One year monitoring of early-stage dune development

Glenn Strypsteen

Hydraulics and Geotechnics, Department of Civil Engineering, Bruges Campus, KU Leuven, Spoorwegstraat 12, 8200 Bruges, Belgium
E-mail: glenn.strypsteen@kuleuven.be

1. INTRODUCTION

The Belgian coast is a sandy coast, and the beach provides natural protection against flooding. During moderate and high wind events, the wind causes the sand to move. Sand moving landward can form dunes, strengthening the coastal protection. At locations without dunes but where, for example, dikes form the protection, the sand can cause nuisance during severe storms. It is therefore that coastal managers are getting convinced of building with nature concepts, such as engineered dunes in front of traditional dikes, to strengthen coastal protection and as sand mitigation measure. For an optimal design of these marram grass planted dunes, a fundamental knowledge of the morphological changes of dune development is required. Hence, the characterization and prediction of aeolian sediment supply from the beach to the dune is a key component in the development of comprehensive models for beach and dune interactions.

In this study, we investigate dune growth of the 120x20m² dune-in-front-of-a-dike pilot site in Oosteroever, Belgium by exploring a multi-monthly dataset of wind characteristics and high-resolution topographic datasets. This dune field is planted with marram grass (Figure 1B) with three different plant densities (6, 9 and 15 plants/m²) and four spatial configurations (gridded, random, clustered, and staggered) providing a unique experimental setup to study dune growth in the early stage.

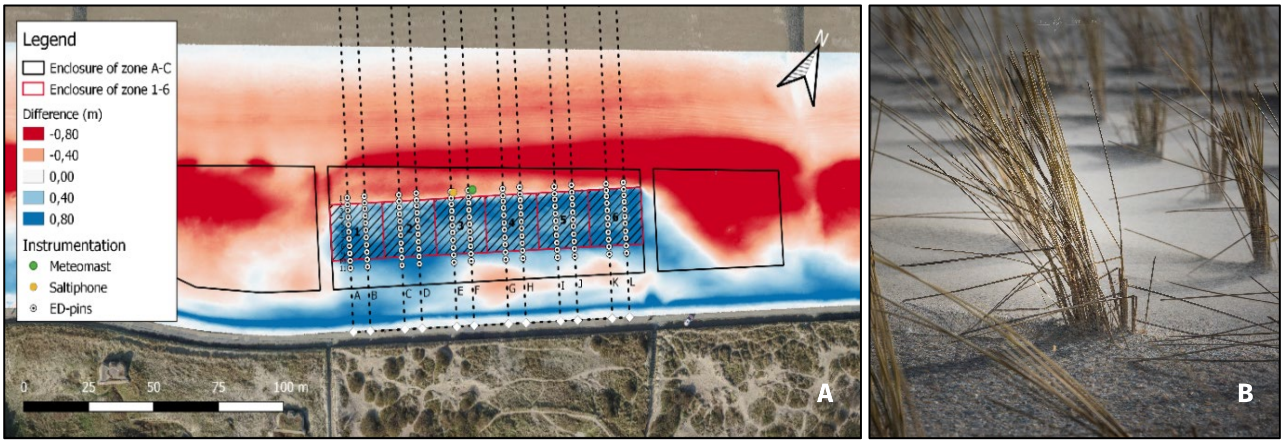

Figure 1: (A) Experimental setup at the dune-in-front-of-a-dike pilot site in Oosteroever. Planted zones are 20x20 m² (6 in total). Blue and red colors show deposition and erosion between the drone surveys of 08/03/2022 and 11/01/2021. (B) Planted marram grass.

2. METHODS

A long-term monitoring station at the study site was erected which permitted the acquisition of continuous records of wind that can be coupled with sand transport measurements over period of months to years. Local wind speed and direction was measured at the seaward side of the dune foot for 9 months with cup anemometers at four logarithmic heights above the surface and a wind vane to extract surface roughness and shear velocities from the vertical wind velocity profiles. Averaged wind data was stored on a Campbell datalogger every 20 seconds. Aeolian transport intensity was measured at a height of 10 cm above the sand surface every one second with a saltiphone. Data on regional wind data, precipitation, and tidal elevations is accessed from Meetnet Vlaamse Banken at Meteopark Oostende located next to the study site. Dune growth is weekly measured by using a combination of erosion-deposition (ED) pins and RTK-GPS measurements along 12 predefined cross-shore profiles (Figure 1A).

Furthermore, topographic elevation changes are measured on a more detailed spatial level with drone flights once every month (except for the summer period) conducted by ATO and Flanders Coastal Division.

3. RESULTS

The total volume of sand in the dune has increased significantly since the plantation of the marram grass (i.e., end of January 2021). In total 14 m³ m-1 of sand has been added due to the aeolian processes translating into a vertical elevation increase of approximately 1 m (Figure 2A). The months March and April 2021 were responsible for half of the annual dune growth (Figure 2B). The other months delivered a comparable amount of net sediment input to the dune (i.e., approximately 1 m³ m-1) but slowly decreased towards the end of the year. From October 2021 onwards the dune volume remained fairly stable due to a combination of supply limitations and a decrease in vegetation trapping efficiency. However, a large amount of sediment is deposited in the landward area of the dune (i.e., 3 m³ m-1). Moreover, the dune suffered from erosion during storm Corrie (i.e., end of January 2022) where cliffs at the dune toe were formed up to 1.5 m exposing the underlying roots of the marram grass. Nearly 1.5 m³ m-1 of sand was eroded in a couple of hours. Initial vegetation patterns in the dune disappeared resulting in a more natural and dynamic dune field. Vegetation growth and density varied throughout the year and thus its sand trapping efficiency.

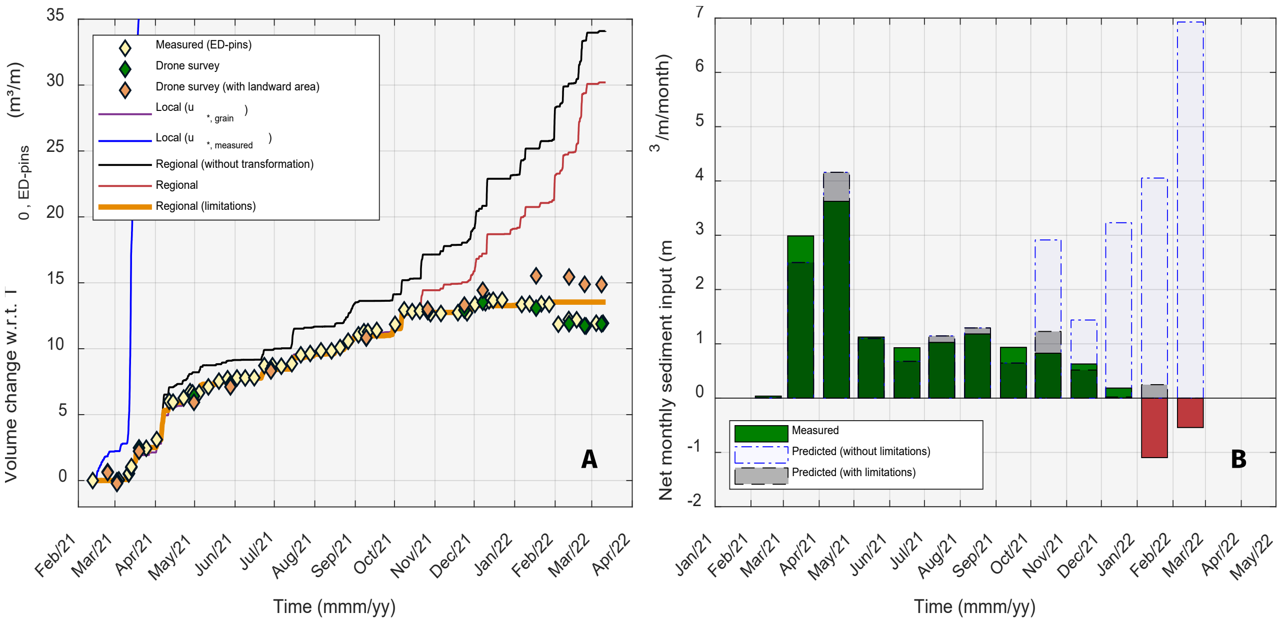

Figure 2: (A) Total sand volume changes in the dune area (120x20m²) with corresponding predictions (with and without supply/vegetation limitations). (B) Monthly net sediment input towards the dune showing measured and predicted values.

The results show a significant dune growth in the dune-in-front-of-a-dike pilot site of Oosteroever which is encouraging for coastal protection. Marram grass proves to be a good mitigation measure to keep the sand on the beach. However, dune growth is influenced by supply limitations, vegetation characteristics, and sediment erosion by wind and storm events.

4. ACKNOWLEDGEMENTS

Thanks to the city of Ostend and Coastal Division to give us the opportunity to work on such a unique pilot site. We thank the support of VLIZ (Flanders Marine Institute) for the use of their research infrastructure. Bart Roest and Jennifer Derijckere, thanks for the help in the field. Thanks to Research Foundation – Flanders for project funding (number: 1243022N).