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Interactive 1D model for cloud formation and atmospheric chemistry on Mars

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Abstract

Atmospheric water vapor is the main driver for the chemistry in the lower atmosphere of Mars. Its photolysis products control the abundances of species such as ozone which, in turn, is photolyzed by UV photons ($\lambda \leq 310$ nm) penetrating down to the Martian surface. This results in the production of the excited molecular oxygen $O_2(^1\Delta)$ and then in the dayglow emission at 1.27 µm [1] observable from Earth [2].

The water abundance in the atmosphere of Mars is controlled by its release from the northern permanent cap and subsequent transport over the planet and locally by cloud formation, precipitation and surface exchanges (e.g. frost deposition and adsorption) [3, 4].

Moreover the isotopic ratio [HDO]/[H_2O] is also controlled by cloud formation and photochemistry [5]. It has also been suggested that water ice clouds may be serving as surfaces for heterogeneous chemistry processes on Mars [6].

The present work focuses on the local scale and intends to investigate in detail the impacts of the water vapor profile shape and of cloud formation on the chemical composition of the Martian atmosphere. To this purpose, we have coupled two 1D atmospheric models: (1) the detailed microphysical cloud model and (2) the photochemistry model described in Refs. [4] and [1], respectively. The resulting coupled 1D model is driven by time-dependent temperature profiles and diffusive mixing coefficients from the GEM-Mars 3D global circulation model (GCM) [7].

The model calculates the diurnal cycle of the water vapor profile as well as the formation of ice clouds. In addition, it also computes their impact on the atmospheric chemistry, especially on the $O_2(^1\Delta)$ dayglow. It will be tested against recent ground-based observations of H_2O, HDO, and $O_2(^1\Delta)$ dayglow on Mars [2, 8]. In particular, a rapid decrease of the dayglow in the afternoon has recently been observed [2]. We thus aim to understand the origins of the resulting asymmetry in the diurnal cycle of emission from $O_2(^1\Delta)$ and investigate especially the role of ice clouds in this behavior.

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