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Large-eddy simulation of coupled turbulence, free surface, and sand wave evolution in an open channel ALI KHOSRONEJAD, FOTIS SOTIROPOULOS, University of Minnesota, ST. ANTHONY FALLS LAB TEAM
— We develop and validate a coupled 3D numerical model for carrying out three-phase large-eddy simulations of turbulence, free-surface, and sand waves-bed morphodynamics under live bed conditions. We employ the Fluid-Structure Interaction Curvilinear Immersed Boundary (CURVIB) method of Khosronejad et al. (Adv. in Wat. Res.,2011). The LES is implemented in the context of the CURVIB method using wall modeling (Kang and Sotiropoulos, Adv. in Wat. Res.,2011). Free-surface motion is simulated by coupling the CURVIB method with a two-phase level set approach as in Kang and Sotiropoulos (Adv. in Wat. Res.,2012). Transport of bed load and suspended load sediments are combined in the non-equilibrium form of the Exner for the bed surface elevation, which evolves due to the spatio-temporally varying bed shear stress field induced by the turbulent flow. Simulations are carried out for the experiments of Venditti et al. (2005). It is shown that the model can accurately capture sand-wave initiation, growth, and migration processes observed in the experiment. The effects of free-surface on bed-form dynamics is also quantified by comparing the three-phase simulation results with two-phase simulations using a fixed rigid-lid as the free surface. This work is supported by NSF Grants EAR-0120914 and EAR-0738726, and National Cooperative Highway Research Program Grant NCHRP-HR 24-33.

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