MBM progress on nutrient and Chl-a simulation

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Outline

- ❑ Anomalous loading issue: redistribution of nutrient loading over time
- ❑ Improvement of MBM simulation on nutrients and chl-a
- ❑ Summary of latest MBM model skill scores
- ❑ Future work

Nutrient Loading Smoothing

(**Mass Conservative redistribution**)

Step 1

Add base flow ($1x10^{-3}$ m^3/s) when original flow rate is zero but loading is non-zero.

Step 2

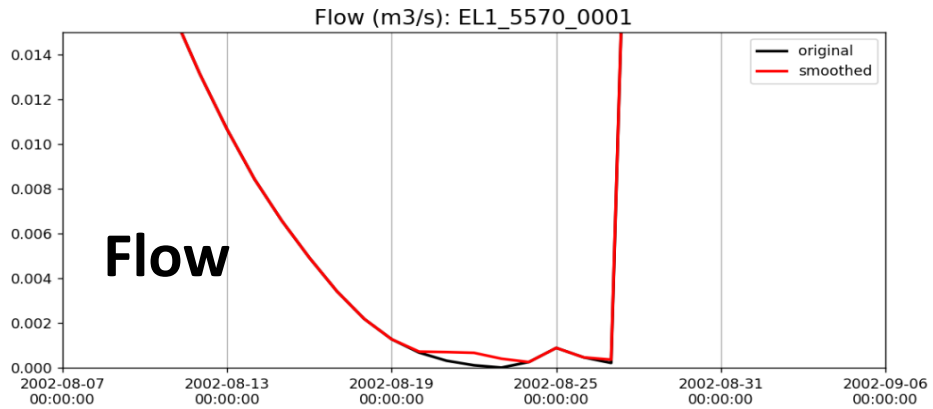
Identify abnormally high nutrient concentrations. Check the total flow within one month around the high concentration points. Redistribute the loading over time, based on the flow rate to bring down the concentration.

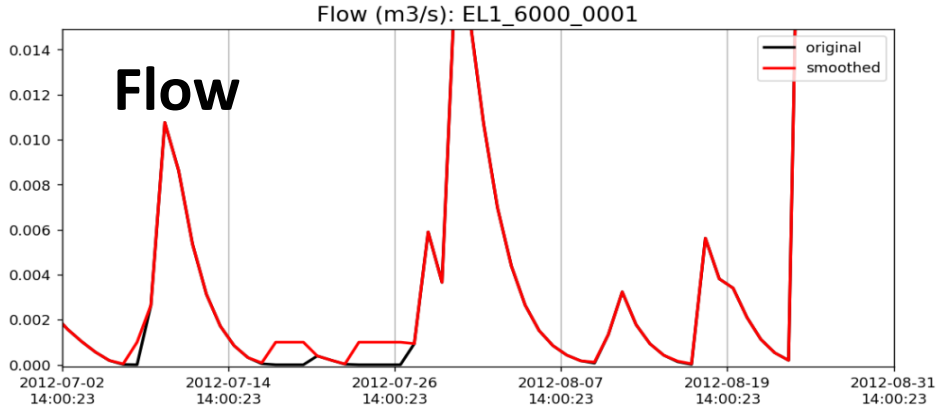
Step 3

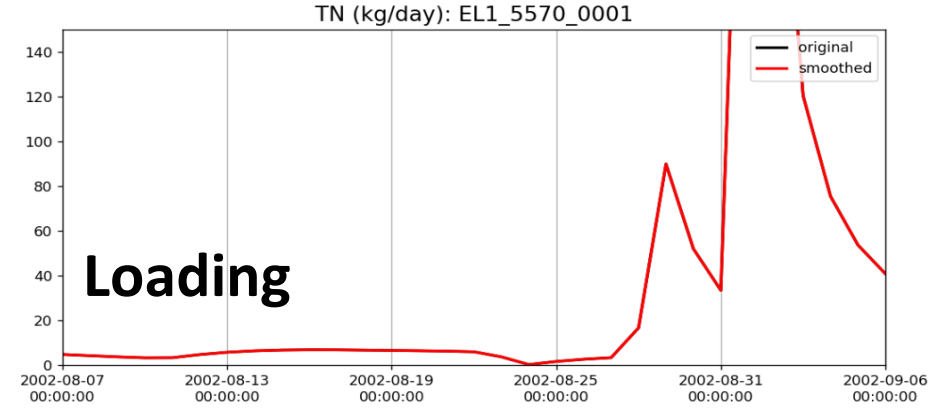
If Steps 1&2 are still not sufficient, then add a small amount of extra flow to reduce the concentration to within user-specified limits

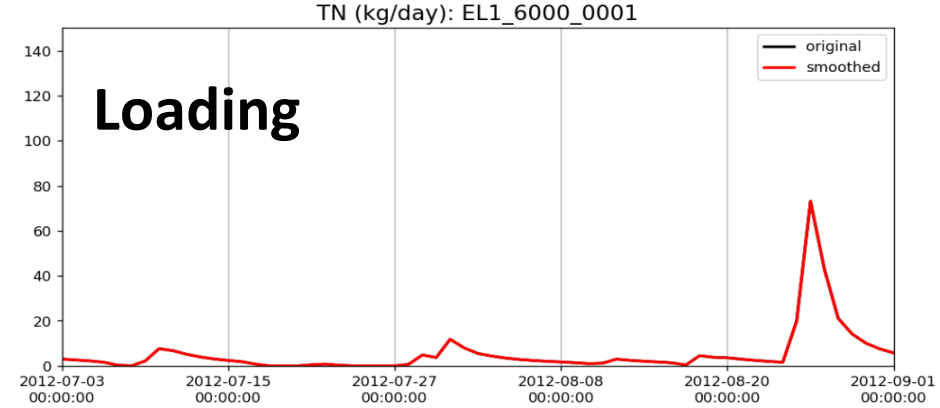
Example of Step 1: adding base flow to fix the high concentrations

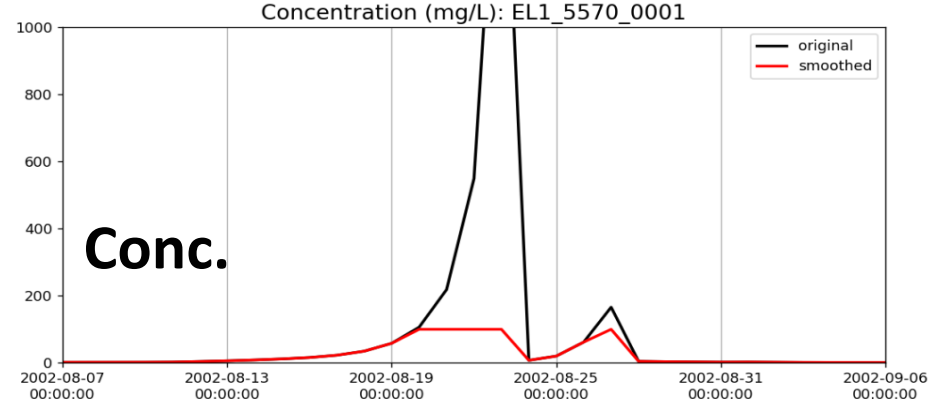
Original
Smoothed

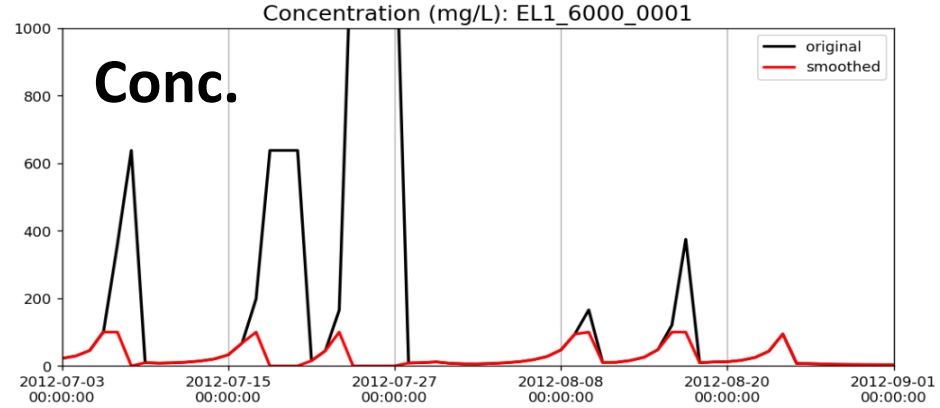




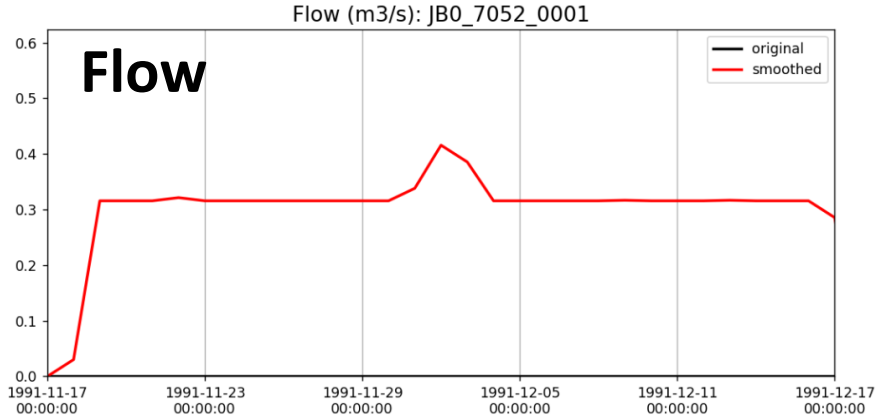


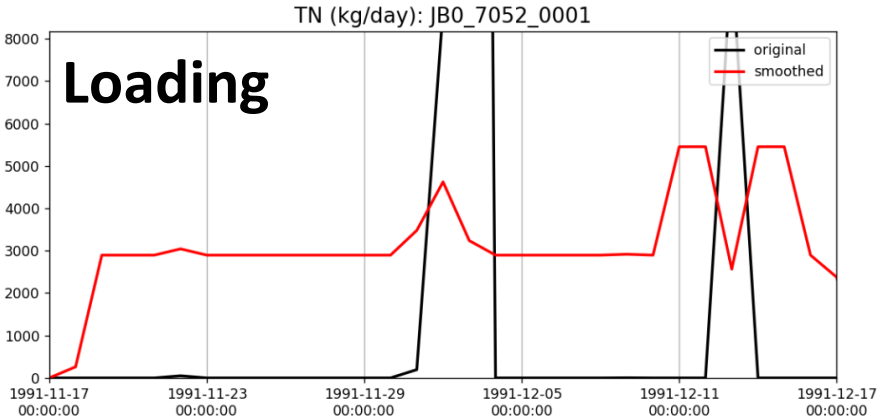


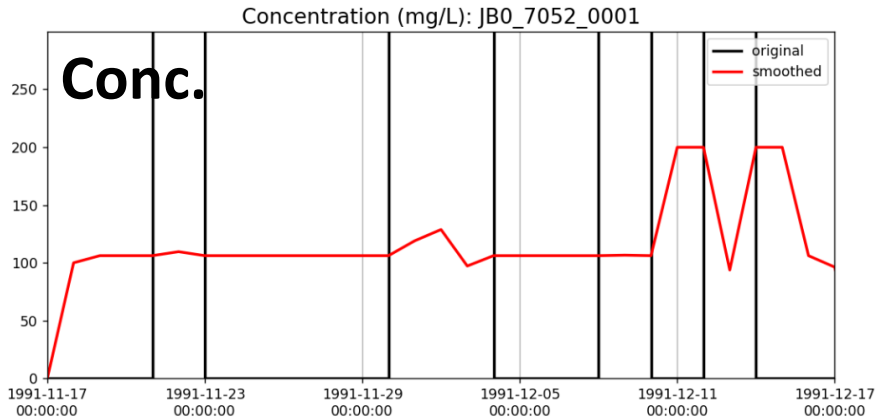


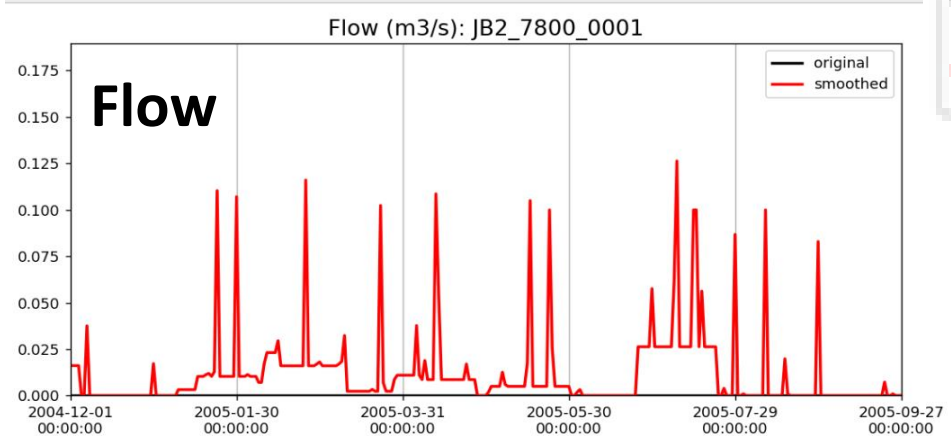


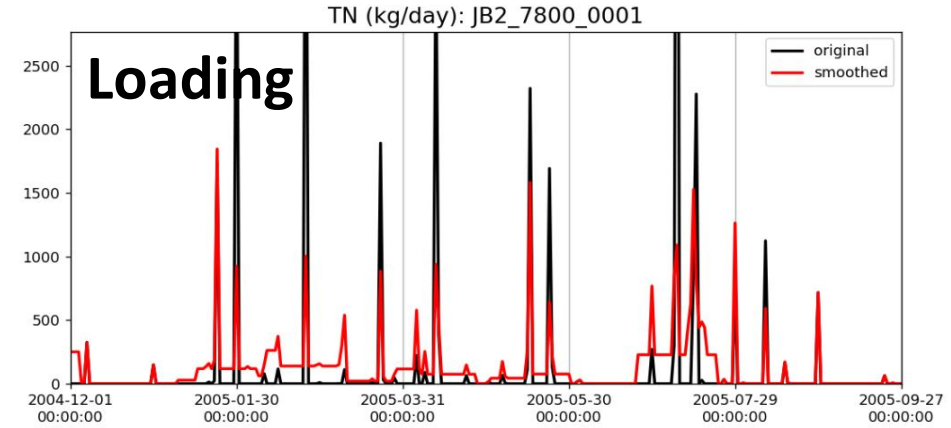
Example of Step 2: redistribution of nutrient loading in time



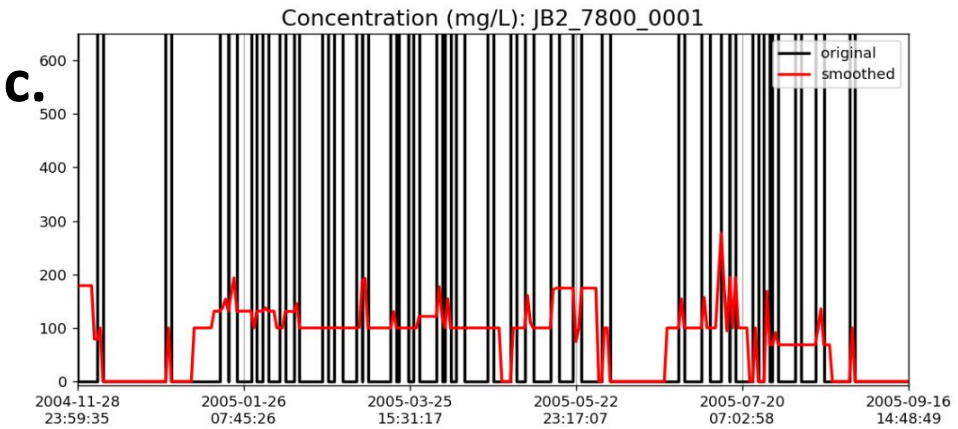








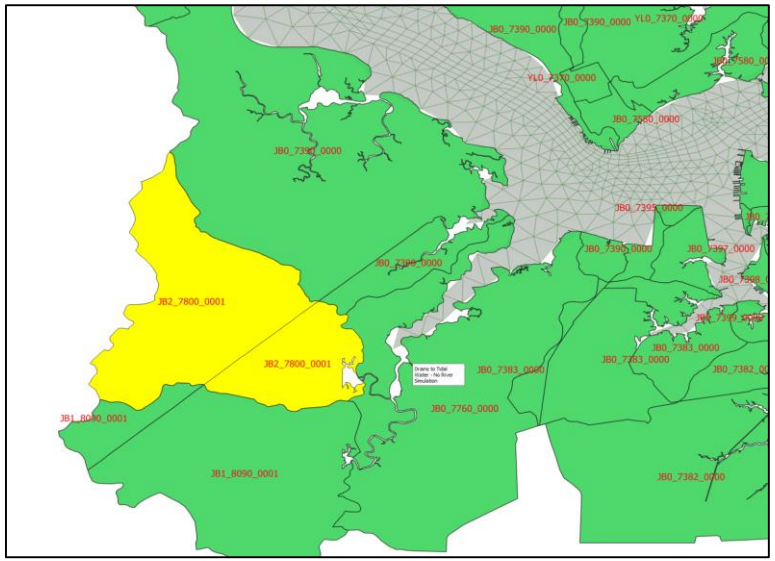
Conc.



Step 3: changes in flow rate (NPS)

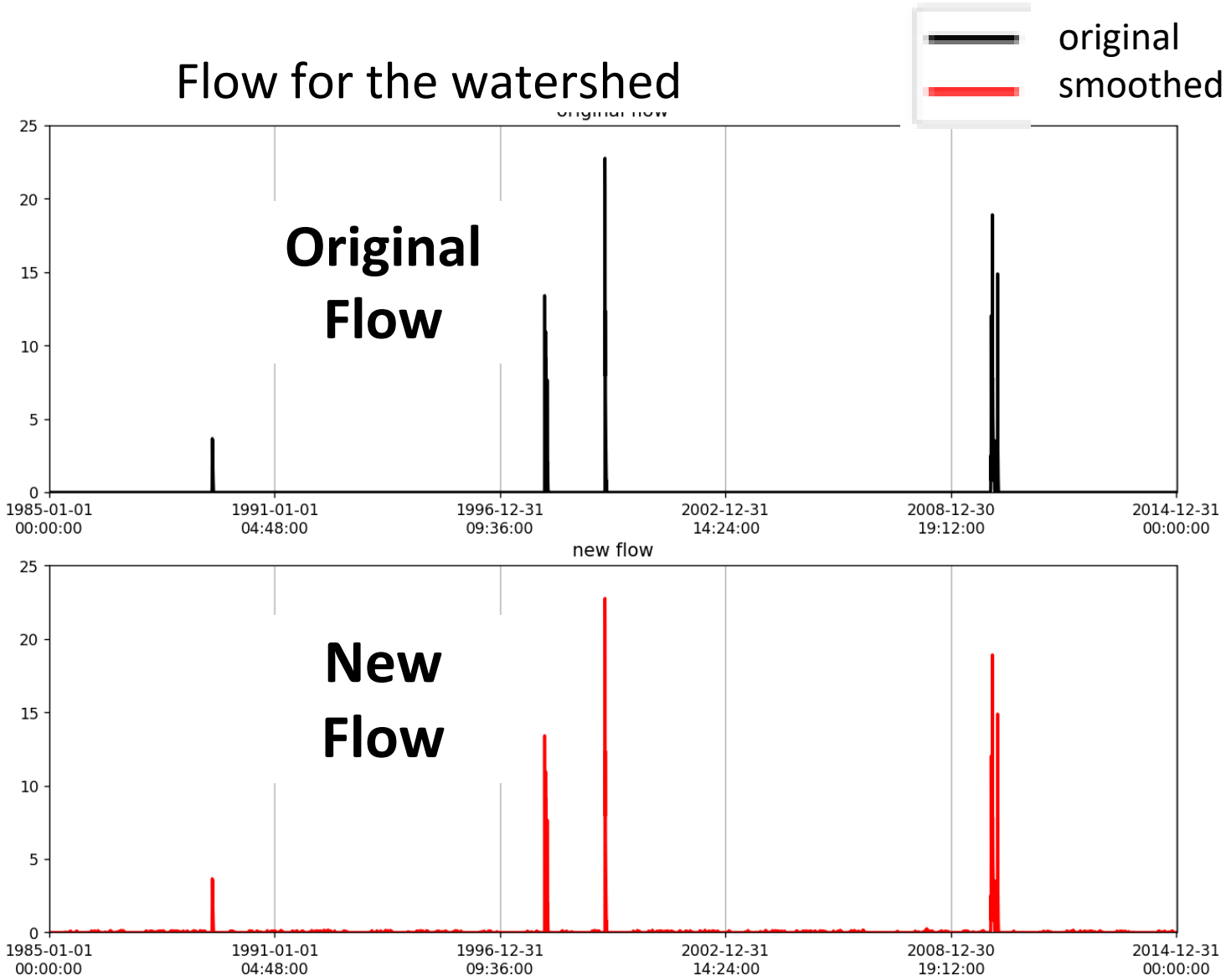
- About 146 m^3/s flow is added to 2.16×10^7 m^3/s for total 30-year data

The largest change (98.4 m^3/s over 30 years on top of base flow of 436.9 m^3/s) comes from one watershed



(Extreme Case)

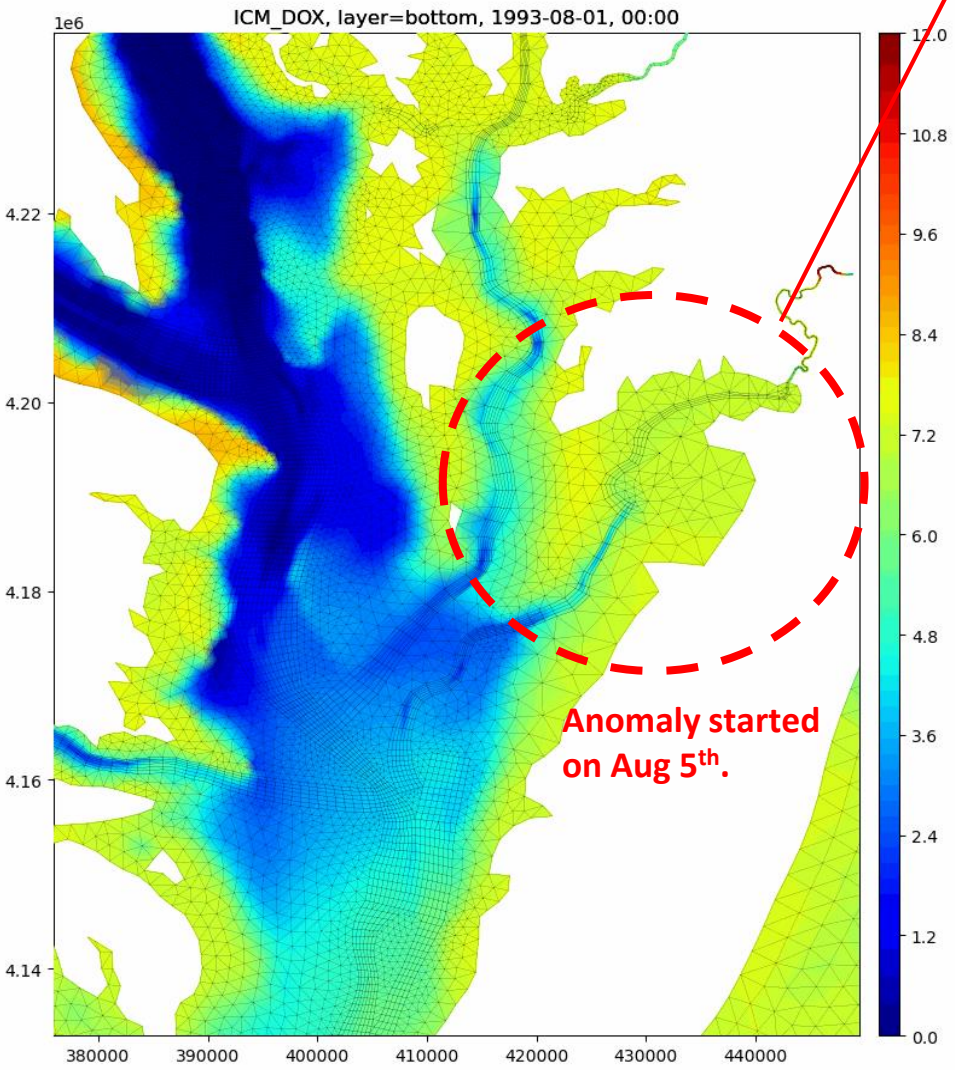
Flow for the watershed



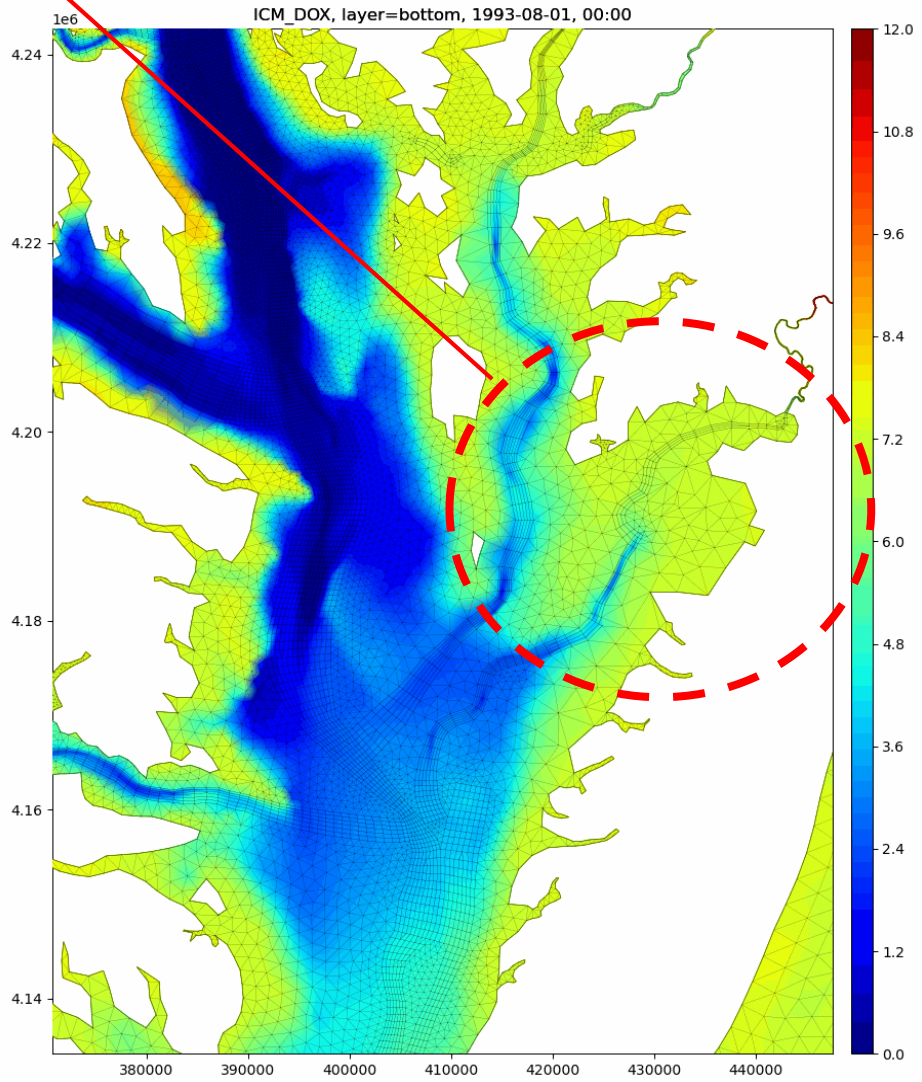
Bottom DO simulation in August, 1993

- After fixing the anomalous loading of DOC, DO in shallow region becomes reasonable

Before Correction

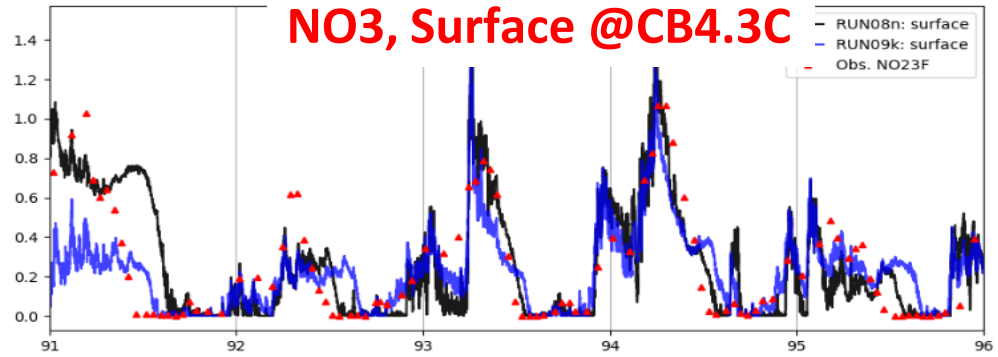


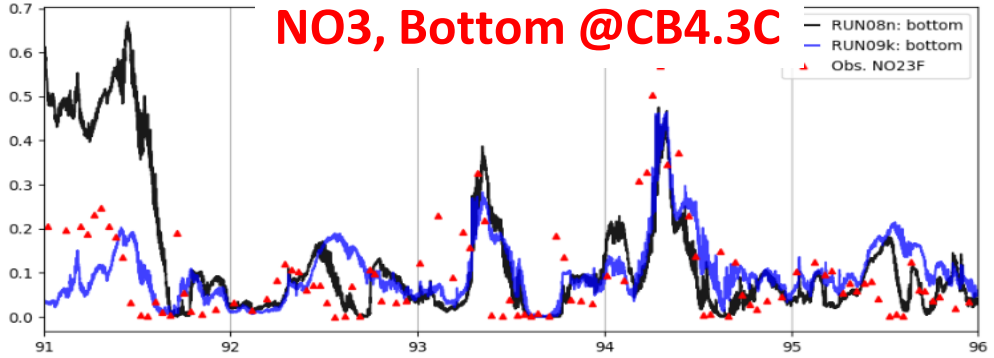
After Correction

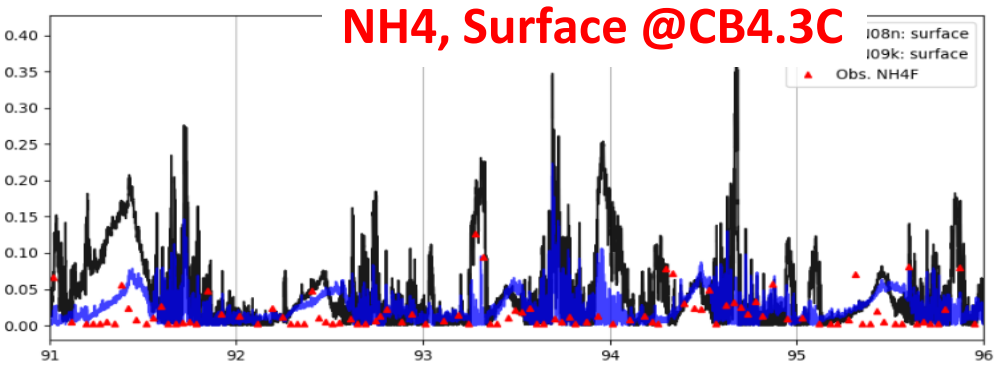


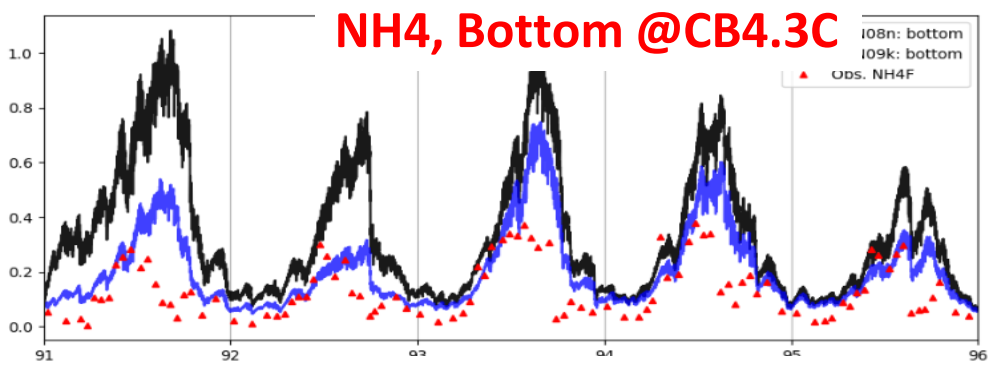
Improvement on dissolved inorganic nutrients

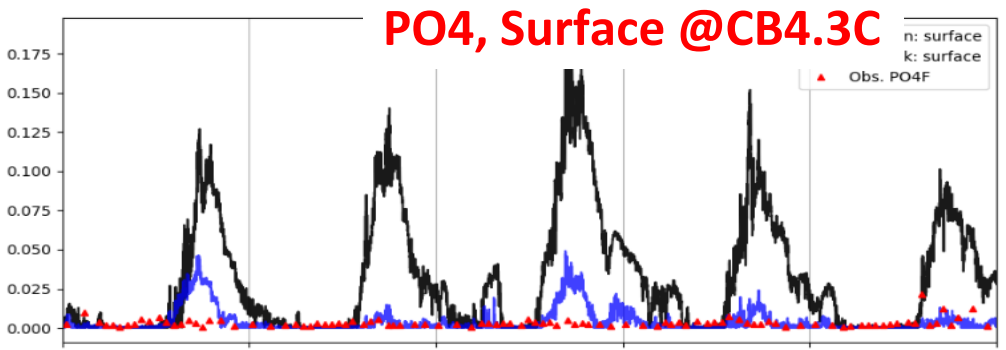
- The simulation of NH4 & NO3 was improved by tuning the nutrient dynamics (e.g decay rate). The large bias in previous simulation was reduced.
- PO4 was also significantly improved by tunning the sediment PO4 release. For bottom PO4, the model get both the seasonal variation and magnitude correct. For surface PO4, the simulation was reasonable, but with some bias.

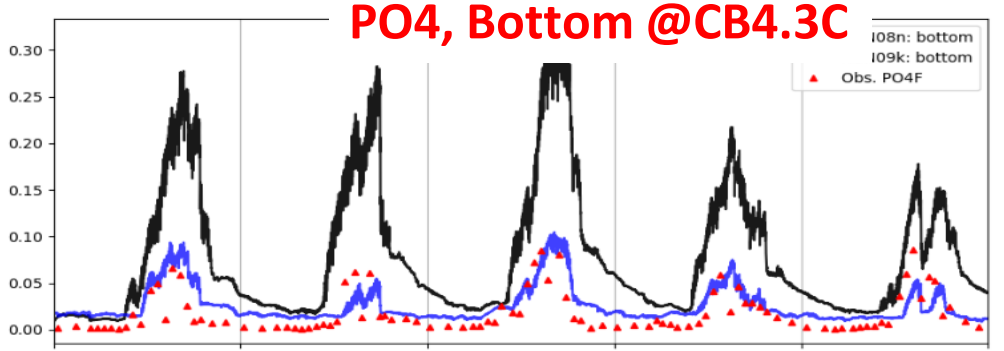










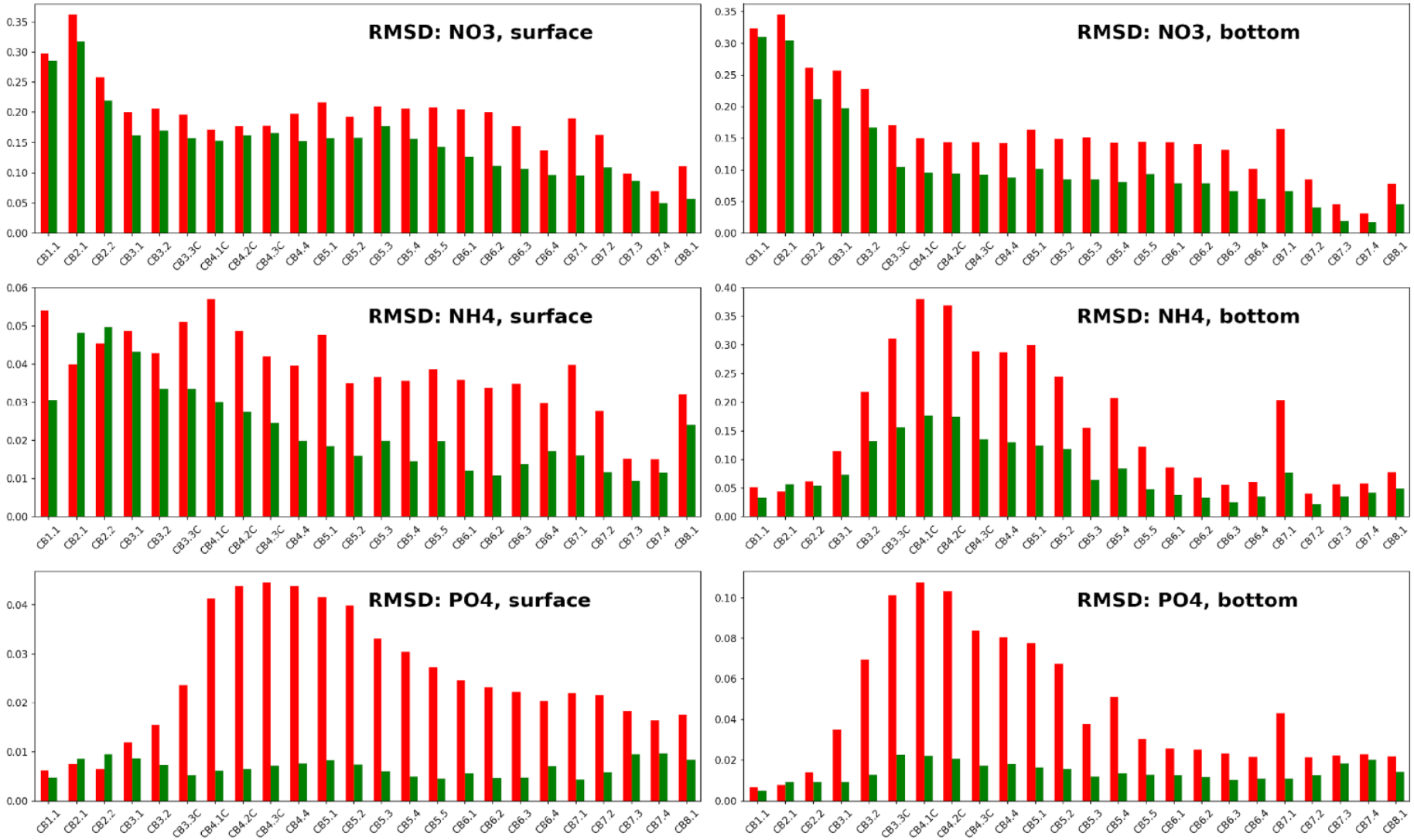


Last Quarterly

Present

Improvement on dissolved inorganic nutrients

- The model scores (RMSE) are improved for NO3, NH4 and PO4 at all stations.



Last Quarterly

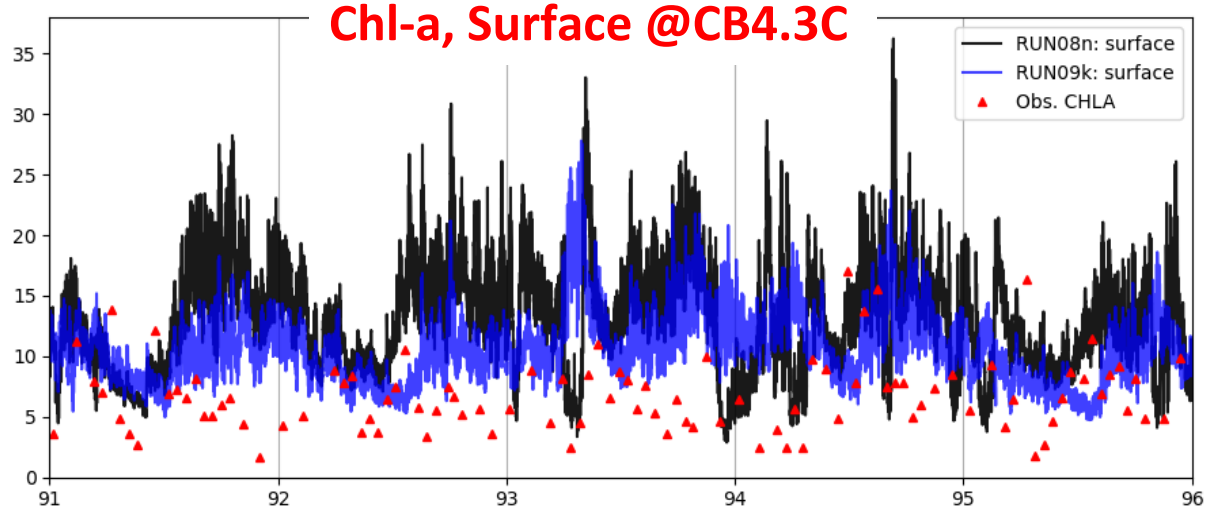
Present

Improvement on Chl-a

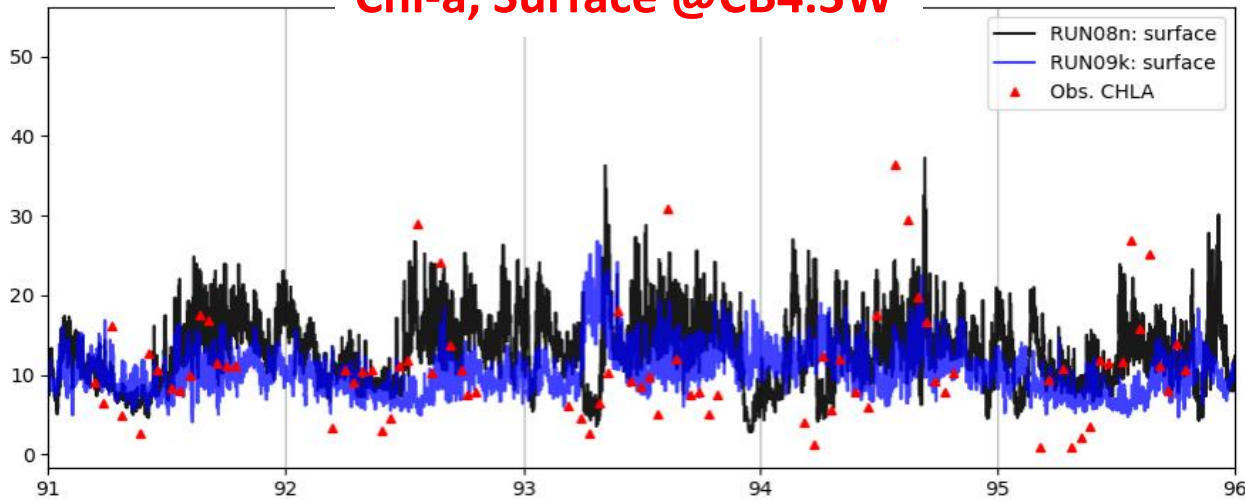
- Simulation of bottom Chl-a is improved with better nutrient simulation
- Seasonal cycle and spring blooms are better simulated

Last Quarterly
Present

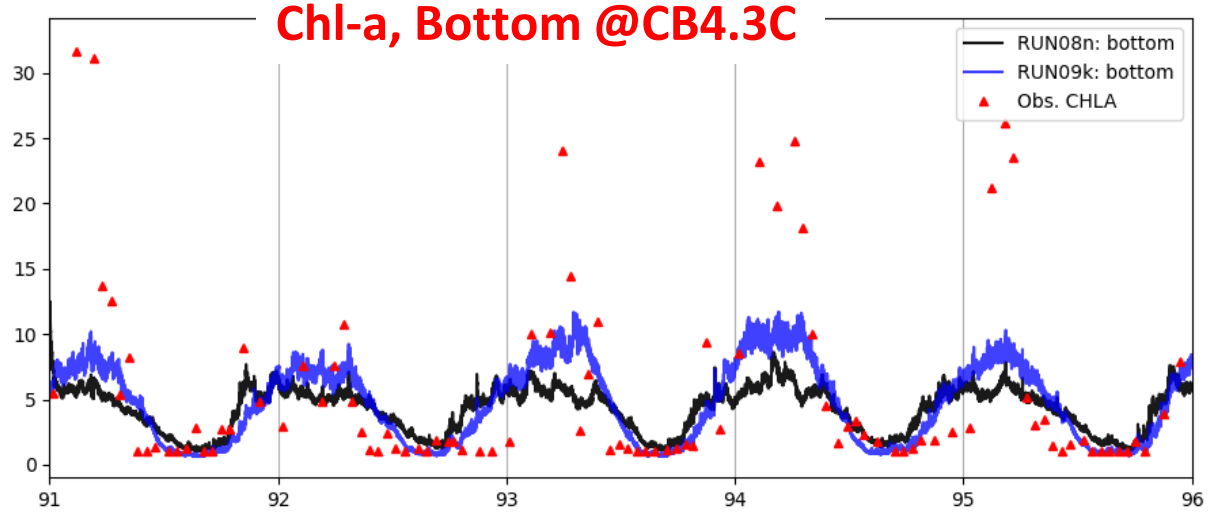
Chl-a, Surface @CB4.3C



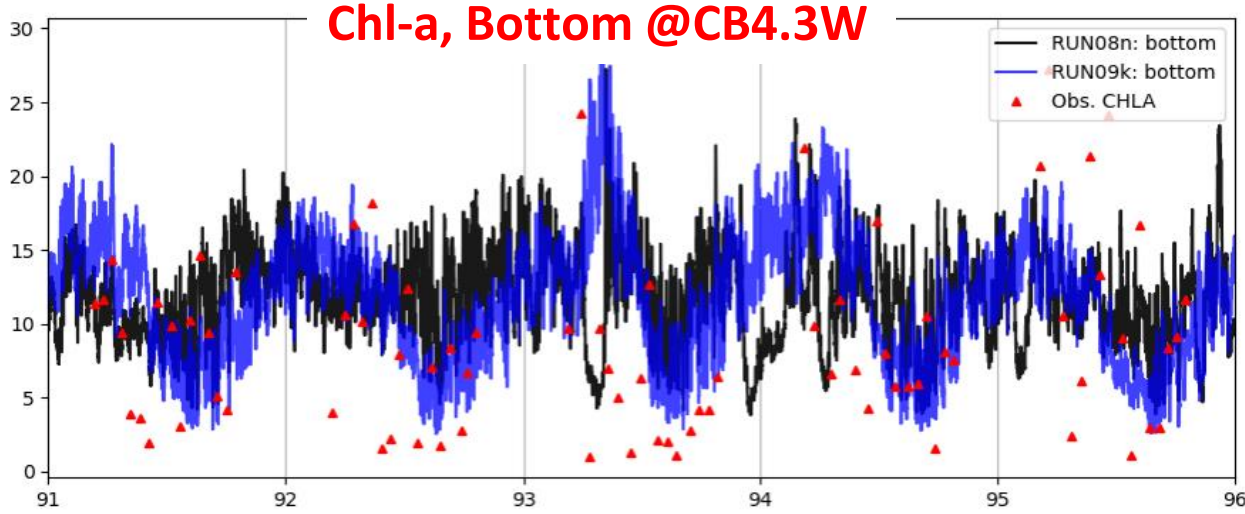
Chl-a, Surface @CB4.3W



Chl-a, Bottom @CB4.3C



Chl-a, Bottom @CB4.3W

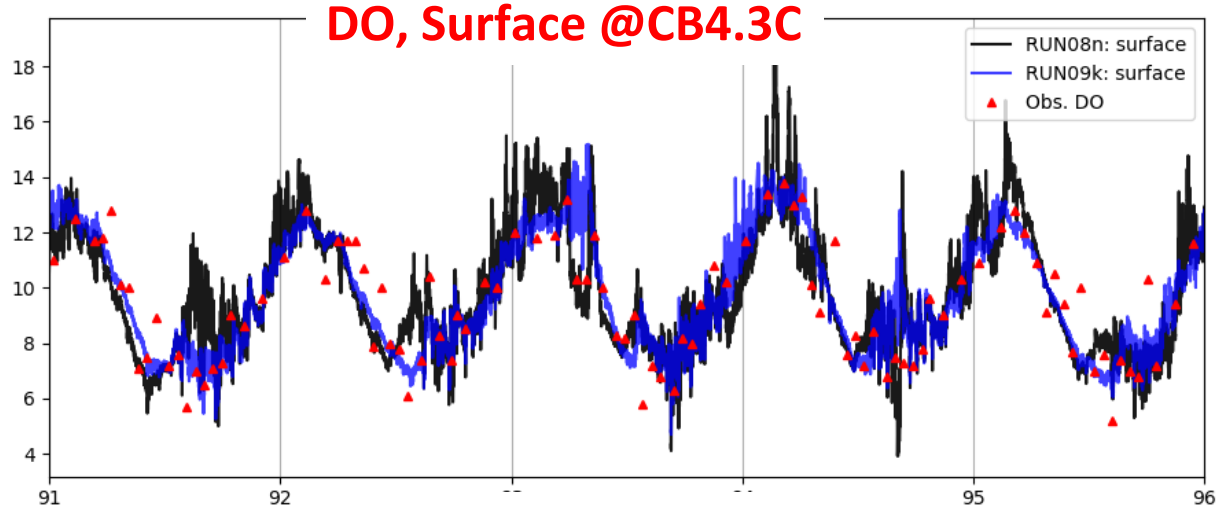


Improvement on DO

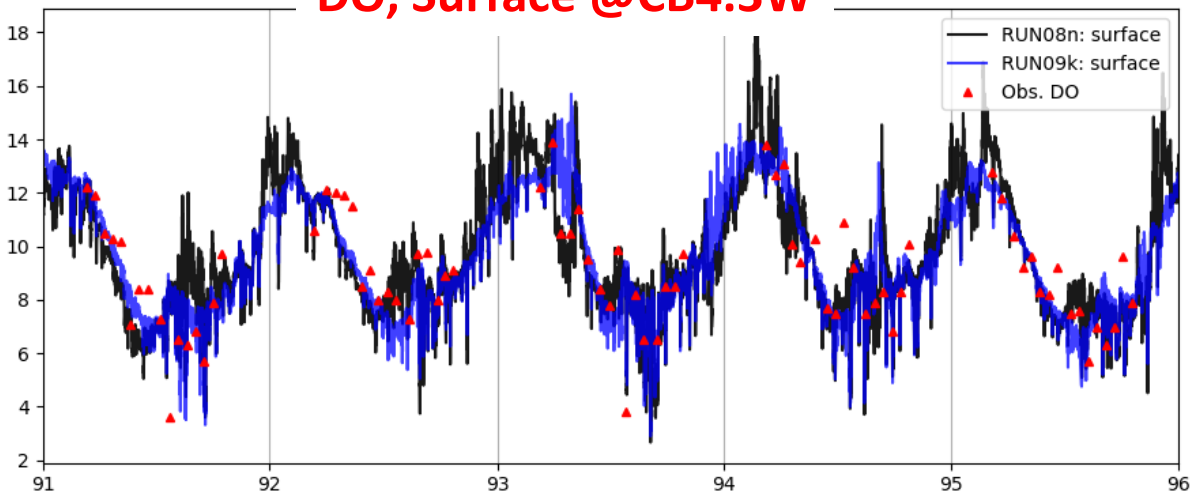
- DO simulation was also improved at both deep and shallow stations due to improvement in nutrients and Chl-a

Last Quarterly
Present

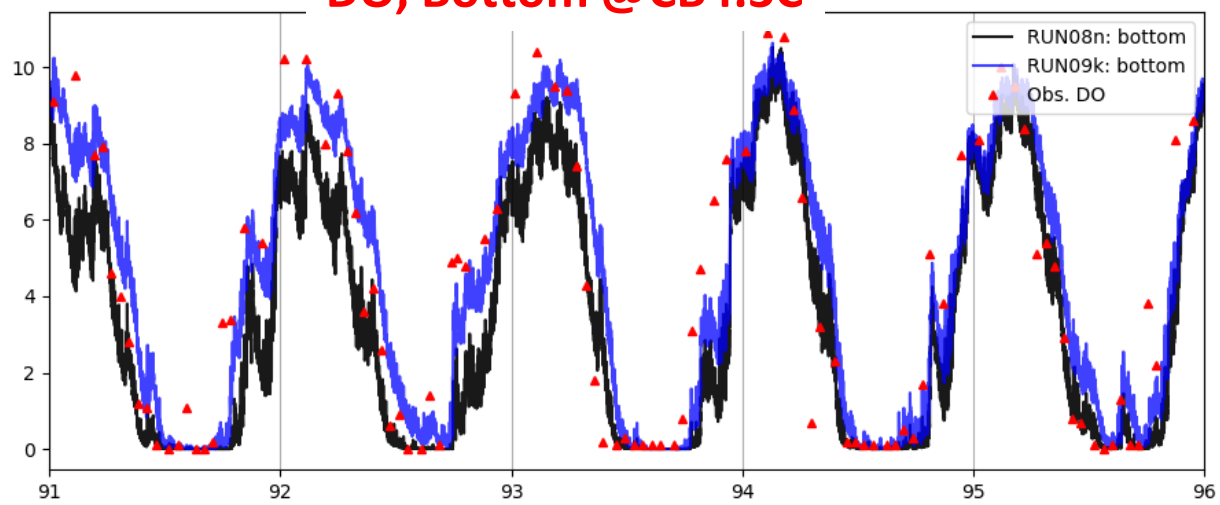
DO, Surface @CB4.3C



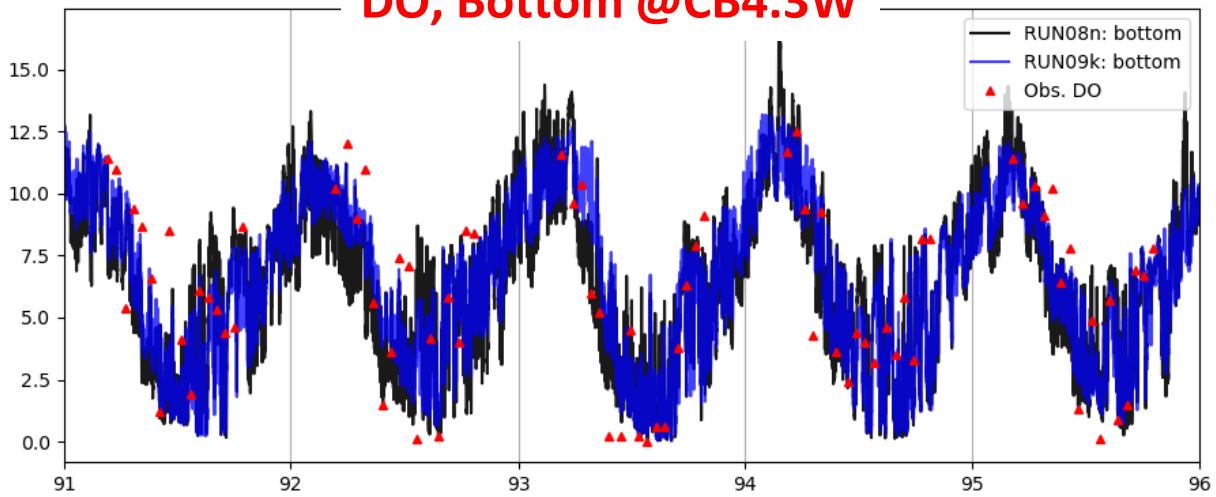
DO, Surface @CB4.3W



DO, Bottom @CB4.3C



DO, Bottom @CB4.3W



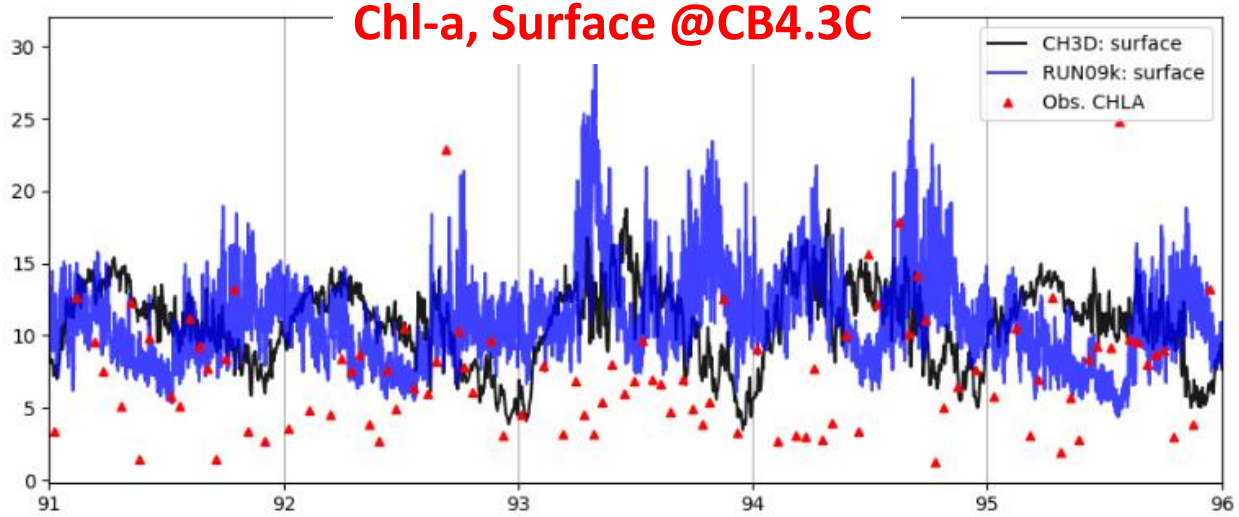
P7 MBM (SCHISM-ICM) model skill assessment, in comparison with P6 MBM (CH3D-ICM)

Comparison of Chl-a and DO

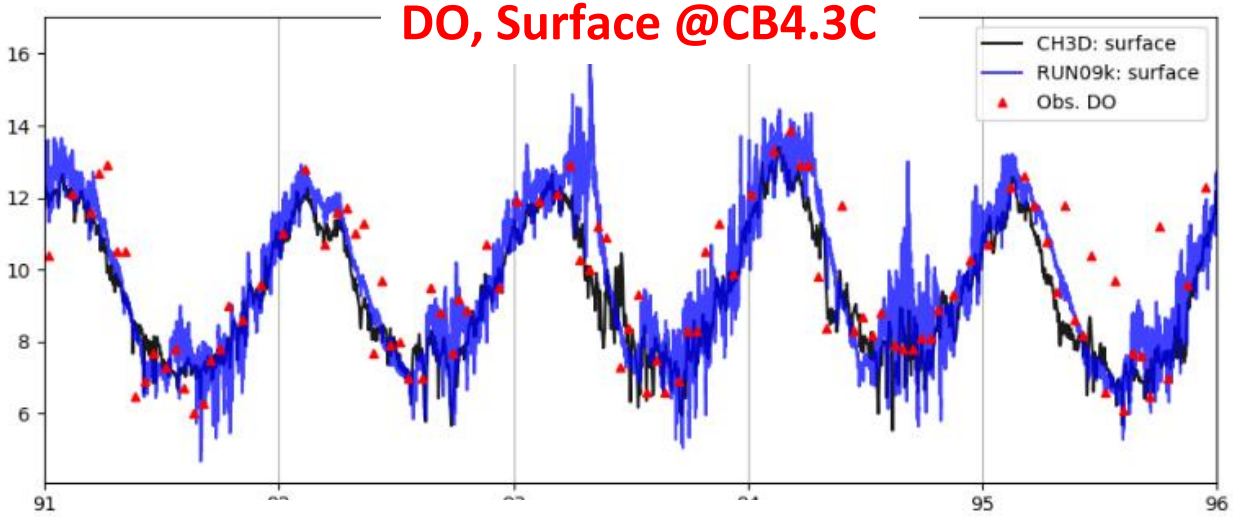
- For surface Chl-a, both models bias high and have larger errors. For bottom Chl-a, both model captured the seasonal pattern.
- For DO, both model did a good job in capturing the hypoxia.

P6 MBM
P7 MBM

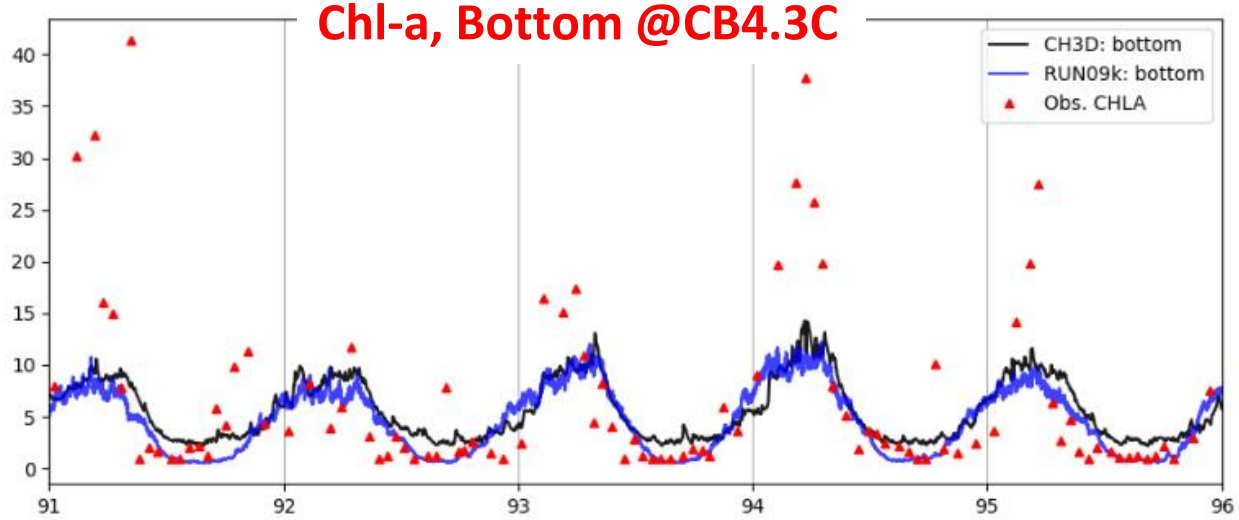
Chl-a, Surface @CB4.3C



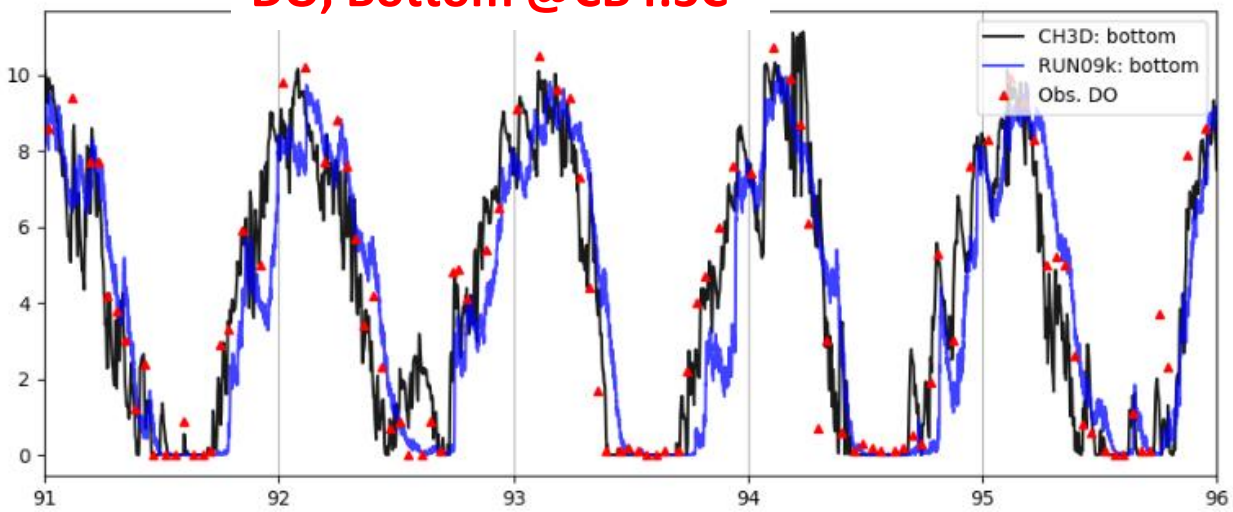
DO, Surface @CB4.3C



Chl-a, Bottom @CB4.3C



DO, Bottom @CB4.3C

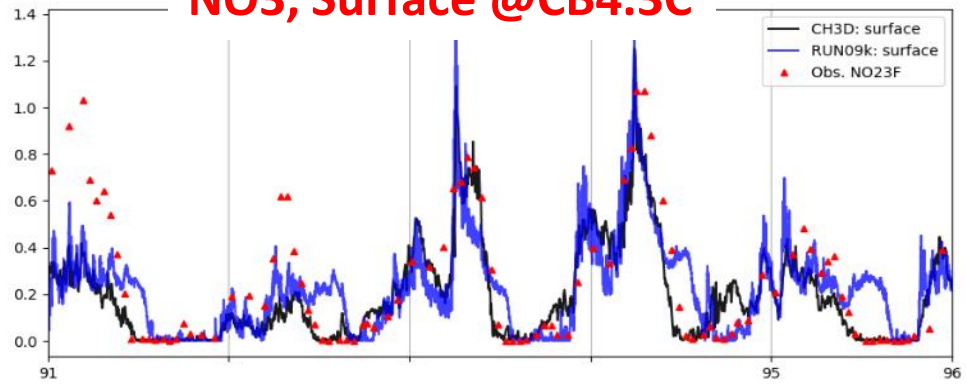


Comparison of Dissolved Inorganic Nutrients

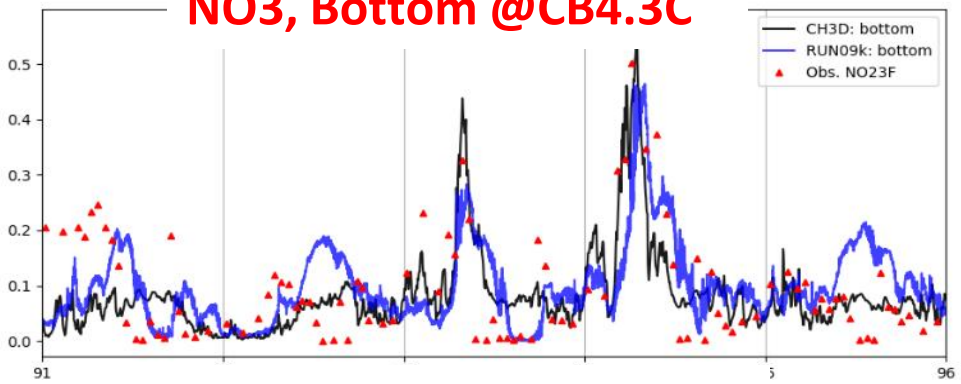
- Overall, the two models are comparable in simulating dissolved inorganic nutrients (NO3, NH4 and PO4)

P6 MBM
P7 MBM

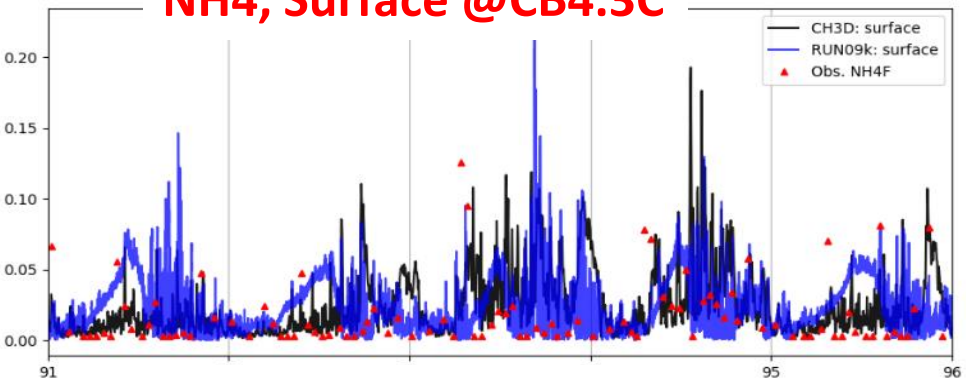
NO3, Surface @CB4.3C



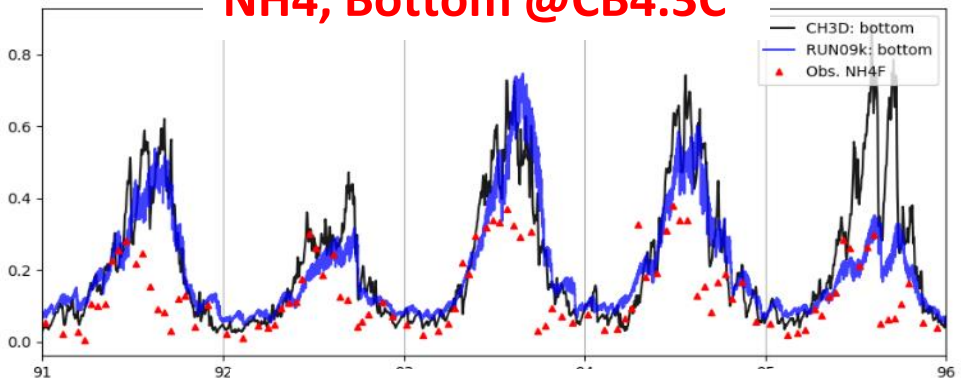
NO3, Bottom @CB4.3C



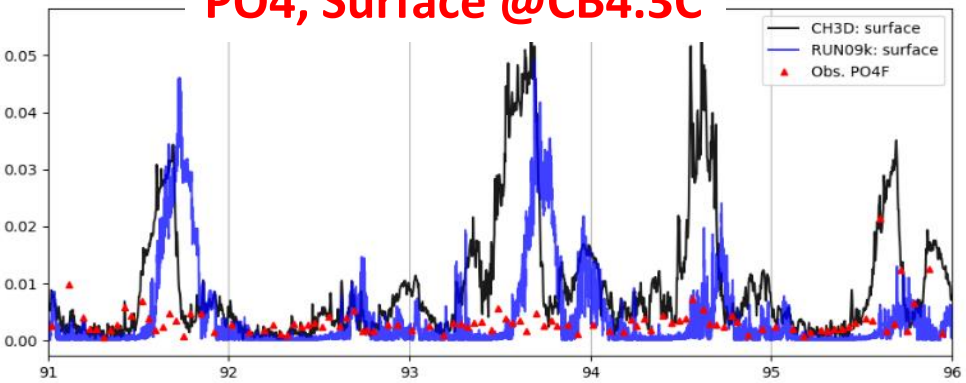
NH4, Surface @CB4.3C



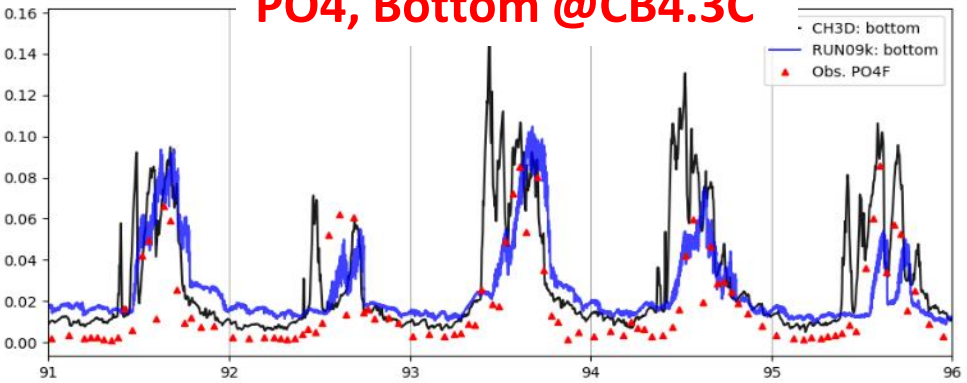
NH4, Bottom @CB4.3C



PO4, Surface @CB4.3C



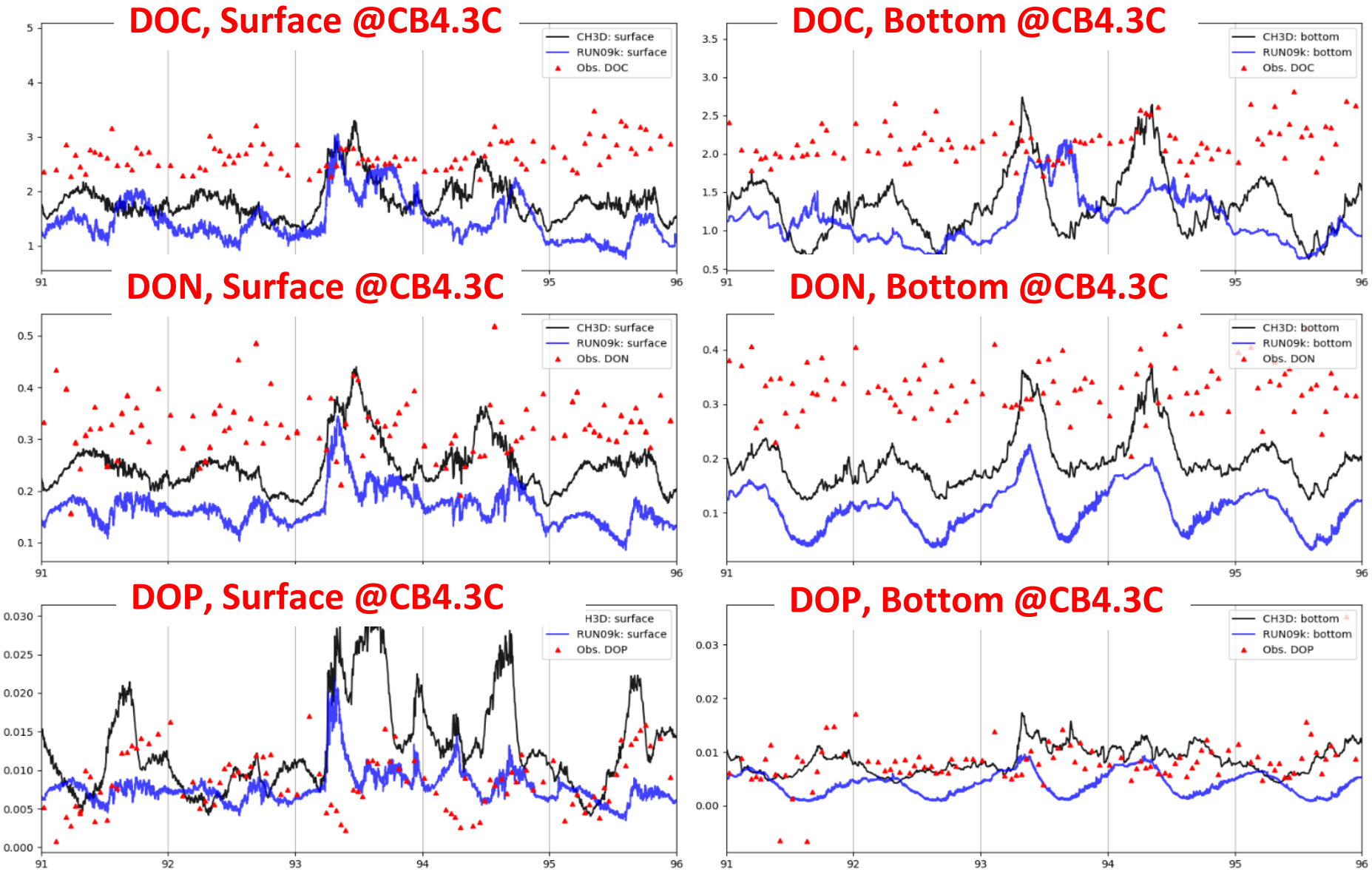
PO4, Bottom @CB4.3C



Comparison of Dissolved Organic Matters

- Both models have large errors, but the bias in P6 for DOC and DON is lower than P7
- It is plausible that the background DOMs are refractory with terrestrial origins

P6 MBM
P7 MBM

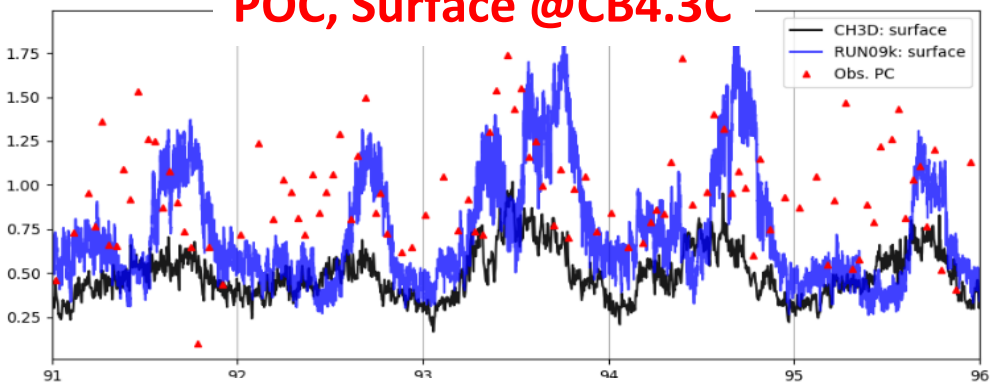


Comparison of Particulate Organic Matters

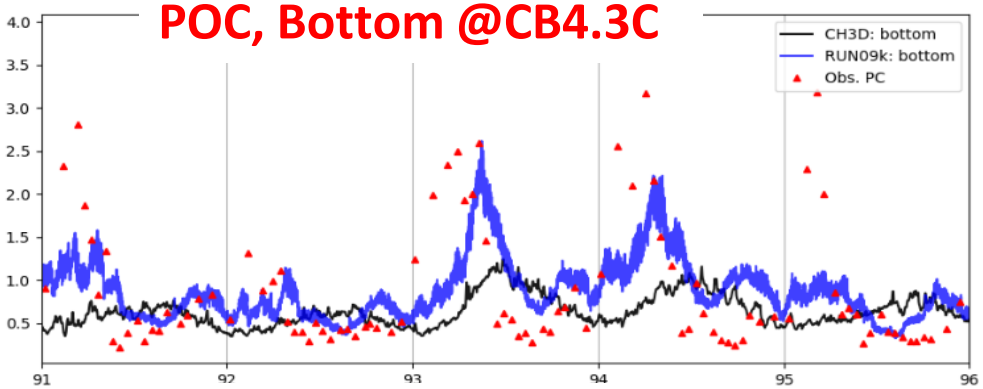
- Overall, P7 performs better than P6 in simulating POM

P6 MBM
P7 MBM

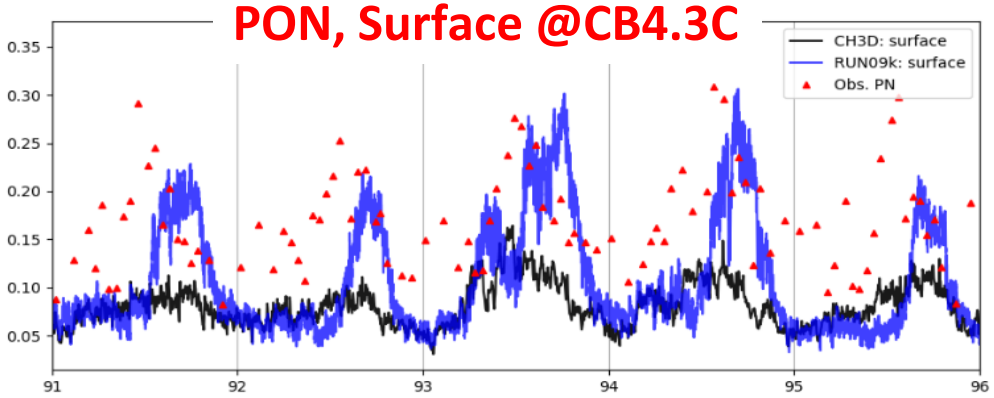
POC, Surface @CB4.3C



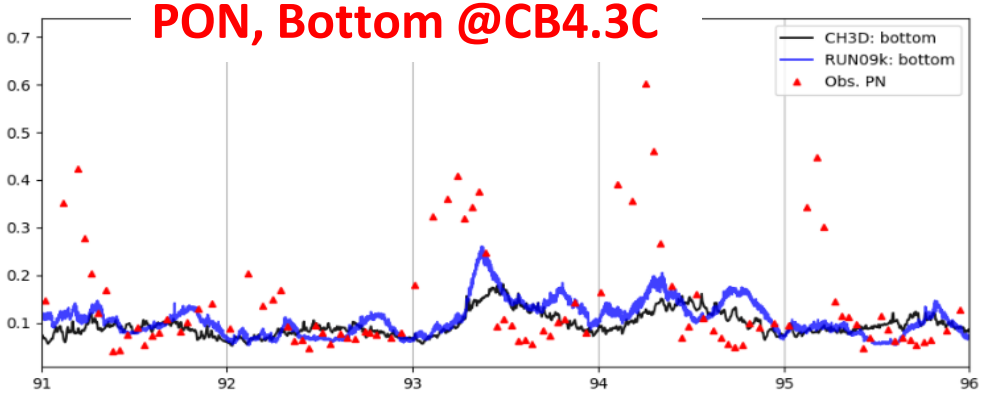
POC, Bottom @CB4.3C



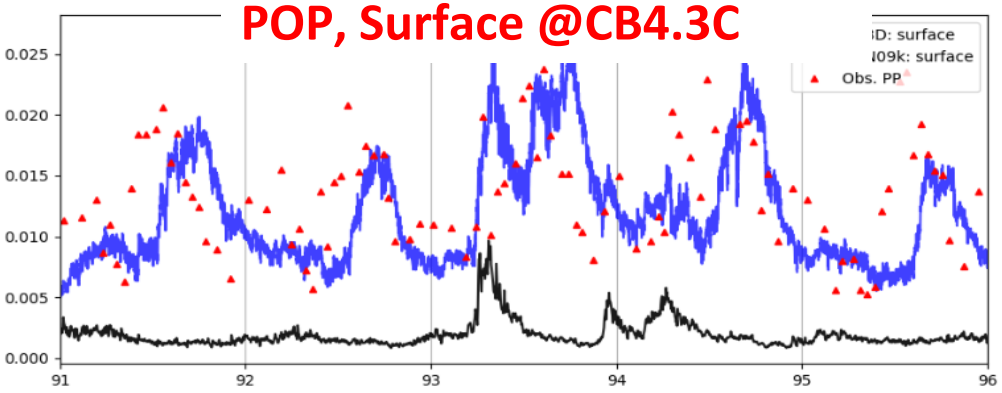
PON, Surface @CB4.3C



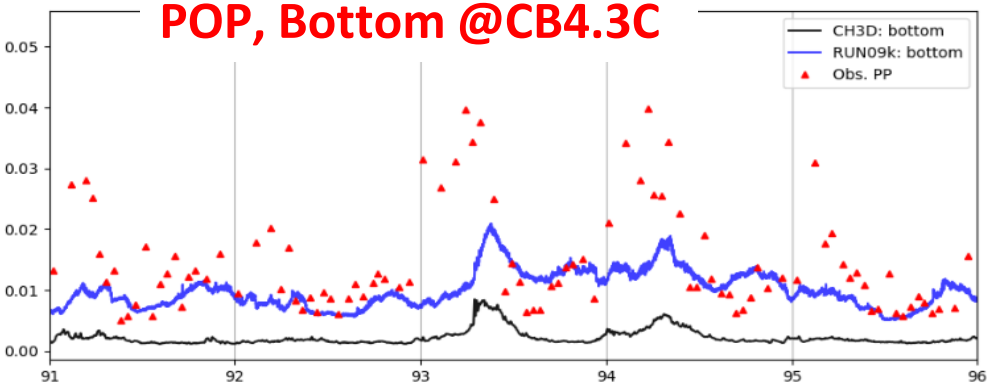
PON, Bottom @CB4.3C



POP, Surface @CB4.3C



POP, Bottom @CB4.3C



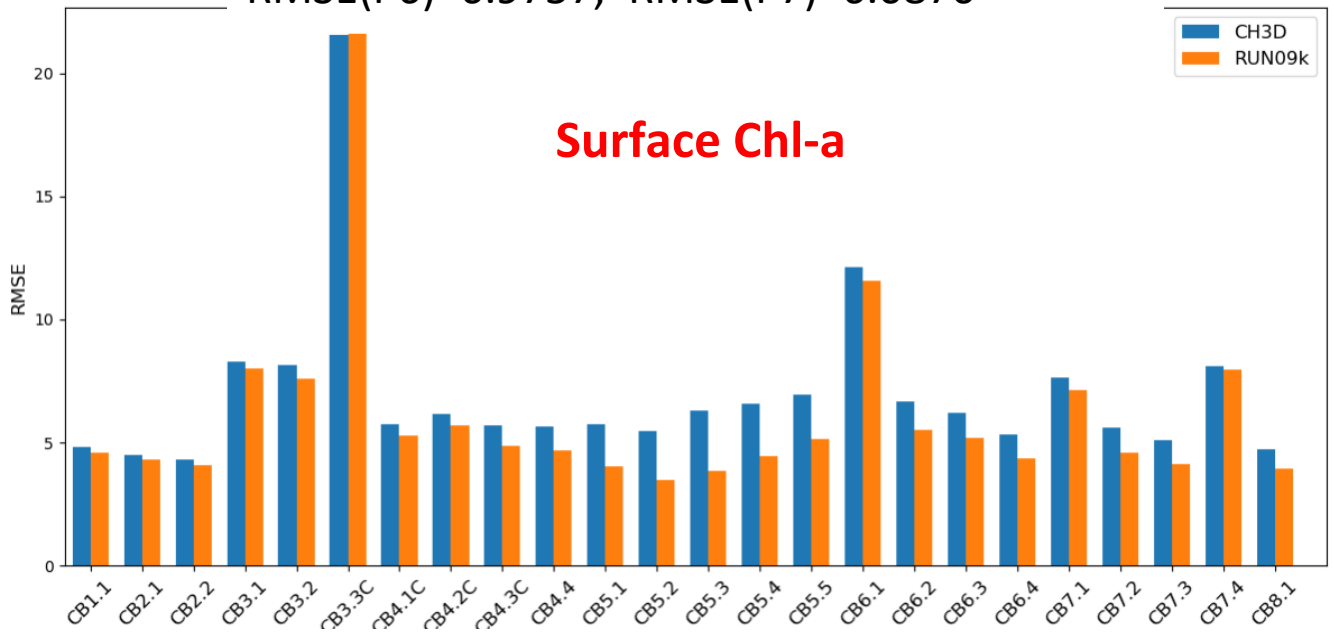
Model Assessment: Chl-a

- Assessment method: best match within the survey day. The same consistent method is applied to both models.
- Overall, both models have similar model skill for Chl-a simulation.
- For surface Chl-a, P7 performs slightly better
- For bottom Chl-a, P6 performs slightly better

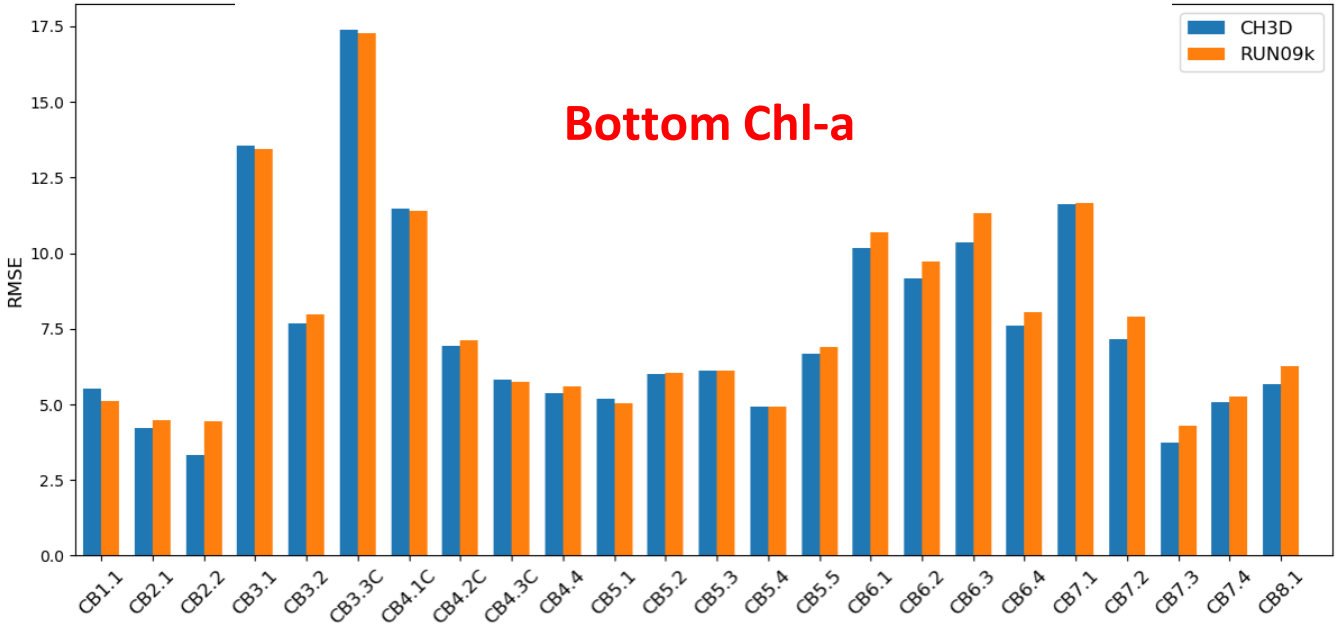
P6 MBM

P7 MBM

RMSE(P6)=6.9757, RMSE(P7)=6.0870



RMSE(P6)=7.5323, RMSE(P7)=7.7848



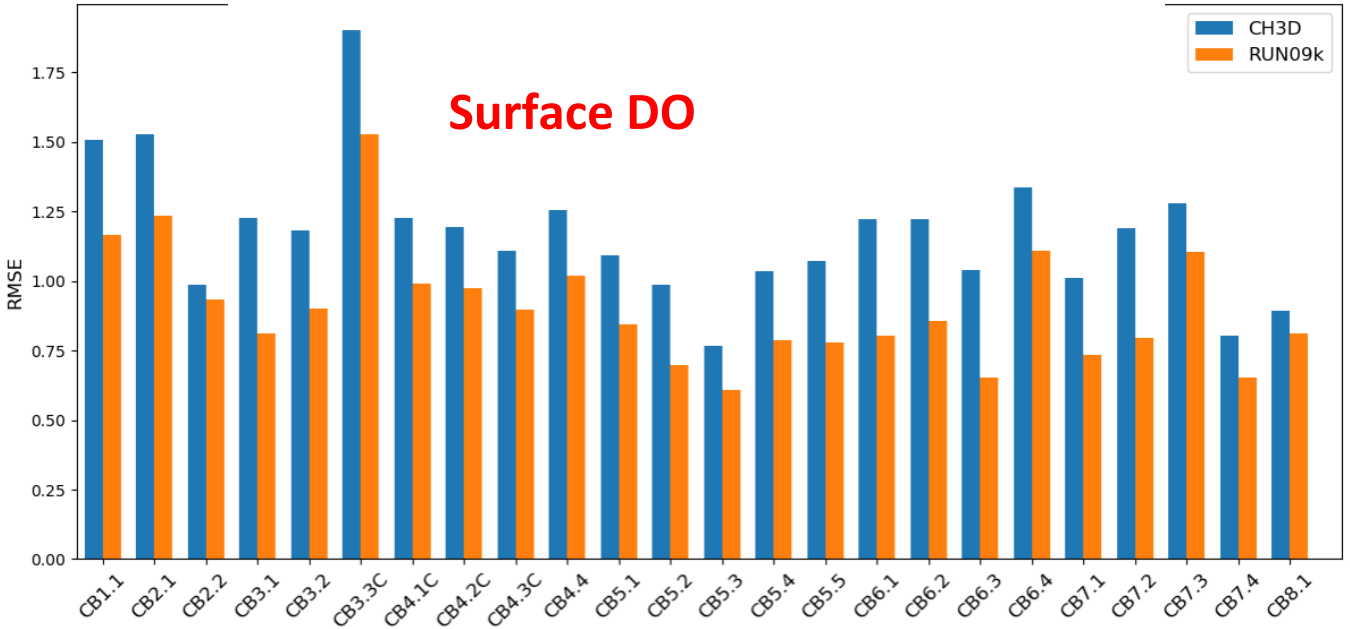
Model Assessment: DO

- In general, these two models have similar skills for both surface and bottom DO.
- P7 performs slightly better than P6 for DO.

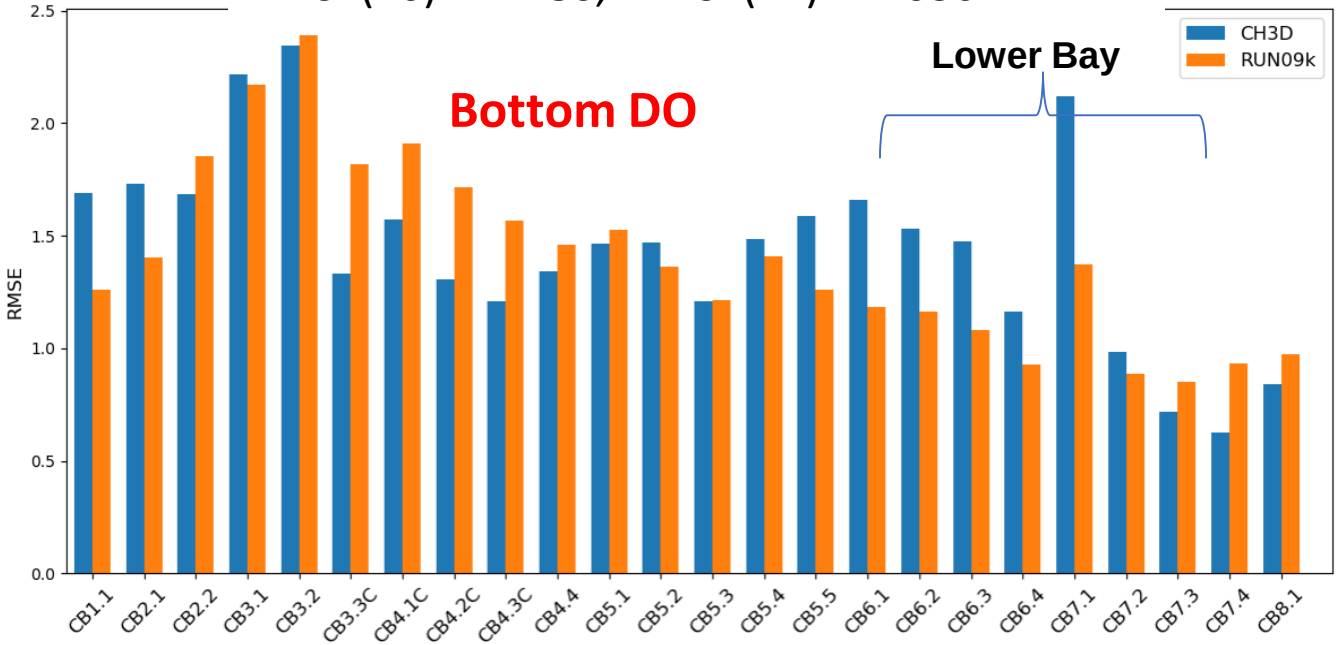
P6 MBM

P7 MBM

RMSE(P6)=1.1694, RMSE(P7)=0.9035

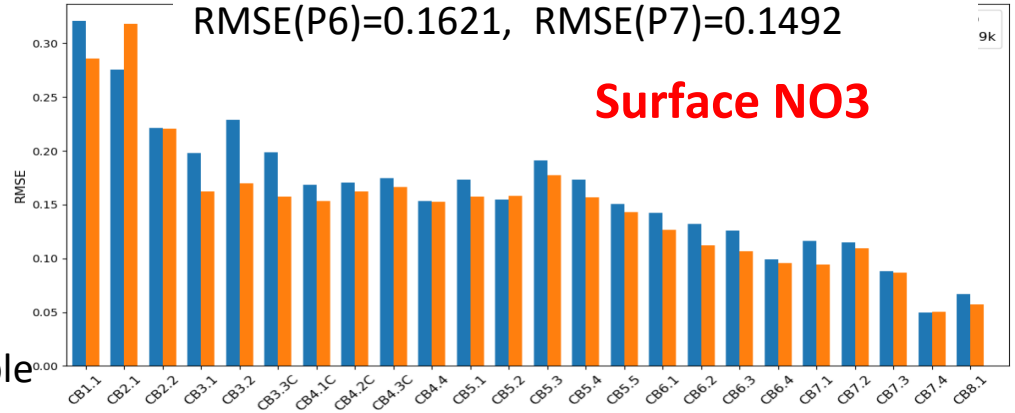


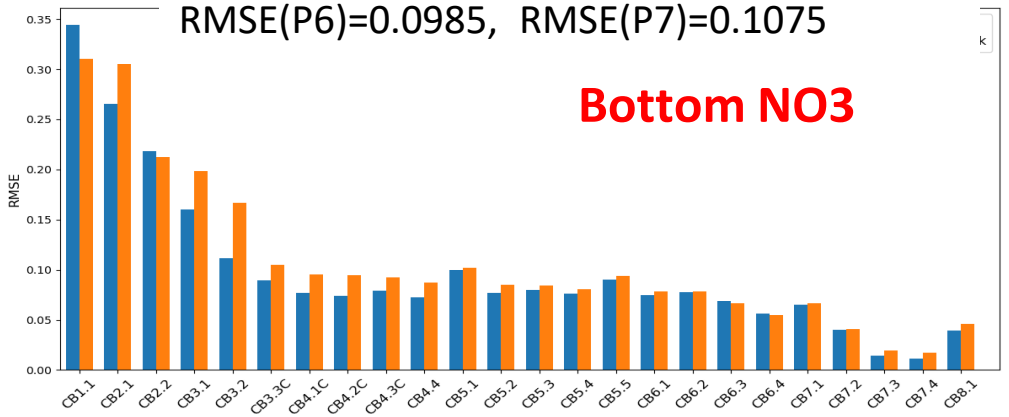
RMSE(P6)=1.4486, RMSE(P7)=1.4036

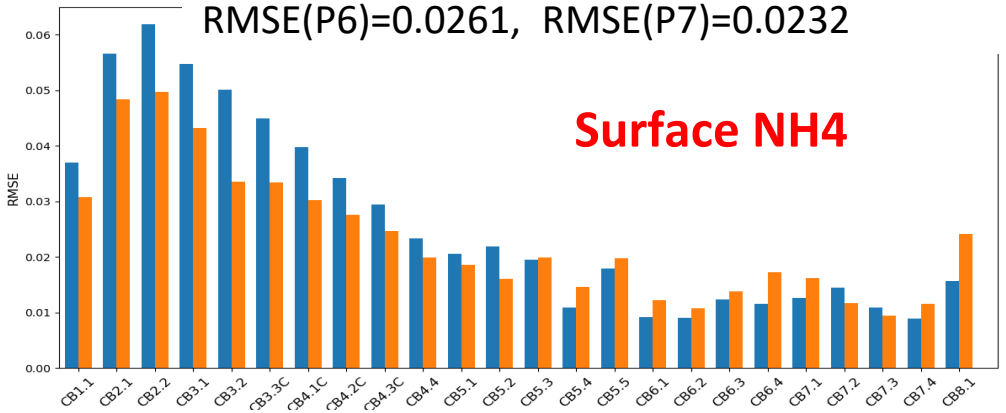


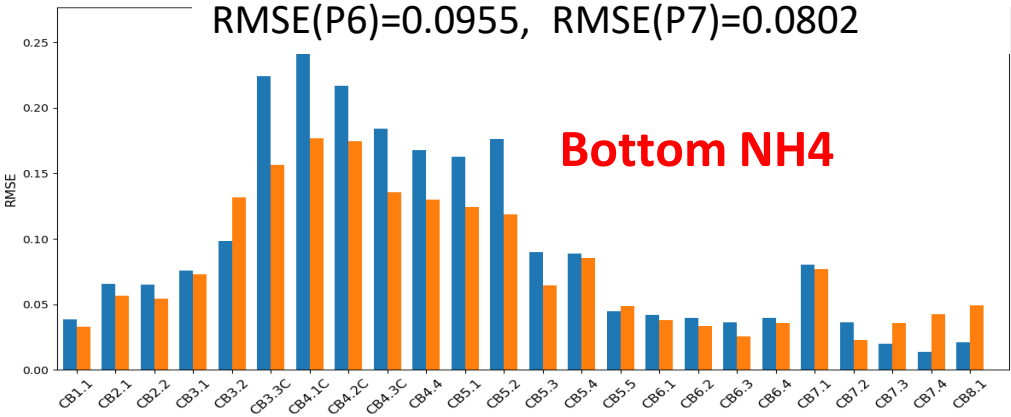
Model Assessment: Dissolved Inorganic Nutrients

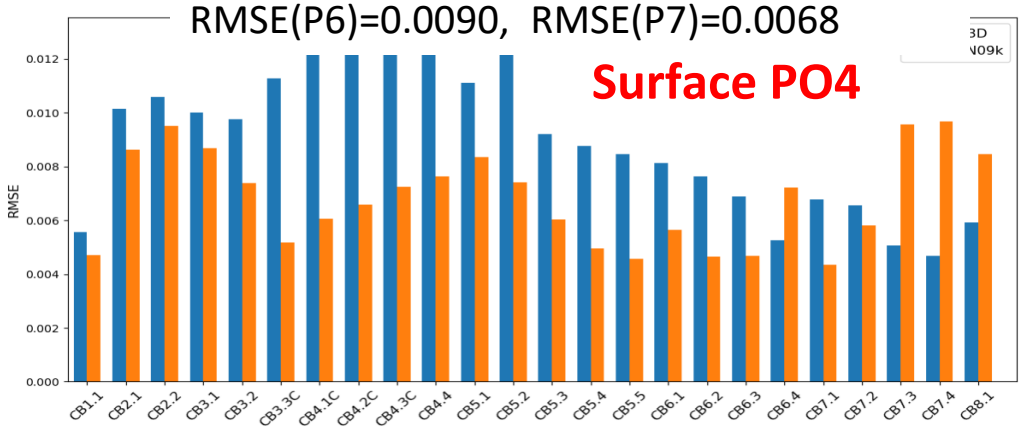
- In general, these two models have comparable skill in simulating DINs.

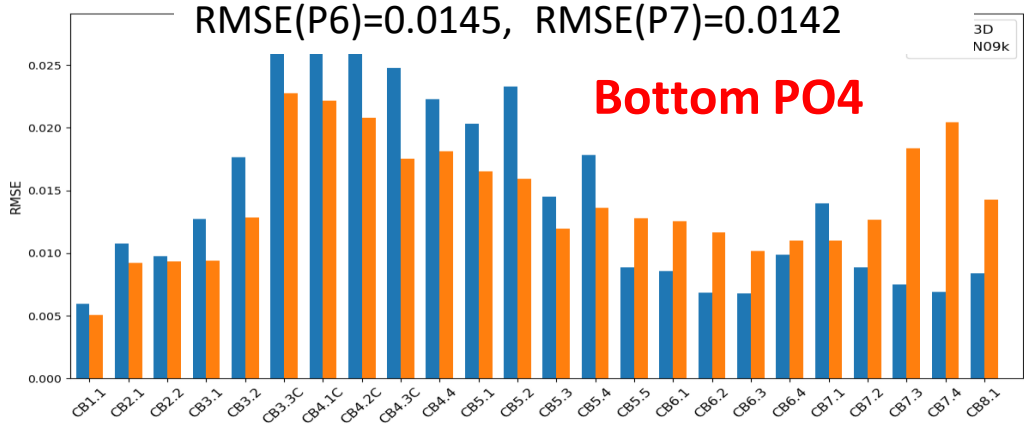












P6 MBM

P7 MBM

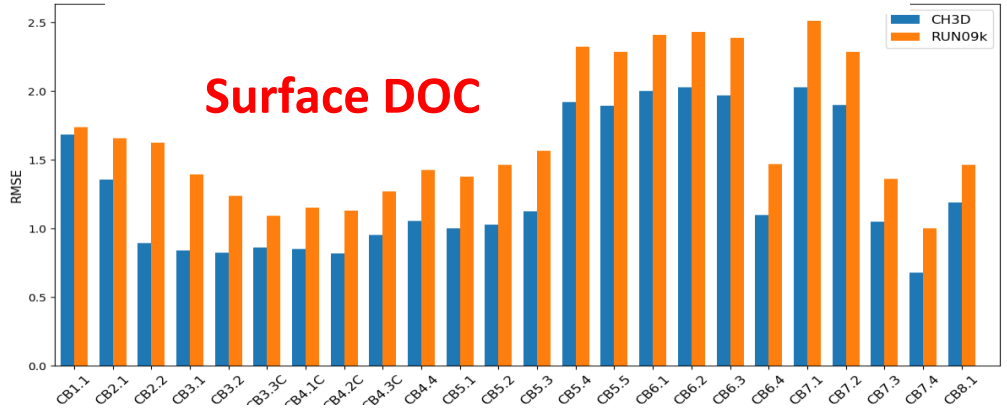
Model Assessment: Dissolved Organic Matters

- P6 seems to perform slightly better than P7, except for surface DOP.

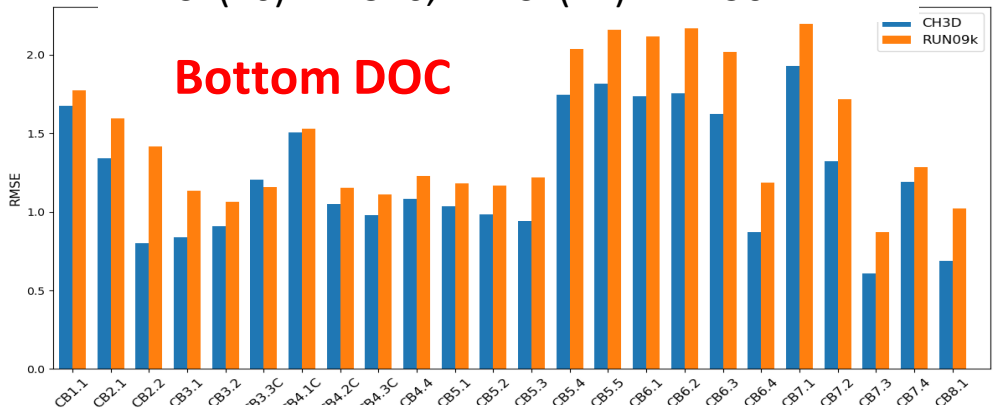
P6 MBM

P7 MBM

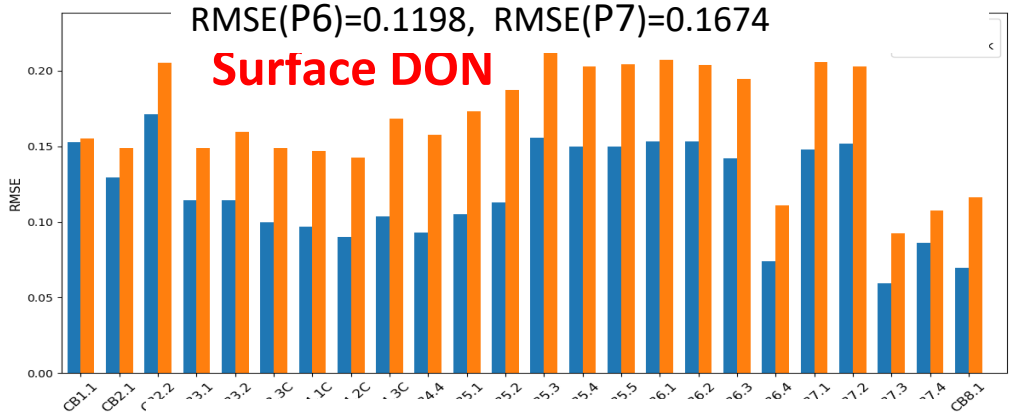
RMSE(P6)=1.2944, RMSE(P7)=1.6702



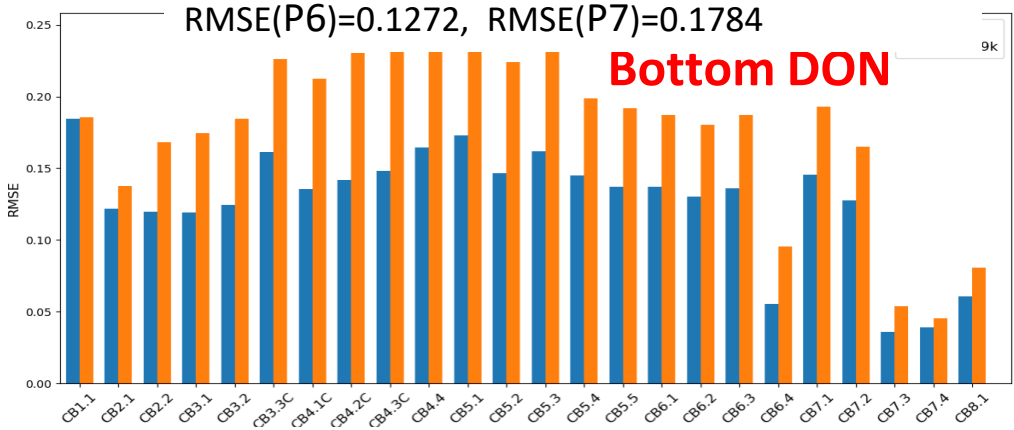
RMSE(P6)=1.2346, RMSE(P7)=1.4790



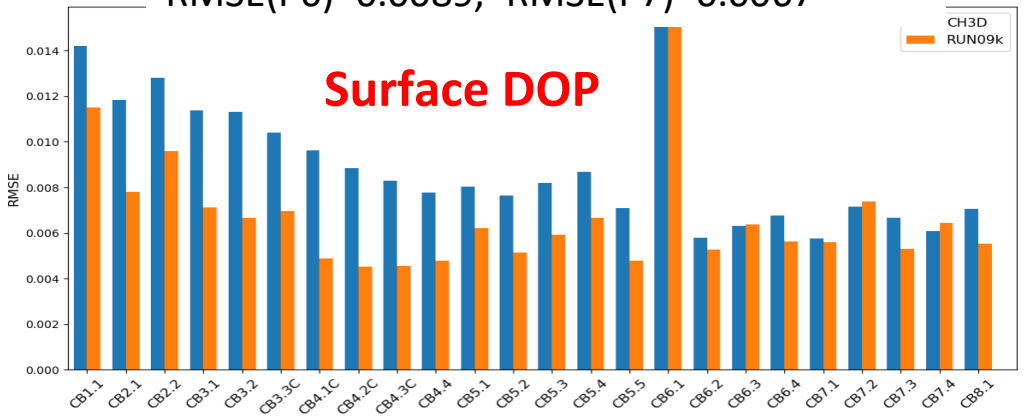
RMSE(P6)=0.1198, RMSE(P7)=0.1674



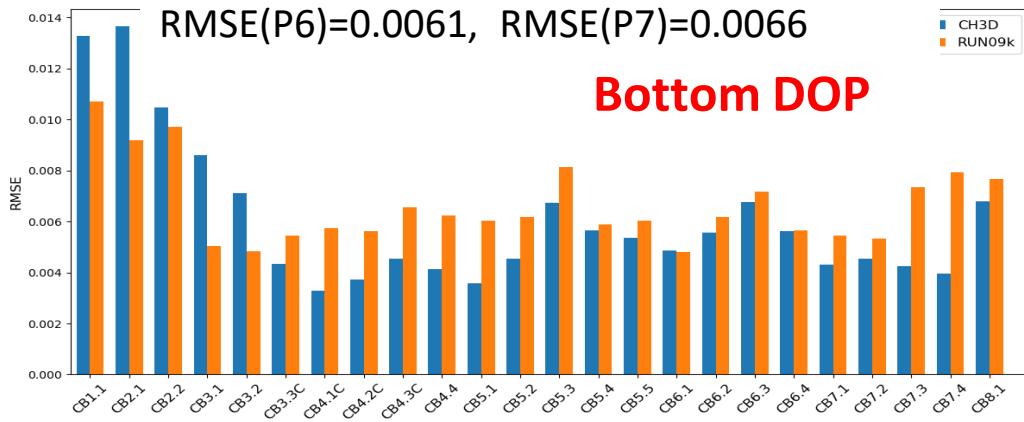
RMSE(P6)=0.1272, RMSE(P7)=0.1784



RMSE(P6)=0.0089, RMSE(P7)=0.0067



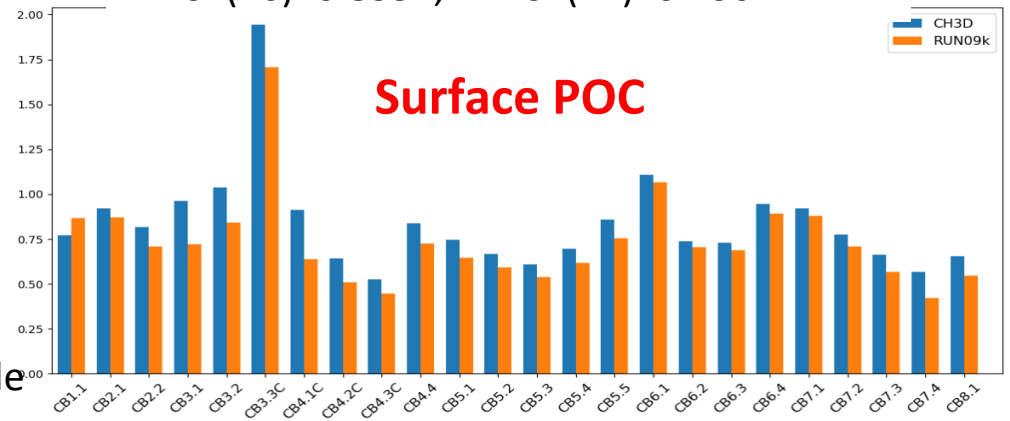
RMSE(P6)=0.0061, RMSE(P7)=0.0066



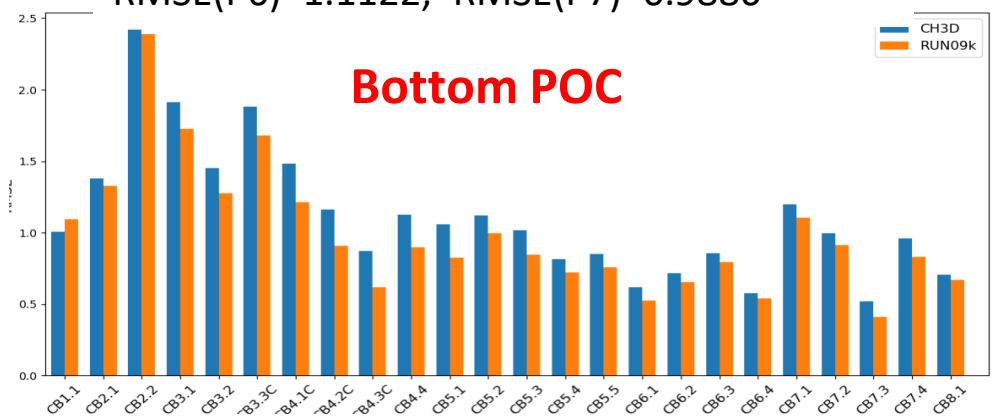
Model Assessment: Particulate Organic Matters

- In general, these two models have comparable skill in simulating POM.
- P7 performs slightly better than P6

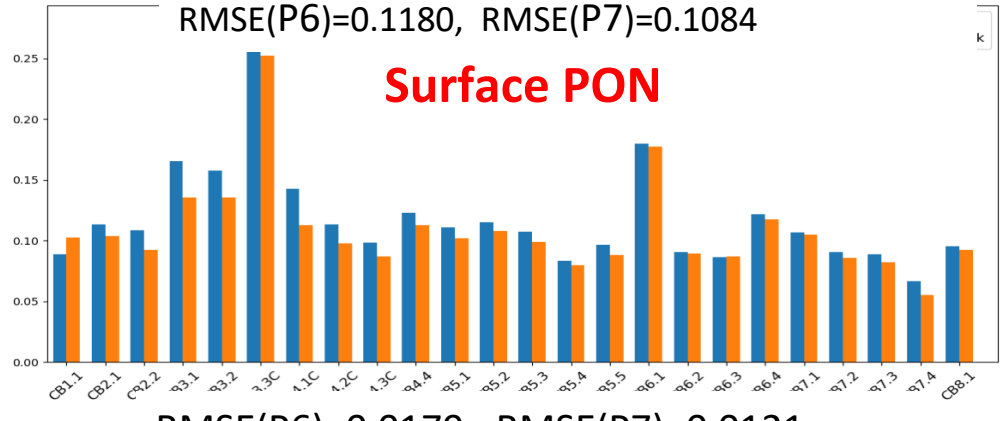
RMSE(P6)=0.8352, RMSE(P7)=0.7361



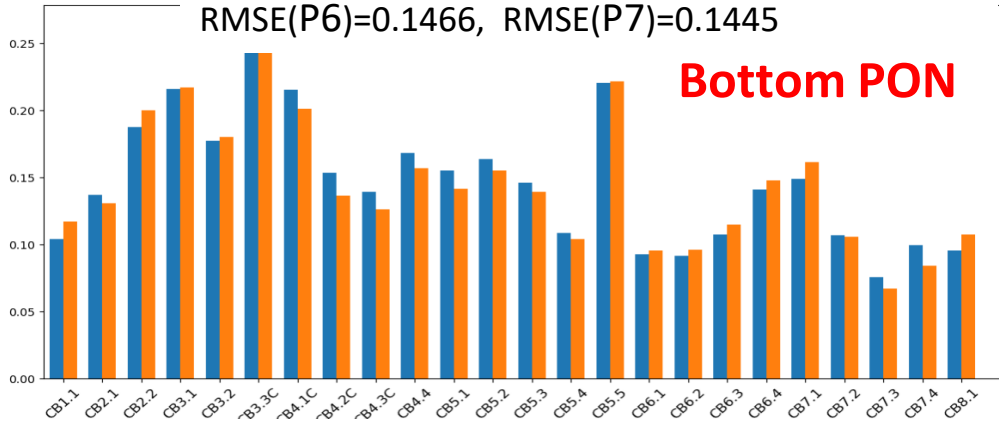
RMSE(P6)=1.1122, RMSE(P7)=0.9886



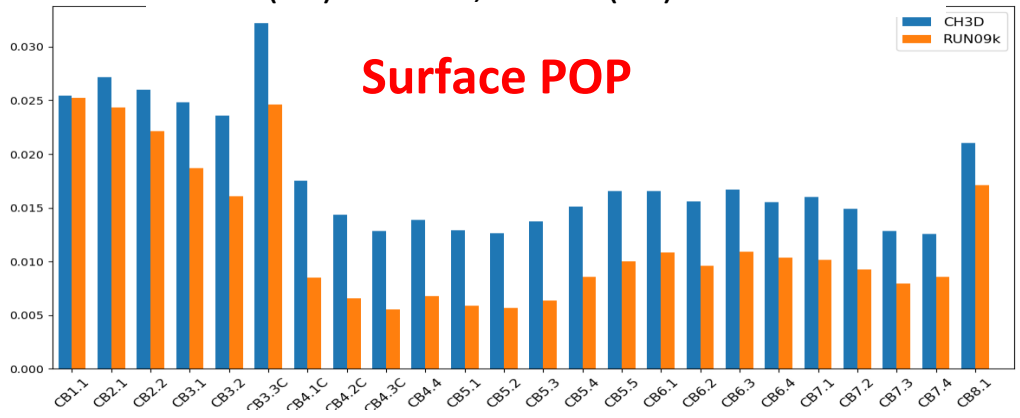
RMSE(P6)=0.1180, RMSE(P7)=0.1084



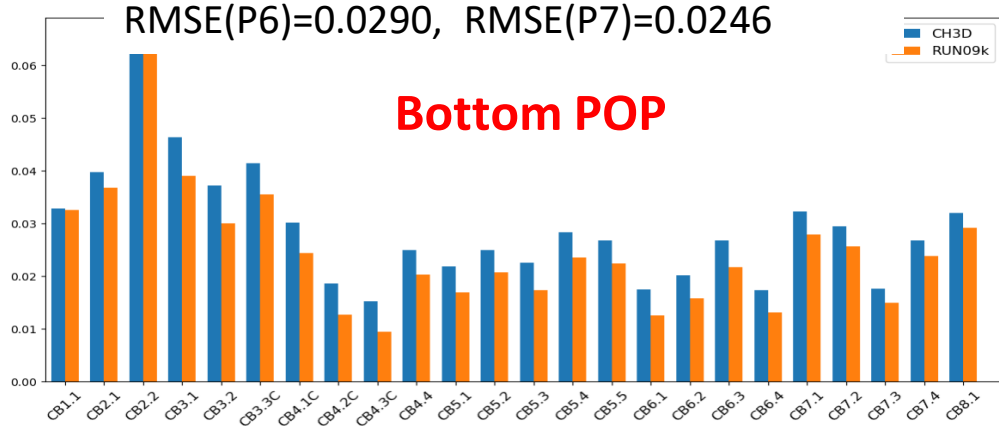
RMSE(P6)=0.1466, RMSE(P7)=0.1445



RMSE(P6)=0.0179, RMSE(P7)=0.0121



RMSE(P6)=0.0290, RMSE(P7)=0.0246



P6 MBM

P7 MBM

Summary

- ❑ We have successfully implemented a method in redistributing watershed nutrient loading over time to fix anomalous nutrient concentrations.
  - No effect on the total nutrient loading (but very small changes in total flow)
- ❑ We have improved the MBM simulation for nutrients and Chl-a.
- ❑ Comparison between phase-6 (CH3D-ICM) and phase-7 (SCHISM-ICM) suggests that the models are largely comparable in mainstem
  - P7 MBM is expected to do better in shallows
- ❑ P7 MBM performance: ~5 SYPD on 256 cores (so 10 years would take < 2 days to finish)
  - New VIMS cluster provides adequate resource for this project!

Future work

- ❑ Finish adding living resources into MBM
  - SAV
  - Wetland
  - Oyster
- ❑ Shoreline erosion: based on wave power approach (Sanford et al.)