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# Finite-amplitude modeling of estuarine sand dunes

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Estuarine sand dunes are primary bedforms existing in many sandy estuaries. They generally have lengths between those of river dunes (tens of meters) and marine sand waves (on the order of hundred meters). Estuaries are known for their complex flow patterns, arising from a mix of riverine and tidal flow, bringing in freshwater from land and salt water from the sea. Two particular flow patterns arising from the interaction between salt- and freshwater are the gravitational circulation and the strain-induced circulation, induced by a longitudinal and a vertical salinity gradient, respectively. Recent research was directed to understanding the influence of these flow patterns on estuarine sand dunes through a linear morphodynamic model ([1], [2]). Linear stability models are capable of capturing initial growth from a flat bed, and yield the system's preferred bedform length and migration rate.

Here, we build upon the linear modeling approach with a nonlinear morphodynamic model capturing both the subsequent bedform development towards equilibrium, and the effect of dunes on the flow as they develop. The model domain has spatially periodic boundary conditions and a rigid lid at the surface; the hydrodynamic module is non-hydrostatic and is solved with a k-omega turbulence closure. Furthermore, we include bed-load sediment transport with a formulation that contains a slope term. Results show the height, length, shape and migration rate of dunes in an estuarine environment, and reveal the flow- and turbulence patterns over these bedforms. Furthermore, we show the deceleration of the flow with development of dunes, and thus quantify the effect of dunes on flow resistance.

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