# PROGRESS REPORT OF RAPPAHANNOCK RIVER MODELING

## Quarterly meeting: April 2025

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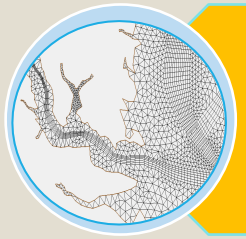
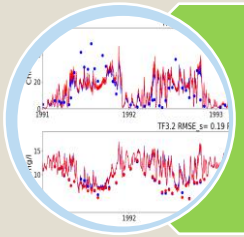
*Advisory team: Joseph Zhang and Marjorie Friedrichs*

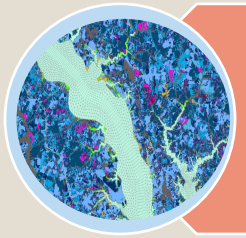
# Outline



**New Approach**

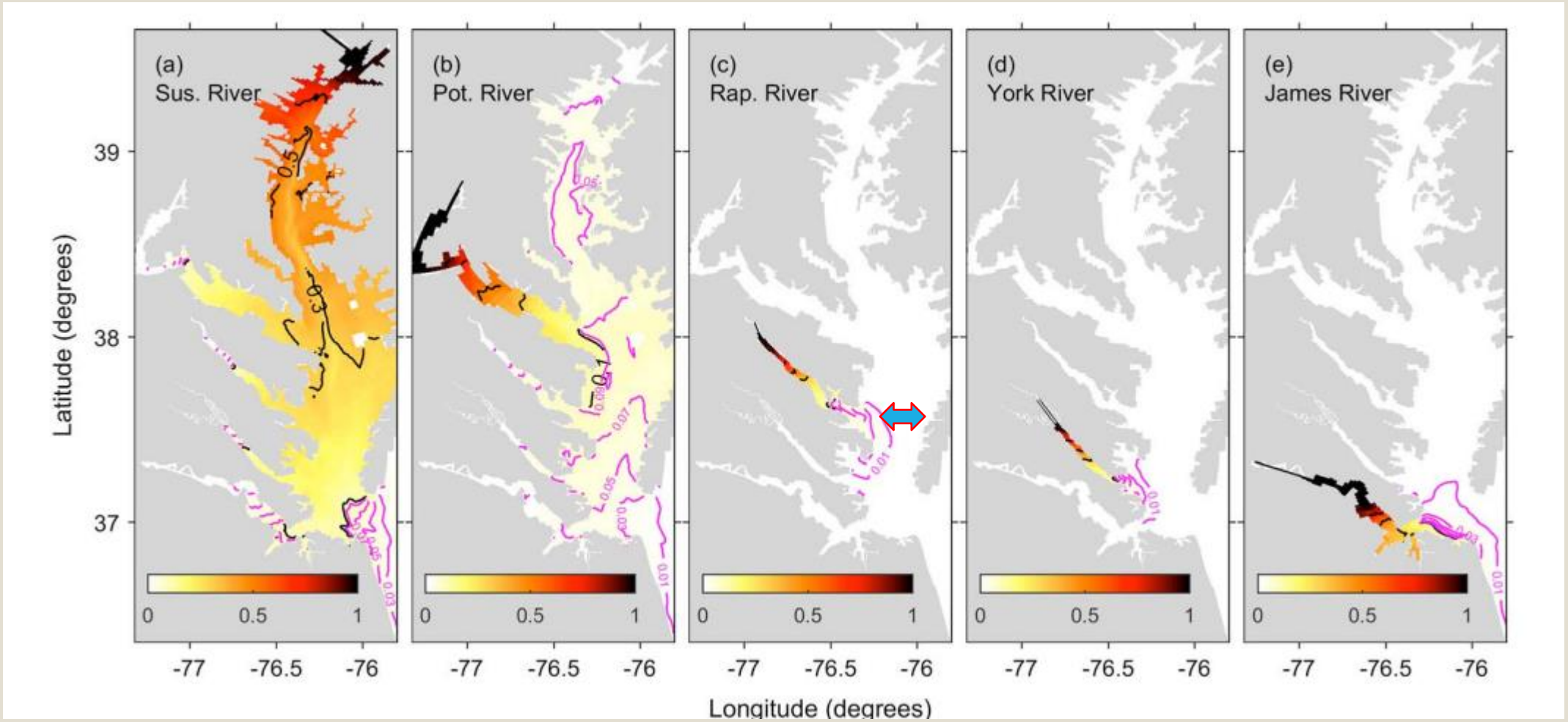


**Hydrodynamic Model Results**

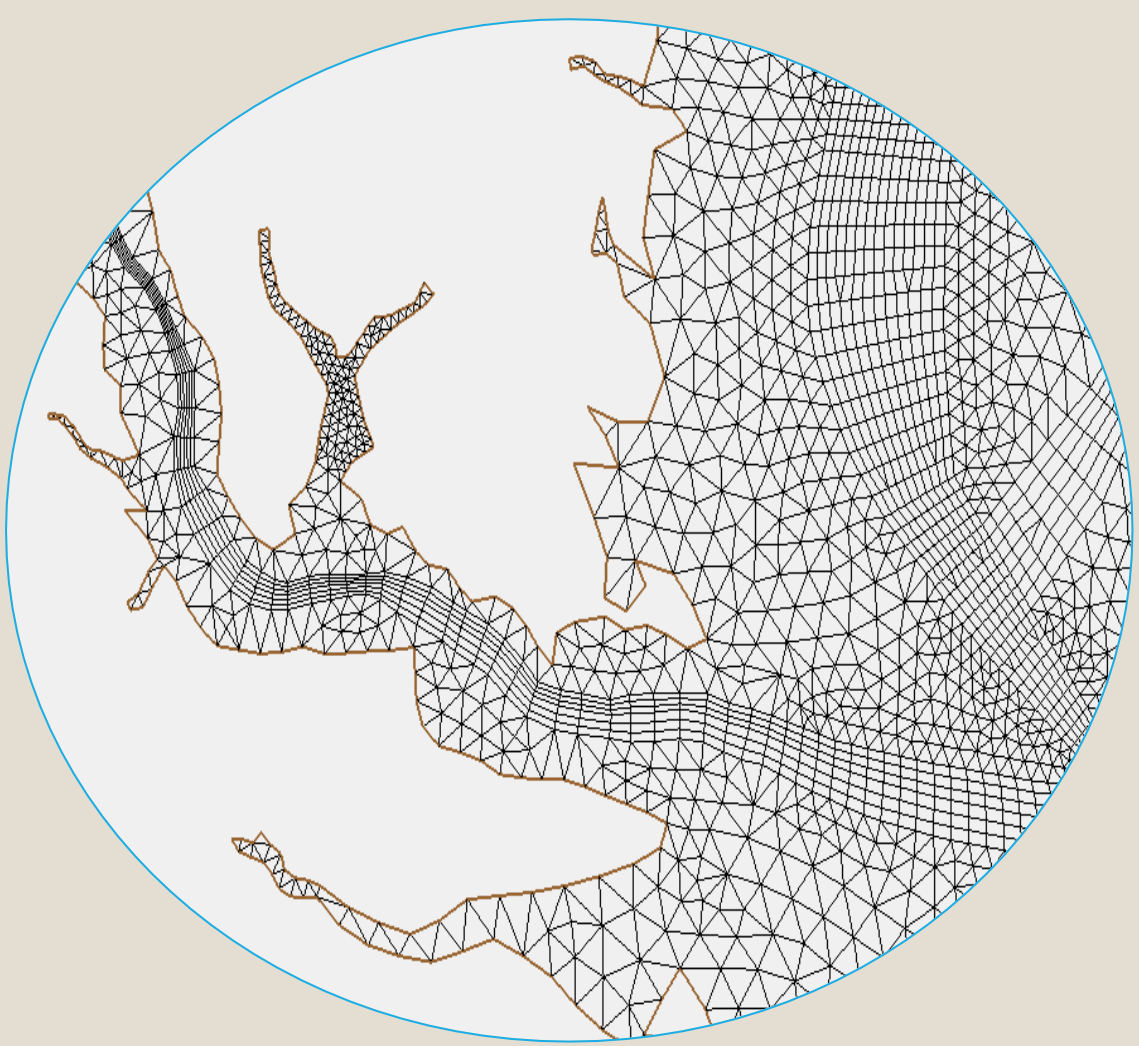


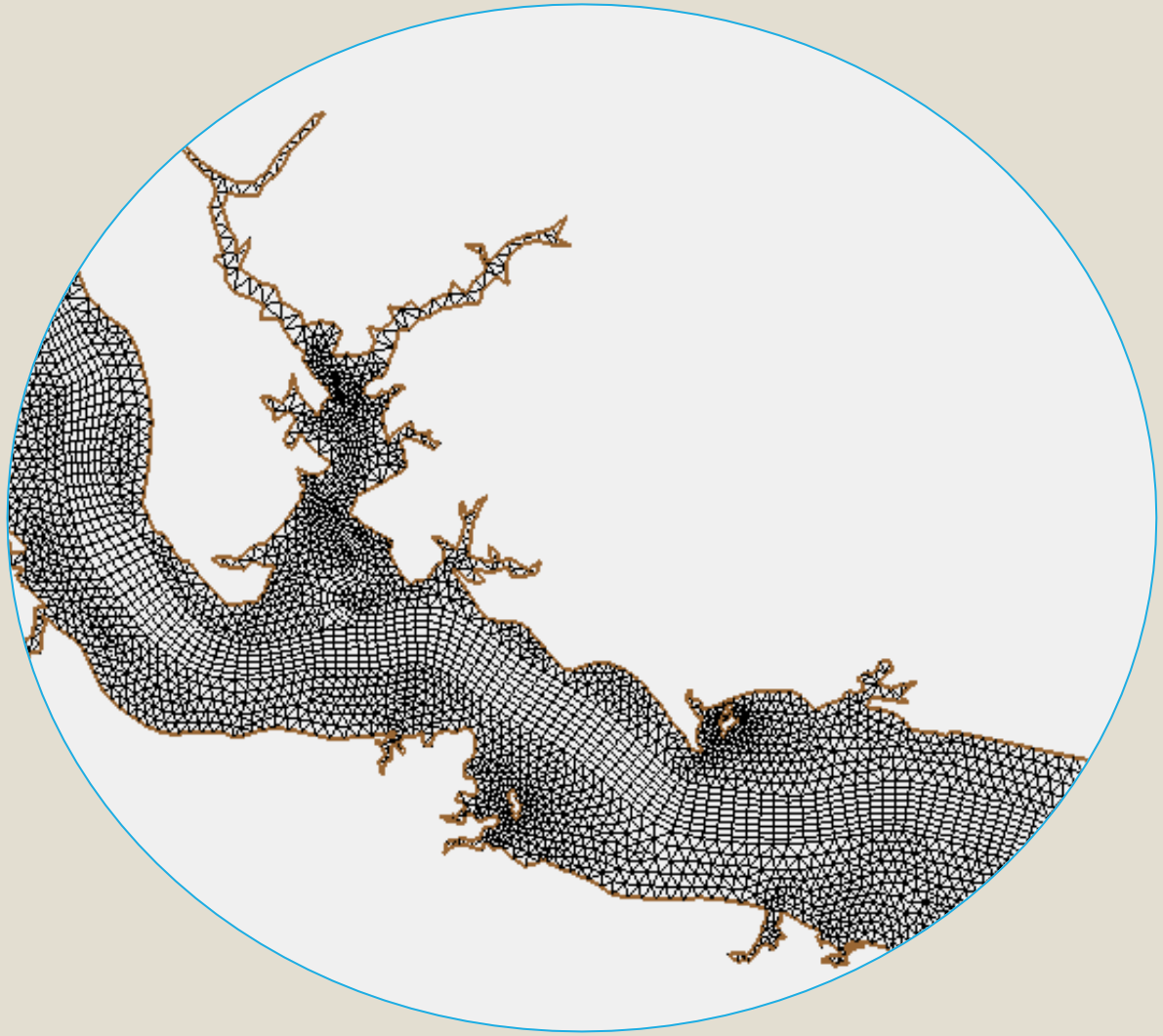
**Water Quality Model Results**

# Example of Contribution of Tributaries to Main Bay

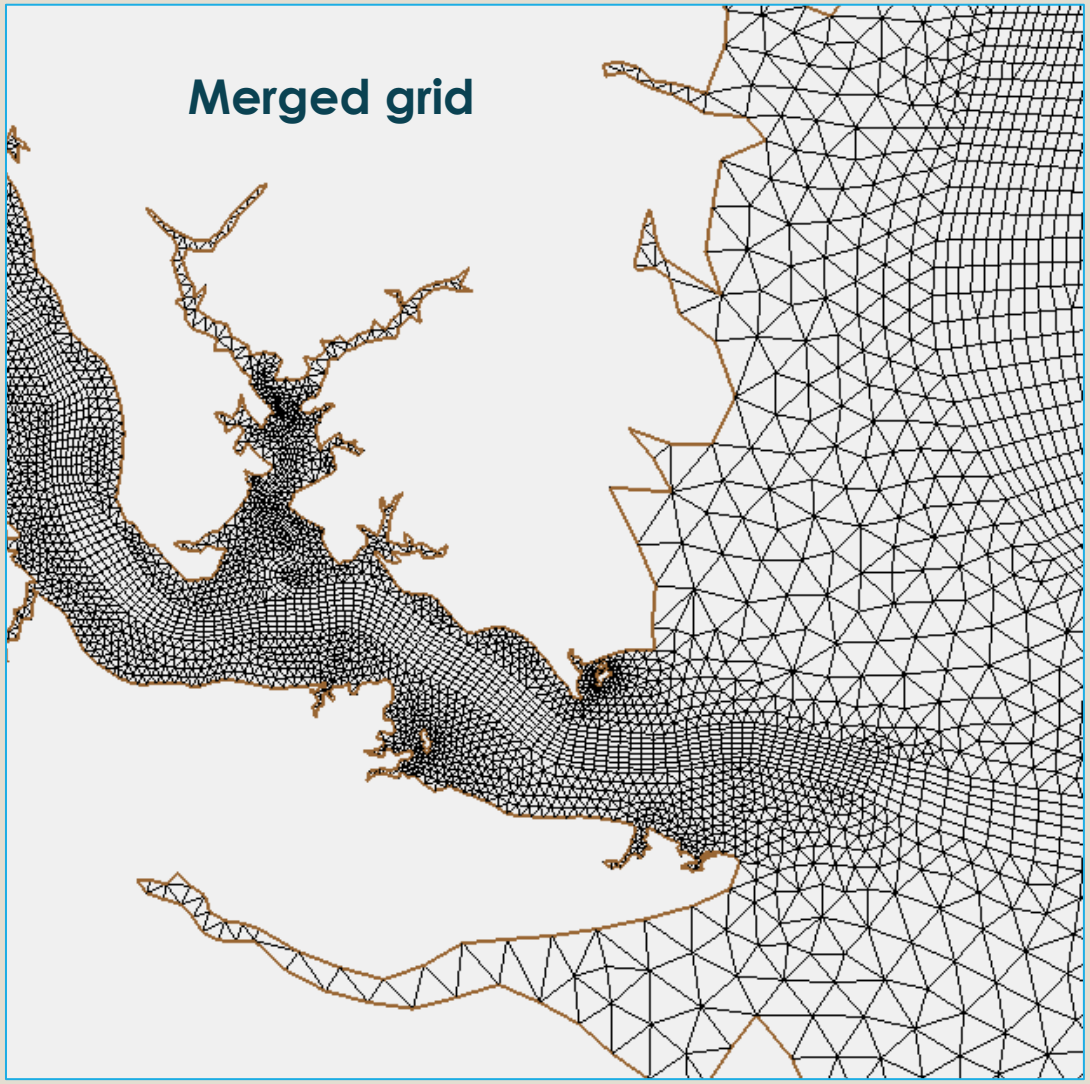


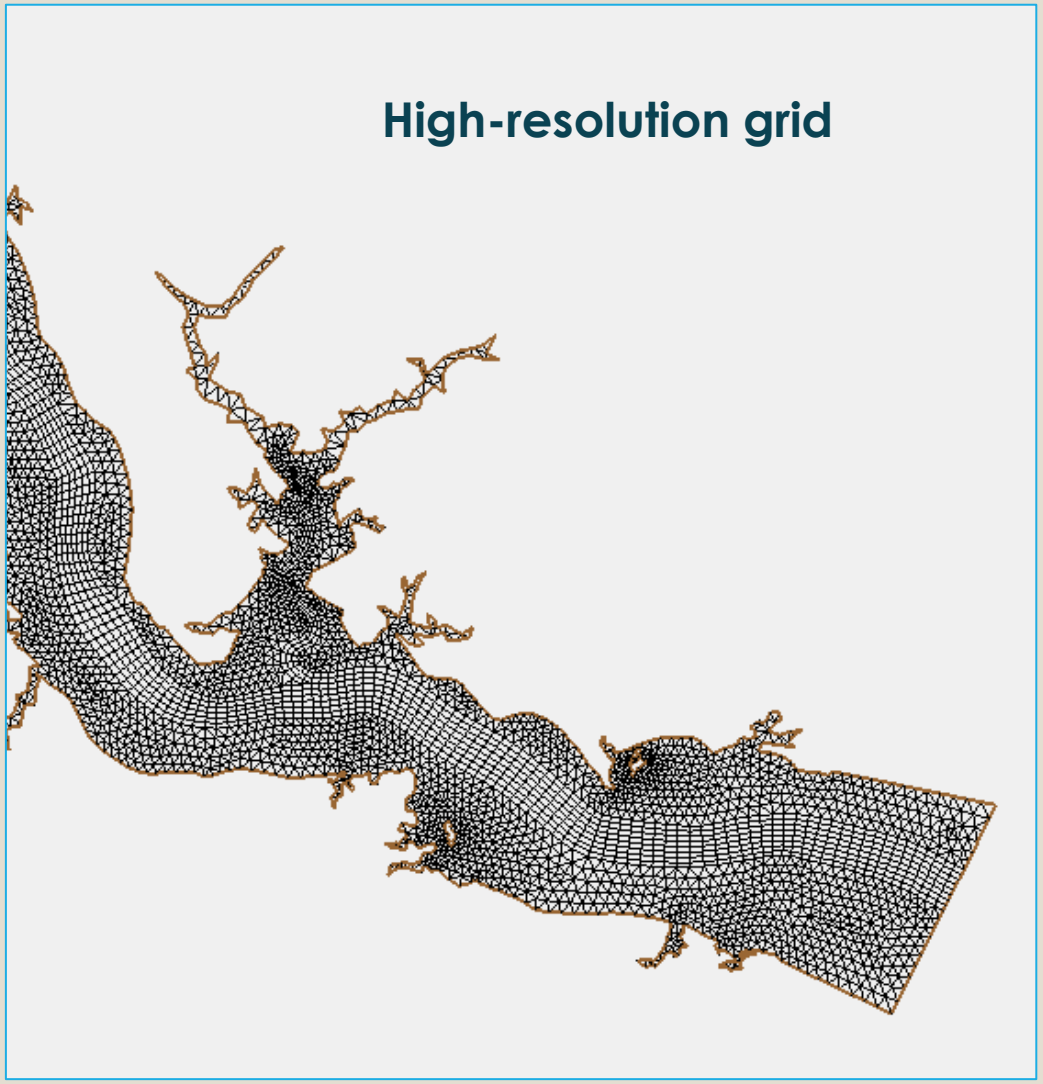
# Main Bay model grid





# Marge bay grid and Rappahannock River grid

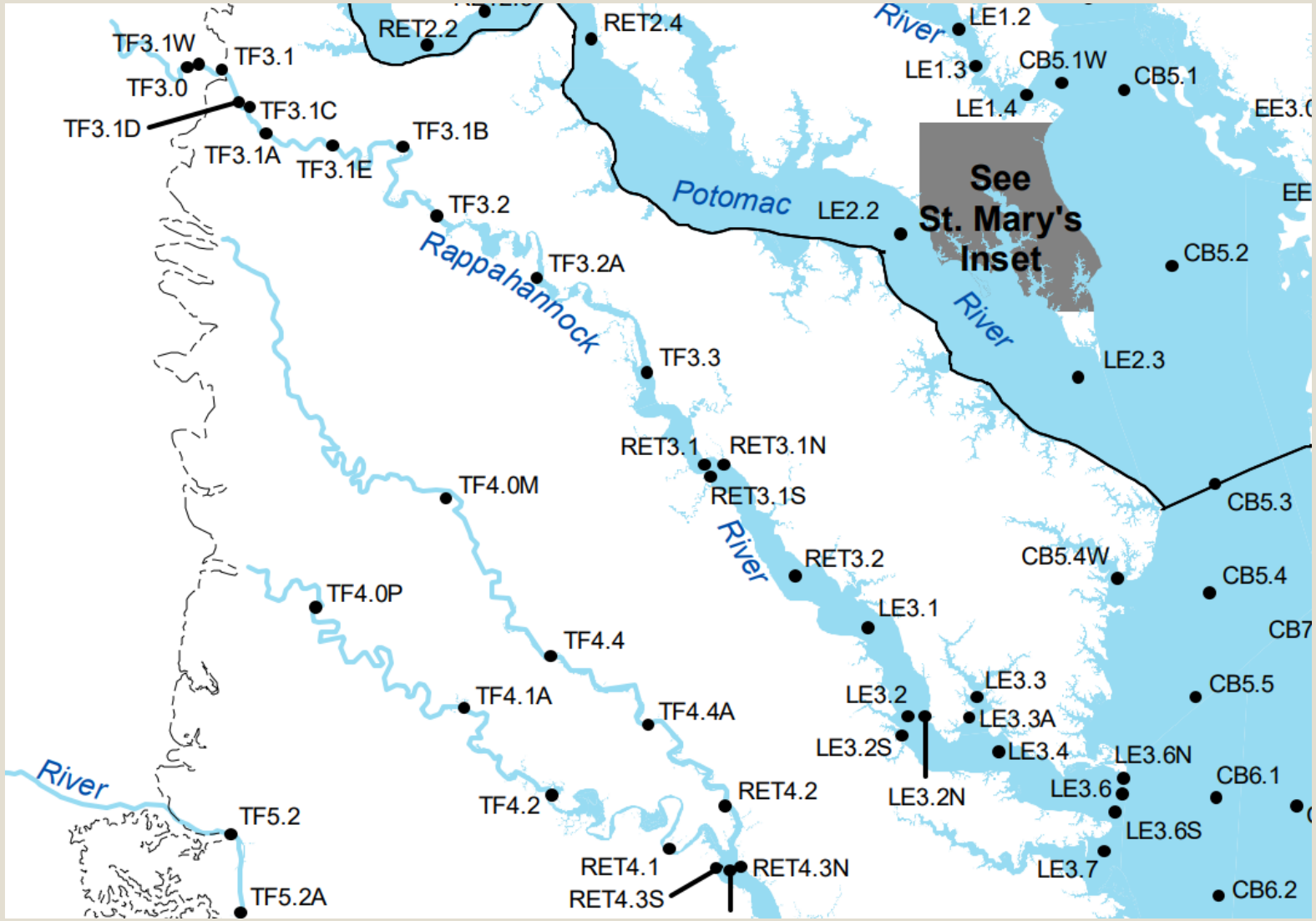


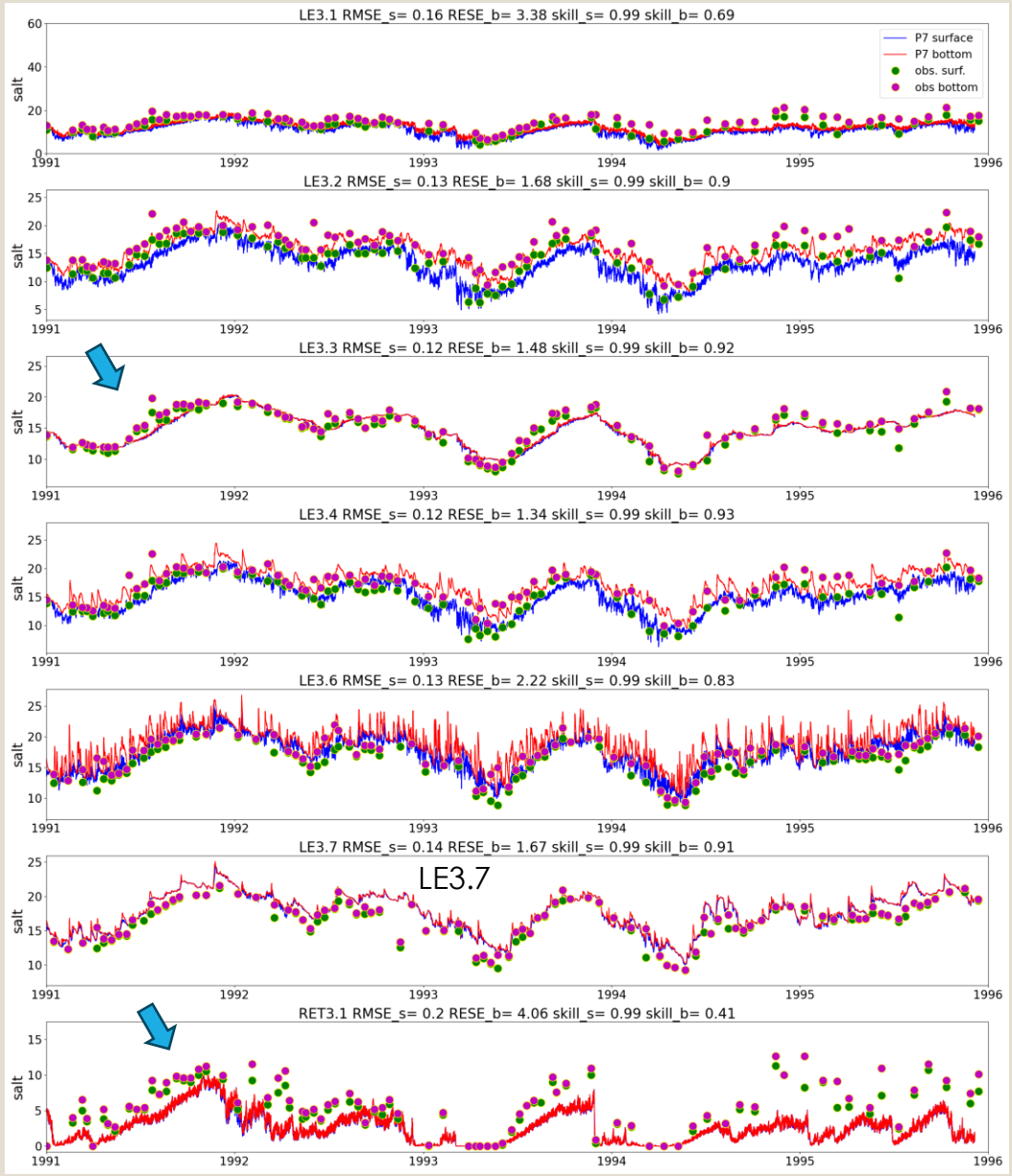
# Advantage

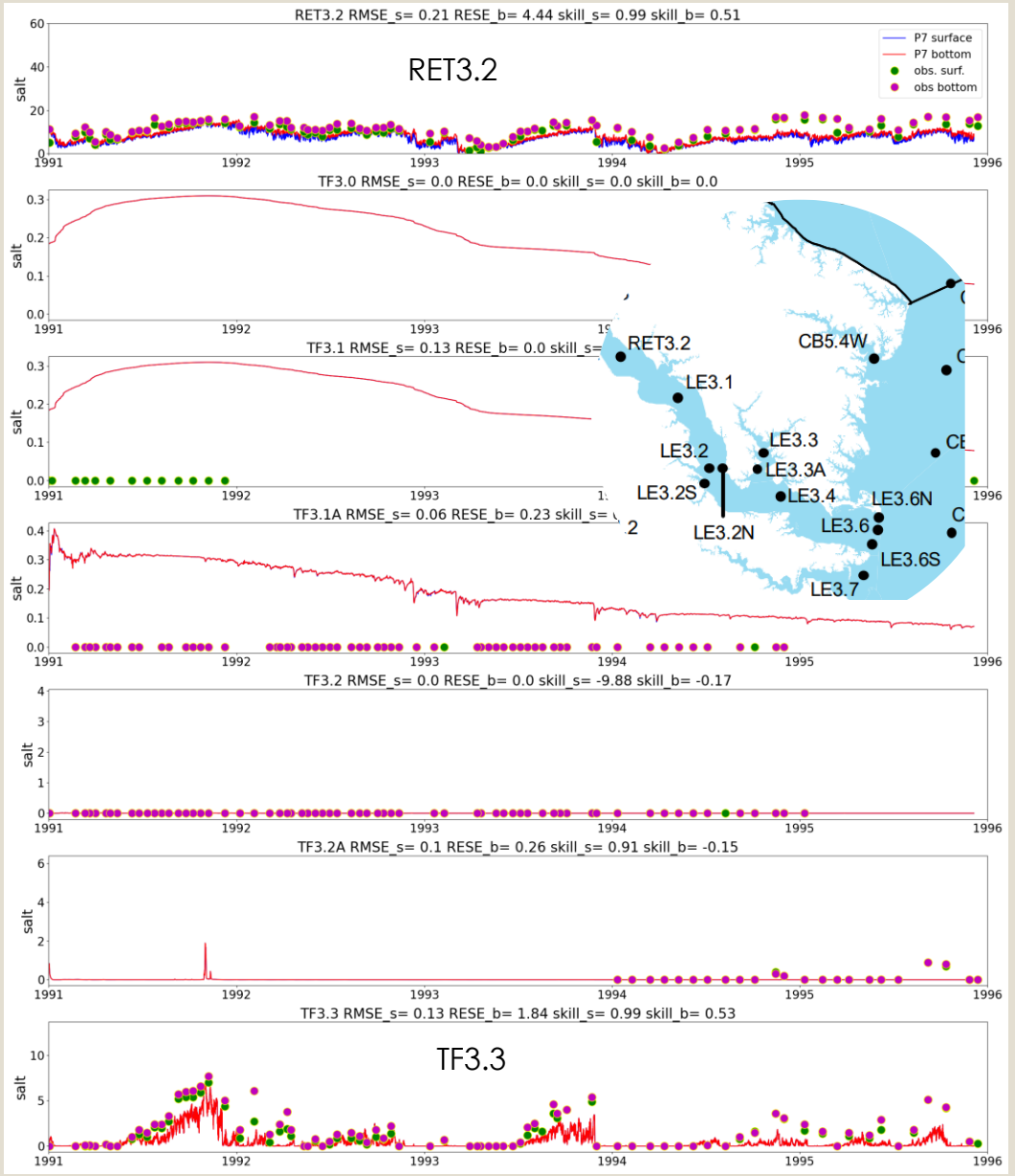
- Account for bidirectional fluxes between the bay and the tributary
- Convenient to pass updated MBM parameters to the Rappahannock River
- Consistency of model setup and loading discharge

# Station Location

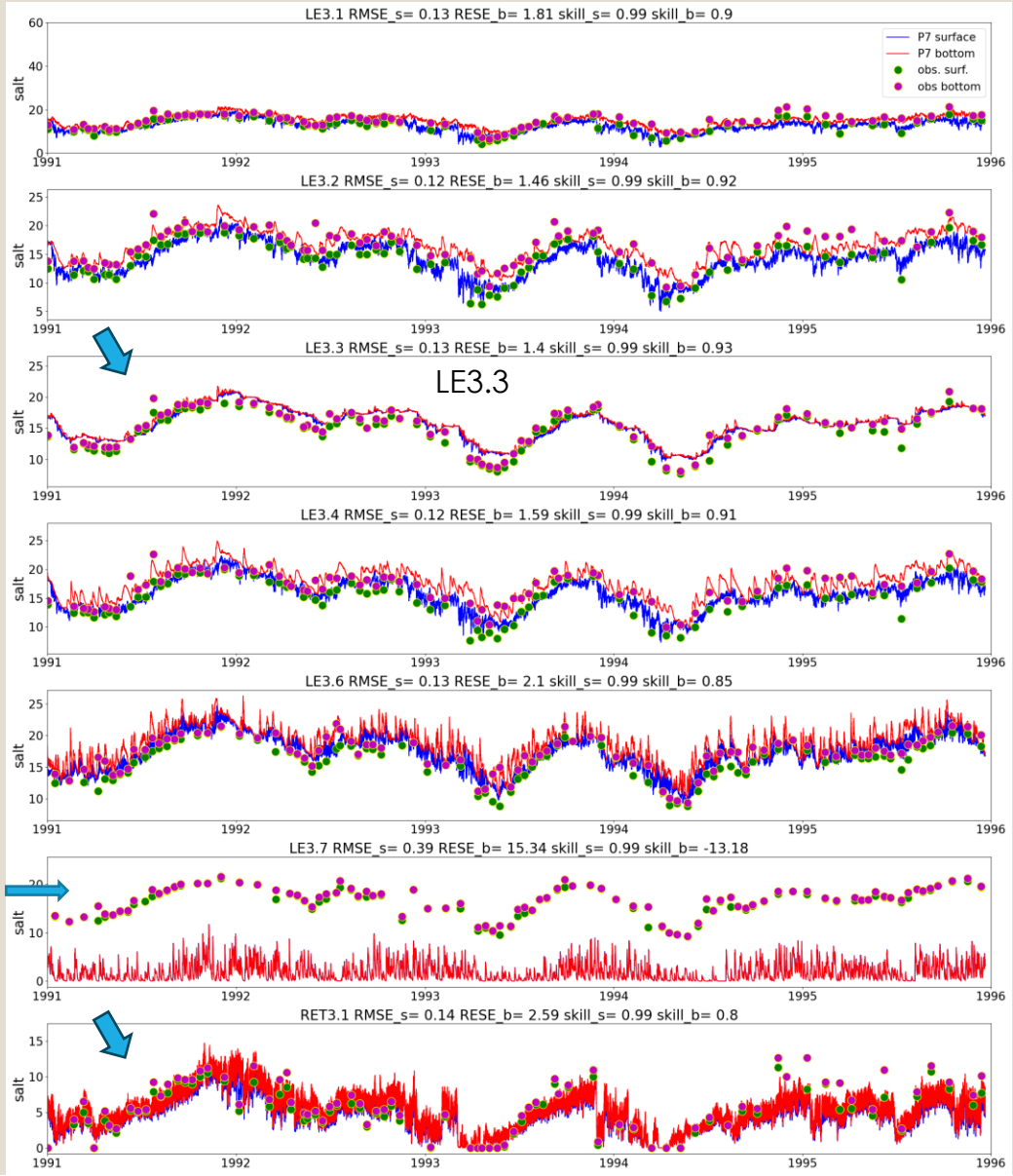


# Results of Main Bay Model Phase 6 flow (Salinity)

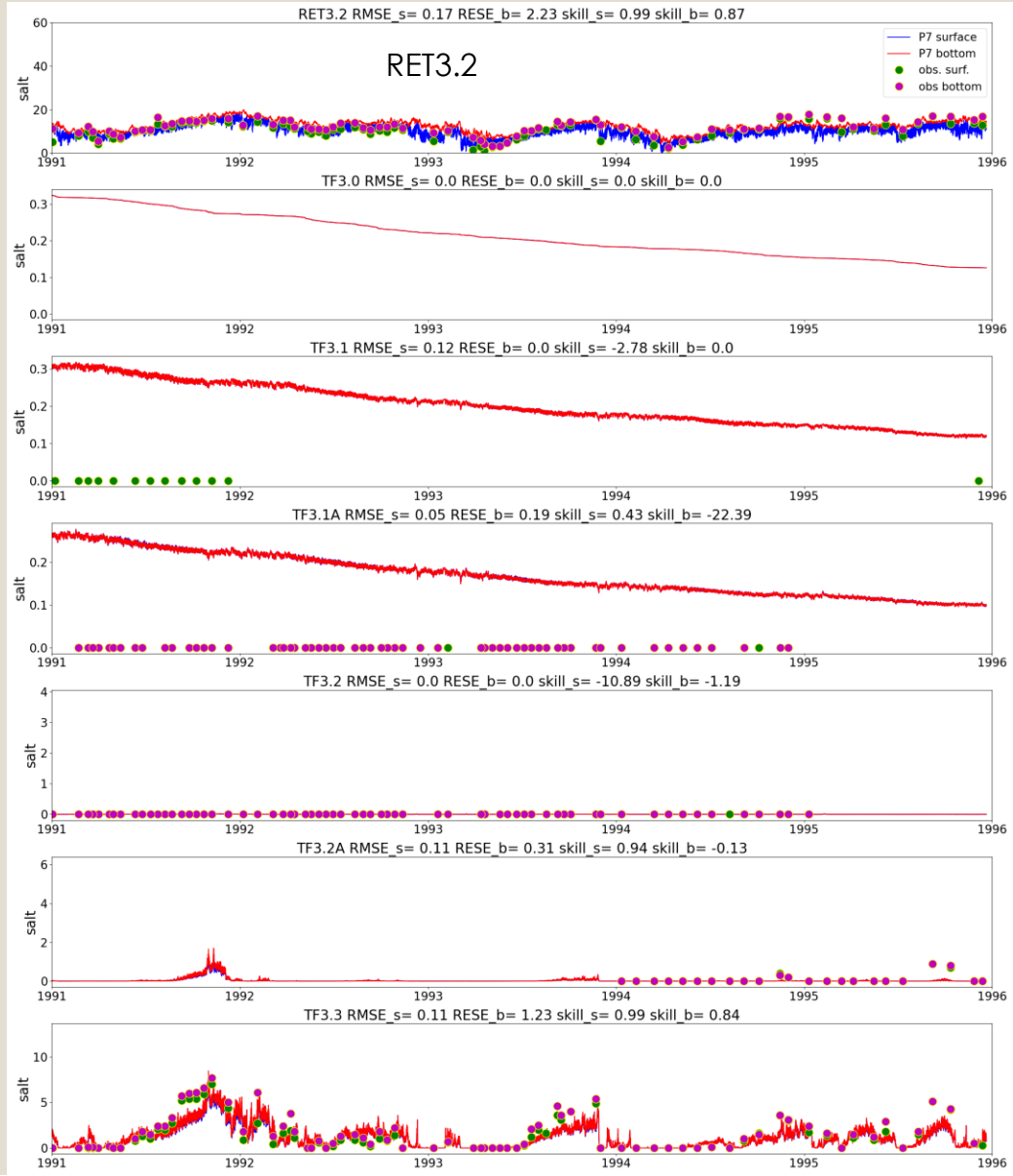


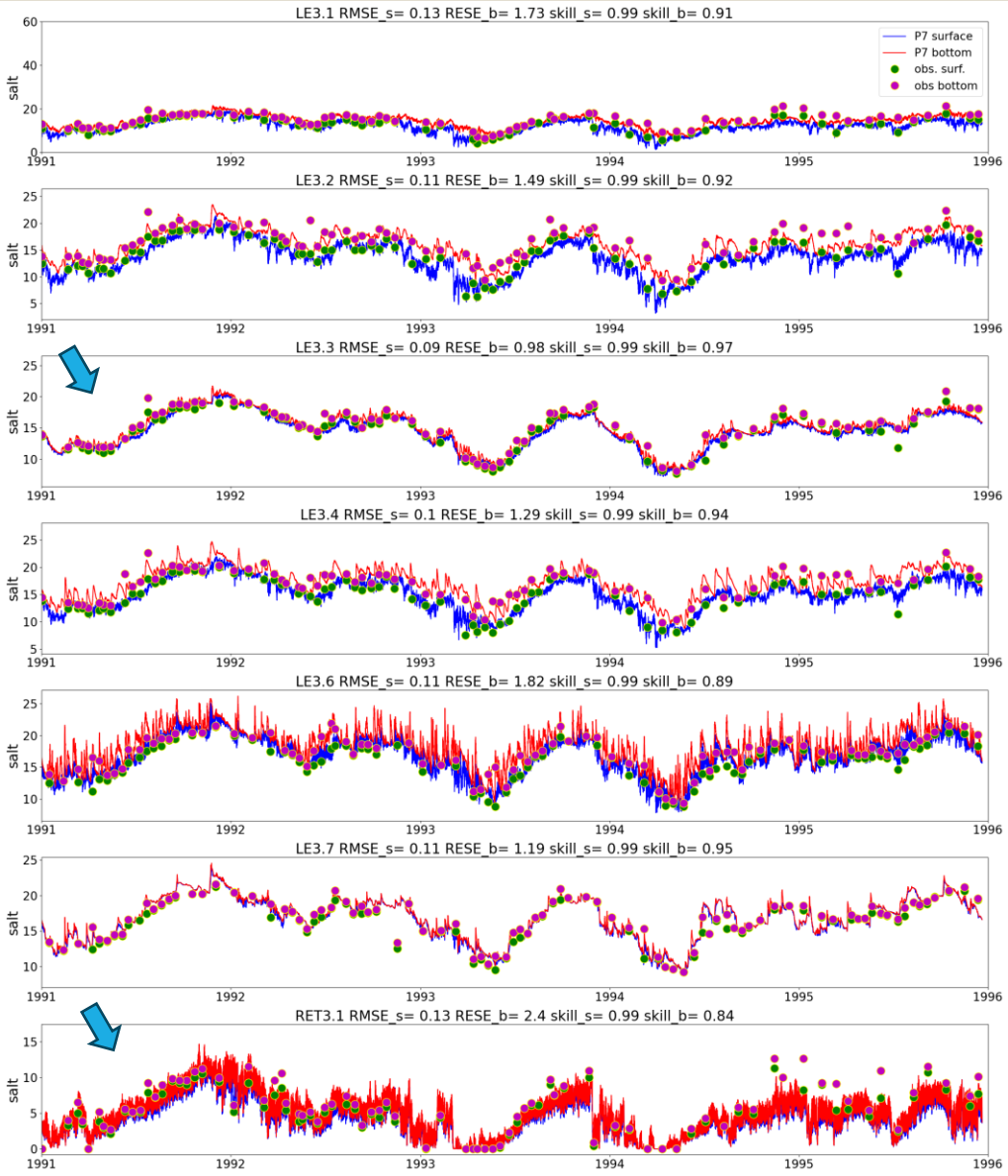
# Results of Small Rappahannock River Grid

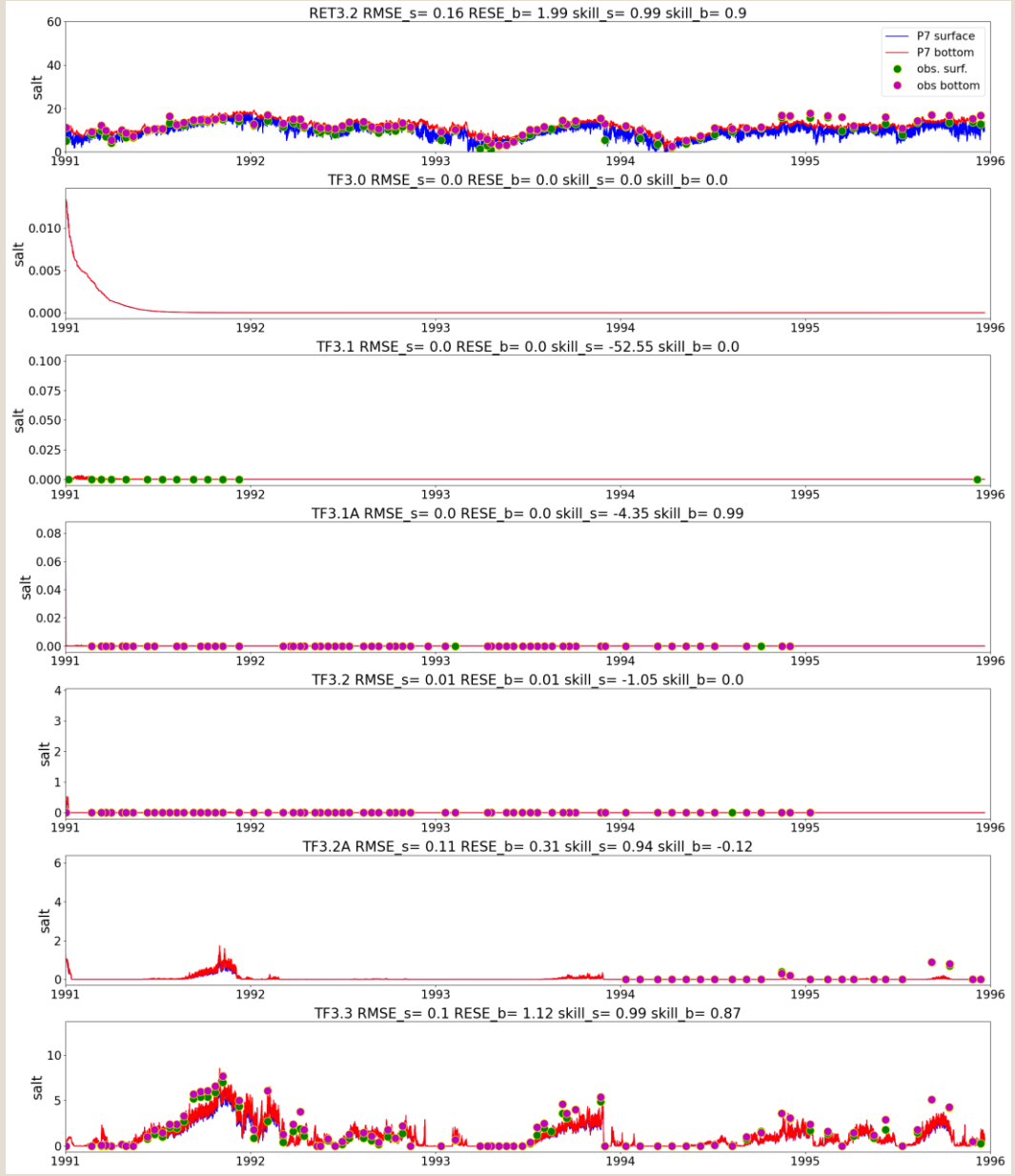



Not inside the grid

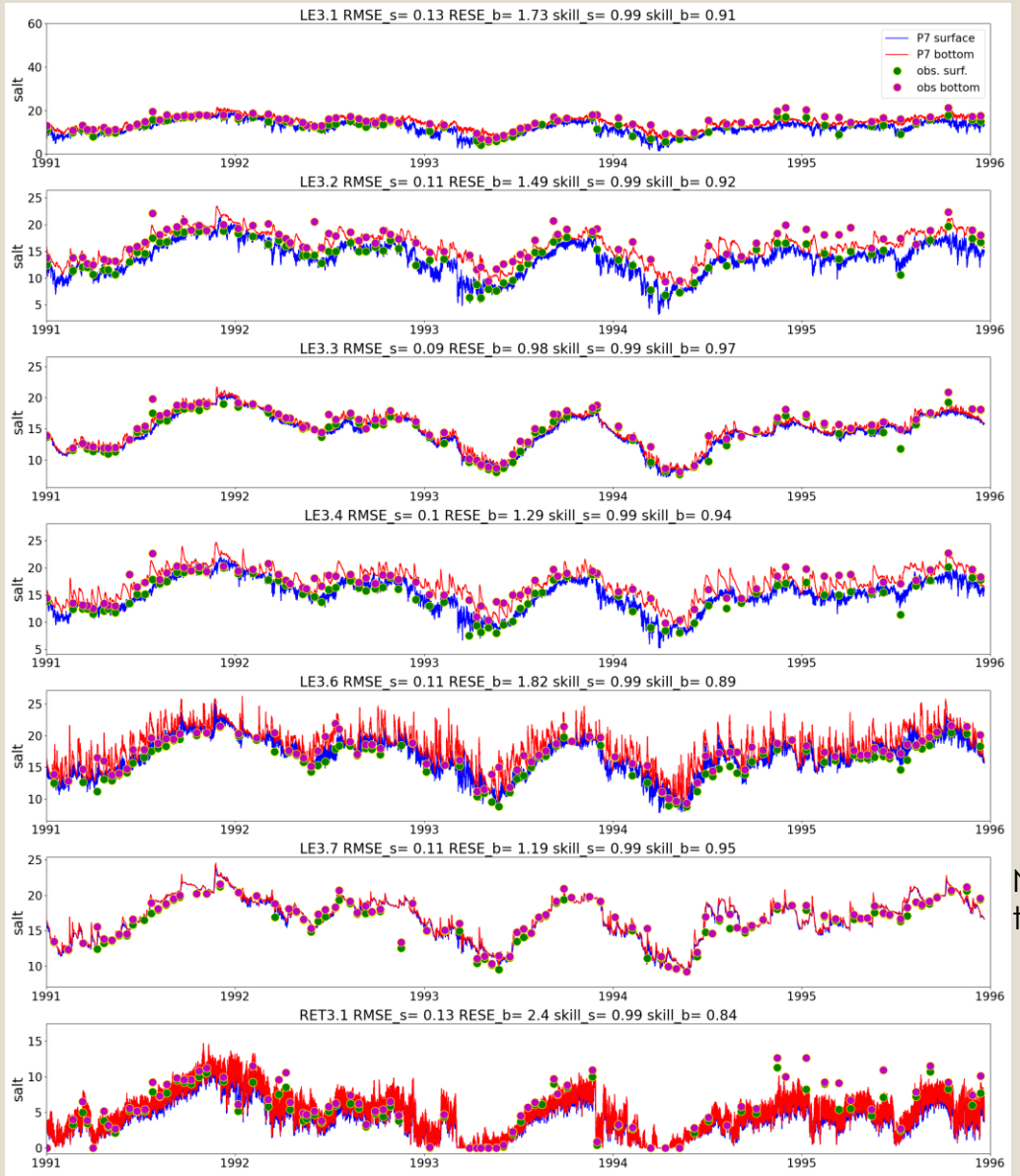


# Results of Merged Bay and Rappahannock River Grid

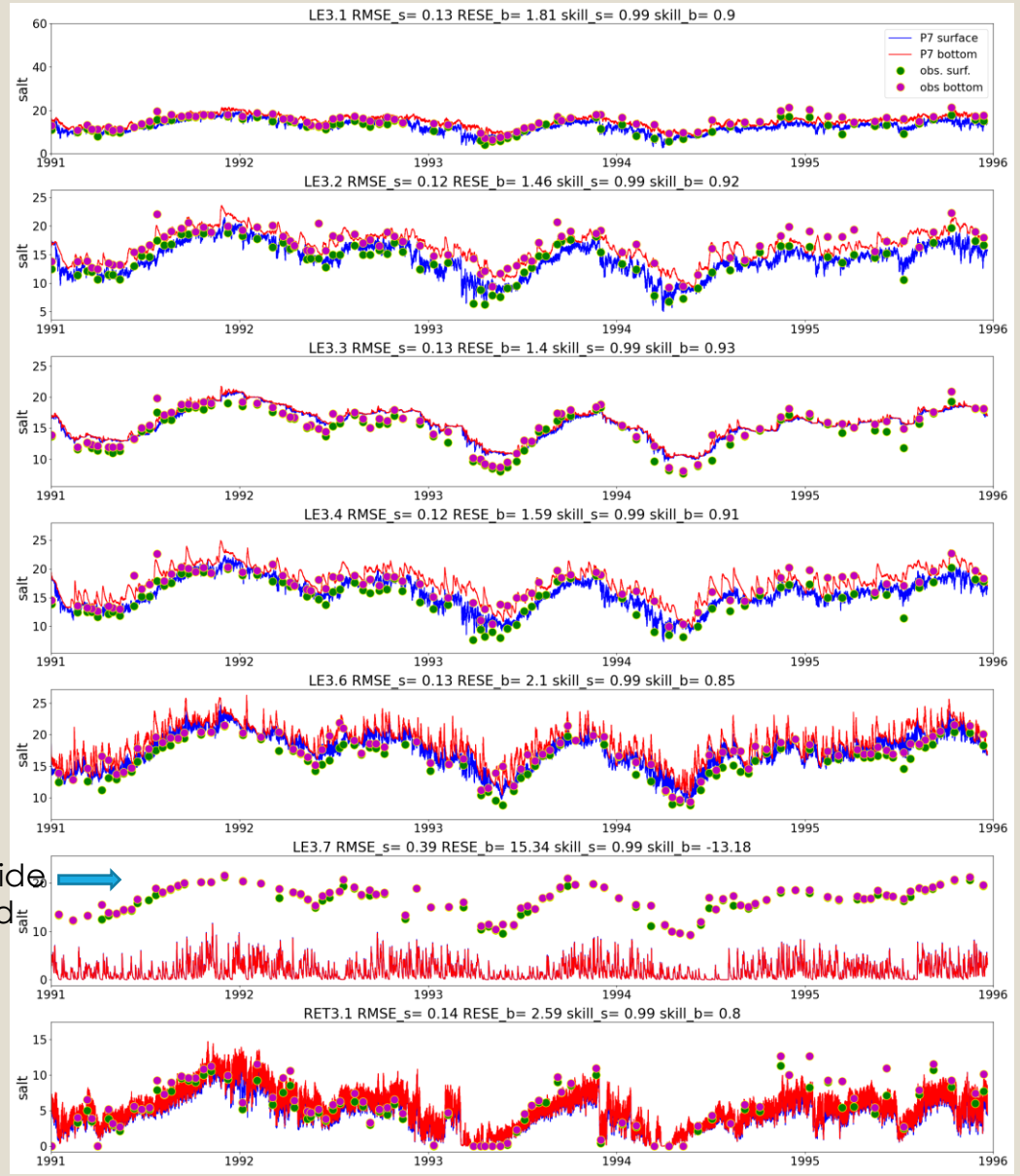


# Merged grid

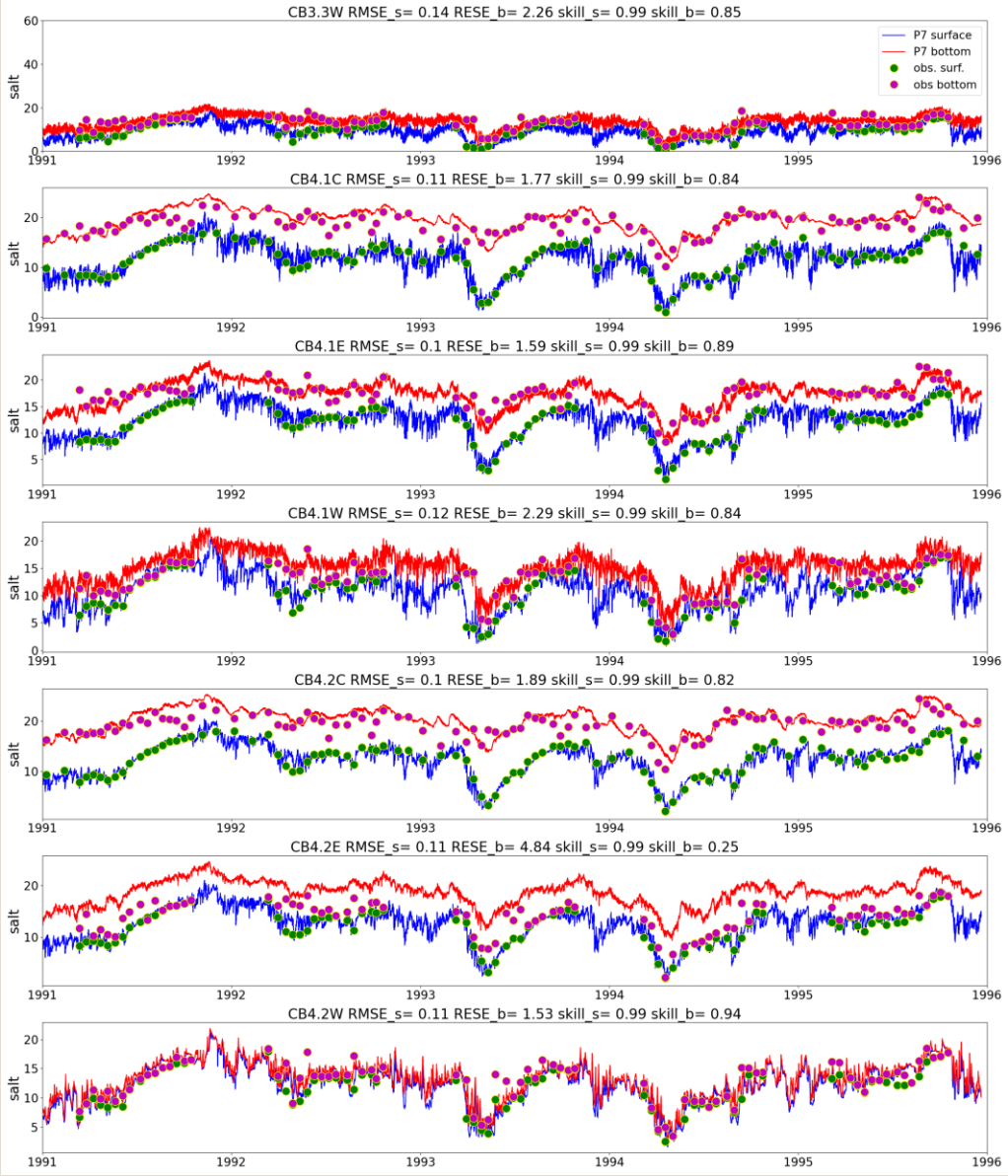


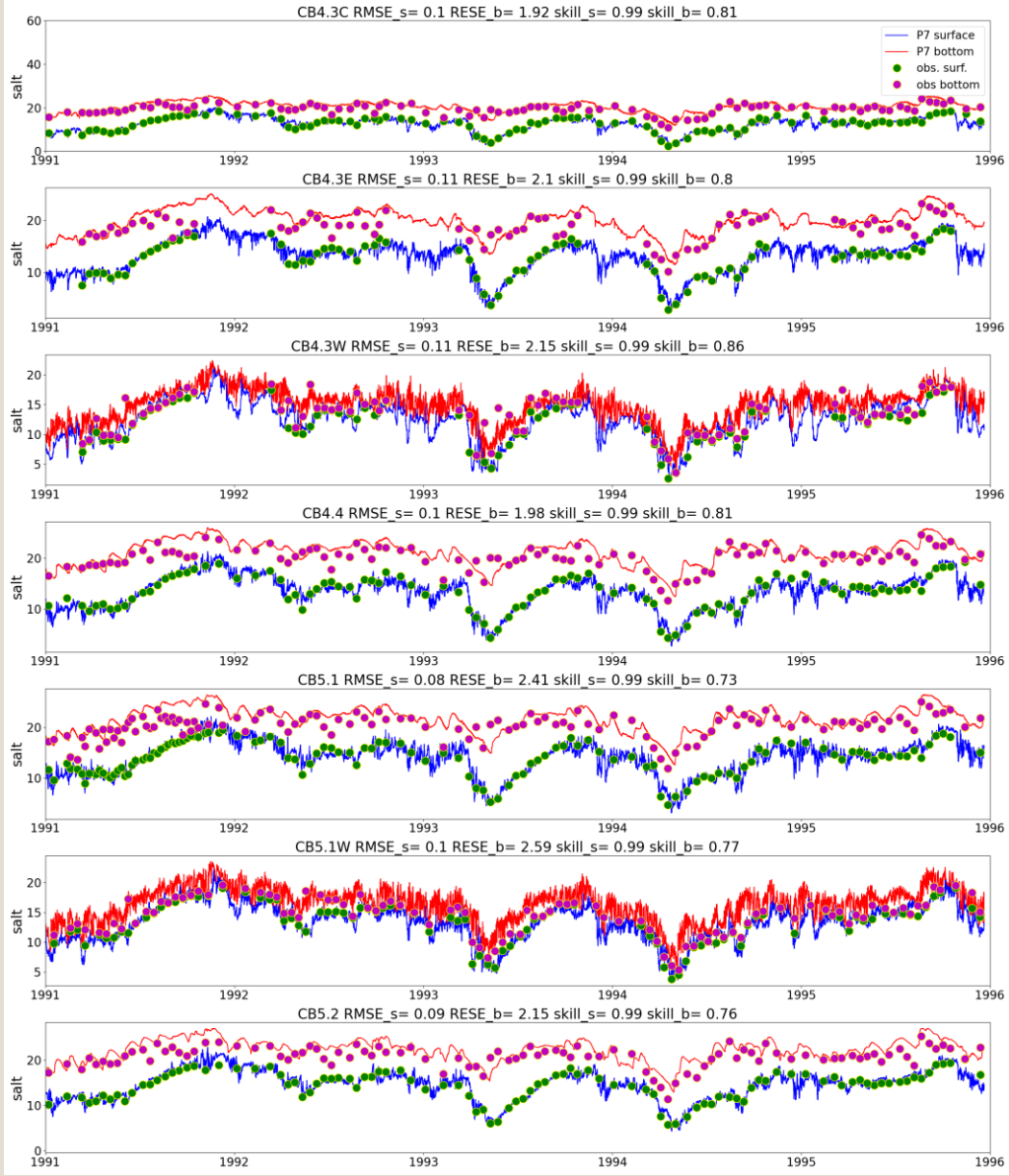

# Rapp small grid




Not inside the grid

# Results of Merged Grid in Main Bay channel

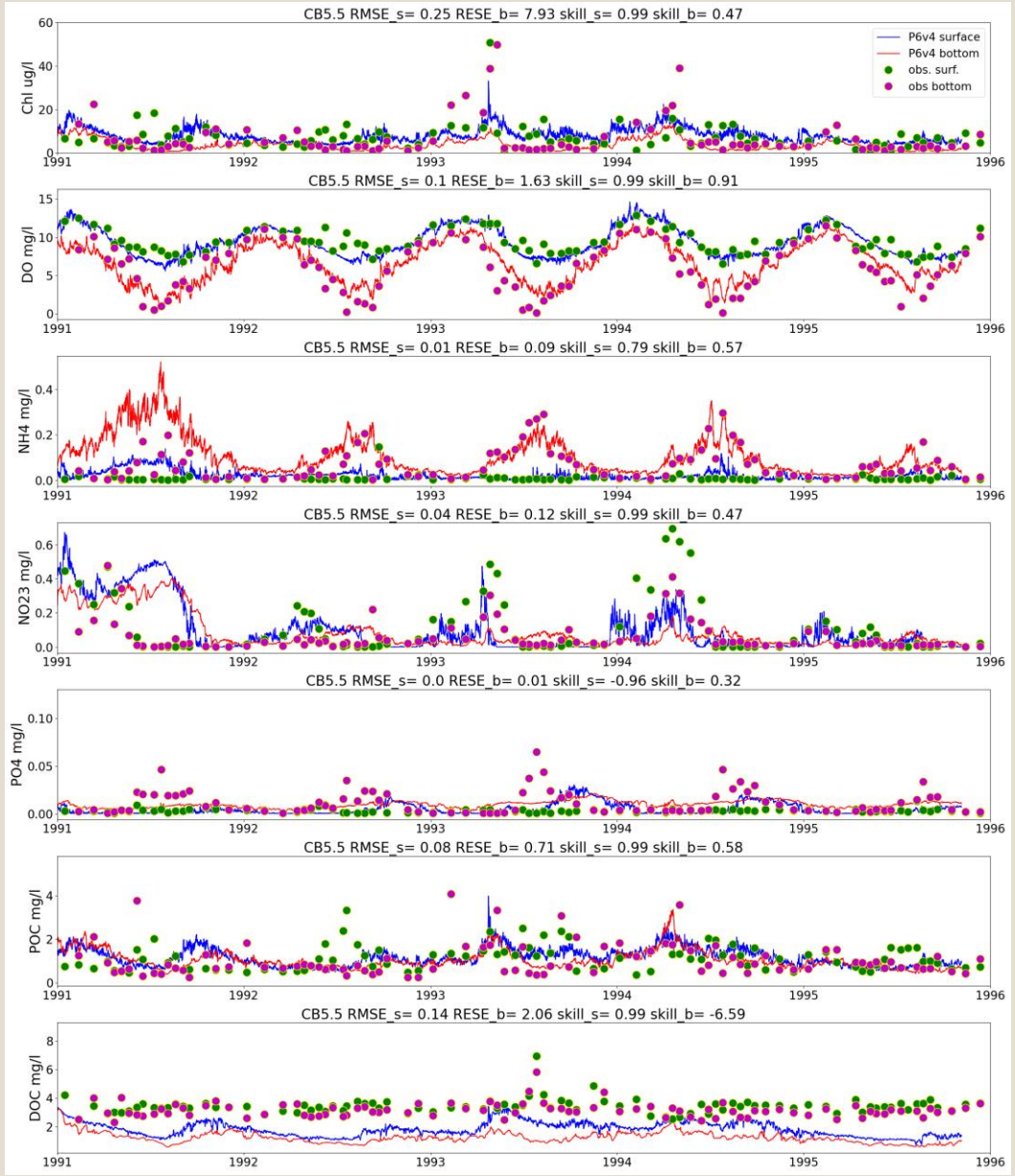


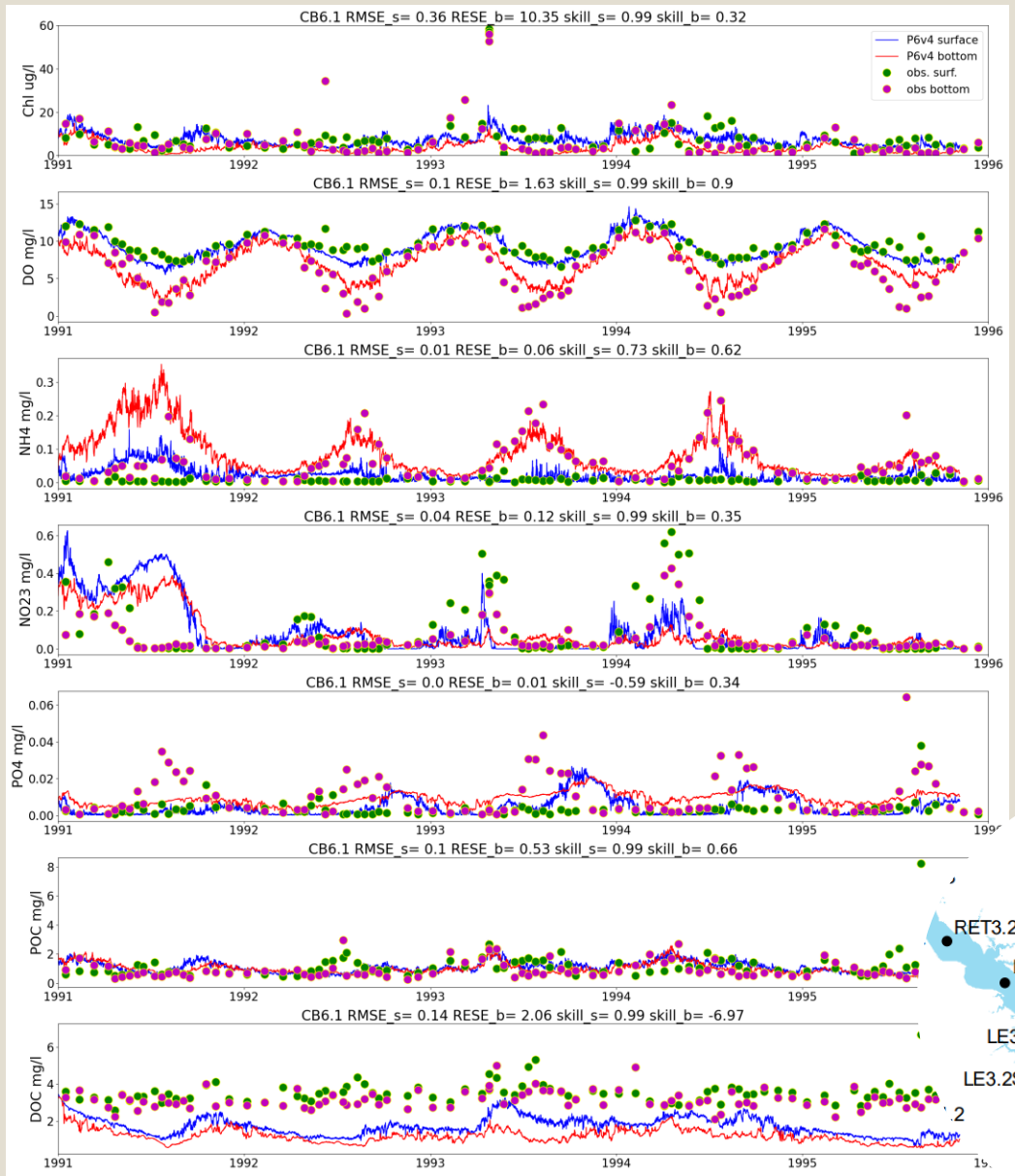
# Water Quality Model Setup

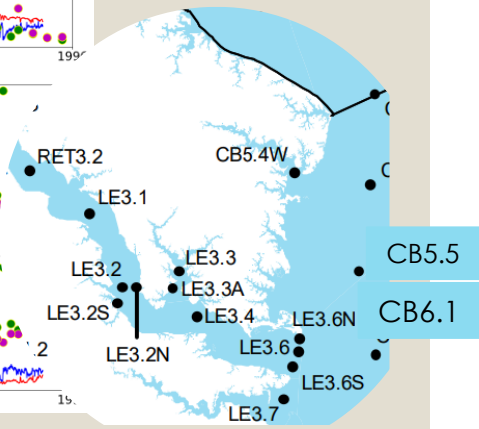
- Use Phase 6 loading
- Use previous SCHISM model (without living resources, and nudging at the Bay open boundary)
- Use the same water quality parameters and open boundary conditions
- Setup is identical to main Bay model

# CB5.5

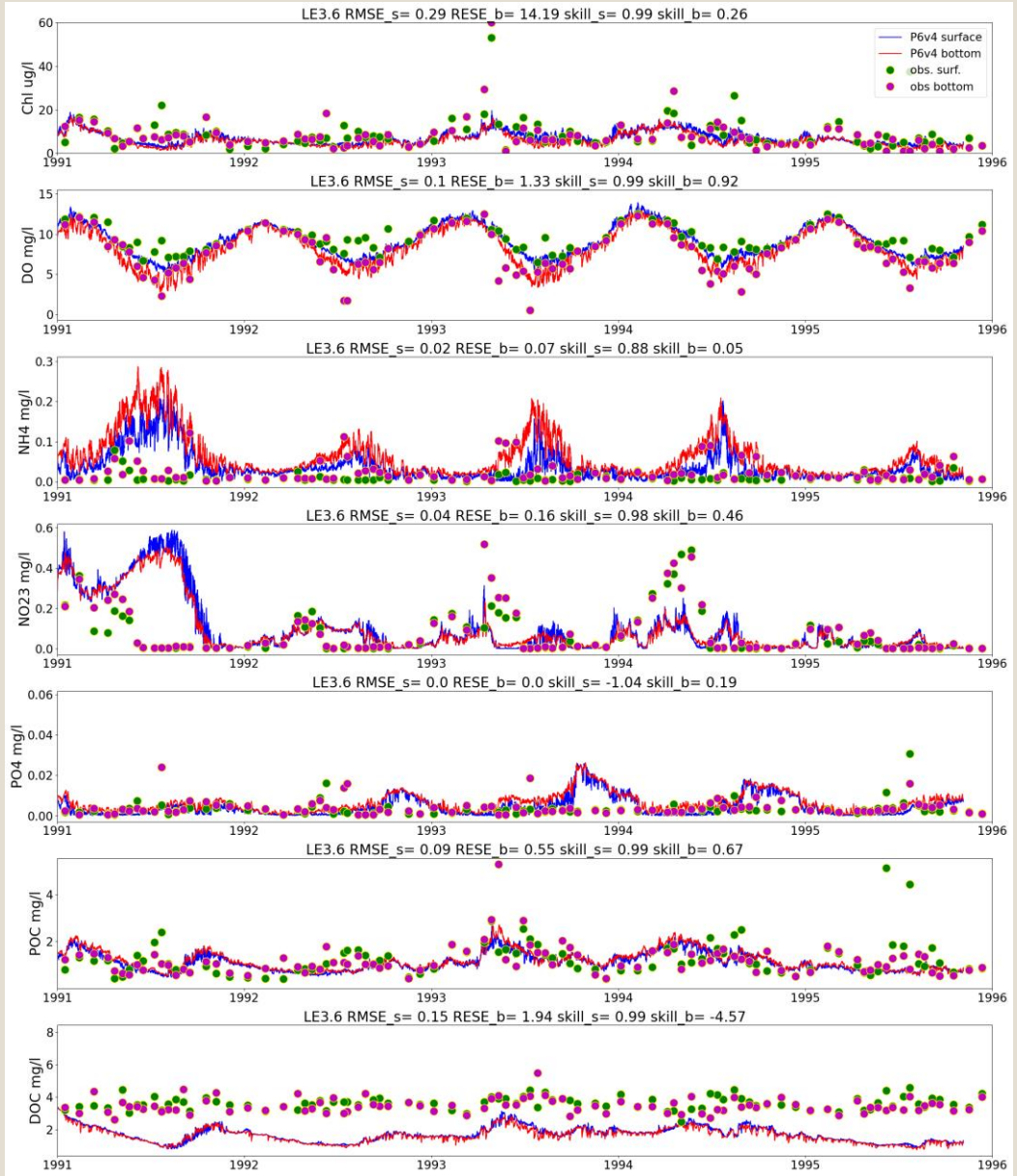

CB5.5 RMSE_s= 0.25 RESE_b= 7.93 skill_s= 0.99 skill_b= 0.47
P6v4 surface
P6v4 bottom
obs. surf.
obs bottom
Chl ug/l
CB5.5 RMSE_s= 0.1 RESE_b= 1.63 skill_s= 0.99 skill_b= 0.91
DO mg/l
CB5.5 RMSE_s= 0.01 RESE_b= 0.09 skill_s= 0.79 skill_b= 0.57
NH4 mg/l
CB5.5 RMSE_s= 0.04 RESE_b= 0.12 skill_s= 0.99 skill_b= 0.47
NO23 mg/l
CB5.5 RMSE_s= 0.0 RESE_b= 0.01 skill_s= -0.96 skill_b= 0.32
PO4 mg/l
CB5.5 RMSE_s= 0.08 RESE_b= 0.71 skill_s= 0.99 skill_b= 0.58
POC mg/l
CB5.5 RMSE_s= 0.14 RESE_b= 2.06 skill_s= 0.99 skill_b= -6.59
DOC mg/l
1991
1992
1993
1994
1995
1996

# CB6.1

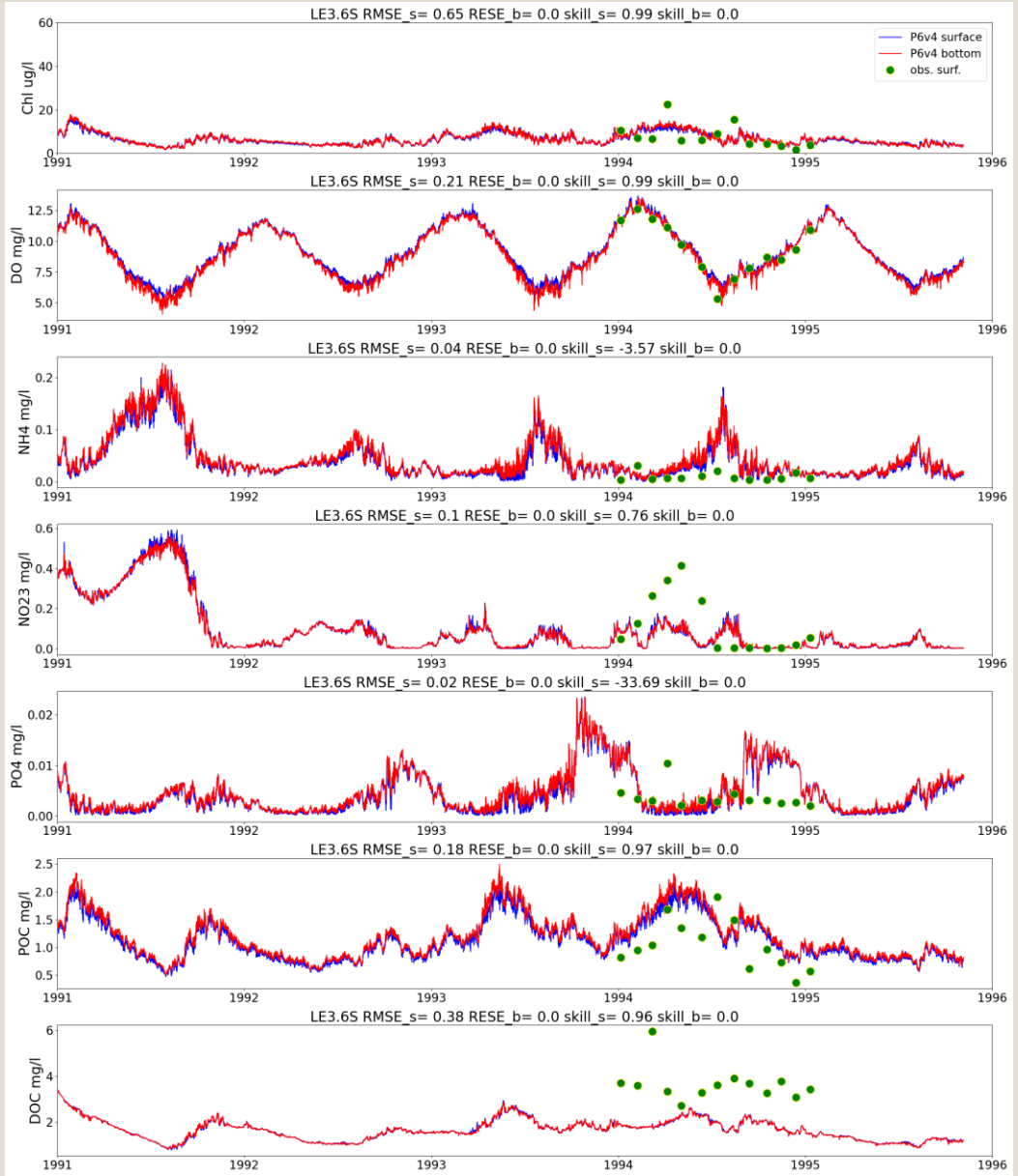

CB6.1 RMSE_s= 0.36 RESE_b= 10.35 skill_s= 0.99 skill_b= 0.32
P6v4 surface
P6v4 bottom
obs. surf.
obs bottom
Chl ug/l
CB6.1 RMSE_s= 0.1 RESE_b= 1.63 skill_s= 0.99 skill_b= 0.9
DO mg/l
CB6.1 RMSE_s= 0.01 RESE_b= 0.06 skill_s= 0.73 skill_b= 0.62
NH4 mg/l
CB6.1 RMSE_s= 0.04 RESE_b= 0.12 skill_s= 0.99 skill_b= 0.35
NO23 mg/l
CB6.1 RMSE_s= 0.0 RESE_b= 0.01 skill_s= -0.59 skill_b= 0.34
PO4 mg/l
CB6.1 RMSE_s= 0.1 RESE_b= 0.53 skill_s= 0.99 skill_b= 0.66
POC mg/l
CB6.1 RMSE_s= 0.14 RESE_b= 2.06 skill_s= 0.99 skill_b= -6.97
DOC mg/l
1991
1992
1993
1994
1995
1996


RET3.2
CB5.4W
LE3.1
LE3.2
LE3.3
LE3.3A
LE3.2S
LE3.4
LE3.6N
LE3.6
LE3.2N
LE3.6S
LE3.7
CB5.5
CB6.1

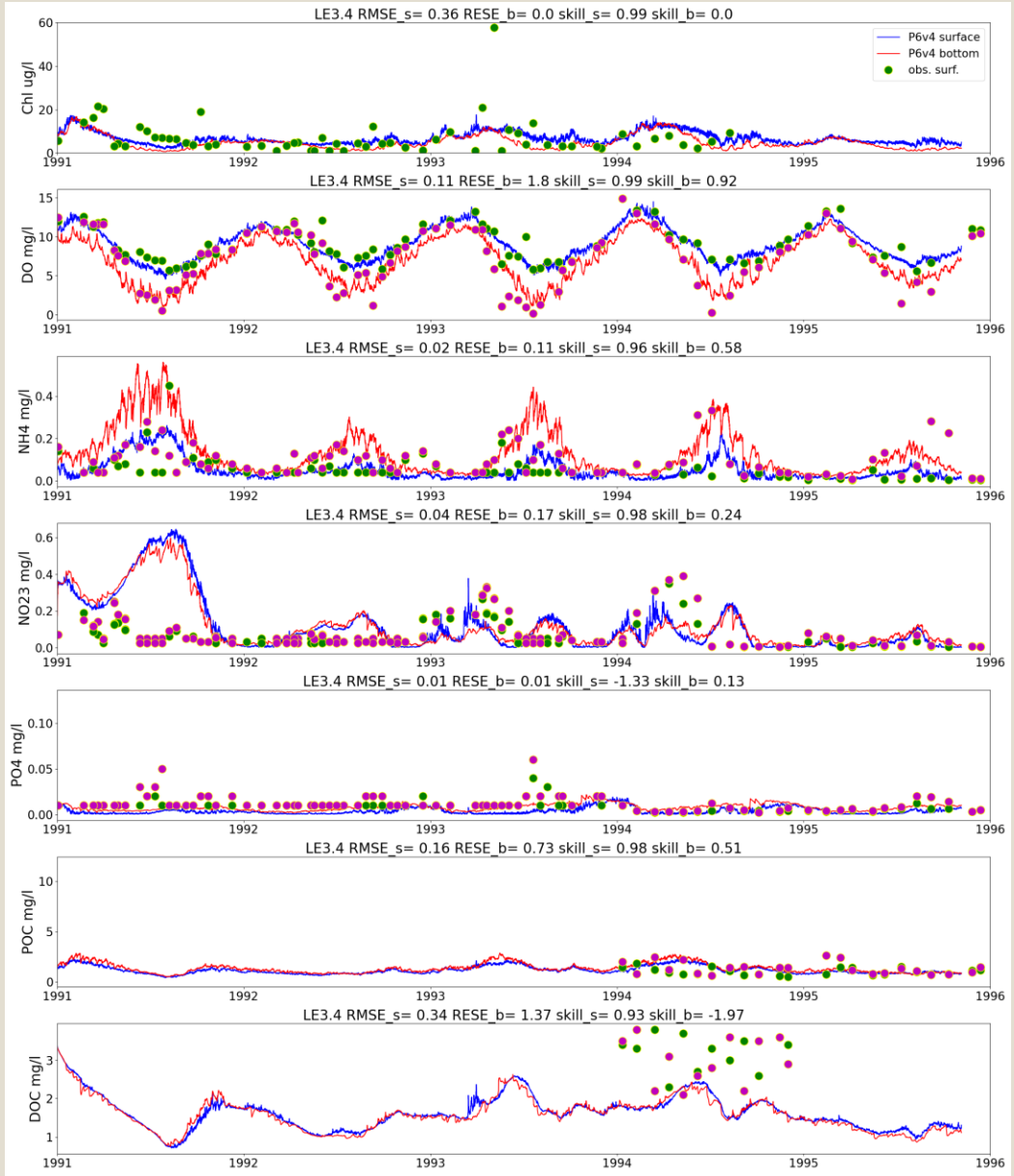
# LE3.6


LE3.6 RMSE_s= 0.29 RESE_b= 14.19 skill_s= 0.99 skill_b= 0.26
P6v4 surface
P6v4 bottom
obs. surf.
obs bottom
Chl ug/l
LE3.6 RMSE_s= 0.1 RESE_b= 1.33 skill_s= 0.99 skill_b= 0.92
DO mg/l
LE3.6 RMSE_s= 0.02 RESE_b= 0.07 skill_s= 0.88 skill_b= 0.05
NH4 mg/l
LE3.6 RMSE_s= 0.04 RESE_b= 0.16 skill_s= 0.98 skill_b= 0.46
NO23 mg/l
LE3.6 RMSE_s= 0.0 RESE_b= 0.0 skill_s= -1.04 skill_b= 0.19
PO4 mg/l
LE3.6 RMSE_s= 0.09 RESE_b= 0.55 skill_s= 0.99 skill_b= 0.67
POC mg/l
LE3.6 RMSE_s= 0.15 RESE_b= 1.94 skill_s= 0.99 skill_b= -4.57
DOC mg/l
1991
1992
1993
1994
1995
1996

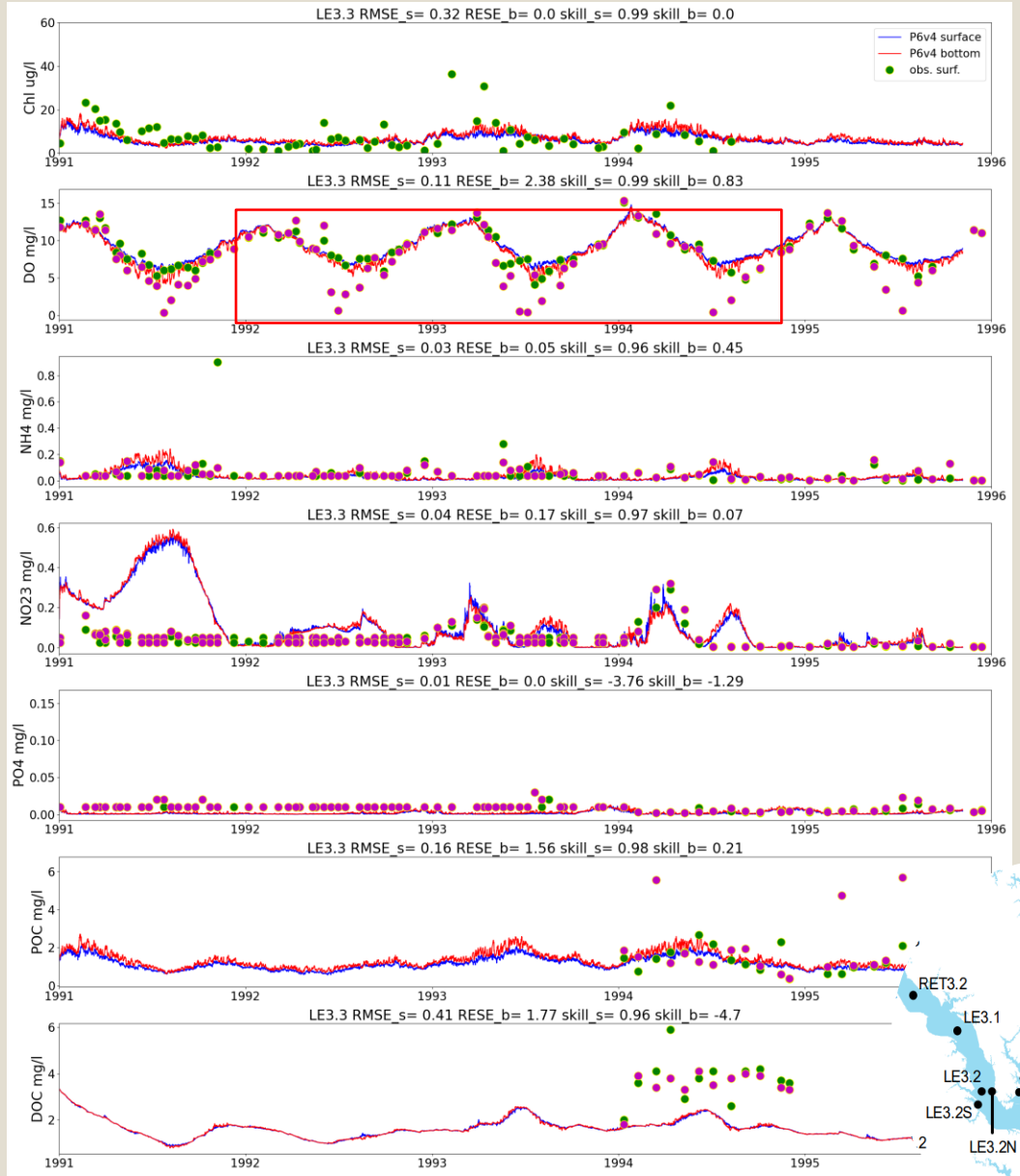
# LE3.6S

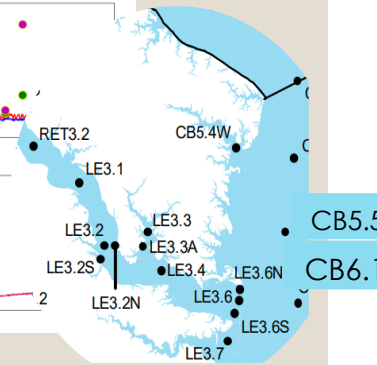

LE3.6S RMSE_s= 0.65 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
LE3.6S RMSE_s= 0.21 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
DO mg/l
LE3.6S RMSE_s= 0.04 RESE_b= 0.0 skill_s= -3.57 skill_b= 0.0
NH4 mg/l
LE3.6S RMSE_s= 0.1 RESE_b= 0.0 skill_s= 0.76 skill_b= 0.0
NO23 mg/l
LE3.6S RMSE_s= 0.02 RESE_b= 0.0 skill_s= -33.69 skill_b= 0.0
PO4 mg/l
LE3.6S RMSE_s= 0.18 RESE_b= 0.0 skill_s= 0.97 skill_b= 0.0
POC mg/l
LE3.6S RMSE_s= 0.38 RESE_b= 0.0 skill_s= 0.96 skill_b= 0.0
DOC mg/l
1991
1992
1993
1994
1995
1996

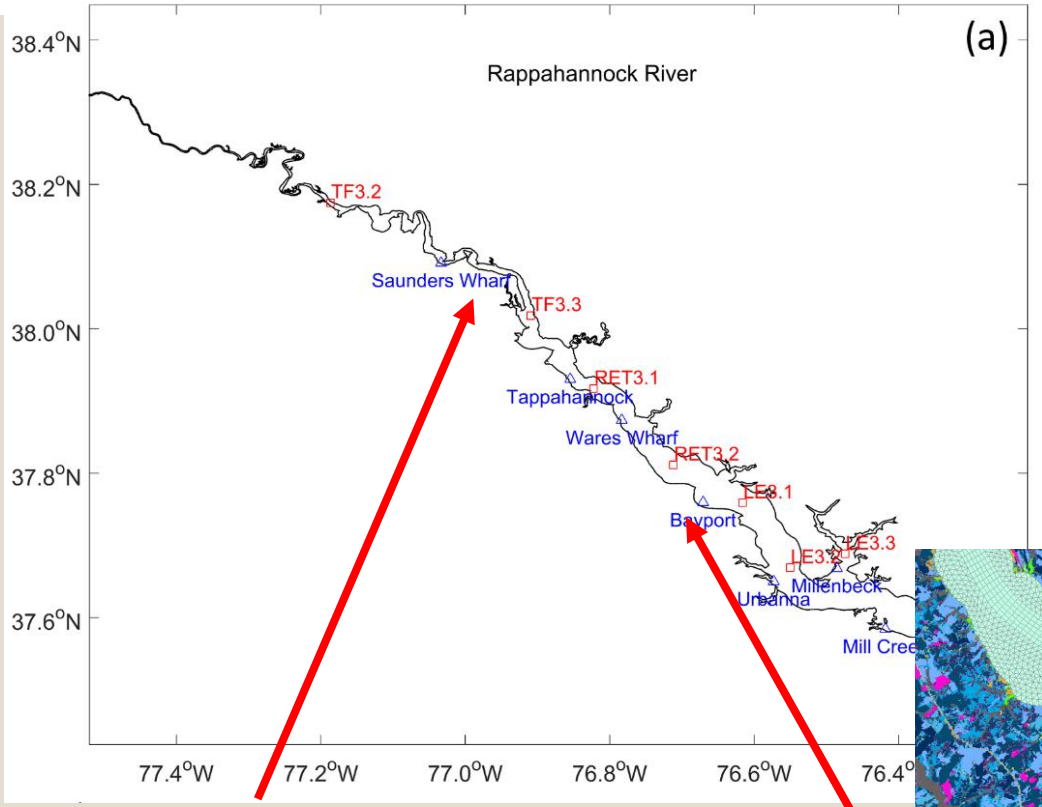
# LE3.4

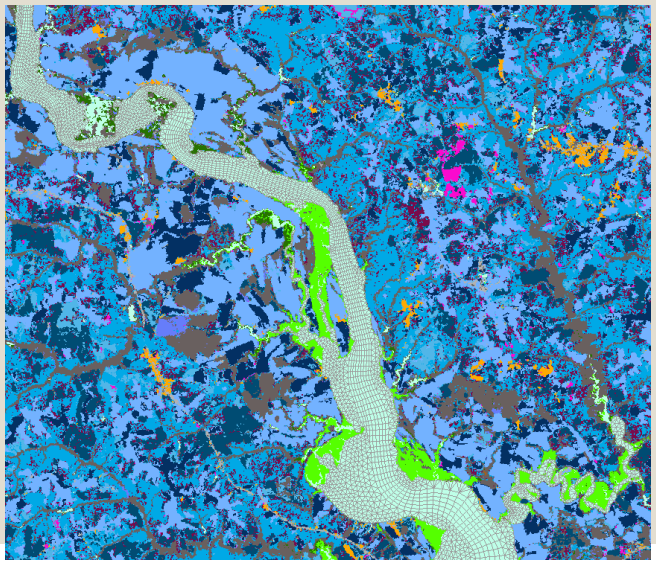

LE3.4 RMSE_s= 0.36 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
LE3.4 RMSE_s= 0.11 RESE_b= 1.8 skill_s= 0.99 skill_b= 0.92
DO mg/l
LE3.4 RMSE_s= 0.02 RESE_b= 0.11 skill_s= 0.96 skill_b= 0.58
NH4 mg/l
LE3.4 RMSE_s= 0.04 RESE_b= 0.17 skill_s= 0.98 skill_b= 0.24
NO23 mg/l
LE3.4 RMSE_s= 0.01 RESE_b= 0.01 skill_s= -1.33 skill_b= 0.13
PO4 mg/l
LE3.4 RMSE_s= 0.16 RESE_b= 0.73 skill_s= 0.98 skill_b= 0.51
POC mg/l
LE3.4 RMSE_s= 0.34 RESE_b= 1.37 skill_s= 0.93 skill_b= -1.97
DOC mg/l
1991
1992
1993
1994
1995
1996

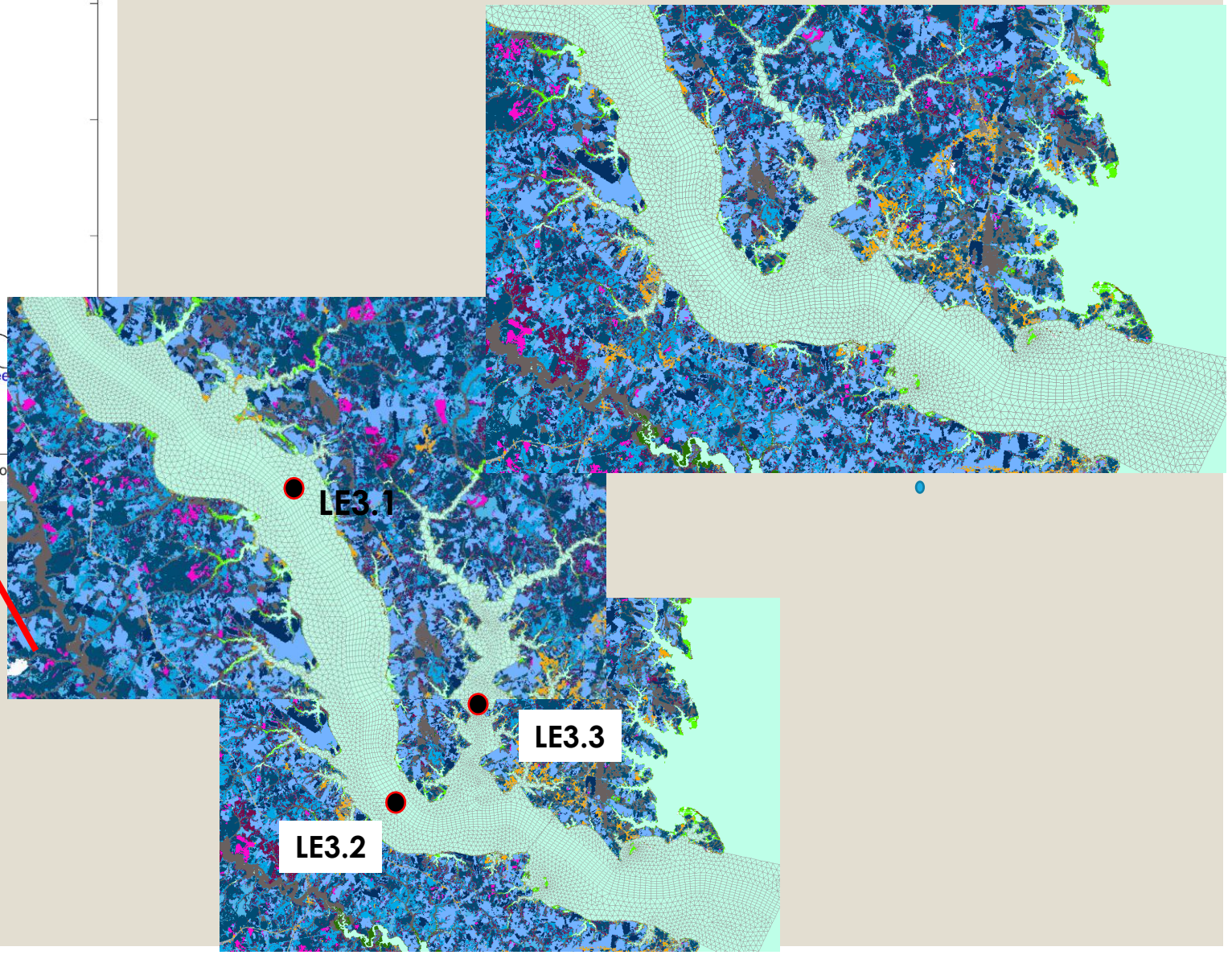
# LE3.3


LE3.3 RMSE_s= 0.32 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
LE3.3 RMSE_s= 0.11 RESE_b= 2.38 skill_s= 0.99 skill_b= 0.83
DO mg/l
LE3.3 RMSE_s= 0.03 RESE_b= 0.05 skill_s= 0.96 skill_b= 0.45
NH4 mg/l
LE3.3 RMSE_s= 0.04 RESE_b= 0.17 skill_s= 0.97 skill_b= 0.07
NO23 mg/l
LE3.3 RMSE_s= 0.01 RESE_b= 0.0 skill_s= -3.76 skill_b= -1.29
PO4 mg/l
LE3.3 RMSE_s= 0.16 RESE_b= 1.56 skill_s= 0.98 skill_b= 0.21
POC mg/l
LE3.3 RMSE_s= 0.41 RESE_b= 1.77 skill_s= 0.96 skill_b= -4.7
DOC mg/l
1991
1992
1993
1994
1995
1996

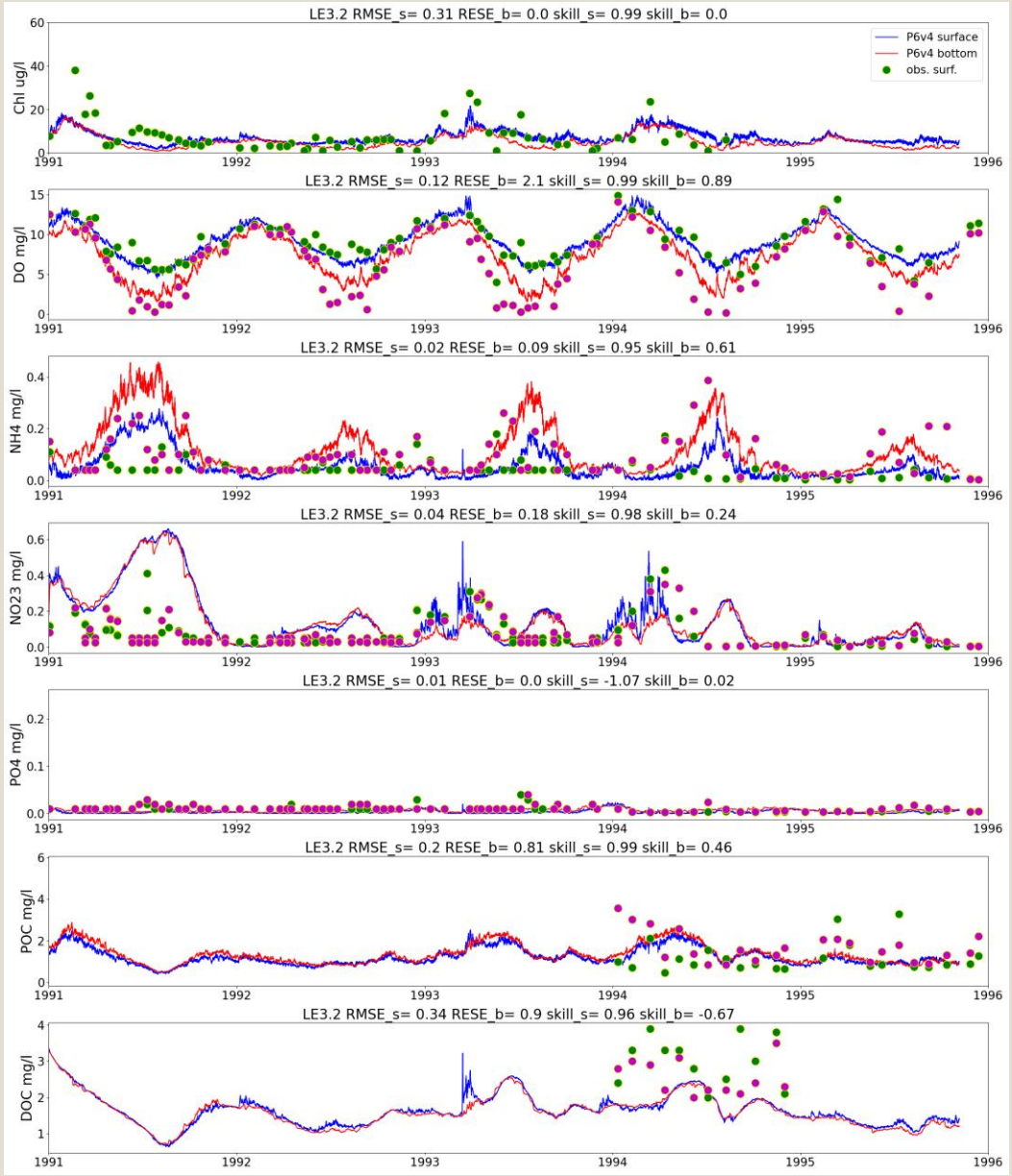

RET3.2
CB5.4W
LE3.1
LE3.3
LE3.2
LE3.3A
LE3.2S
LE3.4
LE3.6N
LE3.6
LE3.2N
LE3.6S
LE3.7
CB5.5
CB6.


(a)
Rappahannock River
38.4°N
38.2°N
38.0°N
37.8°N
37.6°N
77.4°W
77.2°W
77.0°W
76.8°W
76.6°W
TF3.2
Saunders Wharf
TF3.3
RET3.1
Tappahannock
Wares Wharf
RET3.2
LE3.1
Bayport
LE3.2
LE3.3
Millenbeck
Urbanna
Mill Cree

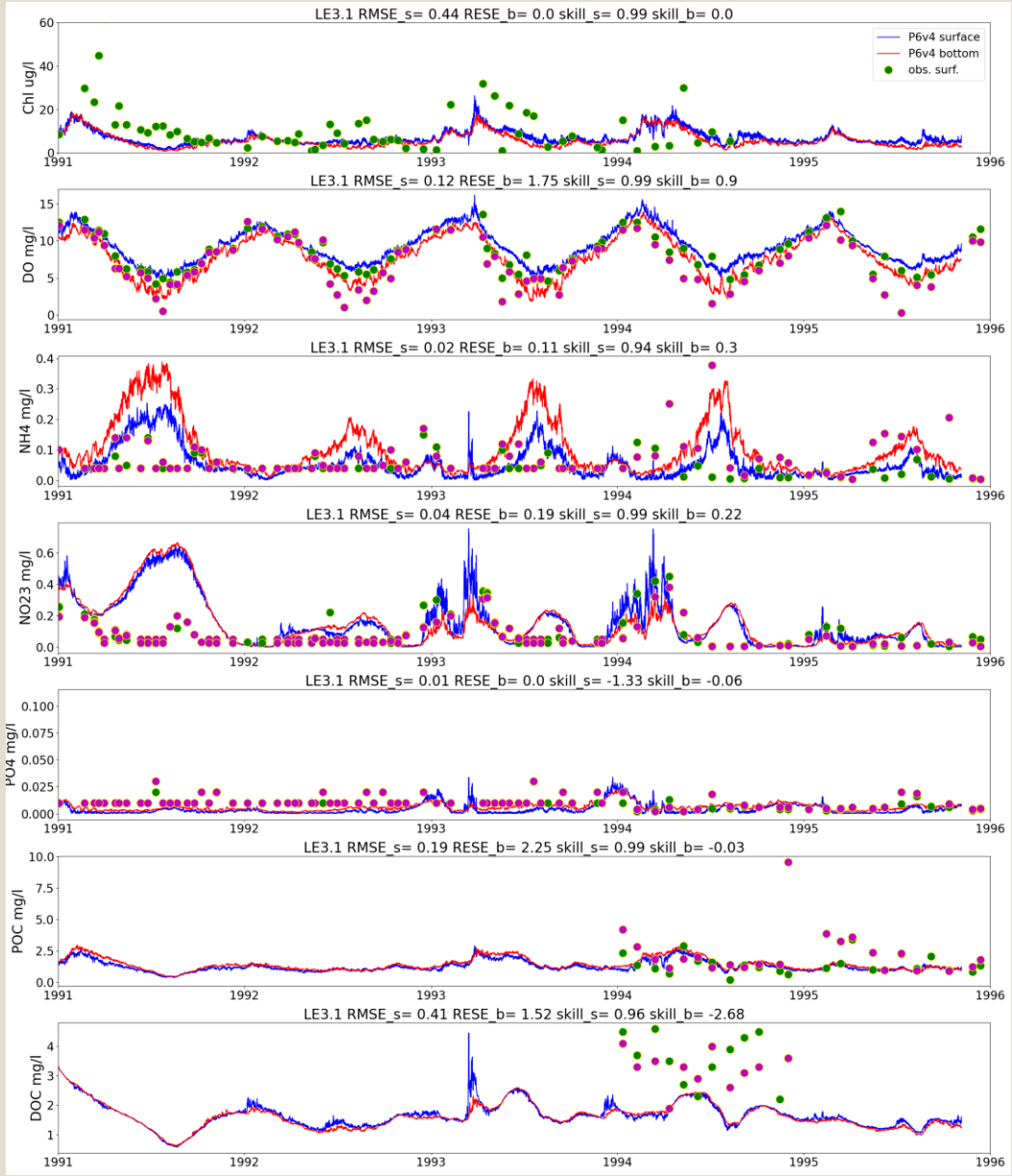



LE3.1
LE3.3
LE3.2

# LE3.2


LE3.2 RMSE_s= 0.31 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
LE3.2 RMSE_s= 0.12 RESE_b= 2.1 skill_s= 0.99 skill_b= 0.89
DO mg/l
LE3.2 RMSE_s= 0.02 RESE_b= 0.09 skill_s= 0.95 skill_b= 0.61
NH4 mg/l
LE3.2 RMSE_s= 0.04 RESE_b= 0.18 skill_s= 0.98 skill_b= 0.24
NO23 mg/l
LE3.2 RMSE_s= 0.01 RESE_b= 0.0 skill_s= -1.07 skill_b= 0.02
PO4 mg/l
LE3.2 RMSE_s= 0.2 RESE_b= 0.81 skill_s= 0.99 skill_b= 0.46
POC mg/l
LE3.2 RMSE_s= 0.34 RESE_b= 0.9 skill_s= 0.96 skill_b= -0.67
DOC mg/l
1991
1992
1993
1994
1995
1996

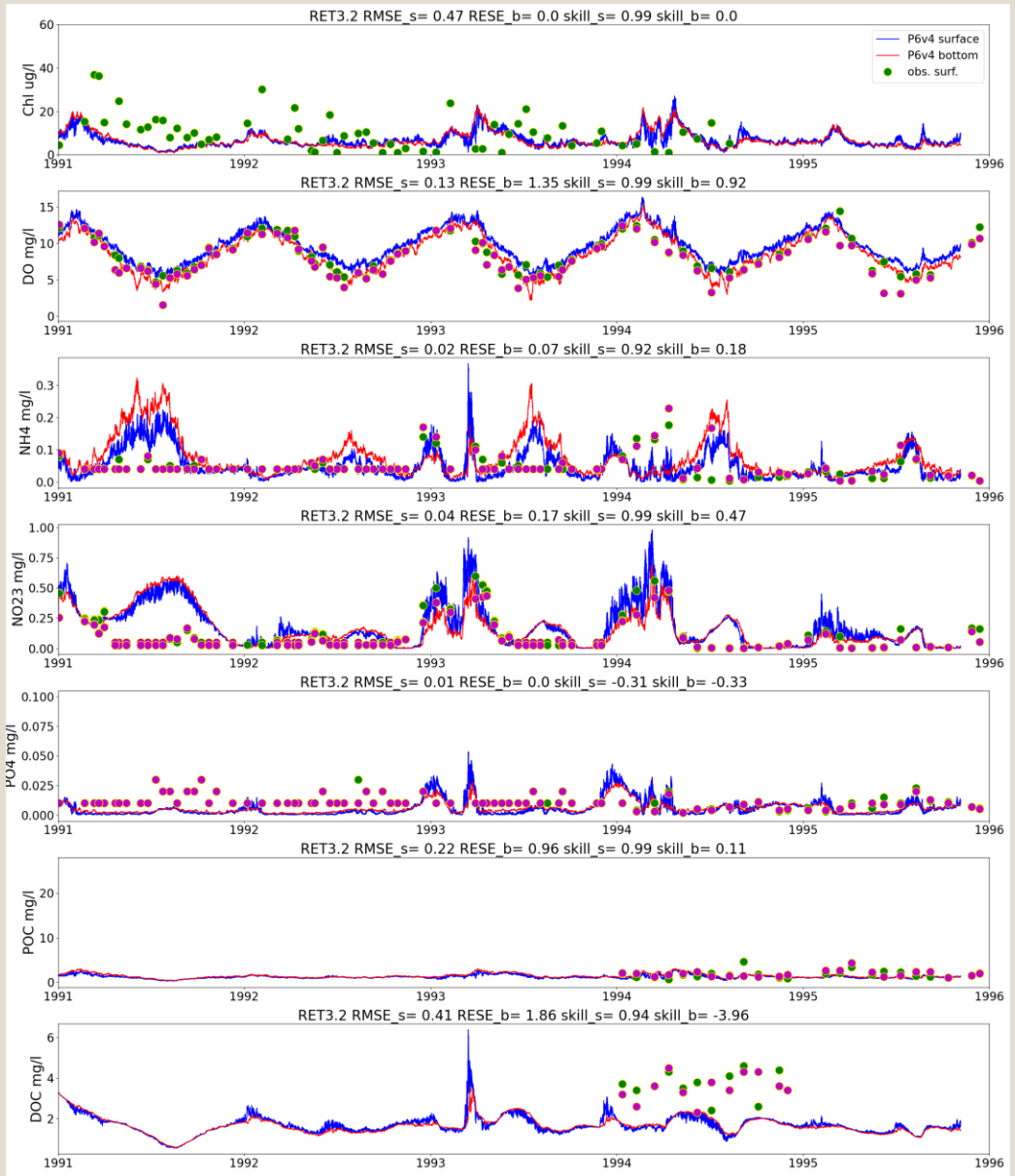
# LE3.1


LE3.1 RMSE_s= 0.44 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
LE3.1 RMSE_s= 0.12 RESE_b= 1.75 skill_s= 0.99 skill_b= 0.9
DO mg/l
LE3.1 RMSE_s= 0.02 RESE_b= 0.11 skill_s= 0.94 skill_b= 0.3
NH4 mg/l
LE3.1 RMSE_s= 0.04 RESE_b= 0.19 skill_s= 0.99 skill_b= 0.22
NO23 mg/l
LE3.1 RMSE_s= 0.01 RESE_b= 0.0 skill_s= -1.33 skill_b= -0.06
PO4 mg/l
LE3.1 RMSE_s= 0.19 RESE_b= 2.25 skill_s= 0.99 skill_b= -0.03
POC mg/l
LE3.1 RMSE_s= 0.41 RESE_b= 1.52 skill_s= 0.96 skill_b= -2.68
DOC mg/l
1991
1992
1993
1994
1995
1996

# RET3.1


RET3.1 RMSE_s= 0.56 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
RET3.1 RMSE_s= 0.13 RESE_b= 1.56 skill_s= 0.99 skill_b= 0.87
DO mg/l
RET3.1 RMSE_s= 0.02 RESE_b= 0.04 skill_s= 0.94 skill_b= 0.54
NH4 mg/l
RET3.1 RMSE_s= 0.04 RESE_b= 0.14 skill_s= 0.99 skill_b= 0.86
NO23 mg/l
RET3.1 RMSE_s= 0.01 RESE_b= 0.0 skill_s= 0.14 skill_b= 0.45
PO4 mg/l
RET3.1 RMSE_s= 0.24 RESE_b= 2.89 skill_s= 0.98 skill_b= -1.29
POC mg/l
RET3.1 RMSE_s= 0.45 RESE_b= 2.03 skill_s= 0.95 skill_b= -1.43
DOC mg/l
1991
1992
1993
1994
1995
1996

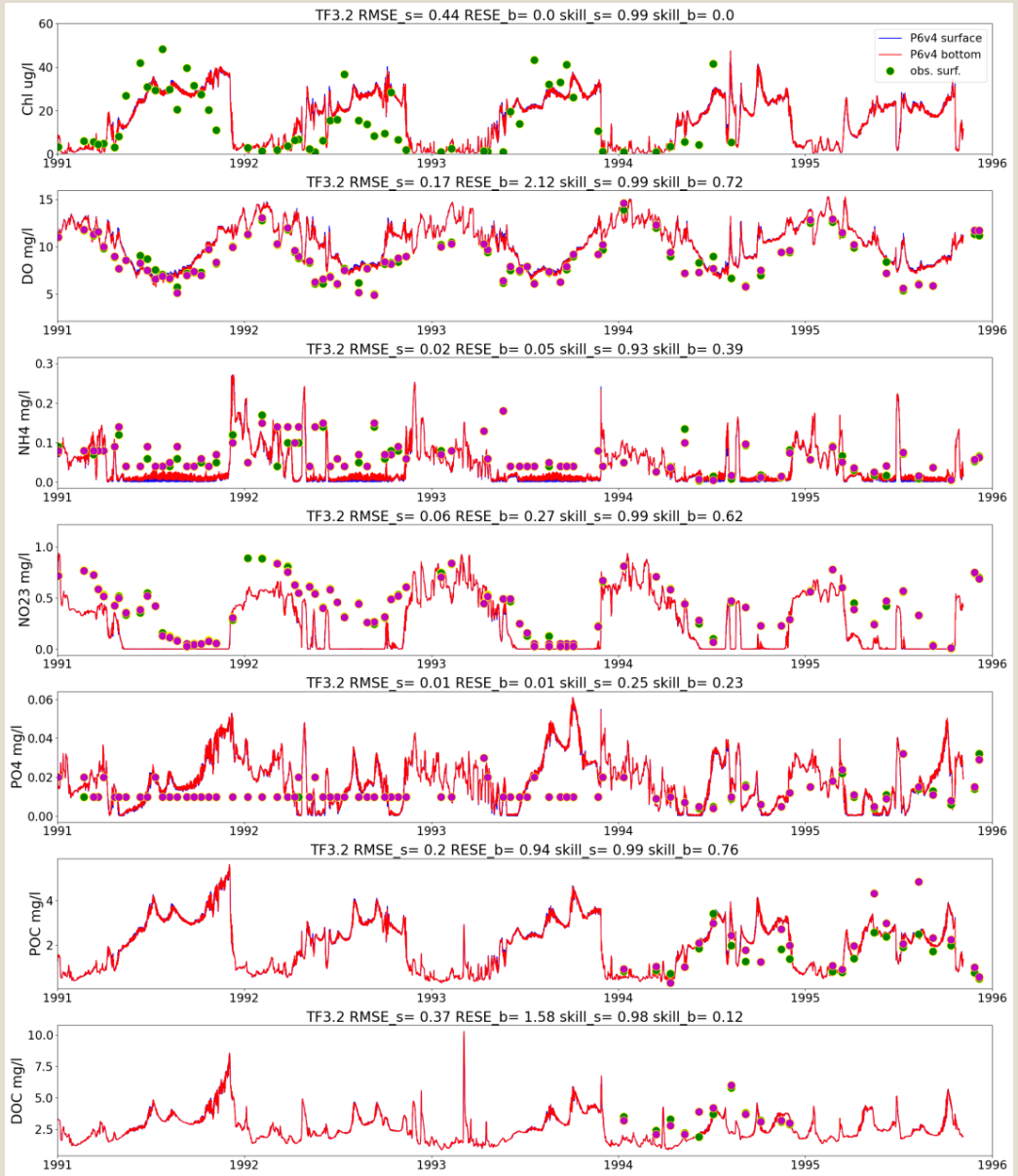
# RET3.2


RET3.2 RMSE_s= 0.47 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
RET3.2 RMSE_s= 0.13 RESE_b= 1.35 skill_s= 0.99 skill_b= 0.92
DO mg/l
RET3.2 RMSE_s= 0.02 RESE_b= 0.07 skill_s= 0.92 skill_b= 0.18
NH4 mg/l
RET3.2 RMSE_s= 0.04 RESE_b= 0.17 skill_s= 0.99 skill_b= 0.47
NO23 mg/l
RET3.2 RMSE_s= 0.01 RESE_b= 0.0 skill_s= -0.31 skill_b= -0.33
PO4 mg/l
RET3.2 RMSE_s= 0.22 RESE_b= 0.96 skill_s= 0.99 skill_b= 0.11
POC mg/l
RET3.2 RMSE_s= 0.41 RESE_b= 1.86 skill_s= 0.94 skill_b= -3.96
DOC mg/l
1991
1992
1993
1994
1995
1996

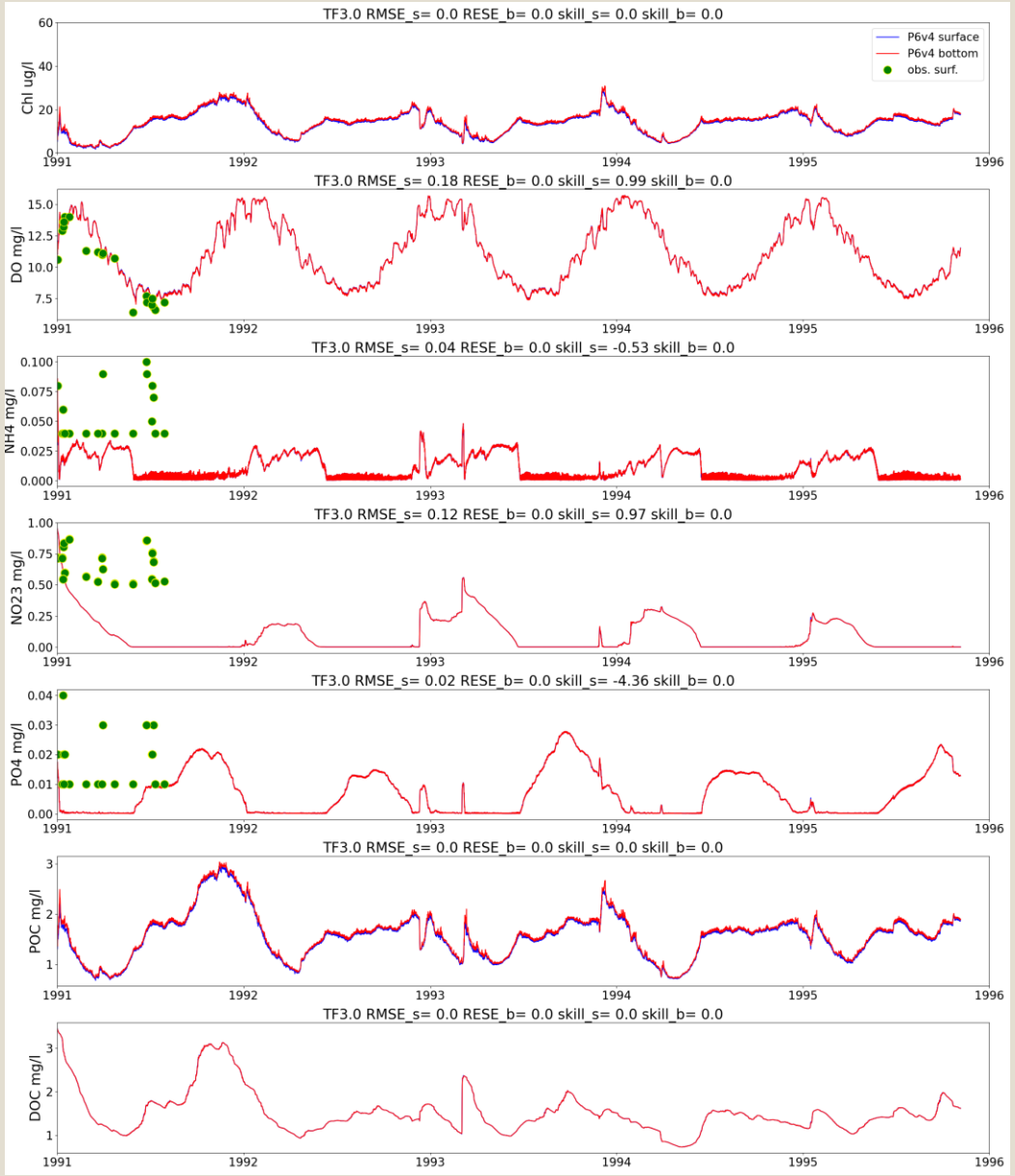
# TF3.3


TF3.3 RMSE_s= 0.37 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
TF3.3 RMSE_s= 0.14 RESE_b= 1.58 skill_s= 0.99 skill_b= 0.87
DO mg/l
TF3.3 RMSE_s= 0.02 RESE_b= 0.05 skill_s= 0.94 skill_b= 0.47
NH4 mg/l
TF3.3 RMSE_s= 0.05 RESE_b= 0.21 skill_s= 0.99 skill_b= 0.77
NO23 mg/l
TF3.3 RMSE_s= 0.01 RESE_b= 0.01 skill_s= -0.01 skill_b= 0.29
PO4 mg/l
TF3.3 RMSE_s= 0.18 RESE_b= 1.89 skill_s= 0.99 skill_b= 0.01
POC mg/l
TF3.3 RMSE_s= 0.41 RESE_b= 2.28 skill_s= 0.97 skill_b= -3.21
DOC mg/l
1991
1992
1993
1994
1995
1996

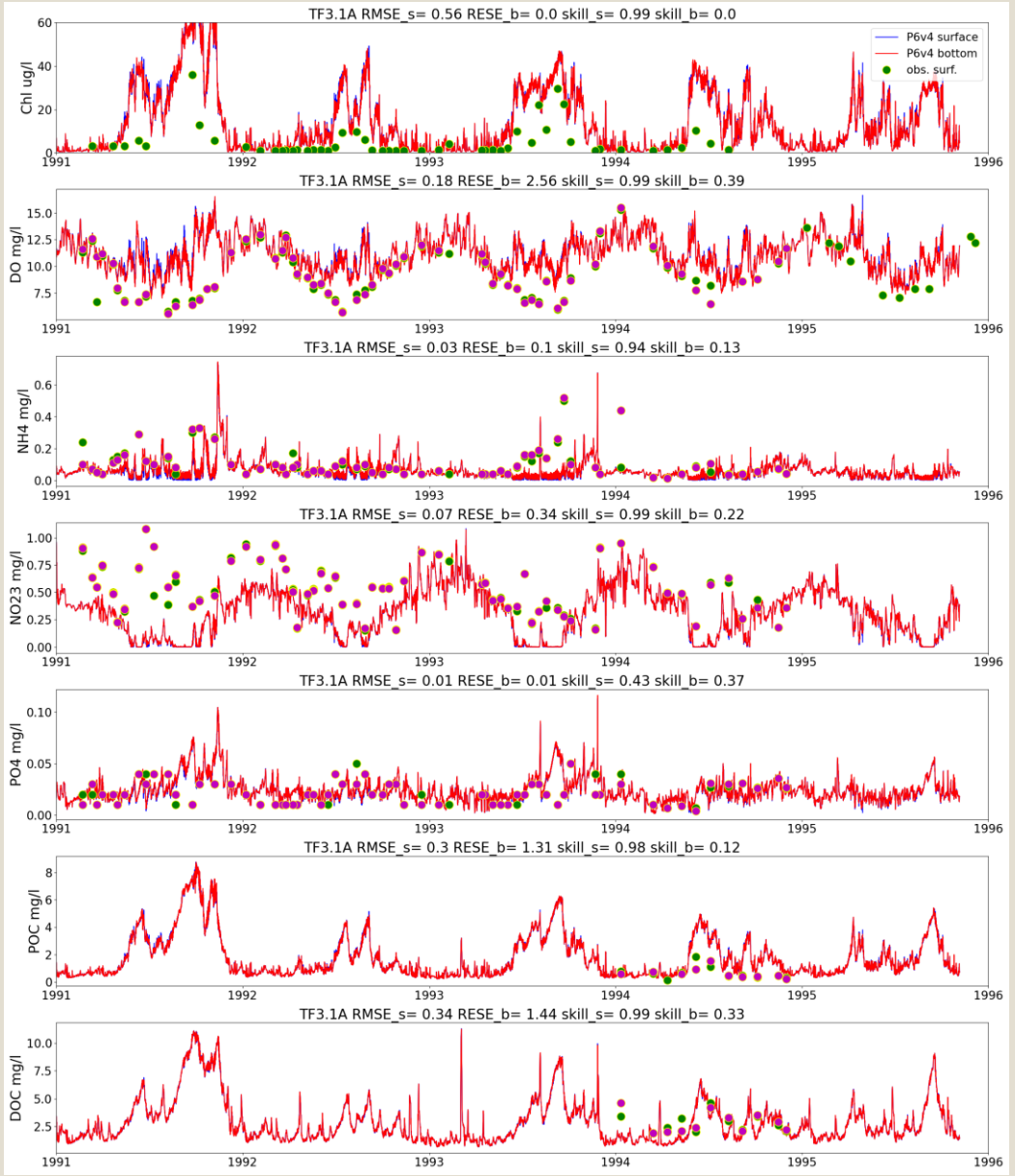
# TF3.2


TF3.2 RMSE_s= 0.44 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
TF3.2 RMSE_s= 0.17 RESE_b= 2.12 skill_s= 0.99 skill_b= 0.72
DO mg/l
TF3.2 RMSE_s= 0.02 RESE_b= 0.05 skill_s= 0.93 skill_b= 0.39
NH4 mg/l
TF3.2 RMSE_s= 0.06 RESE_b= 0.27 skill_s= 0.99 skill_b= 0.62
NO23 mg/l
TF3.2 RMSE_s= 0.01 RESE_b= 0.01 skill_s= 0.25 skill_b= 0.23
PO4 mg/l
TF3.2 RMSE_s= 0.2 RESE_b= 0.94 skill_s= 0.99 skill_b= 0.76
POC mg/l
TF3.2 RMSE_s= 0.37 RESE_b= 1.58 skill_s= 0.98 skill_b= 0.12
DOC mg/l
1991
1992
1993
1994
1995
1996

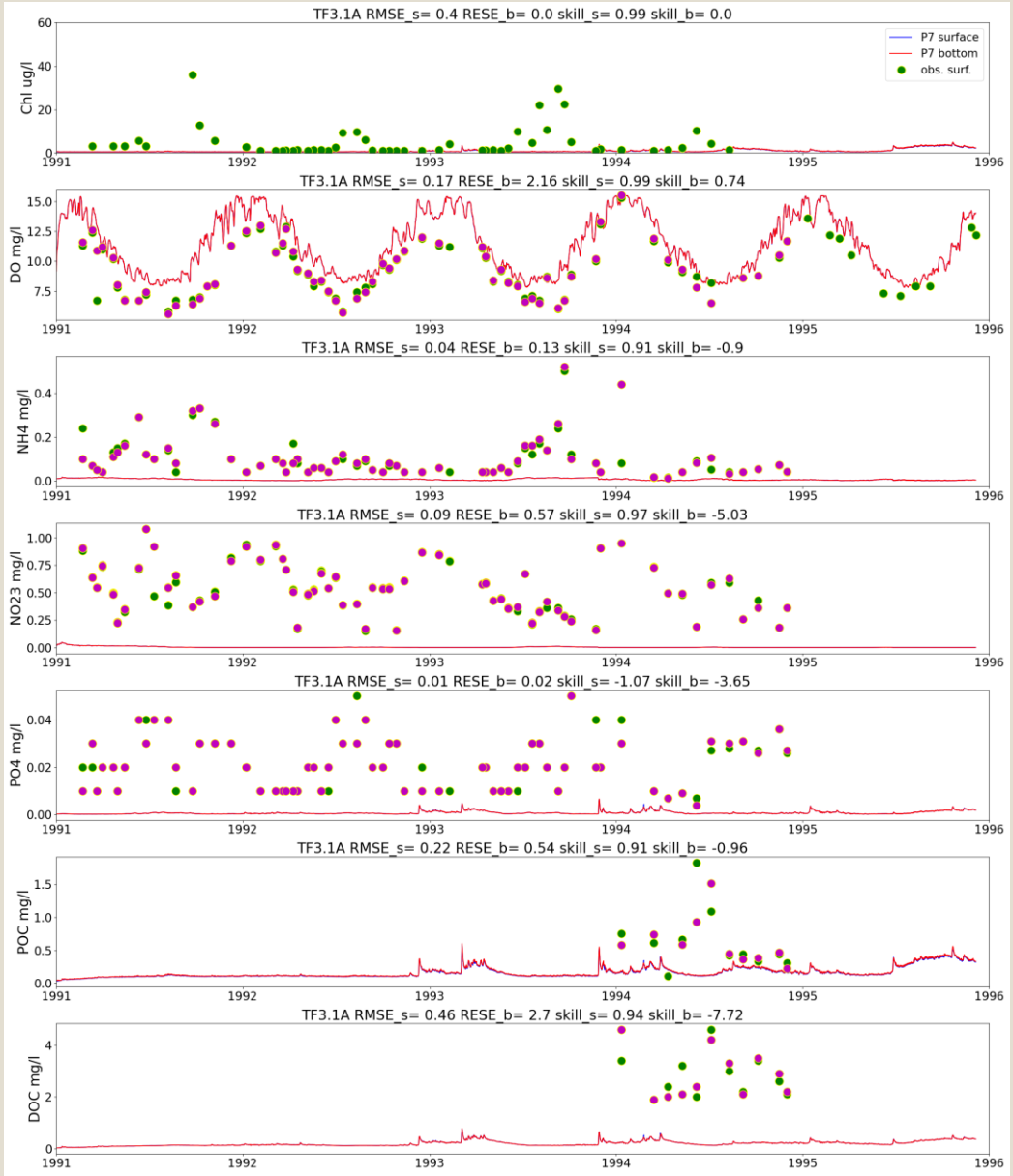
# TF3.0


TF3.0 RMSE_s= 0.0 RESE_b= 0.0 skill_s= 0.0 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
TF3.0 RMSE_s= 0.18 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
DO mg/l
TF3.0 RMSE_s= 0.04 RESE_b= 0.0 skill_s= -0.53 skill_b= 0.0
NH4 mg/l
TF3.0 RMSE_s= 0.12 RESE_b= 0.0 skill_s= 0.97 skill_b= 0.0
NO23 mg/l
TF3.0 RMSE_s= 0.02 RESE_b= 0.0 skill_s= -4.36 skill_b= 0.0
PO4 mg/l
TF3.0 RMSE_s= 0.0 RESE_b= 0.0 skill_s= 0.0 skill_b= 0.0
POC mg/l
TF3.0 RMSE_s= 0.0 RESE_b= 0.0 skill_s= 0.0 skill_b= 0.0
DOC mg/l
1991
1992
1993
1994
1995
1996

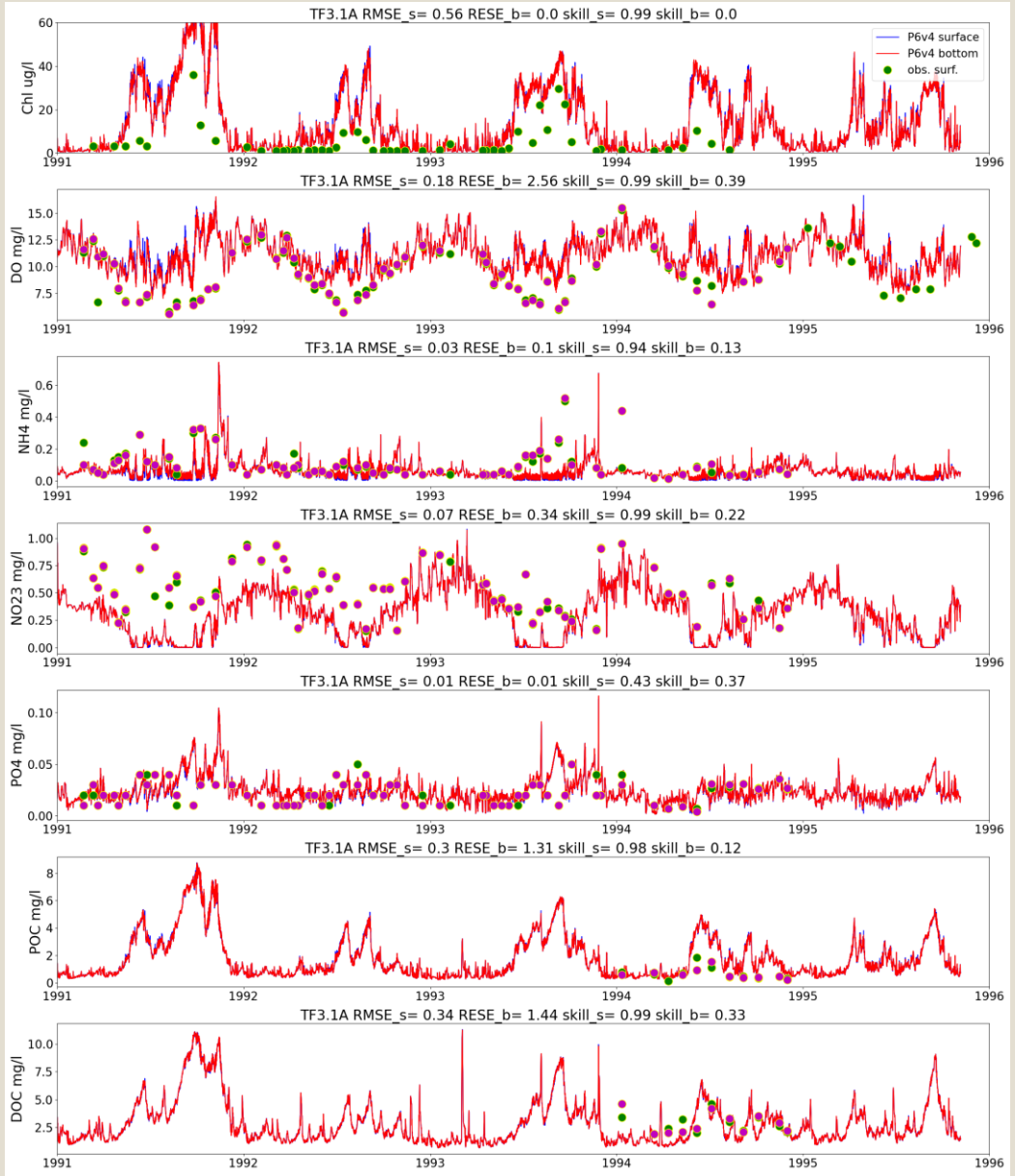
# TF3.1A


TF3.1A RMSE_s= 0.56 RESE_b= 0.0 skill_s= 0.99 skill_b= 0.0
P6v4 surface
P6v4 bottom
obs. surf.
Chl ug/l
TF3.1A RMSE_s= 0.18 RESE_b= 2.56 skill_s= 0.99 skill_b= 0.39
DO mg/l
TF3.1A RMSE_s= 0.03 RESE_b= 0.1 skill_s= 0.94 skill_b= 0.13
NH4 mg/l
TF3.1A RMSE_s= 0.07 RESE_b= 0.34 skill_s= 0.99 skill_b= 0.22
NO23 mg/l
TF3.1A RMSE_s= 0.01 RESE_b= 0.01 skill_s= 0.43 skill_b= 0.37
PO4 mg/l
TF3.1A RMSE_s= 0.3 RESE_b= 1.31 skill_s= 0.98 skill_b= 0.12
POC mg/l
TF3.1A RMSE_s= 0.34 RESE_b= 1.44 skill_s= 0.99 skill_b= 0.33
DOC mg/l
1991
1992
1993
1994
1995
1996

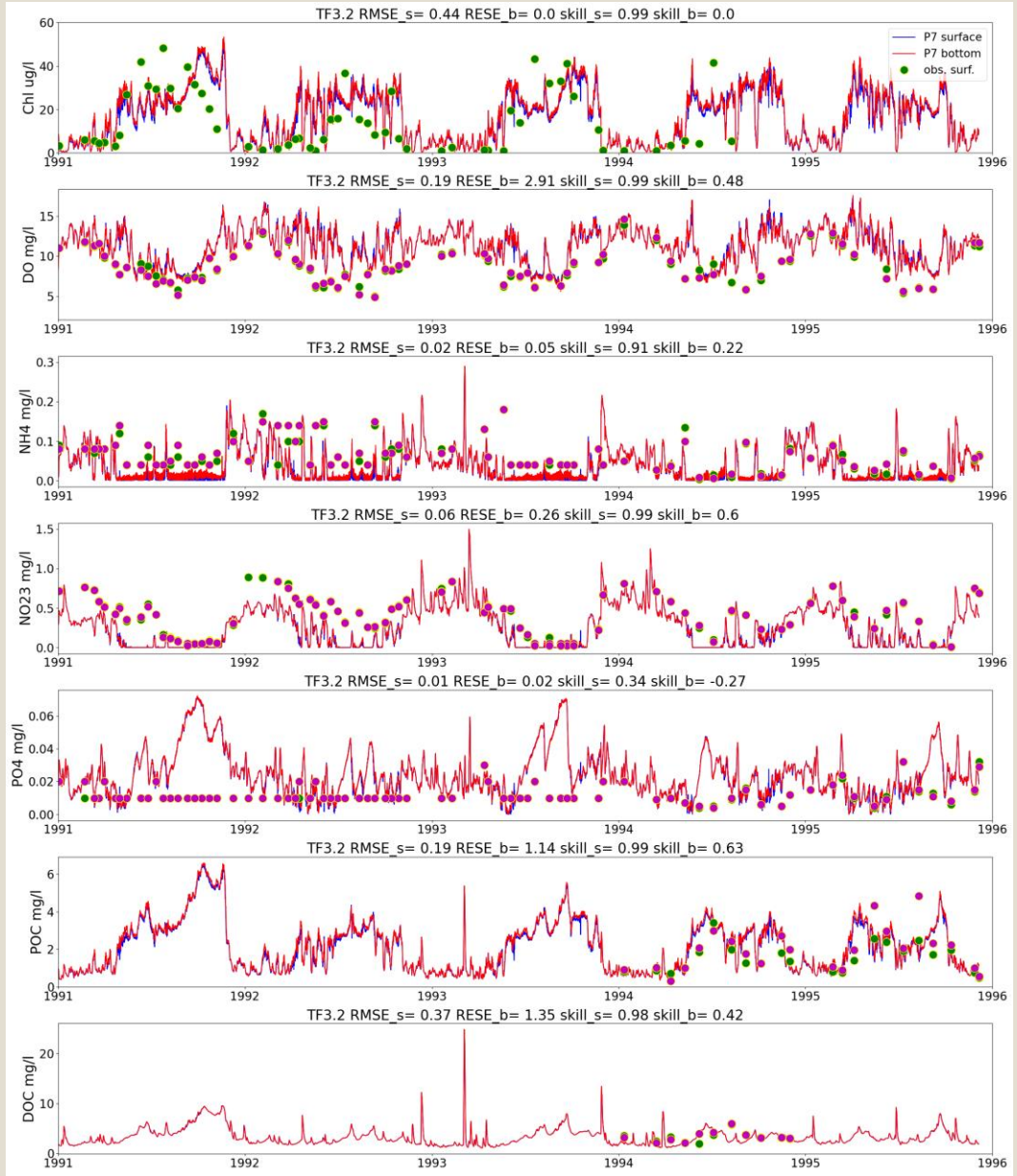
# Bay Model TF3.1A



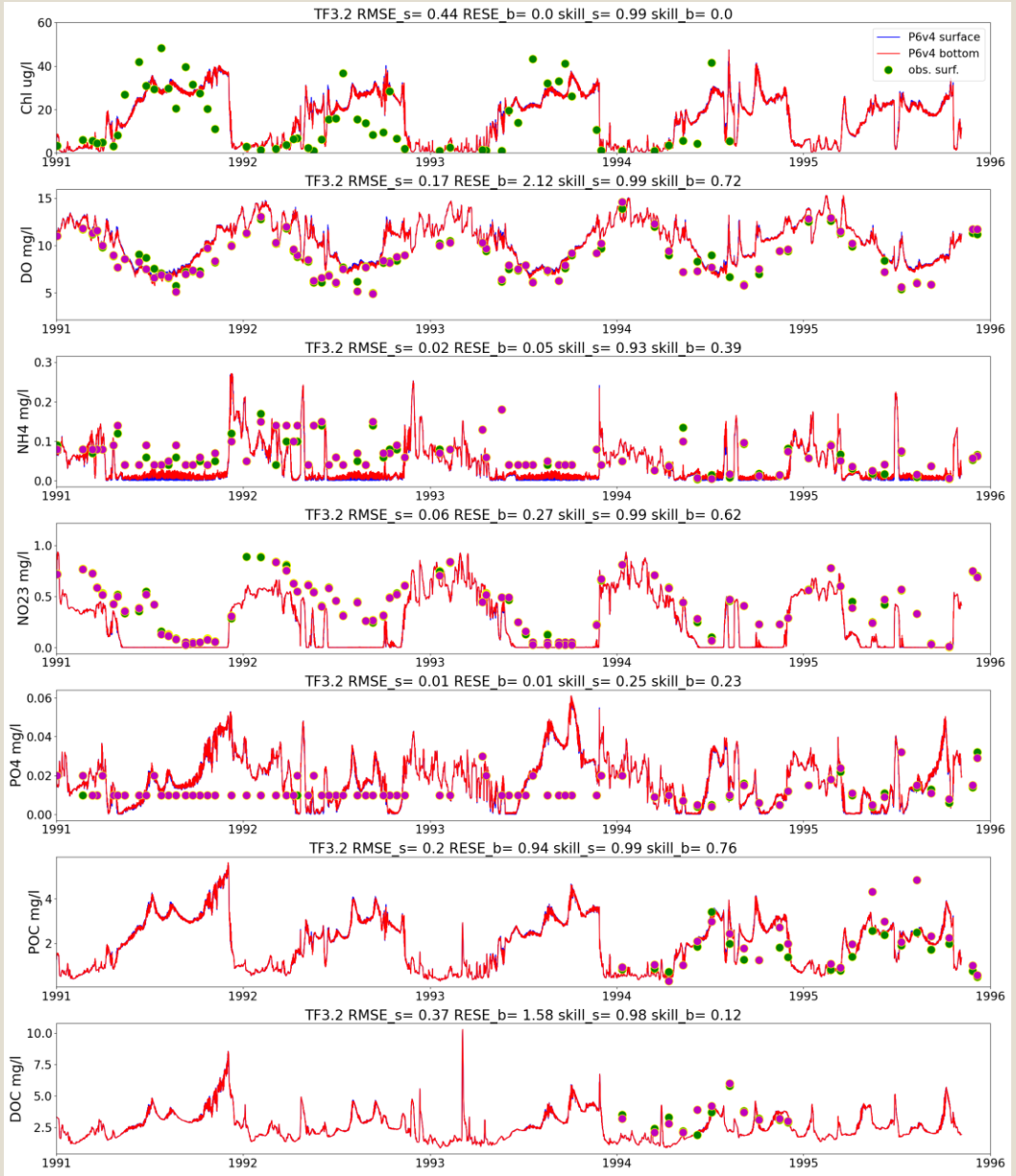

# Rapp.-Bay Model TF3.1A



# Bay Model TF3.2

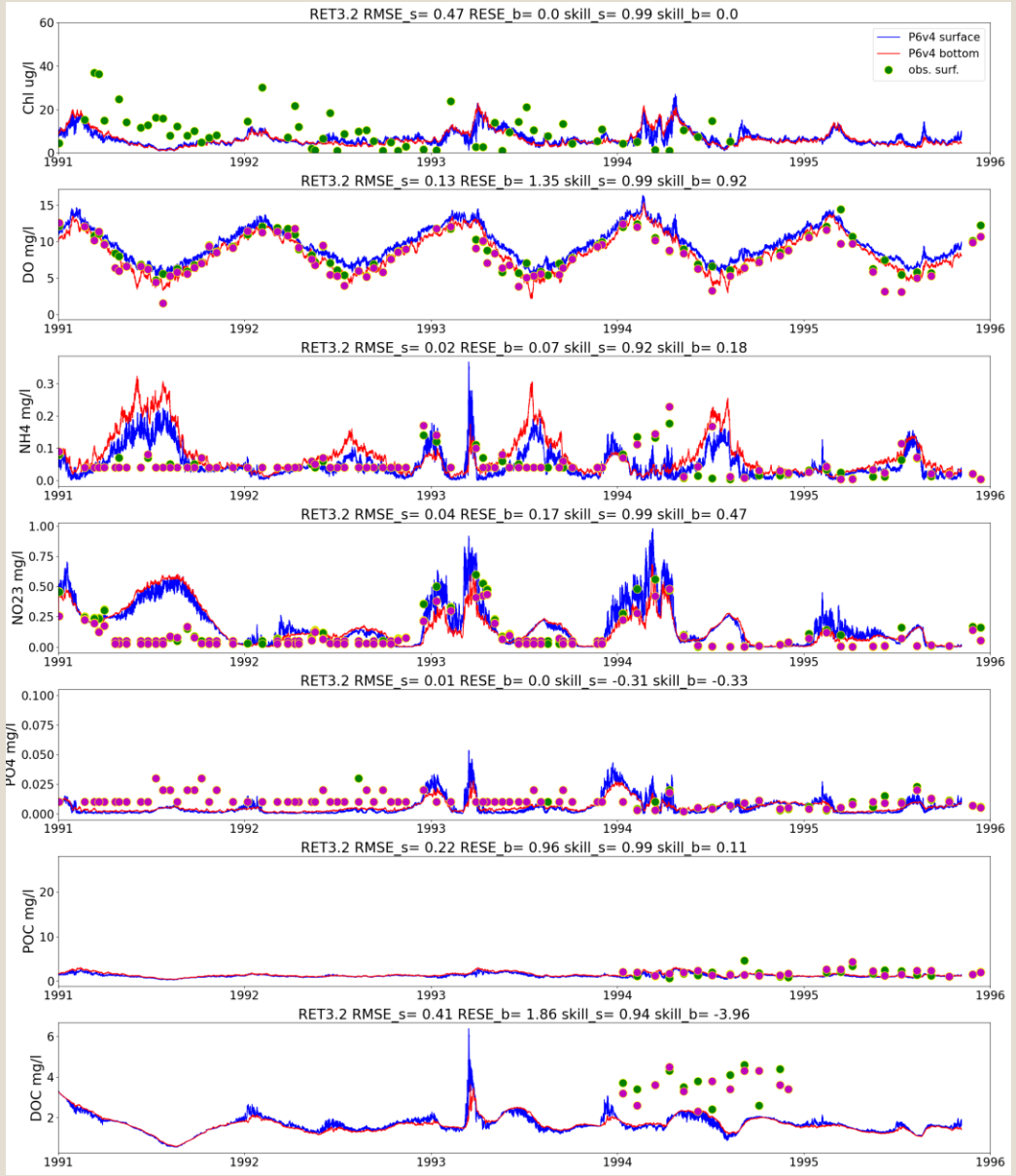



# Rapp.-Bay Model TF3.2



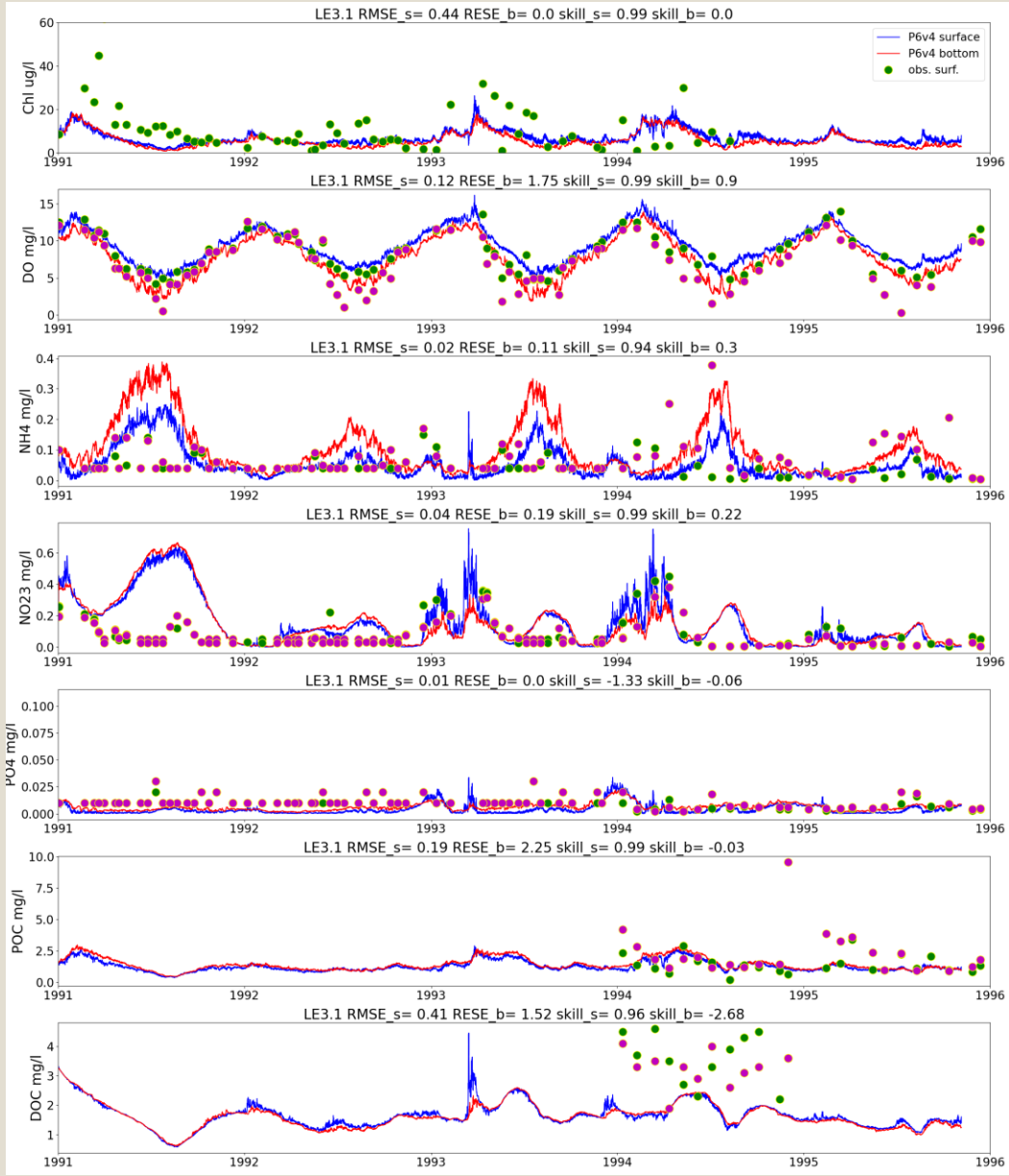
# Bay Model RET3.2


# Rapp.-Bay Model RET3.2



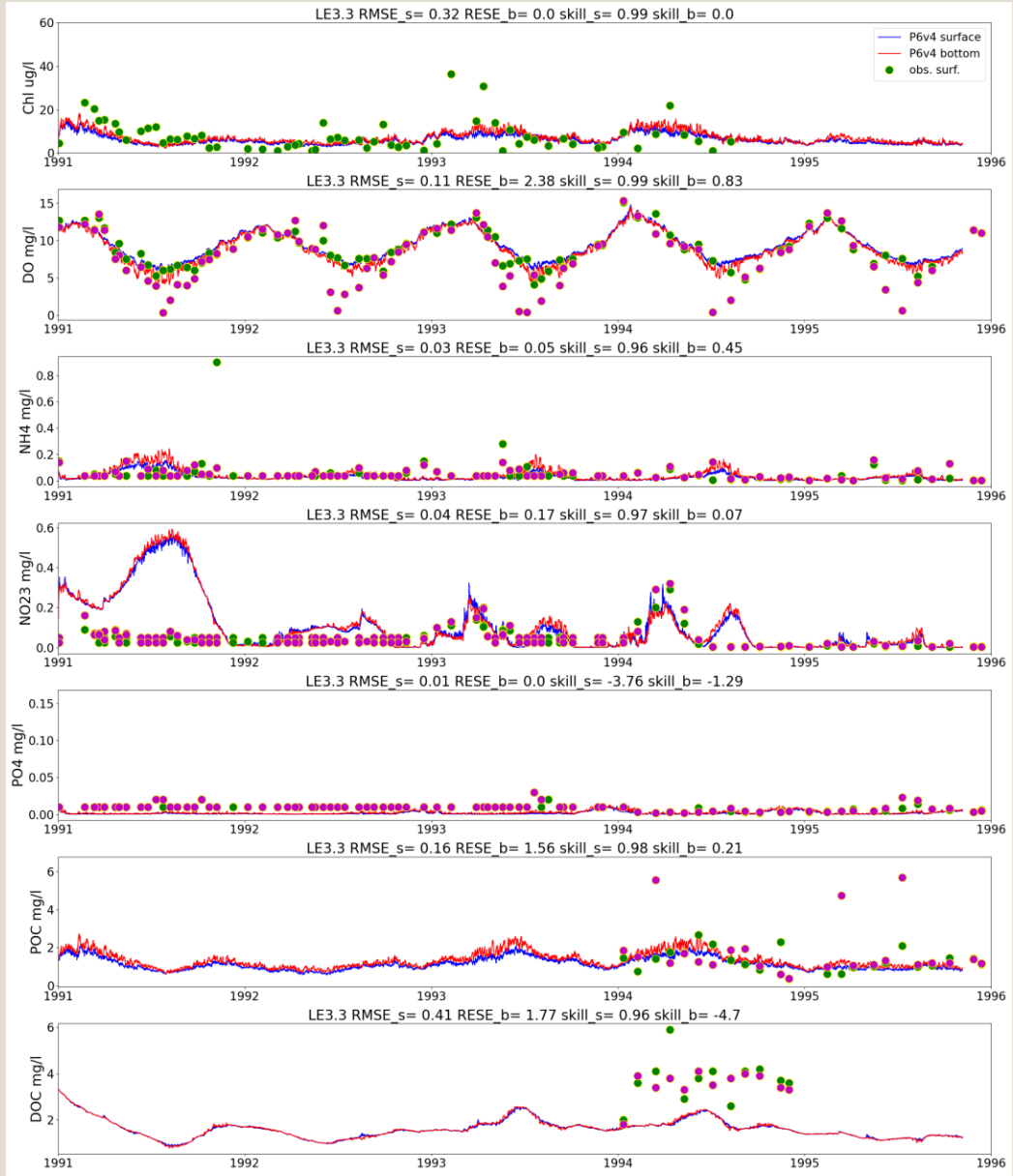
# Bay Model LE3.1


# Rapp.-Bay Model LE3.1

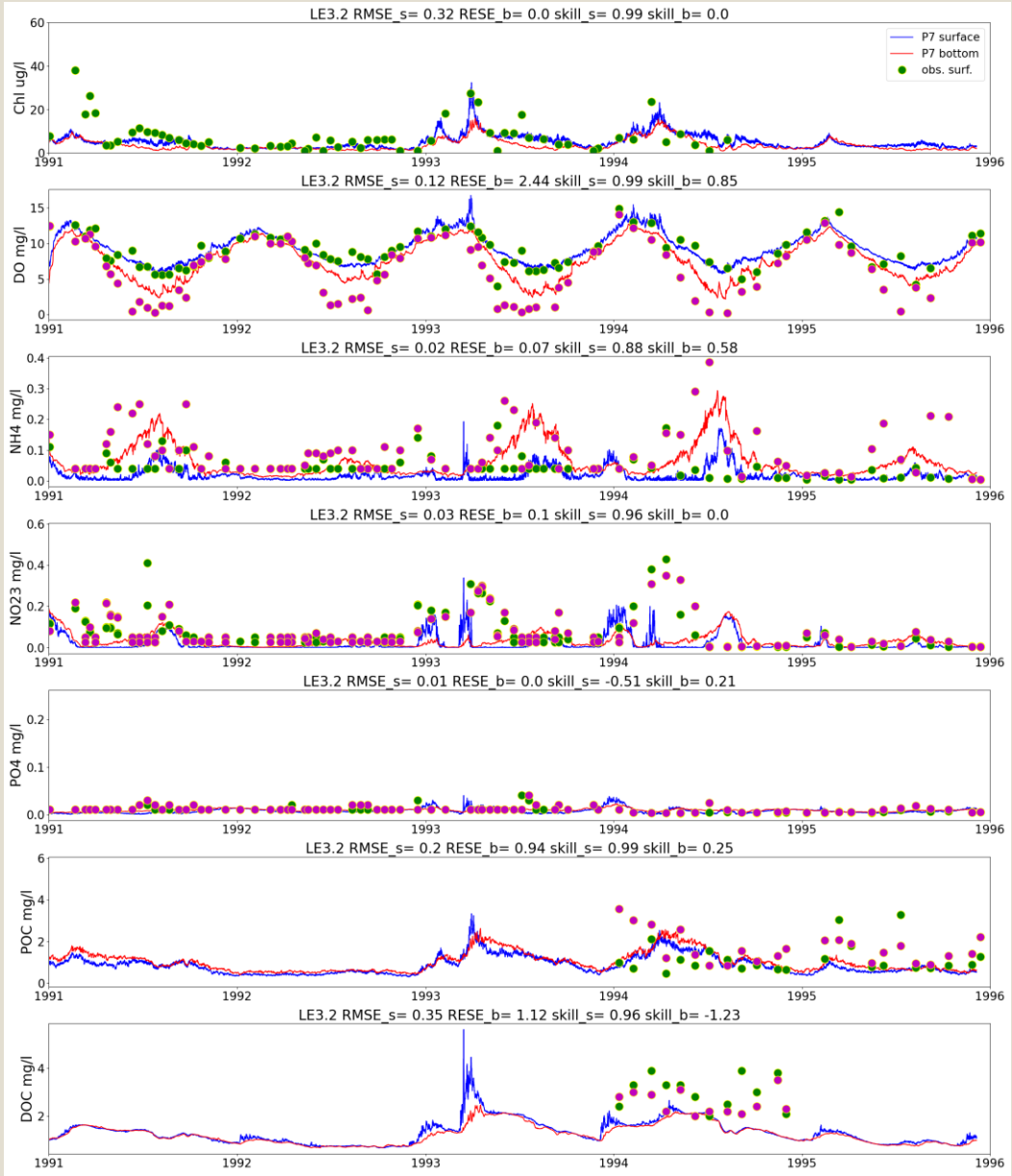


# Bay Model LE3.3

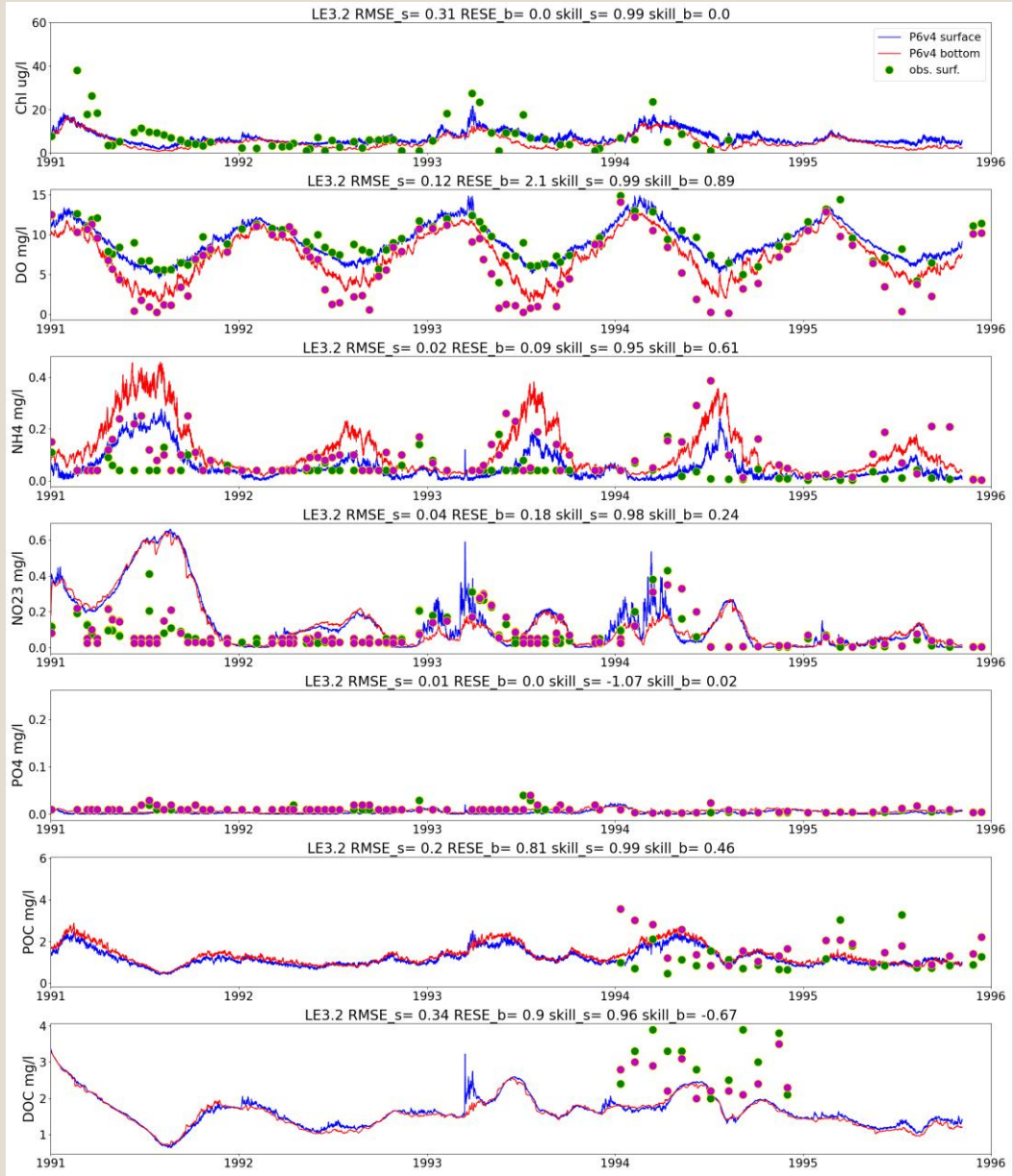

# Rapp.-Bay Model LE3.3



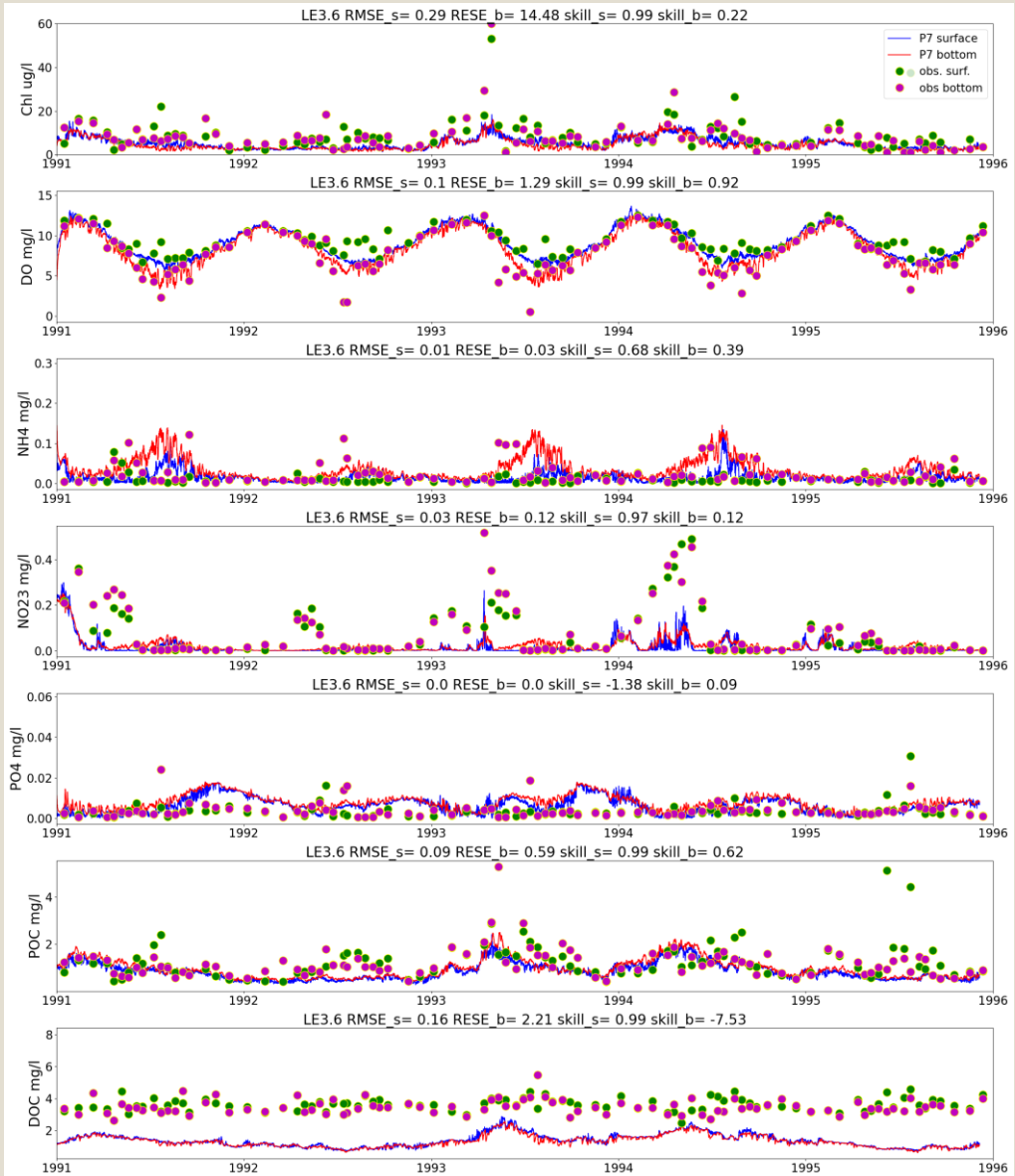
# Bay Model LE3.2



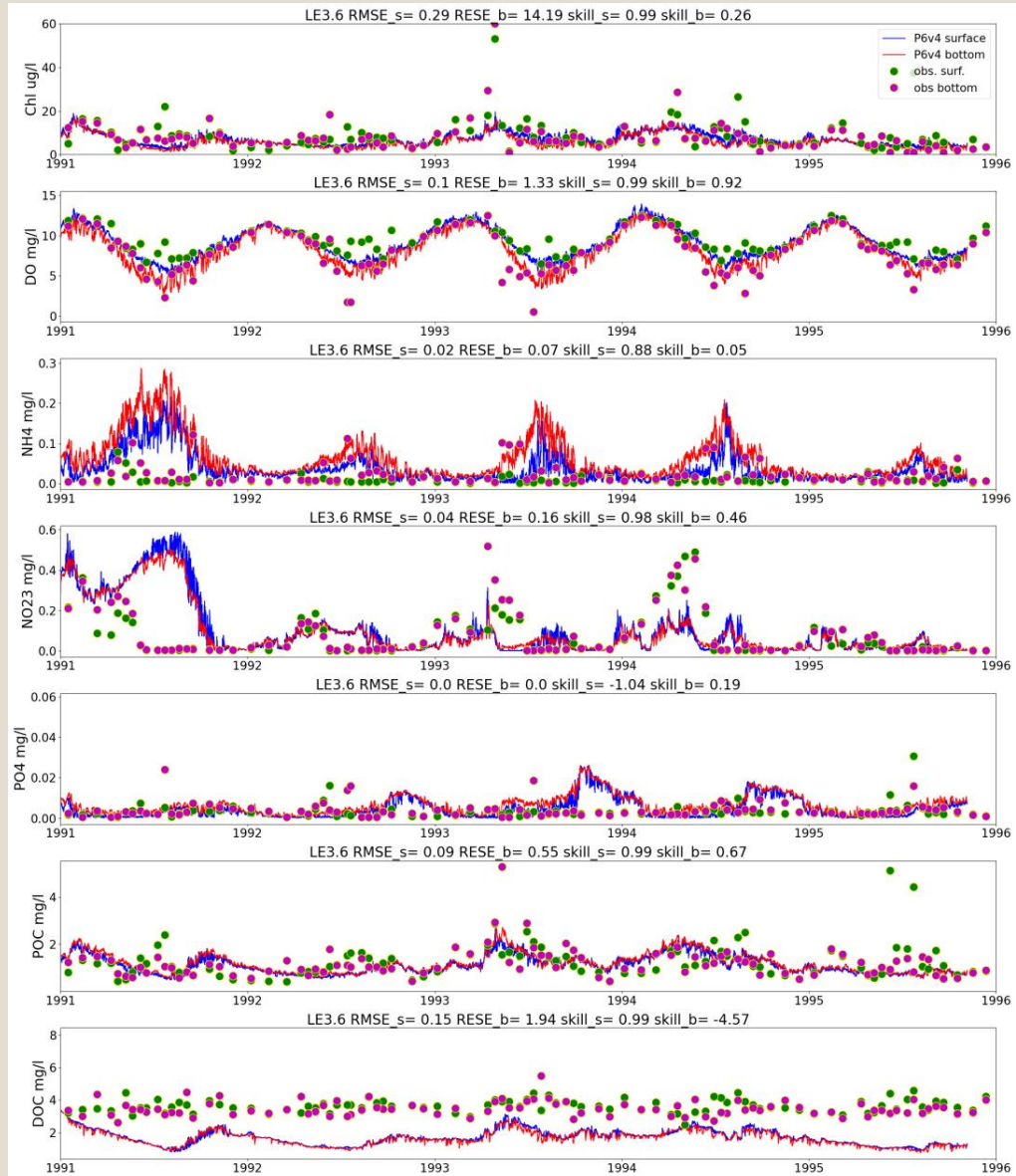

# Rapp.-Bay Model LE3.2



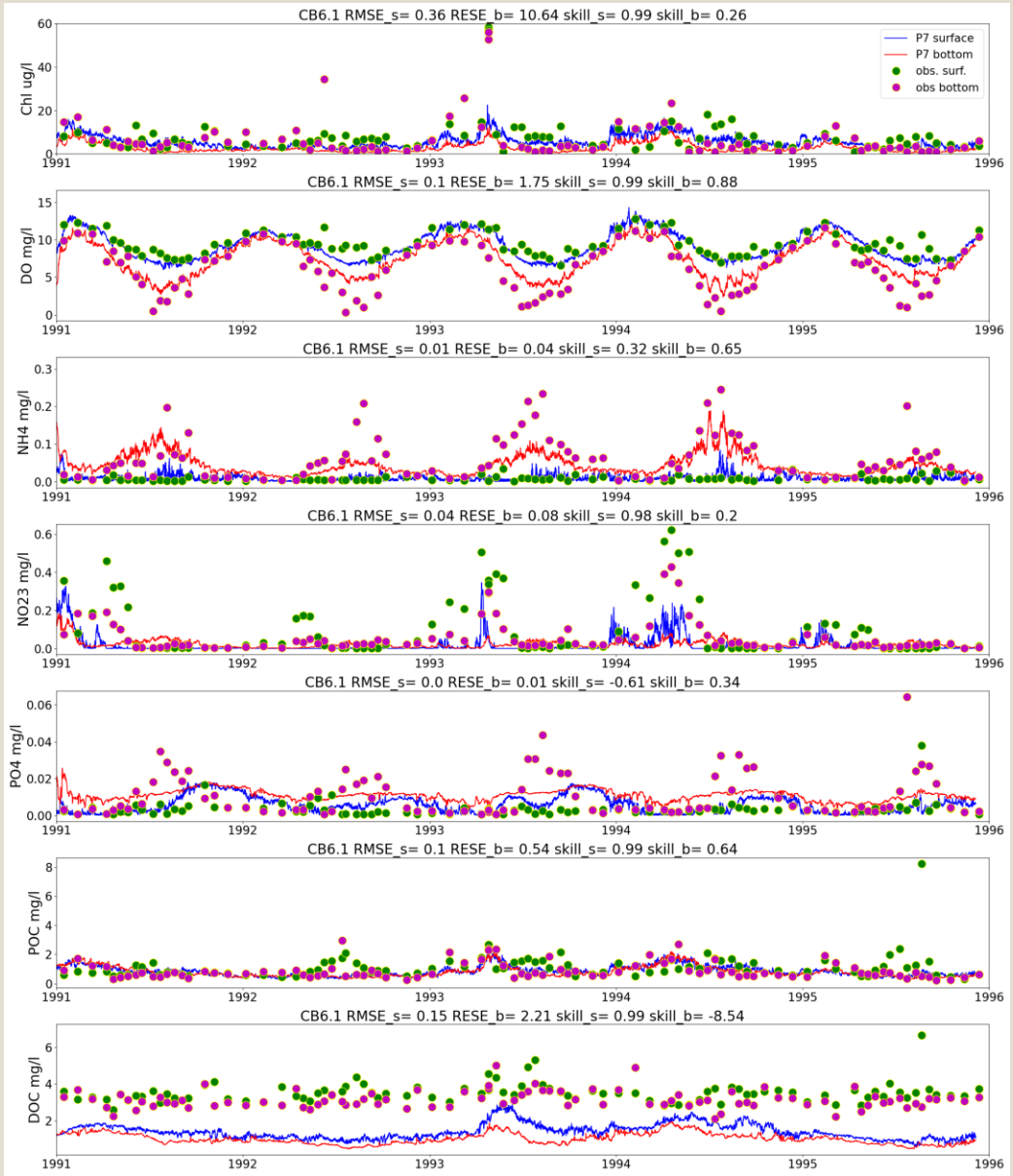
# Bay Model LE3.6




# Rapp.-Bay Model LE3.6



# Bay Model CB6.1




# Rapp.-Bay Model CB6.1

# Conclusions

- Integrating the high-resolution grid of Rappahannock River model into the main Bay model works well
- The combined model works better in salinity simulation in the tributary
- The water quality model is working
- The preliminary water quality model calibration is better than main Bay model results inside the Rappahannock River
- Next Phase:
  - test Phase 7 loading
  - transfer new Main Bay Model to the Rappahannock River and work on model calibration