IMPACT OF RESOLVED TOPOGRAPHIC ROUGHNESS ON FLOOD MODEL PREDICTIONS OF FLOW RESISTANCE

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Depth integrated (2D) models used to predict inundation resulting from storm surge, dam-break, and tsunami floods essentially require two spatially variable parameters: topography and flow resistance. The former defines study area geometry while the latter accounts for momentum dissipation from turbulent shear at the fluid-bed interface and drag from vegetation and other obstructions.

Topographic data used for flood modeling purposes may be resolved at scales of 1 m or less. On the other hand, a computational mesh of this size may be impractical as a result of computational limitations so coarsening (or upscaling or filtering) topography becomes necessary and this raises questions about the proper scale of the coarsened data in relation to the computational grid resolution. A related issue is the give and take between resolved topography (essentially large scale roughness) and bed resistance. It is not clear whether resistance parameters should increase to compensate for roughness in the topography that is filtered out in the upscaling process.

This paper reports on a numerical modeling study to examine grid dependencies to model predictions of flow resistance. A high-resolution Godunov-type finite volume shallow-water model [1] was applied to simulate flow in a virtual channel set on a constant slope but with a hypothetical, two-dimensional, sinusoidal roughness and constant Manning coefficient to account for unresolved roughness and turbulence effects. Simulations covered a range of Froude numbers, channel slopes, and grid resolutions and for each case an iterative modeling procedure was adopted to identify the boundary conditions that attain uniform flow conditions in the channel and hence, the uniform or equilibrium depth. Results of these simulations show that the equilibrium depth deviates by as much as a factor of two from the "normal depth" based on the Manning equation, highlighting the significance of resolved bedforms on flood flow resistance predicted by numerical models. Interestingly, preliminary analysis suggests that model predictions of resistance are less sensitive to grid resolution (e.g., whether a bedform is resolved by 4 versus 8 cells) than channel and flow properties such as the bed slope and Froude number, respectively. Strategies to parameterize resistance coefficients in flood models are discussed in light of these results.

References

[1] L. Begnudelli and B.F. Sanders "Unstructured grid finite volume model for shallow water flow and scalar transport with wetting and drying," *ASCE J. Hydraul. Eng.* (to appear in April, 2006).

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