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

Quarterly meeting: October 2024

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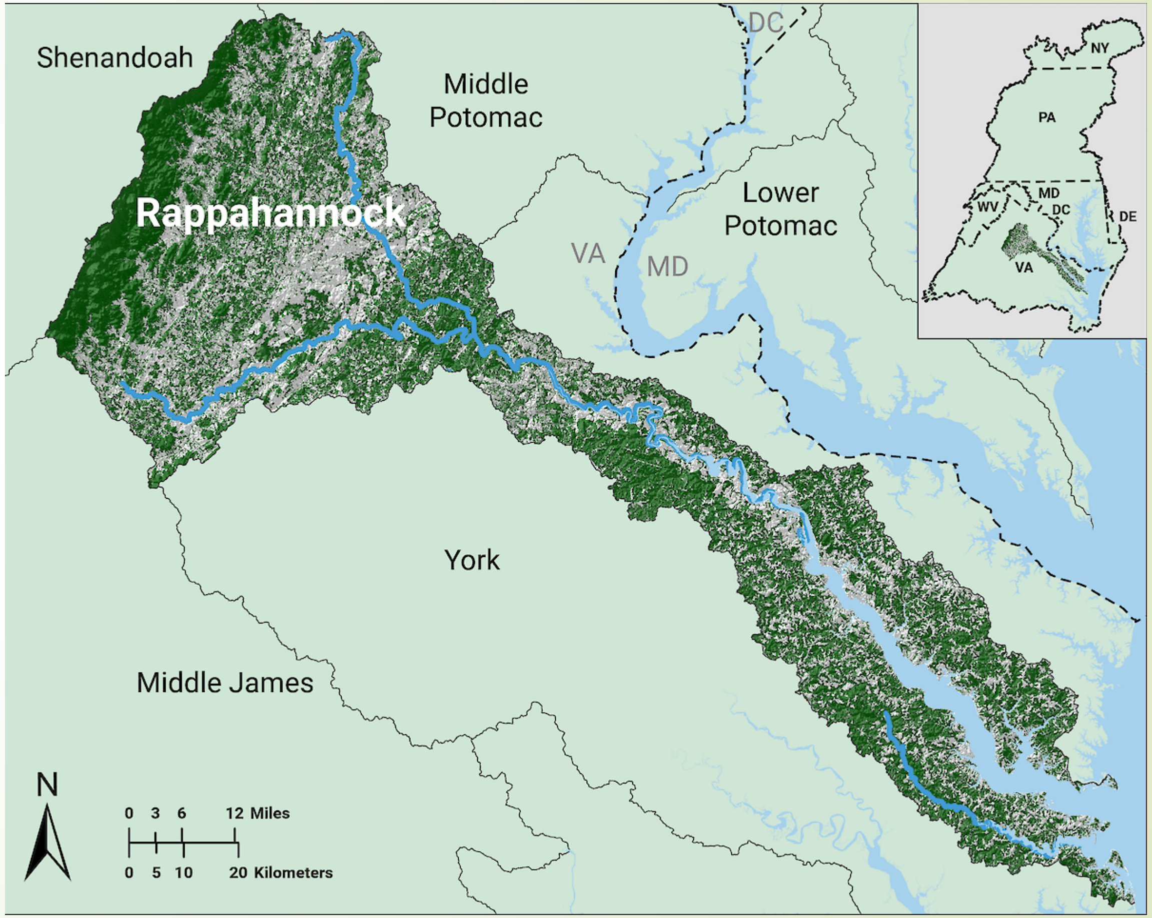
Objectives and tasks

- **Goal**: to develop and calibrate a high-resolution hydrodynamic-water quality model for the Rappahannock River, which can 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.

Progress

- Completed revision of model grid (Task 1)
- Completed hydrodynamics model calibration (Task 4)
- Continue working on model linkage between main bay model (MBM) and tributary model (TM) (Task 2-3)
- Start working on the water quality model setup (Task 4)



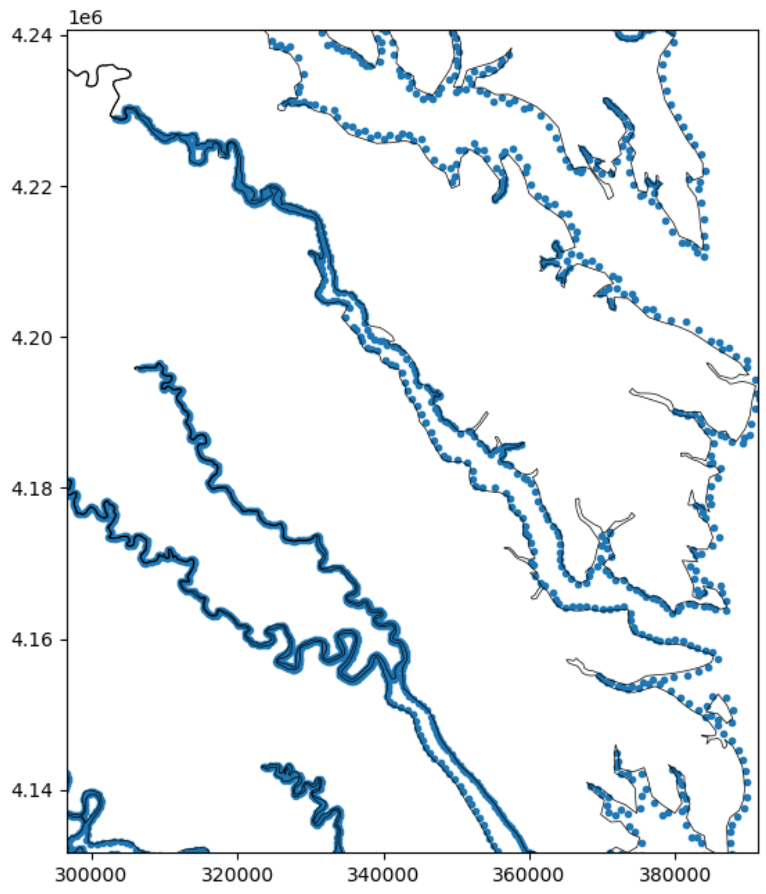
https://ecoreportcard.org/report-cards/chesapeake-bay/watershed-regions/rappahannock/

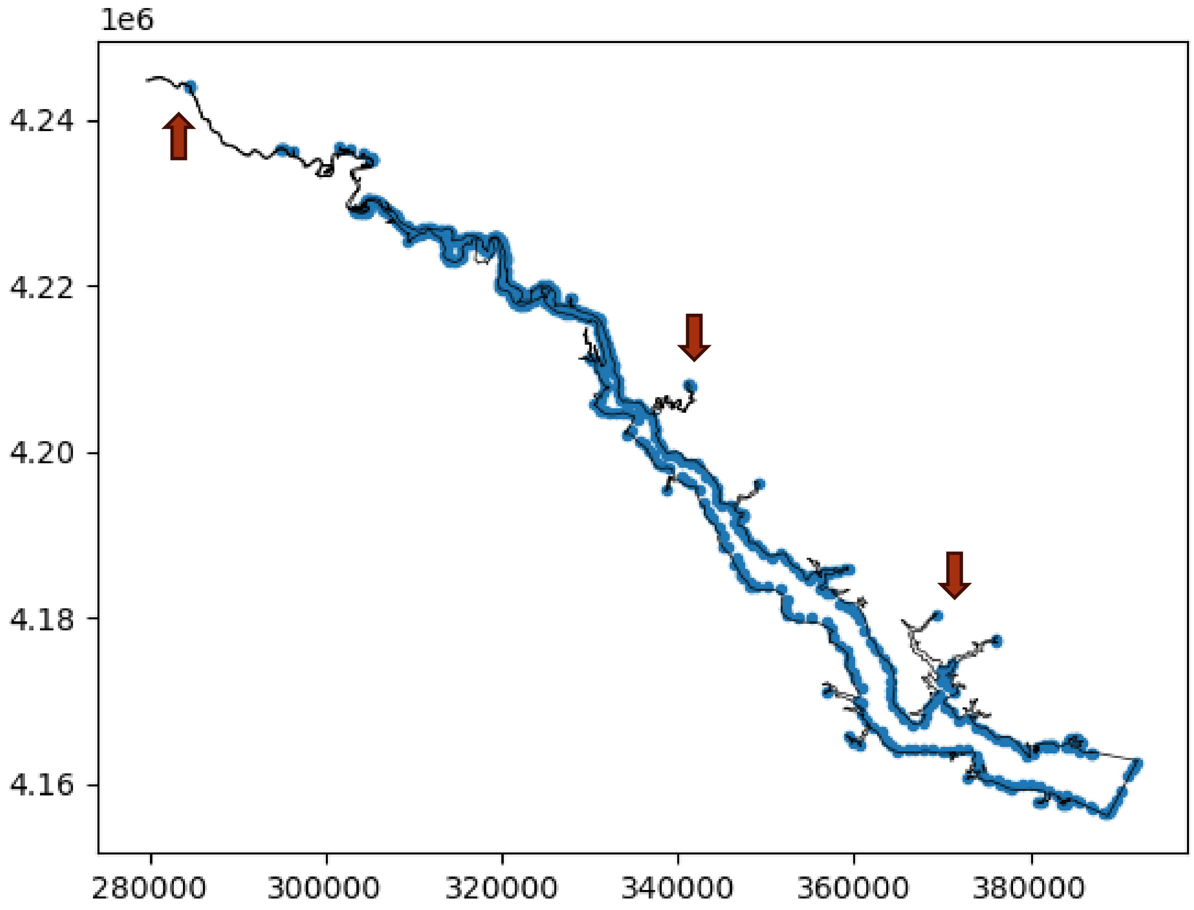
Model linkage between MBM and Rappahannock River model

- Use MBM hourly model results to forcing tributary model (TM)
  - Hydrodynamic model
  - Water quality model
  - Use same discharge and loading for both model

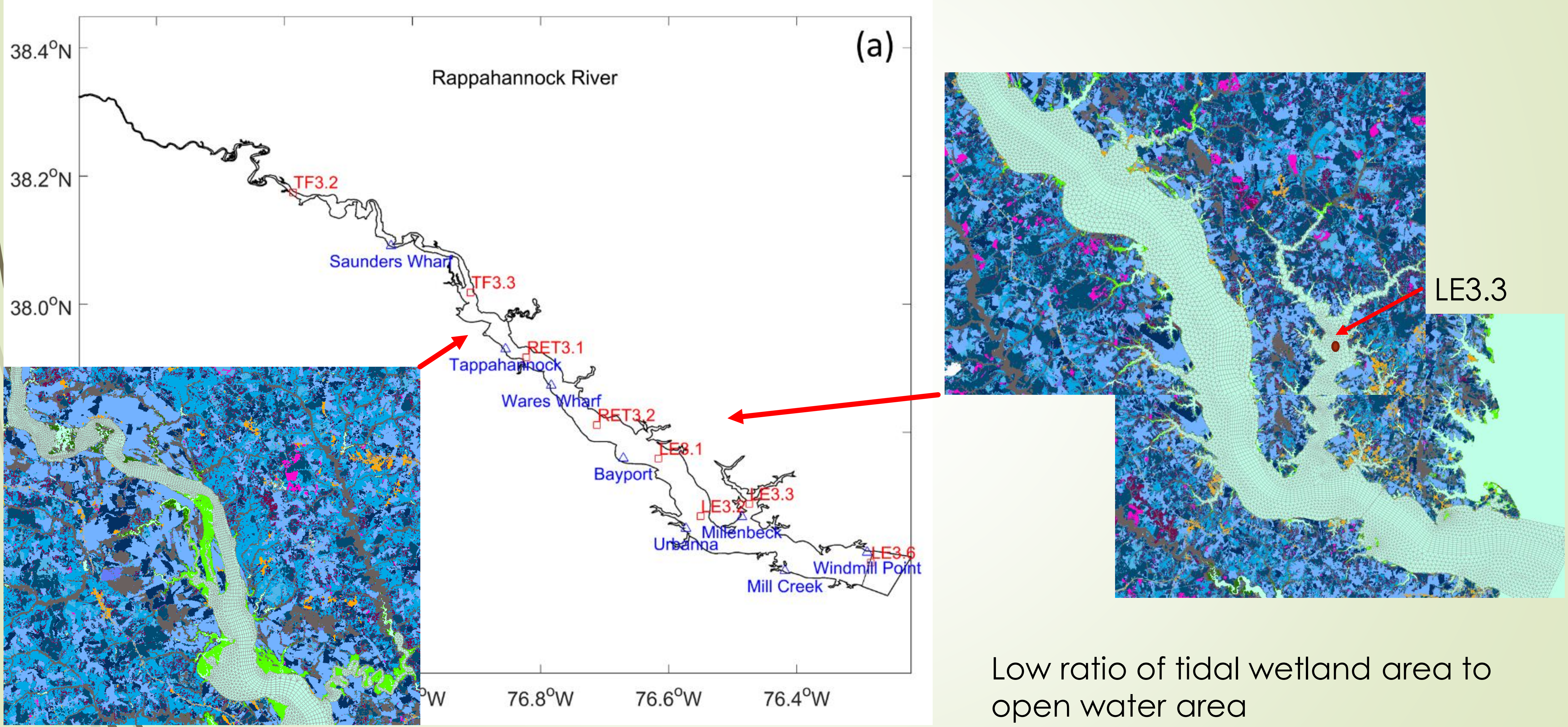
- Can run both coupled and de-coupled modes
- Run TM hydrological model and save dynamics fields
- Run water quality model using decouple model

Model linkage between MBM and Rappahannock River model





Influence of Wetlands on water quality



Low ratio of tidal wetland area to open water area

Wetland Parameters

Table 2
Summary of Wetlands Process Observations for Use in Model Parameterization and Validation.

CBPS	C deposition, g m^{-2} d^{-1}	N deposition, g m^{-2} d^{-1}	P deposition, g m^{-2} d^{-1}	denitrification, g N m^{-2} d^{-1}	solids deposition, g m^{-2} d^{-1}	respiration, g DO m^{-2} d^{-1}
BSHOH		0.008 to 0.032	0.001 to 0.006			
CHSMH		0.02 to 0.064	0.01 to 0.019		3.6	
FSBMH	0.16 to 0.33				0.3	
MPNOH	0.24 to 2.77	0.019 to 0.238	0.004 to 0.085		1.43 to 42.0	
MPNTF						
NANMH	0.033 to 0.126				1.61 to 8.12	
NANOH	0.033 to 0.126				1.61 to 8.12	
PAXOH		0.008	0.002		5.75	
PAXTF		0.033 to 0.064	0.01	0.108 to 0.197	5.75	
PMKOH	0.61	0.05		0.04		1.12 to 2.77
POTTF	1.44			0.043 to 0.06	5.88	
WICMH	0.033 to 0.126	0.037	2.74 e-5 to 0.004		1.61 to 8.12	
CHOMH		0.053 to 0.074	4.9 e-4 to 0.005			
WQGIT			0.0016	0.026		

Table 3
Wetlands Module Parameters

Parm	Definition	Value	Units
WSl	settling velocity of labile organic particles	0.05	m d^{-1}
WSr	settling velocity of refractory organic particles	0.05	m d^{-1}
WSg3	settling velocity of G3 organic particles	0.05	m d^{-1}
WSb1	settling velocity of Group 1 phytoplankton	0.005	m d^{-1}
WSb2	settling velocity of Group 2 phytoplankton	0.005	m d^{-1}
WSb3	settling velocity of Group 3 phytoplankton	0.005	m d^{-1}
WSpip	settling velocity of particulate inorganic phosphorus	0.01	m d^{-1}
WSfclay	settling velocity of fine clay	0.05	m d^{-1}
WSclay	settling velocity of clay	0.13	m d^{-1}
WSsilt	settling velocity of silt	0.432	m d^{-1}
WOC	wetlands oxygen consumption at 20 °C	0.5	g DO m^{-2} d^{-1}
Kh	DO concentration at which wetlands consumption is halved	1	g m^{-3}
MTC	nitrate mass-transfer coefficient	0.05	m d^{-1}

$$\frac{dNO3}{dt} = -K_{NO3}^{W} \cdot A^{W} \cdot f(T) \cdot NO3$$

$$\frac{dPOM}{dt} = -K_{POM}^{W} \cdot A^{W} \cdot POM$$

$$\frac{dDO}{dt} = -A^{W} \cdot f(DO) \cdot f(T) \cdot OC^{W}$$

A^{w} : wetland area to MBM-cell volume ratio (m^{-1})

K_{NO3}^{W} : mass-transfer coefficient for NO3 removal ($m \cdot day^{-1}$)

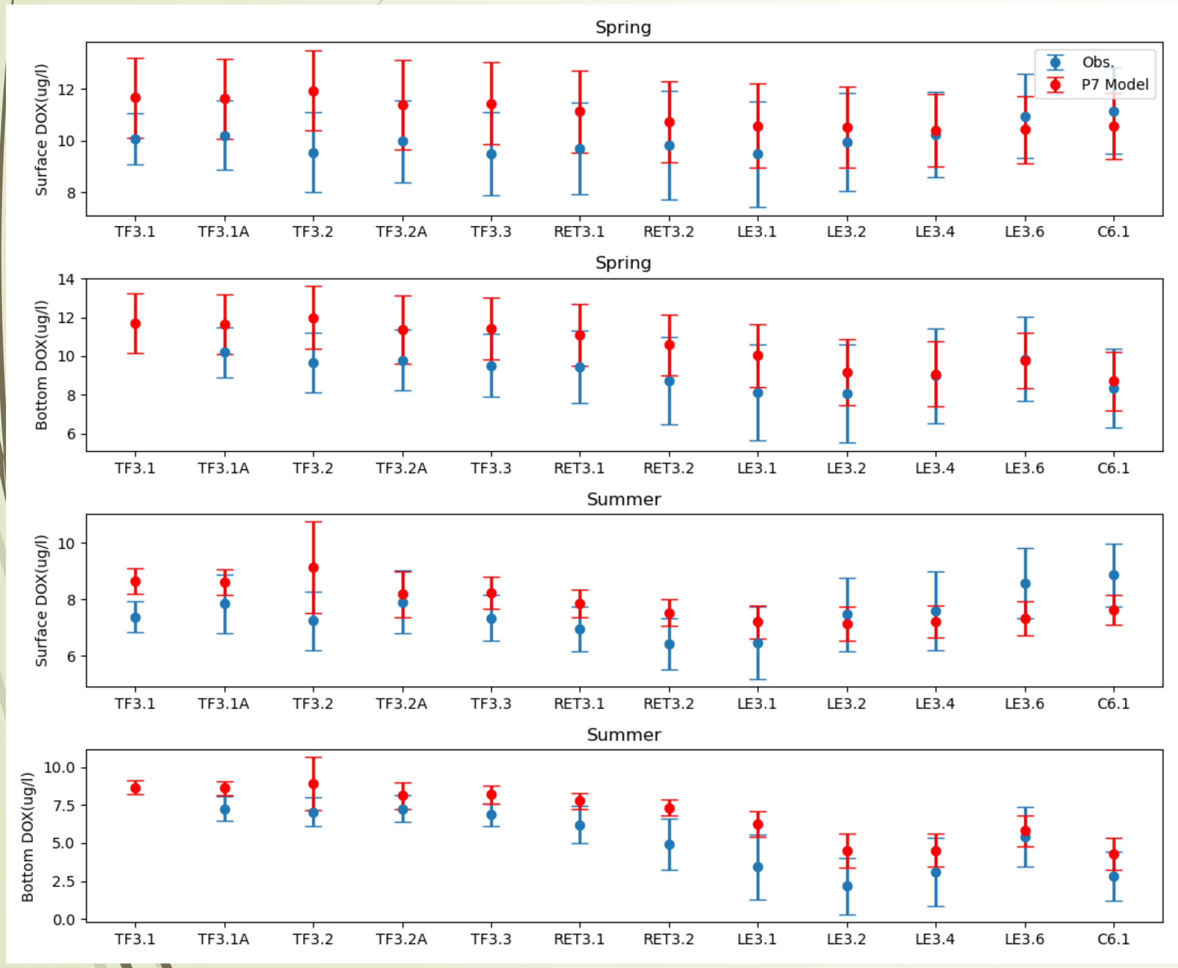
K_{POM}^{W} : settling velocity of POM caused by marsh ($m \cdot day^{-1}$)

OC^{W} : wetlands oxygen consumption rate ($g.m^{-2}.day^{-1}$)

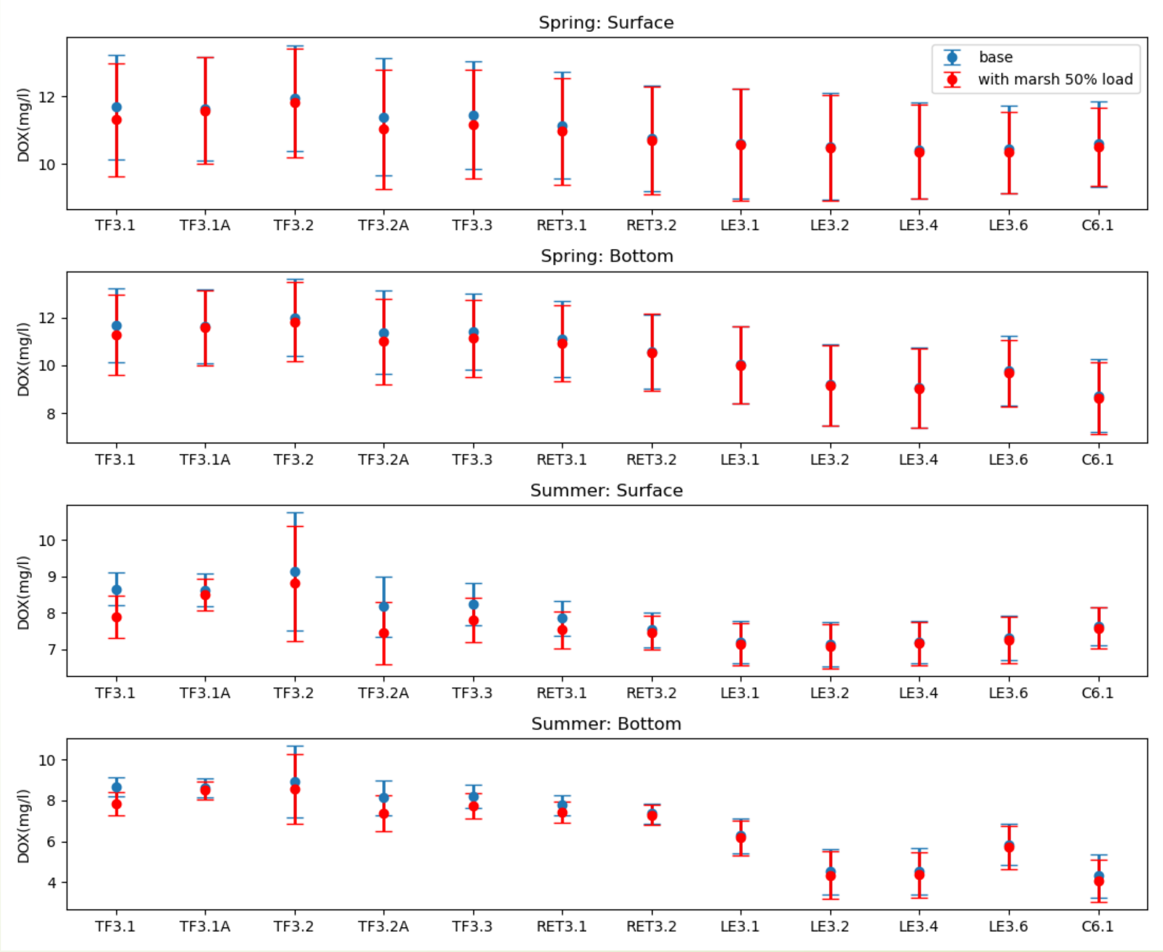
Cerco and Noel, 2017

Influence of Wetlands on water quality (MBM Results)

Baseline

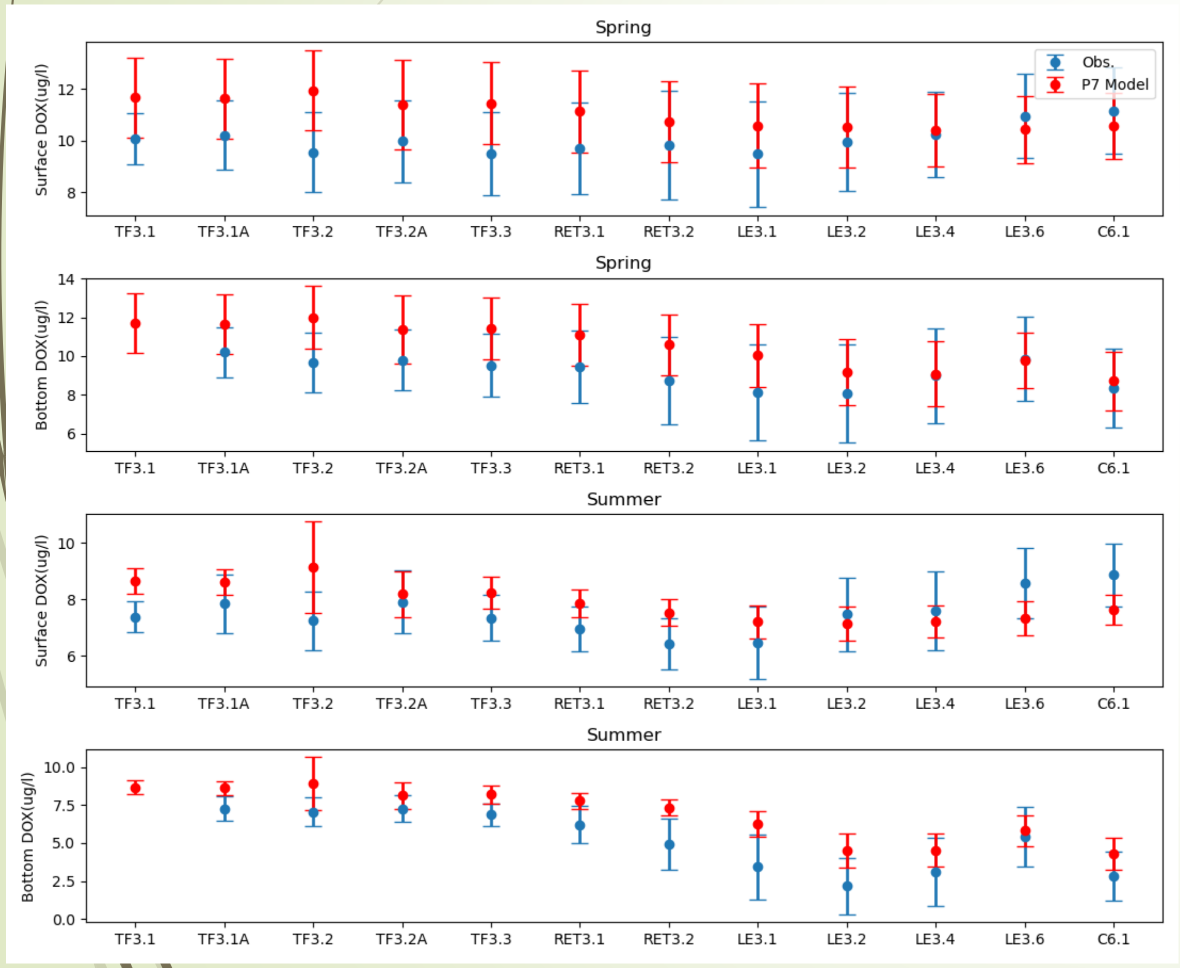


With wetland DO demand (50%)

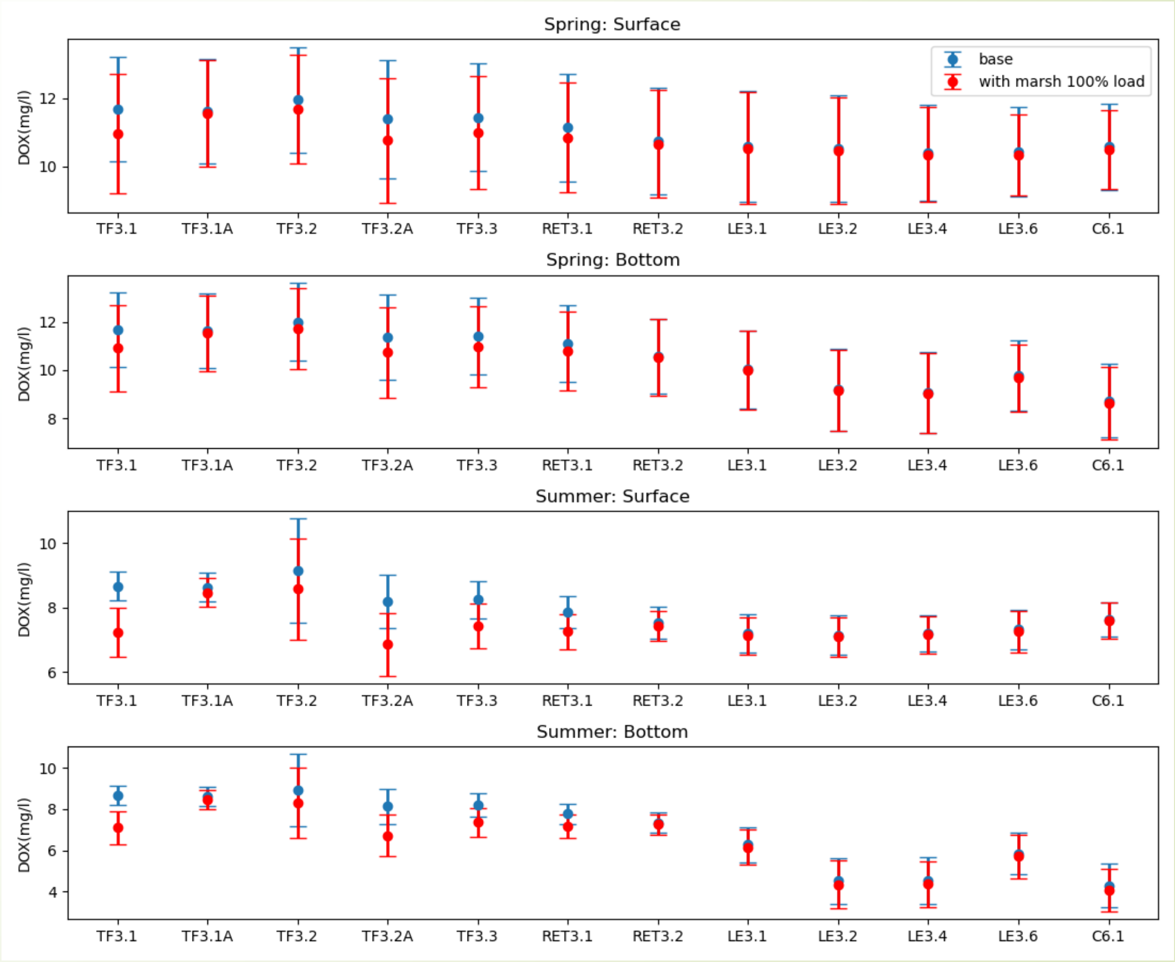


Influence of Wetlands on Water Quality

Baseline

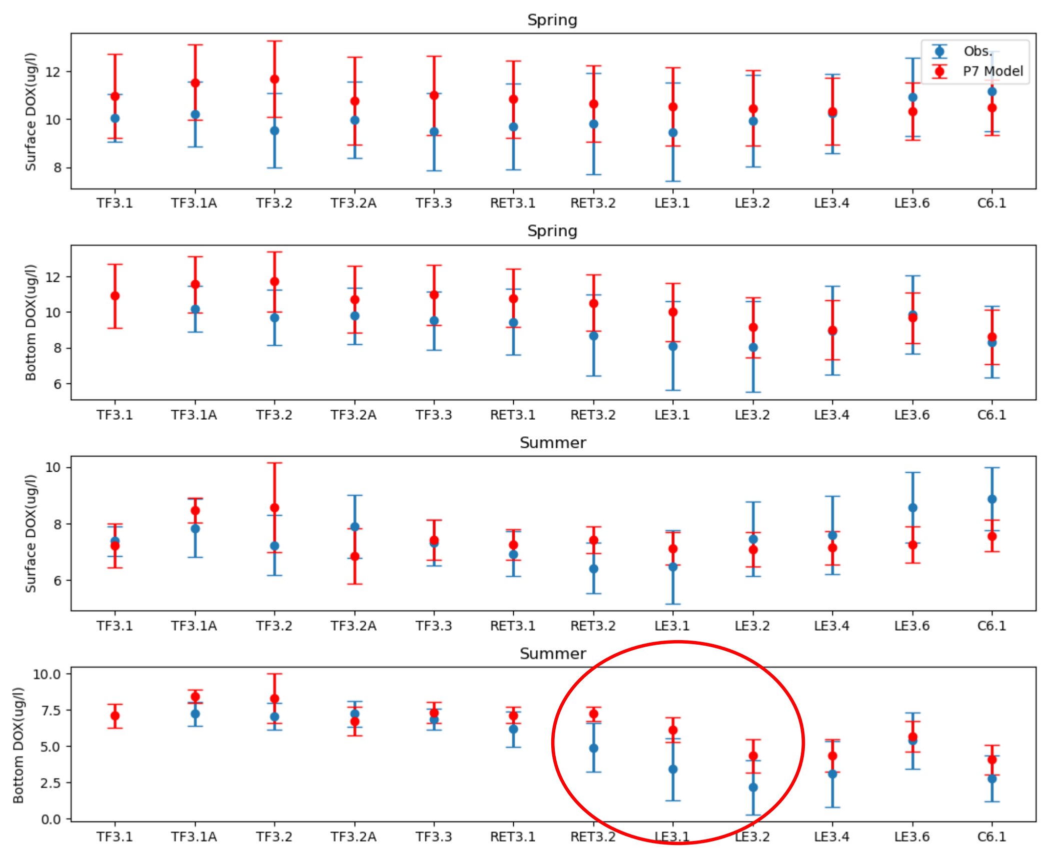


With wetland DO demand (100%)



Comparisons of Model Results and Observation

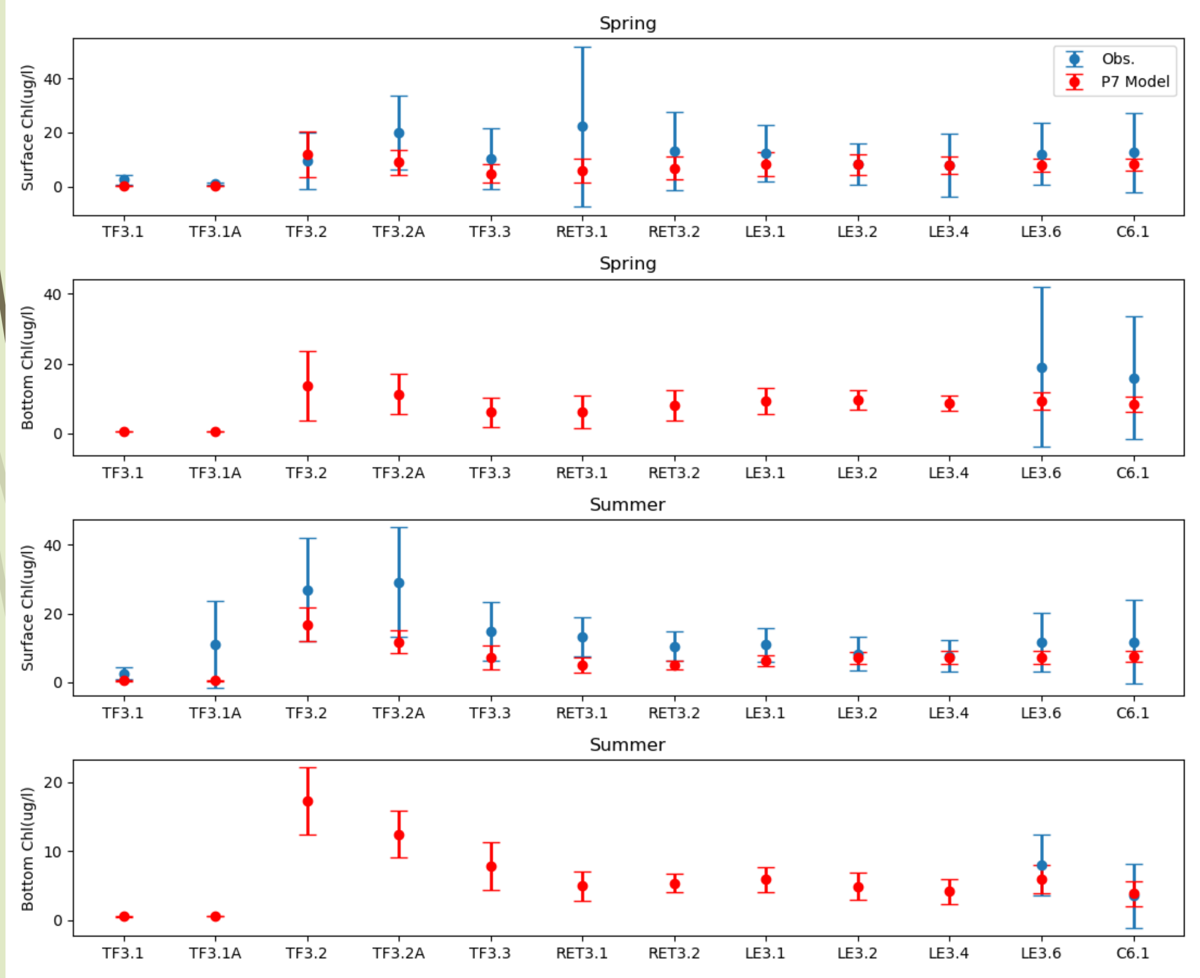
DO (mg/l)



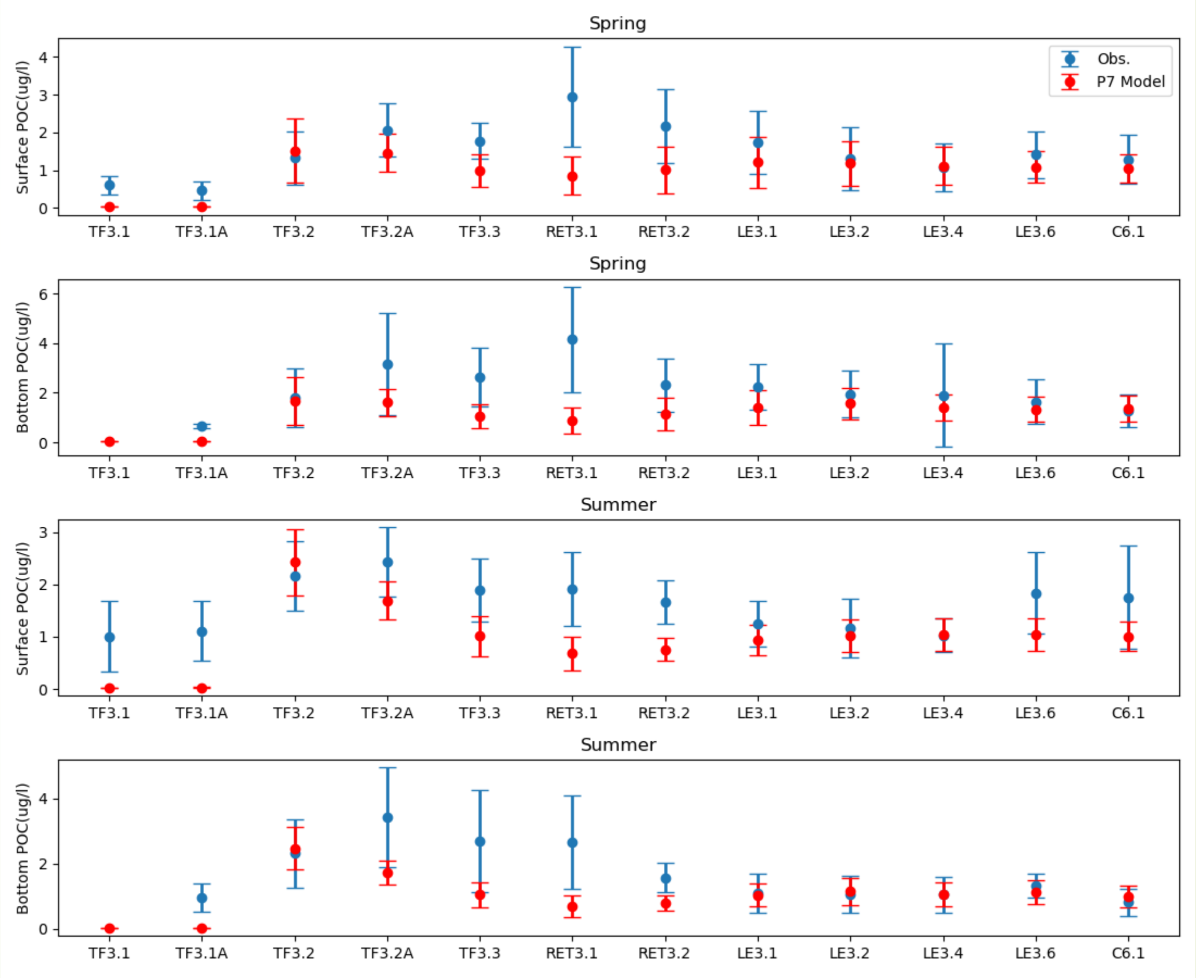
DOC (mg/l)

Comparisons of Model Results and Observation

Chl a

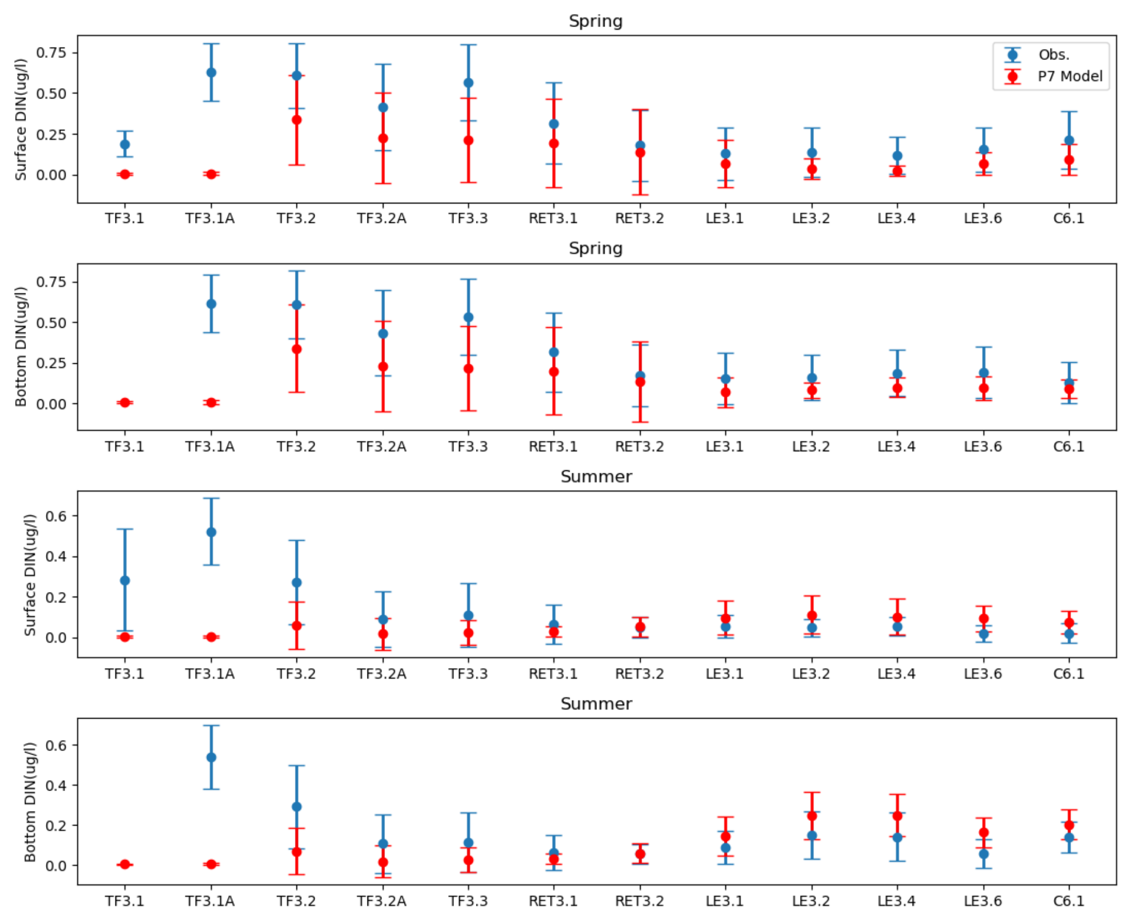


POC

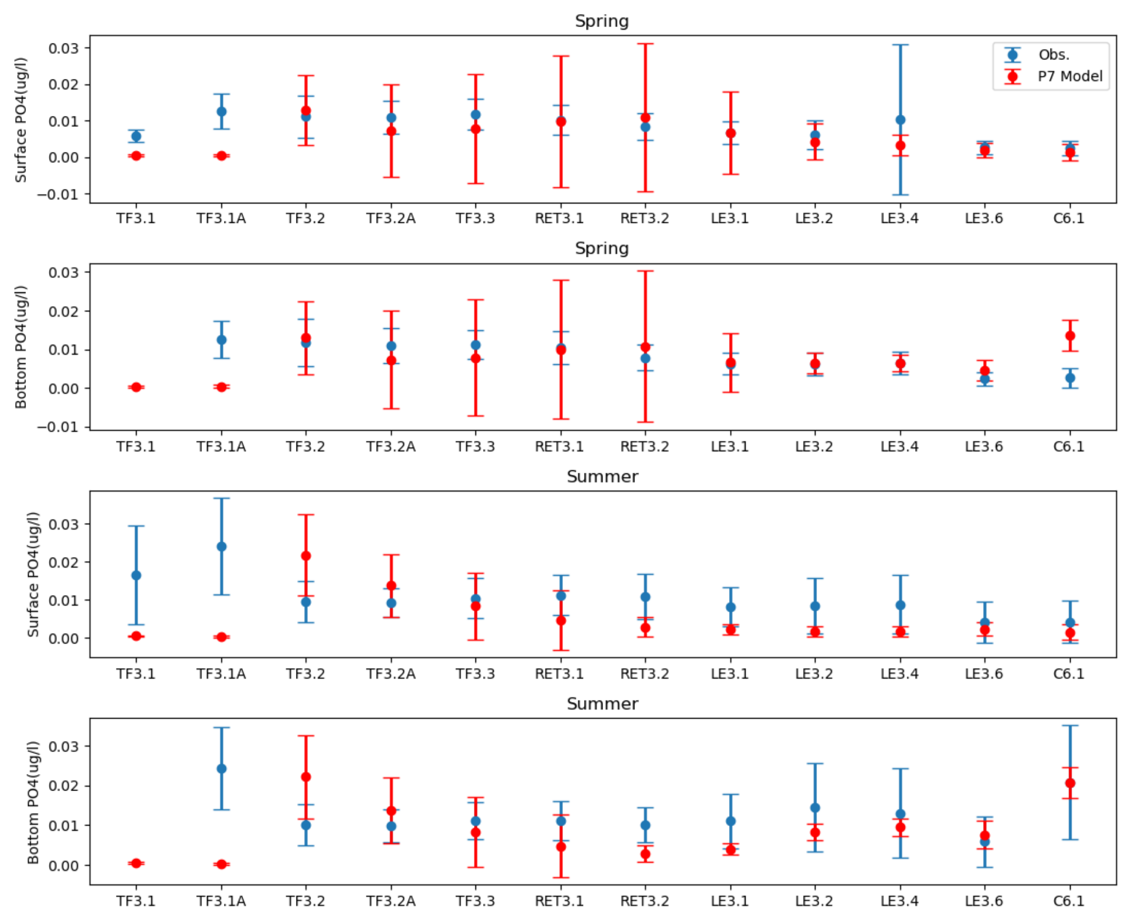


Comparisons of Model Results and Observation

DIN

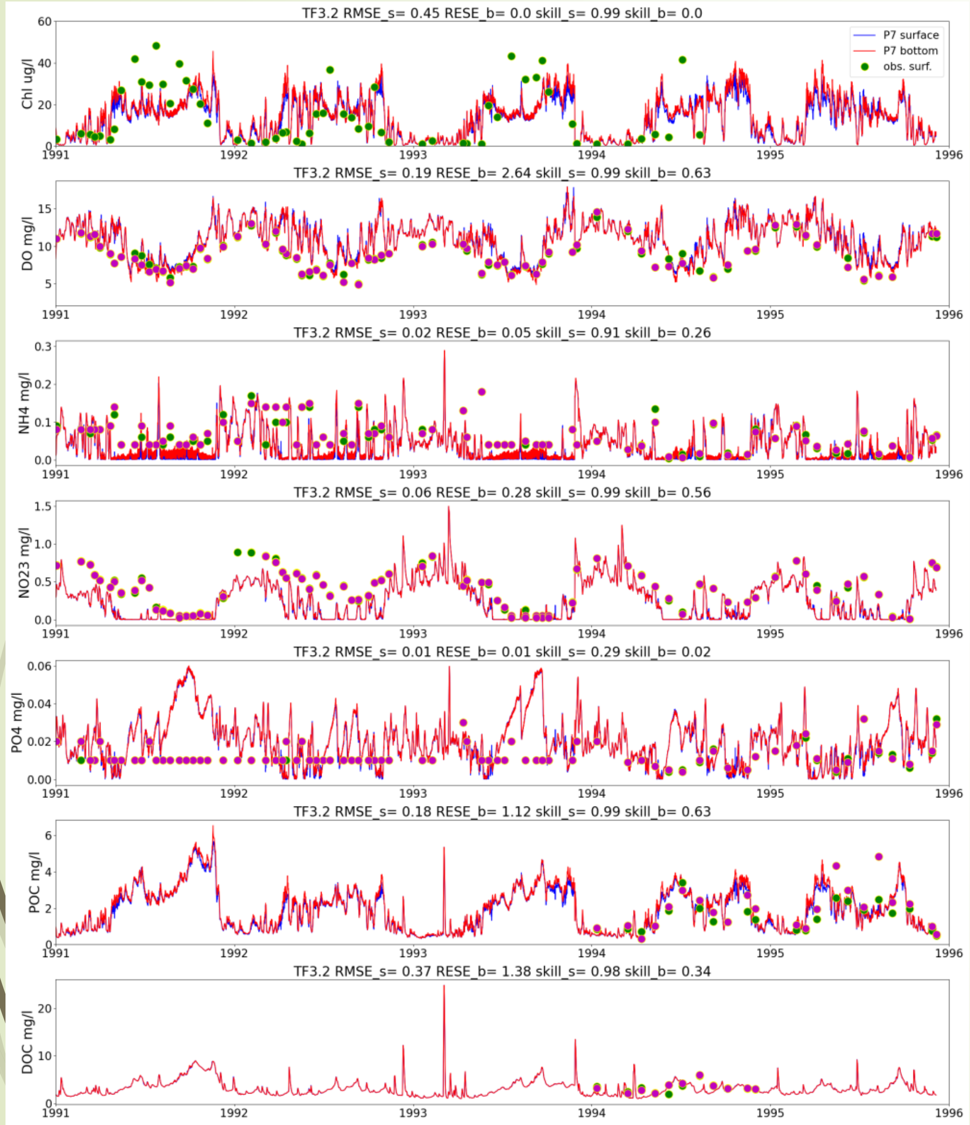


POC



Comparison of Model and Observation

TF3.2



TF3.3

Comparison of Model Results and Observation

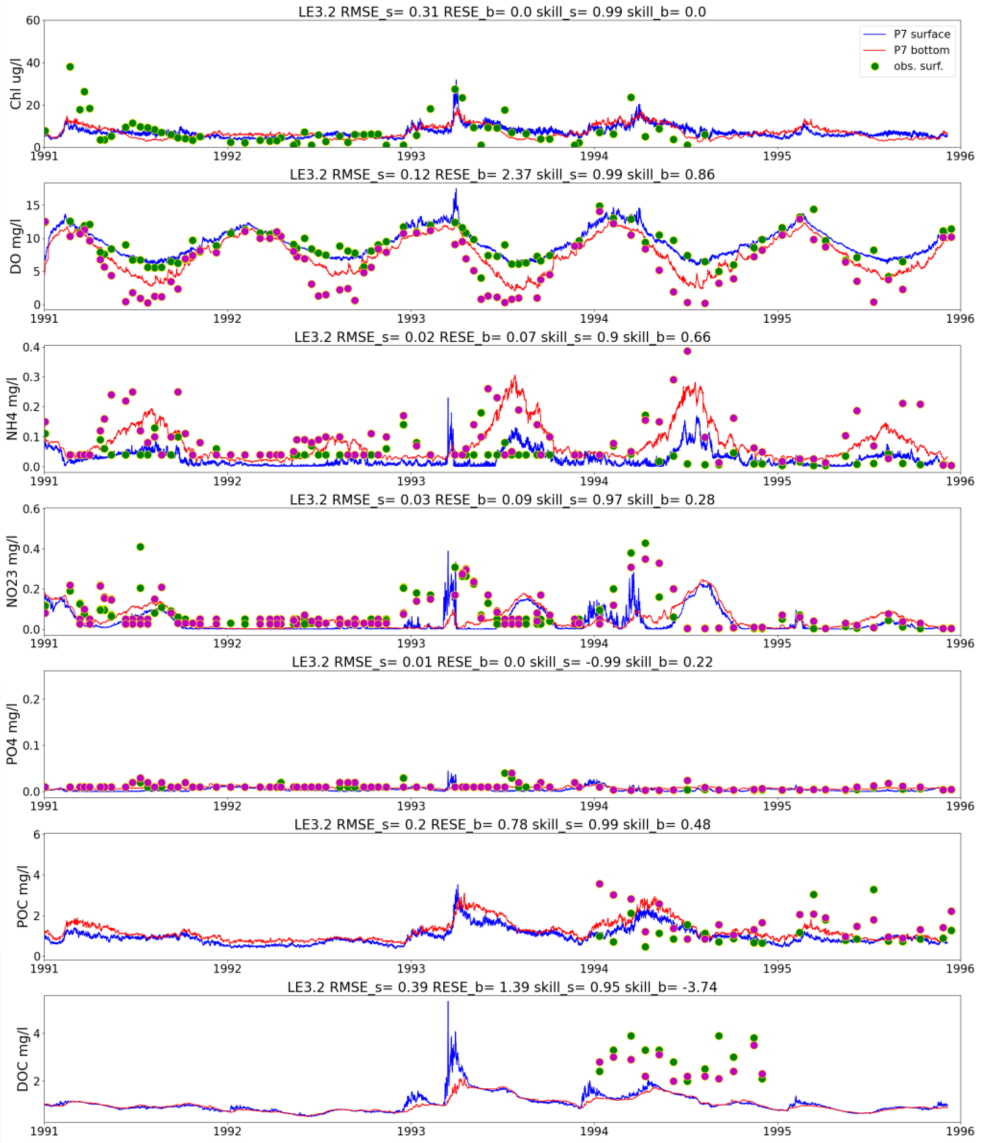
RET 3.1

RET 3.2

Comparison of Model Results and Observation

LE 3.1

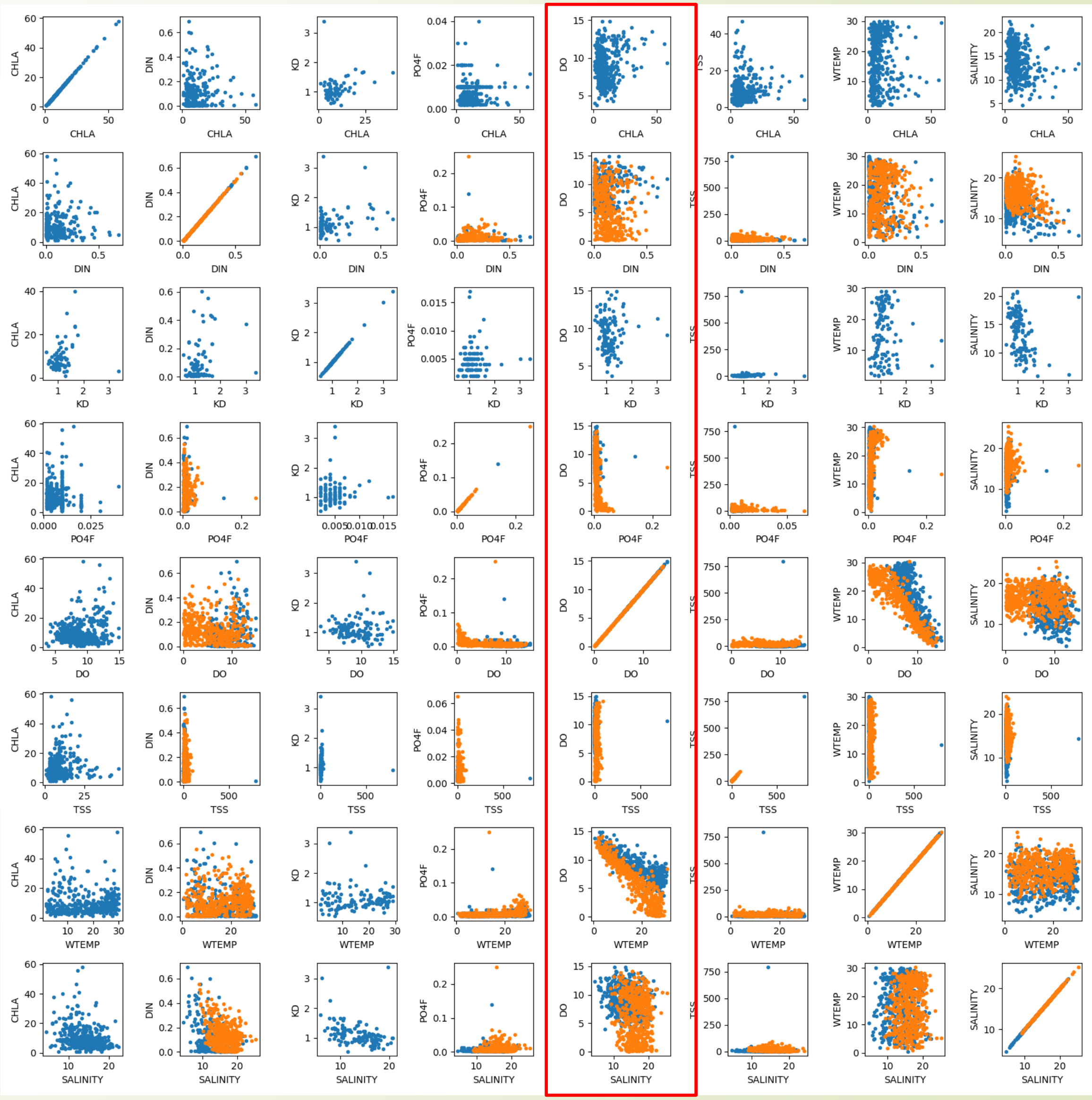
LE 3.2



Correlations among Parameters

LE3.1

LE3.2



Next Phase

- Complete linkage of water quality model between MBM and TM
- Conduct preliminary water quality model calibration using updated MBM.
- Use the same parameters as MBM and loadings.
- Identify any problems during model calibration