Stony Brook University
The Graduate School
Doctoral Defense Announcement

Abstract

Field and Numerical Study for Improved High-fidelity Numerical Modeling of Turbulent Flow of Natural Rivers

By

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This dissertation explored problems commonly encountered in the high-fidelity numerical simulation of natural river flows by considering three environmental complexities: (1) vegetation, (2) irregular bed bathymetry and (3) grain roughness.

In the numerical modeling of natural waterways, vegetation is often ignored because of the varied shapes, sizes and numerous spatial locations of trees, which make them difficult to explicitly incorporate into a computational grid systems. This research investigated two methods of including trees into large-eddy simulations (LESs) to gain insight into the effects of vegetation on the hydrodynamics of a natural river, the American River, under flood conditions. First, LES results of the river without any vegetation were compared with LES results in which the geometry of tress were resolved using the immersed boundary method. In the second approach, a momentum reduction algorithm was utilized along the banks to simulate the overall drag force that trees impart to the turbulent flow of the natural river. It was found that river flow dynamics were significantly impacted by the vegetation.

Secondly, the influence of the resolution of river bathymetry on LES results were investigated. Two sets of survey data were collected in the American River, in which different types of sonar equipment were used to provide differing degrees of resolution of the complex bed forms, rock revetment, and other channel features. From a simple single beam echosounder, a coarse bed resolution was obtained and compared with a high-resolution survey using a multi-beam echosounder. From the LES results of these cases, it was determined that the resolution of riverbed bathymetry plays a key role in the successful LES of the natural river flows.

A third component of research studied was to examine the effect of grain roughness on the flow distribution and velocity profiles in the Sacramento River using uncertainty quantification (UQ) techniques. The field data of the river were collected using an acoustic doppler current profiler (ADCP) and large-scale particle velocimetry to estimate the flow velocity and discharge in the study site. LES results of the site were computed using a range of equivalent roughness heights in the wall model and a range of inlet flow rates based on the uncertainty in the field measurements. The confidence in the LES results was quantified using polynomial chaos expansions and Monte Carlo sampling methods.

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Dissertation Advisor: Dr. Ali Khosronejad

(*If an outside member of the community would like to attend the defense, please contact Ms. Erin Giuliano: Erin.Giuliano@stonybrook.edu.)