ERDC
Engineer Research and Development Center

Nearshore Wave Modeling and Evaluation for the North Atlantic Coast Comprehensive Study

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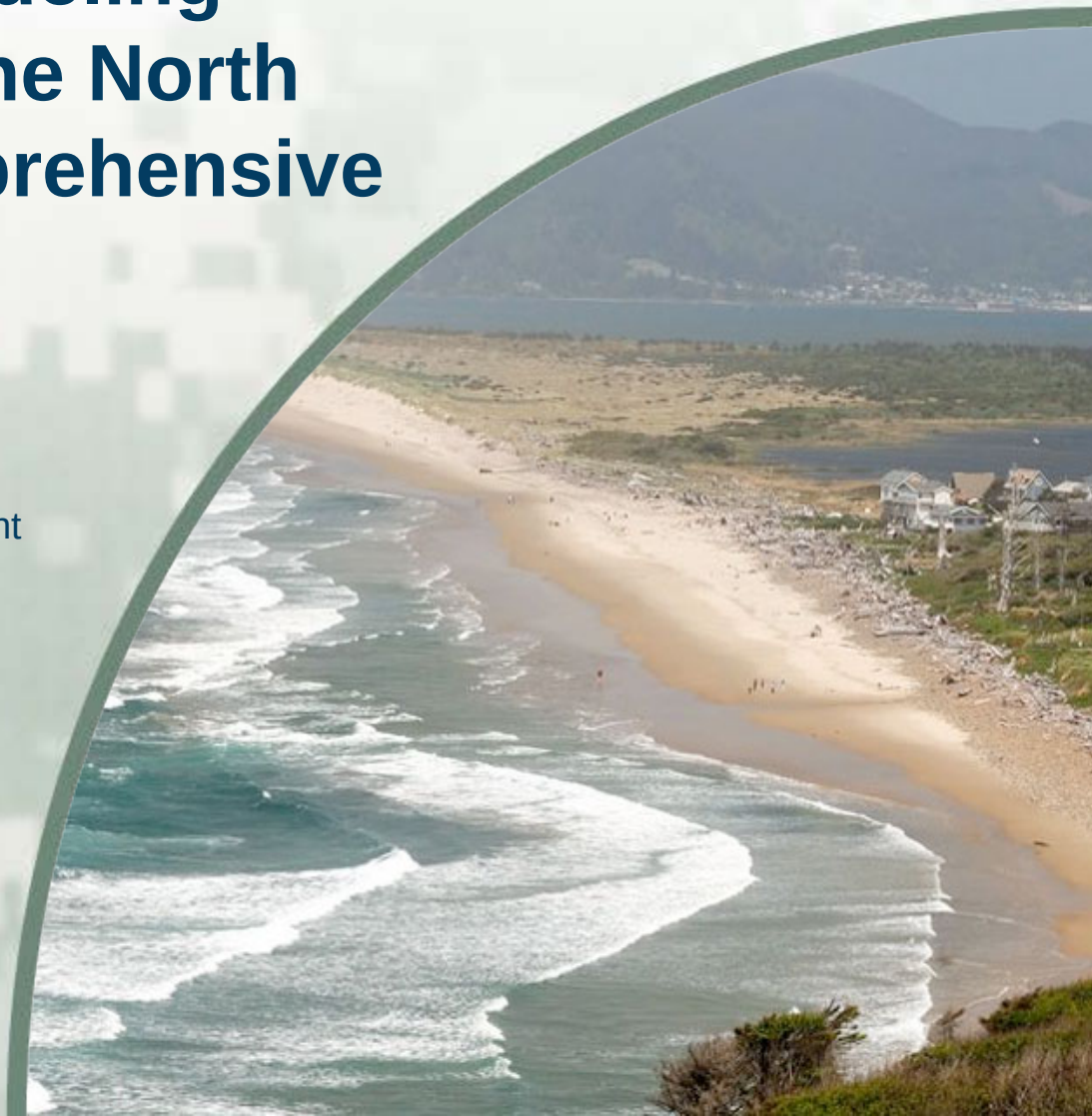
Coastal and Hydraulics Laboratory

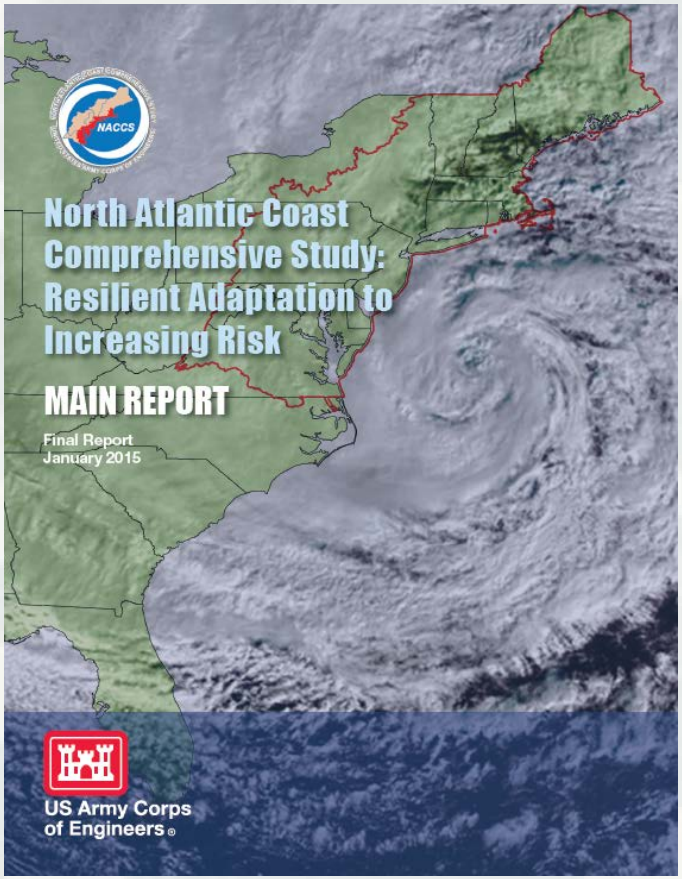
November 12, 2015



US Army Corps of Engineers®

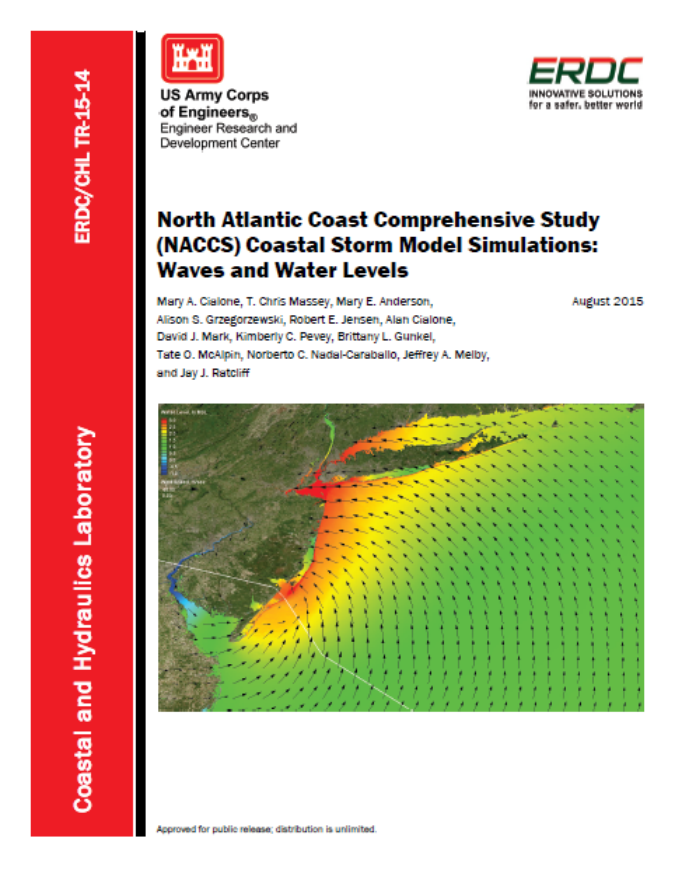
NACCS Overview

- Congressional mandate in response to Hurricane Sandy
  - address the vulnerability of coastal populations, infrastructure, and resources
  - develop risk management framework
  - support resilient coastal communities
- designed to help coastal communities affected by Hurricane Sandy to identify flood risk and to provide tools and guidance to help better prepare for present and future flood risks

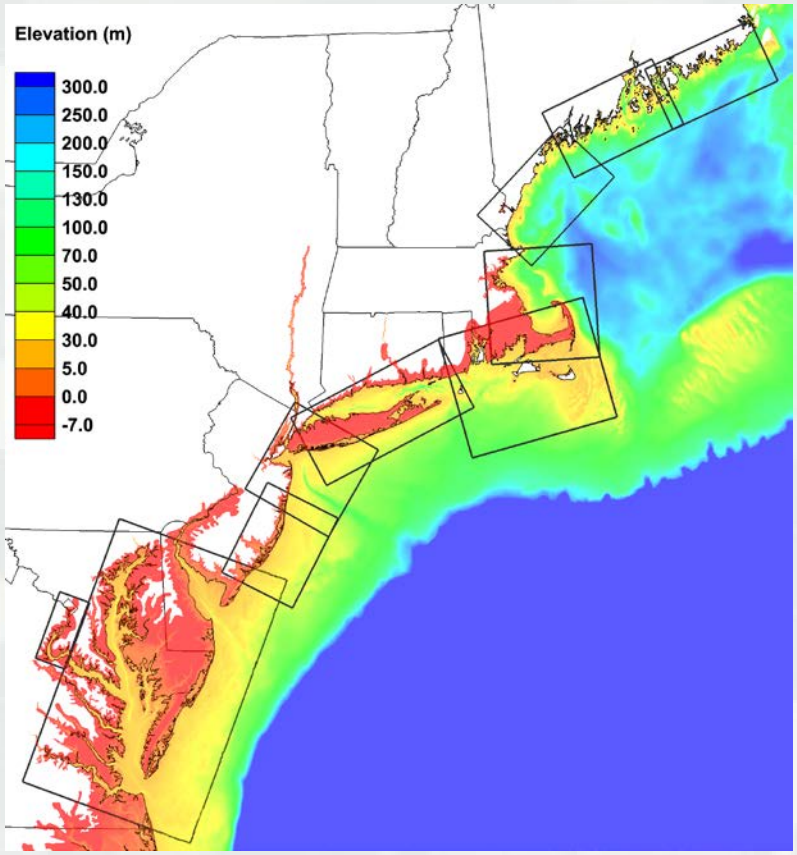


NACCS Numerical Modeling

- characterize the flood hazard by applying high-fidelity hydrodynamic models to quantify coastal storm wave, wind, and water level extremes
  - ADCIRC: circulation and storm surge
  - WAM: global ocean
  - STWAVE: nearshore
- suite of 100 historical extratropical and 1050 synthetic tropical storms to estimate storm-induced water level statistics
- largest civil works modeling project to date

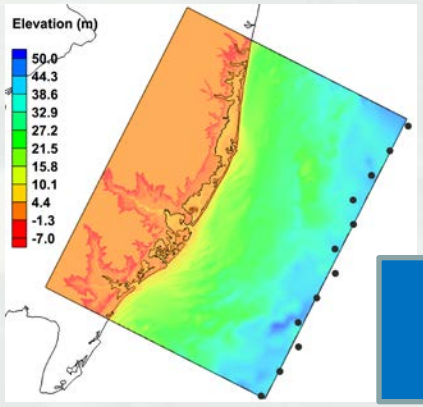


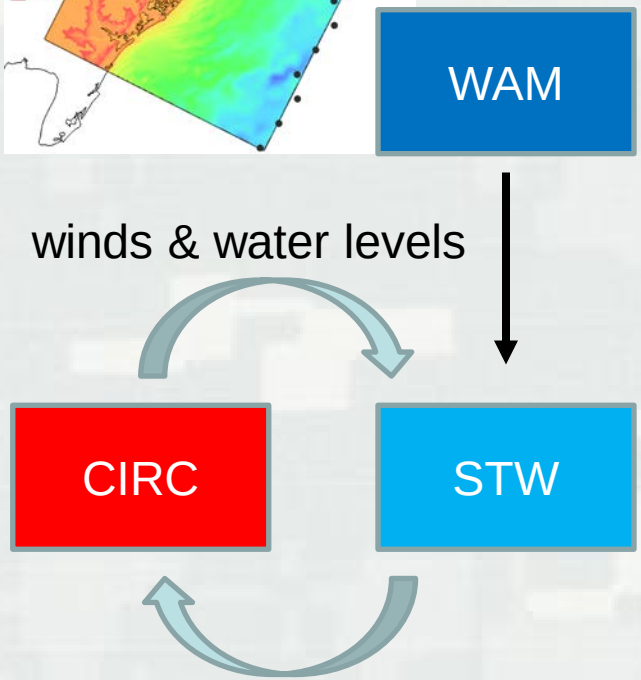
STWAVE Grid Development



- STWAVE is Corps workhorse model for nearshore waves
- 10 full-plane grids
  - wave transformation and generation on full 360-deg plane
- offshore boundaries of at least 40 m
- Cartesian grids:
  - 200 m, 125 m in Chesapeake Bay, 100 m in Washington D.C. vicinity
- bathymetry and bottom friction interpolated from ADCIRC mesh
- parallel in space execution on HPC

Model Coupling

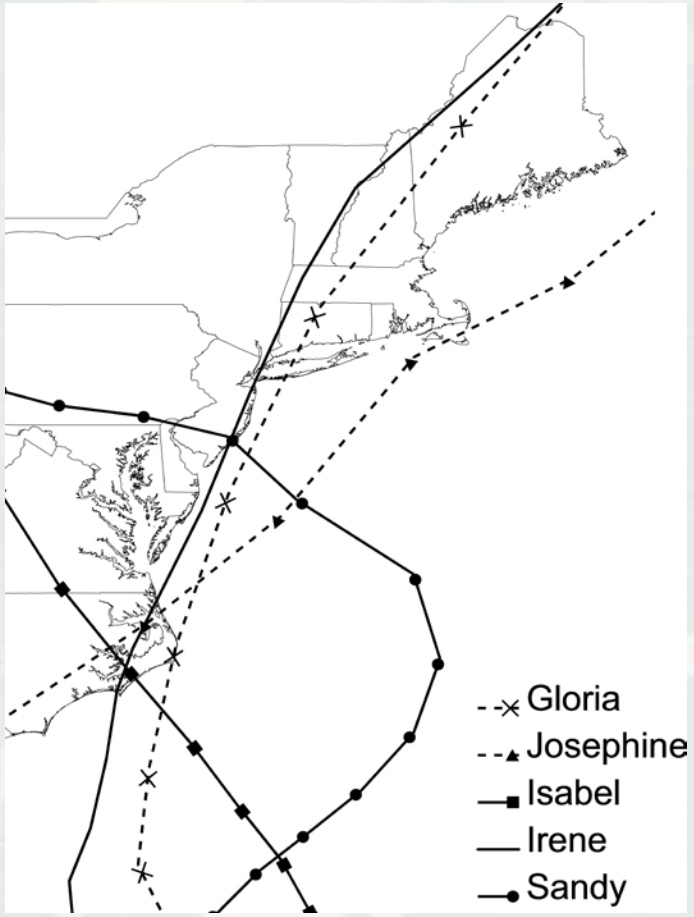




- forcing applied every 30 minutes
- two-dimensional wave spectra from WAM applied along offshore boundary
- CSTORM-MS
  - ADCIRC and STWAVE run sequentially
  - ADCIRC passes spatially variable winds and water levels to STWAVE
  - STWAVE passes spatially variable radiation stresses to ADCIRC

Historical Storms

- Extratropical events
  - January 1996 (ET070)
  - December 1996 (ET073)
- Tropical events
  - Gloria (1985)
  - Josephine (1996)
  - Isabel (2003)
  - Irene (2011)
  - Sandy (2012)



Observations

- 30 identified buoys
  - NDBC, NODC, NERACOOS, CDIP, LISICOS, CBIBS, MVCO, USACE …
- Number operational:
  - Gloria (1985): 1
  - Josephine (1996): 5
  - ET070 (1996): 5
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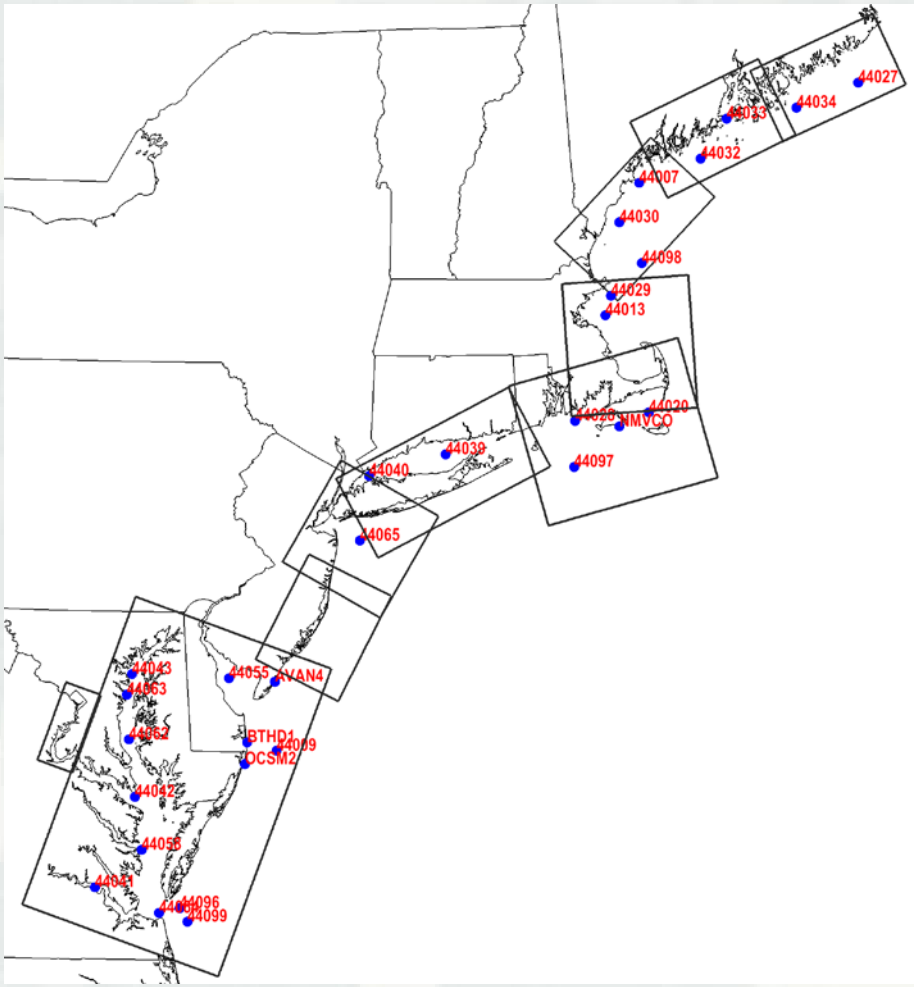

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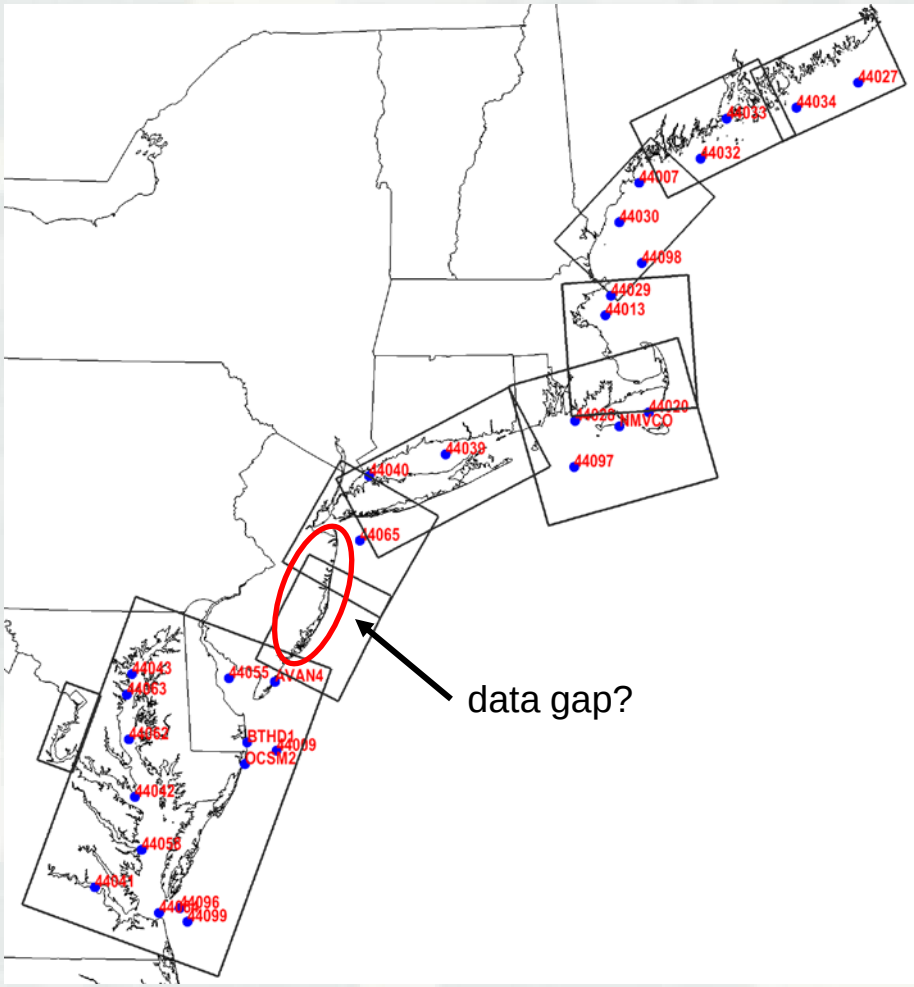
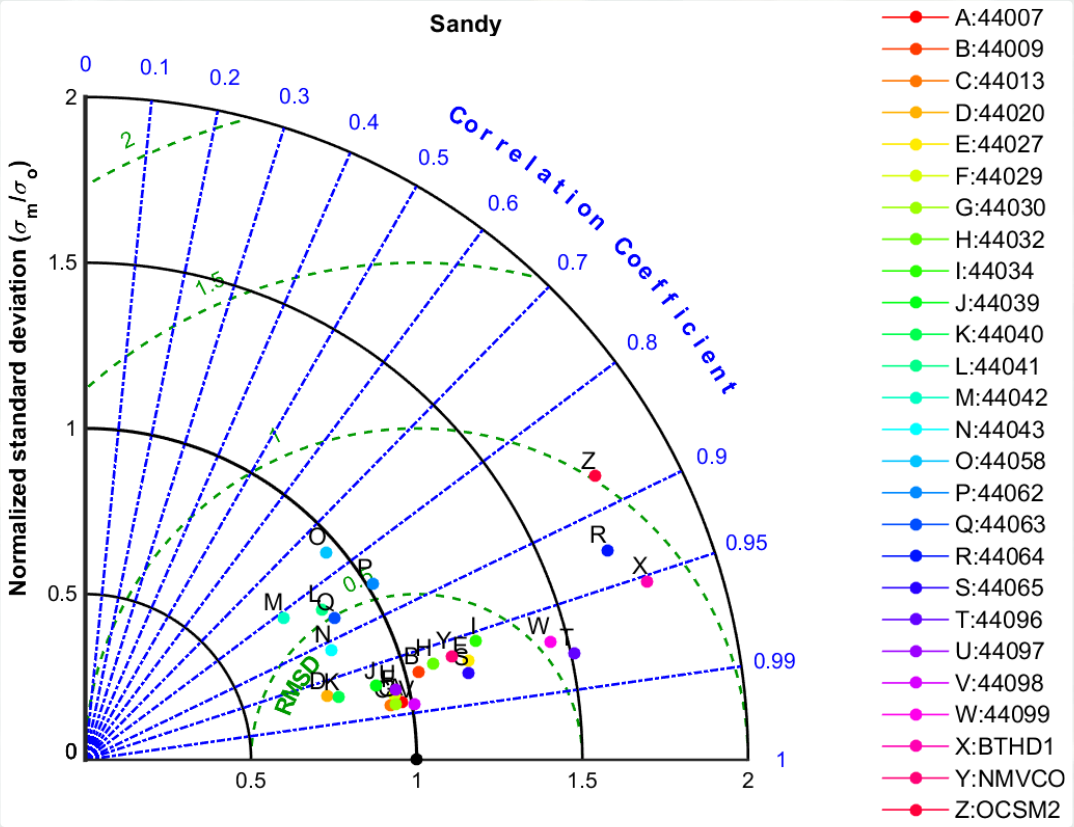


Model Evaluation

- model-observation comparisons using graphical and statistical methods consistent with WAM evaluation
  - time and scatter plots
  - basic statistics
    - bias, RMSE, correlation coefficient
  - Taylor diagrams (Taylor 2001)
    - two-dimensional space that can represent three different statistics simultaneously (RMSE, correlation, and standard deviation)
    - spatialize model performance

Taylor Diagrams

- wave height statistics at each buoy summarized using Taylor diagrams



Taylor Diagrams

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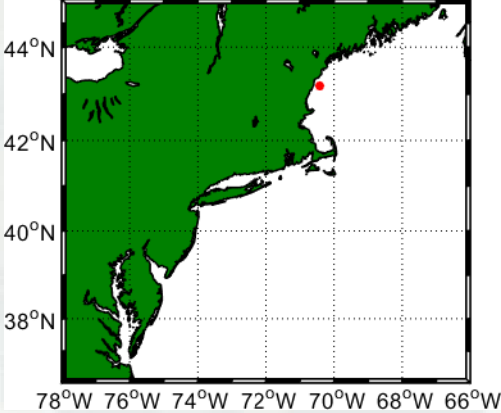

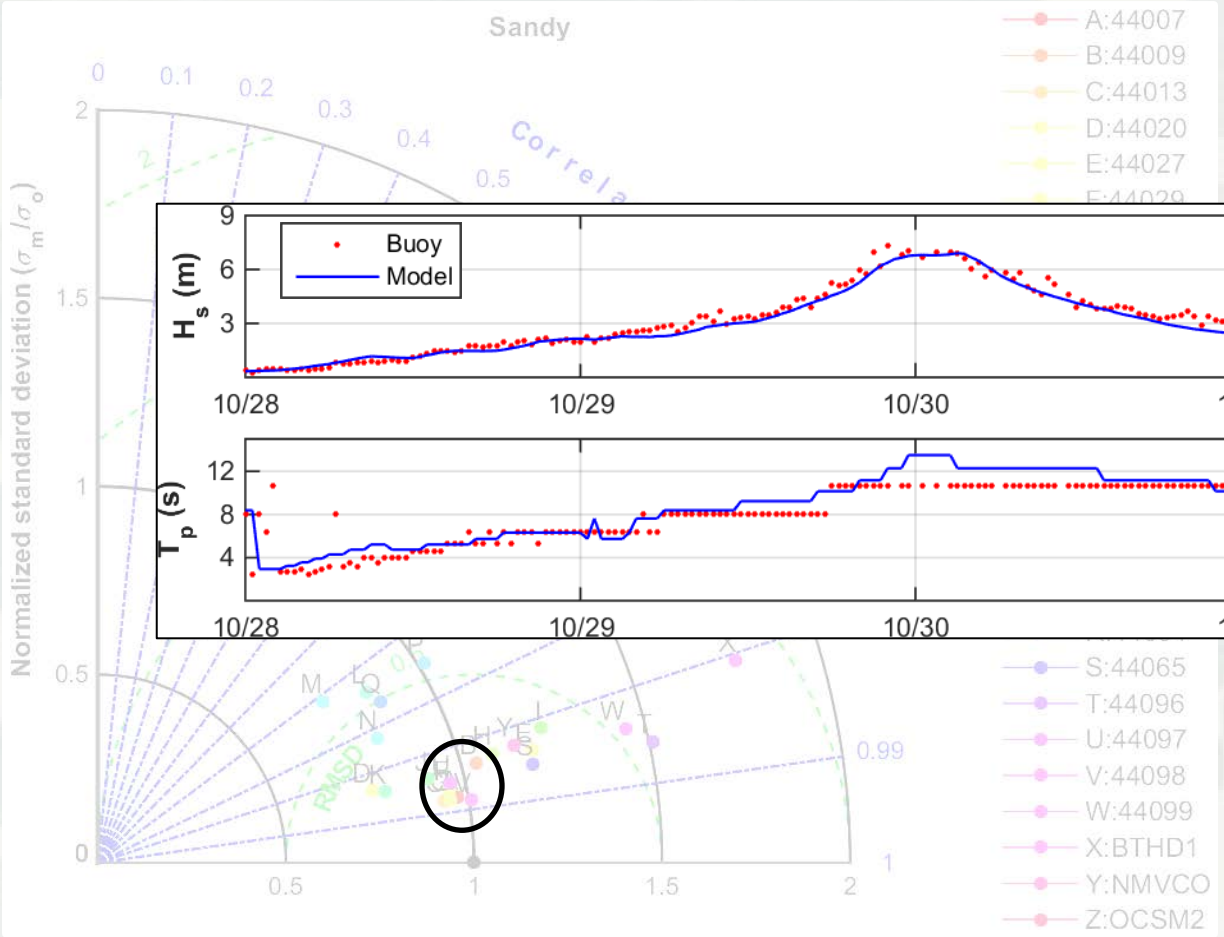

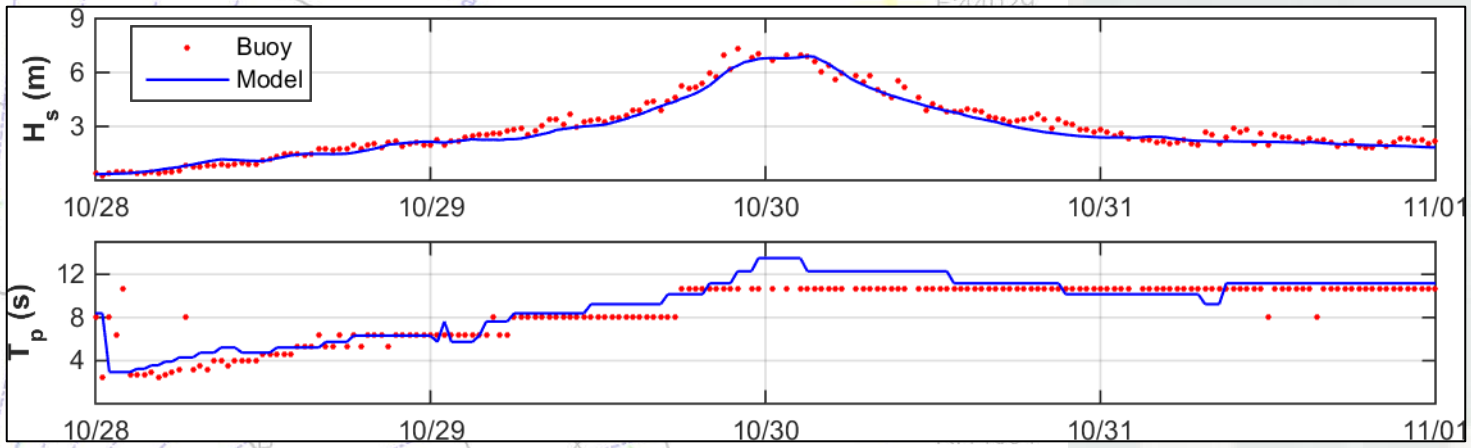

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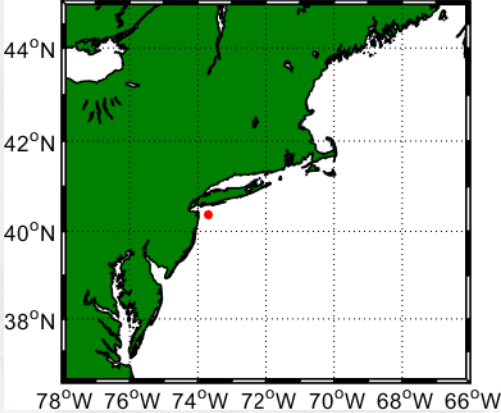
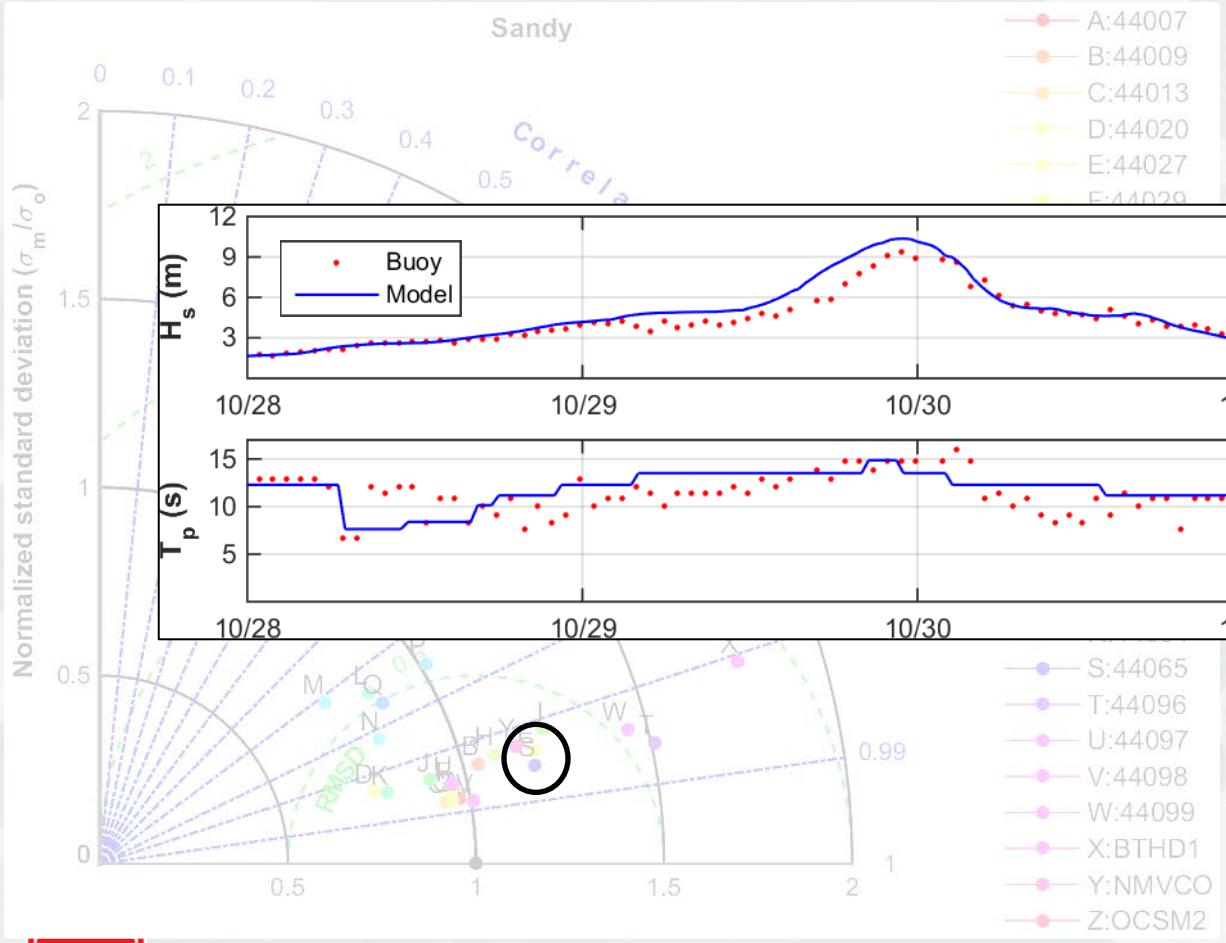
- good news (44065 – NY Harbor Entrance)





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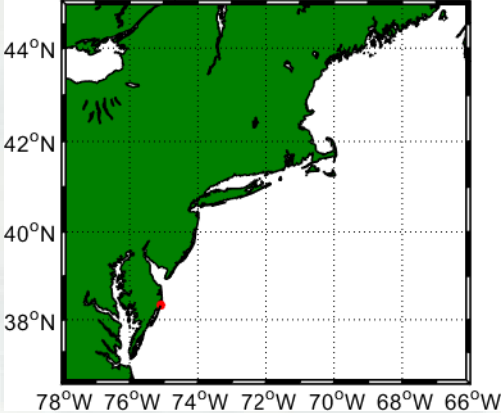
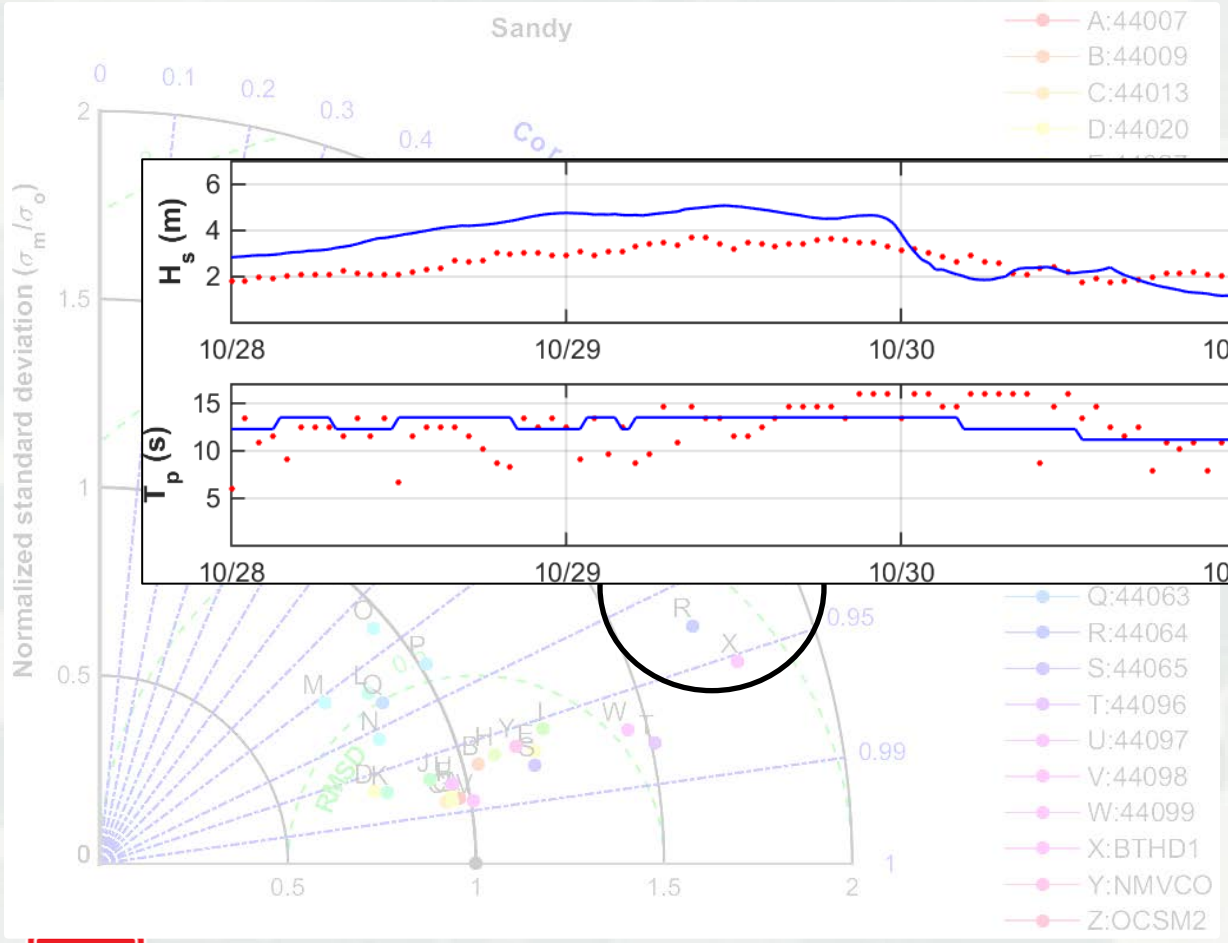
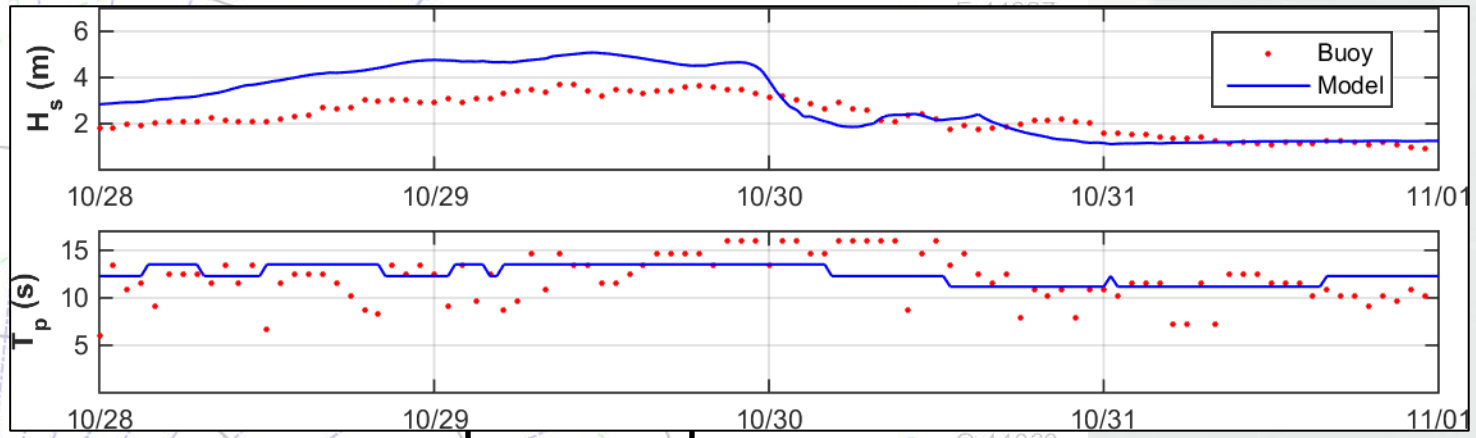
- not so good news (OCSM2 – Ocean City, MD)

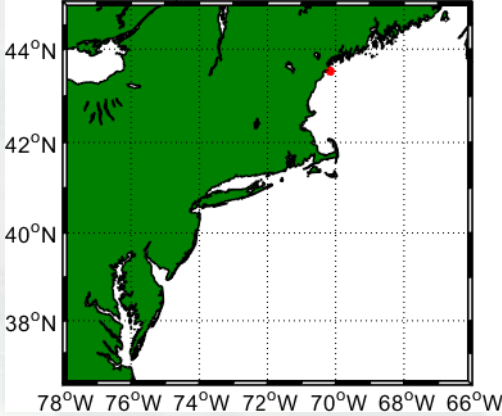


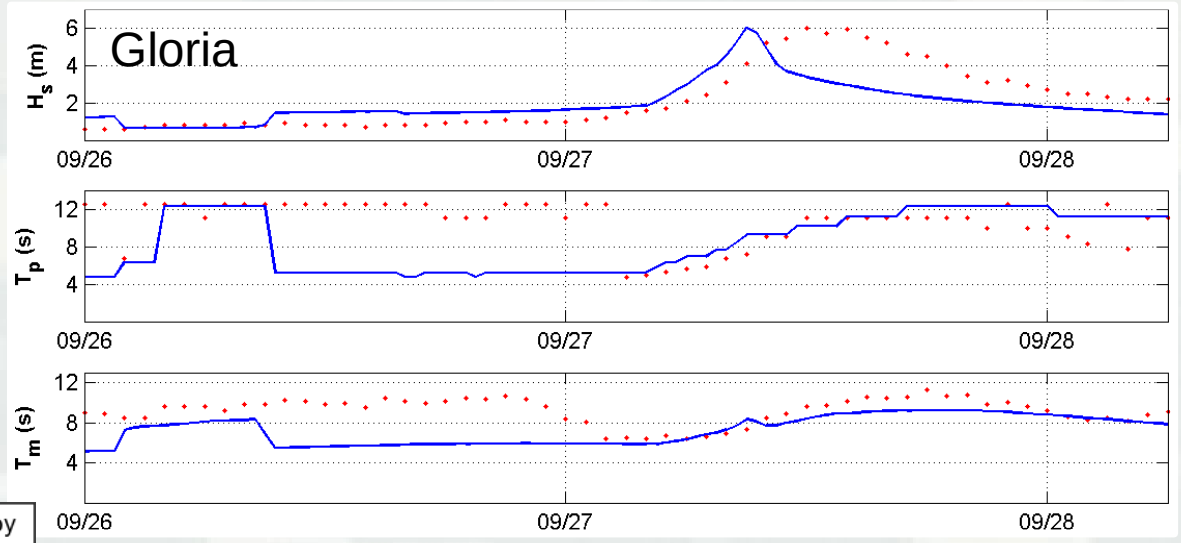


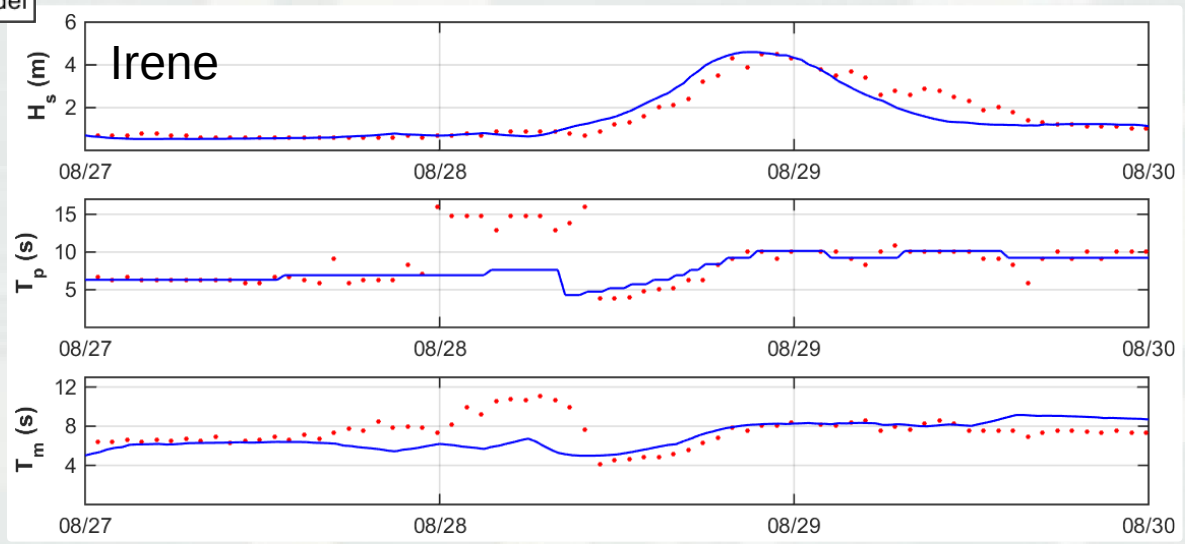


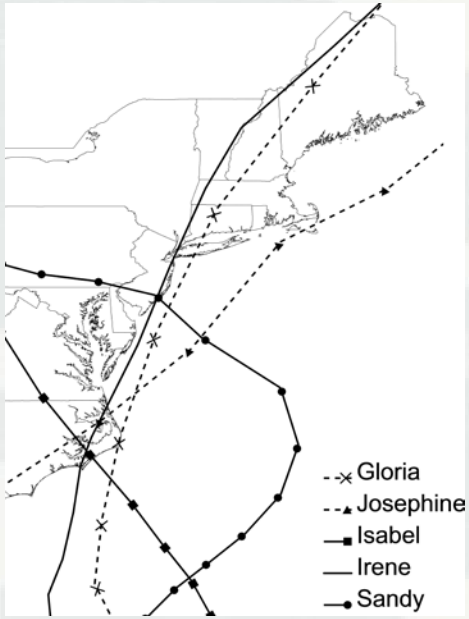
Taylor Diagrams

- improved performance (44007 – Portland, ME)









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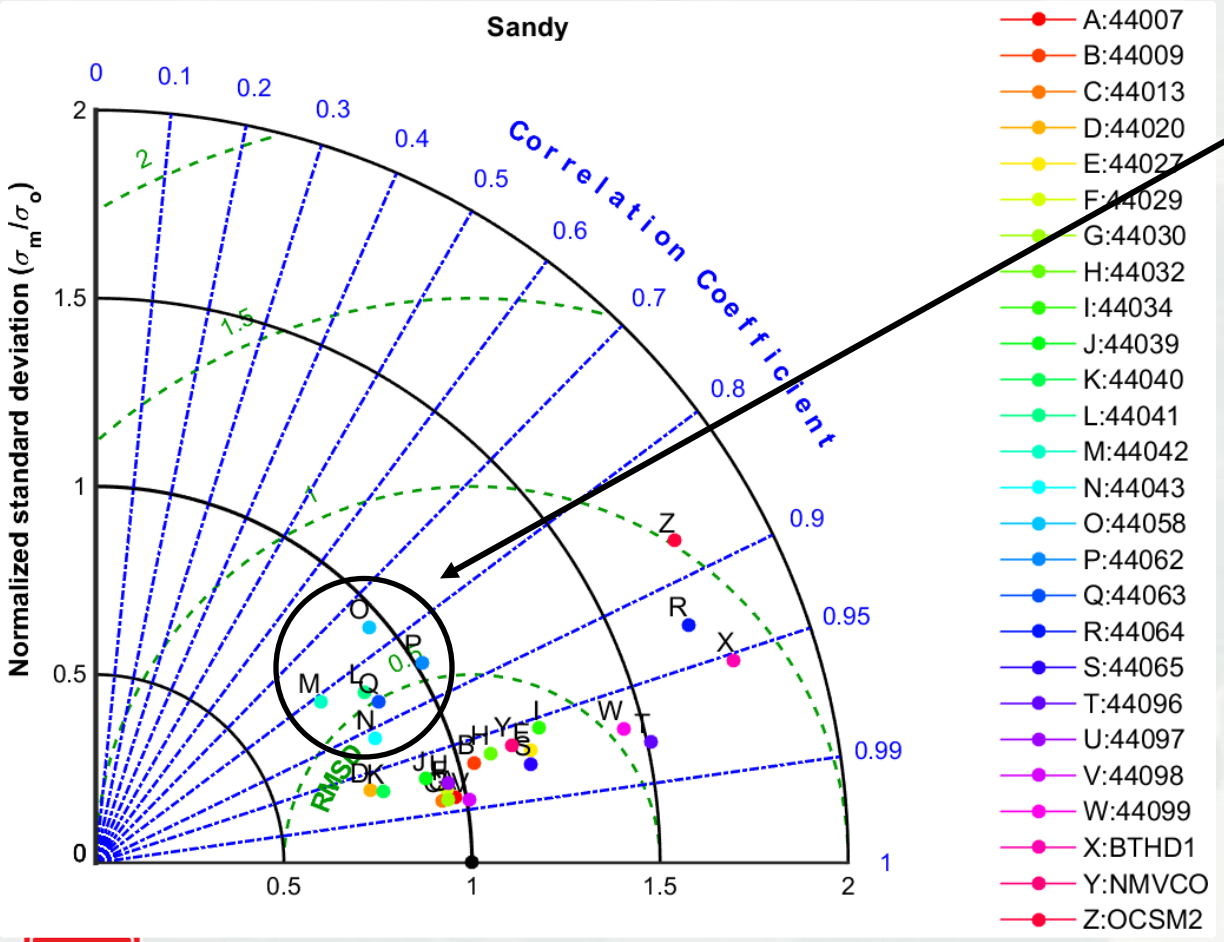
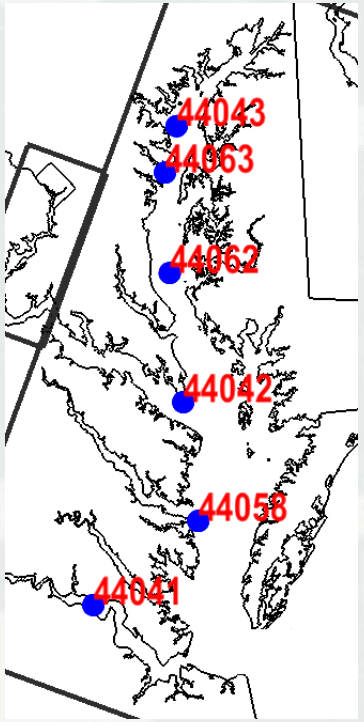


Chesapeake Bay



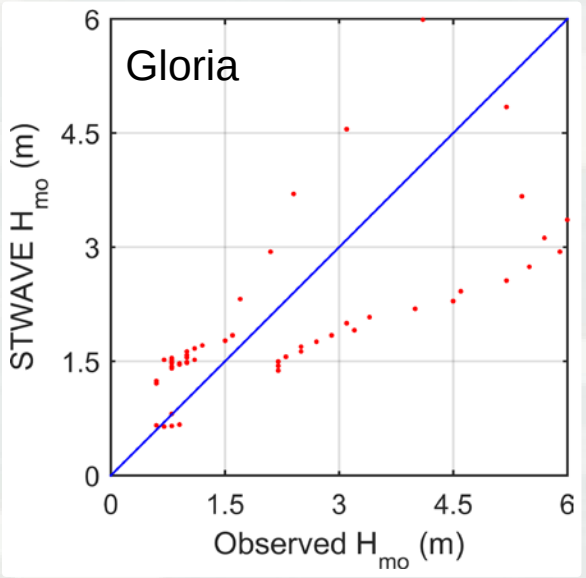
Statistics

Zero-moment wave height

Storm	Sites	Time-Paired Observations	Mean STW (m)	Bias (m)	RMSE (m)	Corr
Gloria	**1**	**55**	**1.92**	**-0.27**	**1.17**	**0.72**
ET070	5	355	2.16	-0.08	0.74	0.88
ET073	4	183	1.67	-0.58	0.53	0.83
Josephine	4	188	1.99	-0.09	0.74	0.71
Isabel	13	697	1.95	0.18	0.58	0.85
Irene	26	2301	1.66	0.10	0.63	0.92
Sandy	26	3516	2.29	0.10	0.55	0.95
All		7295	2.03	0.07	0.61	0.93

Mean wave period

Storm	Sites	Time-Paired Observations	Mean STW (s)	Bias (s)	RMSE (s)	Corr
Gloria	**1**	**55**	**7.26**	**-1.93**	**1.66**	**0.22**
ET070	5	290	6.89	-0.42	1.24	0.85
ET073	4	183	7.20	-1.03	0.87	0.68
Josephine	4	188	7.52	-0.83	1.10	0.65
Isabel	13	378	9.86	1.28	2.52	0.79
Irene	26	1632	6.54	0.95	1.96	0.83
Sandy	26	2786	7.50	1.31	1.41	0.91
All		5512	7.33	0.93	1.80	0.84



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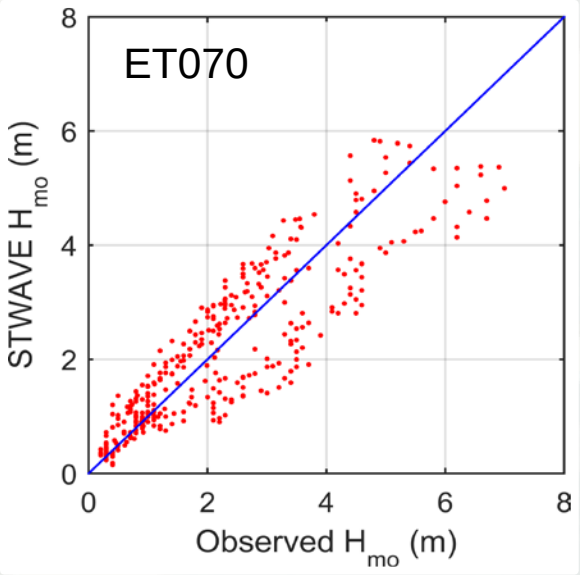

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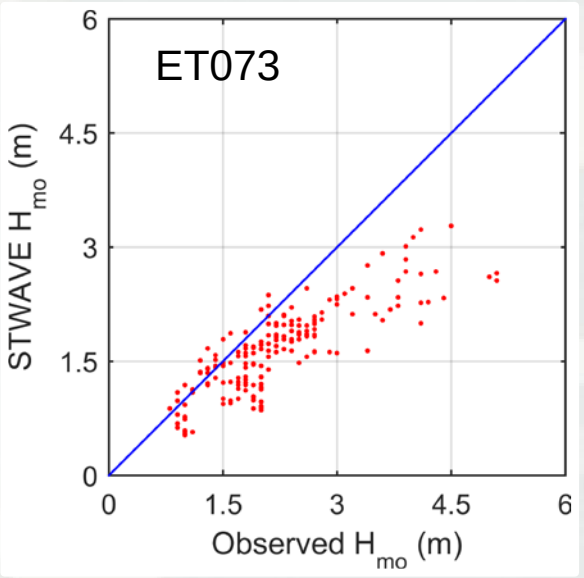

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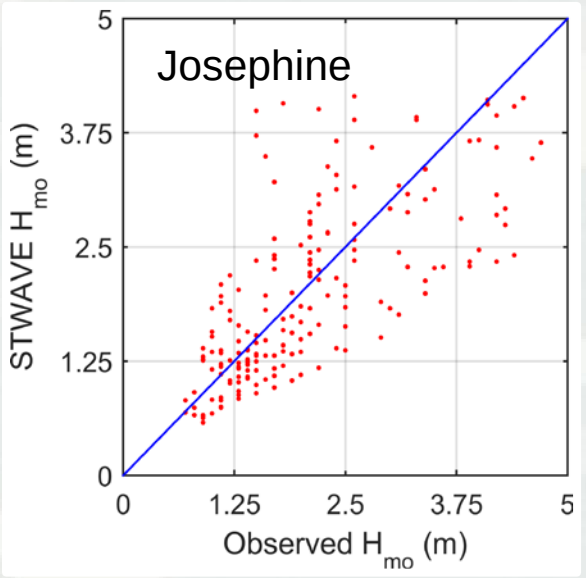

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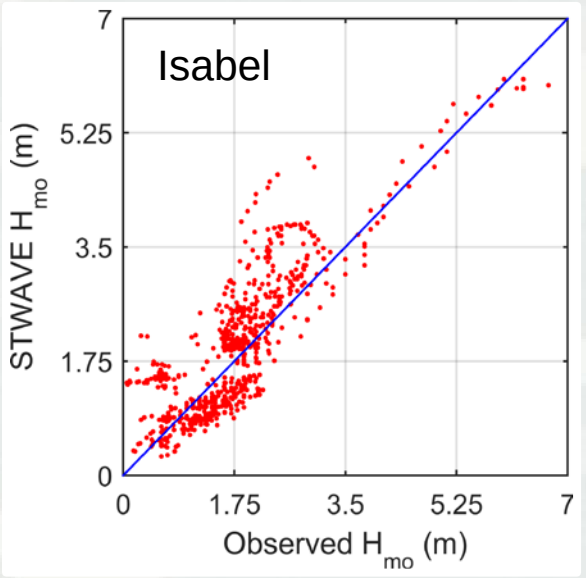

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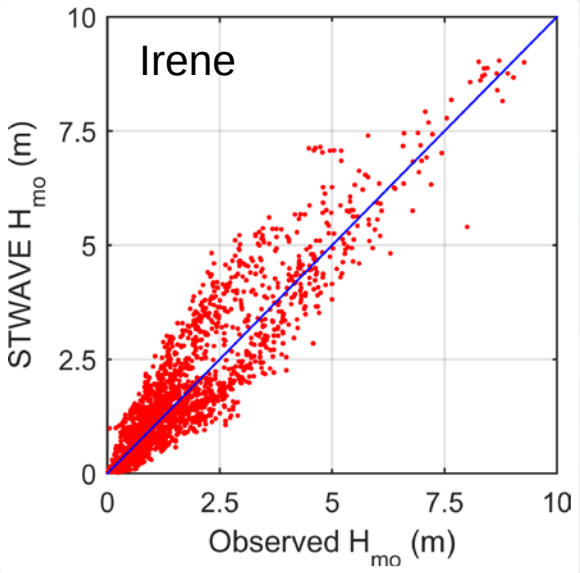

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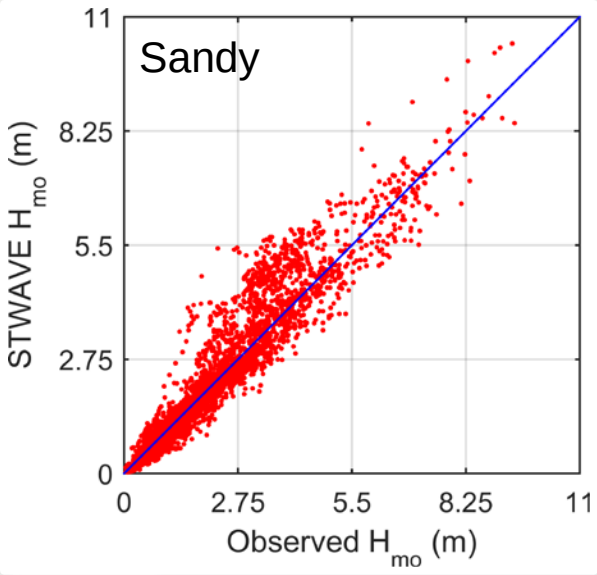


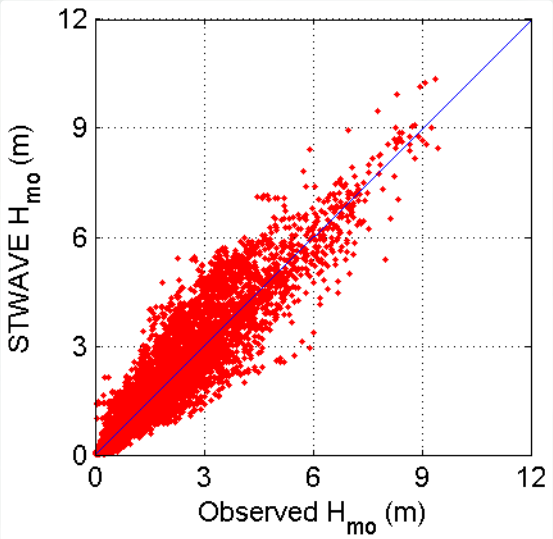
Mean wave period

Storm	Sites	Time-Paired Observations	Mean STW (s)	Bias (s)	RMSE (s)	Corr
Gloria	1	55	7.26	-1.93	1.66	0.22
ET070	5	290	6.89	-0.42	1.24	0.85
ET073	4	183	7.20	-1.03	0.87	0.68
Josephine	4	188	7.52	-0.83	1.10	0.65
Isabel	13	378	9.86	1.28	2.52	0.79
Irene	26	1632	6.54	0.95	1.96	0.83
Sandy	**26**	**2786**	**7.50**	**1.31**	**1.41**	**0.91**
All		5512	7.33	0.93	1.80	0.84

Statistics

Zero-moment wave height

Storm	Sites	Time-Paired Observations	Mean STW (m)	Bias (m)	RMSE (m)	Corr
Gloria	1	55	1.92	-0.27	1.17	0.72
ET070	5	355	2.16	-0.08	0.74	0.88
ET073	4	183	1.67	-0.58	0.53	0.83
Josephine	4	188	1.99	-0.09	0.74	0.71
Isabel	13	697	1.95	0.18	0.58	0.85
Irene	26	2301	1.66	0.10	0.63	0.92
Sandy	26	3516	2.29	0.10	0.55	0.95
All		**7295**	**2.03**	**0.07**	**0.61**	**0.93**



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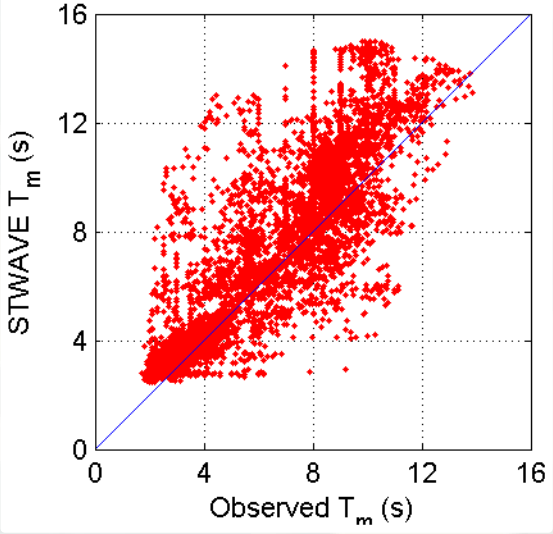
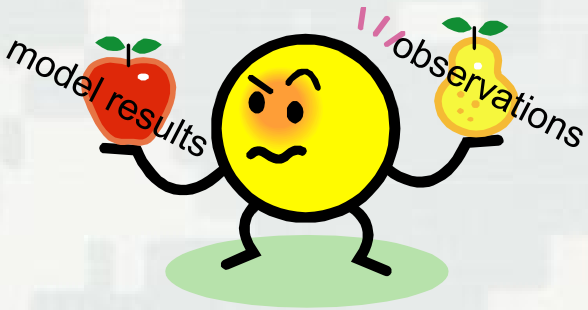


Conclusions

- one of the largest nearshore wave model evaluations undertaken along the East Coast
- performance improved significantly with more recent storms, particularly for Irene and Sandy
  - perhaps due to more accurate wind and offshore forcing, advancements in buoy technology, and a larger measurement population
- STWAVE provided overall good nearshore wave estimates given the model linkages and extent and complexity of the study area
- challenges: gathering nearshore wave data
  - still limited
  - different websites and broken links
  - variable file formats, unclear parameter definitions, spectra often unavailable



Thank you and Questions?