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Biogeomorphic development of foredune trough blowouts quantified from medium-resolution satellite imagery

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Foredune trough blowouts are wind-eroded trough-shaped hollows in the most seaward coastal dune with their adjoining depositional lobes. They evolve on time scales ranging from strong wind events, seasons to multiple decades due to biogeomorphic interactions. Trough blowouts play an essential role in the sand budget of many coastal dune systems by connecting the beach with the backdune. There, the deposited sand can lead to vegetation rejuvenation and an overall larger floral diversity. In Northwestern Europe, nature and coastal managers have started to experiment with constructing trough blowouts in the hope that a positive sand budget beyond the foredune in concert with enlarged biodiversity improves coastal resilience in times of climate change. The spatio-temporal evolution of trough blowouts and the factors driving this evolution are not well understood, despite their common natural occurrence and construction for nature-based management.

The aim of this contribution is to quantify the spatio-temporal development of selected trough-blowout systems around the globe utilizing cloud-free medium-resolution Landsat and Sentinel-2 spectral imagery available in the Google Earth Engine platform. Linear spectral unmixing was applied on a single image basis to extract blowout surface area over time at one man-made blowout system (Zuid-Kennemerland, Netherlands) and two natural systems (Haurvig, Denmark; Padre Island, Texas, USA), assigning pixels with a fractional vegetation cover less than 50% to the blowout. At Zuid-Kennemerland and Haurvig, the blowout surface area fluctuated predominantly on seasonal time scales, with the smallest and largest values in late summer/early autumn and late winter/early spring, respectively. This seasonal variability reflects plant phenology in combination with increased sand accumulation in winter because of the more energetic wind conditions. In summer, vegetation regrew mainly at the edges of the depositional lobes and on the foredune between individual blowouts. The blowout surface area at the subtropical Padre Island varied predominantly on a multi-annual time scale. Most notably, multi-annual area decay was observed when a blowout progressed inland and lost its open connection to the beach, likely resulting in less physical disturbance and hence a dominance of ecological processes. In future work, we will combine our results with auxiliary information (e.g., multitemporal digital elevation models, time series of external forcing conditions, plant species and traits) to develop and test an eco-geomorphological model for blowout evolution. Such a model is adamant to understand what factors contribute to the success or failure of dune restoration projects involving blowouts as nature-based solutions to increase coastal resilience.