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Microphysical properties of Martian CO2 ice clouds

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Abstract

1. Introduction

Carbon dioxide ice clouds have up to now been observed several times in the atmosphere of Mars, from low altitudes in the polar regions to high altitudes (around ~80 km) in equatorial to mid-latitude regions. The peculiar aspect of these clouds stems from the fact that 95% of the martian atmosphere consist of CO_2 gas, thus on Mars we are dealing with the condensation of the main component of the atmosphere. The condensation is moreover occuring in a rarefied atmosphere that can have dramatic consequences on the crystal growth through the heat transfer that has a limiting effect.

Many modeling efforts have tried to explain the formation of such clouds along with their characteristics in the present and early martian atmosphere ([1][2][3][10][13][20]). However, the mesospheric CO_2 clouds observed at equatorial to mid-latitudes are still in need of modeling. The nature of the key parameters in the formation of CO_2 ice clouds is still unclear and wether surface kinetic processes in crystal growth are of importance or not is not well established. Montmessin et al. 2006 observed particle radii in CO_2 mesospheric clouds (80 nm-130 nm) that are not predicted by models. In addition to that [17] reported supercooled atmospheric layers with saturation ratio exceeding 1000 without any concomitant haze layers in the atmospheric profile. The explanation could be either linked to microphysical barriers or to a lack of dust at these altitudes (the source of which might be micrometeorites for instance). Both hypotheses are of interest and should be investigated.

We are currently working in adapting a microphysical model previously developed for the water ice clouds formation on Mars ([14], based on that of [17]) with the aim at coupling it to a mesoscale and a general circulation model We will describe the model used and present the modifications we initiated.

2. Microphysical Model description

2.1 Numerical techniques

Three tracers enable to follow the evolution of the cloud formation: the dust concentration, the CO_2 ice volume concentration, and the dust core concentration. The latter is useful for keeping track on the dust population embedded in crystals. In that way a sublimating crystal will release a dust grain of the original size. The hybrid radius grid ([7]) enables to do so and prevents numerical diffusion during crystal growth.

The condensation and the sedimentation both use an implicit scheme for computing derivatives what guarantees numerical stability whatever the chosen time step. The sedimentation scheme is presented in [18], the condensation scheme in [9] and [16].

2.2 Physics

We adopt classical nucleation theory assuming that nucleation is only heterogeneous, as it most probably is on Mars (e.g. [11]). The contact parameter *m* taken from [4] with a value of 0.95 characterizes the wettability of the dust. Following [6] we aim at accounting for a structural misfit between the dust core and the crystal lattice that can increases the nucleation barrier. Ion induced nucleation seems not to be relevant on Mars.

Concerning the growth of the crystal we aim at testing a parameterization of the surface kinetic effects for the CO_2 ice clouds. On Earth the deposition coefficient might be a good parameter to account for observations of high concentration of small grain sizes observed in cirrus clouds ([5][12]). [7] shows that a parameterization using a deposition coefficient much lower than one might affect the evolution of cirrus on Earth.

In a rarefied atmosphere the diffusive regime has to account for kinetic effects. The Fuchs and Sutugin correction used by [1] is theoretically non relevant for the CO_2 ice condensation because the condensable gas can not be the major species, which is the case of the CO_2 on Mars. However [1] compared their own approach using Fuchs and Sutugin (used by [19]) and another one used by [20], based on the model of [21] which is built for any Knudsen number and vapor mixing ratio. They show a fair agreement above 10% supersaturation. However It appears useful to conduct a more detailed comparisons between the different approaches.

3. Results

We are currently working on the model, using temperature and pressure profiles from the European Mars Climate Database v.4.3 ([25]). First sensitivity tests and results will be presented.

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