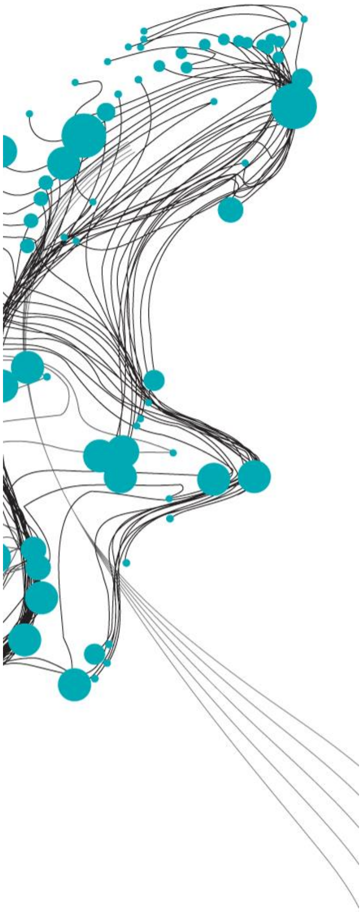
EXPLORATORY MODELLING OF THE FORMATION OF TIDAL BARS UNDER A PROPAGATING TIDAL WAVE USING A LINEAR STABILITY ANALYSIS



Tidal bars are rhythmic bed features that occur in tidal channels. These bars typically have heights of several metres and wavelengths of 1 to 15 km. The formation of rhythmic bed features is often studied using the linear stability concept, in which the formation of bedforms is explained as a free instability of a morphodynamic system. In linear stability models several assumptions are usually applied to simplify and schematise the modelled system. One of these is the so-called rigid lid assumption, through which the free surface effects are neglected. These are effects caused by changes in the position of the water surface due to tidal waves. This assumption is currently applied in most linear stability studies.

In this study we develop a (numerical) linear stability model in which the rigid lid assumption is not applied, i.e., the NRL (non-rigid lid) model. This (numerical) NRL model aims to include (instead of neglect) the free surface effects caused by a propagating tidal wave. The NRL model can therefore be used to obtain physics-based insights into the influence of a propagating tidal wave on the formation of tidal bars. These insights are obtained by comparing the NRL model to a traditional (semi-analytical) linear stability model in which the rigid lid assumption is applied, i.e., the RL (rigid lid) model. This is done for two cases in the Western Scheldt: the standard friction case and the reduced friction case.

Figure 1 contains the growth curves for the reduced friction case obtained using the NRL model (dashed lines) and RL model (solid lines). This figure shows that the peaks of the growth curves (for higher cross channel modes, i.e., $n > 0$) for the NRL model are higher and occur at larger wavenumbers compared to those for the RL model.

We define two preconditions: the abovementioned difference is caused by a propagating tidal wave; and the influence of a propagating tidal wave is the same for both friction cases. Assuming these preconditions are true, we expect that a propagating tidal wave might have the following influence on the formation of tidal bars: (1) formation of shorter tidal bars (i.e., the wavelength of the FGM decreases); and (2) faster formation of tidal bars (i.e., the growth rate of the FGM increases). However, to ensure the validity of these statements, further research must be conducted in which the NRL model is improved and validated.

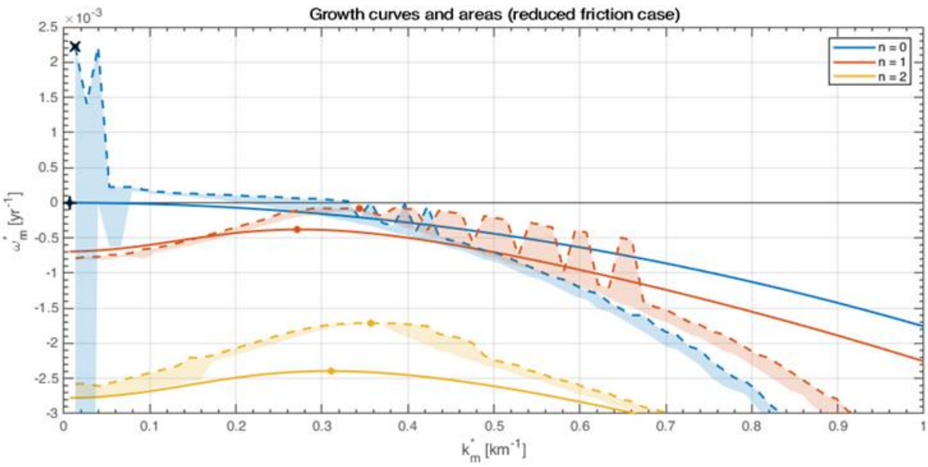


Figure 1: Growth curves (and areas) showing the growth rate (ω_m in yr^{-1}) as a function of the morphological wavenumber (k_m^* in km^{-1}) for different cross-channel modes (n). The growth curves (and areas) are shown for the reduced friction case in the Western Scheldt. The solid lines and dashed lines (with shaded areas) represent the growth curves for the (semi-analytical) RL model and the growth curves (with growth areas) for the (numerical) NRL model, respectively. •, + and × denote the pFGM (partial fastest growing model) for each cross-channel mode, and the FGM (fastest growing mode) for the RL model and NRL model, respectively.

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