Preliminary Water Quality Results from Phase 7 Main Bay Model

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Outline

- ★ **Overview of the current Main-Bay Model (MBM) progress**
- ★ **Overview on the MBM Set-Up**
  - The MBM workflow has been well tested, which supports fast and efficient pre-processing, model setup, model submission, and post-processing (all python based).
- ★ **Preliminary Water Quality results of MBM**
  - We have conducted the 1st-round model calibration for both the hydrodynamic and water quality simulations during the past year, and fixed various issues along the way
  - The preliminary water quality result shows that the model results seem reasonable in general, but several details need to be improved.

MBM Progress: Issues resolved during Model Calibration

1. **Offline transport approach for ICM simulation**
   - The offline mode now can reasonably reproduce the tracer distribution and stratification as the online mode.
   - Caveats: **max_subcyc ≥ 30**, **hydro output interval ≤ 30 mins**

2. **Better Salinity Stratification**
   - Earlier MBM underestimated stratification with hybrid wind forcing (NARR and observed wind & gust).
   - Experiments showed that using NARR wind improved the lower Bay stratification, and mostly importantly, avoided its complete destruction during events.

Focus of this talk

3. **Lower Bay DO/DOC Issue**
   - As ocean boundary is located far from Bay entrance, MBM underestimated DOC/POC in the coastal ocean and lower Bay, mostly due to the little constraint from boundary and coastal ocean.
   - Improved the lower Bay DOC/DO with nudging of DOC and other ICM variables in the coastal region outside of the bay entrance.

4. **Remaining Issues for ICM variables**
   - While the general model performance is now reasonable, MBM model still needs improvement for CHLA, DO and nutrients.

MBM Setup: Physical Step (SCHISM+SED+WWM)

- **Model Grid**
  - We have tested several versions of grids. Most of the calibration are done based on grid v2 (ne=67k, np=49K) for performance
  - More updated grids were also tested, and can be easily used with our MBM workflow.

- **Simulation Period**
  - Model calibration was done for the period of 1991-1995
  - We also tried the simulation for period 1996-2000, and the results are generally consistent.

- **Model Components for Physics**
  - Hydrodynamic Model (SCHISM), 3D Sediment Transport Model (SED), Wave Model (WWM)
  - Both boundary and initial conditions are required for all these components.

Boundary Condition

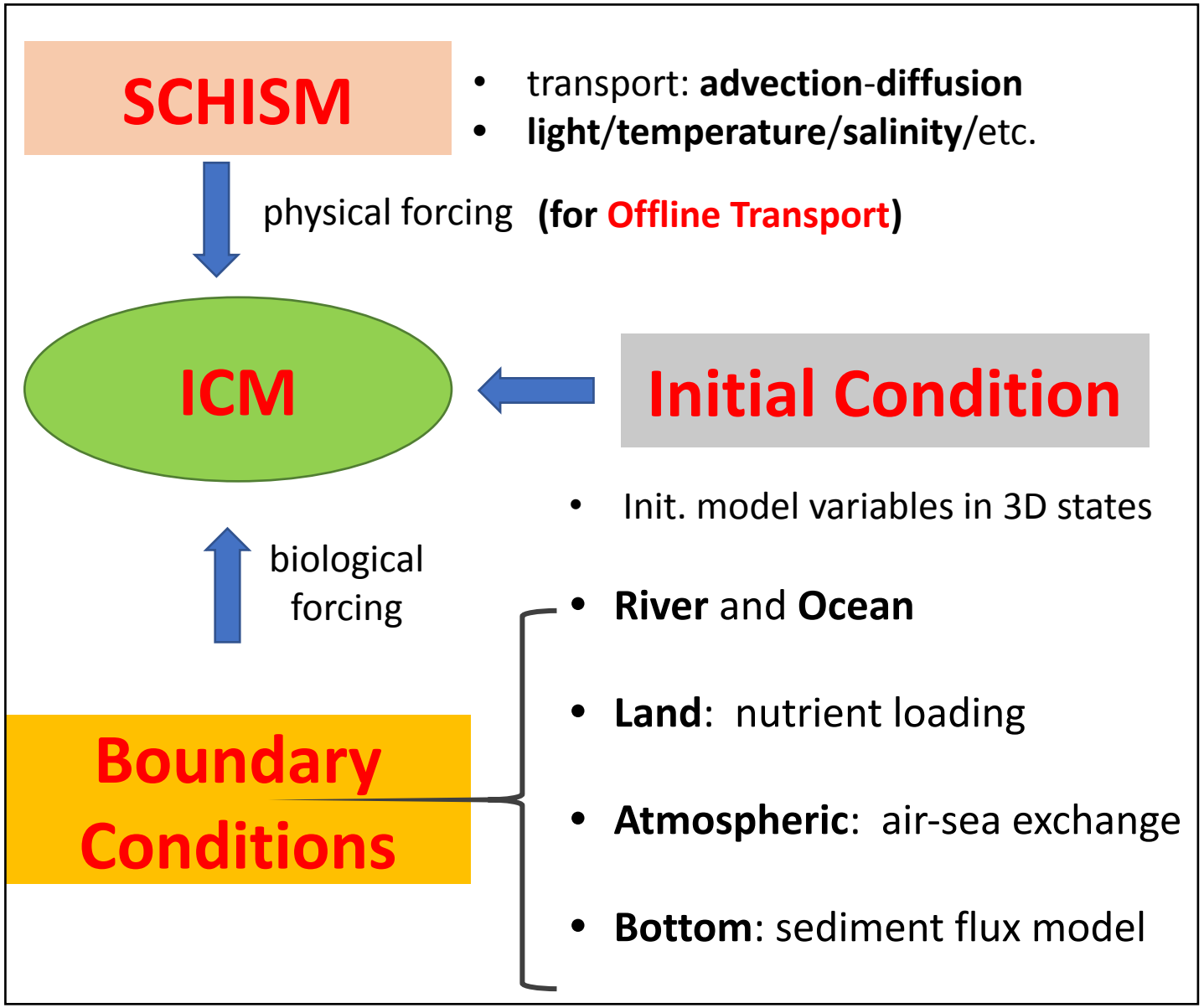
- **River flow**: P6 watershed loading
- **Elevation**: NOAA water level OBS
- **Temperature**: HYCOM
- **Salinity**: ocean climatology data
- **Wave**: Wave Watch III

Initial Condition

- **Temperature**: HYCOM and Bay Program data
- **Salinity**: climatology data and Bay Program data
- **Sediment**: ROMS model results

Atmospheric Forcing: NARR (wind, radiation, precipitation, etc.)

MBM Setup: Biological Step (ICM)



ICM Components

Currently, only ICM core module was included. Other modules (SAV, Marsh, etc.) will be added in the future

Initial condition

- **Bay**: CBP observational data
- **Ocean**: NCEI ship cruise data (climatology)
- **Sediment**: end state after multiple-year model spin-up.

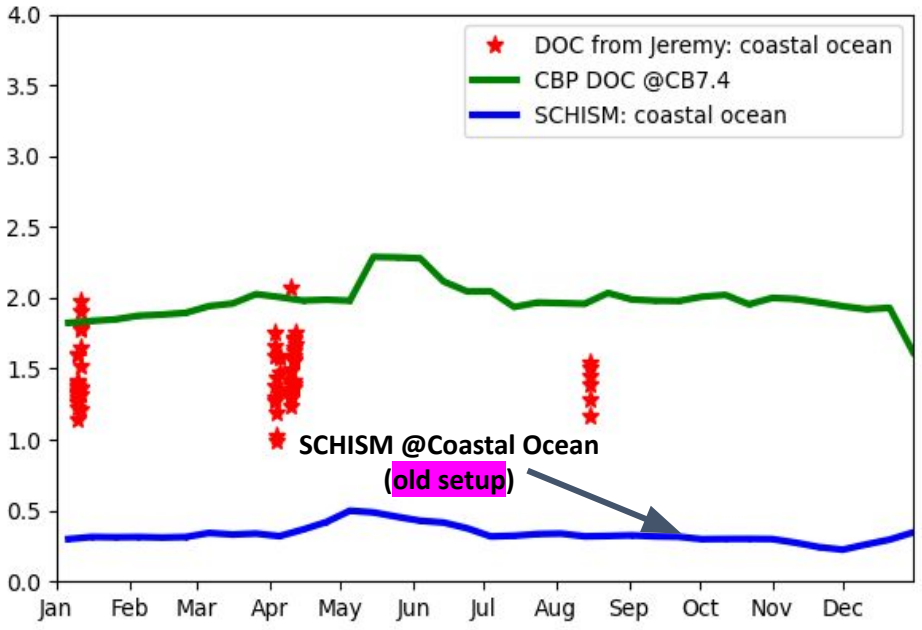
Boundary condition

- **River**: watershed Loading (P6) + CBP data
- **Land**: watershed Loading (P6)
- **Atmos. Loading**: not added yet.
- **Ocean**: NCEI ship cruise data (climatology)

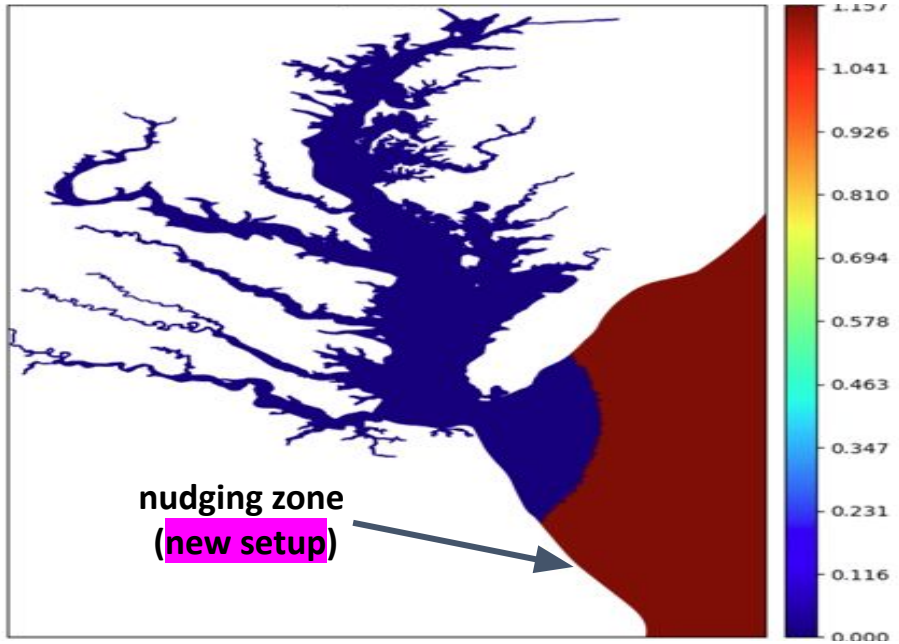
DO Issue in lower Bay: Coastal Nudging

- Rationale: uncertainties in the coastal BGC processes led to gross underestimation of DOC near the entrance
- Importance of Bay-shelf exchange was identified
  - DOC in lower Bay is very sensitive to exchange with coastal ocean
- At the suggestion of Carl, we are focusing calibration by using an effective boundary near the entrance (via strong relaxation), for WQ variables
  - The relaxation method significantly improved the WQ variables (including DO)
  - Keep the original ocean boundary for the Physics Step
  - This is important for the improved salinity and other physics variables

Coastal ocean DOC comparison (mg/L)



Coastal Nudging around bay mouth using CB7.4

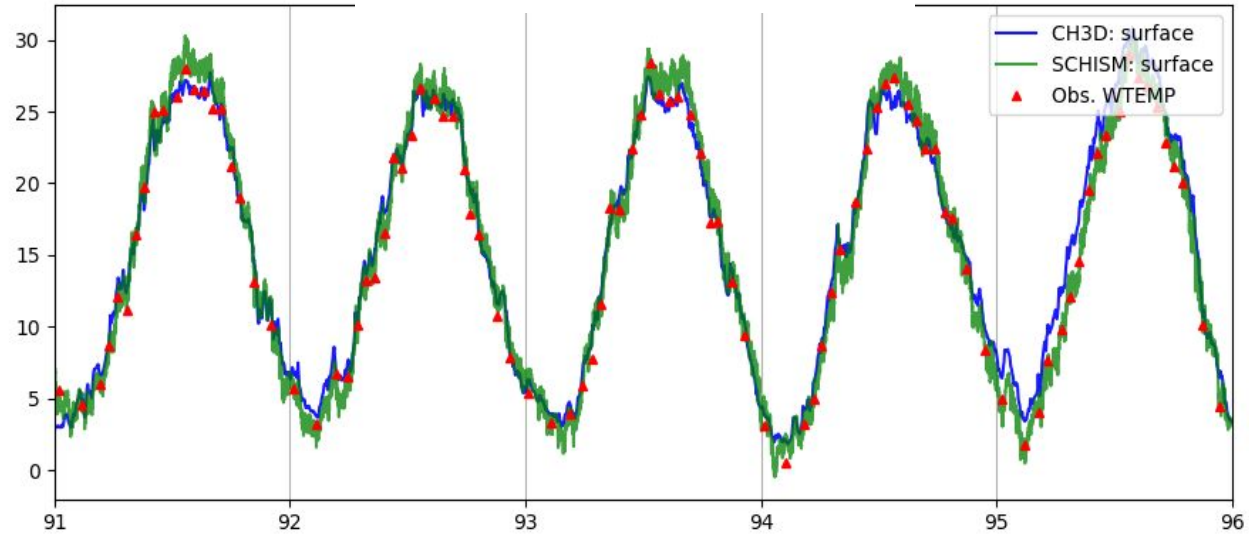


Preliminary Water Quality results of MBM

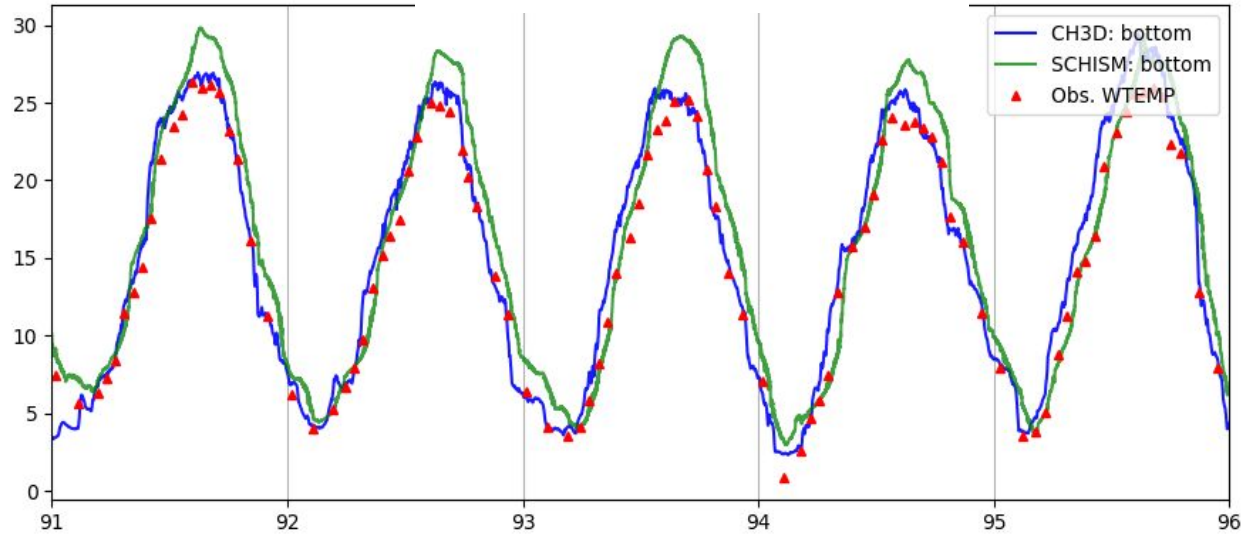
Temperature and Salinity @CB4.3C

CH3D SCHISM

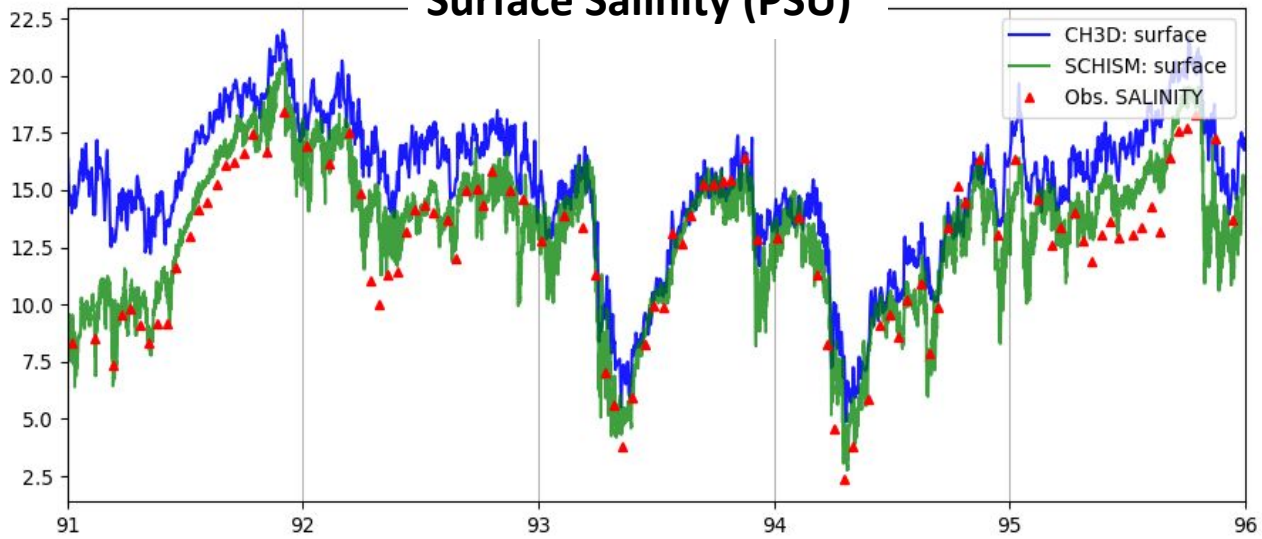
Surface Temperature (°C)



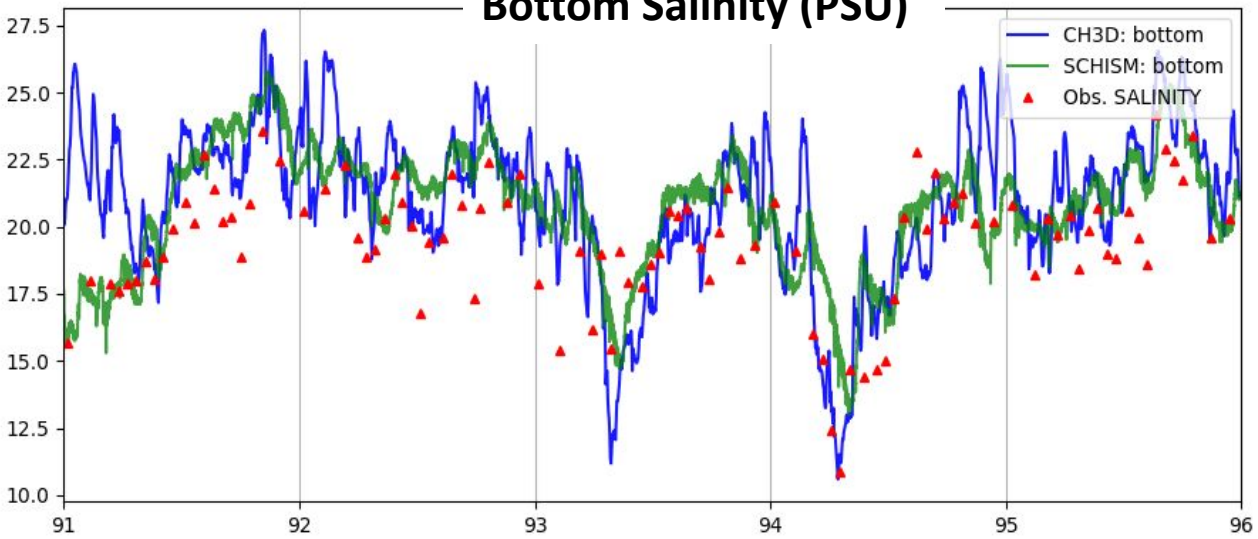
Bottom Temperature (°C)



Surface Salinity (PSU)



Bottom Salinity (PSU)

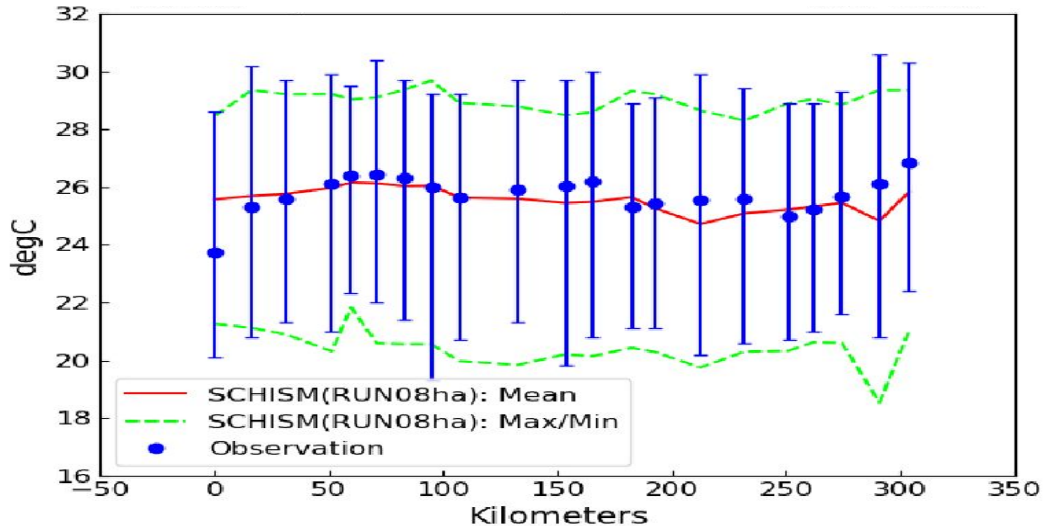


- SCHISM has better salinity simulation than CH3D, but it overestimates the bottom temperature in summer (likely due to water type used)

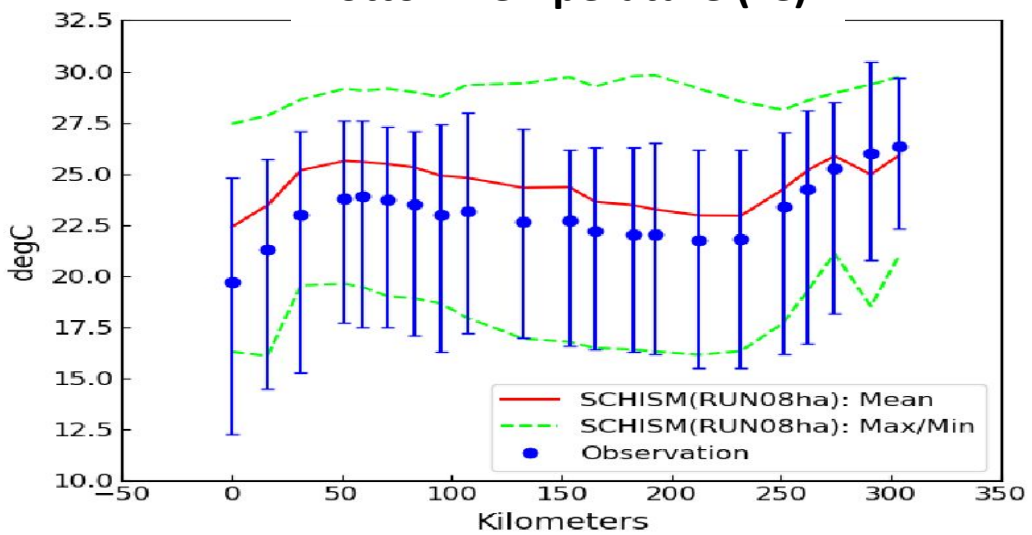
Temperature and Salinity along Bay Channel Axis in summer (1991-1995)

- SCHISM captured the general trends for both temperature and salinity about the variation along the Bay channel

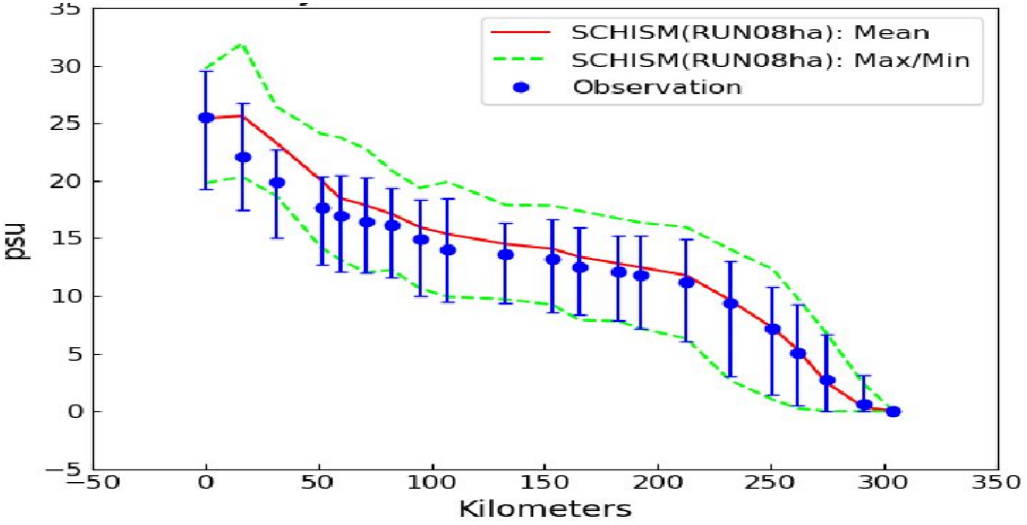
Surface Temperature (°C)



Bottom Temperature (°C)

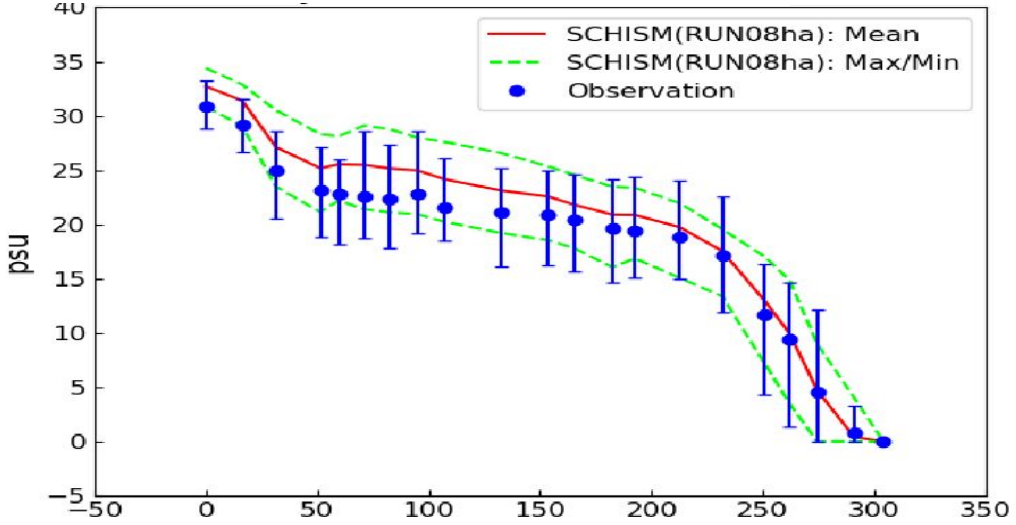


Surface Salinity (PSU)



Bay Mouth Upper Bay

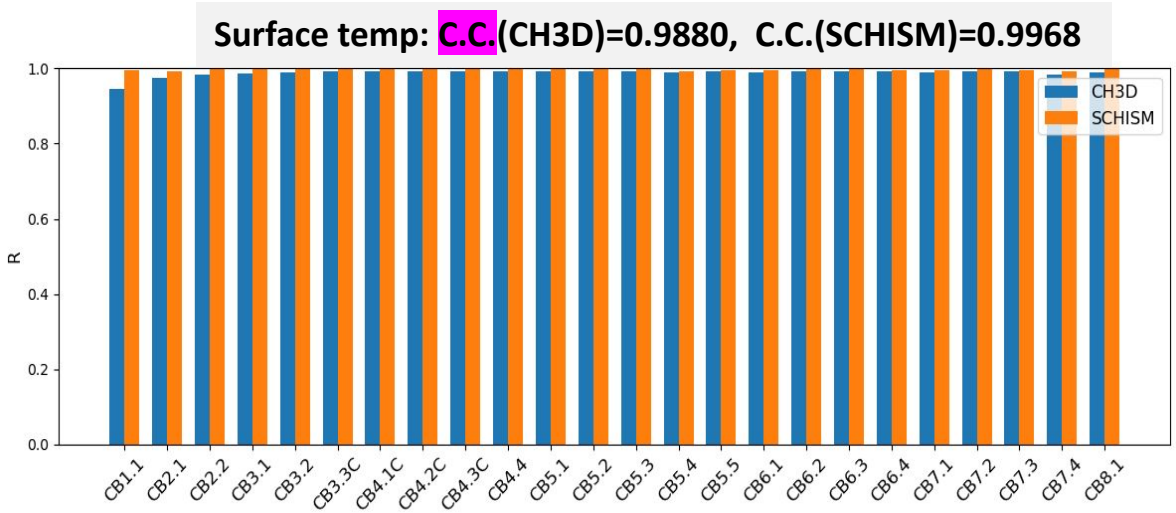
Bottom Salinity (PSU)

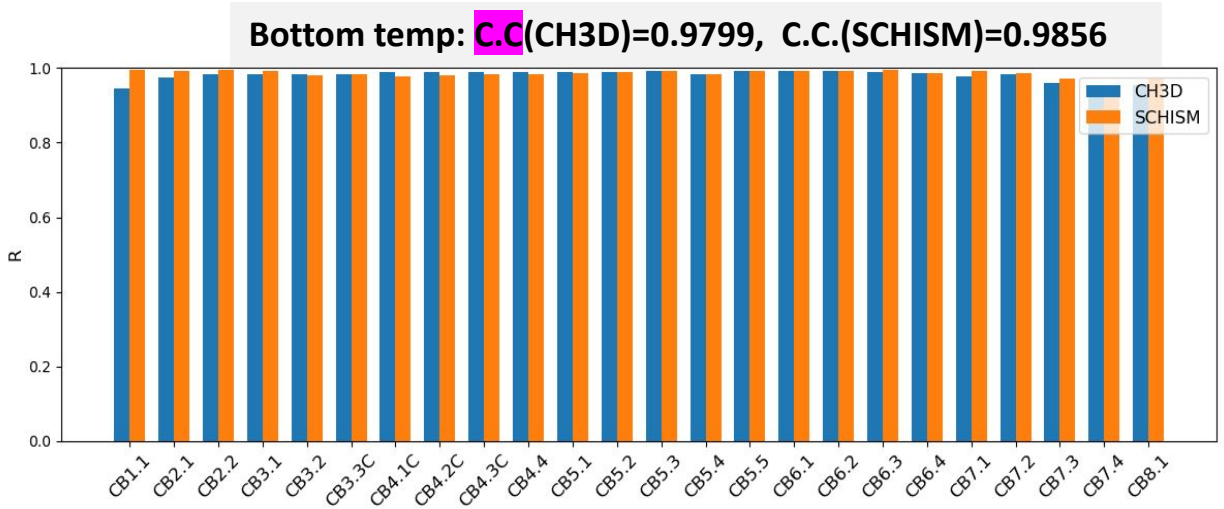


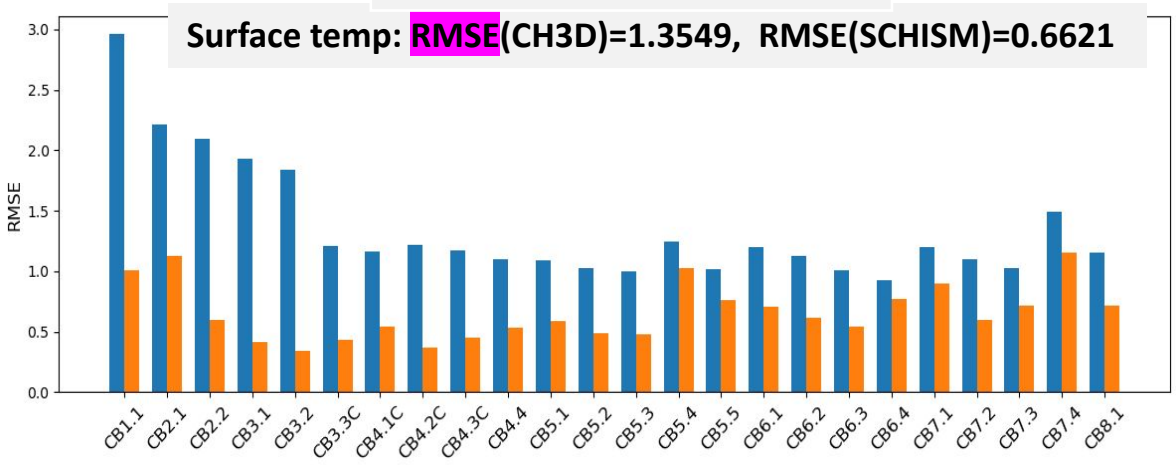
Bay Mouth Upper Bay

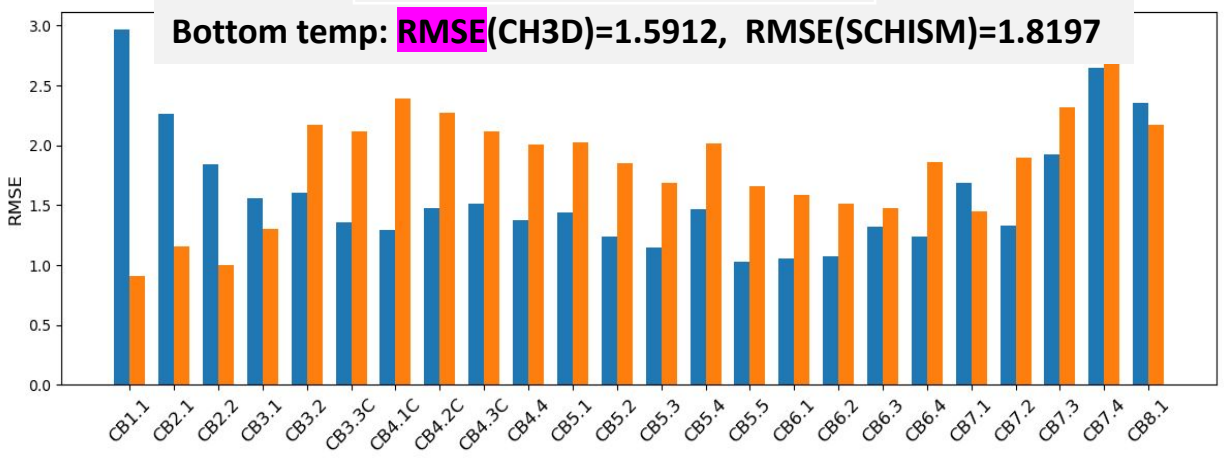
Temperature Comparison with CH3D

SCHISM CH3D





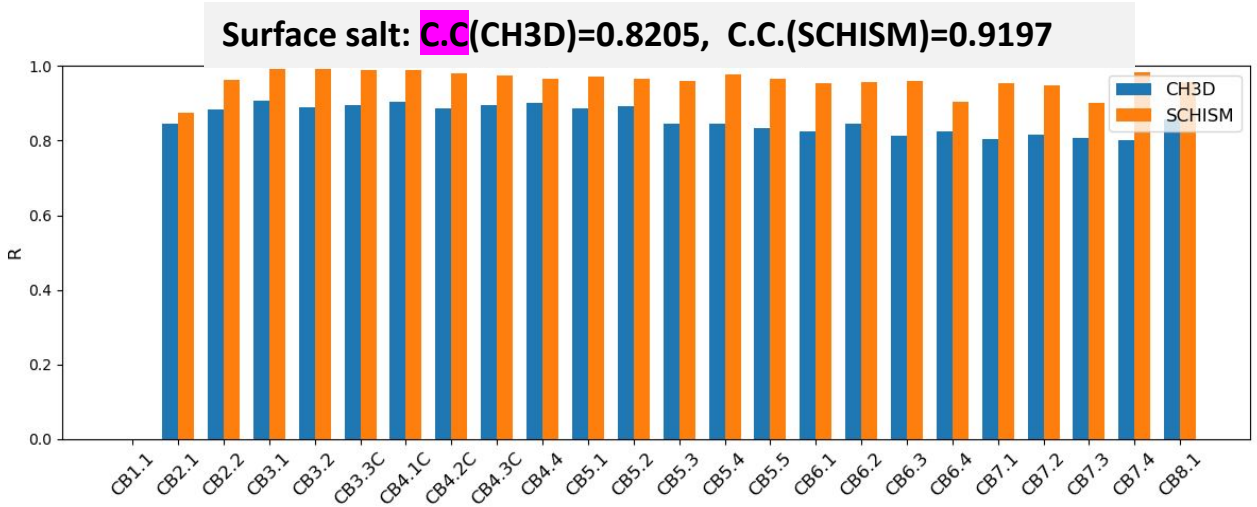


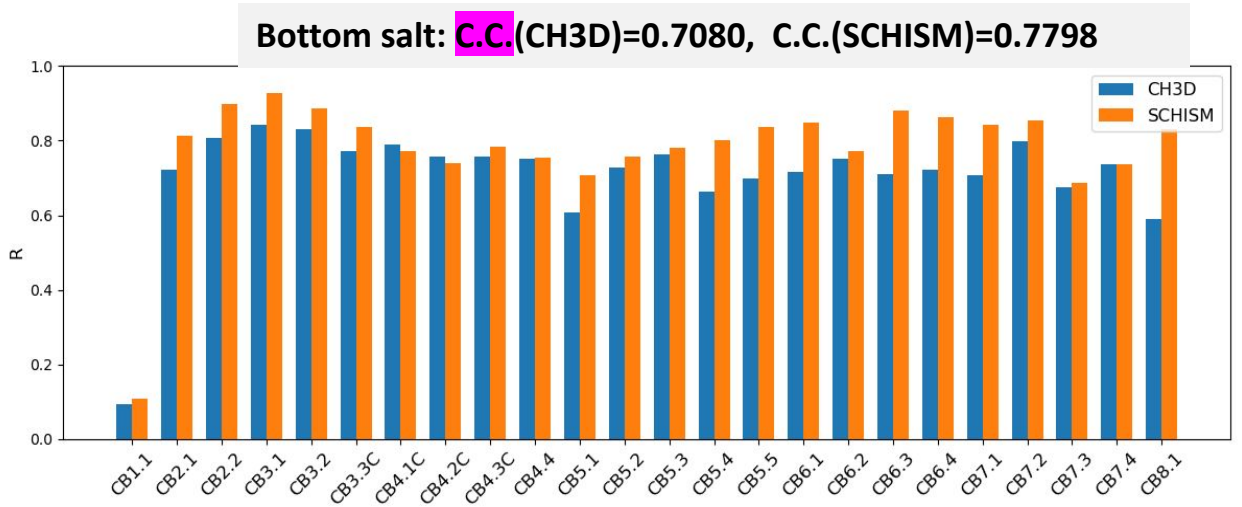


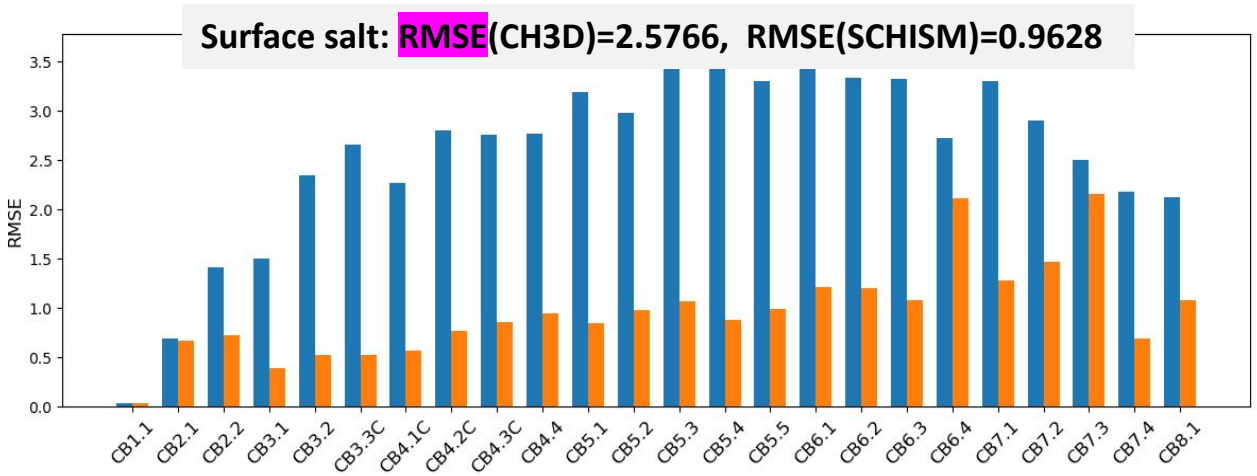
- The surface temperature simulation from SCHISM is generally better than CH3D.
- On the other hand, CH3D has a better performance for the bottom temperature at most stations.

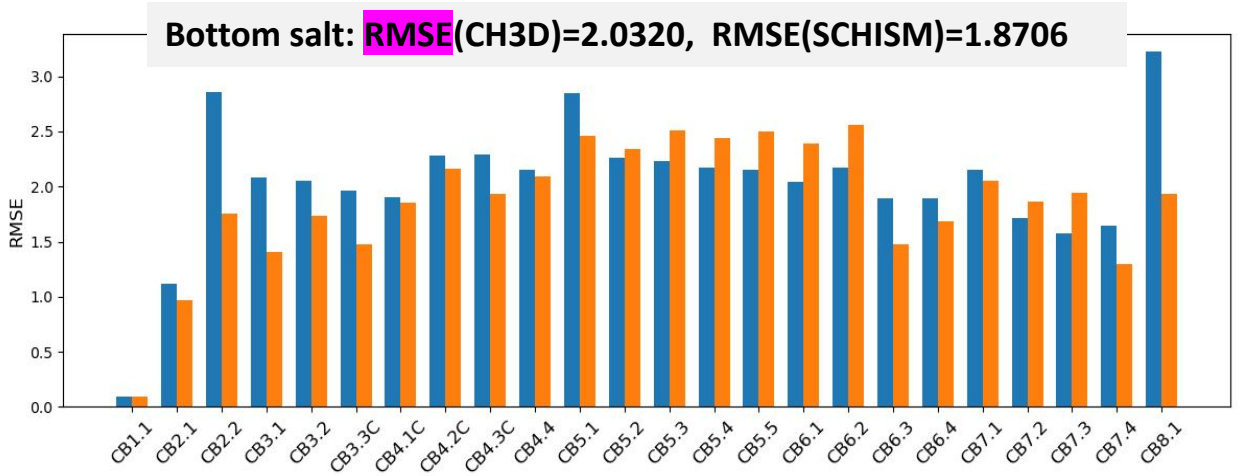
Salinity Comparison with CH3D

SCHISM CH3D







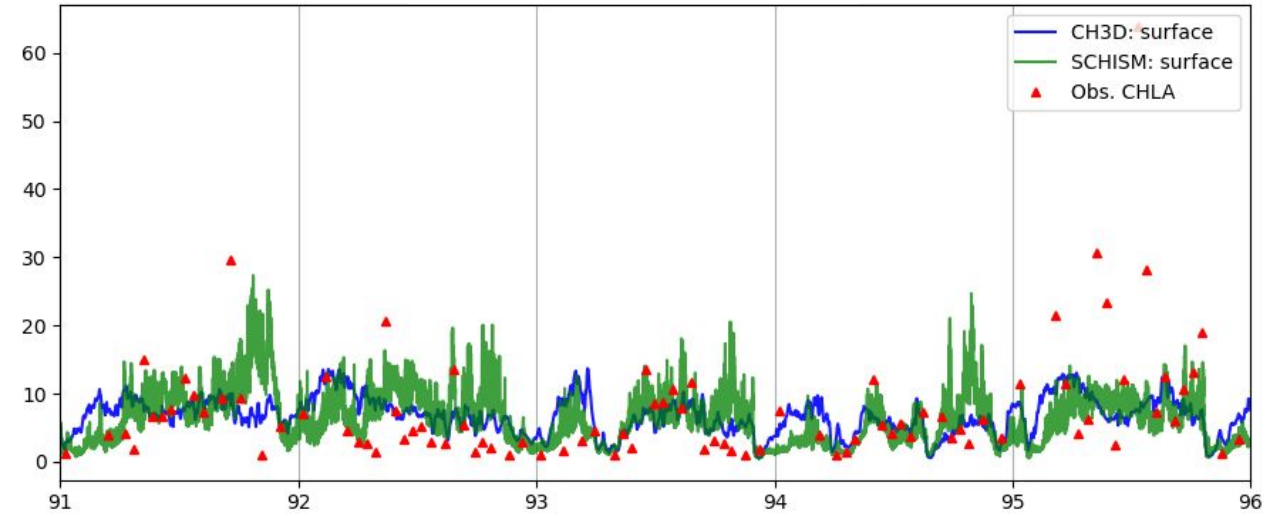


- In general, the salinity simulation in SCHISM is better than CH3D.
- Other physics variables (waves, sediment) have been presented by Jiabi in a previous meeting

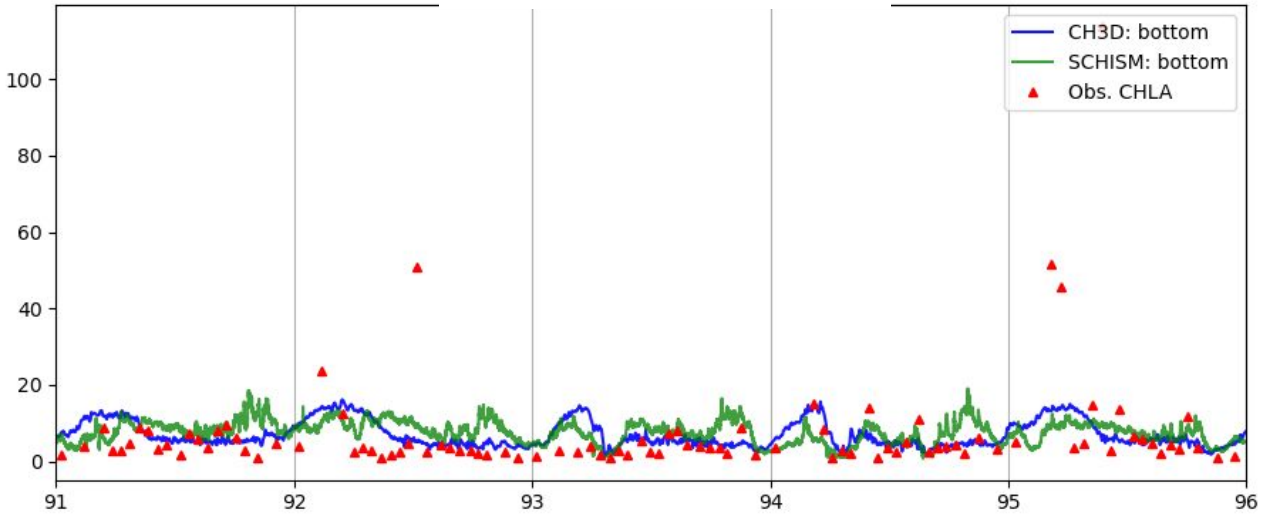
CHLA and DO @CB3.1

CH3D SCHISM

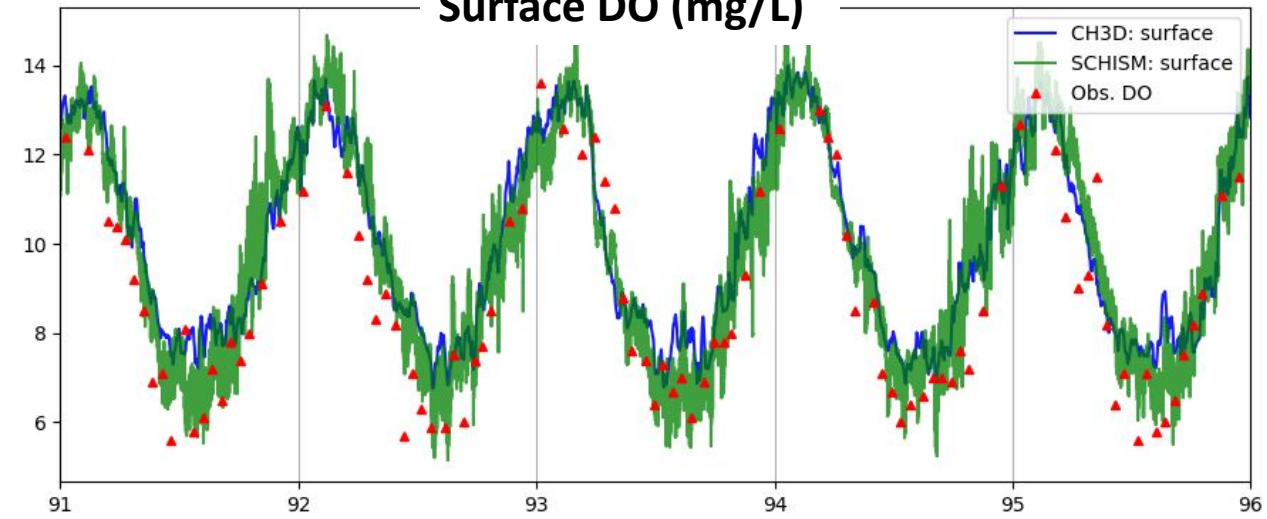
Surface CHLA (ug/L)



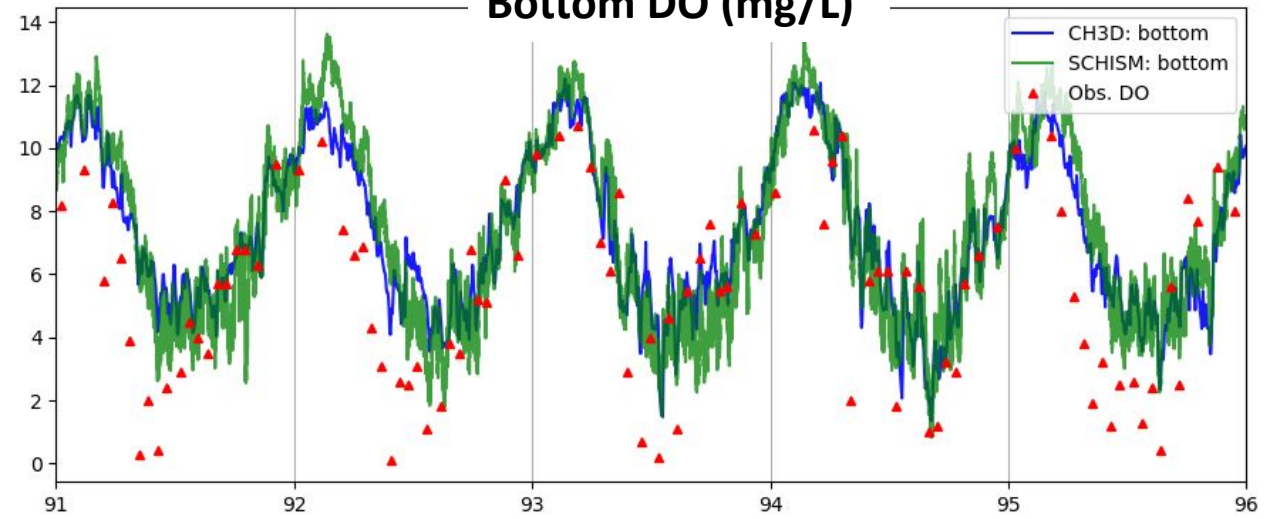
Bottom CHLA (ug/L)



Surface DO (mg/L)



Bottom DO (mg/L)

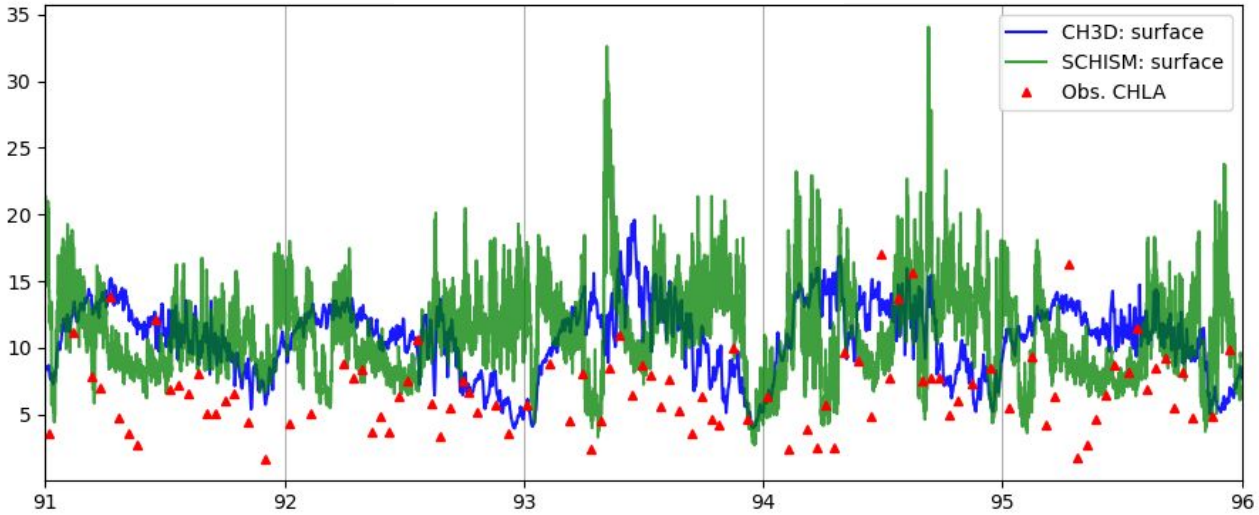


The simulation of CHLA and DO between CH3D and SCHISM are somewhat comparable.

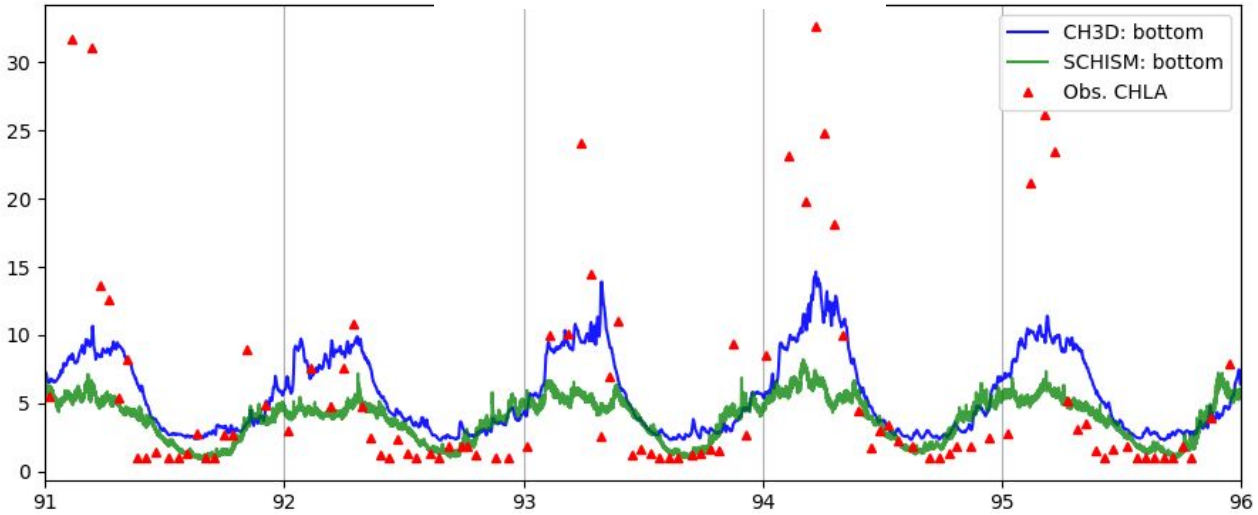
CHLA and DO @CB4.3C

CH3D SCHISM

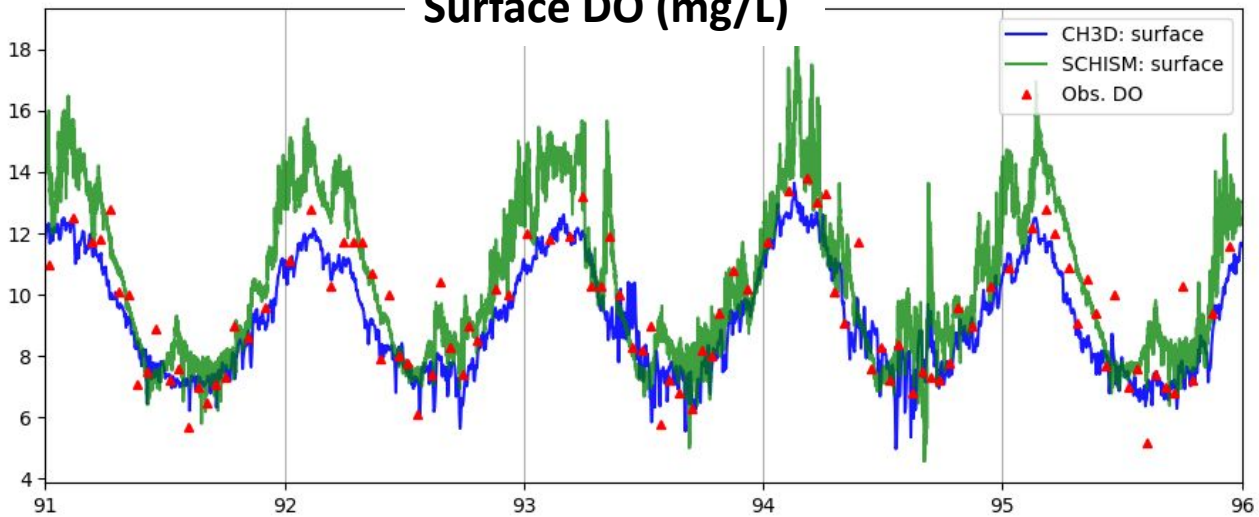
Surface CHLA (ug/L)



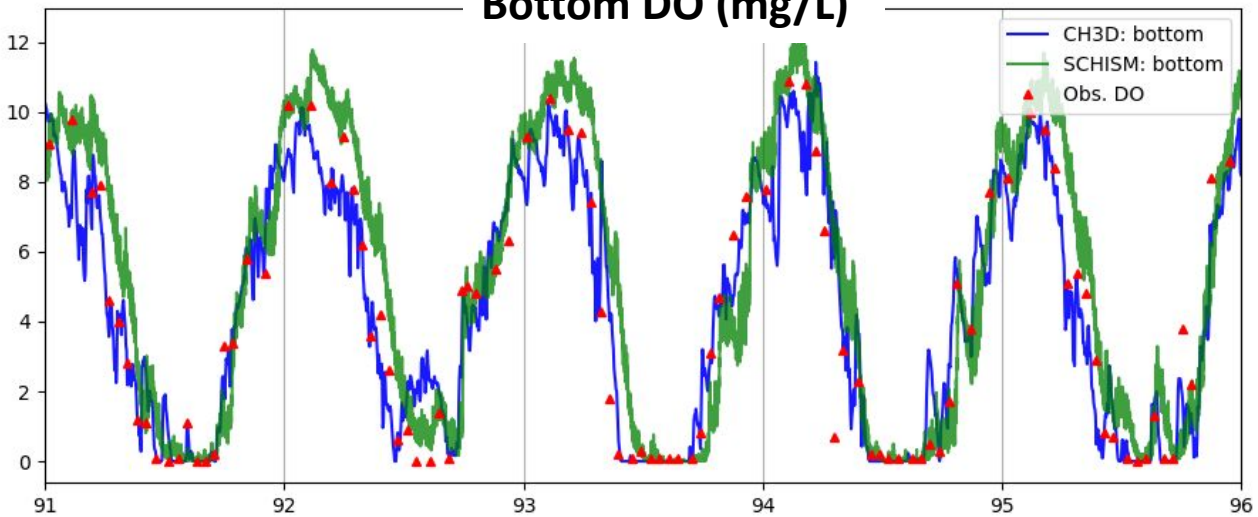
Bottom CHLA (ug/L)



Surface DO (mg/L)



Bottom DO (mg/L)

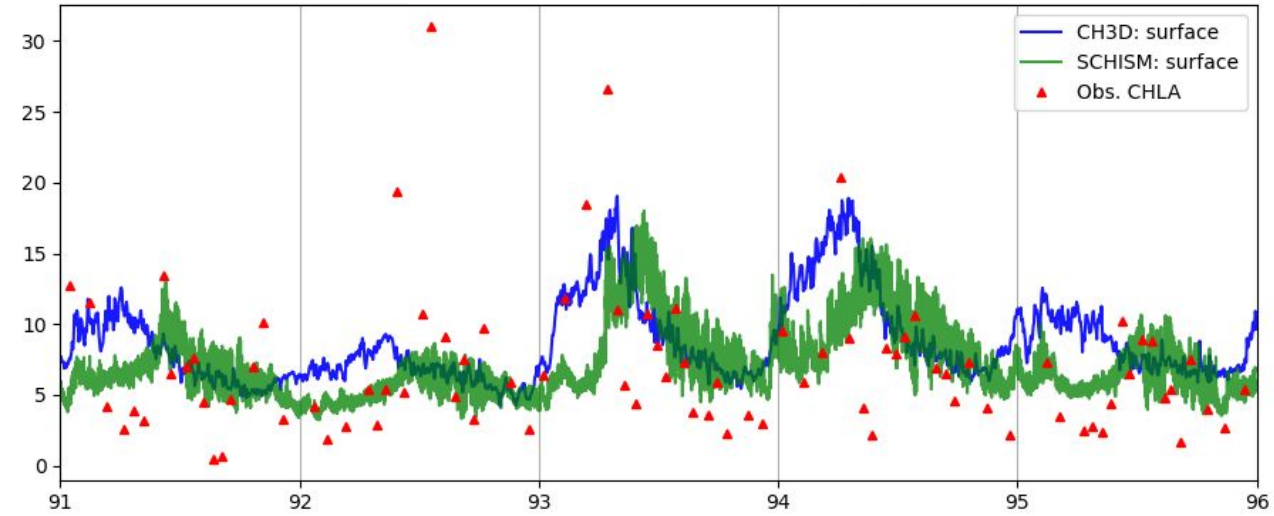


- The simulation of CHLA and DO between CH3D and SCHISM are comparable.
- Need to fix the phase errors in SCHISM results next

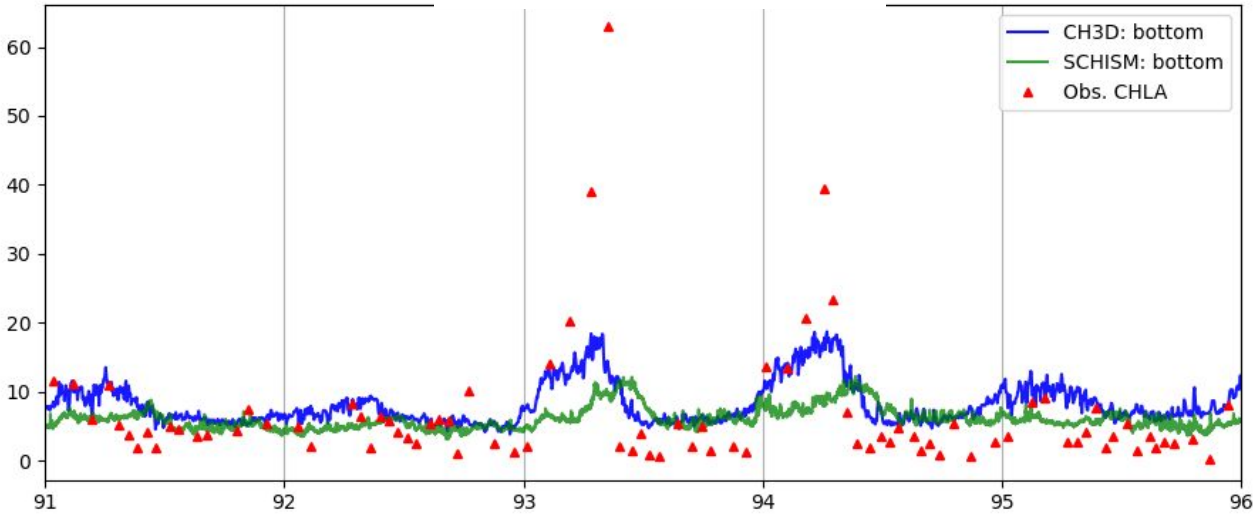
CHLA and DO @CB6.4

CH3D SCHISM

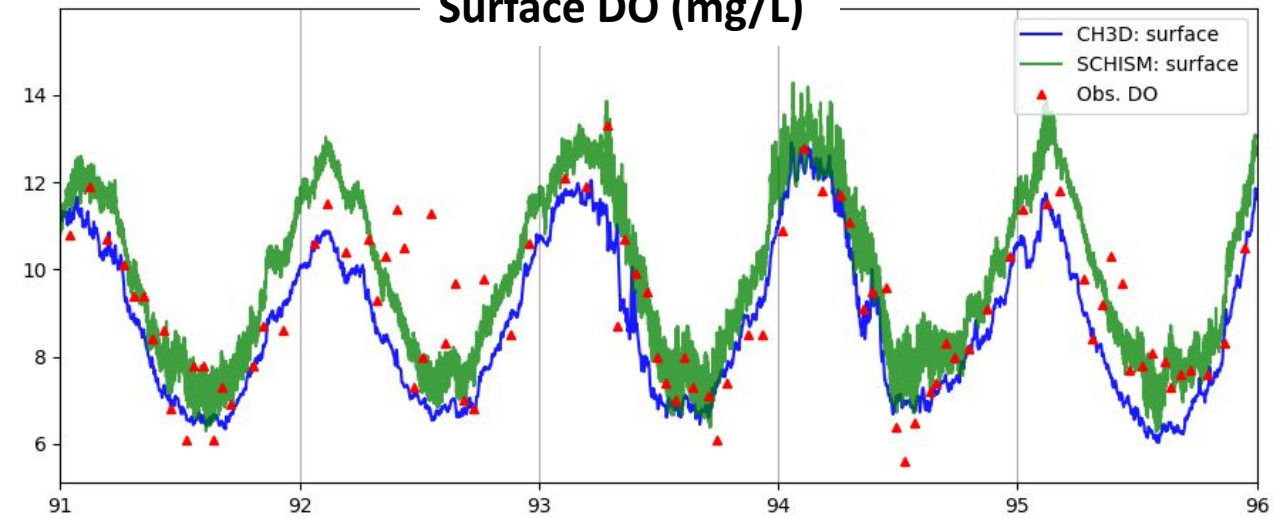
Surface CHLA (ug/L)



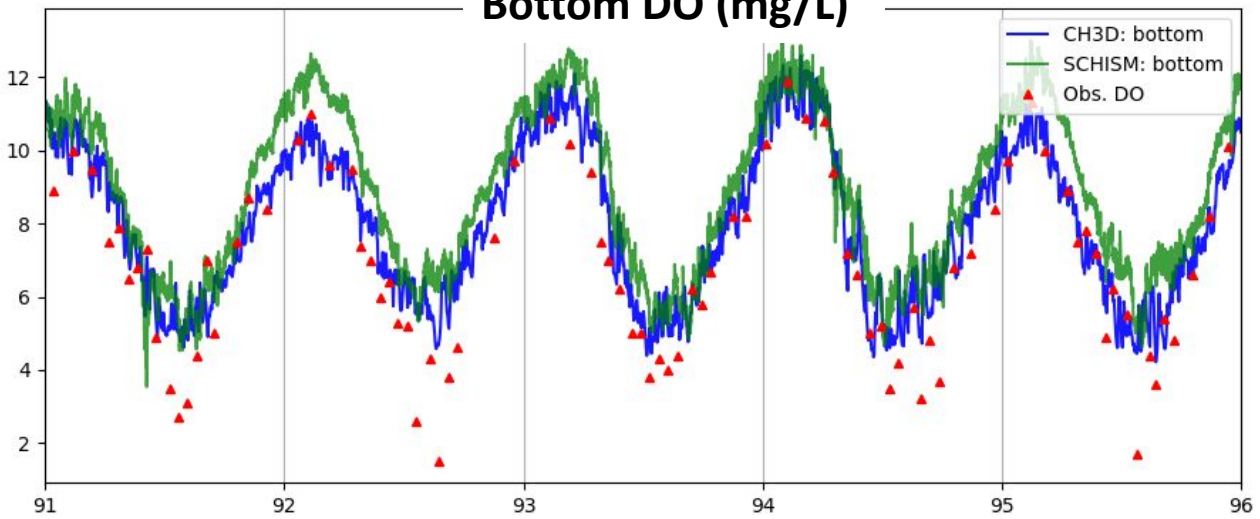
Bottom CHLA (ug/L)



Surface DO (mg/L)



Bottom DO (mg/L)

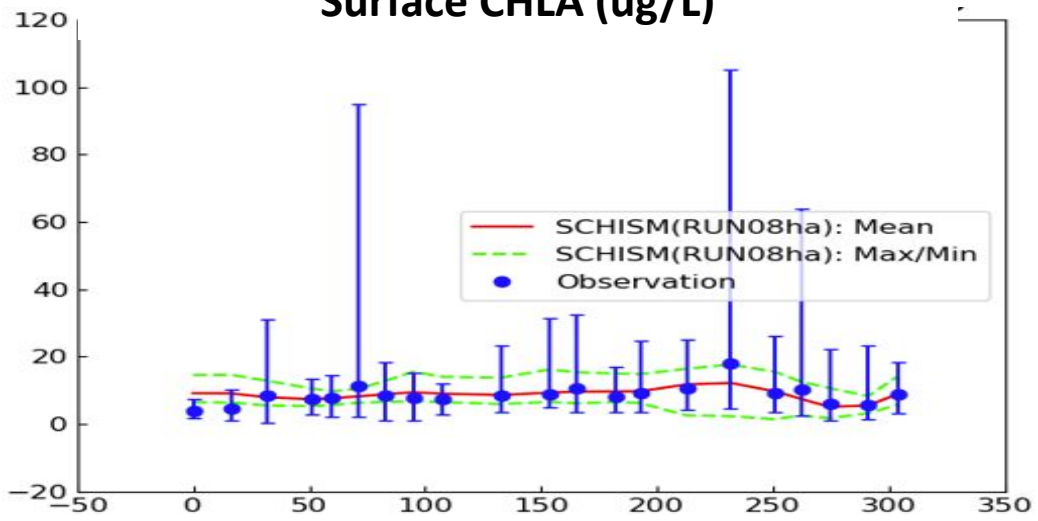


- The simulation of CHLA and DO between CH3D and SCHISM are comparable.

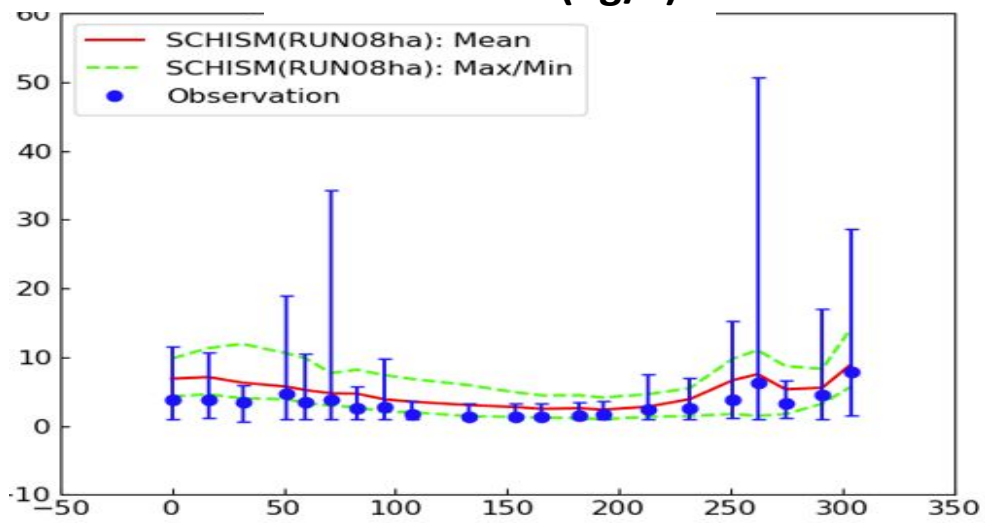
CHLA and DO along Bay Channel in summer (1991-1995)

- The range of simulated CHLA is reasonable.
- DO simulation captured the general trend.

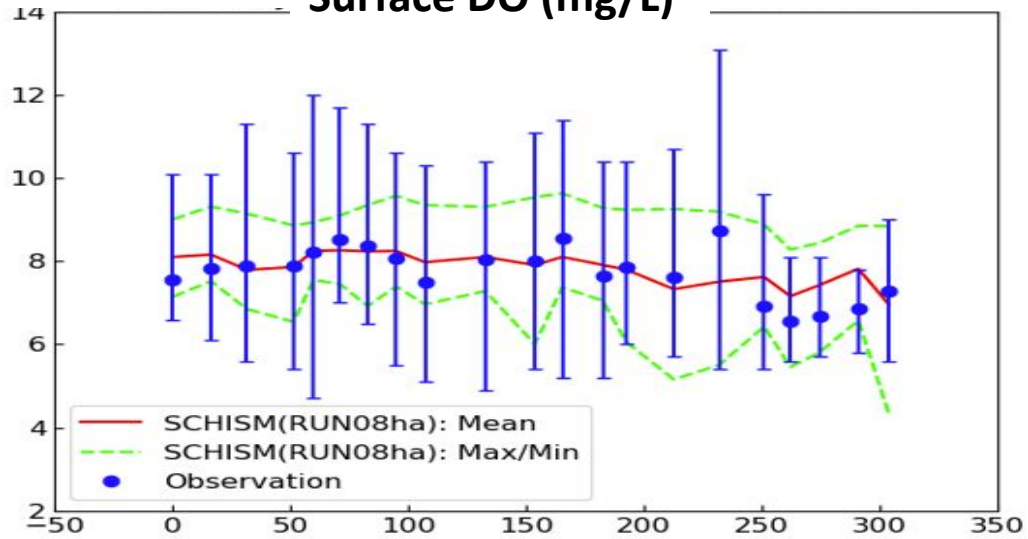
Surface CHLA (ug/L)



Bottom CHLA (ug/L)

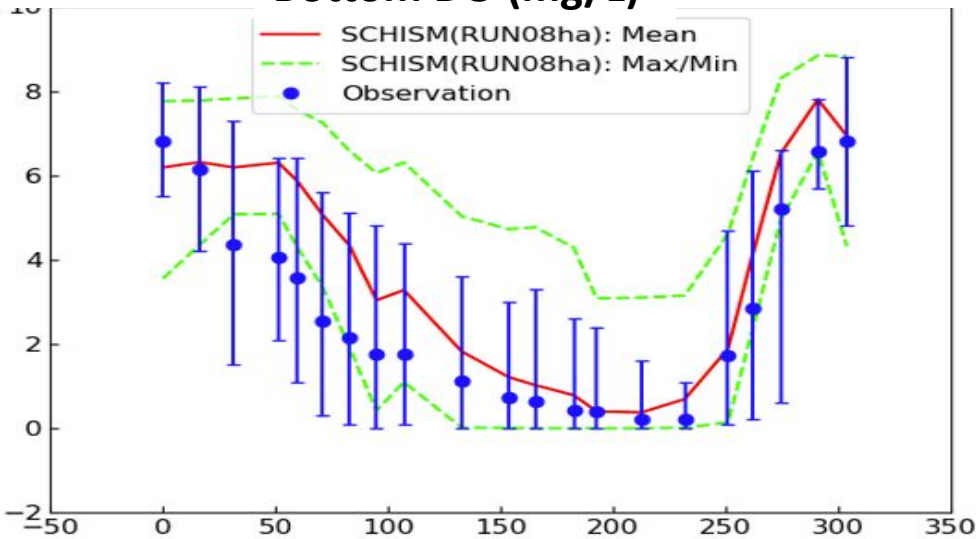


Surface DO (mg/L)



Bay Mouth distance (km) Upper Bay

Bottom DO (mg/L)

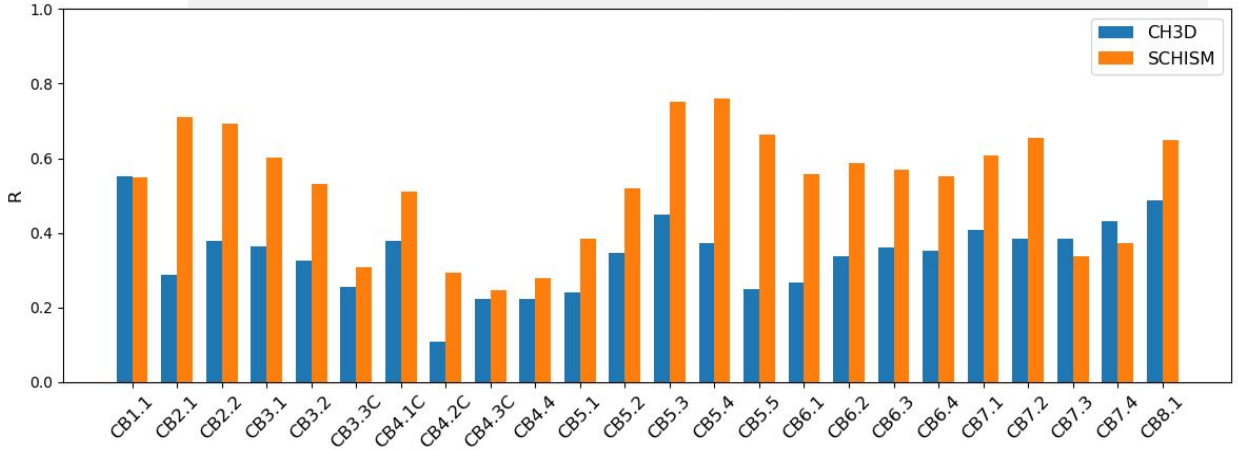


Bay Mouth distance (km) Upper Bay

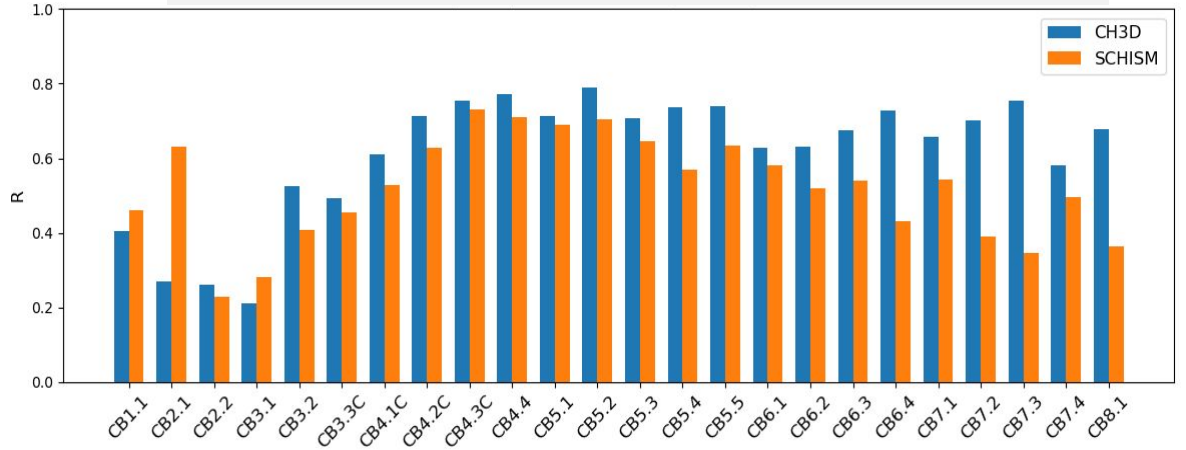
CHLA: Comparison with CH3D

SCHISM CH3D

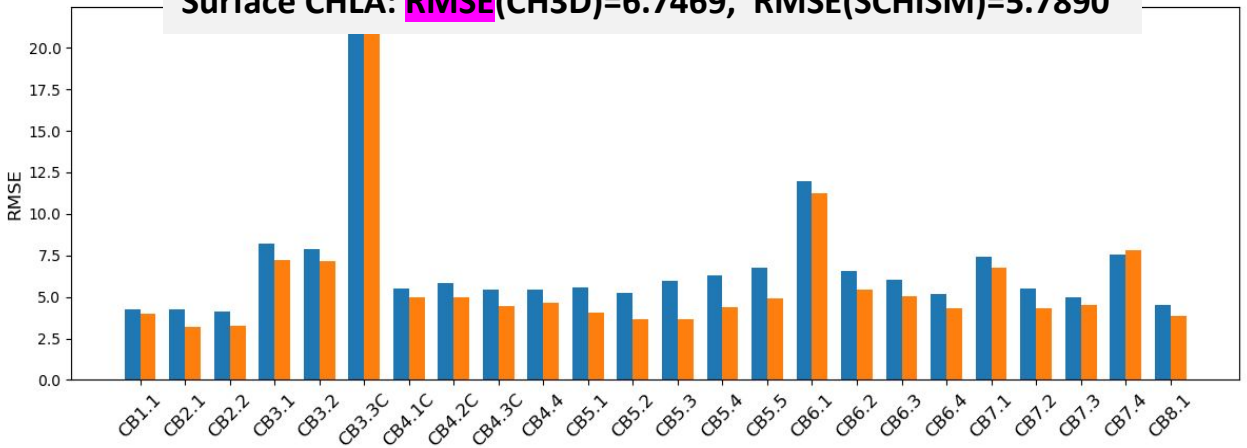
Surface CHLA: C.C.(CH3D)=0.3400, C.C.(SCHISM)=0.5286



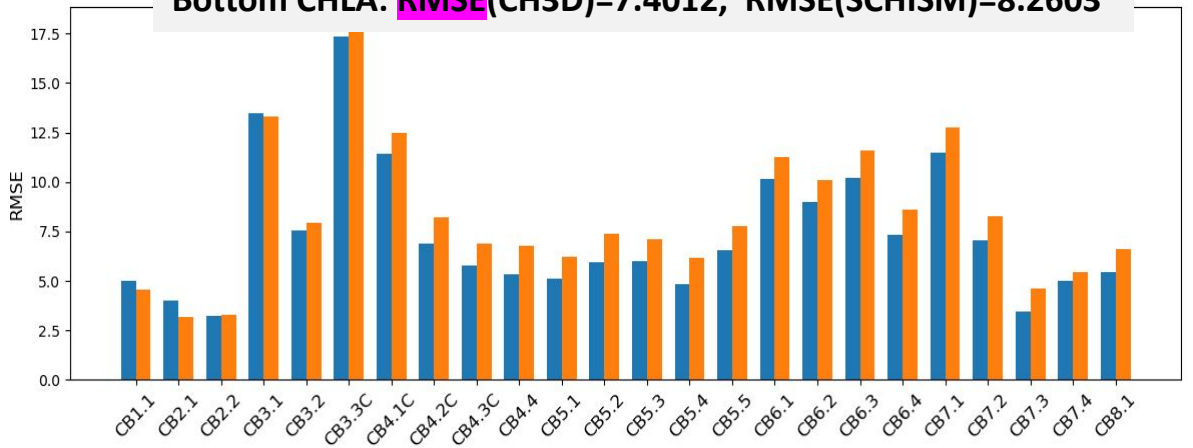
Bottom CHLA: C.C.(CH3D)=0.6140, C.C.(SCHISM)=0.5215



Surface CHLA: RMSE(CH3D)=6.7469, RMSE(SCHISM)=5.7890



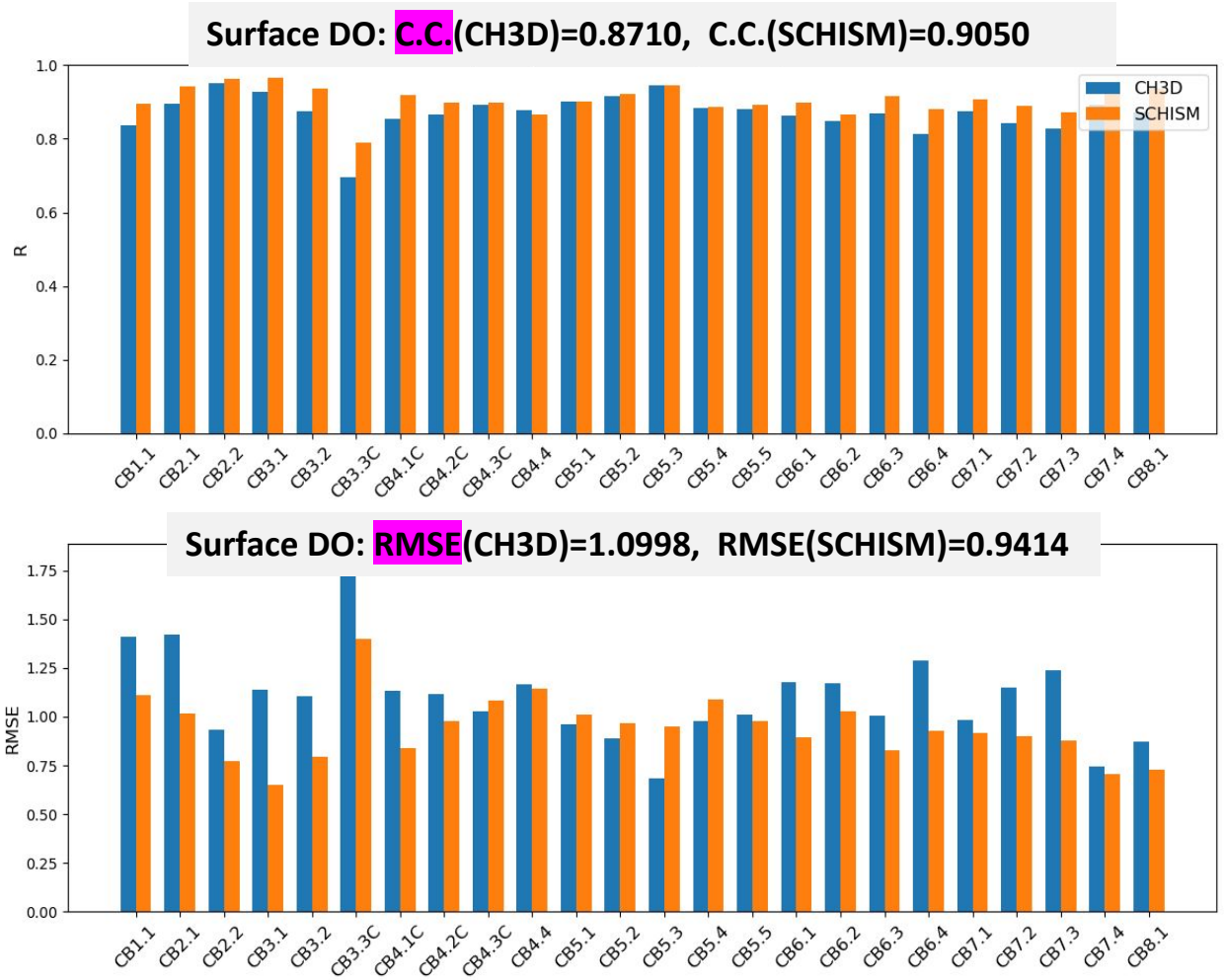
Bottom CHLA: RMSE(CH3D)=7.4012, RMSE(SCHISM)=8.2603

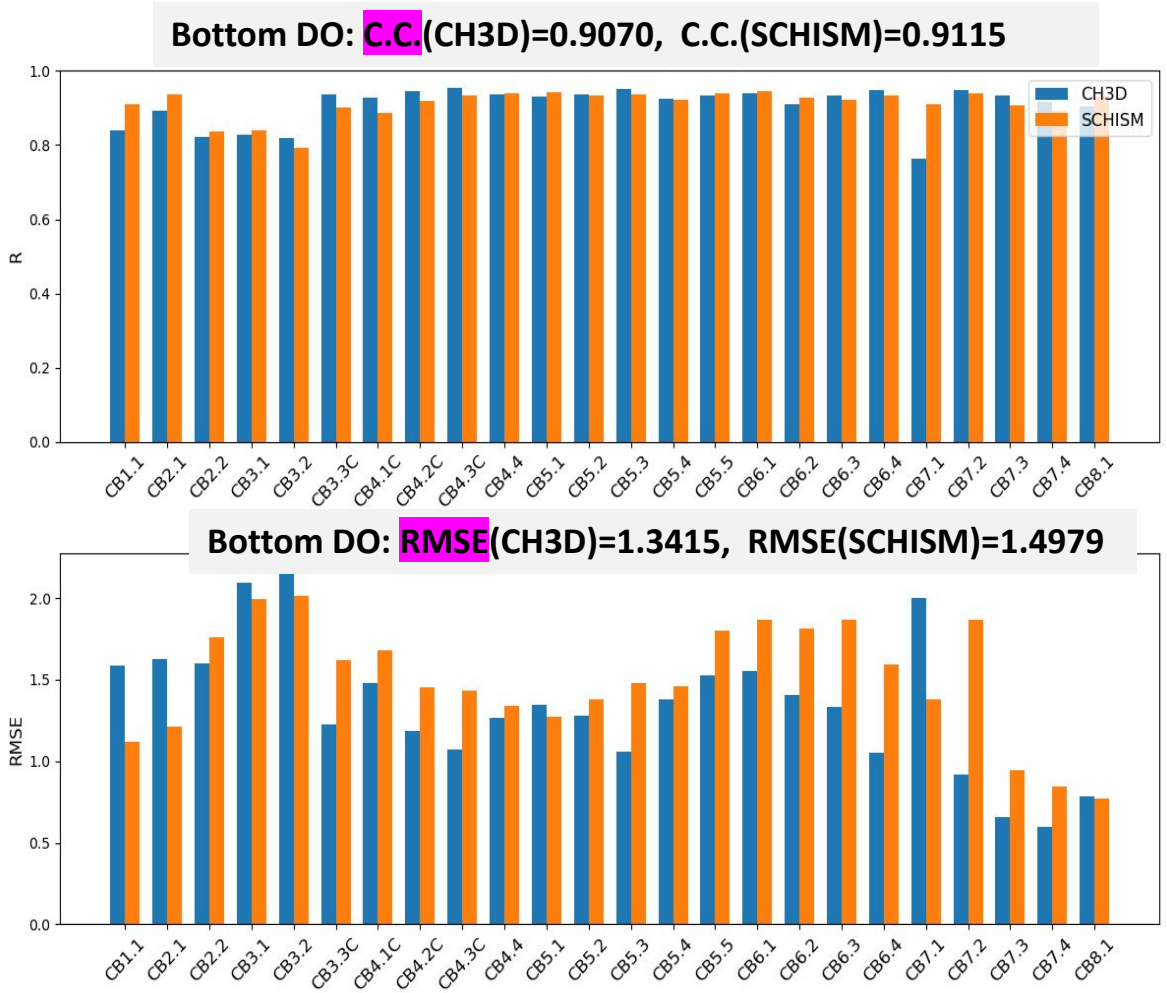


- Overall, the performance of the two models are comparable.
- For surface CHLA, SCHISM performs better than CH3D.
- For bottom CHLA, CH3D did a slightly better job.

DO: Comparison with CH3D

SCHISM CH3D



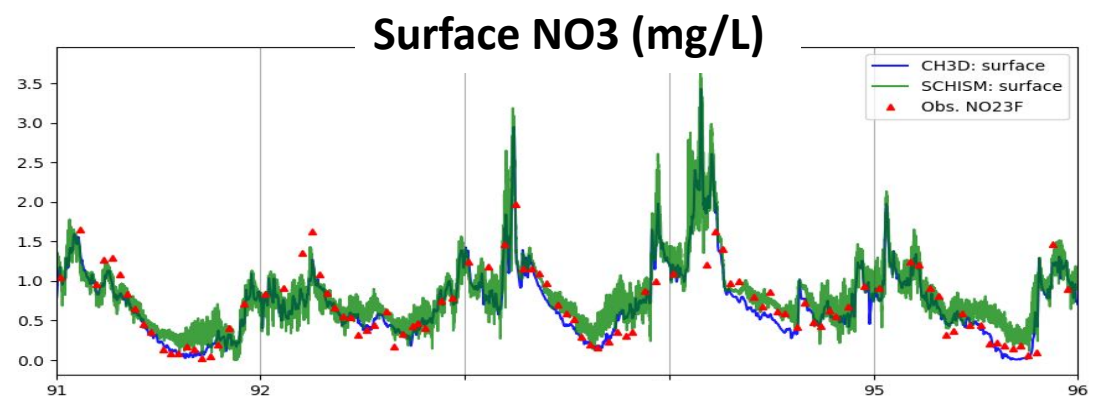


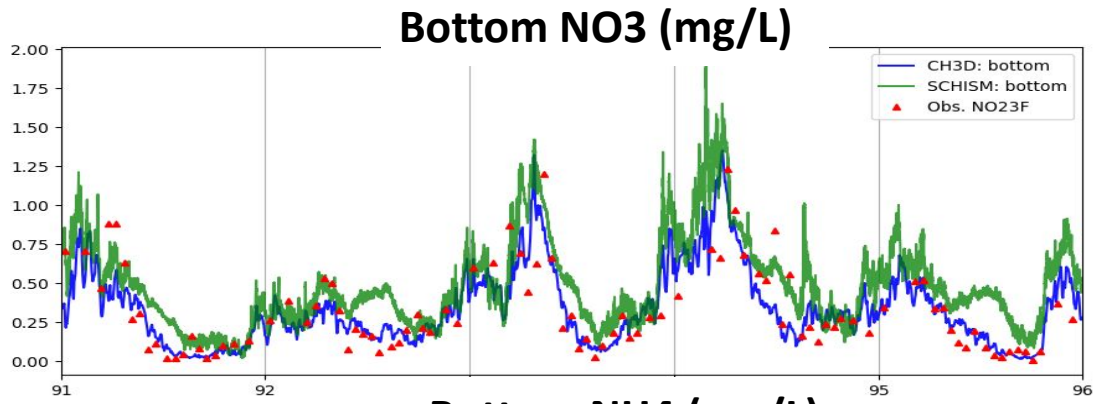
- Overall, for surface and bottom DO simulation, the performances of the two models are comparable *on average*

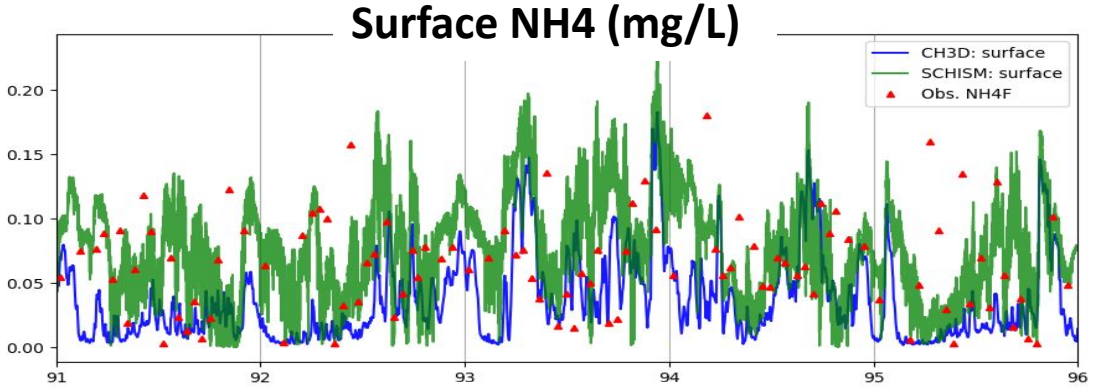
Dissolved Inorganic Nutrients @CB3.1

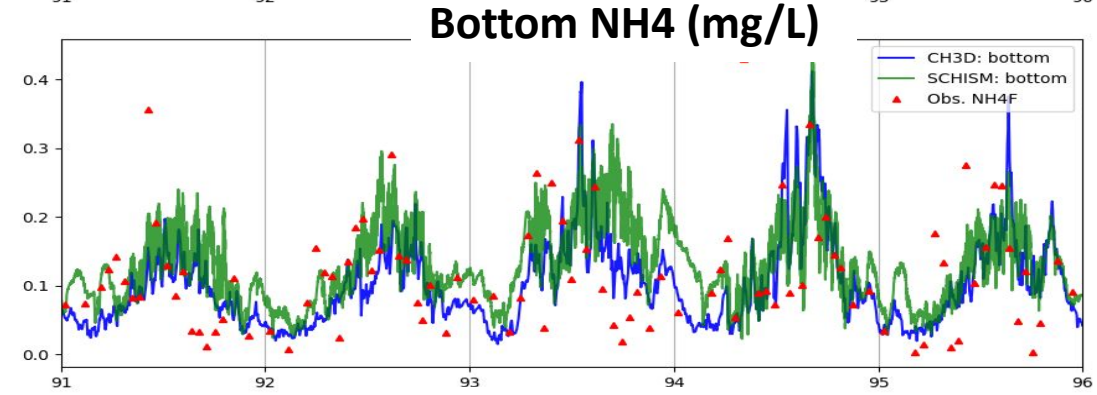
CH3D SCHISM

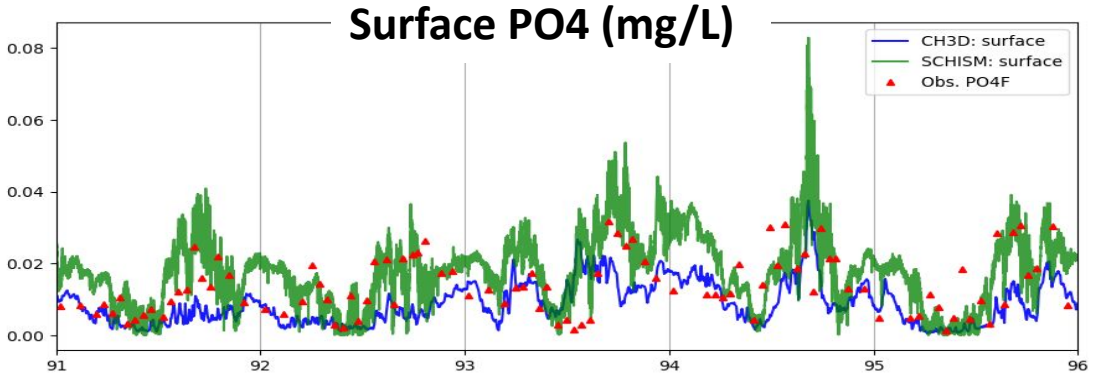
- In general, the dissolved inorganic nutrients from SCHISM are reasonable, but improvement is still needed regarding the details.
- The performances of the two models are comparable (mixed bag).

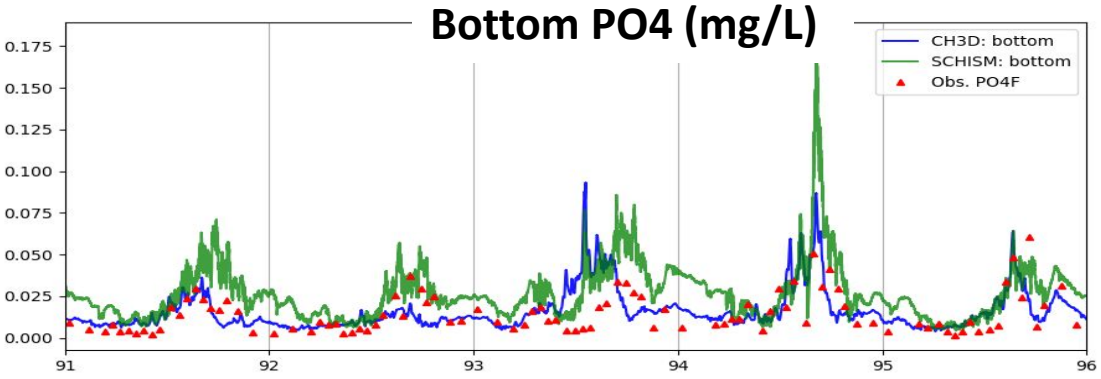








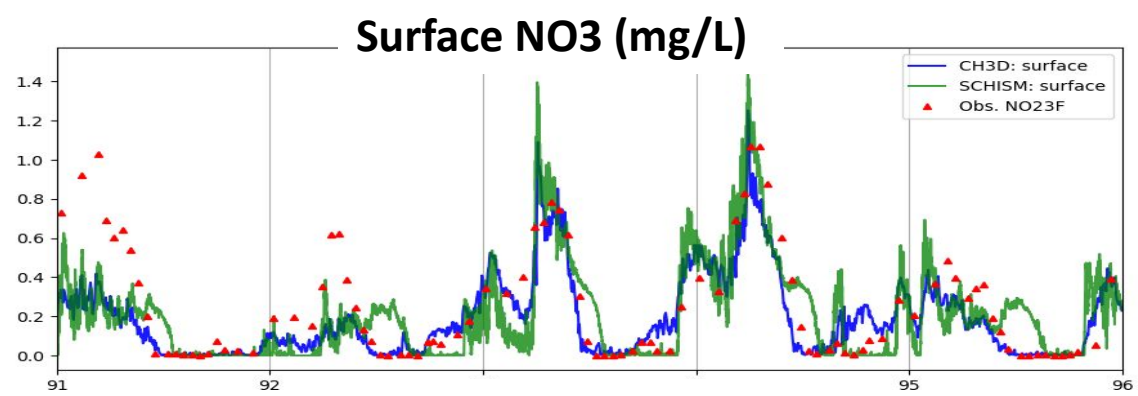


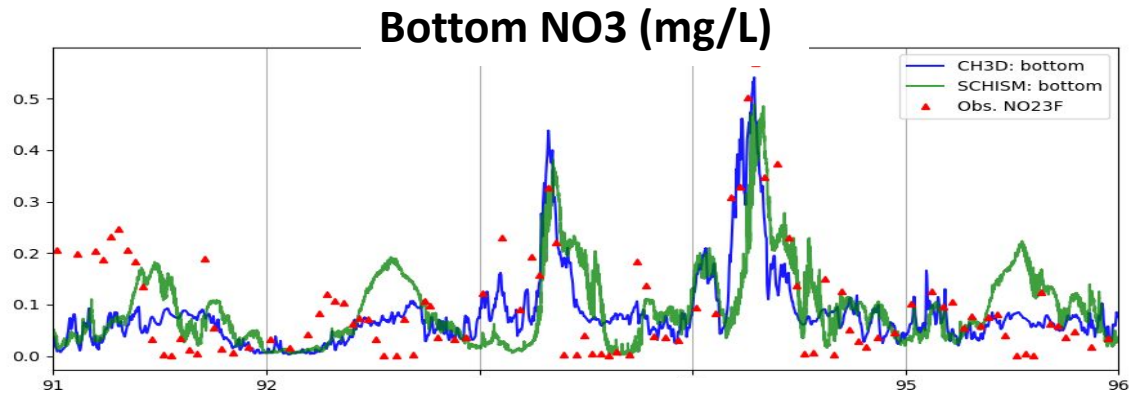


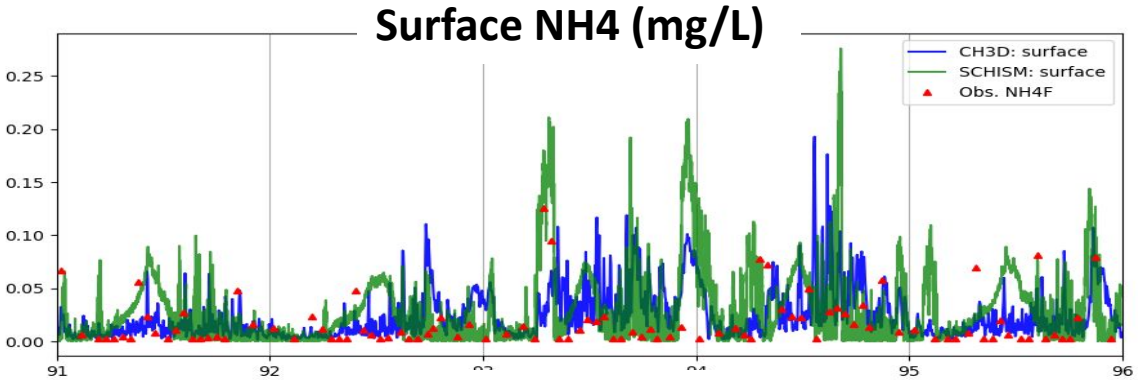
Dissolved Inorganic Nutrients @CB4.3C

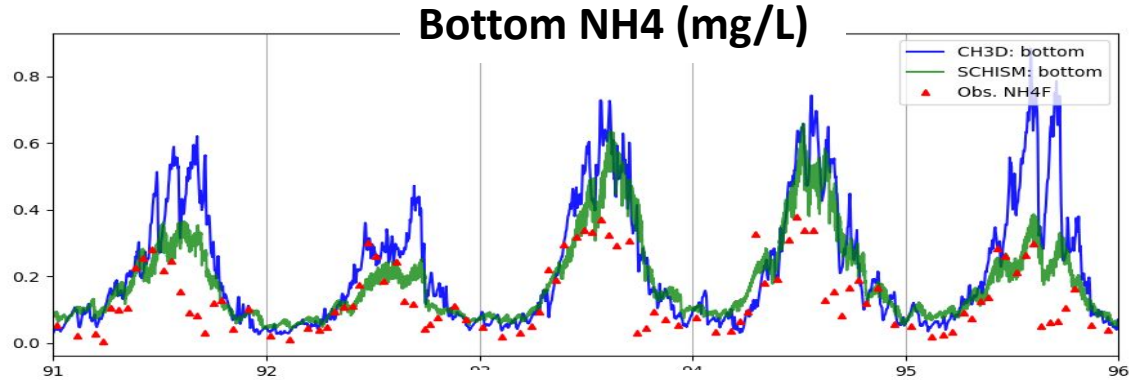
CH3D SCHISM

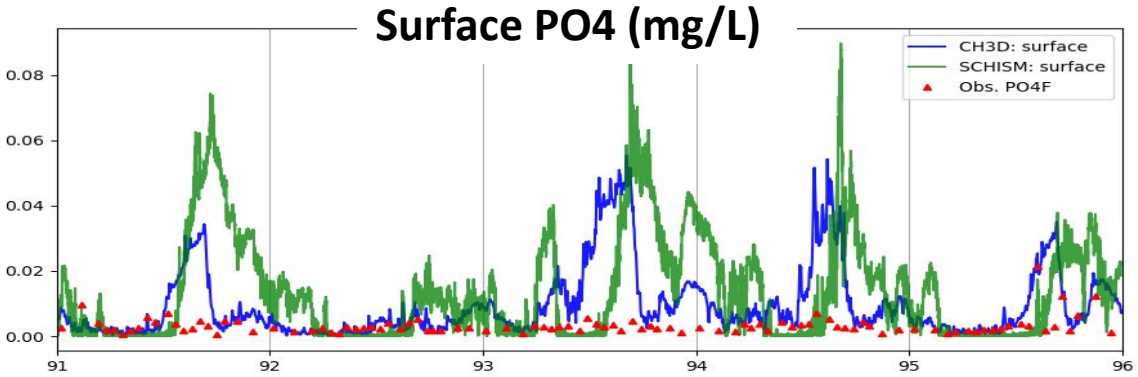
- Similar to CB3.1
- Difference: overestimation of NH4 and PO4 in SCHISM.

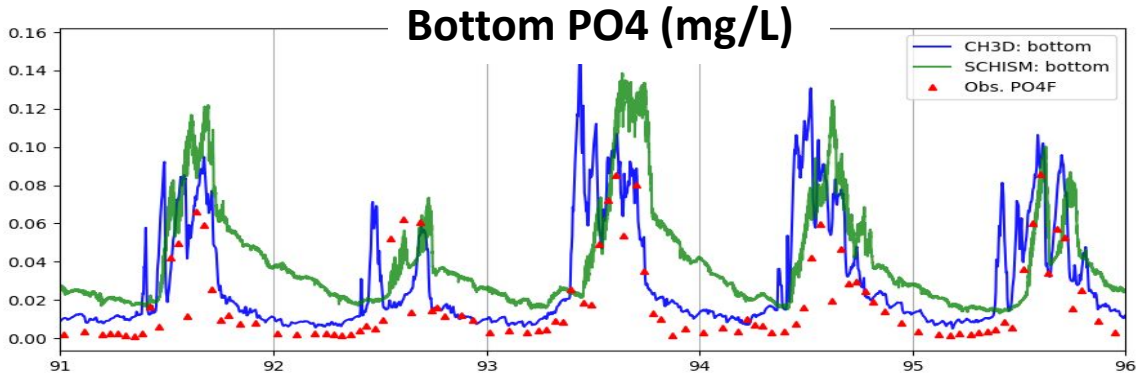








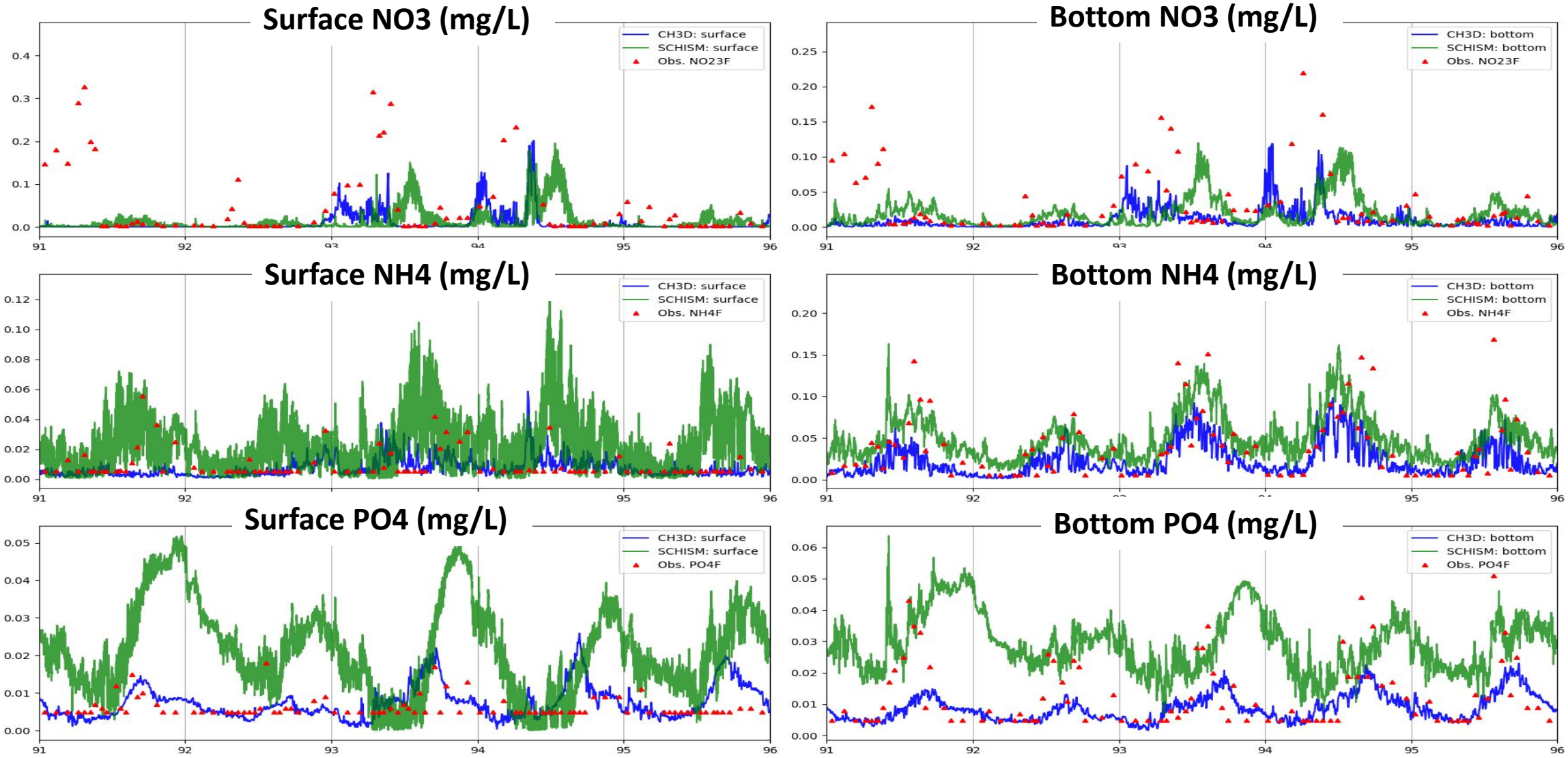




Dissolved Inorganic Nutrients @CB6.4

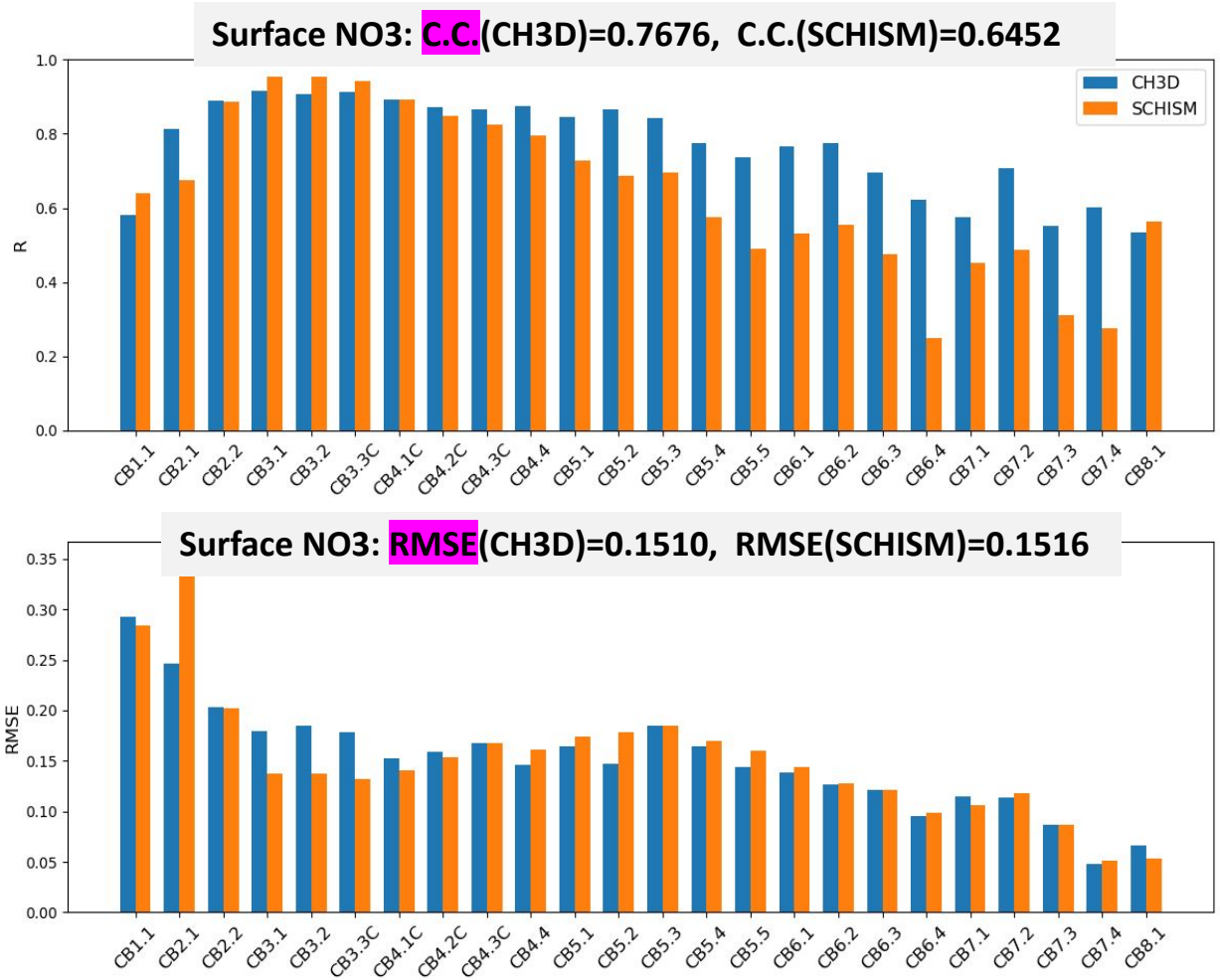
CH3D SCHISM

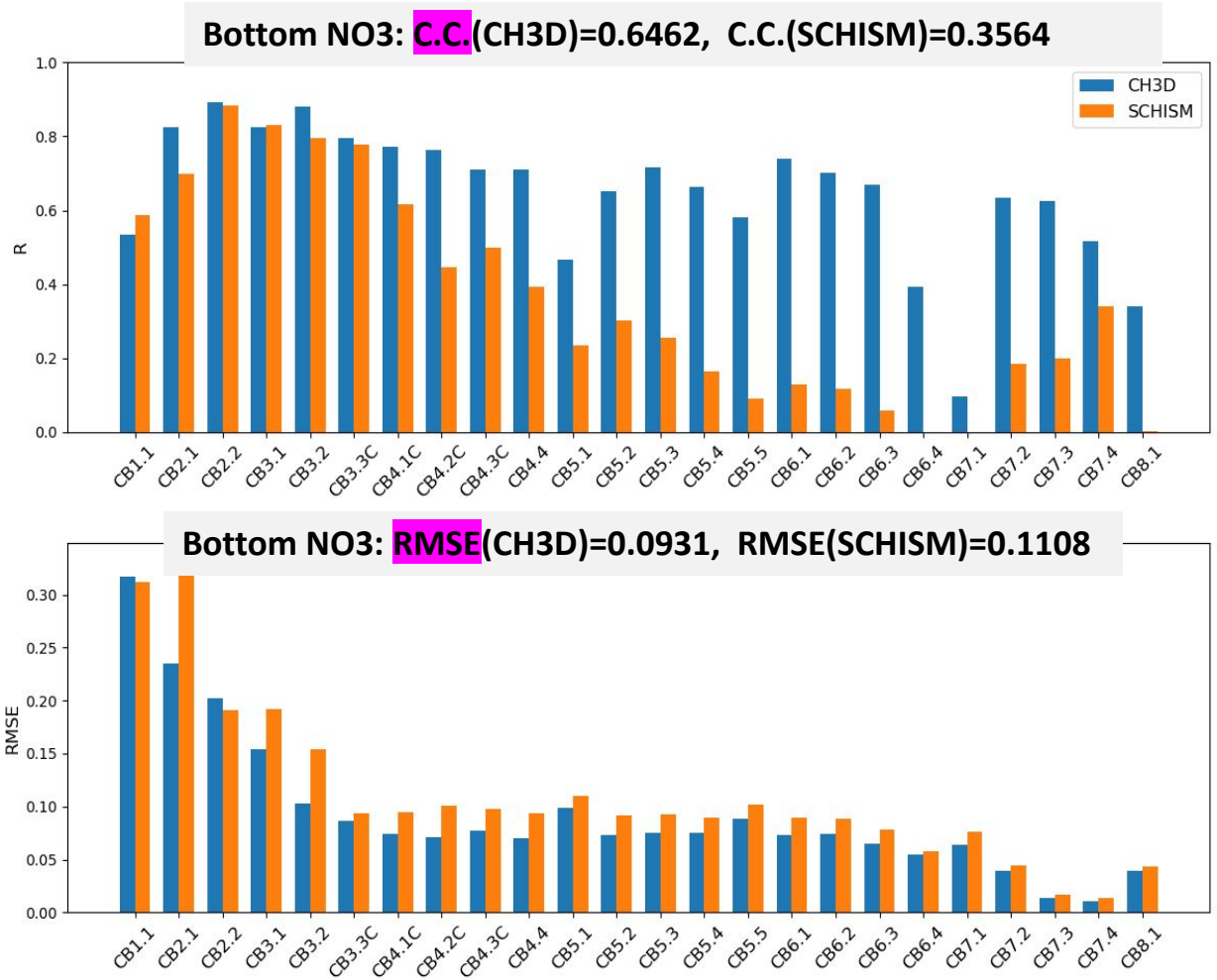
- In general, SCHISM's NO3 and NH4 are reasonable, but overestimated the PO4 at the lower station CB6.4.



NO3: Comparison with CH3D

SCHISM CH3D

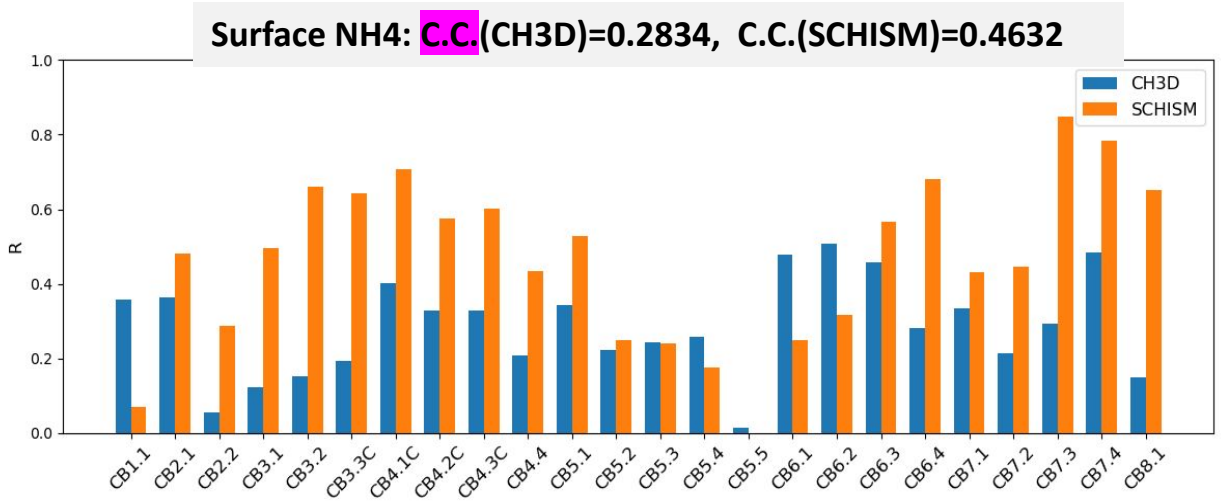


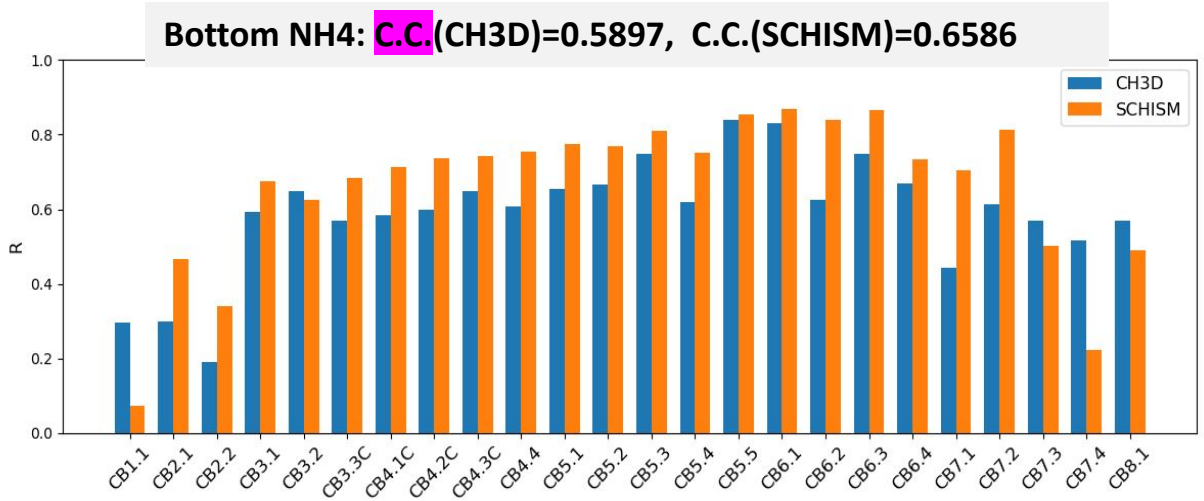


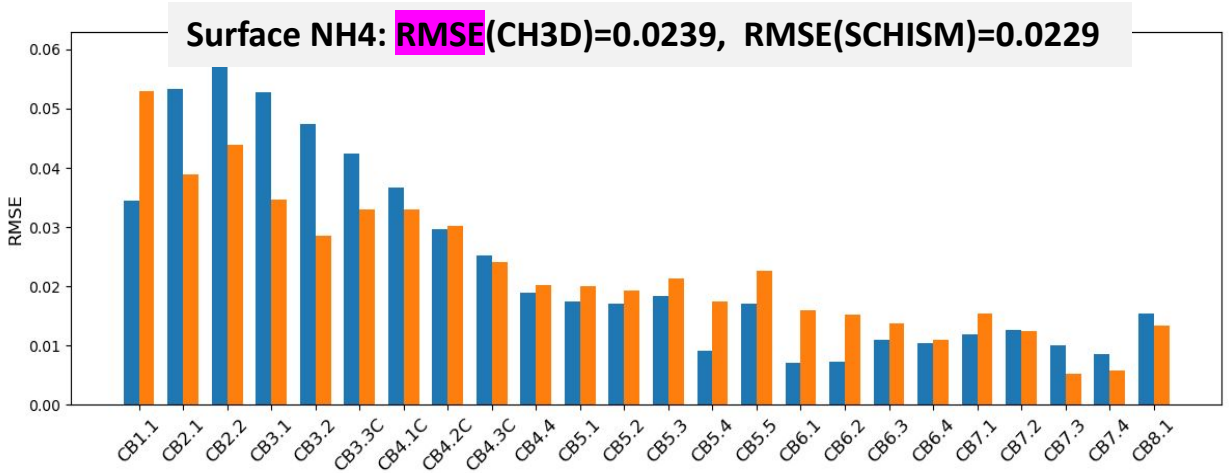
- For surface NO3 simulation, the two models are comparable.
- For bottom NO3, SCHISM needs improvements in the mid and lower bay.

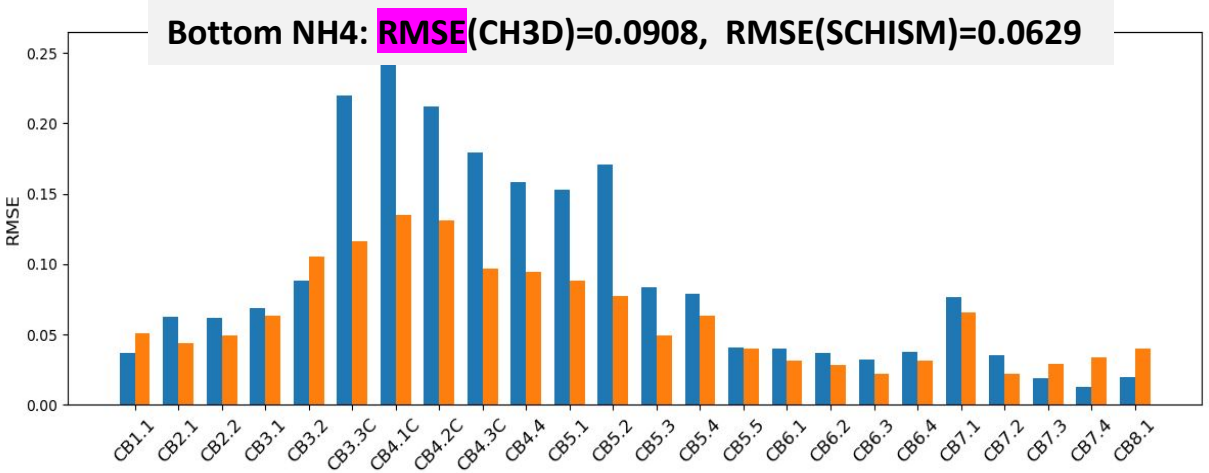
NH4: Comparison with CH3D

SCHISM CH3D







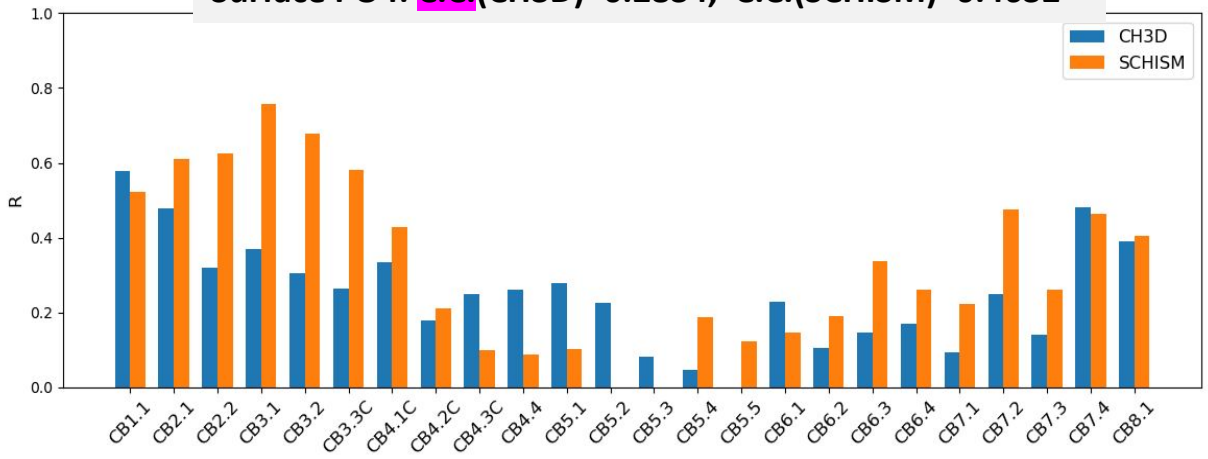


- In general, the model skills for the NH4 simulation between the two model are similar.
- SCHISM has slightly better performance for NH4.

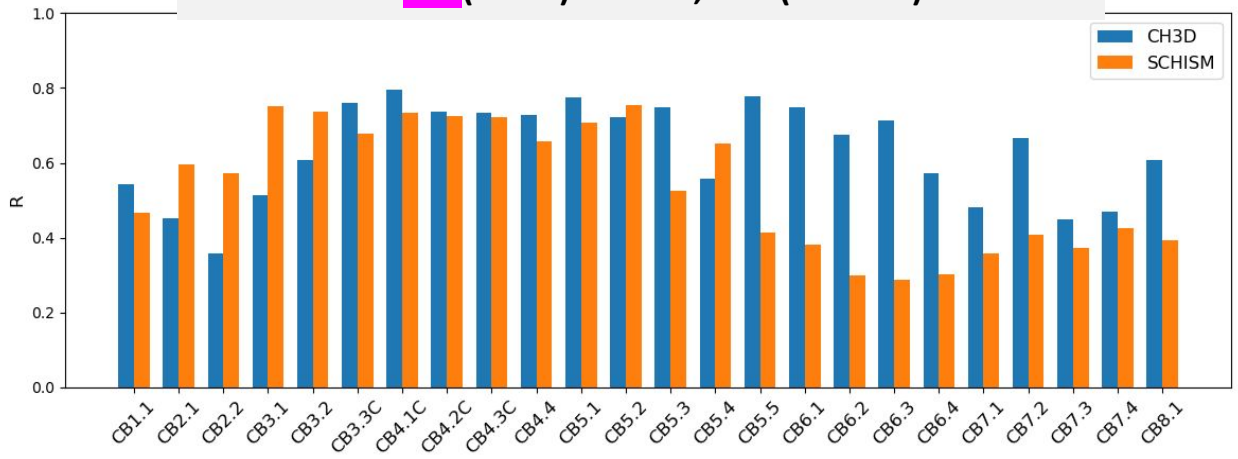
PO4: Comparison with CH3D

SCHISM CH3D

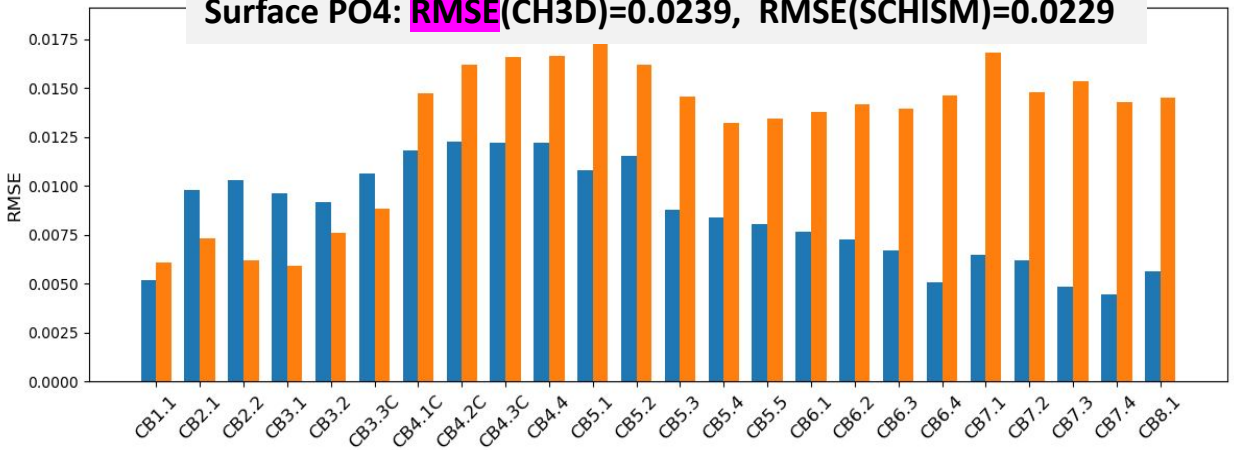
Surface PO4: C.C.(CH3D)=0.2834, C.C.(SCHISM)=0.4632



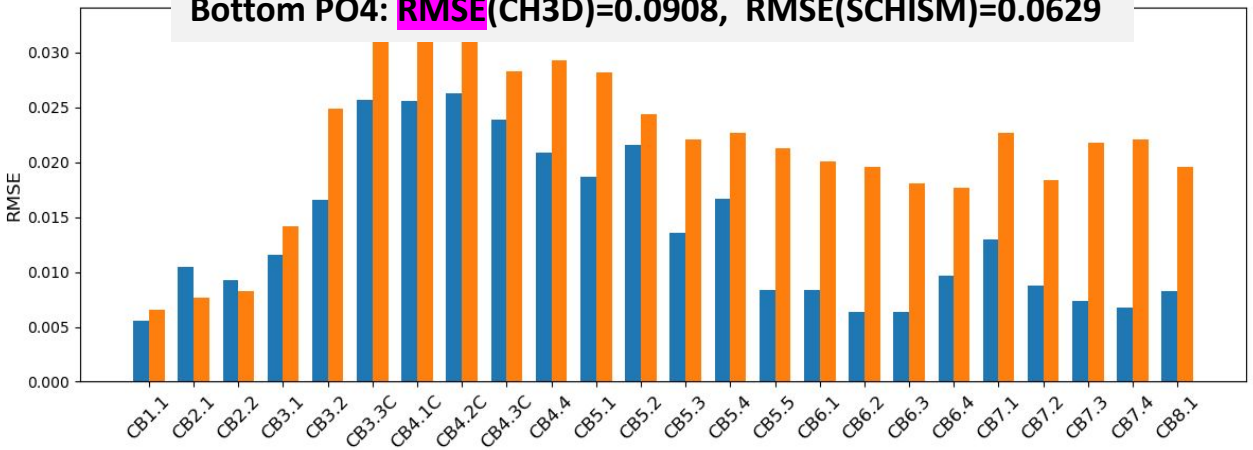
Bottom PO4: C.C.(CH3D)=0.5897, C.C.(SCHISM)=0.6586



Surface PO4: RMSE(CH3D)=0.0239, RMSE(SCHISM)=0.0229



Bottom PO4: RMSE(CH3D)=0.0908, RMSE(SCHISM)=0.0629

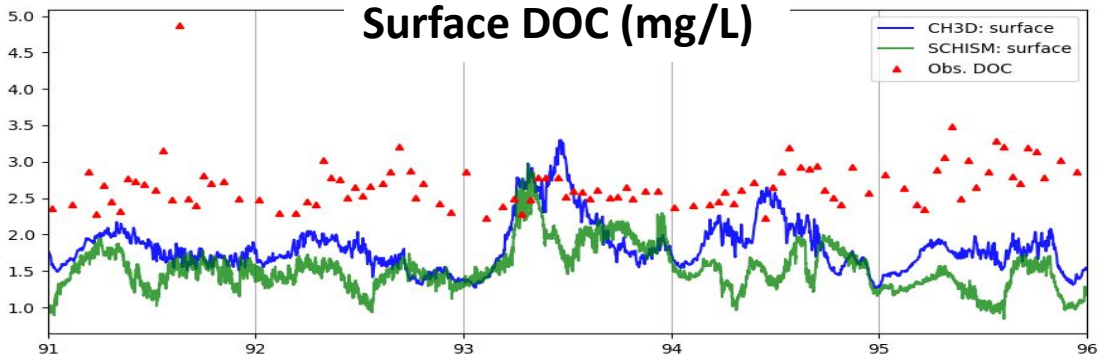


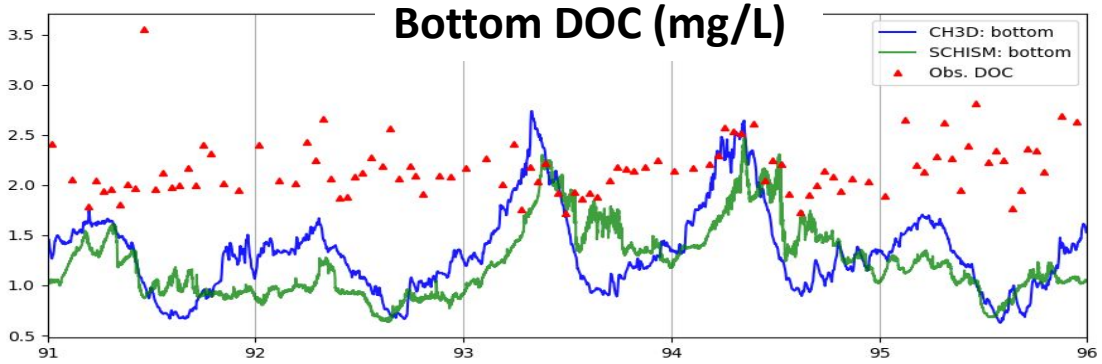
- In general, CH3D has a higher skill of PO4 than SCHISM.
- Needs to work on the over-estimation of PO4 in SCHISM.

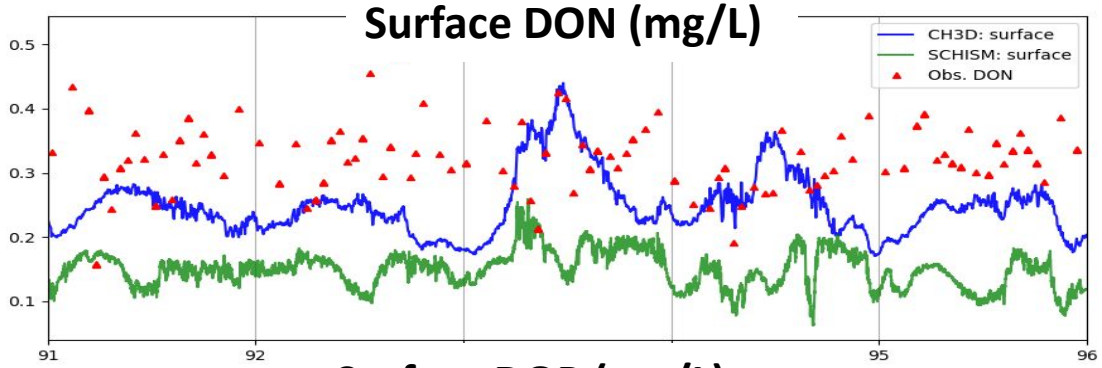
Dissolved Organic Matter @CB4.3C

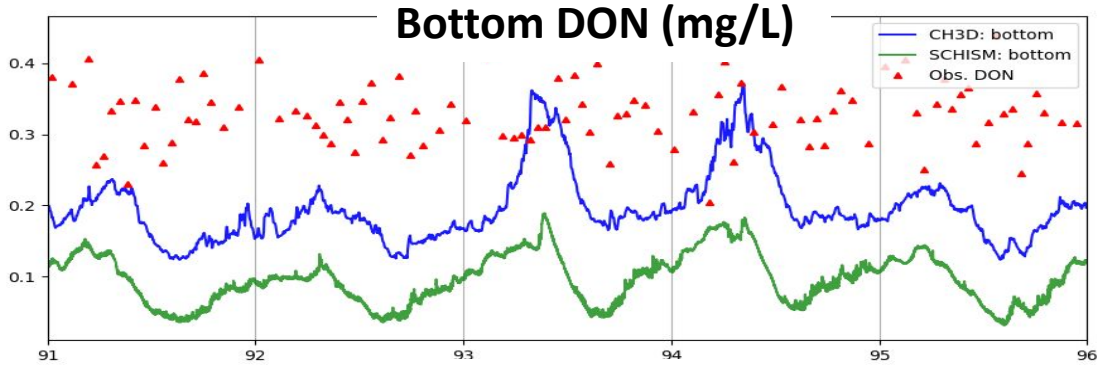
CH3D SCHISM

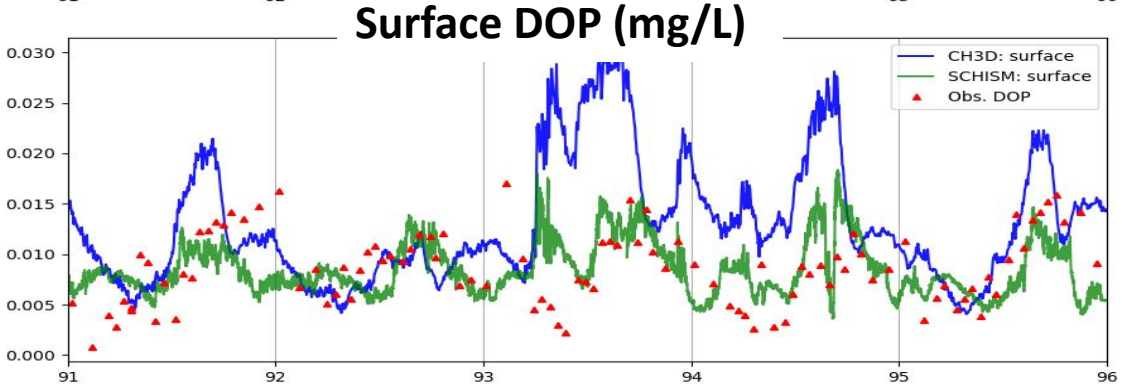
- In general, the simulation of DOM is not satisfactory, and needs further improvements.
- DOM from both models tends to bias low.
- Similarly for other stations.

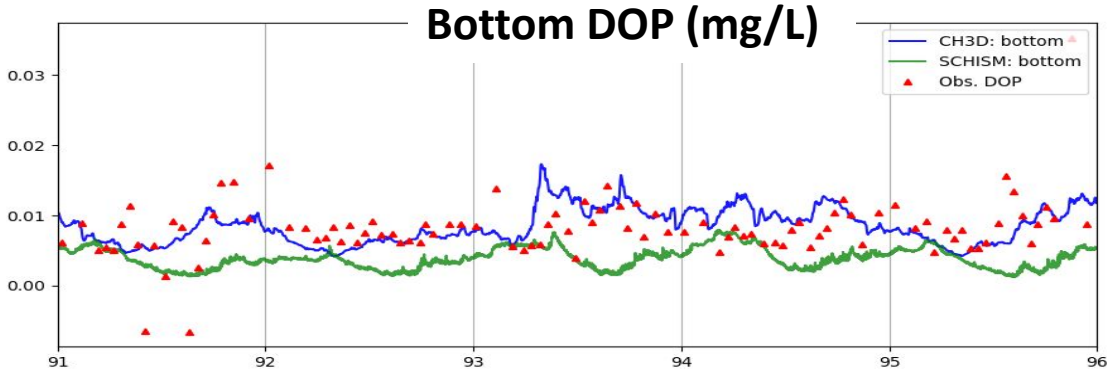








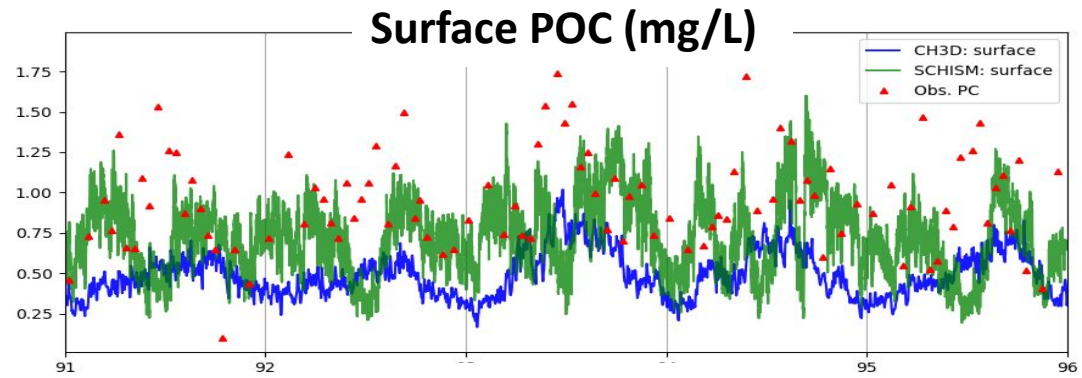


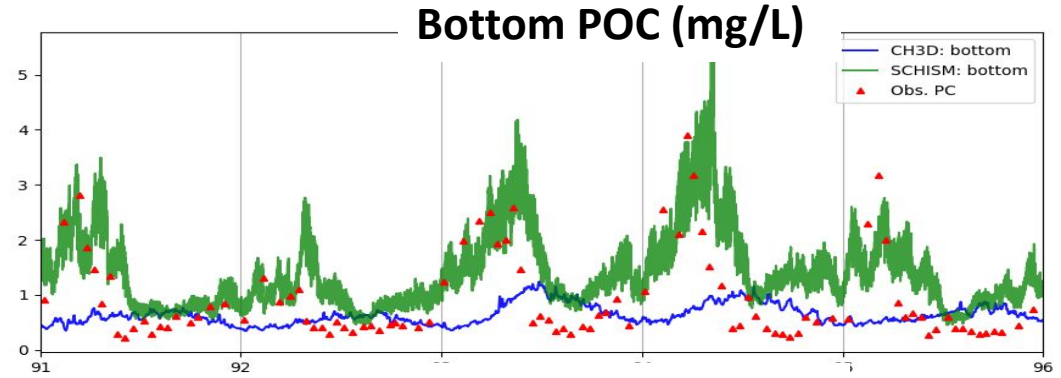


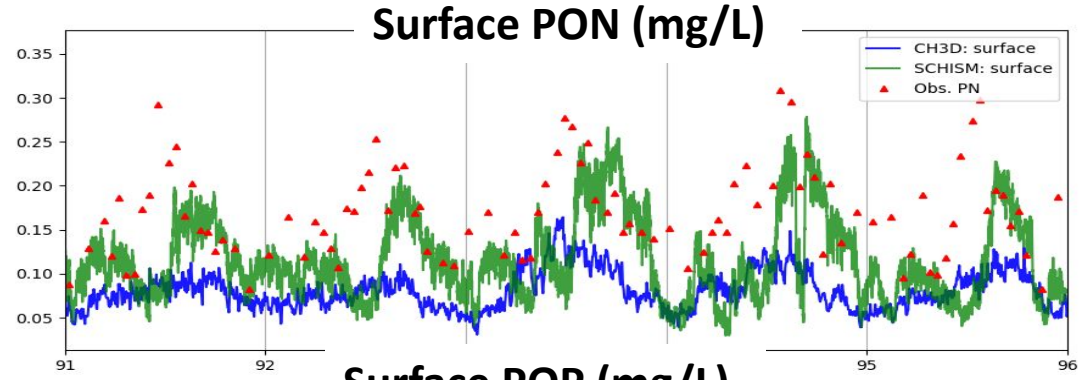
Particulate Organic Matter @CB4.3C

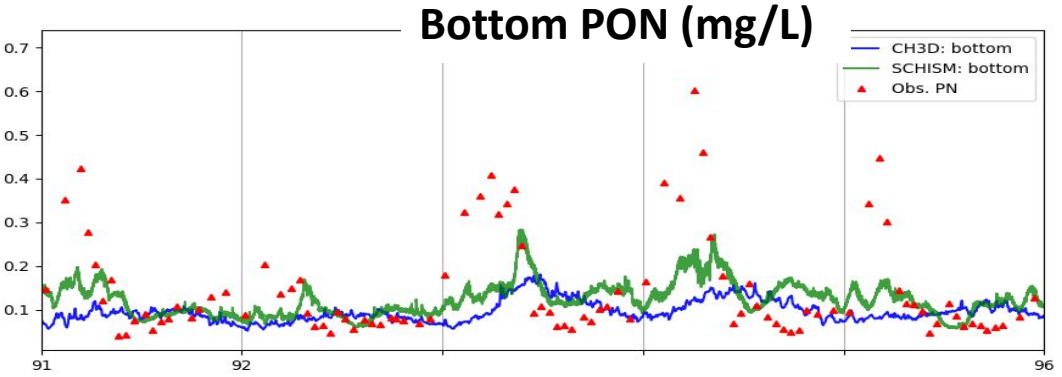
CH3D SCHISM

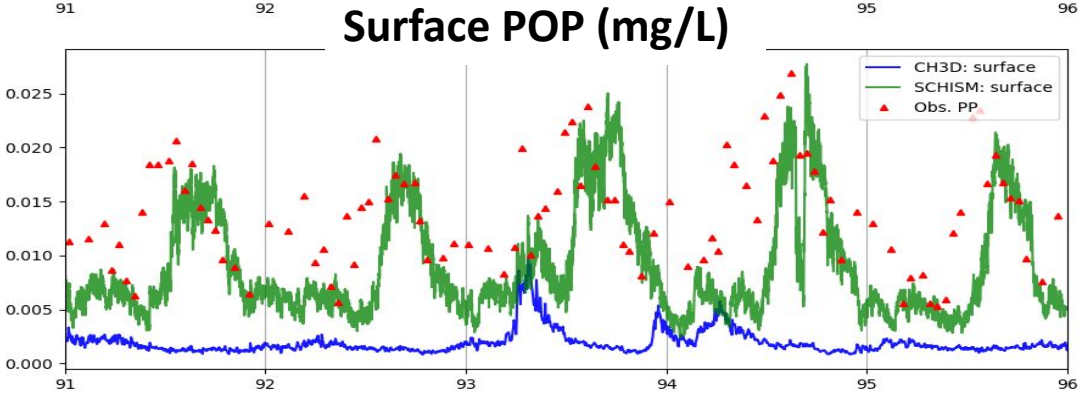
- Overall, POM from SCHISM is better than CH3D regarding the magnitude.
- Some improvement is still needed

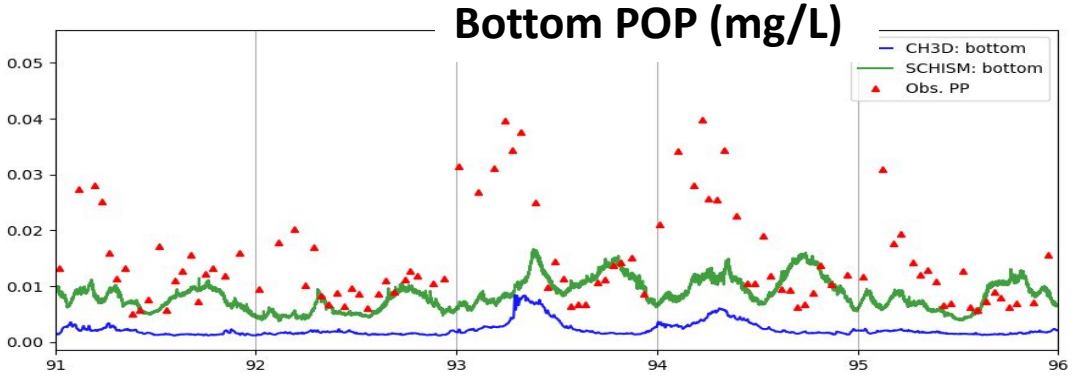












Summary

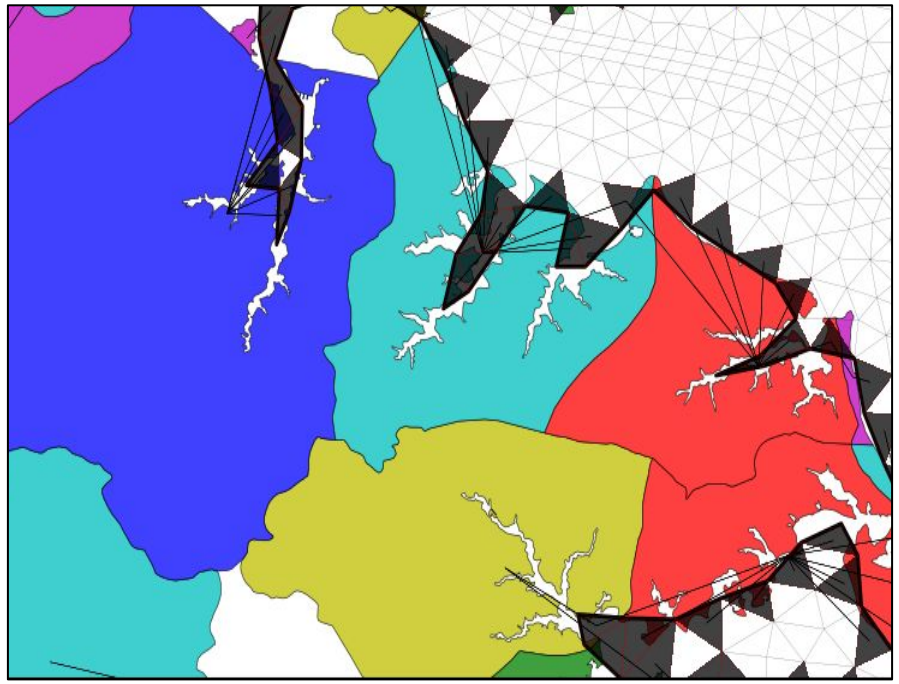
- We have successfully finished the 1st round of model calibration.
- The preliminary results of MBM (version zero) were compared with CBP observation as well as current bay model (CH3D-ICM).
  - In general, the SCHISM model performance is comparable to CH3D, but still needs further improvements in several aspects.
- The python based workflow proved instrumental in speeding up the calibration process.
- Next step
  - Further improve some ICM variables (CHLA, DO, and nutrients).
  - Add shoreline erosion, atmospheric loading
  - Add wetland, SAV, oyster, etc.

MBM Setup: Watershed Loading

P6 watershed loading (NPS, PS) was applied. Shoreline erosion and atmospheric loading will be added next.

- We developed an algorithm that can automatically maps watershed segments to their neighboring SCHISM elements along the land boundary.
- It can easily accommodates future revisions of SCHISM grids and watershed segments.
- High-resolution SCHISM grid and watershed segments are preferred.

Watershed Mapping



Polygon of colors represents watersheds, and black triangles are SCHISM grid along the land boundary.

Watershed flow distribution (m^3/s)