 15 μm cooling, increases the number of CO_2 levels considered so far, and takes into account the effects of solar zenith angle and atomic oxygen on the NIR solar heating [5].

3. Results and comparisons with data

We will study the temperatures in the mesosphere and the thermosphere predicted by the LMD-MGCM. Special attention will be paid to the effect over the temperatures of the new parameterizations of the NIR CO_2 radiative balance. The simulations including the new parameterizations produce usually lower temperatures in the mesopause region (Figure 1)

The temperatures and densities predicted by the model will be compared with the latest measurements. In particular, SPICAM temperature and density profiles in the mesosphere/lower thermosphere of Mars [6] are specially valuable to validate the predictions of the model. This is an ongoing work, and we will focus mainly in the temperature and altitude at the mesopause region, that is particularly sensitive to the NIR thermal balance.

We will also use the constrains over the thermospheric temperatures posed by the recent observations of mesospheric clouds [7]. These clouds seem to appear only at restricted seasonal and geographical ranges, and their presence implies that mesospheric temperatures have to fall below the condensation temperature of CO_2.

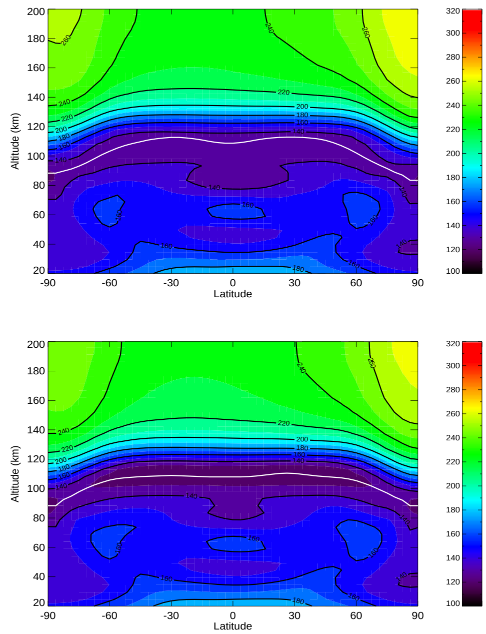

Figure 1: Zonal mean temperatures predicted by the LMD-MGCM using the old NIR thermal balance parameterizations (upper panel) and the new parameterizations (lower panel). The white solid line shows the location of the mesopause. Simulation for L_s=0, constant LT=12

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