



## Study of Martian Polar Caps with GISS ROCKE-3D GCM

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Martian polar caps consist of both H<sub>2</sub>O and CO<sub>2</sub> ice. While H<sub>2</sub>O ice is mainly passive on modern Mars, it may have not been the case in recent Martian history, when its obliquity was higher, or when it was changing rapidly. The distribution of ice species in the snowpack affects its physical and thermodynamic properties. In the upper layers, it determines its albedo and thermal emissivity. Thus understanding the mutual effect between these ices and their interaction with the atmosphere is crucial for understanding the evolution of Martian polar regions. In this study, we employ a newly-developed Exotic Ices snow model coupled to the NASA Goddard Institute for Space Studies (GISS) ROCKE-3D planetary General Circulation Model (GCM) [1] to study the behavior of Martian polar caps. ROCKE-3D is a planetary GCM developed at NASA GISS as an extension of its Earth climate model, modelE [2]. It has been extensively used to simulate climate of various planets, including Mars (e.g. [3,4]).

The Exotic Ices snow model was specially developed for planetary applications which involve more than one condensable in the atmosphere, in which case snow can contain multiple species of ice (CO<sub>2</sub> and H<sub>2</sub>O in the Mars case). For each species of ice, the model uses their proper physical properties and phase diagram, but otherwise it treats all species of ice on an equal footing. The combined effects on albedo, thermal inertia and mutual insulation are treated accordingly. The snowpack interacts with the atmospheric dust cycle, and can accumulate a prognostic amount of dust, though the effect of dust on snow properties is not currently treated explicitly, and is prescribed.

In this study, we first validate our model against the modern Martian climate, for which we use mission results from Mars Climate Sounder (atmospheric temperature and dust optical depth), SPICAM on Mars Express (atmospheric water), and Viking 2 (surface pressure). We investigate the effect of snow radiative properties on CO<sub>2</sub> and water cycles and the ability of our model to accurately reproduce those with minimal model tuning. We then perform simulations for several obliquities from a recent Martian past, and investigate the behavior of the Martian polar caps in

such conditions.

References: [1] Way, M. J. et al. (2017) *ApJS*, **231**, 12. [2] Kelley, M. et al. (2020) *J. Adv. Model. Earth Syst.*, **12**, no. 8, e2019MS002025. [3] Schmidt, F. et al. (2022) *Proc. Natl. Acad. Sci.*, **119**, no. 4, e2112930118. [4] Guzewich, S.D. et al. (2021) *J. Geophys. Res. Planets*, **126**, no. 7, e2021JE006825.