Beach-dune dynamics: Spatio-temporal patterns of aeolian sediment transport under complex offshore airflow

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This study examines sand transport and wind speed across a beach at Magilligan Strand, Northern Ireland, under offshore wind conditions. Traditionally the offshore component of local wind regimes has been ignored when quantifying beach-dune sediment budgets, with the sheltering effect of the foredune assumed to prohibit grain entrainment on the adjoining beach. Recent investigations of secondary airflow patterns over coastal dunes have suggested this may not be the case, that the turbulent nature of the airflow in these zones enhances sediment transport potential. Beach sediment may be delivered to the dune toe by re-circulating eddies under offshore winds in coastal areas, which may explain much of the dynamics of aeolian dunes on coasts where the dominant wind direction is offshore.

The present study investigated aeolian sediment transport patterns under an offshore wind event. Empirical data were collected using load cell traps, for aeolian sediment transport, co-located with 3-D ultrasonic anemometers. The instrument positioning on the sub-aerial beach was informed by prior analysis of the airflow patterns using computational fluid dynamics. The array covered a total beach area of 90 m alongshore by 65 m cross-shore from the dune crest. Results confirm that sediment transport occurred in the 'sheltered' area under offshore winds. Over short time and space scales the nature of the transport is highly complex; however, preferential zones for sand entrainment may be identified. Alongshore spatial heterogeneity of sediment transport seems to show a relationship to undulations in the dune crest, while temporal and spatial variations may also be related to the position of the airflow reattachment zone. These results highlight the important feedbacks between flow characteristics and transport in a complex three dimensional surface.