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Offshore airflow over coastal foredunes: new approaches and methodology

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Exchange of windblown sand between beaches and coastal foredune systems is a key component of sediment budget analysis along many coastlines. The techniques employed to measure and understand processes operating within this key transitional zone have advanced rapidly in recent years, providing important data at a range of temporal and spatial scales. Patterns of foredune development and, by association, beach dynamics holds important implications in better understanding the management of such systems.

When major coastal dune fields are established on coasts where the predominant wind blows offshore it produces a scientific conundrum. The origin of the dunes is normally attributed to past occurrence of significant onshore wind regimes and, by implication, subsequent changes in climate. The occurrence of offshore wind events in local wind regimes is therefore normally excluded from analysis as they are deemed ineffectual in driving sediment onshore and constructing foredunes. However, recent work by the authors has demonstrated that given particular local parameters such as topography, sediment size etc. this offshore component can be steered or undergo flow reversal through leeside eddying (detached flow) to give onshore transport events at the back beach under these offshore flow conditions.

At particular distances from the foredune crest detached flow re-attaches to the surface to continue its incident offshore direction. The location of this re-attachment point has important implications for aeolian transport of sand on the back beach and foredune toe locations. Work is presented that examines the methodology used and some of the results emerging from several experiments conducted at Magilligan Strand, Northern Ireland in September 2009 and Aril 2010. Using detailed field measurements from twenty four, three-dimensional sonic anemometry and computational fluid dynamic (CFD) modelling, a temporal and spatial pattern of reattachment positions is described. The use of in-situ 3D anemometry enables examination of the dominant flow vector at each of the measurement stations. From this surface shear stress and thus potential transport can be determined. Use of highly specialised CFD airflow modelling is a necessary supplement to the suite of techniques used in the study. It provides a useful method of optimally locating instruments on complex terrain in the initial experimental design phase. Modelling then enables a comprehensive spatial examination of the site for characterising flow behaviour.

Results show that over a 150 m longshore distance, the positioning of the re-attachment point is mobile and is driven by incident wind direction (at the foredune crest) and the actual undulations of the foredune crest's topography, giving heterogeneous flow behaviour at the beach. This has direct implications for where particular zones of flow behaviour are located on the beach, ultimately dictating transport patterns on the backbeach and foredune toe areas.

Finally, implications for aeolian transport and dune evolution at other sites will also be discussed.