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Predicting Martian dune shape and orientation from wind directional variability and sediment availability

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Dunes provide a unique set of information to constrain local climatic regimes on planetary bodies where there is no direct meteorological data. Wind directional variability and sediment availability are known to control the dune growth mechanism (i.e. the bed instability or fingering modes) and the subsequent dune shape and orientation (Courrech du Pont at al., 2014; Gao et al., 2015). Here we provide a quantitative analysis of these dependences on Mars using the output of the Martian General Circulation Models (GCM) and satellite imagery such as the Mars Reconnaissance Orbiter (MRO) Context Camera (CTX) images, at a selection of places where there is a high contrast between the dune material and the non-erodible ground. Dunes, mostly composed of unweathered basaltic and andesitic grains, appear dark, whereas the non-erodible ground has a higher albedo. Such a systematic contrast permits to link dune morphology to the local sediment cover. Dune shape, crest orientation and local sediment cover are extracted from CTX images using an automatic linear segment detection method and the local distribution in albedo. In zones of high sediment supply, dune crest alignments are close to the orientation of the bed instability mode predicted from the local winds from the Martian Climate Database (MCD) where is stored the outputs of the IPSL-GCM for Mars (Millour et al., 2014). Using the same wind data, in zones of low sediment supply, the crest angle is close to the orientation of the fingering mode. In addition, there are continuous transitions in dune shape and orientation as the dunes migrate from zone of high to low sediment availability. These results indicate that the prediction of the IPSL-GCM are in good agreement with the present dune shapes and orientations and shed new light on the dynamics of complex dune fields along sand flow path.