Center for Operational Oceanographic Products and Services
NATIONAL OCEAN SERVICE

BIL CIFIM-10 NOS Shared Cyberinfrastructure and Skill Assessment System

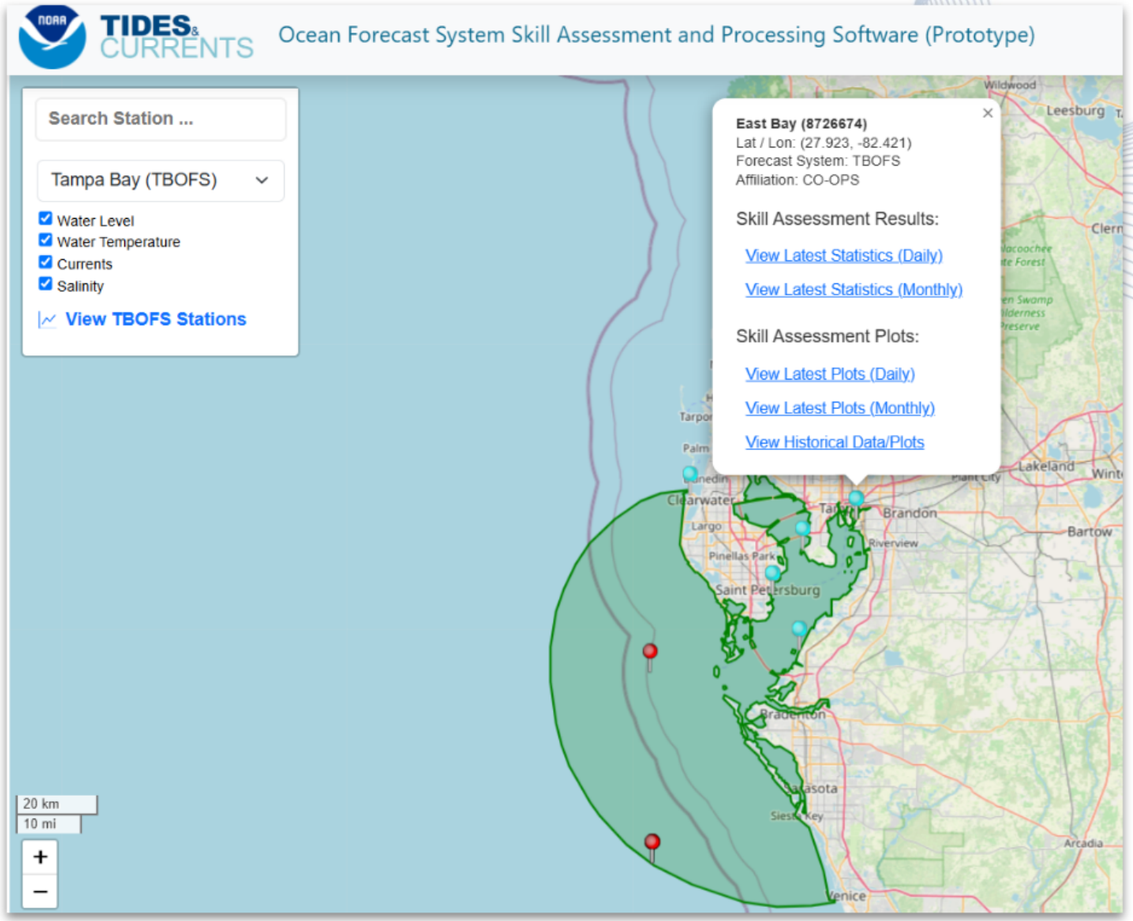
The next gen NOS OFS skill assessment system

Background

What is SCI/SA?

The NOS **S**hared **C**yber**I**nfrastructure and **S**kill **A**ssessment system is a BIL CIFIM-10 funded project aimed to *improve the assessment of NOS operational forecast systems (OFS) for model system developers and operators by providing*:

1. A set of **Python-based tools** to replace and enhance the current Fortran OFS skill assessment package
2. A **web-based application** for **routine quality assessment** of OFS outputs



SCI/SA web application view of Tampa Bay OFS and associated stations with available skill statistics

Purpose

Why are we developing the SCI/SA system?

- New OFS are becoming **bigger and more complex** and require efficient and thorough assessment (e.g., 2D fields evaluation) of their performance vs observations

Map of existing OFS domains

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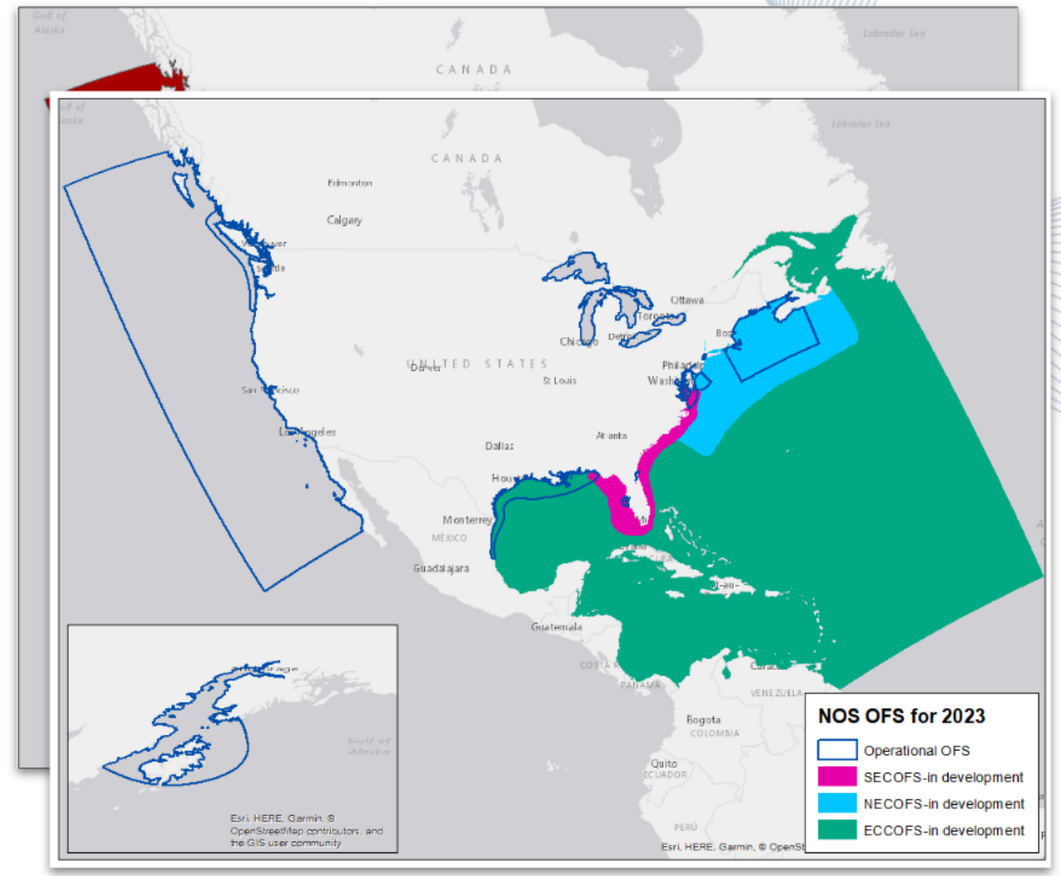
- A **Python-based software package** will be more user-friendly and versatile, allowing OFS developers and operators alike to compare model skill to NOS standards



Map of upcoming, new OFS domain coverage

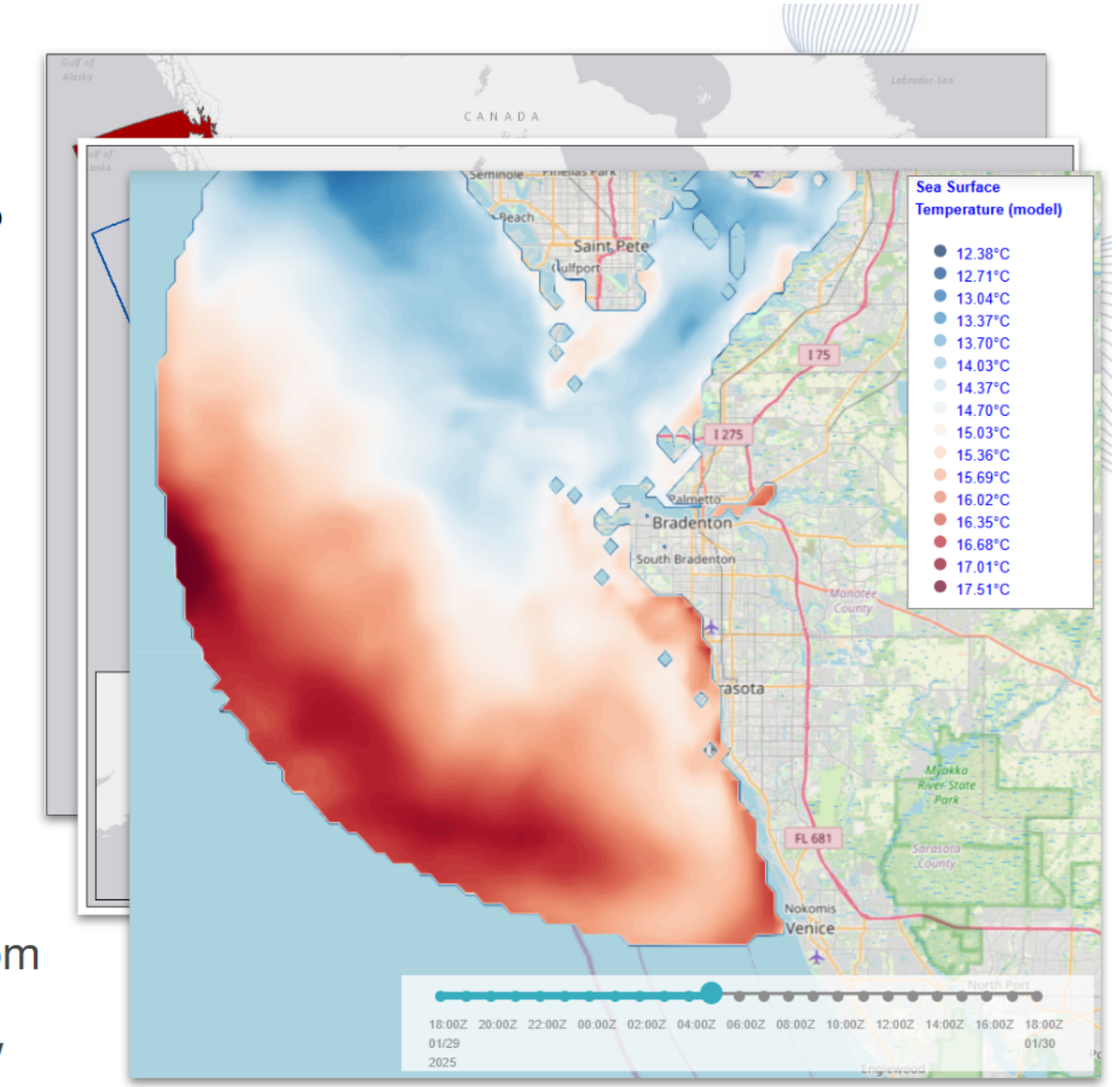
Purpose

Why are we developing the SCI/SA system?

- New OFS are becoming **bigger and more complex** and require efficient and thorough assessment (e.g., 2D fields evaluation) of their performance vs observations

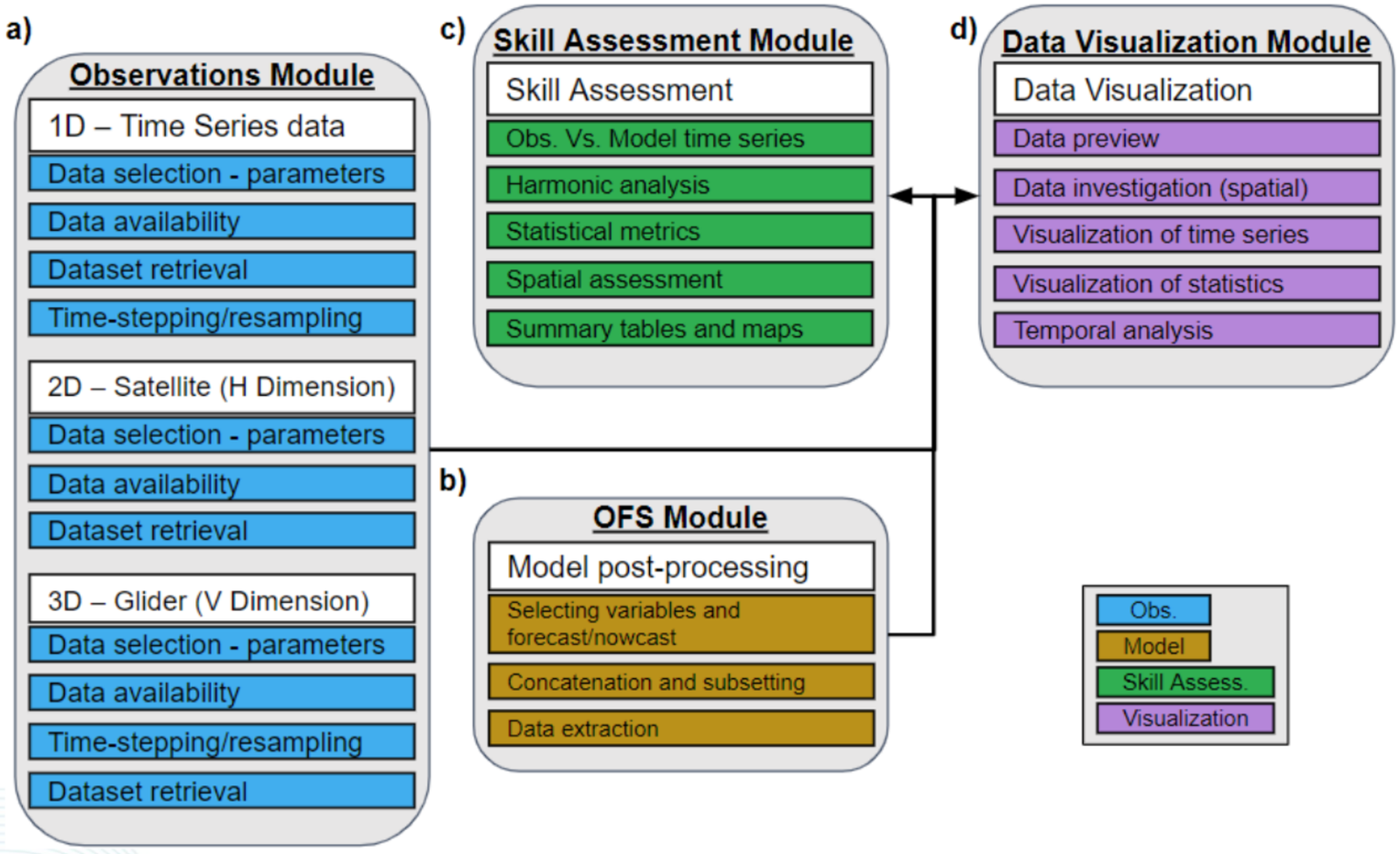
- A **Python-based software package** will be more user-friendly and versatile, allowing OFS developers and operators alike to compare model skill to NOS standards

- The system will **leverage more observations**, from station time series to satellite and glider data for more complete model validation and provide **new tools for visual validation** and verification during model development



2D SCI/SA web application view of Tampa Bay OFS SST output

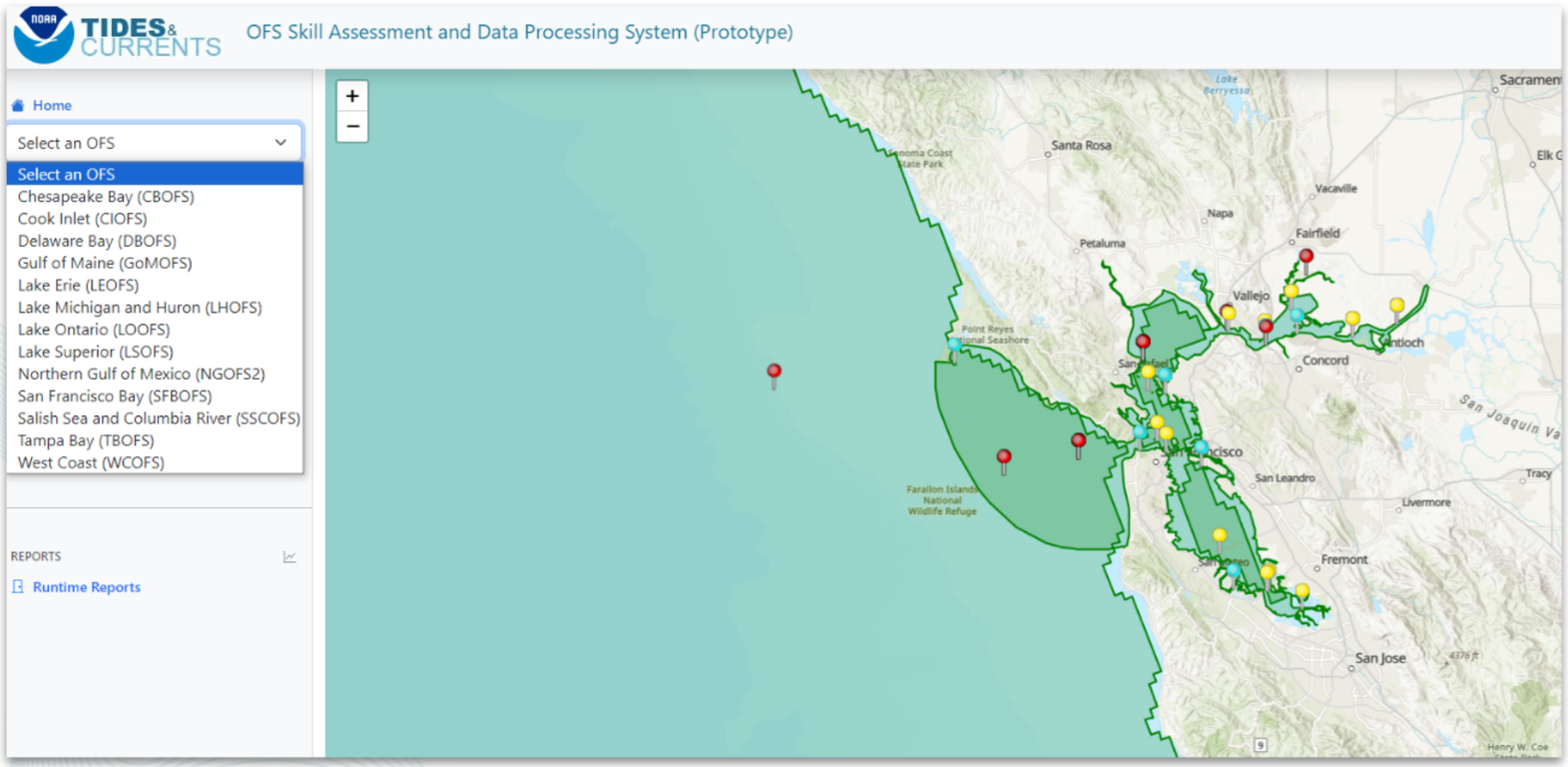
Product Structure



Daily results of Python package for all OFS are displayed on a Leaflet-based GIS web application

Station Time Series (1D) Analysis

Skill assessment of OFS **water level, water temperature, currents, salinity, and ice** using CO-OPS, USGS, and NDBC stations observations



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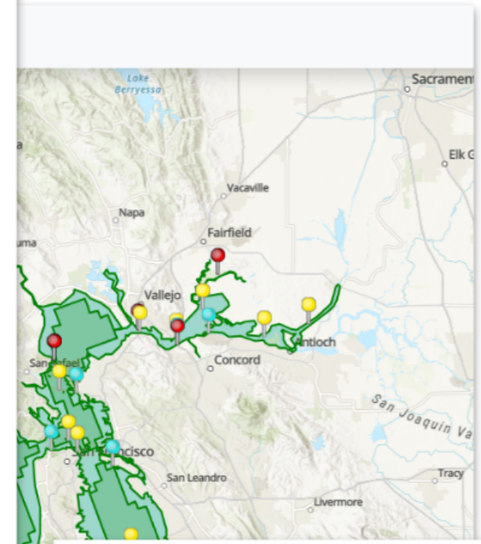

SSCOFS - 12035100 Skill Assessment Statistics - Latest Daily

Last Modified:

OFS	Product	Station ID	Node	RMSE	Corr. Coeff.	Bias	Bias Percent	Bias Direction	Central Frequency	Central Frequency Pass/Fail	Positive Outlier Frequency	Positive Outlier Frequency Pass/Fail
sscofs	water_level_forecast_b.csv	12035100	51300	1.05	0.93	-0.94	-75.65		0.0	fail	0.0	pass
sscofs	water_level	12035100	51300	1.05	0.93	-0.95	-76.46		0.0	fail	0.0	pass

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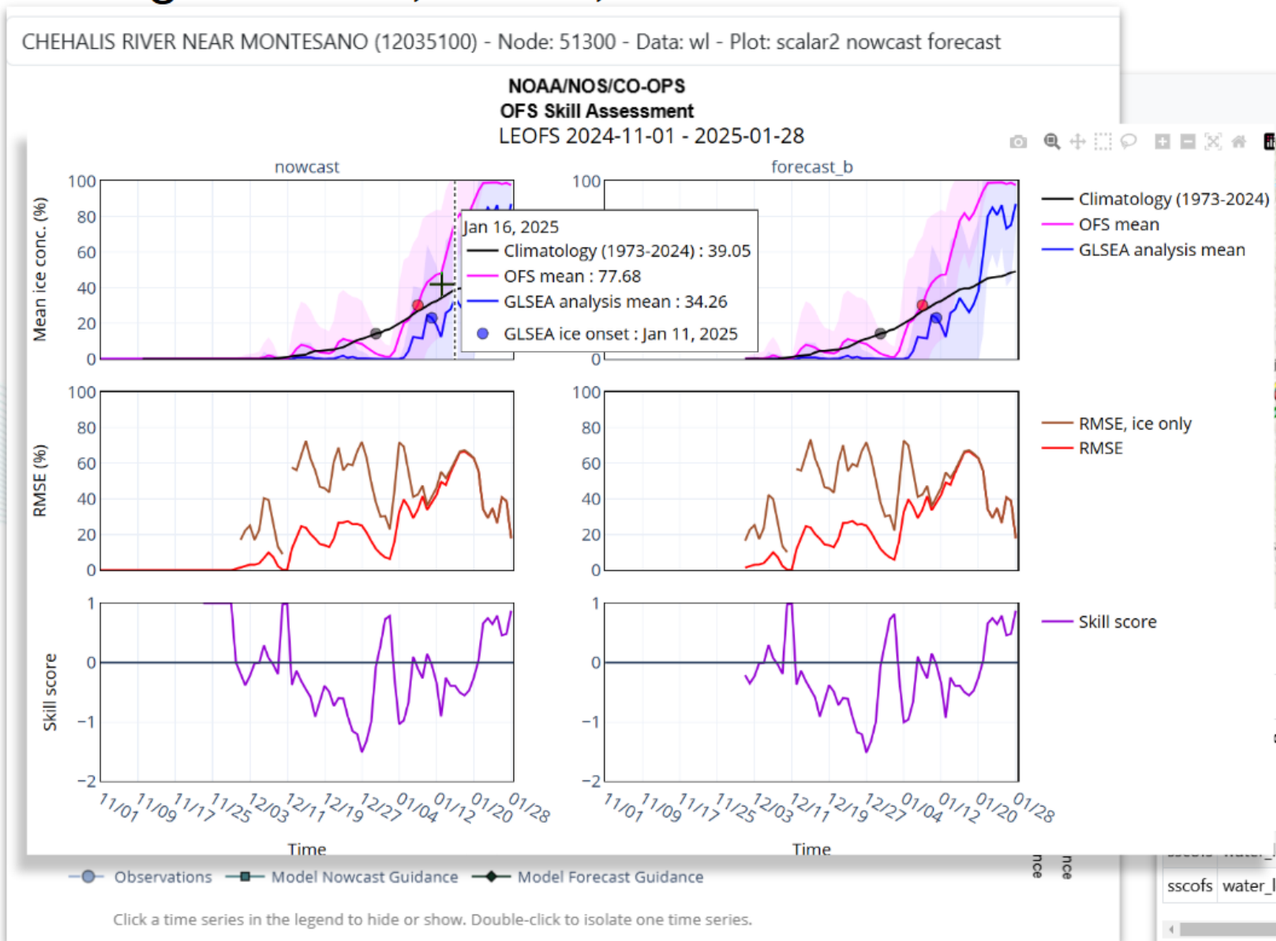

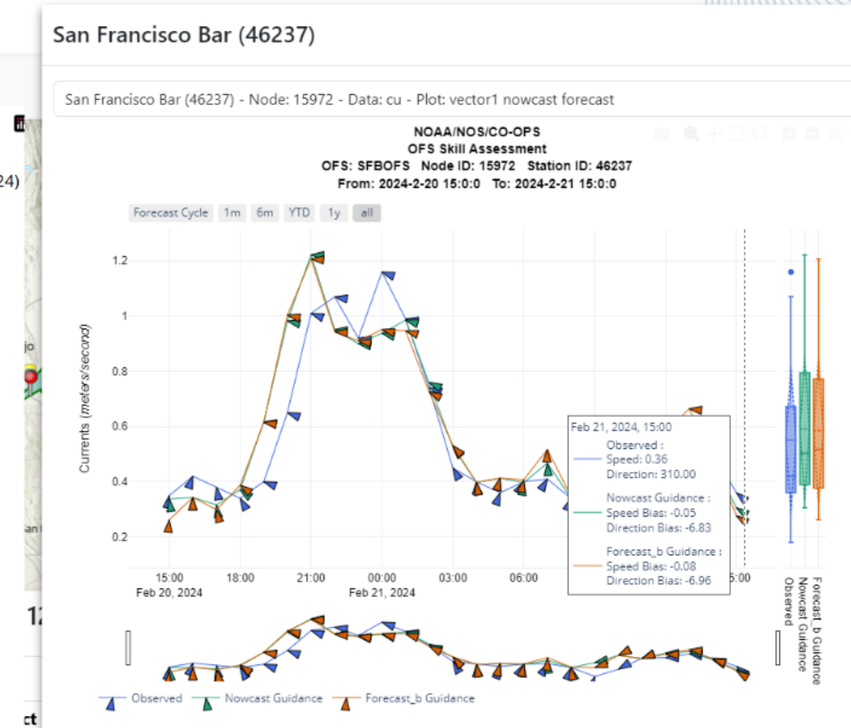

		ID			Coeff.		Percent	Direction	Frequency	Frequency Pass/Fail	Outlier Frequency	Positive Outlier Frequency Pass/Fail
	evel_forecast_b.csv	12035100	51300	1.05	0.93	-0.94	-75.65		0.0	fail	0.0	pass
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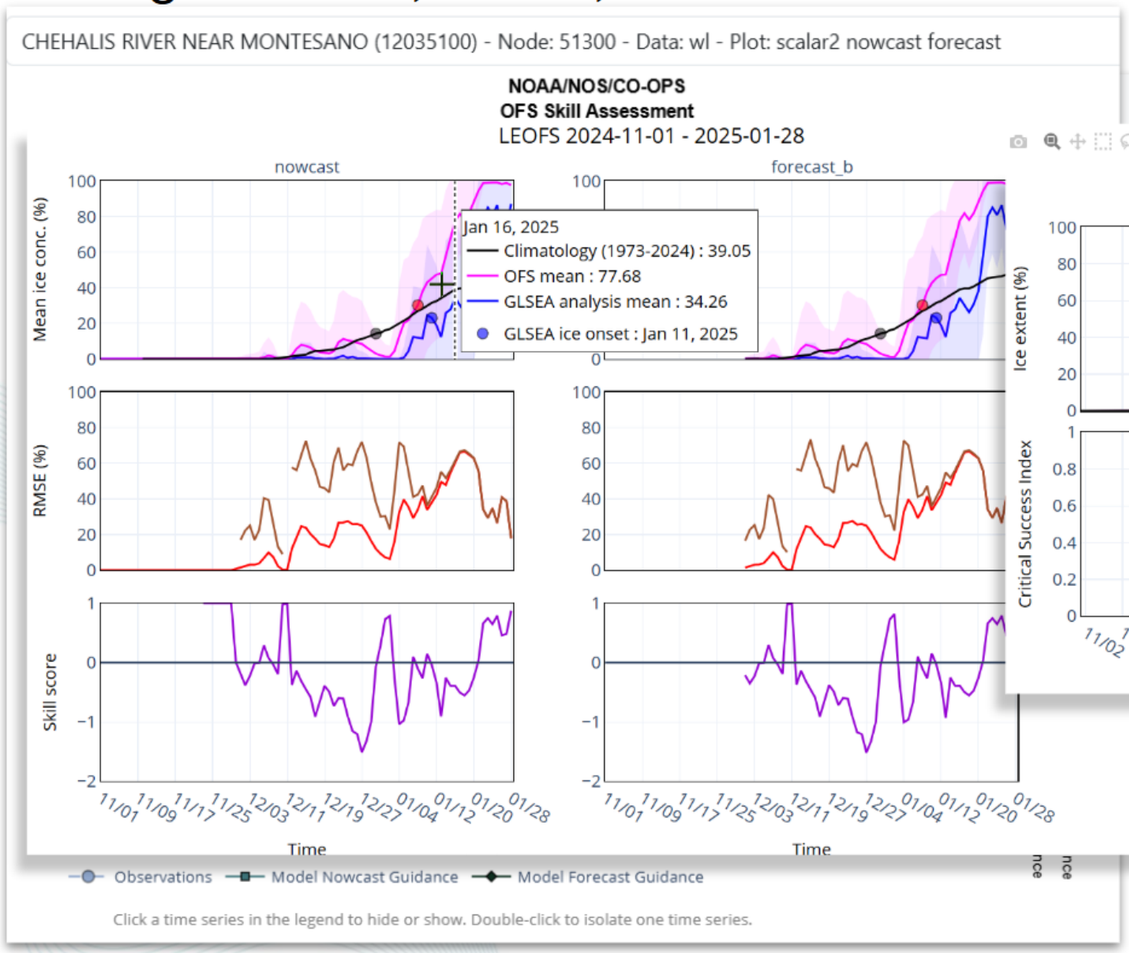
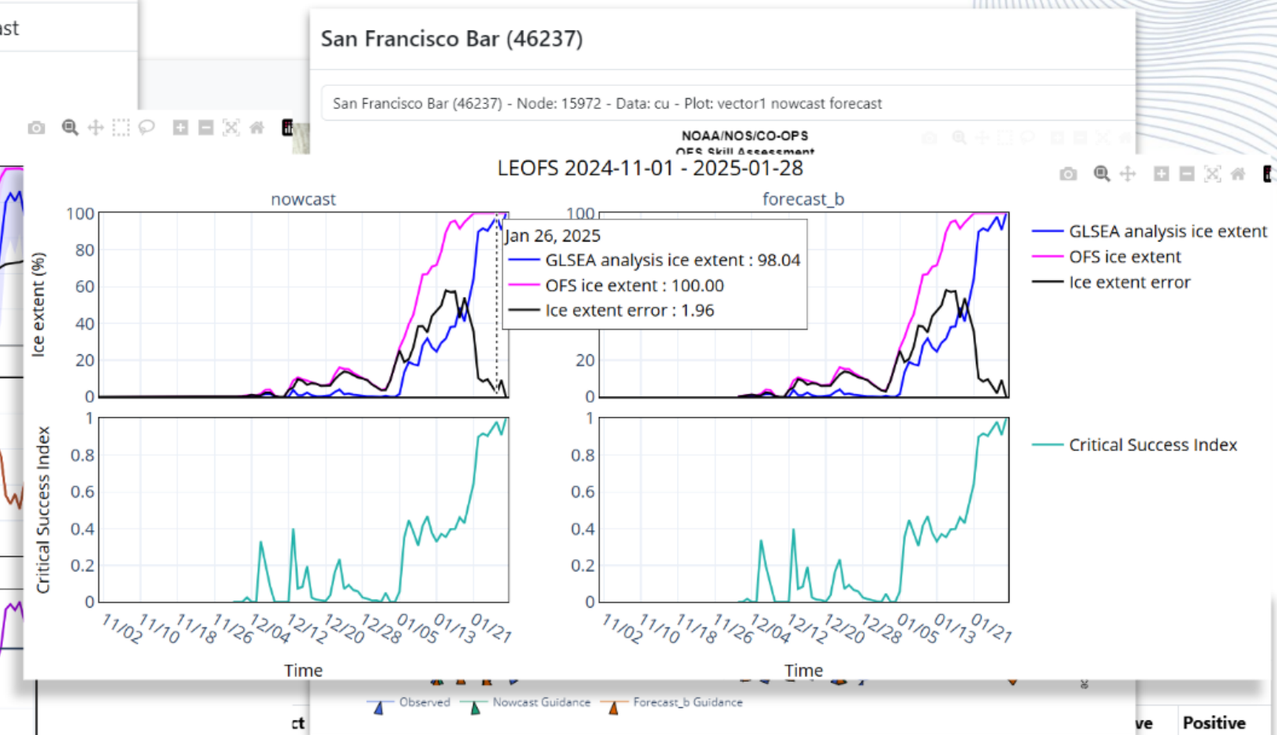
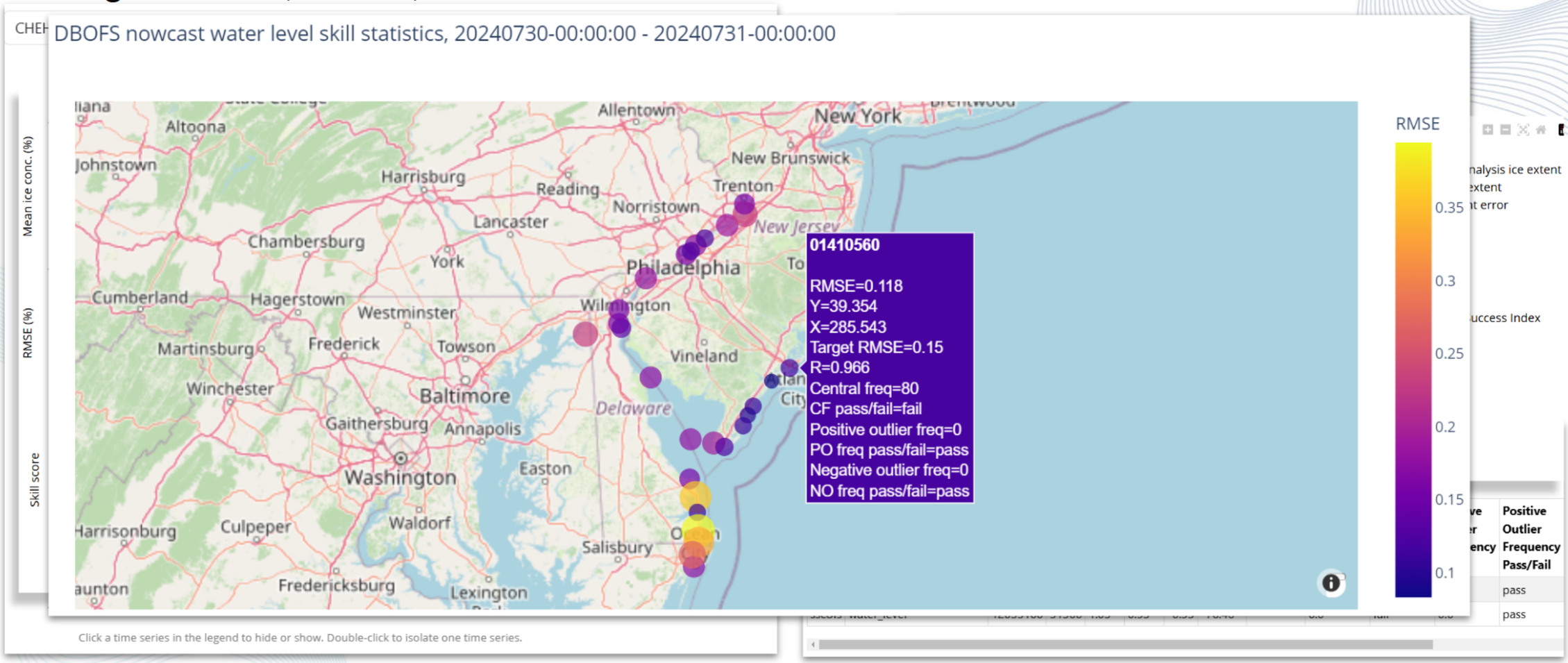




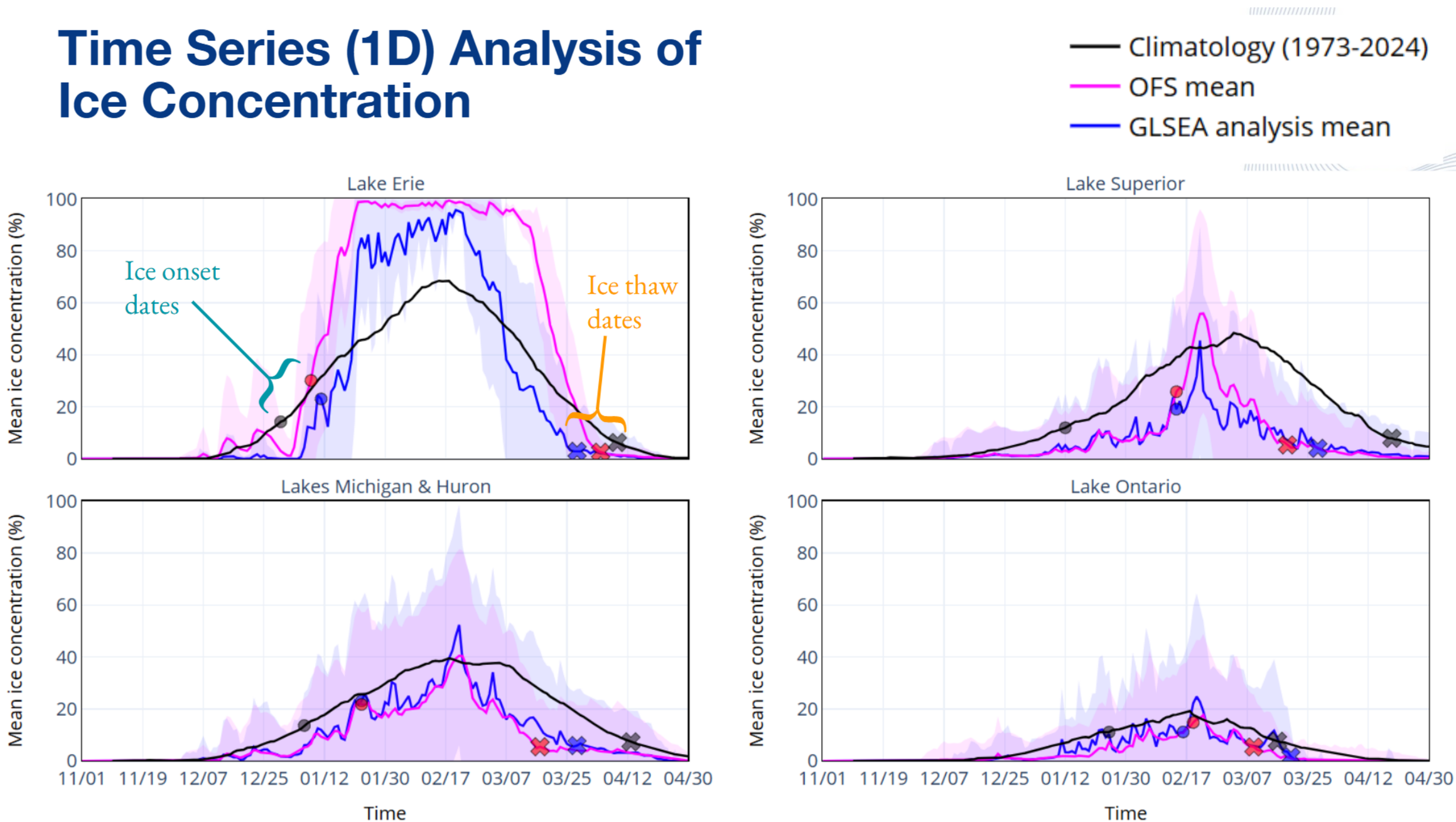
		ID			Coeff.		Percent	Direction	Frequency	Frequency Pass/Fail	Outlier Frequency	Positive Outlier Frequency Pass/Fail
		level_forecast_b.csv	12035100	51300	1.05	0.93	-0.94	-75.65		0.0	fail	0.0	pass
sscofs	water_level		12035100	51300	1.05	0.93	-0.95	-76.46		0.0	fail	0.0	pass

Station Time Series (1D) Analysis

Skill assessment of OFS **water level, water temperature, currents, salinity, and ice** using CO-OPS, USGS, and NDBC stations observations



Time Series (1D) Analysis of Ice Concentration



Time Series (1D) Analysis of Ice Concentration

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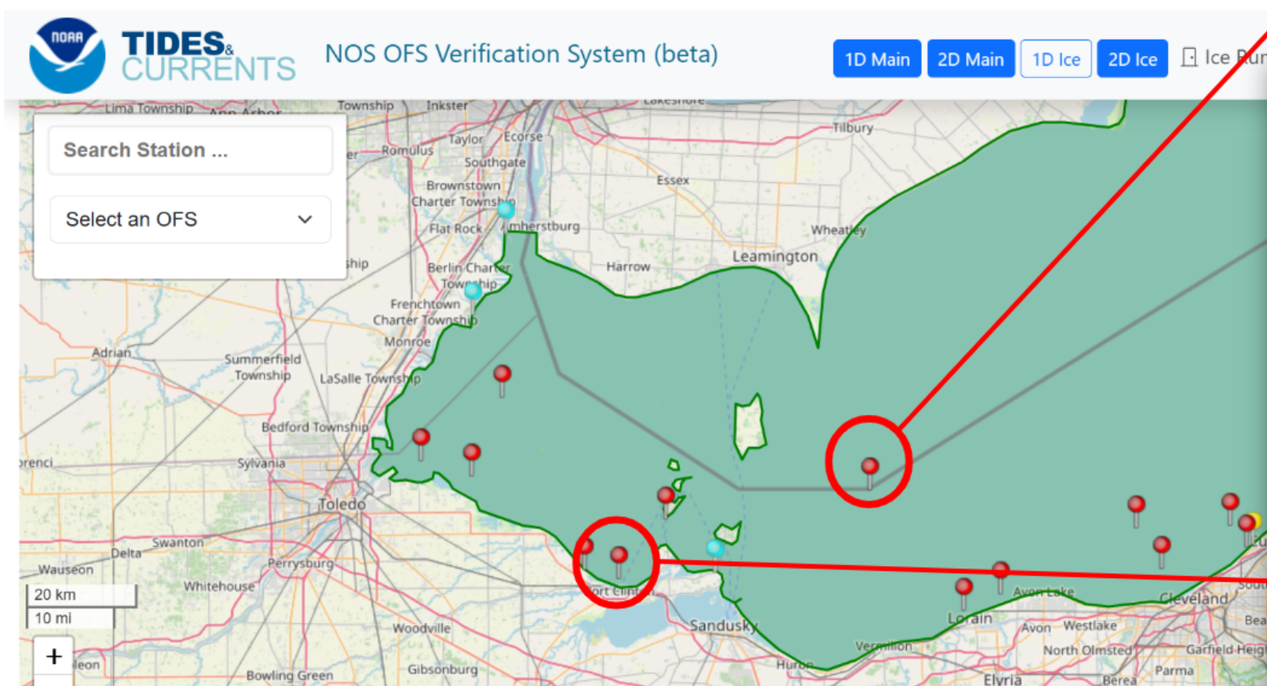
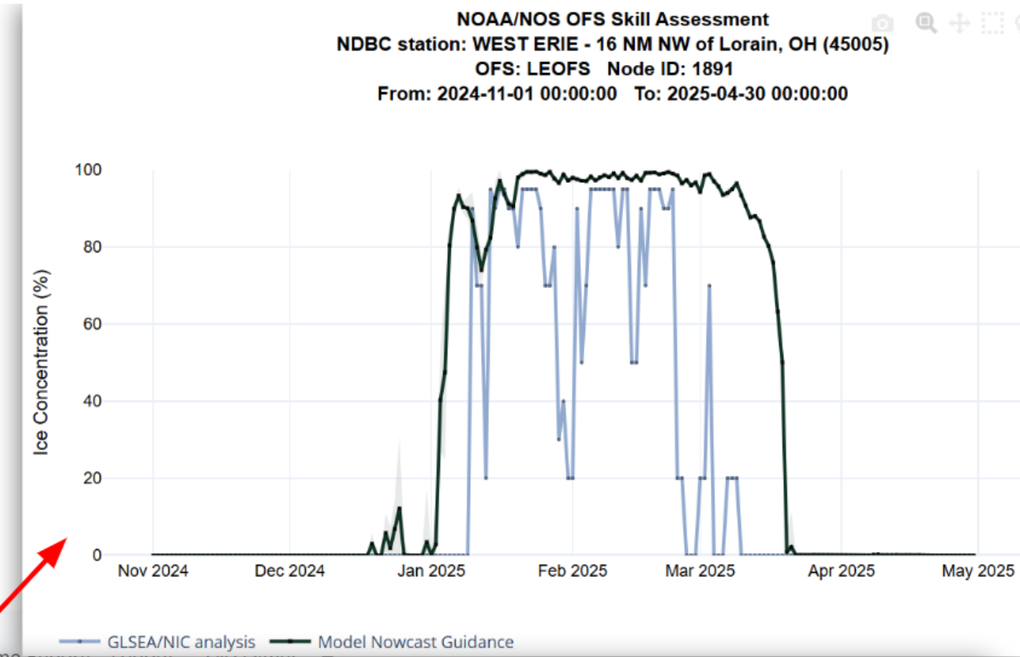
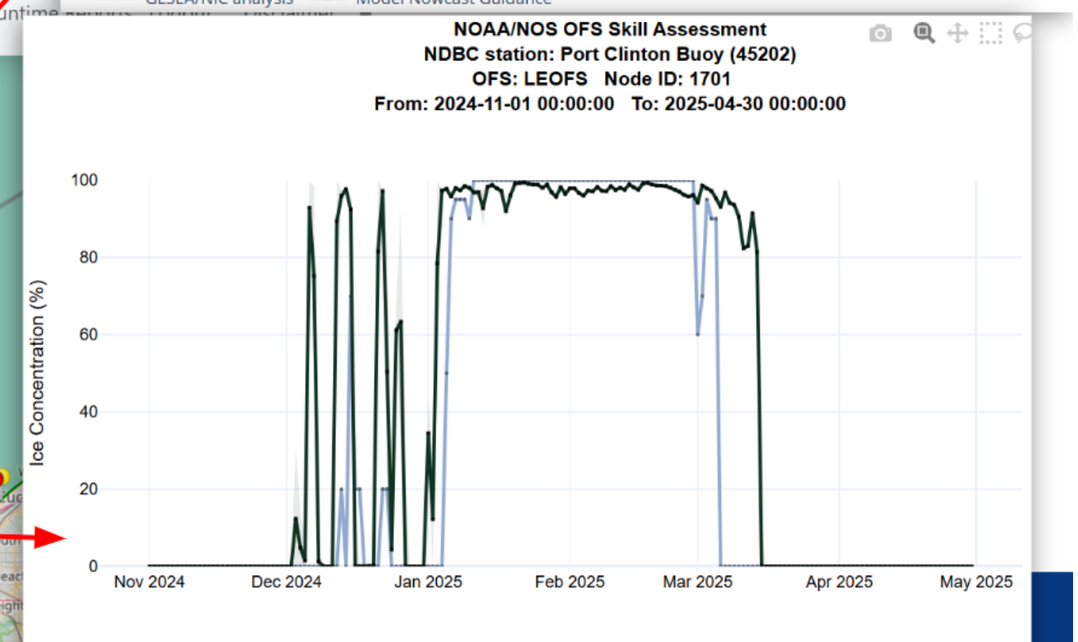






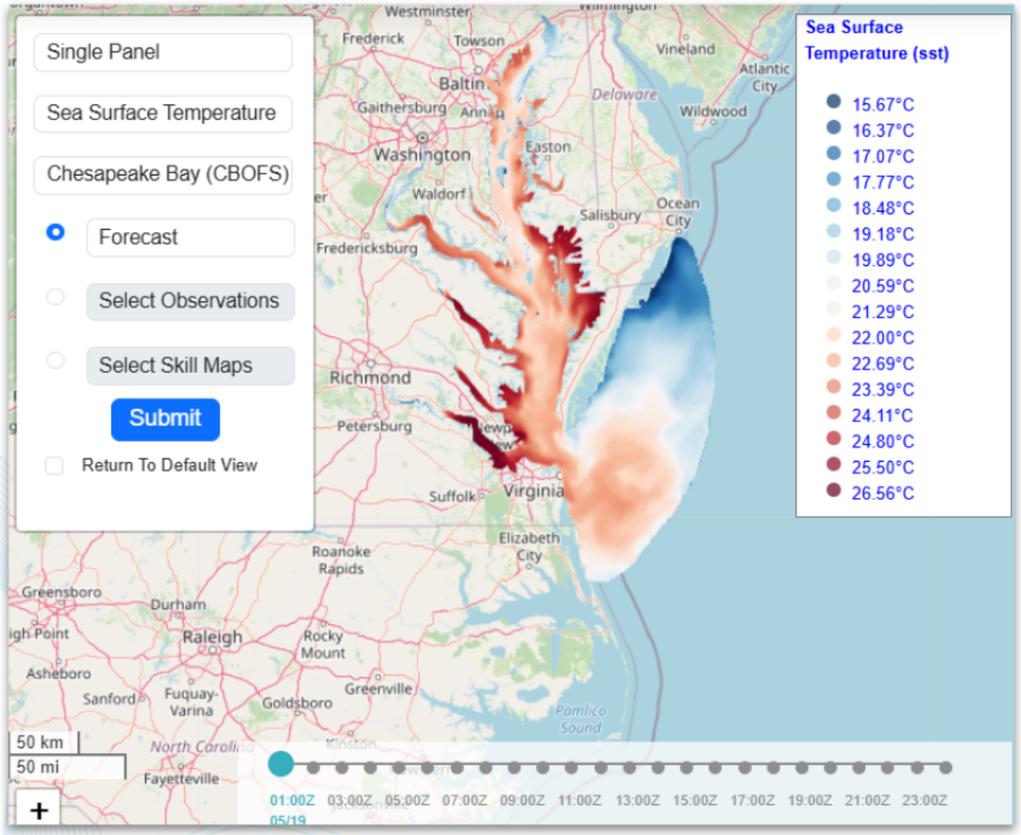
Remote Sensing (2D) Analysis

Current capabilities:

- ➔ Python package: Skill assessment of OFS **sea surface temperature and ice** using L3C SST data and GLSEA analysis
- ➔ Web app: Single pane, and side-by-side comparisons of model and observational 2D fields, with time slider and color bar

Remote Sensing (2D) Analysis

Current capabilities:

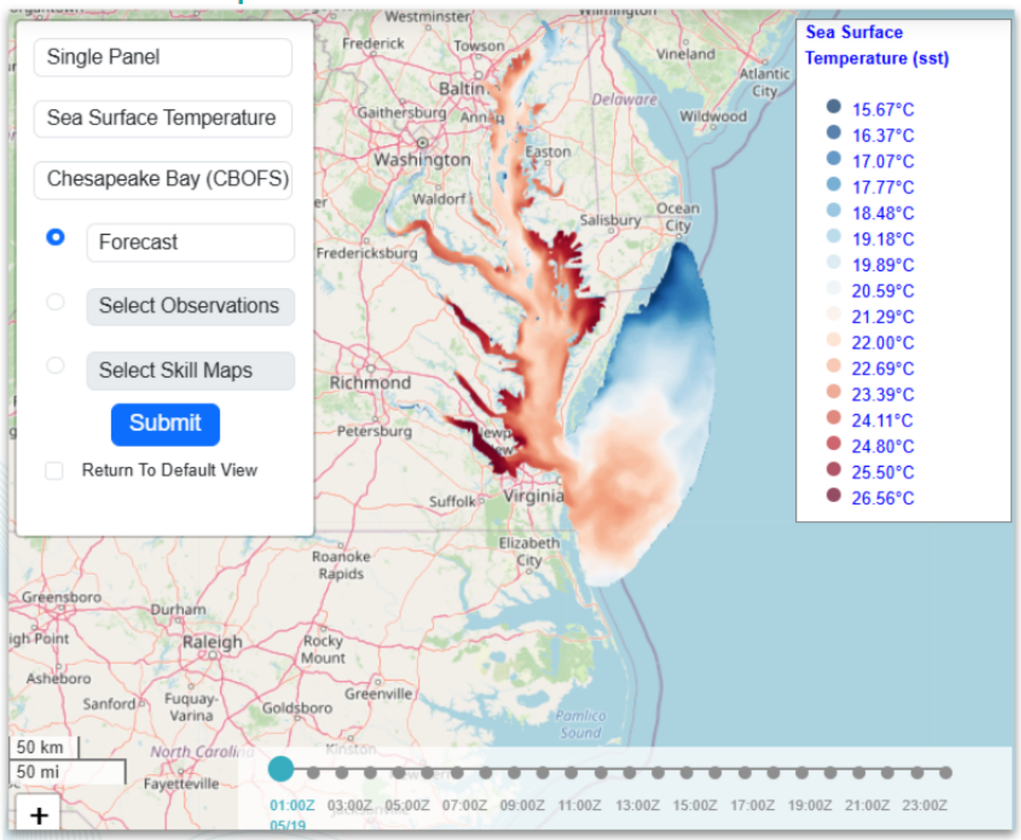


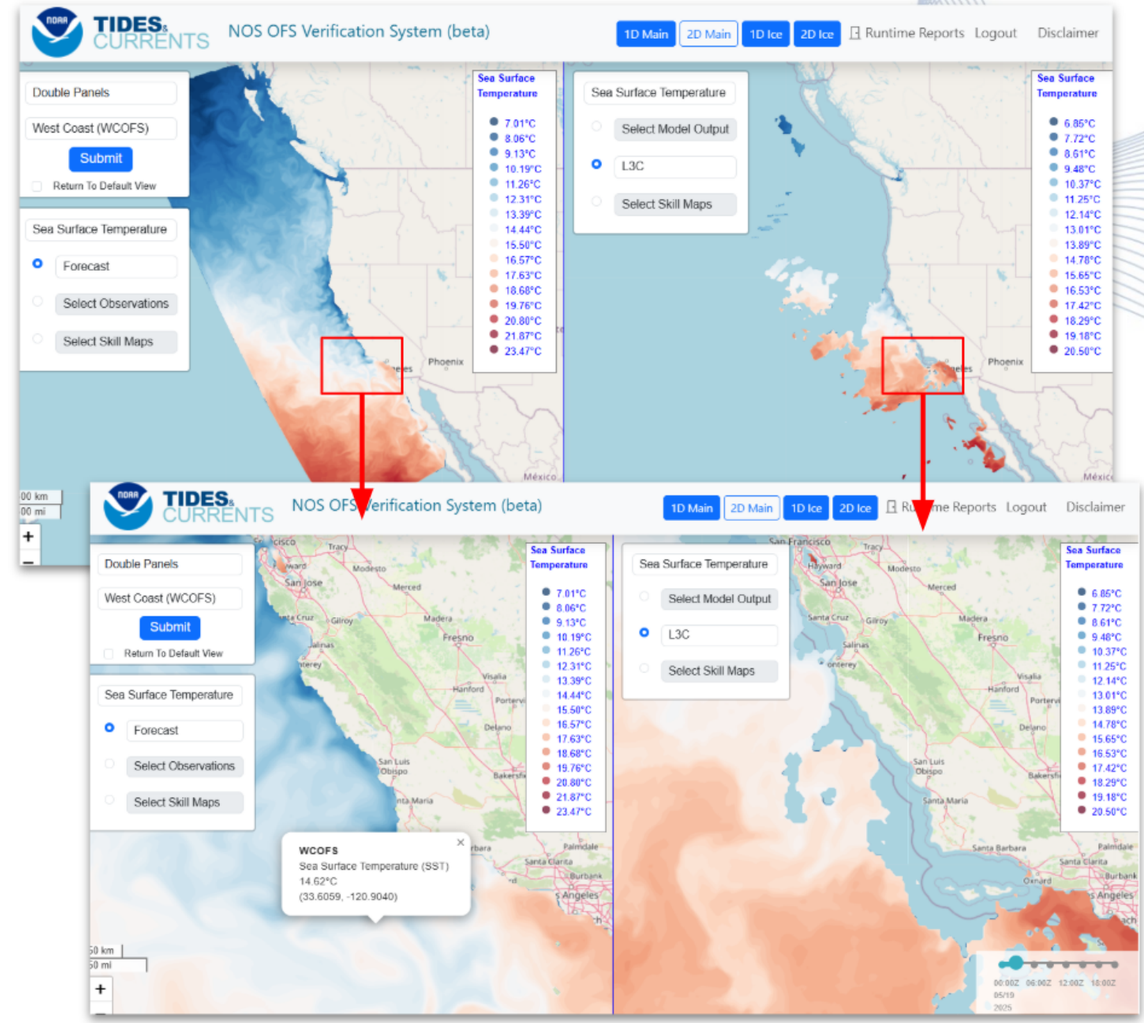
Future capabilities:

- ➔ Python package: Skill assessment of **sea surface height, currents, and salinity**
- ➔ Web app: User customizable color scale.

Remote Sensing (2D) Analysis

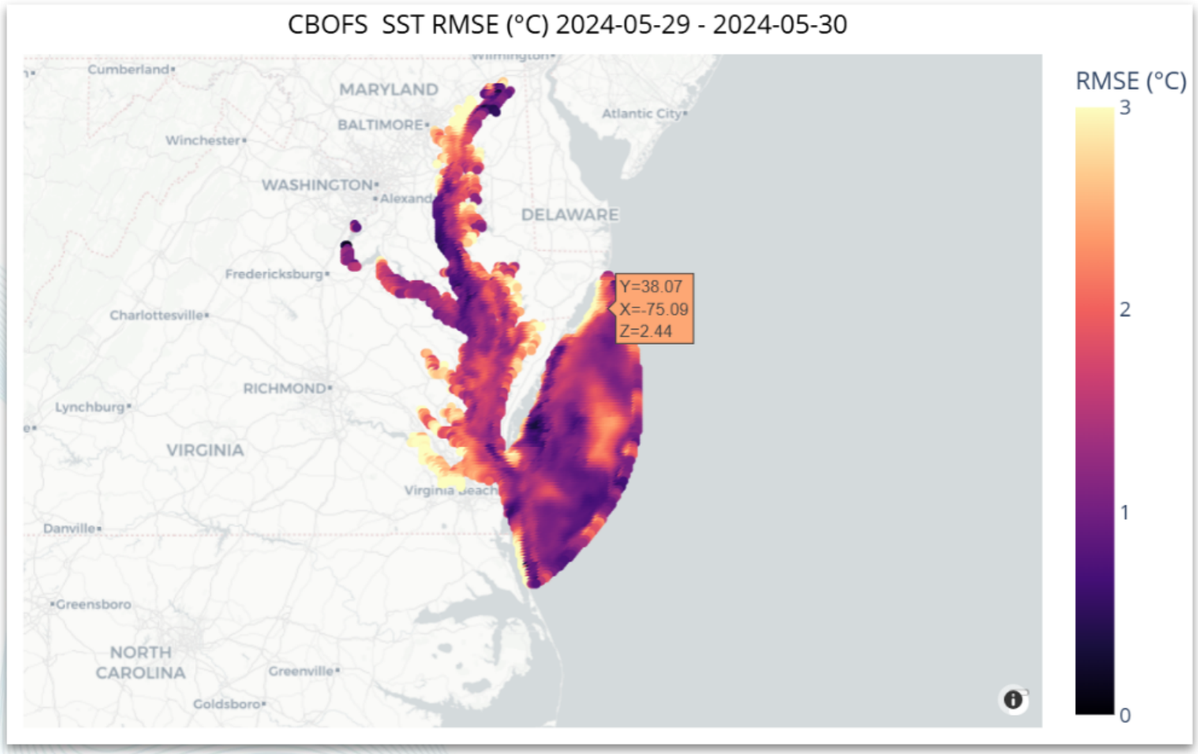
Current capabilities:





Remote Sensing (2D) Analysis

Visualizing model skill



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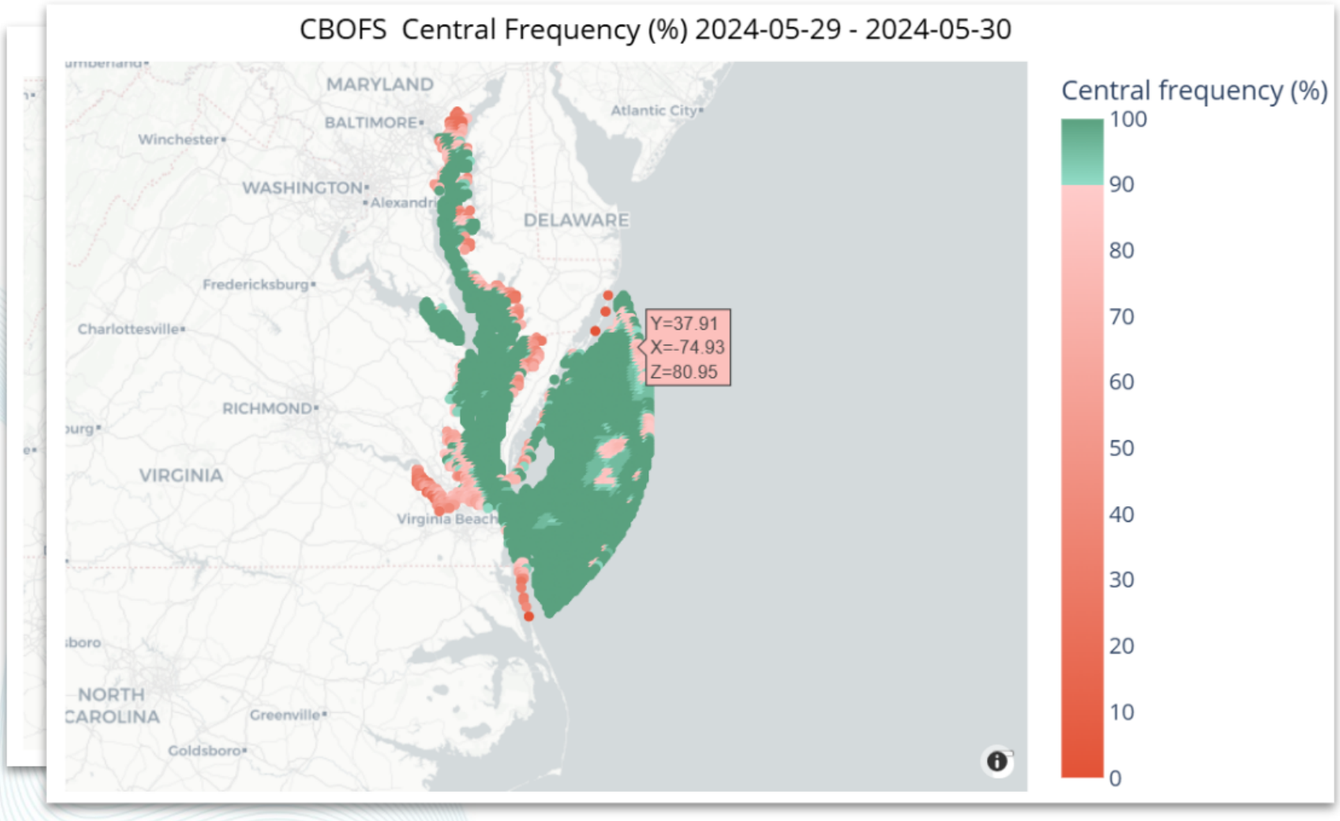

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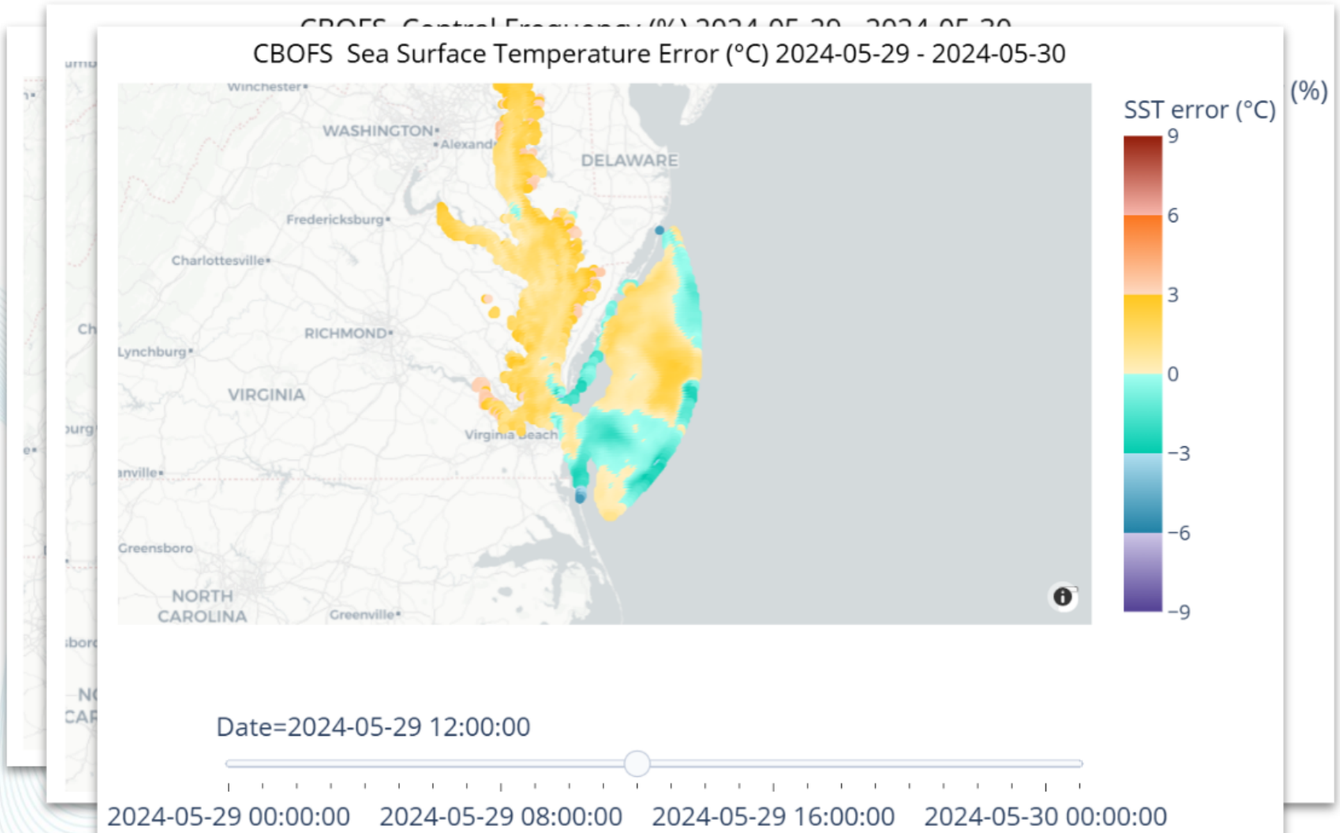

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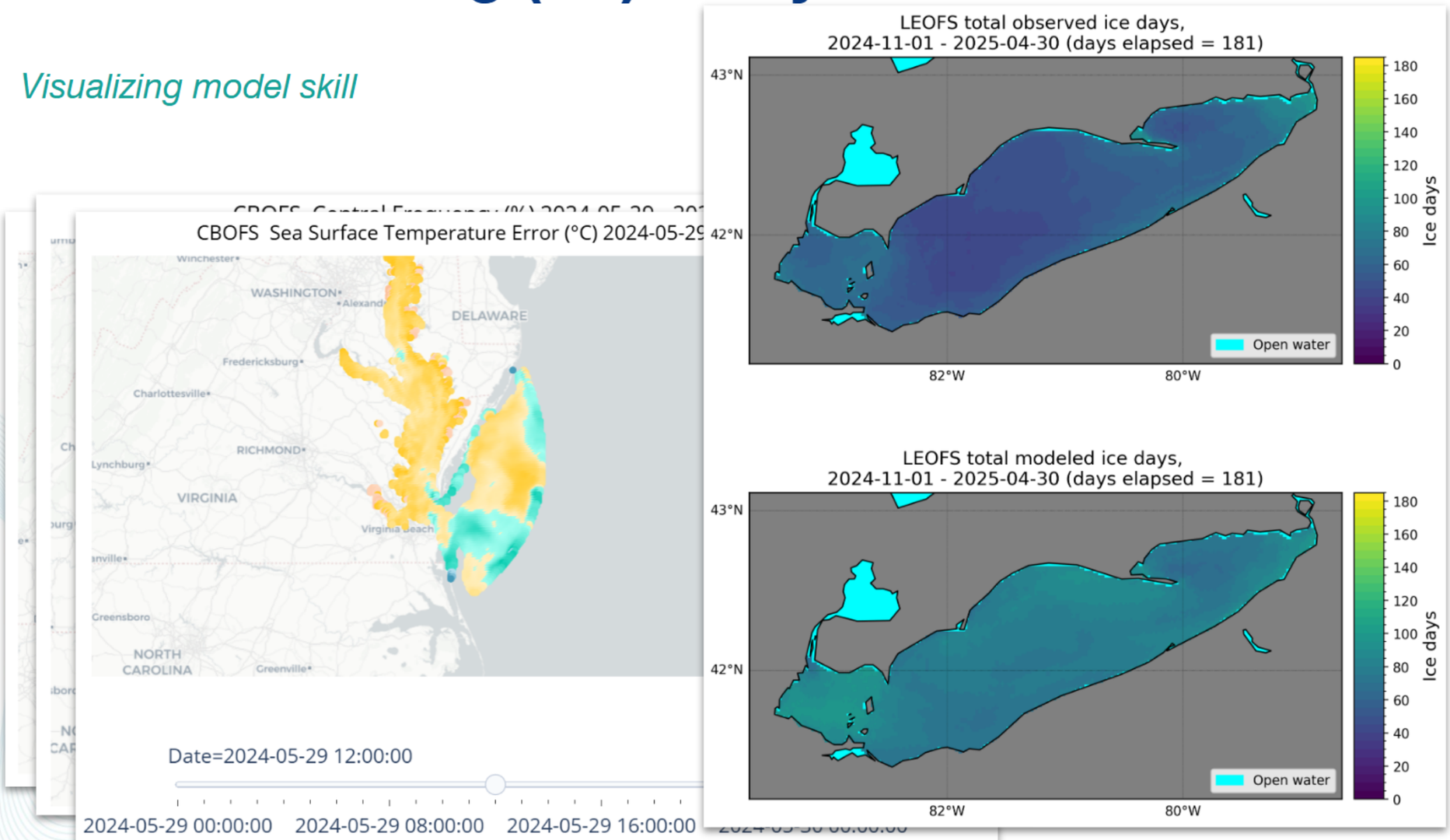
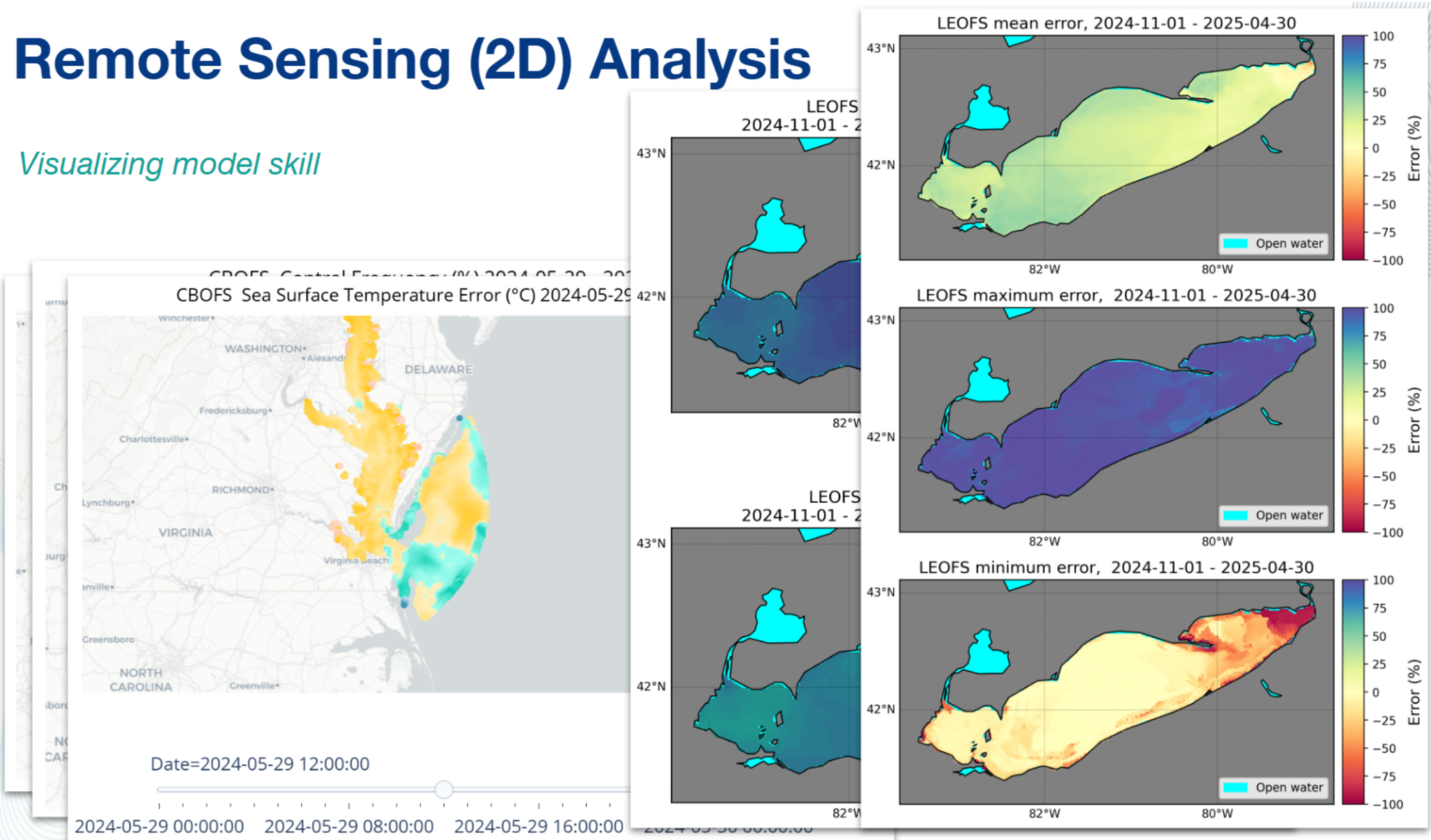


Ice extent stats

Remote Sensing (2D) Analysis

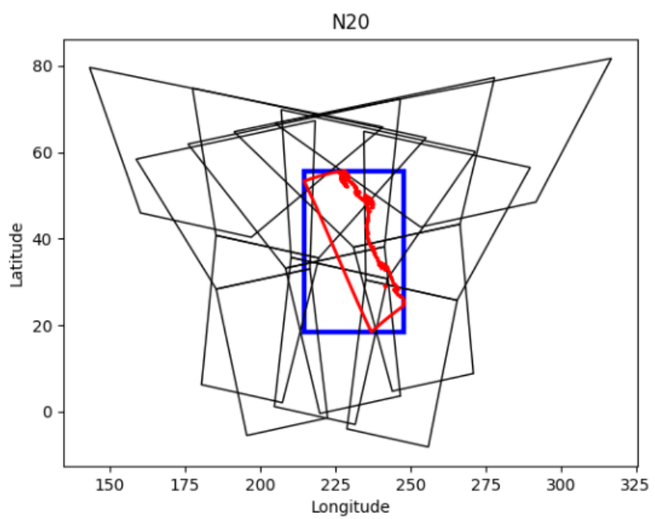
Visualizing model skill

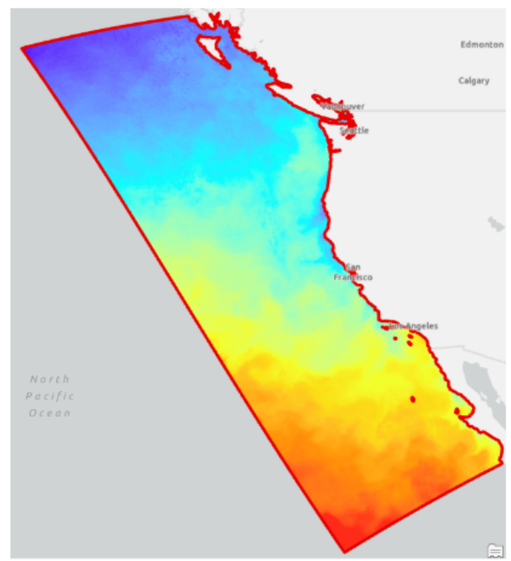


Ice concentration stats

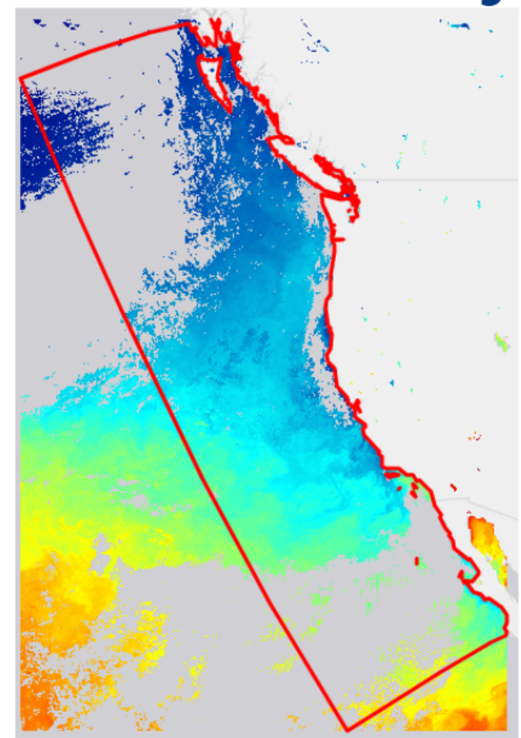
Coming Up: Adding more data for user analysis

- SST
  - L3U VIIRS NRT
  - L3S LEO
  - NASA SPoRT (L4)
- SSH, SSS
- Satellite granule swath intersection calculation for faster processing/fewer downloads and computations

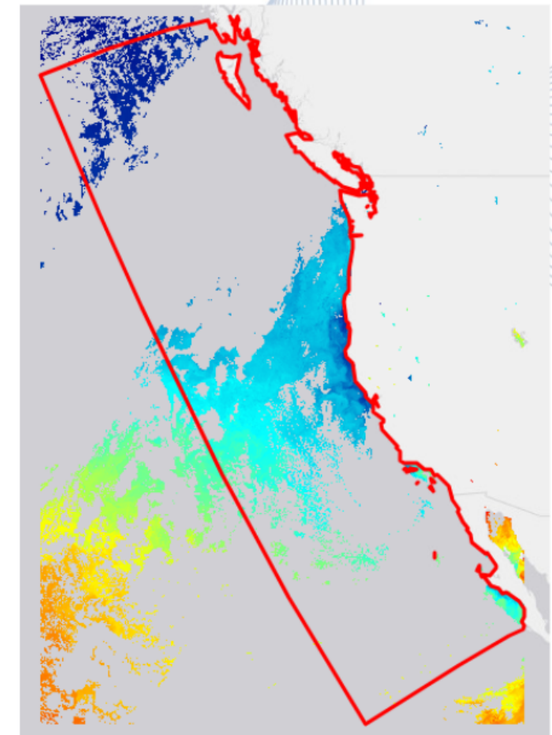




SPoRT



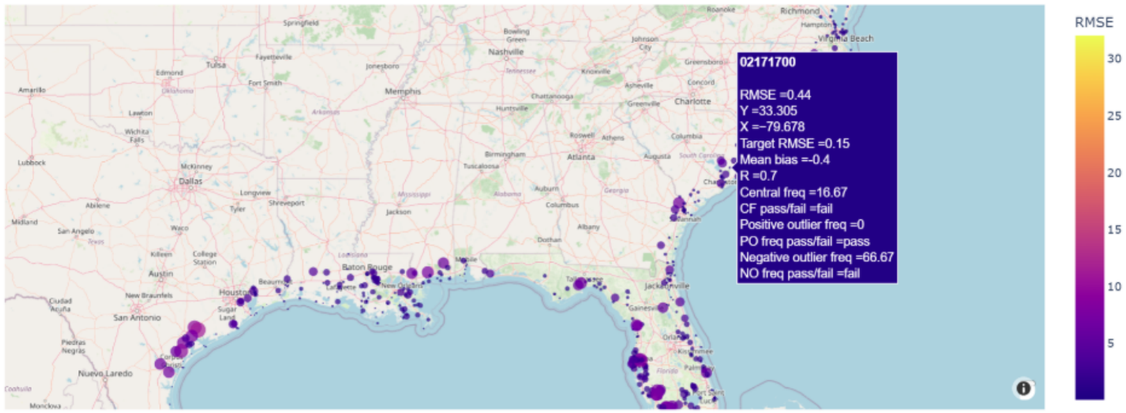
L3S



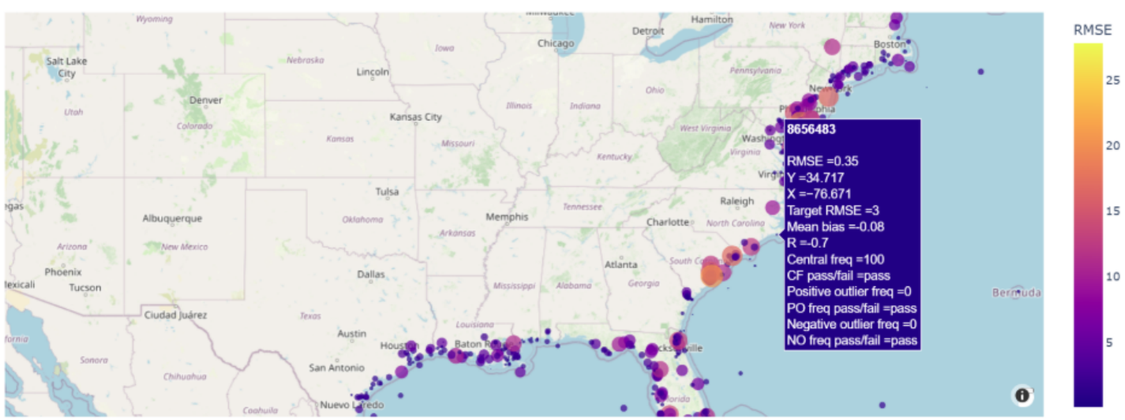
L3U

Coming Up: Adding SCHISM to Python package

STOFS_3D_ATL forecast_b water level skill statistics, 2024-06-06 - 2024-06-06



STOFS_3D_ATL forecast_b temperature skill statistics, 2024-06-06 - 2024-06-06



New capability for storm surge model skill assessment

Current status:

- 1D assessment of STOFS-3D-Atlantic simulated water levels, currents, temperature, and salinity from gridded model outputs.

Future capability:

- Adding 1D assessment of STOFS-3D-Atlantic using station outputs
- Adding 1D assessment of STOFS-3D-Atlantic to the web app
- Adding 2D and 3D assessments of STOFS-3D-Atlantic

Package highlights and key technologies

- New update: Updates to model read method leveraging **Dask and Intake** python packages
  - Resulting in: Eliminated need for writing large concatenated model file, resulting in **significantly faster SCI/SA runtimes** and ability to run SCI/SA for **longer time series**
- New update: Increased usage of linting tools
  - Resulting in: Stricter adherence to pep8 python coding standards, more robust and easier to edit code
- New update: Model data download routine from **NODD S3** bucket
  - Resulting in: More **flexibility** in run environment
- New update: Additional logging and documentation improvements
  - Resulting in: More robust package

- Future capability: Automated **GitHub unit testing**
  - Resulting in: Faster development cycles and **decreased manual developer testing**
- Future capability: Updated python run environment (using uv or pixi)
  - Resulting in: More robust package management and faster build time

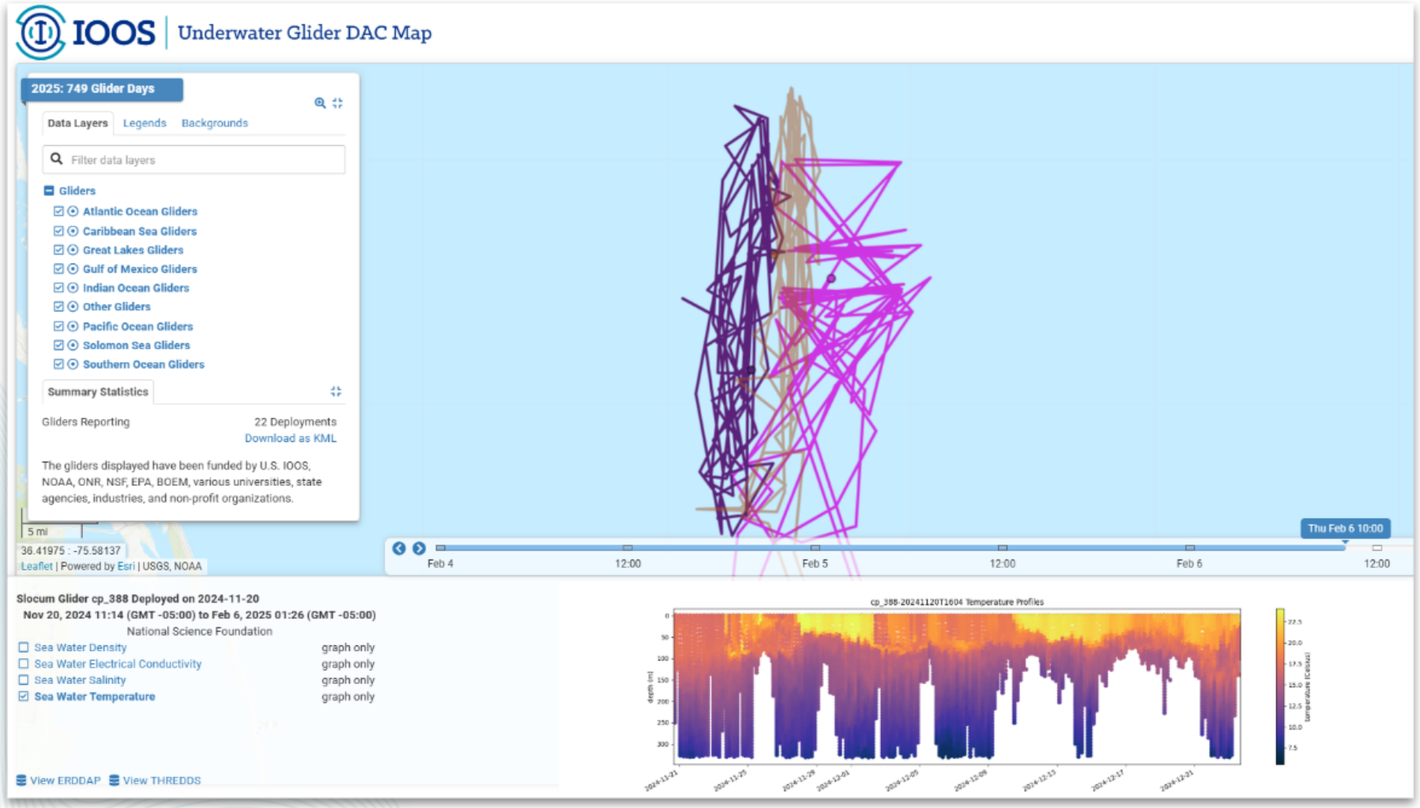
Coming Up: 3D Skill Assessment

Assessment of OFS using observations with varying depth and time

- Statistics and display: to be determined!
- R&D in progress and exploring IOOS glider database
- Looking for other sources of vertical salinity, temperature, and current velocity observations

Coming Up: 3D Skill Assessment

Assessment of OFS using observations with varying depth and time



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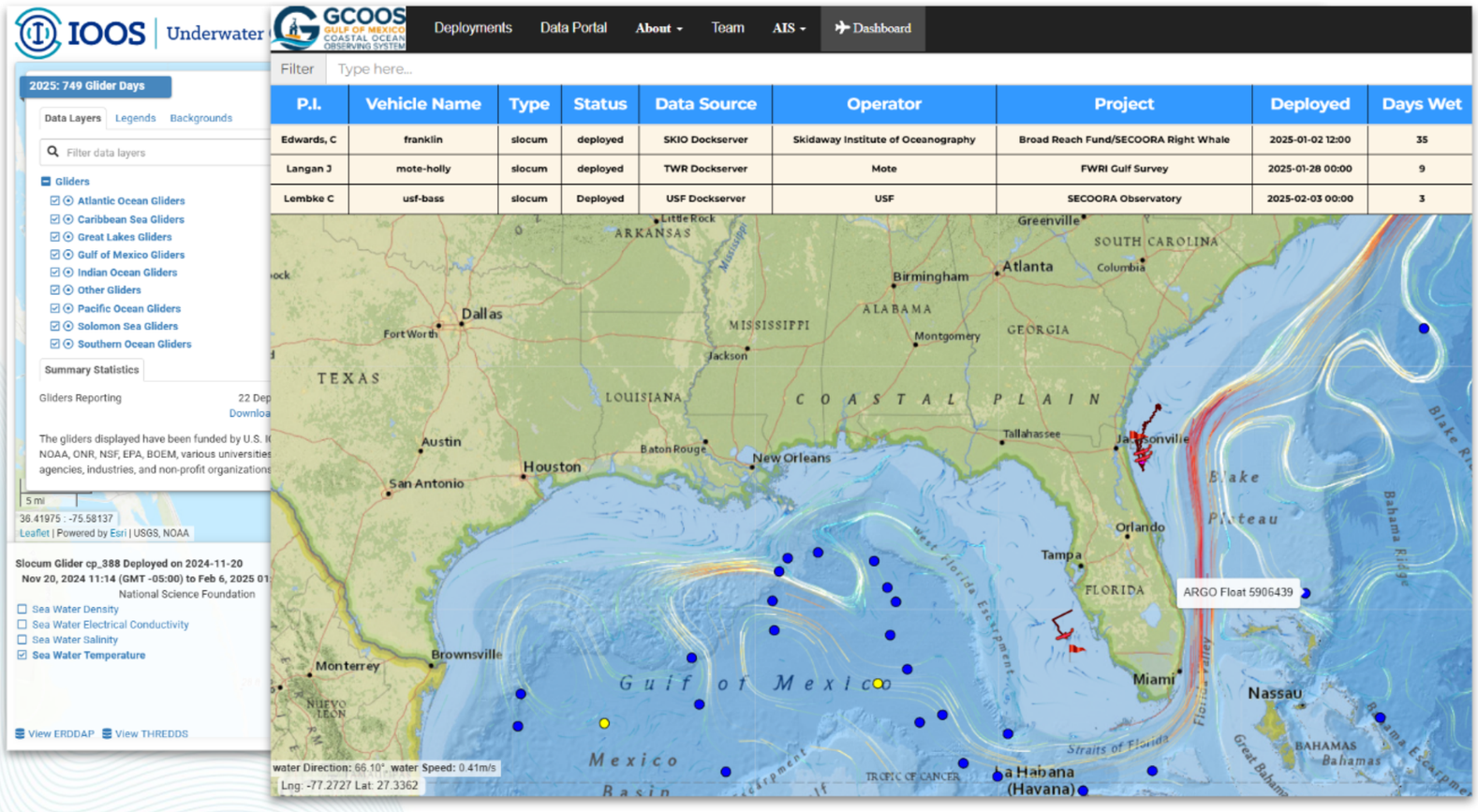

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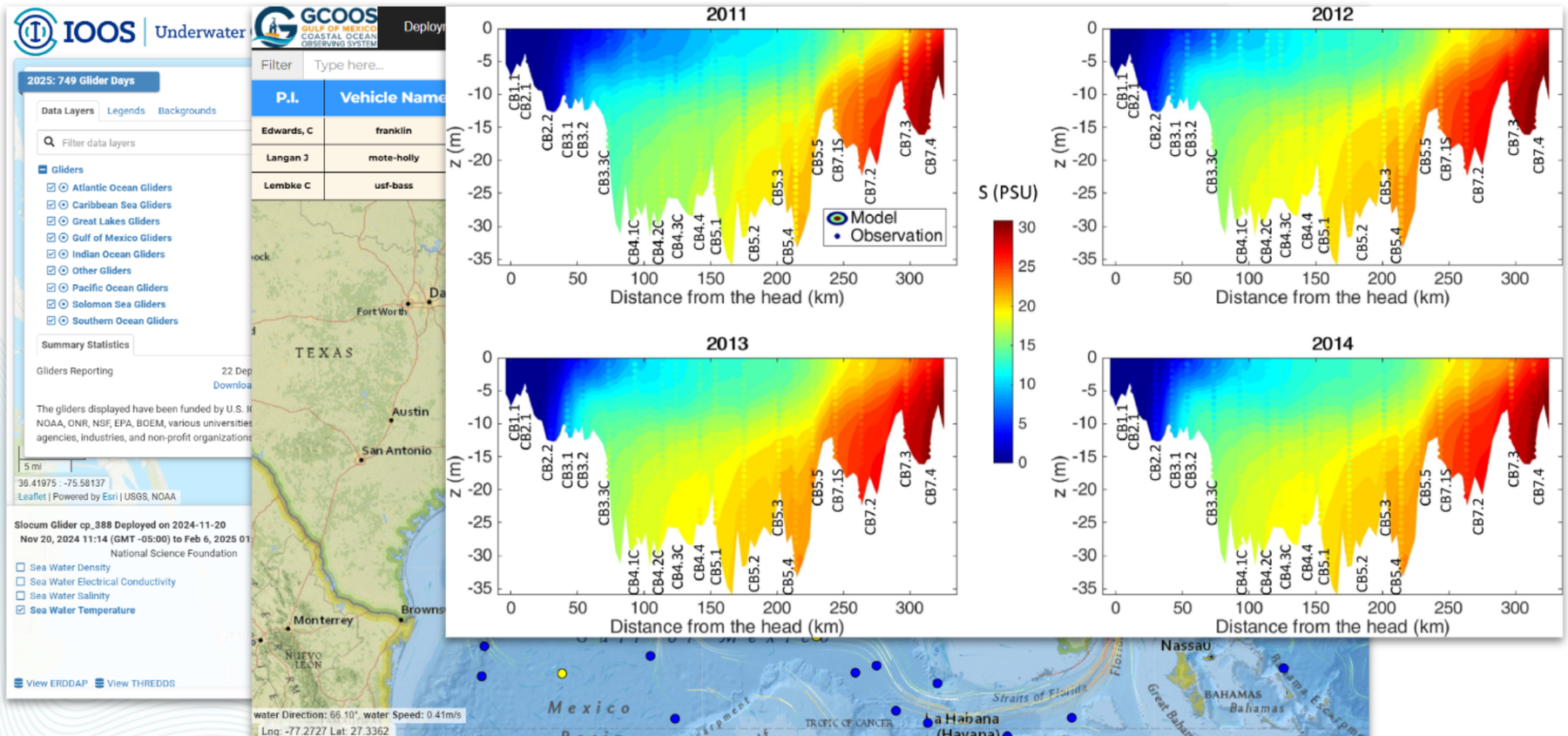

Ye et al. (2018)

Coming Up: 3D Skill Assessment

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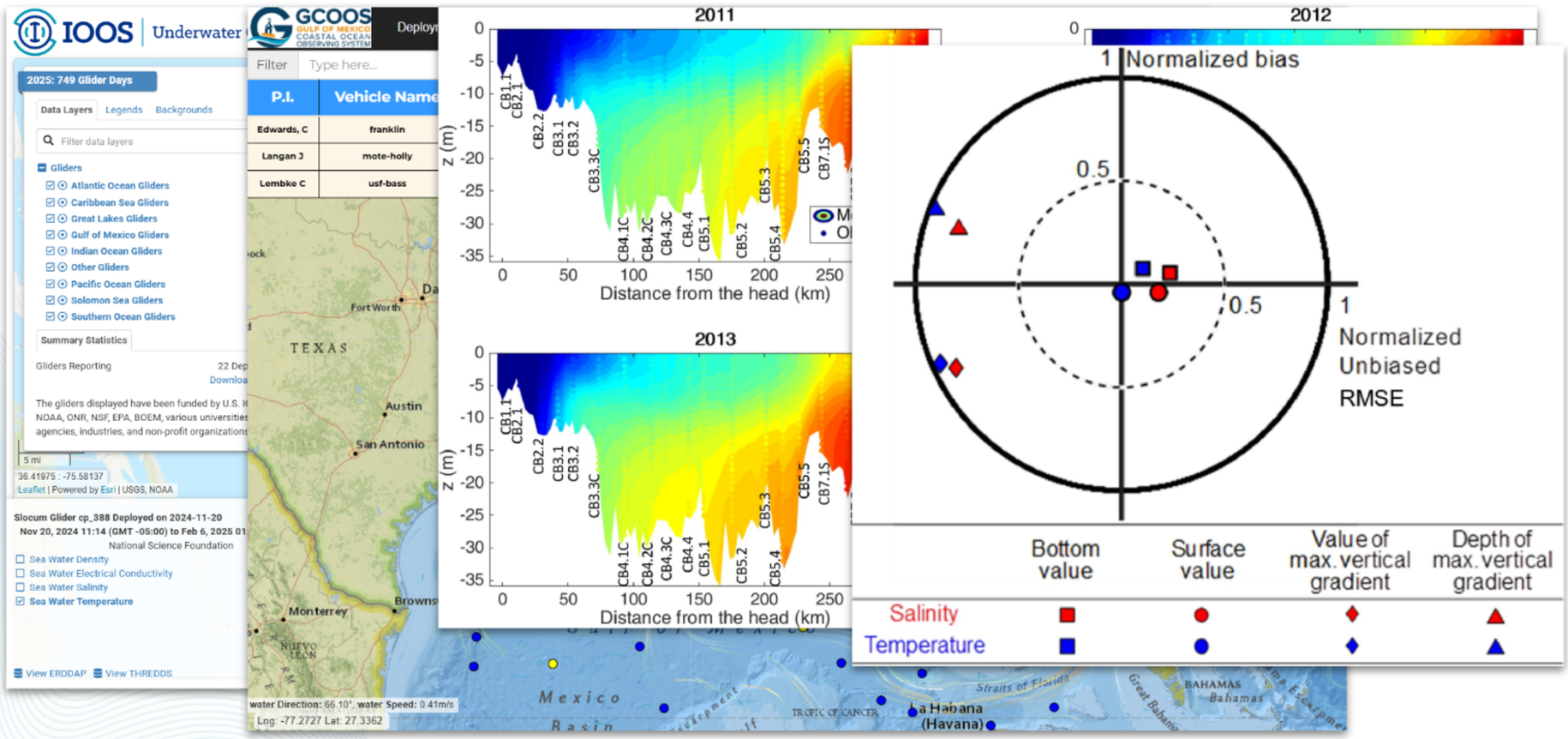
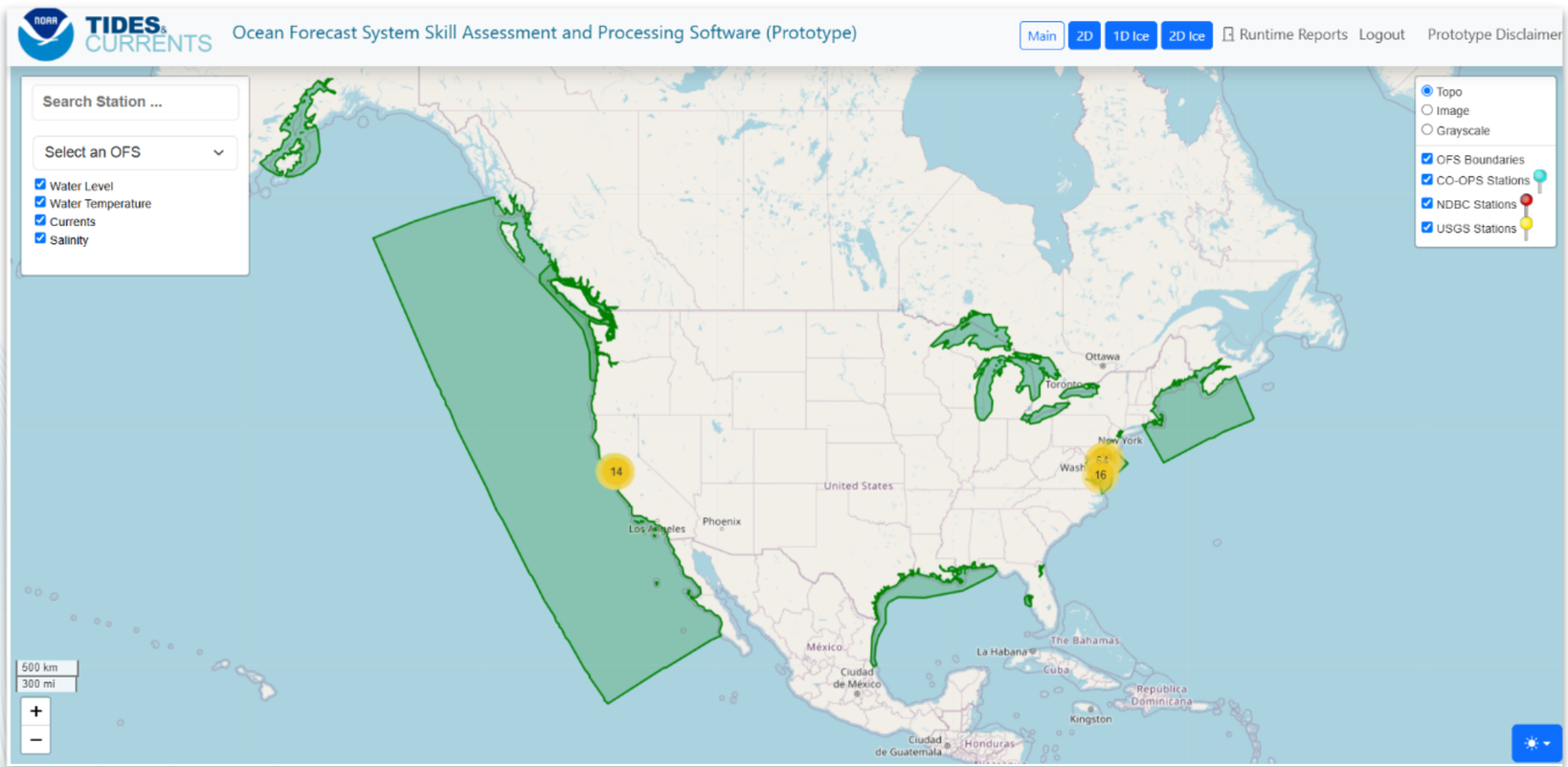


Ye et al. (2018)

Available Products

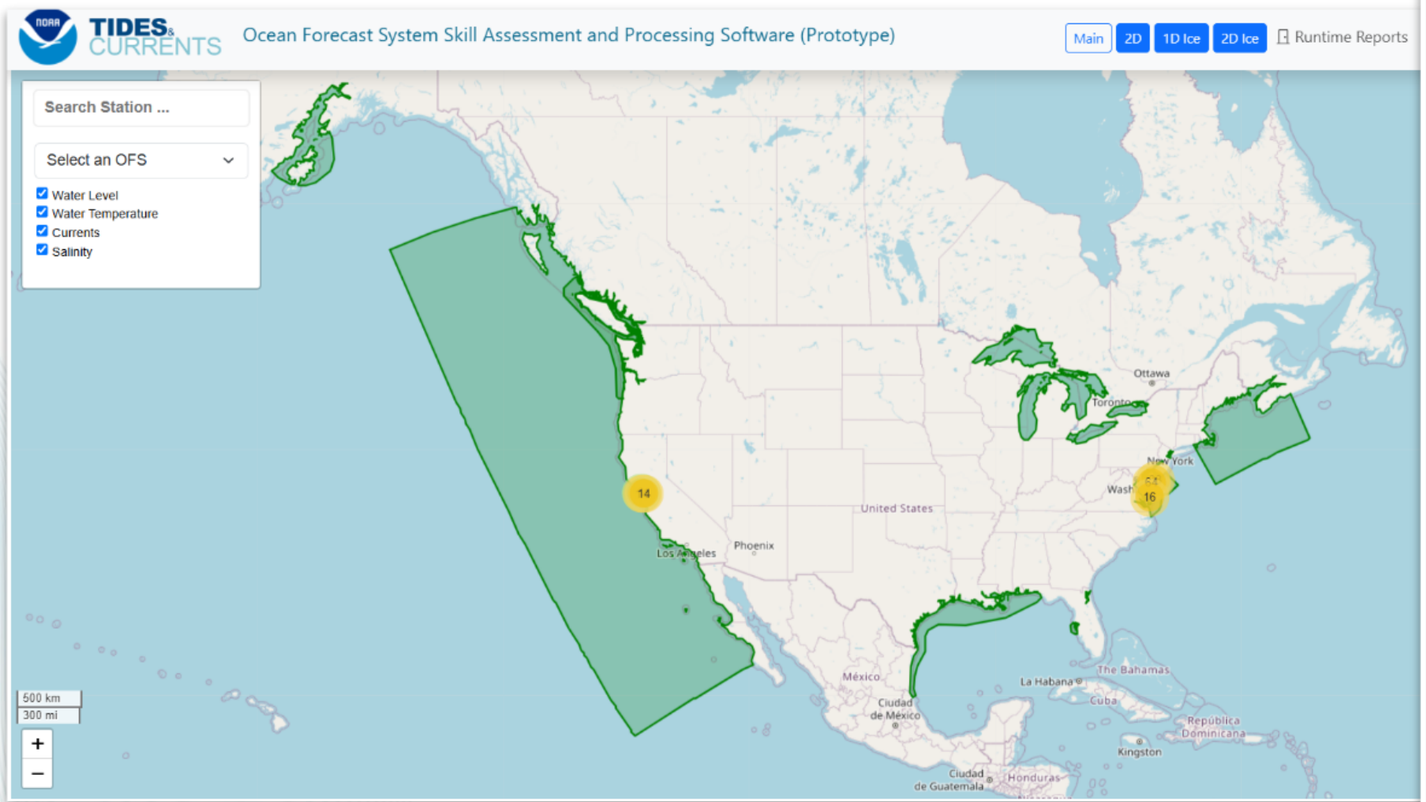
Web application: Version in development available periodically for user feedback



Available Products

Web application: Version in development available periodically for user feedback

Python package: Version 1.0.0-beta available in [this public GitHub repo]



README License

The Ocean Forecast Model Skill Assessment and Processing Software - 1D Prototype

[[TOC]]

This repository contains a prototype of the Ocean Forecast Model Skill Assessment and Processing Software, currently under development by NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) and Office of Coast Survey (OCS) as part of the Bipartisan Infrastructure Law (BIL) and Coastal and Inland Flood Inundation Mapping (CIFIM) project.

NOAA develops and maintains several Operational Forecast Systems (OFS) that provide nowcasts (past 24 hours to present time) and forecasts (up to 120 hours in the future) of water levels, currents, salinity, water temperatures, and winds for a given area. These OFSs are located in coastal waters around the nation and the Great Lakes in critical ports, harbors, and estuaries. Oceanographic output from Operational Forecast Systems can be used for, for example, search and rescue, recreational boating and fishing, and storm effect tracking.

The Ocean Forecast Model Skill Assessment and Processing Software, available and explained here, will provide near real-time evaluation of existing OFS model skill, and support the development of increasingly skillful OFSs. This new Python-based skill assessment software will replace the existing Fortran-based NOS skill assessment software. A map-based interface to view skill assessment results produced by this software will also be available, but is not detailed here.

1. 📌 Overview

The Ocean Forecast Model Skill Assessment and Processing Software consists of four main modules, each built on modular Python scripts:

👉 **Acquisition of observational data**, including water level, water temperature, salinity, and currents (speed and direction) from NOAA CO-OPS, USGS, and NDBC databases;

👉 **Postprocessing of Operational Forecast System (OFS) model outputs**, including nowcasts and forecasts, to match user inputs for time span and location;

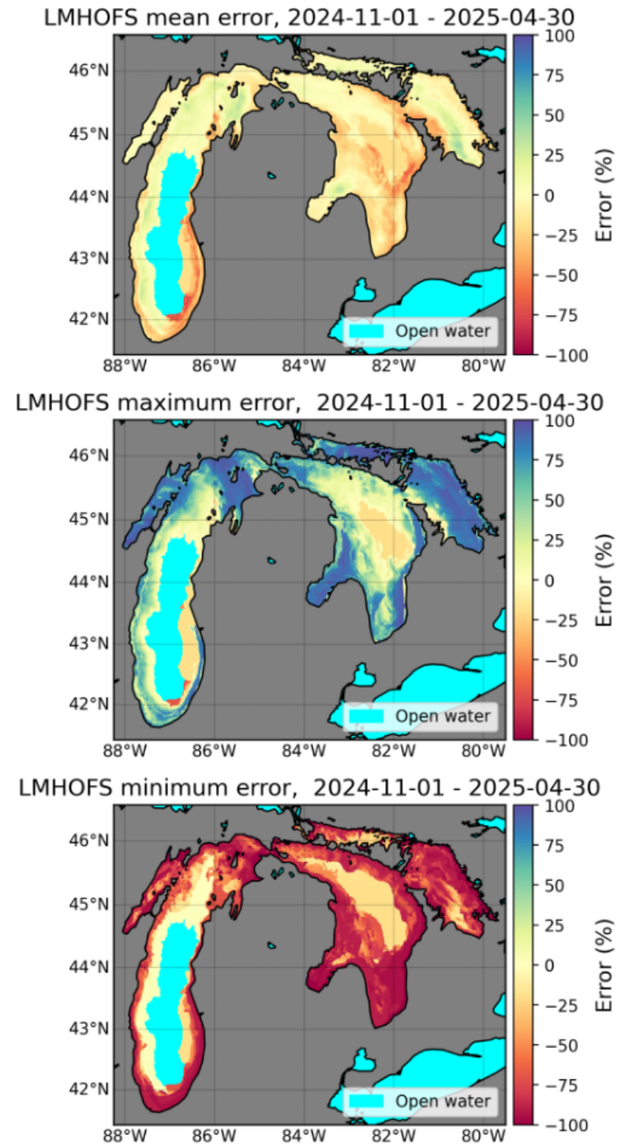
👉 **Skill assessment of OFS model performance** compared to observational data, with basic skill statistics such as root mean square error, bias, and correlation coefficients;

👉 **Data visualization** in interactive plots, with time series of model output compared to observations, as well as boxplots of each time series.

Capabilities included in this prototype software are outlined in dashed red in the flow chart below. In a future update,

Next Steps

- Release the next stable version (v1.1.0-beta) of the web app and Python package for user feedback
- Continue development of modules following coding and testing best practices, including code optimizations to increase efficiency
- Test package against existing Fortran skill assessment software
- Develop new features based on user feedback
- Many, many bug fixes



SCI/SA Dream Team

CO-OPS

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- ★ Andrew Kammerer
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- ★ Xu Chen
- ★ Armin Pruessner
- ★ Lucila Houttuijn Bloemendaal
- ★ *Felicio Cassalho (Previously at CO-OPS)*

OCS

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- ★ Rachel Ackerman
- ★ Alex Kurapov
- ★ John Kelley