

The regolith-atmosphere interaction on the amounts of water vapor on Mars

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The recent observations by Phoenix and Curiosity landers have measured the partial pressure of water vapor at the sites and revealed that Mars has an active water cycle. In addition, space-born observations by the Gamma-Ray Spectrometer (GRS) onboard the Mars Odyssey have shown that there are large water reservoirs in the Martian subsurface. These results implied that the regolith potentially plays a crucial role in the water cycle. The regolith-atmosphere interaction has been studied for a few decades, using both mesoscale models and global climate models (GCMs). The mesoscale simulation (Steele et al., 2017) reproduced the diurnal variations in relative humidity consistently with it measured by the Rover Environmental Monitoring Station (REMS) onboard Curiosity. On the other hand, the previous GCM simulations (Houben et al., 1997; Richardson and Wilson, 2002; Böttger et al., 2005) implied that the influence of regolith on the water cycle of the regolith is inconclusive. Böttger et al. (2005) showed that the regolith is not able to reproduce the diurnal water variations in column water vapor, although it adsorbs water preferentially in the high latitudes of the northern hemisphere. They suggested that the present water ice in the Martian subsurface is not stable, but slowly subliming and being deposited in the northern hemisphere in correlation to the air temperature. However, the subsurface temperature variations and the vertical distributions of the adsorbed water in the active regolith have not been well discussed. Then, we started to study their influence of them on the water vapor amounts on Mars. We newly implemented an active regolith scheme based on the regolith model into a MGCM (Mars General Circulation Model) in this study. The MGCM, named DRAMATIC (Dynamics, RAdiation, MAterial, Transport, and their mutual Interactions) has been developed based on the hydrostatic dynamical spectral core of the terrestrial MIROC (Model for Interdisciplinary Research On Climate) developed in collaboration by the Atmosphere and Ocean Research Institute, the University of Tokyo, the National Institute of Environmental, and the Japan Agency for Marine-Earth Science and Technology (K-1 Model Developers, 2004). DRAMATIC MGCM includes the package of physical parameterizations of Mars (Kuroda et al., 2005; 2013). Also, a global water cycle scheme is implemented into the MGCM including the phase changes and transport of water vapor/ice, gravitational sedimentation and surface accumulation of water ice, and turbulent flux to provide water from the surface water ice mainly from a large water reservoir of Northern polar cap (Kuroda, 2017). Our MGCM can reproduce seasonal-latitudinal distributions of zonal-mean water vapor column density and water ice optical depth, which is consistent with observations (e.g. Smith, 2008). In this study, the horizontal resolution of the MGCM is defined as T21 (a triangular truncation at total wavenumber 21), with 32 grid points in latitude and 64 points in longitude (5.625x5.625 degrees). The vertical resolution is 53 layers with sigma levels and the top altitudes of the model are about 80 km. The regolith scheme applied in this study is based on Zent et al. (1993) and Böttger et al. (2005). The diffusion coefficient in the regolith is calculated using the method of Steele et al. (2017) which accounts for molecular diffusion and Knudsen diffusion which vary in time and space. Water in the regolith may exist in one of the following three states: water vapor, adsorbed water, or iced water. The vertical transport of the water vapor in the regolith occurs according to Fick's law, and the water adsorption occurs according to Jakosky et al. (1997). The subsurface is divided into 5 grids: the first grid point is at the surface, the second one is at 5 mm, and the depth of the lowest grid

point is several meters below the surface. The porosity and the mean pore size of the regolith are assumed to be 30% and $10\text{ }\mu\text{m}$, respectively. The time step of the calculation for both the atmosphere and regolith is set to 50 seconds. We performed the calculation starting from $L_s=180$ degrees for 1 Martian year. In the initial condition, the distributions of atmospheric temperature and water vapor/ice amount are in the equilibrium state, and the water amount in the regolith is set to be 2 kg/m^3 uniformly. In this presentation, we demonstrate the effects of the regolith-atmosphere interaction on the amounts of water vapor, especially from the point of view of the subsurface temperature variations and the vertical distributions of the adsorbed water.

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