

Development of Subdomain Sizing Guidelines for the Subdomain Modeling Extension for ADCIRC

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INTRODUCTION

The Coastal Storm Modeling System (CSTORM-MS) is an integrated numerical simulation system that rigorously represents underlying physical processes involved in coastal storm surge and wave modeling by incorporating a suite of high-fidelity storm modeling tools. The models are well validated and capable of producing highly accurate simulations, but they are computationally expensive, which makes it challenging to use them in iterative design scenarios studies.

To address this concern, a subdomain modeling (SM) technique (Baugh et al., 2015) was recently incorporated in ADCIRC. SM allows subdomain simulations to be performed at a fraction of the computational cost necessary and with the same accuracy as running the full large-scale domains.

SM requires approximating size and location of subdomain boundaries and configuring for use with the full domain model prior to running any simulations. However, no guidelines exist for approximating subdomain size.



Image credit: NOAA/CIRA

SUBDOMAIN MODELING

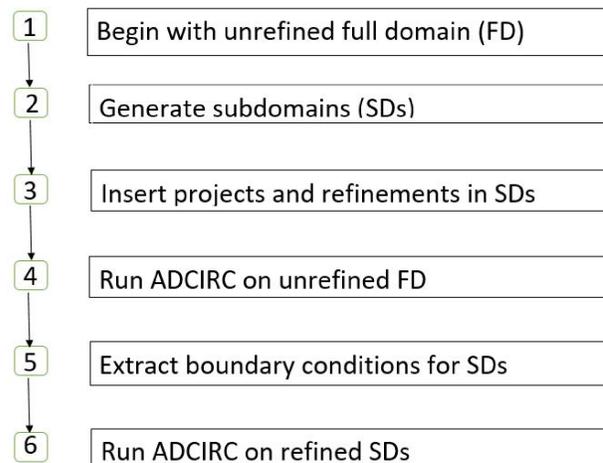


Figure 1 General Workflow for Subdomain Modeling

SCIENTIFIC QUESTIONS

While Subdomain modeling requires predetermination of subdomain sizing and location, no guidelines exist to aid practitioners in determining location of subdomain boundaries. So that SM may be used for more computationally efficient project evaluations.

Factors influencing subdomain sizing include:

- Geometry, topography, and bathymetry of the area of interest
- Type of forcing conditions
- Size, height and type of features to be enclosed within the subdomain

SM has been shown to be mathematically equivalent to ADCIRC full domain simulations through a combination of informal proofs. Therefore, so long as the subdomain is large enough to fully contain altered hydrodynamics, modifications may be made within it without the need to calculate new boundary values. Provided a subdomain is large enough to contain altered hydrodynamics, changes (including refinements and project insertions) may be made within it without the need to calculate new boundary values. Still, heuristic rules of thumb need be developed to minimize subdomain size while also minimizing error.

EXPERIMENTAL DESIGN

$$Sz = f(B, J, P) \quad (i)$$

Where

Sz = subdomain size,

B=geometry/topography/bathymetry of area of interest,

J = forcing conditions

P= size of project alternatives.

Identify test cases incorporating the following parameters:

- Geometric characteristics of area of interest (i.e. open coast, back bay, enclosed riverine environment)
- Type of forcing conditions (storm event vs. non-storm or tides-only events)
- Size of project design (small, medium, large)

For parameter P, Project alternatives may be relatively small on the order of several miles, relatively large on the order of tens (or more) of miles, or somewhere in between

Figure 2 represents an example for parameter B in equation (i), where the area of interest incorporates project alternatives located in a geographically isolated region along the west bank of the Potomac River.

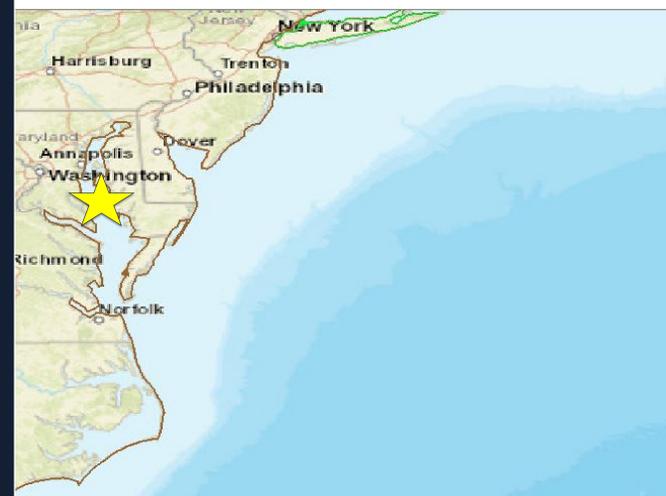


Figure 2 Geographically isolated region

Alternatively, figure 3 represents project alternatives needing evaluation located in an area of interest located along the open coast (figure 3).

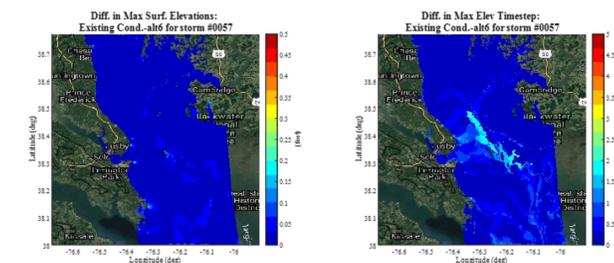


Figure 3 Open Coast

TOOLS

submesh_results_diff.m:

Generates colormaps of the differences between 1) maximum water surface elevation and 2) timestep at max. elev. for existing and project conditions; finds maximum overall differences in water surface elevation and timestep; calculates distance to point of maximum water surface elevation difference from a specified reference point

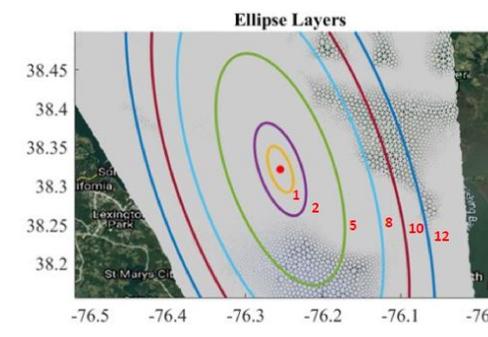


Compare_bndy_values.m:

Determines equivalent values of submesh boundary nodes in full mesh; calculates differences between full mesh and submesh maximum water surface elevations and timesteps, along with maximum, mean, median, and standard deviation of differences; saves values to a summary file.

Generate_ellipses.m:

Generate concentric ellipses around project area/area of interest and output points into a station location file (Map base and alternative results onto set of ellipse points in station location file)



ellipse_points_comp.m

Reads in files with data mapped to ellipse boundary points and calculates the maximum, mean, median, and standard deviation of the differences between existing and with project results for each "layer"; saves values to a summary file.

NEXT STEPS

- Determine acceptable error threshold
- Analyze error metrics from full domain results from existing test cases to select subdomains of various sizes
- Run simulations on selected subdomains and validate against equivalent full domain results
- Develop rules of thumb for subdomain sizing as a function of B,J,P (equation (i))

REFERENCE

Baugh, J., Altuntas, A., Dyer, T., and Simon, J. (2015). An exact reanalysis technique for storm surge and tides in a geographic region of interest. Coastal Engineering, 97, 60-77.