# Predictive Modeling for Storm Surge and Flooding Risks in North Carolina

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#### Analyses of Hurricane Matthew (2016) Models for Hurricane Waves and Storm Surge Real-Time Forecasting Best-Possible Hindcast

# Mapping and Visualization for Decision Support

Connecting with Emergency Managers Downscaling and Extrapolation

# Considering Erosion of Beaches and Dunes

Exploring Morphodynamics during Isabel (2003) Initial Results with XBeach

Summary and Future Work



# Models for Hurricane Waves and Storm Surge Example of Coastal Flooding

Winds and Storm Surge during Arthur (2014)



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# Models for Hurricane Waves and Storm Surge Tight Coupling of SWAN+ADCIRC



JC Dietrich, et al. (2011). Modeling Hurricane Waves and Storm Surge using Integrally-Coupled, Scalable Computations. Coastal Engineering, 58, 45-65, DOI:10.1016/j.coastaleng.2010.08.001.

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# Real-Time Forecasting ADCIRC Surge Guidance System (ASGS)

SWAN+ADCIRC can be employed in real-time via the ASGS

# - Everything happens automatically

 $-\,$  Models are initialized, run and processed by Perl scripts

Wind fields from two sources:

- 1. Under normal conditions:
  - Downloaded from NAM model output by NOAA/NCEP
  - Converted into format compatible with SWAN+ADCIRC
- 2. Under hurricane conditions:
  - Download advisories from NOAA/NHC
  - Generate wind field using parametric model (Holland, 1980)

Guidance can be shared in multiple formats:

- Send directly to stakeholders (NC Emergency Management)
- Share publicly via web service (www.adcirc.org)

#### Real-Time Forecasting during Hurricane Hermine Coastal Emergency Risks Assessment (CERA): nc-cera.renci.org



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# Real-Time Forecasting during Hurricane Matthew Coastal Emergency Risks Assessment (CERA): nc-cera.renci.org



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#### Real-Time Forecasting during Hurricane Matthew

#### High-Resolution Meshes



#### Best-Possible Hindcast of Hurricane Matthew Evolution of Winds Along US East Coast – HSOFS



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#### Best-Possible Hindcast of Hurricane Matthew Evolution of Water Levels Along the US East Coast – HSOFS



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# Best-Possible Hindcast of Hurricane Matthew Water Level Comparison from South to North



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#### Best-Possible Hindcast of Hurricane Matthew Quantifying the Effect of Mesh Resolution

How does mesh resolution affect the model performance?

- Comparison to wind speeds:

Mesh	Stations	RMSE (m/s)
HSOFS	108	1.944
HSOFS	33	2.260
NC9	33	2.367

- Comparison to water levels:

Mesh	Stations	RMSE (m)
HSOFS	310	0.295
HSOFS	90	0.264
NC9	90	0.240

Water level predictions are improving when we have better resolution

- How can we improve for future years?

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#### Connecting with Emergency Managers Flood Inundation Mapping and Alert Network (FIMAN): fiman.nc.gov



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#### Downscaling and Extrapolation LiDAR DEM of Carteret County

Extrapolate water surface elevation predicted by ADCIRC to match topography of a higher-resolution Digital Elevation Model (DEM)

- Interpolate ADCIRC points to raster at resolution of DEM (50 ft)
- Using GRASS GIS, "expand" raster outward only where the ADCIRC cell value is greater than the DEM cell value
- Remove isolated (not hydraulically-connected) ADCIRC cells generated by this process
- Convert new, expanded raster to polygon format



#### Downscaling and Extrapolation Initial Results – Carteret County



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# Considering Erosion of Beaches and Dunes eXtreme Beach (XBeach): xbeach.org

Our forecast system is limited:

- Bathymetry and topography are fixed / constant
- No consideration of beach erosion, dune breaching, etc.
- Flooding impacts are limited behind the dunes



With support from NC Sea Grant, we are coupling with XBeach:

- Open-source model developed in the Netherlands
- Capable of simulating hydrodynamic and morphodynamic processes
- Applied typically at beach scales (a few kilometers)



# Initial Results with XBeach XBeach Profiles at Major Dune Erosion Events Dune Erosion Event #2:

- Removal of first and second dunes
- The erosion and overwash modeled correctly











# Initial Results with XBeach Model Accuracy

Skill Score:

- Compares measured to modeled elevation change
- Skill score greater than 0.5 is "Excellent"
- Modeled profiles match observations: scatter points close to  $1{:}1$



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Predictive Models for Waves, Flooding, and Beach Morphodynamics

Real-time forecasting for coastal North Carolina:

- Available at: www.adcirc.org
- Hurricane Matthew (2016)
  - 47 advisories were issued during the storm
  - Flooding impacts along the U.S. East Coast
  - Hindcasts on meshes with difference coverage, resolution
  - Water level predictions within 1 ft
- Working with NCEM to integrate forecasts into FIMAN

Working with XBeach to simulate beach and dune erosion:

- Preliminary results are encouraging
  - Developing model for Hatteras Island
  - Improving accuracy for complex erosion patterns
- $-\,$  Need to couple with wave and surge models
  - Revised topography to improve flood predictions

