Planar and Volumetric Quantification of Flow Associated with Interacting Barchan Dunes

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An experimental investigation of flow around interacting barchan dunes is presented herein. Barchan dunes are three-dimensional topographic features that are produced by geophysical flows in both aeolian and subaqueous environments (i.e., river beds, continental shelf; Charru and Franklin, 2012). Barchans have been discovered on the surface of several planets, typically in regions with low variability in flow direction and limited sediment supply (Bagnold, 1941, Lancaster, 2009). They appear in fields in which each bedform is characterized by a mean migration rate that is inversely proportional to the bedform size (Andreotti et al., 2002). In such a scenario, dune-dune interaction mechanisms control dune evolutionary processes that involve collision, merging and splitting, producing highly dynamic topographic systems (Endo et al., 2004). While the morphology of barchan dunes has been widely studied (Lancaster, 2009), the morphodynamic interaction mechanisms controlling their formative processes remain poorly understood.

In this paper, we report both high-resolution planar and volumetric PIV measurements focusing on a number of simplified tandem configurations in which the interaction between barchan dunes modifies the flow as compared to the flow around an isolated dune (Fig. 1). The case of a symmetrical isolated barchan dune is reported for comparison. The investigation is based on use of a refractive index matching (RIM) approach developed in previous work (Blois et al., 2012, 2013). Physical models of barchan dunes, whose morphology was based upon previous wind tunnel experiments (Palmer et al., 2012), were fabricated by casting a urethane material into a mold that was 3D printed. The models were fixed in a RIM flow tunnel and rendered invisible, thus facilitating unimpeded data collection around the whole bedform. Planar measurements at high spatial and temporal resolution were conducted in the x-z plane at several elevations in order to reveal the three-dimensionality of the flow. In addition, volumetric measurements were performed to reveal the three-dimensional coherent structures shedding from the barchan crests and observe their evolution as they convect and impinge onto the downstream barchans. Our results have significant morphodynamic implications. The offset cases we considered show that the flow symmetry is highly sensitive to dune alignment and this can provide insight to understand the imperfect symmetry of barchans in natural environments. The RSS and TKE maps generated by our measurements demonstrate that the dynamics of the shear layer separating at the crest may drive the transport of sediment from the upstream dune and also erosion processes on the downstream dune.

![Fig. 1 Schematics of the barchan tandem configurations.](image)