R009-23
B 会場 ：9/27　AM2 （10:45-12:30）
11:30〜11:45

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Global effects of regolith properties on the subsurface ice distribution on Mars using a General Circulation Model

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The distribution and abundance of subsurface ice on present-day Mars are essential for understanding the environmental evolution of the hydrosphere. Exposed ice following meteorite impacts has been found in recent decades, suggesting the presence of subsurface ice in the shallow layers (Byrne et al., 2009; Dundas et al., 2008, 2014, 2023). Several numerical simulations have investigated the subsurface ice distribution, calculating the water vapor exchange between the shallow subsurface and the atmosphere. Previous studies have shown that surface albedo, thermal inertia, weather variables (e.g., atmospheric water vapor column abundance and atmospheric dustiness), and orbital parameters (e.g., obliquity and eccentricity) play important roles in the subsurface ice distribution (Mellon and Jakosky, 1993; Tokano, 2003; Schorghofer and Forget, 2012; Steele et al., 2017). However, soil properties (e.g., porosity, pore size, and specific surface area of the regolith for adsorption) have received less attention.

Here, we investigated the effects of soil properties on the simulated distribution and abundance of subsurface ice using our Mars General Circulation Model (Kuroda et al., 2005, 2013), coupled with a regolith scheme that has been developed based on Zent et al. (1993), Steele et al. (2017), and Jakosky et al. (1997). The regolith scheme considers the water vapor exchange between the regolith and the atmosphere and phase changes, including adsorption and condensation. Calculations were performed under different conditions of pore size (with globally uniform values of 10 and 100 um, and a globally inhomogeneous distribution diagnosed from thermal conductivity referring to Presley and Christensen, 1971), and porosity (with globally uniform values of 30, 40 and 50%, and a globally inhomogeneous distribution which has defined corresponding to grain size) for 30 years, starting from the initial condition of 3-5wt% of subsurface ice.

First, we found that the globally inhomogeneous pore size distribution increased the contrast of the subsurface ice distribution. The subsurface ice distribution is influenced by ground temperature and geothermal gradient, but also water vapor flux, which is controlled by the Knudsen diffusion coefficient. Pore size, one of the parameters determining the diffusion coefficient, is highly correlated with thermal conductivity. Therefore, the effects of thermal conductivity and pore size tend to overlap. When grain size is taken into account, the range of diffusion coefficients increases by up to an order of magnitude or more. Our results suggest that the setting of a globally uniform pore size of 10 um, which is used by previous studies (Bottger et al., 2005; Steele et al., 2017), would underestimate the amount of subsurface ice in the northern equatorial to mid-latitudes below several meters.

Second, the higher porosity accelerated the convergence of the calculations globally, and subsurface ice decreased in the northern hemisphere but increased in the southern hemisphere. This suggests that the southern hemisphere has a greater potential for subsurface ice accumulations than the northern hemisphere. However, it will adversely affect the amount of atmospheric water vapor if the porosity is inadequate. With a globally uniform porosity of 50%, the atmosphere became too wet. Our results suggest that 35-40% is suitable for near-surface porosity in terms of reproducing the water cycle on Mars.

This study suggests the possible significant influence of soil properties on the subsurface ice distribution. However, the long-term orbital climate forcing should be considered for quantitative discussion of subsurface ice distribution.