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## Recent ice ages on Mars by destabilization of the Northern Polar Cap at 35° obliquity

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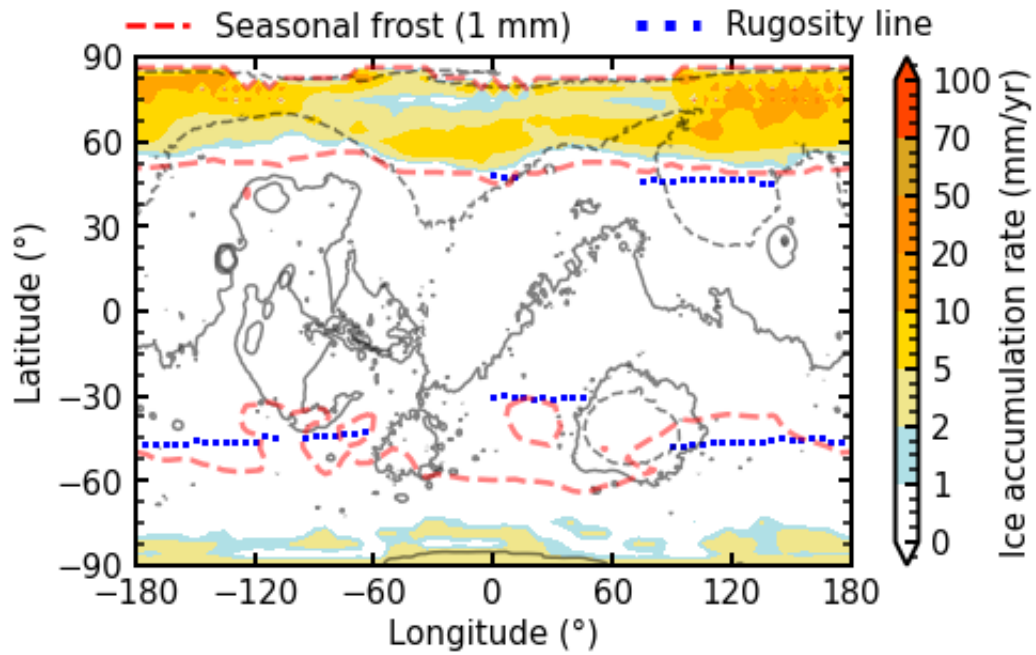
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Surface water ice is unstable on present-day Mars outside of the polar regions. However, prominent geological features show that during its recent past the surface of Mars was covered, on multiple occasions, by a « latitude-dependent mantle » (LDM) of water ice, from the polar regions to the tropics [1].

Different studies conducted with Global Climate Models, in particular the Mars PCM (previously Mars LMD-GCM) led to the formulation of a climate scenario for the emplacement of ice ages : during high obliquity phases (>45°, as opposed to present-day ~25°), strong destabilization of the Northern Cap allowed for the aerial deposition of ice on the flank of tropical volcanoes, forming glaciers. When returning at lower obliquity, these glaciers were in turn destabilized but ice accumulated in the mid and high latitudes, and thus formed the observed surface ice deposits (LDM) [2]. However, the 45° obliquity excursions occurred before the last 5 million years, while the last ice age occurrence is dated of 400 000 years at most.

Previous numerical experiments did not account for the radiative effect of water-ice clouds. Previous studies show that, even though somewhat negligible in the present-day Martian climate, this effect is overriding at higher obliquity with the intensification of the water cycle [3]. We have conducted new experiments at 35° obliquity with the Mars PCM using an improved physical package for the radiatively active clouds (RACs) and surface ice. Here, we present the resulting climate regime in our simulations. At 35° obliquity, the atmosphere is almost two orders of magnitude wetter than present-day, due to the greenhouse effect of RACs over the polar regions. In the high to mid latitudes, the seasonal winter ice accumulation is increased dramatically, while the summer sublimation is dampened by the latent heat cooling. Surface water ice thus accumulates at rates corresponding to tens of meters at each high obliquity excursion, reconciling the climatic scenario with the inferred age of emplacements of the LDM.



**References:**

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- [3] Madeleine et al. (2014), Recent Ice Ages on Mars: The role of radiatively active clouds and cloud microphysics, *Geophysical Research Letters*, 41, 4873

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