Climate Simulations of Mars at Low Obliquity

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Résumé

In some high latitude craters, intriguing moraines are interpreted to have been formed by CO2 ice glacier flows (1). These glaciers might have formed when Mars's obliquity was low and the local climate was colder (1,2). The obliquity of Mars reached values _˜15○ nearly 800,000 years ago, and probably less than a few degrees during the Amazonian era (3). The climate of Mars at such low obliquities has been little studied. (2,4) suggested that the atmosphere could totally collapse into CO2 glaciers, leaving behind a residual atmosphere of only Ar and N2 that is 20 times less dense than today.
However, these results are based on a radiative equilibrium that does not take into account all the dynamics of the atmosphere. Such periods of low obliquities generally last tens of thousands of years (3), making a complete simulation with a classical Global Circulation Model impossible. We, therefore, built a new tool called the " Planetary Evolution Model " to simulate the evolution of the climate over long time steps. This model has been validated by comparing its results with the ones of LMD GCM (5) long-runs made at low obliquity Furthermore, the moraines observed in (1) are rather of the order of one km. We introduced in the LMD GCM a detailed parametrization of the topography distribution at the kilometer scale. This parameterization enables to model the microclimate on local slopes and thus the formation of CO2/H2O glaciers. This parametrization has been tested and validated using the current observations of ice deposits on pole-facing slopes (6,7).

We will present the preliminary results of our climate simulations of Mars at low obliquity based on the Planetary Evolution Model with the slope parametrization. Particular attention will be paid to the condensation of the atmosphere in the form of CO2 glaciers, the formation of H2O glaciers, the impact on the subsurface thermal profile, and to the composition of the residual atmosphere.

(1) Kreslavsky and Head, 2011
10.1016/j.icarus.2011.08.020
(2) Kreslavsky and Head, 2005
10.1029/2005GL022645.

*Intervenant

(3) Laskar et al., 2004
10.1051/0004-6361:20041335
(4) Buhler and Piqueux, 2021
10.1029/2020JE006759

(5) Forget et al., 1999
10.1029/1999JE001025
(6) Vincendon et al. 2010,
10.1029/2009GL041426
(7) Vincendon et al. 2010,
10.1029/2010JE003584