





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

# Year 4 Progress

André van der Westhuysen, Joannes Westerink,

Juan Gonzalez, Jaynese Perez, Dongming Yang, Jane Smith, Jamie Rhome, Julio Morell, Aurelio Mercado, Reniel Calzada, Volker Roeber, Carlos Anselmi, Ernesto Rodriguez, Brian McKenna, Kelly Knee (and thanks to Luis Aponte)







SURA IOOS All-Hands Meeting, Washington DC, Jul 31-Aug 1, 2017



# Contents

- 1. Objectives and Testbed Composition
- 2. Year 4 goal: Model sensitivity/Inter-comparison
- 3. Model results: Phase-averaged models
- 4. Model results: Phase-resolved model
- 5. R2O: Transition to Operations
- 6. Summary

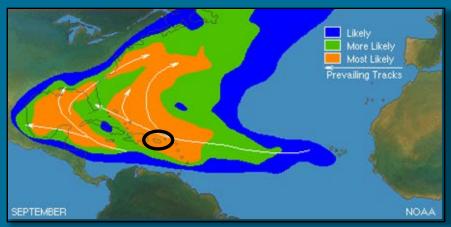






# Objective

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



www.caricoos.org

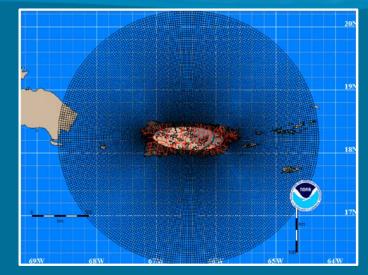




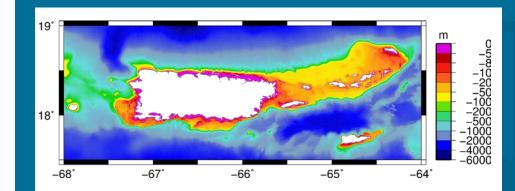


# **Puerto Rico/USVI: Model selection**

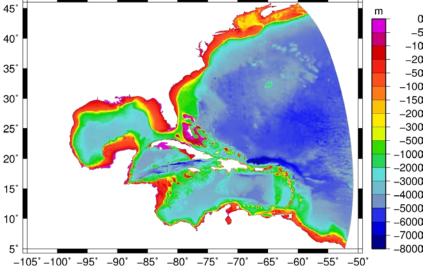
- UND: ADCIRC+SWAN
- NCEP/USACE: ADCIRC+WW3
- NHC: SLOSH-Wave
- **UPR:** XBeach/BOSZ/FUNWAVE



Curvilinear grid (min res: 90 m)

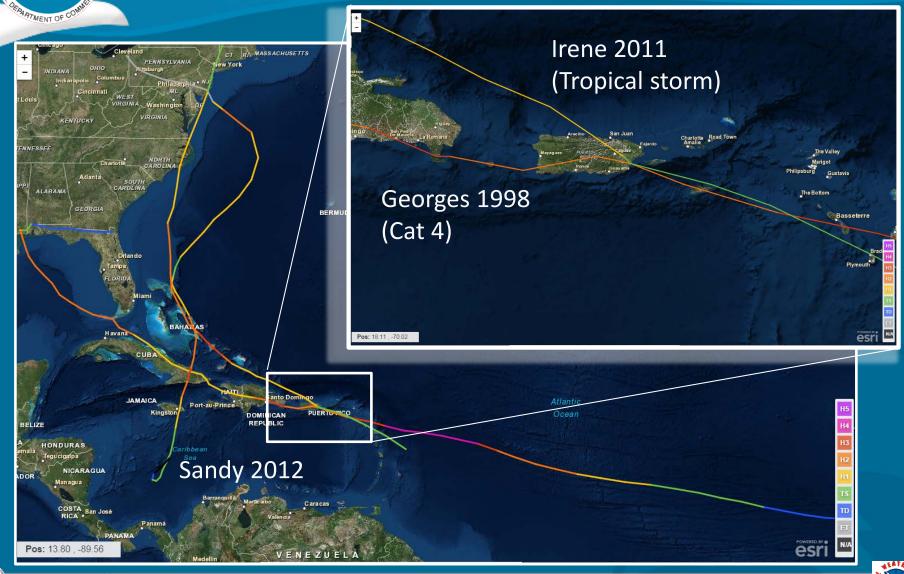


Unstructured, 2,7M nodes (min res: 50 m)





# **Regional hindcast cases**



5/3

NOAA

DATMOSPA

NOAA

6



# 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	-





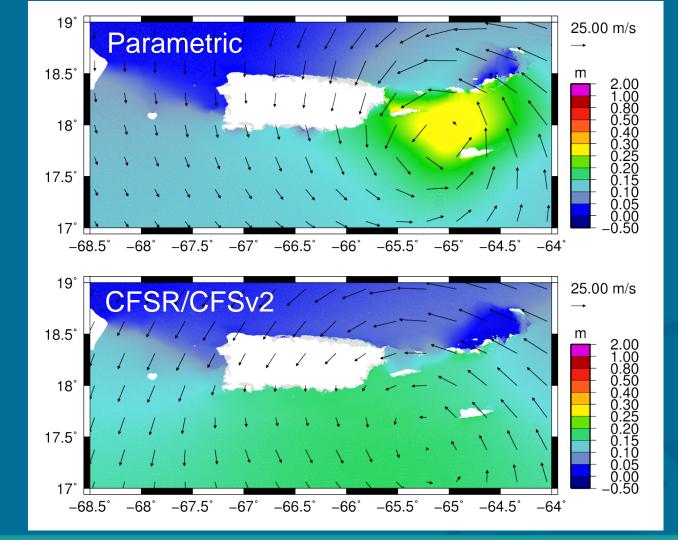
# How much can surge from CFSR/CFSv2 and parametric wind fields differ?

#### Hurricane Irene (2011)

DATMOSP

NOAA

RTMENT OF C





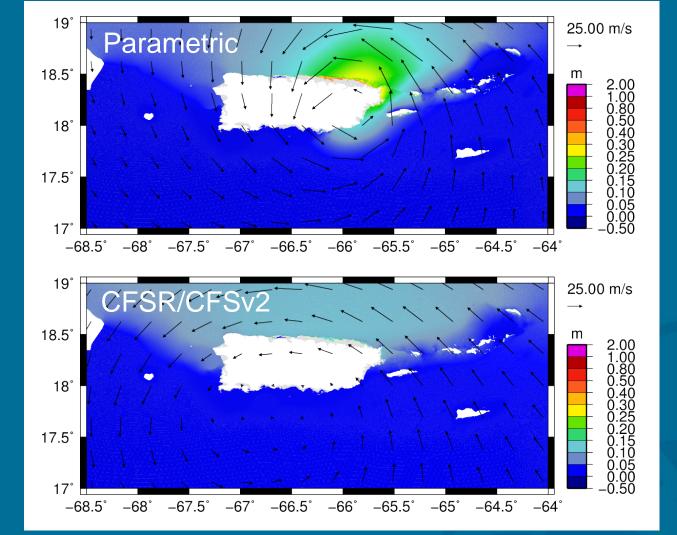
# How much can surge from CFSR/CFSv2 and parametric wind fields differ?

#### Hurricane Irene (2011)

DATMOSPA

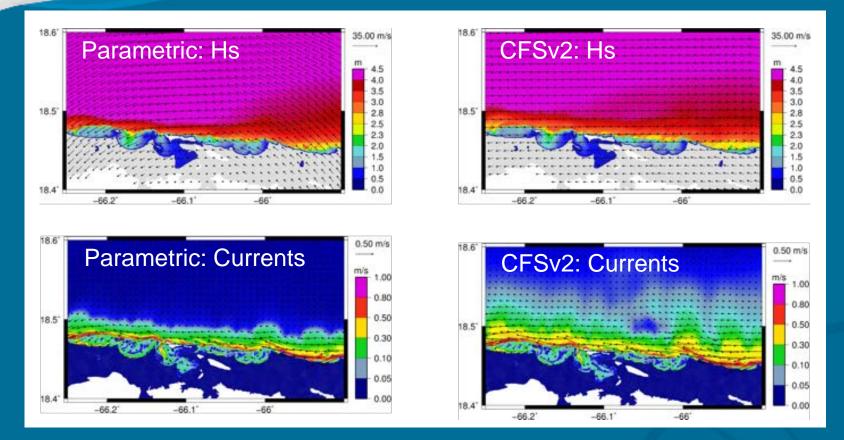
NOAA

ATMENT OF CO





# 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.



NOAA

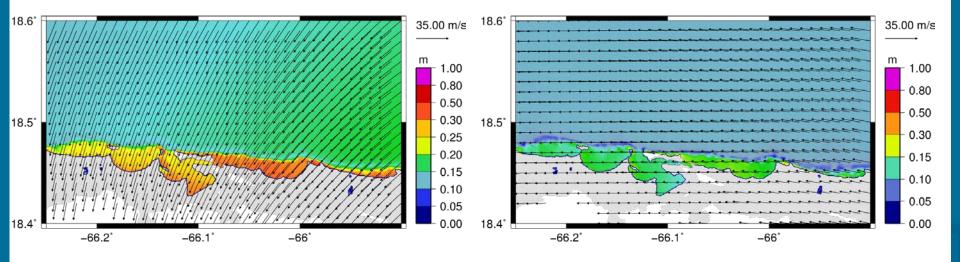
TMENT OF C



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

#### Parametric: 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.



noaa

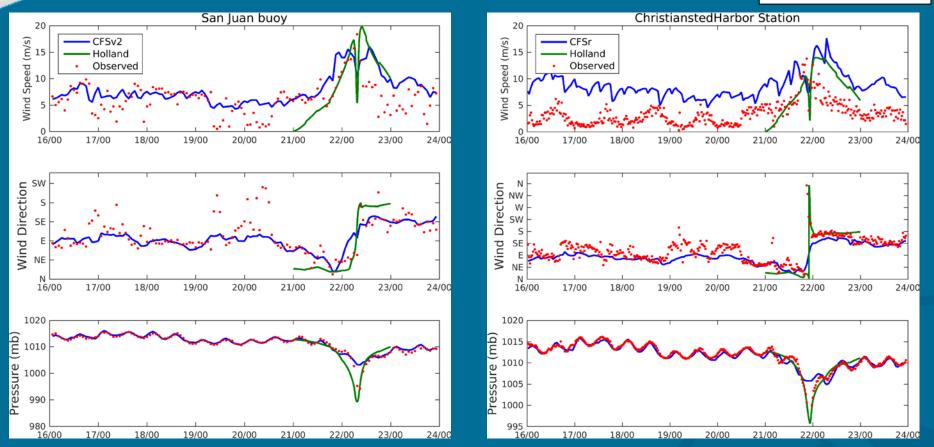
MENT OF



## Validation of CFSv2 and Parametric Wind Fields

#### Hurricane Irene (2011)





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.



DATMOSP

NOAA

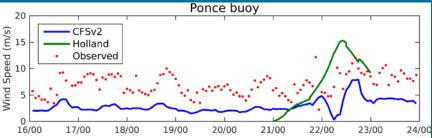
ARTMENT OF CO

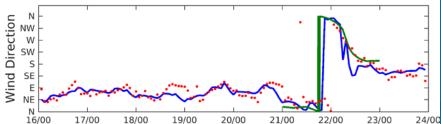


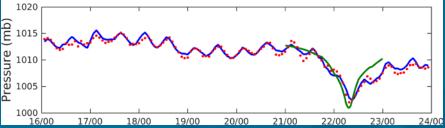
## Validation of CFSv2 and Parametric Wind Fields

#### Hurricane Irene (2011)

St John buoy 20 20 Wind Speed (m/s) 2 0 2 Wind Speed (m/s) <sup>2</sup>
<sup>12</sup>
<sup>2</sup> CFSv2 CFSv2 Holland Holland Observed Observed 0 0 16/00 17/00 18/00 19/00 20/00 21/00 22/00 23/00 24/00 16/00 17/00 18/00 S Wind Direction N Wind Direction NW SE W sw S SE NE NF N└── 16/00 Ν 17/00 18/00 19/00 20/00 21/00 22/00 23/00 24/00 16/00 17/00 18/00 1020 1020 Pressure (mb) Pressure (mb) 1015 1015 1010 1010 1005 1005 1000 995 1000 17/00 18/00 19/00 20/00 21/00 22/00 23/00 24/00 16/00







NORA

ND ATMOSPH

NOAA

DEPARTMENT OF COM

S. N NATIONA

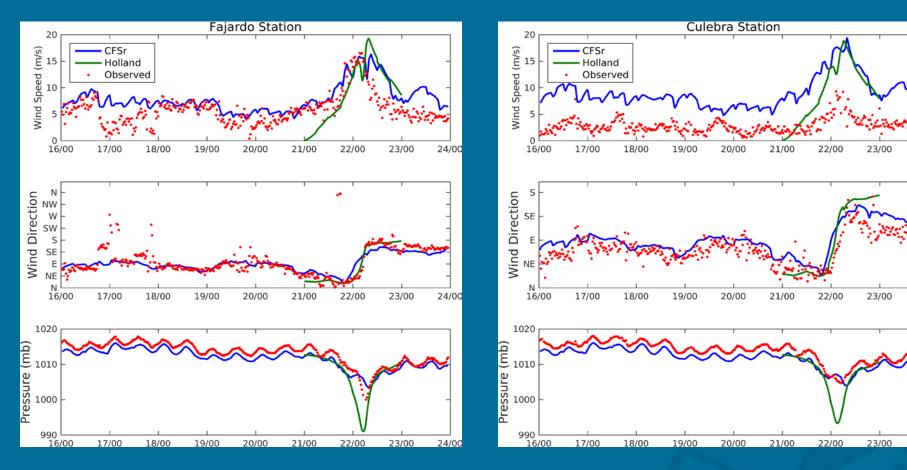


NIVERSITY OF

# DOAR HID ATMOSPHERIC TO HISTRATION

## Validation of CFSv2 and Parametric Wind Fields

#### Hurricane Irene (2011)



NOAR



24/00

NIVERSITY OF

RE DAME

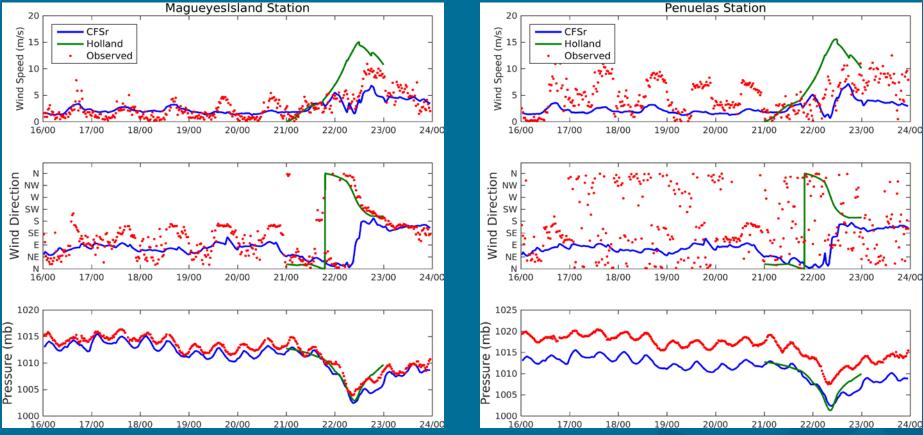
24/00



## Validation of CFSv2 and Parametric Wind Fields

#### Hurricane Irene (2011)





NORA



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

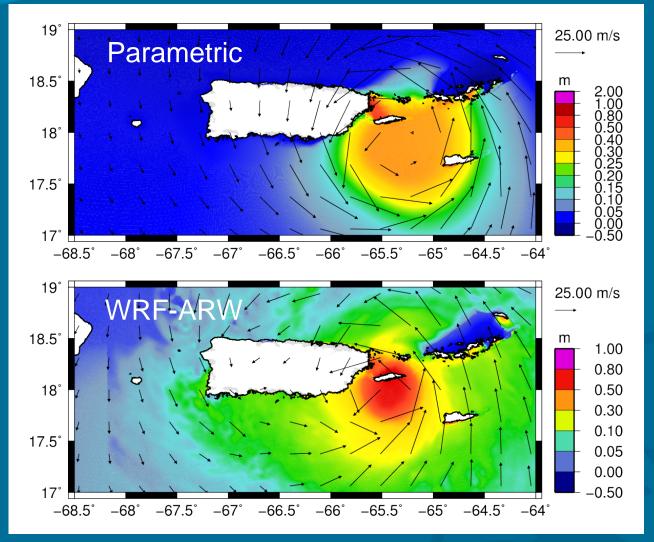
Hurricane Georges (1998)

DATMOSPA

NOAA

ATMENT OF C







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

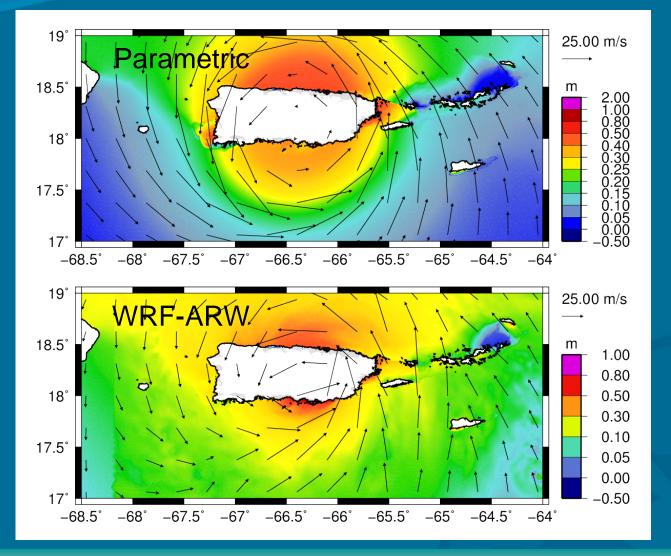
Hurricane Georges (1998)

DATMOSPA

NOAA

ATMENT OF C



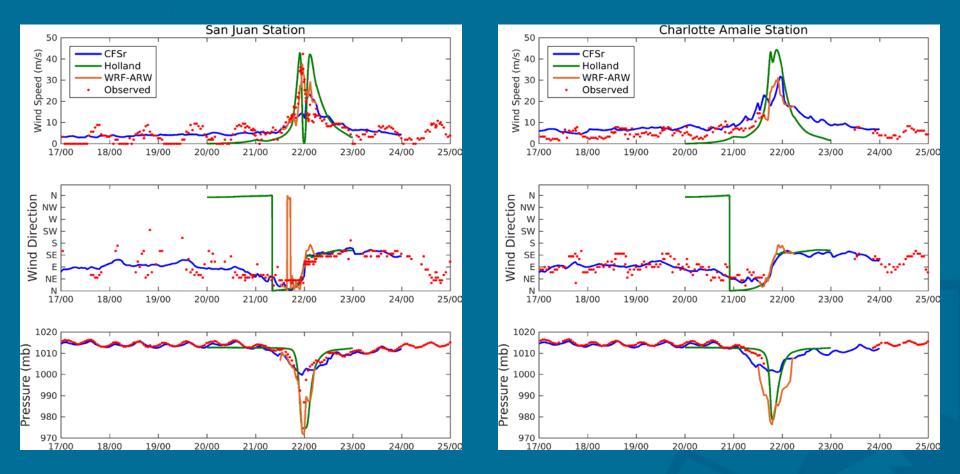






# Validation of CFSv2, WRF and Parametric Winds

#### Hurricane Georges (1998)





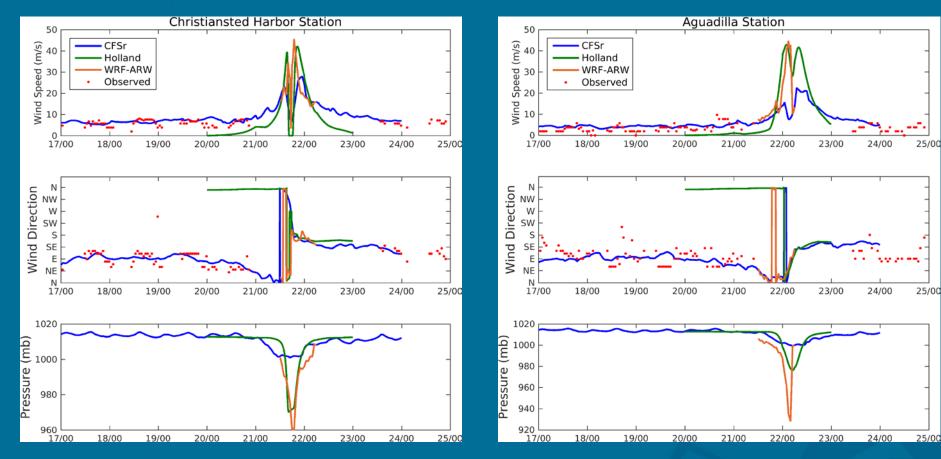


UNIVERSITY OF NOTRE DAME



# Validation of CFSv2, WRF and Parametric Winds

#### Hurricane Georges (1998)



This station is at an elevation of 72 m!



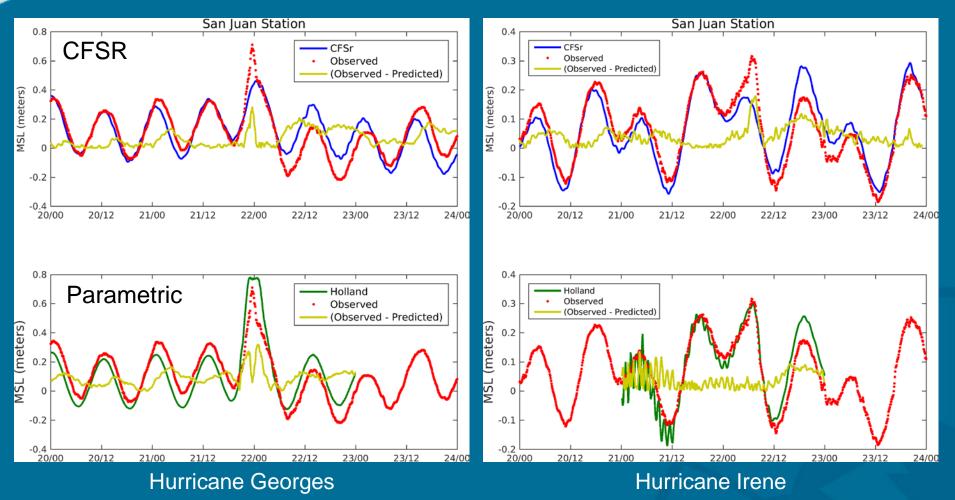


NIVERSITYOF

**RE DAME** 

## Validation of CFSv2 and Parametric Wind Fields

#### Water Levels





DATMOSPA

NOAA

PARTMENT OF CO

IN NATION

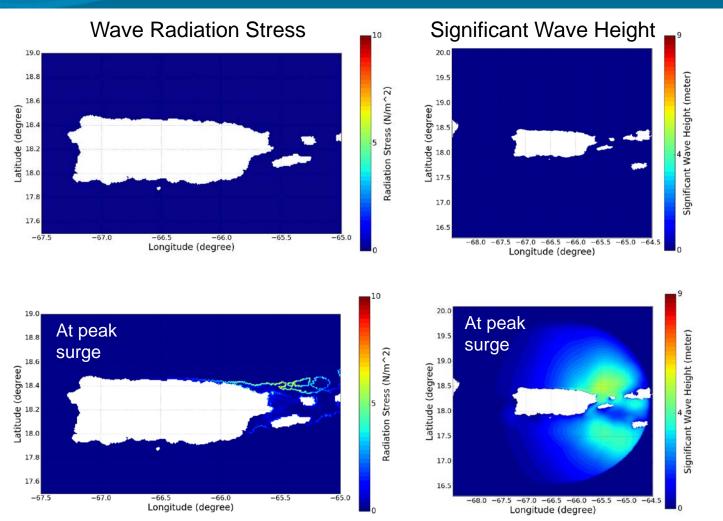


UNIVERSITY OF

**RE DAME** 



# SLOSH+Parametric Wave model Hurricane Irene: SLOSH parametric wind forcing



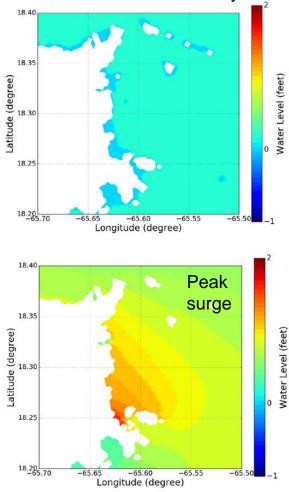
NOAR

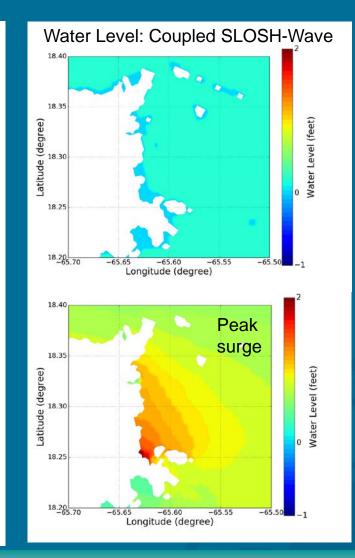




# SLOSH+Parametric Wave model Hurricane Irene: SLOSH parametric wind forcing

Water Level: SLOSH-only



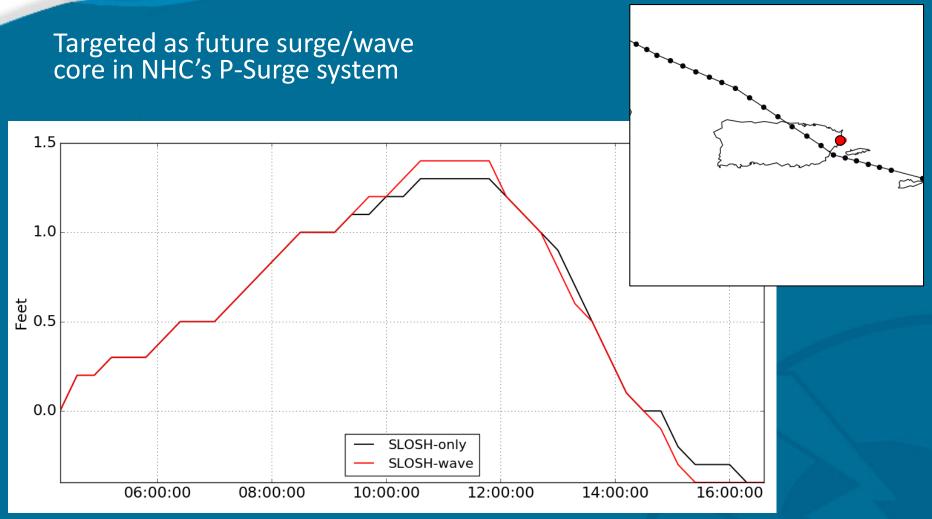








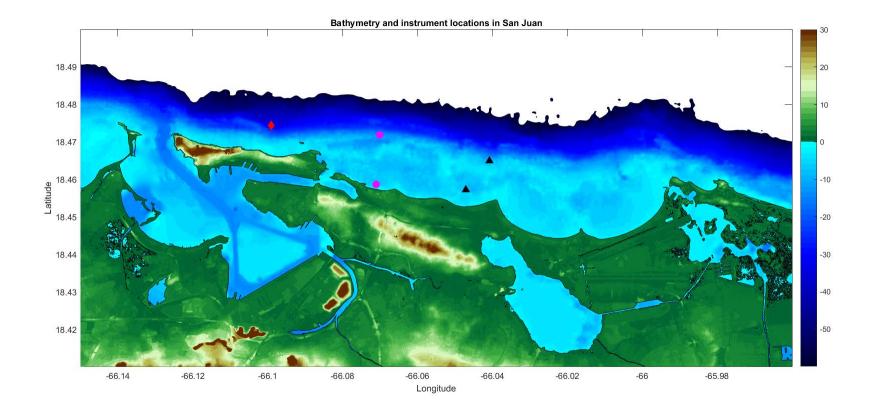
# SLOSH+Parametric Wave model Hurricane Irene: SLOSH parametric wind forcing







# Phase-resolved modeling Bathymetry and instrument locations San Juan, PR





DATMOSP

NOAA

ATMENT OF C



# 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:
  - $H_{m0} = 4.39 \text{ m}$
  - T<sub>rep</sub> = 8.11 s
  - Mean dir = 60.7 deg N





NOAA

MENT OF C



San Juan, CAT-1 Simulation time: 0.0000 seconds





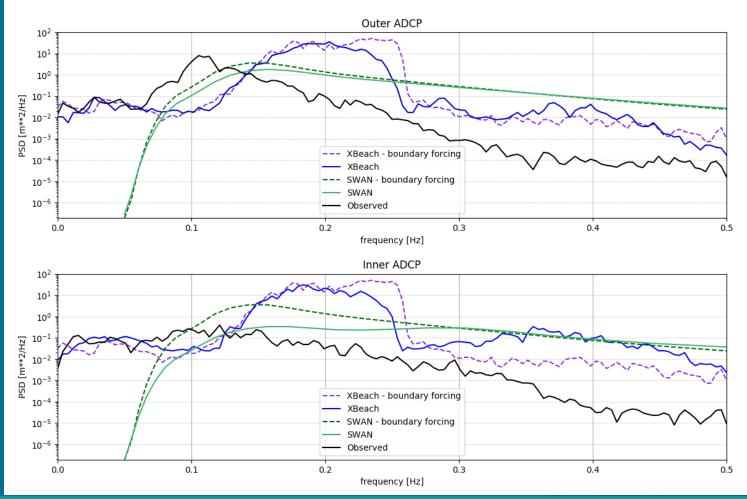
ATMOSP

NOAA



# XBeach phase-resolving model San Juan: Hurricane Irene, Aug 22, 2011 03:00 LST

Intermodel Comparison between XBeach (non-hydrostatic), SWAN+ADCIRC and observations





DATMOSPHE

NOAA

PARTMENT OF CO

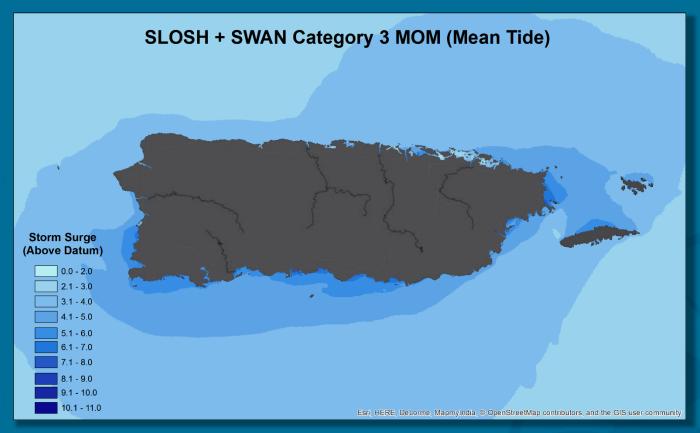
NATION

NC.



**Transition to Operations** 1. Storm surge envelopes

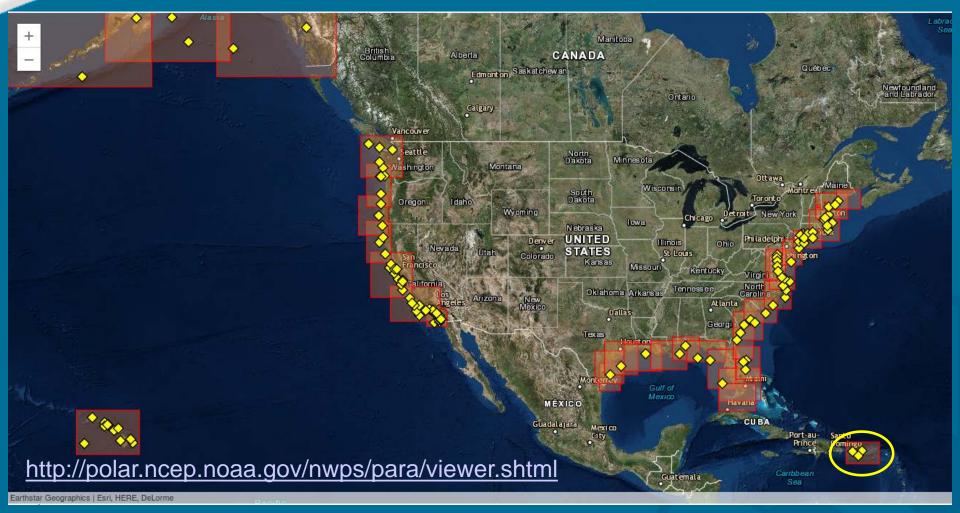
Maximum of Maximums (MOM) surge hazard database produced for Puerto Rico, using coupled SLOSH+SWAN. To be used for evacuation planning and response. *Operational this hurricane season* 







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



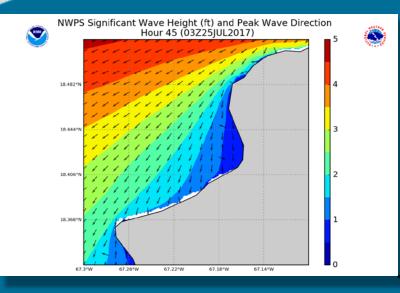
ATMOSP

NOAA

PTMENT OF CO



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



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

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

NWPS Significant Wave Height (ft) and Peak Wave Direction Hour 45 (03Z25JUL2017) 5 з 17 \*\* 65°W



noaa

VENT OF



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

NWPS WFO-SIU: NDBC 41053 real-time validation 2017/07/31 00Z

NDBC 41053 NWPS 2017/07/29 06Z Wave Height [ft] NWPS 2017/07/30 06Z WW3 Multi1 4 arc-min Improved wave height prediction relative to operational WAVEWATCH III igodol. ug 07/29 Guidance of rip current hazard due to ightarrow07/30 07/31 08/01 08/02 08/03 08/04 08/05 25 elevated wave height and surge Peak Period [s] 20 5 **National Weather Service** 07/29 07/30 07/31 08/01 08/02 08/03 08/04 08/05 z 350 Environmental Modeling Center 300 [Deg. 250 200 NWPS Nearshore Wave Prediction System Dir 150 Wave I 100 50 0 07/30 07/31 08/01 08/02 08/03 08/04 08/05 07/29 18 Wind Speed [kts] Rip Current Station 191: MODERATE risk next 24 18.4703 -66.107 **Rip Current Time Series** 07/29 07/30 07/31 08/01 08/02 08/03 08/04 08/05 Q. Zoom to Time [UTC]

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

ATMOSE

**NOAA** 

PTMENT OF C



08/06

08/06

08/06



# 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).



