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

Year 4 Progress

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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
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.
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

Sandy 2012

Irene 2011
(Tropical storm)

Georges 1998
(Cat 4)
<table>
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<tr>
<th>ADCIRC-SWAN Unstructured</th>
<th>SLOSH-Parametric Wave Curvilinear/Regular</th>
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<tr>
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<td>SLOSH parametric wind model (ATCF input)</td>
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<td>Holland parametric wind model (ATCF input)</td>
<td>Gridded Holland parametric wind model (ATCF input)</td>
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<tr>
<td>CFSR/CFSRv2 wind model</td>
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<td>WRF wind model</td>
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<tr>
<td>Wave coupling on/off</td>
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<td>Phase-resolved wave model nest</td>
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How much can surge from CFSR/CFSv2 and parametric wind fields differ?

Hurricane Irene (2011)
How much can surge from CFSR/CFSv2 and parametric wind fields differ?

Hurricane Irene (2011)
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.
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)
Validation of CFSv2 and Parametric Wind Fields

Hurricane Irene (2011)
How much can surge from WRF-ARW and parametric wind fields differ?

Hurricane Georges (1998)
How much can surge from WRF-ARW and parametric wind fields differ?

Hurricane Georges (1998)
Validation of CFSv2, WRF and Parametric Winds

Hurricane Georges (1998)
Validation of CFSv2 and Parametric Wind Fields

Water Levels

San Juan Station

CFSR

Holland

Parametric

Hurricane Georges

Hurricane Irene

MSL (meters)
SLOSH+Parametric Wave model
Hurricane Irene: SLOSH parametric wind forcing

Wave Radiation Stress

Significant Wave Height

At peak surge

At peak surge
SLOSH+Parametric Wave model

Hurricane Irene: SLOSH parametric wind forcing
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
• 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:
  - \( H_{m0} = 4.39 \text{ m} \)
  - \( T_{\text{rep}} = 8.11 \text{ s} \)
  - Mean dir = 60.7 deg N
XBeach phase-resolving model
San Juan: Hurricane Irene, Aug 22, 2011 03:00 LST

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

Outer ADCP

Inner ADCP
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
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
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.


6. JGR manuscripts in preparation (model inter-comparison; detailed analysis of PR wave/tide/surge dynamics).