RECENT FORMATION OF ICE-RICH LATITUDE-DEPENDENT MANTLE FROM POLAR ICE RESERVOIRS. J. Naar[1], F. Forget[1], J.-B. Madeleine[1], E. Millour[1], A. Spiga[1],M. Vals[1], A. Bierjon[1], L. Benedetto de Assis[1], [1]Laboratoire de Météorologie Dynamique, UMR CNRS 8539, Institut Pierre-Simon Laplace, Sorbonne Universités, UPMC Univ Paris 06, 4 place Jussieu, 75005, Paris, France. (joseph.naar@lmd.jussieu.fr)

Introduction: Corroborating evidences in geomorphology and modeling has unveiled the presence of a subsurface latitude-dependent mantle (LDM) of water-ice-rich deposits down to 30° latitude in both martian hemispheres [1]. These layers appear to be less than ~ 2Myr and were possibly deposited as snowfall in response to climate change driven by shift in obliquity, similar to Earth glacial/interglacial periods [2].

However, martian climate models usually struggle to reproduce environmental conditions required to form LDM under recent paleoclimatic orbital forcing.

We present a new parametrization of ice/frost albedo which, along with radiatively active water-ice clouds (RAC), predicts ice accumulation rates in mid-latitudes compatible with deposition of a tens of meters-thick LDM under recent obliquities (several incursions to 35°).

Evolution of water stability regions with obliquity: Remnant glacial and periglacial geological features are observed at equatorial and mid-latitudes on Mars, a few tens of million years old. These landforms likely result from equatorward shift of water-ice stability with rising obliquity [3]. This tropical ice becomes unstable during low obliquity phases, and ice has been modeled to accumulates in high latitudes [4,5]. Yet, these former ice reservoirs are millions of years older than the LDM, likely formed during higher obliquity phases (~45°). The water source of the LDM is therefore not thought to be of low-latitude origin, but may be remobilized polar water-ice.

Water-ice clouds in recent paleoclimates: Water-ice clouds effects have a small effect on the present-day martian climate [6], corresponding to a ~25.2° obliquity. When obliquity shifts up to 35°, atmospheric humidity is enhanced by polar warming and water-ice cloud become a key element of martian climate [7,8].

Their radiative effect strongly warms the atmosphere, amplifies meridional circulation and water transport toward tropical latitudes. [7] showed that taking into account radiatively active clouds allow for mid-latitude ice deposits considering only polar caps as a water source in this obliquity regime. However, the accumulation of these ice deposits required the prescription of high atmospheric dust content to ensure its persistence during summer.

Frost and ice albedo: During recent high obliquity episodes up to ~35°, ice accumulates in mid-latitudes as frost. Frost should have a much higher albedo than perennial ice [9]. This was not taken into account in [7]. We improve the parametrization of ice albedo by decoupling older ice,with a canonical albedo of 0.35, and frost, whose albedo can reach 0.7. We find that it has a compelling influence regarding surface water stability and persistence over the years. High albedo inhibits sublimation in summer by lowering surface heating.

Paleoclimatic simulations: Using this refined parametrization, we perform climatic simulations at 35° obliquity with null eccentricity. The corresponding accumulation rates of ice are compatible with the setting of hundreds of meters of LDM down to ~45° latitude in both hemispheres and its persistence year by year (Figure 1). In the last ~2 Myr on Mars, obliquity has reached ~35° a dozen times, for approximately 1000 years each time [10]. Assuming an efficient preservation process, the accumulation rate is sufficient to form a hundreds of meters thick latitude-dependent mantle of ice-rich deposits. The latitudinal extension of the LDM down to 30° isn't represented in these simulations, but many orbital configurations remain to be explored with our model.

Future studies: These preliminary results are part of the "Mars Through Time" program. Scientific perspectives include understanding the formation of LDM, and more generally investigating recent paleoenvironments leading to the formation of geologically young glacial and periglacial landforms on Mars.

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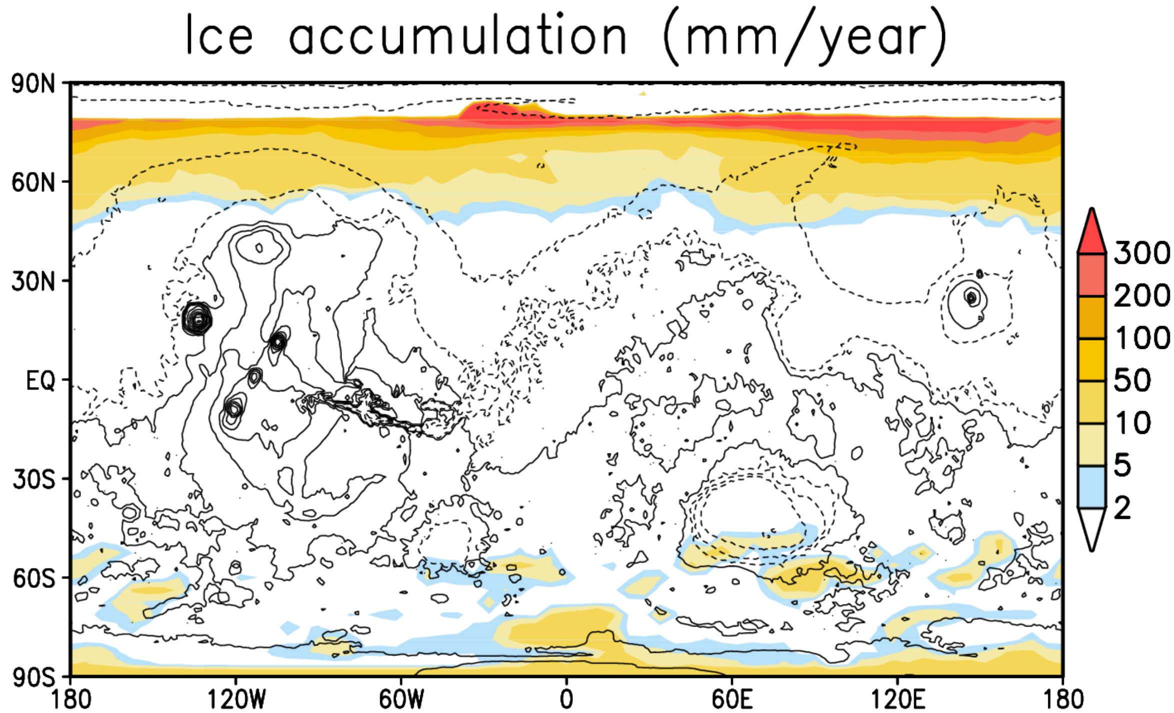

Figure 1 : Net accumulation of surface water ice (mm per year) at obliquity 35° and eccentricty 0 predicted by the LMD GCM assuming an ice frost albedo of 0.7. The model takes into account radiatively active clouds as in [8], and assumes a clear atmosphere all year long (dust opacity at 610 Pa set to 0.2).