COMPREHENSIVE SIZE-RESOLVING MODEL OF WATER ICE CLOUD IN THE MARTIAN ATMOSPHERE

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The objective of the work is to develop a microphysical block with explicitly resolved size distribution of dust and cloud aerosols for the 3D general circulation model. The use of semiimplicit 2-moment scheme of integration of the kinetic equations describing microphysical processes in clouds [1] allows to change a time step and a coarseness of a size grid largely, thereby selecting the necessary time resolution. Therefore, this model can be integrated into a GCM of the Martian atmosphere. The aerosol block has been tested with an 1D model which takes into account the processes of sedimentation and eddy diffusion. No transport is allowed across the top boundary; sources of water vapor and dust are specified at the absorbing bottom boundary.

Diurnal cycle of condensational processes is obtained on the basis of GCM temperature profiles [2]. As starting conditions there are only water vapor and dust in the atmosphere, the aerosol is formed in processes of nucleation and condensation. An initial mass concentration of water vapor in the atmosphere is 40 ppm. The model time step is 0.1 sec in the microphysical part and 10 sec in the spatial part, which provided sufficient stability for equilibrated solution. The model has been fitted by SPICAM UV and IR solar occultation data [3].

The 2D distribution of cloud particles vs. size and height is presented in Figure 1. The effective radius of ice particles varies from 0.8 to 2 μm at lower layers of the cloud, with number density within 8-12 cm^{-3}. The effective radius is 0.2-0.3 μm at number density of 0.1-1 cm^{-3} above 50 km. An effective radius of dust particles is equal to 0.8 μm at saturation latitude, the effective radius corresponds 0.8-0.9 μm at a surface, consistent with SPICAM data.

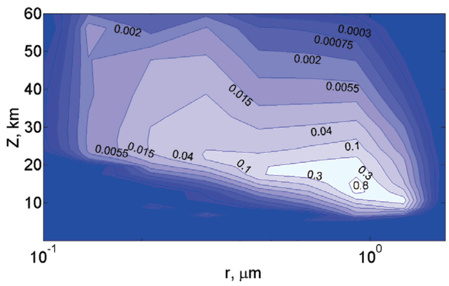

Figure 1: Distribution of ice particles (ppm/μm).

In the lower part of troposphere, there is a fog rise in the morning, with its size distribution peaking at 1-1.5 μm.

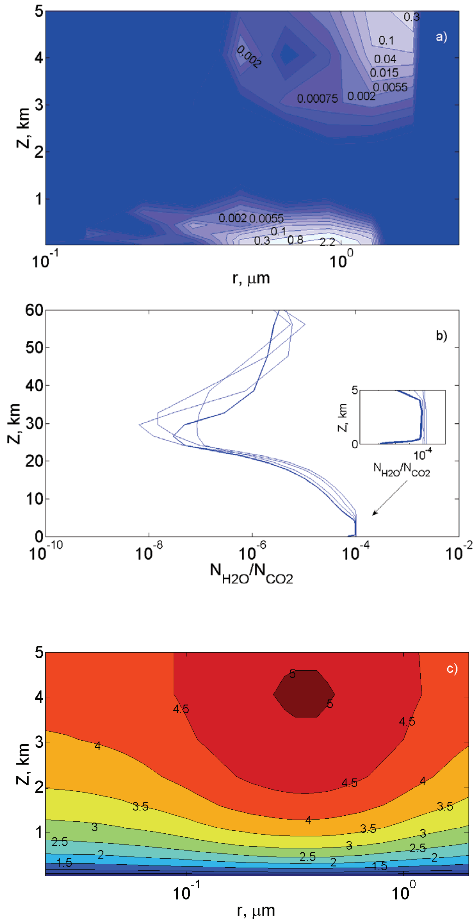

Figure 2: **a)** distribution of ice particles (ppm/μm); **b)** Water vapor profiles (ppm); **c)** distribution of dust particles (ppm/μm).

The dependence of condensation processes and macroscopic parameters on the microphysical properties of aerosol particles has also been analyzed, particularly on the contact parameter of cloud condensation nuclei. Comparing model results at various $\cos\theta$ (the contact parameter), it is seen that larger ice particles are formed at smaller nucleation probability, with the atmosphere becoming drier.

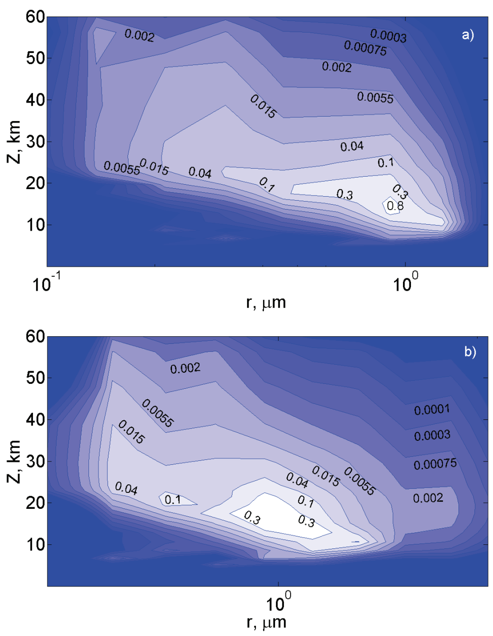

Figure 4: A size distribution of ice particles (ppm/μm): **a)** $\cos\theta \sim 0.9$; **b)** $\cos\theta \sim 0.5$.

This result is consistent with the experimental data obtained in laboratory conditions with the use of the new data about phase transitions at Martian parameters [4]. At small $\cos\theta$ the process of heterogeneous nucleation demands high supersaturations of water vapor that explains the concentrations of water vapor exceeding a saturation level by several times [5]. Thus, it is possible to make a conclusion that at the values corresponding to the last experimental data, the model reproduces the distributions which does not contradict the experimental data, and in some cases allows to explain the observed anomalous high concentrations of water vapor.

After testing the microphysical block in the framework of a 1D model, it has been incorporated into a new generation model, based on the approximation of fractional eddy diffusion. The substitution of classical diffusion to fractional one in the 1D model allows us to consider a lot of processes integrally, including eddy diffusion itself, Hadley cell and large-eddy advection. A fast and efficient numerical scheme was developed for evaluation of the vertical fractional diffusion term. This scheme may further be implemented in the 3D GCM.

Finally, the microphysical block has been incorporated into the MGCM based on GFDL's FMS dynamical core. Preliminary results of water cycle simulation confirm the robustness and flexibility of the selected numerical scheme.

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