A STUDY OF ICE ACCUMULATION AND STABILITY IN MARTIAN CRATERS UNDER PAST ORBITAL CONDITIONS USING THE LMD MESOSCALE MODEL. J.-B. Madeleine[1], J. W. Head[1], A. Spiga[2], J. L. Dickson[1] and F. Forget[2], [1]Dept. of Geological Sciences, Brown University, Providence RI, USA (jean-baptiste_madeleine@brown.edu), [2]Laboratoire de Météorologie Dynamique (LMD), Paris, France.

Many geological features on Mars suggest that glacial cycles occurred during the Late Amazonian (last hundreds of millions of years). These features often form with a preferential orientation, and their distribution and detailed morphology are potential indicators of past depositional environments (pole-facing, equator-facing) and flow directions. The goal of the present study is to better understand the climate conditions under which these features formed, using geological observations [e.g., 1-4] and mesoscale climate simulations [5] of the corresponding regions.

Methodological approach: To accomplish this goal, we focus on ice-related features formed in impact craters. Indeed, the wide variety of martian craters which have been affected by glacial erosion allows us to study the formation of glacial features under different boundary conditions, i.e. in craters of different sizes and located at different latitudes.

Geological observations: Some of the glacial features of Mars, such as the viscous flow features or the gullies [1], were possibly formed in the last few millions years, whereas other features, such as the lobate debris aprons, lineated valley fill and concentric crater fill [2-4] seem to be older and to have formed during the last hundreds of millions of years. If we focus on craters, two main geological features are found: concentric crater fill (CCF), and gullies. Detailed analysis of CCF features [3] reveals that they formed in specific locations and with a preferential orientation (see Fig. 1). Moreover, their detailed morphology reveals various flow directions and sublimation patterns [3, 4] that also reflect the climatic environment in which they formed.

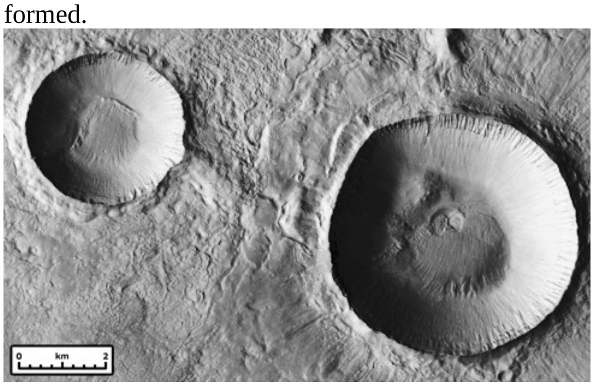

Figure 1: Two craters with identical fill deposits emanating from the southern (pole-facing) slope. CTX orbit P17_007619_2153 (latitude = 34.8°).

Therefore, these glacial features provide essential constraints on the mesoscale climate which prevailed during their formation, and substantial insight can be gained by comparing the geology to mesoscale simulations of the climate characterizing these craters.

Mesoscale simulations: We utilized this information to perform mesoscale simulations of the craters' climate under different orbital conditions, for craters of different sizes and located at different latitudes.

LMD Mars mesoscale model. The model used for this purpose is the LMD Mars mesoscale model [5], which couples the set of parameterizations developed for Mars by the LMD team to the dynamical core of the WRF model [6]. The resolution of the mesoscale simulations ranges from hundreds of kilometers to tens of meters, and their typical time scale is a few days. The simulations can be either performed under idealized conditions or real conditions. In the latter case, the simutions are more difficult to achieve because the mesoscale simulation needs to be guided by the GCM (Global Climate Model) results, and a full GCM simulation must be performed beforehand.

Simulations. In order to study the glacial climate in craters under different conditions, we first focus on the temperatures and circulation regimes found in ideal craters under ideal conditions. The crater topopography is described by simple analytic functions, using different depths and diameters. Simulations are run under different latitudes and for various obliquities.

Perspectives: We are comparing the results of the simulations to the geological observations to understand both the influence of regional to global insolation and weather trends, and the micro-climates that are induced by the topography of craters of different sizes and states of degradation. Our analyses also show where the atmospheric conditions are favorable to ice accumulation, locations of preferential orientation, and sublimation of the deposits. These data also provide the basis to undertake glacial flow models to help understand the structure and morphology of the concentric crater fill.

References: [1] J. W. Head, et al. (2003) Nature 426:797. [2] J. W. Head, et al. (2008) 39th LPSC Conference Abstract 1295. [3] J. L. Dickson, et al. (2011) 42nd LPSC Conference Abstract 1324. [4] J. Levy et al. (2010) Icarus 209:390. [5] A. Spiga et al. (2009) JGR Planets 114:E02009. [6] W. C. Skamarock, et al. (2008) Journal of Computational Physics 227(7):3465.