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Curvilinear immersed-boundary method for simulating unsteady flows in shallow natural streams with arbitrarily complex obstacles[1]
SEOKKOO KANG, IMAN BORAZJANI, FOTIS SOTIROPOULOS, St. Anthony Falls Lab, University of Minnesota — Unsteady 3D simulations of flows in natural streams is a challenging task due to the complexity of the bathymetry, the shallowness of the flow, and the presence of multiple nature- and man-made obstacles. This work is motivated by the need to develop a powerful numerical method for simulating such flows using coherent-structure-resolving turbulence models. We employ the curvilinear immersed boundary method of Ge and Sotiropoulos (Journal of Computational Physics, 2007) and address the critical issue of numerical efficiency in large aspect ratio computational domains and grids such as those encountered in long and shallow open channels. We show that the matrix-free Newton-Krylov method for solving the momentum equations coupled with an algebraic multigrid method with incomplete LU preconditioner for solving the Poisson equation yield a robust and efficient procedure for obtaining time-accurate solutions in such problems. We demonstrate the potential of the numerical approach by carrying out a direct numerical simulation of flow in a long and shallow meandering stream with multiple hydraulic structures.

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