# NH31C-0988: Downscaling of Real-Time Coastal Flooding Predictions for Decision Support

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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**.

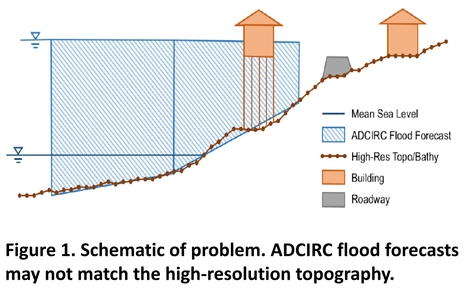



**Figure 1. Schematic of problem. ADCIRC flood forecasts may not match the high-resolution topography.**

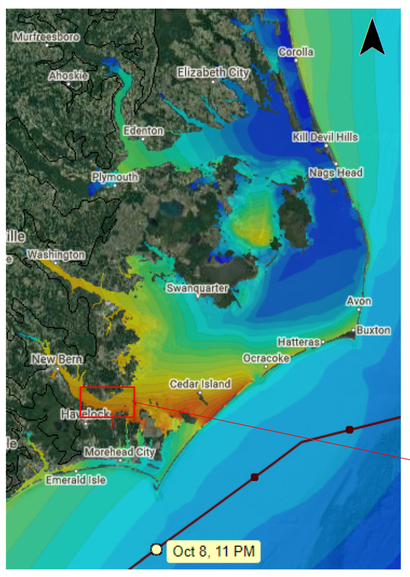
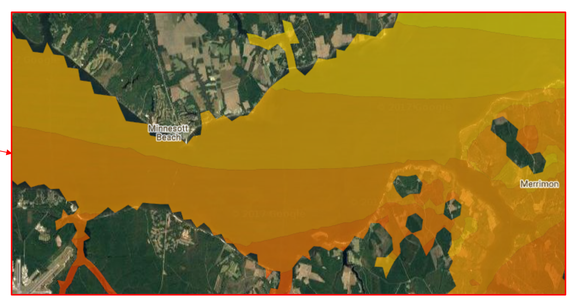


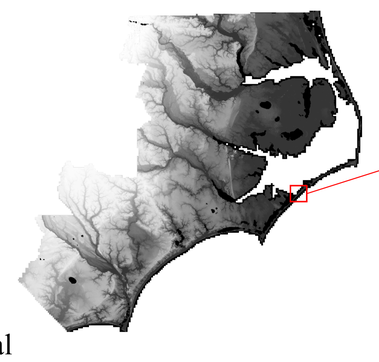

**Figure 2. Maximum water levels for Hurricane Matthew visualized on the Coastal Emergency Risks Assessment (CERA) website.**

- 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.

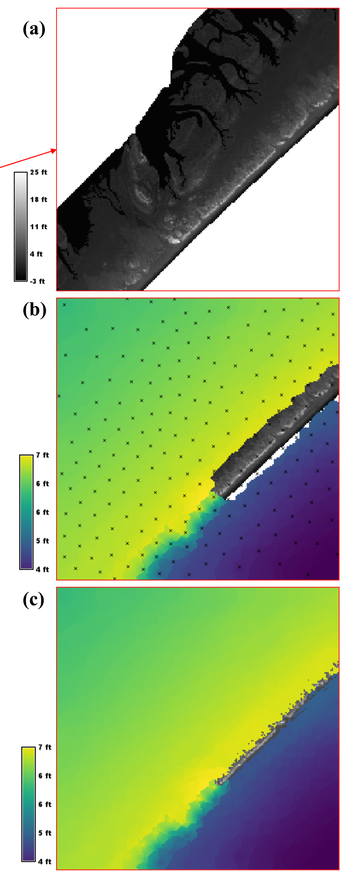



**Figure 3. Initial test region in Carteret County. (a) DEM only. (b) Interpolated ADCIRC raster overlying DEM, where points represent ADCIRC grid nodes. (c) Enhanced resolution surface.**

## 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.**

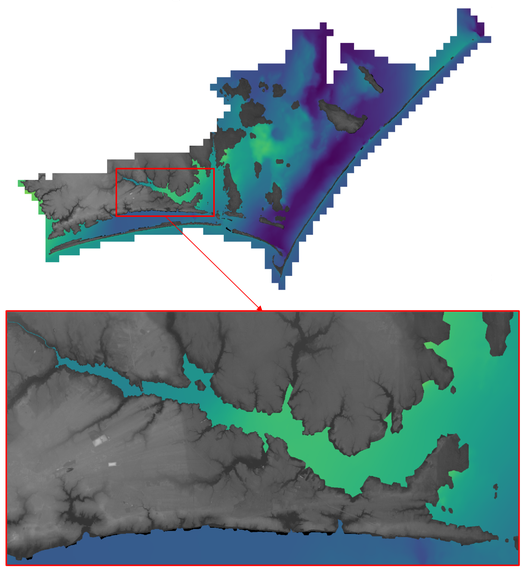


**Figure 4. Water level raster before enhancing resolution. In some areas water is not reaching the mean shoreline.**

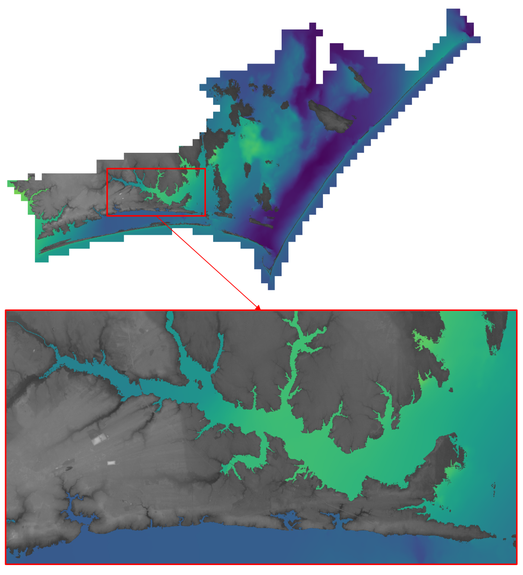


**Figure 5. Water level raster after enhancing resolution. Flooding is extended across low-lying topography.**

## 4. STATE LEVEL RESULTS

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

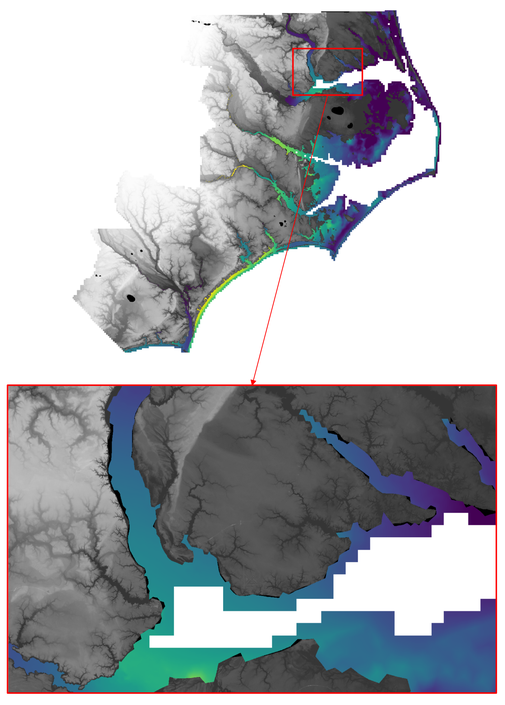


**Figure 6. Water level raster before enhancing resolution.**

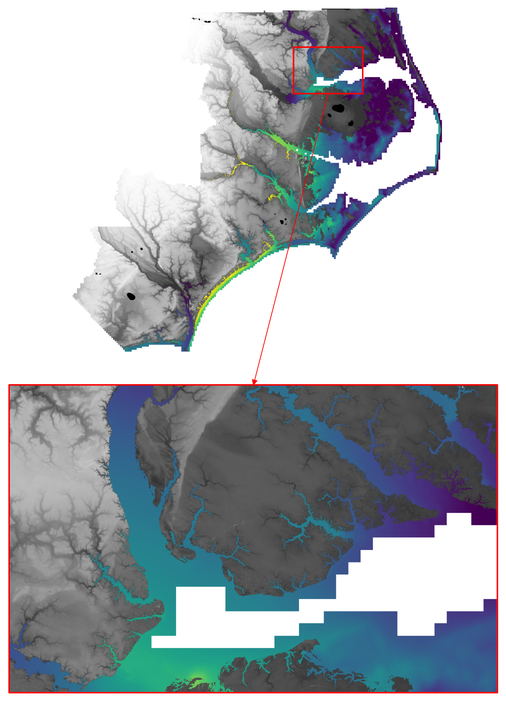


**Figure 7. Water level raster after enhancing resolution.**

- 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

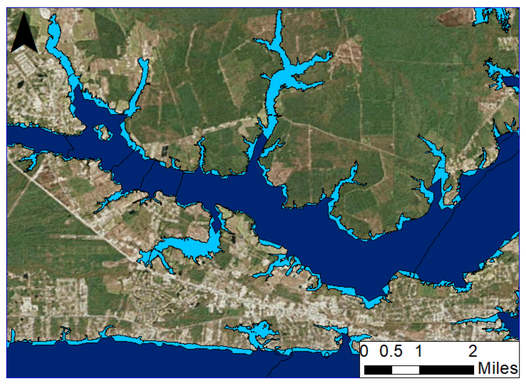



**Figure 8. Example of final product in polygon format, Newport River near Morehead City, NC. Dark blue is original ADCIRC surface, light blue is enhanced surface.**

- 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.
- This project was supported partially by NSF PREEVENTS award number 1664037.