Improving Accuracy of
Real-Time Storm Surge Inundation Predictions

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1. MOTIVATION

- North Carolina Emergency Management (NCEM) relies on storm surge forecasts from computer models for decision-making during a storm.
- Prediction of the extent of coastal flooding may be limited by resolution of the model grid, because topography can be smoothed out and **small-scale features such as roadways and small channels are not represented**.

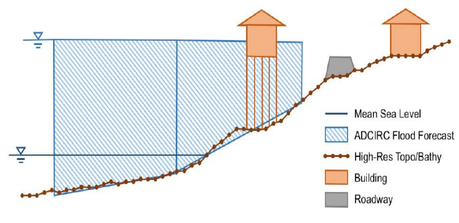


Figure 1. Schematic of problem. ADCIRC flood forecasts may not match the high-resolution topography.

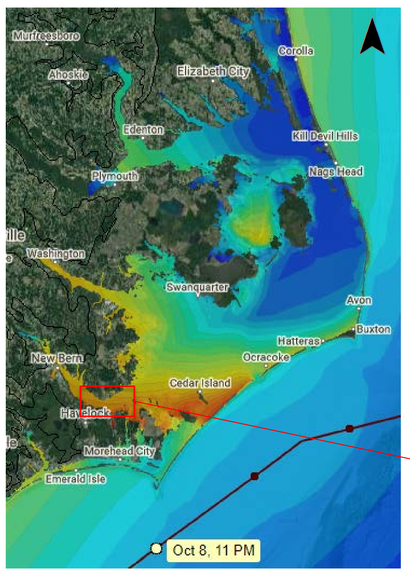
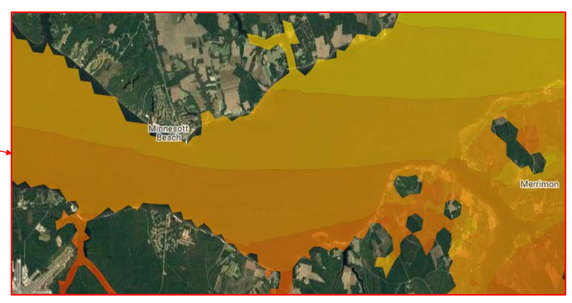


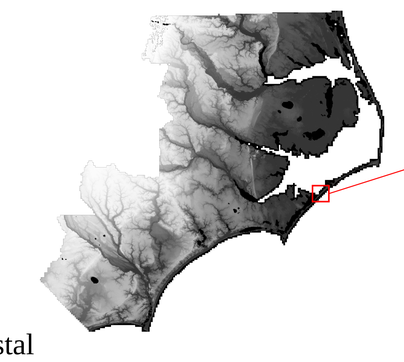
Figure 2. Maximum water levels for Hurricane Matthew visualized on the Coastal Emergency Risks Assessment (CERA) website.

- The polygon boundary shown in the Figure 2 zoom, representing the predicted extent of flooding, is irregular. This is an artifact of the model resolution.
- Improving this flooding boundary is of interest to North Carolina Emergency Management (NCEM), as they are concerned with the smaller, building-to-building scale.



2. METHODOLOGY

- "Enhancing resolution" of ADCIRC using a high-resolution **Digital Elevation Model (DEM)** makes use of Python scripts and the **Geographic Resources Analysis Support System (GRASS)**, an open-source GIS application.



- The DEM used covers 32 coastal North Carolina counties at **50-foot resolution**, totaling more than **430 million grid cells**.
- Initial tests were performed on a small sub-region of Carteret County, NC, before moving onto the entire county and then the entire coast of North Carolina.
- The general steps are:
  1) Interpolate ADCIRC points to a raster at 50-foot resolution (Figure 3b).
  2) Expand ADCIRC raster outward only where the water levels are greater than the ground elevation.
  3) Remove isolated (not hydraulically-connected) cells (Figure 3c).
  4) Convert the new "grown" raster to polygon format for distribution.

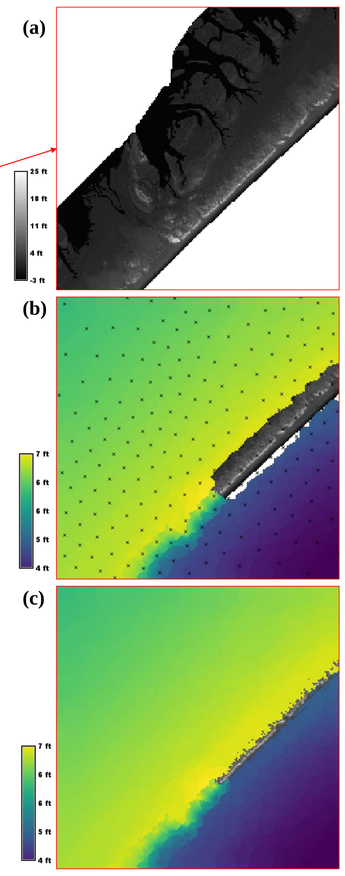


Figure 3. Initial test region in Carteret County. (a) DEM only. (b) Interpolated ADCIRC raster overlying DEM, where points represent ADCIRC grid nodes. (c) Enhanced resolution surface.

3. RESULTS IN CARTERET COUNTY, NC

- Figures 4 and 5 show before and after the enhanced resolution on the county scale.
- Analyzing a Carteret County building dataset for a Hurricane Matthew Hindcast:
  - Before enhancement: **2,435 buildings are predicted to be flooded.**
  - After enhancement: **3,886 buildings are predicted to be flooded.**
  - This is a **60 percent increase.**

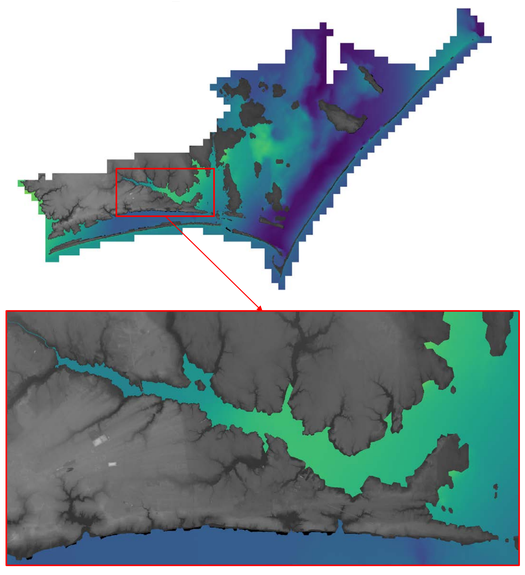


Figure 4. Water level raster before enhancing resolution. In some areas water is not reaching the mean shoreline.

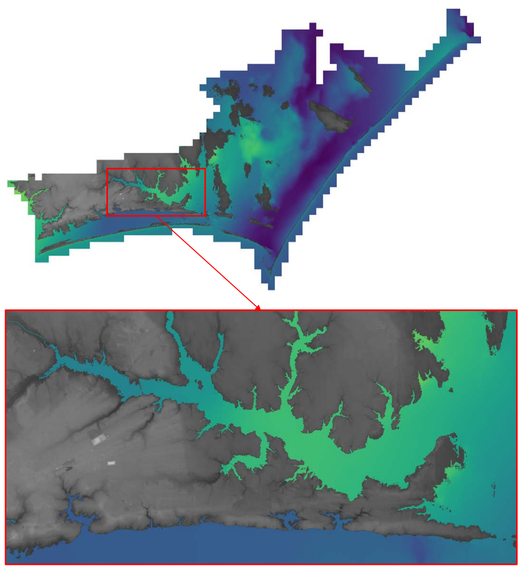


Figure 5. Water level raster after enhancing resolution. Flooding is extended across low-lying topography.

4. STATE LEVEL RESULTS

- For all of coastal North Carolina, we get similar results:

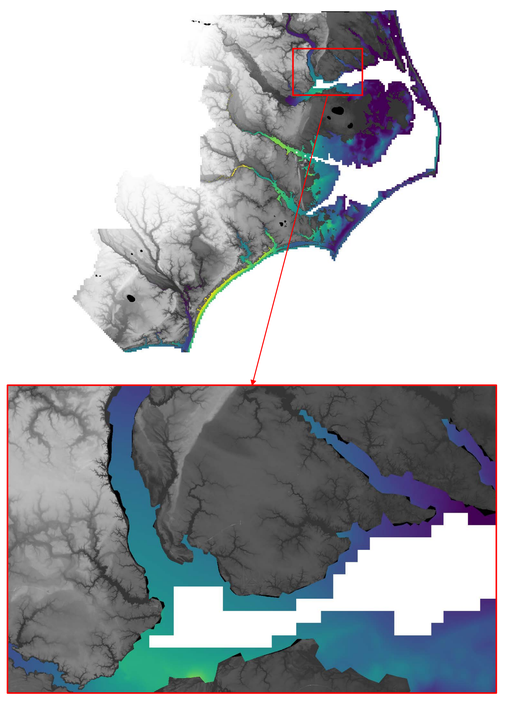


Figure 6. Water level raster before enhancing resolution.

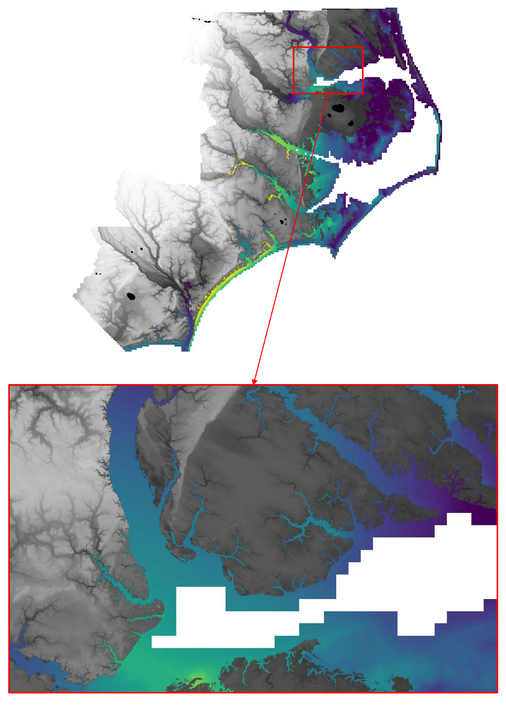


Figure 7. Water level raster after enhancing resolution.

- Low-lying floodplains (darker grey colors) that should be flooded are now flooded (Figure 7).
- The boundary of the flooding is more defined, characteristic of the high-resolution DEM.

5. SPEED AND REAL-TIME FORECASTING

- To speed up interpolation step:
  - Text file containing precomputed Inverse-Distance Weights was created for each ADCIRC mesh.
  - Code was parallelized for running on up to 16 processors.
- The program now takes **13-15 minutes** to process ADCIRC results for a tropical storm using the latest North Carolina mesh.
- A script is running the following process continuously during hurricane season:
  1) Latest ADCIRC forecast is detected
  2) Simulation output is downloaded
  3) Enhanced resolution script is submitted
  4) Final result is e-mailed to NCEM

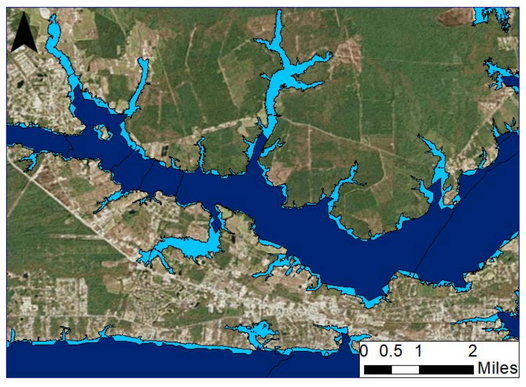


Figure 8. Example of final product in polygon format, Newport River near Morehead City, NC. Dark blue is original ADCIRC surface, light blue is enhanced surface.

- NCEM can intersect these shapefiles with their spatial building datasets to determine at-risk buildings and estimate post-storm damages.

6. CONCLUSIONS AND FUTURE WORK

- A post-processing tool has been developed that improves accuracy of ADCIRC storm surge forecasts using a high-resolution DEM.
- Current work is considering how neglecting the physics of inundation impacts the accuracy of the resulting enhanced surface.
  - This involves running ADCIRC with 50-ft grid resolution over land and comparing to the results of the enhanced resolution technique described here.
  - Preliminary results indicate that predicted flooding is strongly dependent on the source of the elevation data.
  - Results may also depend on the land-use type and slope of topography.
- Future work could involve incorporation of simple physical processes such as mass conservation and frictional dissipation, as well as application to other coastal regions.