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Validation of the IPSL Venus GCM thermal structure with VIRTIS data

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Abstract

The understanding of the mechanisms behind the planetary atmospheres along with their dynamics and structure, relies on General Circulation Models (GCMs). Here we compare the thermal structure from the latest version of the LMDZ Venus GCM developed at the Laboratoire de Météorologie Dynamique of Paris, against the one retrieved by VIRTIS, the Imaging Spectrometer flown on board the ESA Venus Express mission.

Introduction

The high latitudes in the atmosphere of Venus are characterized by polar vortexes, variable in their morphology, but always present, surrounded by a colder region, the cold collar. The latest version of the LMDZ for Venus [1] was capable to successfully reproduce this feature. The main focus of this work is to validate this version of the LMDZ Venus GCM. For this purpose, the thermal structure of the modelled atmosphere has been compared to the one retrieved by VIRTIS data.

Model and data

The LMDZ is coupled with a full radiative transfer module, that derives the temperature structure. The radiative transfer module adopted in the latest version of the GCM, takes into account the cloud model derived in [2] and [3], which is based on Venus-Express data. The resolution of the model is 96 longitudes x 96 latitudes x 50 vertical levels. On the other hand, data used for this comparison are presented in [4] and [5]: they are respectively the temperature retrievals for VIRTIS-M and VIRTIS-H, the two VIRTIS subsystems. Due to the presence of reflected sunlight during daytime and to CO_2 non-LTE emission, the thermal fields of Venus atmosphere were only retrieved from nighttime observations. Therefore, we limit our comparison in nighttime and, in addition, to the southern hemisphere where, due to Venus Express orbit geometry, we have the best coverage.

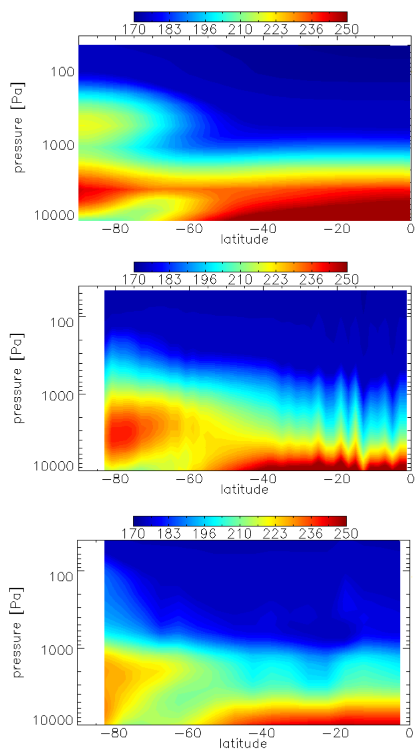

Figure 1: Pressure-latitude distribution of the temperature field, zonally and temporally averaged. Top panel: LMDZ; mid panel: VIRTIS-M; bottom panel: VIRTIS-H.

Results

The pressure-latitude distribution of the temperature field averaged over 360° and 1 Vd-nighttime (Fig. 1), shows a qualitatively good agreement between model and data, with a temperature inversion - the cold collar - clearly appearing in the model at latitudes poleward of -60° and pressures higher than 4 x 10^3 Pa. This cold collar displays a similar extent and temperatures close to the ones retrieved in both VIRTIS-M and VIRTIS-H. At lower pressures, a second inversion of the temperature arises in the model, due to the appearance of a warmer region. This feature is not observed in neither VIRTIS-M or VIRTIS-H.

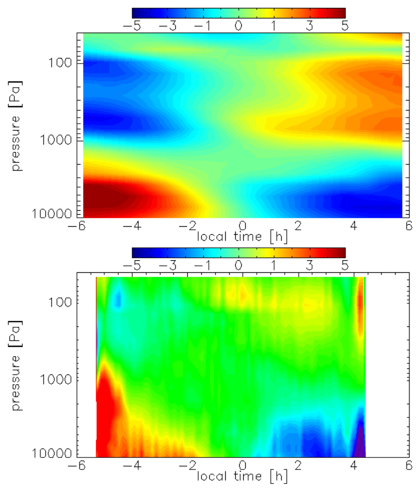

Figure 2: Pressure-local time distribution of the temperature residuals field at -75°. Top panel: LMDZ; bottom panel: VIRTIS-M.

The pressure-local time distributions of the residuals of the temperature field (Fig. 2 and Fig. 3), reveal maxima and minima induced by the thermal tides. The phase and the amplitude of these thermal tides are in agreement with data. Indeed, the fluctuations between maxima and minima are about 10 K in model and observations. Moreover, in both cases we recognize the diurnal component at high latitudes, and the semidiurnal component at mid latitude, peaking at similar local time for any given pressure level.

Summary and Conclusions

We presented a comparison of the Venus atmosphere produced by the LMDZ model with data obtained by VIRTIS, focusing on the thermal structure. The model is capable to reproduce the general behavior of the thermal field and its most peculiar feature, the cold collar. The variability due to thermal tides is also taken into account, as the variation of the temperature residuals with local time are well represented. The second inversion of the temperature appearing at high levels and high latitudes, requires further simulations and investigations.

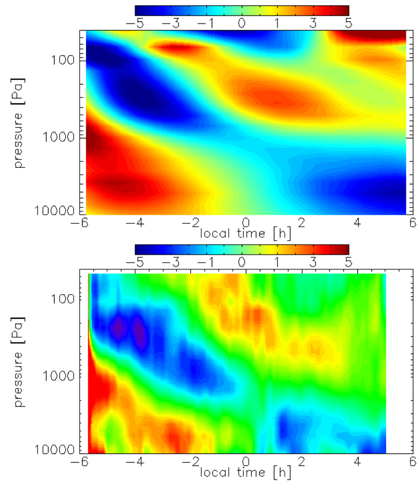

Figure 3: Pressure-local time distribution of the temperature residuals field at -45°. Top panel: LMDZ; bottom panel: VIRTIS-M.

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