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Plano-altimetric equilibrium morphology of tidal channels

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Tidal channels exert a crucial role for the morphodynamic evolution of tidal environments: They furnish preferential pathways for flooding and drying of intertidal areas and for the circulation of sediment and nutrients. A number of studies have analyzed the evolution and equilibrium configuration of tidal channels, focusing on the dynamics and equilibrium profile of the channel bed for a given channel-width distribution, as well as on the channel equilibrium cross-sectional shape. However, a complete modelling framework assessing both the altimetric and planimetric equilibrium features of tidal channels is still lacking.

We have developed a modelling framework which allows one to analyze the equilibrium configuration of a straight, short tidal channel and of the adjacent intertidal platform. The model considers a rectangular domain subjected to a sinusoidal tide at the seaward boundary and to a no-flux condition at the landward boundary. A quasi-static hydrodynamic model provides the instantaneous water discharge flowing through any cross section, whereas the local value of the instantaneous bed shear stress is computed on the basis of the procedure introduced by Pizzuto (1990). Simulations start from an initially flat bottom configuration with a small incision along the longitudinal axis of the domain. Water discharge flowing through any cross section is computed, together with the instantaneous distribution of bed shear stresses, possibly leading to bed erosion. The model is then run until an equilibrium plano-altimetric configuration is asymptotically attained.

Different forcings such as sediment supply, rate of sea level rise and tidal range have been considered. The calculated equilibrium profile nicely agrees with observed profiles, confirming theoretical predictions and the O'Brien-Jarrett-Marchi "law" relating the equilibrium cross-sectional area to the flowing tidal prism. Finally, new insights are obtained on the dependence of the channel width to depth ratio on the relevant hydrodynamic and morphodynamic parameters.