The Evaluation of a Data Assimilative Northeast Coast Operational Forecast System in 2021

Lixia Wang[1,2], Jiangtao Xu[2], Aijun Zhang[2], Wei Wu[3], Changsheng Chen[4], Qichun Xu[4], Siqi Li[4], Lu Wang[4] , Lucila Houttuijn Bloemendaal[2], Edward Myers[3]
[1]Ocean Associates Inc. [2]National Ocean Service/Center for Operational Oceanographic Products and Services [3]National Ocean Service/Office of Coast Survey [4]University of Massachusetts Dartmouth
Lixia.Wang@noaa.gov

Abstract

NOAA's National Ocean Service (NOS) has been jointly developing and testing a new data assimilative U.S. Northeast Coast Operational Forecast System (NECOFS) based on the Finite Volume Community Ocean Model (FVCOM) developed by the University of Massachusetts - Dartmouth (UMASSD) - WHOI research team. The goal of this project is to operationally implement NECOFS on NOAA's Weather and Climate Operational Supercomputing System (WCOSS) by the end of FY27 Q1. This presentation will focus on model performance from a 6-month hindcast simulation (July 1 –December 31, 2021) by comparing NECOFS outputs with observations and outputs from the existing NOS Operational Forecast Systems (OFS) of the New York-New Jersey OFS (NYOFS), the Chesapeake Bay OFS (CBOFS), the Delaware Bay OFS (DBOFS), and the Gulf of Maine OFS (GOMOFS). The hindcast simulation is driven by a full suite of forcing conditions including tidal and non-tidal water levels, 3-D currents, water temperature, and salinity from the Real Time Ocean Forecast System (RTOFS) on the lateral open ocean boundary; along with meteorological forcing from the North American Model (NAM) on the surface and river discharges from USGS observations. NECOFS assimilates the satellite absolute dynamic topography, sea surface temperature (SST), and in-situ observations of temperature and currents. NECOFS provides comparable results in water level as the existing OFS, and significantly improves water temperature performance due to the assimilation of satellite SST and in-situ observations. The inclusion of in-situ currents observations also demonstrated noticeable improvements in model performance.

1. Computational Domain and Grid

This new NECOFS model domain extends from Bald Head Island, North Carolina northeastward to Nova Scotian Shelf, Canada. It covers the four existing operational forecast systems: CBOFS, DBOFS, NYOFS, and GOMOFS (Fig.1). The model grid has been further refined in Chesapeake Bay, Delaware Bay, New York Harbor, and New Jersey harbors using NOAA's National Centers for Environmental Information (NCEI) Continuously Updated Digital Elevation (CUDEM) data and the most recent bathymetry available from NOAA's National Bathymetric Source (NBS).

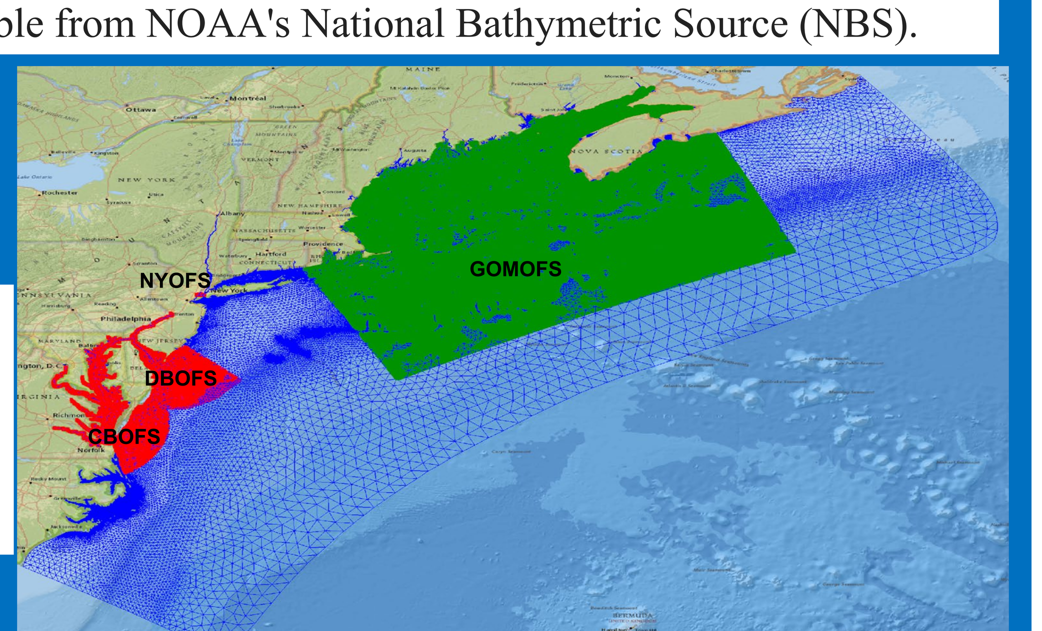

Fig.1 The model grid and the computational domain of the new Northeast Coast Operational Forecast System (NECOFS). The grid covers four existing Operational Forecast System (OFS), CBOFS, DBOFS, NYOFS, and GOMOFS.

2. NOAA's NECOFS Model Hindcast Configuration

- FVCOM-based unstructured grid:
  207081 nodes, 371290 elements, 45 vertical layers
  Horizontal grid size: 80 m - 40 km
  Time step 10s
  Semi-implicit mode
- Surface forcing: North American Mesoscale Forecast System (NAM)
- Open boundary forcing:
  Water level and currents: Tides + Real Time Ocean Forecast System (RTOFS)
  Temperature and salinity: RTOFS
  Longshore forcing: inflow of cool and lower salinity water from upstream Scotian Shelf
- River discharge forcing: USGS observations
- Data assimilation (DA):
  Satellite daily absolute dynamic topography (sea surface height (SSH)), satellite sea surface temperature(SST), and in-situ temperatures and currents
- Hindcast time period: July 1 ~ December 31, 2021

3. Data Assimilation

The new NECOFS uses a combined optimal interpolation (OI) and nudging scheme to assimilate various observational data and to produce more accurate and dynamically consistent forecasts. The OI scheme is employed to assimilate the in-situ observation of temperature and the nudging scheme is used to assimilate satellite-derived SSH and SST, as well as in-situ current velocity observations. The in-situ temperature and current data are collected from all publicly available sources, as shown in Fig.2 and Fig.3).

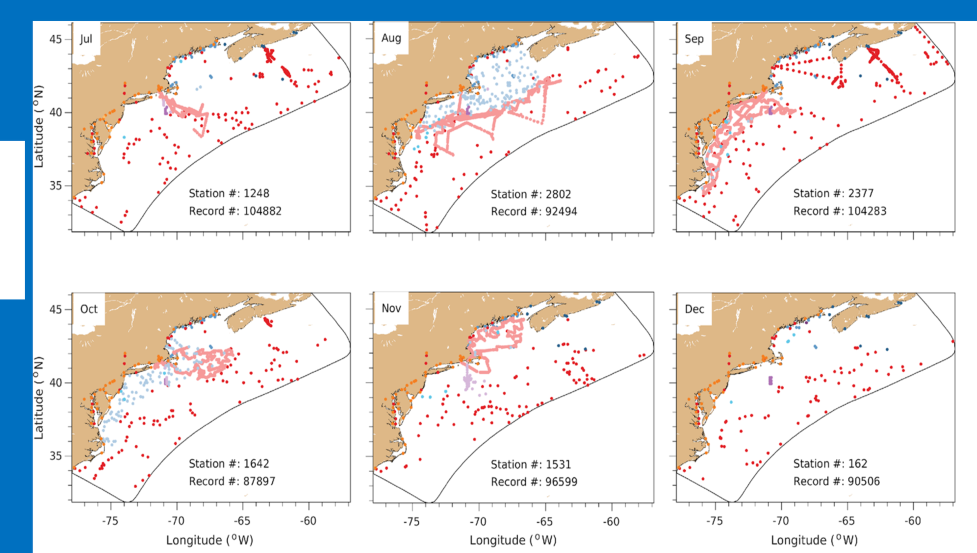

Fig.2 Locations for in-situ temperature observations in different months

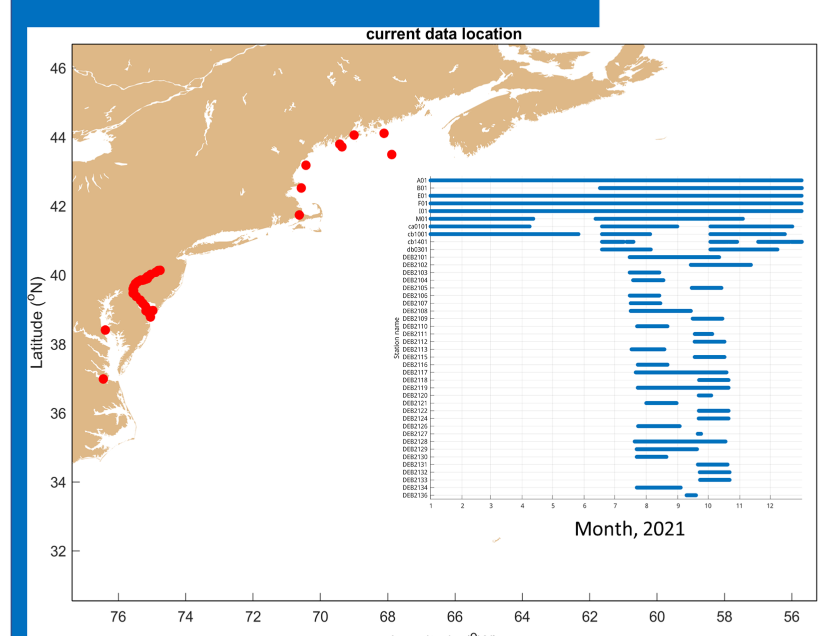

Fig.3 Locations and time periods for in-situ current observations

4. NECOFS Hindcast Simulation

The hindcasts from July 1 to December 31, 2021 have been conducted and the simulation results for two scenarios are presented here: without data assimilation (Non-DA) and with data assimilation (DA). RMSE skill assessment (Fig.4) show NECOFS with data assimilation significantly improve the performance for the water temperature and current speed by assimilating satellite SST and in-situ observation data.

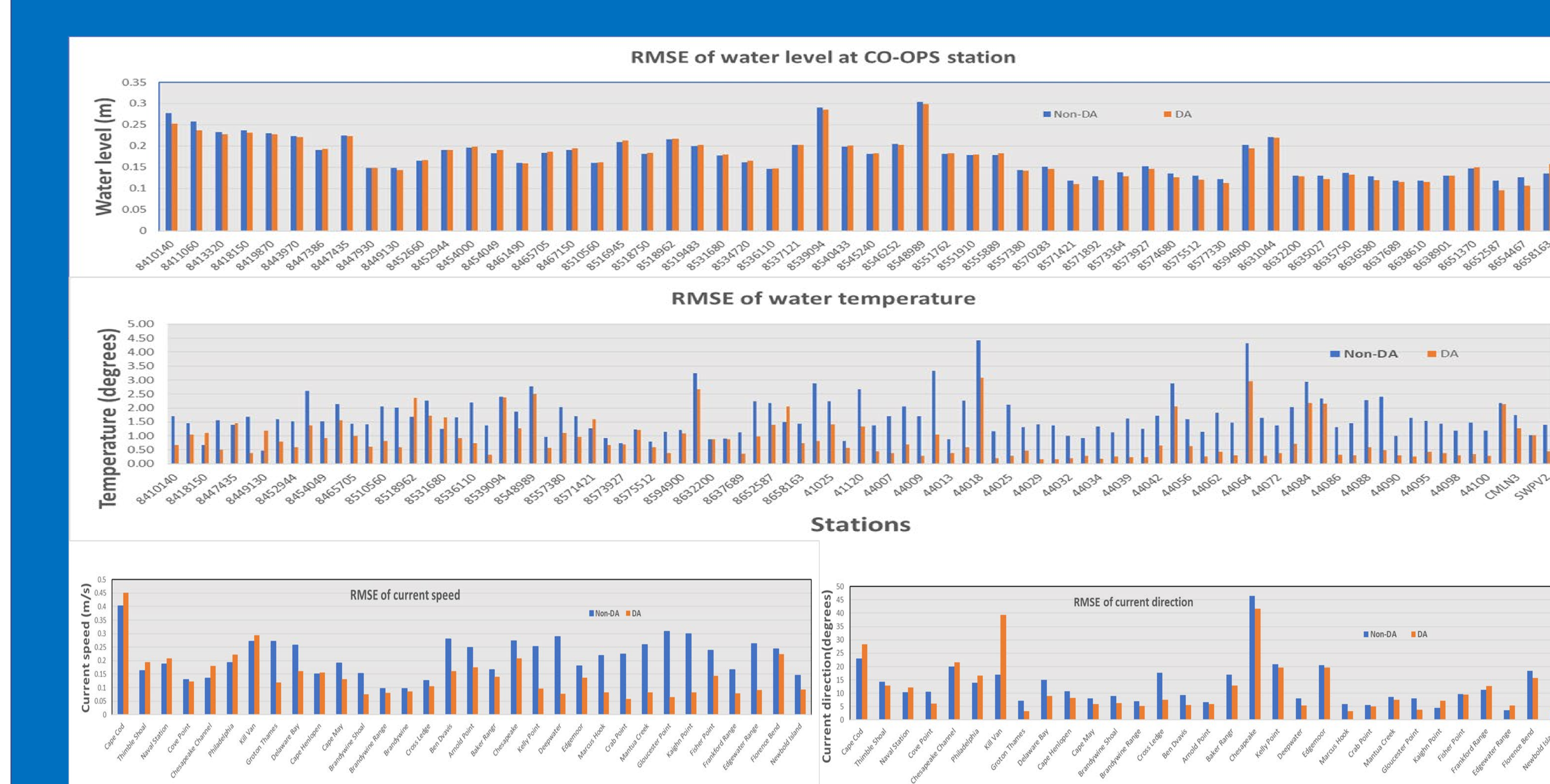

Fig. 4 Comparisons of water level (upper), temperature (middle), and current speed and direction (lower) between the cases with/without DA.

5. Cross-model Comparison

NECOFS is FVCOM-based unstructured grid and the existing CBOFS, DBOFS, and GOMOFS are ROM-based structured grids, while NYOFS is a POM-based structured grid. Although their numerical configurations and the computational domains are different, the cross model comparisons provide pros and cons of different models. Figures 5-8 show the comparisons between NECOFS and the existing OFS.

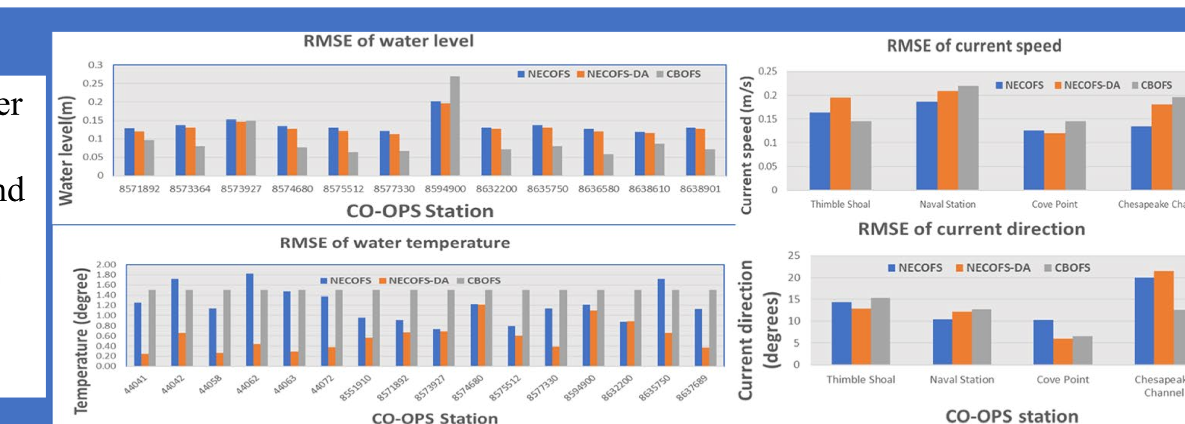

Fig.5 Comparisons of water level(left upper), temperature(left lower), and current speed(right upper) and direction (right lower) between NECOFS and CBOFS

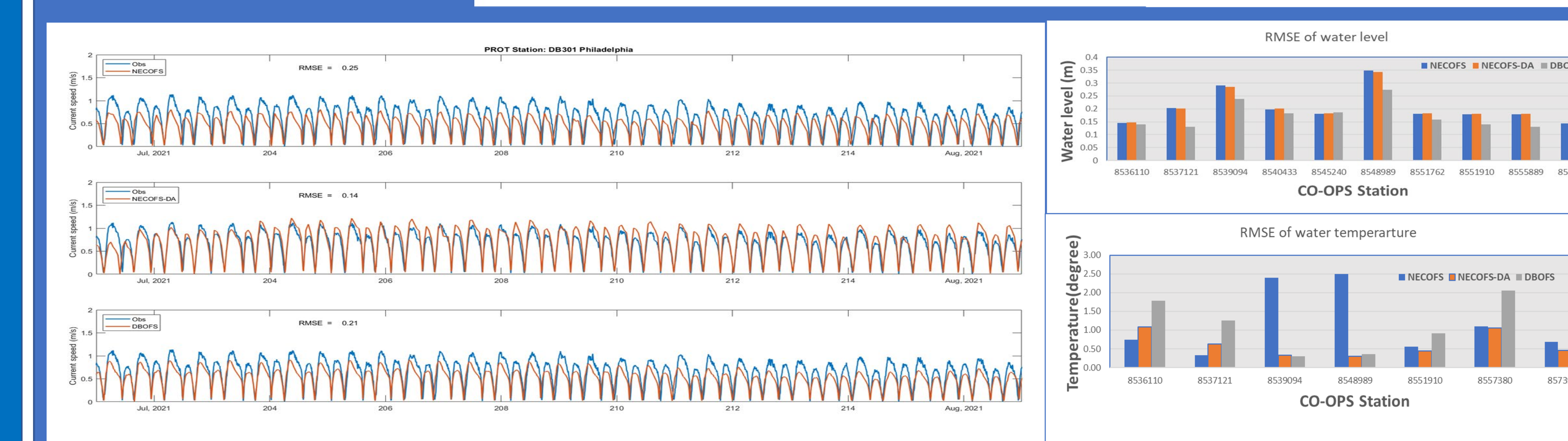

Fig.6 Comparisons of NECOFS and DBOFS for water level(right upper), temperature(right lower), and the time series of current speed at the only available station db0301(left upper: Non-DA, middle: DA, lower: DBOFS)

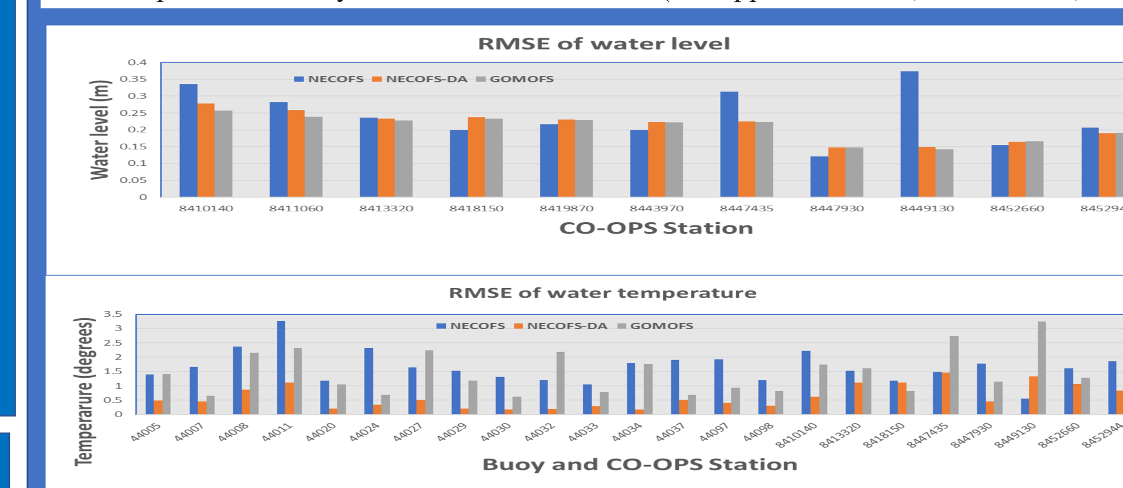

Fig.7 Comparisons of water level (upper) and temperature (lower) between NECOFS and GOMOFS

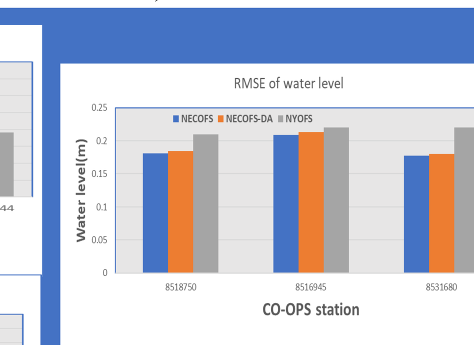

Fig.8 Comparisons of water level between NECOFS and NYOFS at three available stations

6. Summary

Cross-model comparisons show:

- For water levels, NECOFS performs similarly well with the existing OFS (slightly better than GOMOFS and NYOFS, but slightly worse than CBOFS and DBOFS). This is likely due to the fact that NECOFS's open boundary from Bald Head Island, NC, northeastward to Nova Scotia Shelf is further offshore, while CBOFS and DBOFS' open boundaries are closer to shore and adjusted with observations.
- For water temperatures, NECOFS without DA has similar skills as existing OFS; While NECOFS with DA significantly outperforms existing OFS.
- For water currents, NECOFS has similar skills with existing OFS (based on very limited analysis at few available stations).

With the use of data assimilation, NECOFS' overall performance is significantly improved, particularly for the water temperature prediction. This improved skill is primarily due to the assimilation of satellite SST with in-situ temperature observations.

UIFCW25
A UFS Collaboration Powered by EPIC