UFS Coastal and Applications:

A brief history, current status and the path forward

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May 8, 2025

UFS Webinar Series

Safe, Efficient Navigation

Managing Marine Living Resources

Protecting Human Health

NOS Modeling Vision

Spill Response & Search & Rescue

Coastal Resilience

Mapping & Coastal Mngmt

Protecting our coastal communities and the nation's economy

Courtesy : Tracy Fanara

UFS-Coastal applications and components

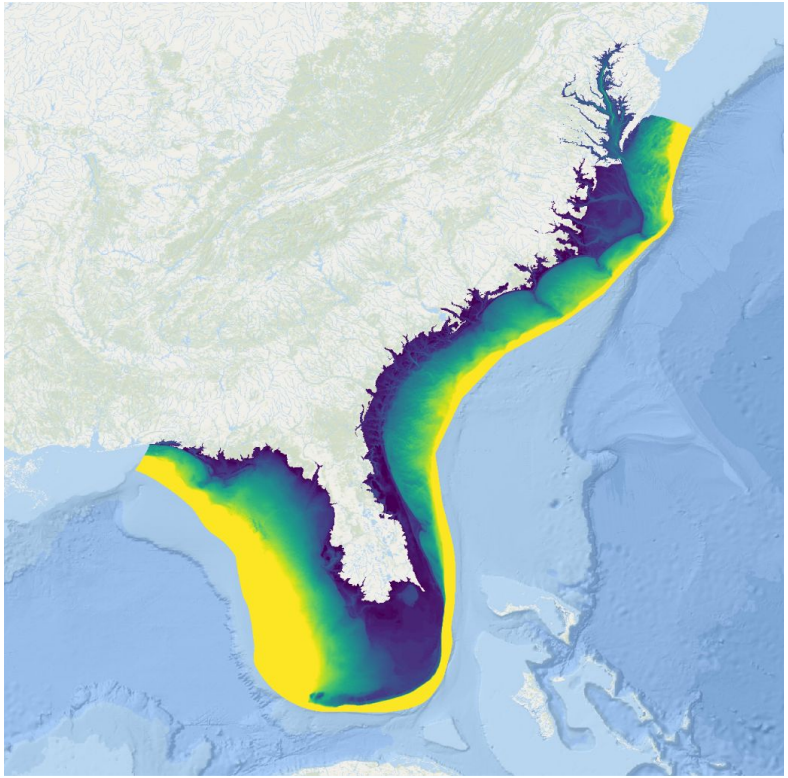
- **SECOFS:** DATM+SCHISM+WW3 (Leveraged - BIL)
- **STOFS-3D-Alaska:** DATM+SCHISM+CICE+WW3 (partially funded - DRSA / NOS Water team)
- **Hurricane-Surge:** PAHM+SCHISM+WW3 (Leveraged - BIL)
- **UFS-Surge-Wave:** NOS / STOFS-2D-Global & NWS / Wave prediction System

  DATM+ADCIRC+WW3 (Initially developed through COASTAL Act - JTTI proposal in review)
- **NOS Workflow:** Unified workflow for NOS coastal applications (partially funded - DRSA)
- **UFS-Coastal code base** (Leveraged - BIL)

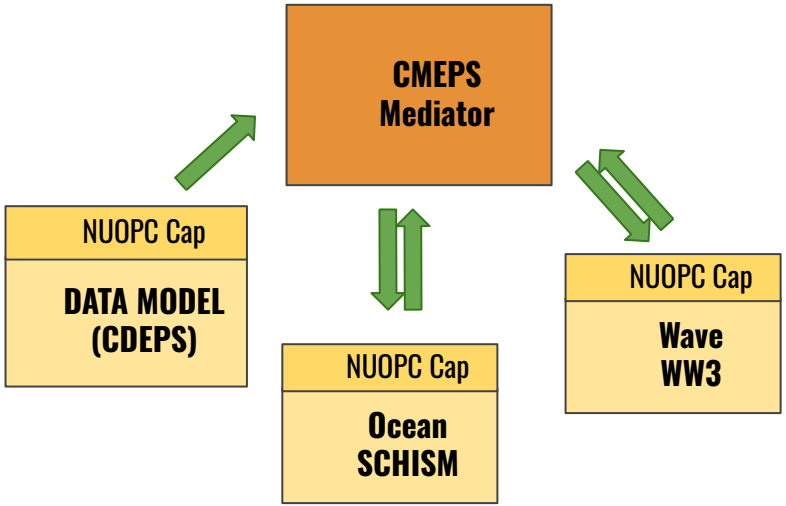
SECOFS: Southeast Coastal Operational Forecast System
STOFS: Surge & Tide Operational Forecast System

Refs: The state of the UFS July 2024 (link)

SECOFS: DATM+SCHISM+WW3



CIFIM 12 - Southeast Coastal Operational Forecast System (**SECOFS**)



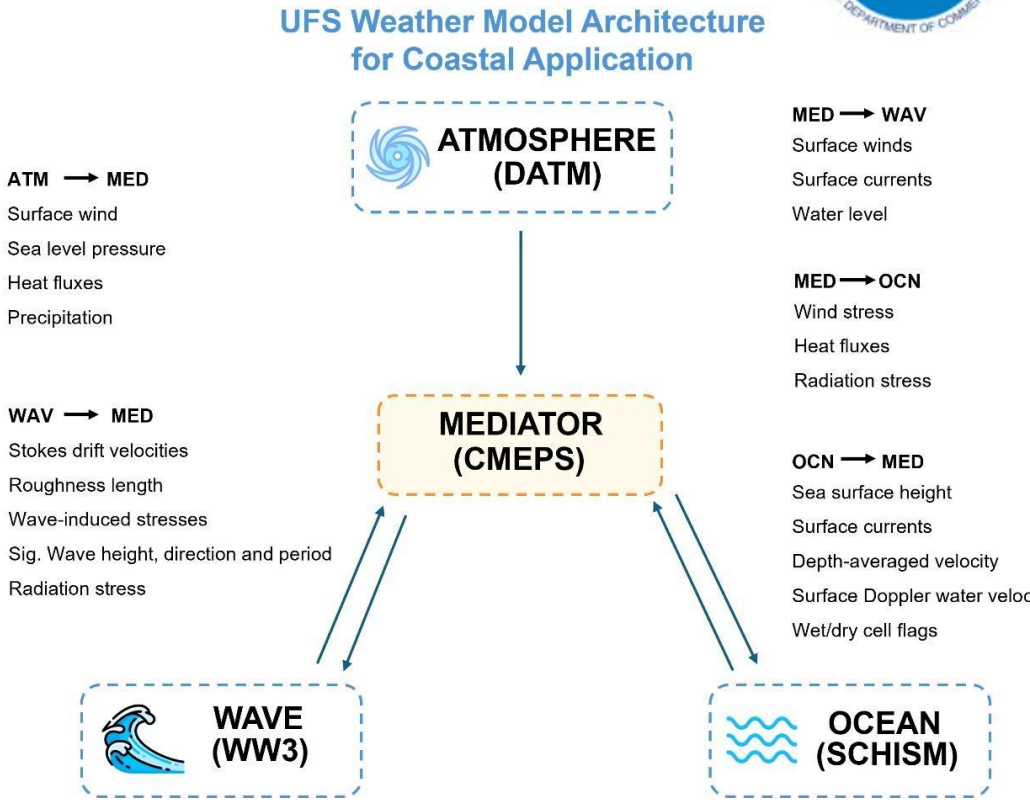
UFS-Coastal and SECOFS (iterative plan)

- **2025: UFS development**
  - Cap dev for SCHISM and WW3
  - Testcase: Duck NC for DATM+SCHISM, UFS-SCHISM-alone, DATM+SCHISM+WW3
  - Dev: CDEP-SCHISM-WW3 testing with vortex formalism (Duck)
  - Pre-op test (6 month parallel quasi-operational testing) with SCHISM alone under UFS-Coastal executable
- **2026: Implement and test UFS enabled SCHISM-WW3**
  - Dev: CDEP-SCHISM-WW3 testing
  - Test SECOFS (SCHISM standalone) under UFS environment on WCOSS2
  - Pre-op test with CDEP-SCHISM
- **2027: implement SECOFS using SCHISM-WW3 as a potential upgrade after operation starts in FY27**
  - Long-term hindcasts (2-5 years) to test robustness
  - Pre-op: CDEP-SCHISM-WW3 development
  - Operational implementation: CDEP-SCHISM
- **Beyond 2027:**
  - Long-term hindcasts (2-5 years) to test robustness of CDEP-SCHISM-WW3
  - Operational implementation / upgrade: CDEP-SCHISM-WW3

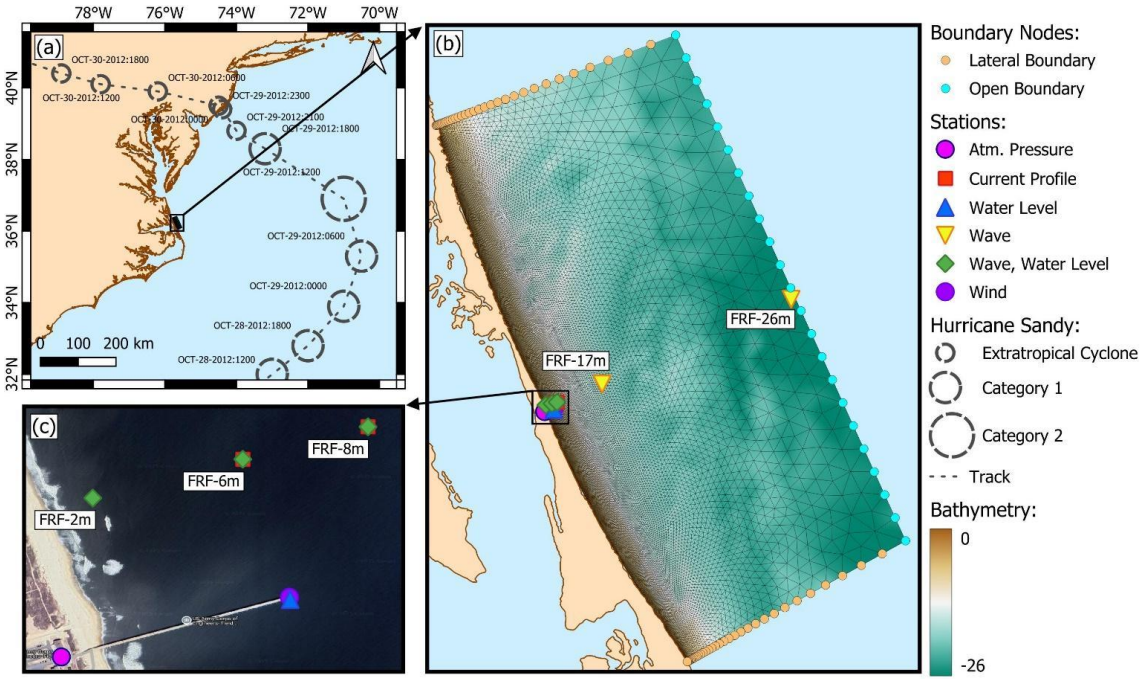
SCHISM-WW3 coupling

Case	Components	Details
#1	ATM+WW3	Without water level forcing
#2	ATM+OCN+WW3	With water level forcing
#3	ATM+SCH	2D
#4	ATM+SCH	3D
#5	ATM+SCH+WW3	Longuet-Higgins Radiation Coupling
#6	ATM+SCH+WW3	3D Vortex Coupling

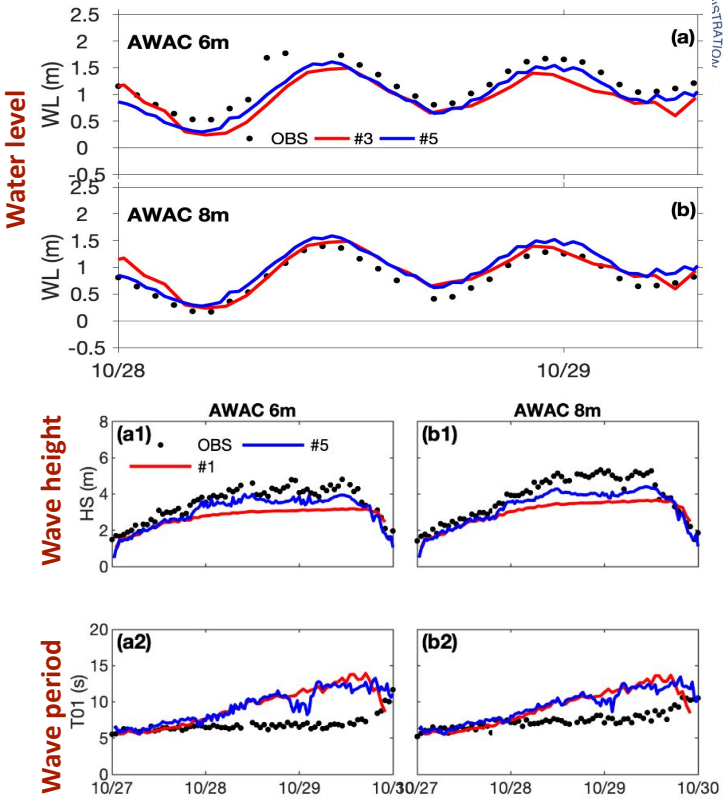
Duck, NC test case



SCHISM-WW3 coupling - Duck, NC test case

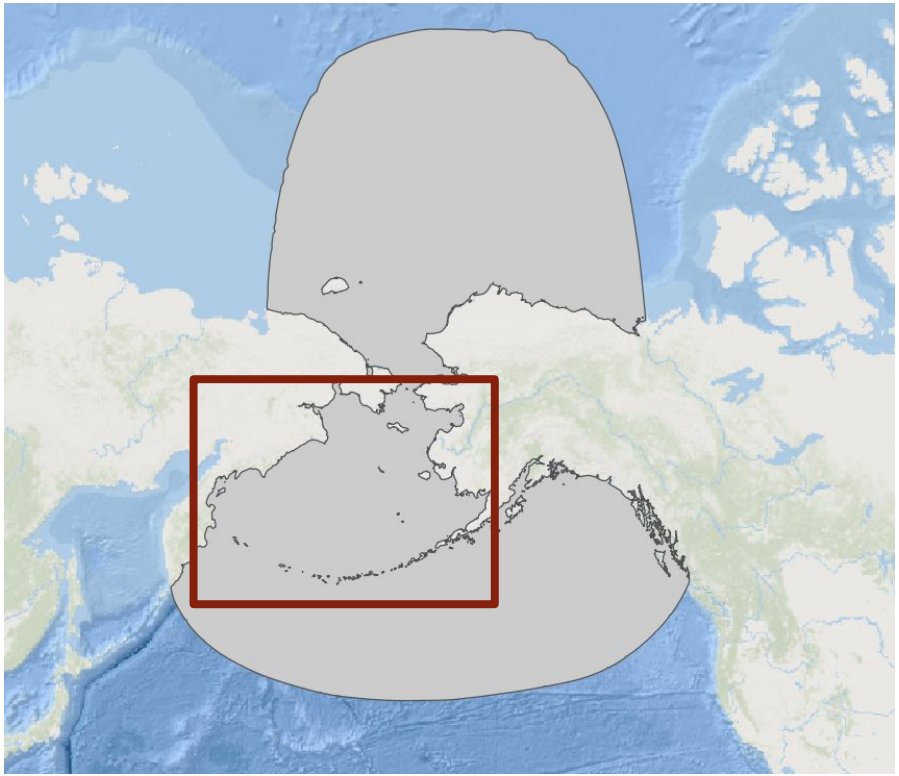


Duck, NC domain & meshes for SCHISM and WW3 & Stations where observations are available during **Hurricane Sandy 2012**

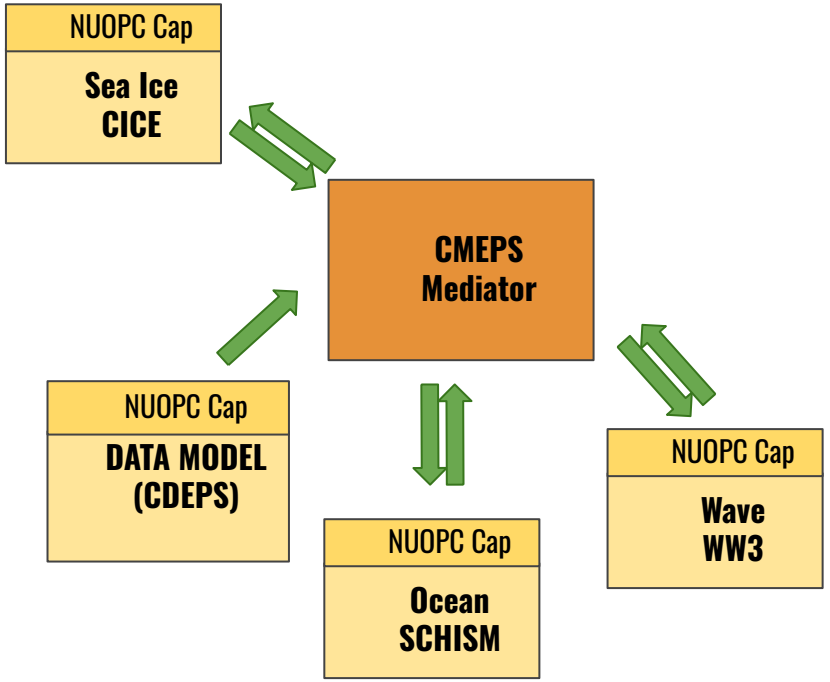


#1	ATM+WW3
#3	ATM+SCH
#5	ATM+SCH+WW3

STOFS-3D-Alaska: DATM+SCHISM+CICE+WW3



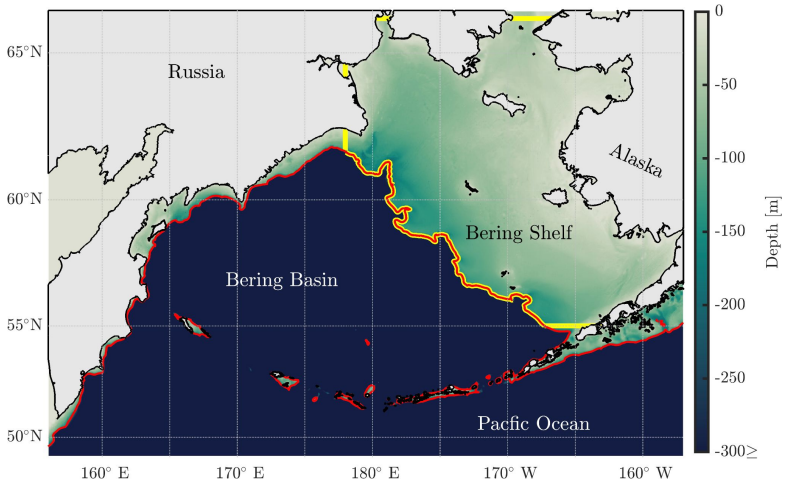
Surge & Tide Operational Forecast System (STOFS)

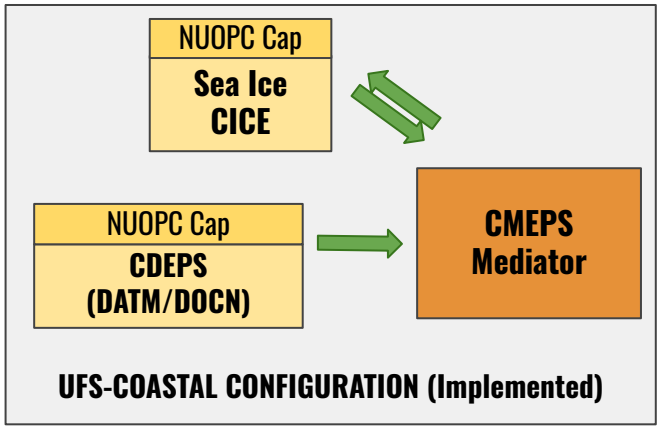


DATM+CICE+SCHISM - Bering Sea

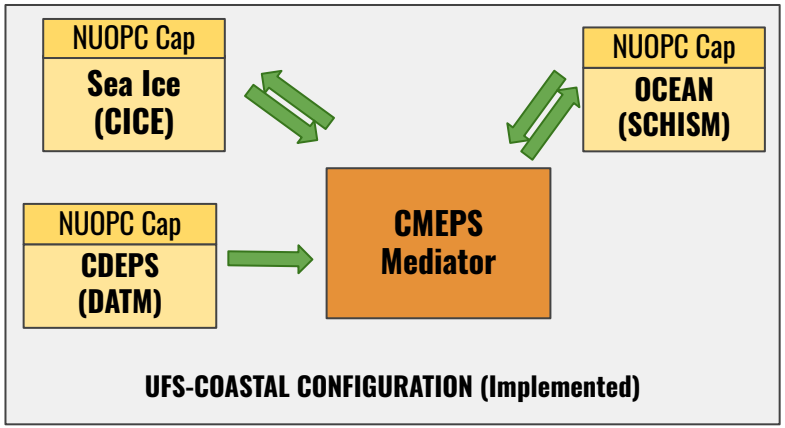
Standalone CICE development

- ➔ **CICE standalone (CDEPS+CICE)**:
  - 4km Standalone CICE using UFS-coastal coupling infrastructure (Domain top right)
  - Actively Benchmarked against statelite data
- ➔ *Recently implended* DATM+CICE+SCHISM coupling



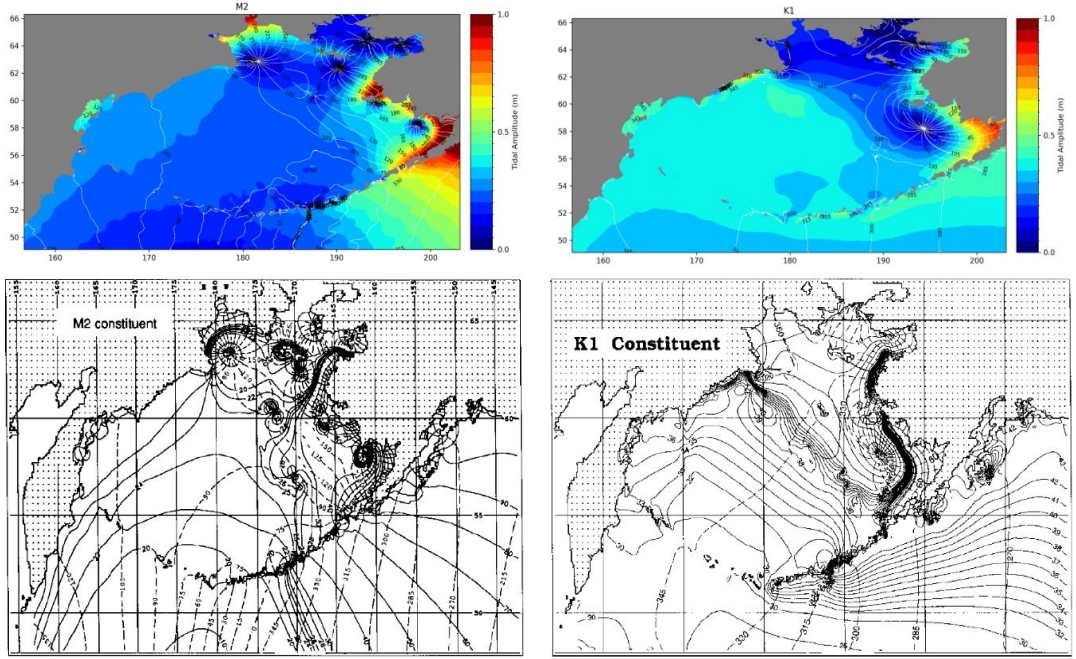


Transitioning to…

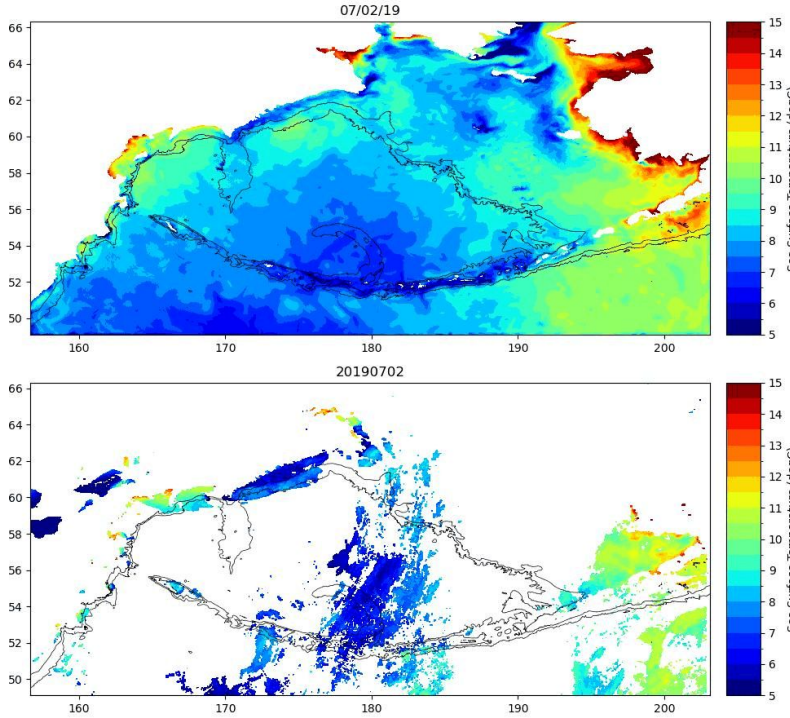


Bering Sea domain - Summer (no ice)

SCHISM 3D - Qualitative Skill Assessment



Major Tidal Constituents



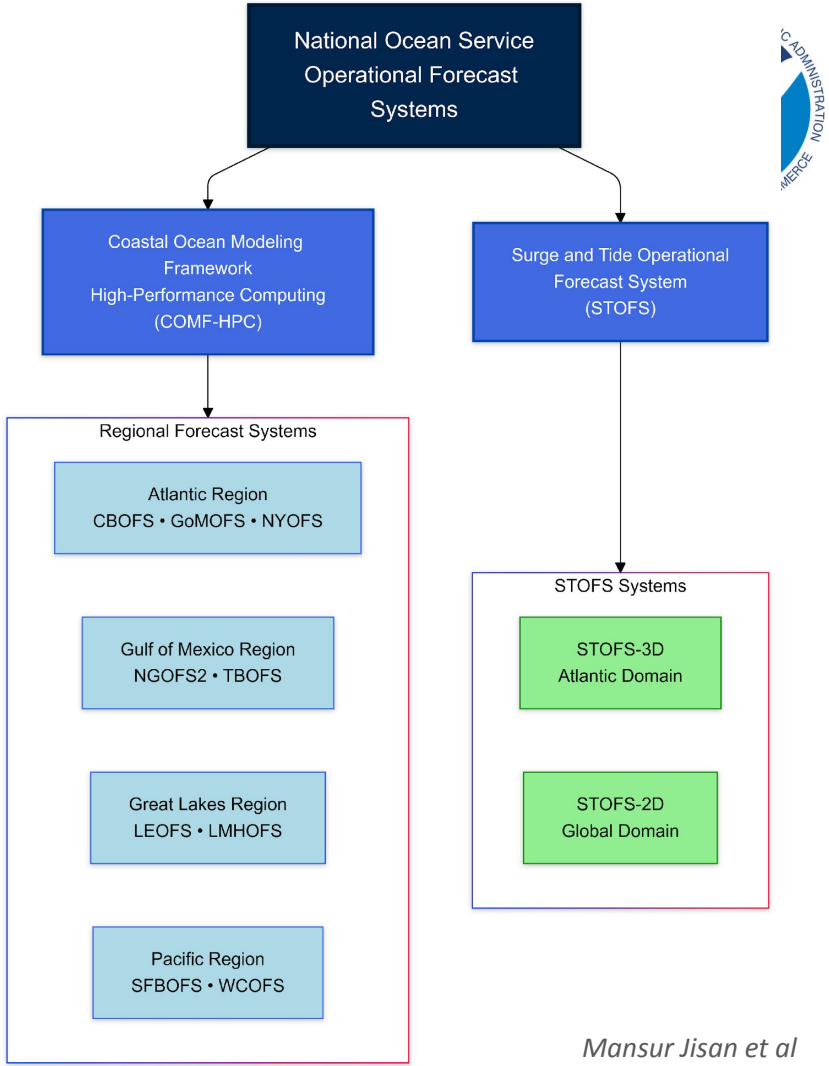
Sea Surface Temp. vs. Level 3 Satellite

Cassalho et al

Unified Workflow for the
NOS' Operational Forecast Systems

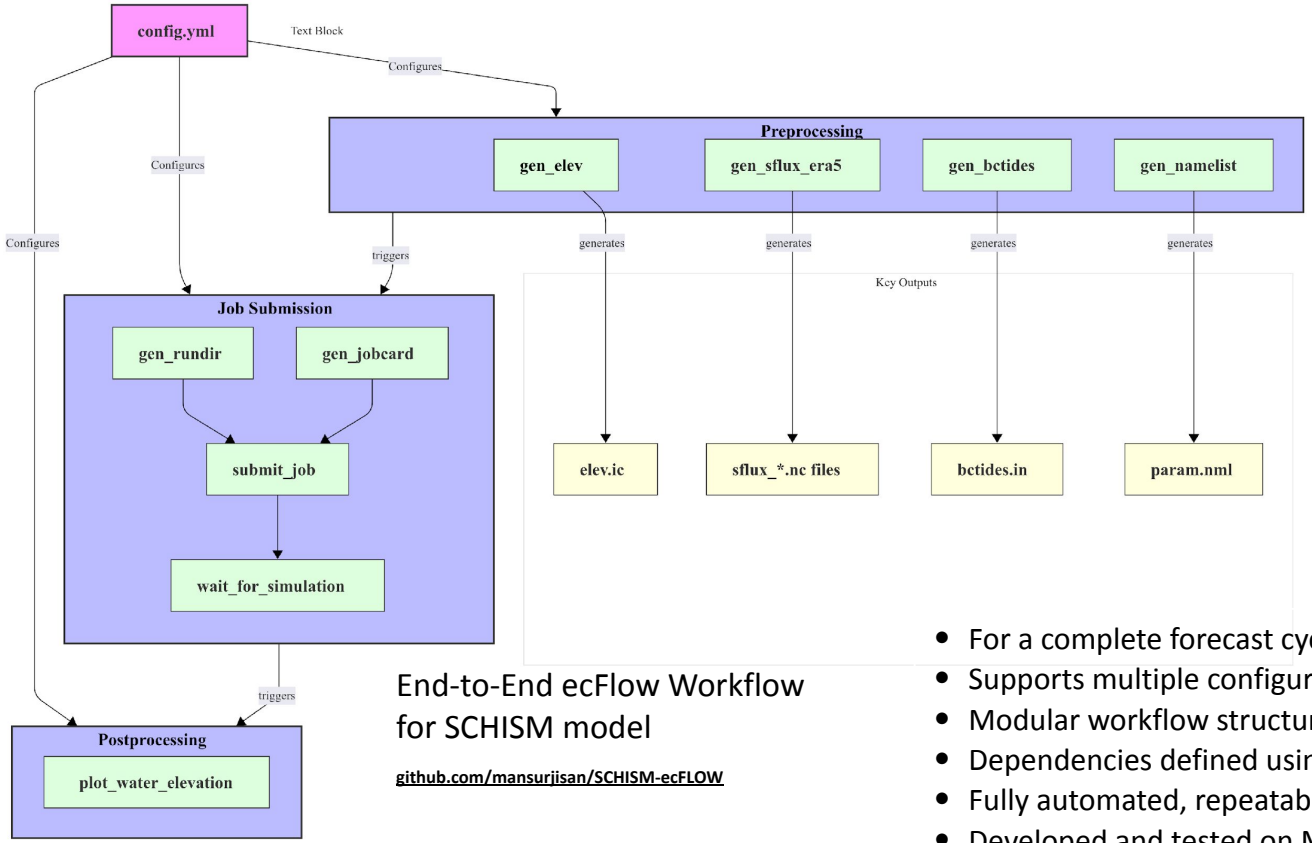
- NOAA National Ocean Service (NOS) operates a suite of operational forecast systems
  - Coastal Ocean Modeling Framework (COMF) based high-resolution, regional modeling systems
  - Surge and Tide Operational Forecast System (STOFS) for storm surge and tidal predictions

- **A unified workflow across all NOS' operational models is being planned to enhance efficiency, scalability, and ease of maintenance**



Mansur Jisan et al

YAML-Driven ecFlow-Based Workflow

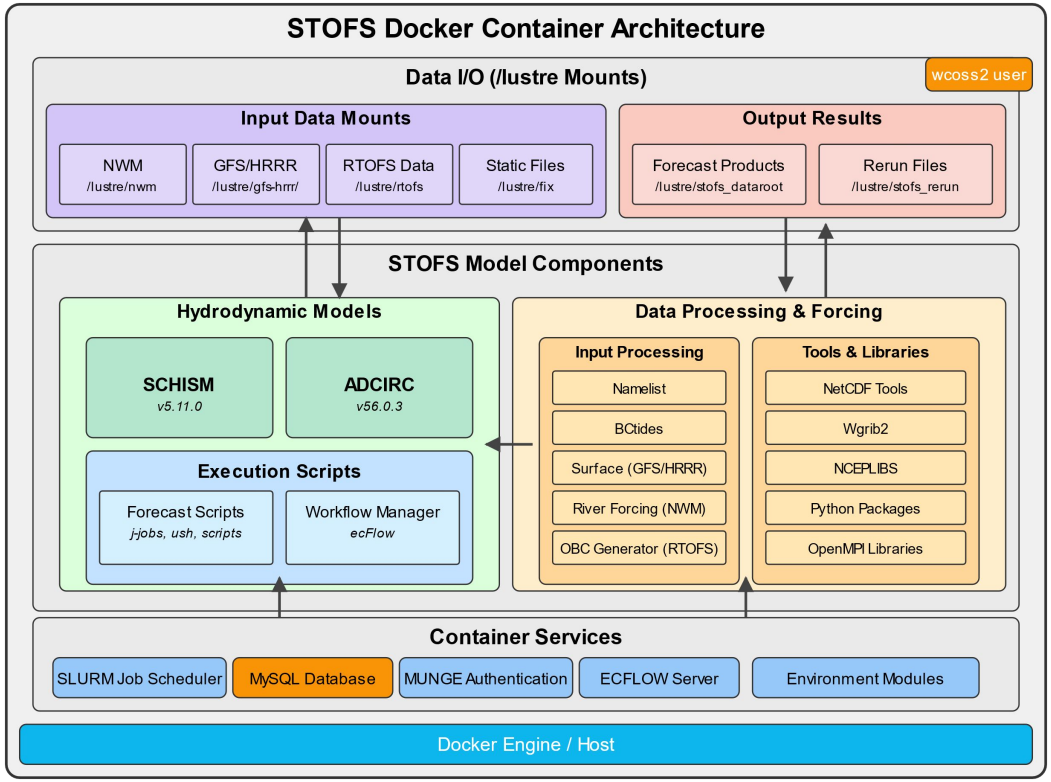


End-to-End ecFlow Workflow for SCHISM model

github.com/mansurjisan/SCHISM-ecFLOW

- For a complete forecast cycle
- Supports multiple configurations via a single YAML file.
- Modular workflow structure.
- Dependencies defined using ecFlow's trigger conditions.
- Fully automated, repeatable, end-to-end pipeline.
- Developed and tested on MSU Hercules cluster

Container for STOFS System Emulating WCOSS2 Environment



Objectives

- Emulate WCOSS2 operational environment to support STOFS workflow development and testing.
- Incorporate NCO software stack to mirror production.
- Facilitate collaboration with external partners involved in upgrading STOFS workflows.

Progress Highlights

- Successfully tested the STOFS Atlantic preprocessing workflow within containerized environment.
- Integrating and testing a new YAML-driven command-line configuration system for STOFS3D-Atlantic within the container

NOAA National Ocean Service

Zach Cobell et al

Let's pause here for a moment to assess our foundation by:

- reviewing our journey,
- examining existing infrastructure,
- acknowledging challenges, and charting a path forward.

COASTAL Act: Supporting FEMA's National Flood Insurance Program (2016-2022)

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

Surge Model

Wave Model

Hydrology

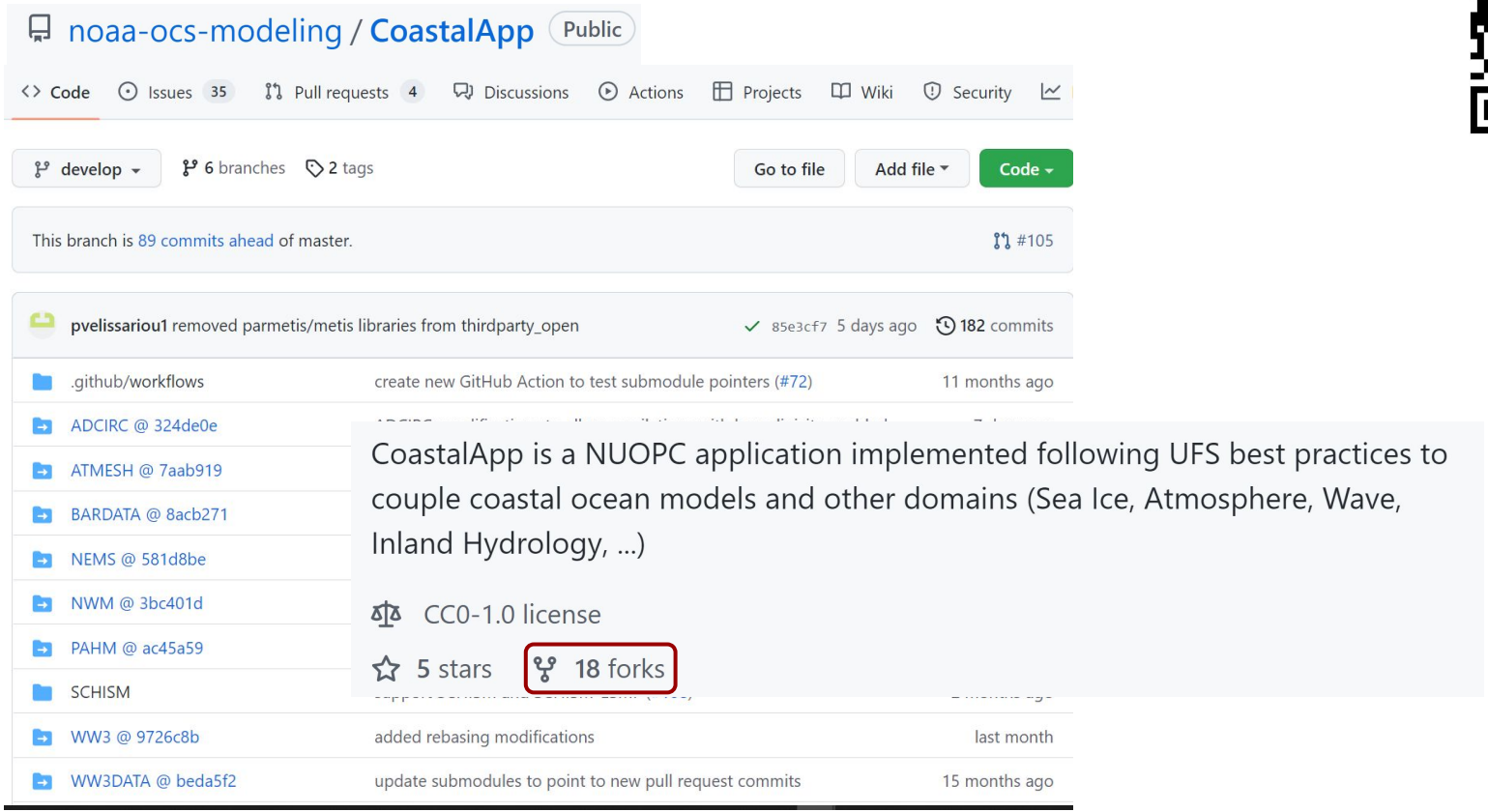
Aftermath of Hurricane Michael in Mexico Beach, FL.
AP Photo/Gerald Herbert

- 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

Coastal Coupling base (CoastalApp)



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

CoastalApp Test Suite

Number of reg tests: 18

Model components:

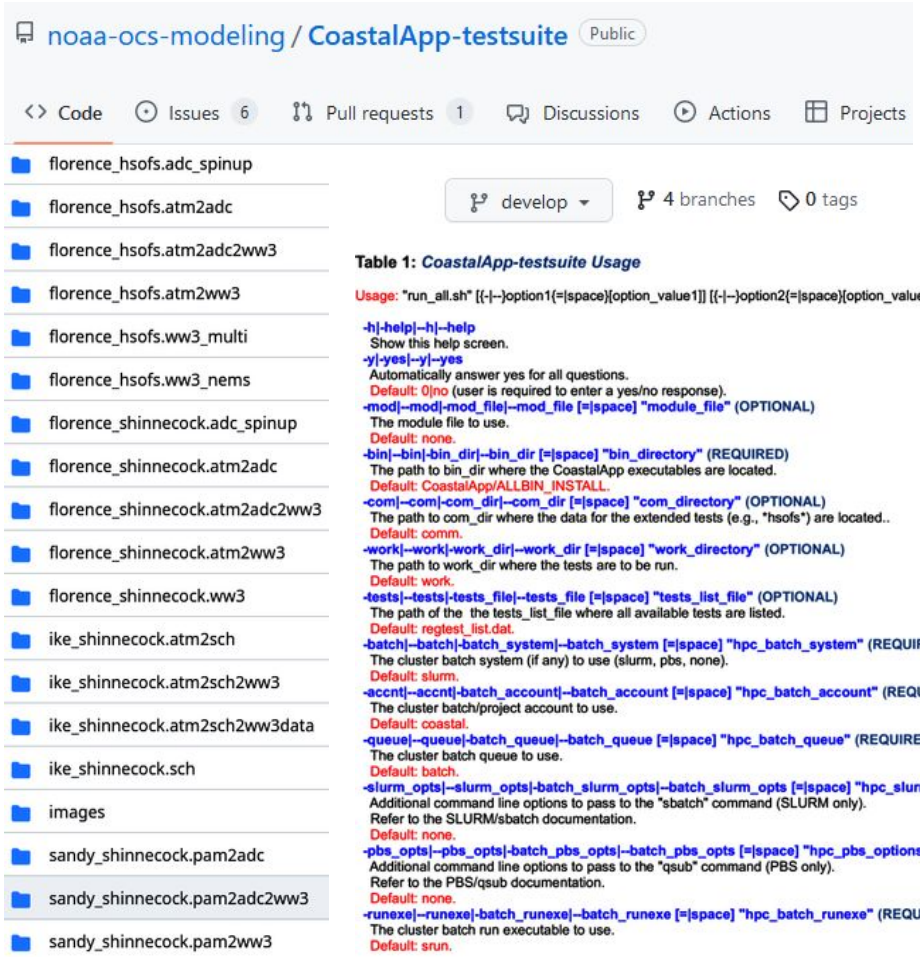
- ADICRIC
- SCHISM
- WW3
- PaHM
- ATMESH
- WW3DATA

Platforms Tested:

- RDHPCS - Hera, Orion, Cloud, …
- NSF - TACC (Frontera, Stampede)
- Various Academic/Research Institution HPC/Clusters
- Local Clusters/Desktops

Job Scheduling:

- Slurm
- PBS
- Plain mpirun/mpiexec (no scheduler)



Breakthrough

IIJA / BIL Provision 3

Driver: H.R.3684 Infrastructure Investment and Jobs Act (IIJA), Provision 3: $492,000,000 shall be for coastal and inland flood and inundation mapping and forecasting, and next-generation water modeling activities, including modernized precipitation frequency and probable maximum studies

Multiple related research and development projects were initiated including the **OAR/NOS/NWS collaborative project entitled:**

Advancing UFS Infrastructure in Support of Inland and Coastal Coupling

UFS Coastal development team

NOS team
Saeed Moghimi (NOS/OCS) - NOS Earth System Model Coupling lead; Jana Haddad (OCS) - Technical project management; Yunfang Sun (OCS) - Scientist / Developer; Mansur Jisan (CO-OPS) - Scientist / Developer;

ESMF / NUOPC: Ufuk Turuncoglu (NCAR), Daniel Rosen (NCAR), Ann Tsay (NCAR)

OAR/EPIC team: Keven Blackman (NOAA/OAR/WPO/EPIC, RTX), Jong Kim (NOAA/OAR/WPO/EPIC, STC), Kristopher Booker (NOAA/OAR/WPO/EPIC, Tomorrow.io), Christopher Domanti (NOAA/OAR/WPO/EPIC, RTX), Anna Kimball (NOAA/OAR/WPO/EPIC, RTX)

SCHISM: Y. Joseph Zhang (VIMS), Carsten Lemmen (Helmholtz-Zentrum Hereon)

WW3: Saeideh Banihashemi (NOAA/EMC), Ali Salimi (NOAA/EMC), Ali Abdolali (USACE-ERDC), Denise Worthen (NOAA/EMC), Jessica Meixner (NOAA/EMC)

ROMS: Hernan G. Arango (Rutgers), John Wilkin (Rutgers)

ADCIRC: Damrongsak Wirasaet (UND), Joannes Westerink (UND)

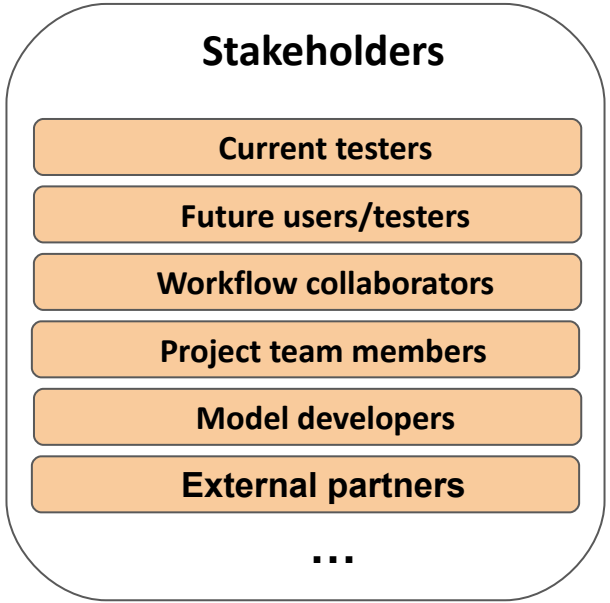
FVCOM: Jianhua Qi (UMass-D), Siqi Li (UMass-D), Changsheng Chen (UMass-D)

CICE: Joseph Smith (OSU), Jihun Jung (OSU), Scott Durski (OSU), Alexander Kurapov (NOAA/NOS/OCS)

This is a non-exhaustive list of team members who have actively contributed code, but many others have been involved in the UFS Coastal project.

UFS Coastal is a community-centric project

Next-generation coastal ocean coupling infrastructure for integration into the Unified Forecast System portfolio



Github Platform	Discussions	Wiki	Roadmap
Tech. advice	Office Hours	Monthly Stakeholder Meetings	
Presentations	UIFCW	AGU	AMS

Community-owned collaborative environment

Ocean Modeling Collaboration

https://github.com/oceanmodeling

People

View all

ufs-weather-model Public

forked from ufs-community/ufs-weather-model

About

This repo is forked from ufs-weather-model, and contains the model code and external links needed to build the UFS coastal model executable and model components, including the ROMS, FVCOM, ADCIRC and SCHISM plus WaveWatch III model components.

ufs-coastal-app Public

About

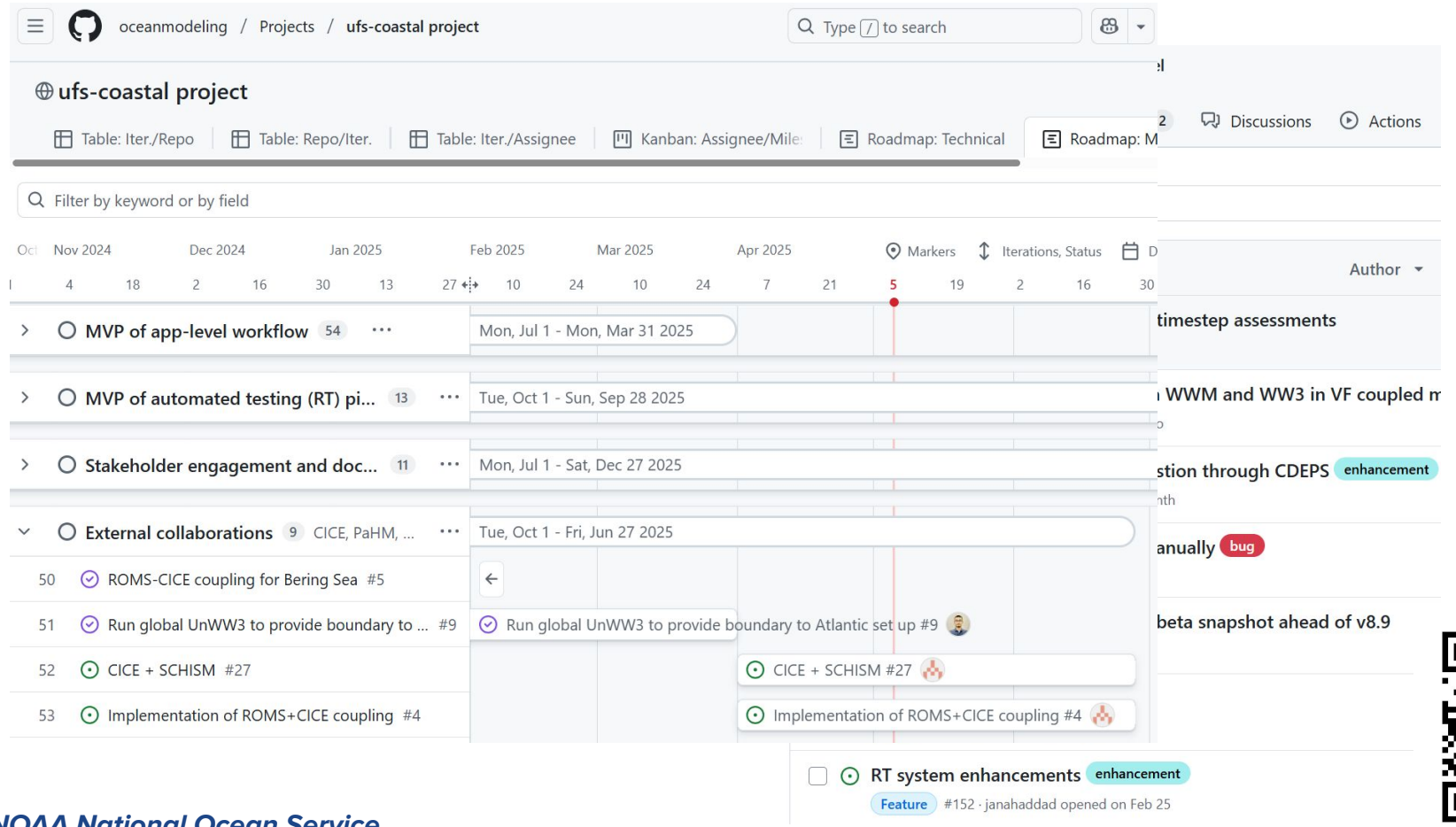
UFS Coastal Application is a NUOPC based application implemented following UFS best practices to couple coastal ocean models and other domains (Sea Ice, Atmosphere, Wave, Inland Hydrology, ...)

oceanmodeling.github.io/ufs-coastal-app/

oceanmodeling

Overview | Repositories 40 | Discussions | Projects 7 | Packages | Teams 7 | People 75

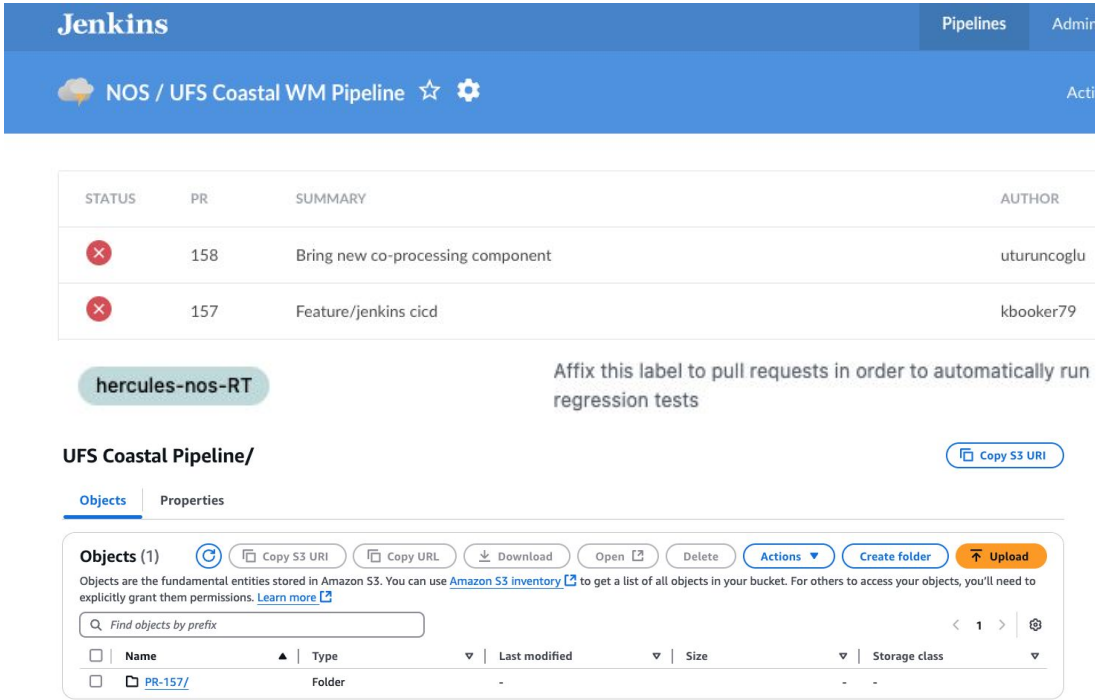
UFS-Coastal Project Management



UFS Coastal CI/CD

Continuous Integration / Continuous Deployment

- Nightly build and full regression test suite at MSU Hercules
- On-demand build/tests triggered by Github pull request
- Build-test artifact results stored in publicly accessible AWS S3 bucket



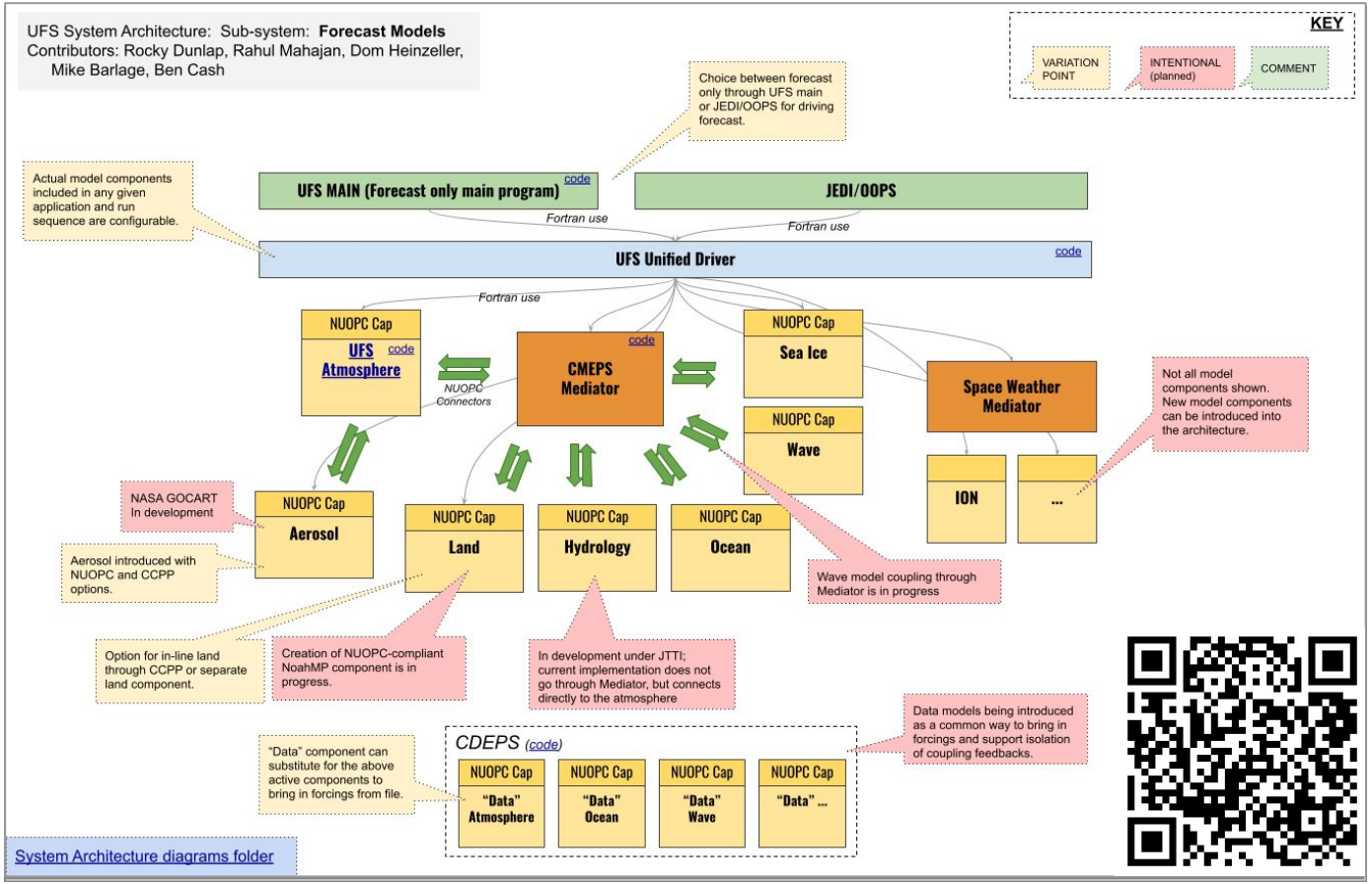
GitHub

Jenkins

EPIC CI/CD pipeline to expedite UFS Coastal development

Read the article here: https://epic.noaa.gov/ufs-coastal-app-development/

UFS Weather Model (Fork) => UFS Coastal Model



Additional Components:

Ocean:

- NUOPC Cap — SCHISM
- NUOPC Cap — ADCIRC
- NUOPC Cap — ROMS
- NUOPC Cap — FVCOM

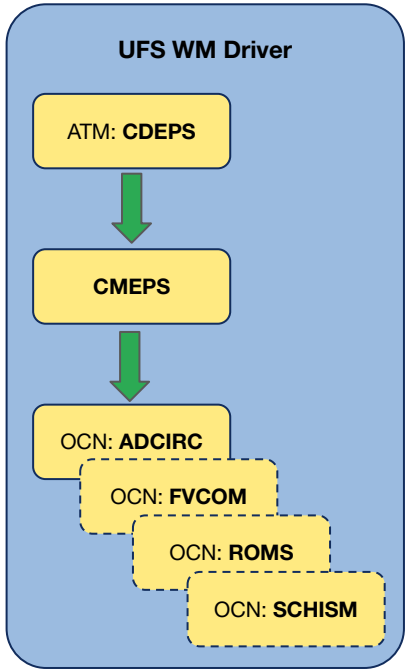
Atmosphere:

- NUOPC Cap — PaHM

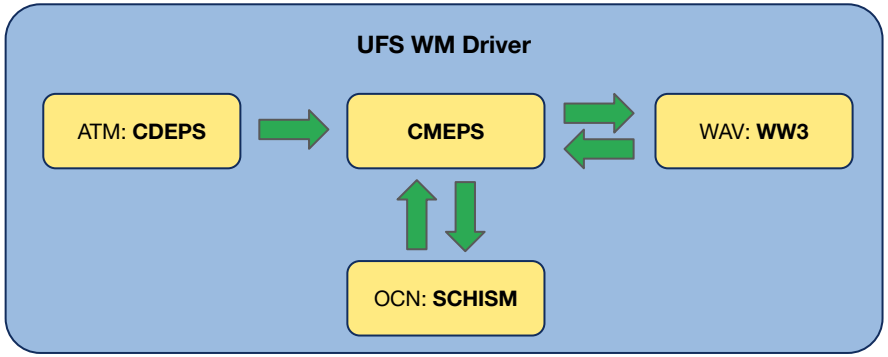
UFS Coastal Model / Application

- It is a fork of UFS WM with additional features and components
- Additional components:
  - Ocean: ADCIRC, FVCOM, ROMS, SCHISM
  - Parametric Atmosphere: PaHM
  - Co-processing: GeoGate (still under development and in a development branch)
- Sphinx based documentation (needs to be extended)
- Application
  - Includes initial version of UWTools based workflow (active collaboration between UWTools and UFS Coastal Teams)
  - Currently supports coupled DATM+SCHISM configuration (WW3 is the next)

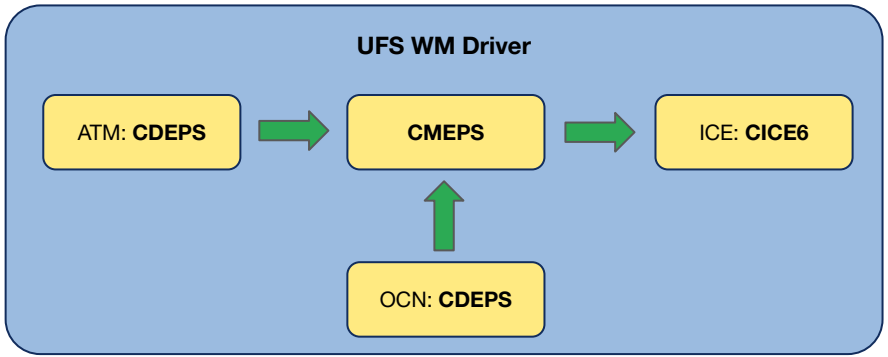
Supported Configurations



DATM coupled configurations



DATM+SCHISM+WW3 coupled configurations
OCN <-> WAV: 2d and 3d vortex formulation



DATM+DOCN+CICE6 coupled configuration

DATM+SCHISM+CICE6 under development

Once the configurations are finalized and tested, they will be available as a part of the RT system

Testing: UFS Coastal Specific Regression Tests and CI/CD

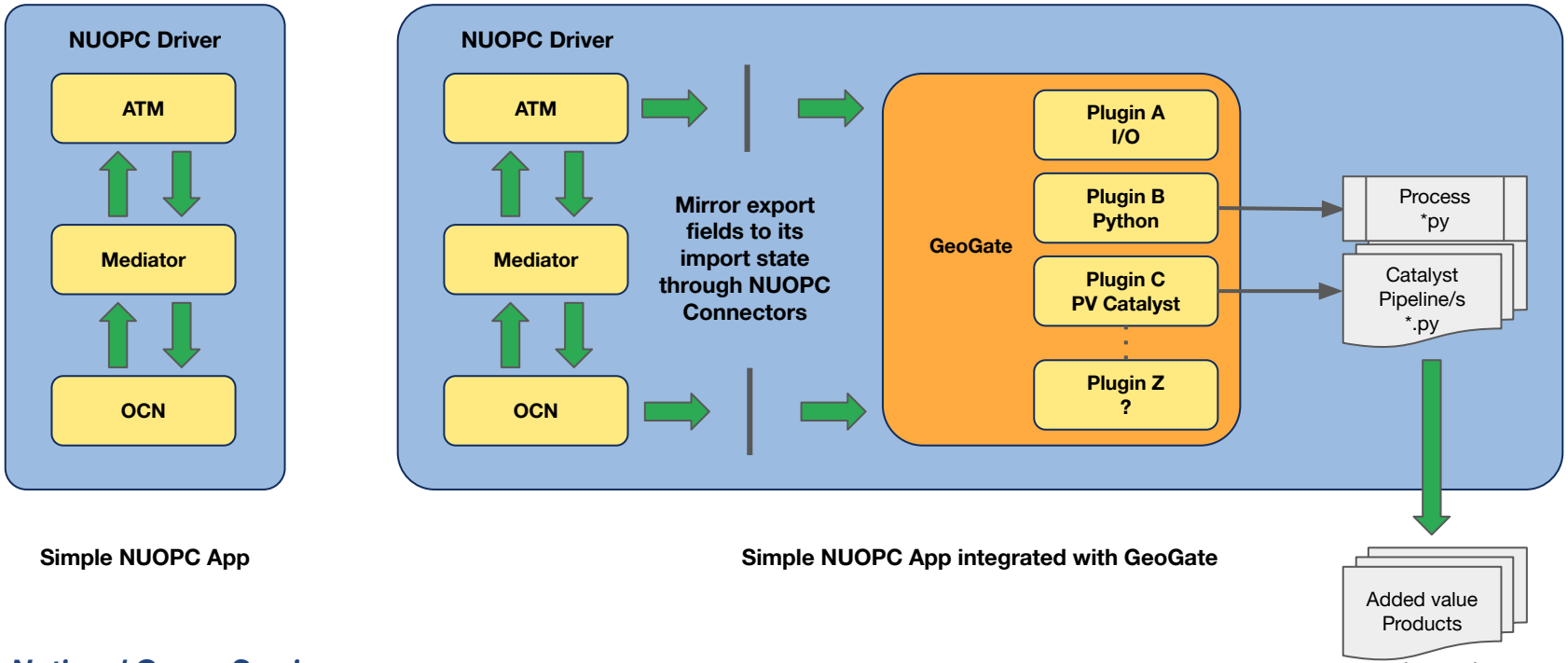
- UFS Coastal heavily relies on existing testing infrastructure provided by UFS WM
- List of the available RTs (seen also in *tests/rt_coastal.conf*)

coastal_ike_shinnecock_atm2adc	Intel	DATM+CMEPS+ADCIRC
coastal_scituateharbor_atm2fvc	Intel	DATM+CMEPS+FVCOM
coastal_ike_shinnecock_atm2sch	Intel	DATM+CMEPS+SCHISM
coastal_ike_shinnecock_atm2sch2ww3	Intel and GNU	DATM+CMEPS+SCHISM+WW3
coastal_irene_atm2roms	Intel and GNU	DATM+CMEPS+ROMS
coastal_ike_shinnecock_ww3	Intel	WW3
coastal_ike_shinnecock_atm2ww3	Intel	DATM+CMEPS+WW3

- The input files for UFS Coastal specific RTs are available only on **Hercules** (development platform) and **Frontera** (used by external collaborators and testing)

New Co-processing Component: GeoGate

- Aims to bring co-processing capability to NUOPC based coupled modeling applications (like UFS Coastal and WM) with minimal effort.



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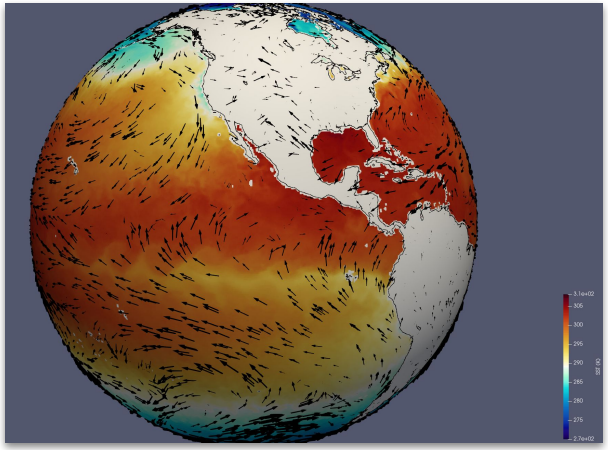
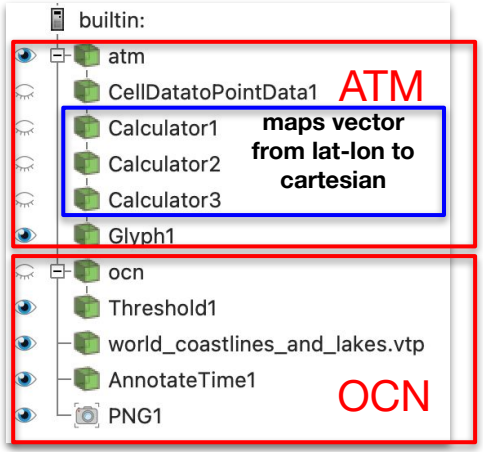
Designed to be Totally Independent and Flexible

- Plugin based generic component uses LNLL developed Conduit library to transfer data between different programming languages *Fortran*, *C* and *Python*
- Currently has three plugins: (1) basic I/O (dumps all fields to disk), (2) Python (pass desired fields to Python to process, (3) ParaView Catalyst (in situ, co-processing)
- Example for PV ParaView pipeline - two channel (atmosphere, ocean):

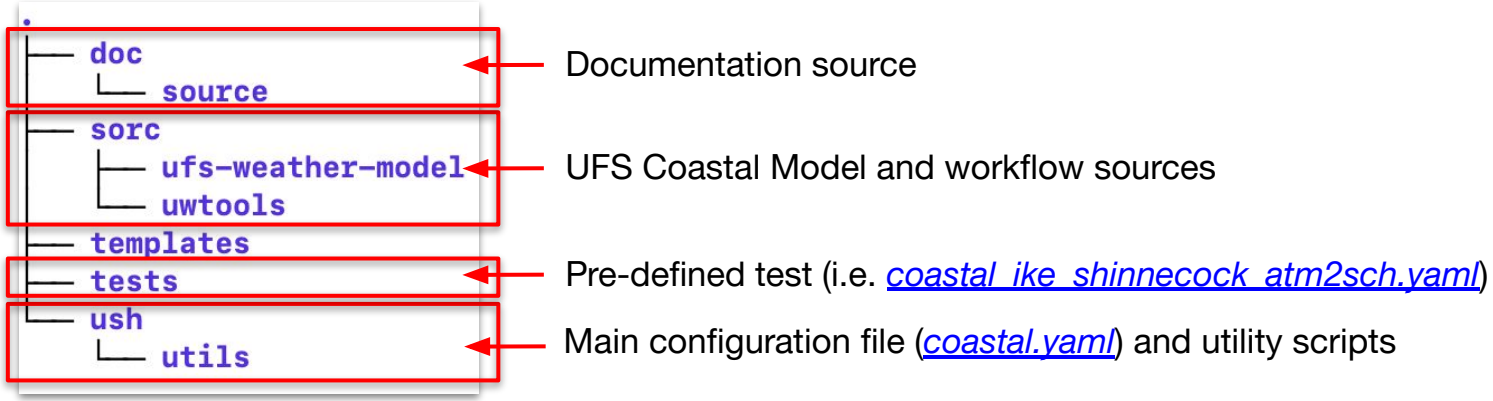





```
Driver:
  componentList: [ATM, OCN, COP]
  attributes:
    Verbosity: low
  runSequence: |
    @43200
      ATM -> COP :remapMethod=redist
      OCN -> COP :remapMethod=redist
      COP geogate_phases_catalyst
      #COP geogate_phases_io
      #COP geogate_phases_python
      ATM
      OCN
    @
```

UFS Coastal Application

- UFS Coastal App enables easy to use and configurable workflow to create supported configurations



- The workflow currently supports DATM+SCHISM configuration only but this will be extended to cover also WW3 wave component in the near future

Application Level Workflow

- The workflow uses UWTools as a task manager
  - Currently using development fork and branch (feature/cdeps) based on 2.5.1
  - It uses iotaa Python package for task dependencies
- Running workflow
  - Install UWTools (or use available one if it is compatible with UFS Coastal App)
  - Build model (*./build.sh*)
  - Customize *coastal.yaml* and run
- The detailed documentation
  - https://ufs-coastal-application.readthedocs.io/en/latest/Workflow.html

Does not currently need management attention
May need management attention
Management attention needed

Project snapshot

Project Purpose/Description:

- Next-gen coastal coupling using UFS
- Apply Agile principles in planning/managing
- Community modeling approach
- Model-level code that creates a model executable
- App-level code that will host workflow wrappers around the executable

Project Team:

- Link to diff slide with full team

Project Tracking:

- Model-level repository, app-level repository

	Target	Status
MVP of app-level workflow	FY25	In progress
MVP of the CI/CD pipeline on Jenkins (EPIC's automated testing platform)	FY25	In progress
Stakeholder engagement	FY25	In progress
Documentation improvements	FY25	In progress

Progress/Accomplishments:

- Created initial version CI/CD pipeline on Jenkins
- SCHISM+WW3 3D model cap modifications to use vortex formalism
- Sync'd with UFS-WM and resolved all resulting issues
- Sync'd with latest coastal model releases
- Stakeholder engagement
- Initial version app-level workflow for DATM+SCHISM
- …

Next steps (see roadmap for relevant issues):

- Continue testing of SCHISM+WW3 configuration
- Resolve CI/CD pipeline issues
- Resolve issues resulting from latest sync's
- Add small-domain regression tests
- Workflow MVP implementation
- …

Emerging project risks & possible mitigation:

- Active support from partners, especially WW3 developers, is essential.
- Several tasks are currently unplanned/blocked due lack of resources or needed collaboration to move forward: link
- While we have benefited from EPIC support, uncertain future EPIC support limits our ability to provide the best support to stakeholders given our small core team, e.g. documentation, multi-platform/cloud support, code maintenance, user support, etc.
- Relying on the UW tools project and collaboration with that team for workflow development. Changes to that project (positive or negative) would impact UFS Coastal app-level workflow timeline.

Outlook - UFS and UFS-Coastal

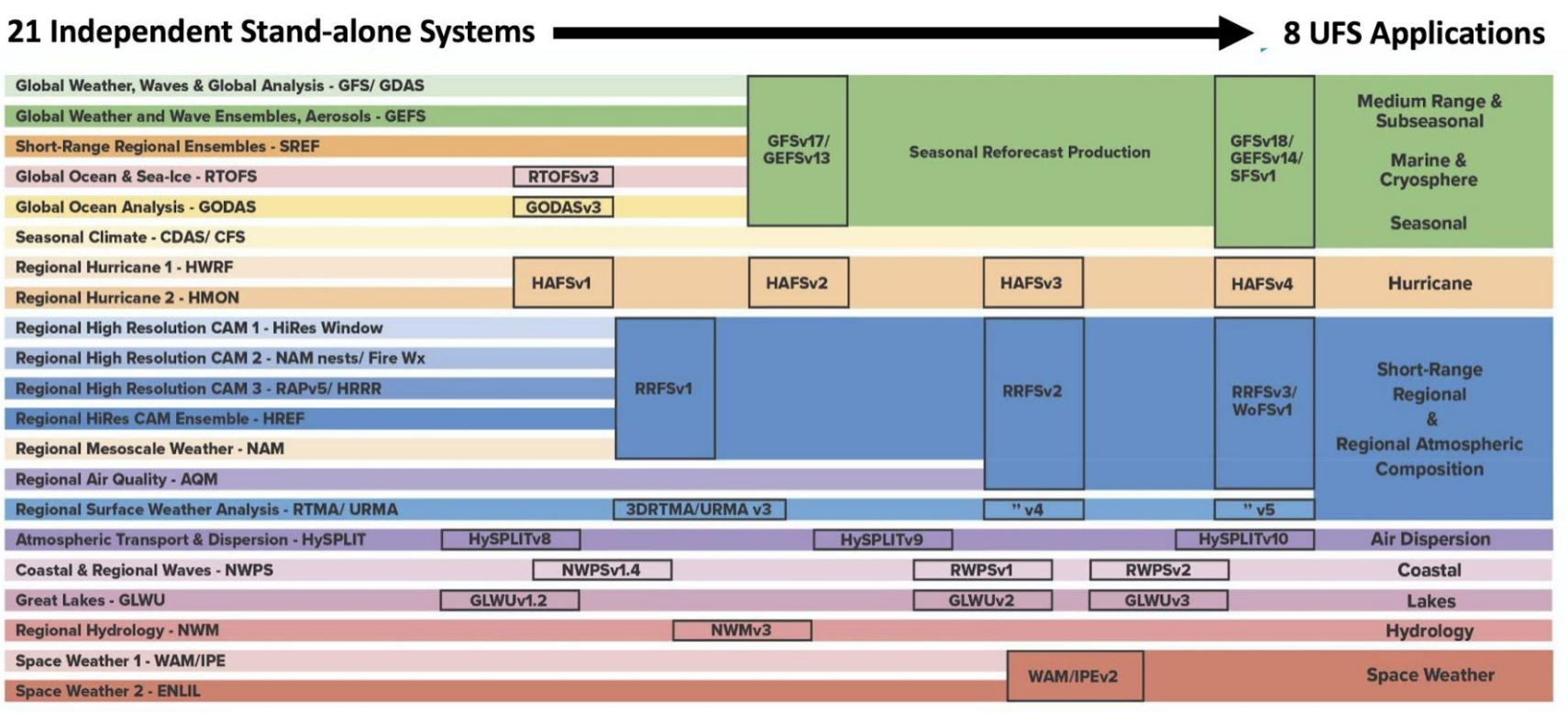
- **Unclear UFS-WM and UFS-Coastal Relationship:**
  - Consideration should be given to whether the two projects should eventually merge.
  - Guidance based on UFS Governance framework is needed to clarify the relationship between UFS-WM and UFS-Coastal.

- **EPIC Program Support and R2O Pipeline:**
  - Support from the EPIC program, resulting from UFS Governance updates, will significantly impact development.
  - It will also clarify how UFS-Coastal fits into the R2O pipeline and define necessary next steps for operations and upgrades.

Thanks for your attention

Contact: Saeed.Moghimi@noaa.gov

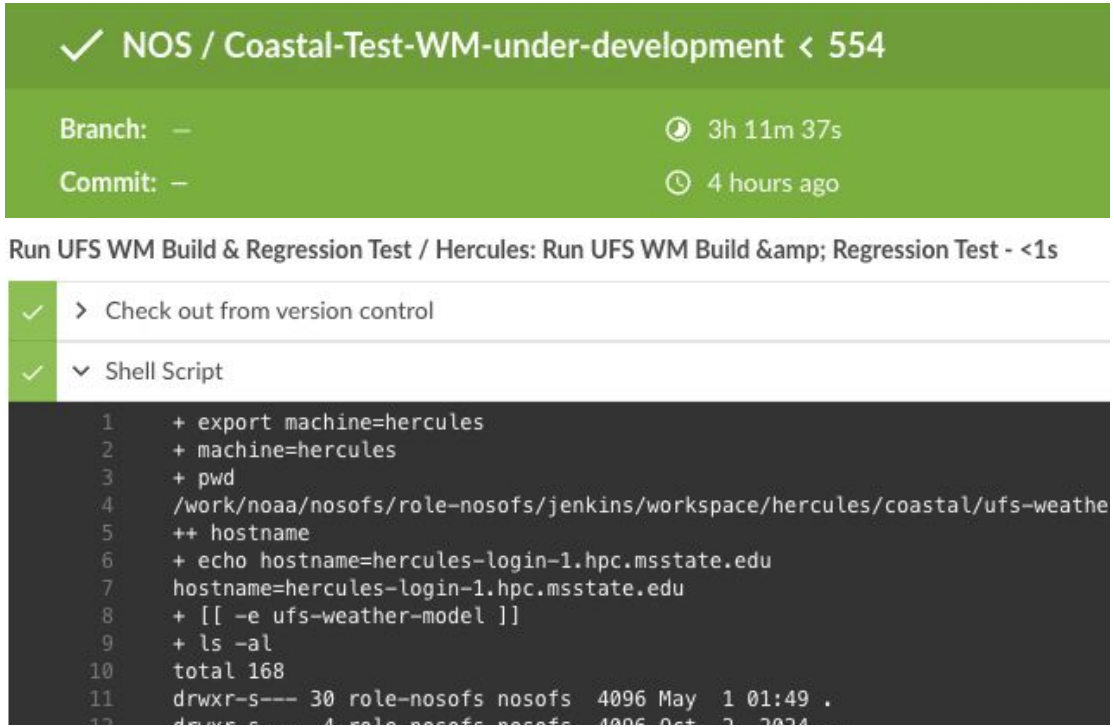
Very old Rainbow chart



UFS Coastal CI/CD

Continuous Integration / Continuous Deployment

- Jenkins as the CI/CD tool
- Nightly build and full regression test suite at MSU Hercules



GitHub

Jenkins

NOAA Unified Forecast System &

Coastal ocean modeling