James River Water Quality Model Refinement and Scenario Runs

Progress Report

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VIMS | William & Mary
Virginia Institute of Marine Science

DEQ
Virginia Department of Environmental Quality

Outline

- Progress update
- Revised model calibration/verification
- Model scenario simulations
- Conclusions

Progress Update

- Update model calibration and verifications
  - Reviewed comments and feedbacks from preliminary model calibration results
  - Update model boundary condition from 2005-2013
  - Revised model calibration and verification
  - Revised model report for review
  - Conducted more sensitivity runs (open boundary, model parameters (half-saturation rates for N and P)
- Update watershed loading
  - Received updated Phase 6 baseline and used for model calibration
  - Received loadings for multiple point source reduction scenarios
  - Conduct model simulations for loading reduction scenarios

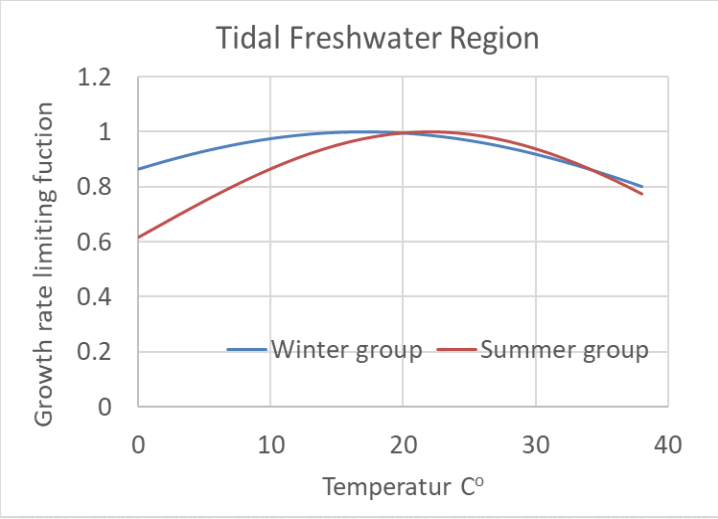
Update of model calibration and verification

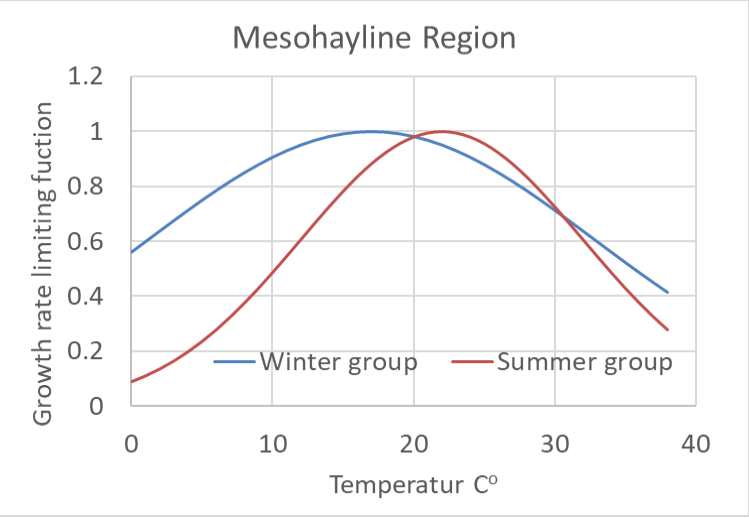
- Model setup
  - Use CBP 3D model output as James River model open boundary condition (1991-2000, 2005-2013)
  - Use time-varying C:Chl-a ratio (Cerco and Noel, 2004)
  - Calibrate model using latest Phase 6 baseline condition (JCHLACAL20180808)

- Model parameters
  - Half-saturation rate for N and P

Model	N (mg/L)	P(mg/L)
Preliminary	0.015	0.0015
Final	0.02	0.0025

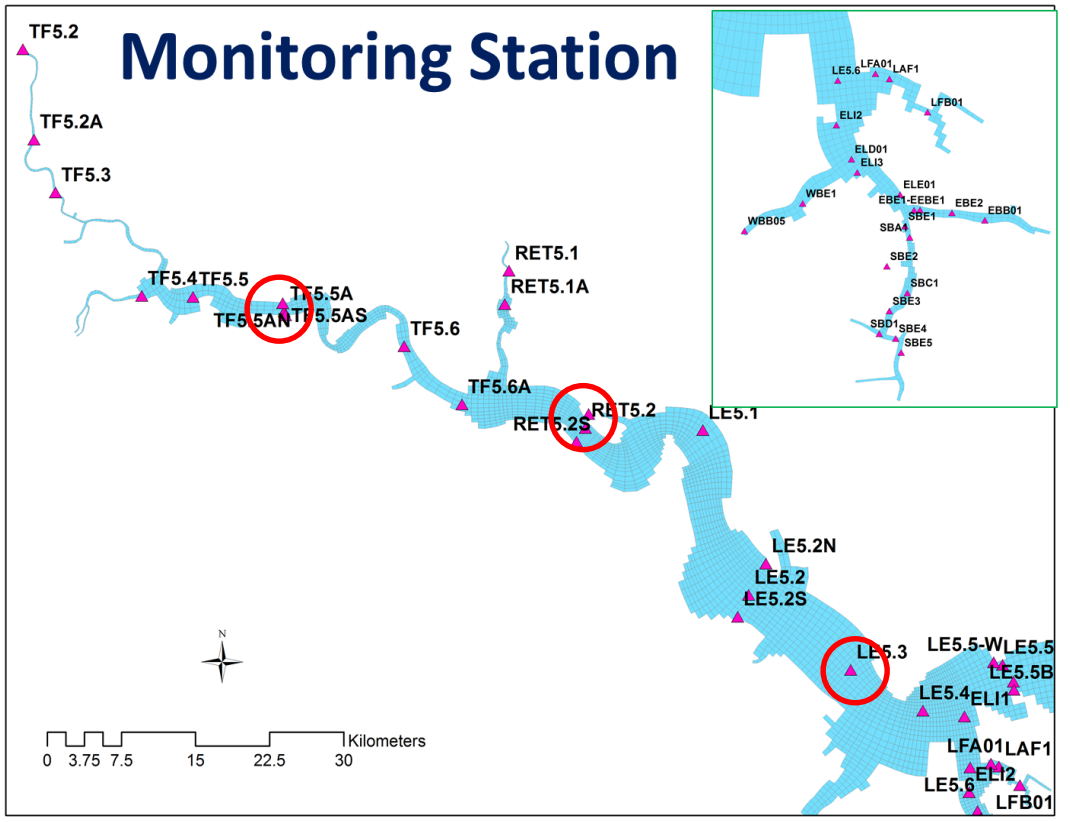
  - Temperature related function



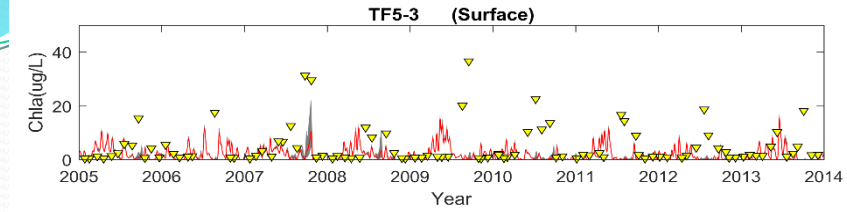


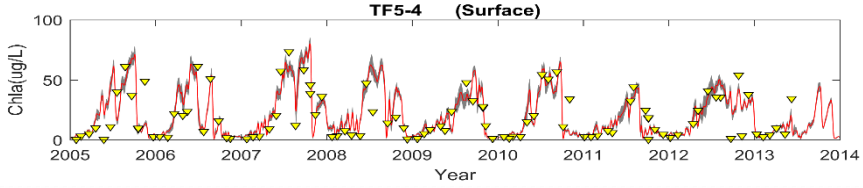
Examples of Model Calibration

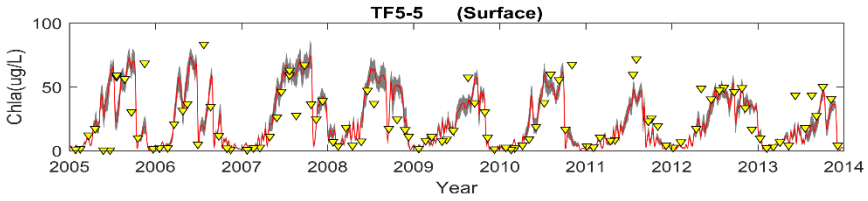
- Tidal freshwater (TF5-5)
- Oligohaline (RET5-2)
- Mesohaline (EL5-3)

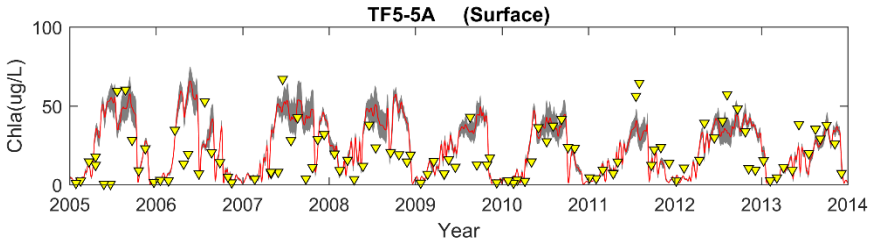


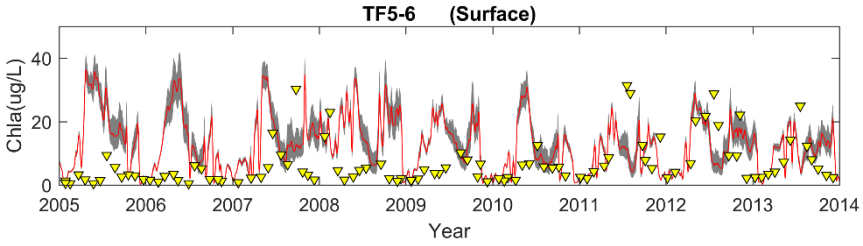
Model Calibration Results

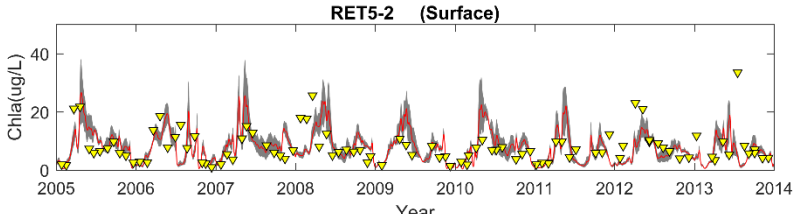


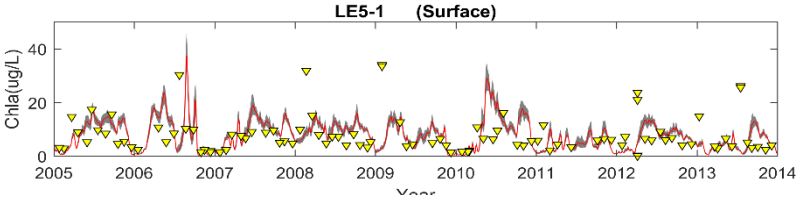


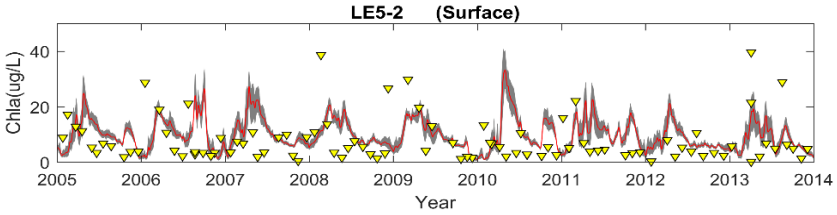


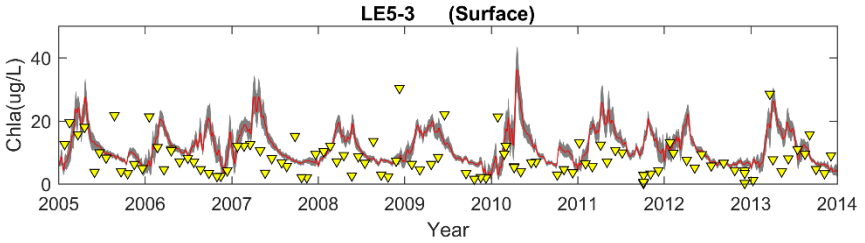


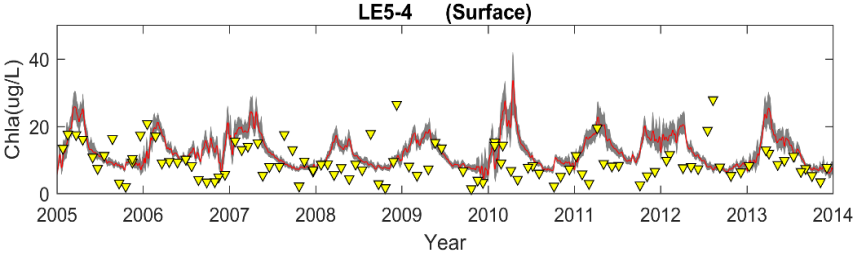






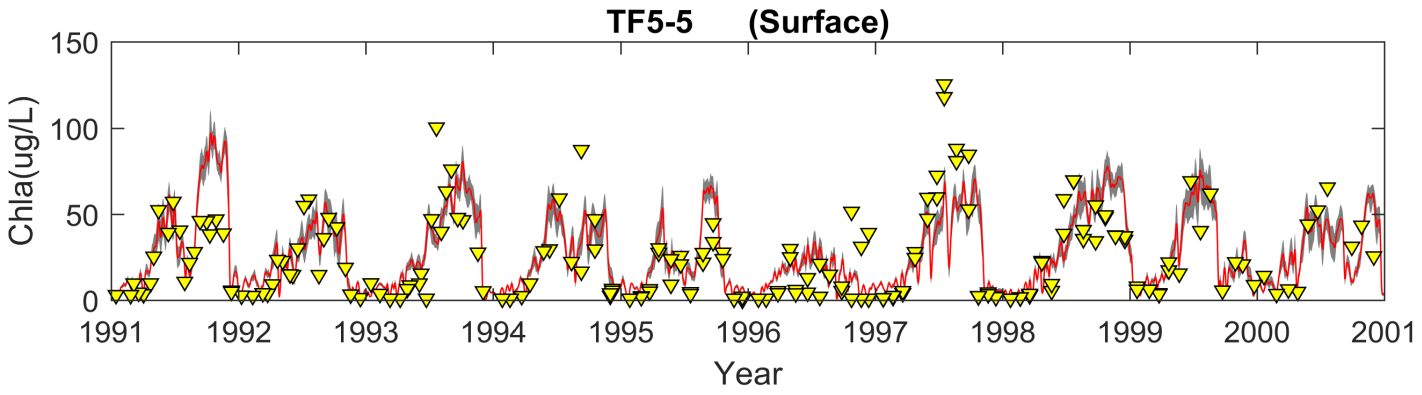




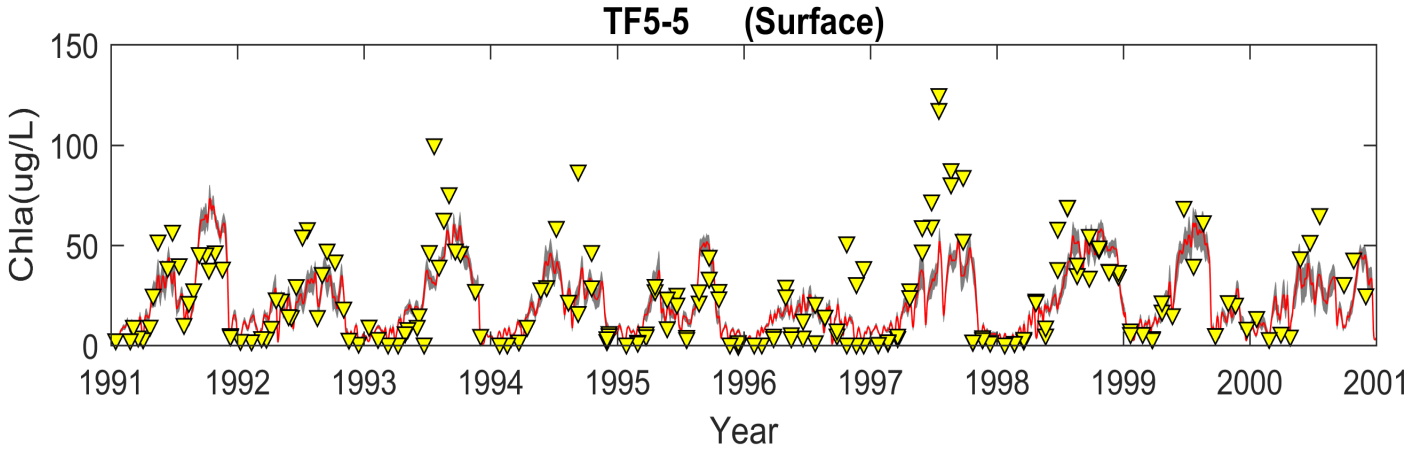


Sensitivity Test of C:Chl-a Ratio

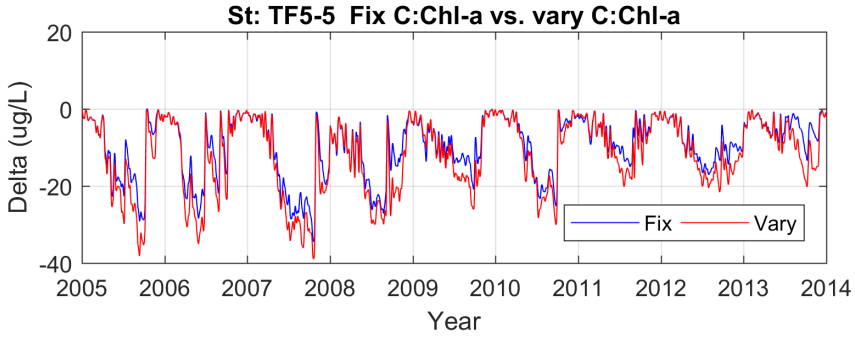
Varying

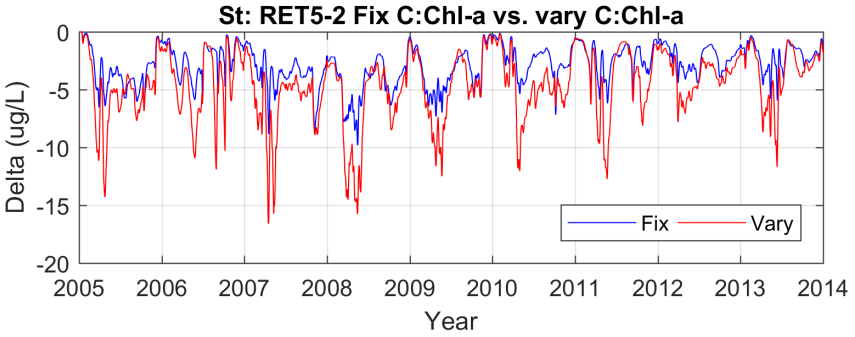


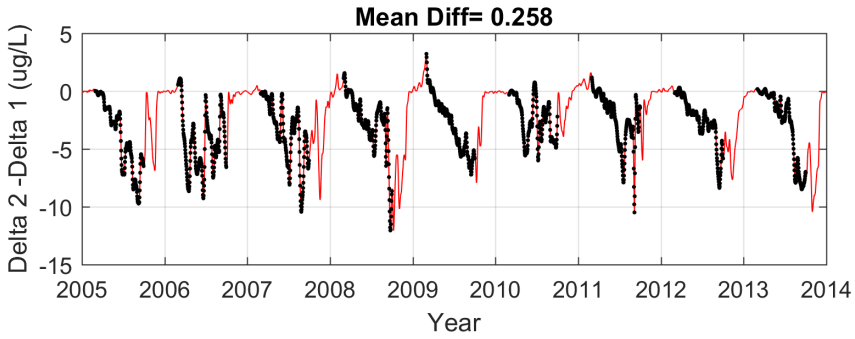
Fixed

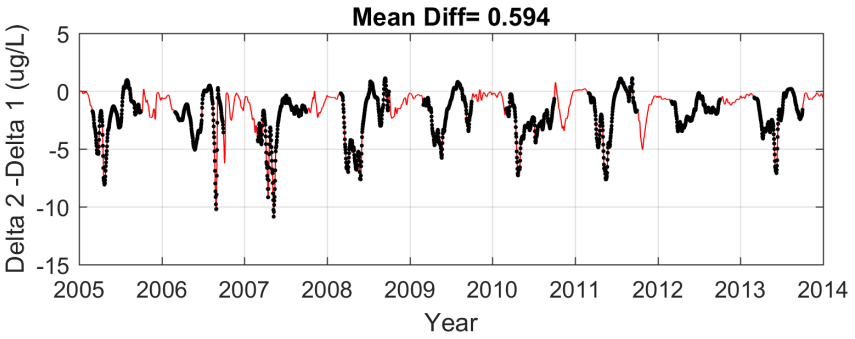


Sensitivity Test of C:Chl-a Ratio

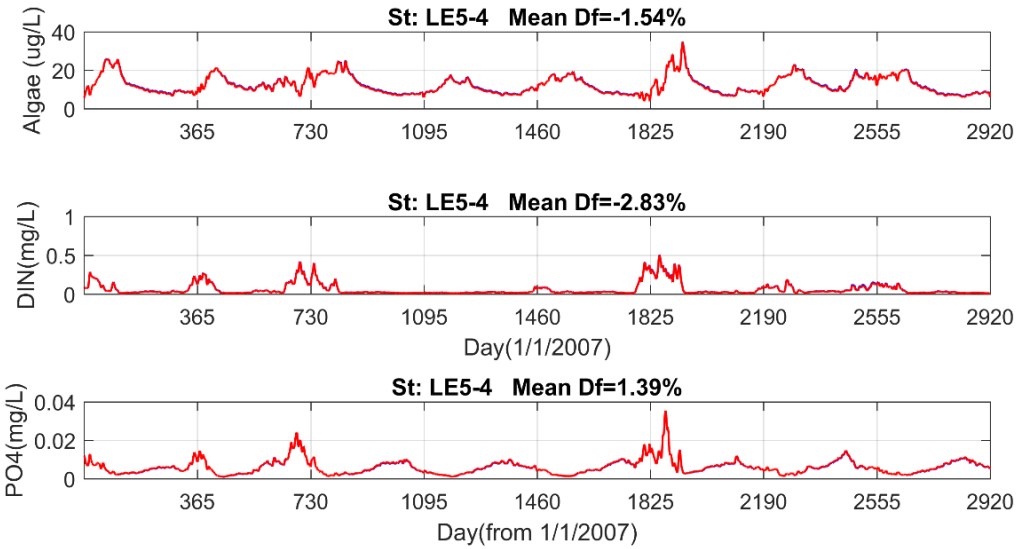




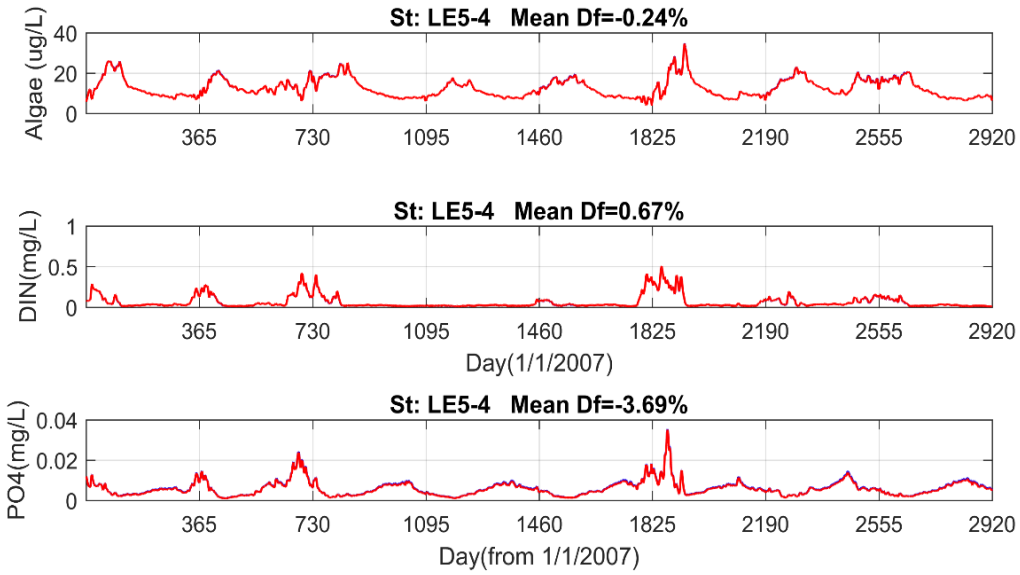


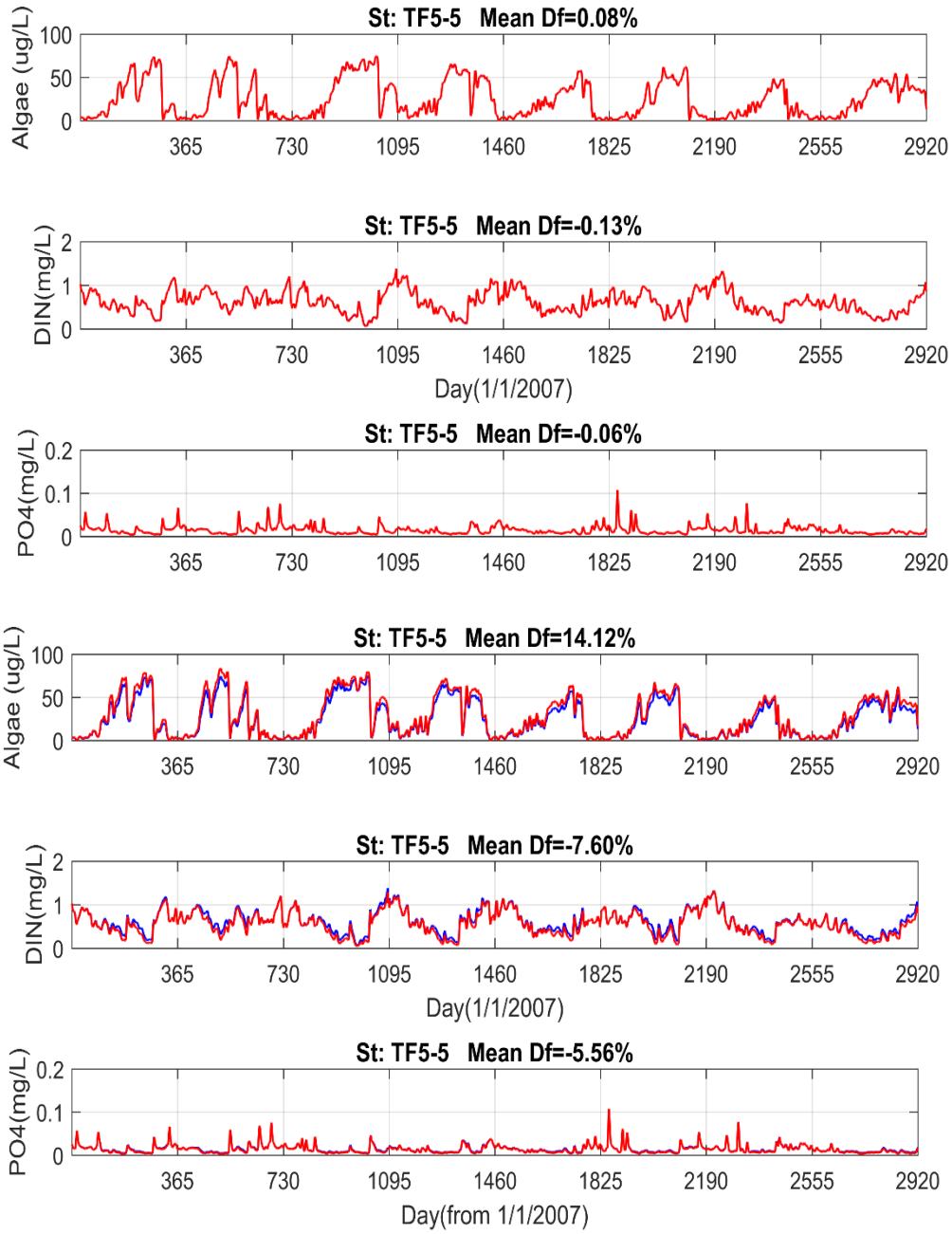


10% decrease of Nitrogen at open boundary



10% decrease of phosphorus at open boundary



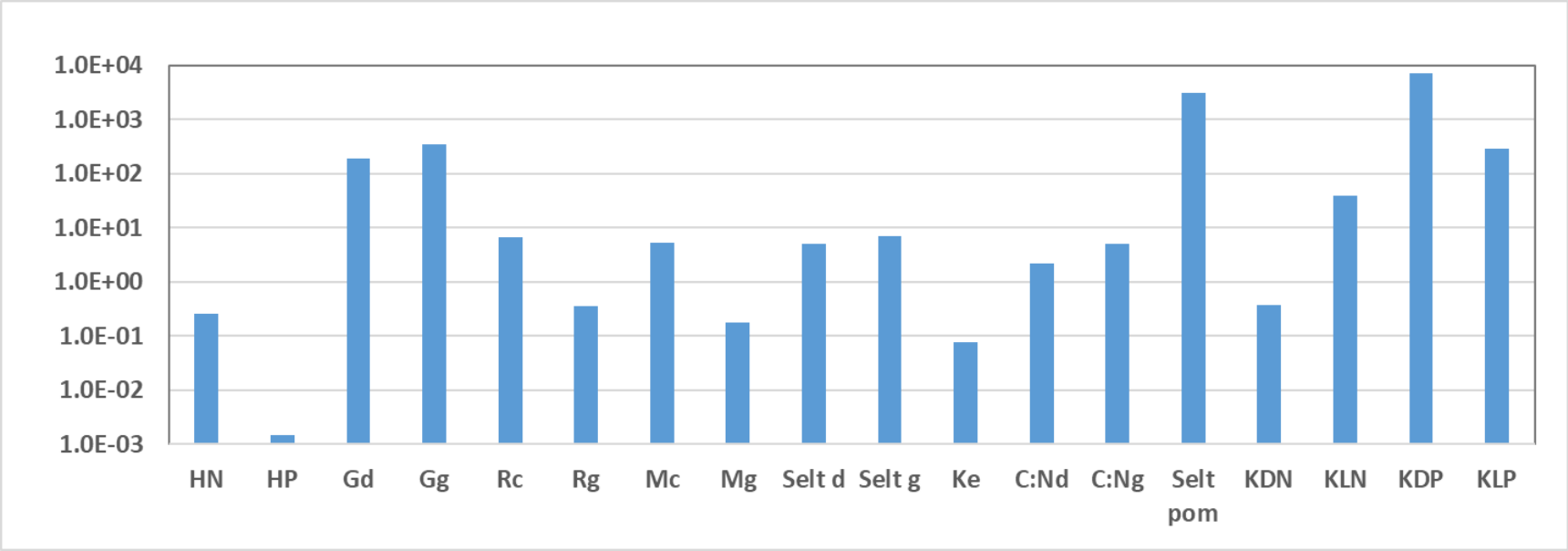


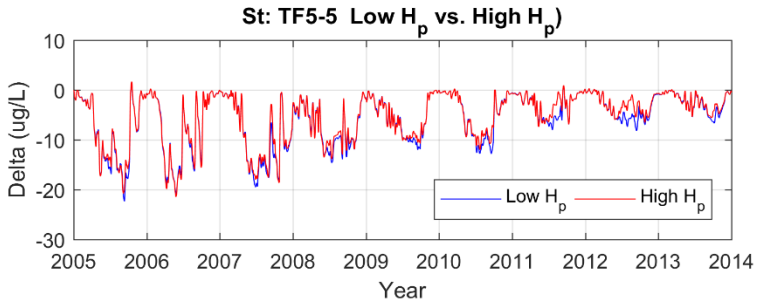
Change
TN half-saturation rate

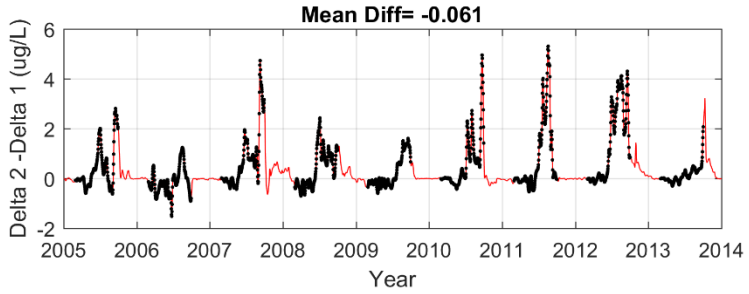
Change
TP half-saturation rate

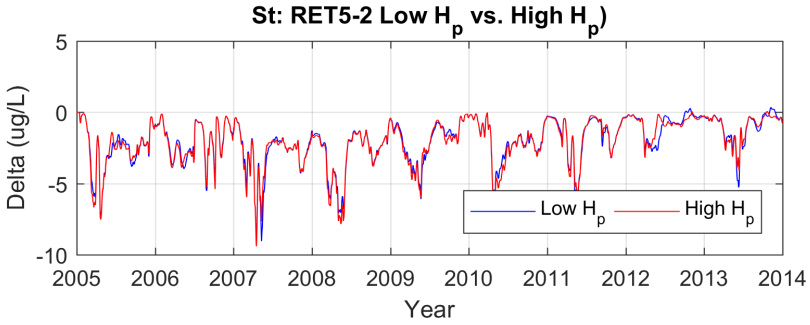
Parameter Uncertainty

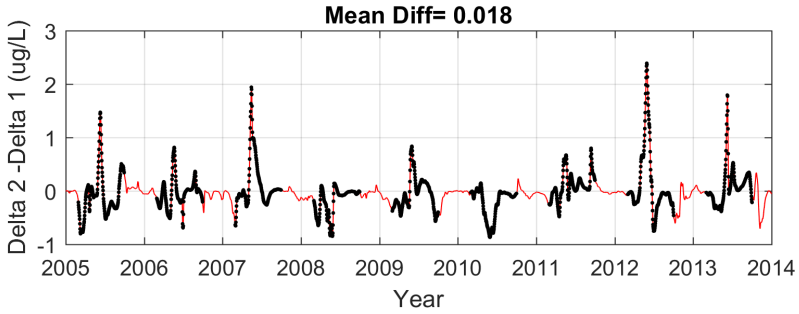
- Conduct model experiments with 5% perturbation of model kinetic parameters. Compute sensitivity matrix and model uncertainty (inverse of sensitivity matrix)

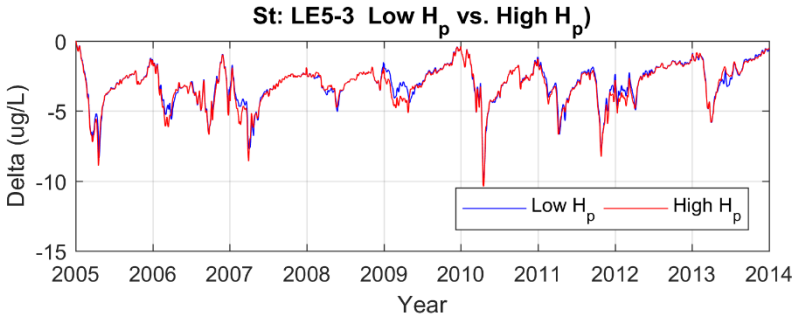


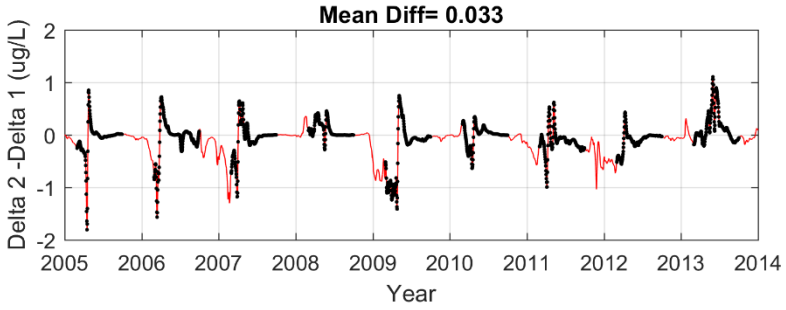

St: TF5-5 Low Hp vs. High Hp)
Delta (ug/L)
Low Hp
High Hp
Year


Mean Diff= -0.061
Delta 2 -Delta 1 (ug/L)
Year


St: RET5-2 Low Hp vs. High Hp)
Delta (ug/L)
Low Hp
High Hp
Year


Mean Diff= 0.018
Delta 2 -Delta 1 (ug/L)
Year

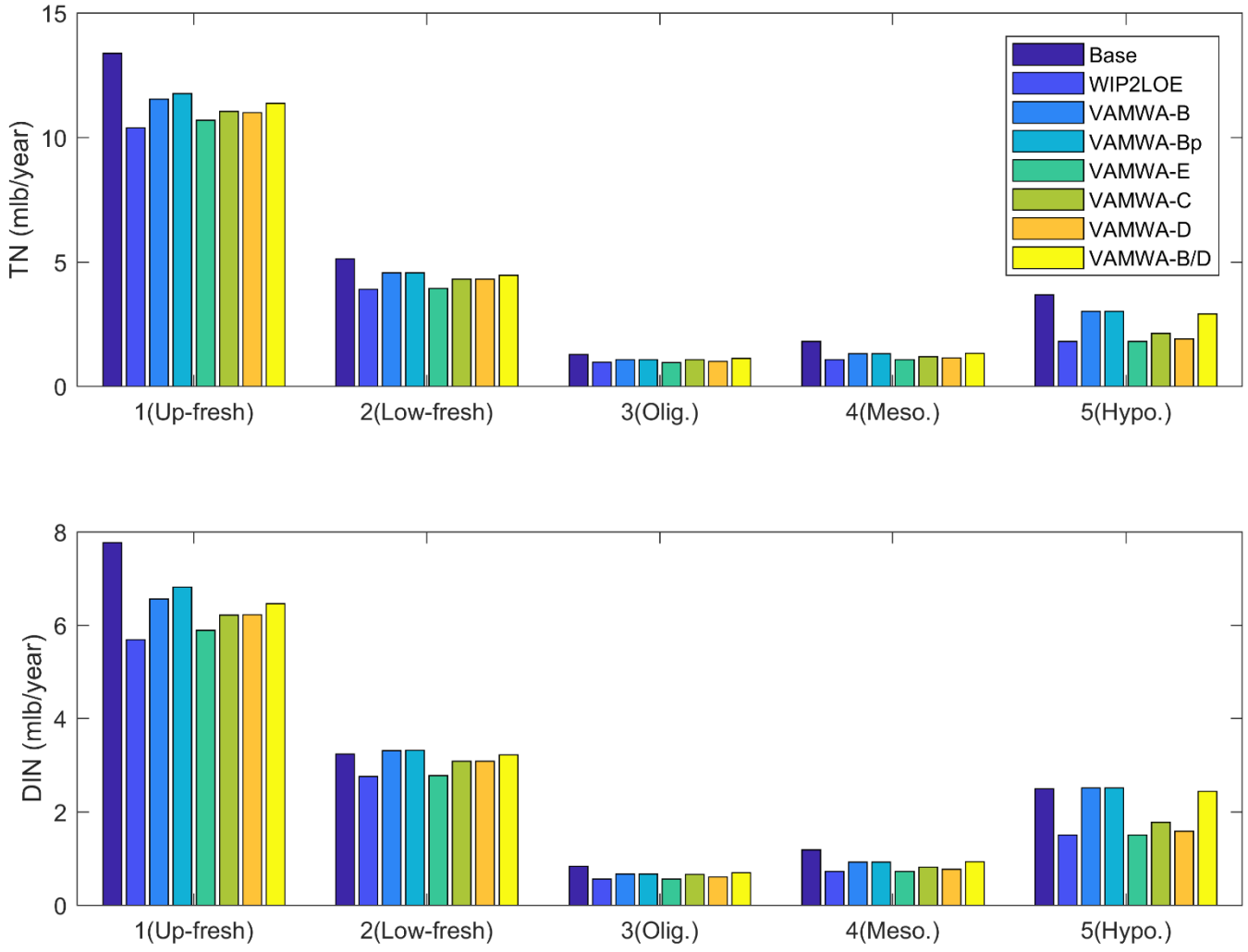

St: LE5-3 Low Hp vs. High Hp)
Delta (ug/L)
Low Hp
High Hp
Year


Mean Diff= 0.033
Delta 2 -Delta 1 (ug/L)
Year

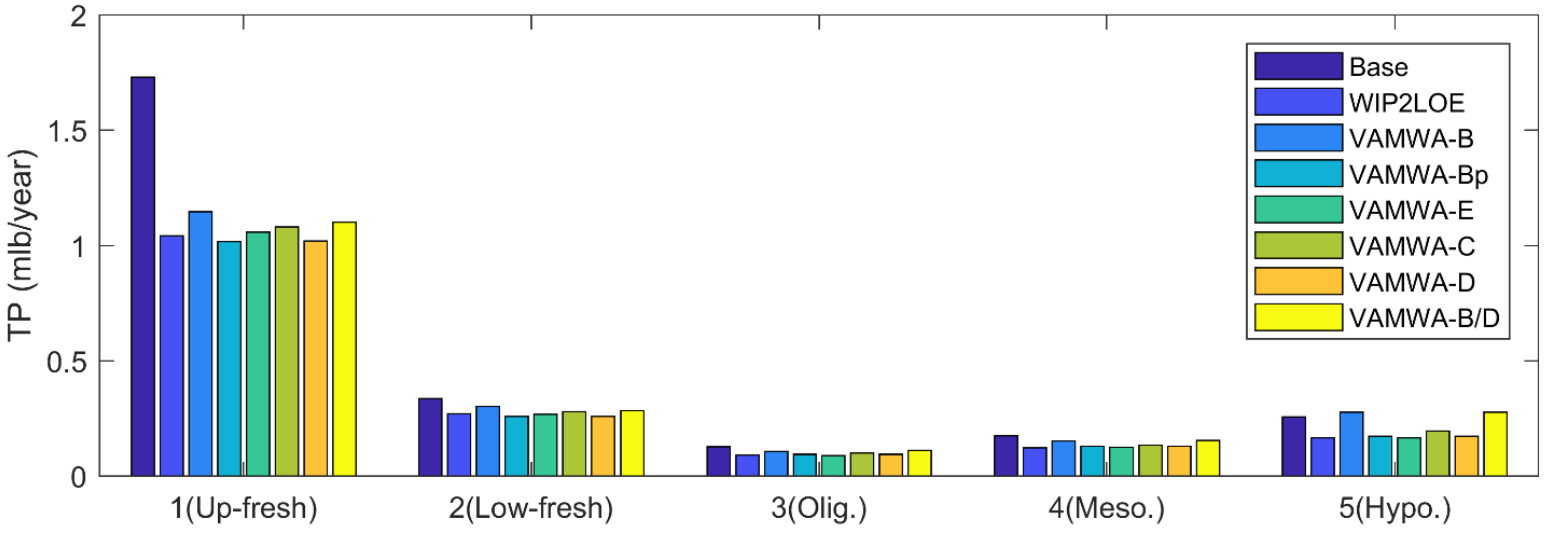
Scenarios

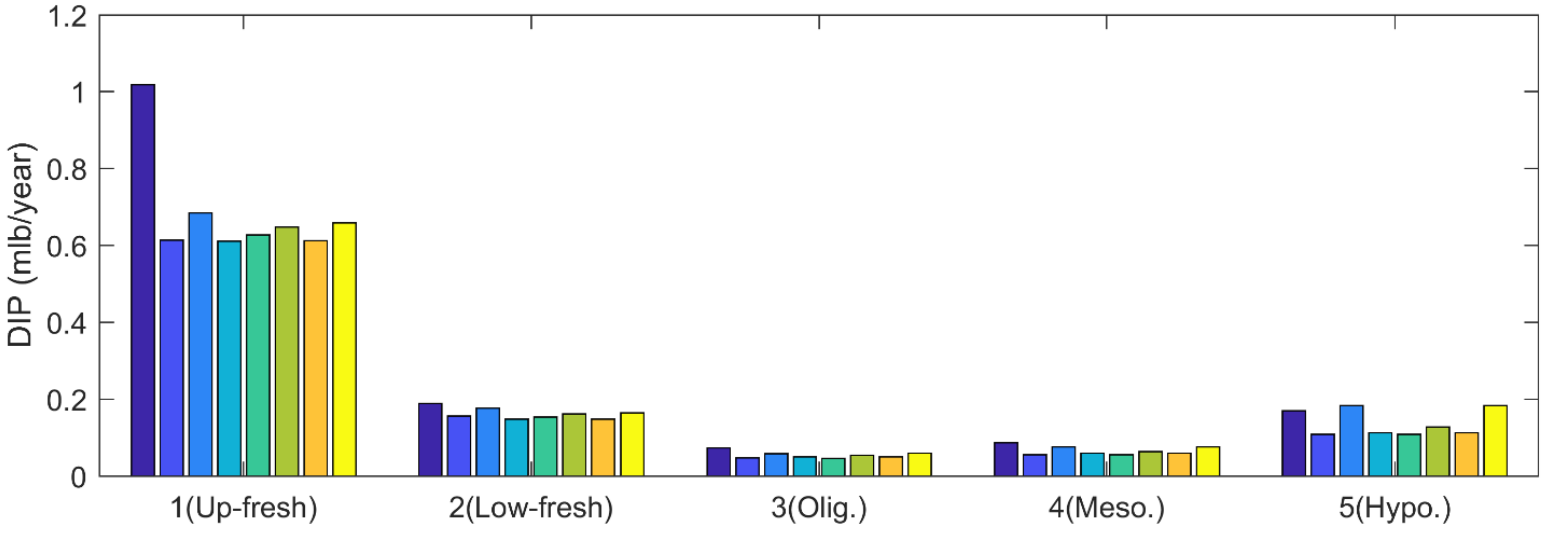
- **2017 Watershed General Permit Waste Load Allocations**
- **Watershed Implementation Plan II (Mar. 2012) Level of Effort**
- **VAMWA Scenario "B+“**
- **VAMWA Scenario "C": Intermediate scenario**
- **VAMWA Scenario "D": Intermediate scenario**
- **VAMWA Scenario "B/D"**

Comparison of TN Reduction

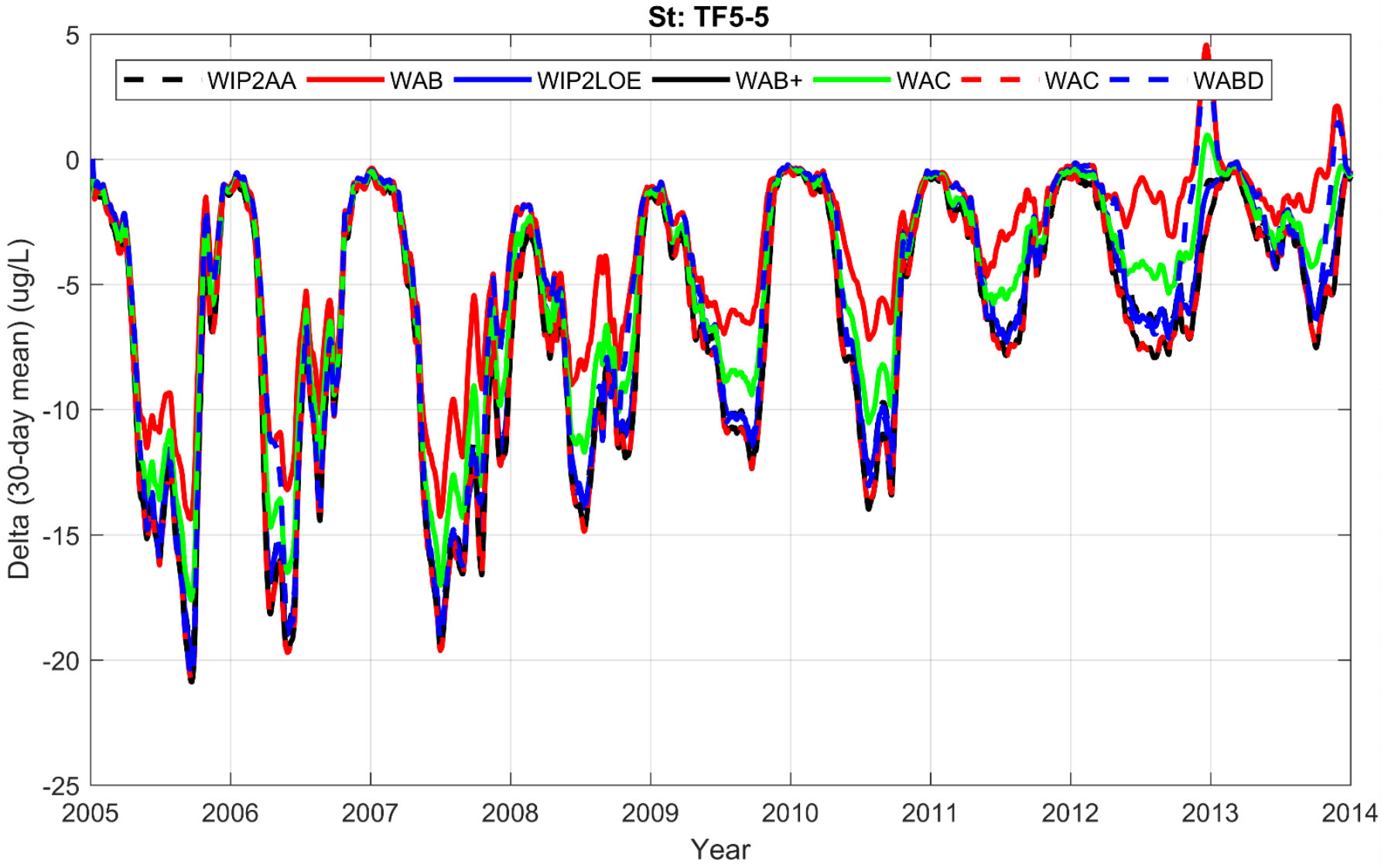


Comparison of TP reduction

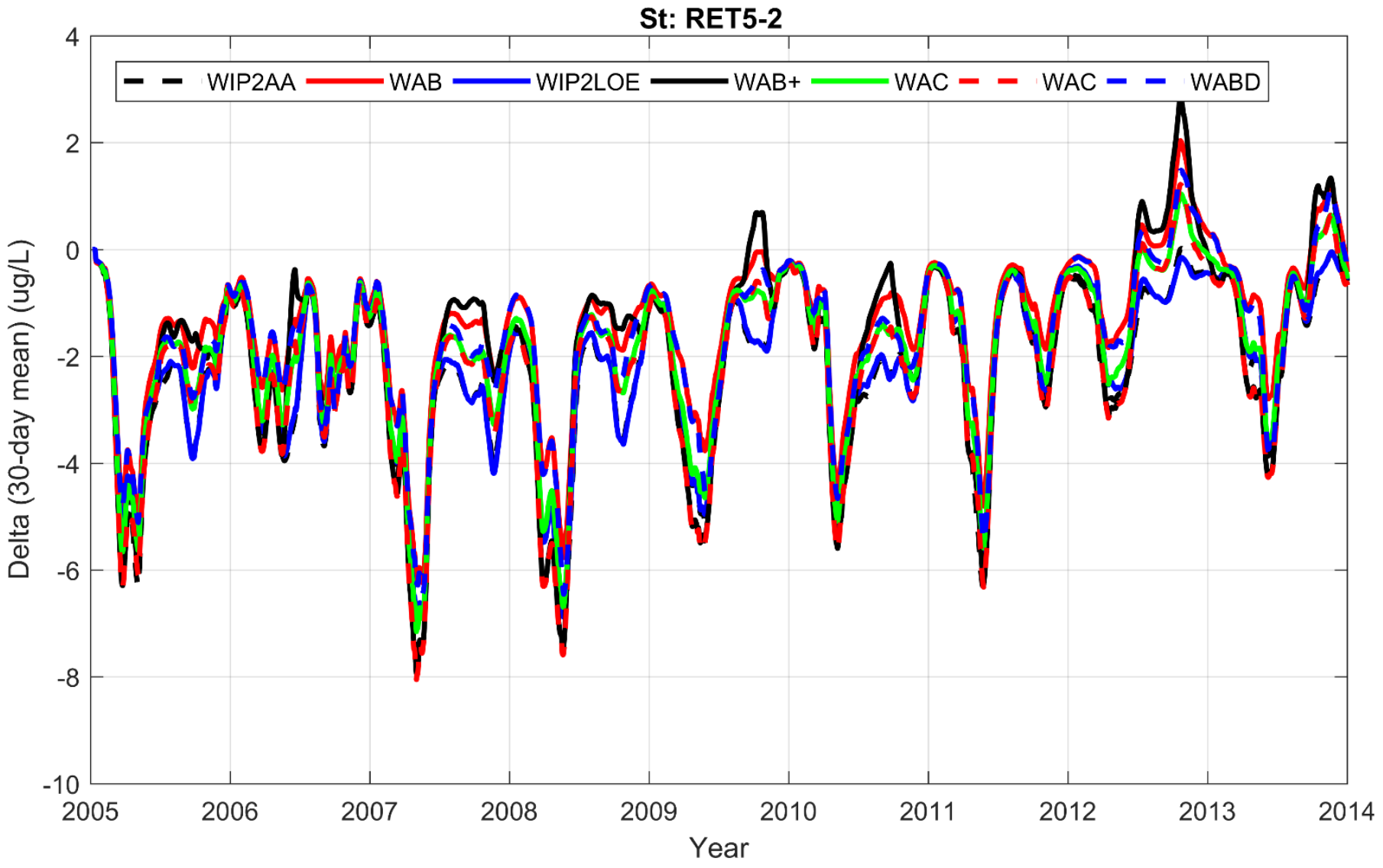




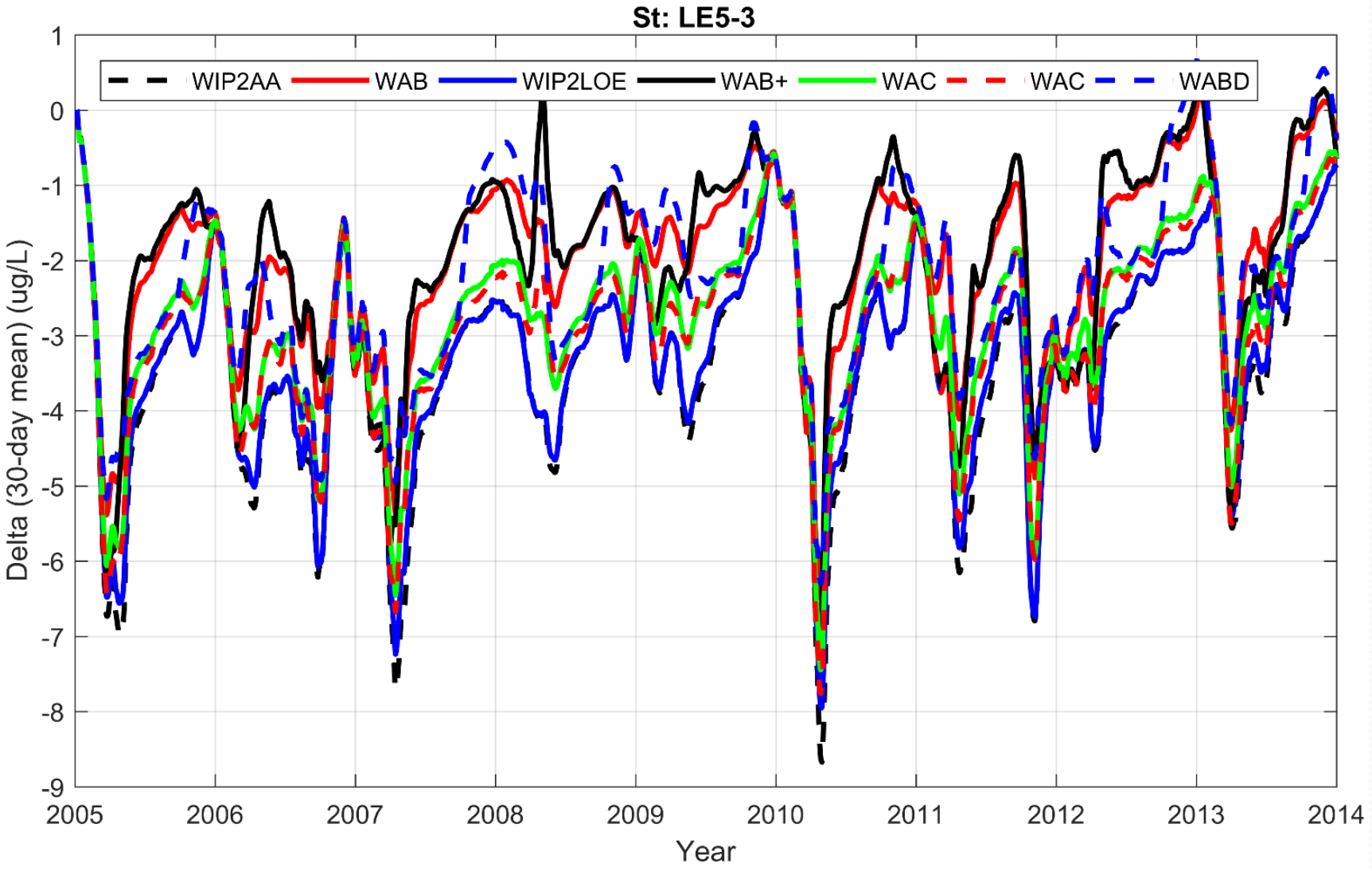
Tidal Freshwater



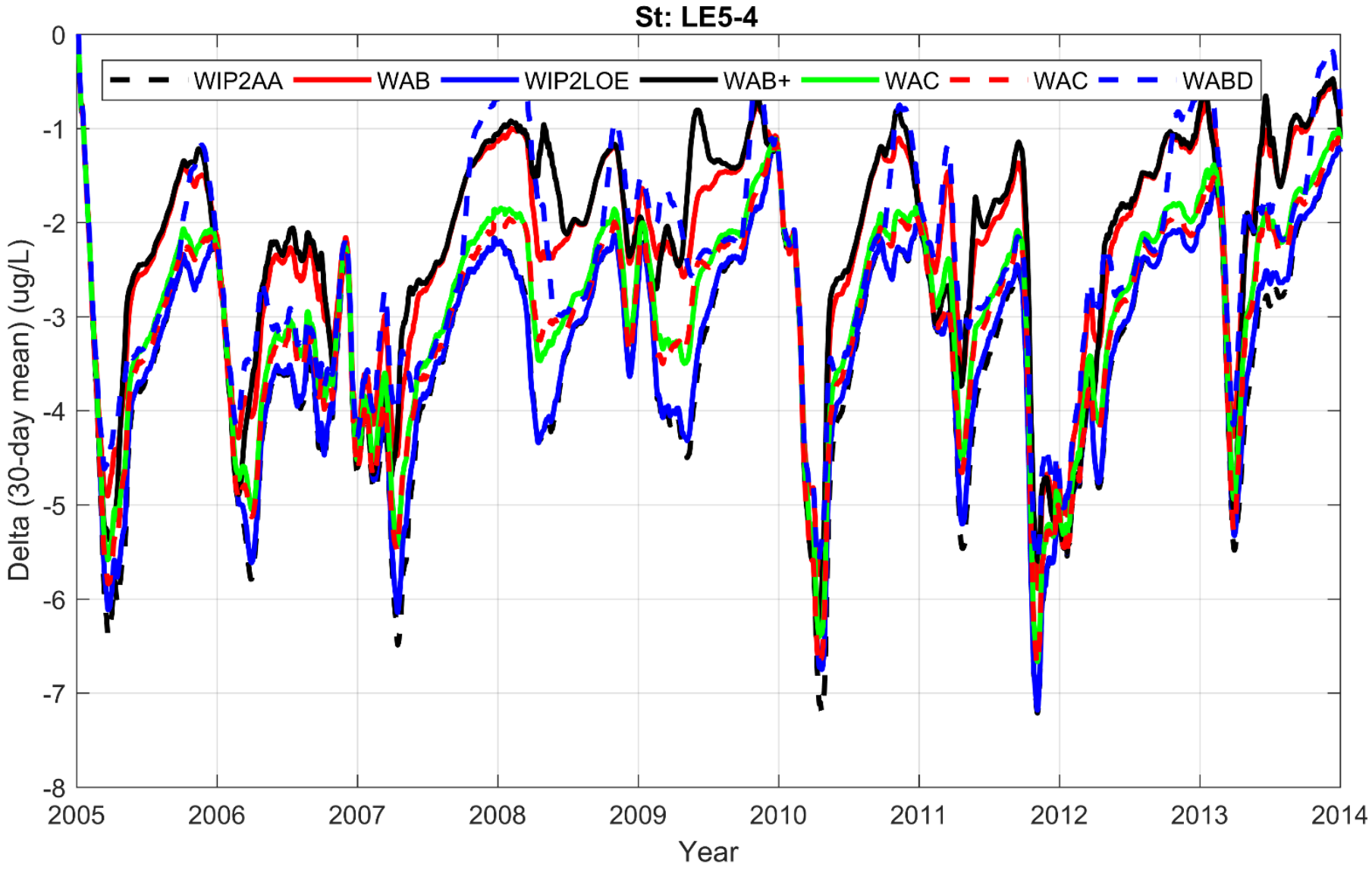
Oligohaline

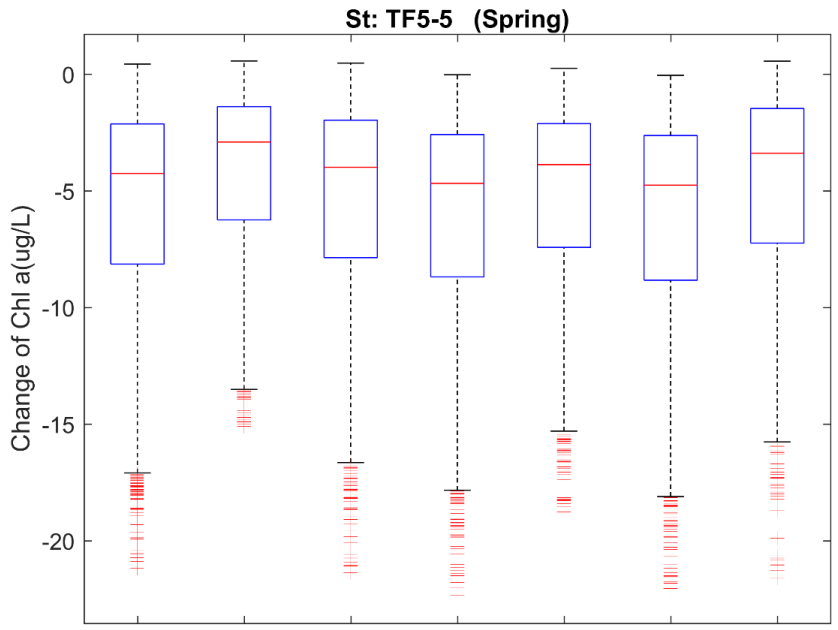


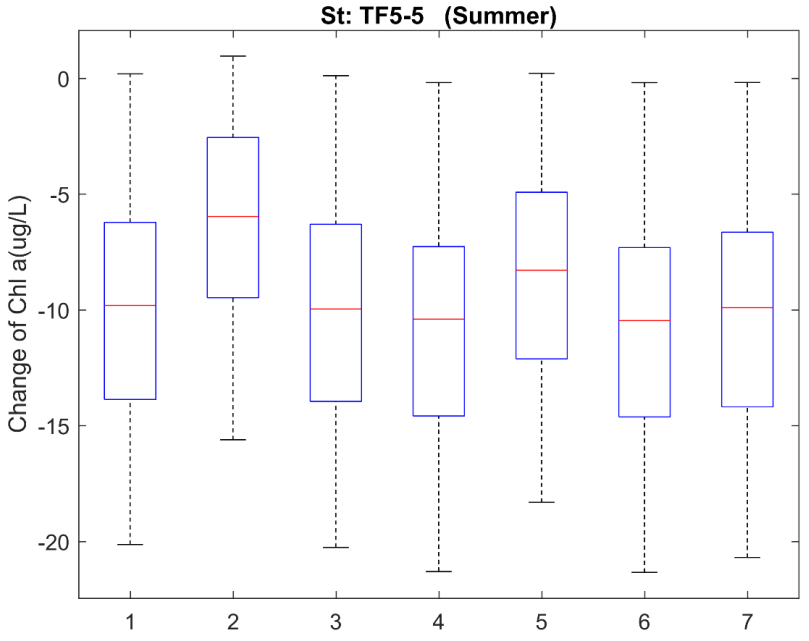
Mesohaline

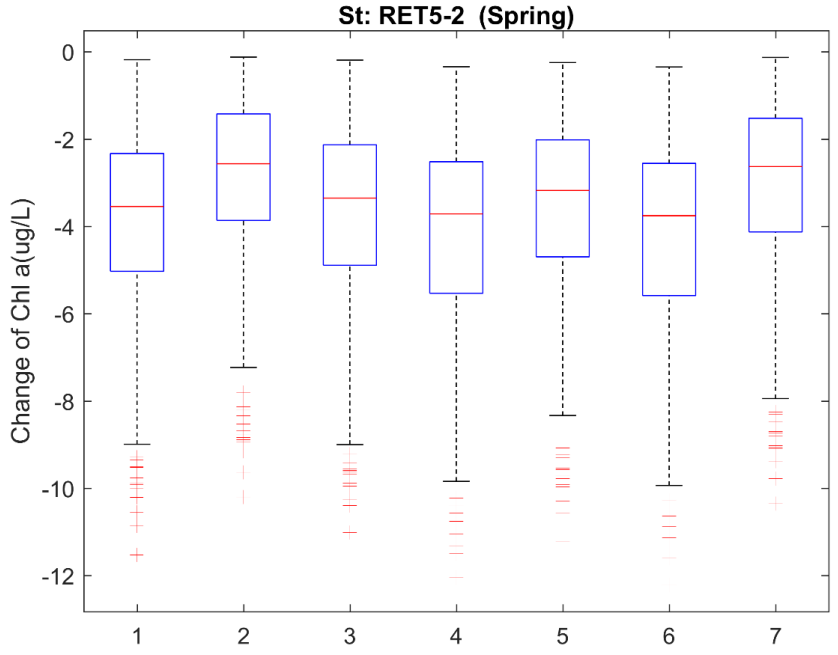

St: LE5-3
WIP2AA
WAB
WIP2LOE
WAB+
WAC
WAC
WABD
Delta (30-day mean) (ug/L)
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year

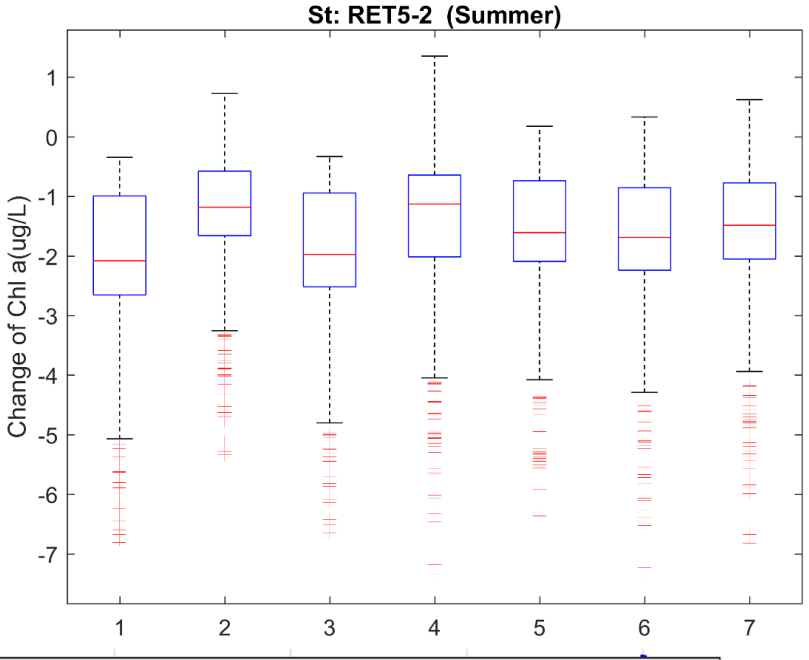
Polyhaline


St: LE5-4
WIP2AA
WAB
WIP2LOE
WAB+
WAC
WAC
WABD
Delta (30-day mean) (ug/L)
0
-1
-2
-3
-4
-5
-6
-7
-8
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year

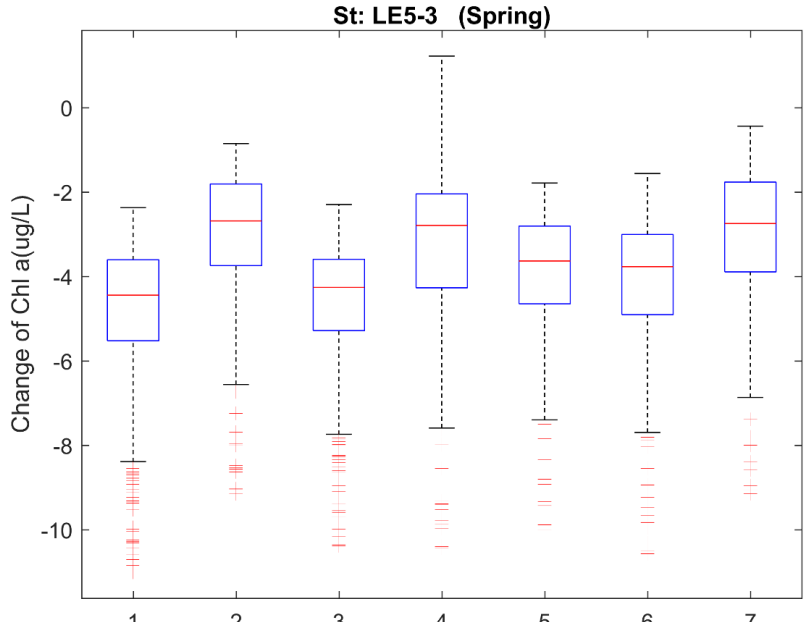

St: TF5-5 (Spring)
Change of Chl a(ug/L)
0
-5
-10
-15
-20

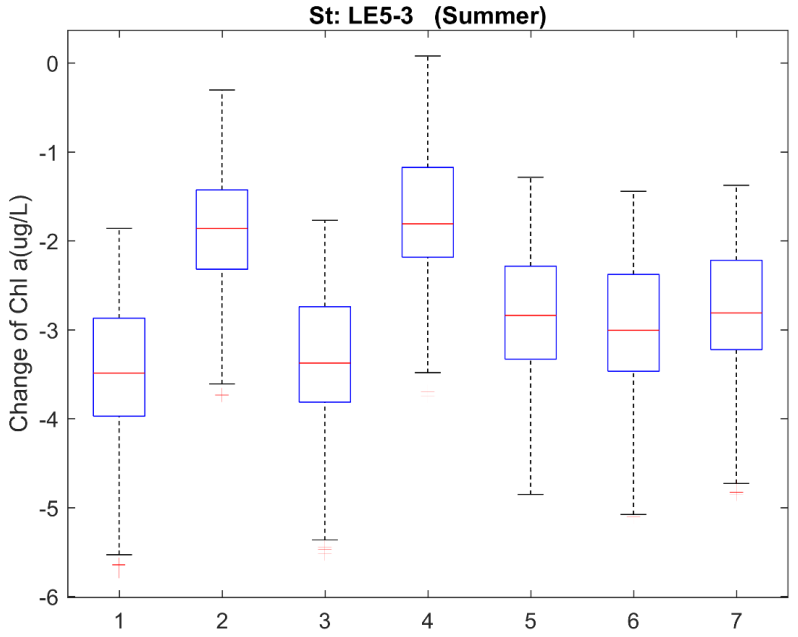

St: TF5-5 (Summer)
Change of Chl a(ug/L)
0
-5
-10
-15
-20
1
2
3
4
5
6
7

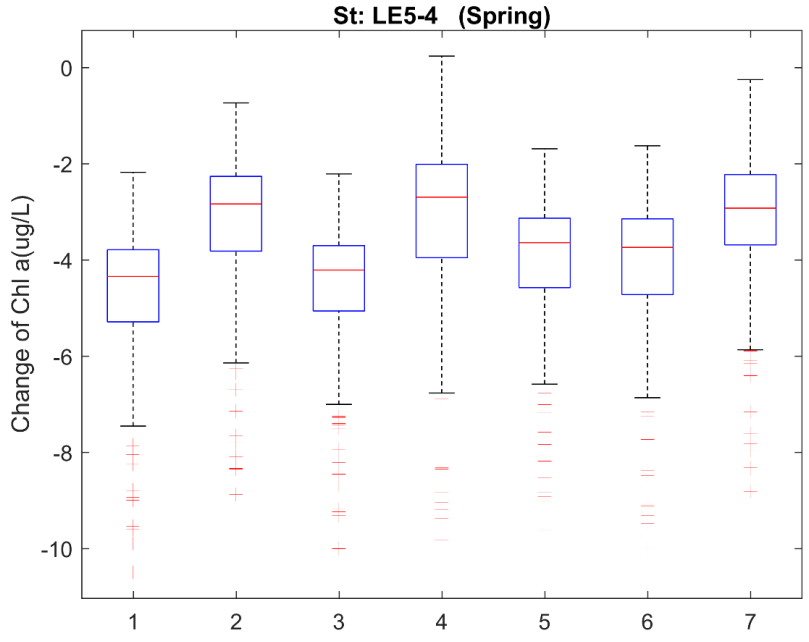

St: RET5-2 (Spring)
Change of Chl a(ug/L)
0
-2
-4
-6
-8
-10
-12
1
2
3
4
5
6
7

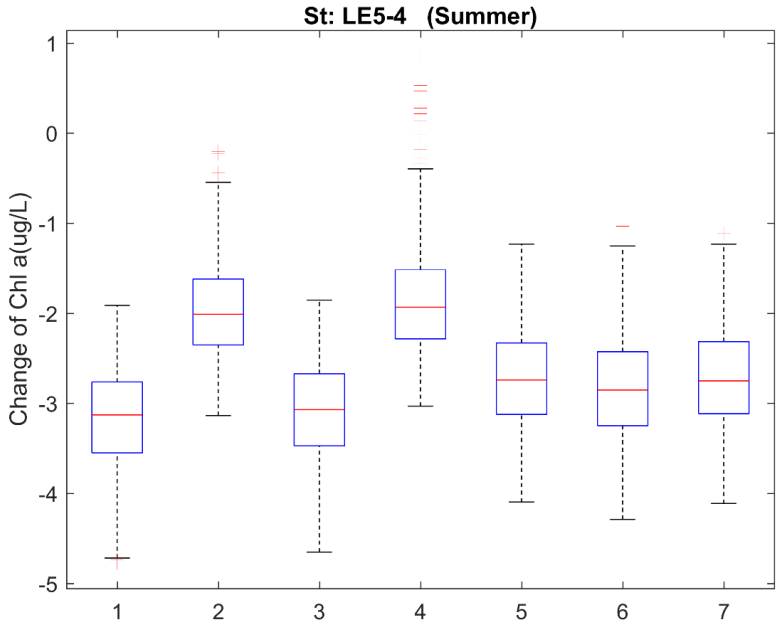

St: RET5-2 (Summer)
Change of Chl a(ug/L)
1
0
-1
-2
-3
-4
-5
-6
-7
1
2
3
4
5
6
7

WIP2AA
WAB
WIP2LOE
WAB+
WAC
WAC
WABD


St: LE5-3 (Spring)
Change of Chl a(ug/L)
0
-2
-4
-6
-8
-10
1
2
3
4
5
6
7

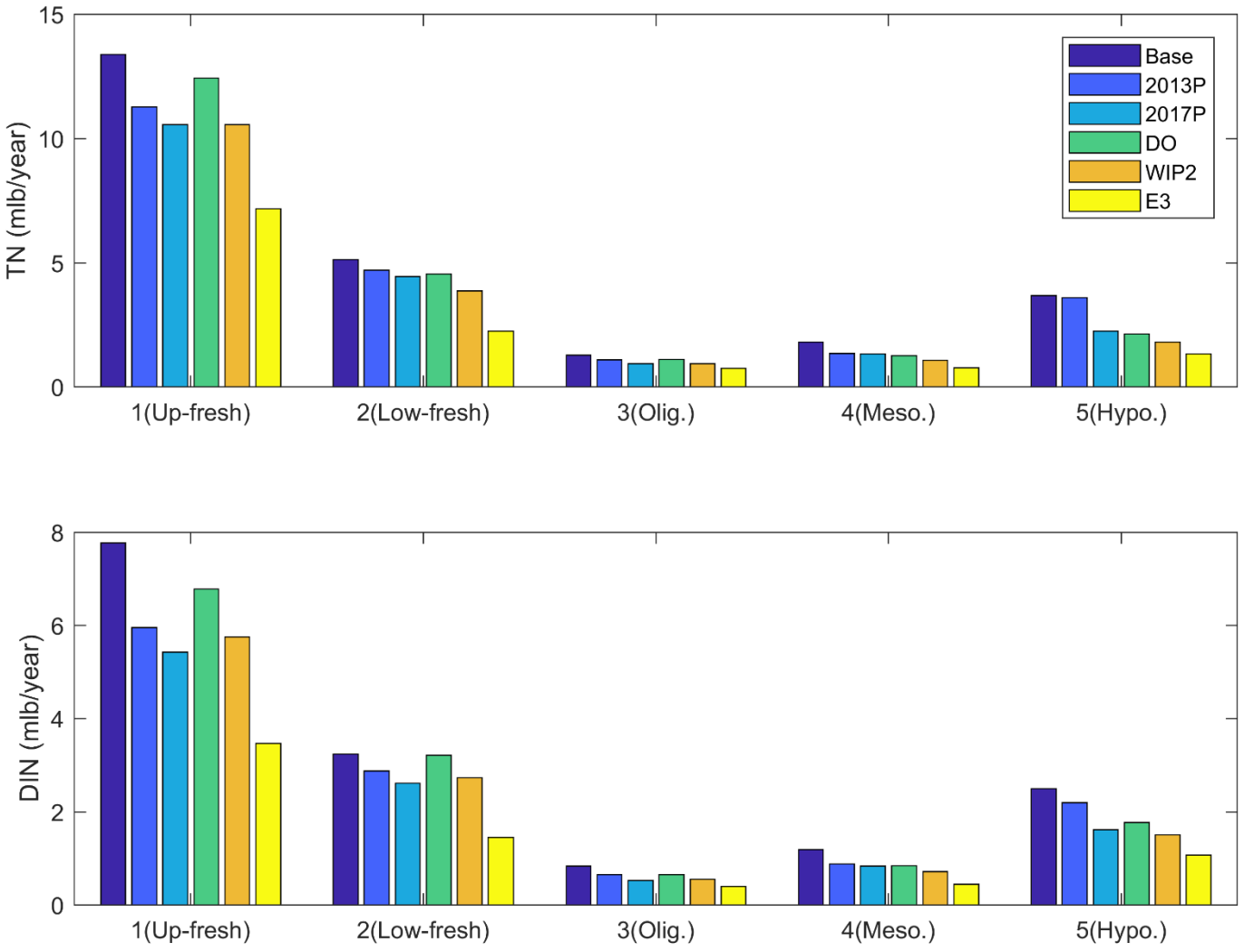

St: LE5-3 (Summer)
Change of Chl a(ug/L)
0
-1
-2
-3
-4
-5
-6
1
2
3
4
5
6
7


St: LE5-4 (Spring)
Change of Chl a(ug/L)
0
-2
-4
-6
-8
-10
1
2
3
4
5
6
7

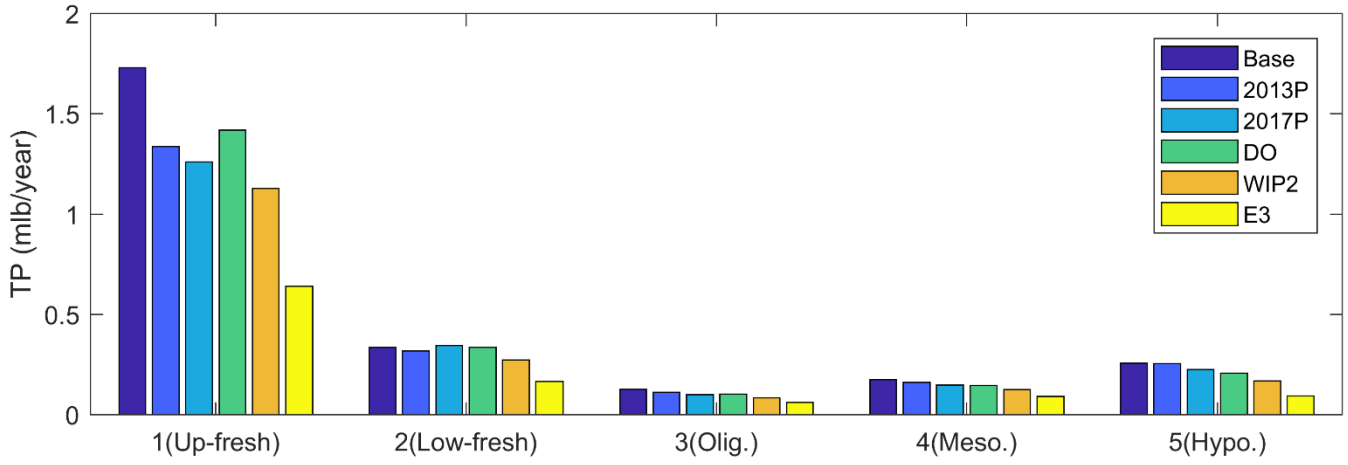

St: LE5-4 (Summer)
Change of Chl a(ug/L)
1
0
-1
-2
-3
-4
-5
1
2
3
4
5
6
7

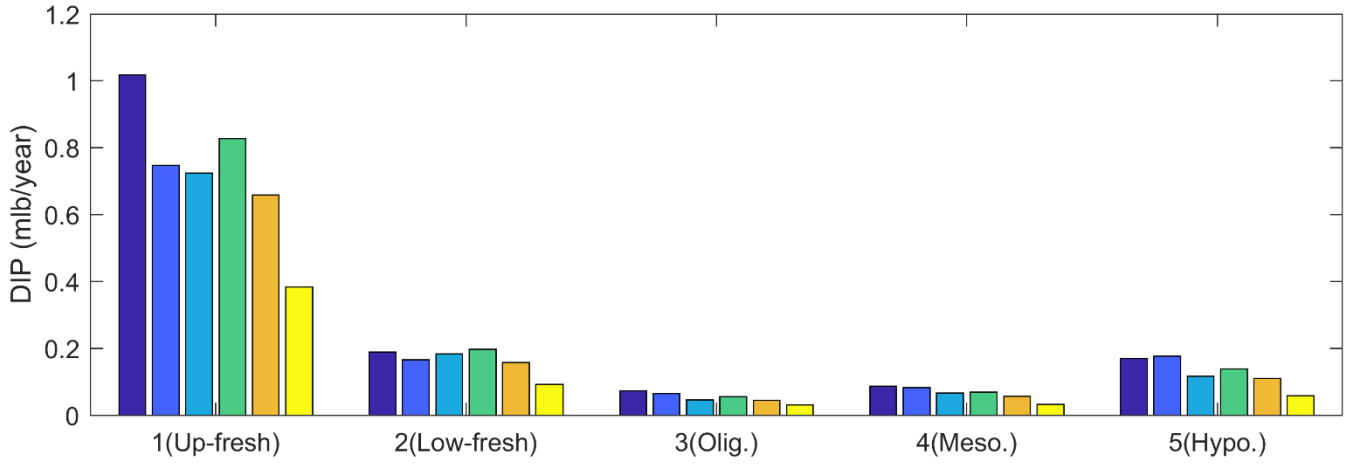
WIP2AA
WAB
WIP2LOE
WAB+
WAC
WAC
WABD

Comparison of TN Reduction

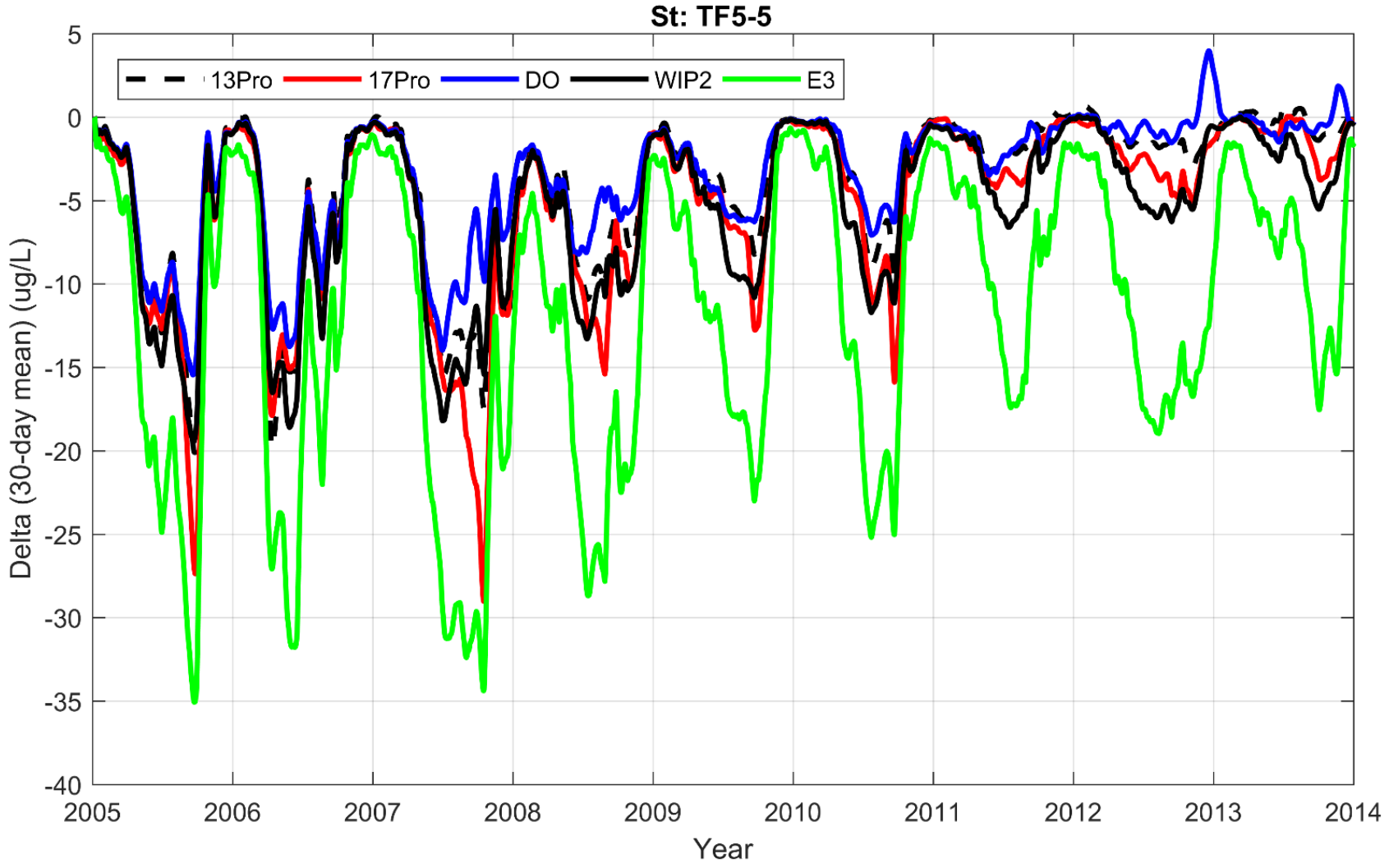


Comparison of TP Reduction

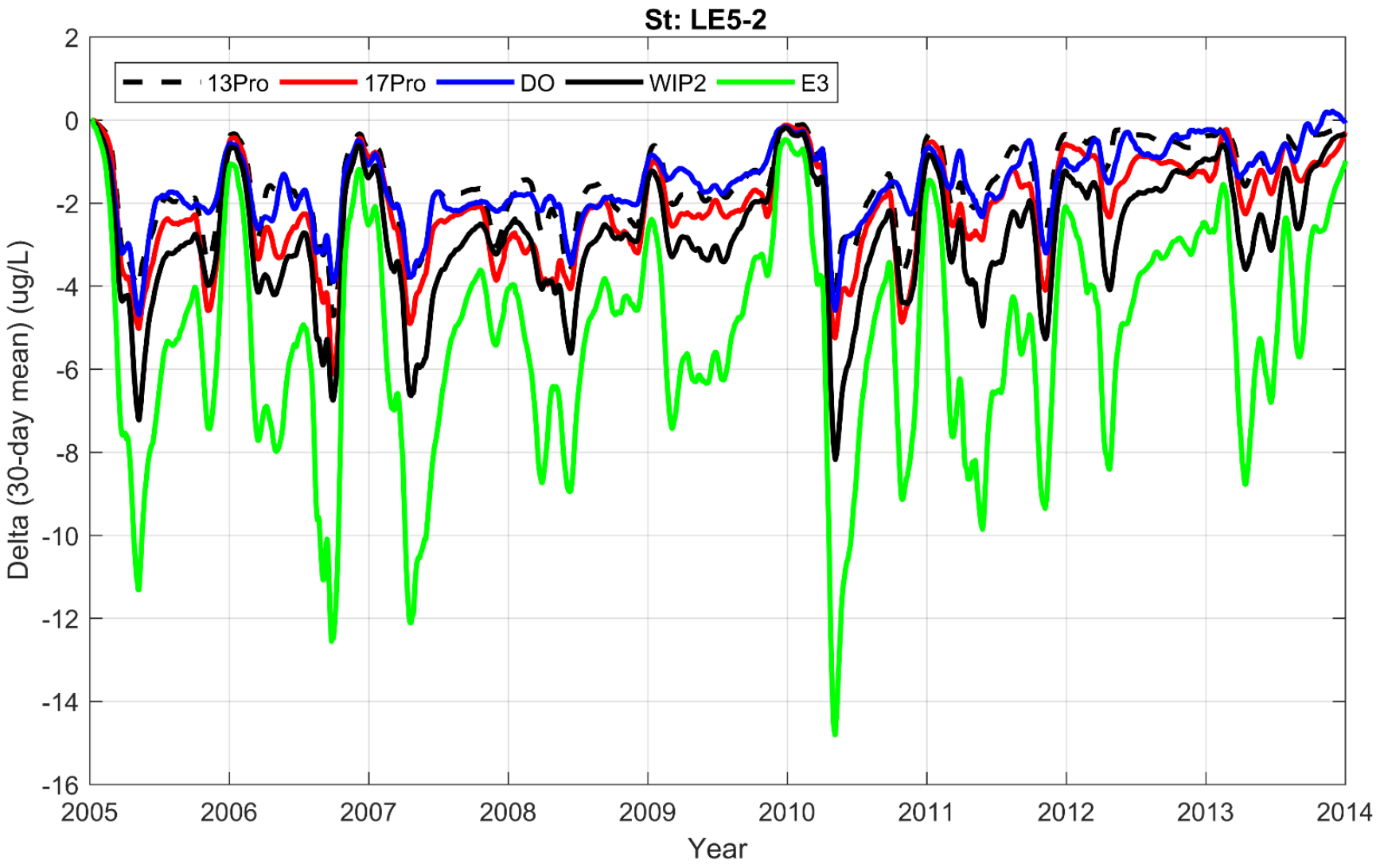




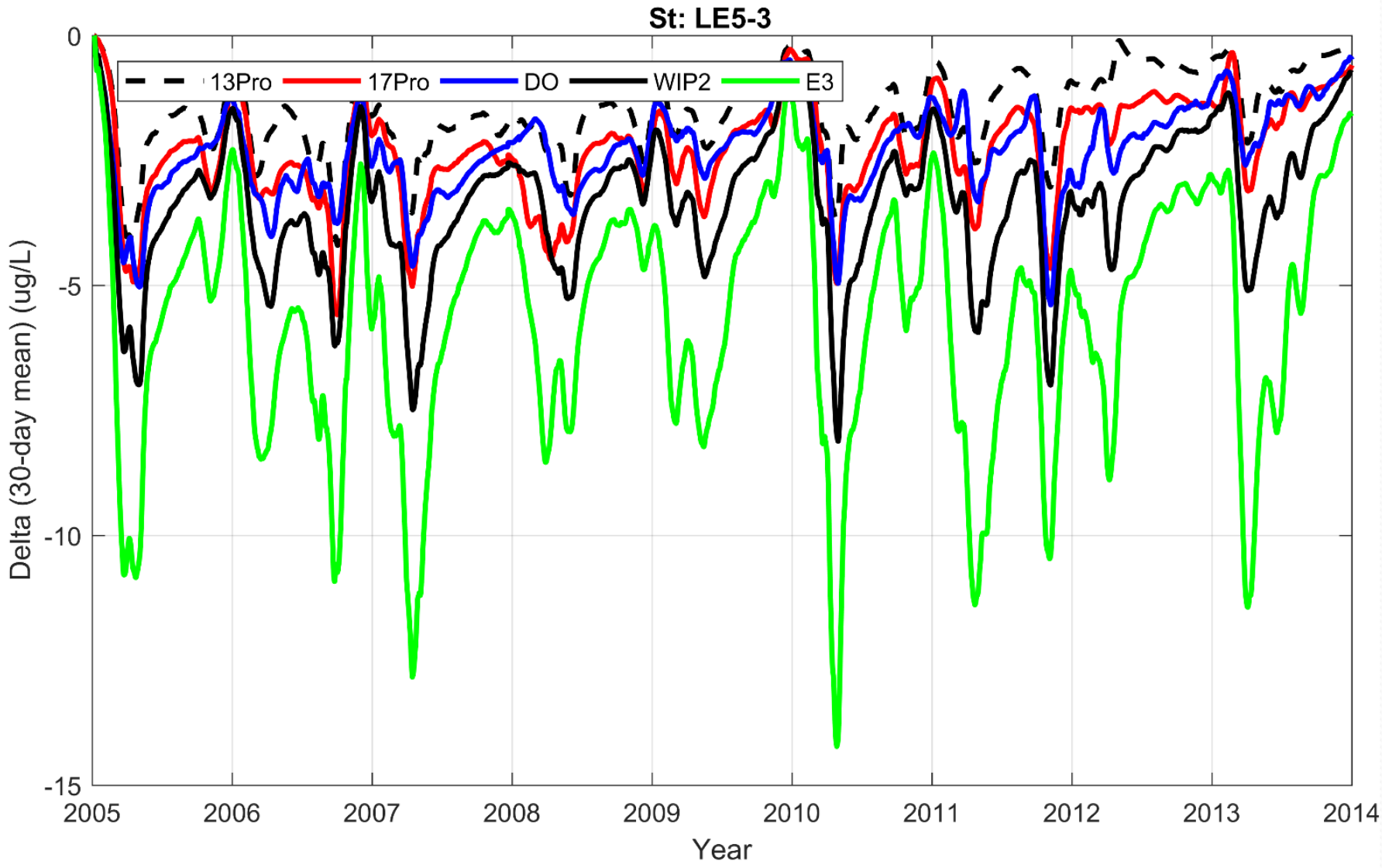
Tidal Freshwater



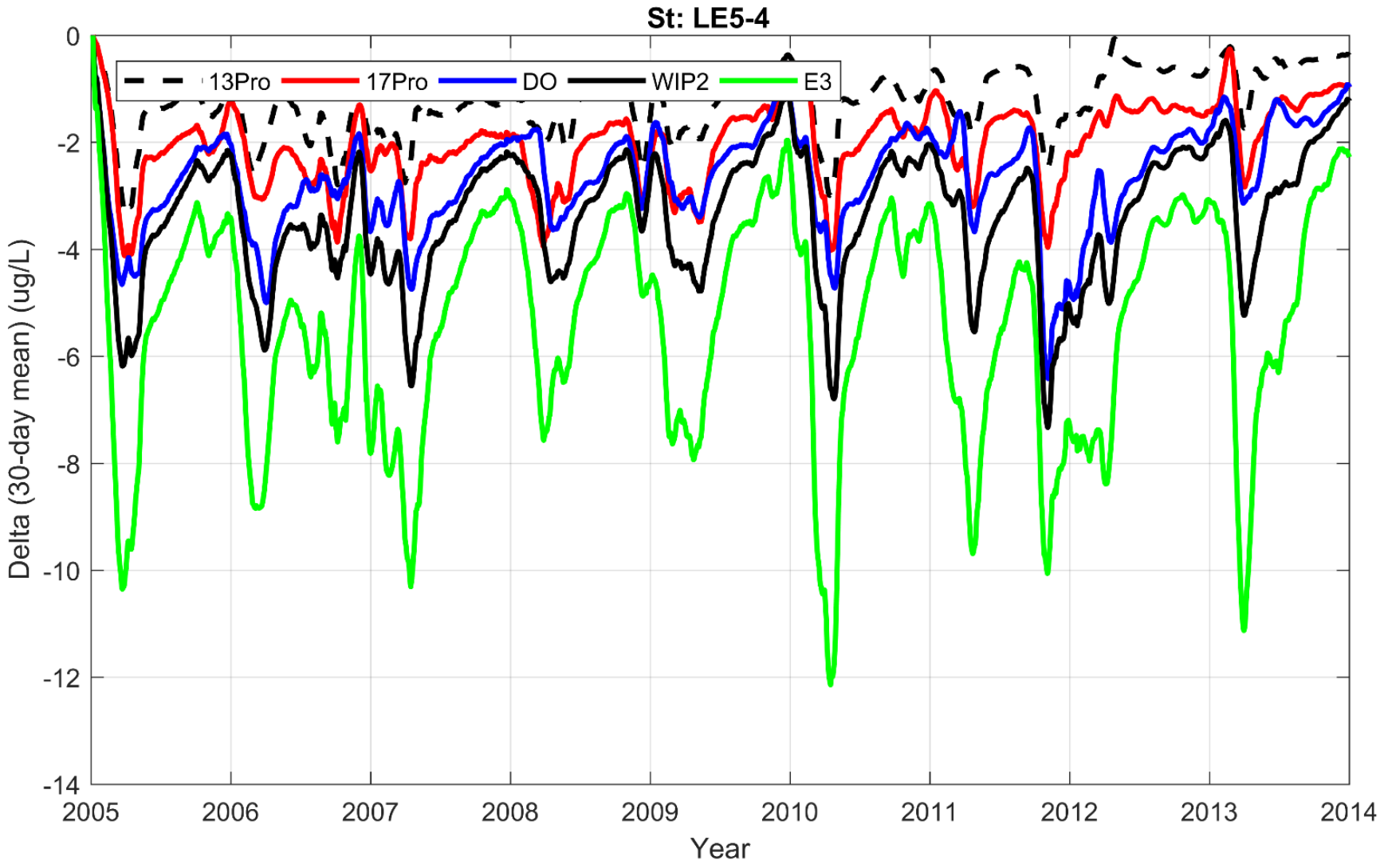
Oligohaline

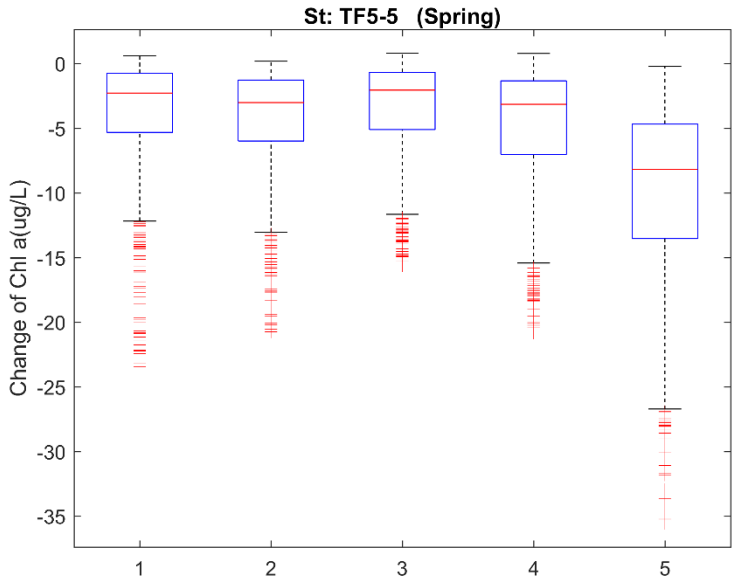


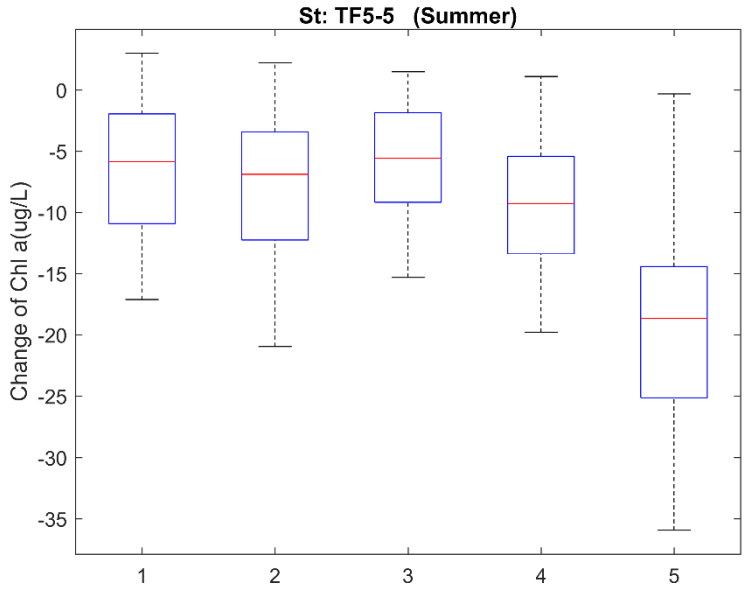
Mesohaline

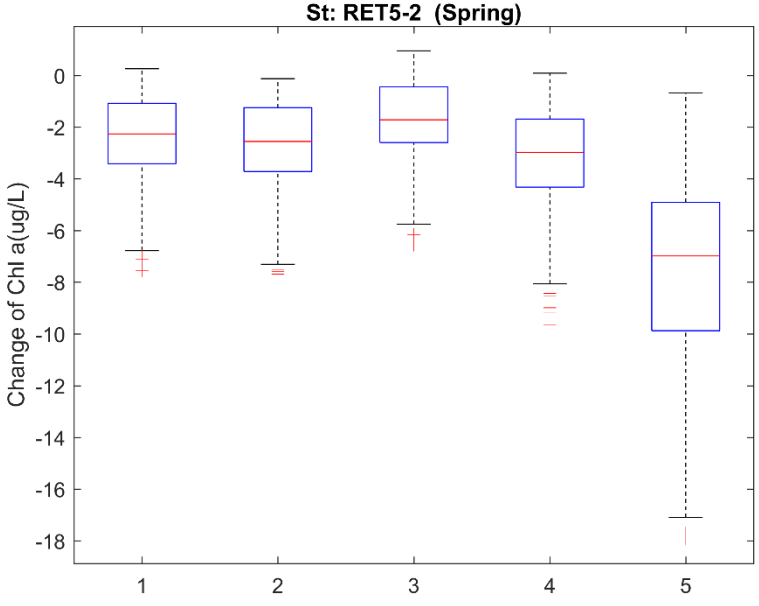

St: LE5-3
13Pro
17Pro
DO
WIP2
E3
Delta (30-day mean) (ug/L)
0
-5
-10
-15
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year

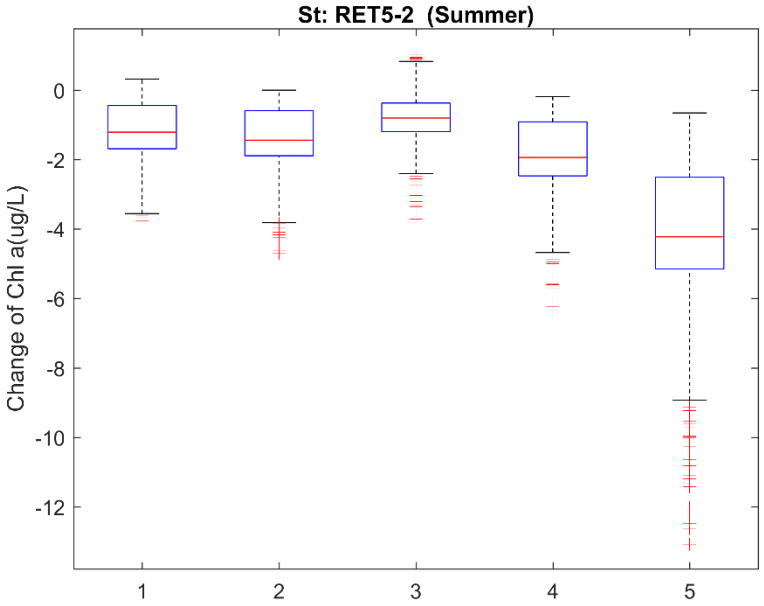
Polyhaline

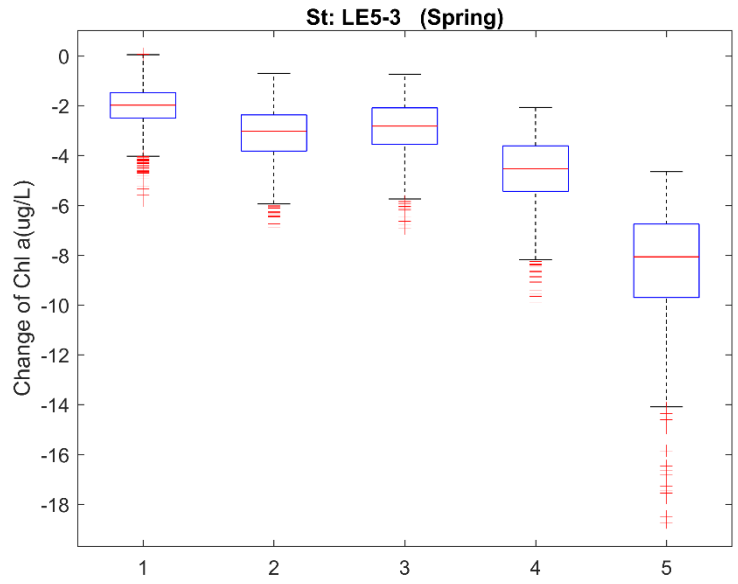

St: LE5-4
13Pro
17Pro
DO
WIP2
E3
Delta (30-day mean) (ug/L)
0
-2
-4
-6
-8
-10
-12
-14
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year

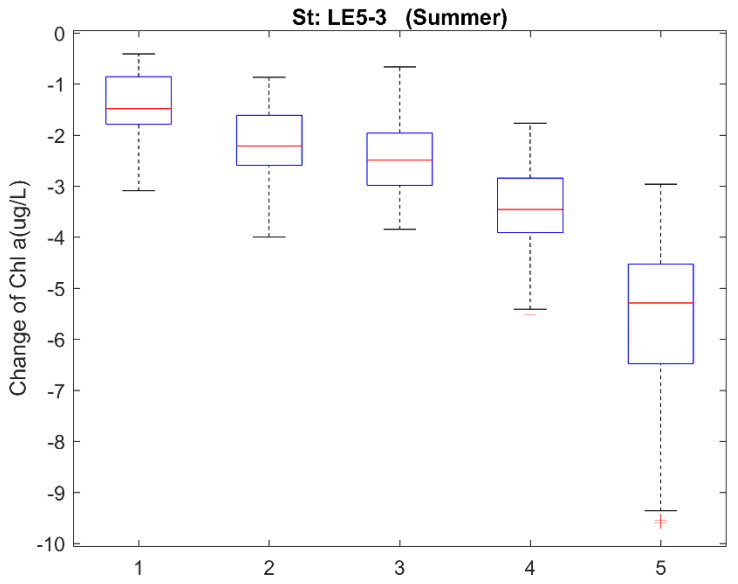

St: TF5-5 (Spring)
Change of Chl a(ug/L)
0
-5
-10
-15
-20
-25
-30
-35
1
2
3
4
5

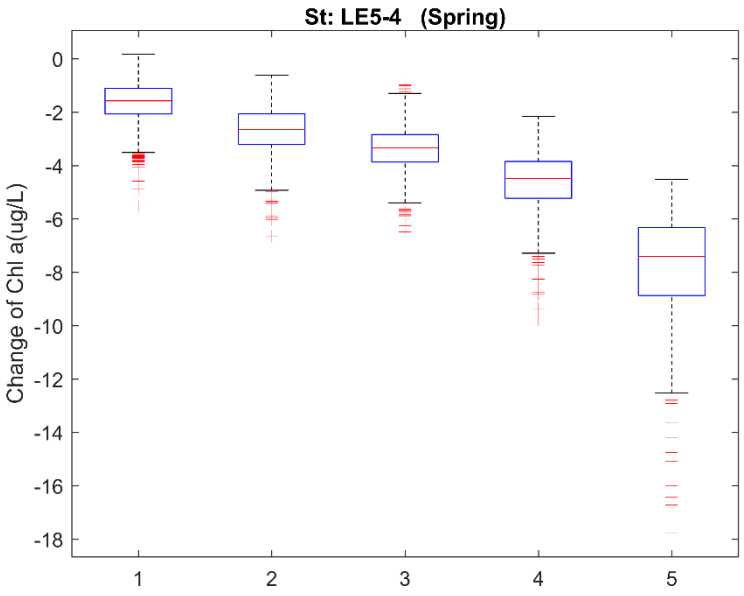

St: TF5-5 (Summer)
Change of Chl a(ug/L)
0
-5
-10
-15
-20
-25
-30
-35
1
2
3
4
5

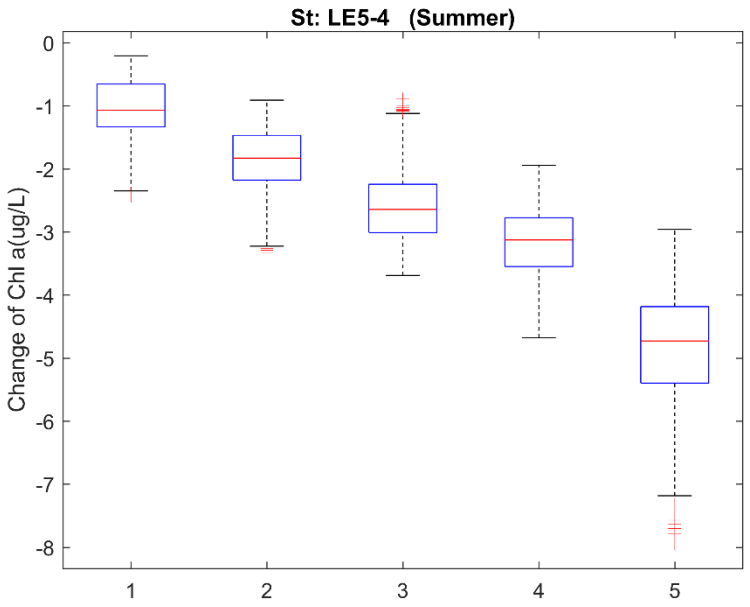

St: RET5-2 (Spring)
Change of Chl a(ug/L)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
1
2
3
4
5


St: RET5-2 (Summer)
Change of Chl a(ug/L)
0
-2
-4
-6
-8
-10
-12
1
2
3
4
5


St: LE5-3 (Spring)
Change of Chl a(ug/L)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
1
2
3
4
5


St: LE5-3 (Summer)
Change of Chl a(ug/L)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
1
2
3
4
5


St: LE5-4 (Spring)
Change of Chl a(ug/L)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
1
2
3
4
5


St: LE5-4 (Summer)
Change of Chl a(ug/L)
0
-1
-2
-3
-4
-5
-6
-7
-8
1
2
3
4
5

Conclusions

- The model sensitivity tests indicate that a slight change of a model kinetic parameter will only result in minor changes of model calibration.
- Although different calibrations many result in differences in model-data comparison, it will not affect assessment based on the CBP's method to correct observations based on difference of baseline and reduction. It accounts for model uncertainty due to mismatch between model and observations.
- The use of time varying C:Chl-a ratio has large impact on Chl-a reduction compared to use of fix C:Chl-a
- Model is robust and is capable of conducting management scenarios.