# A Coupling Infrastructure Developed in Partnership with Coastal Ocean Modeling Community



CoastalApp

tests passing    build passing    license CC0-1.0

https://github.com/noaa-ocs-modeling/CoastalApp

**Team:**
Saeed Moghimi (NOAA-OCS), Panagiotis Velissariou (NOAA-OCS/UCAR), Andre Van der Westhuysen (NOAA-EMC), Edward Myers (NOAA-OCS), Ali Abdolali (NOAA-EMC), Avichal Mehra (NOAA-EMC), Guoming Ling (UND), Damrongsak Wirasaet (UND), Joannes Westerink (UND), Ayumi Fujisaki-Manome (CIGLR), Y. Joseph Zhang, (VIMS), Carsten Lemmen (Hereon), Jianhua Qi (UMASS-Dartmouth), Changsheng Chen (UMASS-Dartmouth), Soroosh Mani (NOAA-OCS/SFI), Jason Ducker (NOAA-OWP), Julio Zyserman (NOAA-OWP), Rocky Dunlap, (NCAR/ESMF), Shachak Pe'eri (NOAA-OCS) and …

Unifying Innovations in Forecasting Capabilities Workshop
July 18-22, 2022 College Park, MD
UFSR20

# It takes a village to raise a child …

## NOS Storm Surge Modeling Team

Saeed Moghimi, Panagiotis Velissariou, Soroosh Mani, Yuji Funakoshi, Greg Seroka, Georgios Britzolakis, Zizang Yang, Bahram Khazaei, Edward Myers, Shachak Pe'eri

**Academic partners** (>20 PIs, Scientists, Postdocs and PhD students)

- University of Notre Dame
- Virginia Institute of Marine Science
- Argonne National Laboratory
- National Center for Atmospheric Research
- Texas Advanced Computing Center
- Columbia River Inter-Tribal Fish Commission
- Louisiana State University
- Sandia National Laboratories
- University of Massachusetts – Dartmouth
- University of North Carolina at Chapel Hill
- Cooperative Institute for Great Lake Research
- Oregon State University

**International partners**

- Helmholtz-Zentrum Hereon, Germany
- Laboratório Nacional de Engenharia Civil, Portugal
- European Commission Joint Research Centre, Belgium
- International Hydrographic Organization
- United Nations

**NOAA and agency partners**

- National Ocean Service
  - The U.S. Integrated Ocean Observing System
  - Center for Operational Oceanographic Products and Services
  - National Geodetic Survey
- National Weather Service
  - Office of Science and Technology Integration
  - Environment Modeling Center
  - National Hurricane Center
  - Office of Water Prediction
- Oceanic and Atmospheric Research
  - Great Lakes Environmental Research Laboratory
  - Earth Prediction Innovation Center (EPIC)
- U.S. Geological Survey
- U.S. Environmental Protection Agency
- National Science Foundation

**Industrial and cooperative partners**

- UCAR
- Spatial Front Inc
- Axiom

Contact: *Saeed.Moghimi@noaa.gov*

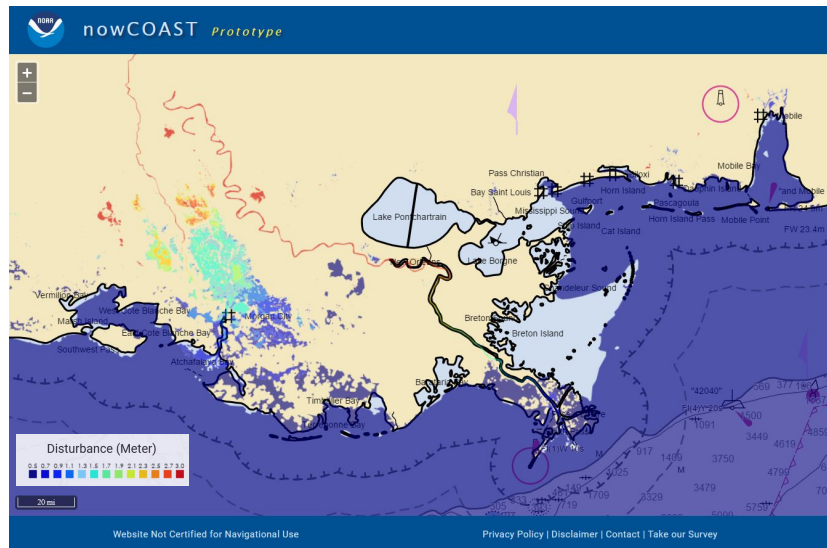# NOS Storm Surge Modeling Team - Products and Services

## Operational

- Global Surge and Tide Operational Forecast System (STOFS-2D-Global)

## Pre-operational (R2O)

- Inland-Coastal Flooding Guidance System (STOFS-3D-Atlantic)

## Research and development (R&D)

- COASTAL Act: Named Storm Event Model
- Enhancing Northern Pacific Ocean Modeling
- Hurricane Storm Surge On-Demand (HSOFS)
- Automated on-demand unstructured mesh generation (OCSMesh)



**Pre-operational once-day STOFS-3D-Atl**

**Hurricane Ida (Aug 2021)**

# NOS Storm Surge Modelling Team workflow

Planning, research, development, operation and maintenance of the
NOAA National Ocean Service storm surge modeling portfolio including:

- Research and development;
- Research-to-operation (R2O);
- Operational implementation and support;
- Regular upgrades and maintenance;
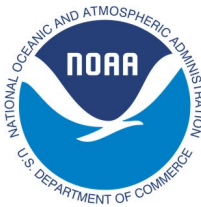- Dissemination

Contact: Saeed.Moghimi@noaa.gov
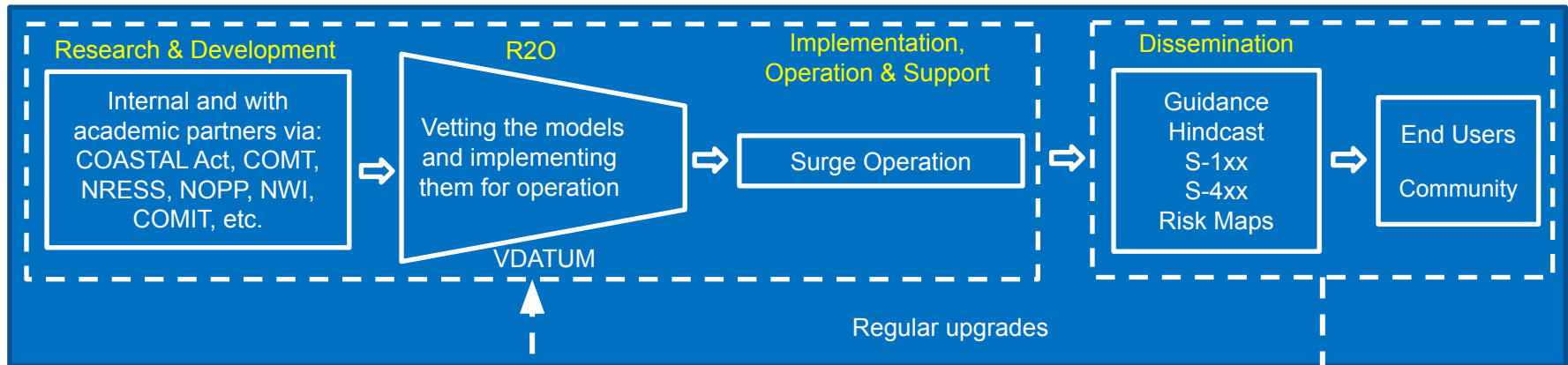
# Coastal Ocean Model Coupling

## Following Unified Forecast System (UFS) Best Practices

Case study:

COASTAL Act: Name Storm Event Model (NSEM)

# NOAA Unified Forecast System &
## *Coastal ocean modeling*
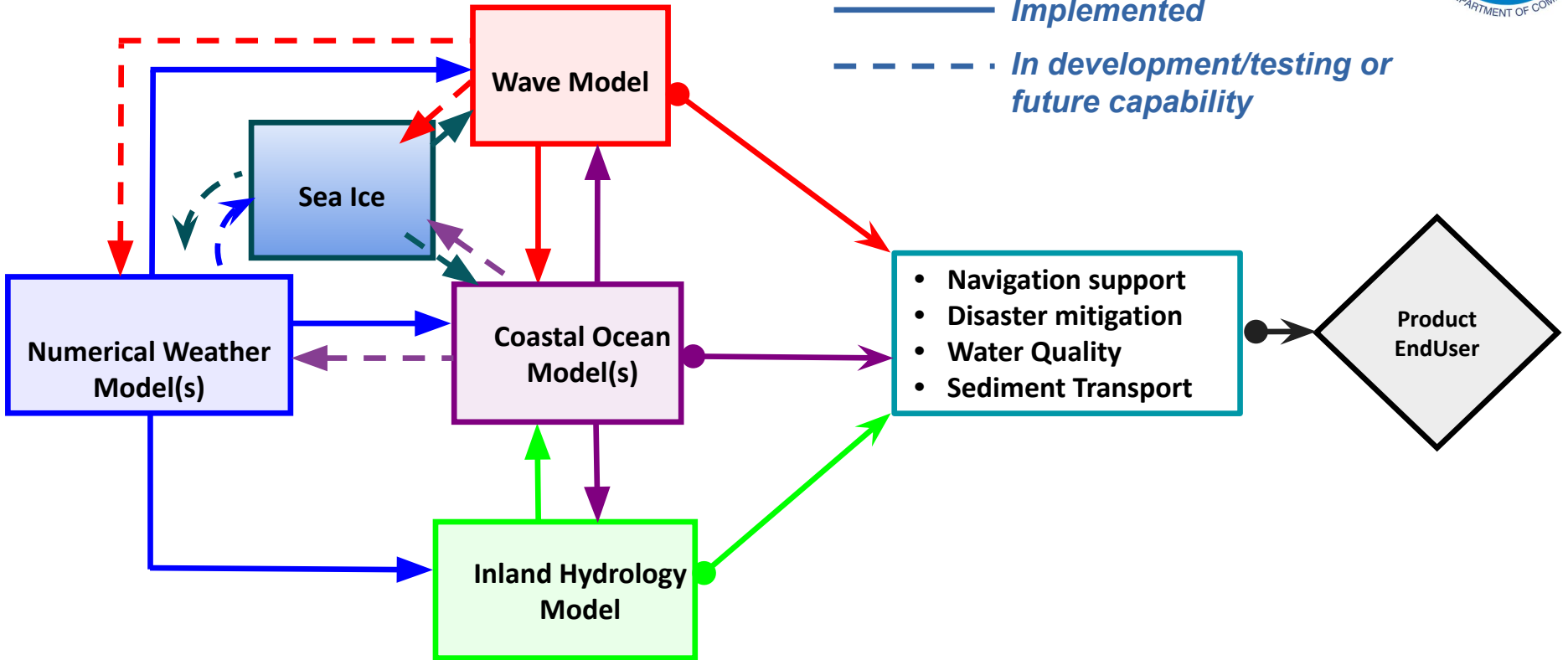
# Coastal coupling Application Code base (CoastalApp)



☐ noaa-ocs-modeling / **CoastalApp**   Public

`<>` Code  ⊙ Issues 35  ⁛ Pull requests 4  ⊡ Discussions  ⊙ Actions  ⊞ Projects  ⊞ Wiki  ⊙ Security  ⬓

⑁ develop ▾   ⑁ 6 branches  ⬙ 2 tags          Go to file   Add file ▾   Code ▾

This branch is 89 commits ahead of master.                    ⑁ #105

🧑 pvelissariou1 removed parmetis/metis libraries from thirdparty_open    ✓ 85e3cf7 5 days ago  ⏱ 182 commits

📁 .github/workflows
📑 ADCIRC @ 324de0e
📑 ATMESH @ 7aab919
📑 BARDATA @ 8acb271
📑 NEMS @ 581d8be
📑 NWM @ 3bc401d
📑 PAHM @ ac45a59
📁 SCHISM
📑 WW3 @ 9726c8b
📑 WW3DATA @ beda5f2

CoastalApp is a NUOPC application implemented following UFS best practices to couple coastal ocean models and other domains (Sea Ice, Atmosphere, Wave, Inland Hydrology, …)

⚖ CC0-1.0 license

☆ 5 stars  ⑁ 18 forks

support SCHISM and SCHISM-ESMF (#108)          2 months ago
added rebasing modifications                    last month
update submodules to point to new pull request commits    15 months ago

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*NOAA/NOS' Office of Coast Survey*   ⚙ tests passing  ⚖ license CC0-1.0   https://github.com/noaa-ocs-modeling/CoastalApp

# Modeling and Data Components: current status

The components in **dark red** are tested and functional

| Atmosphere | | Ocean | | Wave | |
|---|---|---|---|---|---|
| **ATMESH**[1] | *(implemented)* | **ADCIRC**[2] | *(implemented)* | **WW3DATA**[1] | *(implemented)* |
| *PaHM*[1] | *(implemented)* | SCHISM[4,5] | *(in development)* | **WW3**[3] | *(implemented)* |
| HWRFcap[1] | *(in development)* | FVCOM[6] | *(in development)* | | |
| FV3 (ATM) | *(future capability)* | **BARDATA**[1] | *(implemented)* | | |
| | | CICE[7] | *(in development)* | | |
| NWM[8] | *(in development)* | | | | |

1  NOAA/CSDL/CMMB
2  U. of Notre Dame
3  NOAA/NCEP/EMC
4  Virginia Institute of Marine Science
5  Helmholtz-Zentrum Hereon

6  University of Massachusetts – Dartmouth
7  Cooperative Institute for Great Lakes Research
8  NOAA/NWS National Water Center

# COASTAL Act: Supporting FEMA's National Flood Insurance Program

## Hindcast / Reanalysis

**The Consumer Option for an Alternative System to Allocate Losses (COASTAL) Act**

- NOAA develops multi-component Named Storm Event Model (NSEM) to lower costs to FEMA's National Flood Insurance Program (NFIP) by better discerning wind vs water damage in "indeterminate losses"

- Detailed post-storm assessment in the aftermath of a damaging tropical cyclone that strikes the U.S. or its territories, 90% accuracy required

Aftermath of Hurricane Michael in Mexico Beach, FL.
AP Photo/Gerald Herbert

**Surge Model**

**Wave Model**

**Hydrology**

- The skill analysis is confined to a duration of an event, e.g.:

  - High-water mark (HWM) data validation
  - Skill against coastal tide gauges during the storm

- Last issued inundation *forecast* to guide placement of HWM data
- Coastal anomalies to reduce *hindcast* bias
- Fully coupled ADCIRC/WaveWatch III to *hindcast* the best estimate of inundation

https://www.weather.gov/sti/coastalact

Contact: Saeed.Moghimi@noaa.gov

# Coastal Act – Name Storm Event Model (current status)

NSEM will be collection of separate, but interdependent, model products that provide time-dependent analyses of specific meteorological and hydrologic factors that contribute to indeterminate losses.
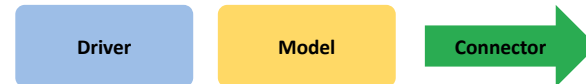
The three main model product areas will be:

- Storm Surge / Waves
- Wind and Surface Pressure Analyses
- Precipitation and Hydrologic

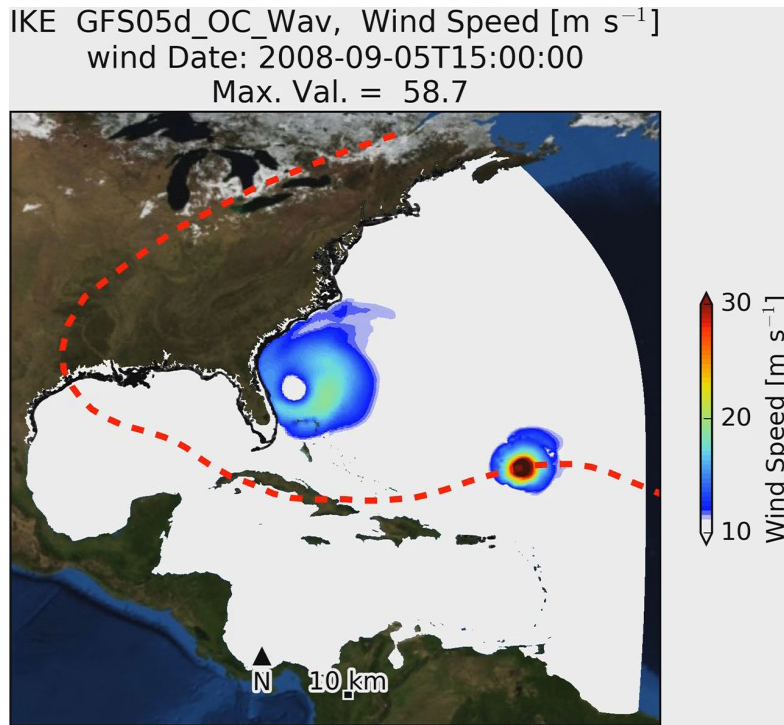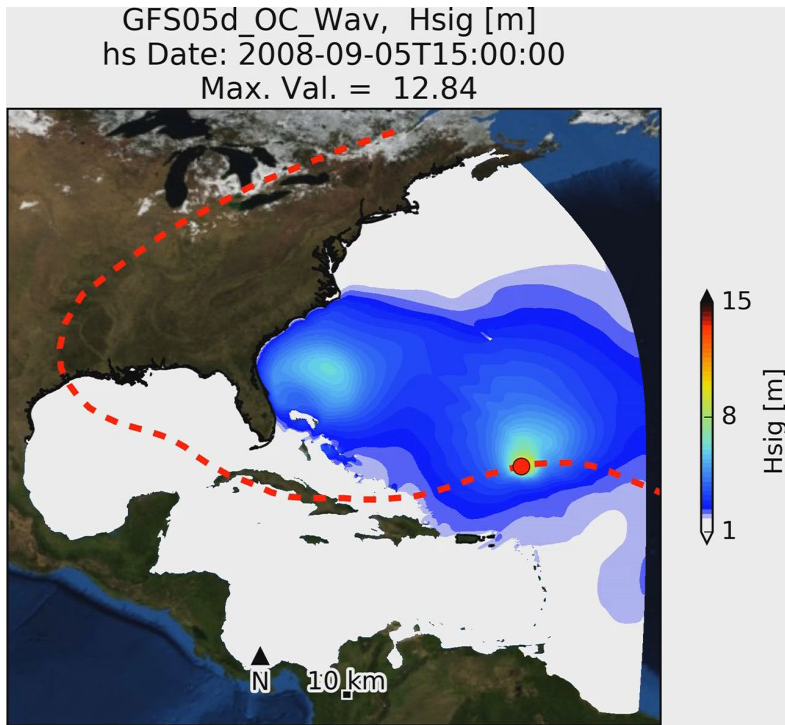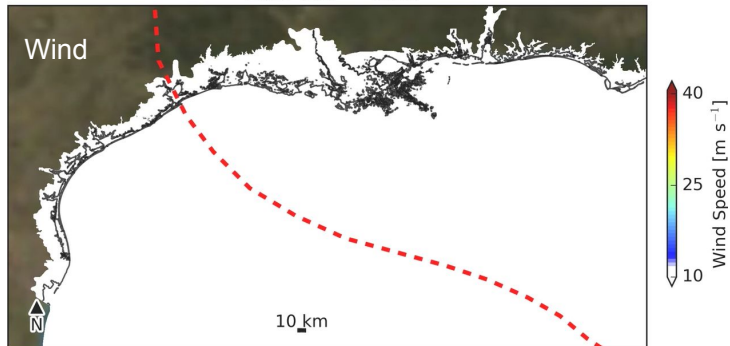*Kurkowski et al, 2020, NWS R2O Transition Plan Review Meeting.*

**Post-storm assessment**
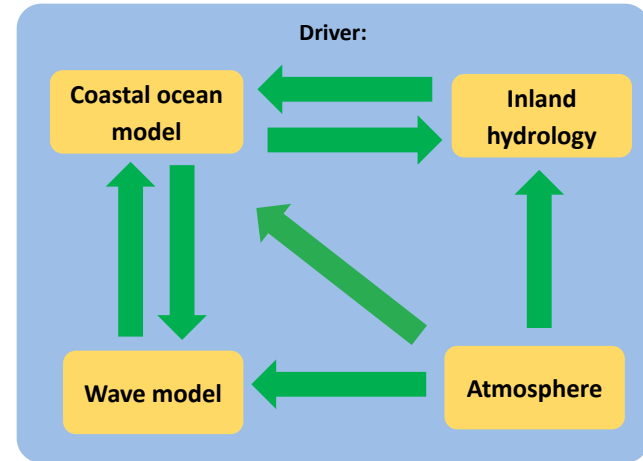


Moghimi et al, 2019;

# Atmospheric and wave (Ike, 2008)



GFS05d_OC_Wav, Hsig [m]
hs Date: 2008-09-05T15:00:00
Max. Val. = 12.84

IKE GFS05d_OC_Wav, Wind Speed [m s$^{-1}$]
wind Date: 2008-09-05T15:00:00
Max. Val. = 58.7

Ma and Mehra, EMC/NOAA
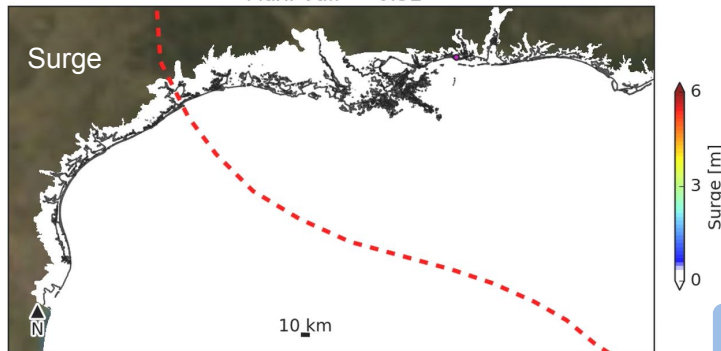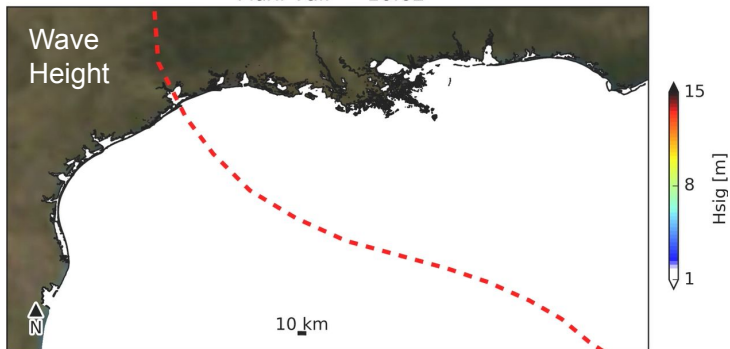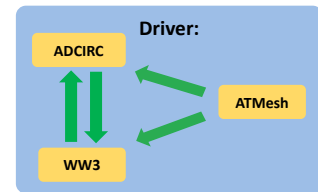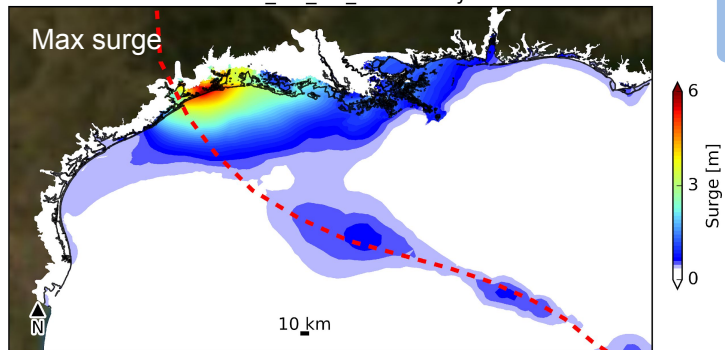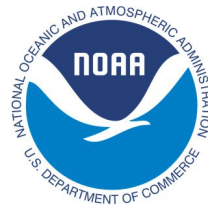
Wind, wave and storm surge (IKE, 2008)
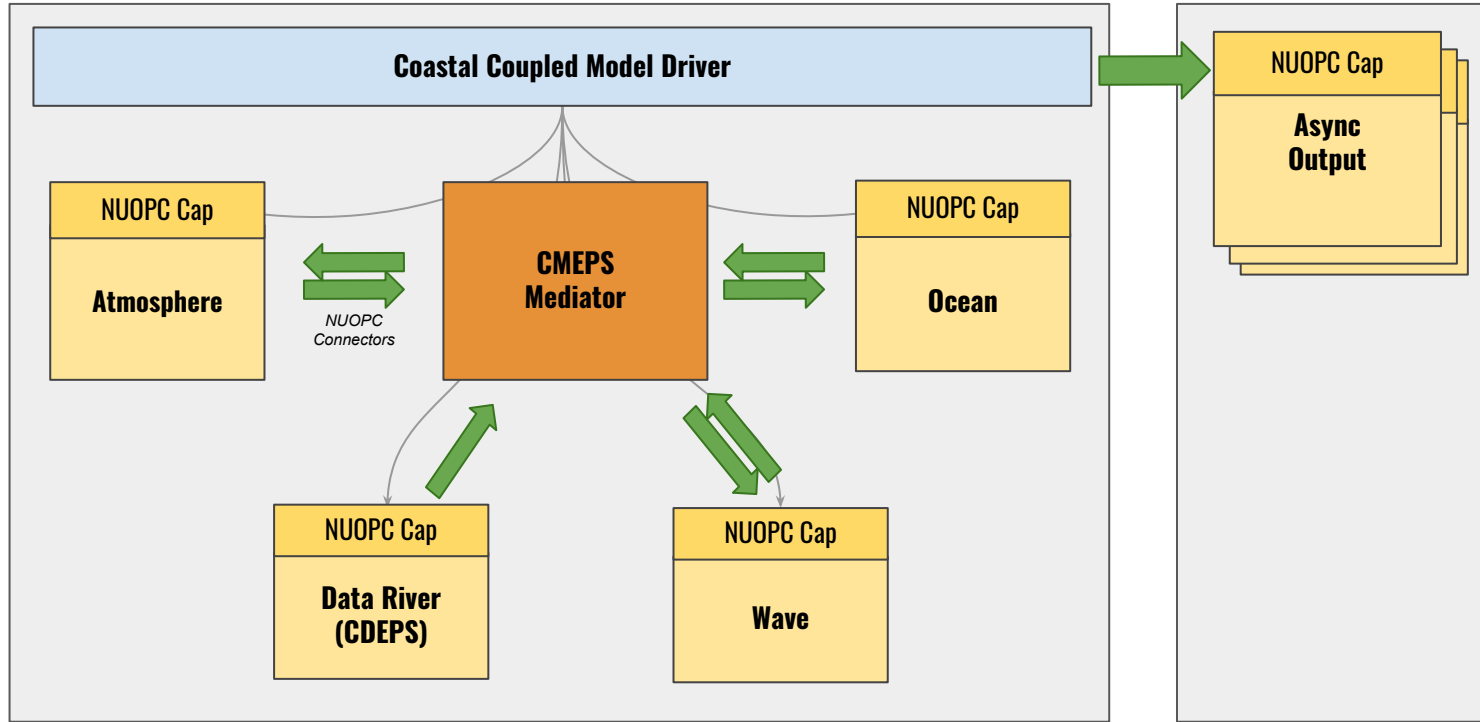
# Advancing NOAA's Coastal Ocean Model Coupling Capabilities - TODO

- "Data" models for integrating forcing datasets
- Component-level testing and cap optimization
- Asynchronous output & regridding
- Coastal Mediator component
- Configurable driver
- Computational performance optimization

# Advancing NOAA's Coastal Ocean Model Coupling Capabilities
- draft

# Thanks for your attention!

**Contact:** *Saeed.Moghimi@noaa.gov*