UFS Coastal Applications Team
HSRP Update

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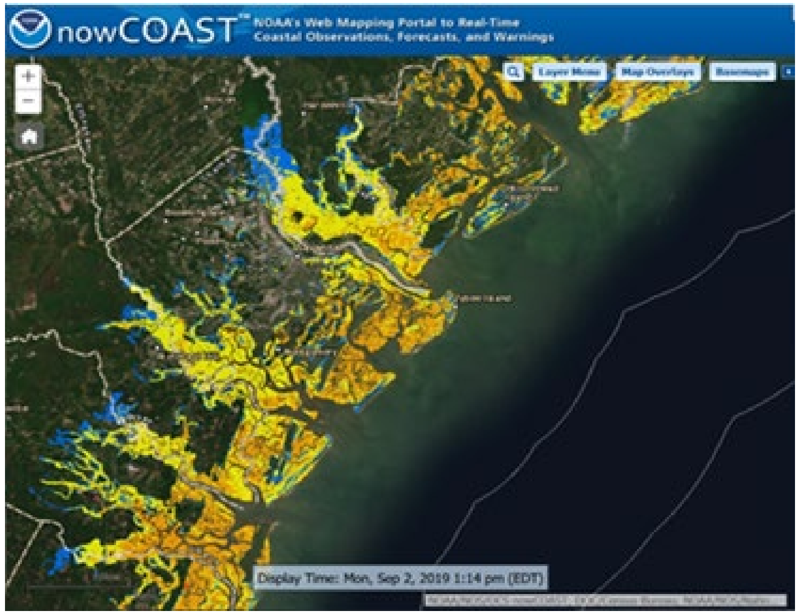
Safe, Efficient Navigation

Schematic illustration of S-1XX and S-4XX layers (IHO.int)

Risk Reduction

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

Total Water Level



NWS Potential Storm Surge Flooding Map for Hurricane Dorian (NowCOAST - 9/2/2019)

UFS Coastal Applications Team
Background

The Unified Forecast System (UFS) Coastal Application Team (CAT) is part of a larger development within NOAA that includes federal and academic partners to review NOAA needs and consolidate them into individual modeling systems (i.e., global and regional atmosphere, ocean, land, etc.) using a smaller set of coupled Earth System models that would continue to serve its various stakeholders.

Under the **UFS CAT Marine Navigation working group** (also known under the title of "**Safe, Efficient Navigation**"), the goal is to evaluate the leading oceanographic circulation models that operate in complex coastal environments.

Safe, Efficient Navigation

Schematic illustration of S-1XX and S-4XX layers (IHO.int)

Team Members:

Federal

Greg Seroka (NOAA/NOS/OCS) – WG Co-Lead
John Kelley (NOAA/NOS/OCS) – WG Co-Lead
Fred Ogden (NOAA/NWS/OWP)
Tracy Fanara (NOAA/NOS/IOOS)
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Academia

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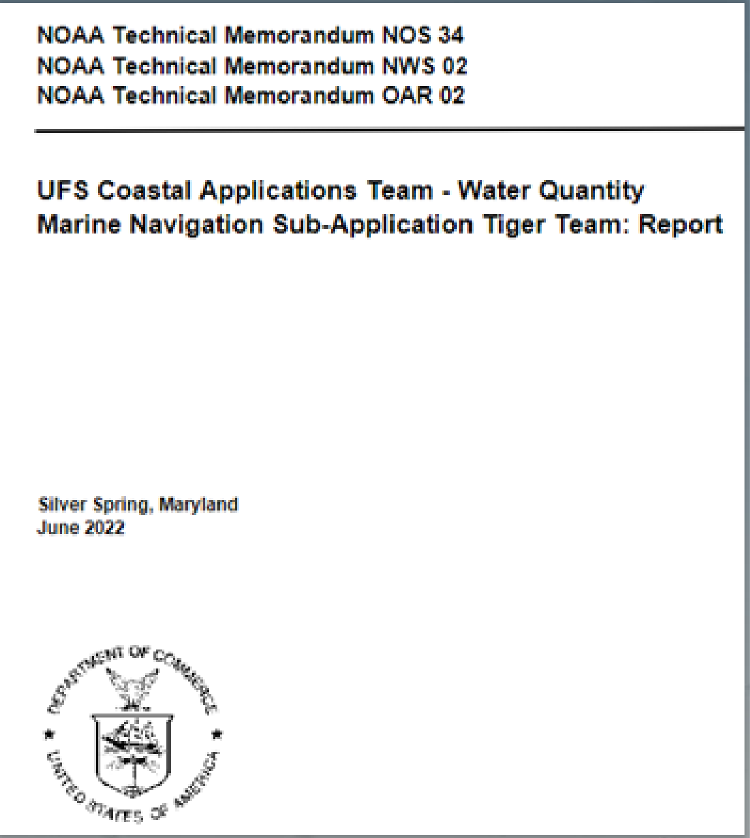
Cigdem Akan (University of North Florida)
Timothy Cockerill (NSF/TACC)

The UFS CAT team would like to thank the **NOAA NOS Water Team** for funding support for two years of research (FY23 and FY24). We would also like to thank **Dr. Changsheng Chen** from School of Marine Science and Technology (University of Massachusetts – Dartmouth) and **Dr. Joseph Zhang** from Virginia Institute of Marine Sciences (William and Mary) for their support throughout the model evaluation process, and educating and engaging with testers from government and academia. Similarly, we would like to thank **NSF/TACC** for providing development work space and IT support for developers and testers to evaluate the models.

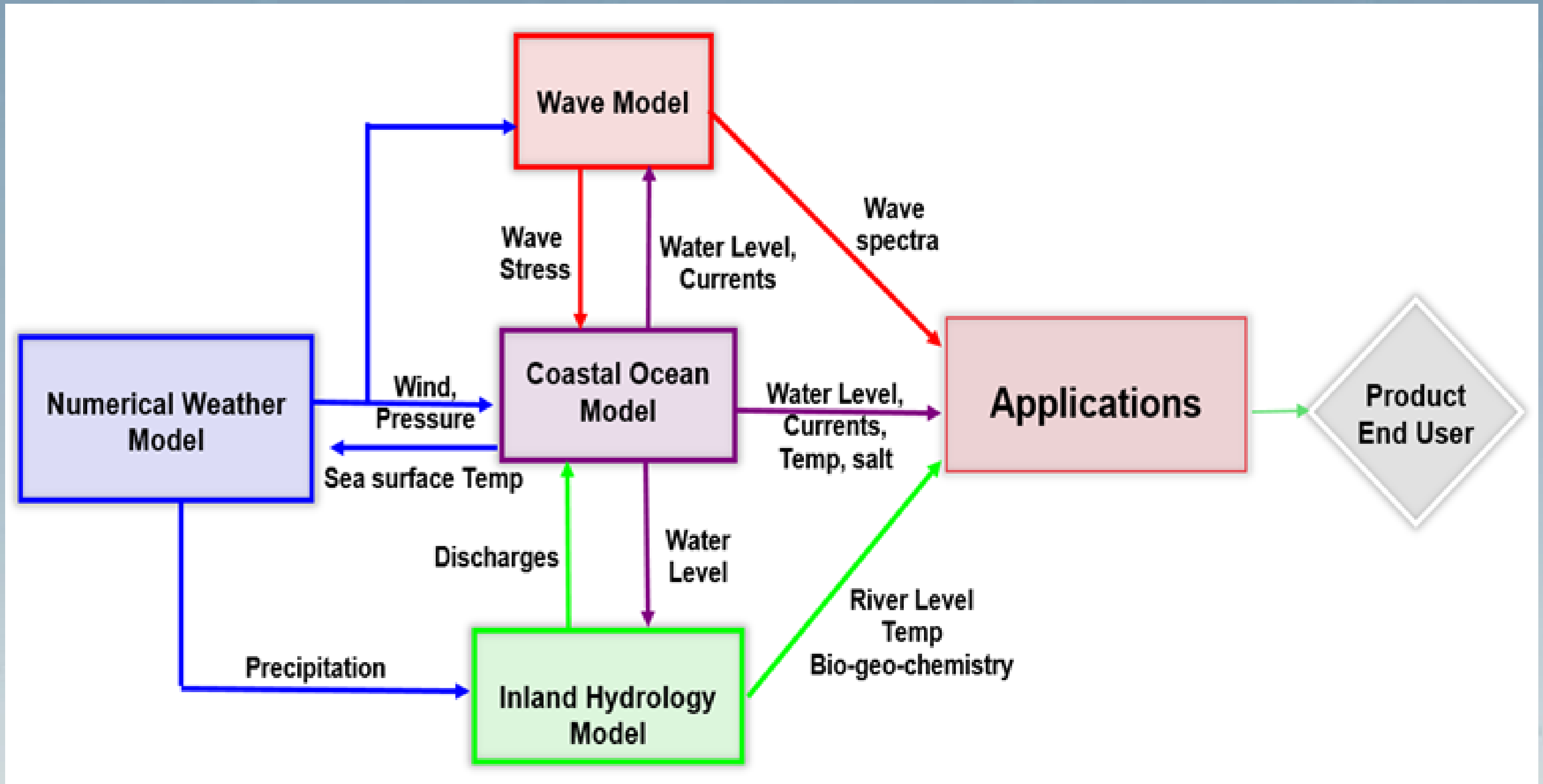
Model Evaluation

The UFS Coastal Applications Team (CAT) requested all three working groups (sub-application teams) to generate consensus guidelines (i.e., metrics, criteria, and competing numerical oceanographic models) for a **model evaluation**.


NOAA Technical Memorandum NOS 34
NOAA Technical Memorandum NWS 02
NOAA Technical Memorandum OAR 02

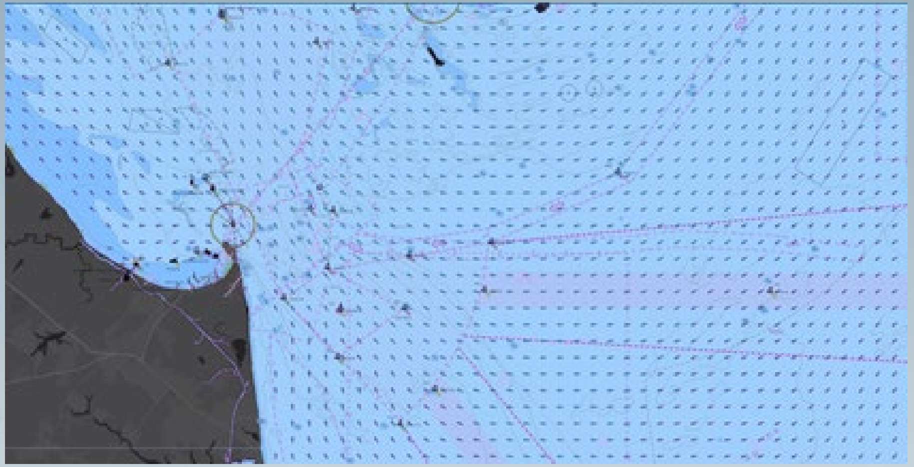
UFS Coastal Applications Team - Water Quantity Marine Navigation Sub-Application Tiger Team: Report

Silver Spring, Maryland
June 2022



Requirements

To support marine navigation in the waterways and ports of the U.S., mariners need forecast guidance of all the following variables: **water levels, surface water currents, sea and lake ice, and water temperature and salinity.** NOAA and its partners have collected user requirements from the marine navigation and related communities, including: commercial and recreational mariners, port authorities, NWS and private forecasters, marine educators/researchers, search and rescue, manufacturers of marine navigational systems, and offshore wind energy operators.



The International Hydrographic Organization (IHO) has also been collecting user requirements in order to create product standards **(IHO S-1xx)** to be used as part of a carriage suite on certain vessels that can be displayed on an **Electronic Chart Display Information System (ECDIS).**

****Other required user variables for marine navigation that were considered here and should be coordinated include winds and waves.***

Forecast configuration requirements

Key user variables:	Specifications
Forecast frequency	Every 6 hours
Forecast turnaround time	< 1 hr before forecast cycle deadline (NWS), and before start of the next model forecast cycle (NOS)
Output temporal resolution	At least hourly, optimally up to 6 minutes
Forecast range	5 to 7 days, 14 days for planning (monthly/seasonal for lake/sea ice)
Reliability	99-99.9%
Areas of interest	Coastal ocean, Great Lakes, including ports, harbors, bays, and connecting channels and rivers, and islands/atolls in the Pacific (e.g. Hawaiian Islands and Guam)
Depth of currents	**Navigation** - 4.5 m below surface **Search and Rescue** - 0-1 m below surface
Spatial reference system	**Vertical** - Chart datum (e.g. MLLW and LWD for Great Lakes) **Horizontal** - WGS-84 or ITRF2020.
Horizontal resolution	**Rivers** - 10 m in rivers, **Shipping channels** – 10 m - 50 m in shipping channels, **Sea ice conditions** - 30 m for sea ice, **Within inlets, bays and lakes** - 50 m-1km, **Around small islands** - <=2 km , **Open ocean conditions** - 5 km (1 km for surface currents in EEZ)

Accuracy requirements of key variables

Key user variables:	Specifications
Water level accuracy	Under Keel Clearance (UKC) - 15 cm (0.5 ft) Time of high water and time of low water - 0.5 hr
Surface current accuracy	Speed - 26 cm/sec (0.5 kt); at time of max flood or ebb 30 min; for slack water times, 15 min Direction: 22.5 degrees provided current speed is not less than 26 cm/s (0.5 kt) (Note: For USCG SAR: 0.1 m/sec / 10 degrees)
Sea and lake ice accuracy	Depth/thickness - 10 cm Concentration - 10% Extent - 10% Motion - 0.25km/day / 10 degrees
Water density accuracy	Salinity - 3.5 psu for salinity Water temperature - 7.7C (Note: Desired accuracy is to forecast a ship's draft within 7.5 cm of its actual draft).
Product formats:	S-100/HDF5, GRIB2, Web mapping services, GIS compatible files, NetCDF, SHEF; documentation describing files

The operational requirements

Stability and computational efficiency - Computation and delivery of model products need to be fast enough to provide forecasters and users actionable information in a timely manner.

Accuracy - The accuracy should be defined based on physical calculations.

Resolution - New bathymetry grid can be used to generate a mesh sufficient for forecast guidance.

Code management - The code is managed by a scientific community..

Coupling - able to couple to ocean, wave, inland hydrology, atmosphere, and sea ice models.

Community support and license type - All coupled model components are required to be community models that are open source (License C00).

NOAA Readiness Levels - Following NOAA project metric/measurement.

Geographic coverage - Operate successfully in coastal environments that include all of the United State's top 50 ports.

Methodology (baseline simulations)

Two models were selected: **FVCOM and SCHISM**. In round 1, the baseline simulation used **open boundary conditions** for evaluating only the tides. Eight constituents were used for tidal forcing, where the top four tidal constituents (in the list below) were evaluated in skill assessment:

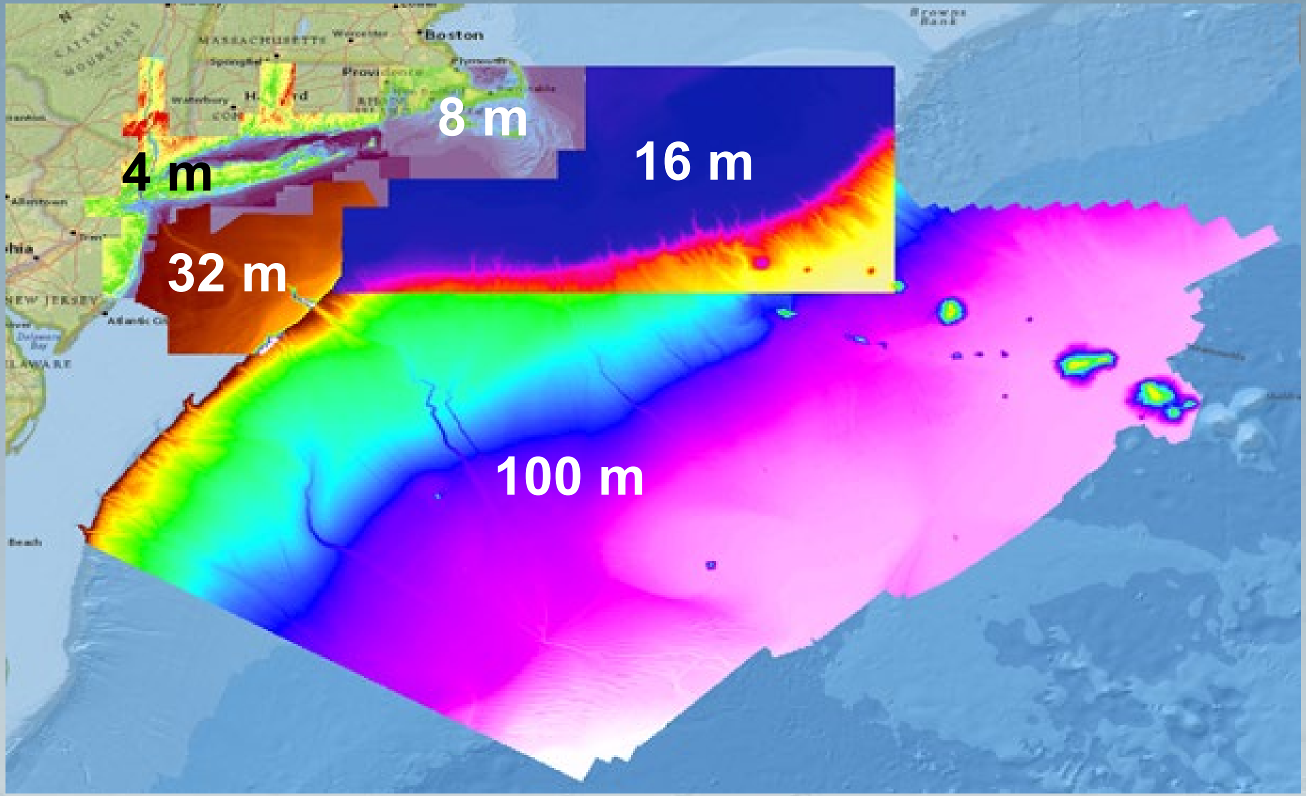
- M2 - principal lunar semidiurnal constituent,
- S2 - principal solar semidiurnal constituent,
- N2 - larger lunar elliptic semidiurnal constituent,
- K1 - lunar diurnal constituent,
- K2 - principal lunar diurnal constituent,
- O1 - lunar diurnal constituent,
- P1 - solar diurnal, and
- Q1 - larger lunar elliptic diurnal

Hindcast Period. 3 months, not including warm-up period.

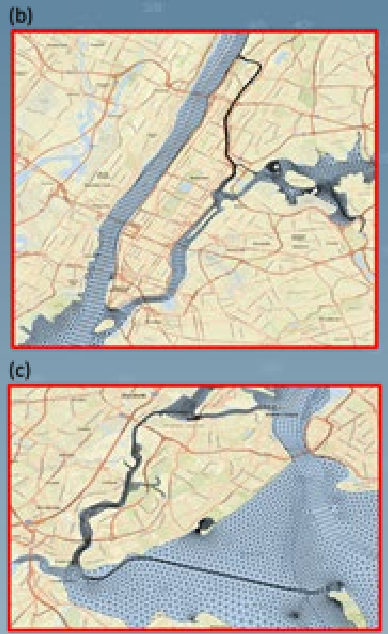
1. Jan 1 - Mar 31, 2022: includes Nor'easter (Jan 14-17; Jan 28-29)
2. Jul 1 - Sep 30, 2021: includes hurricanes (Elsa, Henri, Ida)

Study Site (New York Harbor)

Mesh generation: Use provided bathymetry, geographic polygon for mesh generation. Resolve small riverine areas at ~10 m horizontal resolution.

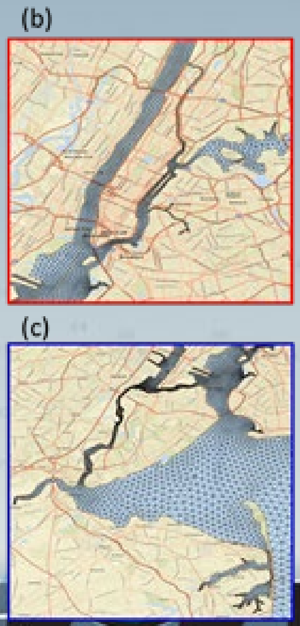


Available bathymetry datasets at the study site (NY Harbor) for model evaluation



SCHISM Mesh

FVCOM Mesh



Outcomes from Round 1

The main goals of Round 1 was getting the team familiar with models and the development environment, and getting the testers to the “storming and norming” phases in the team development cycle. As such, no specific results will be provided in this report. Instead, the discussion on the results will focus on the successes, challenges and lessons learned throughout this round.

Success 1- communication and team building - Routine meetings provided the testers opportunities for feedback and collaboration. Also, the UFS CAT team maintained live documentation of suggestions and lessons from testers and model developers to guide future efforts and improve on each round of this effort.

Success 2- learning the models/ exposure to NOAA ops - Testers were able to use a prepared script to process the statistics of these constituents that was provided to the testers, or the testers could generate their own scripts.

Success 3- conducting skill assessment - The model results from each team were compared against 23 stations in the New York Harbor and surrounding area. The observation data were analyzed without any data filtering.

Outcomes from Round 1 (Continued)

Challenge 1- consistency and guidance - The testers wanted more guidance in mesh coverage, resolution, boundary conditions, and so on. This feedback prompted the co-leads to develop a baseline configuration for testers to begin with, if they chose.

Challenge 2- Issues with the DEMs - Early on in the mesh generation process testers had highlighted issues with the provided DEM and bathymetry, especially along the Arthur Kill and Bayonne channels. An updated DEM was provided to the developers and the testers. This resulted in an immediate improvement in the skill assessment results, reinforcing the importance of DEM quality early on in the process.

Lessons Learned - Based on the success and challenges mentioned above, several lessons learned will be implemented in the next rounds. The three categories of lessons learned are: meetings and structure, mesh development and DEM/bathymetry suggestions, and pre/post-processing techniques.

Lesson 1- Meetings - The success of the Monthly meetings has proved itself as a good communication tool. We will continue having bi-weekly meetings hosted by a fellow student to prompt a lower-stakes environment for collaboration and questions.

Lesson 2- Clearer guidance and consistency - With the benefits of having freedom and flexibility of the testers in their configurations and methodology, there is a need for consistency. This might be also connected for the UFS CAT to provide more support and feedback to the testers

Next Steps and Recommendations

The model evaluation is already in the second round that will incorporate the atmospheric forcing components onto the existing tidal model, and switch to running the model in three dimensions (3D). The co-leads will provide atmospheric (GFS, HRRR), ocean (Global RTOFS), and river (National Water Model, USGS) forcing data as well as additional observational data (water levels, water currents, water temperature, salinity) for the testing.

In addition to **water levels**, **surface currents** (top 4.5 m water layer), **water temperature and salinity** are also evaluated in the second round. The evaluation results will be shared with the developers and with the UFS community for feedback and will also evaluate time of performance, ease of operation, update of elevation models and use of observations for calibration and skill assessment.