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Modelling river dune length adaptation during variable flow conditions

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River dune modelling ranges from linear stability analysis to analyse the initial growth of the dunes (Fredsøe, 1983) up to three dimensional numerical models which can simulate the dune evolution by modelling the sediment transport on particle level (Nabi et al., 2013). For engineering purposes, such as efficient planning of dredging operation or dynamic modelling of dune roughness for water level predictions, a quick and accurate dune development model is needed. Therefore we further develop the model of Paarlberg et al. (2009), in order to accurately model dune shape and migration during high, median and low flow situations.

This model simulates dune development using a flow module in a two dimensional vertical plane and a bed load transport module which calculates the bulk transport. The model solves the flow over the domain of one dune length, using cyclic boundary conditions. The domain length, covering one dune length, is determined using a numerical linear stability analysis. It has been proven to accurately and fairly quickly reproduce the dune height of flume experiments and it is also able to simulate the transition to upper stage plane bed accurately (Duin et al., 2021).

However, for low flow situations it has not been validated yet. One of the main issues during low flow is that the relation between water depth and dune length is not linear and the adaptation of the dune length to new, smaller, water depths and flow velocities is not instantaneous (Lokin et al., 2022). The linear stability routine determines the dune length to which the dunes will grow based on a plane bed with a small disturbance, and directly updates the domain length to this newly determined dune length. In this research we have investigated options to incorporate the lag in the dune length adjustment during the falling stage of a flood wave. Implementing a lag in the dune length adjustment, such that the dune length adapts at a rate that is linked to the depth averaged flow velocity, leads to more realistic dune lengths.

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