Progress Report Task B (July-September 2010)
Project: Amount, Fate, and Transport of Oil and Dispersants in Estuarine Environments

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1. Initial approach

The research will focus in the Grand Bay (Mississippi Gulf Coast) area with possible expansion to Perdido Bay (Florida). The two bays are included in the study provide a spectrum of heavily to lightly impacted coastal waters to be modeled and results compared.

Ocan boundary conditions of the model(s) will be provided by other NGI modeling efforts. Alternatively, an existing hydrodynamic model for the Mobile Bay and surrounding ocean waters may provide boundary conditions to hypothesize realistic scenarios.

Fresh water boundary conditions (upland and coastal watersheds) will be provided by HSPF hydrological models of the regions draining to the bays included in this study. These HSPF models will be developed as part of this study.

The EFDC hydrodynamic model(s) (updated or developed) for this study will include transport of an inorganic tracer (DYE related cards in EFDC) and hypothesize on the transport of oil-spill related contaminants based on tracer simulations, i.e., under what circumstances would those contaminants get to the coast/bay.

2. Hydrodynamic and water quality models

2.1 In-house EFDC/WASP models in the project area

Figure 1. Existing EFDC model of Mobile Bay. Exploratory dye transport experiment.

Our group counts with a hydrodynamic model of the Mobile Bay and surrounding coastal waters. The model has also been previously linked to a WASP water quality model. Figure 1 shows an exploratory simulation of hydrodynamic transport of dye concentration from a constant dye source. The objective of this experiment was to generate the expertise for simulating and visualizing dye transport using EFDC. The next step to this experiment was to design a tailored EFDC hydrodynamic model for Grandbay and perform the same experiment on the new model.

2.2 EFDC model for Grandbay

2.2.1 Bathymetry and coastline data

Bathymetric and coastline information were acquired from the NOAA National Geophysical Data Center (NGDC). A custom bathymetric dataset was produced using the GEODAS Grid Translator available at the NGDC website. The downloaded data was converted to in ARCINFO GRID format for further geoprocessing. Similarly, a custom polygon shape was generated from downloaded coastline data. Both datasets, bathymetry and coastline, were re-projected to UTM coordinates.

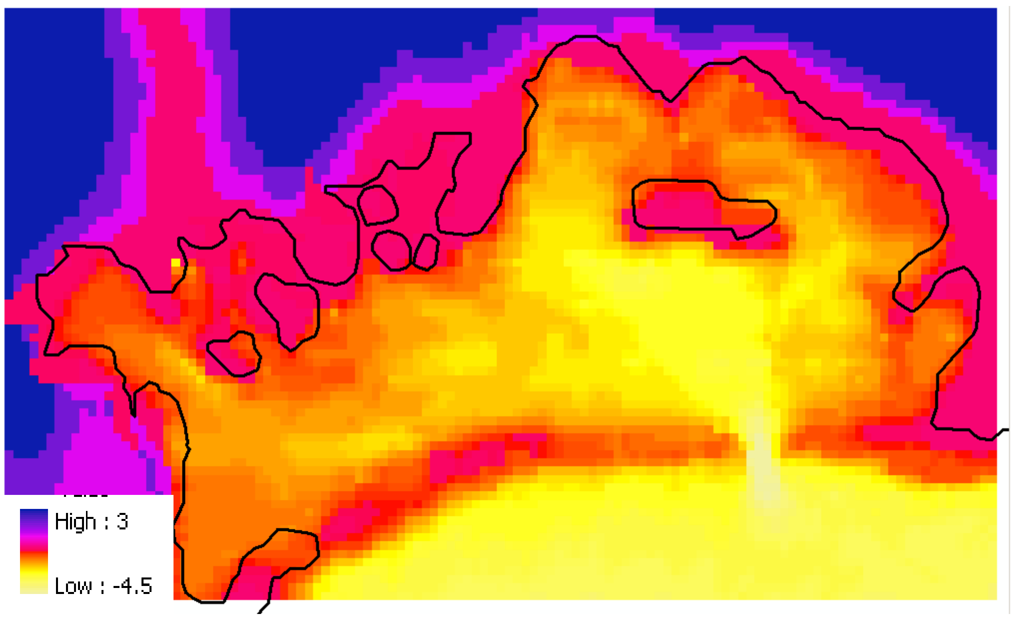

Figure 2. Bathymetry and coastline for Grandbay.

2.2.2 Computational grid/mesh generation

The objective of the grid generation portion of this research was to capture the physiographic characteristics of the Grand Bay estuary into a computational mesh that is friendly to the EFDC requirement for computational grids. EFDC can use Cartesian (regular and irregular) grids, and also curvilinear convex-orthogonal grids. Figure 3 shows several curvilinear grids that were created through the process of choosing the best grid.

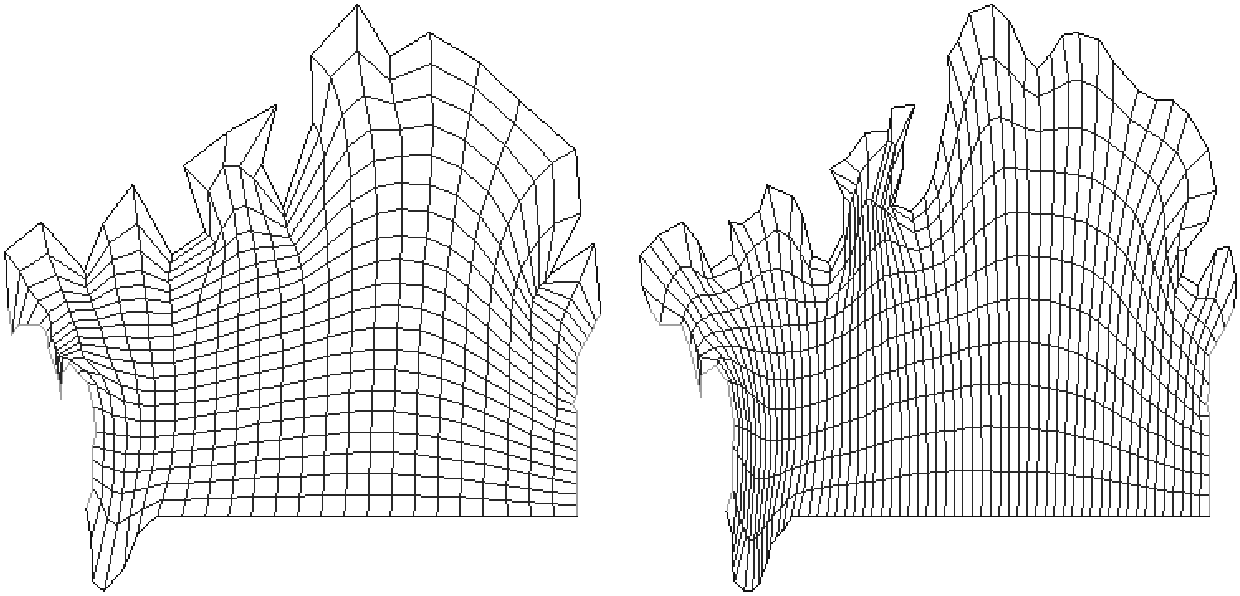

Figure 3. Curvilinear computational meshes for Grandbay

Although the curvilinear grids shown in Figure 3 capture the coastline geometry for the bay adequately, convexity and orthogonality issues did not allow generating higher resolution grids (higher number of grid cells) for the project area. In addition to assessing curvilinear grids for the Grandbay project area, a regular structured grid option was also explored. Figure 4 shows the resulting structured grid for Grandbay superimposed on the bathymetry dataset.

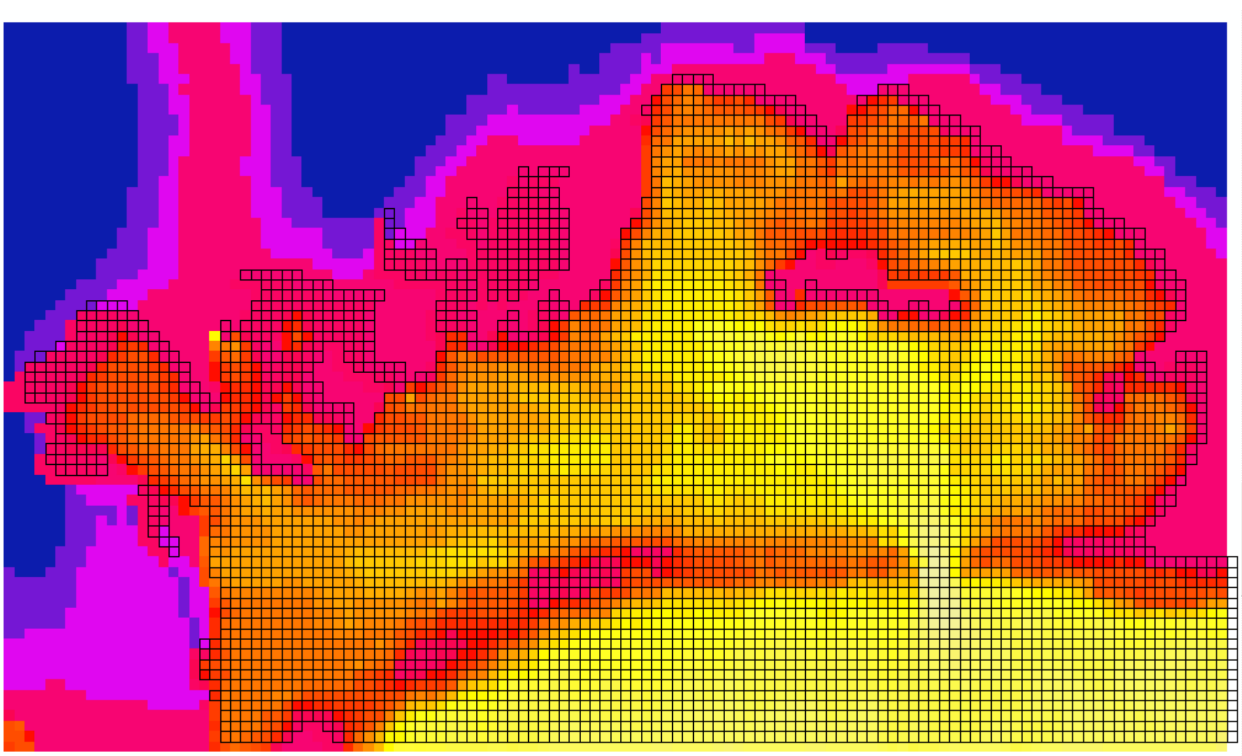

Figure 4. Final structured computational mesh for Grand Bay after assessing several options.

2.2.3 Preliminary hydrodynamic and dye transport simulation results

The number of cells of the resulting computational mesh (Figure 4) is 5202. The standard EFDC version can only use around 3000 cells. The high resolution of our computational mesh forced to use two flavors of the EFDC model: the Dynamic Solutions EFDC (EFDC_DS), and a tailored EFDC code re-compiled in house for allowing use of up to 6000 cells (EFDC_A), for subsequent hydrodynamic modeling. EFDC_DS provides a user friendly Graphical User Interface (GUI) for visualizing results and also run the EFDC model. The re-compiled EFDC_A code can generate the *.HYD file that links EFDC output to the water quality modeling system WASP.

The EFDC model application to Grandbay requires, besides the grid files, a number of additional input files that establish boundary conditions, location of water and dye inflows and outflows, geographical data, etc. All of those files were generated using either the GEFDC program (grid generator for EFDC), tailor made C codes, spreadsheets, and other. Once all these files were produced, the initial EFDC model for Grandbay was used to run the dye transport experiments shown in Figure 5.

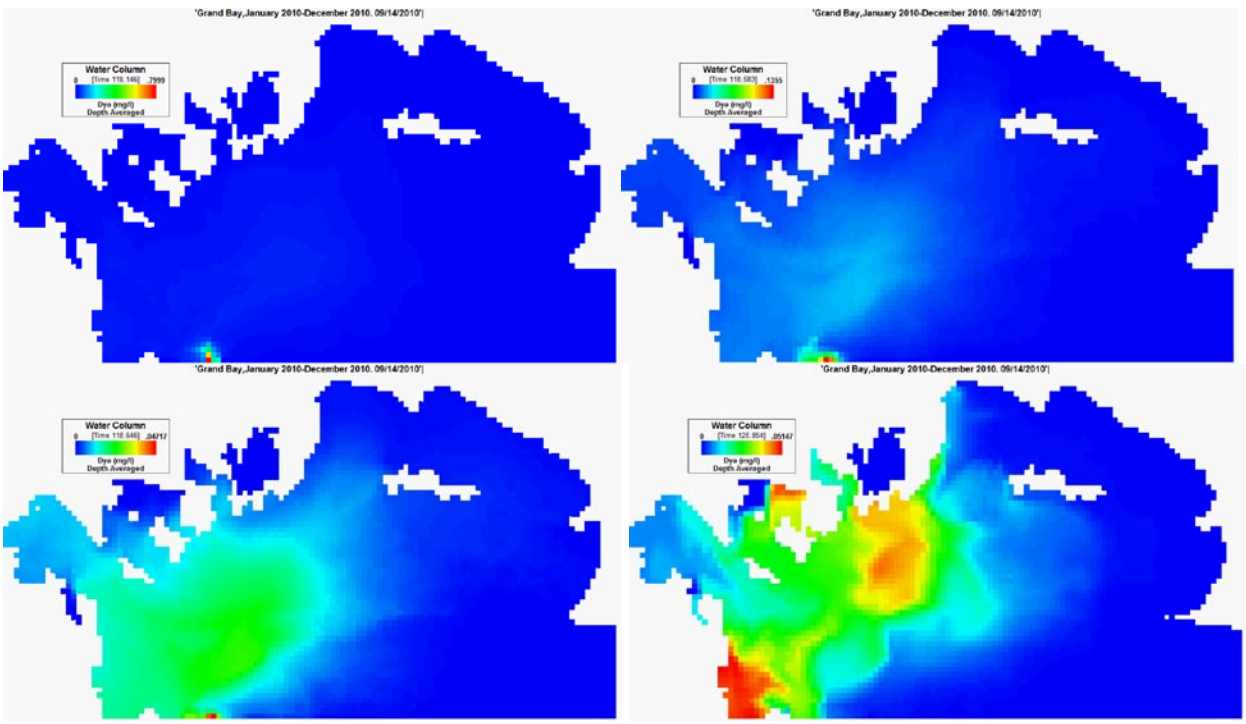

Figure 5. Dye transport experiment using the EFDC model application to Grandbay. A constant dye concentration is applied at 3 cells located in the lower left ocean boundary.

Two experiments were performed to assess the capabilities of the developed EFDC model application to Grandbay. Constant dye concentrations were applied to sets of three adjacent cells at the lower lef ocean boundary (Figure 5), and at the lower right ocean boundary (Figure 6). The model, however, can be set up to receive dye concentrations along all the ocean boundary cells (105 cells in total). Since the actual input concentrations at the ocean boundaries will be determined by other research efforts (surge/hurricane models from other research groups), the model is currently set up to receive dye/contaminant concentrations at any or all ocean boundary cells.

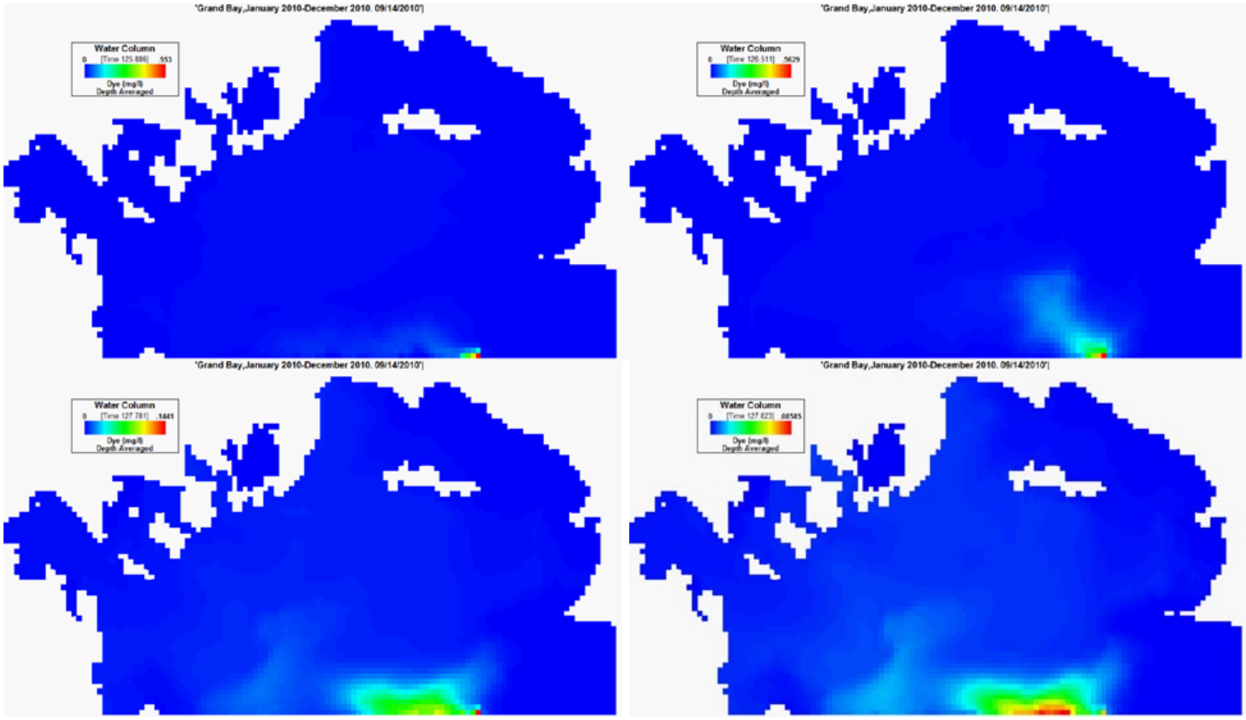

Figure 6. Dye transport experiment using the EFDC model application to Grand Bay. A constant dye concentration is applied at 3 cells located in the lower right ocean boundary.

The reader is welcome to explore the simulations of dye transport developed for this progress report at http://www.msstate.edu/~vja1/dye/dye.htm.

2.2.4 EFDC model for Perdido Bay

An existing model for Perdido Bay will be used for this project. The model, developed by Dynamic Solutions, LLC. for the Florida DEP, has been acquired and is undergoing initial testing.

3. Other activities

Along with the development of the hydrodynamic models, water quality data from EPA's "Response to BP Spill in the Gulf of Mexico" website were downloaded.