SECOORA
Southeast Coastal Ocean Observing Regional Association

Modeling Framework

The purpose of this document is to establish a modeling framework for SECOORA that:

- **Characterizes the range of modeling goals SECOORA will pursue**
- **Includes a process to assess modeling gaps and identify new opportunities**
- **Articulates a model lifecycle evaluation process, including guidelines that cover development to retirement of models**
- **Outlines SECOORA's engagement with principal investigators (PIs), the broader modeling community, NOAA, and stakeholders**

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1. Purpose

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For this framework, we define a coastal model as a tool for predicting the behavior of dynamical systems in the coastal and estuarine environment. Models can include numerical, statistical or machine learning (ML) methods and can be applied to any aspect of the coastal environment including questions of a physical, geological, ecological, biological, or chemical nature.

2. Vision

SECOORA will make investments in coastal modeling alongside coastal observations to address critical user needs for environmental information for the region.

3. State of Coastal Modeling at SECOORA

A central goal of SECOORA is to develop, in partnership with users, models that will support decision-making. SECOORA is implementing a robust observing strategy to acquire atmospheric and oceanographic observations from high frequency radar, coastal and oceanographic stations, and autonomous vehicles. Even with a strong strategy in place, coastal and ocean observations cannot be collected everywhere and all the time, so SECOORA supports predictive models to fill gaps in both space and time. The available observations are being linked to predictive models essential to improving modeling of ocean circulation and other marine environment conditions. SECOORA supports a numerical modeling framework, at regional to sub-regional scales, to provide validated modeling products for managers and other users. With its 5 year (July 1, 2021 – June 30, 2026) proposal *Delivering actionable coastal and ocean information from high-quality science and observations for the Southeast*, SECOORA is funding three separate predictive modeling efforts.

A Coupled North Atlantic Prediction System (CNAPS) model developed by North Carolina State University: This fully coupled ocean circulation, wave, and atmosphere modeling system predicts conditions over a wide area of the coastal northwest Atlantic Ocean on a daily basis. CNAPS is designed to predict coastal ocean conditions over the entire SECOORA domain with a high degree of scientific accuracy and provide detailed sub-regional information through relocatable grid refinement and nesting technology, and to update and transmit such information to stakeholders in a timely and clear fashion.

The West Florida Coastal Ocean Model (WFCOM) developed and maintained by the USF College of Marine Science Ocean Circulation Lab: This model focuses on the eastern Gulf of Mexico and downscales from the deep ocean, across the continental shelf and into the major estuaries by nesting the Finite Volume Coastal Ocean Model (FVCOM) in the HYbrid Coordinate Ocean Model (HYCOM). WFCOM provides daily, automated ocean

circulation nowcast/forecasts from the Mississippi River Delta to the Florida Keys. The model simulations include real-time river inflows and are quantitatively gauged against in situ observations for the region. By further nesting a higher resolution version of FVCOM in WFCOM, the Tampa Bay Coastal Ocean Model (TBCOM) provides daily automated nowcast/forecasts for Tampa Bay, Sarasota Bay, the Intracoastal Waterway, and all of the inlets connecting these with the Gulf of Mexico. Both WFCOM and TBCOM in collaboration with the Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute provide short-term (3.5-day) harmful algal bloom (HAB) trajectory forecasts for both the surface and the near bottom waters that are used by local, state and other public entities for tracking blooms of the neurotoxic *Karenia brevis*.

A high-resolution, Web-based system to monitor and forecast pelagic Sargassum in coastal zones of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico developed by modelers at the University of South Florida (USF) College of Marine Science: The USF team developed algorithms suitable for high-resolution satellite data to map and quantify Sargassum distribution and abundance and they are working on a short-term forecasting system to forecast Sargassum trajectory. Rafts of Sargassum are identified with satellite remote sensing. The latitude and longitude, current speed and direction (integrated daily from HYCOM) are used to predict the movement of the raft and a possible beaching time, in essence, forming an early warning system.

4. SECOORA Coastal Modeling Framework

SECOORA will use a strategic and forward-looking approach to identify model needs for the region and implement modeling efforts. This is done by focusing on the goals of the various types of modeling projects that SECOORA may support, describing how SECOORA and modeling teams will engage with partners and users to improve collaboration and service delivery, and outlining the process SECOORA will use to ensure modeling projects are addressing user needs and identified gaps.

4.1 Coastal Modeling Goals

Operational and quasi-operational models

These models are focused on sustained, near real-time model operations. The goals of these modeling activities are typically to produce forward looking predictions on a regular basis to provide guidance regarding a range of coastal environmental questions. The output from these models can be a user product in-and-of-themselves, however typically there will be some downstream visualization or product to address specific user needs and requirements. The operational or quasi-operational models SECOORA will support fall under two categories:

Operate and maintain quasi-operational models
For these modeling projects, SECOORA would support continued model operations and product delivery by PIs within the SECOORA region. The project deliverables would be near real-time model output meeting a specific user need. The project should have a predetermined start and end date, at which point the project can be re-evaluated to determine if continued operations are needed or warranted.

Transition models to NOAA Operations
For these modeling projects, SECOORA would seek NOAA's support to transition models from PIs in the SECOORA region to NOAA Operations. The project deliverables would result in an operational model continually operated and maintained by NOAA. Continued support beyond the initial transition is possible pending the NOAA need and funding availability. This type of project will require a NOAA transition plan.

Model research and development

These activities are focused on the research and development of new models, techniques, model improvements, or products derived from model output. These efforts should be concise and highly focused with clear goals and deliverables determined by partner and/or user needs. This includes activities such as:

Develop new models
The development of new coastal models to address a partner or user need. Models can include numerical, statistical, or machine learning models.

Improve existing operational or quasi-operational models
Improving existing operational or quasi-operational models to provide more accurate output, output at improved spatial or temporal resolutions, better computational efficiency, or expanding the geographic domain or type of output that is provided. Models are also improved by integrating SECOORA funded observations from buoys, gliders, radars, and other assets.

Add new modules to existing ocean circulation models
Adding new modules to existing ocean circulation models to provide practical applications such as a tracer module to track pollutants or coupling an ecosystem module to simulate active biology (HABs) in the coastal ocean.

Develop new modeling techniques or methodologies
Developing modeling techniques or methods that could be applied to existing models. These may include innovative applications of technology such as artificial intelligence (AI) / machine learning (ML), data assimilation, cloud computing and the use of big data.

Develop products or tools relying on model output
Developing user products or tools that rely on existing model output. These could include alerts, applications or model output visualizations.

Non-real-time model applications

These activities include operating models in a non-real-time capacity. Examples include running a model to generate historical data which can be used to evaluate model performance, learn about the coastal environment, or to complement limited observational data. Non-real-time modeling applications include the following:

Model non-real-time forecasts
Predictions of future conditions that are run on a one-time, ad-hoc or infrequent basis. These models might be used to simulate long-term environmental processes or change (e.g. decadal sea level rise), that doesn't require real-time or regular operations. Deliverables are typically forward-looking model guidance and derived products and services that aid in user decision making.

Model hindcasts
An examination of a coastal environmental process over a time period in the past. Typically hindcasts will be run in the same manner that forward looking or real-time models are run, but without the constraints of an operational environment. Deliverables from these types of studies might include model skill assessments, the evaluation of processes under different environmental conditions, or the generation of data to better answer an environmental question.

Model reanalysis
Similar to model hindcasts in that these are backward looking, non-real-time model runs. However, model reanalyses are typically run using the best available physical forcing and data assimilation possible to closely replicate observations or "truth". Reanalysis is often used to supplement existing limited observations, enabling one to fill observational gaps in space and time. Deliverables in this case are likely a well-curated data set that can be used to answer a range of different climatological questions.

Model case studies
The application of modeling techniques to answer a specific coastal environmental question, or address a specific user need. These will often be limited in scope and applicability, possibly using existing models or developing new ones to answer a highly constrained question. These studies can also be theoretical in nature and include simplified or approximate models. The deliverable will usually be a report or publication, or information delivered to a user to aid in decision making.

4.2 Partner and User Engagement

Engagement with partners, stakeholders and users ensures collaboration and adequate service delivery of model output.

Application of the NOAA service delivery framework to help engage users with modeling projects

The NOAA service delivery framework provides a good basis for the steps SECOORA and their PIs should follow for both assessing broad modeling needs and gaps, as well as for completing a specific modeling project. The following steps should be completed and documented over the lifecycle of a modeling project.

1. **Build user relationships (Build)**
   The specific users will vary depending on the type of modeling project, but the range is broad, and may include the general public, specific communities, local, state and federal partners, industry partners, the academic community, etc. Building and documenting these relationships should be done by SECOORA and PIs to ensure the correct users are identified for a particular modeling project.

2. **Gather user needs (Gather)**
   It is essential that user needs are collected and documented at the start of any modeling project or early in a project once initial prototypes can be vetted and improved. Needs should be documented prior to SECOORA awarding funding to any modeling effort.

3. **Define model requirements (Translate, Assess)**
   It is up to the PI to take the user needs and translate those into specific technical requirements and deliverables of the model being developed or applied. When putting forth a modeling proposal, PIs should ensure that user needs are clearly specified along with methods for addressing those requirements.

4. **Respond to user needs (Address)**
   Communication with users should occur throughout the lifecycle of the project to ensure that the project is addressing their needs. This is particularly true during the project development phase, when

PIs are encouraged to have and document regular contact with users.

5. **Deliver model output or product to users (Deliver)**
   After completion of the project, the deliverables should be provided to the users, and available and accessible to the broader SECOORA community. PIs are encouraged to hold SECOORA webinars and/or present at the SECOORA annual meeting to communicate the results of the project.

6. **Evaluate the user impact of the model project (Evaluate)**
   After the project is completed, or over some regular defined interval for longer term projects, the user impact of the modeling project should be evaluated and documented. This is important to demonstrate that the project addressed user needs, and to determine if continued or additional support is warranted.

Coordinate closely with NOAA National Ocean Service (NOS) to identify potential operational transitions

There are many opportunities to engage with NOAA and NOS on the transition of models to NOAA operations. These can include specific funding opportunities presented by NOAA or NOS, such as the Coastal Ocean Modeling Testbed (COMT), or through NOAA support of specific model projects that NOS, SECOORA and the PIs agree should be NOAA operational models. SECOORA should engage with the NOS Modeling Advisory Board on at least a bi-annual basis, to understand what future operational modeling needs and opportunities will exist at NOS.

Engage with active Subject Matter Expert (SME) communities to identify collaboration opportunities

SECOORA and their PIs should regularly engage with SME communities to identify opportunities for collaboration, funding and partnership. This can include NOAA supported communities such as the Coastal Coupling Community of Practice and the AI Community of Practice, or academic communities such as those at the American Meteorological Society (AMS) or American Geophysical Union (AGU). Further, SECOORA should look for opportunities to engage SME communities that are tangential to modeling, such as groups working on sea level rise or coastal flooding, harmful algal blooms (HABs), webcams for coastal observations and operational support (WebCOOS), Radiowave Operators Working Group (ROWG) and others. These types of tangential engagement are particularly important to identify ways that modeling and observations can support and complement each other to address user needs or answer specific environmental questions.

Identify and grow SECOORA partnerships internally and with other RAs and government agencies

It is important to identify and cultivate partnerships between PIs, as well as with industry partners and local and state agencies within the SECOORA region. It is also vital to explore partnerships outside of SECOORA with other IOOS Regional Associations, industry and federal partners. These partnerships can help ensure that SECOORA modeling efforts are building on existing modeling efforts, and pulling in expertise from partners and SMEs within and outside of the SECOORA region. Exploring new partnerships has the added benefit of opening doors to new coastal modeling funding opportunities that have yet to be pursued.

4.3 SECOORA Model Needs Assessment Process

This section describes the process SECOORA will use to ensure their coastal modeling projects are meeting the criteria discussed above, prioritized based on existing gaps and needs, reaching their -goals, and leveraging partnerships and collaboration within and outside of SECOORA. This information is presented as a table listing the necessary actions, and the time interval the actions should occur over.

Time interval	Action
Every 5 years	Gather and document SECOORA user needs following the NOAA Service Delivery Framework that coastal modeling can help address
	Determine and document modeling gaps as part of the 5-year RCOOS plan
	Prioritize modeling user needs as part of the 5-year RCOOS plan
	Evaluate coastal modeling proposals as part of the 5-year SECOORA proposal
	Establish and re-evaluate roles and responsibilities between NOAA, SECOORA, RAs, PIs
Every year	Review deliverables of existing modeling projects and evaluate user impact
	Evaluate existing and continuing model projects to assess if on track and if continued support is warranted
	Work with internal and external partners to identify and explore new funding opportunities for SECOORA coastal models
	Work with IOOS Association to establish and update coastal modeling budget priorities and needs
Bi-annually	Meet with the NOS Model Advisory Board to understand future operational modeling needs and opportunities
As needed	Engage with active SME communities to identify collaboration opportunities
	Work with PIs to encourage community modeling and open code and data principles
	Constantly work with users to build relationships and understand how coastal modeling might address their needs

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