Reattachment zone characterisation under offshore winds with flow separation on the lee side of coastal dunes

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Airflow separation, lee-side eddies and secondary flows play an essential role on the formation and maintenance of sand dunes. Downstream from dune crests the flow surface layer detaches from the ground and generates an area characterised by turbulent eddies in the dune lee slope (the wake). At some distance downstream from the dune crest, flow separates into a reversed component directed toward the dune toe and an offshore "re-attached" component. This reattachment zone (RZ) has been documented in fluvial and desert environments, wind tunnel experiments and numerical simulations, but not yet characterised in coastal dunes. This study examines the extent and temporal evolution of the RZ and its implications for beach-dune interaction at Magilligan, Northern Ireland. Wind parameters were measured over a profile extending from an 11 m height dune crest towards the beach, covering a total distance of 65 m cross-shore. Data was collected using an array of nine ultrasonic anemometers (UAs) deployed in April-May 2010, as part of a larger experiment to capture airflow data under a range of incident wind velocities and offshore directions. UAs were located along the profile (5 m tower spacing) over the beach, which allowed a detailed examination of the RZ with empirical data. Numerical modelling using Computational Fluid Dynamics (CFD) software was also conducted with input data from anemometer field measurements, running over a surface mesh generated from LiDAR and DGPS surveys.

Results demonstrate that there is a wind threshold of approximately 5-6 ms^{-1} under which no flow separation exists with offshore winds. As wind speed increases over the threshold, a flow reversal area is quickly formed, with the maximum extent of the RZ at approximately 3.5 dune heights (h). The maximum extent of the RZ increases up to 4.5h with stronger wind speeds of 8-10 ms^{-1} and remains relatively constant as wind speed further increases. This suggests that the spatial extent

of the RZ is largely independent of incident wind speed and is located between 4-5h. The magnitude of the maximum extent of the RZ is similar to that simulated using CFD and is consistent with previous studies conducted in desert dunes and wind tunnel simulations for offshore winds blowing over tall and sharp-crested dunes. Ongoing analyses are being conducted to evaluate the effect of changing wind direction, dune height and shape.