Modeling the Combined Coastal and Inland Hazards from High-Impact Storms

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Student Researchers: Xuanyu Chen (poster), Mansur Ali Jisan (poster),
Angelos Papandreou (poster), Deb Crowley (poster)

Program Goals:

- Develop and transition to operations new and improved wind, coastal ocean circulation, wave, and hydrological modeling capabilities of the real-time ADCIRC-Surge Guidance System (ASGS) for predicting hazards and potential impacts from tropical and extratropical cyclones on critical infrastructure and communities in the U.S.
- Engage key end-users in the development and dissemination of ADCIRC-based hazard and impact analysis to make more relevant, and useable for planning and response

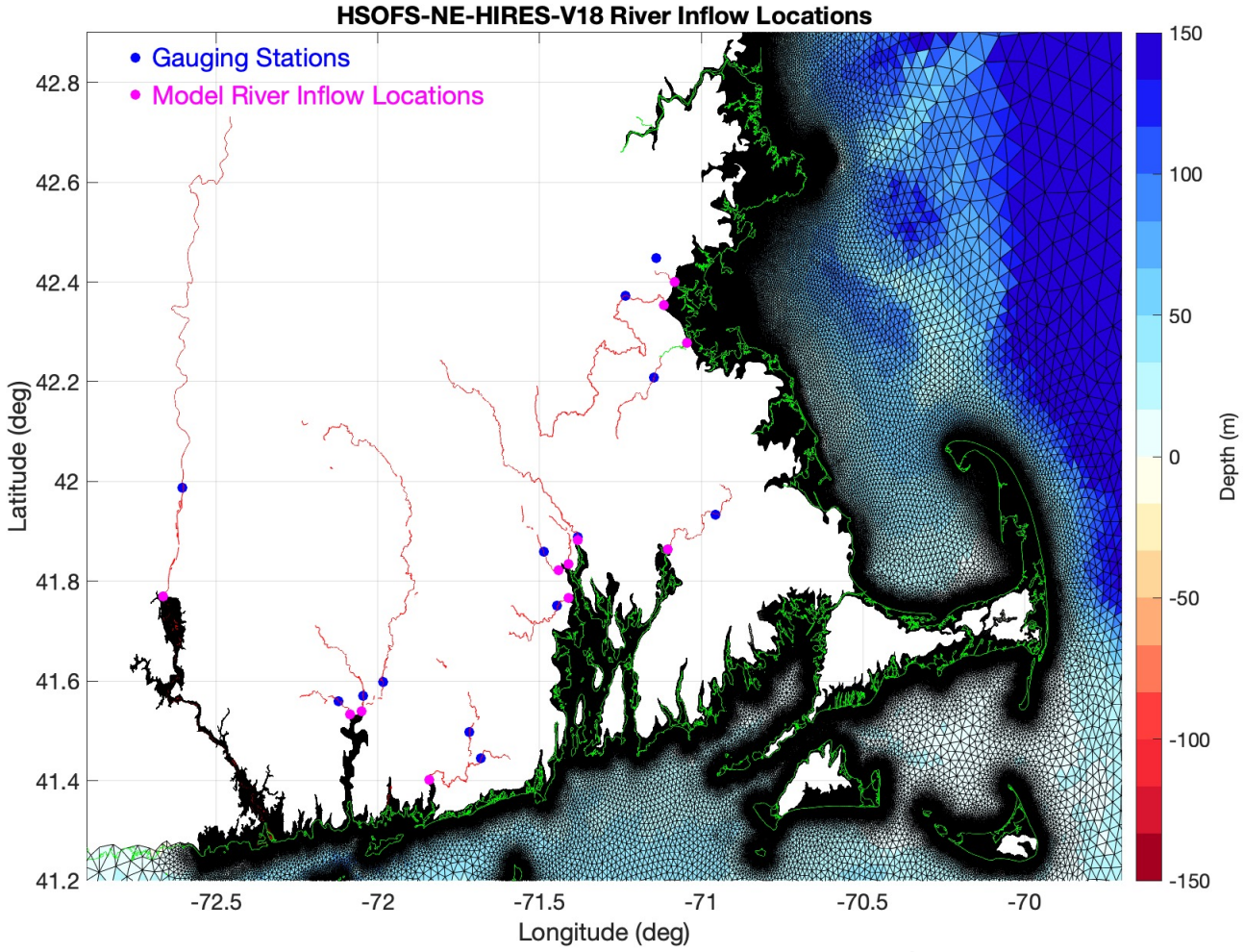
Federal partners: NOAA National Weather Service Northeast, NOAA National Center for Environmental Prediction, NOAA National Ocean Service, FEMA Region 1

State & municipal partners: RIEMA, RIDOH, RIDEM, PEMA, emergency responders, facility managers, & other critical decision makers

ADCIRC high-resolution regional mesh in New England

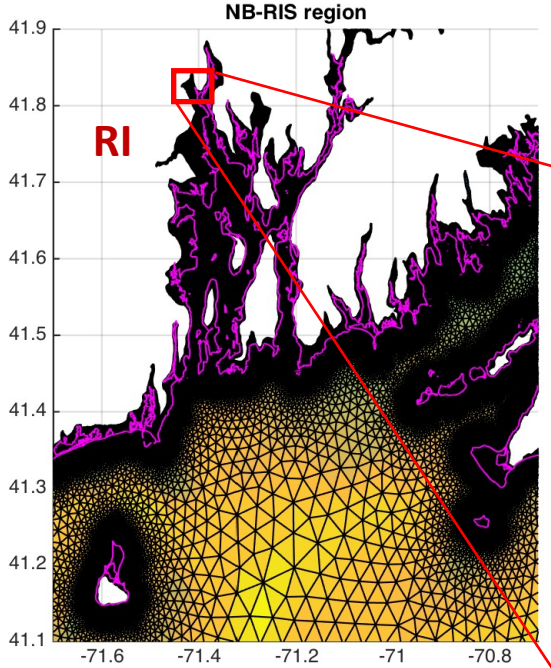
- Presently have 12 rivers configured
- For hindcast simulations, discharges for these rivers available from USGS at gauging stations
- For forecasts, will utilize output from National Water Model

Most rivers in Southern New England are relatively short, increasing the likelihood that effects of river flooding and wind-driven storm surge can interact.

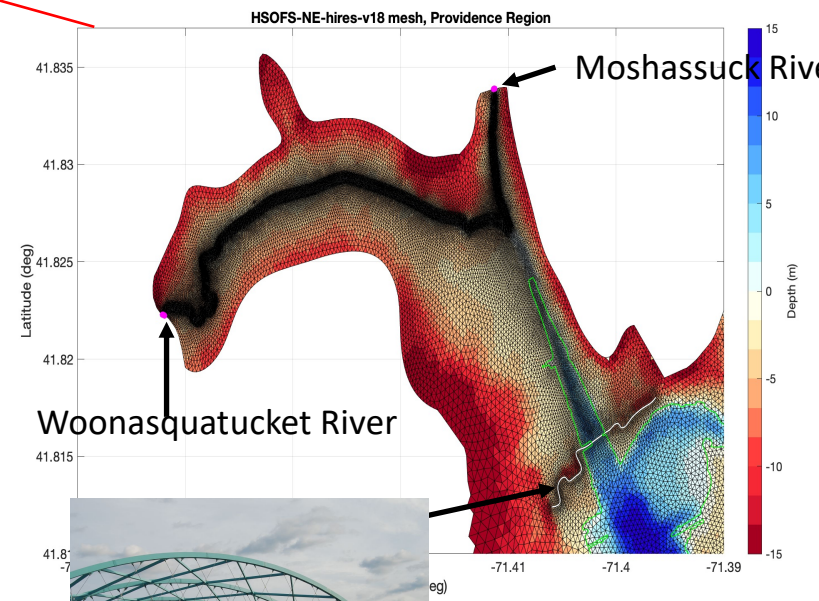


ADCIRC high-resolution regional grid in New England:

Rhode Island – Providence



Grid resolution near Providence ~ 5-10 m

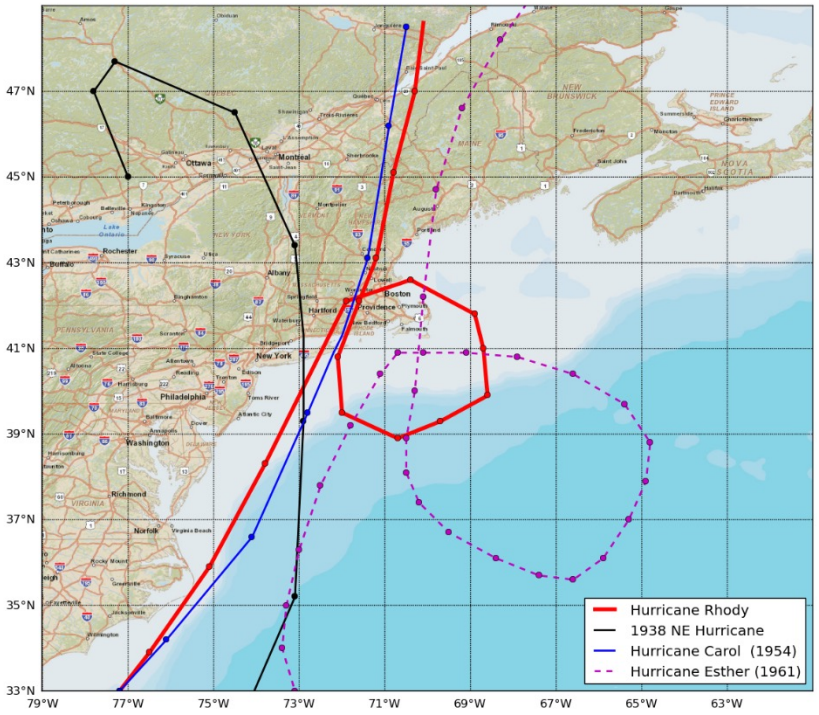


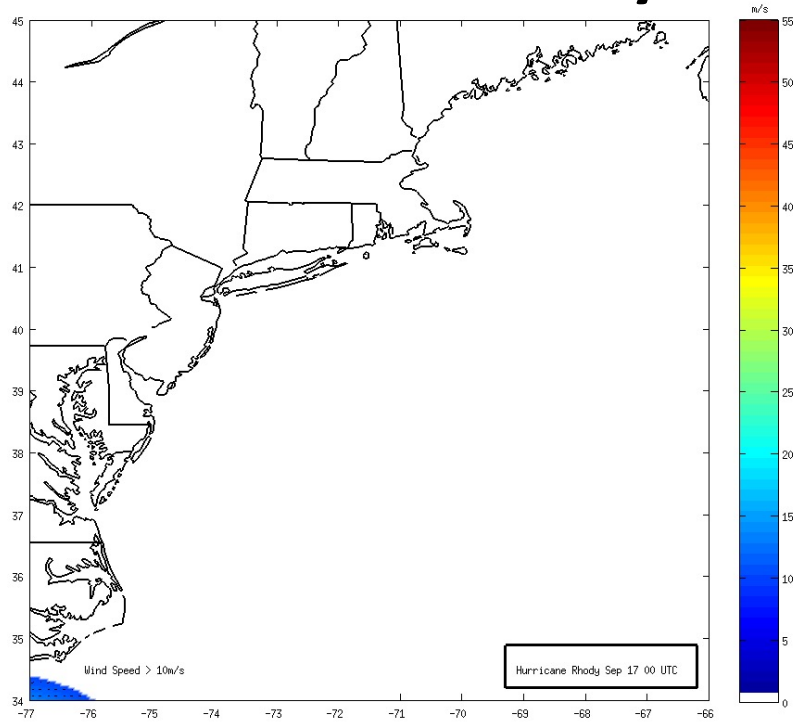
Fox Point Hurricane Barrier

Investigating the effect of Fox Point Hurricane Barrier during extreme hurricanes

- Heavy flooding in Providence during Hurricane Carol spurred construction of Fox Point Hurricane Barrier in the 1960th. The Barrier with 7-meter height was built to protect city from storm surge (from south).
- Barrier has pumps to discharge river water from rivers entering the area to the north.

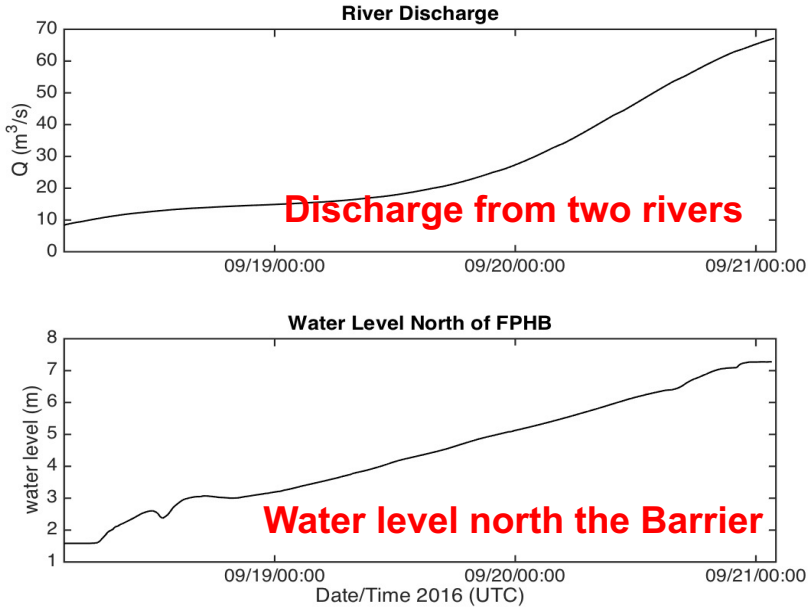
Assessing Multiple Impacts of Extreme Hurricanes in Southern New England: Hurricane Rhody

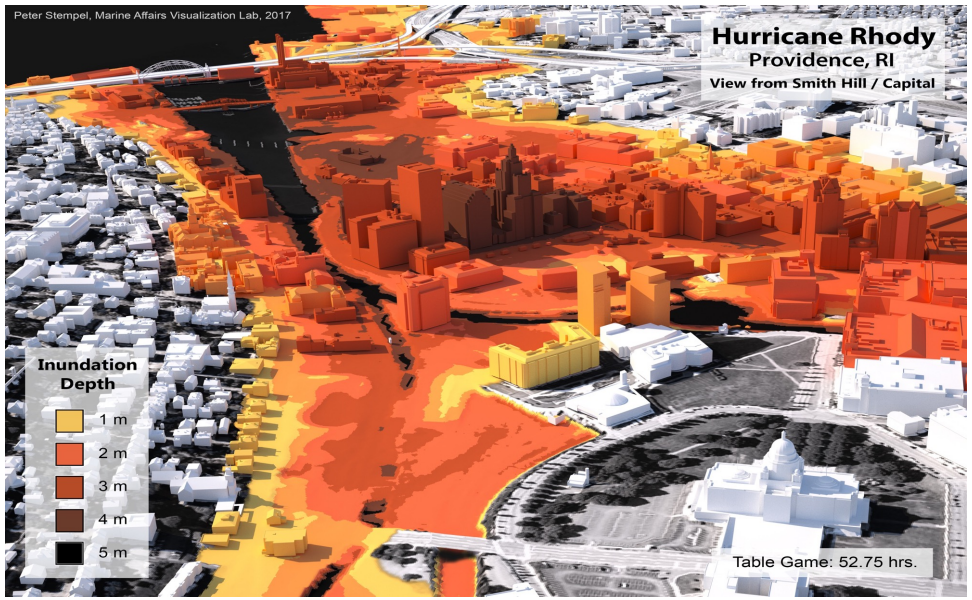




Hurricane Rhody is a physically plausible hurricane scenario created to simulate the effect of a extreme impact storm in Rhode Island.

Hurricane Rhody Flooding in Providence



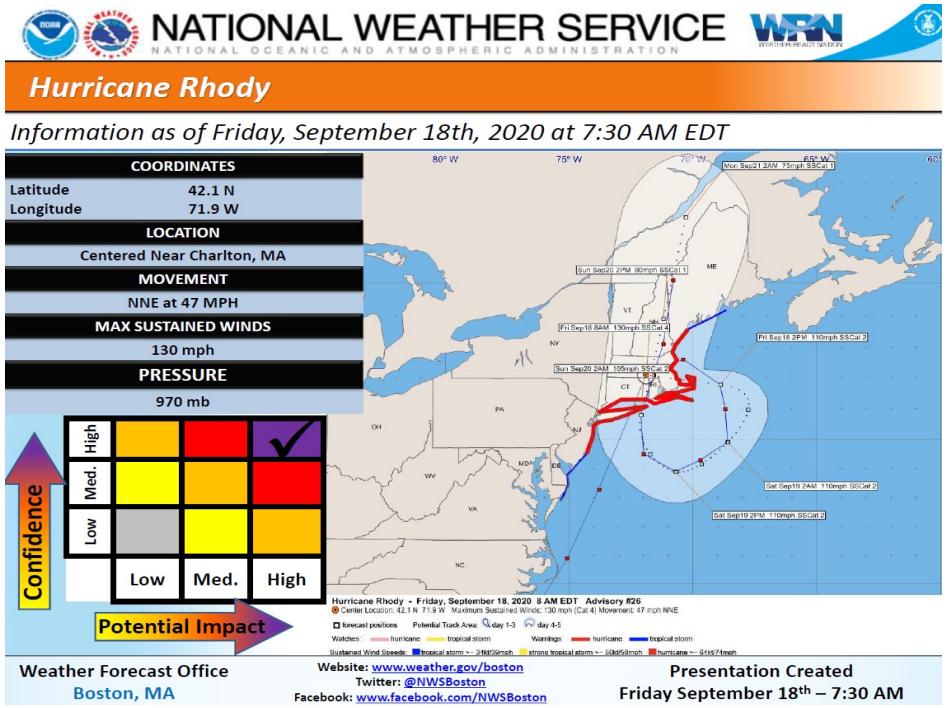


Combined rivers discharge from Woonasquatucket and Moshassuck rivers during Hurricane Rhody computed from the HEC-RAS model and applied as inflow forcing in ADCIRC in a scenario with the barrier closed and pumps disabled (Ullman et al, 2018)

COASTAL RESILIENCE CENTER

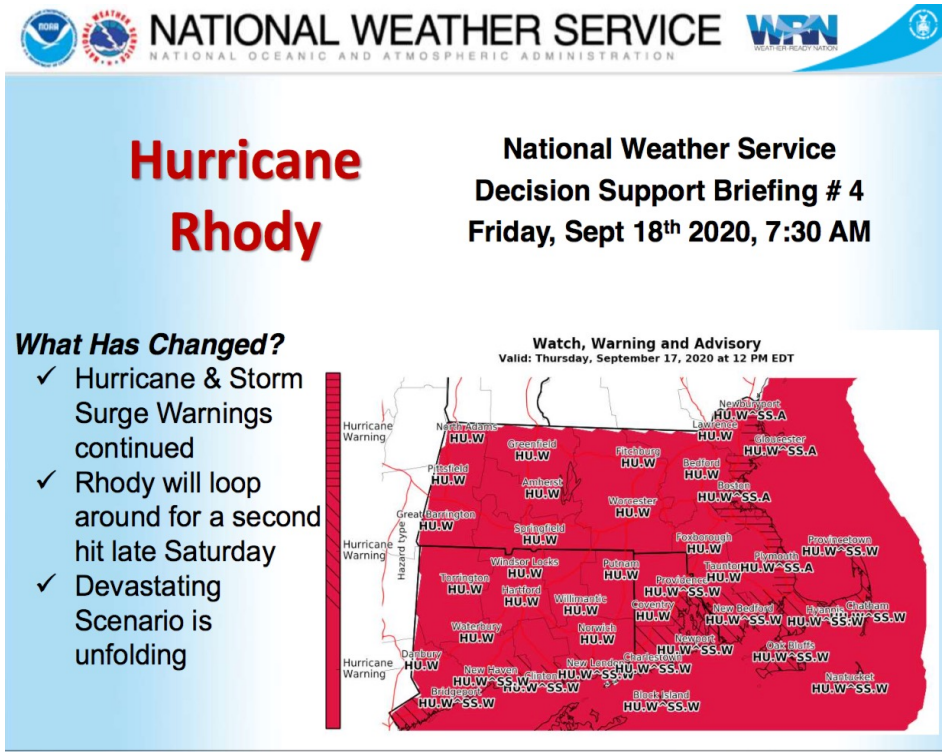
A U.S. Department of Homeland Security Center of Excellence

FEMA Integrated Emergency Management Course
June 19 – 22, 2017



Attended by more than 160 participants from Rhode Island municipalities, state agencies, non-profit organizations and FEMA Region 1.

NWS Office in Taunton, MA developed tropical storm advisories and hazard graphics for the Hurricane Rhody weather briefings.



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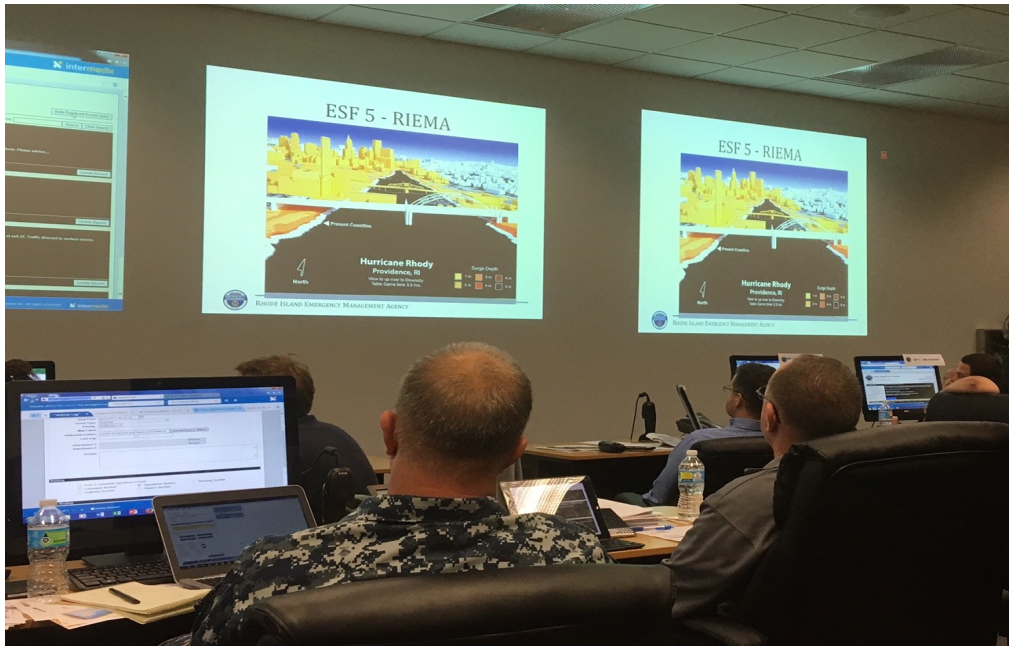
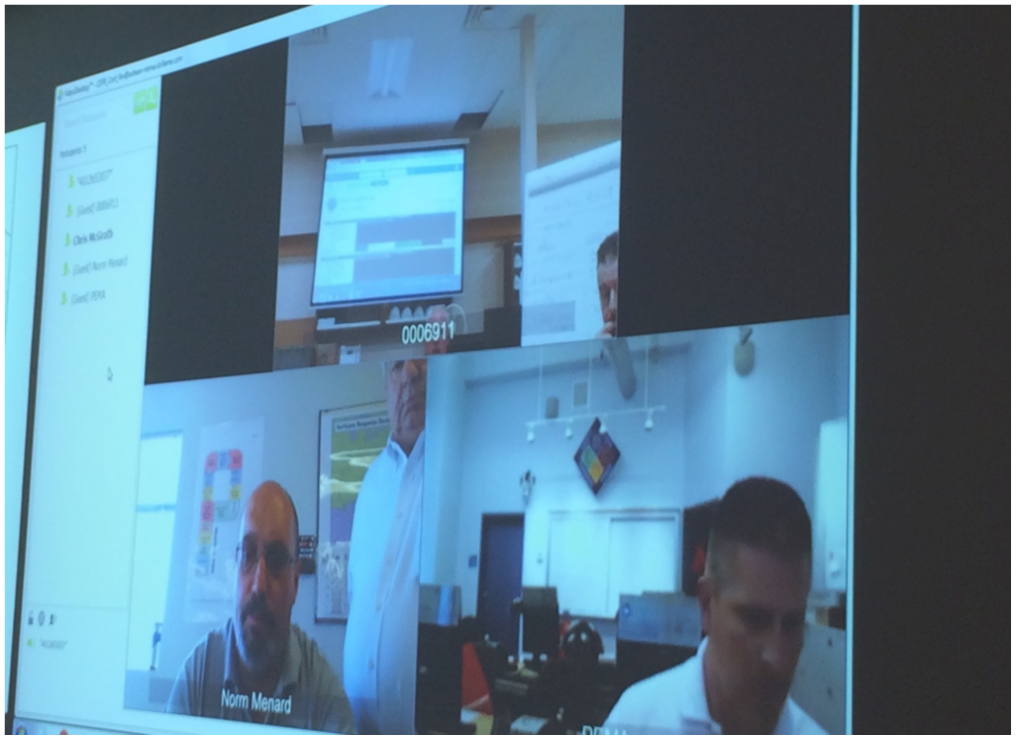




Culmination of IEMC was the functional exercise in the State Emergency Operations Center (EOC) and 4 municipal EOCs, which were connected virtually.

The Providence Journal

Are we "ready for Hurricane Rhody?"

eco RI news

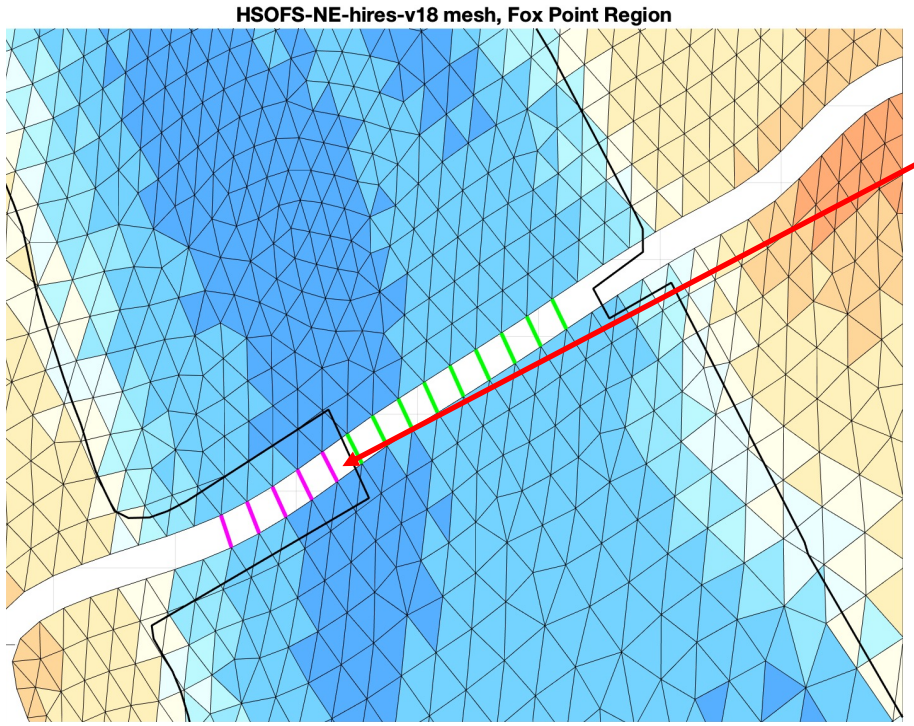
Hurricane Rhody Bears Down on Rhode Island's Future

Newsweek

TECH & SCIENCE

Future Hurricane Could Loop Around and Make Landfall Twice in the U.S., Causing Catastrophic Flooding and Storm Surges

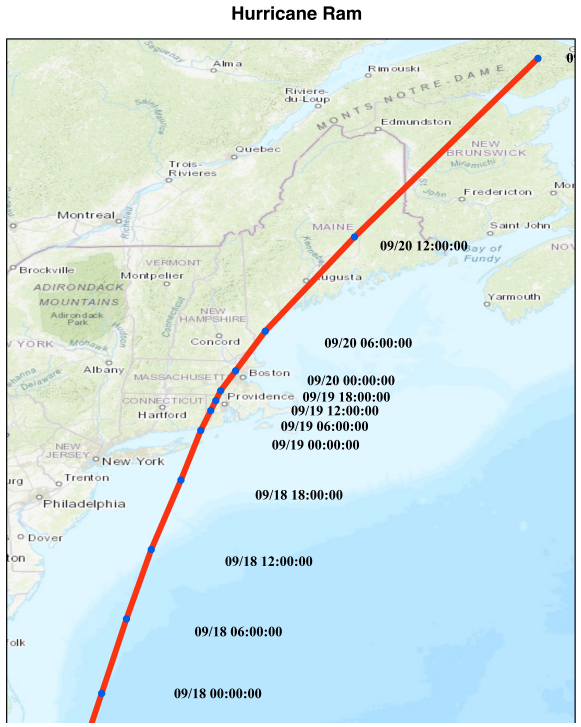
Developing ADCIRC capabilities to model Hurricane Barrier Pumps



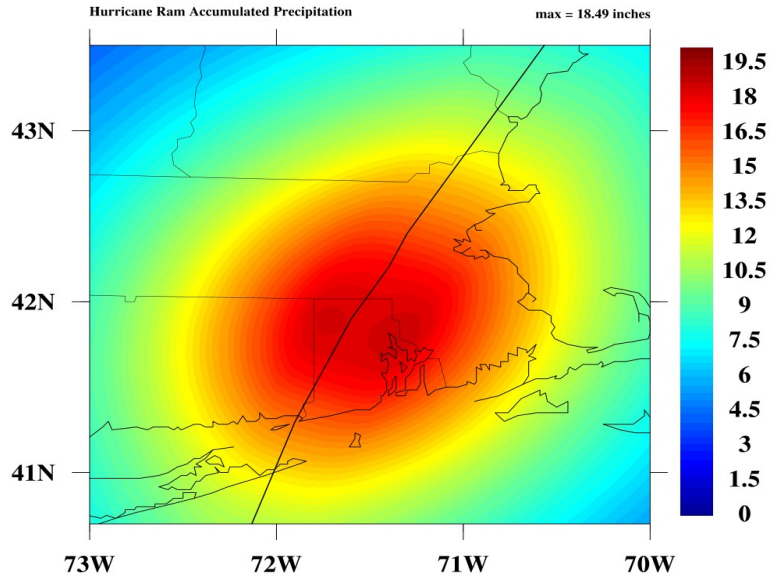
Pumps

Providence EMA and other local stakeholders are interested in the ability of pumps to handle various hurricane scenarios.

Assessing Multiple Impacts of Extreme Hurricanes in Southern New England: Hurricane Ram



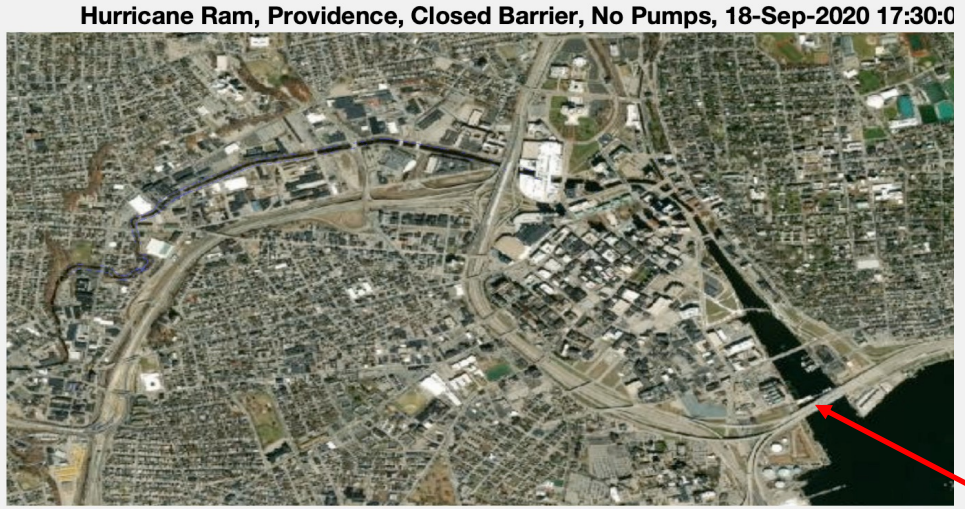
Total accumulated rainfall



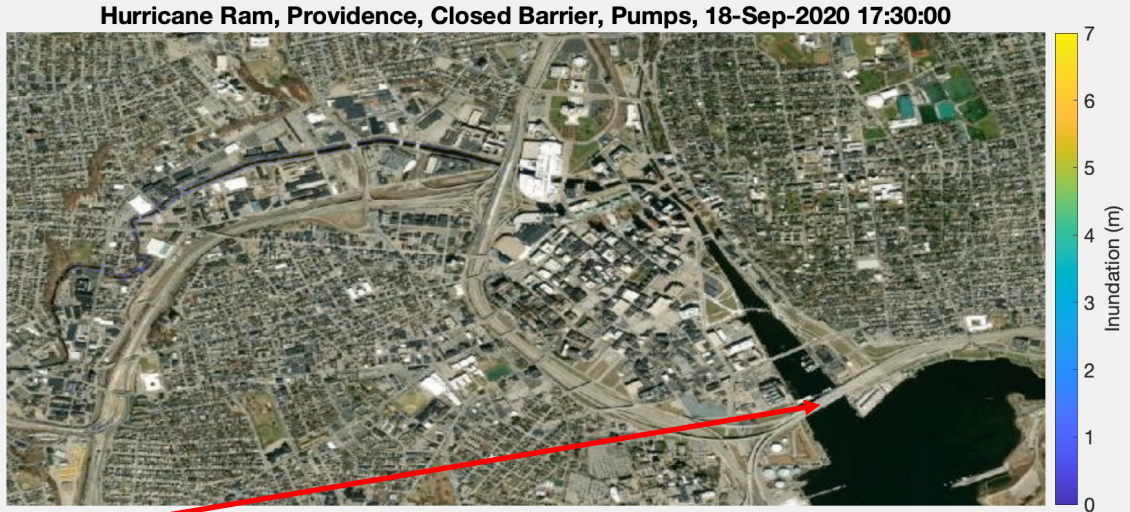
Hurricane Ram is a physically plausible hurricane scenario created to simulate the effect of an extreme impact storm in Rhode Island.

ADCIRC simulations of the effect of Hurricane Barrier Pumps during Hurricane Ram

Barrier closed, No pumps



Barrier closed, With pumps



Fox Point Hurricane Barrier

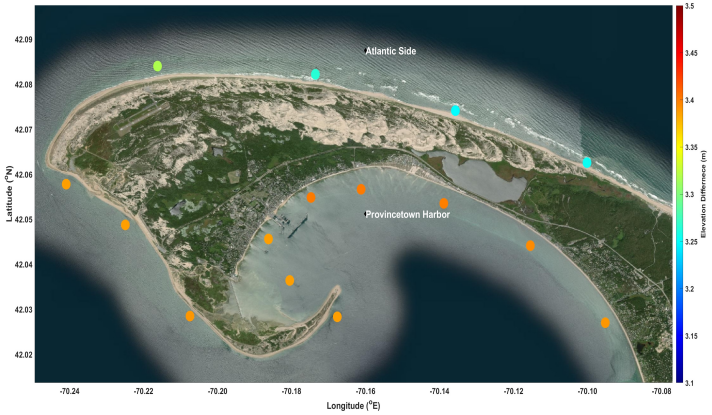
Inland flooding is produced by river runoff from Woonasquatucket River and Moshassuck River due to heavy rainfall

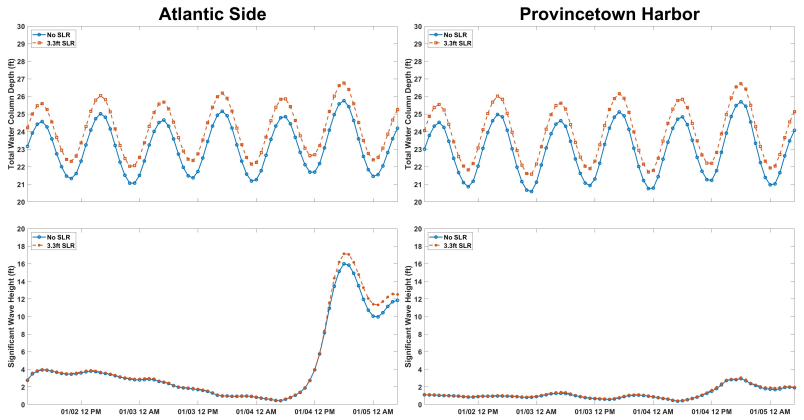
Applying ADCIRC to Assess Changing Coastal Risks from Nor'easters with Sea Level Rise in New England

(poster by Deborah Crowley)

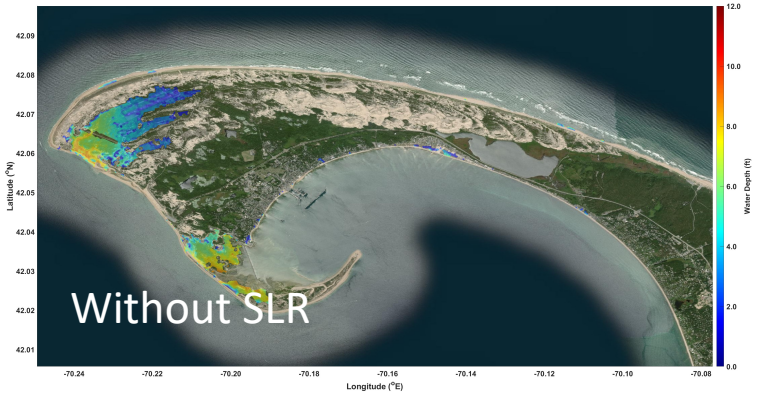
March 2018 Nor'easter

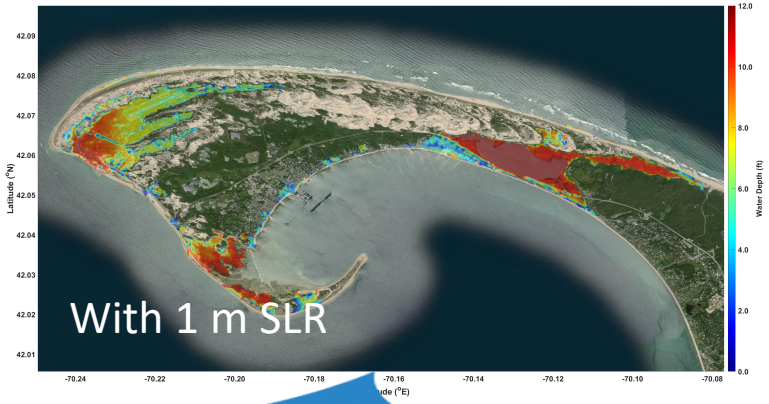
ADCIRC mesh: Cape Cod, MA





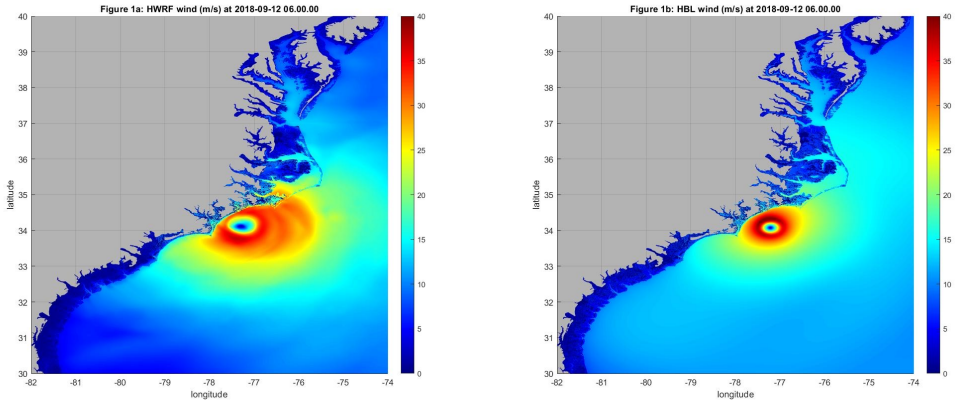
Maximum inundation



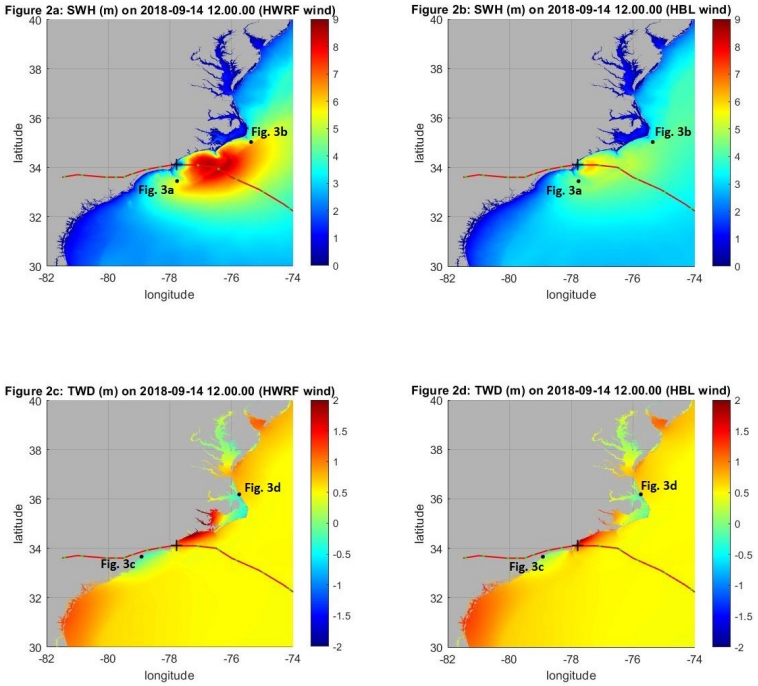


ADCIRC Hurricane Florence numerical simulations of waves and storm surge using different wind forcing products

(Poster by Angelos Papandreou)



Hurricane WRF wind reanalysis (left) and URI HBL wind (right), 6 hours before landfall

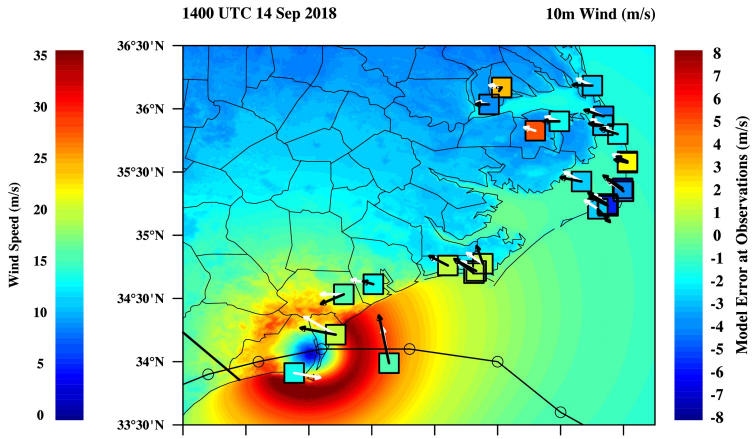


Significant wave height (top) and total water depth (bottom) simulated using the HWRF and HBL winds.

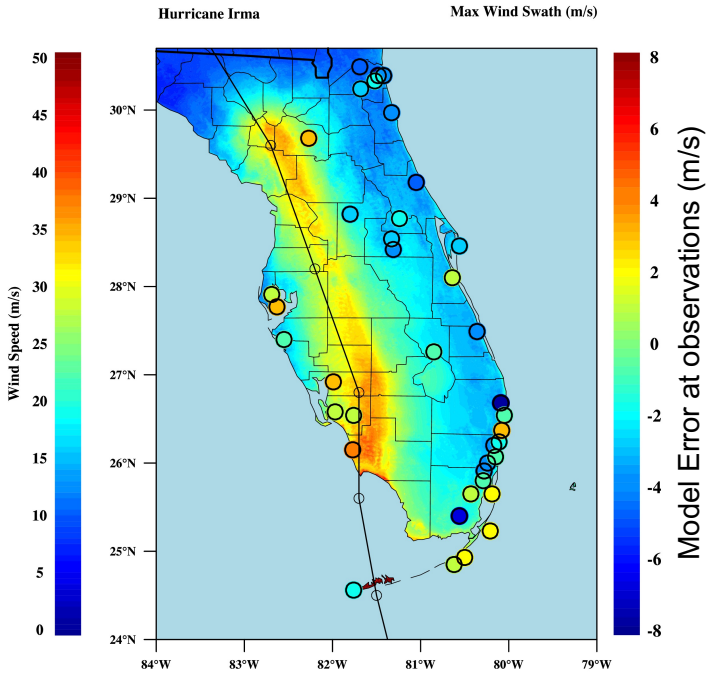
Application of a Hurricane Boundary Layer Model for Improved Surface Wind Forecast

(Poster by Mansur Ali Jisan)

Hurricane Florence (2018)

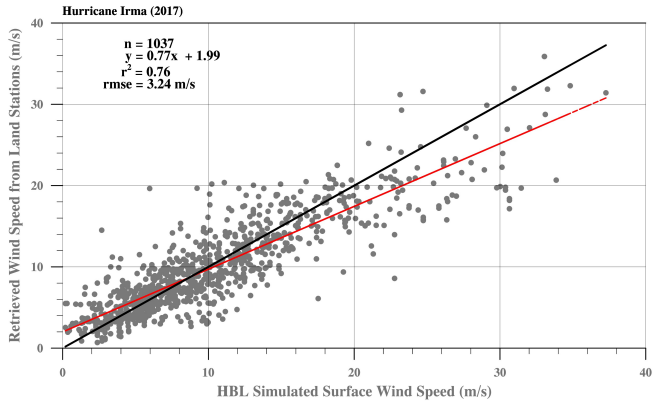


Wind speed and direction comparisons with observations during landfall. Markers represent the magnitude of error at the location of observations. The black and white colored arrows representing the observed and modeled wind direction.



Hurricane Irma (2018)

Maximum wind speed over land: Comparisons with observations

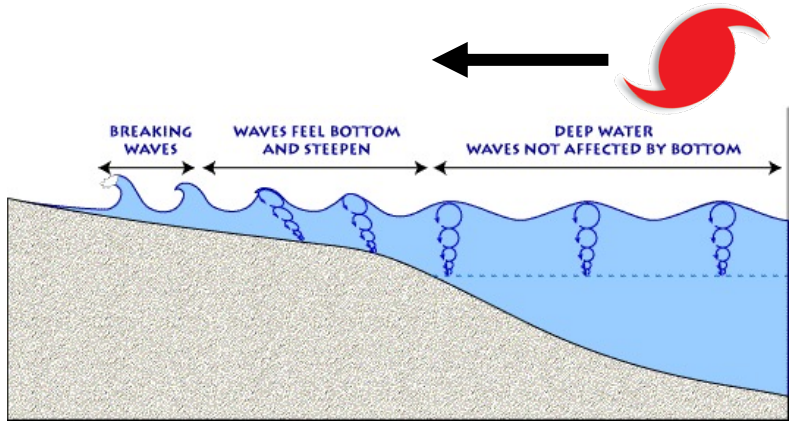


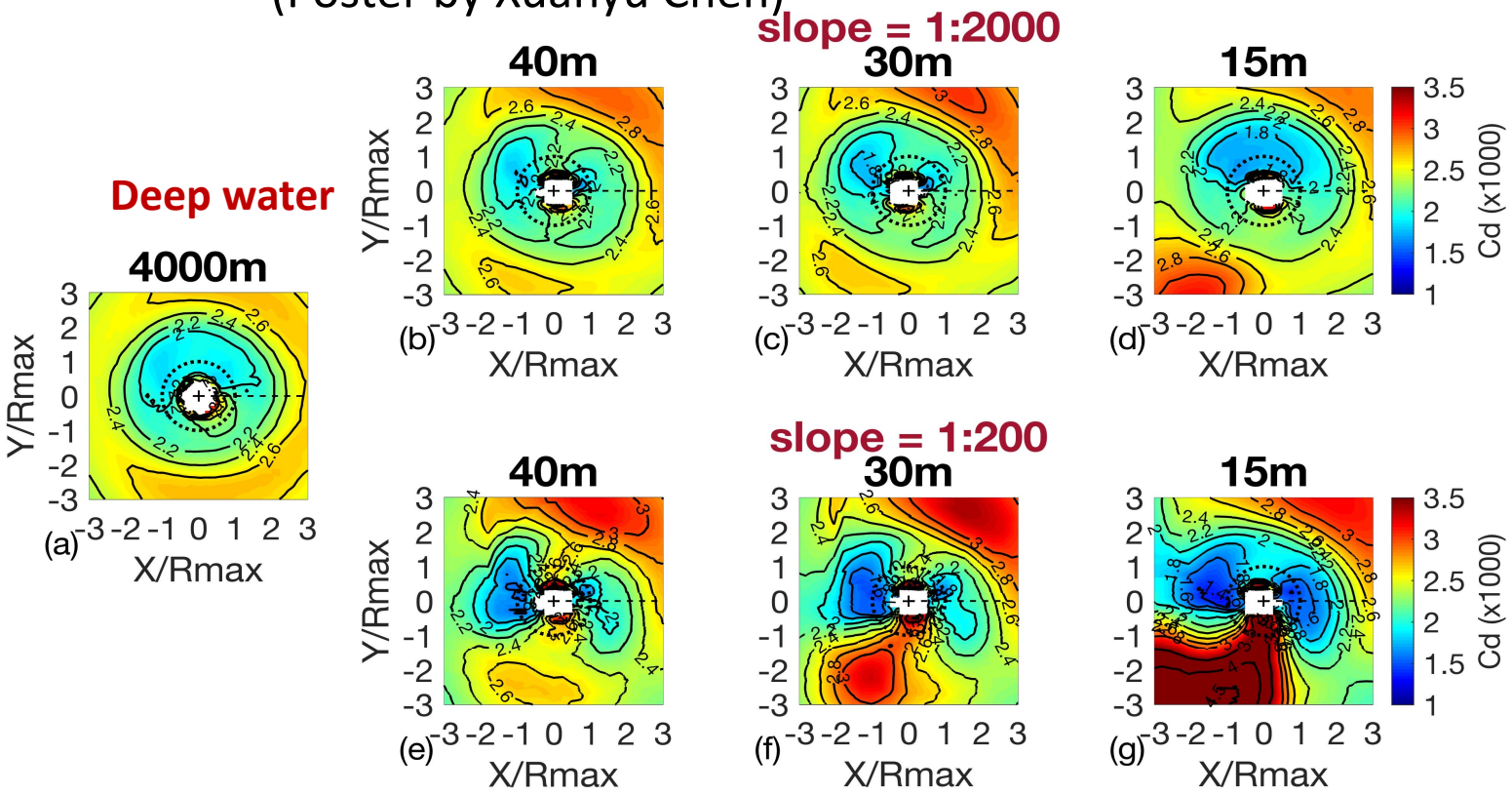
The hurricane boundary layer model is developed based on the numerical framework by Gao and Ginis (2014, 2018)

Advancing ADCIRC air-sea interaction physics

Effect of shoaling waves on wind stress and drag coefficient in coastal water

(Poster by Xuanyu Chen)



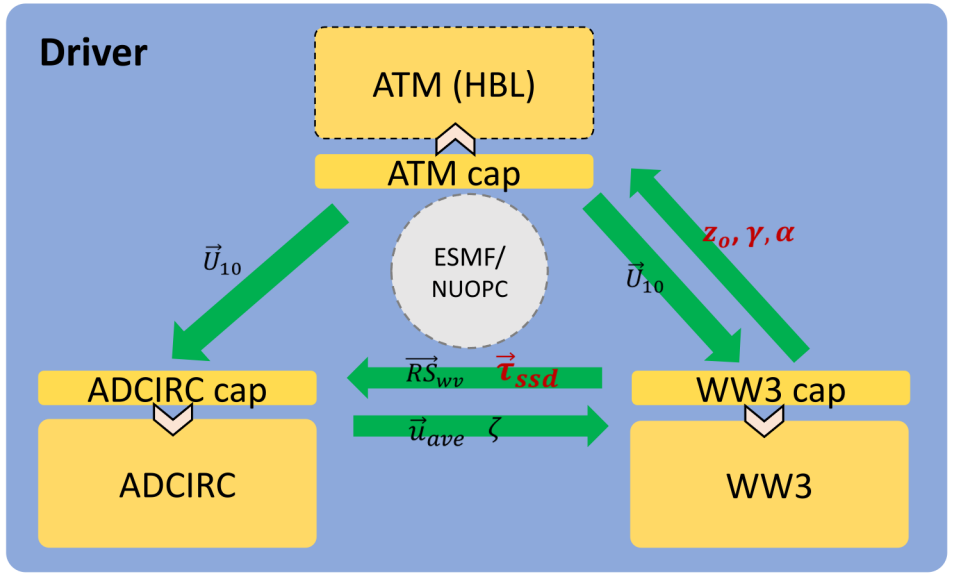


Chen, X, I. Ginis, T. Hara 2020: Impact of shoaling ocean surface waves on wind stress and drag coefficient in coastal waters: Part II Tropical Cyclones, *J. Geophys. Res.* 125, https://doi.org/10.1029/2020JC016223

Implementation and Evaluation of the Flexible ADCIRC-WAVEWATCH III coupled system

(poster by Xuanyu Chen)

Collaborative effort with NOAA's National Centers for Environmental Prediction/Environmental Modeling Center and National Ocean Service/Storm Surge Modeling Center.



"I am pleased to provide support and guidance whenever possible to this project. We are interested in advancing the ADCIRC-WW3 coupled system and research on the combined effects of storm surge, waves, and sea-level rise on coastal flooding which will benefit future operational systems at NCEP like COASTAL Act."
Chief, Dynamics and Coupled Modeling Group Modeling and Data Assimilation Branch, NOAA/NWS/NCEP/EMC.

Coastal Hazards Analysis, Modeling, and Prediction System for Emergency Management and Response

Combining ADCIRC with Hazard Consequence Threshold Database and Interactive Dashboard
Collaborative effort with Dr. Austin Becker, URI Marine Affairs and the team.