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THE LATMOS VENUS CLOUD MODEL VENLA: STATUS REPORT.

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Introduction

The clouds of Venus and the aerosols in the Earth's stratosphere are close relatives: both are mostly composed of sulphuric acid droplets. Venus' clouds are optically thick and absorb most of the insolation arriving at Venus, letting only few percent of sunlight reach the surface and having an important climatic effect. The clouds on Venus are, based on the snapshot profile published by [6], divided in three layers that have different properties (particle size distributions, number densities, mass loads). Even though the upper cloud and upper haze can be directly studied with satellite instruments, only a handful of observations have acquired information on the properties of the lower cloud layers [6] and thus modeling is an important tool for studying the lower and middle cloud layers.

Methods

The LATMOS Venus cloud model VenLA (Venus Liquid Aerosols) is based on a terrestrial Polar Stratospheric Cloud (PSC) model [7]. The PSC model [7] is a sectional microphysical model that can describe a multimodal particle size distribution on a radius grid discretized in tens or hundreds of bins (radius intervals). In its original configuration the PCS model includes all of the microphysical processes relevant to the PSCs, including the multiple phase transitions related to the particle types including liquid and solid phases of water, sulfuric acid, nitric acid and their mixtures, and sedimentation of the particles.

The PSC model went through several modifications when becoming VenLA. The major ones include: removal of nitrous species and related cloud particle types and inclusion of the condensation nucleus particle type, addition of homogeneous and heterogeneous nucleation parameterizations, accounting for both intra-type and inter-type particle coagulation, and adding a parametrization of vertical mixing via eddy diffusion. Because of the extreme dryness of the Venus atmosphere, we also needed to add an iteration of the calculation of the weight fraction of sulfuric acid in the droplet in order to correctly account for the change in total water content.

VenLA describes the formation, growth and decay of sulfuric acid - water droplets, and when used in one-dimensional (vertical profile) version it also accounts for sedimentation and mixing of particles and vapors via eddy diffusion. Homogeneous nucleation is described with the parameterization of [14] and heterogeneous nucleation with a simple parameterization as in [3]. Condensation and evaporation are treated in two steps: simple (fast) equilibration whenever a droplet experiences a change in environmental conditions (temperature, partial pressure of water vapor) causing a change in the equilibrium composition, and (slow) condensation/evaporation during which the droplet grows/shrinks conserving the equilibrium composition [9]. We account for Brownian and gravitational coagulation (coalescence) and we use the numerical method of [4]. The coagulation kernels are calculated as in [1, 12] and the sum of the Brownian and gravitational kernels is corrected as in [10, 11]. Vertical transport (sedimentation and eddy diffusion) is treated following the method of [13] and settling velocity is calculated using [9, 1] and corrected to account for mixing. The model has undergone several updates, the latest of which focused on accounting for, in all microphysical processes, the condensation nuclei (CN) captured within the droplets. This required transforming the pure two-component solution droplet type into a "mixed" particle type that includes both volatile and CN masses.

The runs are initialized with profiles from VIRA [5] for temperature and pressure and from occultation data concerning the vapors, as in [8]. VenLA receives also as input the properties of the condensation nuclei (a lognormal size distribution defined in a given altitude range [3]). A prescribed droplet distribution can also be used as an initial state. The vapors are consumed during nucleation and condensation and replenished when the droplets evaporate or when mixing brings in vapor-rich air. In these simulations the temperature and pressure profiles are not changed and thus the simulated clouds are considered as formed in average conditions and do not reflect effects of large-scale dynamics.

Results

We will focus on finalizing the reference version of the model and reproducing the [6] in-situ observations of the cloud properties. We will present results of reference runs and sensitivity tests. We compare the results to observations on cloud droplet number densities and sizes, and to other modeling studies. One of the main sensitivity tests will be the effect of CN on the cloud properties. The nucleation pathway may prove significant in the simulations since it defines the number of formed particles. This regulates the particle size for a constant condensible mass. In our preliminary test runs, when using only the homogeneous nucleation parameterization, we reach the observed condensed mass load, but the droplet number concentrations are too low and consequently the droplets are too large. Using heterogeneous CN activation it is much easier to attain observed number concentrations and sizes, however, the used initial CN concentration profile dictates the development of the cloud.

Summary and Conclusions

We have developed a microphysical model for Venus' sulfuric acid clouds. The VenLA cloud model and reference run and sensitivity test results will be presented, with a particular focus on the role of CN. The results will be compared with other modeling studies and observations. The VenLA model defines the baseline for a parallel project on development of a moment method scheme to be used in a global climate model (see abstract Guilbon et al., [2]).

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