A field-based model predicting early-stage dune development

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1. INTRODUCTION

An understanding of aeolian sediment transport processes and its interaction with vegetation (i.e., marram grass) is crucial for predicting the development and evolution of coastal sand dunes. More particularly, coastal managers are getting convinced of building with nature concepts, such as dunes in front of dikes, for coastal protection. For an optimal design of these artificial dunes, a fundamental knowledge of morphological changes during the early stages of dune development is required, which heavily relies on the interactions between plant density, distribution, height and morphology and sediment. Despite many decades of research, we remain unable to accurately predict aeolian sediment transport as input for dune growth and the subsequent dune development due to a lack of process knowledge and because of the inherent spatiotemporal complexities of aeolian sediment transport.

With this project, we aim to develop a field-based model predicting dune development in a unique engineered dune field in Oosteroever (Ostend), Belgium by means of dedicated field experiments focusing on sediment transport rates, wind characteristics, vegetation characteristics, and topographic changes (Figure 1). This dune field is planted with different plant densities (6, 9, and 15 plants/m²) and spatial configurations (regular, random, and clustered) providing a unique experimental setup to study dune growth in the early stage. The project offers the necessary link to an integrated coastal zone model describing long-term coastal evolution which can be used to assess the effects of climate change and human disturbance.

Figure 1: Location of the dune-in-front-of-a-dike in Oosteroever, Belgium (image taken on 11 March 2021). Within the engineered dune design marram grass is planted in different spatial distributions with three densities. The dune is surrounded by a fence to prevent beach passage.

2. SCIENTIFIC RESEARCH OBJECTIVES

In this research, the supply-limiting effects of shells, moisture, and vegetation on aeolian sediment transport rates are targeted as well as the improvement of estimating bed roughness, bed shear stress, threshold shear velocity and saturated transport rate. All this information is of fundamental interest to better predict dune development and evolution.

The specific objectives of this research are addressed in three work packages (see Figure 2):

(1) To quantify aeolian sediment transport rates as driving factor for dune development. Here, we obtain a large and high-quality field dataset on aeolian sediment transport processes by quantifying it through dedicated field experiments.

(2) To couple aeolian sediment transport to topographic changes within the dune field. Here, we conduct field experiments focusing on the interaction between aeolian sediment transport rates and vegetation. In this objective we do not focus on the biological processes of the vegetation.

(3) To setup and validate a field-based model predicting early-stage dune development (first 3 years). Here, the objective is to develop a field-based model starting from the process-based aeolian sediment transport model AeoLiS.

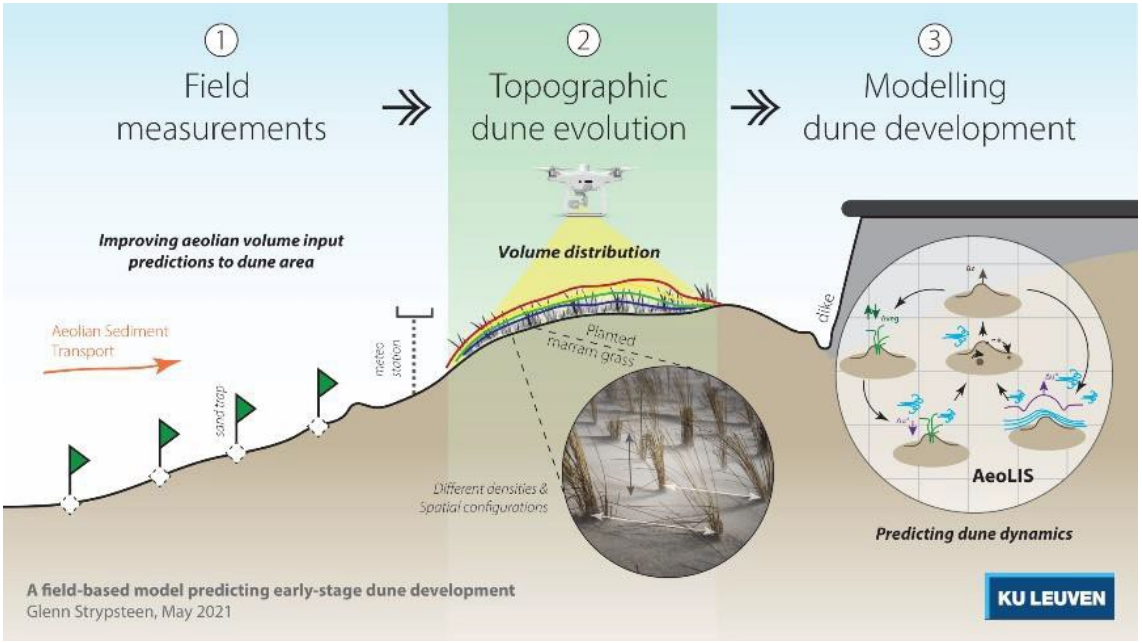

Figure 2: The research methodology consists of three work packages targeting three specific research objectives

3. RESEARCH METHODOLOGY

To reach the objectives of this project, we address the research hypothesis using a combination of field data, analysis and state-of-the-art aeolian models. The results from work package 1 and 2, focusing on aeolian sediment transport processes and its interaction with vegetation respectively, form the basis to setup and validate the field-based model predicting early-stage spatiotemporal dune development developed in work package 3. This project revolves around a unique data-rich study site. This site is a real-life case study of a dune-in-front-of-a-dike coastal defense system and gathered data will form the knowledge base needed for scientific analysis and exploration of new coastal managing strategies.

4. NOVELTY

The focus of this research on aeolian sediment transport and early-stage dune development addresses some unique knowledge gaps. So far, we are unable to predict dune development in an accurate manner and we have not a good understanding on the evolution of engineered dune fields. The high-quality data set on aeolian sediment transport and analytical relationships between vegetation and dune morphologic evolution that will be achieved in this project will encompass a necessary scientific step in the integrated understanding of coastal dune landscapes.

The approach to use a unique dune-in-front-of-a-dike using state-of-the-art measurement equipment and research methodologies is original and extraordinary. Moreover, the use of innovative tools for field measurements and numerical models to quantify dune development is exclusive.

5. ACKNOWLEDGEMENTS

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