Numerical modeling of flow and morphology induced by a solitary wave on a sloping beach

A fully-coupled (hydrodynamic and morphologic) numerical model based on the open-source computational fluid dynamics (CFD) package OpenFOAM is presented and utilized to simulate flow and morphology induced by a solitary wave on a sloping beach. The hydrodynamic model is based on Reynolds-averaged Navier-Stokes (RANS) equations together with k-ω turbulence closure and volume of fluid (VOF) method for capturing the free surface. These are then coupled with both bed load and suspended load transport descriptions, which drive resultant morphology of the bed. The present numerical model is validated against a laboratory experiment of flow and morphological change induced by a solitary wave. The rigid-bed simulation illustrates that the numerical model can reasonably reproduce the characteristic sequences as observed in the experiment, including the wave shoaling, breaking, runup, rundown, hydraulic jump and trailing wave. The quantitative agreement between computed and measured results, including surface elevation, bed shear stress, and turbulent kinetic energy are satisfactory. The sediment-bed simulation demonstrates that the computed tendency of the bed profile evolution fits well with the measured results, showing the general pattern of both offshore deposition and onshore erosion. The deposition height is fairly well predicted, while the erosion depth is generally underestimated in the swash zone where the water depth is extremely thin. Overall, the results obtained from the present model are promising, especially considering the complexity of the coupled flow and morphological processes involved.

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