

A map of the Patuxent Estuary, showing the complex network of waterways and surrounding land. The land is colored in shades of green and yellow, while the water is light blue. The title text is overlaid on the map.

Patuxent Estuary Model: Hydrodynamic Setup

Amir Reza Azarnivand and Jeremy M. Testa

Chesapeake Biological Lab, University of Maryland Center for Environmental Science

4/8/2026

Why I'm Bringing This Here

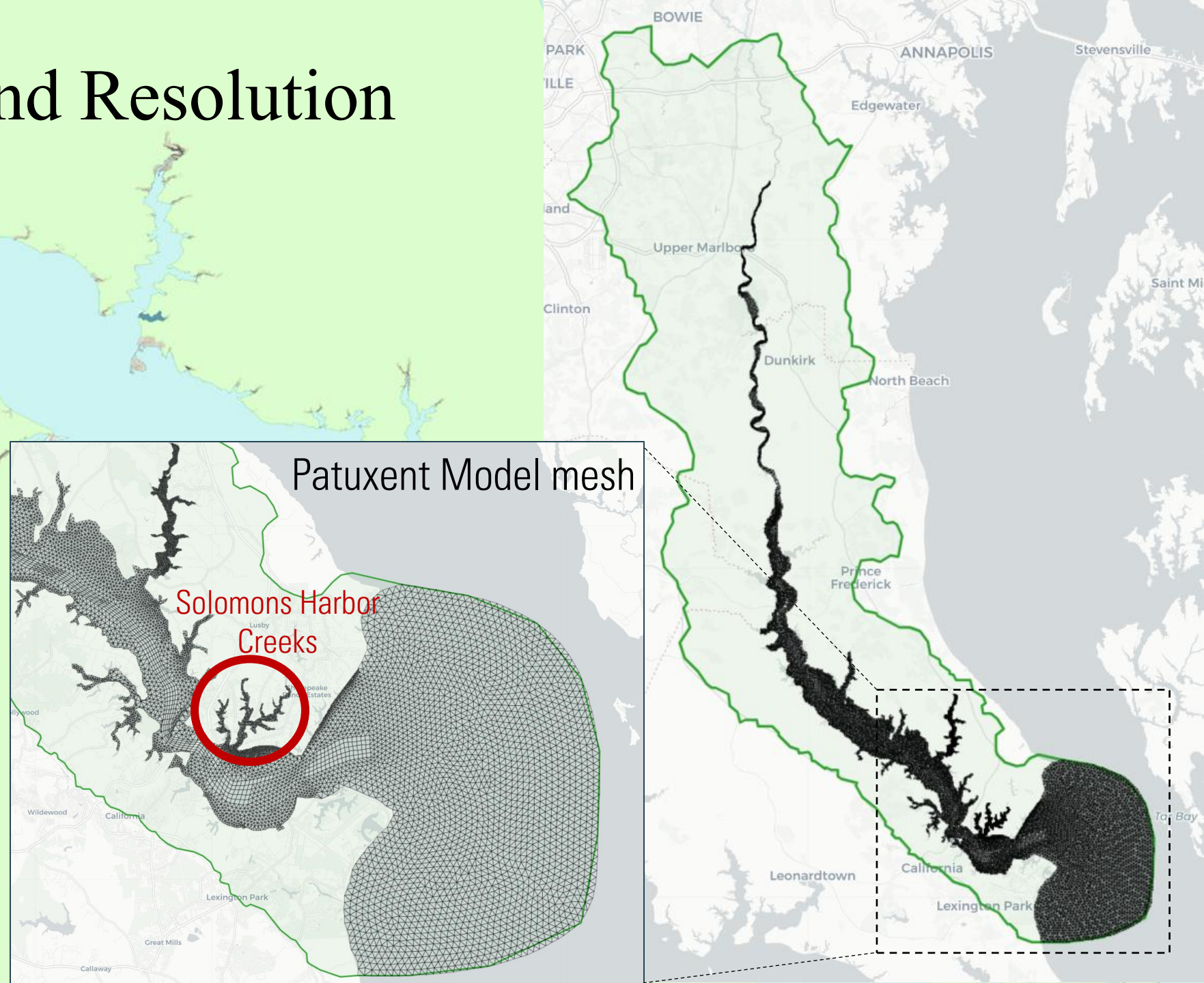
- **Purpose of today**

- Present current Patuxent hydrodynamic model
- Show 10-year run validation
- Get feedback on setup and biases
- Explore how this fits within the MTM framework



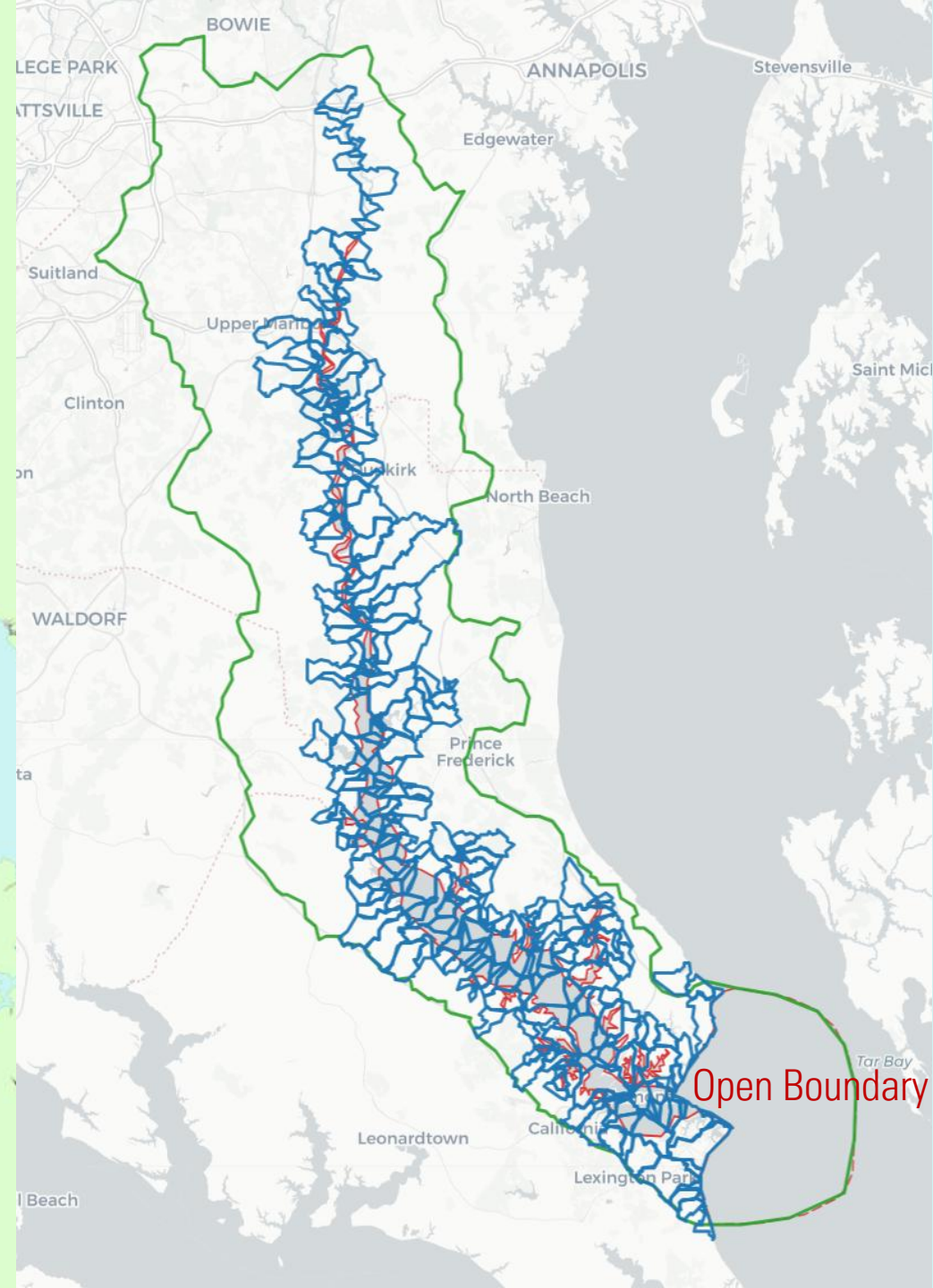
Model Domain and Resolution

- Unstructured SCHISM grid covering full estuary
- Open boundary at Chesapeake Bay
- Resolves mainstem and tributary creeks
- Higher resolution in lower estuary and creeks
 - Min element area $\sim 55 \text{ m}^2$
 - Max element area $\sim 73600 \text{ m}^2$



Boundary and Forcing

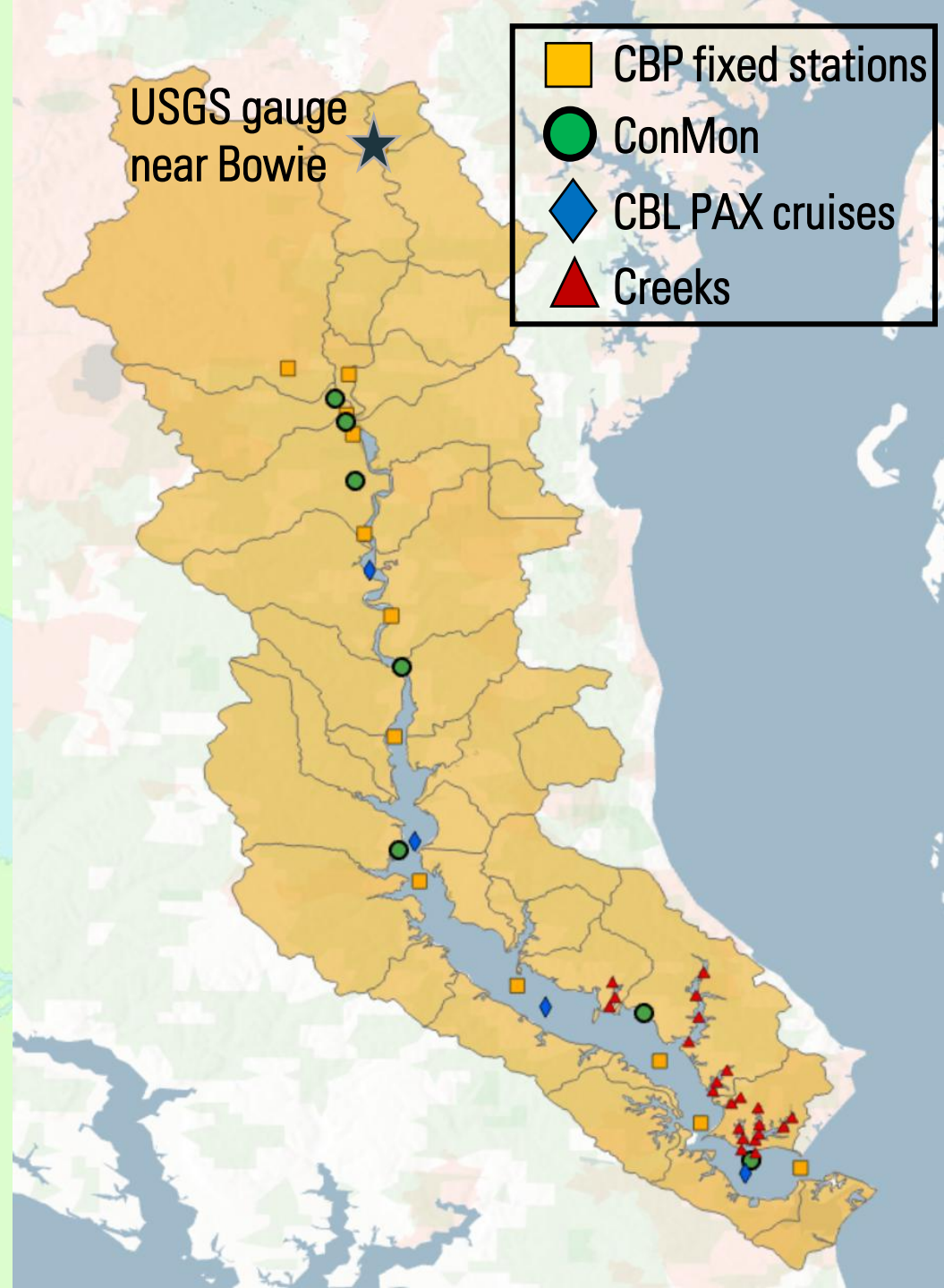
- Open boundary: CBP Main Bay Model (Run 11fb)
- 3D boundary forcing for elevation, velocity, temperature, and salinity
- Watershed inputs from Phase-7 CBP WSM
 - Patuxent river flow replaced by USGS (near Bowie) daily flow data
- Atmospheric forcing from ERA5 (sflux)
- 10-year continuous simulation (1991-2000)



Validation Stations and Data

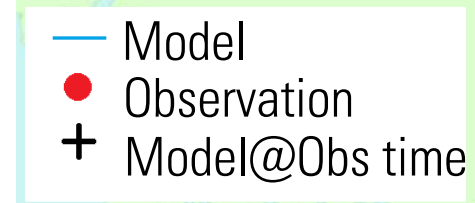
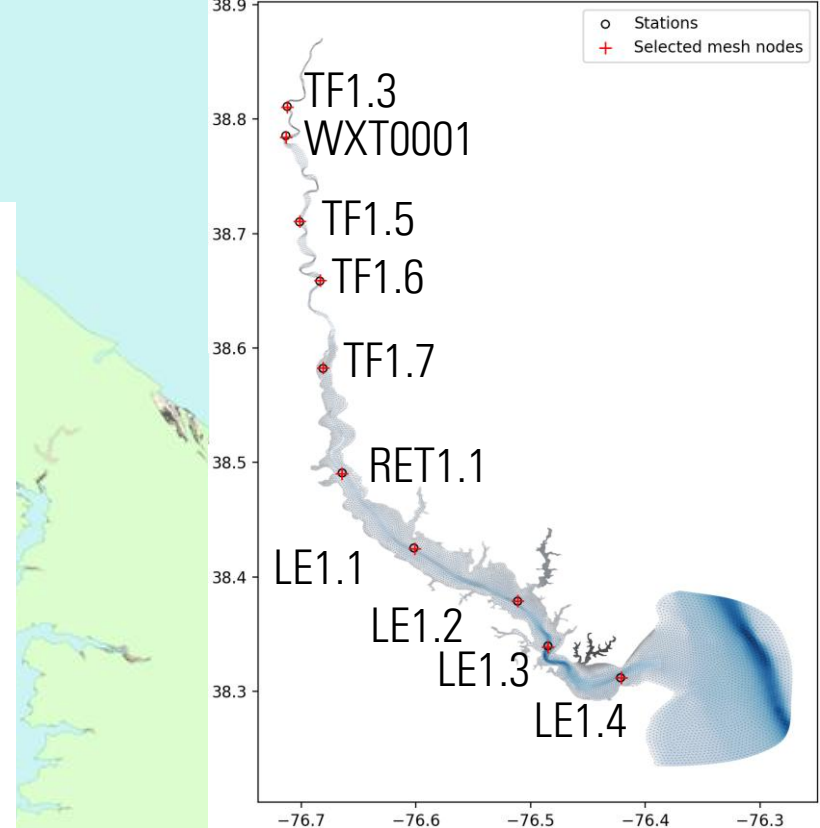
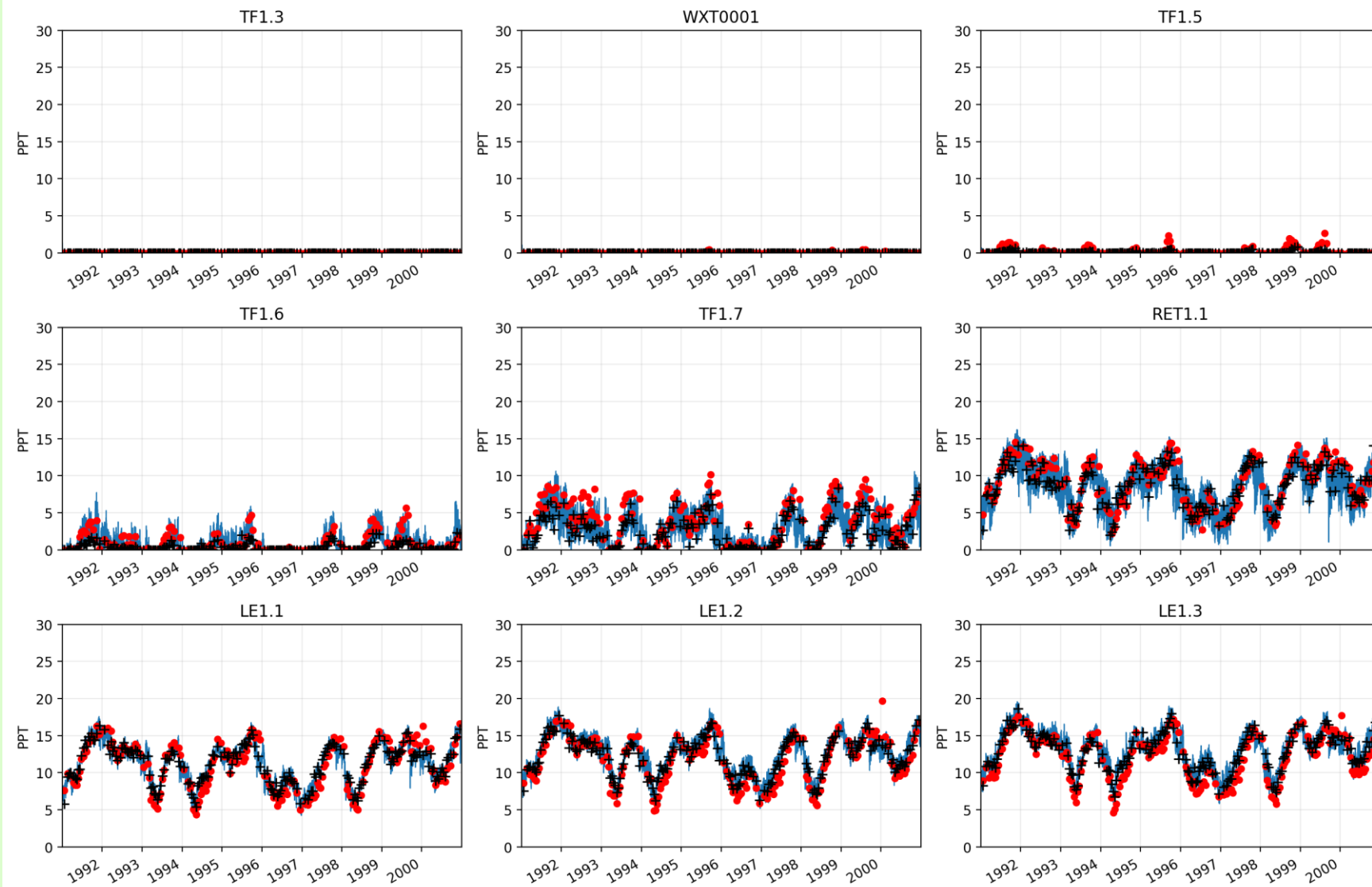
- CBP fixed monitoring stations and Continuously Monitoring stations across the Patuxent estuary
- CBL PAX cruises
- Selected tributary / creek locations

- Evaluation focused on salinity, temperature, and water level



Salinity Validation (1991–2000)

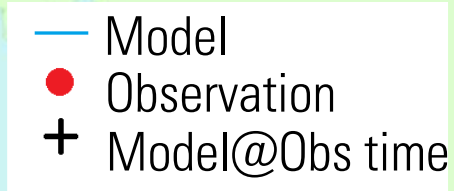
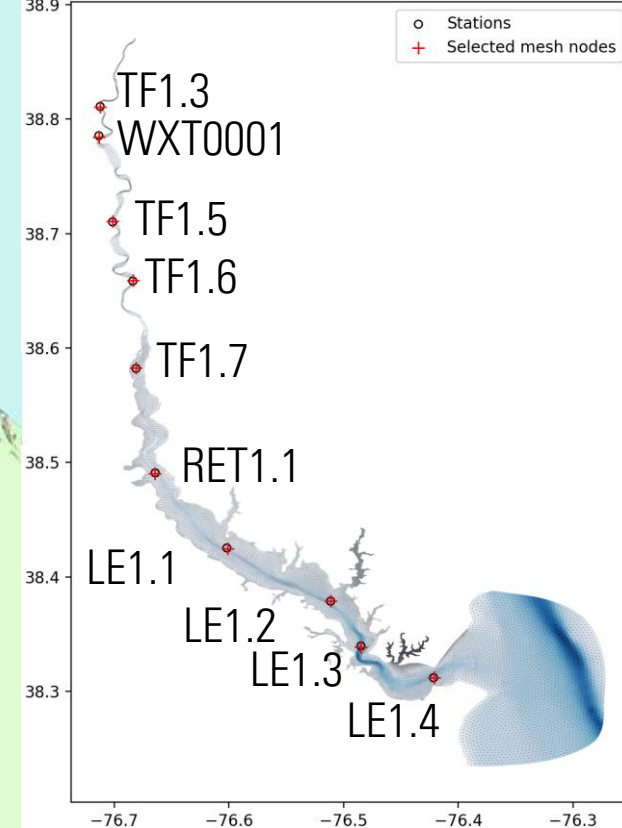
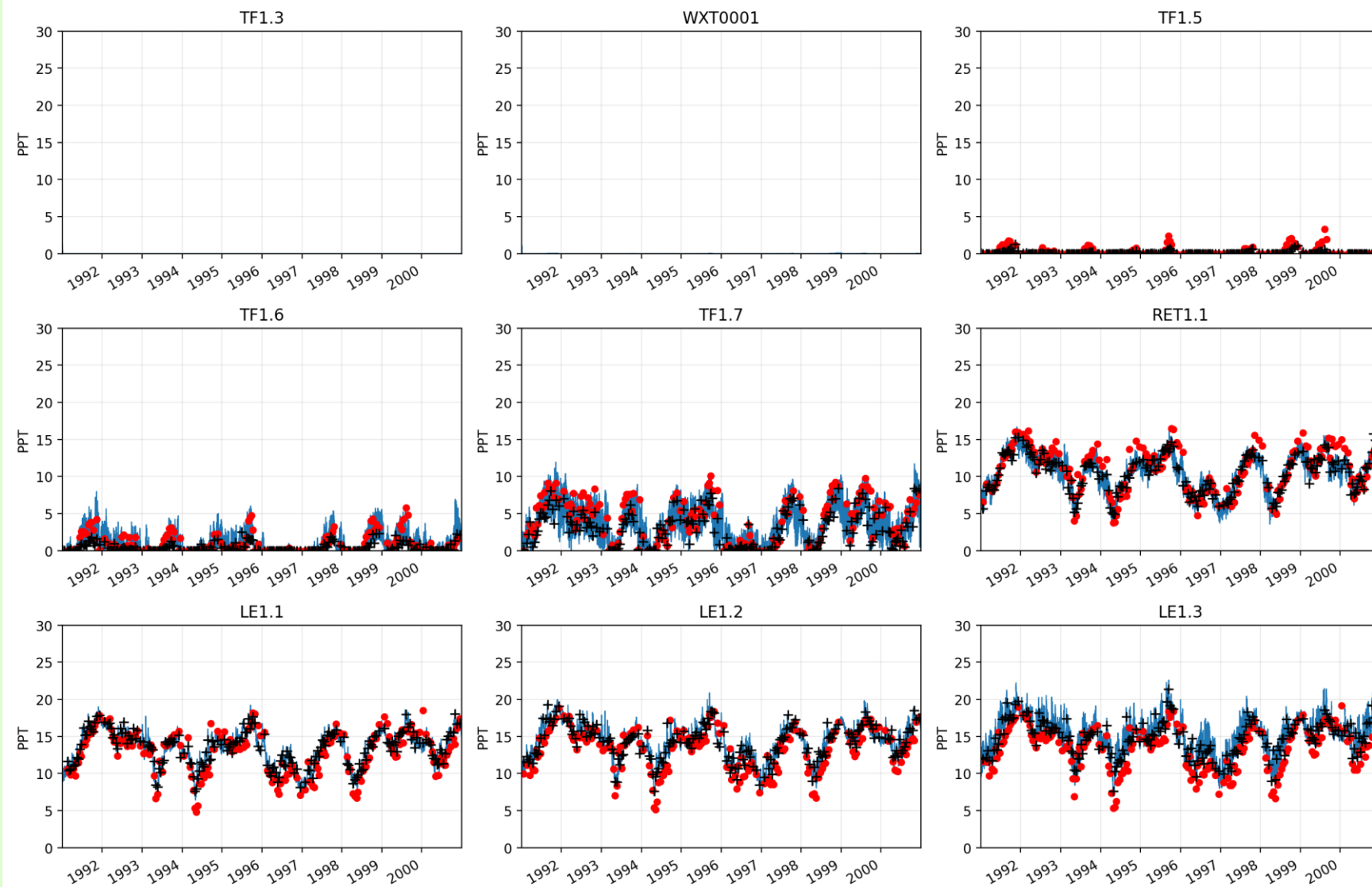
SALINITY vs model salinity (S) | model line + obs circles + model@obs plus



Surface Salinity in the main channel
CBP fixed stations

Salinity Validation (1991–2000)

SALINITY vs model salinity (B) | model line + obs circles + model@obs plus

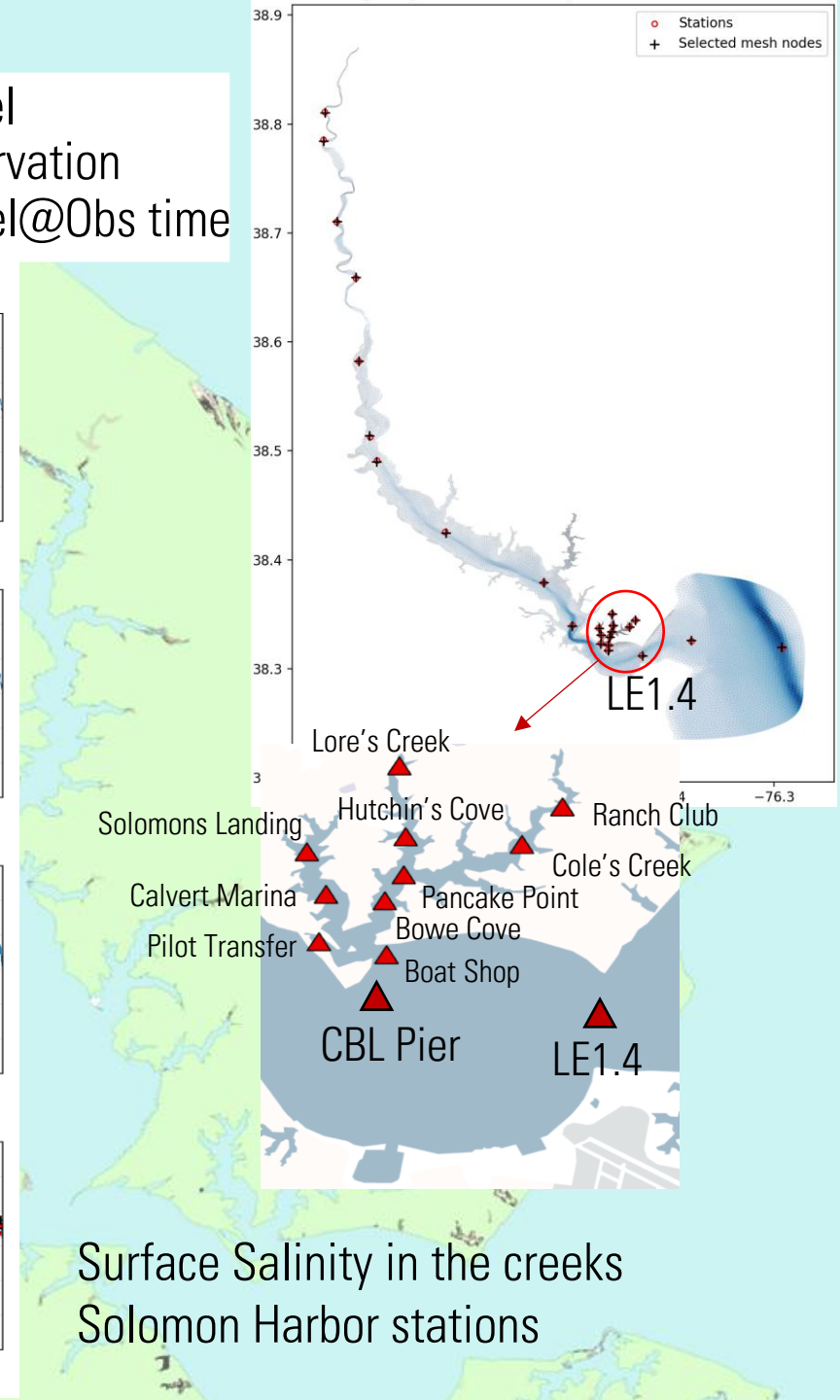
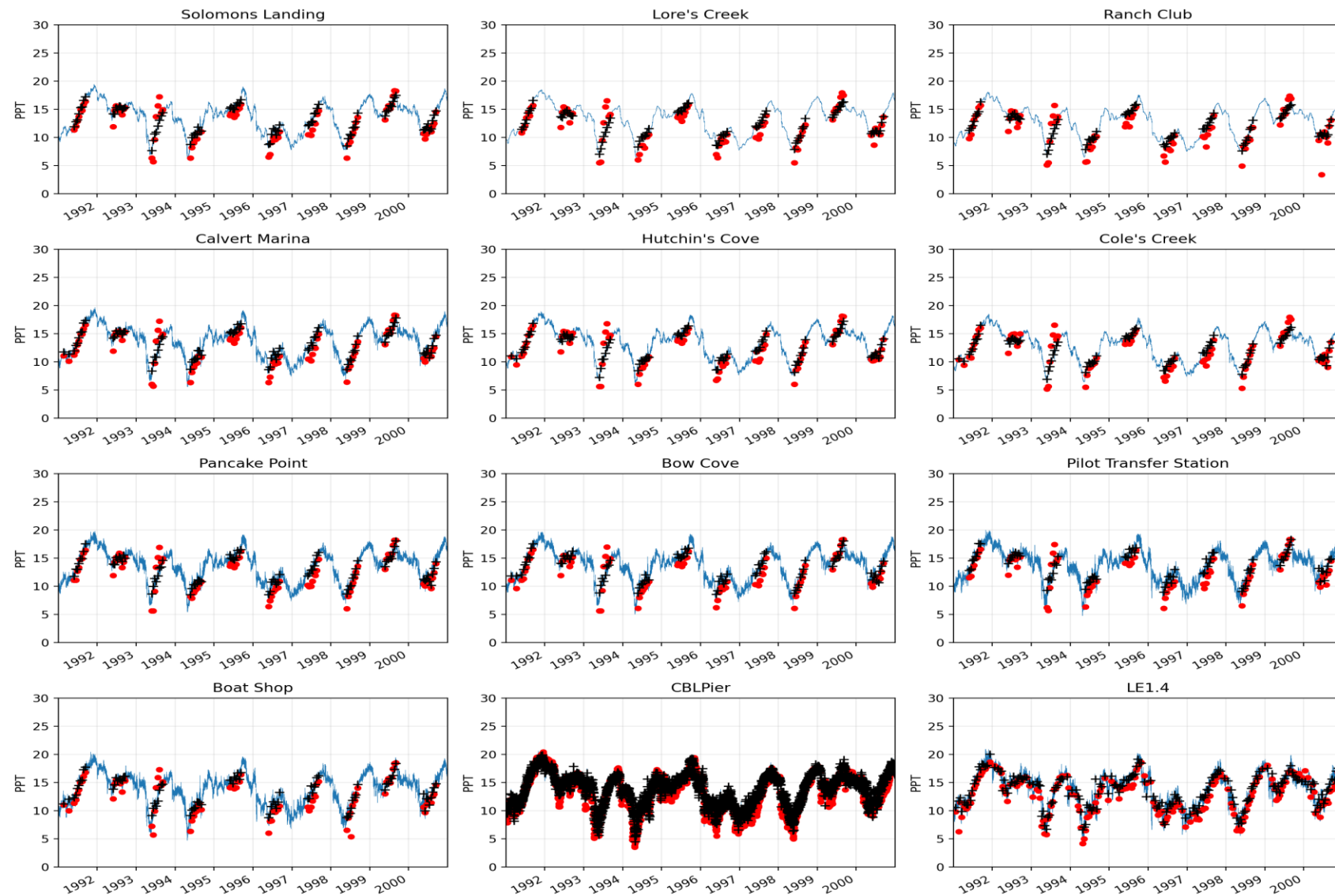


Bottom Salinity in the main channel
CBP fixed stations

Salinity Validation (1991–2000)

— Model
● Observation
+ Model@Obs time

SALINITY vs model salinity (S) | model line + obs circles + model@obs plus

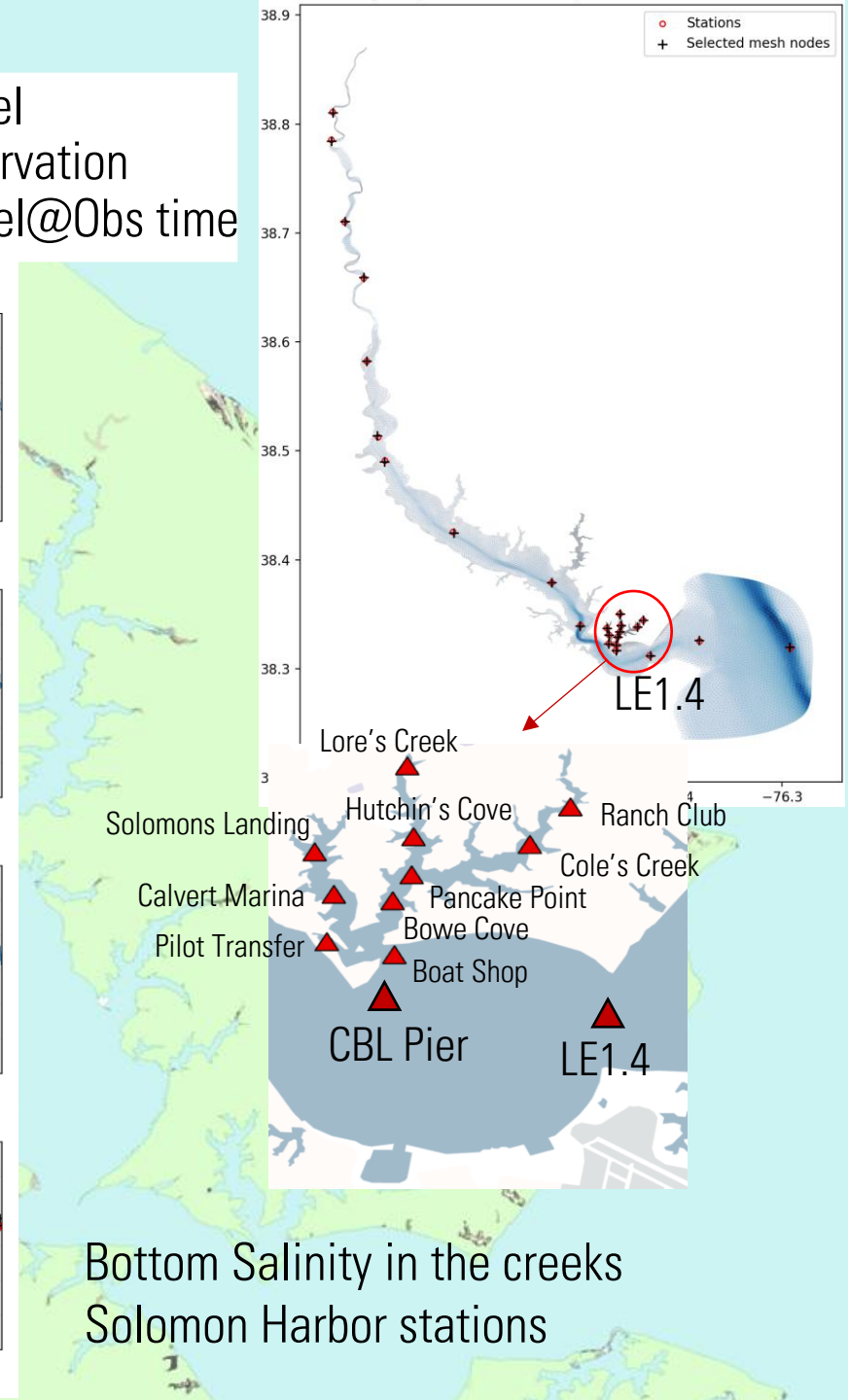
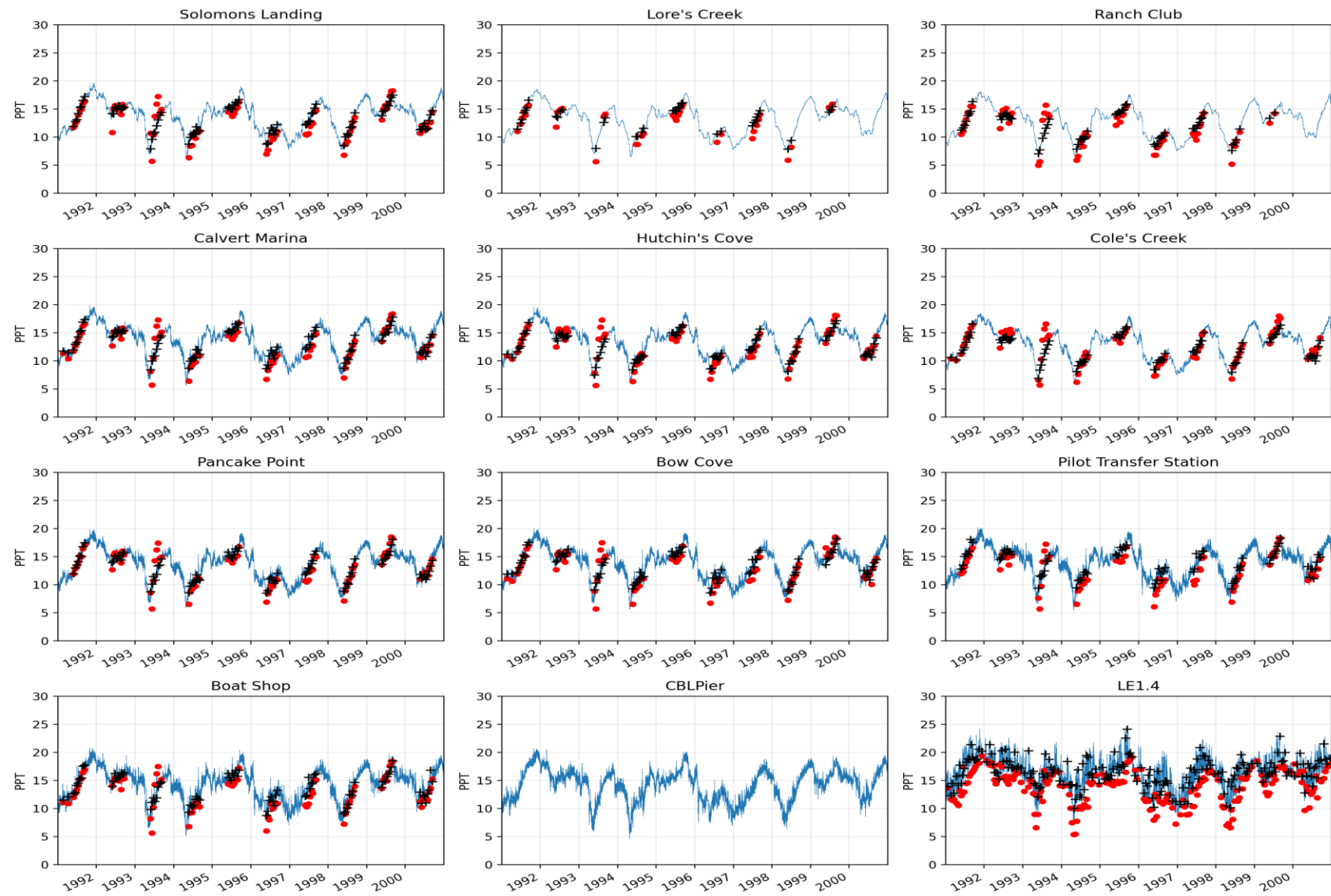


Surface Salinity in the creeks
Solomon Harbor stations

Salinity Validation (1991–2000)

- Model
- Observation
- + Model@Obs time

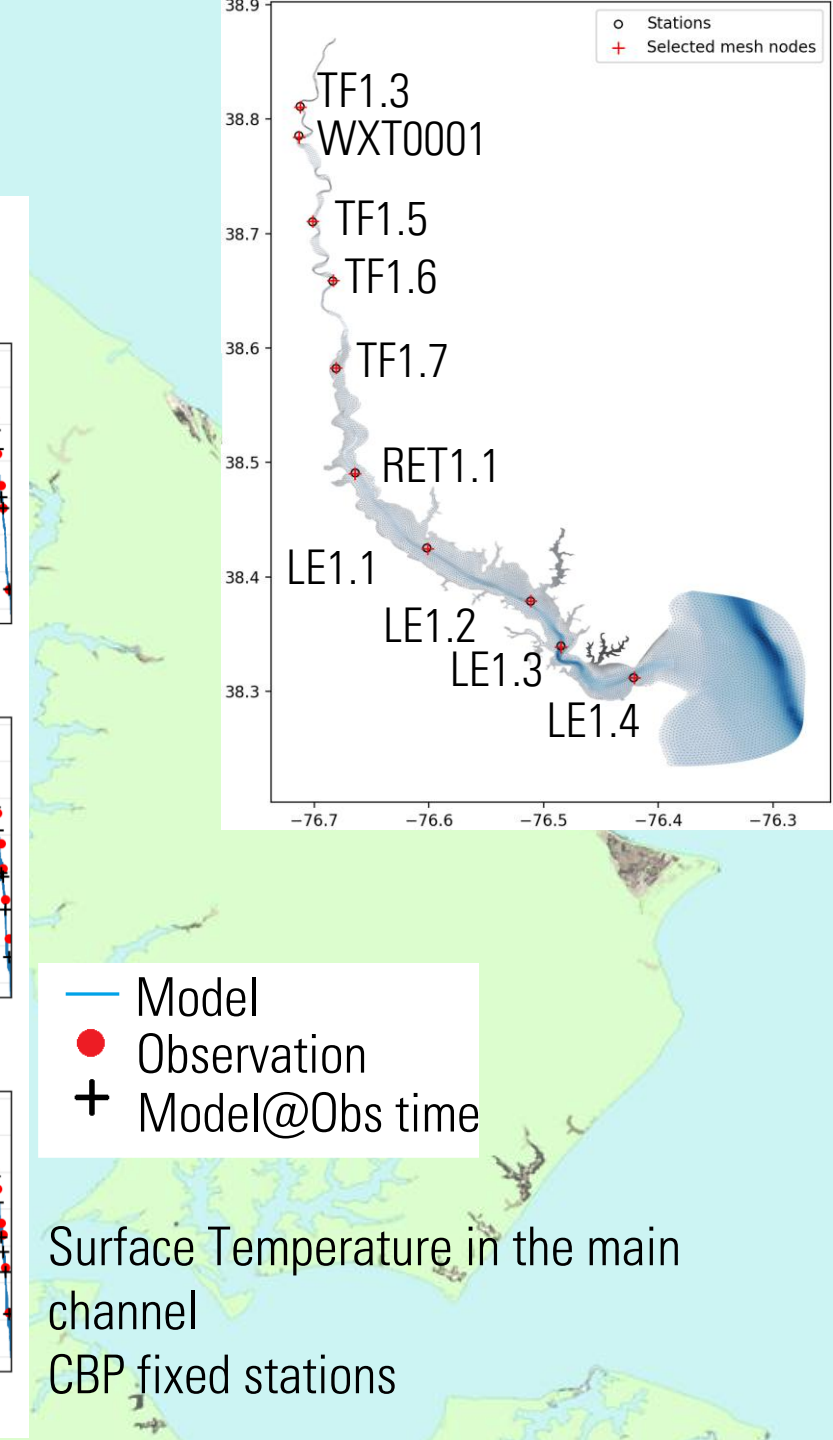
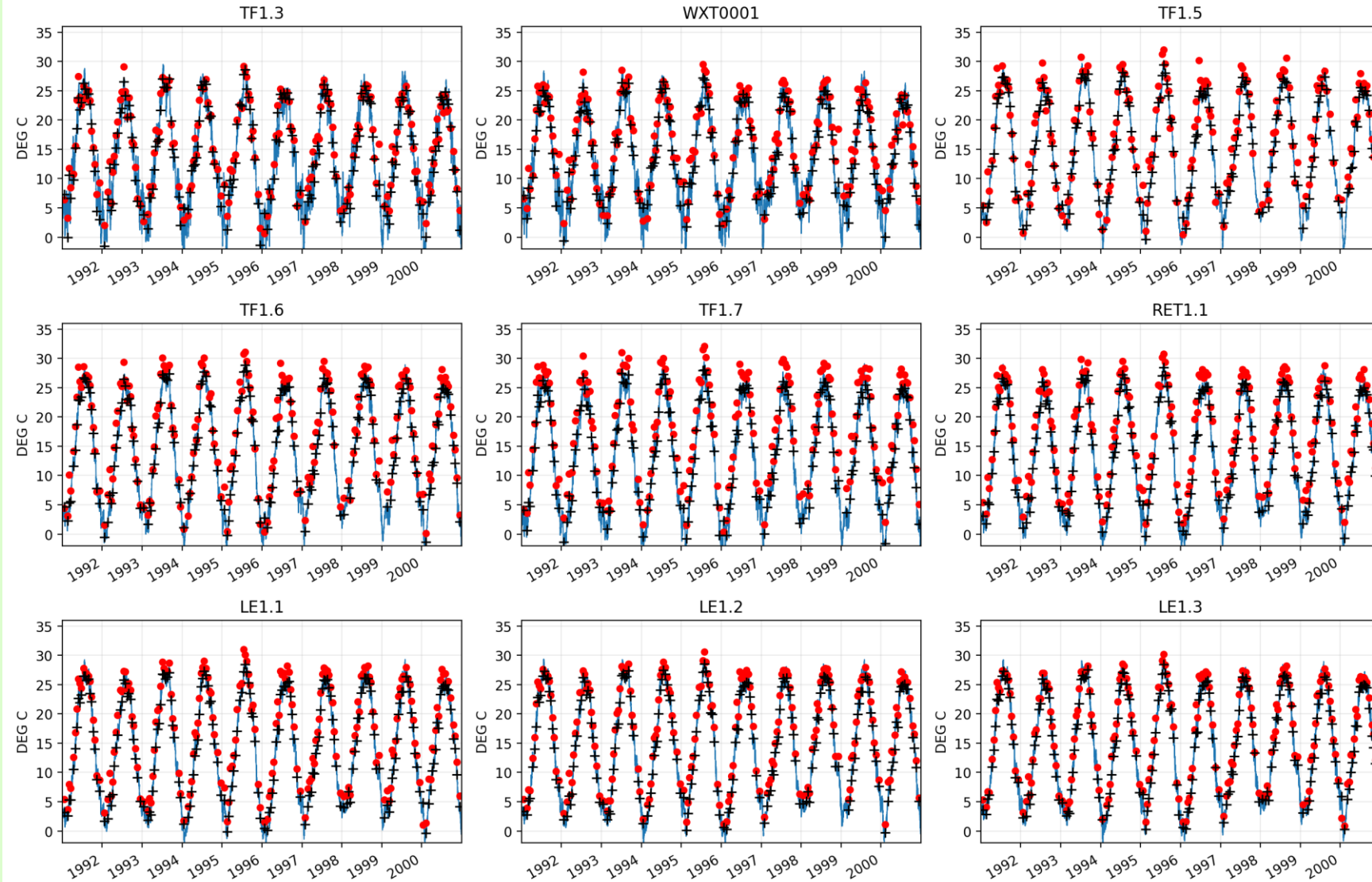
SALINITY vs model salinity (B) | model line + obs circles + model@obs plus



Bottom Salinity in the creeks
Solomon Harbor stations

Temperature Validation (1991–2000)

WTEMP vs model temperature (S) | model line + obs circles + model@obs plus

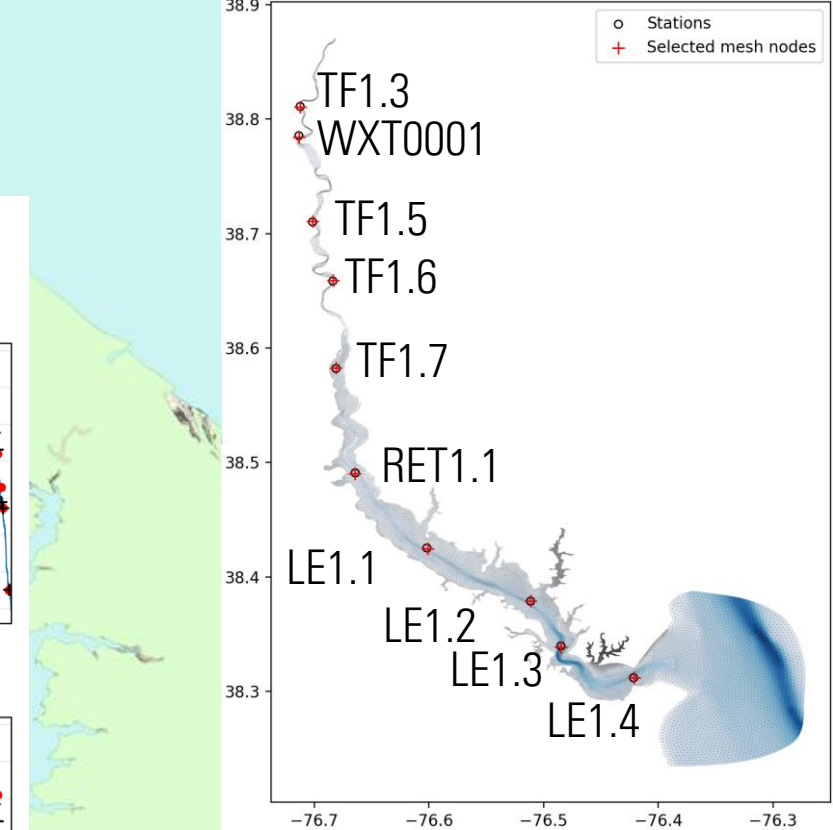
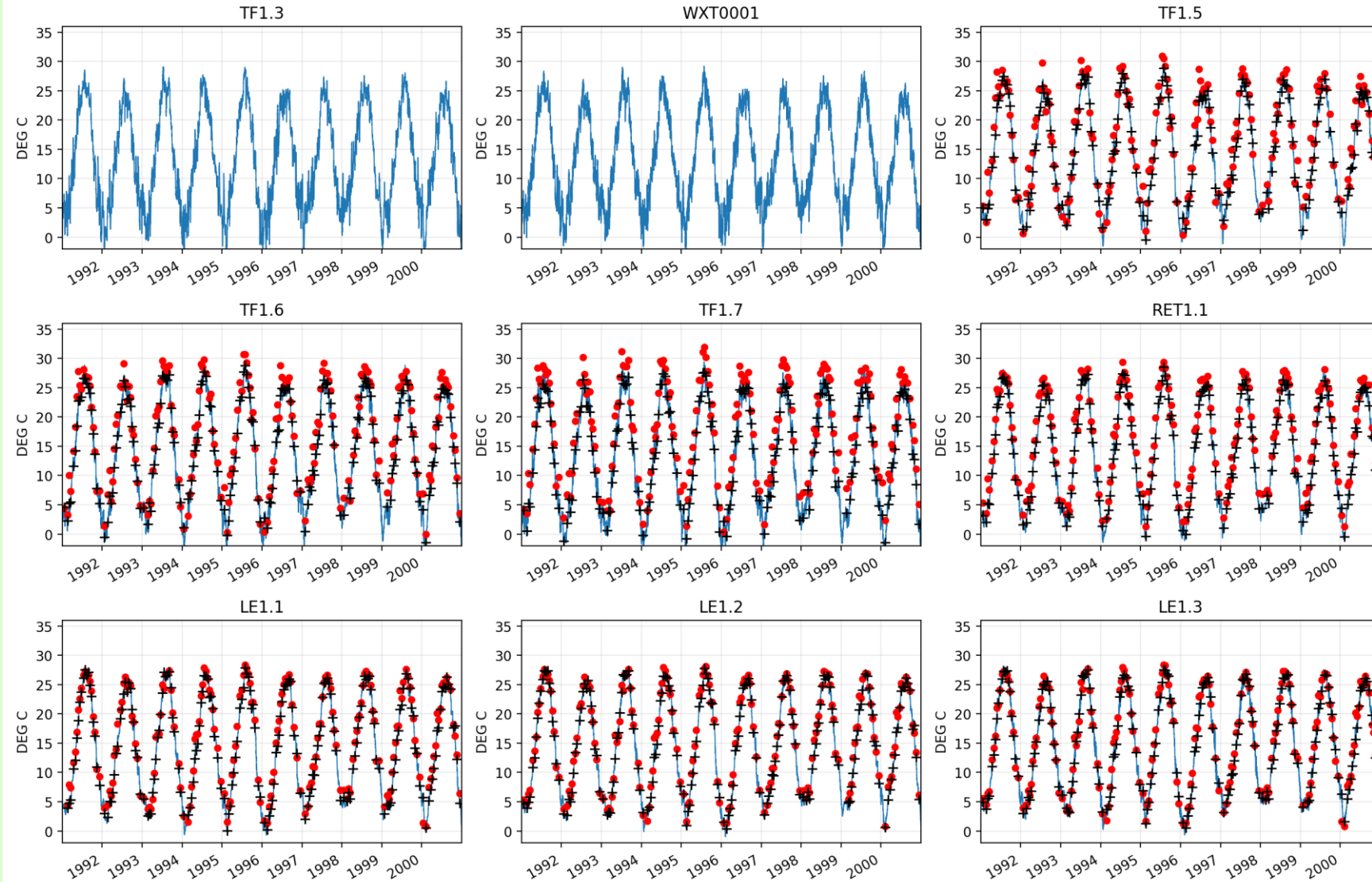


— Model
● Observation
+ Model@Obs time

Surface Temperature in the main channel
CBP fixed stations

Temperature Validation (1991–2000)

WTEMP vs model temperature (B) | model line + obs circles + model@obs plus



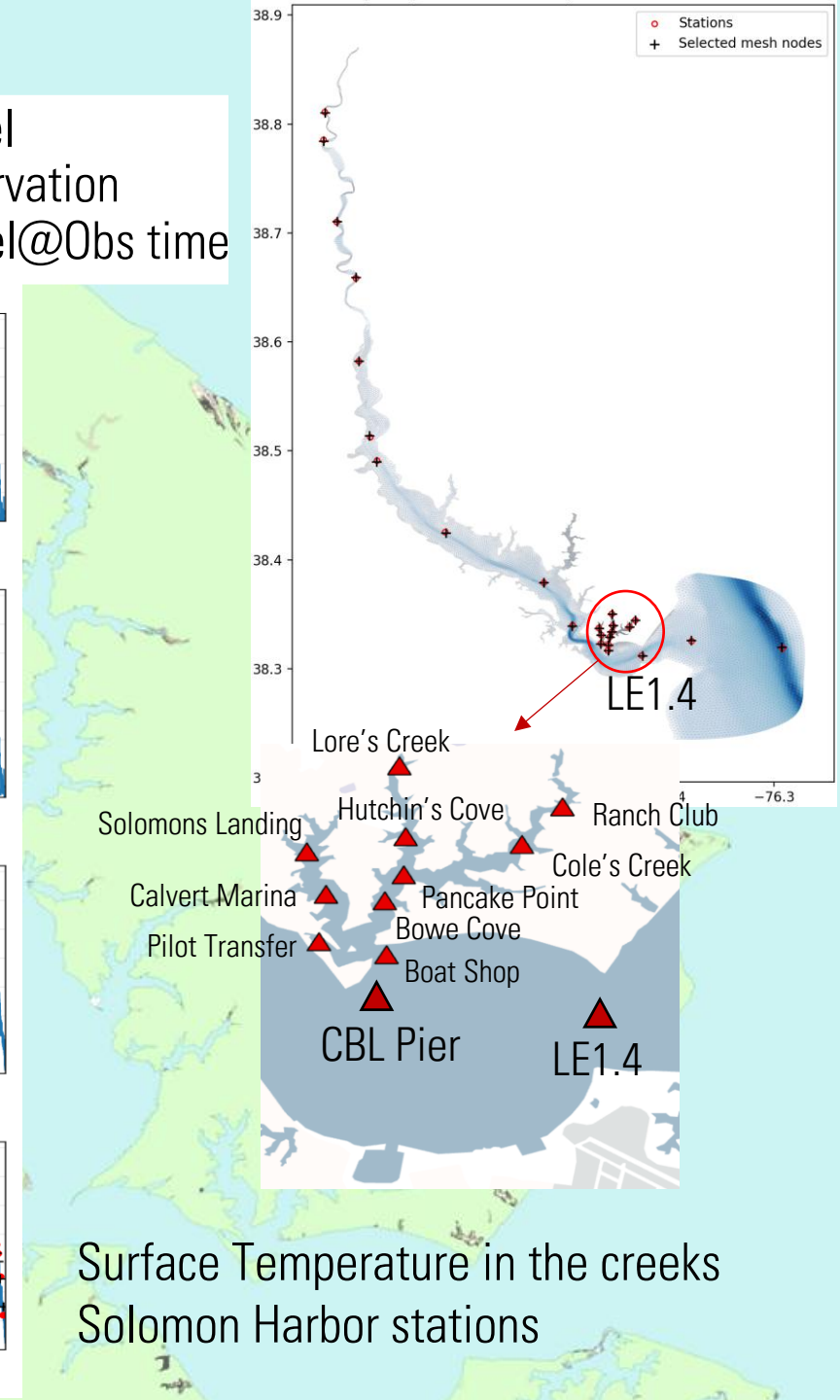
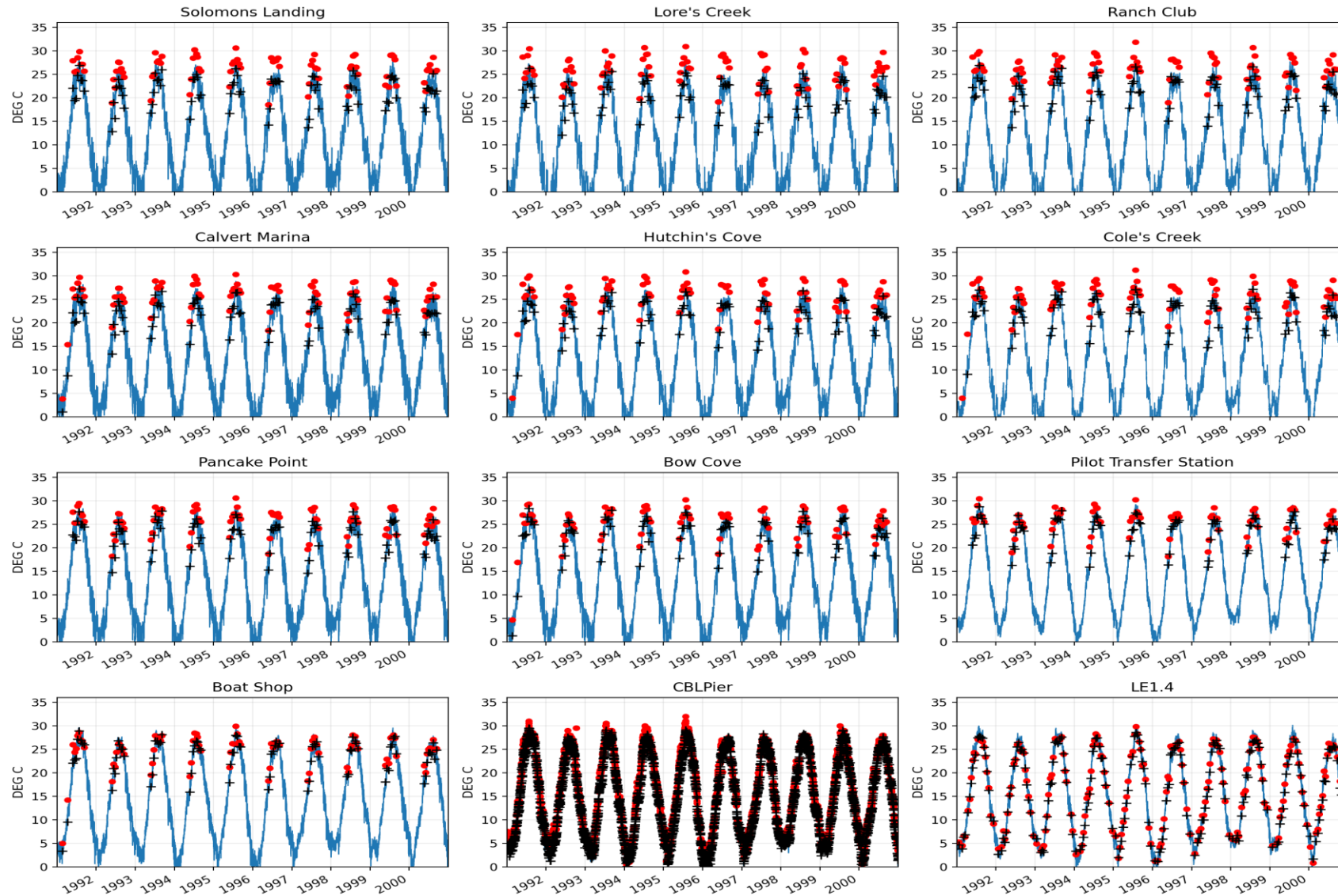
— Model
● Observation
+ Model@Obs time

Bottom Temperature in the main channel
CBP fixed stations

Temperature Validation (1991–2000)

WTEMP vs model temperature (S) | model line + obs circles + model@obs plus

- Model
- Observation
- + Model@Obs time

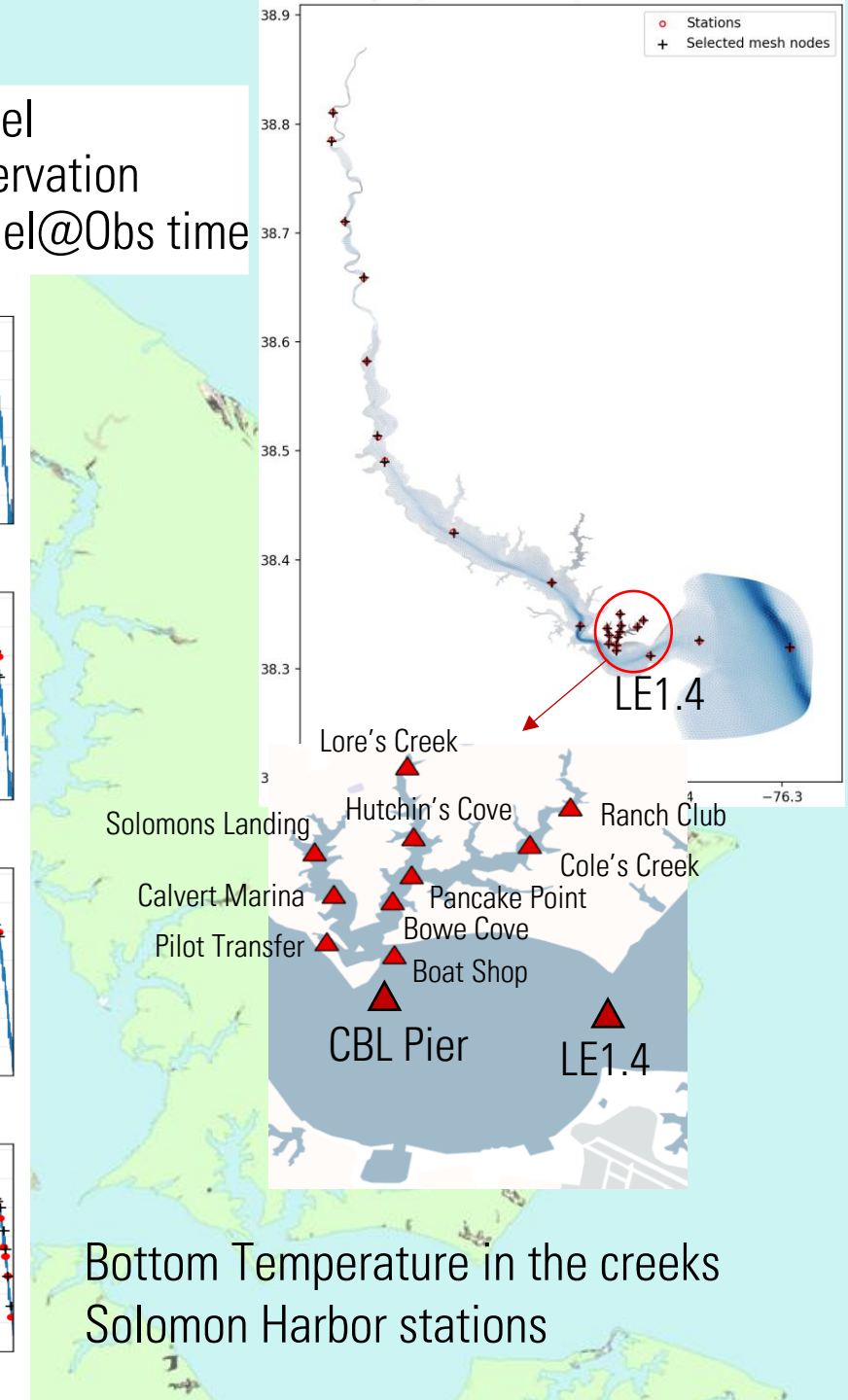
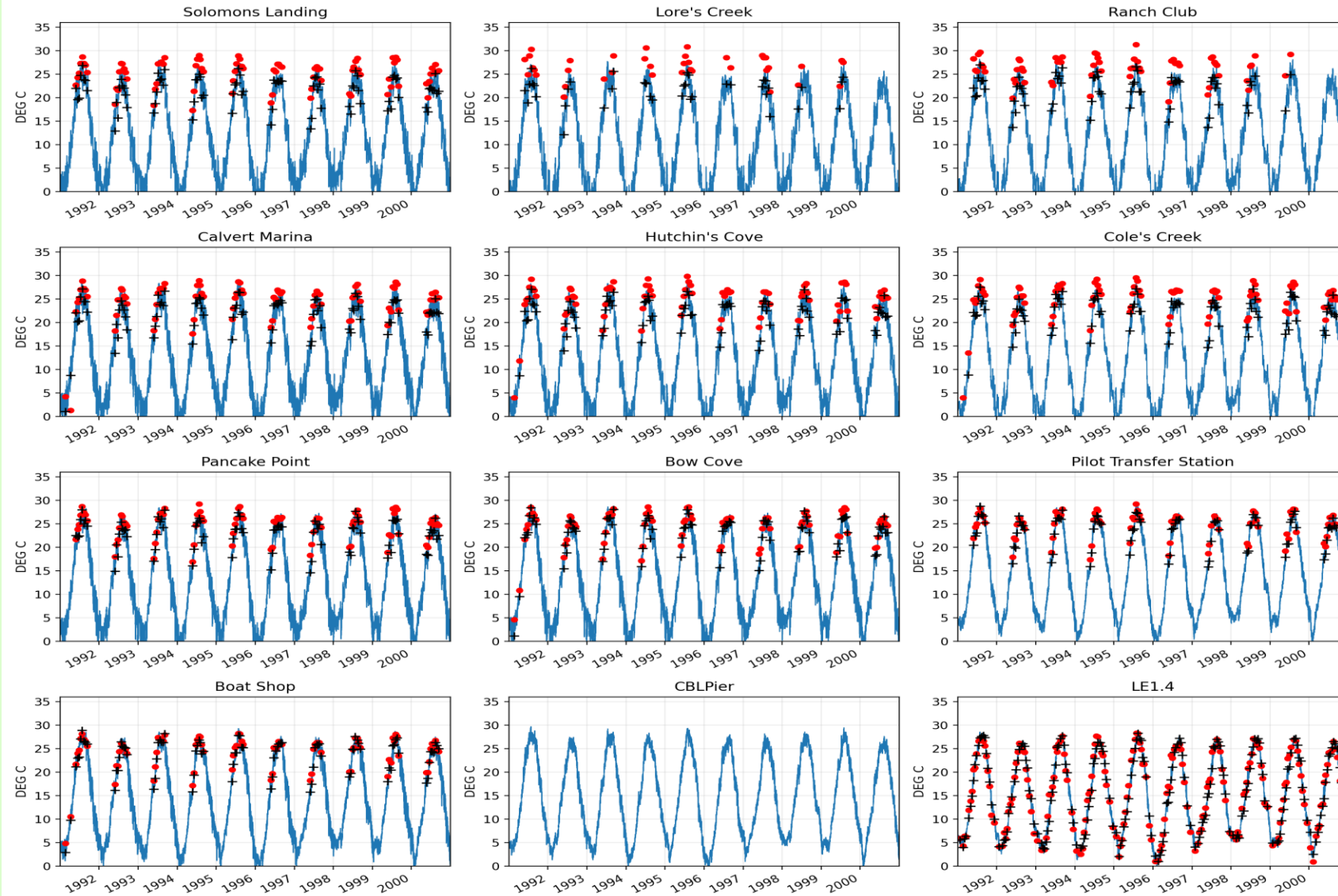


Surface Temperature in the creeks
Solomon Harbor stations

Temperature Validation (1991–2000)

- Model
- Observation
- + Model@Obs time

WTEMP vs model temperature (B) | model line + obs circles + model@obs plus



Bottom Temperature in the creeks
Solomon Harbor stations

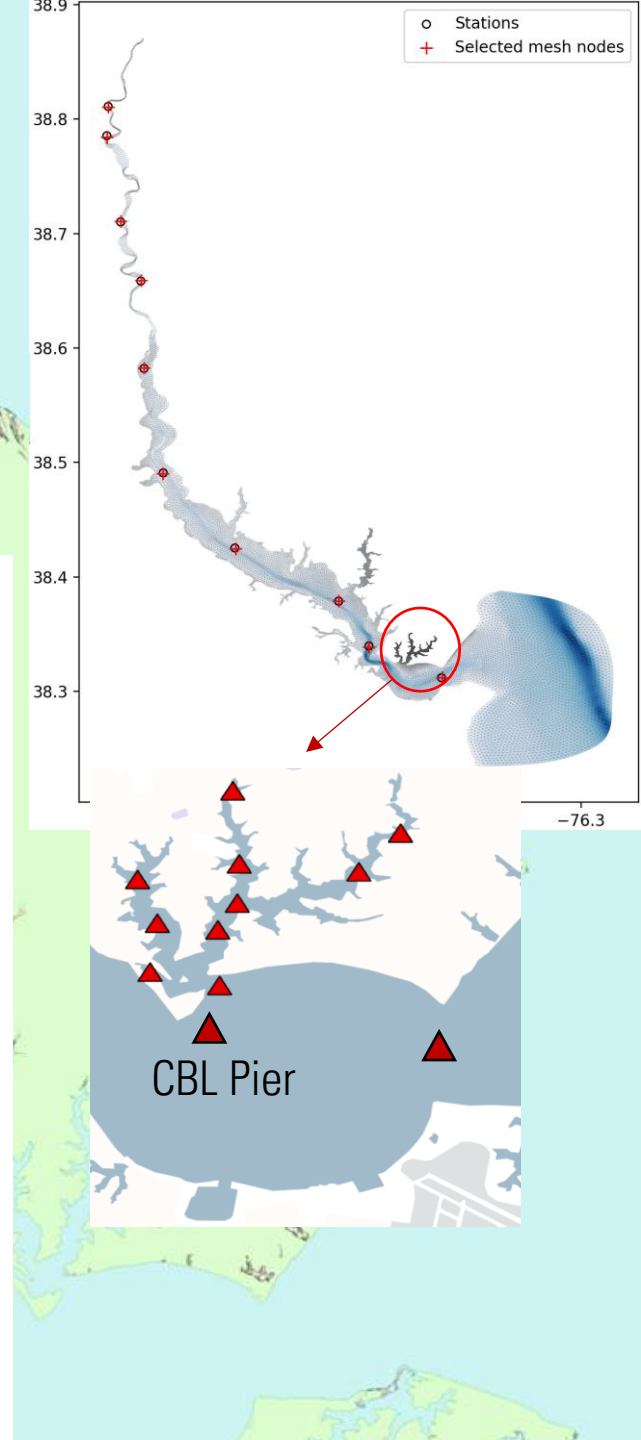
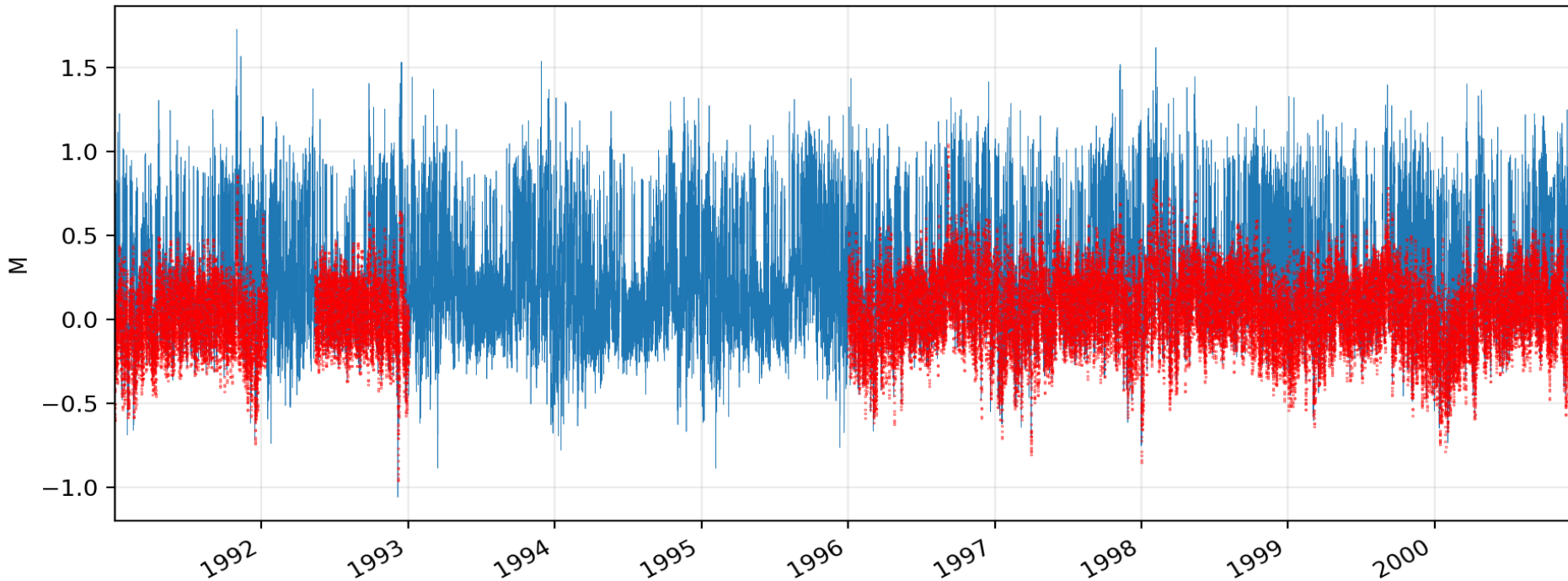
Water Level Validation (1991–2000)

- Water level at CBL Pier

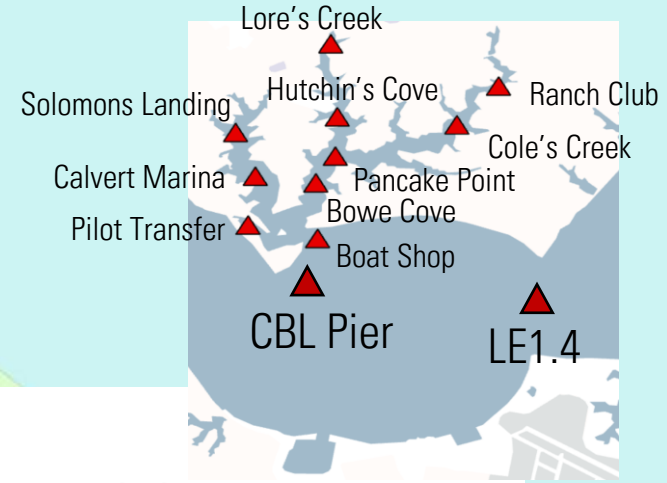
— Model
● Observation

WLEVEL vs model elevation (2D) | model line + obs circles + model@obs plus

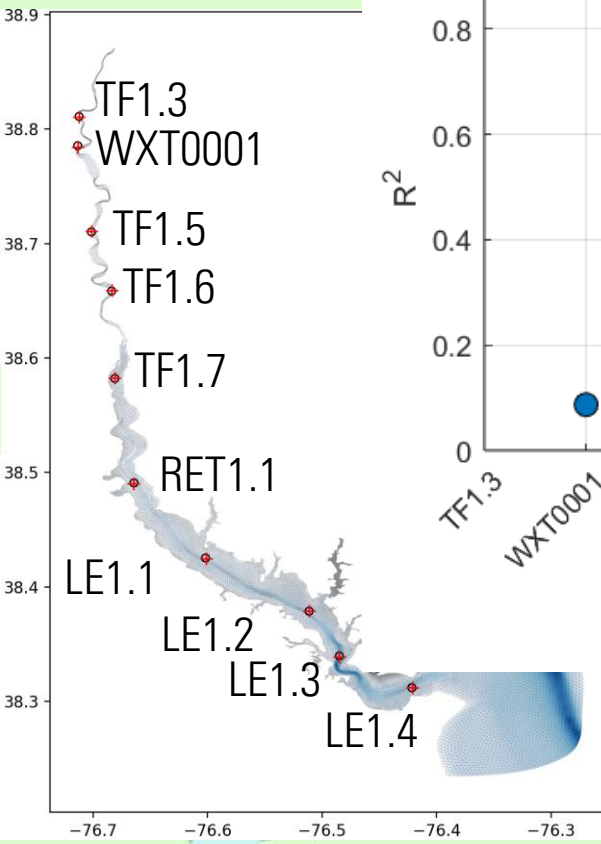
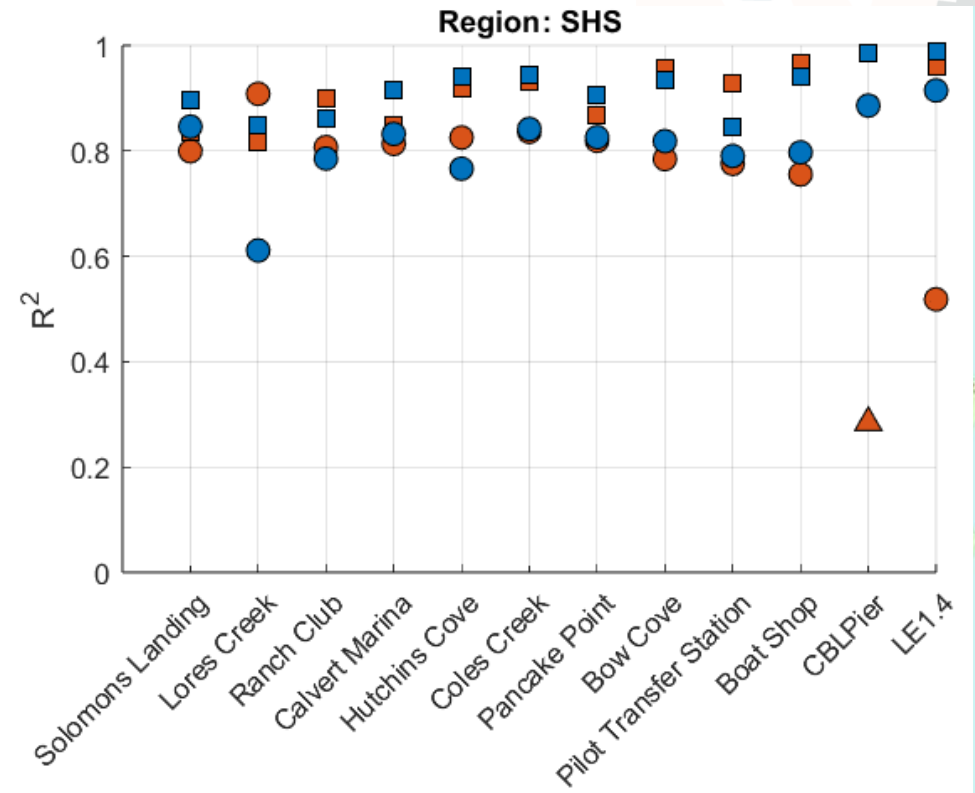
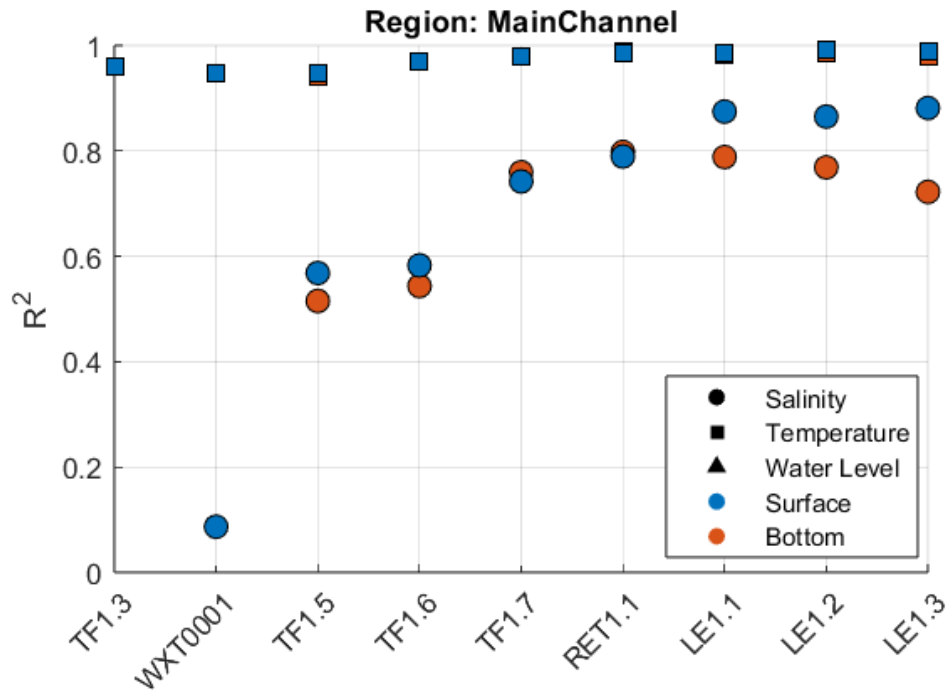
CBLPier



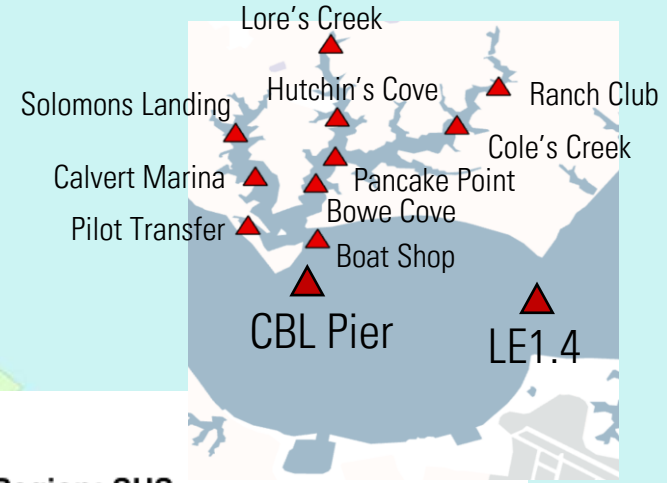
Performance



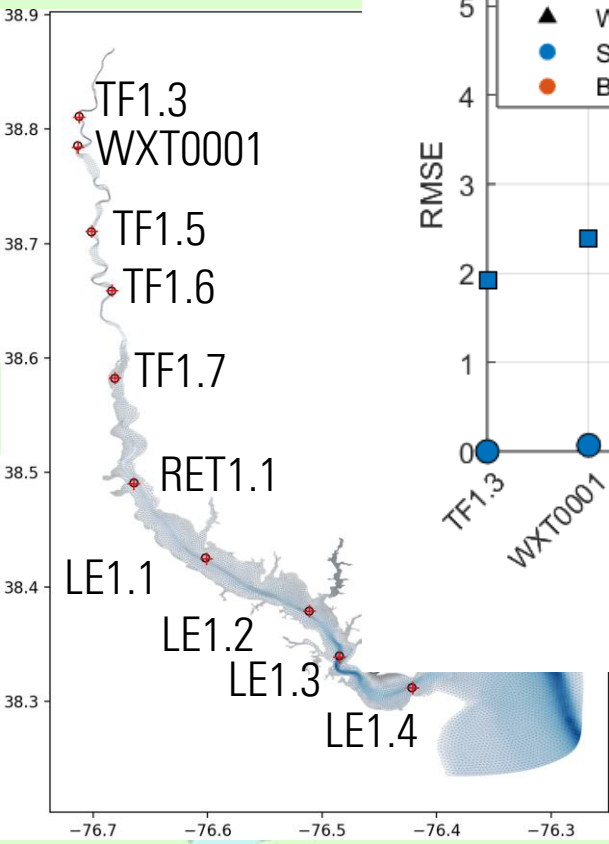
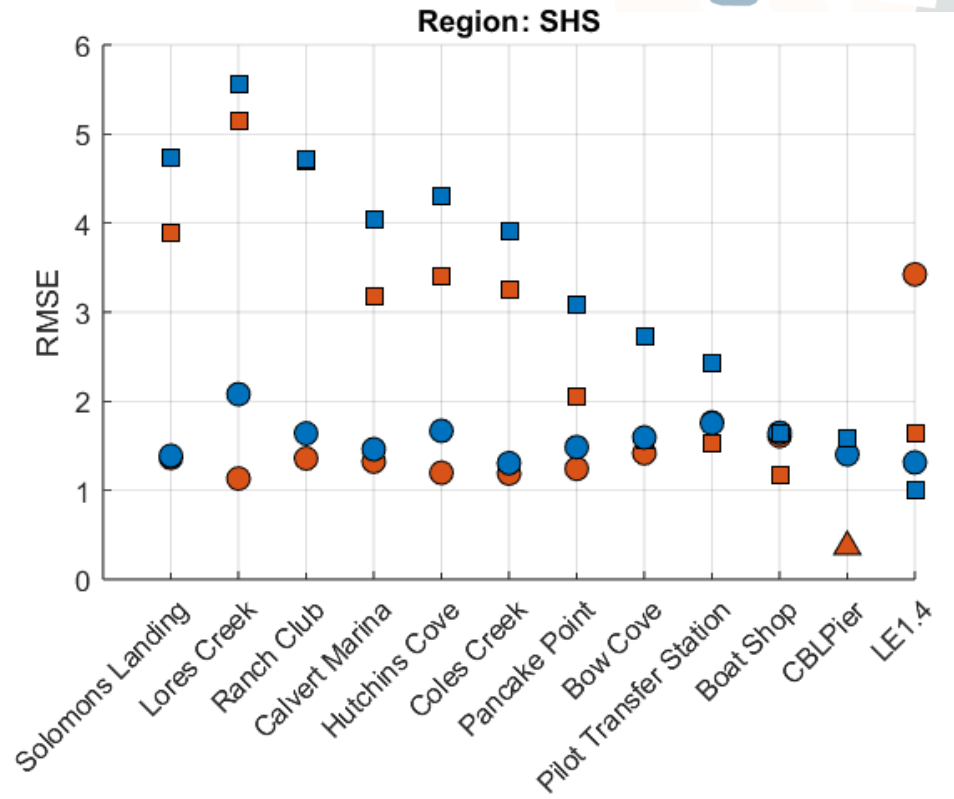
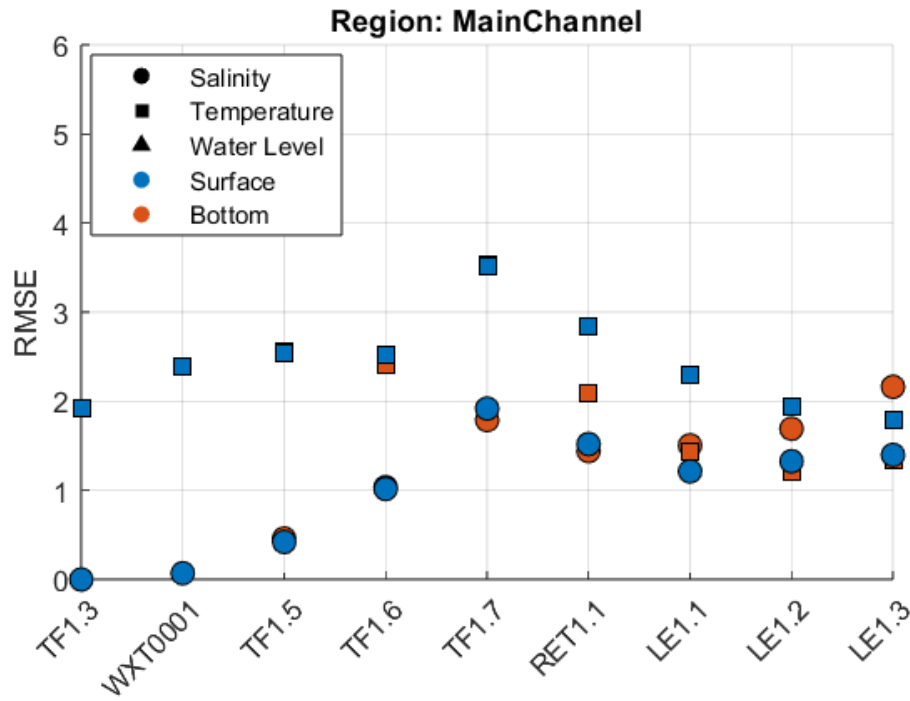
R^2 by Station, Region, and Variable



Performance



RMSE by Station, Region, and Variable



Summary

- **What Works Well**

- Salt intrusion into the tidal fresh region is reasonably represented
- Seasonal salinity and temperature variability are well captured
- Water level variability pattern is well captured

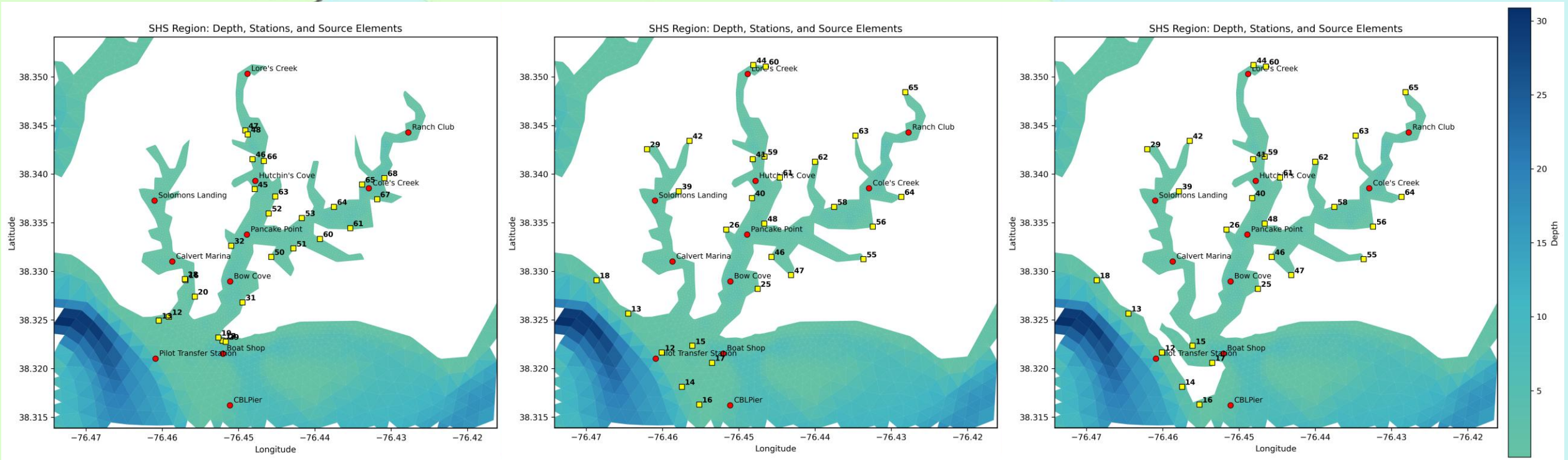
- **What I Changed and What Helped**

- Boundary forcing updated from RUN7b → RUN11fb, resulting in improved salinity
- Watershed inputs updated from Phase 6 → Phase 7 WSM, resolving prior inconsistencies
- Tested sensitivity to water type parameterization → no significant improvement in temperature bias
- Atmospheric forcing updated from NARR → ERA5, leading to improved overall performance

- **Current Issues**

- Salinity bias at specific stations (e.g., RET1.1 too fresh; LE stations slightly too salty)
- Salinity peaks and troughs not well captured in some shallow creeks
- High temperatures in the upper reaches of Solomons Harbor not well reproduced

NEXT STEP



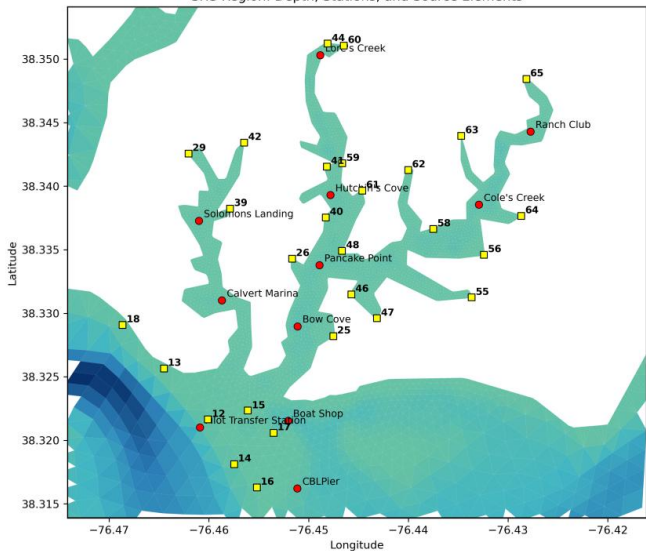
- The presented results
 - WSM is too cold in this area
 - Sources are not in the accurate location
 - Solomons Island is ignored in the mesh

- Tests #1,2
 - Test #1: sources in the right location
 - Test #2: using Bowie temperature here

- Test #3
 - Seeing Solomons Island in the mesh

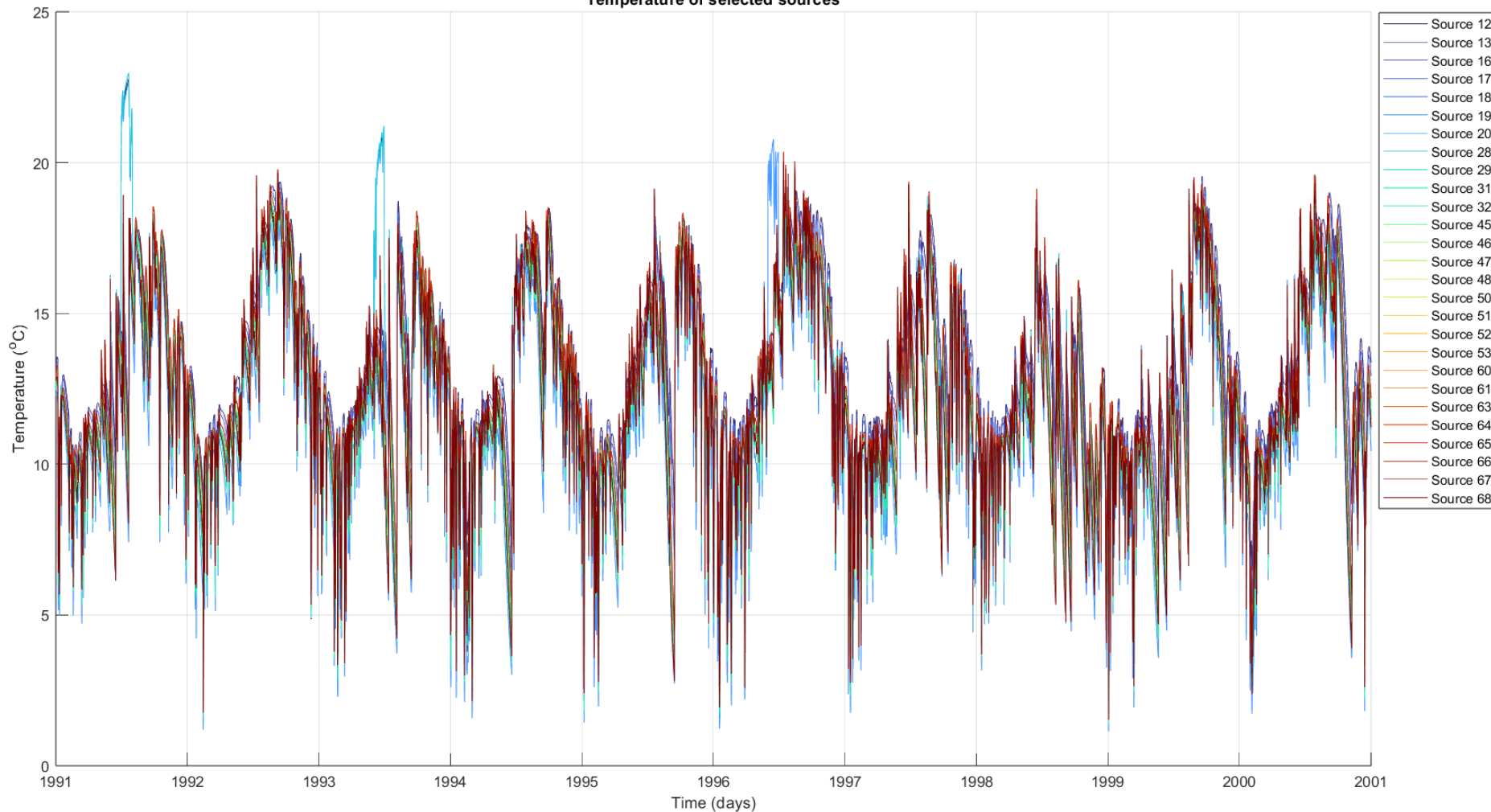
NEXT

SHS Region: Depth, Stations, and Source Elements

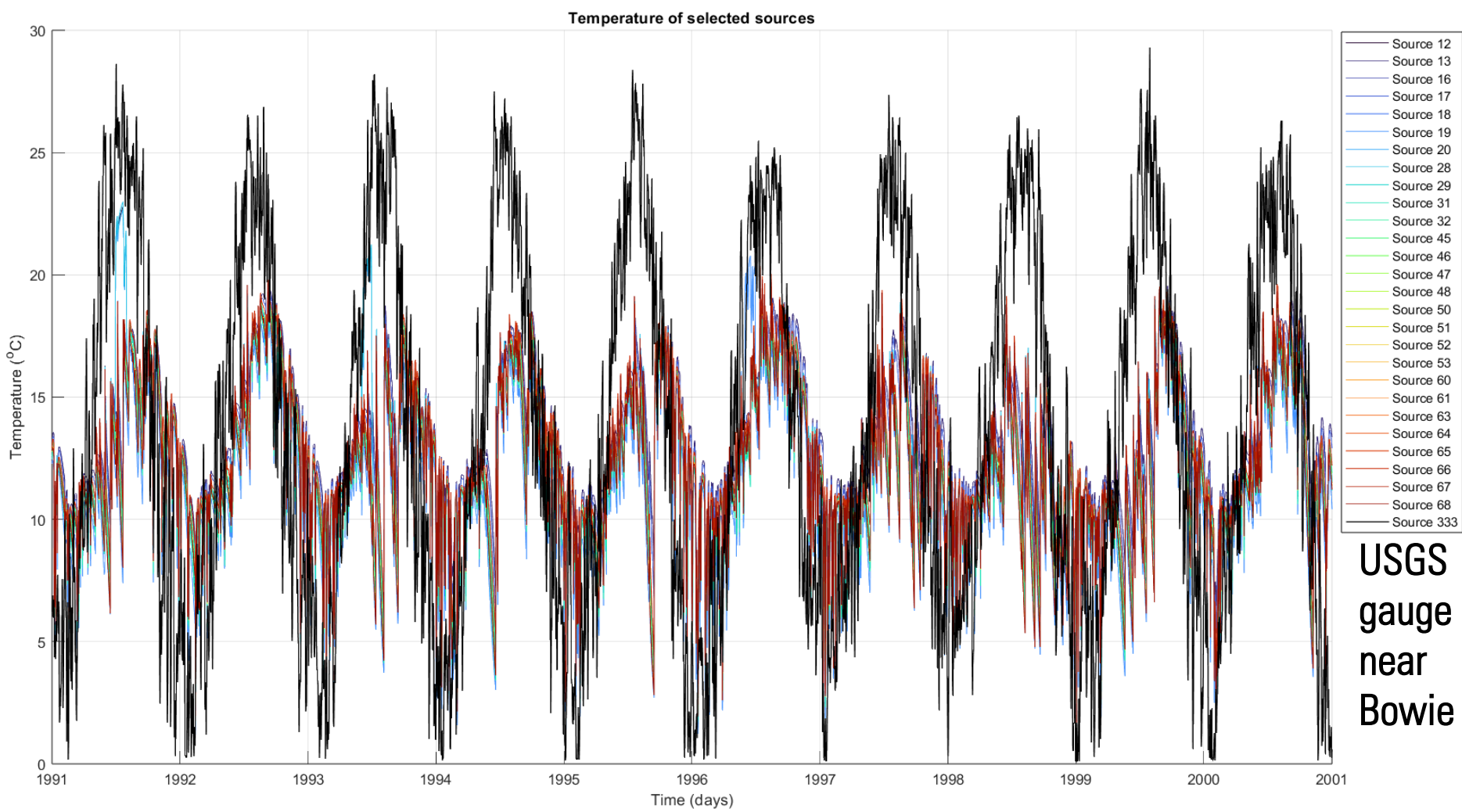
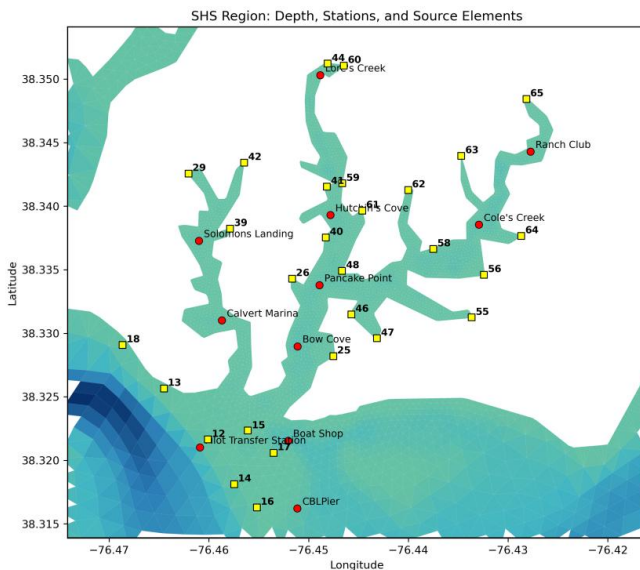


Water temperature of
the WSM sources in
SHS area

Temperature of selected sources



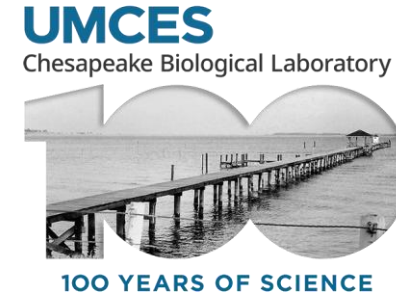
NEXT



Water temperature of the WSM sources in SHS area AND WSM at Bowie

USGS gauge near Bowie





THANK YOU