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Topographical control over seasonal sublimation of the Mars North polar cap

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Abstract

Spectroscopic analysis of the Mars permanent North polar cap (NPC) by MEX/OMEGA and MRO/CRISM instruments reveal apparent seasonal changes in the ice morphology during the summer season, implying that ice surface becomes increasingly coarse during the progression of season. This general trend is non-uniform in space, being particularly strong near inner edges of the spiral terraces. The comparison of spectroscopic data with high-resolution images returned by MRO/HiRISE camera shows that the extent of NPC apparent seasonal change revealed by NIR spectroscopy correlates with the orientation of dunes on the ice surface. In the inner edges of the spiral terraces, dunes are aligned preferentially in zonal direction, implying their formation under control of the meridional winds. In turn at the outer edges, where seasonal changes are less evident, dunes are aligned mostly in the meridional direction, assuming impact of the zonal atmospheric flow. Indeed, zonally aligned dunes have better conditions in terms of sunlight exposure, and their surface is expected to reveal faster aging. However the question arises what processes are responsible for this alignment.
We hypothesize that the dunes are formed under strong control of the local meteorology, dominated with competing mesoscale zonal circulation and local katabatic winds. In most cases the latter have meridional direction and maximize near the steepest relief, i.e. southward of the boundary between neighboring terraces. In some cases katabatic winds directions are in the strong interconnection with certain local and mesoscale topography features. Thus seasonal changes of the ice surface microstructure are connected with the relief on the scale of tens of meters, which in turn may be formed under influence of the local wind pattern controlled by large-scale relief of the North polar cap.

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