IOOS Coastal and Ocean Modeling Testbed for Puerto Rico and Virgin Islands:

Year 4 Progress

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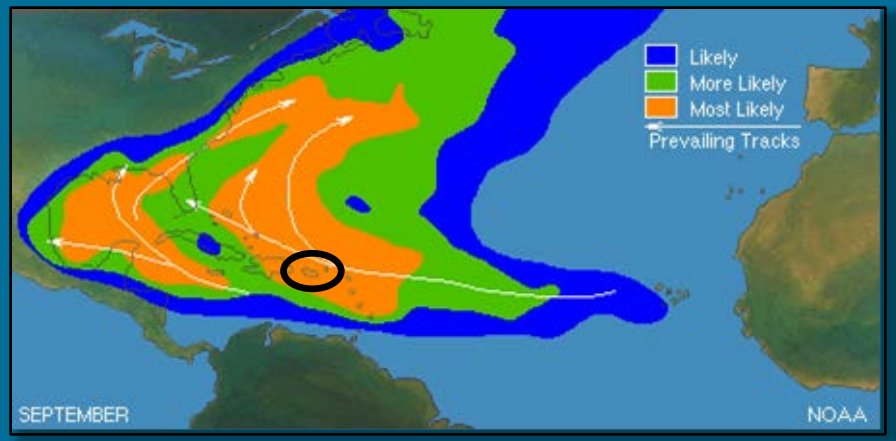
Ernesto Rodriguez, Brian McKenna, Kelly Knee (and thanks to Luis Aponte)

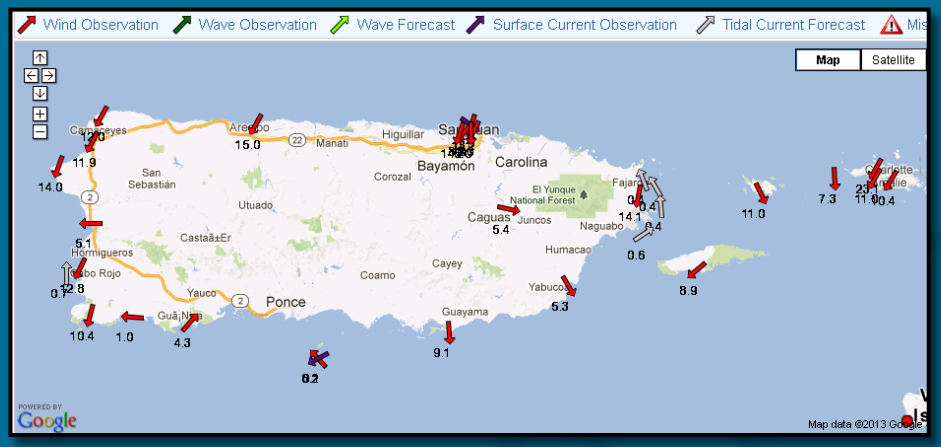
Contents

Objective

To extend the present **operational surge forecasting** capability from mild-sloped coastal areas such as the US East and Gulf of Mexico coasts to **steep-sloped areas** such as Caribbean and Pacific islands, and study the **contribution of waves**. Identify models or techniques to transition to NOAA's **National Hurricane Center** and **local WFOs**.



www.nhc.noaa.gov/climo



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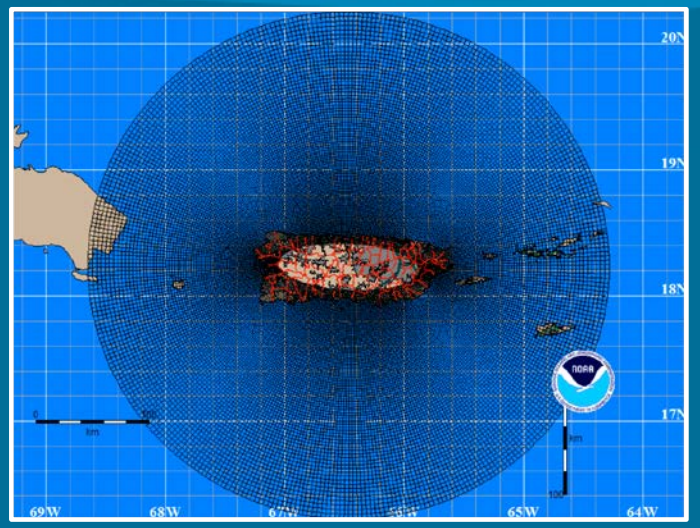
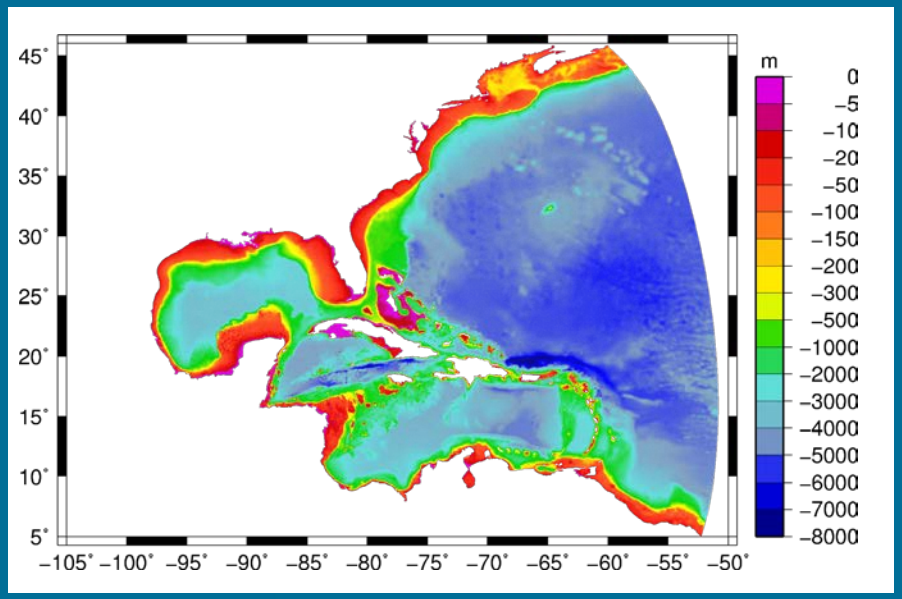
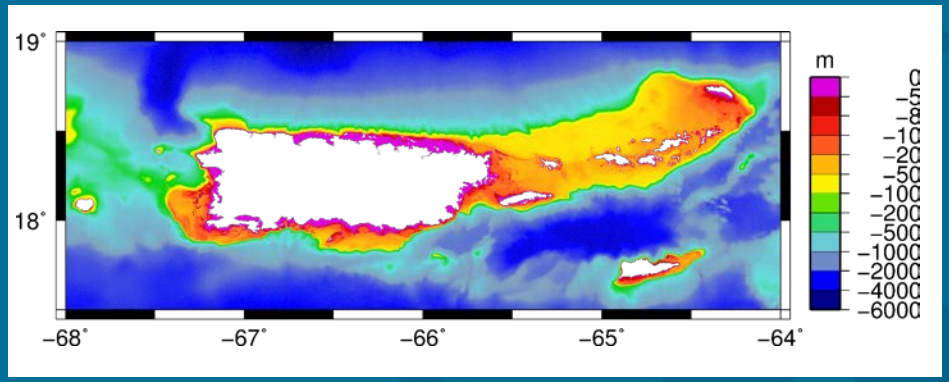
Puerto Rico/USVI: Model selection

- **UND:** ADCIRC+SWAN
- **NCEP/USACE:** ADCIRC+WW3
- **NHC:** SLOSH-Wave
- **UPR:** XBeach/BOSZ/FUNWAVE



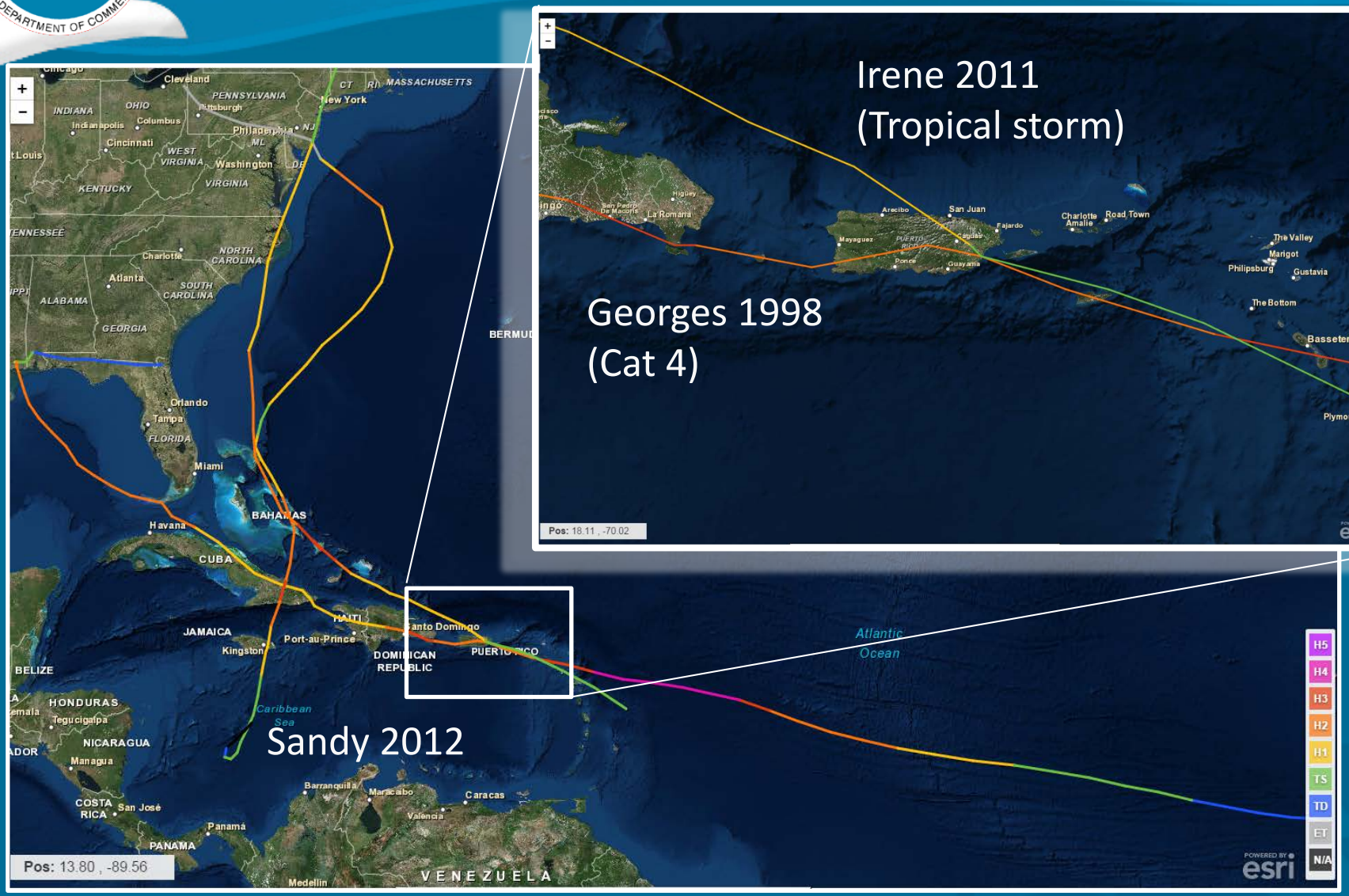
Curvilinear grid (min res: 90 m)





Unstructured, 2,7M nodes (min res: 50 m)

Regional hindcast cases

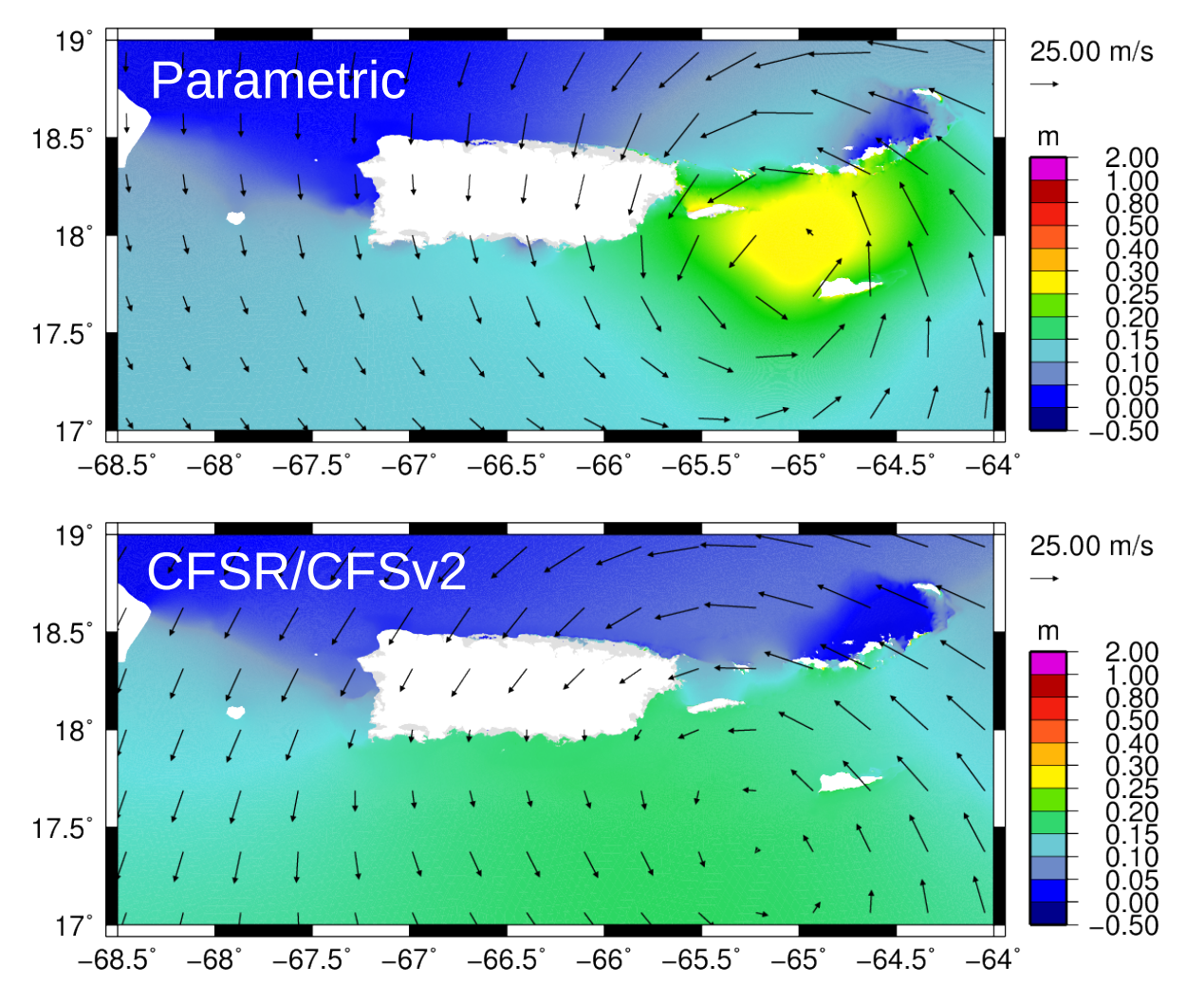


Year 4: Model sensitivity/inter-comparison

ADCIRC-SWAN Unstructured	SLOSH-Parametric Wave Curvilinear/Regular
-	SLOSH parametric wind model (ATCF input)
Holland parametric wind model (ATCF input)	*Gridded* Holland parametric wind model (ATCF input)
CFSR/CFSRv2 wind model	CFSR/CFSRv2 wind model
WRF wind model	WRF wind model
Wave coupling on/off	Wave coupling on/off
Phase-resolved wave model nest	-

How much can surge from CFSR/CFSv2 and parametric wind fields differ?

Hurricane Irene (2011)



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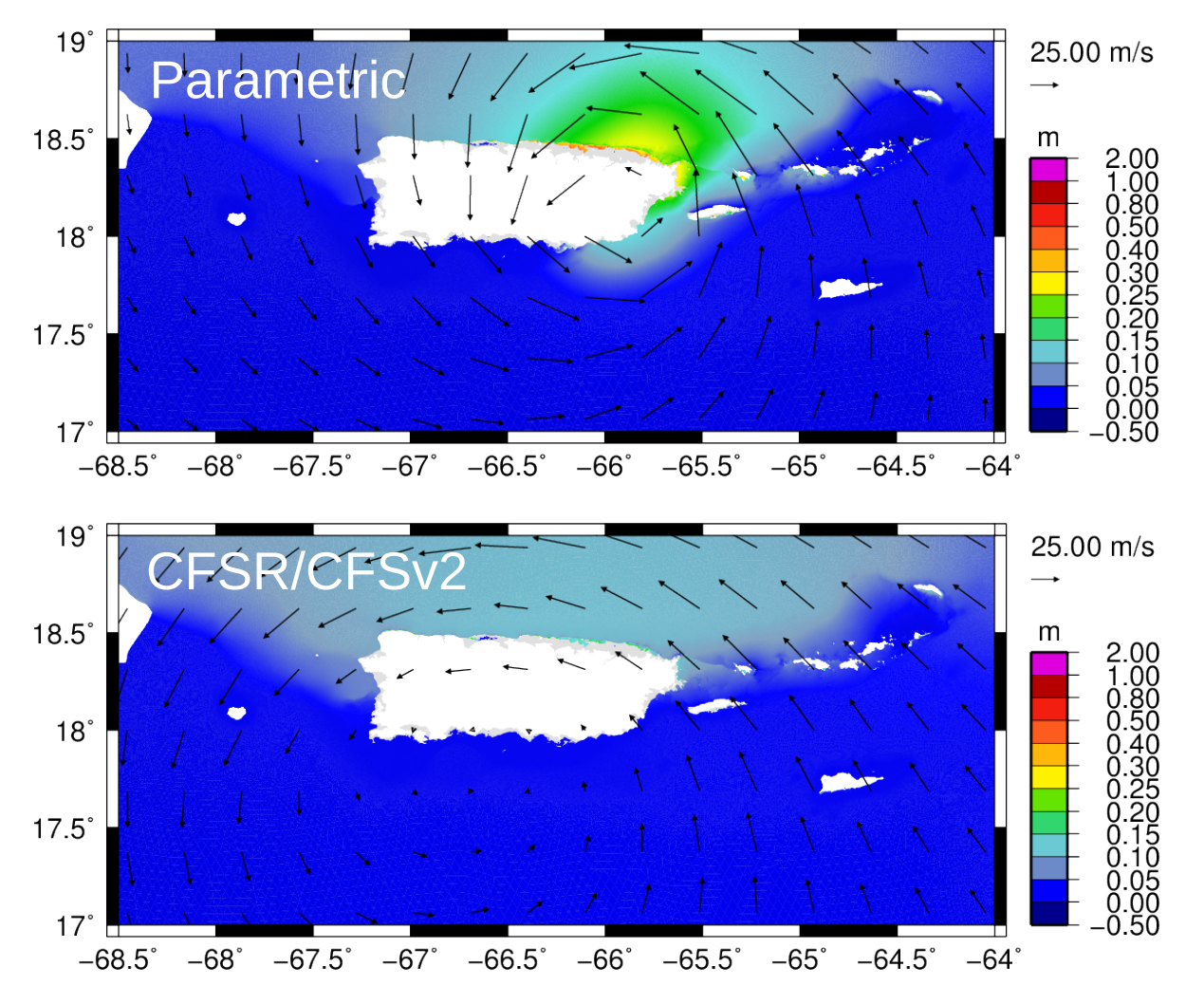

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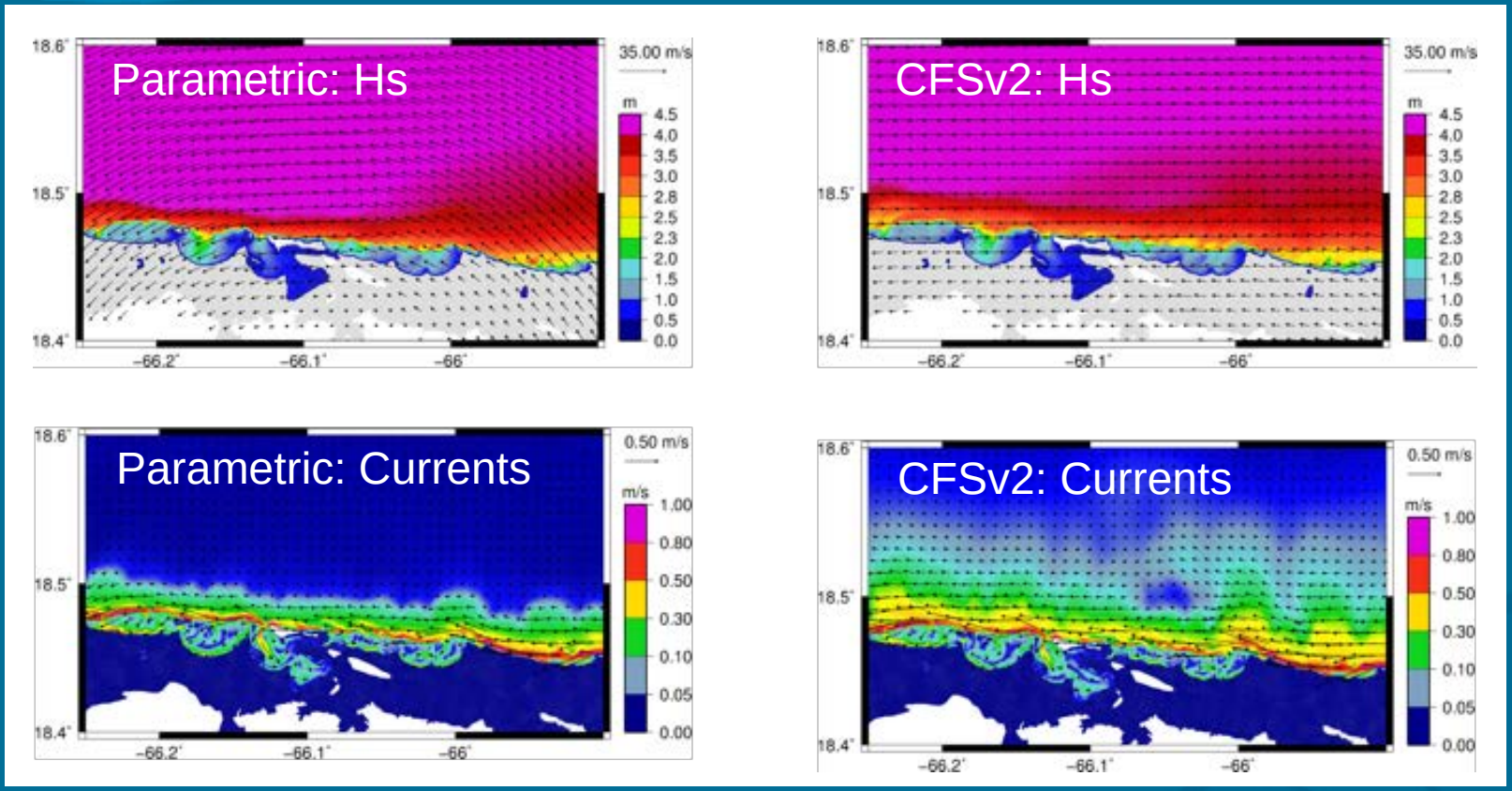
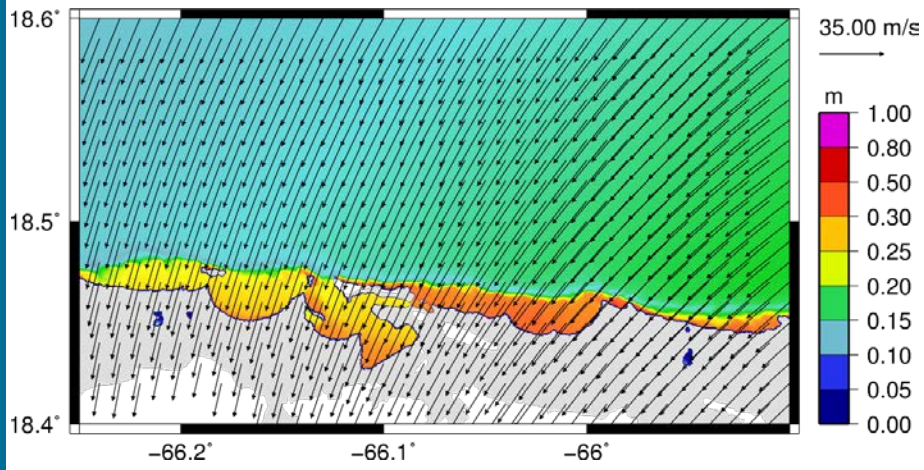
How much can CFSR/CFSv2 and best track parametric winds affect the solution?



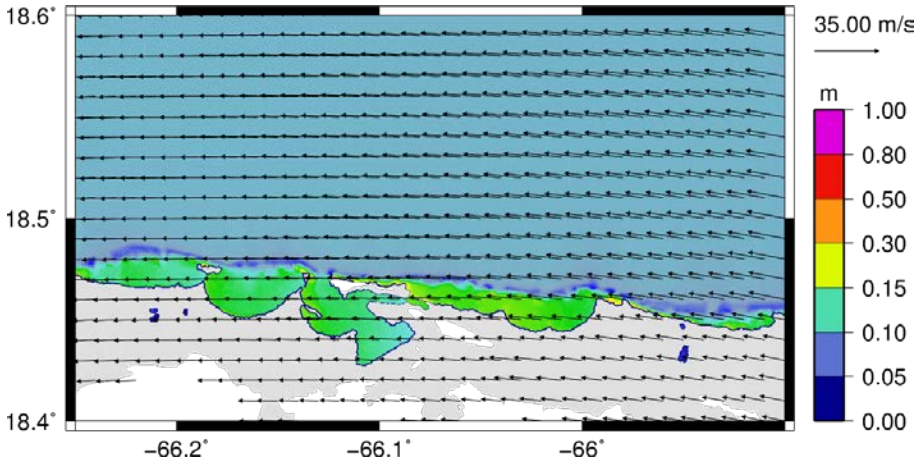
Top: Significant wave height in the San Juan area when using parametric (left) and CFSv2 (right) wind forcing. Bottom: Depth-averaged currents in the San Juan area with wind forcing in same order as top. Notice how each wind forcing results in very different flood, wave height, and current scenarios.

How much can CFSR/CFSv2 and best track parametric winds affect the storm surge?

Parametric: Water levels



CFSv2: Water levels



For H. Irene ATCF wind speeds used for parametric wind model had to be reduced by 30% to achieve agreement with observations. Reported ATCF wind speeds were incorrectly obtained from non-calibrated radar. All other parameters are remarkably accurate.

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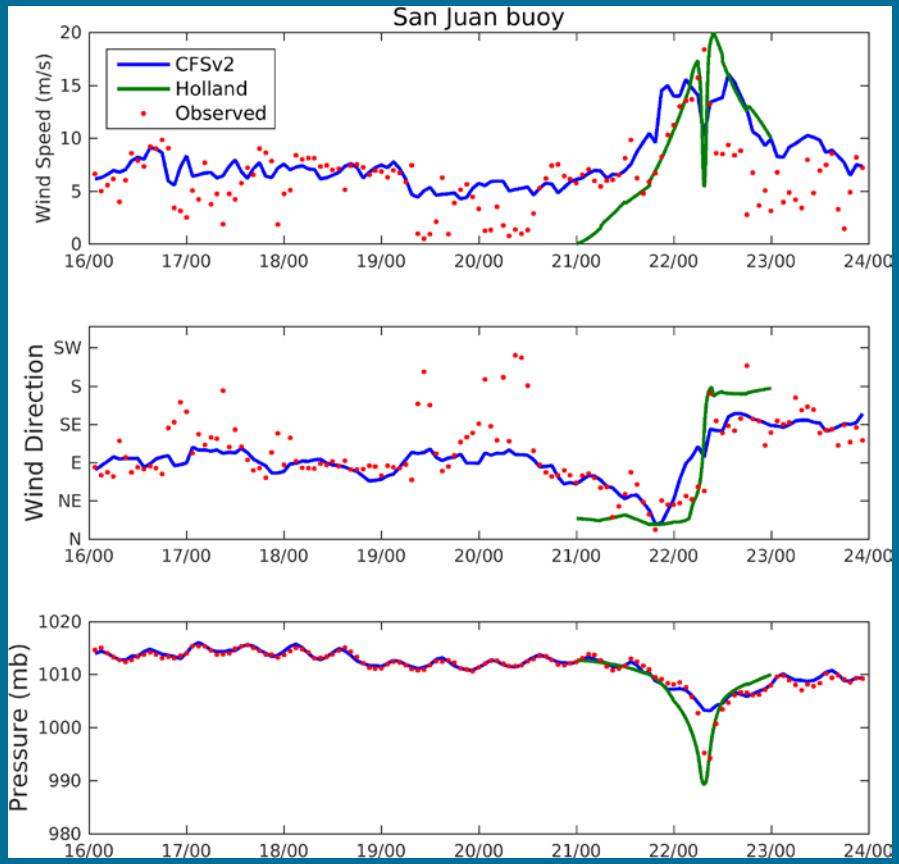
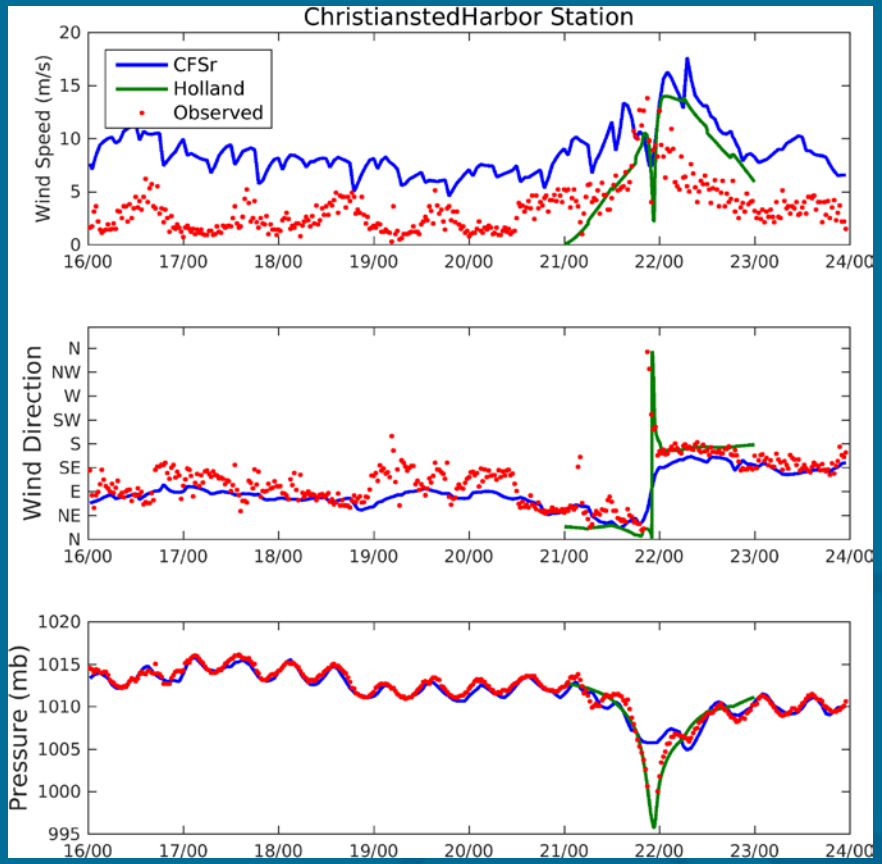
Validation of CFSv2 and Parametric Wind Fields

Hurricane Irene (2011)





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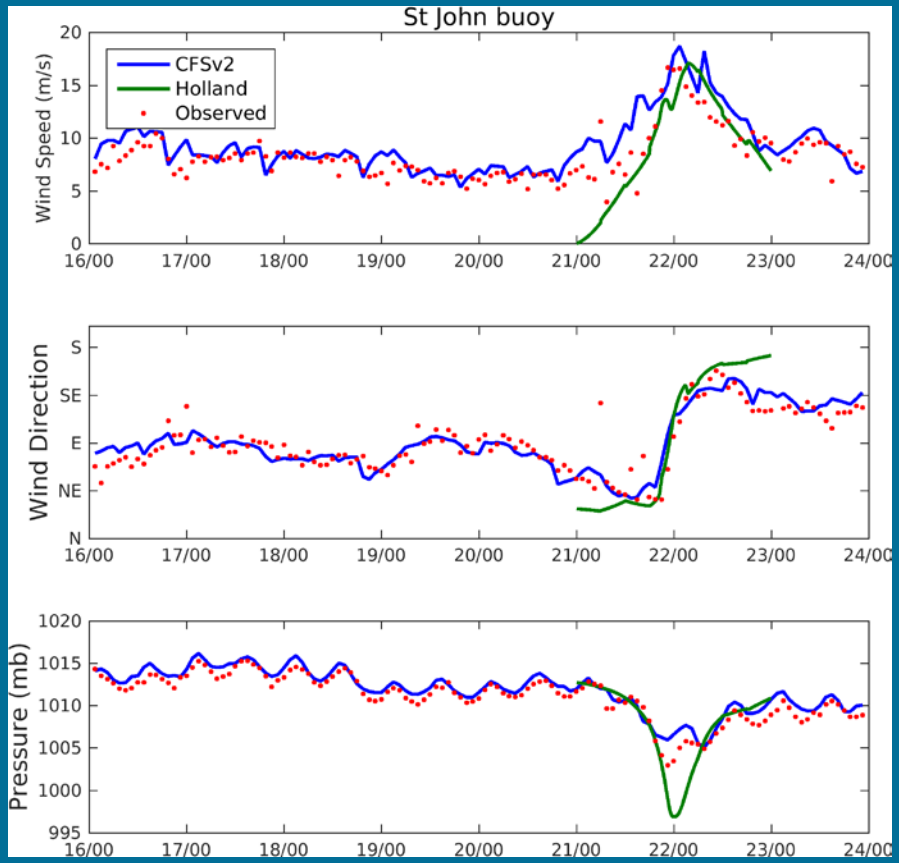

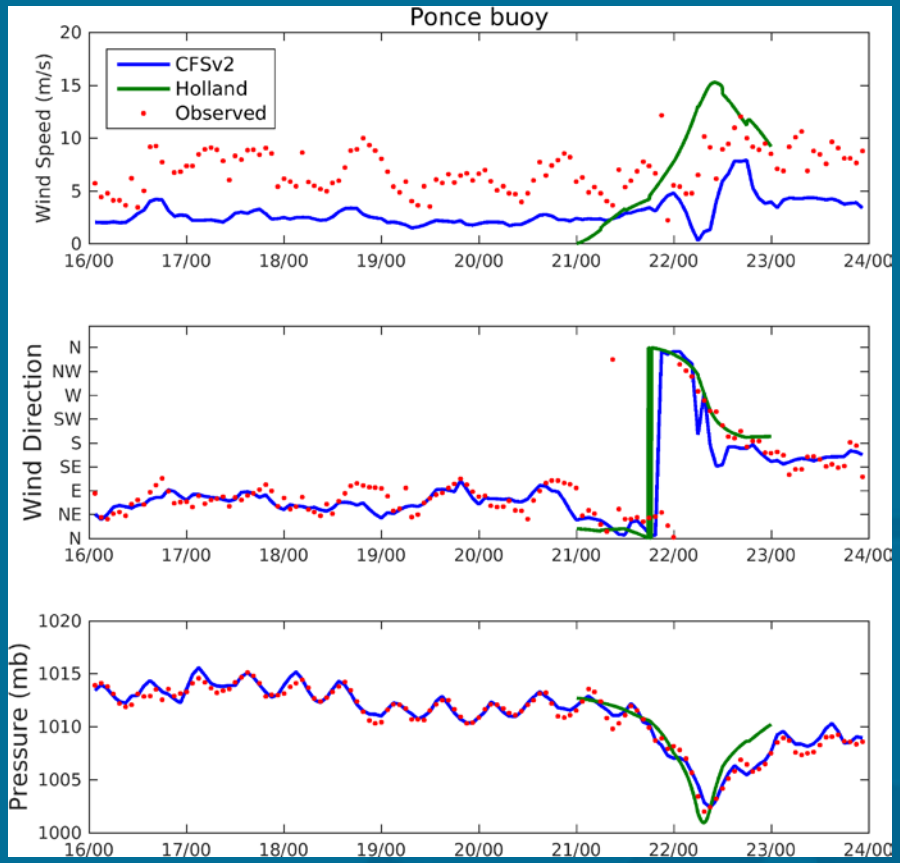

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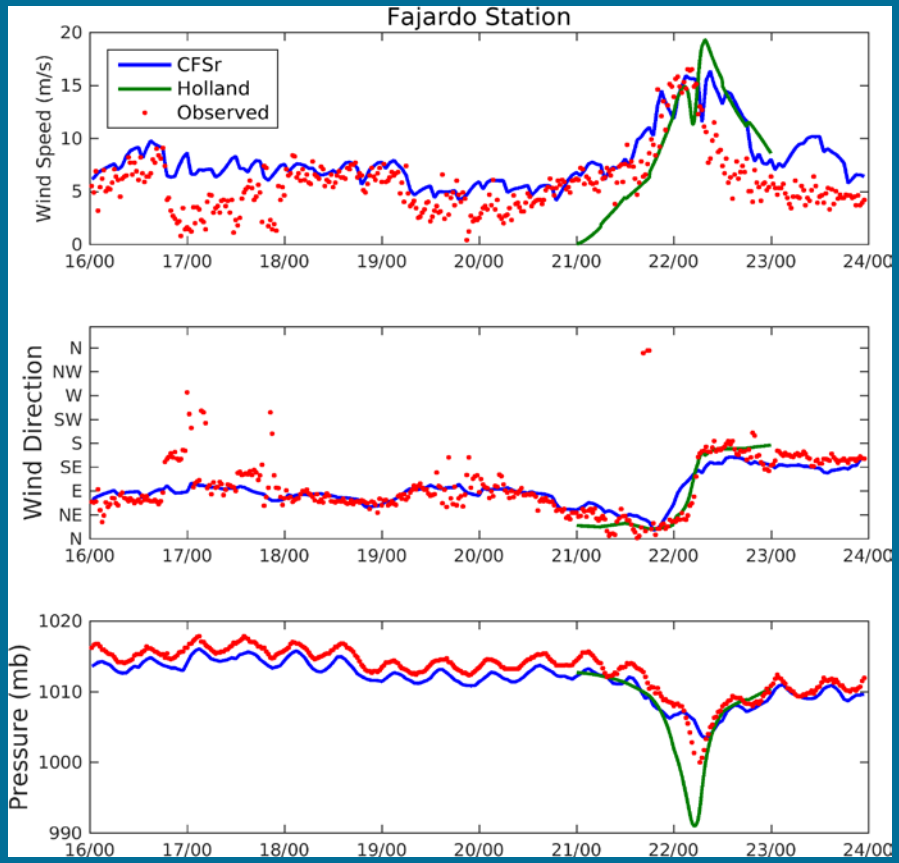

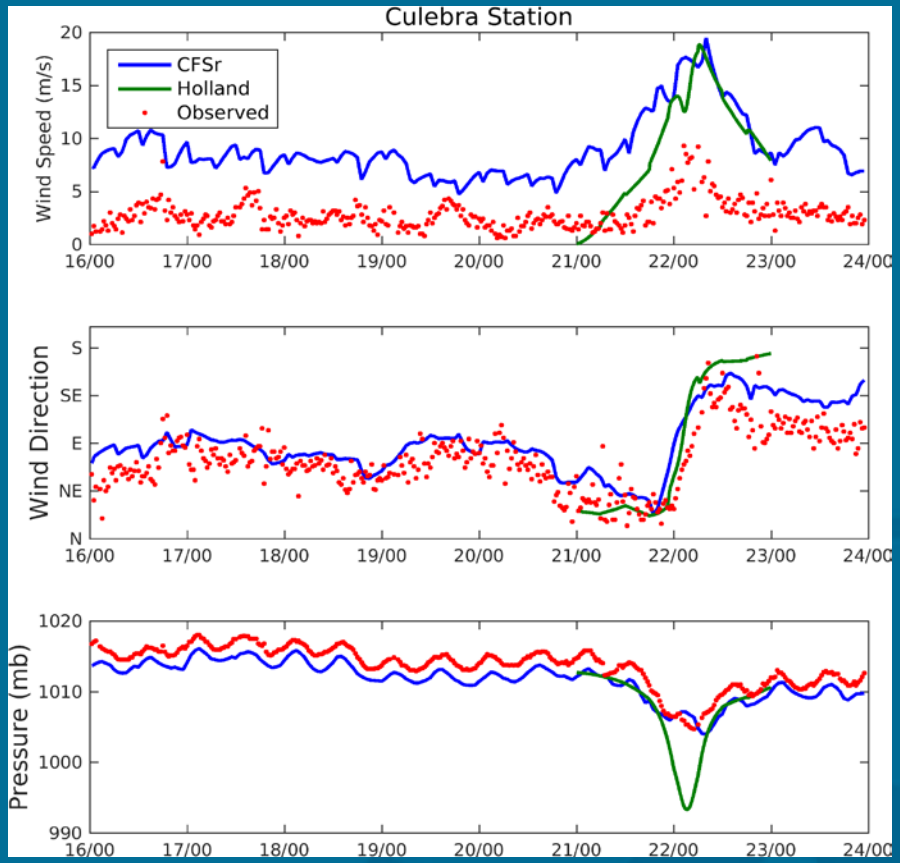

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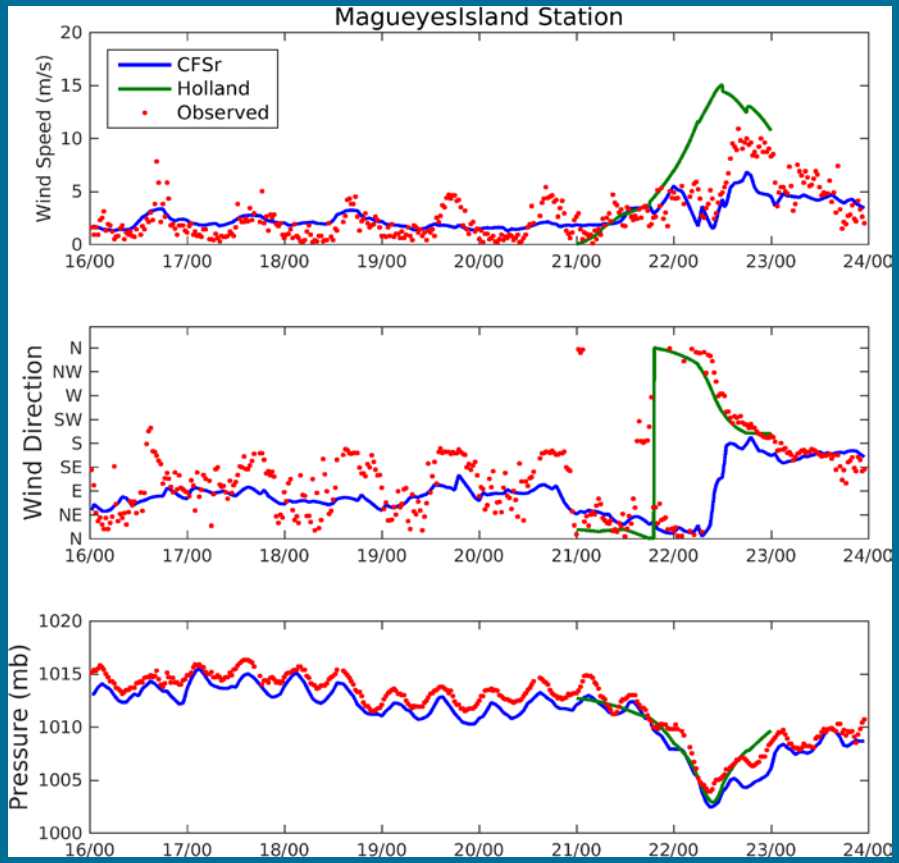
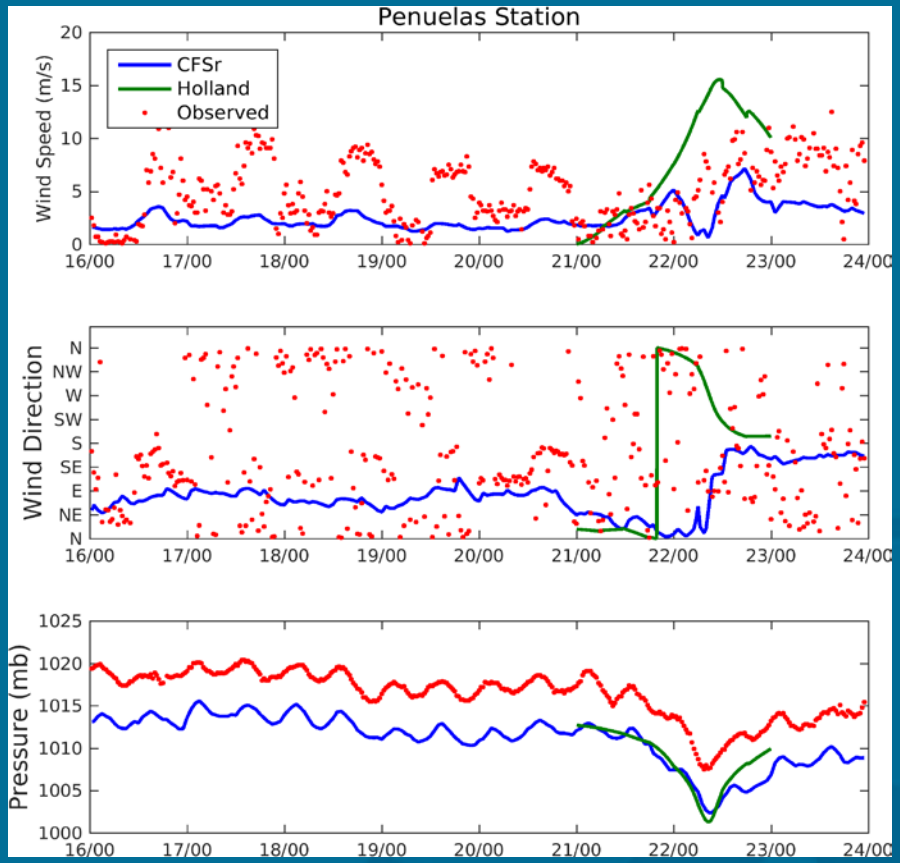
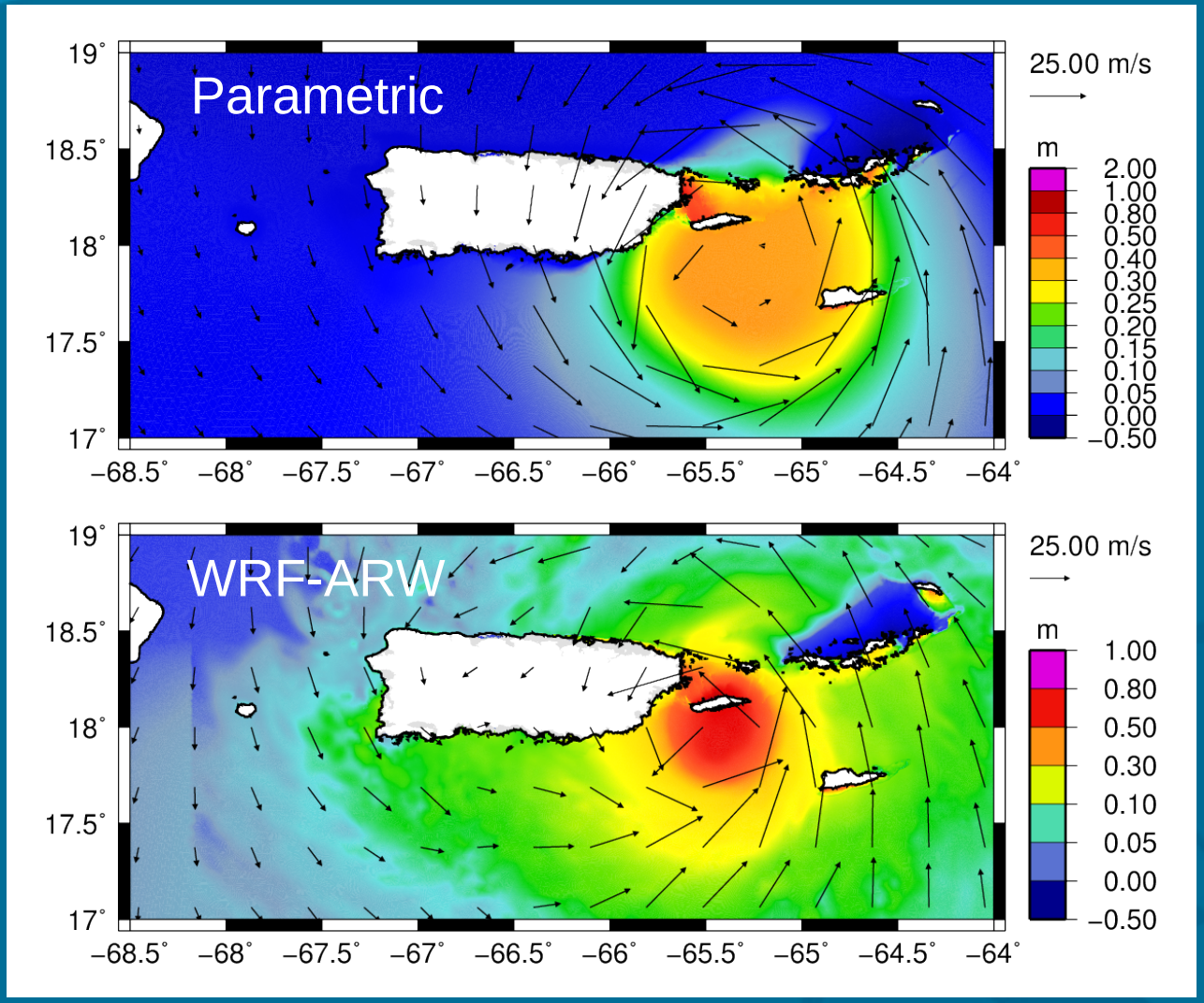




How much can surge from WRF-ARW and parametric wind fields differ?

Hurricane Georges (1998)



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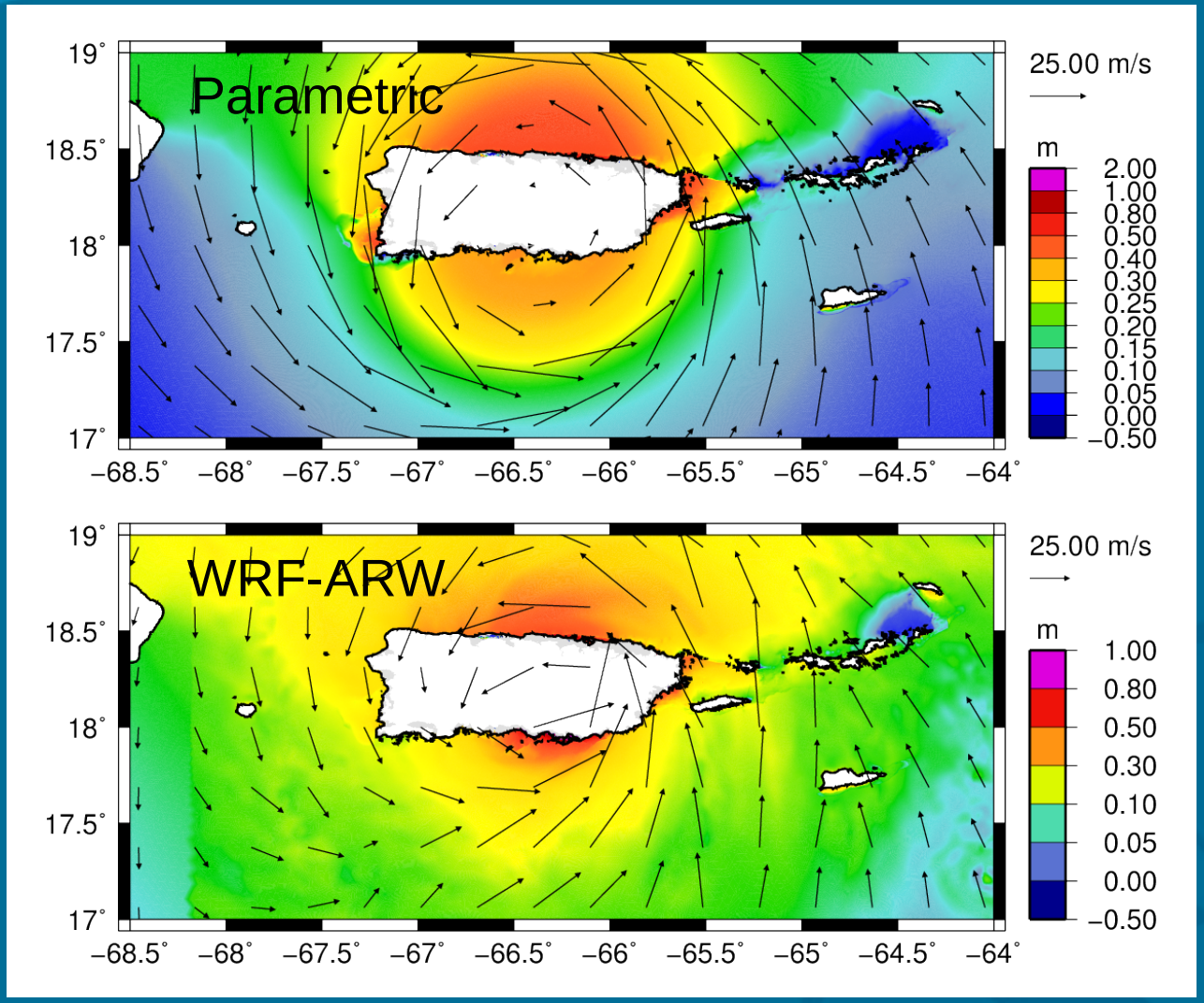

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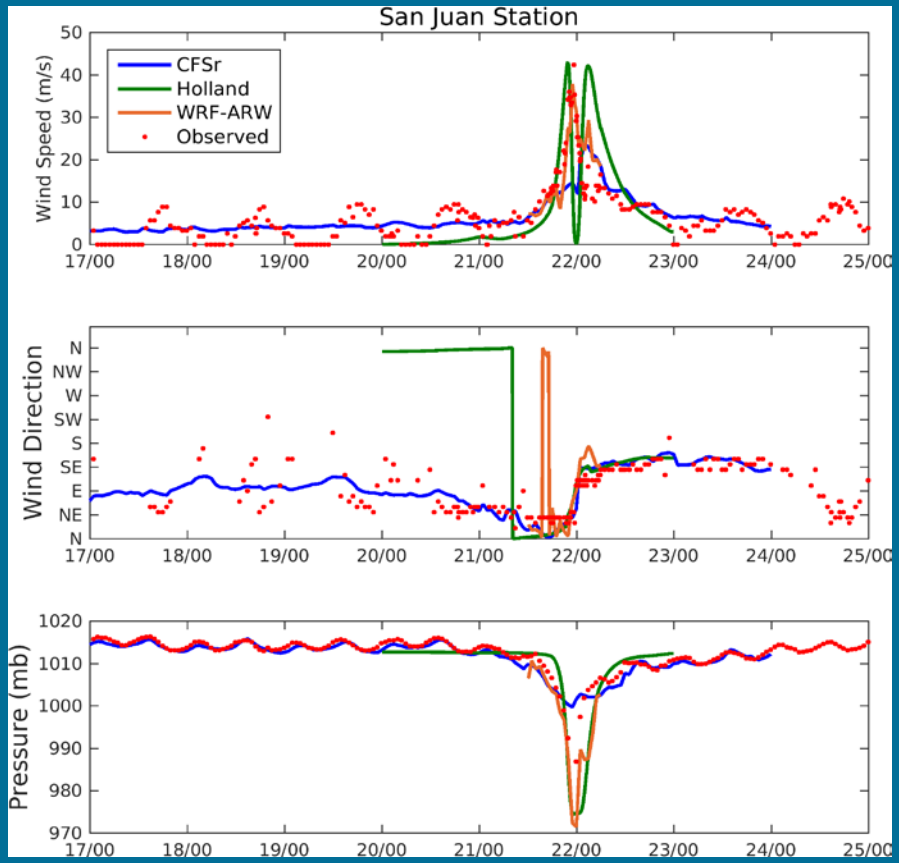
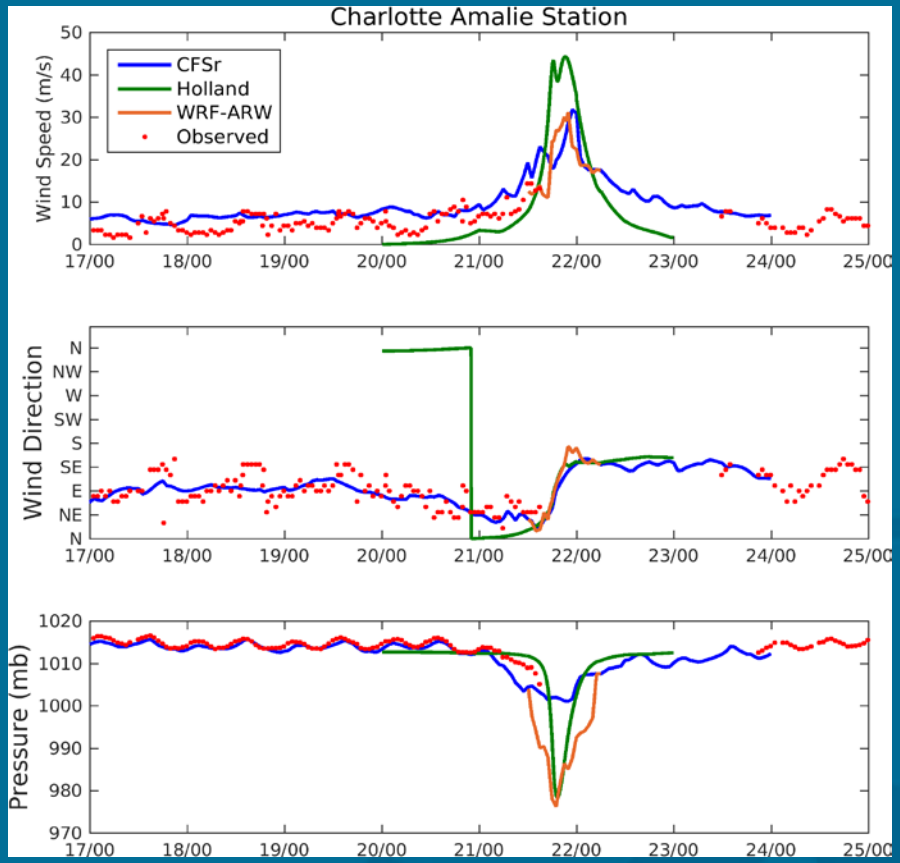
Validation of CFSv2, WRF and Parametric Winds

Hurricane Georges (1998)





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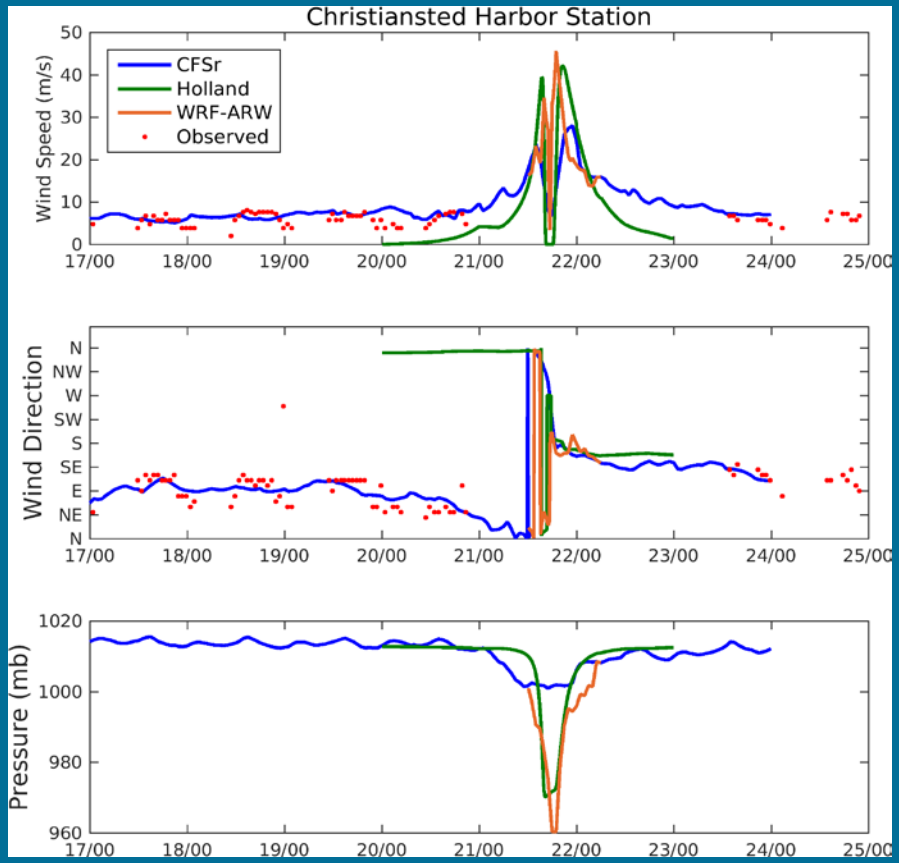
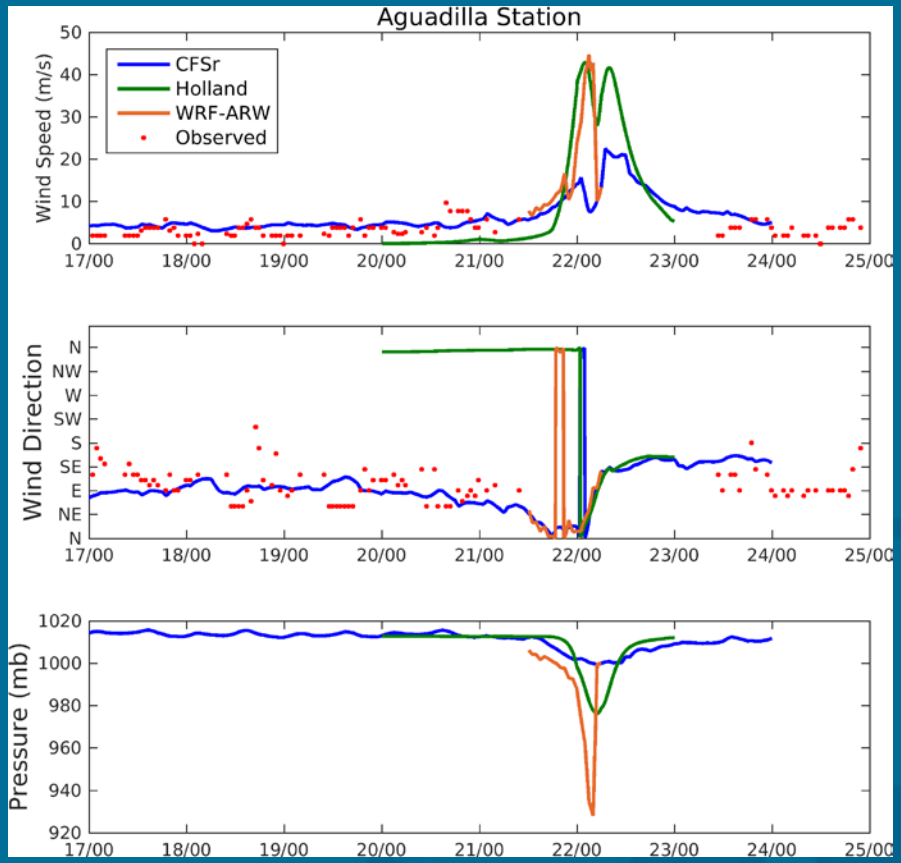
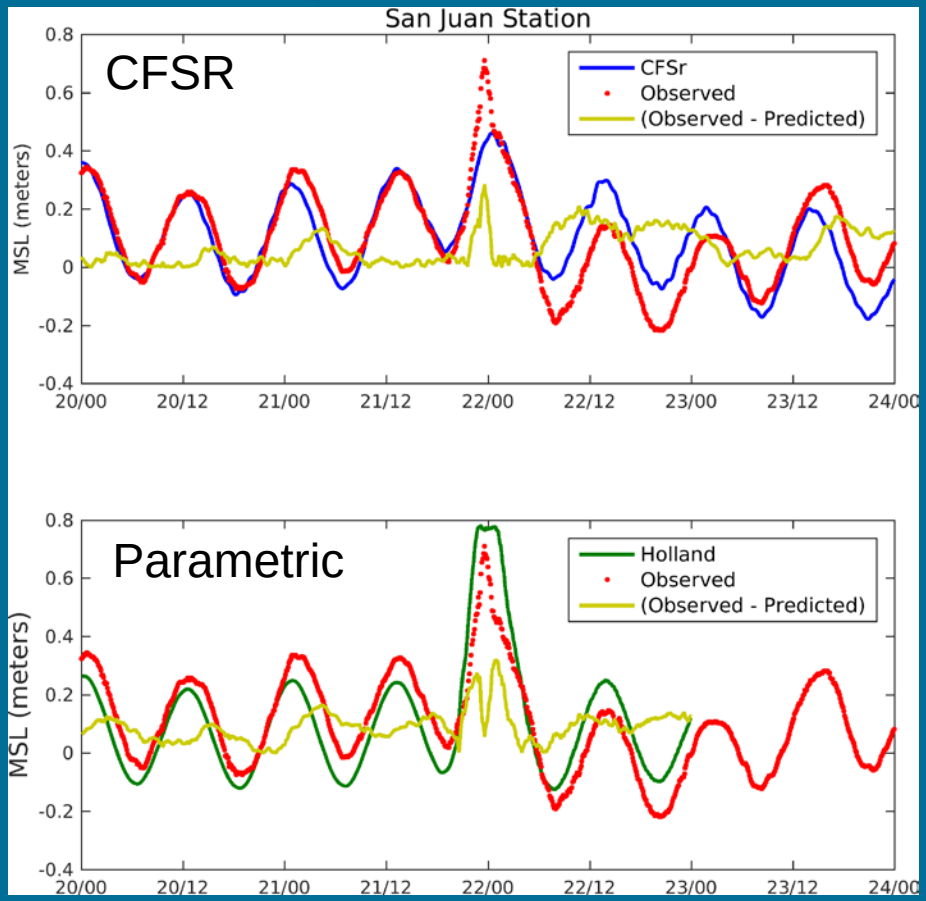




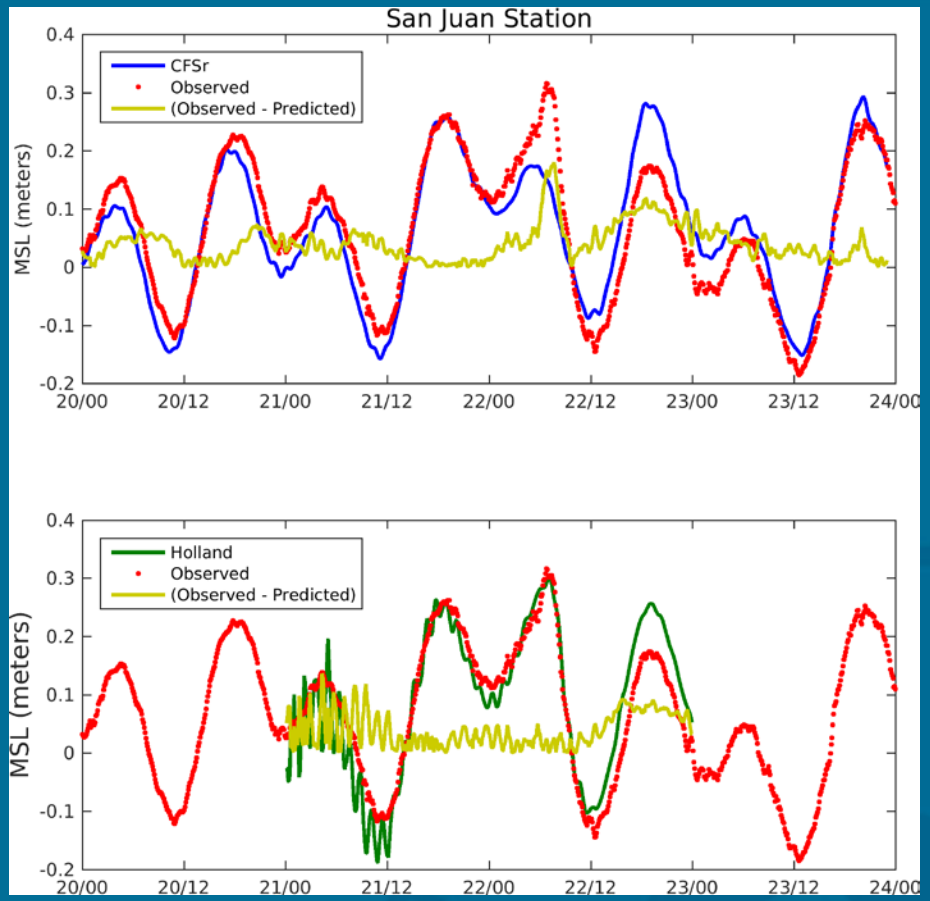
This station is at an elevation of 72 m!

Validation of CFSv2 and Parametric Wind Fields

Water Levels



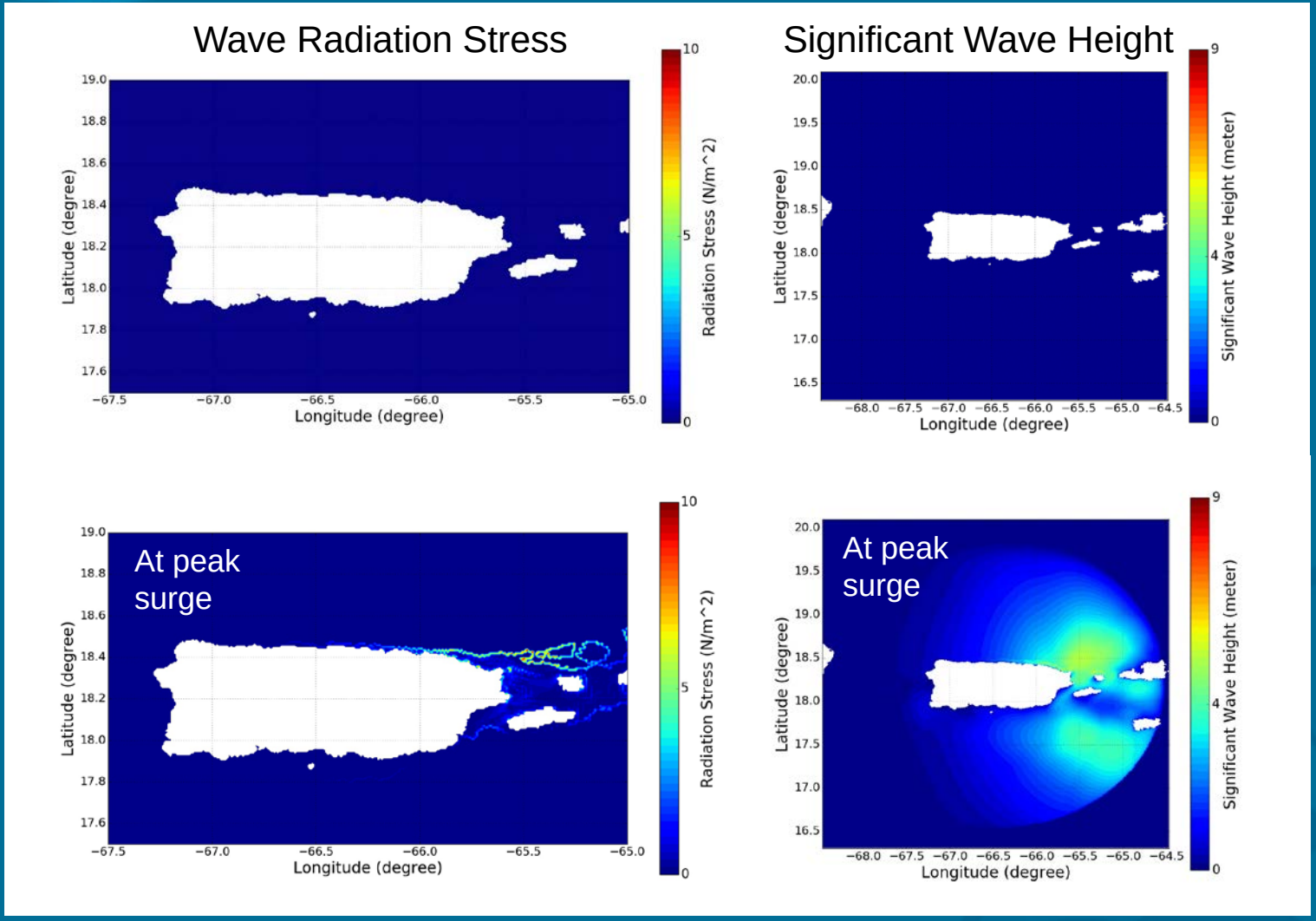
Hurricane Georges



Hurricane Irene

SLOSH+Parametric Wave model

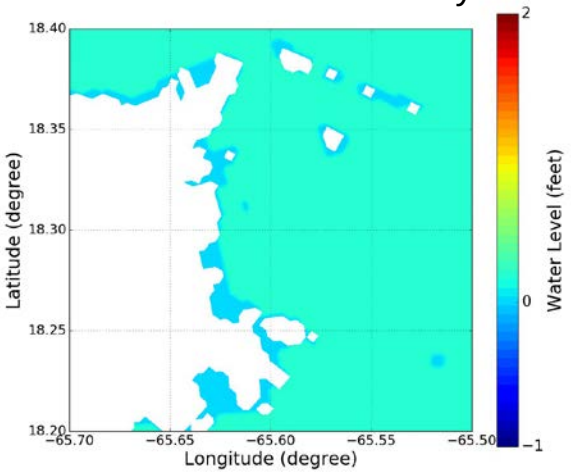
Hurricane Irene: SLOSH parametric wind forcing

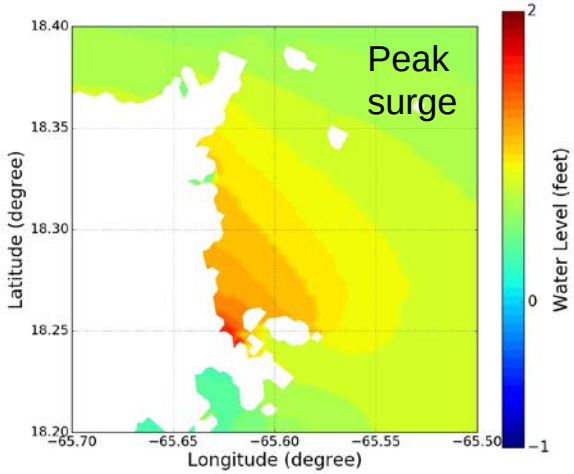


SLOSH+Parametric Wave model

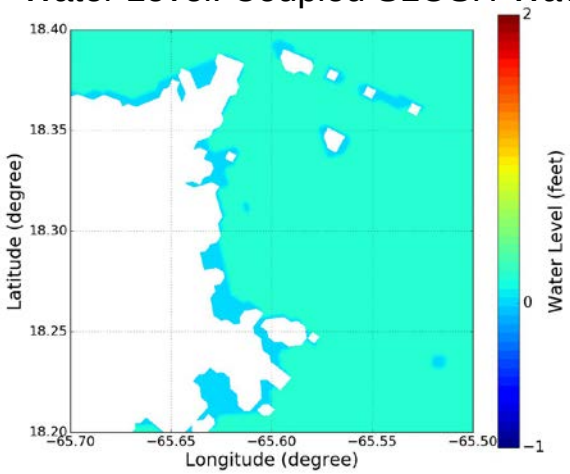
Hurricane Irene: SLOSH parametric wind forcing

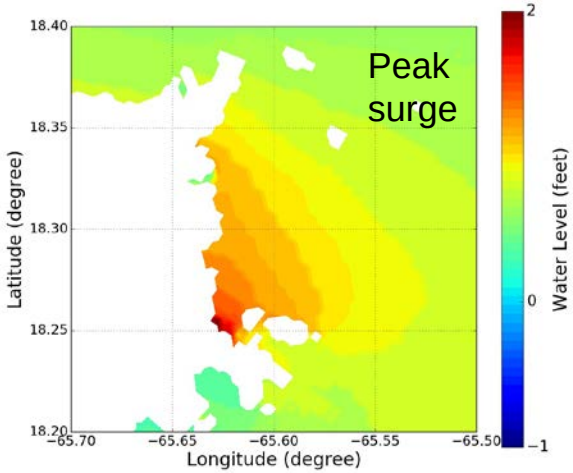
Water Level: SLOSH-only





Water Level: Coupled SLOSH-Wave

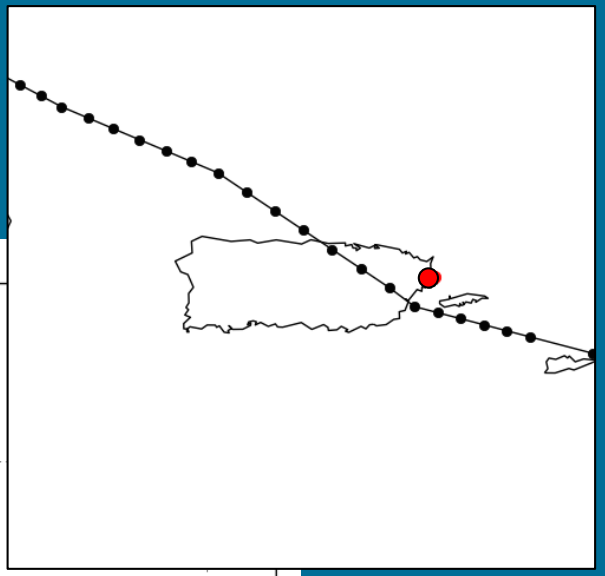


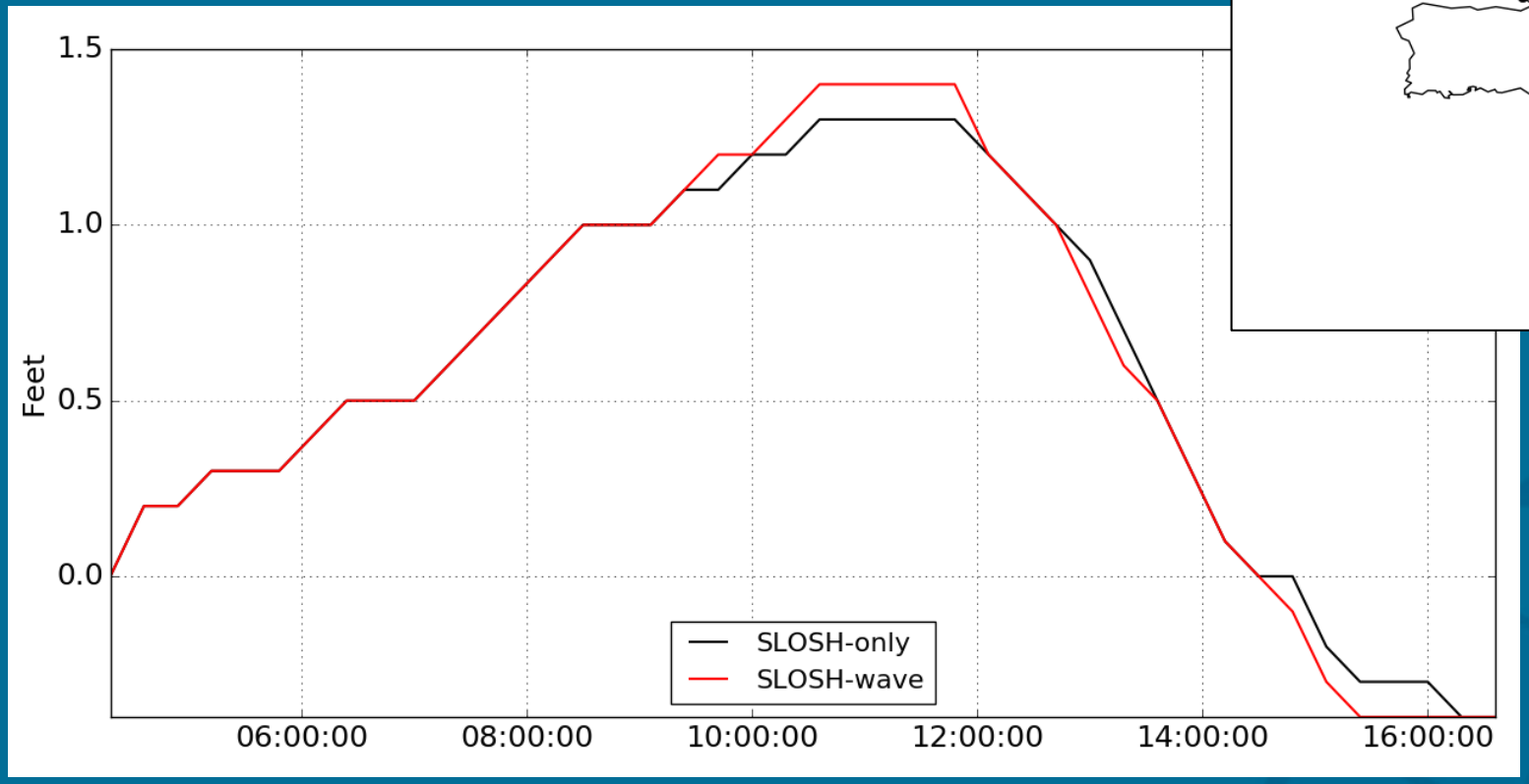


SLOSH+Parametric Wave model

Hurricane Irene: SLOSH parametric wind forcing

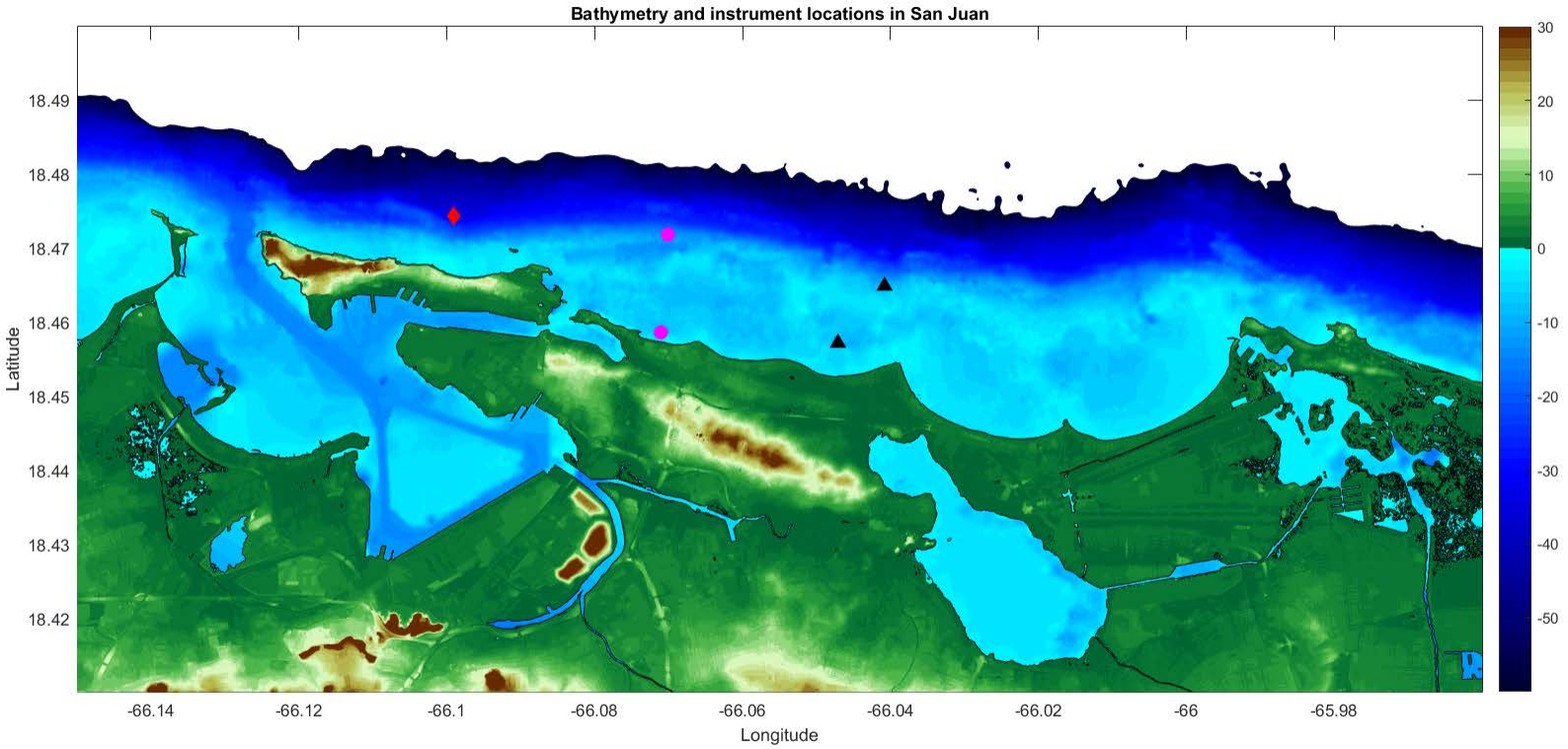
Targeted as future surge/wave core in NHC's P-Surge system





Phase-resolved modeling

Bathymetry and instrument locations San Juan, PR

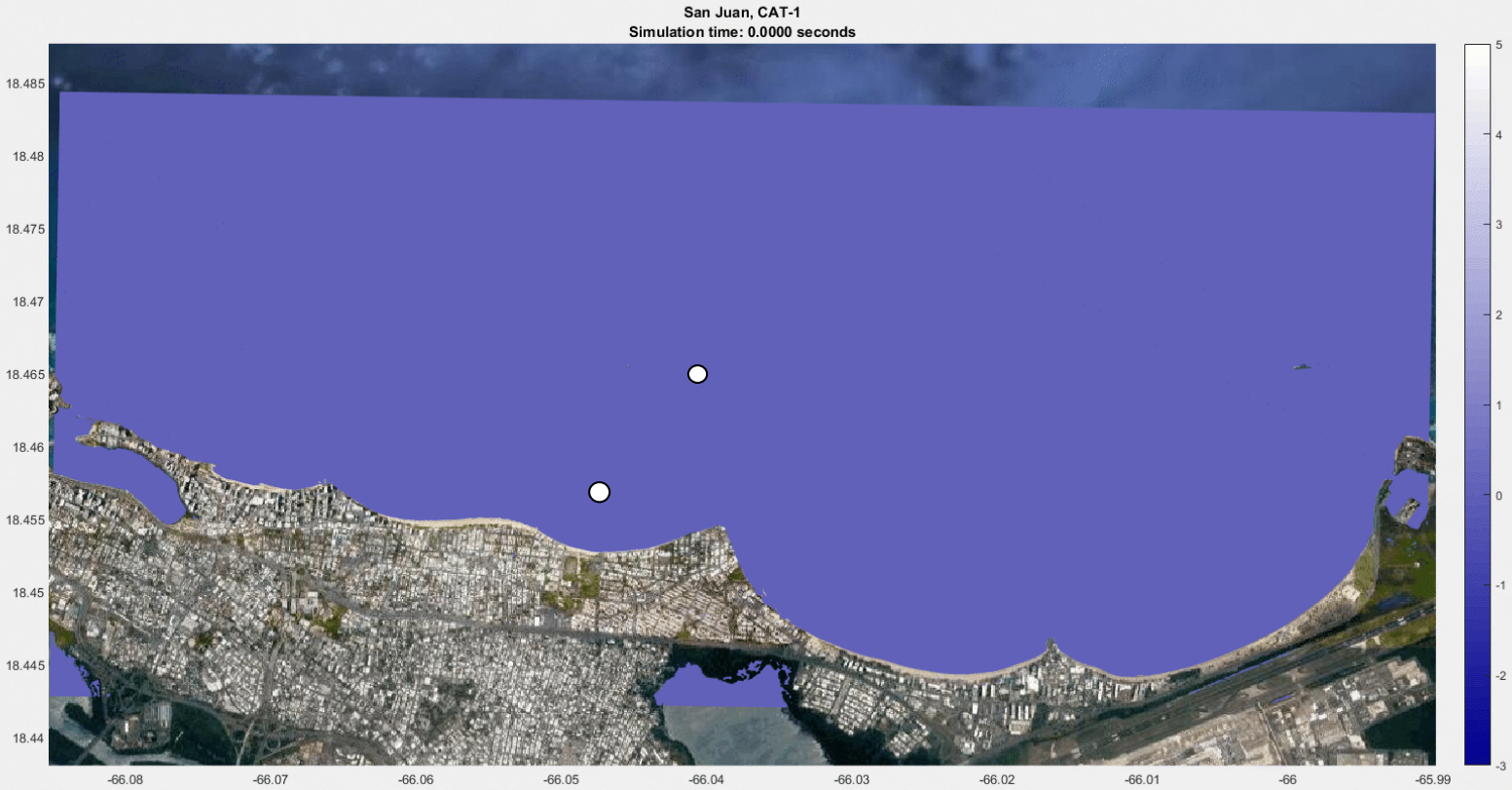


XBeach phase-resolving model

- Boundary forcing was obtained by providing the spectral output files from ADCIRC+SWAN simulation of H. Irene to XBeach.
- XBeach interprets this spectral output and computes a time series for forcing the model.
- Values calculated from SWAN spectrum:
  - H_{m0} = 4.39 m
  - T_{rep} = 8.11 s
  - Mean dir = 60.7 deg N

XBeach phase-resolving model

San Juan: H. Irene, Aug 22, 2011 03:00 LST



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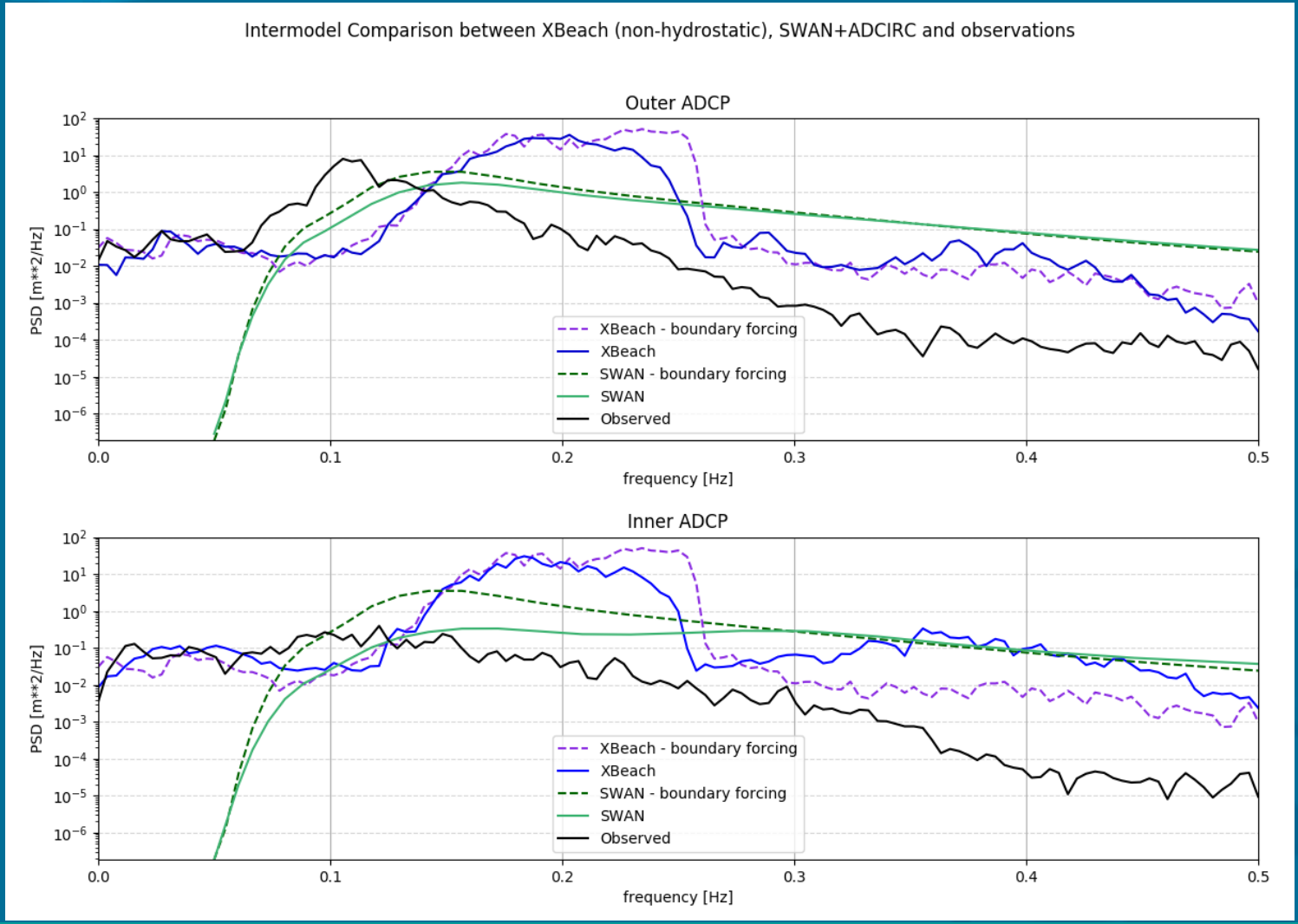
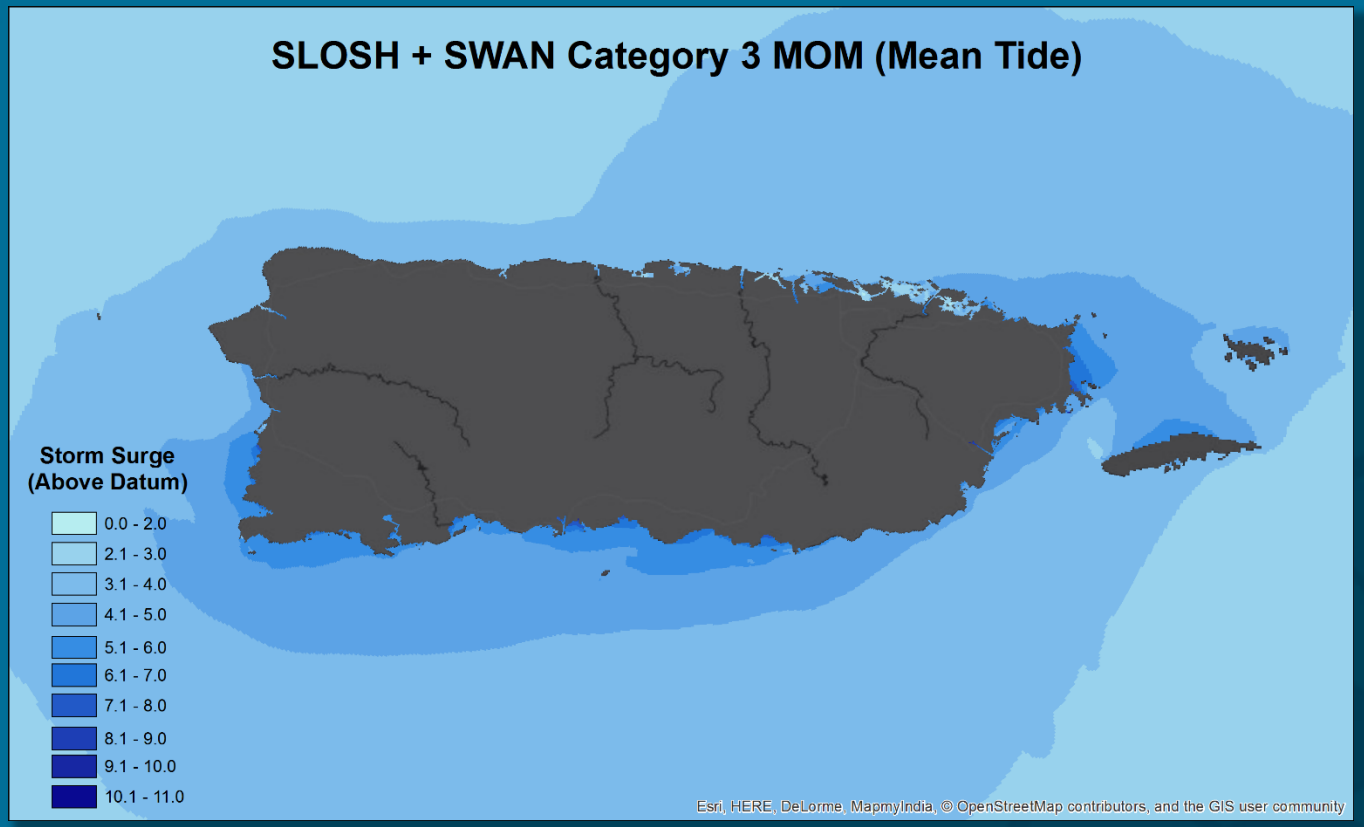


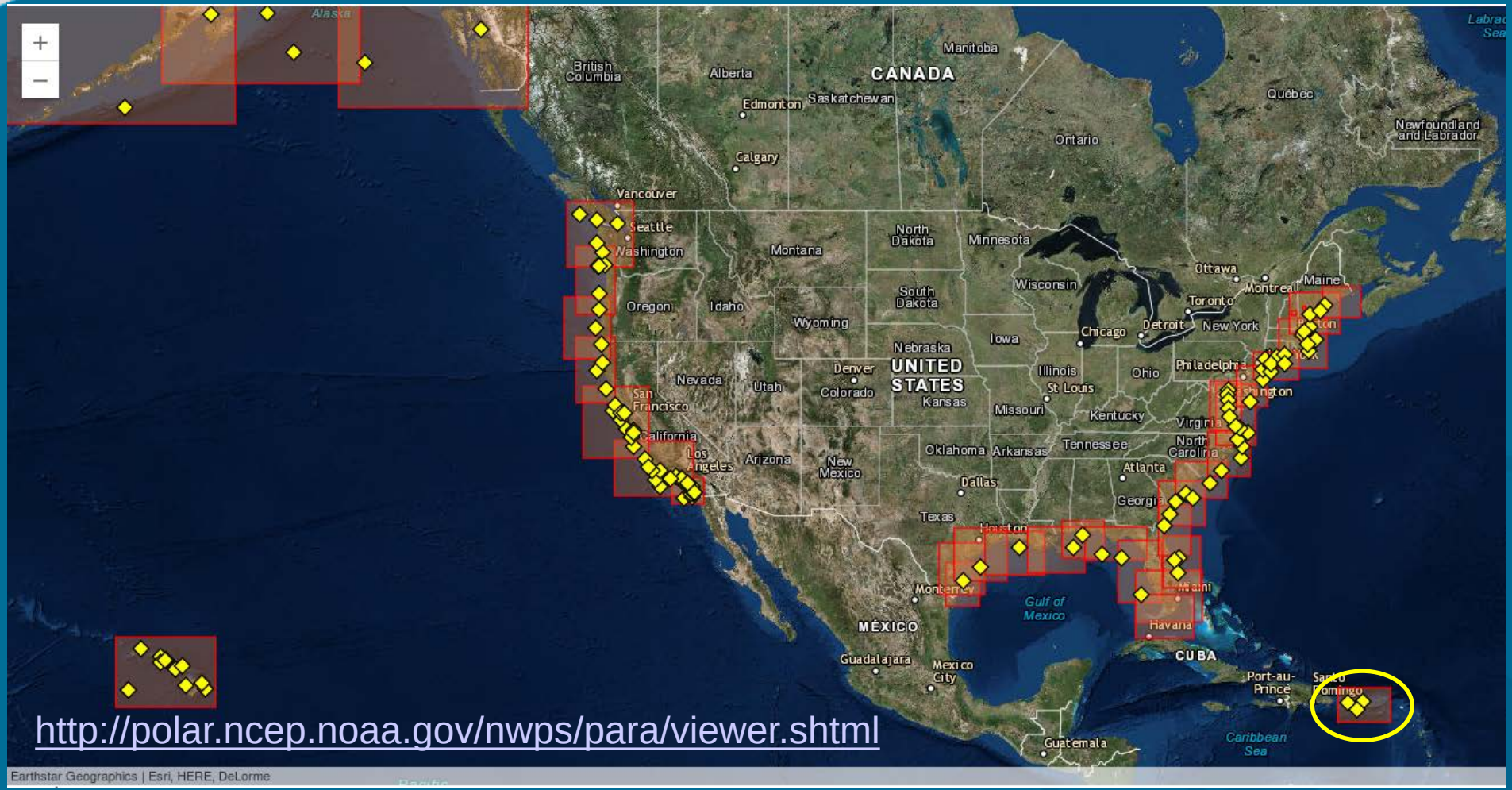
Transition to Operations
1. Storm surge envelopes

Maximum of Maximums (MOM) surge hazard database produced for Puerto Rico, using coupled SLOSH+SWAN. To be used for evacuation planning and response. ***Operational this hurricane season***



Transition to Operations

2. PR domain in Nearshore Wave Prediction System



http://polar.ncep.noaa.gov/nwps/para/viewer.shtml

Transition to Operations

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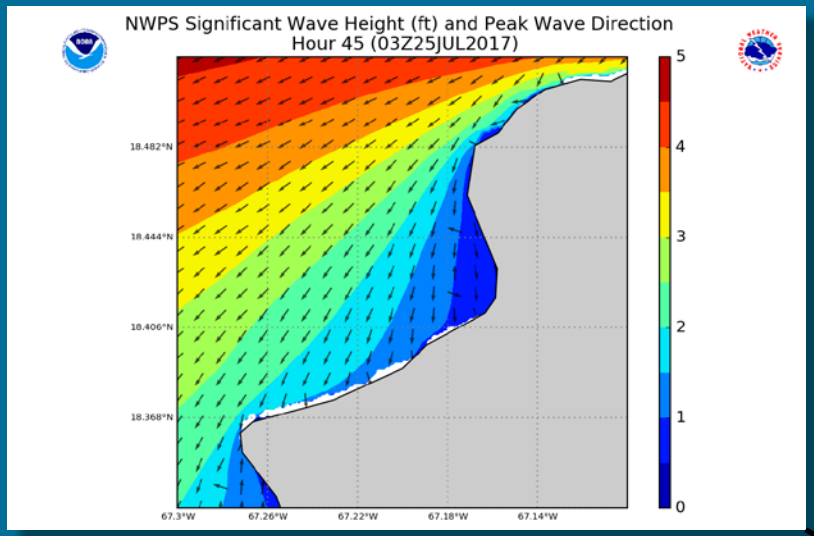
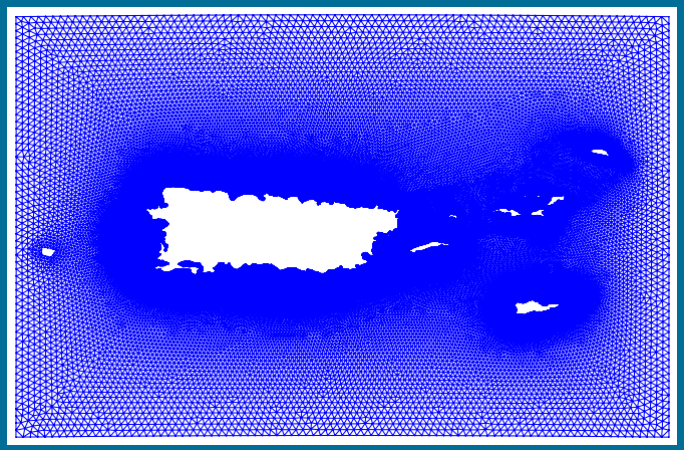
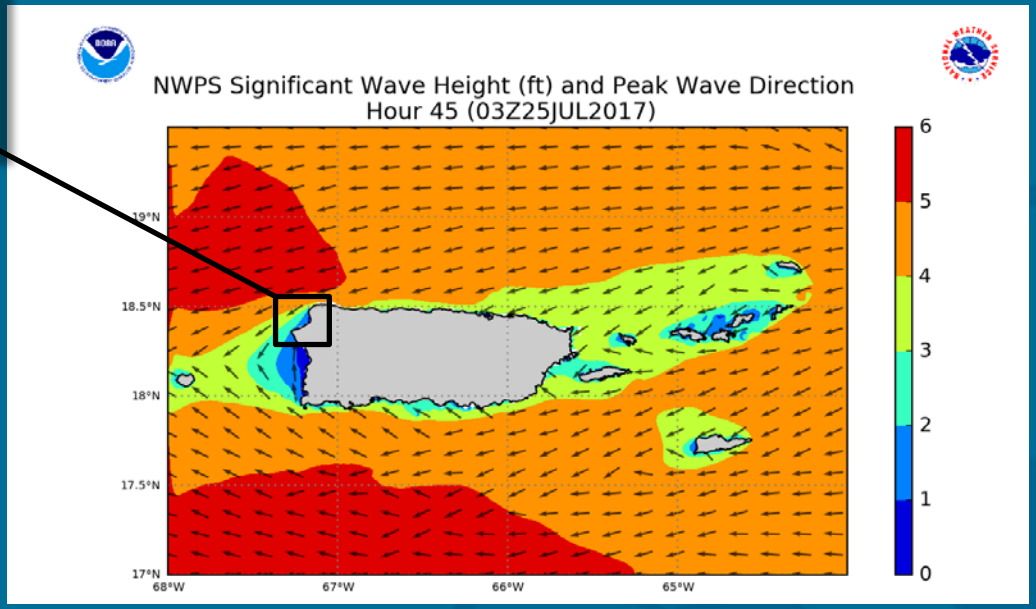




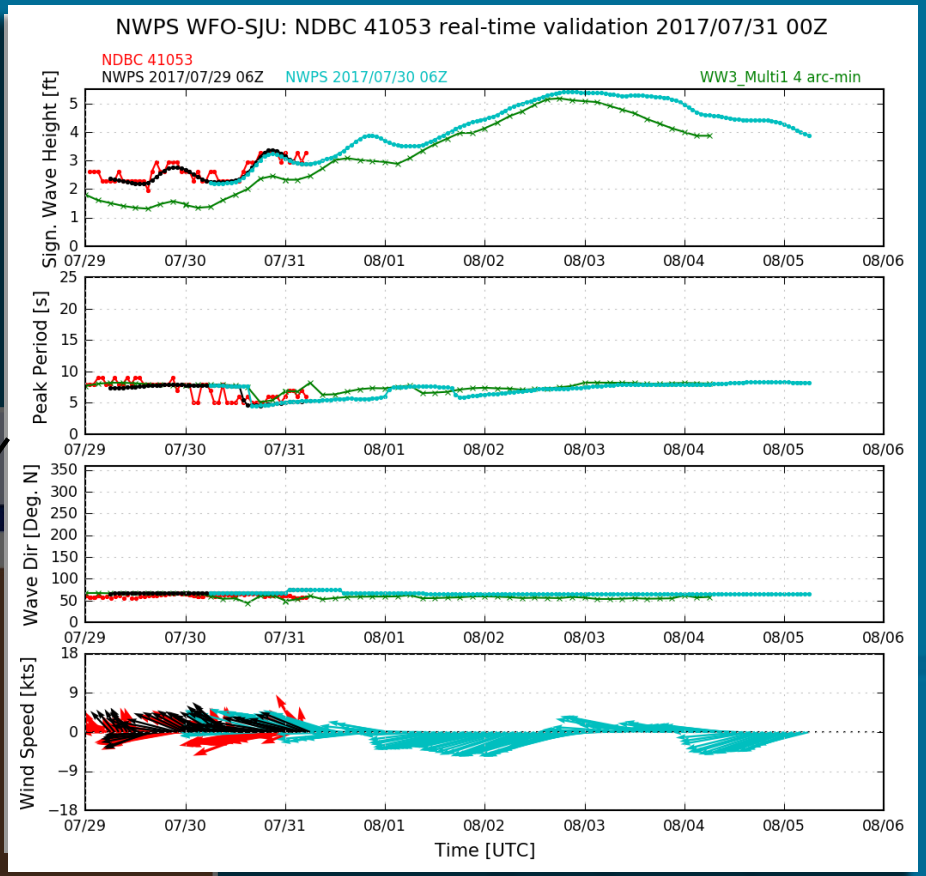


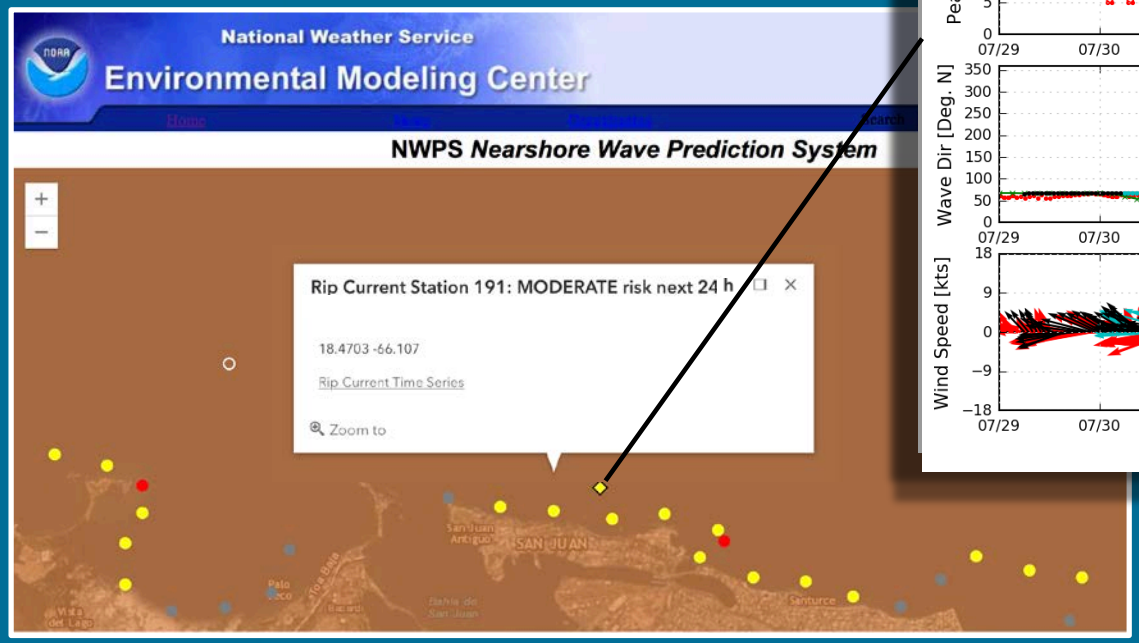
On-demand NWPS system, based on COMT-developed ADCIRC-SWAN mesh.

Operational implementation at NOAA/NCEP scheduled for Oct 31, 2017

Transition to Operations
2. PR domain in Nearshore Wave Prediction System

- Improved wave height prediction relative to operational WAVEWATCH III
- Guidance of rip current hazard due to elevated wave height and surge





http://polar.ncep.noaa.gov/nwps/para/viewer.shtml

Summary

1. Significant variability in hurricane and intensity observed between CFSR, WRF-ARW and parametric fields from ATCF data. Has significant influence on coastal waves, current and storm surge patterns in Puerto Rico/USVI.
2. New parametric wave model in SLOSH shows realistic surge results for PR, at approx doubling of SLOSH run time (only). Operationally feasible for probabilistic application.
3. XBeach phase-resolving model being nested into ADCIRC-SWAN for wave/surge cross-reef dynamics. Key processes reproduced.
4. R2O: Puerto Rico surge and wave MOM/MEOWs operational at NHC.
5. R2O: Puerto Rico domain included in Nearshore Wave Prediction System. Improved wave heights, new experimental rip current guidance. Operational October 31, 2017.
6. JGR manuscripts in preparation (model inter-comparison; detailed analysis of PR wave/tide/surge dynamics).