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# Migration of Reversing Dunes Against the Sand Flow Path as a Singular Expression of the Speed-Up Effect

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We study the morphodynamics of reversing dunes on the gravel deposits of the alluvial fan of the Molcha river at the border between the Tibetan Plateau and the Taklamakan Desert (Gao et al., 2021). Independent sets of wind data show that this area of low sand availability is exposed to two prevailing winds from opposite directions and of different strengths. The predicted resultant transport direction of sand particles is westward. Nevertheless, satellite observations combined with field measurements and ground-penetrating radar surveys reveal that isolated dunes a few meters high migrate eastward. This apparent dune migration paradox is resolved using numerical and analytical models that take into account the speed-up effect and the continuous change in dune shape after each wind reversal. When a newly established wind hits what was before the steeper lee slope of the dune, the sand flux at the crest abruptly increases before relaxing back to a constant value as the crest migrates downwind and as the dune reaches a new steady shape. Integrated over the entire wind cycle, we find that this non-linear behavior causes reversing dunes to migrate against the resultant transport direction. This migration reflects the difference in dune slope seen by irregular storm events blowing to the east and the westward wind of the daily cycle. Thus, we explore the impact of extreme events on dune morphodynamics and examine new aspects of the permanent feedback between dune topography and wind speed. We conclude that transient behaviors associated with crest reversals contribute to the observed diversity of dune patterns, even within the same area for dunes of different sizes.

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