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Modeling the clouds on Venus: model development and improvement of a nucleation parameterization

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1. Introduction

Sulfuric acid aerosols are the main component forming the Venusian clouds, which are optically very thick in the visible, inhibiting visual observation of the surface. The clouds are organized in three quite distinct layers with differing properties in terms of particle size distributions and possibly composition. Some early observations hint to a possible existence of other species than sulfuric acid in the clouds, but with no confirmation from recent missions. Previous modeling efforts have revealed that the lowest cloud layers are very dynamic and that the reason for the different size distributions could be explained by mixing. However, the issue of differing phases and chemical compositions of cloud droplets have not yet been evaluated.

An interesting analogy can be made between the clouds of Venus and aerosols found in the Earth's stratosphere: both are composed of sulfuric acid droplets. On the Earth, the sulfur in the stratosphere originates from OCS, a long-lived sulfur species emitted at the surface and transported by the general circulation, and from volcanic eruptions that can inject material above the tropopause.

It is thought that the water – sulfuric acid droplets form by binary homogeneous nucleation on both planets. However, the existence of condensation nuclei on Venus cannot be ruled out. We are planning to include the effects of (in)soluble condensation nuclei in the model at a later stage.

We will use a model developed for stratospheric sulfuric acid aerosol layer and polar stratospheric clouds (PSC) to study the clouds on Venus. This model includes a nucleation parameterization developed for stratospheric conditions that we aim to improve to take into account very low relative humidities observed on Venus. In this presentation we will describe the model used, the modifications required for applying the terrestrial stratospheric model to Venus, and the first results obtained.

2. Model description

We use a model developed for the sulfuric acid aerosols and PSCs in the terrestrial stratosphere [1,3].

The model describes several key microphysical processes including a parameterization for two-component nucleation [6] of water and sulfuric acid. This parameterization are in principle quite applicable for the Venusian atmosphere, but we discovered that the lower limit of relative humidity is still too high regarding the extremely dry Venusian atmosphere. We are extending the parameterization of [6] to lower relative humidity.

The model includes formation of water – sulfuric acid droplets by two-component homogeneous nucleation of the vapors, subsequent growth by condensation, evaporation of droplets, coagulation, and sedimentation. The model describes explicitly the size distribution with about 50 size bins. It can handle several particle modes , which are described with a log-normal size distribution. In the future, we will explore simplifications of the fully size-resolved model in order to develop a moment model for coupling with a global atmospheric model [4].

3. Results

First tests of the model are carried out with a standard temperature profile from the VIRA [2] and a compilation of water vapor and sulfuric acid concentration profiles, as in [5]. Several sensitivity tests with profiles from the LMD Venus GCM are performed. Preliminary results are evaluated against a range of cloud observations from Venus Express (SPICAV IR can scan the highest cloud levels and give profiles and microphysical properties, and for the deeper cloud levels we will compare with the VIRTIS instrument).

We will also describe the development of the nucleation parameterization and compare the new parameterization results with the results obtained with [6]. We will assess the importance of nucleation processes in the Venusian atmosphere.

4. Summary and Conclusions

We have developed an aerosol dynamics model for the Venusian clouds by adapting a model of terrestrial stratospheric aerosols and PSCs to the Venusian case. We will present the first results and some improvements included in the model during the development phase. The development is still ongoing, but we aim, after a full phase of testing, at developing a simplified version of the model for implementation into the LMD Venus GCM.

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