Geophysical Research Abstracts
Vol. 20, EGU2018-2054-1, 2018
EGU General Assembly 2018

Generation of periodic bedforms on Earth and Mars by sublimation/condensation of ice under turbulent winds

Maï Bordiec (1), Sabrina Carpy (1), Olivier Bourgeois (1), Marion Massé (1), and Laurent Perret (2)

(1) Laboratoire de Planétologie et Géodynamique, Université de Nantes, NANTES, France (mai.bordiec@etu.univ-nantes.fr), (2) Laboratoire de recherche en Hydrodynamique, Energétique et Environnement Atmosphérique, Ecole Centrale de Nantes, NANTES, France

Periodic transverse bedforms of differing wavelengths are common at the surface of glaciers. Ice ripples (20 to 30 cm in wavelength) and megadunes (2 km to 5 km in wavelength) have been described in Antarctica while their equivalents on Mars appear to be larger in wavelength: about 7 m and from 15 to 60 km, respectively. We aim to understand the mechanisms that generate and develop these periodic bedforms and to evaluate the plausibility that the same processes are involved on Earth and Mars.

Periodic transverse bedforms can develop and migrate on glaciers in response to ice redistribution by turbulent winds. We hypothesize that this kind of redistribution does not necessarily involve solid particle transport but may be controlled by sublimation and condensation, because these phase transition effects are dominant on Mars. Sublimation and condensation induce mass transfers between icy surfaces and overlying steady boundary layer turbulent flows. These mass transfers diffuse water vapor into the atmosphere and may be responsible for the instability of transverse bedforms.

To explore these mechanisms, we performed a linear stability analysis applied to a turbulent boundary layer flow perturbed by a wavy ice surface. The flow description requires the use of a turbulence model adapted to the damping induced by the perturbation of the wavy surface. Once the flow dynamics and the transport-diffusion equations are solved, the dispersion relation gives the growth rate, migration direction (upstream or downstream) and velocity of bedforms. We test two configurations (i) unbounded flow, where the bedform wavelength is smaller than the depth of the flow and (ii) bounded flow, where the bedform wavelength is larger than the depth of the flow.

For unbounded flow, our model shows that the primary linear instability results in amplification and propagation of centimetric to metric ice ripples. According to our model, the preferential wavelength of ice ripples on Mars should be about 30 times larger than on the Earth. We also find a good match between the most likely wavelengths predicted by the model and those observed in Antarctica and at the surface of Martian polar caps.

For bounded flow, both the free surface and the stable stratification of the atmosphere cause confinement effects on the generation and development of larger bedforms. These stabilizing effects have been widely explored for granular transport contexts. We are currently developing a new numerical model for finite-height flow, to evaluate whether a similar kind of stabilization is effective when mass transfers are controlled by sublimation and condensation. This model introduces a new valid dispersion relation (growth rate, velocity) for large-scale bedforms.