MODELLING MARS PAST WATER CYCLE : GLACIER, ICE MANTLING, GULLIES AND POLAR CAPS .

F. Forget, *Laboratoire de Météorologie Dynamique, Institut Pierre Simon Laplace, Paris, France (forget@lmd.jussieu.fr)*, **F. Montmessin,** *Service d'Aéronomie, CNRS, Verrière le Buisson, France*, **B. Levrard,** *IMCCE, Obs. de Paris, France*, **N. Mangold, F. Costard,** *IDES, CNRS, Université Paris-sud, Orsay, France*, **R.M. Haberle,** *NASA Ames Research Center, USA*, **James W. Head III,** *Brown University, Providence, USA*.

Introduction

Surface conditions on Mars are currently cold and dry, with water ice unstable on the surface (except near the poles) and surface liquid water thought to be never present. However, geologically recent glacier-like landforms have been identified in the tropics and mid-latitudes of Mars, an ice-rich mantling seems to cover both hemisphere above 60°latitude, and recent gullies apparently carved by liquid-water rich debris flows are observed.

Recent results

In the past few years, to better understand the climate conditions and processes that have formed such features, we have conducted a first set of studies by adapting models used to simulate present-day Mars to other orbital and excentricity parameters. Our results can be find in the references below.

Briefly, we have performed high resolution climate simulations with a numerical model designed to simulate the details of the present-day Mars water cycle, but using different obliquities, like on Mars a few millions of years ago.

At high obliquity (e.g. 45^o), the model predicts the accumulation of ice and the formation of glaciers on the western flanks of the great Tharsis volcanoes if the current northern polar cap remains a source of water, and in eastern Hellas if a water ice polar cap is assumed to be present at the southern pole [1] This is precisely where the most characteristic Glacier-like features have been discovered. The agreement between observed glacier landform locations and model predictions points to an atmospheric origin for the ice and permits a better understanding of the details of the formation of Martian glaciers.

Using the same model, we show that when Mars returns to lower obliquity conditions, the low and mid-latitude glaciers becomes unstable, partially sublimes and tend to accumulate in both hemisphere above 60^o. Once water is no more available from the low and mid-latitude glaciers, water tends to return to the poles (where it is now), but probably leave some ice under a dry layer. We suggest that such a processes probably explain the presence of the ice-rich mantling observed by geomorphology and detected by the GRS instrument aboard Mars Express [2]

In this scenario, the formation of glaciers and ice layers on Mars is the product of the same Martian climate system as that of today, except that the enhanced water cycle allows the precipitation and accumulation of ice in specific locations controlled by the atmospheric circulation. In reality, the complex variations of orbital parameters probably led to all sorts of regimes in the past, with water ice alternatively mobilized from the poles to the tropical and mid-latitude glaciers and to the high latitudes. In particular After several obliquity cycle, this processes should have created layers that could be detected by Phoenix in 2008. Moreover, on the basis of the ice accumulation or loss rate that are modeled at the pole, we can try to reconstruct the history of the ice accumulation at the North pole in the past 10 Million years and compare the modeled layers with the actual structures that are observed in the polar deposits throughs [3, 4].

It is also likely that some of the past Mars Climate regimes led to the accumulation of ice on slopes that could have had reached the melting point of water and initiate debris flows and Gullies, in some specific conditions that we can investigate with the climate models [5].

Overall, we can thus propose a simple, consistent scenario to explain the formation many of the amazonian icy landforms by the climate system that we know today, without the involvement of subsurface reservoir.

Issues

In Granada, we will focuss on the uncertainties that remains in the current past climate simulations and that could be addressed by the Mars atmosphere community. For instance, the radiative feedback of water ice clouds and water vapor may play a role, but we do not yet take them into account. Another uncertainty is atmospheric dust, which has a strong impact on our results. In particular, The amount of dust present in the atmosphere at high obliquity is unknown. GCM simulations show that the near-surface circulation amplifies considerably with increasing obliquity (Haberle et al. 2003, Newman et al. 2005) such that potential dust lifting could be much higher than today. However, the atmospheric dust load may have been limited by the finite amount of surface dust available in the windy locations41 so that the opacity may not have been higher than today. In any case; in the ice accumulation region, precipitations should have contributed to the cleaning of the atmosphere by scavenging dust particles, as on Earth today. Such a process should be investigated in future studies. Last the formation of lag deposits on sublimaing water ice reservoir remains to be well understood, as well as the local stability of water ice and liquid water.

Reference of the group modelling studies

(1) Forget, F.; Haberle, R. M.; Montmessin, F.; Levrard, B.; Head, J. W.Formation of Glaciers on Mars by Atmospheric Precipitation at High Obliquity Science, Volume 311, Issue 5759, pp. 368-371 (2006).

(2) B. Levrard, F.Forget, F. Montmessin, and J. Laskar. Formation of recent martian high-latitude ice-rich deposits by sublimation of unstable equatorial ice at low obliquity . Nature, 431, 1072-1075, 2004.

(3) B. Levrard, F. Forget, F. Montmessin, and J. Laskar. A GCM recent history of martian layered deposits. To be sumitted to Jour. Geophys. Res.

(4) F. Montmessin, R. M. Haberle, and F. Forget. Making Water Ice Permanent at the South Pole 25000 Years Ago. In Lunar and Planetary Institute Conference Abstracts, pages 1312-+, March 2004.

(5) F. Costard, F. Forget, N. Mangold, and J. P. Peulvast. Formation of Recent Martian Debris Flows by Melting of Near-Surface Ground Ice at High Obliquity. Science, 295:110-113, 2002.