Microphysical modeling of the Venusian clouds with the IPSL Venus GCM

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Abstract

To understand the Venus atmosphere, LMD and LATMOS laboratories have developed a 3D IPSL Venus Global Climate Model (Lebonnois et al. 2010). In this GCM, the cloud description is simplified. As clouds play a crucial role in radiative transfer, dynamics and generally the climate of Venus, it is necessary to improve the VGCM with a microphysical representation.

1. Introduction

Venus is a terrestrial planet enshrouded by a 20 km-thick layer of clouds. The clouds are thin, like cirrus on Earth but they are stratified and create a large opacity. The cloud layers are surrounded by haze above and below. Moreover, this cloud system is divided by properties of particle size distribution into three layers: the upper cloud deck (57 to 68 km), the middle cloud deck (51 to 57 km) and the lower cloud deck (48 to 51 km) [1]. The droplets that constitute the clouds are composed of a H_2SO_4-H_2O solution. The crystalline phase of the cloud particles is still debated [1,2]. There is only one complete in-situ profile on cloud droplet properties measured by Pioneer Venus during its descent [1].

The upper cloud deck and the upper haze were studied by several missions, for example recently by Venus Express [3]. The droplet size distribution is divided in several size modes. The mode 1 (mean radius $r_m \approx 0.2\mu m$) is the smallest but has the largest number concentrations. Modes 2 ($r_m \approx 1.0\mu m$) and 3 ($r_m \approx 3.5\mu m$) hold most of the condensed mass [1]. The division in modes 2 and 3 of the largest particles and the existence of mode 0 and 2' are still debated [1,4,5]. The cloud top and base altitude change with latitude, and the particle size has a latitudinal dependence [4,6].

In addition, an unknown UV absorber is present in the cloud layers and may be related to clouds. At last, the clouds affect the radiative balance, the sulfur chemical cycle, the dynamics and the atmospheric structure of Venus.

2. Modelling

In order to understand the observations and the atmospheric processes on Venus, it is crucial to develop a climate model like the IPSL Venus GCM.

2.1 The IPSL Venus GCM

The Venus Global Climate Model has been developed at the LMD [7]. The characteristics of this model include radiative transfer, dynamics, atmospheric chemistry, diurnal cycle and a full topography defined by Magellan mission's data. With this full GCM, the Venusian atmosphere is simulated between 0 and 150 km. However, the description of the cloud layers is simplified. [7] have pointed out some problems with the prediction of the temperature profile. These problems may be due to the too simple representation of clouds. Thus, to achieve better simulations of the Venus climate, the GCM needs a microphysical model.

2.2 MAD-VenLA and the moments

To this end, we develop a microphysical bi-modal model based on Modal Aerosol Dynamics of Venus Liquid Aerosol cloud model (MAD-VenLA). This model uses an implicit moment scheme to describe the particle size distribution and the microphysical processes in 0D. The moment method is a statistical method to describe a distribution function with few parameters called moments. Each moment is associated with meaningful parameters of the aerosol size distribution. In our case the particle size distribution is described by its first moments: total particle number (zeroth moment) and total particle volume (third moment) of the size distribution [8]. Moreover, with this representation, the form of the size distribution is assumed to be a log-normal function. MAD-VenLA takes into account condensation/evaporation, nucleation and coagulation. To represent a source of aerosol particles and the sedimentation of our cloud droplets, we have developed a 1D extension to our model. MAD-VenLA is coupled with the 1D version of the IPSL Venus GCM and by extension can also be used within the 3D version of the GCM.

3. Results

The preliminary results of MAD-VenLA in 1D show a good agreement with observations [3] in the calculation of the droplets' weight percent of sulfuric acid (**Figure 1**).

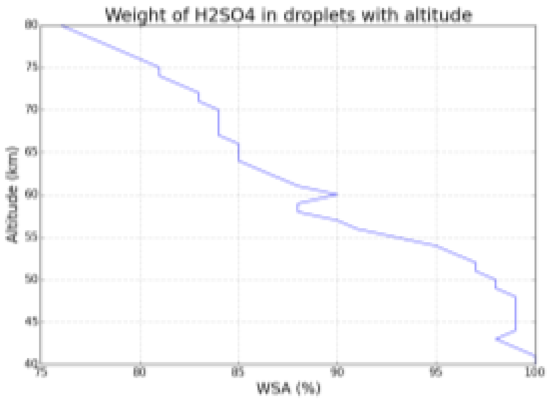

Figure 1. *The Weight percent of sulfuric acid in droplets at different altitudes, at low latitudes (0-30°). The results between 62 and 72 km are more or less 82% like [3].*

We are currently studying the 1D results of IPSL Venus GCM coupled with MAD-VenLA.

First, we will describe MAD-VenLA and the assumptions that we made in the development of this model. Then, we will compare the 1D results with CARMA, a sectional model of Venus [9], and the Pioneer Venus LCPS observations [1]. At last, we will present you the firsts results of the IPSL Venus GCM with a microphysical model.

4. Summary and Conclusions

The development of this model will allow us to have a better understanding of Venusian climate with a complete global climate model. The moment method is already used in the IPSL Mars GCM [11] and the IPSL Titan GCM [12] to describe the cloud microphysics.

Acknowledgements

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