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GLACIATIONS ON MARS: RESPONSE TO ORBITAL VARIATIONS INFERRED FROM CLIMATE MODELLING, AND COMPARISON WITH EARTH. J.-B. Madeleine[1] (jbmlmd@lmd.jussieu.fr), F. Forget[1], J. W. Head[2], F. Montmessin[3]. [1]Laboratoire de Météorologie Dynamique (LMD), CNRS/UPMC/IPSL, Université Paris 6, BP99, 75252 Paris Cedex 05, France; [2]Brown Univ., Providence RI 02912, USA; [3]Service d'Aéronomie, CNRS/UVSQ/IPSL, Verrières-le-Buisson, France.

Introduction: The last two million years of Earth history have seen large variations of ice covering, ranging from the present-day ice caps to vast ice sheets, covering approximately one-third of our planet [1]. As many as 21 glacial cycles occurred on Earth during this so-called Quaternary period, leaving a precious record of the corresponding climate variations in the Earth stratigraphy, for instance in the EPICA Dome C ice core of East Antarctica [2].

Like on Earth, geomorphological and orbital analyses of Mars suggest that atmospheric mechanisms were available during the Late Amazonian period (past 400 million years) and operating to deposit significant amounts of ice in widespread regions of the planet, ranging from the latitude dependent mantle covering at least 23% of the planet to regional mid-latitude valley and tropical mountain glaciations [3, 4, 5, 6]. These glaciations have been interpreted as resulting from the orbital variations of Mars, based on the terrestrial Milankovitch theory. These orbital variations are much larger than on Earth. For example, obliquity on Earth varies from 22 to 24,5 degrees, compared to 15 to 60 degrees approximately on Mars [7, 8].

The aim of this study is to paint a comparative picture of the Martian and terrestrial glaciations, based on climate predictions by the LMD/GCM (Global Climate Model), in order to further understand the two climate systems.

Comparative method: Glaciers, and more generally the cryosphere, is a subsystem of the climatic system, on the same level as the biosphere, the atmosphere, the geologic activity, and the ocean subsystem. Our approach is thus to identify links between these subsystems that are shared by both planets, and study their response to orbital variations.

Timescale. Orbital variations are considered on the 10 kyr time scale, which corresponds to the growth and destruction of large ice sheets. At this time scale, we can consider that Mars and Earth have three subsystems in common: the atmosphere, the geologic activity (for example the volcanic activity) and the cryosphere.

Tools. Comparison of the two climate systems is based on the modeled response of the LMD/GCM to variations of insolation (see [9] and [10] for a description of the Earth and Mars climate models).

Example of result: Fig. 1 shows an example of GCM prediction described in [11], and proposed as a climatic scenario for the northern mid-latitude glaciation [6].

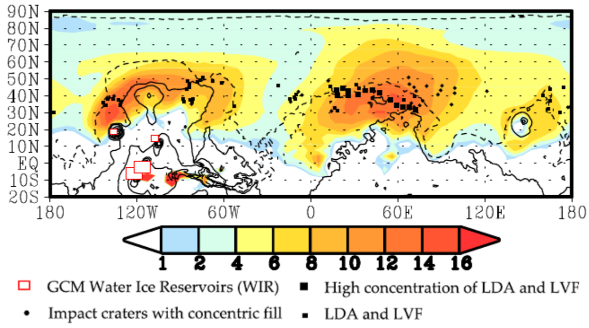

Fig. 1: Winter accumulation of ice (in mm) predicted by the LMD/GCM under dusty, 35° obliquity and 0.1 eccentricity conditions (solar longitude of perihelion is 270°). Black points represent the ice-related landforms mapped by [12] and formed during the Late Amazonian northern mid-latitude glaciation.

During the conference, further results and comparisons with the Earth will be presented.

References:

[1] Benn, D. I. and Evans, D. J. A. (1998), *Glaciers & glaciation*. [2] Lambert, F. et al. (2008) *Nature, 452-7187,* 616-619 [3] Kreslavsky, M. A. and Head, J. W. (2002) *GRL, 29,* 14-15 [4] Head J. W. et al. (2003) *Nature, 426,* 797-802. [5] Head J. W. et al. (2005) *Nature, 434,* 346-351. [6] Head, J. W. et al. (2006) *EPSL, 241,* 663-671. [7] Berger, A. et al. (1995) *Future climates of the World*. [8] Laskar, J. et al. (2004) *Icarus, 170,* 343-364. [9] Hourdin, F. et al. (2006) *Climate Dynamics, 27-7,* 787-813. [10] Forget, F. et al. (1999) *JGR, 104,* 24155-24176. [11] Madeleine, J.-B. et al. (2009) *Icarus, submitted*. [12] Squyres, S. W. (1979) *JGR, 84,* 8087-8096.