THE IMPACT OF KATABATIC WINDS ON MARTIAN THERMAL INERTIA RETRIEVALS. A. Spiga[1], S. R. Lewis[1], F. Forget[2], E. Millour[2], L. Montabone[2] and J.-B. Madeleine[2], [1]Dept. of Physics and Astronomy, The Open University, Milton Keynes, United Kingdom (a.spiga@open.ac.uk, spiga@lmd.jussieu.fr); [2]Laboratoire de Météorologie Dynamique, Université Pierre et Marie Curie, Paris, France

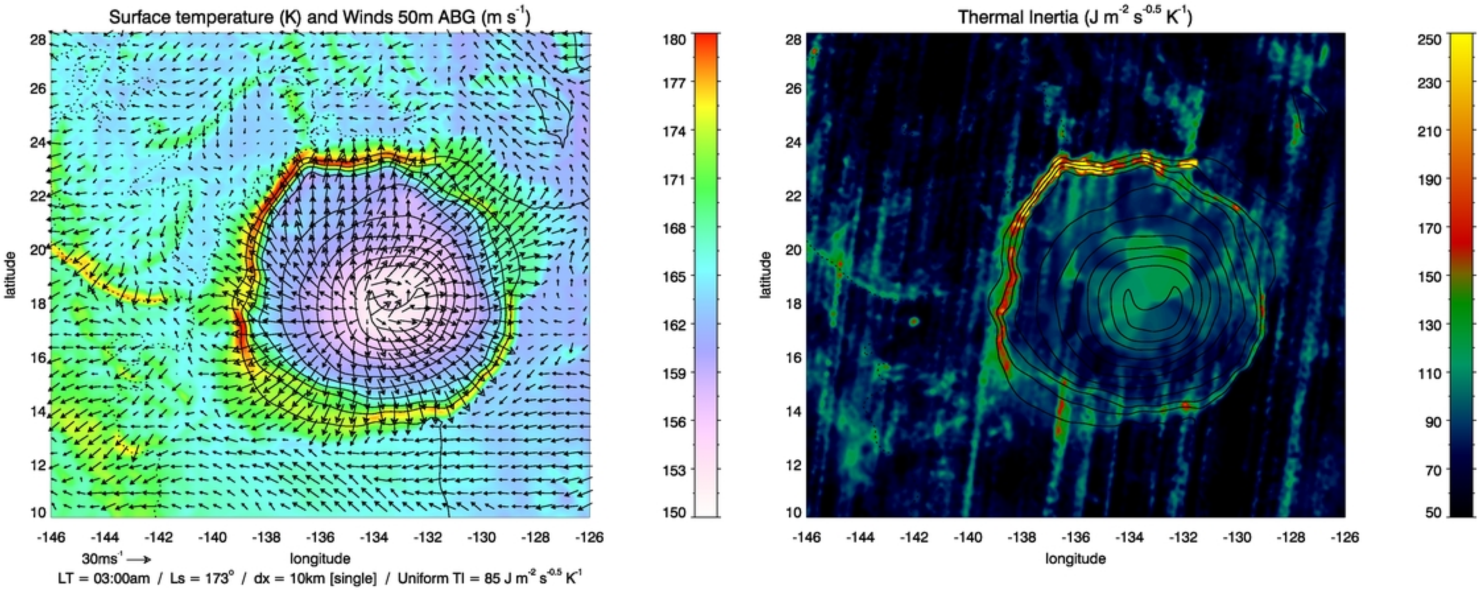

Figure 1: [Left] LMD Mesoscale Model predictions of horizontal wind and surface temperature in northern fall nighttime conditions [see ref. 7]. Uniform value of thermal inertia is set in the whole Olympus Mons / Lycus Sulci domain. Warming of the surface occurs under the radiative influence of the atmosphere adiabatically heated by katabatic (downslope) winds. Predictions for surface temperature are in close agreement with observations carried out by the Thermal Emission Spectrometer (TES); [Right] Thermal inertia retrievals based on TES measurements in the Olympus Mons / Lycus Sulci region [see ref. 2]. Apparent thermal inertia derived from modeled surface temperature by the mesoscale model (using for this retrieval single-column modeling with complete soil / subsurface scheme) shows close agreement to the field displayed here.

Summary: Our work describes significant artifacts in remote-sensing retrievals of Martian thermal inertia close to topographical slopes. Maps of apparent thermal inertia exhibit spatial structures, which we show are not related to soil properties but to the nighttime warming of the surface by the atmosphere adiabatically heated by katabatic winds.

Definition: Thermal inertia combines thermal conductivity with heat capacity and quantifies the soil's ability to store heat in daytime and to radiate it in nighttime. It is the key quantity controlling regional, diurnal and seasonal variations of surface temperature on Mars. Thermal inertia is dependent on the physical properties of near-surface geologic materials: particle size, rock abundance, bedrock outcropping and induration [1, 2]. Accurate high-resolution mapping of thermal inertia from orbit is a necessary prerequisite to many studies of geology, meteorology and exobiology.

Retrievals: At the Martian surface, upward radiative loss is balanced by heat flux due to insolation, downwelling atmospheric radiation, and seasonal CO2 condensation, together with subsurface heat conduction. Numerical modeling enables one to calculate an apparent thermal inertia [2, 3, 4] from remotely-sounded surface temperatures [5], taking into account diurnal and seasonal variations of the local insolation and atmospheric constituents [e.g. dust, 6], as well as small-scale surface heterogeneities.

Katabatic winds and Surface Temperature: Nighttime warm departures of surface temperature at the base of the Olympus Mons and Lycus Sulci topographical slopes have been recently predicted by the LMD mesoscale model [7]. Surface temperature enhancement reaches +20K compared to the surrounding plains (Figure 1). Such signatures can be identified all night long, at various seasons and in various topographically uneven areas (e.g. Meridiani cratered terrains, Figure 2). Warming of the surface occurs under the influence of katabatic (downslope) winds which develop during the night and cause air masses 10-100 meters above the surface to be adiabatically compressed as they descend along steep slopes. The surface temperature increases because the warmer overlying atmosphere enhances the downward thermal infrared flux to the surface.

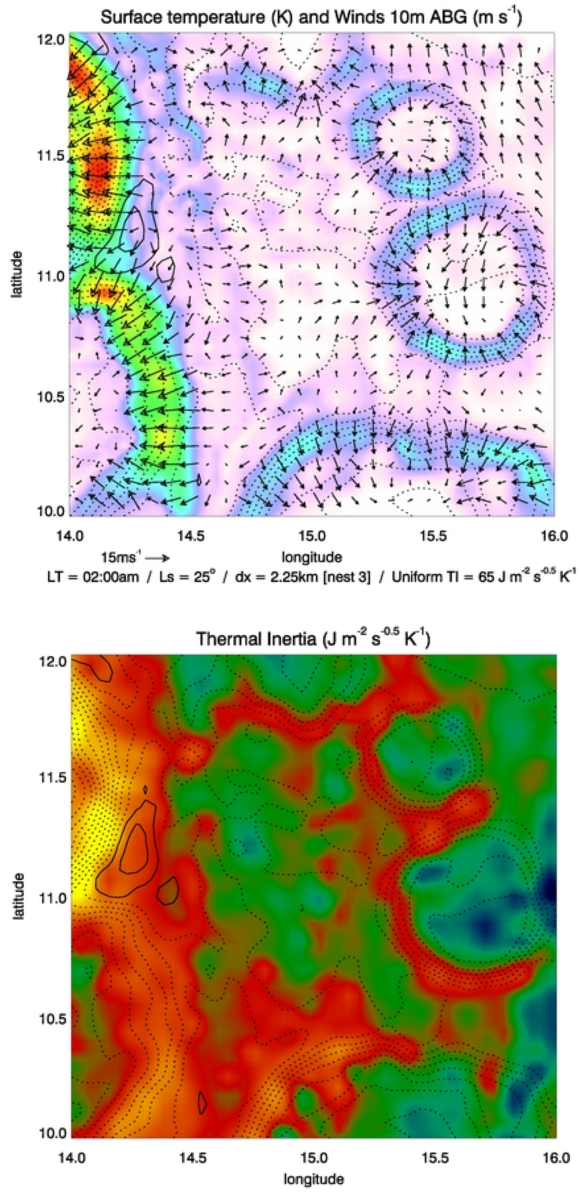

Figure 2: Same as in Figure 1, except that Meridiani Terra cratered terrains are considered and mesoscale model is run at finer resolution, employing grid nesting to zoom in that specific region.

Thermal Inertia Artifacts: In the case of Olympus Mons, the surface temperature enhancement adopts the form of a "warm ring" at the base of the volcano. Thermal inertia shows similar spatial structure in high-resolution maps retrieved from Thermal Emission Spectrometer (TES) surface temperature measurements. In addition, signatures are identified both in simulations with normal or constant (average) thermal inertia fields. In the latter case, although no spatial variations of thermal inertia are considered, the mesoscale model is able to predict surface temperatures in very good agreement with TES measurements. Thus, the validity of thermal inertia retrievals in these specific areas is questionable; apparent thermal inertia obtained through soil modeling might not correspond to actual thermal inertia as inferred from soil characteristics. Models for thermal inertia retrievals do not take into account variations of downwelling atmospheric radiation caused by atmospheric circulation. This causes soil models to fit the surface temperature field with anomalously high thermal inertia, e.g. values between 200 and 300 J / m2 / s1/2 / K instead of 80 J / m2 / s1/2 / K.

Regional variability: The amount of surface warming is itself influenced by the thermal inertia. A prominent surface temperature signature is observed in the Olympus Mons region where thermal inertia is low and enhancement of downwelling atmospheric radiation caused by slope winds likely to significantly influence the surface temperature. In order to examine this effect and to produce global maps of atmospheric impacts, we performed high-resolution (~ 40 km) General Circulation Model simulations with the UK spectral model, which shares similar physical parameterizations as the LMD mesoscale model. To identify surface temperature departures caused only by the winds and not by thermal inertia contrasts, we run one baseline simulation and one simulation where near-surface winds have been switched off by setting huge Rayleigh friction in the boundary layer. Differences of surface temperature between the two simulations arise from the effects of winds: the presence of the Olympus Mons warm ring and Lycus Sulci signatures is confirmed and Meridiani/Elysium low thermal inertia terrains also show strong wind-induced surface temperature signatures. Interestingly, where thermal inertia is high in the Valles Marineris canyon, surface temperature does not appear significantly impacted by slope winds. Global maps of apparent thermal inertia departures caused by mesoscale circulations can be generated through this method.

Conclusion: It is vital to include atmospheric effects in retrievals of planetary thermal inertia maps, especially in topographically uneven areas. Martian high resolution GCMs and mesoscale models should allow a better estimate of true thermal inertia with these effects accounted for.

References:

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