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3D Airflow patterns over coastal foredunes: implications for aeolian sediment transport

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A fundamental criterion for the development of coastal sand dunes is usually highlighted as a significant onshore wind component of the local wind field. The presence of large sand dune systems on coasts where the predominant wind blows offshore is therefore difficult to explain and usually they are attributed to the past occurrence of onshore winds and, by implication, subsequent changes in climate.

Recent studies have shown that offshore winds can be deflected or 'steered' by existing dunes so that their direction changes. This can occur to such an extent that a process known as 'flow reversal' can arise, whereby the initially offshore wind actually flows onshore at the beach. This process is important because it can cause sand to be blown from the beach and into the dunes, causing them to grow. This may be central in explaining the presence of extensive dunes on coasts where the dominant wind is offshore, but is also important in how dunes recover after periods of wave erosion during storms. Offshore winds have traditionally been excluded from sediment budget calculations for coastal dunes, but when they do transport sand onshore, this may have been an important oversight leading to significant underestimates of the volume of sand being transported by wind.

This work investigates the controls on the processes and the mechanisms involved in deformation of the flow and resulting sediment transport at coastal foredunes in Northern Ireland. We use a combination of field measurement of wind and sediment transport coupled with state-of-the-art aerodynamic modelling using computational fluid dynamics (CFD) and 3-D sonic anemometry. Our working hypothesis is that offshore winds contribute substantially to foredune behaviour on leeside coasts.

Preliminary results show strong reverse flow eddies in the seaward side of the foredunes during offshore wind events. These secondary flow reversals have been above velocity threshold and are transport capable. Using CFD modelling across a high resolution LIDAR surface of the dunes and beach we have isolated key areas of wind direction and velocity patterns which are important in aeolian transport budgets.

Results are particularly important in post-storm recovery of foredunes damaged under wave action as offshore winds can initiate significant onshore transport, re-supplying the backbeach and foredune zones.