THE INFLUENCE OF BEACH-FOREDUNE MORPHOLOGY ON LOCAL WIND CHARACTERISTICS

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Introduction

Along the Holland coast in the Netherlands high and steep dunes act as a primary defense against flooding of the hinterland. To predict dune erosion by wave action, advanced numerical models can be used in both scientific projects and policy-making. However, coastal foredunes recover in between storms by aeolian sediment transport from the (intertidal) beach. Predictive models for dune recovery are still in their infancy because of, among a number of aspects, the potentially strong spatial variability in wind characteristics on the beach. Mean wind characteristics (speed and direction) are likely to vary across the beach, owing to the presence of the foredune front. Furthermore, because aeolian transport is strongly intermittent, a better understanding of wind turbulence across the beach is needed to improve predictions of sediment transport rate. In our research we examine the spatial variability of mean wind velocity and direction, and of turbulence at the beach of Egmond aan Zee, the Netherlands.

Methods

Three-dimensional wind velocities were measured at a height of 0.9 m and a frequency of 10 Hz. We used 4 to 6 ultrasonic anemometers (Figure 1) in a cross-shore array between the waterline and the dune foot, depending on the beach width. During two 6-week field campaigns in autumn 2015 and 2017 and three additional days with strong winds (winter 2017), measurements were performed nearly every day during daytime. This field work resulted in an extensive dataset with mean wind speeds ranging from no wind up to 15 m/s. The velocity data were processed into a 10-minute mean velocity ($\bar{u}$), mean turbulent kinetic energy (TKE) and wind direction.

Results

Results show that during onshore winds the mean wind velocity is decreasing from the waterline towards the dune foot, while the TKE remains constant over the beach and is slightly higher at the dune foot. As a result, the gustiness (that is, the ratio of TKE to mean wind speed) increases towards the dune foot. The mean wind velocities can be 1.5 times higher at sea than at the dune foot. During times of more alongshore winds, wind speed and TKE are spatially more uniform, but the wind direction is steered substantially in the alongshore direction, especially near the dune foot.

Discussion and outlook

The effect of a coastal foredune on local wind patterns has the potential to substantially reduce the aeolian sand supply to coastal foredunes, because the drop in velocity near the dune foot reduces pick-up rates and promotes deposition. Our findings show that in order to accurately predict aeolian sand supply to coastal foredune systems, at least the effects of local wind patterns should be incorporated. Moreover, a cubic relation between TKE and windspeed, a basic assumption for most sediment transport equations, was not found here. Further research is needed to elucidate the role of turbulent structures and spatial variation herein on sediment pick-up rates.

Figure 1. An ultrasonic anemometer in front of the high and steep foredune at Egmond aan Zee, the Netherlands.