Progress on the Choptank MTM

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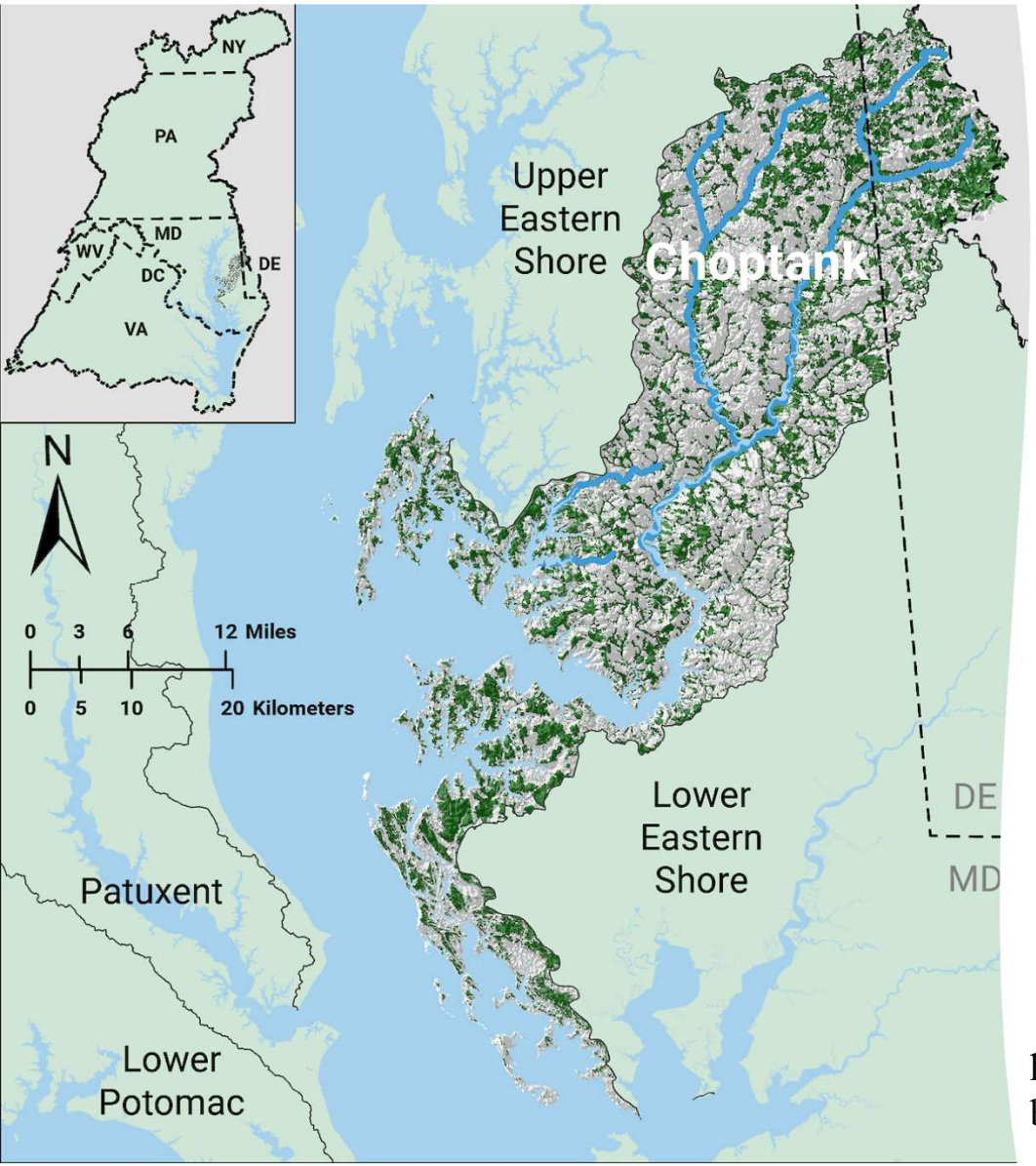
Acknowledgement: Zhengui Wang; Gopal Bhatt and Gary Shenk

Modeling Workgroup Quarterly Review

October 2024



Choptank River

The Choptank River complex is located on Maryland's Eastern Shore and includes the Choptank River and its major tributaries (Little Choptank River and Honga River).

The largest of the Chesapeake's Eastern Shore river (about 68 miles).

https://ecoreportcard.org/report-cards/chesapeake-bay/watershed-regions/choptank/

Tasks

- Develop a tributary model for the Choptank River complex. (Different configurations are tried)

- Calibrate and validate the hydrodynamic and water quality variables and understand the physical-biogeochemical processes in the Choptank River. (hydrodynamic simulations almost done; water quality module started)

- Work with the Main Bay Model (MBM) team to integrate our tributary model into the bay model framework. (connection between MTM-Choptank and MBM is established)

- Assist in preparation and testing for the operational model.

- Evaluate TMDL in the Choptank River for 2035 Climate Change Assessment.

Outline

- Choptank River hydrodynamics simulations.

- Efforts to address the identified issues (salt intrusion in the upper choptank river).

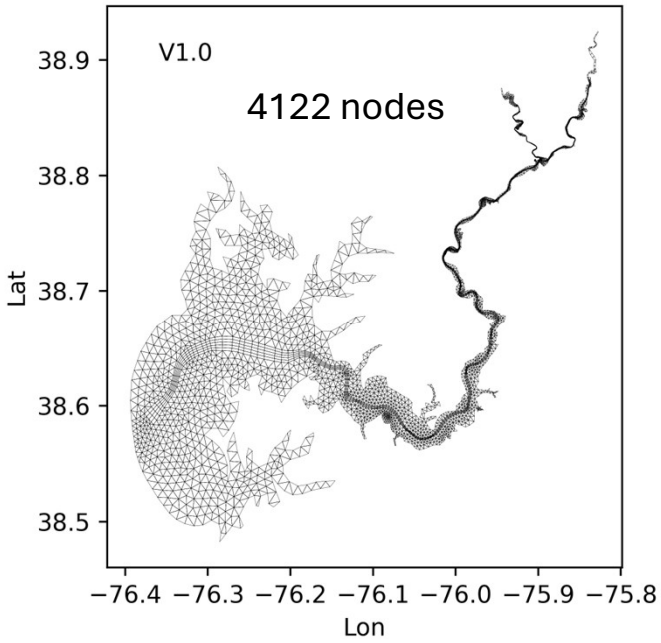
Part I

Choptank River hydrodynamics simulations based on different configurations.

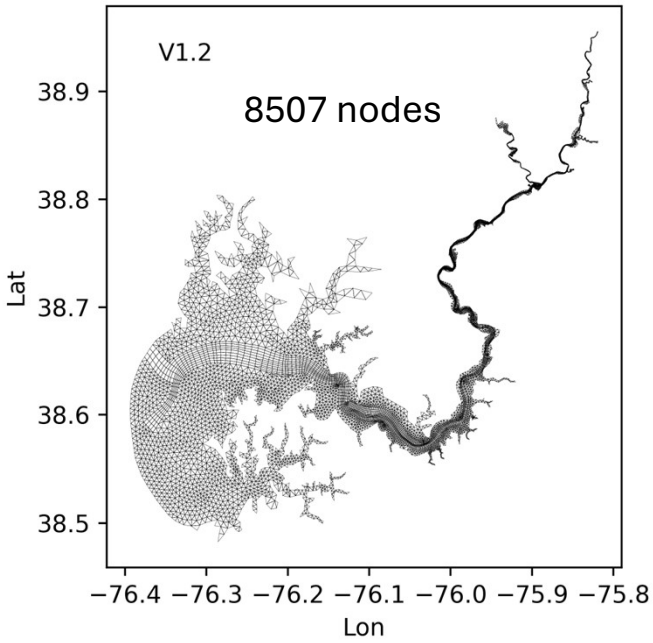
A tributary model for Choptank River

We have tried different model grids.

V1.0 (base run)

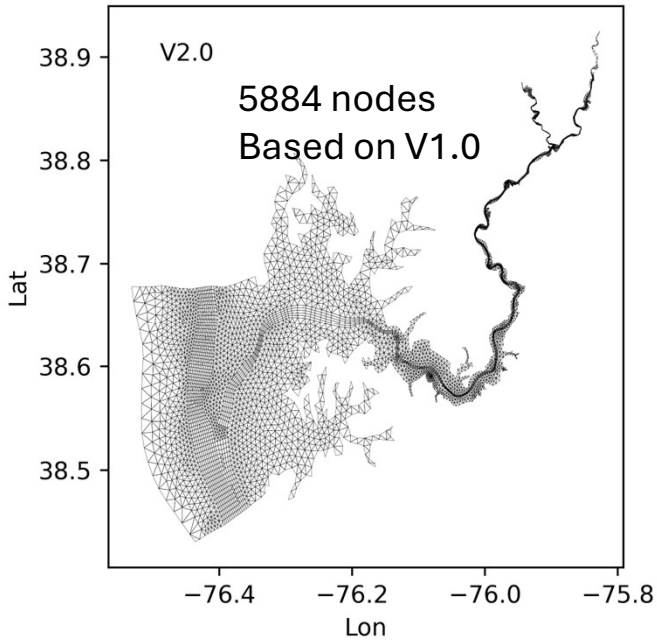


V1.2 (More grids across the channel)



V2.0

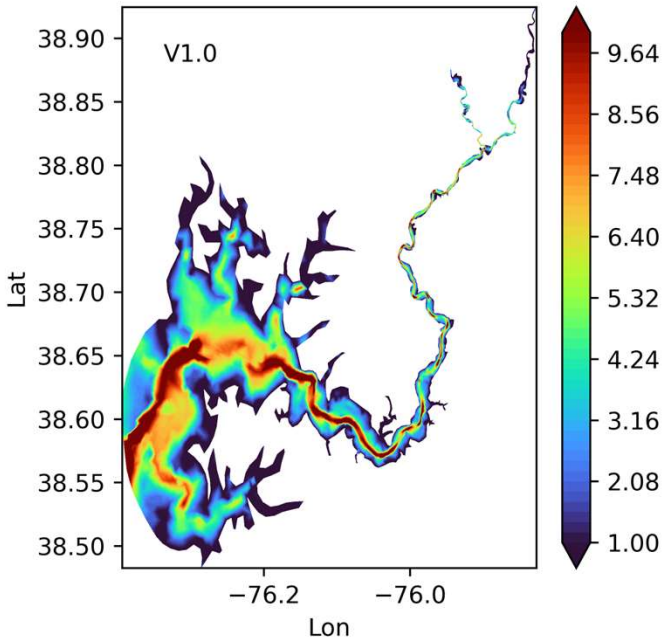
- Model domain extended
- Two open boundaries



Bathymetry

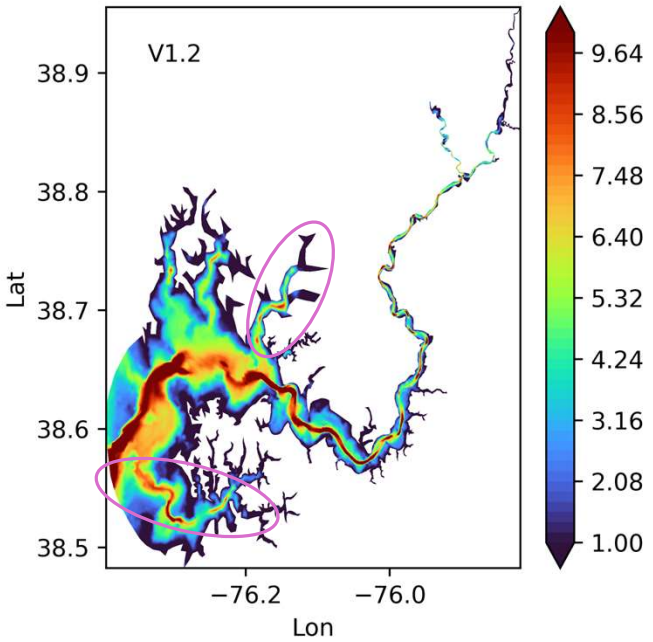
A deeper channel connects the bay and choptank river.
Shoalings are found near the river entrance.

V1.0

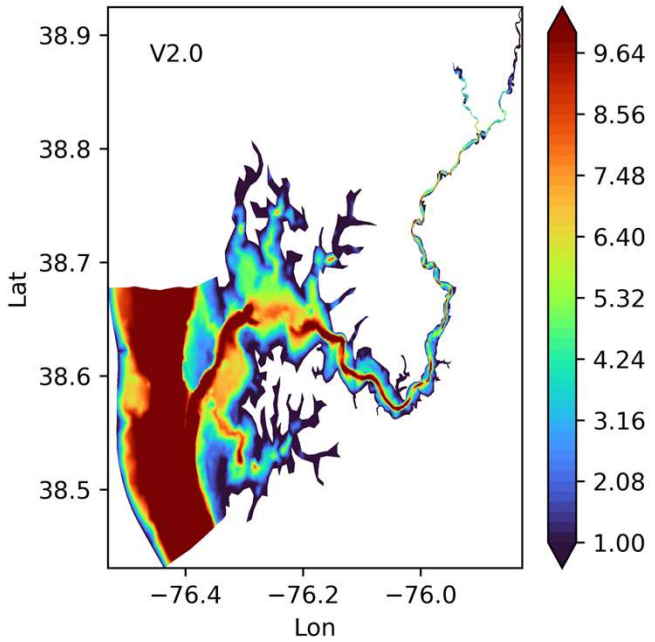


V1.2

Better representation of bathymetry

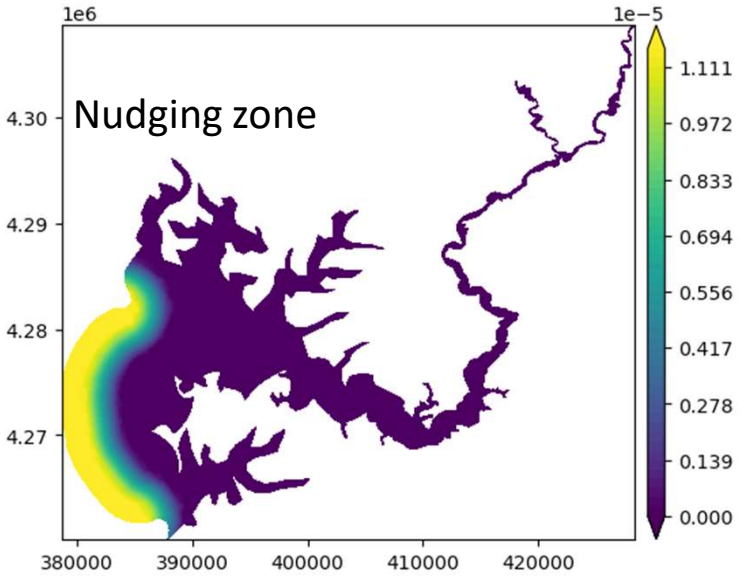


V2.0

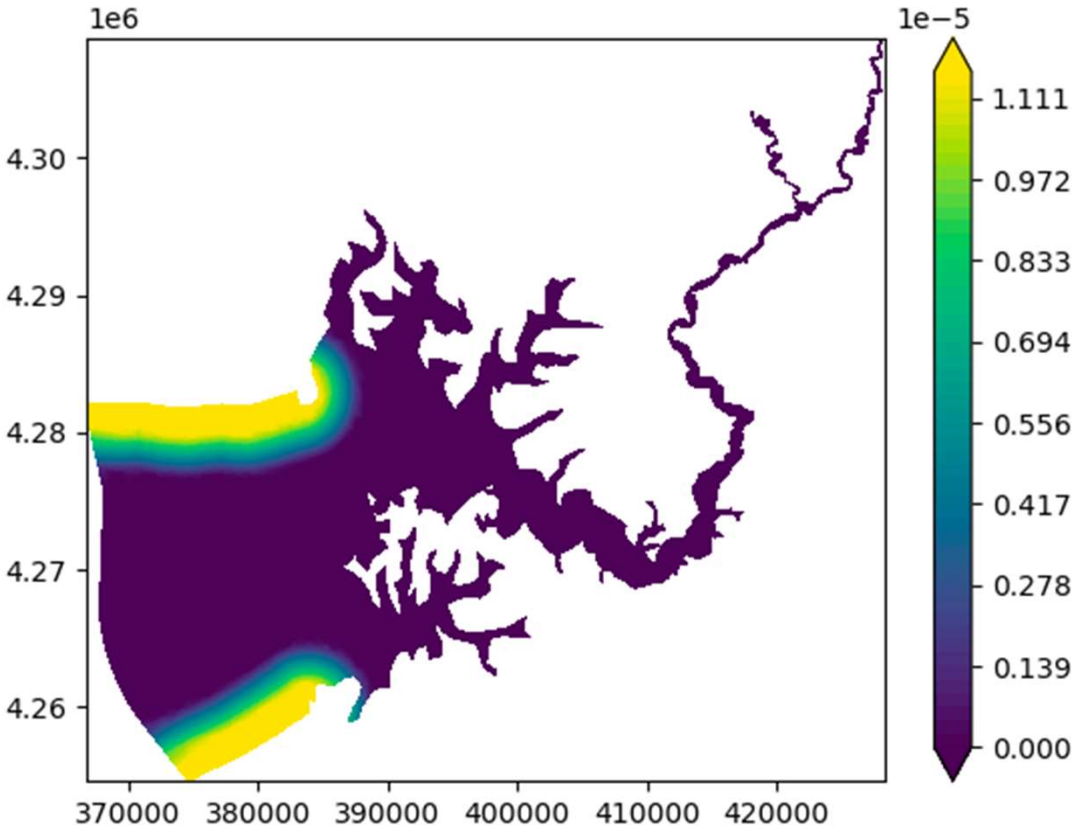


The tributary model is coupled with Main Bay Model (MBM)

- Open boundary: salinity, temperature, velocity and surface elevation interpolated from MBM outputs (run07b). (extractions based on Zhengui's pylib package)
- MBM output frequency: 30-minute
- A 5km nudging zone (383 grid nodes)



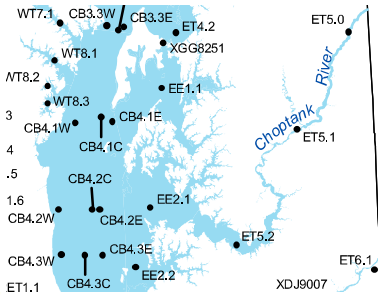
Grid V2.0



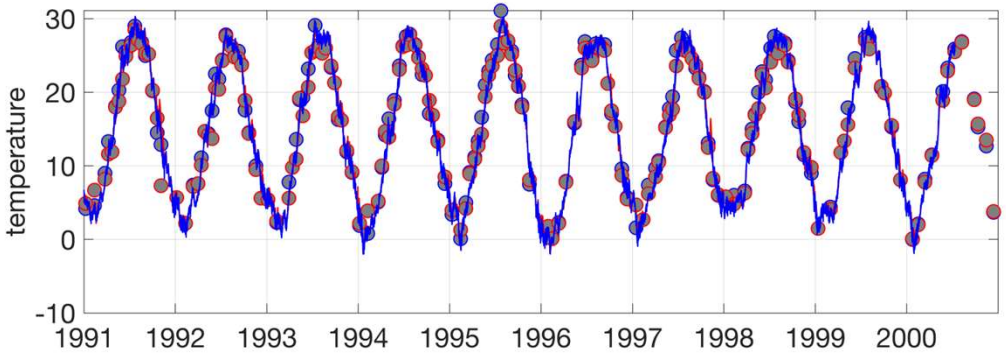
Nudging zones near the upper and lower open boundaries

Temperature Validation

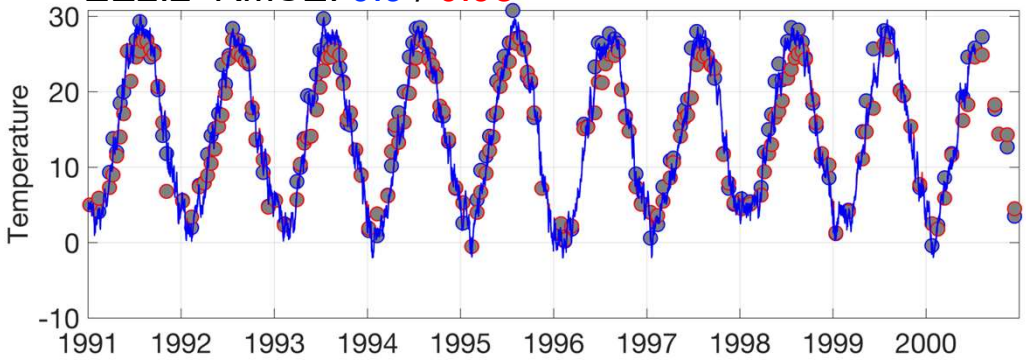
Seasonal cycle is reproduced.



EE2.1 RMSE: 0.8 / 0.92

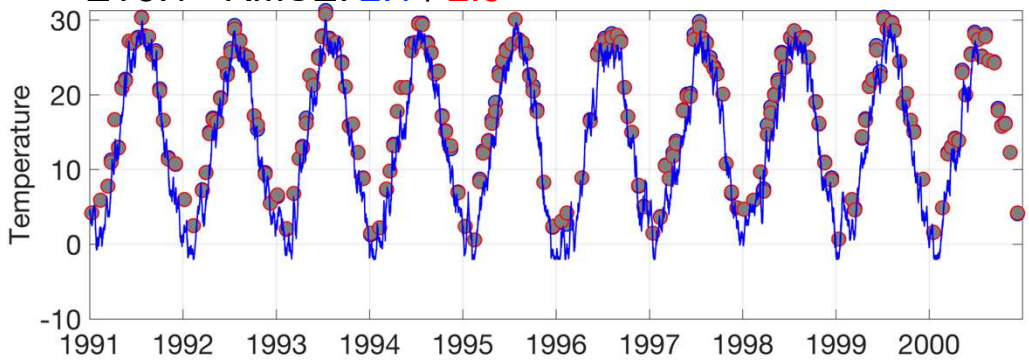


EE2.2 RMSE: 0.9 / 0.98

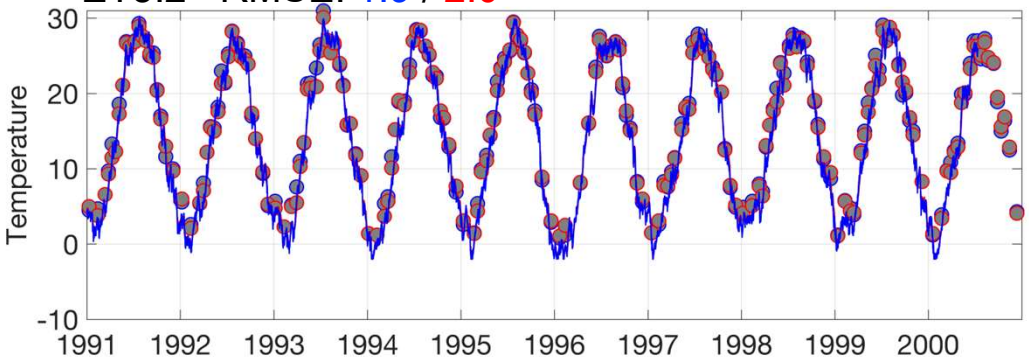


Surface/ Bottom

ET5.1 RMSE: 2.1 / 2.3

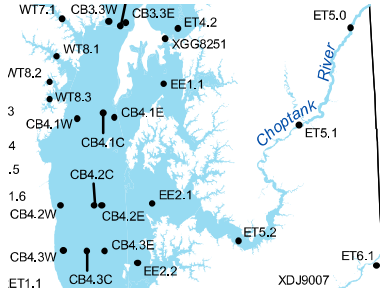


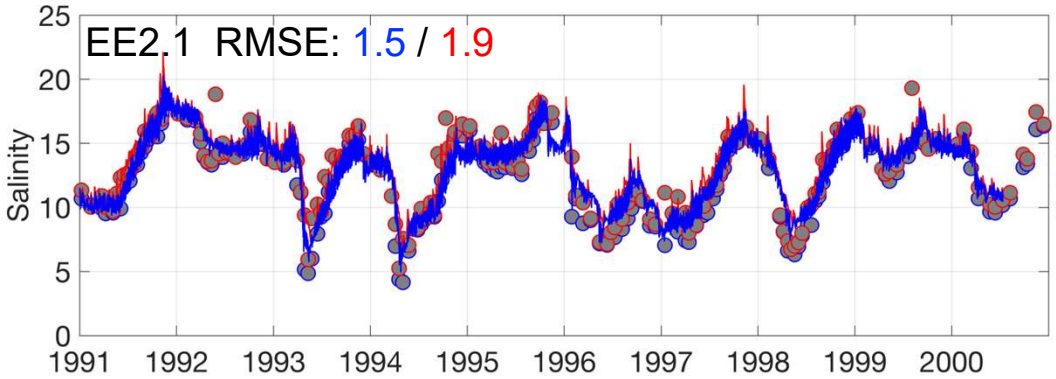
ET5.2 RMSE: 1.9 / 2.0

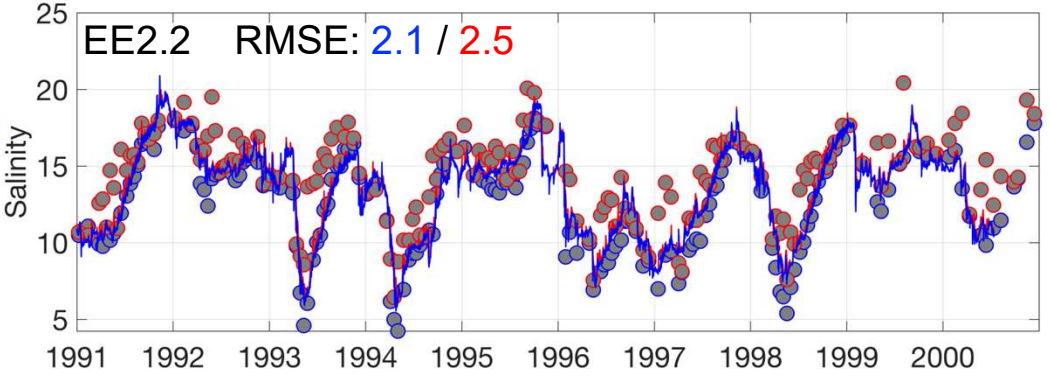


Salinity Validation

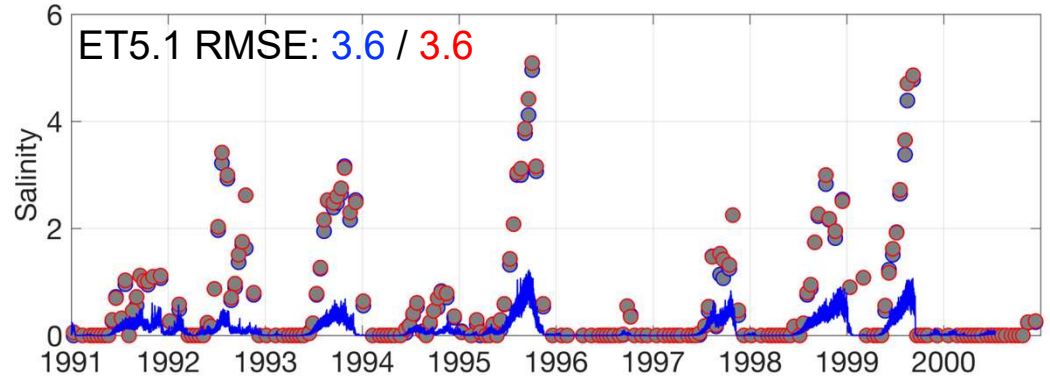
Need further improvement: salt intrusion in the upper part (ET5.1).

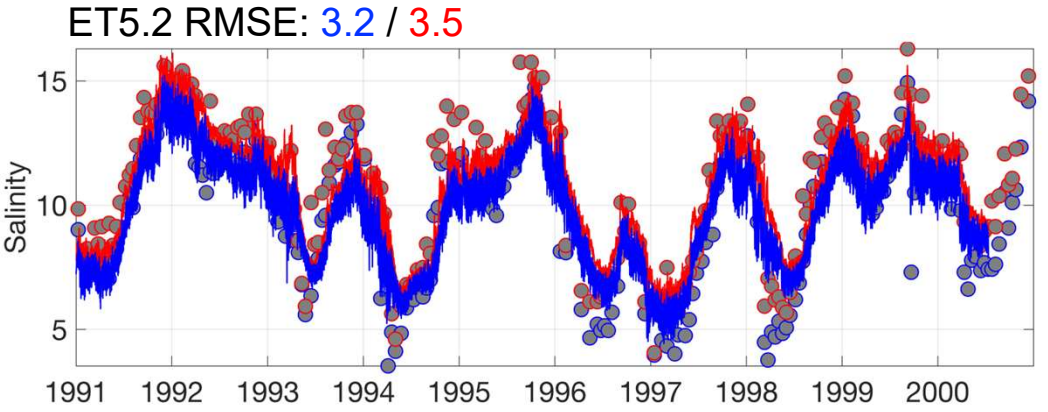






Surface / Bottom



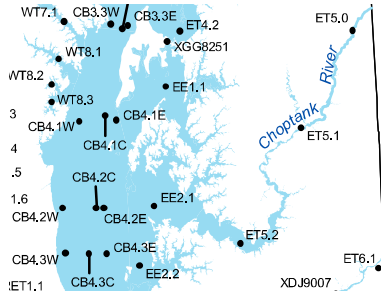


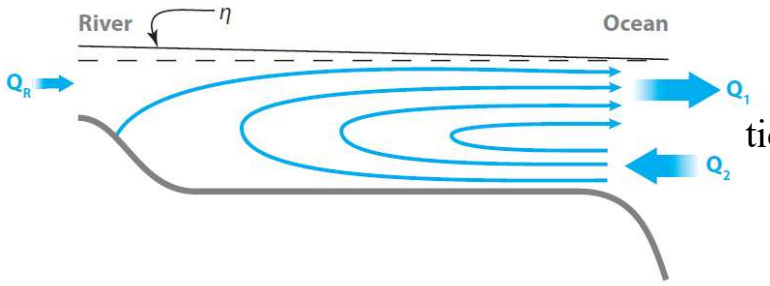
Part II

Efforts to address the identified issues (salt intrusion in the upper choptank river).

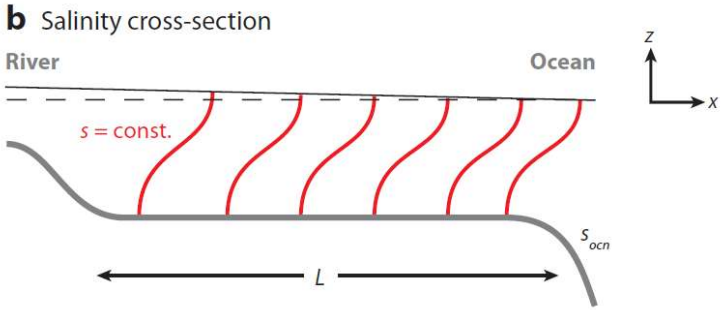
- 1, freshwater discharge
- 2, eddy viscosity/diffusivity
- 3, wind

Salinity in an idealized partially mixed estuary



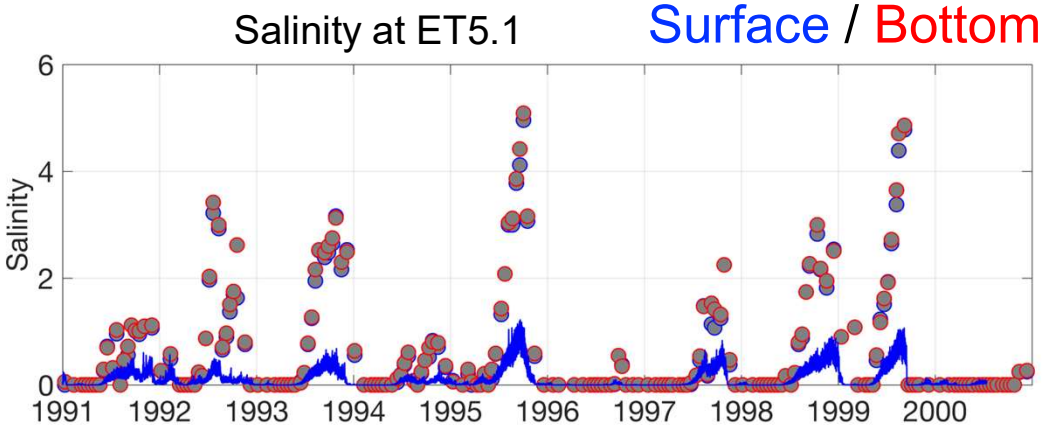


tidally averaged circulation highlighting the exchange flow



Salt structure

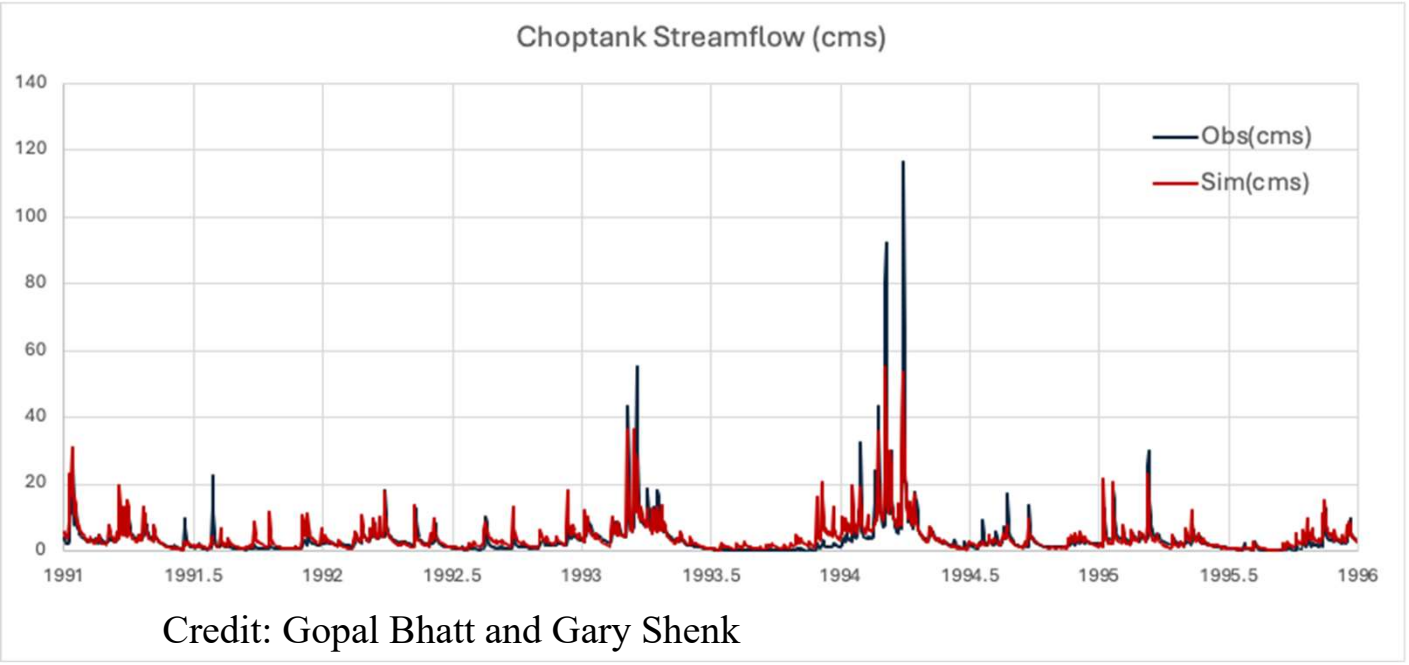
MacCready and Geyer (2010) Advances in Estuarine Physics.
Annual Review of Marine Science



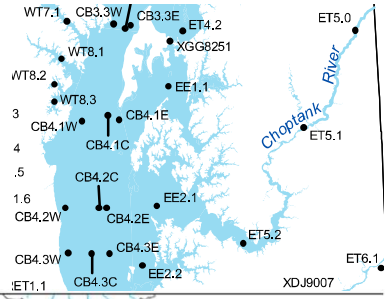
Freshwater discharge in Choptank River and Tuckahoe Creek

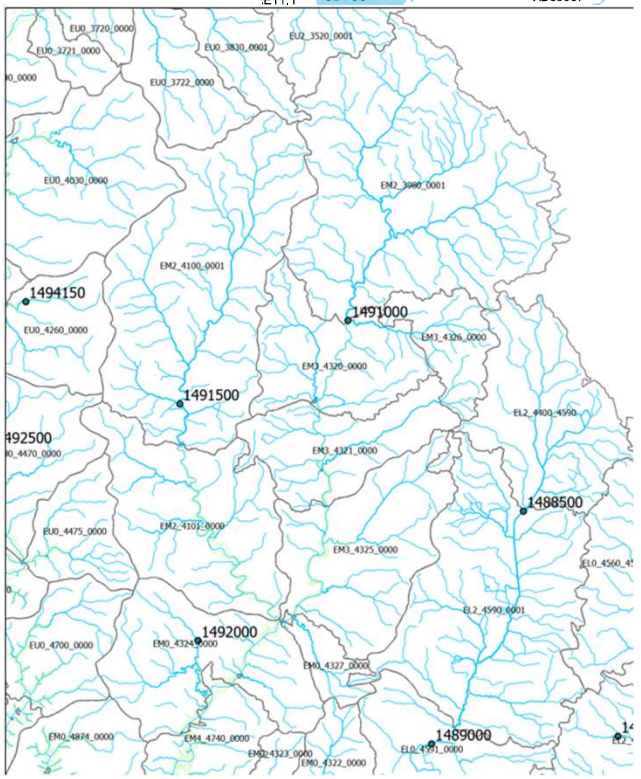
USGS 01491000 CHOPTANK RIVER NEAR GREENSBORO, MD

Stats 91-95	Obs(cms)	Sim(cms)
Mean	3.409	3.792
Median	2.095	2.518

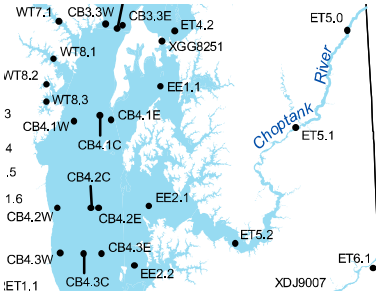


Credit: Gopal Bhatt and Gary Shenk



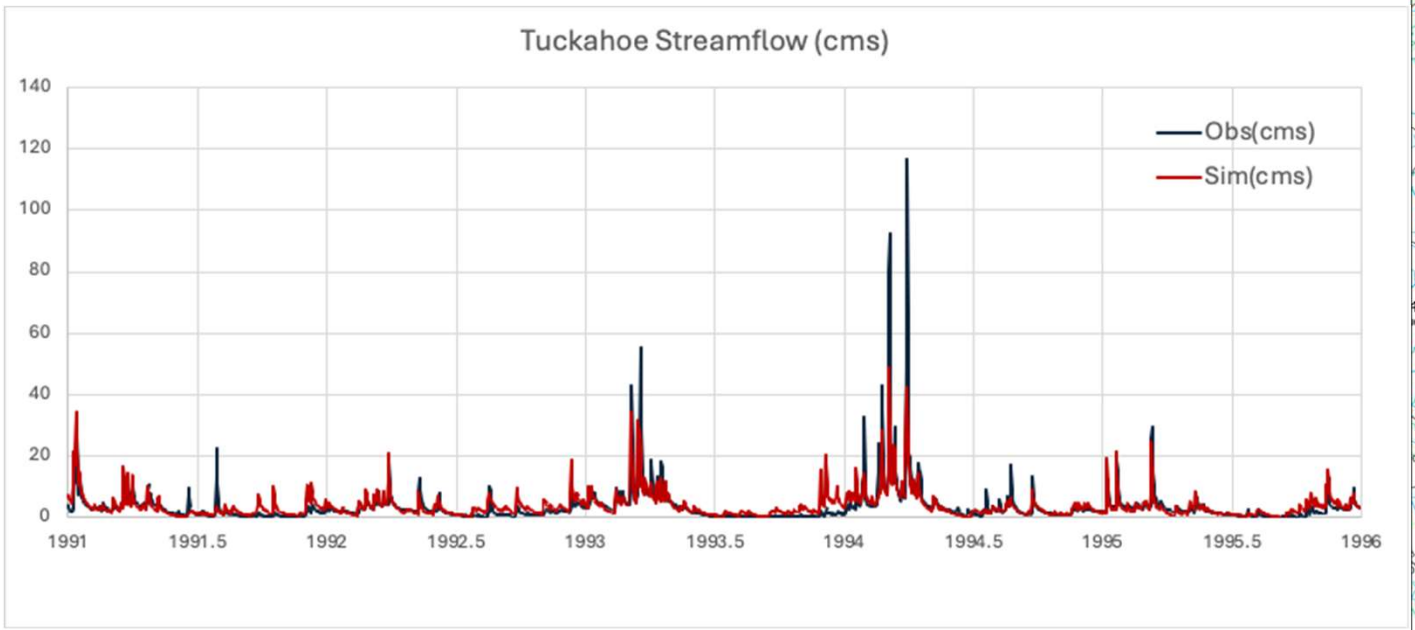


Freshwater discharge in Choptank River and Tuckahoe Creek



USGS 01491500 TUCKAHOE CREEK NEAR RUTHSBURG, MD

Stats 91-95	Obs(cms)	Sim(cms)
Mean	3.409	3.720
Median	2.095	2.621

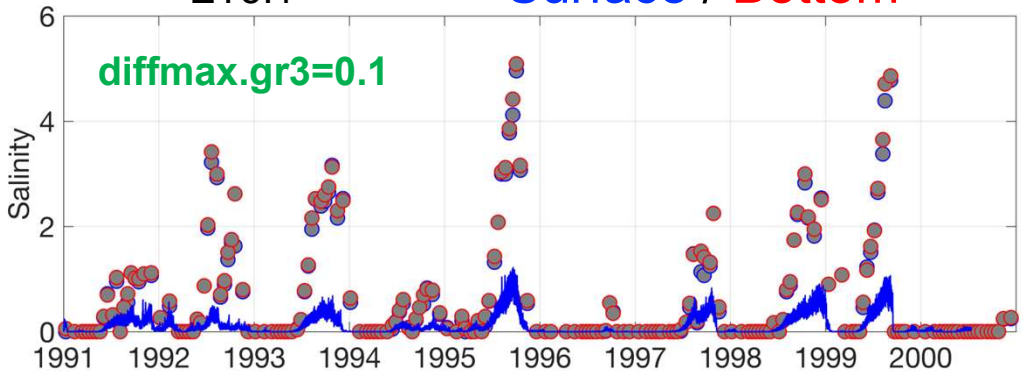


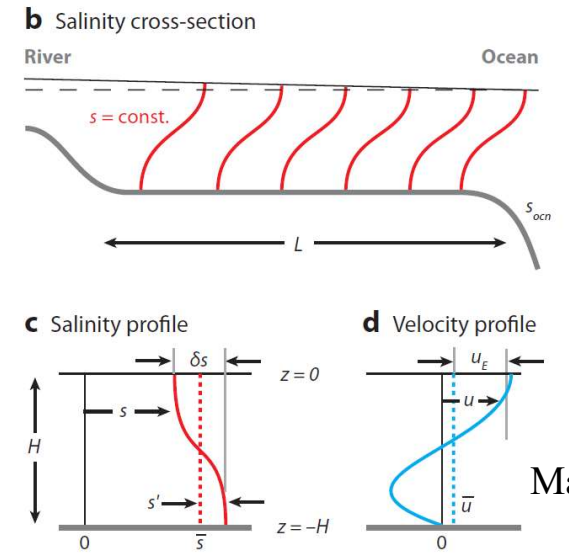
Credit: Gopal Bhatt and Gary Shenk

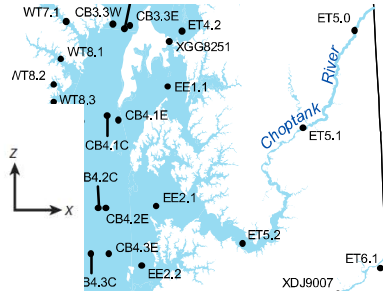
Enhance exchange flow

$$u_E = g\beta\bar{s}_x H^3/(48K_M).$$

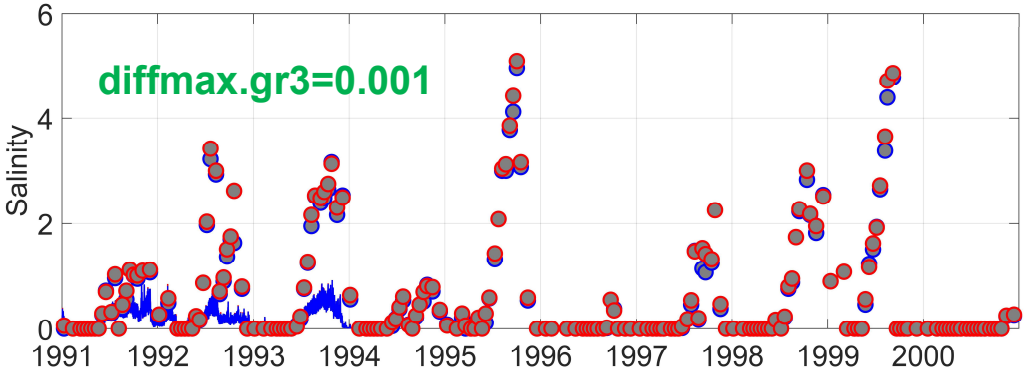
ET5.1 Surface / Bottom

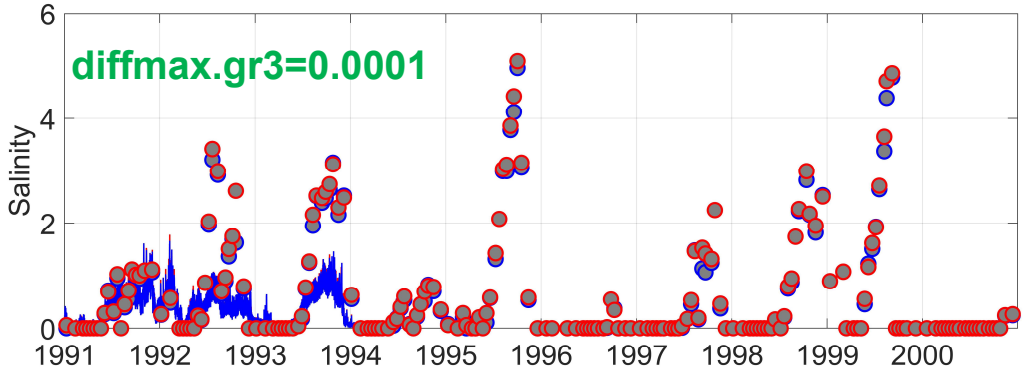




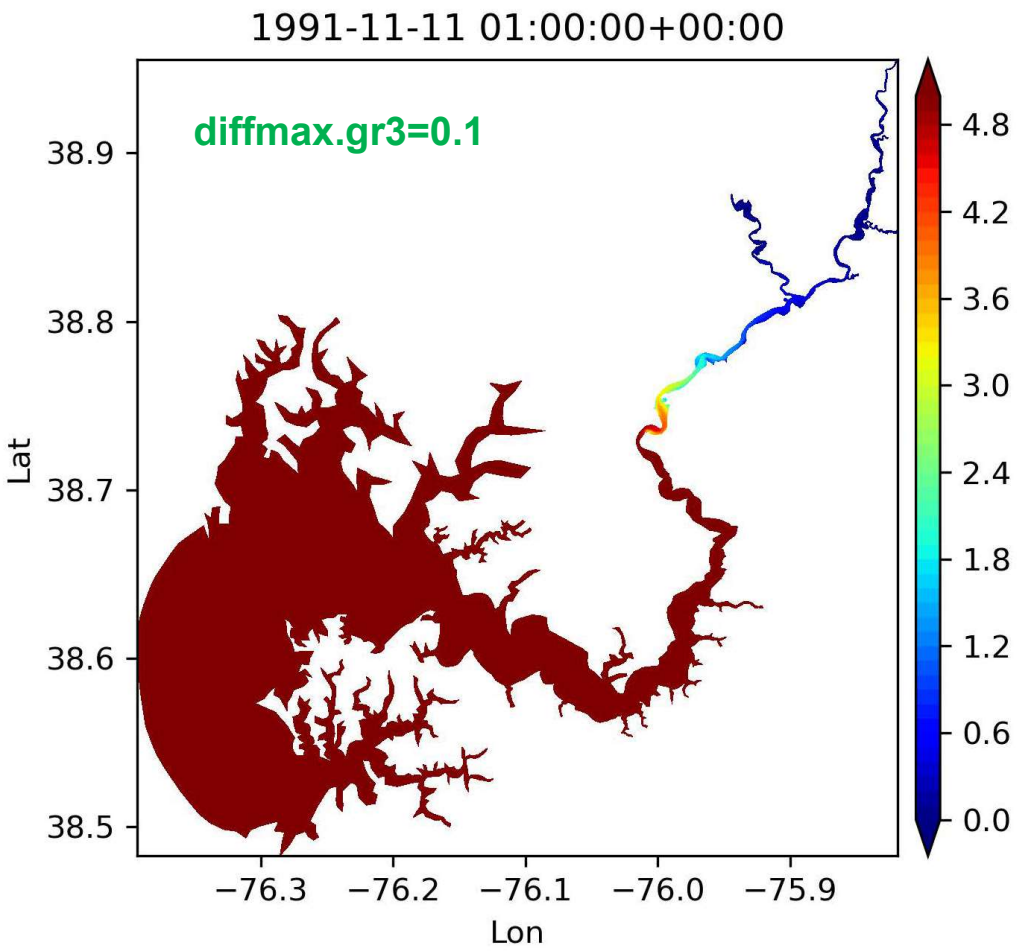


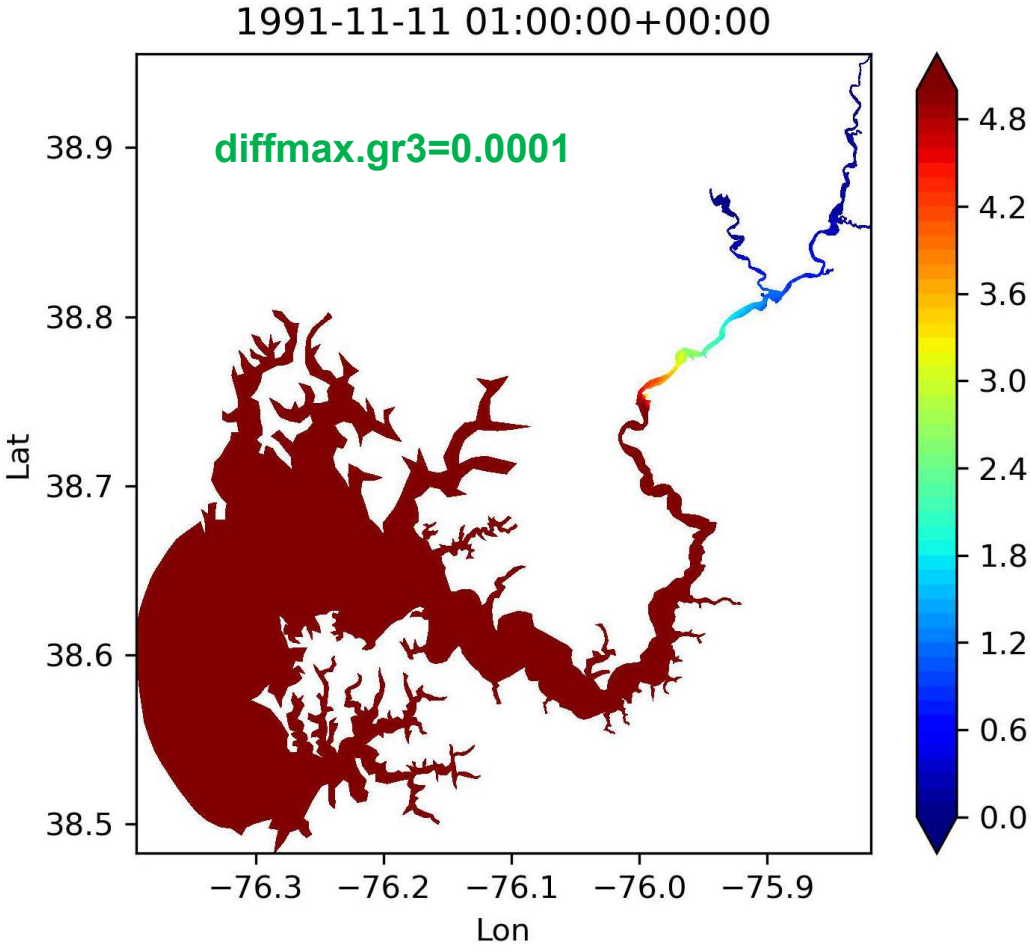
MacCready and Geyer (2010)





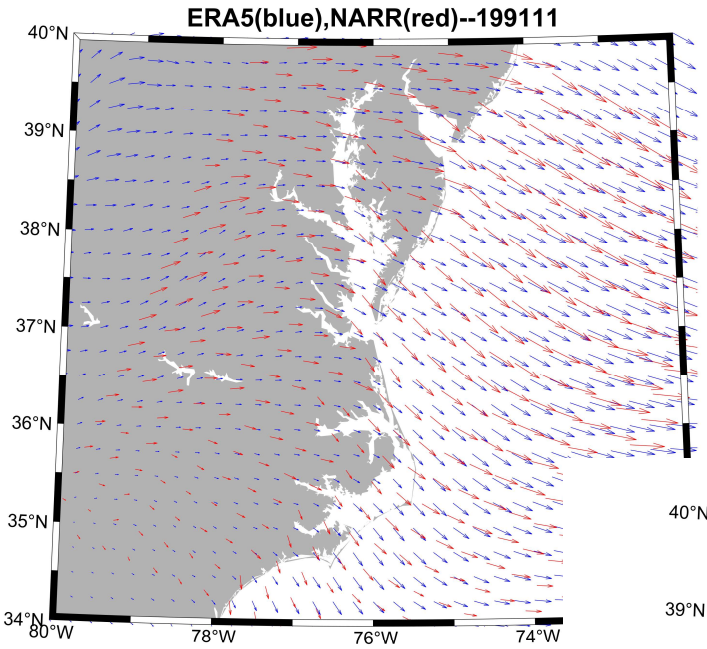
Salinity horizontal structure

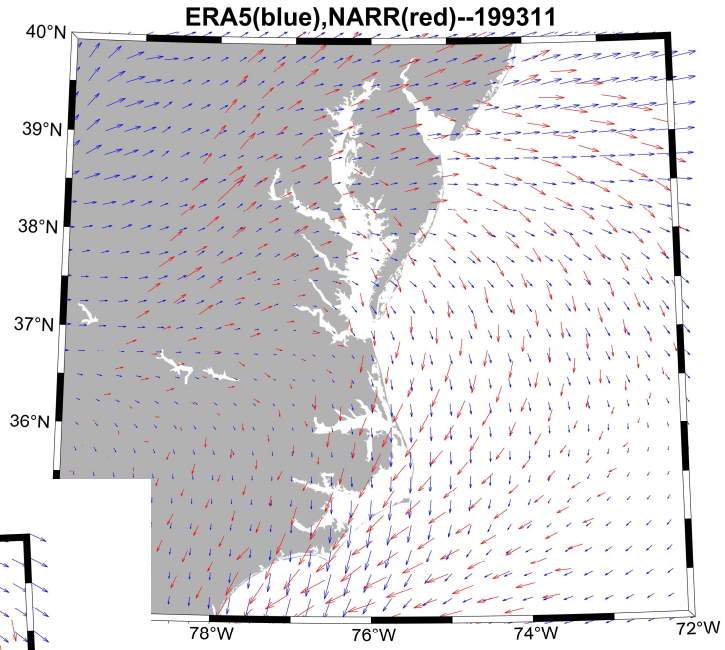


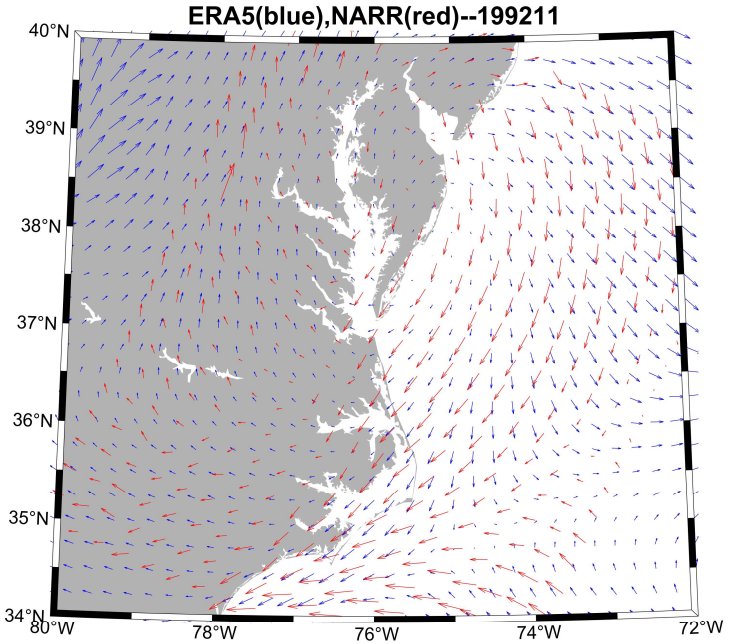


Wind impact

The model is forced by
NARR (red)

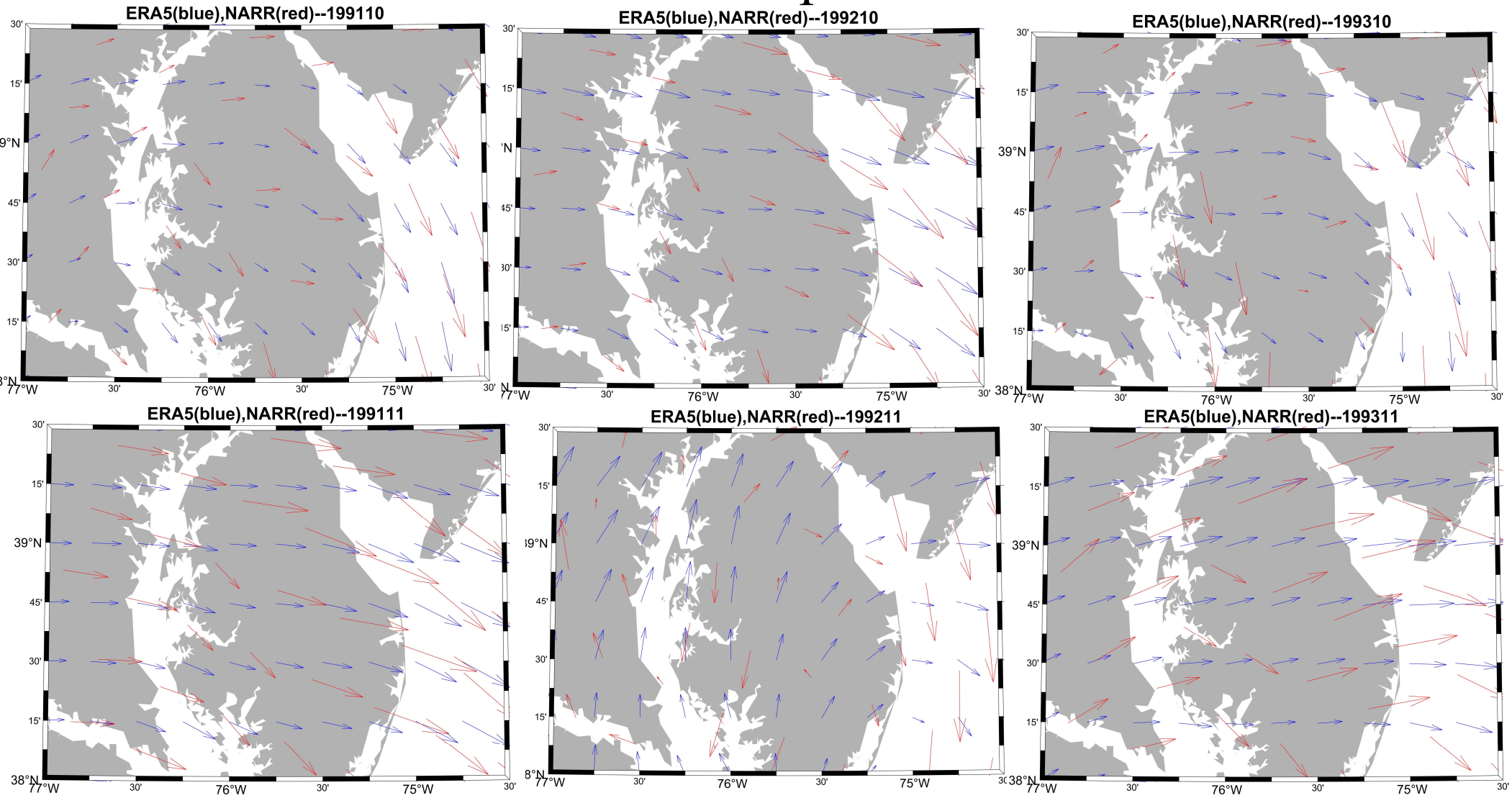






10m wind from
NARR (red);
ERA5 (blue)

Wind impact


ERA5(blue),NARR(red)--199110
ERA5(blue),NARR(red)--199210
ERA5(blue),NARR(red)--199310
ERA5(blue),NARR(red)--199111
ERA5(blue),NARR(red)--199211
ERA5(blue),NARR(red)--199311
77°W
76°W
75°W
39°N
38°N

Summary and Next Steps

A fine-scale tributary model for the Choptank river is set up.

Different model configurations are tested to assess the performance.

Explore possible causes for the underestimated salt intrusion in the upper choptank river: river discharge; eddy viscosity/diffusivity are ruled out.

Possible biases in the NARR wind fields.

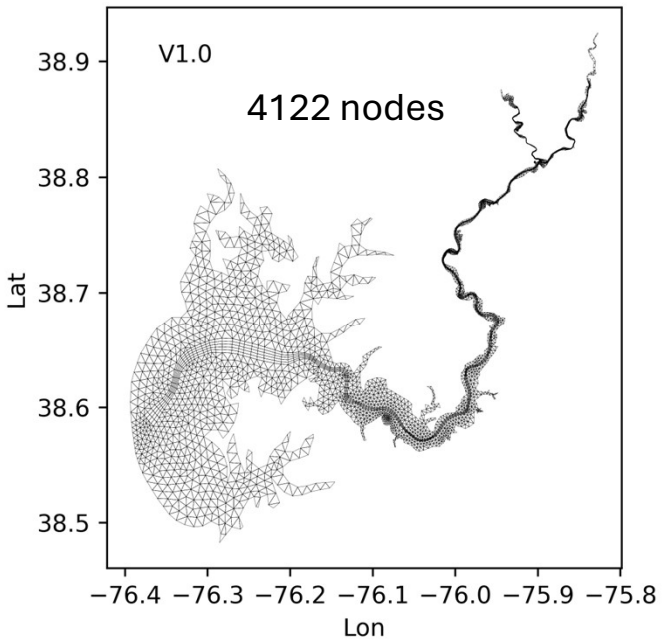
Next steps: try different era5 wind (should be consistent with MBM?)

Water quality module is in progress.

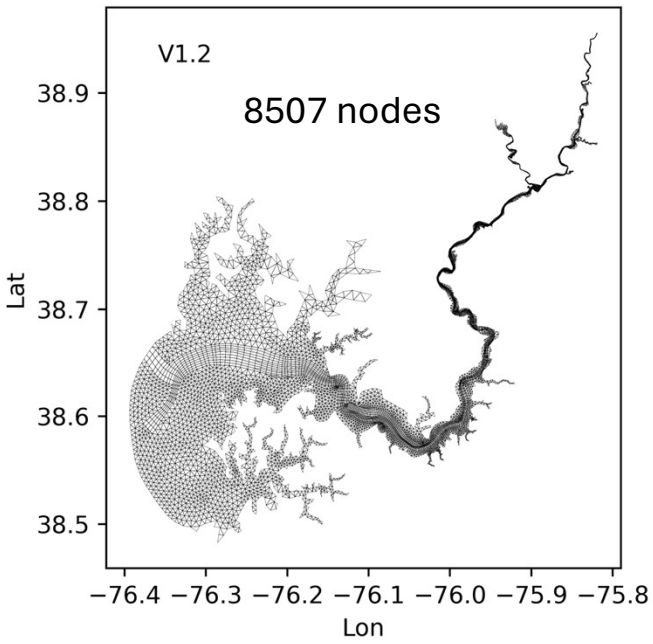
Questions ?

different model grids

V1.0 (base run)

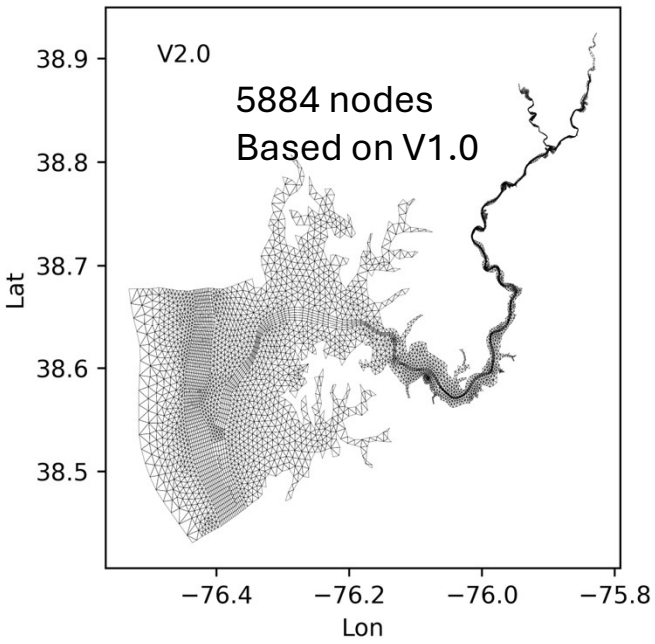


V1.2 (More grids across the channel)



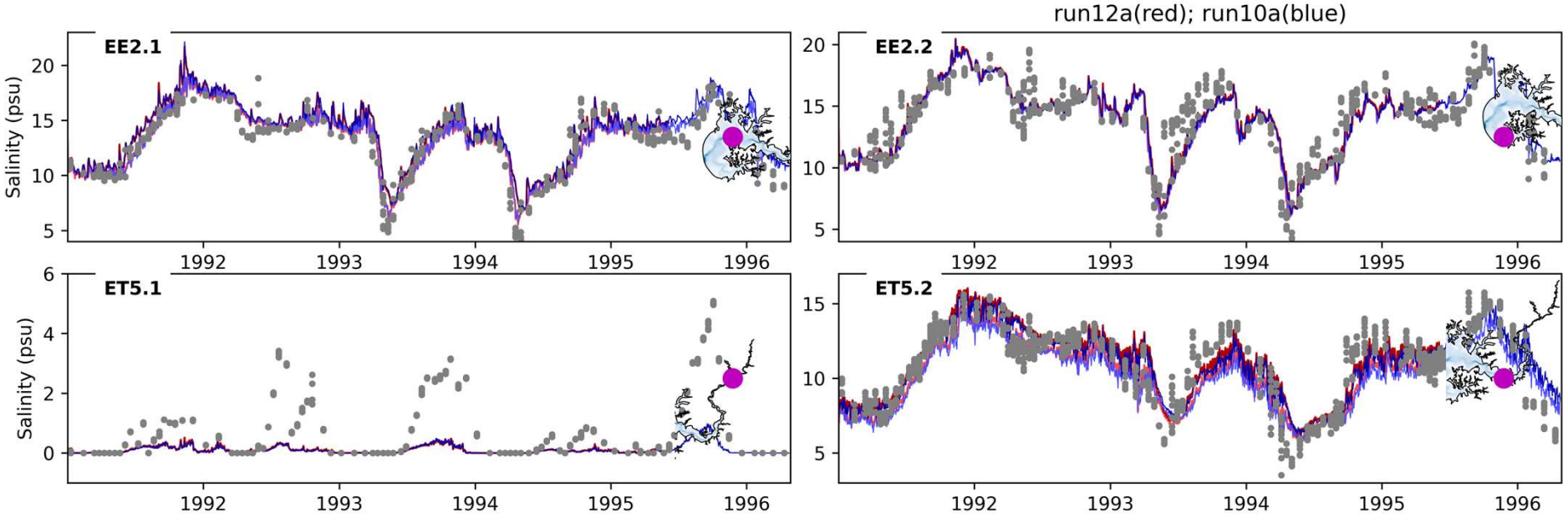
V2.0

- Model domain extended
- Two open boundaries



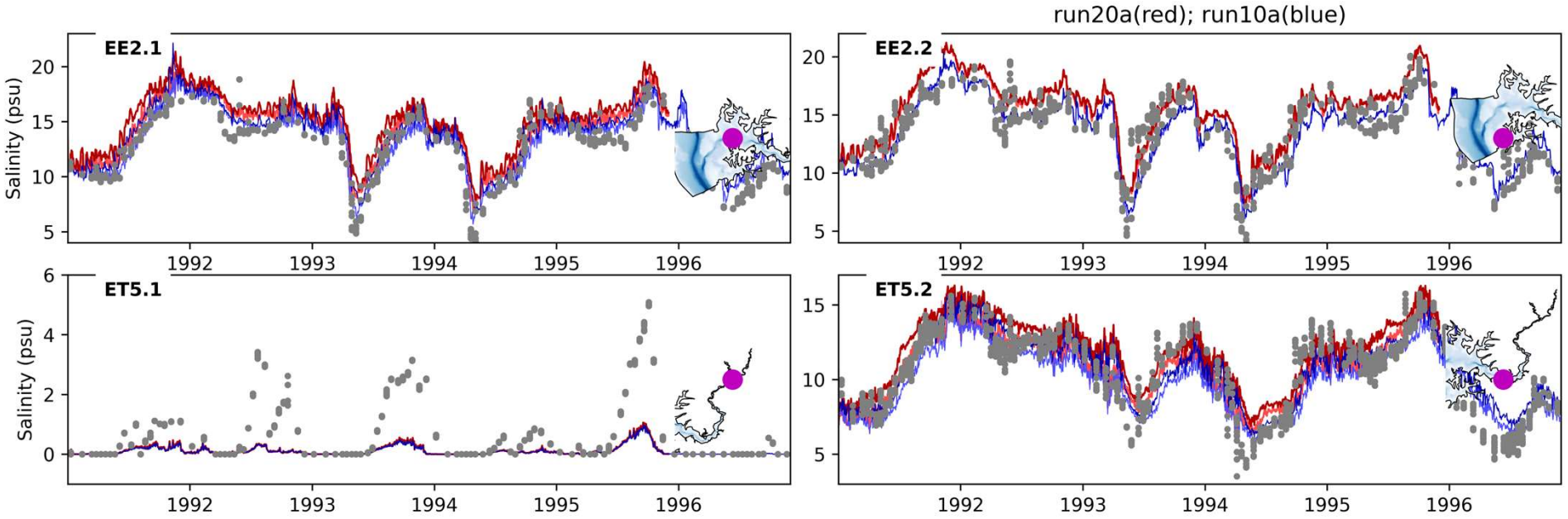
V1.2 grid (run12a)

- salinity is nearly identical to base grid (run10a)



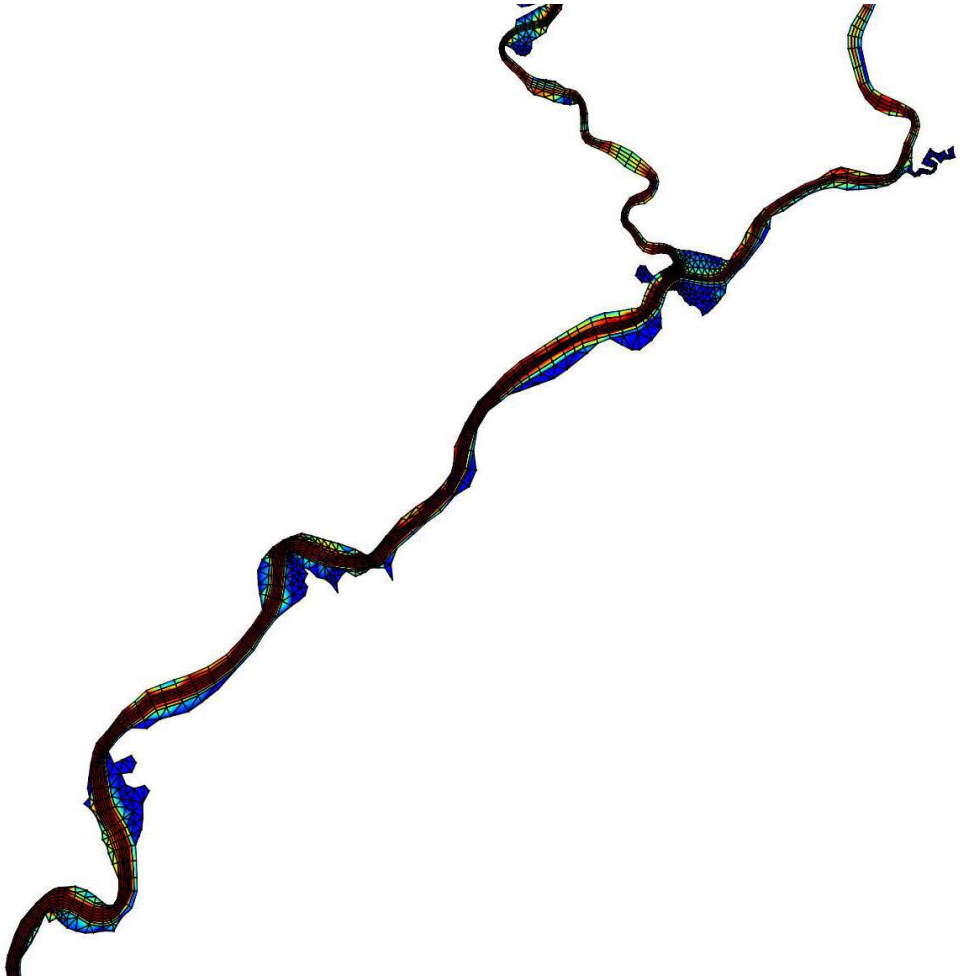
V2.0 grid (run20a)

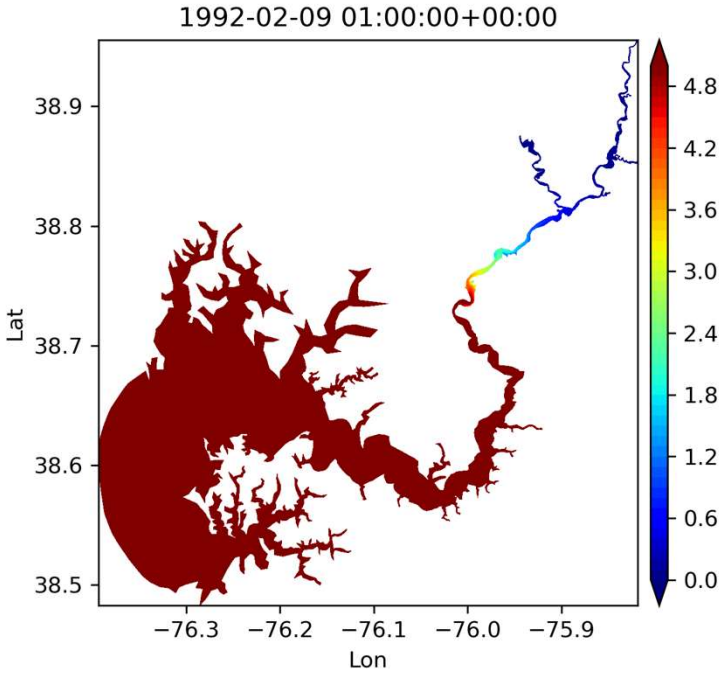
- salinity is slightly larger inside the Choptank River
- Stratification remains the same as the base grid (run10a)



Bathymetry in grid V1.2

The central channel is fully resolved.





Surface salinity snapshot

Surface salinity snapshot