TERRESTRIAL ANALOGS FOR PLANETARY SUBLIMATION/CONDENSATION BEDFORMS ENHANCED BY THE WIND. S. Carpy[1], O. Bourgeois[1], M. Bordiec[1], A. Collet[1], M. Massé[1], C. Herny[2], S. Pochat[1], [1]Laboratoire de Planétologie et géodynamique (sabrina.carpy@univ-nantes.fr), [2]Centre d'étude de la neige.

Introduction: The condensation/sublimation process is dominant on many solar system bodies where there is a large occurrence of volatile ices (N2, CH4, CO2, H20, NH3) that are stable at the average surface temperature and pressure. Nevertheless, forms generated by sublimation or condensation on terrestrial glaciers are rarely observed because other modes of transport are more common.

In recent decades, new space missions and improved detection methods have allowed a better understanding of landforms on icy planetary surfaces and a better determination of their origin. The interaction of the icy substratum with (even tenuous) atmospheres can result in landforms-shaping processes at different scales on Earth and Mars: sublimation ripples [1-2], ice megadunes [3-4], large ice trough on Mars [5-6] that are enhanced by the wind. The analogies made from these terrestrial observables allow the extrapolation of our knowledge to other environments or, conversely, a better understanding of the shapes we know on Earth.

A new type of geomorphic markers on icy planetary surface: On planetary surfaces, two type of aeolian bedforms can be generated by the wind: (1) on a loose substrate (dust, sand) or (2) on a solid substrate (ice, rock). Loose bedforms are subject to erosion, transport and deposition of grains according to different transport mechanisms (creep, saltation, suspension, bedload). They have thus highlighted that aeolian processes are central geomorphic agent on many bodies of the Solar System. They are found at different scales (ripples, dunes, giant aeolian dunes) and migrate in the direction of the flow.

Loose bedforms are relatively well understood and scaling laws have been derived. Such scaling laws make it possible to characterise the size of dunes as a function of the nature of the fluid, the velocity, the size of the grains and the gravity. The observations of these bedforms therefore make it possible to constrain or predict some environmental characteristics.

Solid bedfoms are induced by ablation or accumulation (resp.) transport mechanisms such as phase transitions. We call them sublimation and condensation waves (resp.). Less studied than loose bedforms, this solid bedforms on ice could be used for the same purposes (Earth, Mars, Pluto,...).

Mass-wasting or supply induced by phase change: In order to theoretically demonstrate the link between the geomorphological characteristics of these bedforms (wavelengths, amplitudes, migration) and the flow (velocity, viscosity, flow height) we have modelled the coupling of flow dynamics and mass transfer and performing a linear stability analysis with two subjacent objectives: do natural examples exist and are their dimensions linked to the environment? can we obtain scaling laws for all these objects?

Sublimation waves [2] have been observed on water ice on Earth (in Antarctica and in ice caves), we describe them on Mars and we have conducted wind tunnel experiments on CO2 ice. The adequacy between the observations/experiments and our model allows us to validate the approach of the formation of these sublimation waves by a hydrodynamic instability of the turbulent flow, in the case where the flow heigh is larger than the wavelength. The coupling of hydrodynamics with mass transfer allows us to deduce scaling laws for their size, their migration speed and their formation time to the characteristics of the environment [2].

Moreover, our model shows that condensation waves for an infinite flow can exist at a size observable by satellites. We can apply scaling laws similar to those for sublimation waves for these condensation waves. As these latter bedforms are built up, they have the advantage of having an internal stratigraphy, which implies the importance of radar for future exploration missions in search of this type of condensation waves.

Conclusion: Periodic bedforms can be generated by mass wasting/supply induced by phase change at different wavelengths, depending on the environmental conditions, on the direction of transfer (sublimation or condensation) and on the height of the flow in front of the wavelength. Thanks to the scaling laws we propose, these sublimation /condensation waves can therefore be used as geomorphological markers of surface-atmosphere interactions. To go further, we now seek to study the influence of the flow height on the morphological characteristics of these objects.

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