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From sand pile to migrating dune - morphological transition of a barchan in a laboratory wind tunnel

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Aeolian sand dunes have always attracted the attention of researchers around the world not only for their beautiful shapes, but also for their complexity and demanding physics. Yet the genesis and evolution of dunes and dune fields on Earth, as well as on other planets and moons, e.g. Mars and Titan, are not fully understood. Due to the increasing impact of climate change on our environment the investigation of dunes and their dynamics has an even higher importance and could help to take protective measures against desertification effects.

However, the investigation of dunes by means of field research and remote sensing is only possible to a limited extent, due to the large time scales involved. Moreover, the large separation of length scales does not allow to simulate every single sand grain of a dune, while small-scale experiments are challenging, as the smallest aeolian dunes observed on Earth have a length of 10 meters.

Here we show the investigation of centimeter sized barchan dunes in a laboratory wind tunnel by using specifically tailored particles that show uniquely reduced cohesive forces. Starting from an initial sand pile, we observe the formation of a proto-barchan, its morphological transition into a barchan dune and subsequent migration. While the morphology shows great similarities to Martian dunes, the migration velocity scales with wind speed in accordance with barchan dunes in nature.

Due to the high level of flexibility to perform experiments in a small space and a short time, the investigation of dunes in a laboratory wind tunnel complement the naturally less controlled field measurements and offers a test bed for detailed comparisons with models of dune formation. Hence our laboratory dunes have the potential to shed light on the genesis, evolution and dynamics of aeolian dunes on earth and remote planets from a new perspective.