Assessing 2035 Climate Change Risks to TMDL in the Rappahannock River using SCHISM

(co-)PIs: Qubin Qin, Jian Shen, Zhengui Wang, and Pierre St-Laurent

Advisory team: Joseph Zhang and Marjorie Friedrichs

CBP Modeling Quarterly Review

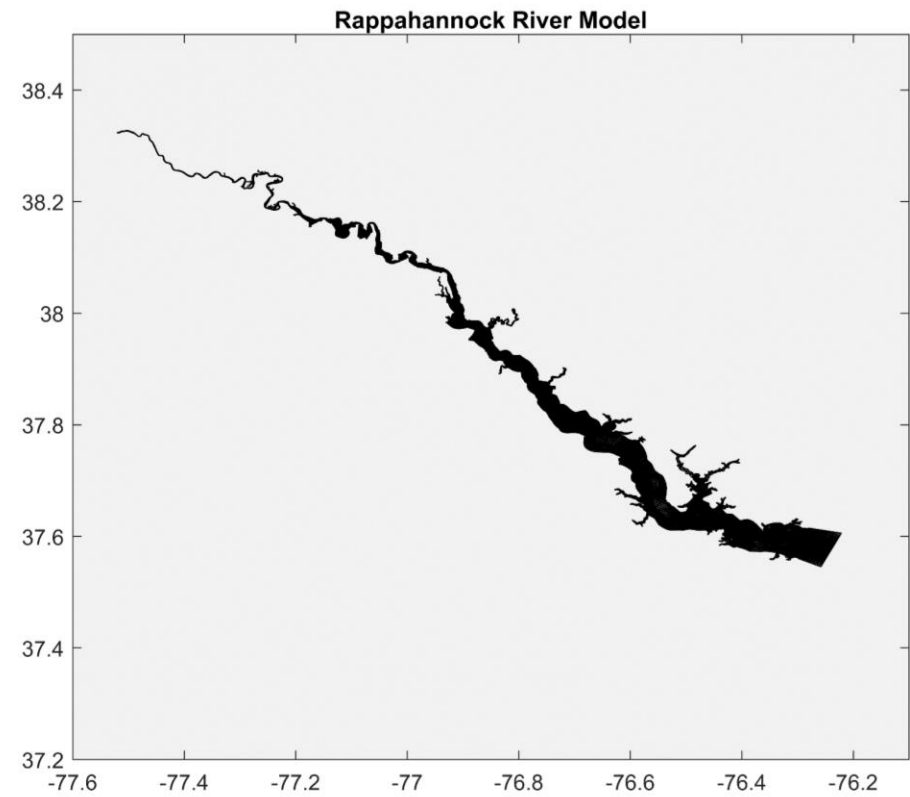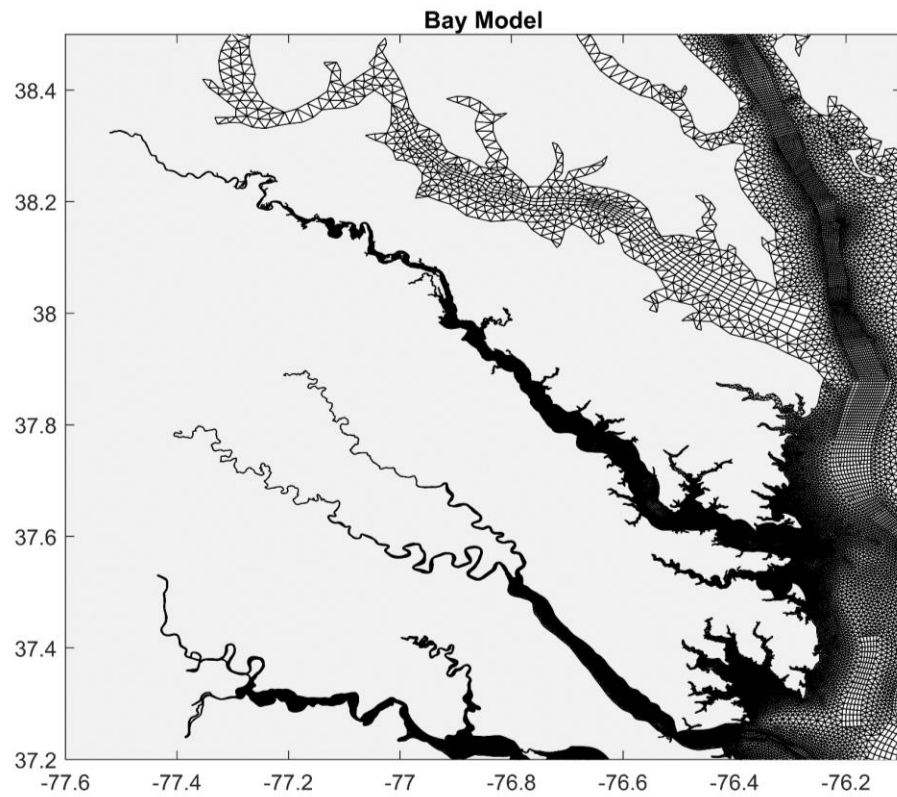April 3, 2024

Outline

- Goal and Tasks

- Model Grid, and the 2011 Scenario

- Initial Ten-Year Hydrodynamic Model Run (1991-2000)
  - Model Setup
  - Linkage Between MTM and MBM
  - Hydrodynamic Model Results

- Model Grid Coverage Regarding SAV and Marshes
  - Discussion

Objectives and tasks

- **Goal**: to develop and calibrate a high-resolution hydrodynamic-water quality model for the Rappahannock River, which will enable us to investigate and assess the water quality of the river.

- Specifically, we aim to use the model to forecast the potential risks to TMDL due to climate change by the year 2035.

- Task 1: revise the current MBM grid of the Rappahannock River and increase the resolution in accordance with Modeling Workgroup's recommendations and important dynamic properties of the river to ensure sufficient spatial coverage and resolution to represent the true geometry and bathymetry of the river.

- Task 2: work with the MBM team to transfer of the latest version of the SCHISM-ICM model code and the open boundary conditions generated by the MBM. We will setup the model and test the tributary model. We will also provide feedback to MBM for any issues and required changes in tools used for model setup.

- Task 3: work closely with watershed, airshed, hydrological modeling groups to ensure proper execution of coupling, scaling, and interface mechanisms, as well as incorporating information on climate change and model biochemical parameters for the water quality model.

- Task 4: conduct full calibration and verification of hydrodynamic and water quality model.

- Task 5: understand the physical-biogeochemical processes in the Rappahannock River and conduct management and climate change scenarios.

- Task 6: document the findings and recommendations in the final report.

- Task 7: transfer of the software package to CBPO for operational testing. During this phase, we will collaborate with CBPO personnel to conduct tests on the model package in operational environments and address any issues that may arise.

- Task 8: disseminate our research findings and experiences via 1-2 journal papers each year.
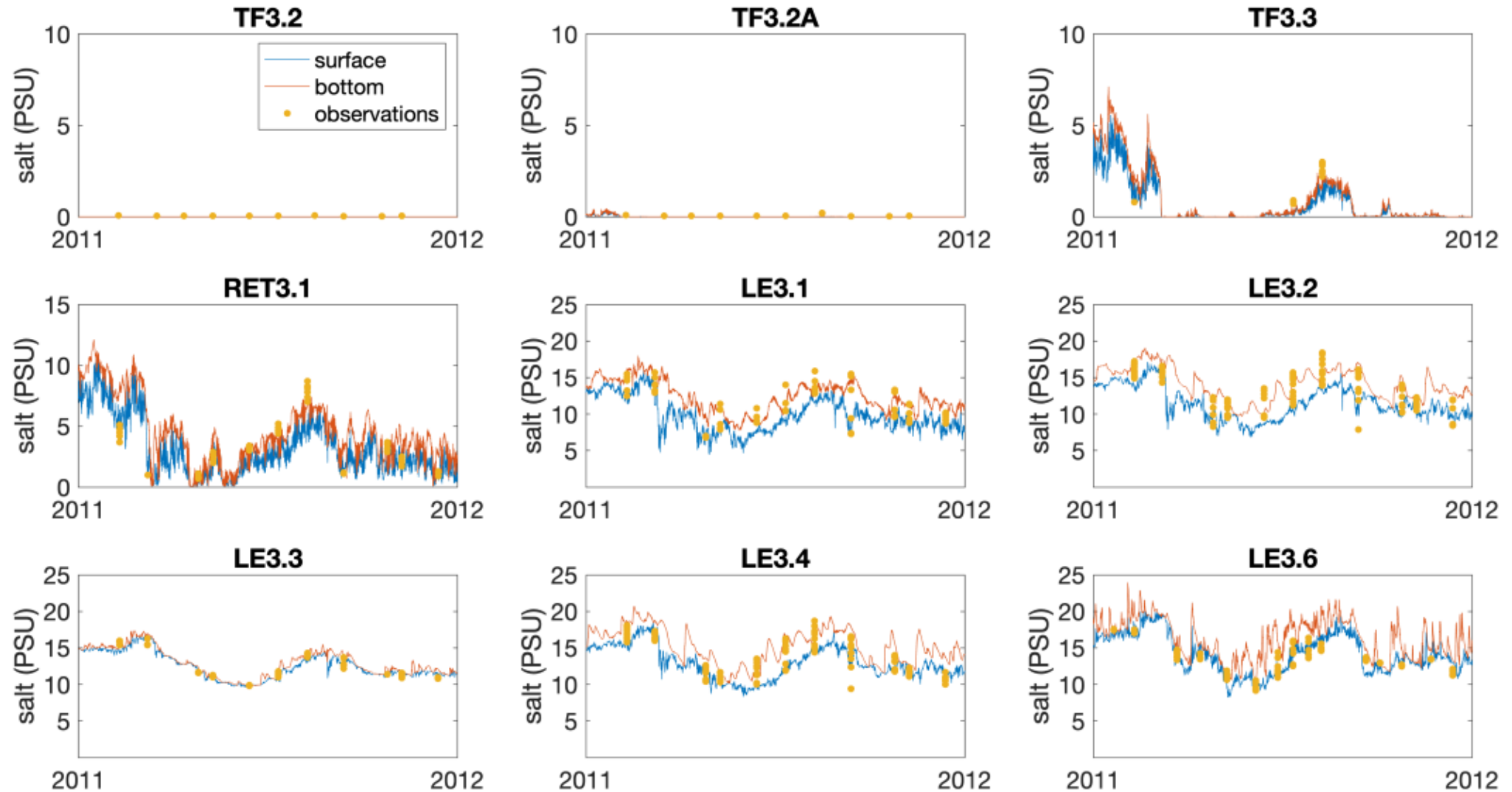
Rappahannock River Model Grid

Calibration of tidal range along the river
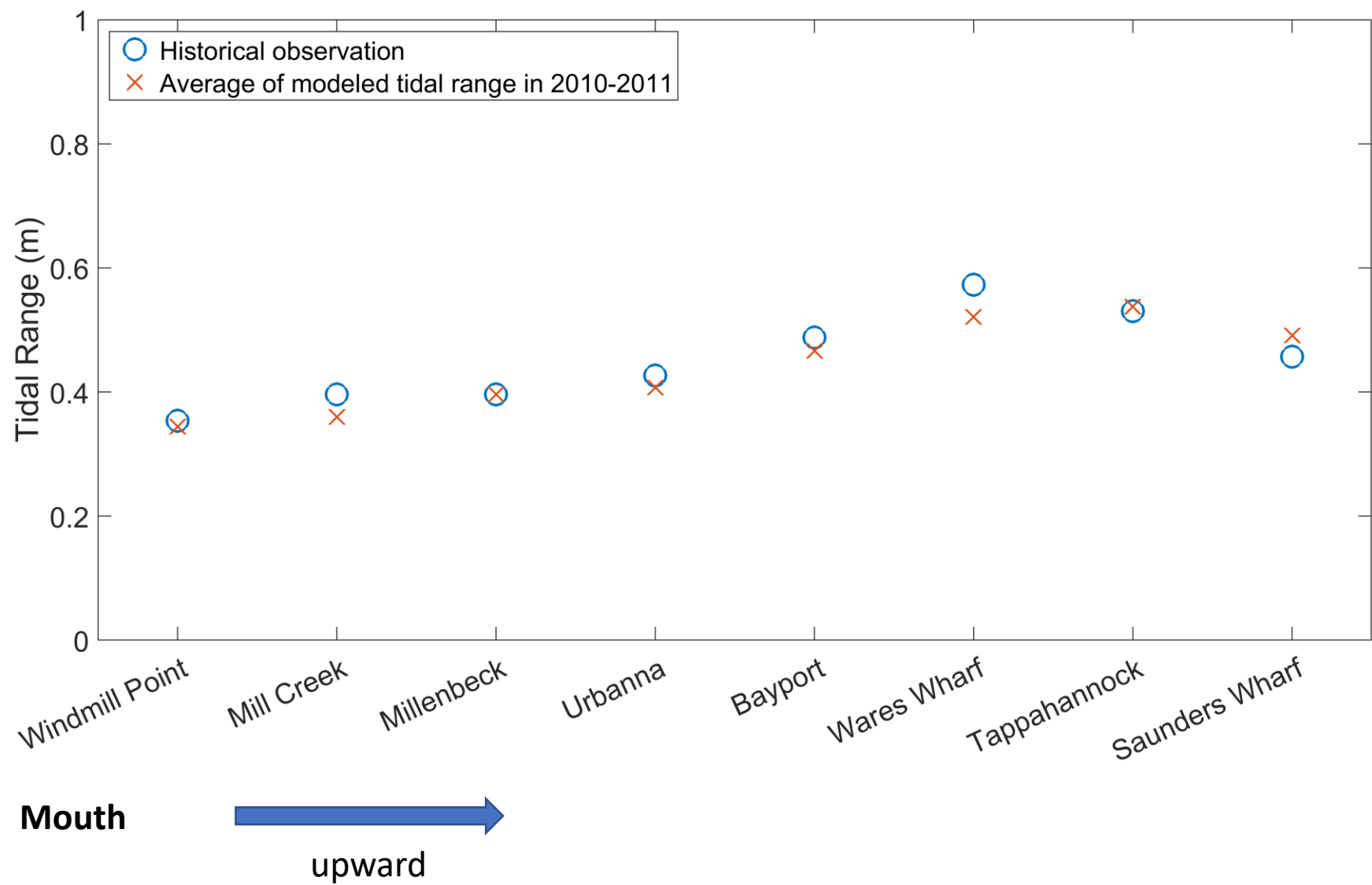
# Calibration of salinity along the river for the selected year

Outline

- Goal and Tasks
- Model Grid, and the 2011 Scenario
- **Initial Ten-Year Hydrodynamic Model Run (1991-2000)**
  - Model Setup
  - Linkage Between MTM and MBM
  - Hydrodynamic Model Results
- Model Grid Coverage Regarding SAV and Marshes
  - Discussion

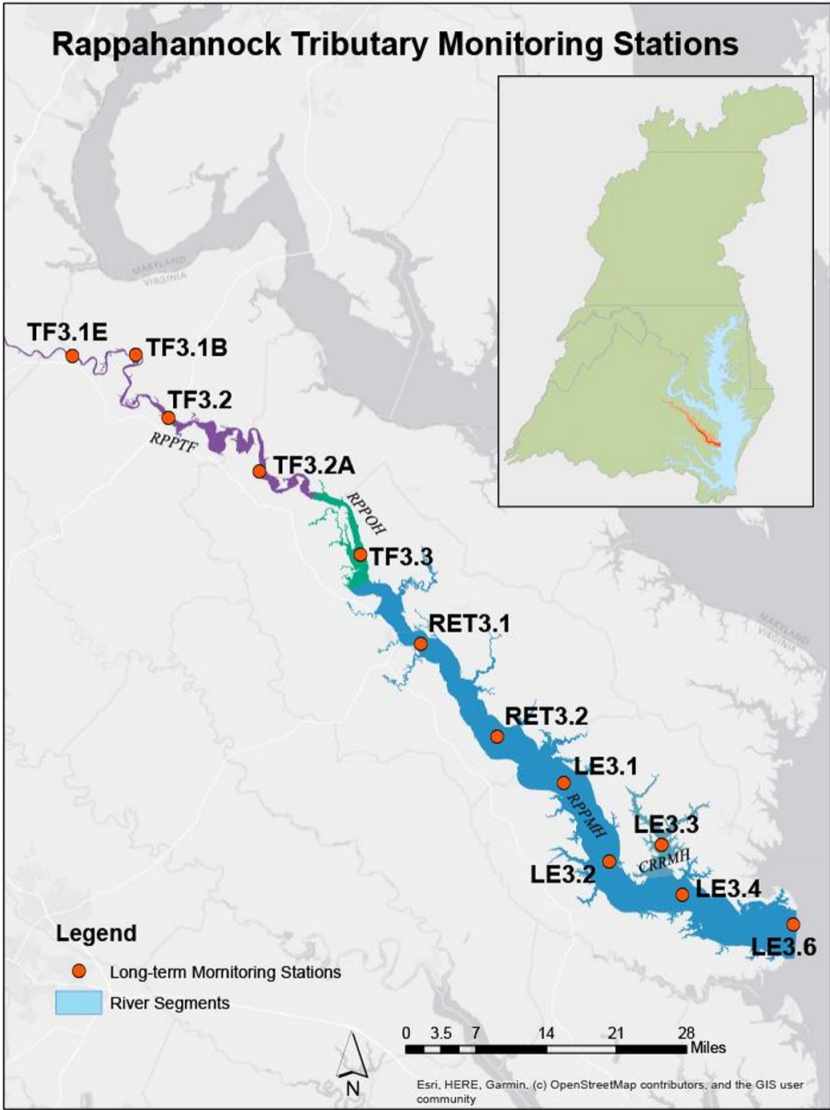# Rappahannock River Model Setup

Linkage between MTM and MBM

- MTM receives boundary conditions and nudging files from MBM model
  - elev2D.th.nc
  - TEM_3D.th.nc
  - TEM_nu.nc
  - SAL_3D.th.nc
  - SAL_nu.nc
  - uv3D.th.nc

- The extraction of boundary conditions was streamlined using python language, based on Zhengui's pylib package.

MTM boundary
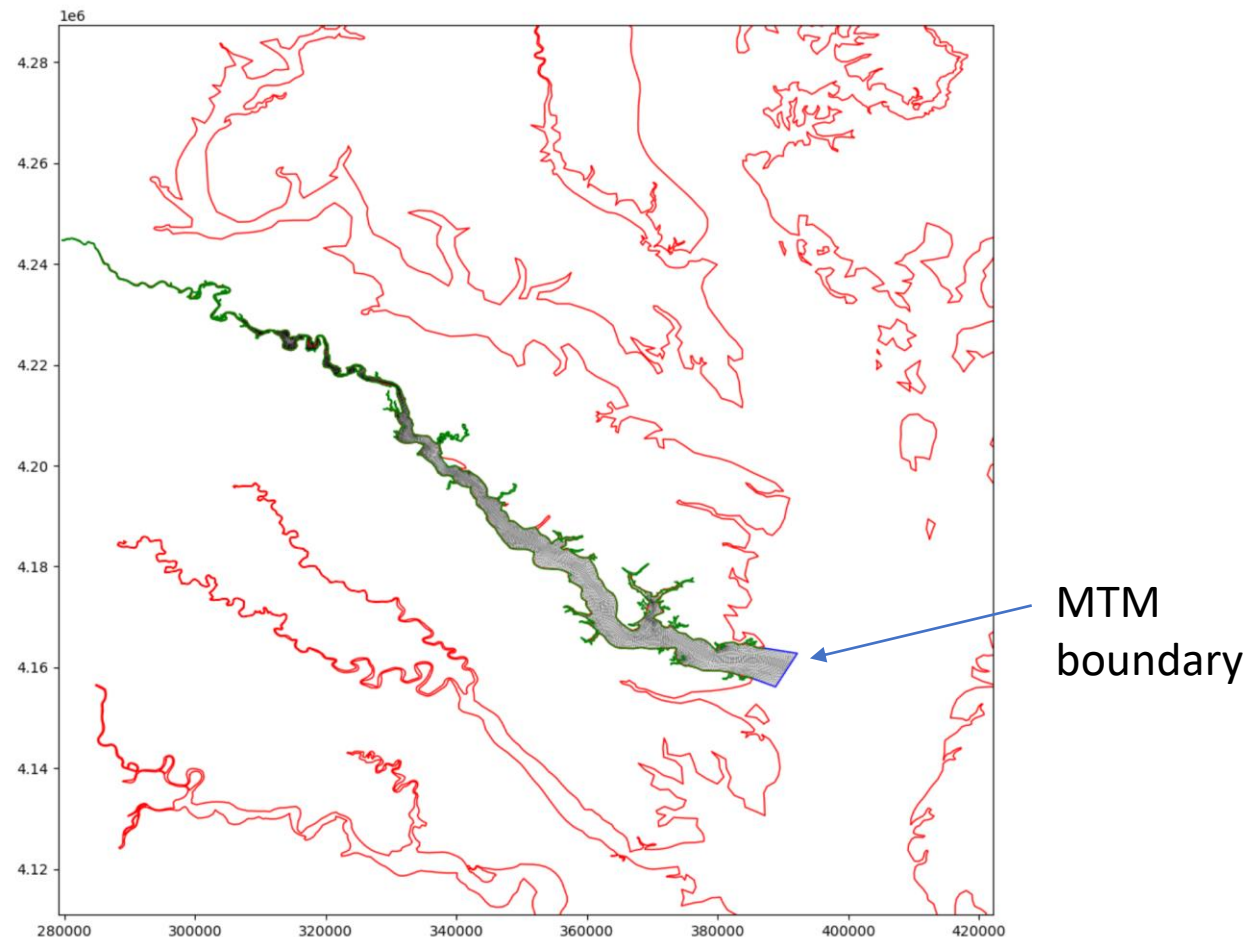
Rappahannock River Model Setup

- Initial condition of Rapp MTM was extracted from MBM results

- Watershed loading
  - We manually selected the watersheds from the Rapp. River
  - However, the MBM grid was still used in the mapping relation from the watershed to MTM model grid, which can be improved by using the MTM grid with a finer resolution

- Parameter values and other inputs are the same as the MBM setup.
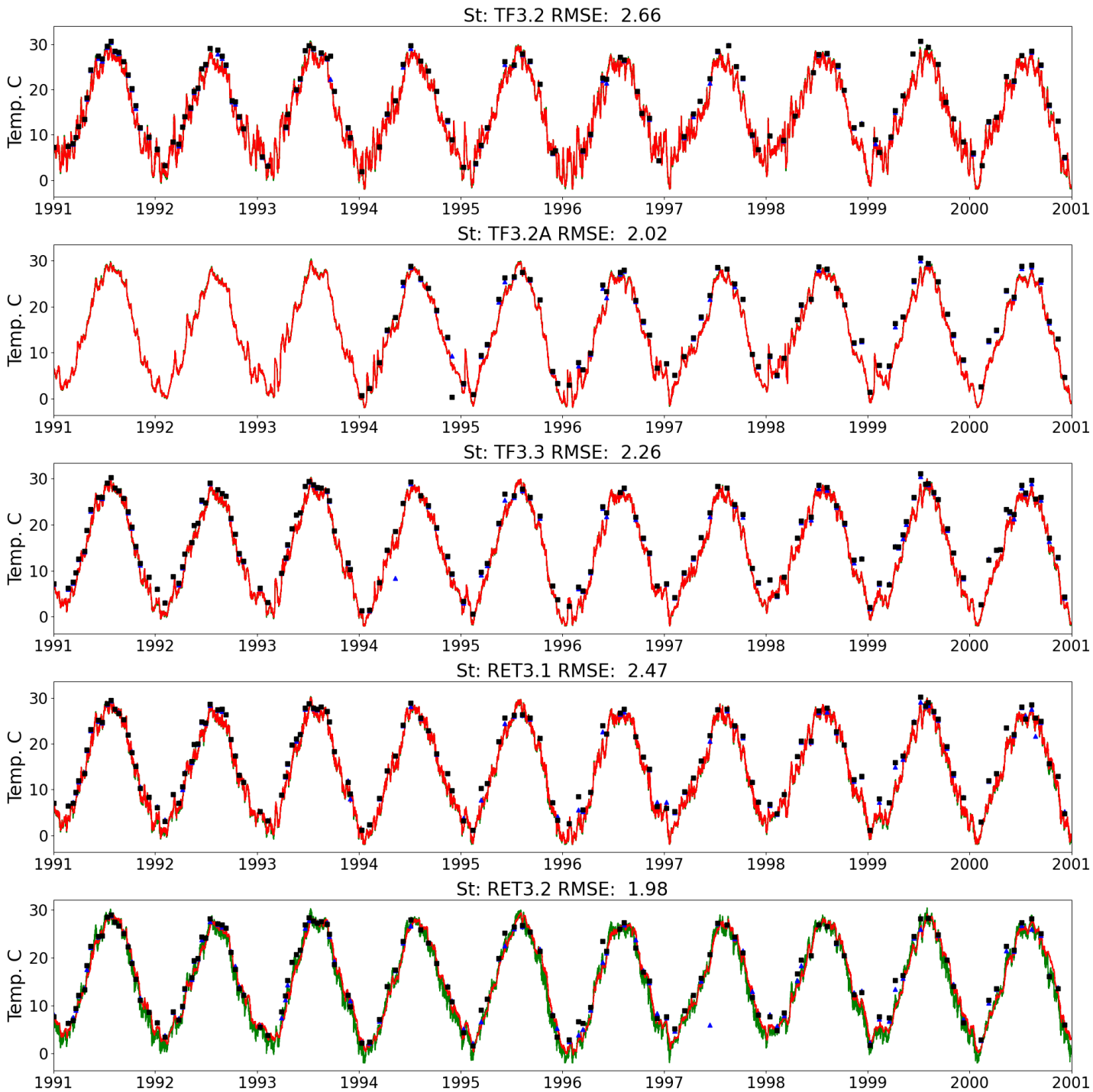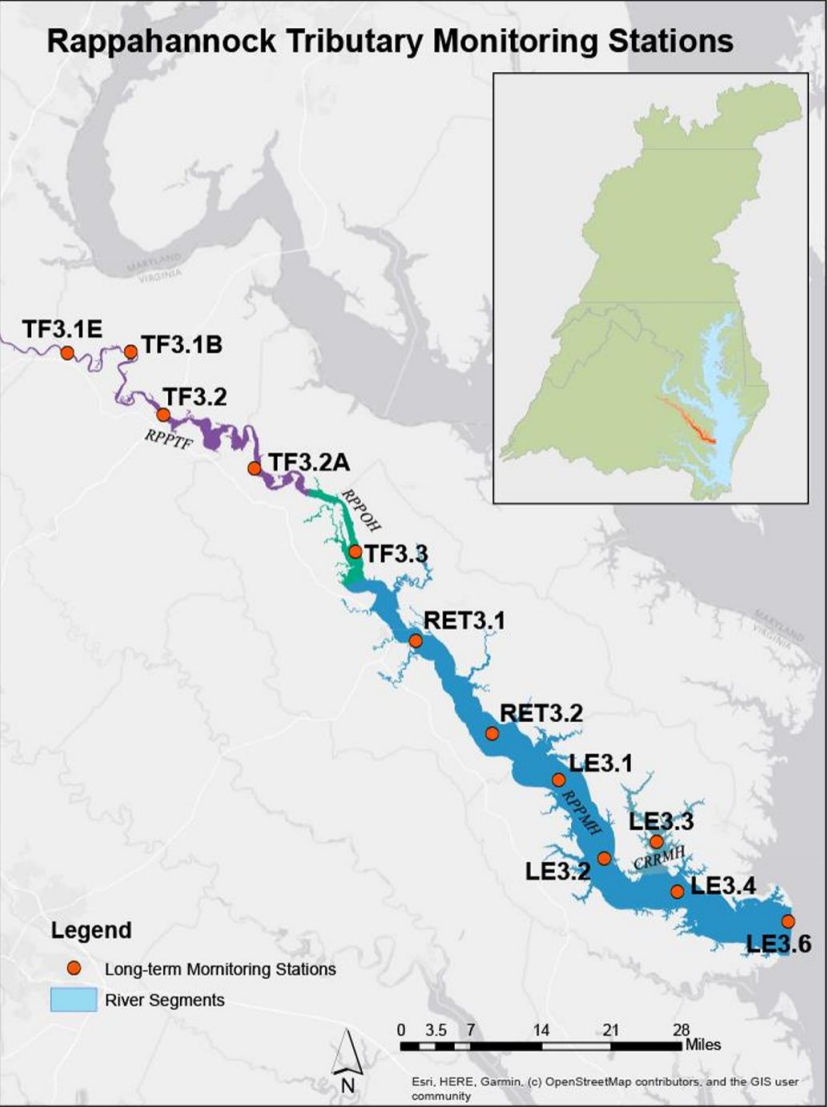
- MTM run from 1991 to 2000

Temperature

Rappahannock Tributary Monitoring Stations

Devereux et al. (2021)

Temperature

Rappahannock Tributary Monitoring Stations

Devereux et al. (2021)

St: TF3.2 RMSE: 2.66

St: TF3.2A RMSE: 2.02

St: TF3.3 RMSE: 2.26

St: RET3.1 RMSE: 2.47

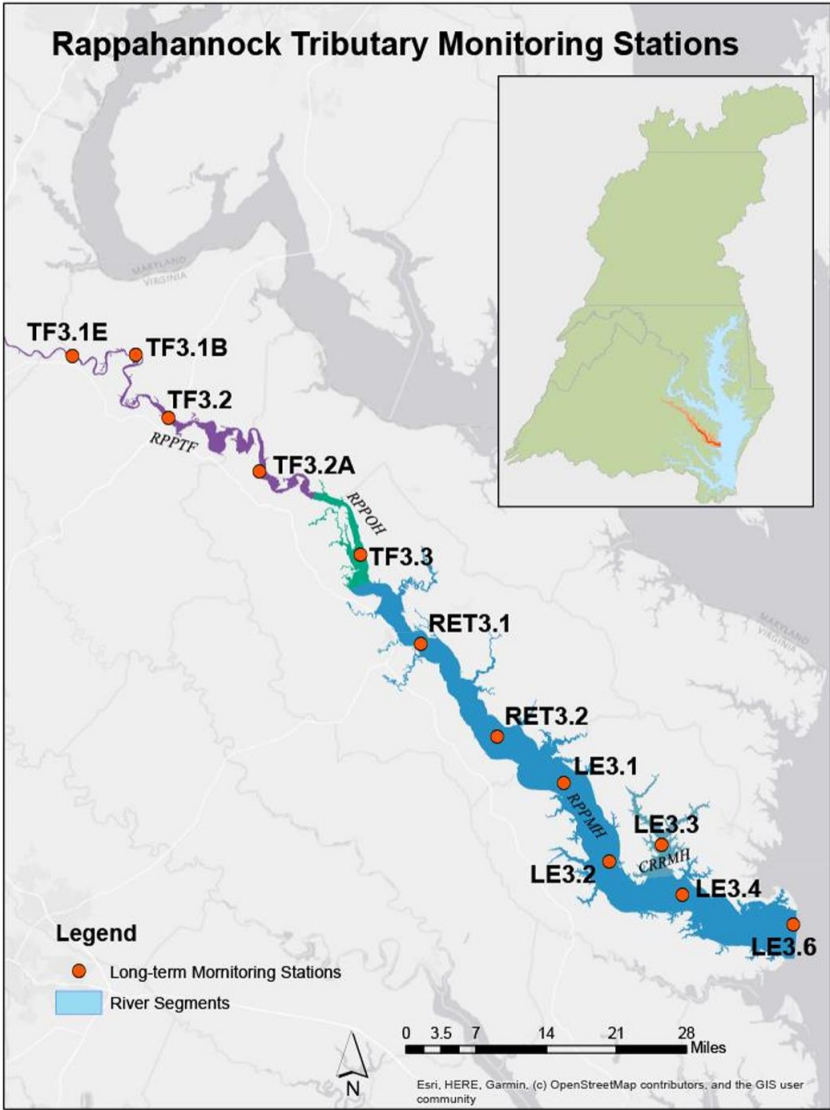St: RET3.2 RMSE: 1.98
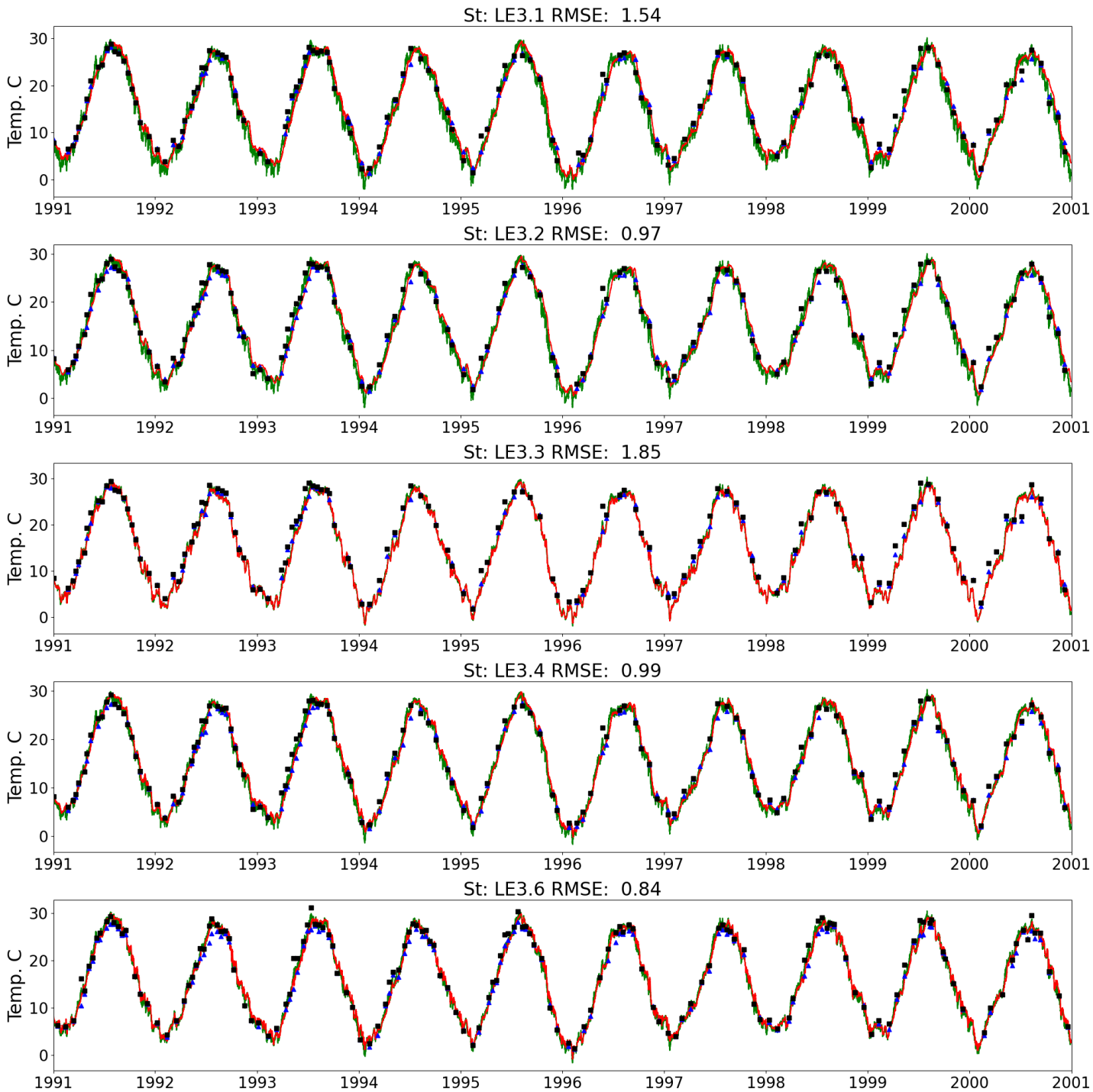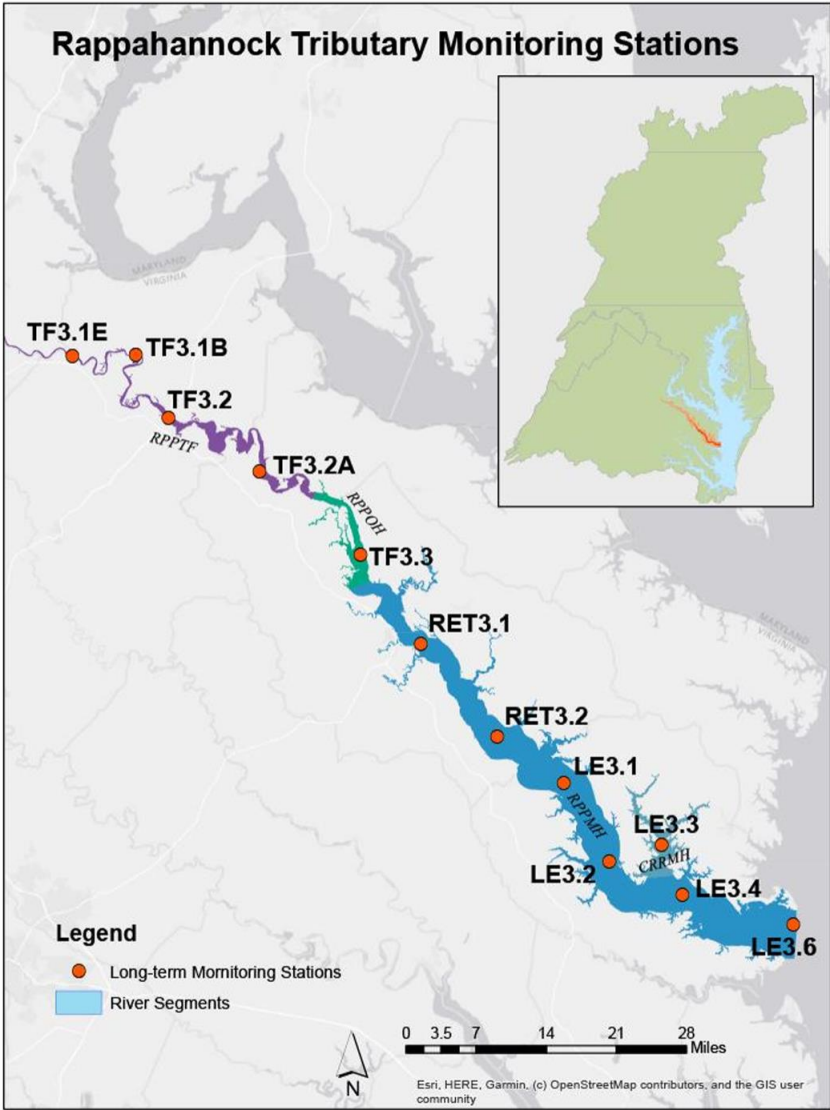
Salinity

Devereux et al. (2021)

Salinity
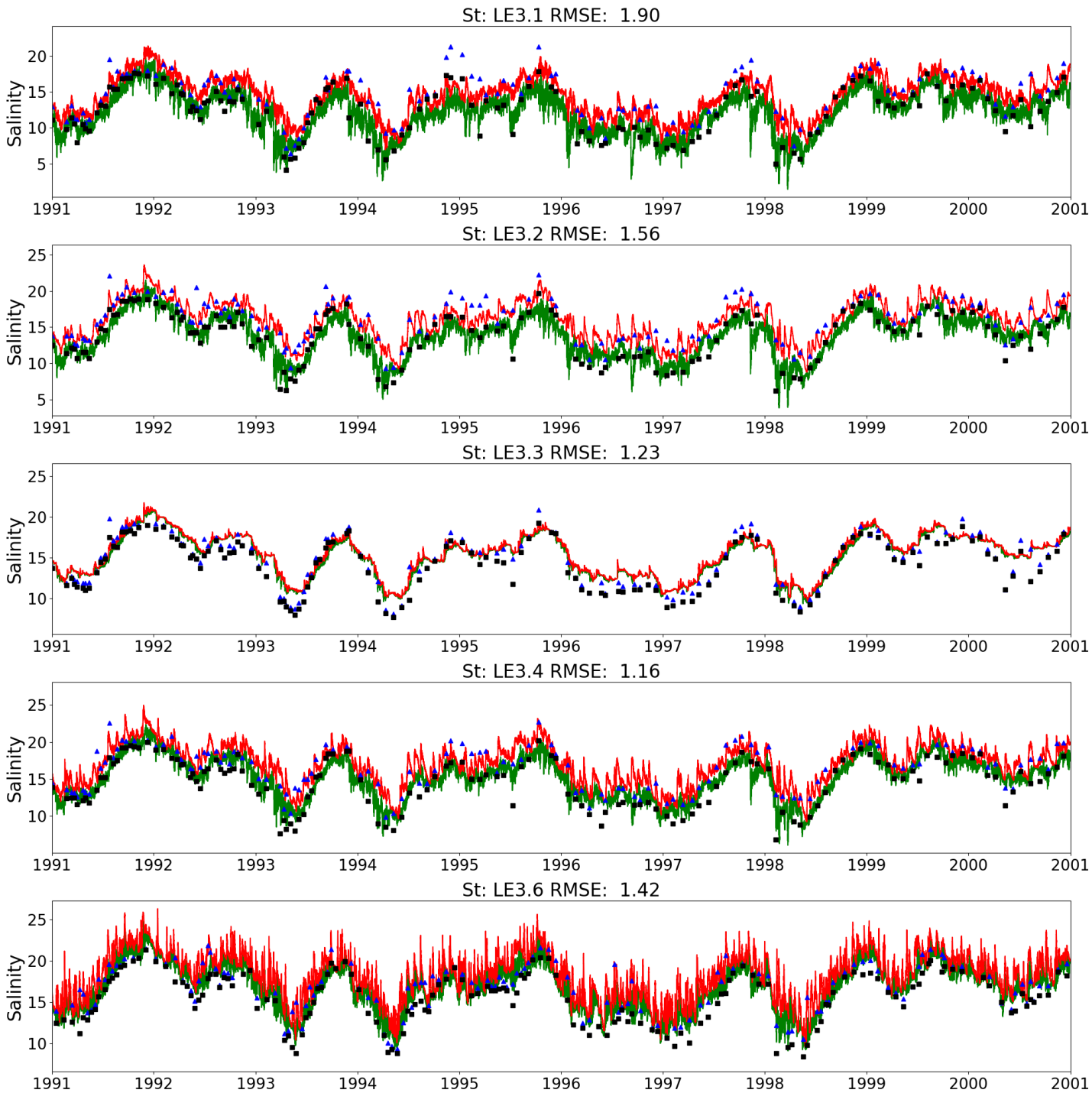
Devereux et al. (2021)
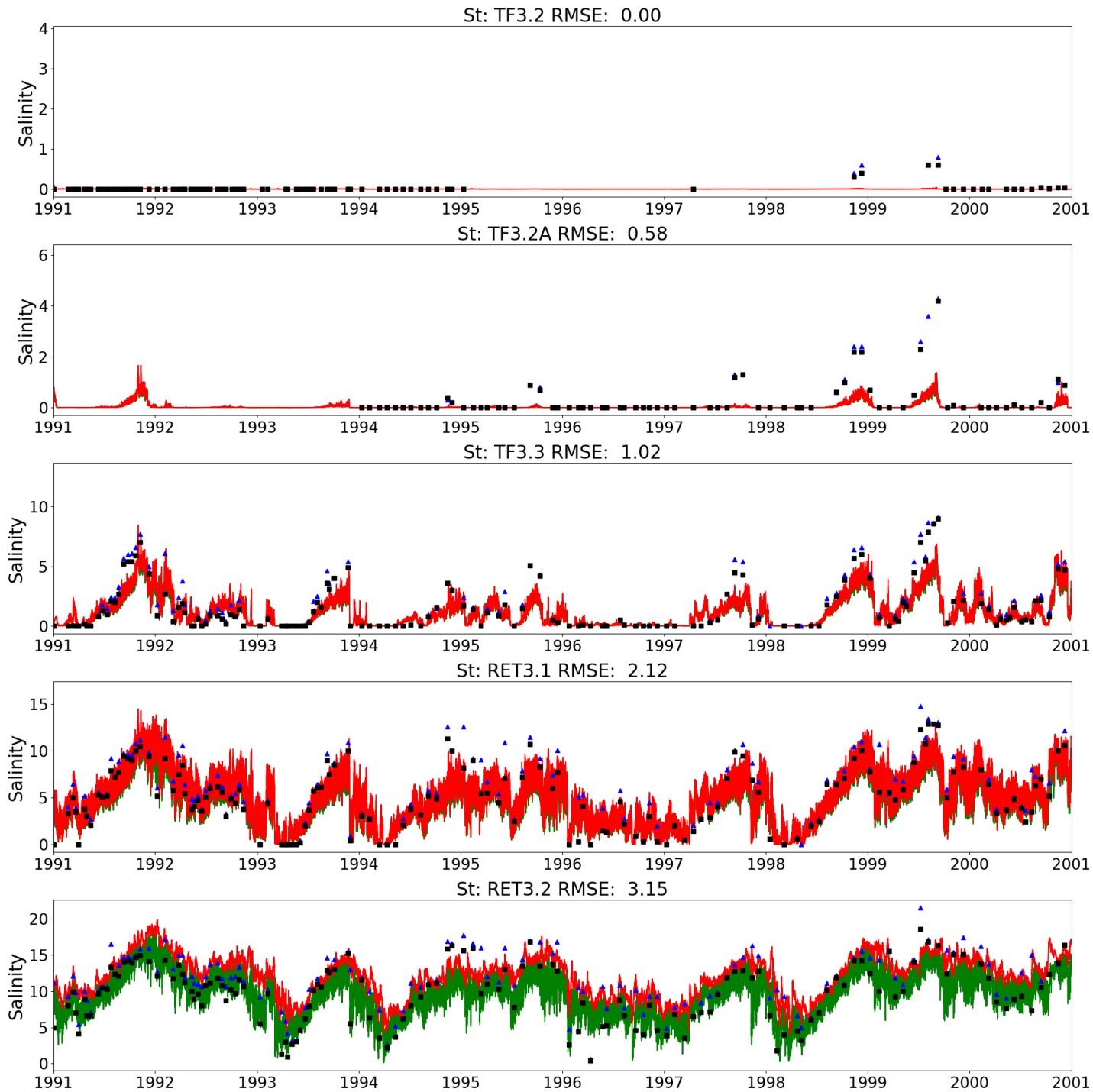
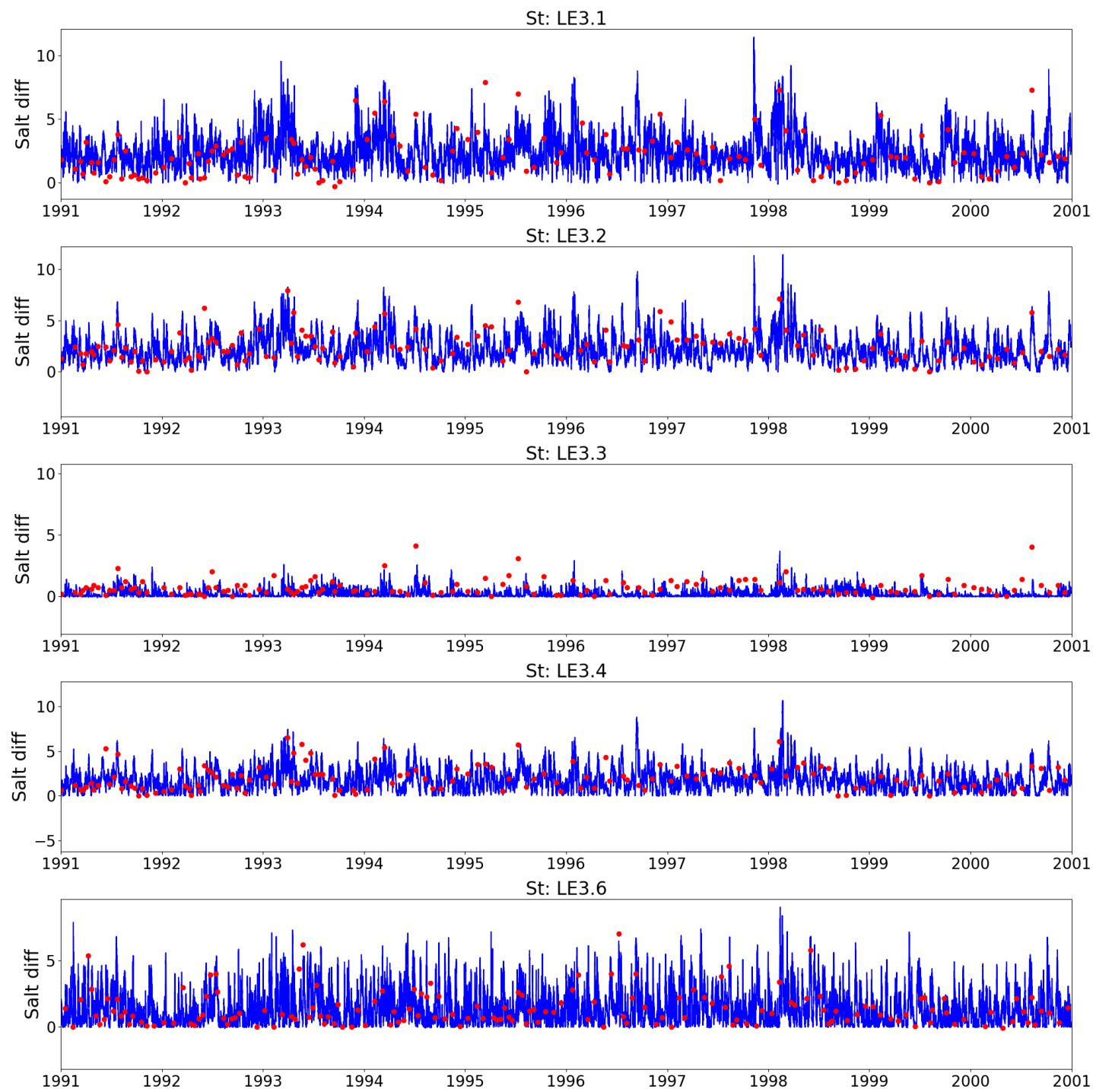# Salinity Difference (bottom - surface)

Rappahannock Tributary Monitoring Stations
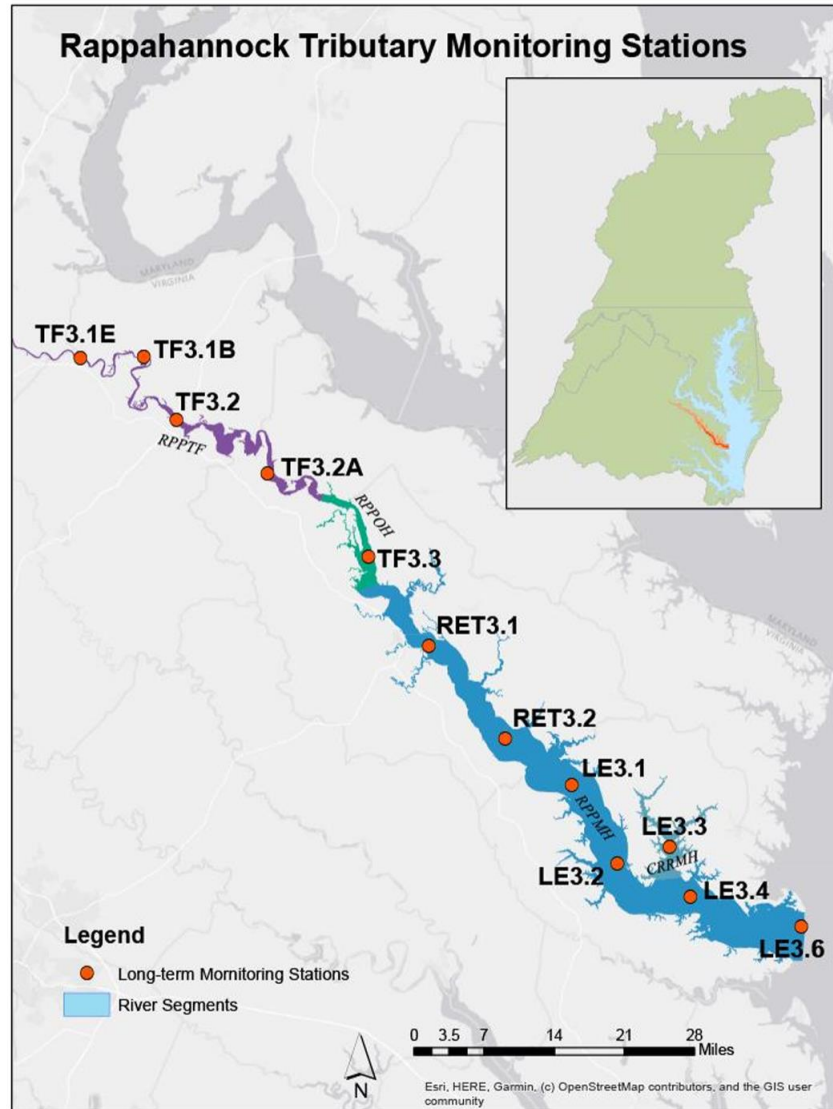
Devereux et al. (2021)

This is the initial run of the model for ten years

Future Rapp MTM may be improved by
- using a more localized parameter setup,
- river flow adjustment, and
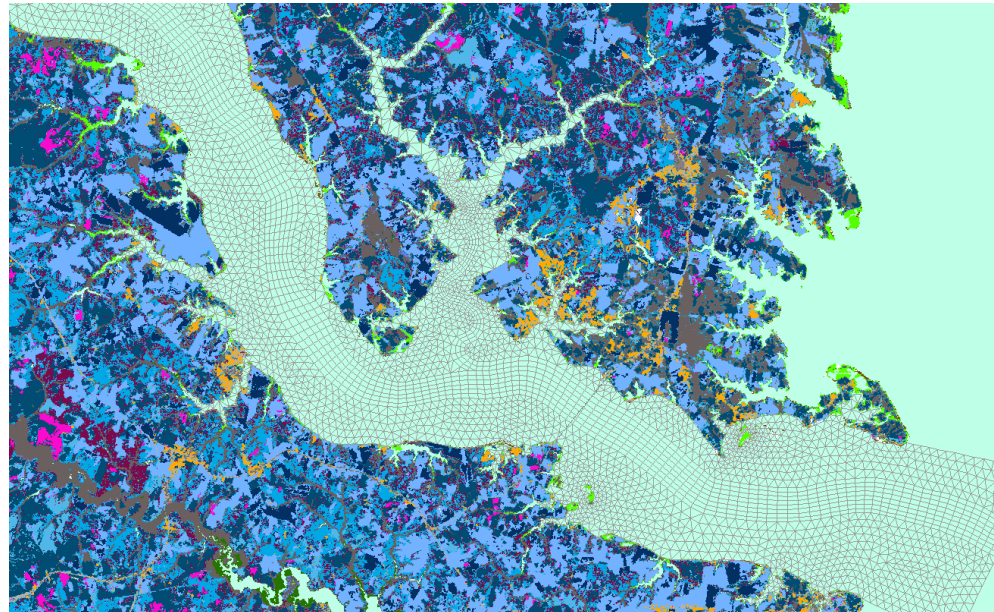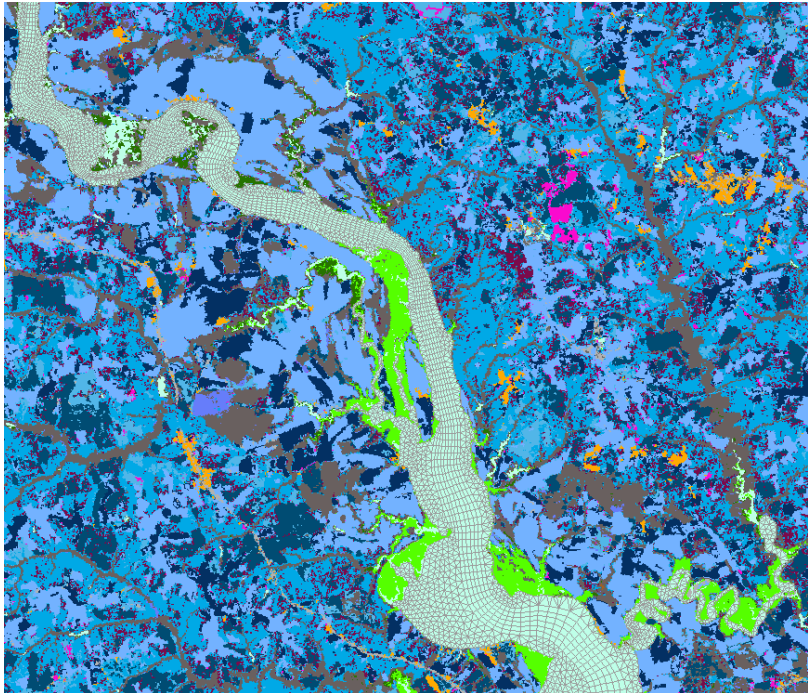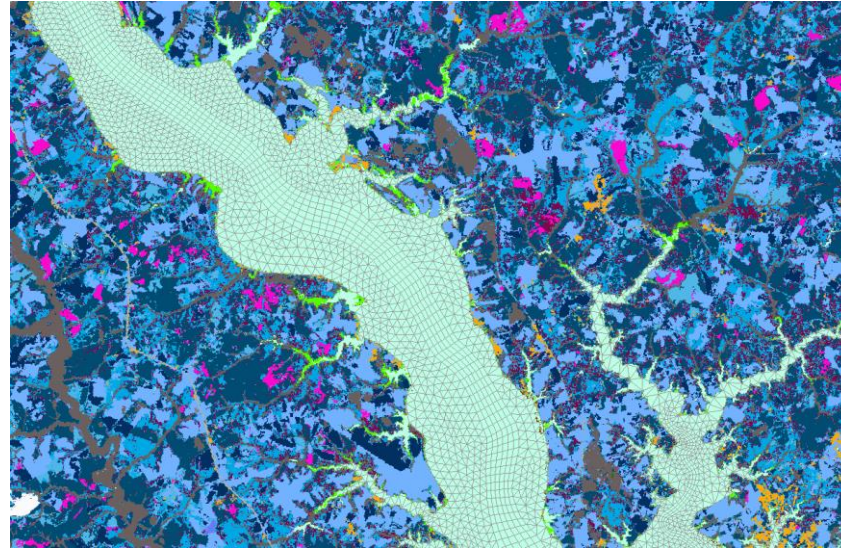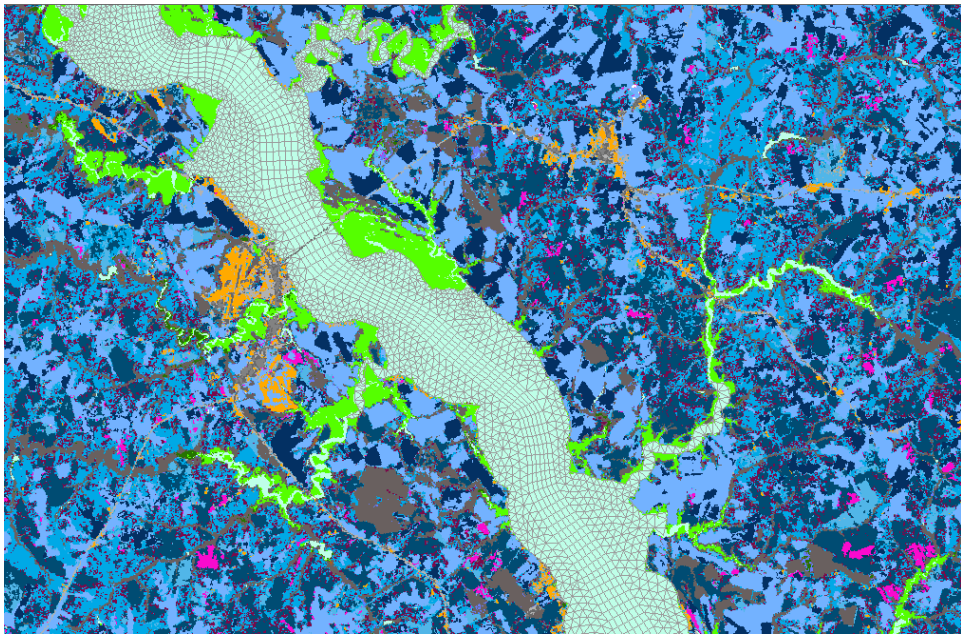- adjustment on the boundary conditions.

Outline

- Goal and Tasks

- Model Grid, and the 2011 Scenario

- Initial Ten-Year Hydrodynamic Model Run (1991-2000)
  - Model Setup
  - Linkage Between MTM and MBM
  - Hydrodynamic Model Results

- **Model Grid Coverage Regarding SAV and Marshes**
  - Discussion

Check SAV
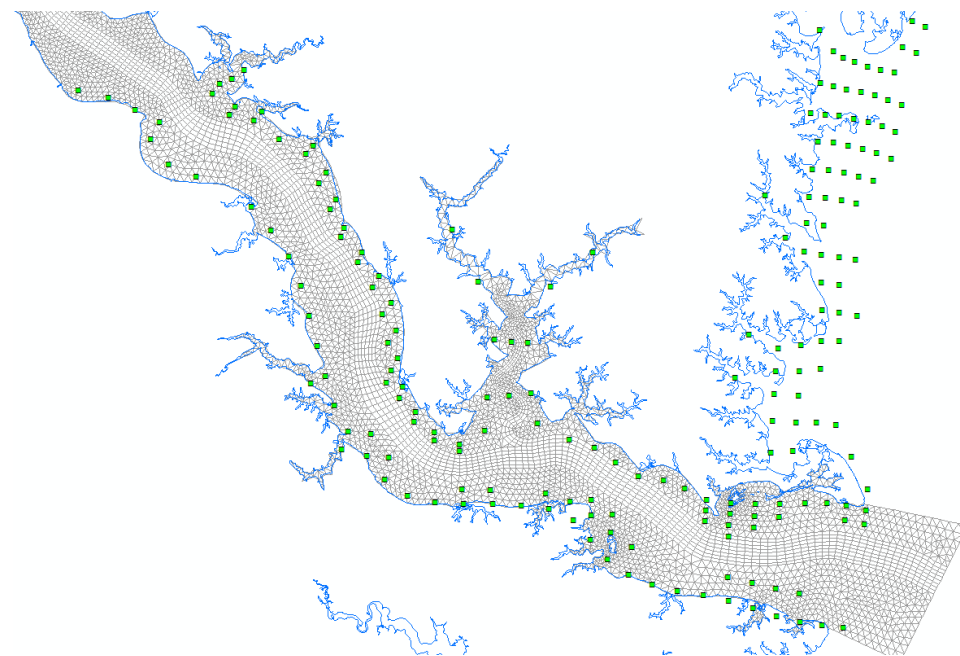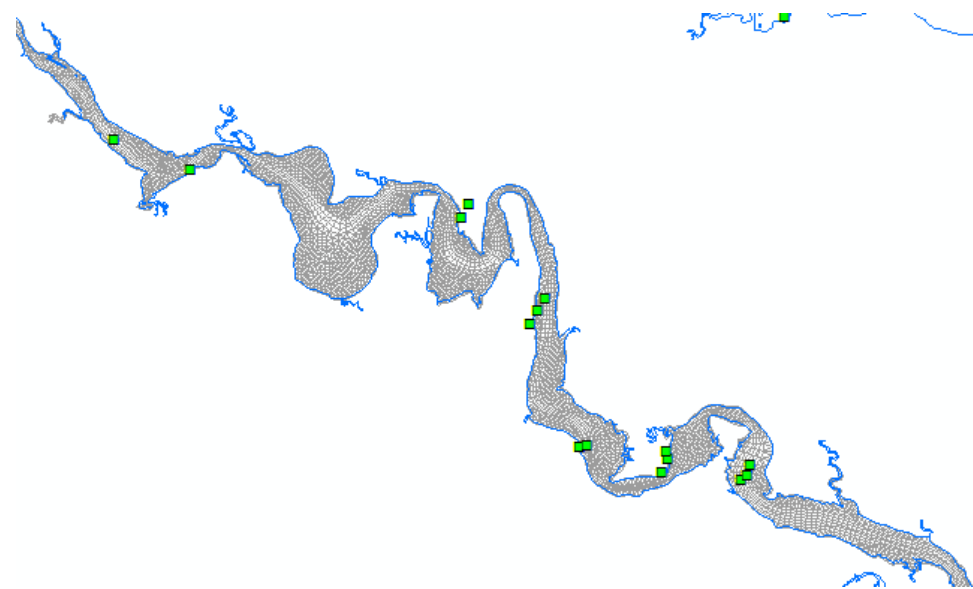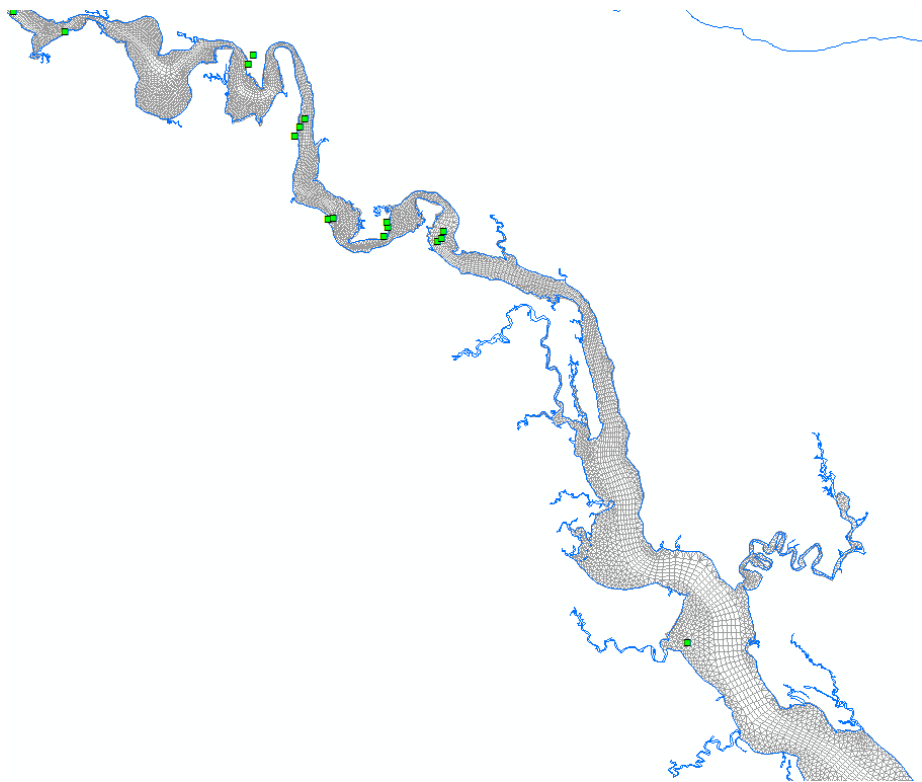
No large wetlands within the River

Discussion:

Do we need to simulate wetlands in the model or use approximation as Carl did?