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

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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

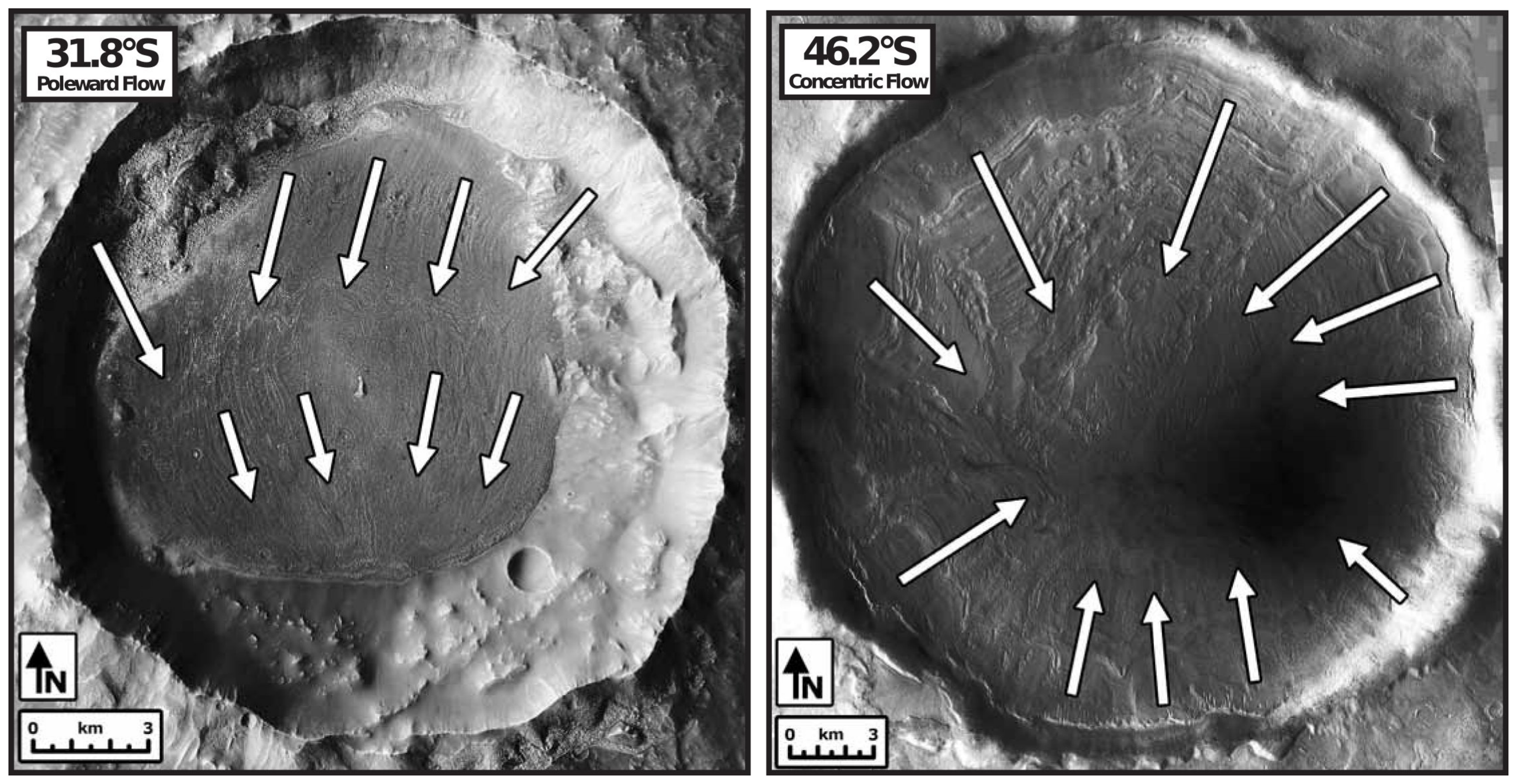


Figure 1: Concentric crater fills **[1]**
Poleward of 45°: Ice accumulation on slopes of any orientation;
Equatorward of 45°: Ice accumulation favored on pole-facing slopes.

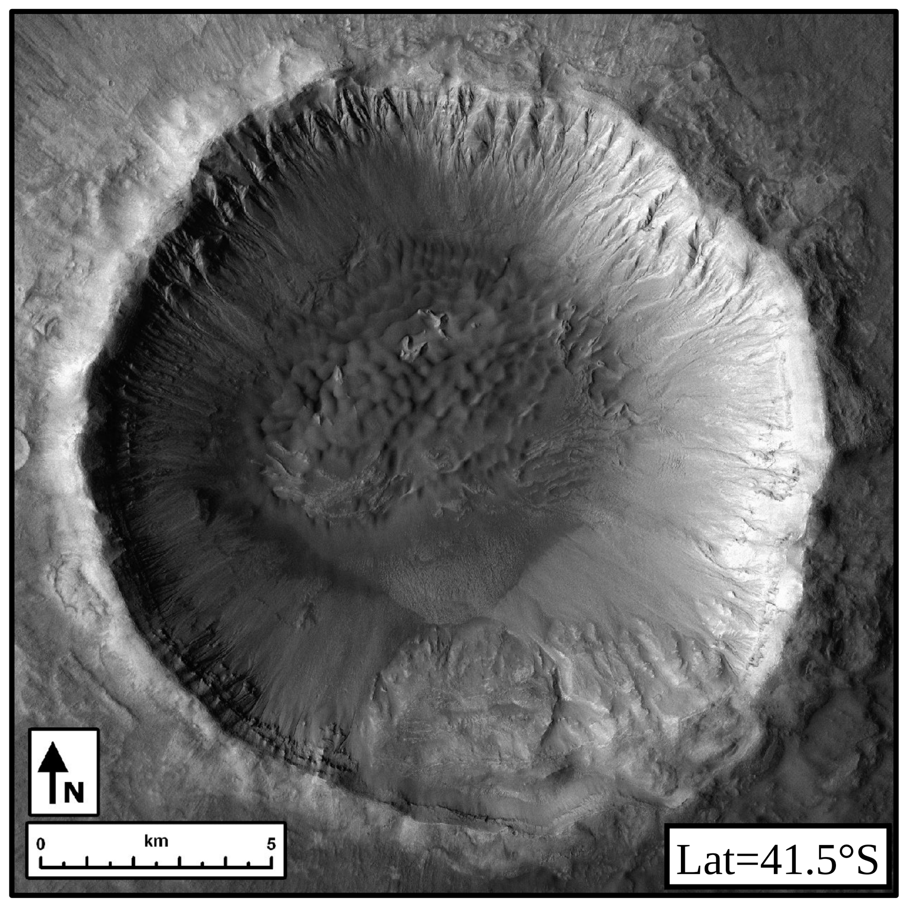
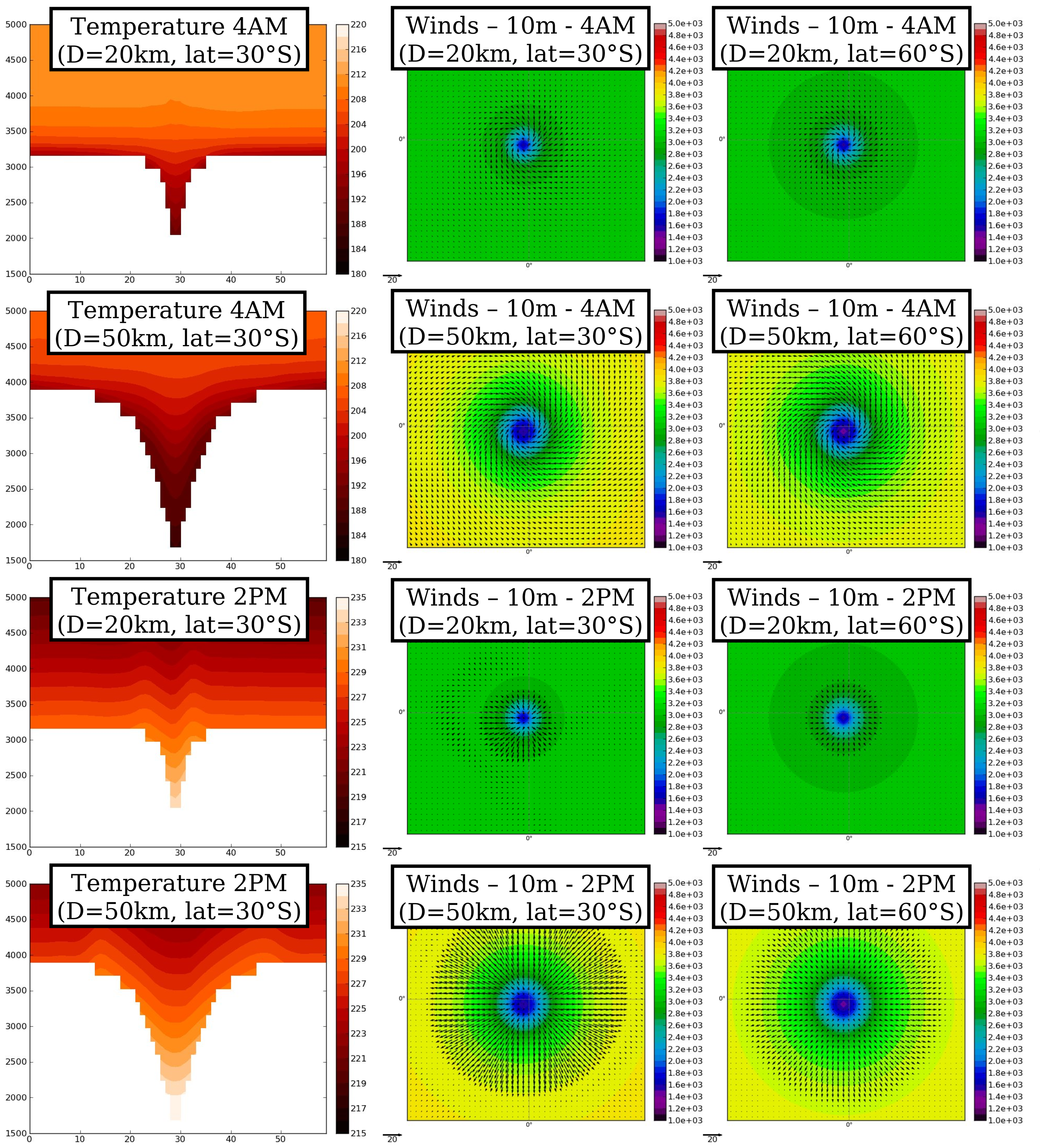
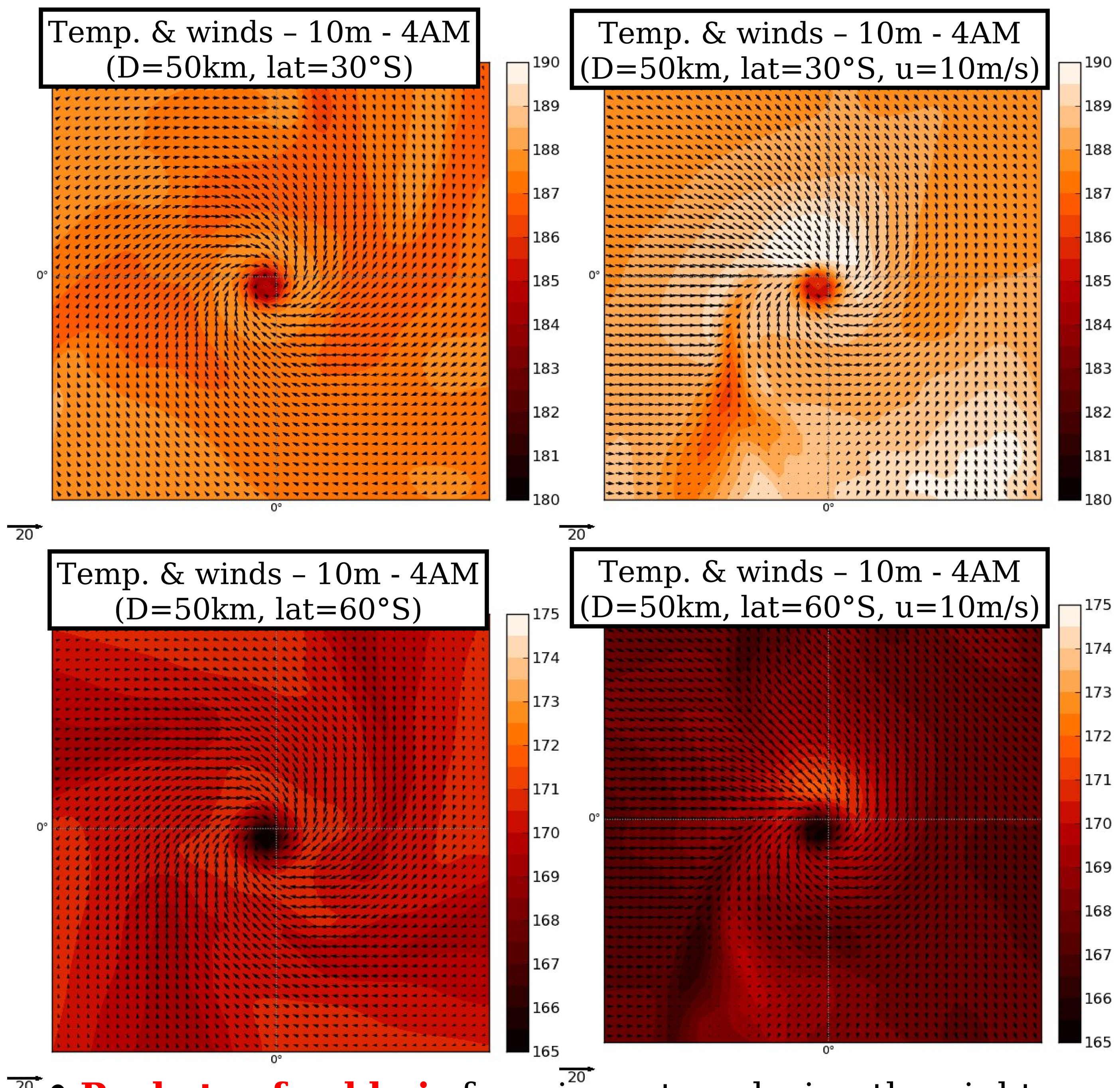


Figure 2: Gullies **[2,3]**
- Mostly found in the 30-45° latitude bands of both hemispheres;
- Around 80% of the gullies are on pole-facing slopes depending on latitude;
- Occur on >20° slopes and are not found above 3km above the datum;
- Found on crater/valley walls as well as on the flanks of isolated surfaces.

Results





- **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.

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:

Preferential sublimation of the deposits located **on the crater floor** is possible, due to warmer atmospheric temperature during the day.

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 topopography 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 [1] J. L. Dickson et al. (2012) Submitted to Icarus. [2] J. L. Dickson et al. Icarus (2007) 188:315-323. [3] J. W. Head et al. (2008) PNAS 13258-13263 vol. 105 no. 36. [4] A. Spiga et al. (2009) JGR Planets 114:E02009. [5] W. C. Skamarock, et al. (2008) Journal of Computational Physics 227(7):3465.