Geophysical Research Abstracts, Vol. 7, 05899, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05899

Patterning mechanism on Martian polar ice caps

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The permanent polar ice caps on Mars display conspicuous spiraling troughs that have no terrestrial analogue. A study of the origin of these troughs promises insights on the surface processes involved in shaping ice and other deposits in a unique environment. This paper investigates the underlying mechanisms, starting with the hypothesis that the trough planform is governed by atmospheric circulation, due to spatial instability operating in the flow direction of near-surface winds—which could explain the observation that the troughs at each pole spiral out in a sense opposite to that expected for local winds under Coriolis deflection. We study the instability by modeling surface interactions, focusing on how atmospheric dust and moisture (H_2O) regulate the surface albedo and mass and energy balance. It is found that pattern formation results from unstable coupling between albedo and H_2O-vapour pressure when moisture is driven by wind over the ice surface. The corresponding albedo pattern causes an alternating accumulation-ablation mass balance, so that an undulating topography develops which mimics the (dark) troughs and their adjacent (bright) smooth terrains on the polar caps. Because albedo patterning is fast, whereas topographic patterning is slow, we suggest that today's trough morphology may have been preconditioned by an ancient and rapid imprinting of surface albedo.