Abstract

Firstly, we present a linear stability analysis of sand waves sheared by a turbulent flow. The flow model is coupled with the sediment transport model to study the instability of sand waves. Both the modes of sediment transport as bedload and suspended load are considered. The study highlights the role of particle parameter and relative roughness number on the instability process.

Then, we examine the fluvial bars from both linear and weakly nonlinear perspectives. The linear and weakly nonlinear analyses render the wavelength and amplitude of fluvial bars, respectively. We examine the marginal stability, growth rate and amplitude of patterns for a given quintet formed by the channel aspect ratio, wavenumber of patterns, shear Reynolds number, Shields number and relative roughness number. This study highlights the sensitivity of pattern formation to the key parameters and shows how the classical results can be reconstructed on the parameter space.

Thereafter, we investigate the instability and planform evolution of a meandering channel with variable width and curvature using the depth-averaged formulations for the flow and sediment transport. Unlike the conventional instability analysis that considers mainly the bedload transport, we consider both the bedload and suspended load. The analysis addresses the variations of the near-bank excess azimuthal velocity and the bed topography deviation with the meander wavenumber for different pertinent parameters, such as Shields number, relative roughness number, channel aspect ratio, width-variation amplitude, and shear Reynolds number. In addition, we study the dynamics of an erodible meandering channel subject to combined curvature and autogenic width oscillations. The planform evolution is found to be influenced by four key parameters: Shields number, relative roughness number, channel aspect ratio, and shear Reynolds number.

Afterwards, we explore the submarine channel formation driven by the interaction of turbidity currents with an erodible bed. The theoretical analysis considers the three-dimensional continuity and momentum equations of the fluid phase, and the advection–diffusion and Exner equations of the solid phase. We study the response of both the base flow (profiles of velocity and suspended sediment concentration) and perturbations (growth rate and perturbation fields) to changes in key parameters related to the flow and sediment transport.

Finally, we analyse the stability of longitudinal sand waves triggered by the interaction of turbidity currents with an erodible bed. We perform the stability analyses from both linear and weakly nonlinear perspectives. The linear analysis uses the standard linearization, whereas the weakly nonlinear analysis uses the centre-manifold-projection. The model results are sensitive to the gravitational parameter, longitudinal bed slope, sediment concentration at the edge of the driving layer, and Rouse number.

Keywords: Instability, sediment transport, bedforms, meandering channels, turbidity currents