Improvements in Internal Barrier Modeling for Fluid-Structure Interaction Models with Storm Surge

Dylan M. Wood*, Ethan J. Kubatko†

The Computational Hydrodynamics and Informatics Laboratory (The CHIL)
The Ohio State University
2070 Neil Ave, Columbus, OH 43201, USA
e-mail: *wood.1054@osu.edu, †kubatko.3@osu.edu

ABSTRACT

Numerical solution of fluid-structure interaction (FSI) problems stands at the forefront of efforts to study the effects of extreme weather events, such as storm surge, on infrastructure and ecosystems, as well as efforts to mitigate these effects. A significant concern within these studies are the properties of FSI between storm surge flows (or similarly extreme flows) and flood-control infrastructure, such as levees and weirs. Accurate modeling of failure mechanisms for these types of infrastructure, such as sliding, piping and overtopping, is essential for effective design of structures that will mitigate infrastructure damage and loss of life. Levees, weirs, raised roadways, etc. are often represented as subgrid-scale 'internal barriers' within the computational domains of current storm surge models, such as ADCIRC [1] and DG-SWEM [2], where the only failure mechanism captured within these models is overtopping, flow rates for which are calculated using standard weir formula. We present efforts towards the coupling of current models based on the shallow-water equations, to a water wave model capable of resolving non-hydrostatic pressures for storm surge [3]. Such pressure results will allow the accurate calculation of FSI forces to capture failure mechanisms with greater accuracy and wider variety. Some failure mechanisms may result in displacement, erosion or entire destruction of internal barriers; these phenomenon are also inaccurately captured by current models. To address this problem, we also present further efforts in implementation of adaptive meshing techniques to capture such transformations in internal barrier structure.

REFERENCES

[1] Westerink, J.J., Luettich, R.A., Feyen, J.C., Atkinson, J.H., Dawson, C.N., Powell, M.D., Dunion, J.P., Roberts, H.J., Kubatko, E.J., Pourtaheri, H., *A basin- to channel-scale unstructured grid hurricane storm surge model applied to southern Louisiana*, Monthly Weather Review, 135, pp. 833–864, 2008.

[2] Dawson, C., Kubatko, E.J., Westerink, J.J., Trahana C., Mirabito, C., Michoskia C., Panda, N., *Discontinuous Galerkin methods for modeling hurricane storm surge*, Advances in Water Resources, 34, pp. 1165–1176, 2011.

[3] Donahue, A.S., Zhang, Y., Kennedy, A.B., Westerink, J.J., Panda, N. and Dawson, C., *A Boussinesq-scaled, pressure-Poisson water wave model*, Ocean Modelling, 86, pp. 36–57, 2015.