Model Reduction For Shallow Water Flows

M. Farthing*, C. Kees*, A. Lozovskiy†,

† Institute of Scientific Computation
Texas A&M University
1 Ireland Street, College Station, TX 77843, USA
lozovskiy@math.tamu.edu

* Coastal and Hydraulics Laboratory
Engineering Research and Development Center
3909 Halls Ferry Road, Vicksburg, MS 39180-6199, USA
matthew.w.farthing@usace.army.mil,
christopher.e.kees@usace.army.mil

ABSTRACT

To capture the hydrodynamics of shallow water flows in natural systems, it is often essential to characterize the system's bathymetry as well as the impact of bottom stress caused by surface roughness. Unfortunately, constants like Manning's friction coefficient in common parameterizations of bottom stress are not directly measureable, while direct measurement of bathymetry can be expensive and impractical in many environments. This leads to the need to solve one or more inverse problems to estimate depths and/or roughness parameters using available data, which may be limited to surface velocities and/or free-surface elevations [1].

While a variety of inversion techniques can be used, most if not all can be expected to require a large number of (forward) shallow water simulations to provide a representative set of velocities and depths [2]. These computations can be quite expensive and serve as a limiting factor in the effectiveness of the inversion process. In this work, we provide a global model reduction framework for stabilized finite element schemes for the shallow water equations (SWE) by means of Proper Orthogonal Decomposition (POD). An "optimal" reduced order basis is constructed based on high-dimensional solution snapshots. Additional nonlinear complexity reduction is made using the Discrete Empirical Interpolation method (DEIM). Previous work on those methods, applied to Finite Difference scheme for SWE, may be found in [3]. We present numerical results to compare accuracy and execution times to justify our choice for model reduction in the context of a forward simulation.

REFERENCES

[1] Wilson G., Ozkan-Haller H., and Holman R., Data assimilation and bathymetric inversion in a two-dimensional horizontal surf zone model. *Journal of Geophysical Research: Oceans* (1978–2012), 115(C12), 2010.

[2] Tossavainen O.-P., Percelay J., Stacey M., Kaipio j. and Bayen A., State estimation and modeling error approach for 2-d shallow water equations and lagrangian measurements. *Water Resources Research*, 47(10), 2011.

[3] Ştefănescu R., Navon I., POD/DEIM nonlinear model order reduction of an ADI implicit shallow water equations model. *Journal of Computational Physics,* 237, p. 95-114, 2013.

.