A STUDY OF ICE ACCUMULATION AND STABILITY IN MARTIAN CRATERS UNDER PAST ORBITAL CONDITIONS USING THE LMD MESOSCALE MODEL.

J.-B. Madeleine¹, J. W. Head², A. Spiga³, J. L. Dickson¹, K. E. Scanlon¹ and F. Forget²
¹Dept. of Geological Sciences, Brown University, Providence RI, USA, ²Laboratoire de Météorologie Dynamique (LMD), Paris, France
http://www.lmd.jussieu.fr/~jbmlmd

References

Science objective
Better understand the local distribution of gullies and glaciers in martian craters (see figures 1 and 2).

Methodological approach
Use of the LMD (Laboratoire de Météorologie Dynamique) Mars mesoscale model [4] and focus on:

Ice accumulation:
- Precipitation = cloud formation = availability in water vapor + saturation temperature + favorable atmospheric circulation (mixing of cold-dry / warm-humid air masses);
- Direct deposition = cold temperatures and supersaturation in the lower atmosphere;
- Blowing snow = snow coming from other areas and brought by winds.

Ice sublimation:
- High surface temperature, low relative humidity in the lower atmosphere, high wind strength;
- High wind erosion.

Geological constraints

Results

Implications

Ice accumulation:
- Craters could be preferential sites of precipitation or/and direct deposition of ice during the night by lower temperatures relative to the surrounding terrains;
- Nighttime katabatic winds may favor the accumulation of blowing snow on certain rims depending on latitude.

Ice sublimation:
- Pockets of cold air form in craters during the night, and atmospheric temperature decreases with increasing size of the crater.
- During the day, the atmospheric temperature inside the crater increases with decreasing elevation.
- Strong upslope/anabatic winds during the day and downslope/katabatic winds during the night;
- Small impact of nighttime katabatic winds on the temperatures of the surface and lower atmosphere.

Perspectives
- Use of improved topographic profiles which include the crater rims;
- Mesoscale simulation of real craters at different locations and under different orbital conditions;
- Inclusion of the cloud scheme and simulation of ice deposition and sublimation.

Technical details
- LMD (Laboratoire de Météorologie Dynamique) Mars mesoscale model [4];
- Couples the set of parameterizations developed for Mars by the LMD team to the dynamical core of the WRF model [5];
- Idealized simulations, 120x120x25 km domain (cube of 61 grid points, 2km horizontal resolution);
- No cloud scheme is included;
- An analytic function is used for topography and defined as:

\[ z(x, y) = z_0 + H \left( 1 - \frac{1}{1 + \left( \frac{x-x_0}{L} \right)^2 + \left( \frac{y-y_0}{L} \right)^2} \right) \]

with H the depth of the crater and L the characteristic length.
- Open boundary conditions, damping of spurious waves at the borders and at the top of the domain. Hydrostatic pressure coordinates. Time step of 10 seconds. 2-day long simulations, ~12 hours of computation time.
- To focus on the impact of the atmospheric circulation on local temperatures, the numerical scheme that accounts for the effect of local slope on surface temperature is turned off.

References