Understanding spatial variation in river dune dynamics for operational forecasts of peak bed levels

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1. Introduction

River dunes are dynamic bedforms formed by the constant interaction between the stream flow and an erodible bed. A better understanding of the spatial variation in dune height, length and celerity with interaction with the underlying morphology helps to forecast shallow areas in navigation channels. Such forecasts can help river managers to communicate shallow areas to shippers and effectively plan maintenance dredging of the fairway to enable shipping.

Local morphology, such as bars and bends, can influence the development and shape of river dunes (Ruijsscher et al., 2020). Especially differences in hydraulic forcing, resulting local shoals and deeper areas influence dune height and celerity. We, therefore, hypothesize that lateral variation in dune dynamics, both dune shape and celerity is mainly related to spatial variability in hydrodynamic forcing, and that 3D behaviour is the result of the interaction between the local 2D dune dynamics.

This hypothesis is studied by analysing the spatial propagation of dune crests in frequently measured bed elevation maps of the fairway and tested with numerical modelling of river dune dynamics.

2. Methods

To derive the spatial varying dune celerity, a set of weekly bed elevation maps of the Waal River in The Netherlands is analysed using a spatial cross-correlation algorithm that is inspired by techniques used in particle tracking velocimetry (Willert & Gharib, 1991). Therefore, we specify an area around the crest in a bed elevation map at t_0, the sample, and search for the location where the sample results in the highest cross-correlation in a predefined search area in the bed elevation map at $t_0 + \Delta t$. This is done for multiple samples covering each crest line to derive a dune celerity field. Differences in dune propagation and dune shape are compared to the local larger scale morphodynamic features such as bars and river bends.

The derived dune celerity and variation over the cross-section will be combined with a numerical dune development model (Lokin et al., submitted) to make predictions of the most likely bed development.

3. Preliminary Results and Remarks

First results show that the method of spatial cross-correlation is able to identify where a dune crest is moving towards (Figure 1). However, the interval between two measurements must be such that the shape has not changed such that correlations cannot be made.

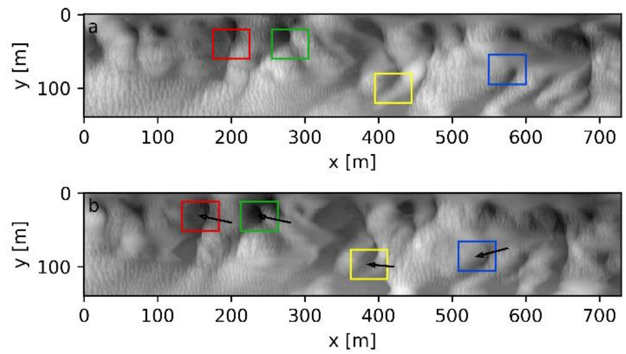

Figure 1. Example of two consecutive dune fields in the Waal River. a) Bed elevation at t = 0 days, b) bed elevation at t = 6 days. The boxes indicate the samples and the arrows in b indicate the displacement and direction.

We found that automized spatial cross-correlation between bed elevation maps is a promising tool to determine the spatial variation in dune propagation. Combined with the dune development model this tool can help to better understand the 3D dynamics of river dunes and help to predict shallow areas to proactively plan fairway maintenance in the future.

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