Geophysical Research Abstracts
Vol. 19, EGU2017-6056, 2017
EGU General Assembly 2017

A general mixture model and its application to coastal sandbar migration simulation

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A mixture model for general description of sediment laden flows is developed and then applied to coastal sandbar migration simulation.
Firstly the mixture model is derived based on the Eulerian-Eulerian approach of the complete two-phase flow theory. The basic equations of the model include the mass and momentum conservation equations for the water-sediment mixture and the continuity equation for sediment concentration. The turbulent motion of the mixture is formulated for the fluid and the particles respectively. A modified k-ε model is used to describe the fluid turbulence while an algebraic model is adopted for the particles. A general formulation for the relative velocity between the two phases in sediment laden flows, which is derived by manipulating the momentum equations of the enhanced two-phase flow model, is incorporated into the mixture model. A finite difference method based on SMAC scheme is utilized for numerical solutions. The model is validated by suspended sediment motion in steady open channel flows, both in equilibrium and non-equilibrium state, and in oscillatory flows as well. The computed sediment concentrations, horizontal velocity and turbulence kinetic energy of the mixture are all shown to be in good agreement with experimental data.
The mixture model is then applied to the study of sediment suspension and sandbar migration in surf zones under a vertical 2D framework. The VOF method for the description of water-air free surface and topography reaction model is coupled. The bed load transport rate and suspended load entrainment rate are all decided by the sea bed shear stress, which is obtained from the boundary layer resolved mixture model. The simulation results indicated that, under small amplitude regular waves, erosion occurred on the sandbar slope against the wave propagation direction, while deposition dominated on the slope towards wave propagation, indicating an onshore migration tendency. The computation results also shows that the suspended load will also make great contributions to the topography change in the surf zone, which is usually neglected in some previous researches.