New investigation of coastal dunes evolution along the Belgian coast using ground-penetrating radar

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1. INTRODUCTION

Coastal foredunes are natural features, reflecting interaction among geomorphological and ecological processes. Their formation depends on a wide range of environmental factors, but is associated with strong onshore winds, an ample supply of sediment for aeolian transport and the presence of vegetation to trap sand. Foredune evolution is thus controlled by a broad spectrum of spatial and temporal forcing processes. The advance of geophysical methods such as the ground- penetrating radar (GPR) allows to obtain stratigraphic information on aeolian landforms by reconstructing evolutionary characteristics of the sub-surface. The analysis of GPR data results in the interpretation of radar facies indicating the architectural elements related to depositional environments and allows to extend the more recent 2D database obtained using traditional topographic instruments (Robin et al., 2021). The aim of this study is to investigate coastal foredune evolution at multidecadal scale by combining GPR and airborne LiDAR surveys.

2. STUDY SITE

Groenendijk is a macro-tidal beach located in the western part of the Belgian coast, between Oostduinkerke and Nieuwpoort-Bad (Figure 1). It is typically characterized by well-developed and vegetated foredunes approximately 10m high above TAW. The dune and beach have propagated at a significant rate over the last decades. Onshore high wind speed events (>10 m/s) are associated with SW-W-NW atmospheric circulations which are also associated with the possible occurrence of storm surge (Montreuil et al., 2016).

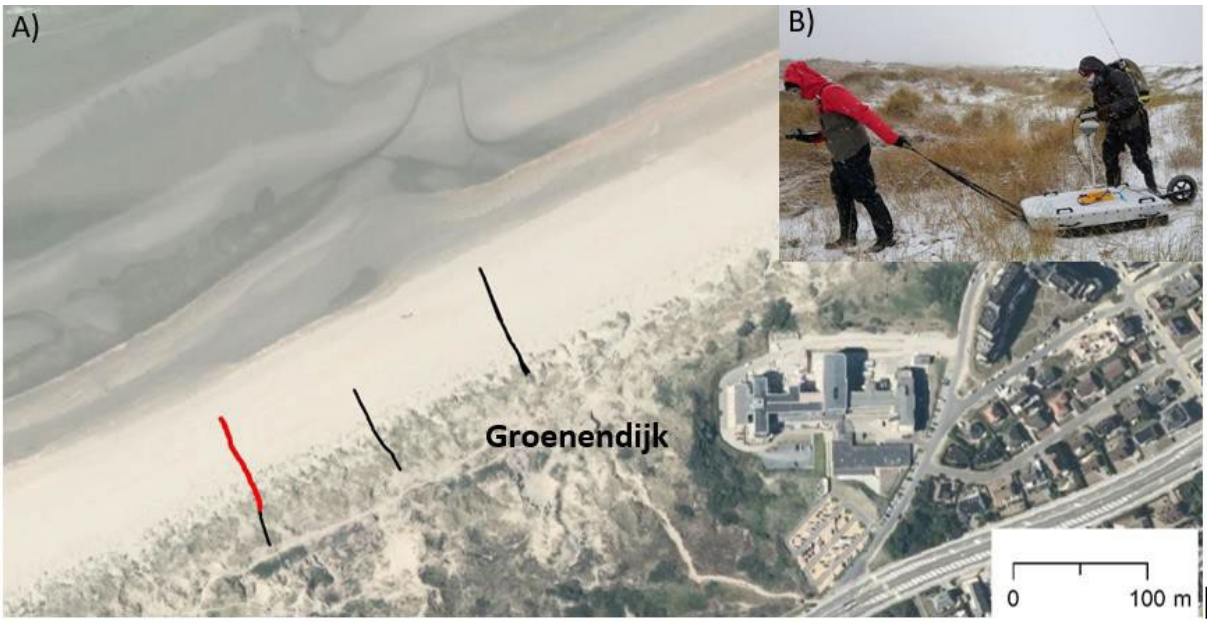

Figure 1: A) Location map of the 6 GPR profiles (profile 601 in red), B) field photograph of the equipment

3. METHODOLOGY

Ground Penetrating Radar (GPR) is a geophysical non-destructive method used to image sedimentary structures and it has been successfully applied in coastal studies (e.g. Robin et al., 2021).

It is based on the propagation and reflection of transmitted electromagnetic pulses. The internal architecture of the foredune at Groenendijk was surveyed in January 2012 using a Mala ProEx system coupled with a RTK-GPS along six cross-shore profiles (Figure 1). The detailed internal architecture of the coastal dune system was imaged using three GPR antennae (100, 250 and 500MHz). Data were processed using ReflexW Software and a constant radar velocity of 0.06 m/ns. After processing, the GPR images were interpreted on the basis of radar facies identified on the profile. The results were then compared with a profile time series extracted from LiDAR surveys provided by Coastal Division.

4. RESULTS

The GPR signal recorded across the profile indicates the upper 3-5m of the internal structure of the dune (Figure 2). It shows two stages of construction and evolution. There was a formation of the foredune at D=70m principally by aggradation until 2010. The position of the dunefoot changed slightly. After 2010, the internal architecture displays a progradational configuration with oblique reflectors towards the NW (seaward), suggesting a rapid development of the foredune and seaward regression of the coastline. During this period, most of the evolution occurred in the center of the profile, while the dune located to the SE of the profile (D = 70m) seems to undergo only a slight change. This study highlights that GPR method combined with chronological topographic data is an efficient tool to understand foredune evolution over the last decades and for management applications.

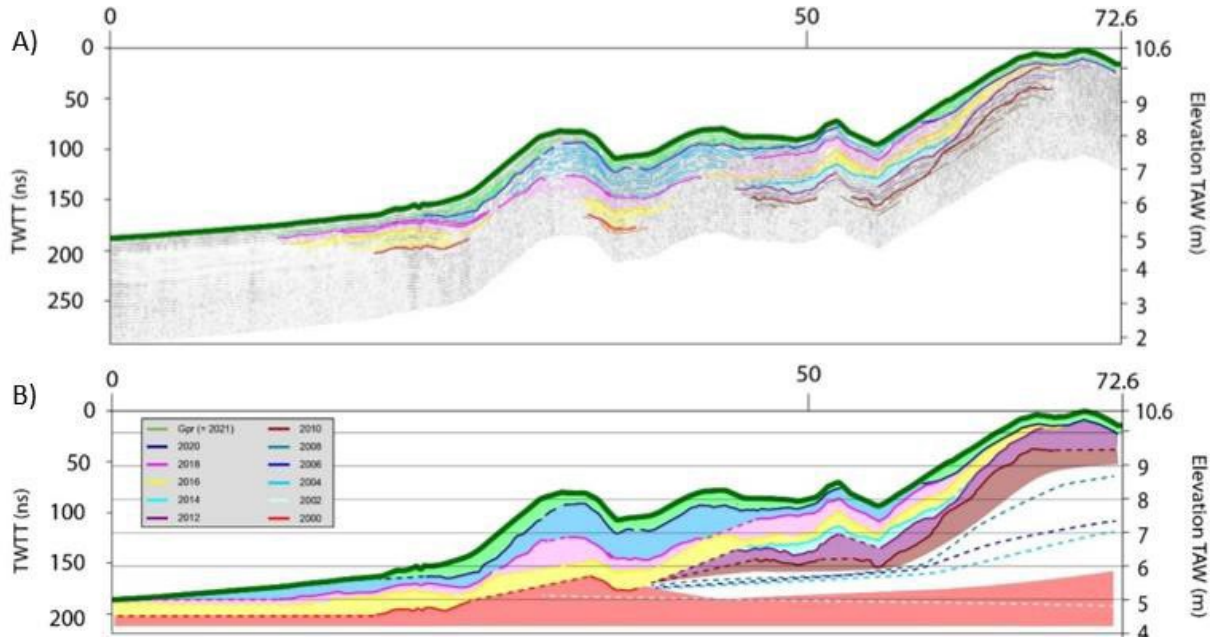

Figure 2: A) reflection-traced versions of the internal architecture of the 601 profile, B) superposed on interpreted GPR and LiDAR profiles.

5. ACKNOWLEDGEMENTS

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