Development of a coupled coastal circulation and inland hydrology modeling framework based on ESMF/NUOPC infrastructure

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² NOAA/NWS (NWS: National Weather Service)
³ ESMF/NUOPC Development Team

NOAA: National Oceanic and Atmospheric Administration
ESMF: Earth System Modeling Framework
NUOPC: National Unified Operational Prediction Capability
# NOAA Environmental Modeling System (NEMS)

<table>
<thead>
<tr>
<th>Category</th>
<th>Example Models</th>
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<tbody>
<tr>
<td>ATM</td>
<td>FV3, GSM, NMNMb</td>
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<tr>
<td>OCN</td>
<td>MOM5, MOM6, ADCRIC, ROMS, FVCOM</td>
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<tr>
<td>WAV</td>
<td>WWIII</td>
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<tr>
<td>ICE</td>
<td>CICE, KISS</td>
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<tr>
<td>HYD</td>
<td>WRF-Hydro, NWM</td>
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<tr>
<td>LND</td>
<td>LIS</td>
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<td>AER</td>
<td>GOCART</td>
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<td>IPM</td>
<td>IPE</td>
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Validating: Examples
In development: Examples
Plan to develop: Examples

Note: Preliminary Results
## NEMS (NUOPC/ESMF) Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>ATM</th>
<th>OCN</th>
<th>WAV</th>
<th>ICE</th>
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Note: Preliminary Results

Contact: Saeed.Moghimi@noaa.gov
Unified NOAA Modeling Strategy for Integrated Water Model Coupling

- Hurricane Weather Modeling
  - Operational models
  - NHC Official Forecasts
  - Ensembles

- Coastal Ocean Modeling
  - Wind, Pressure
  - Wave Stress
  - Water Level, Currents

- Nearshore Wave Model
  - Wave Spectra

- Hydrologic Modeling
  - Precipitation
  - Inflow
  - Water Level

- Basin-scale Wave Model
  - Wave Spectra

Products

Example Products
- Maps and Visualizations
- Ensembles, Probabilities
- Product Uncertainties
- Wave Conditions

Contact: Saeed.Moghimi@noaa.gov
National Unified Operational Prediction Capability (NUOPC) Layer

NSEModel Application

- Model components
  - HWRF
  - ADCIRC
  - WW3
  - NWM

NUOPC components

- Driver
- Model
- Connector

Contact: Saeed.Moghimi@noaa.gov
Sandy landfall area

Wave height

Wind speed

Surge

Max Surge

WWIII

HWRF

ADCIRC

SAN ATM WAV2OCN
hs Date: 2012-10-27T00:00:00
Max. Val. = 14.24

SAN ATM WAV2OCN
wind Date: 2012-10-27T00:00:00
Max. Val. = 37.86

SAN Try01+WAV - Only tide
Date: 2012-10-27T00:00:00
Max. Val. = 0.27

SAN ATM WAV2OCN - Only tide

Note: Preliminary Results

Contact: Saeed.Moghimi@noaa.gov
Coupling of NWM and Coastal Models
Case study: Delaware Bay

Calibrated basins:
- NWMv1.1: 48 (from USGS GAGES-II)
- NWMv1.2: 1,164 (from USGS GAGESII + CADWR)

ADCIRC Domain
# Exported and imported variables

## NWM to Coastal models

<table>
<thead>
<tr>
<th>Data Field</th>
<th>Exported</th>
<th>Imported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge</td>
<td>NWM</td>
<td>Coastal models</td>
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<tr>
<td>Lateral fluxes</td>
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<td>Coastal models</td>
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## Coastal models to NWM

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<tr>
<th>Data Field</th>
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<th>Imported</th>
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<tr>
<td>Sea surface elevation</td>
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<td>Eastward sea water velocity</td>
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</tr>
<tr>
<td>Northward sea water velocity</td>
<td>Coastal models</td>
<td>NWM</td>
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</tbody>
</table>
On-going and planned projects

COASTAL Act

NOAA Water Initiative
- University of Oklahoma: “Steps Towards Automating River Connections and Addressing Precipitation in ADCIRC”
- Notre Dame University: “Grid Development and Automated Grid Generation for River Connections”
- Virginia Institute of Marine Sciences: “Implementing SCHISM model to Improve Integrated Water Modeling Projects”

Hurricane Harvey supplemental projects
- NWC/CSDL/EMC: Develop and Demonstrate Dynamic Coastal Coupling between the National Water Model and NOS Extratropical Surge and Tide Operational Forecast System
- CSDL/EMC/STI: Develop and Demonstrate Dynamic Coastal Coupling between the National Water Model and NOS Extratropical Surge and Tide Operational Forecast System

Contact: Saeed.Moghimi@noaa.gov
On-going projects

**IOOS Coastal Ocean Modeling Testbed (COMT)**
- University of North Carolina: “Coupling the National Water Model to the Coastal Ocean for Predicting Water Hazards”
- University of Massachusetts-Dartmouth: “Coupling the Northeast Coastal Ocean Forecast System (NECOFS) to NWM and the Water Balance Model”
- North Carolina State University: “Multi-Level River-Ocean Coupling using the Coupled Northwest Atlantic Prediction System”

**Joint Technology Transfer Initiative (JTTI)**
- Notre Dame University: “Advancing ADCIRC U.S. Atlantic and Gulf Coast Grids and Capabilities to Facilitate Coupling to the National Water Model in ESTOFS Operational Forecasting”
- NOAA Great Lakes Environmental Research Laboratory: “Improving Water Cycle Prediction in the WRF-Hydro National Water Model Through Regional Customization of Calibration, Data Assimilation, and Coastal Coupling Schemes”

Contact: Saeed.Moghimi@noaa.gov
Future work

- Continue development efforts for coupling National Water Model and coastal ocean models for Storm Surge and 3D coastal ocean models’
- Expanding unified modeling frameworks capabilities for Storm Surge and 3D ocean models (NUOPC/NEMS)
- Developing capabilities to support water quality and ecosystem modeling in estuaries and coastal oceans (in connection with inland processes)
- Inclusion of ice to the inland-coastal coupled system to support safe navigation and integrated water overall goals in Alaska region
Thanks for your attention
Sandy: High Water Marks
NWM/hydrology module results

NWM Channel Structure

NWM streamflow output indexed by feature_id. Does not contain river geometry.

Runoff Input
Streamflow Output

Cosgrove et al, 2018
Locations for handing-off NWM data to ADCIRC (for testing)

Discharges from NWM

Lateral fluxes from NWM
Towards NOAA Unified Modeling Strategy

The long-term approach regarding NOS coastal modeling capability is to move towards implementing full 3D coastal modeling linked to the inland hydrology models, on a national scale.

We have identified that direct coupling of the coastal circulation model to the inland hydrology model is the suggested long-term approach for NOS national scale coastal circulation models.

Boundary conditions from NOS operational models are always available to NOAA partners to support their inland flood modeling efforts.
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**Operational models**

**NHC Official Forecasts**

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