07/08/2025

Phase 7 WSM Development – Calibration and Refinements of the Dynamic Watershed Model (DWSM)

Modeling Workgroup Quarterly Meeting – July 2025

Gopal Bhatt[1], Isabella Bertani[2], Lewis Linker[3], Robert Burgholzer[4]

[1] Penn State, [2] UMCES, [3] US EPA, [4] VA DEQ – Chesapeake Bay Program Office

Presentation Outline

Phase 7 Dynamic Watershed Model (DWSM)

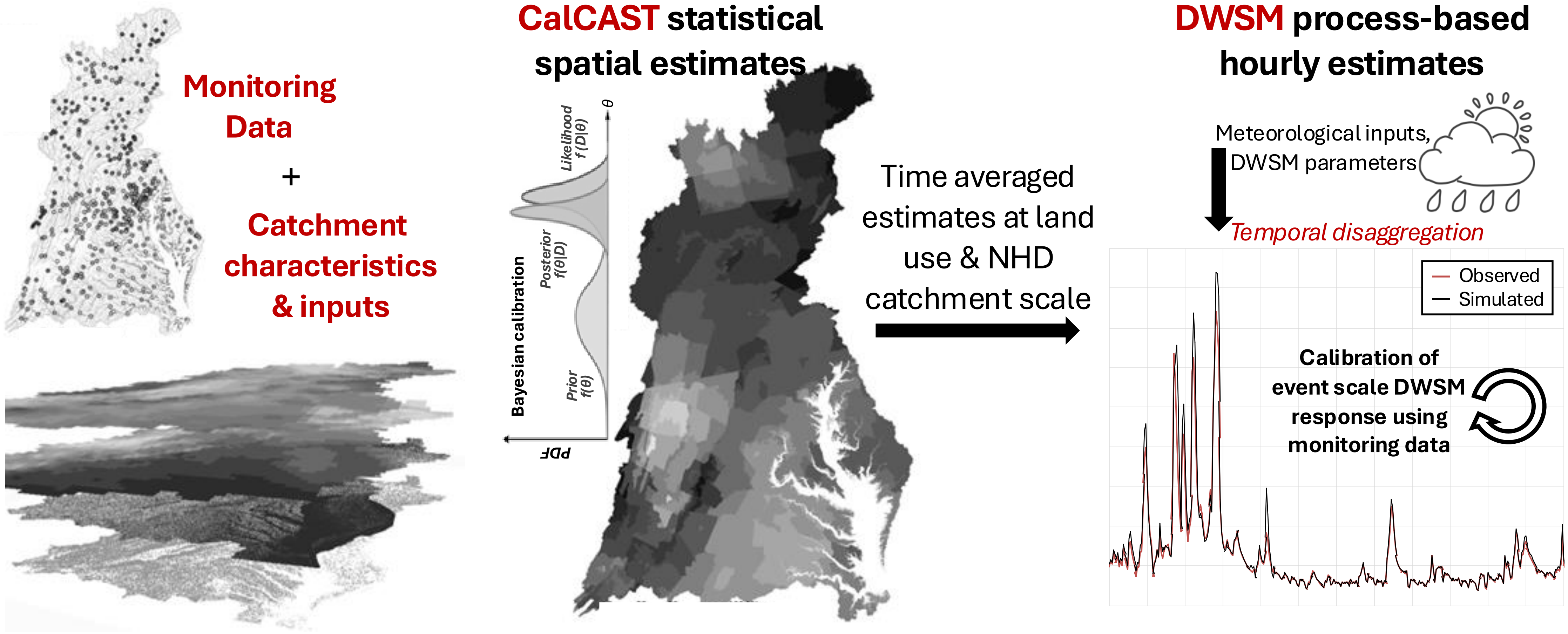
1. **Dynamic Watershed Model Overview**
2. **Review of prior model development progress**
3. **Linkage of the DWSM and Main Bay Model (MBM)**
    - April 2025 Beta version
    - Incorporation of newly developed beta-parameters
    - Simulation of sediment transport in small streams
    - Review of existing calibration method
    - Implementation and testing of new calibration methods
4. **Summary and next steps**

Purpose

NHD Scale Dynamic Watershed Model (DWSM)

- Inputs for the estuarine models (MBM/MTMs)
- Watershed model calibration and scenario applications
- Support research and collaboration activities

Framework: Statistical Model (CalCAST) → Dynamic Watershed Model (DWSM)



- Data-driven CalCAST informs DWSM parameters and responses.
- NHD-scale DWSM prototype is now using CalCAST *average annual* (a) total flow, (b) stormflow, (c) sediment erosion and delivery factors, and (d) total nitrogen and total phosphorus loads and delivery factors.

Dynamic Watershed Model (DWSM) Development

- Year 2022: NHD-scale model structure and prototypes for hydrology, sediment, and nutrients.

CY2022
[1] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/progress-in-phase-7-wsm-development-1.4.2022-gopal_bhatt_penn_state.pdf
[2] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/progress_in_phase_7_wsm_development_4.5.2022_-_gopal_bhatt_penn_state.pdf
[3] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/progress_in_phase_7_wsm_development_-_gopal_bhatt_penn_state_7.12.22.pdf
[4] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-10.4.22-v2.pdf
[5] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-1.10.2023.pdf

- Year 2023: Incremental refinements of model prototypes in terms of model segmentation, CalCAST→DWSM linkage, and simulation of the small streams.

CY 2023
[1] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/20230404-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2023Q1.pdf
[2] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-6.20.2023.pdf
[3] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-10.17.2023.pdf
[4] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/20240109-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2023Q4.pdf

- Year 2024: stream water quality routing based on β parameters; refinements of small stream flow and water temperature routing modules; mechanics of riverine water quality calibrations.

CY 2024
[1] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-CBPO-4.2.2024.pdf
[2] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Phase-7-WSM-Development-Modeling-WG-July-2024.pdf
[3] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/3_1000_20241008-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2024Q3.pdf
[4] https://www.chesapeakebay.net/files/documents/1035-20250107-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2024Q4.pdf

- **Year 2025:** Q1: development and testing of DWSM and MBM linkage through beta versions; **Q2: April beta version, calibration and further refinements of the DWSM;**

CY 2025
[1] https://www.chesapeakebay.net/files/documents/1025_20250401-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2025Q1.pdf

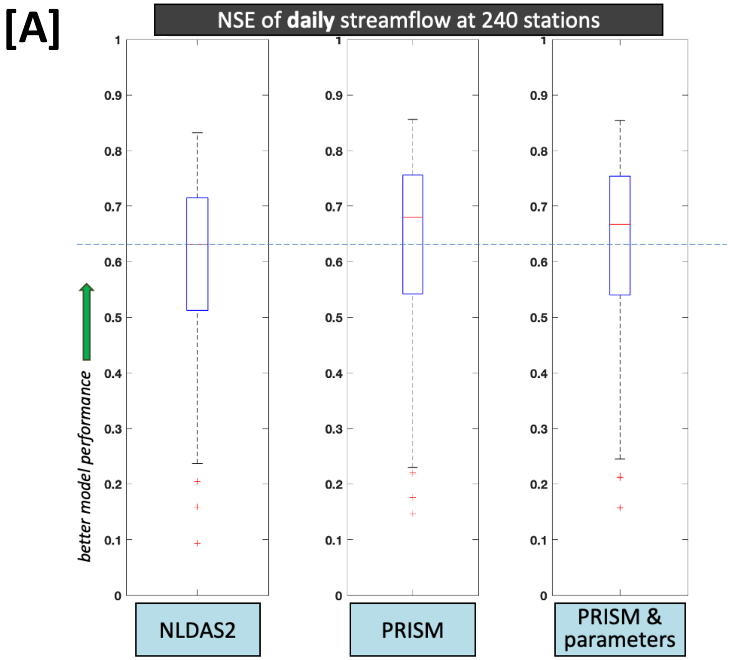
April 2025 Beta Version

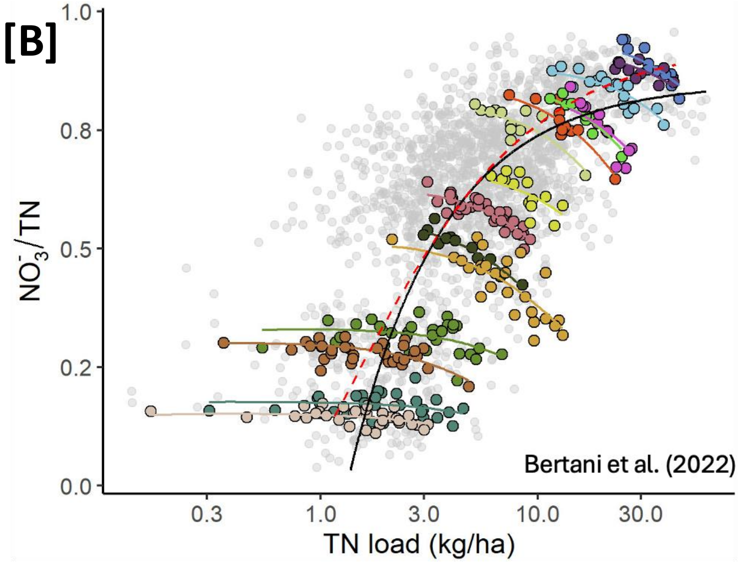
- At the April Quarterly meeting we reviewed isolated DWSM calibrations showing –

  [A] PRISM precipitation resulted in better hydrology model performance than NLDAS precipitation;

  [B] A new module incorporating emergent behavior of N-speciation in Phase 7 at the interface of land and aquatic transport models improved the simulation of nitrate loads.

- We combined those elements in the April 2025 Beta version –
  - Hydrology model was recalibrated while changing the calibration period from 1985-2014 to 1985-2020.
  - Model outputs with 234,306 timeseries [{ 2,858 terminal + 10,159 tidal } x 18 variables] were archived in one NetCDF file.





Bertani, I., G. Bhatt, G.W. Shenk, and L.C. Linker. 2022. "Quantifying the Response of Nitrogen Speciation to Hydrology in the Chesapeake Bay Watershed Using a Multilevel Modeling Approach." Journal of the American Water Resources Association 58 (6): 792–804. https://doi.org/10.1111/1752-1688.12951.

April 2025 Beta

CalCAST (v20250114) + Septic + HSPF Sediment + PRISM + NO3 + ReCal

RIM stations: Phase 7 loads vs. WRTDS

Wq20250430cal

(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

Rivers	Flow	Nitrogen	Phosphorus	Sediment
Susquehanna Conowingo MD	+00.9% (+0.910)	-09.2% (+0.665)	+18.2% (+0.763)	-32.9% (+0.534)
Susquehanna Marietta PA	-00.9% (+0.944)	-09.9% (+0.687)	-13.9% (+0.789)	-08.9% (+0.734)
Potomac Washington, DC	+00.8% (+0.929)	-20.9% (+0.670)	-05.5% (+0.541)	-00.9% (-0.211)
James Cartersville, VA	+04.8% (+0.904)	-22.8% (+0.632)	-21.8% (+0.615)	+12.2% (-2.588)
Rappa. Fredericksburg, VA	+00.1% (+0.931)	-05.7% (+0.853)	-11.3% (+0.732)	+11.1% (+0.240)
Appomattox Matoaca, VA	+00.8% (+0.826)	+10.2% (+0.702)	+12.8% (+0.713)	+11.3% (+0.212)
Pamunkey Hanover, VA	+03.6% (+0.807)	+04.9% (+0.786)	+04.2% (+0.506)	+20.6% (-0.918)
Mattaponi Beulahville, VA	+09.3% (+0.789)	+19.9% (+0.378)	+11.2% (-0.035)	+44.8% (-4.080)
Patuxent Bowie, MD	+04.0% (+0.870)	-01.6% (+0.308)	-11.8% (+0.348)	+23.9% (-0.125)
Choptank Greensboro, MD	-05.3% (+0.721)	-03.1% (+0.732)	+06.6% (+0.499)	-03.7% (-0.596)

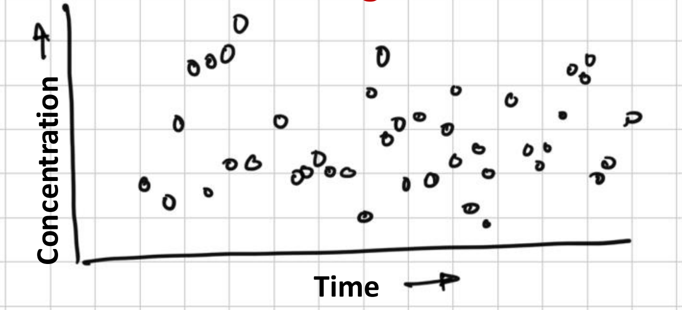
→ *some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period*

Small-stream flow and concentration (Q-C) relationship

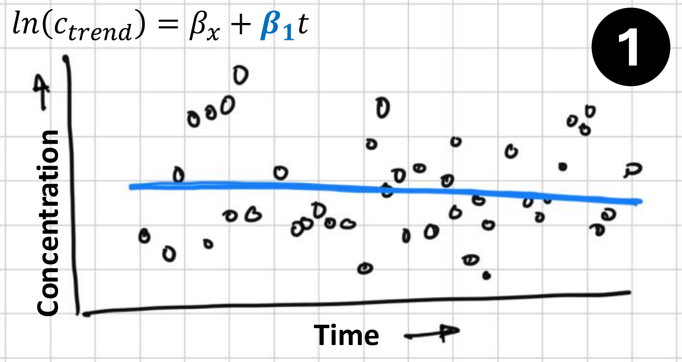
$$\underbrace{ln(c) = \beta_o + \beta_1 t}_{1} + \underbrace{\boldsymbol{\beta_2}\, ln(Q)}_{2} + \underbrace{\boldsymbol{\beta_3} sin(2\pi t) + \boldsymbol{\beta_4} cos(2\pi t)}_{3} + \varepsilon$$

[FluxMaster]

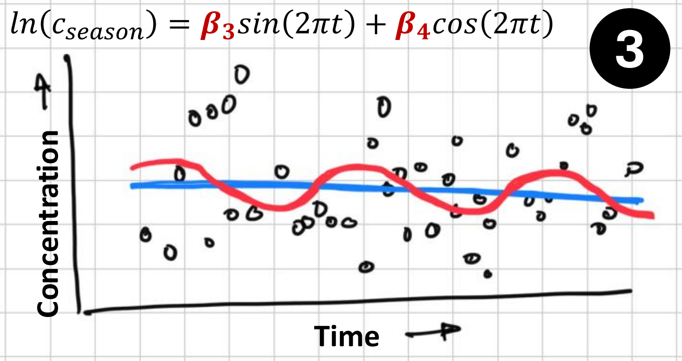
> data at a monitoring station



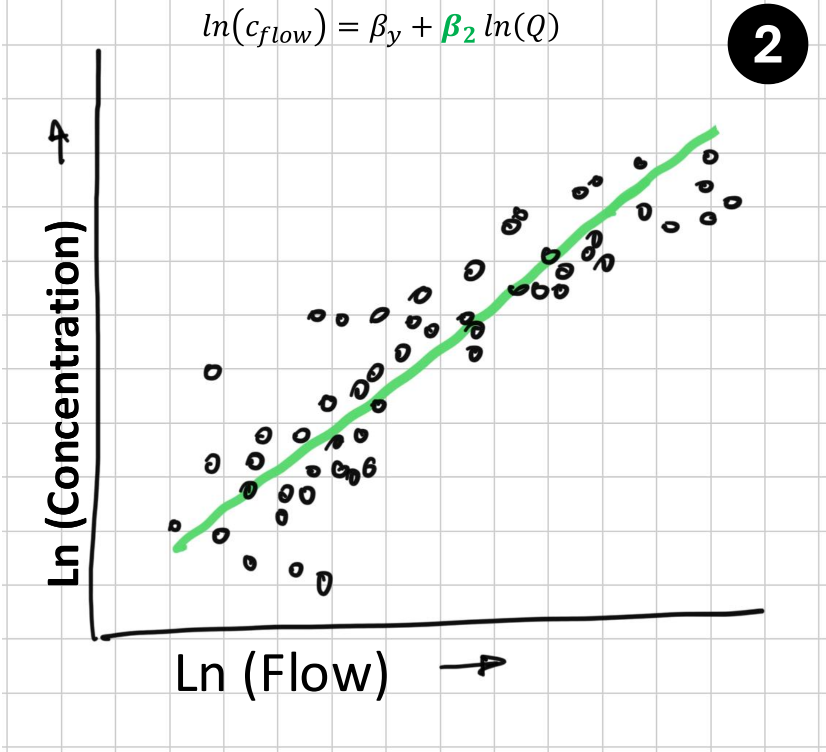
$ln(c_{trend}) = \beta_x + \boldsymbol{\beta_1} t$

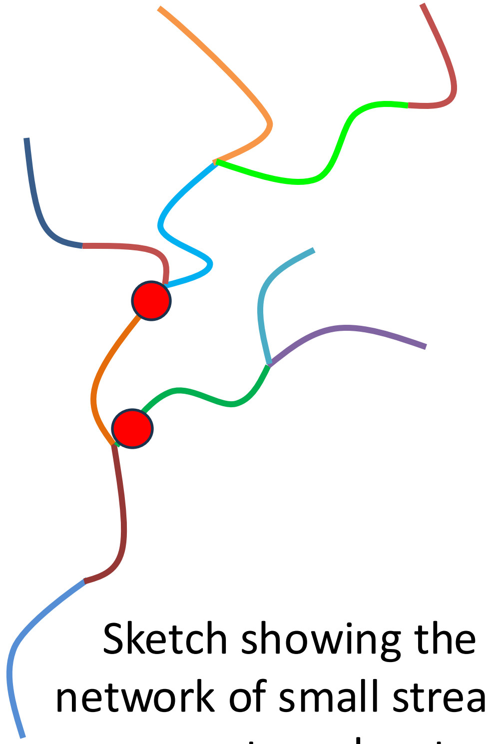


$ln(c_{season}) = \boldsymbol{\beta_3} sin(2\pi t) + \boldsymbol{\beta_4} cos(2\pi t)$



$ln(c_{flow}) = \beta_y + \boldsymbol{\beta_2}\, ln(Q)$





Sketch showing the network of small stream segments and water quality and streamflow monitoring stations

Small-stream flow and concentration (Q-C) relationship

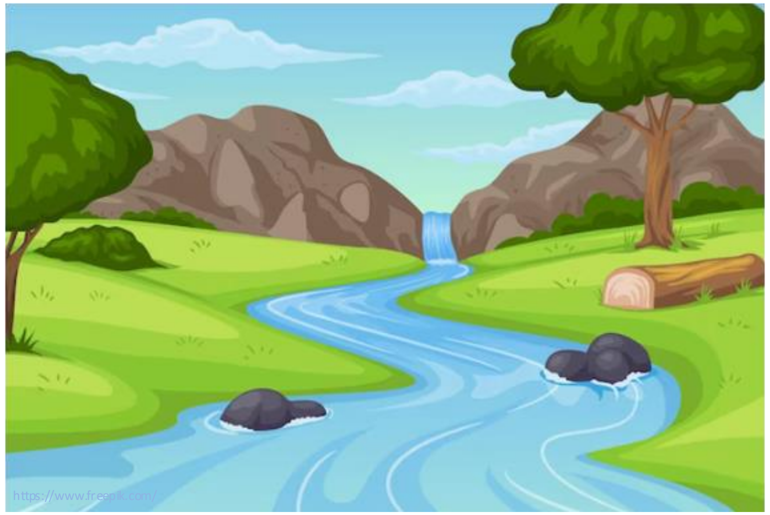
HSPF model: hourly surface and groundwater hydrology of land uses

UNEC model: annual surface and groundwater concentrations as a function of input history and estimates of lag-times

agricultural

natural

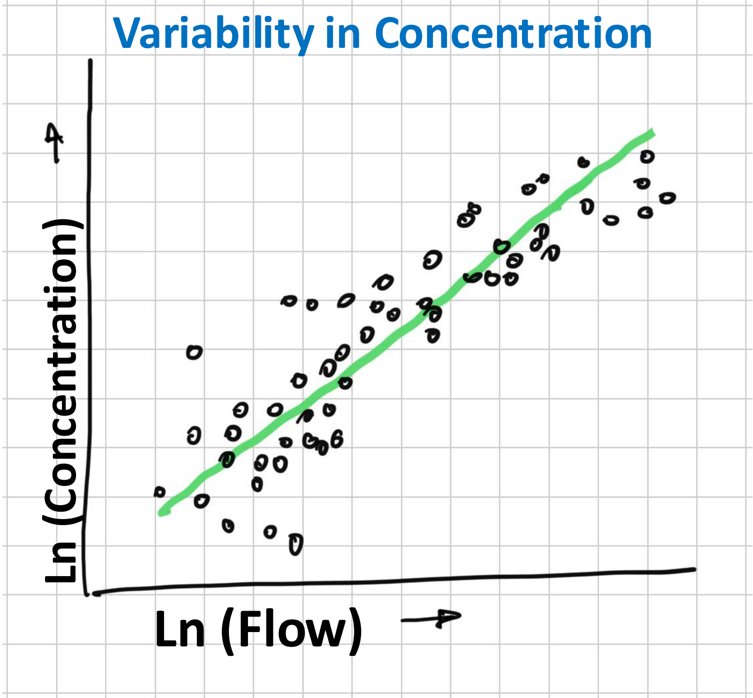
developed



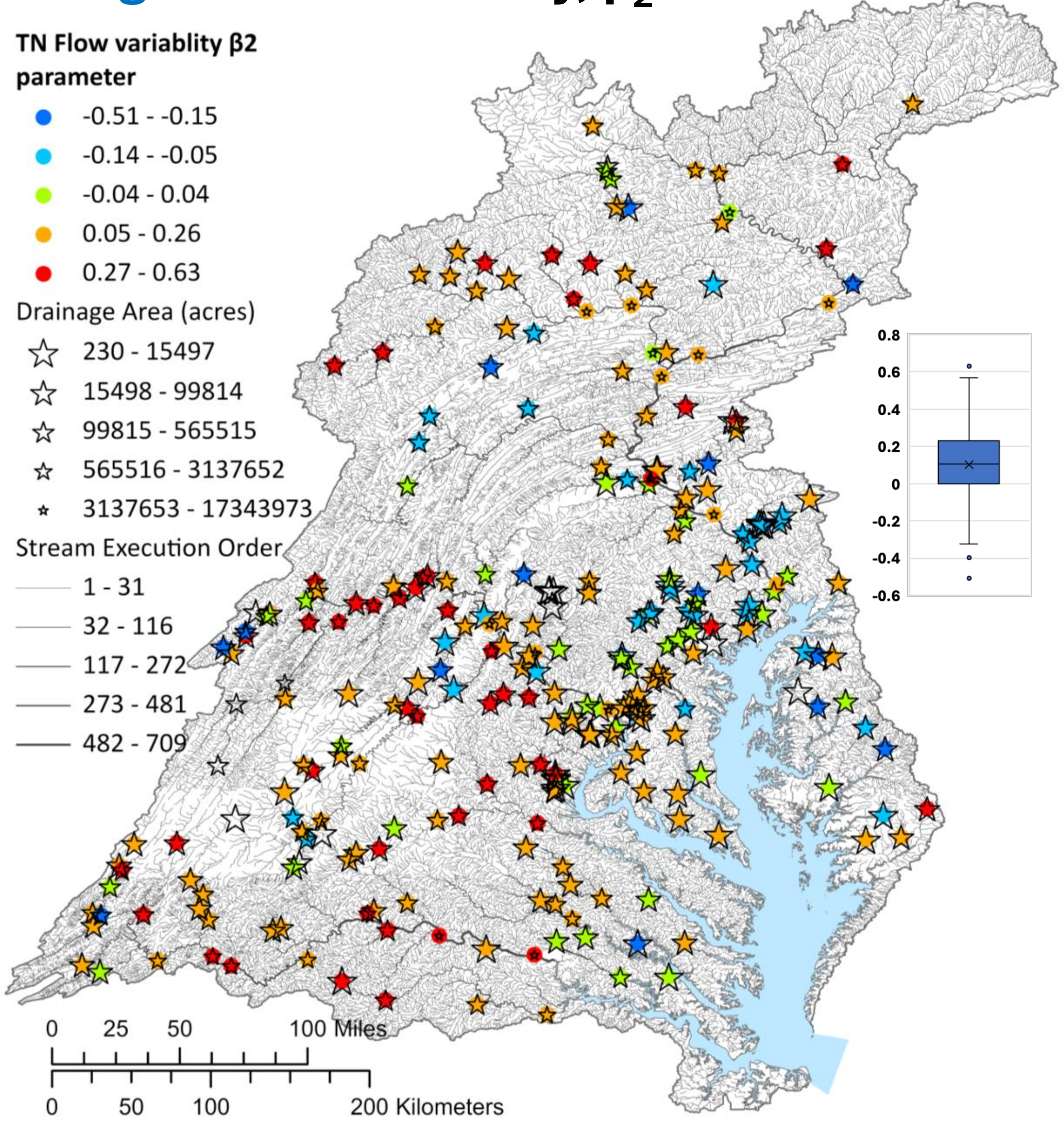
Biogeochemical processing, Storage/deposition, Scour, etc.
➔ Fate and Transport

? ... emergent behavior

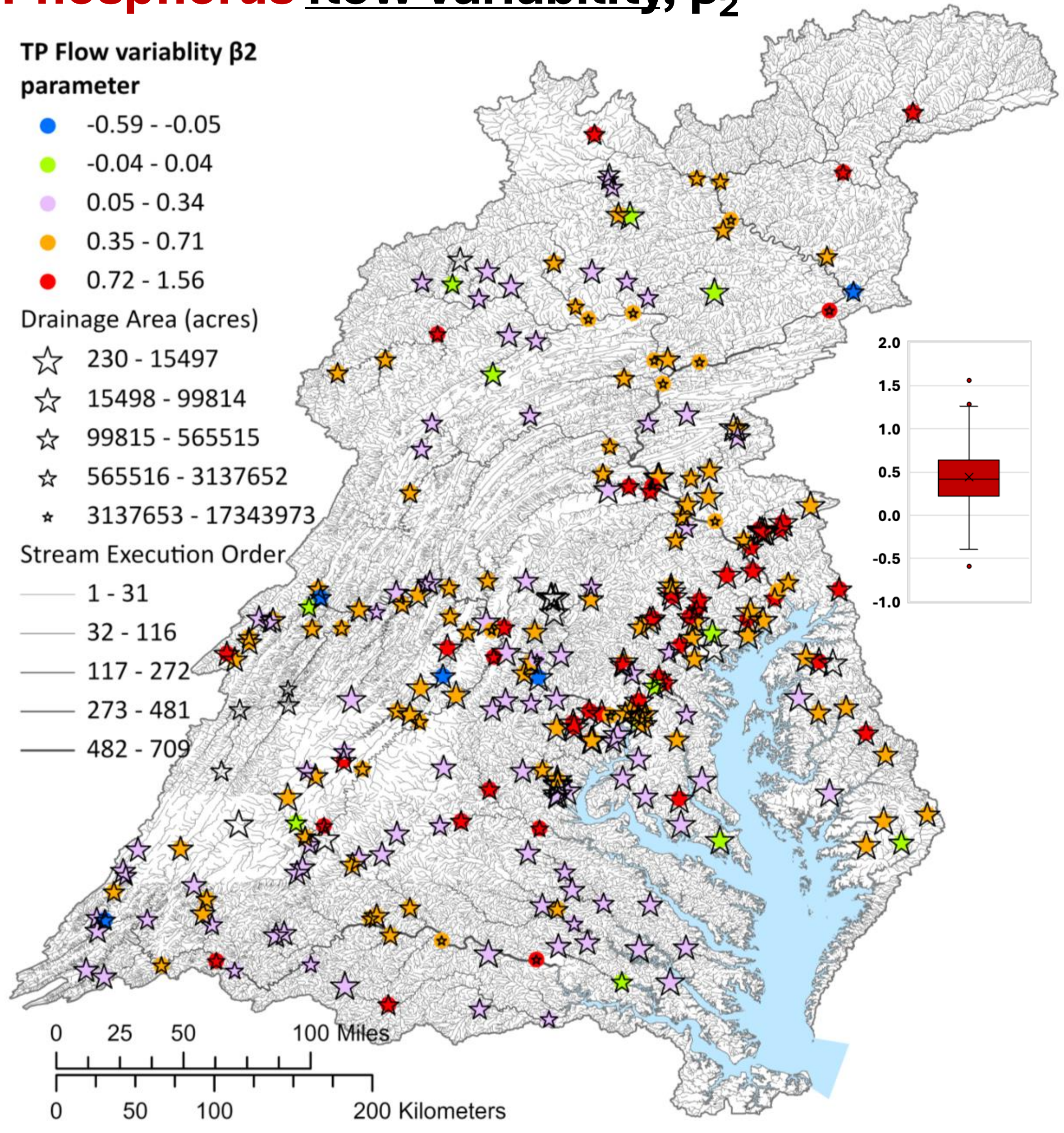
Stream Transport Factor (STF)



Nitrogen flow variability, β_2



Phosphorus flow variability, β_2



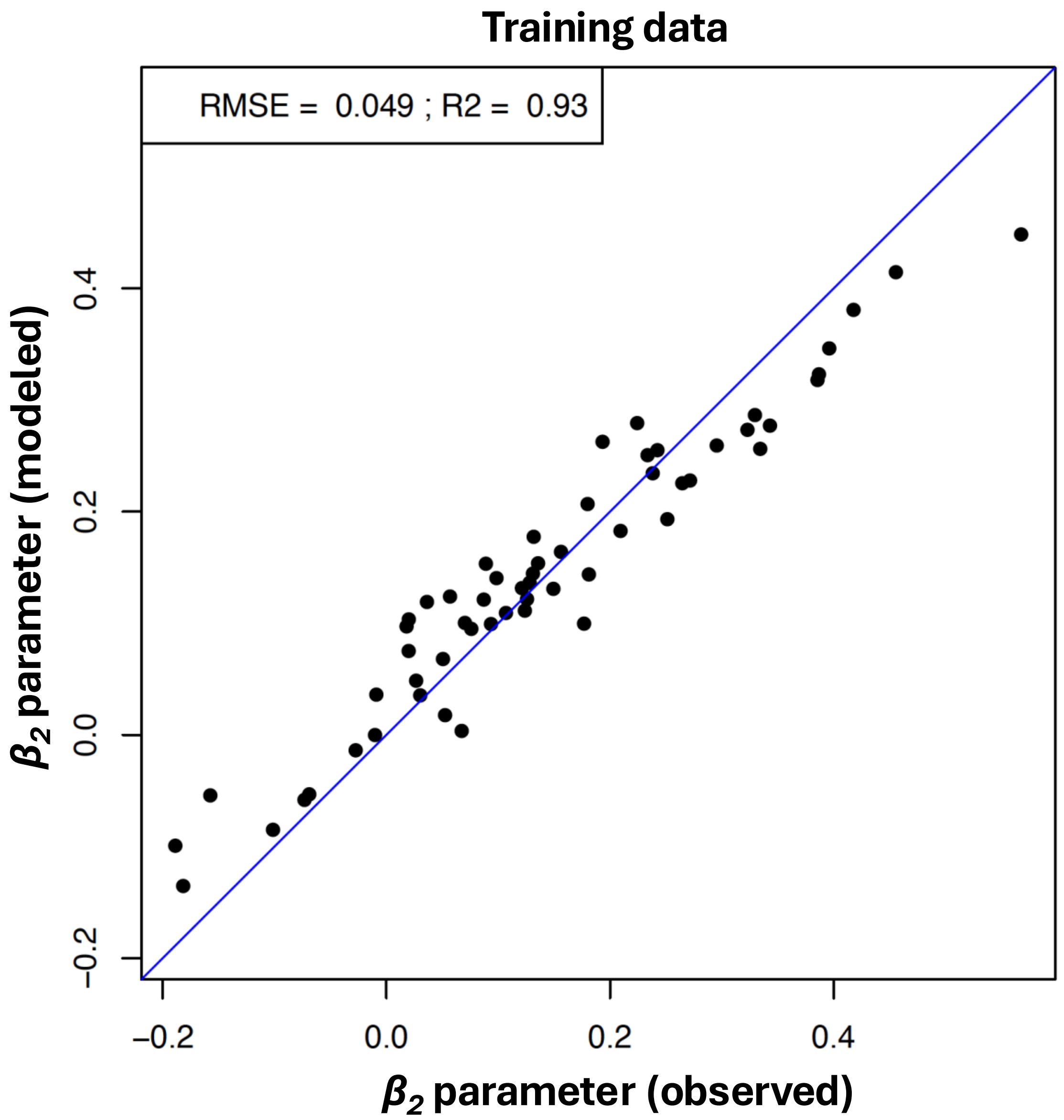
$$ln(c) = \beta_o + \beta_1 t + \boldsymbol{\beta_2}\, ln(Q) + \beta_3 sin(2\pi t) + \beta_4 cos(2\pi t) + \varepsilon$$

Generalization of β parameters

with contributions of Qian Zhang & Isabella Bertani

***Random Forest (RF)* models were developed:**

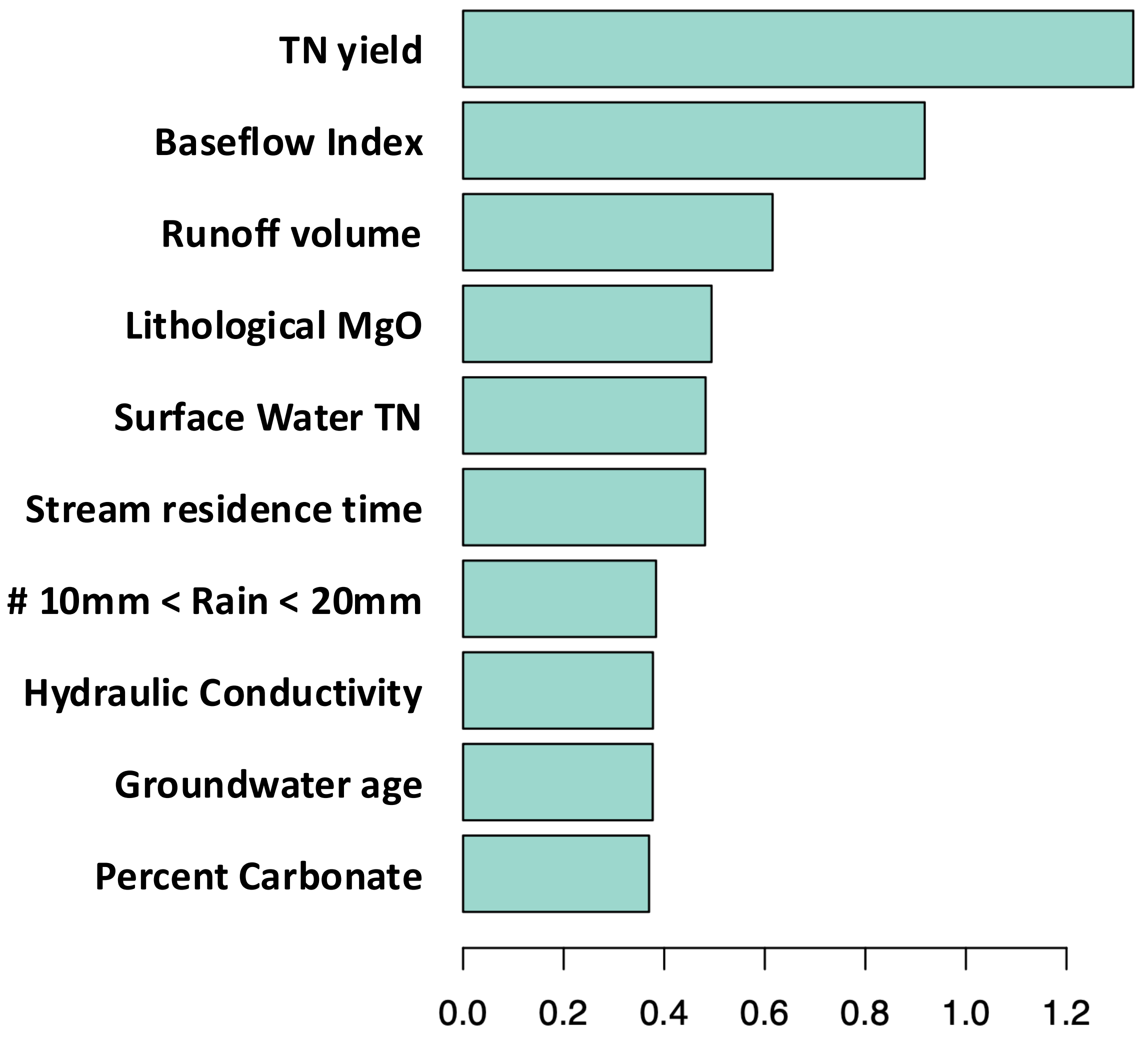
- **The RF models links flow variability (β_2) parameters for nitrogen, phosphorus, and sediment with accumulated watershed attributes.**
- **Performance of the model for training data (70% vs. 30% split) is shown in the figure for nitrogen.**
- **RF models of seasonal (β_3 and β_4) parameters for nitrogen, phosphorus, and sediment were also developed.**



Generalization of β parameters

with contributions of Qian Zhang & Isabella Bertani

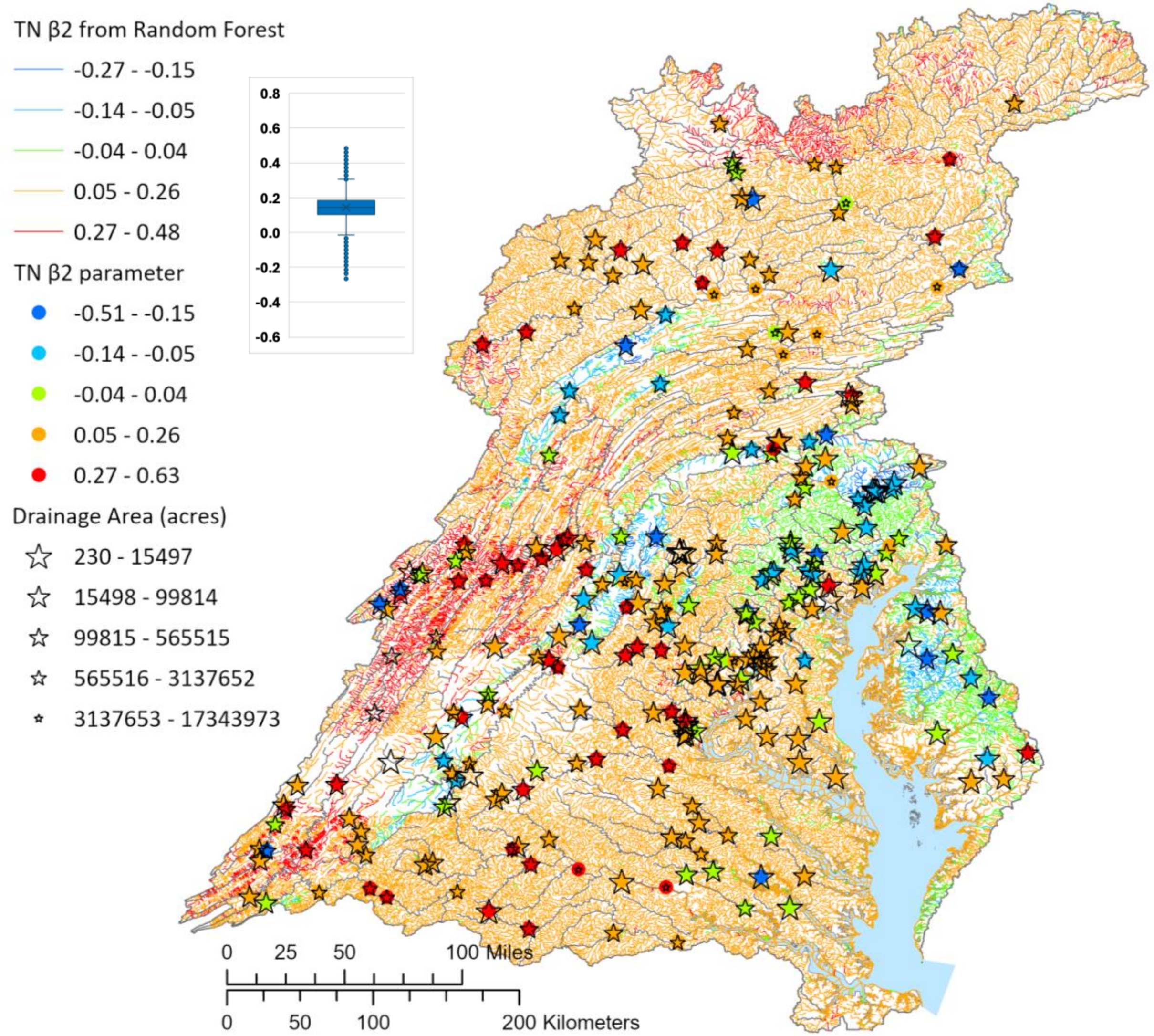
Importance of watershed attributes



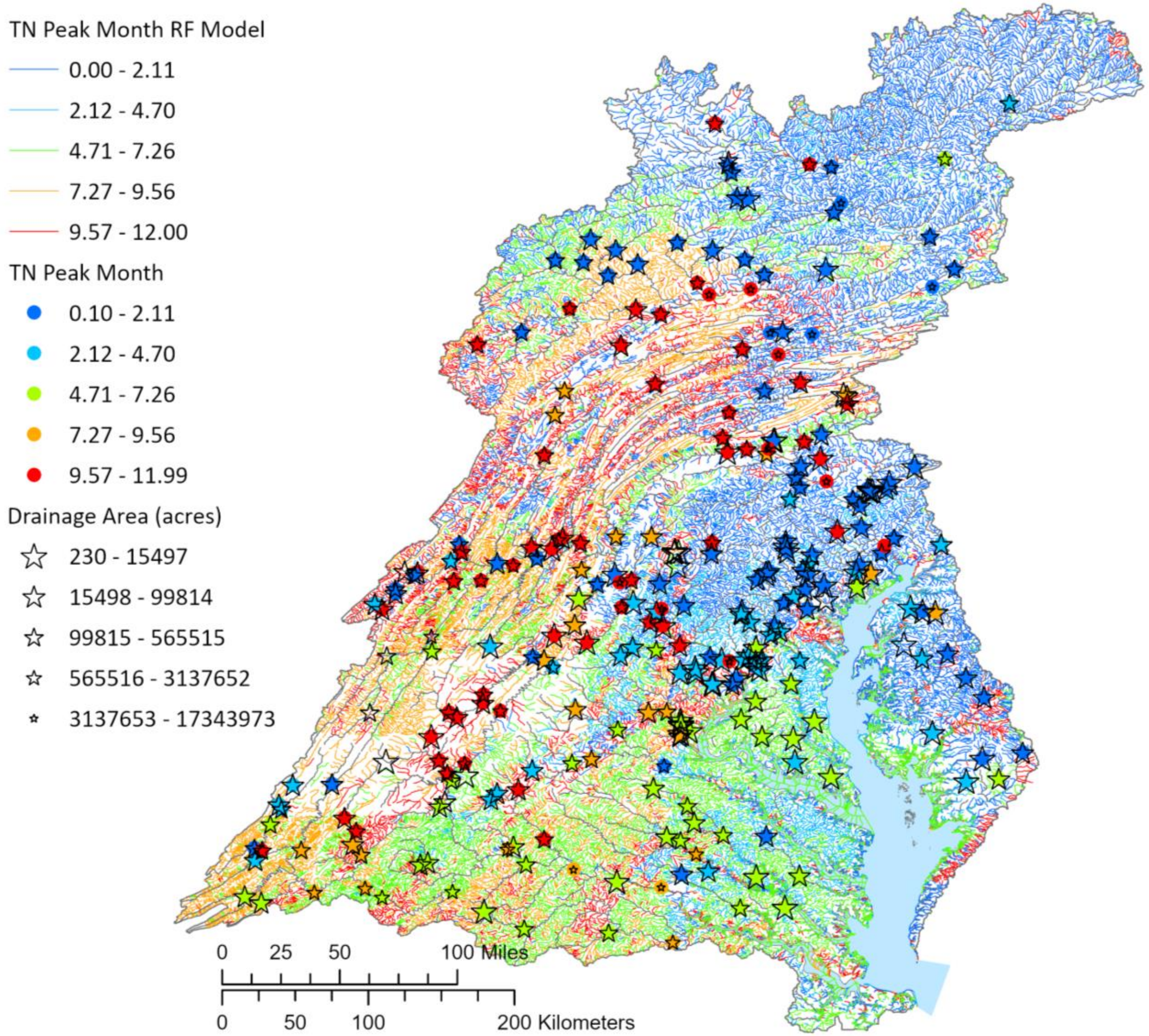
RF Model workflow –

- **Evaluated predictor variables to remove those with (a) high correlation or (b) very small variance.**
- **Train the model using a 70% vs. 30% split between training and test data.**
- **Retain the 10 most important variables to reduce model complexity.**
- **Redo the training using all data.**
- **Develop predictions for the beta parameters.**

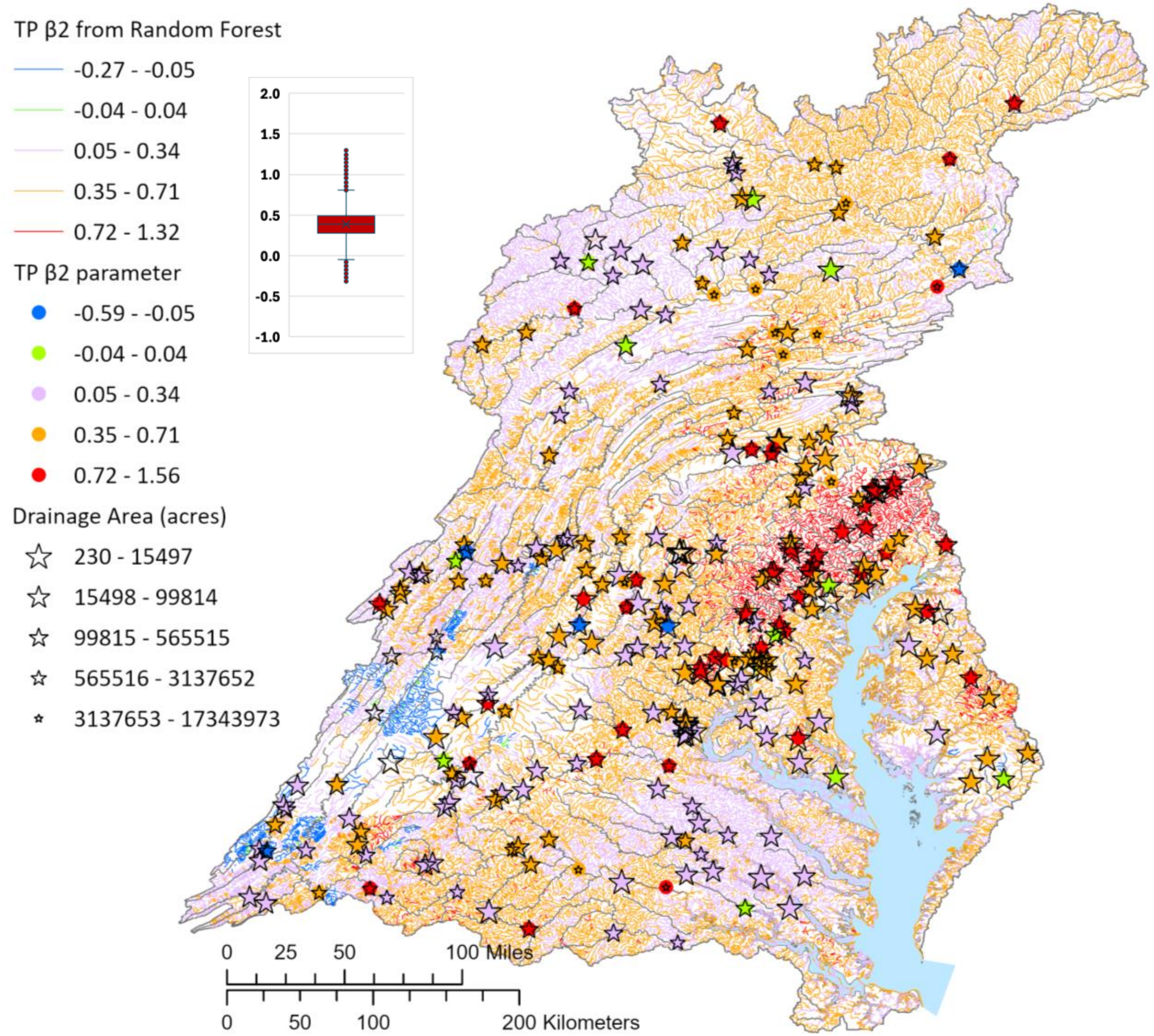
Nitrogen flow variability, β_2



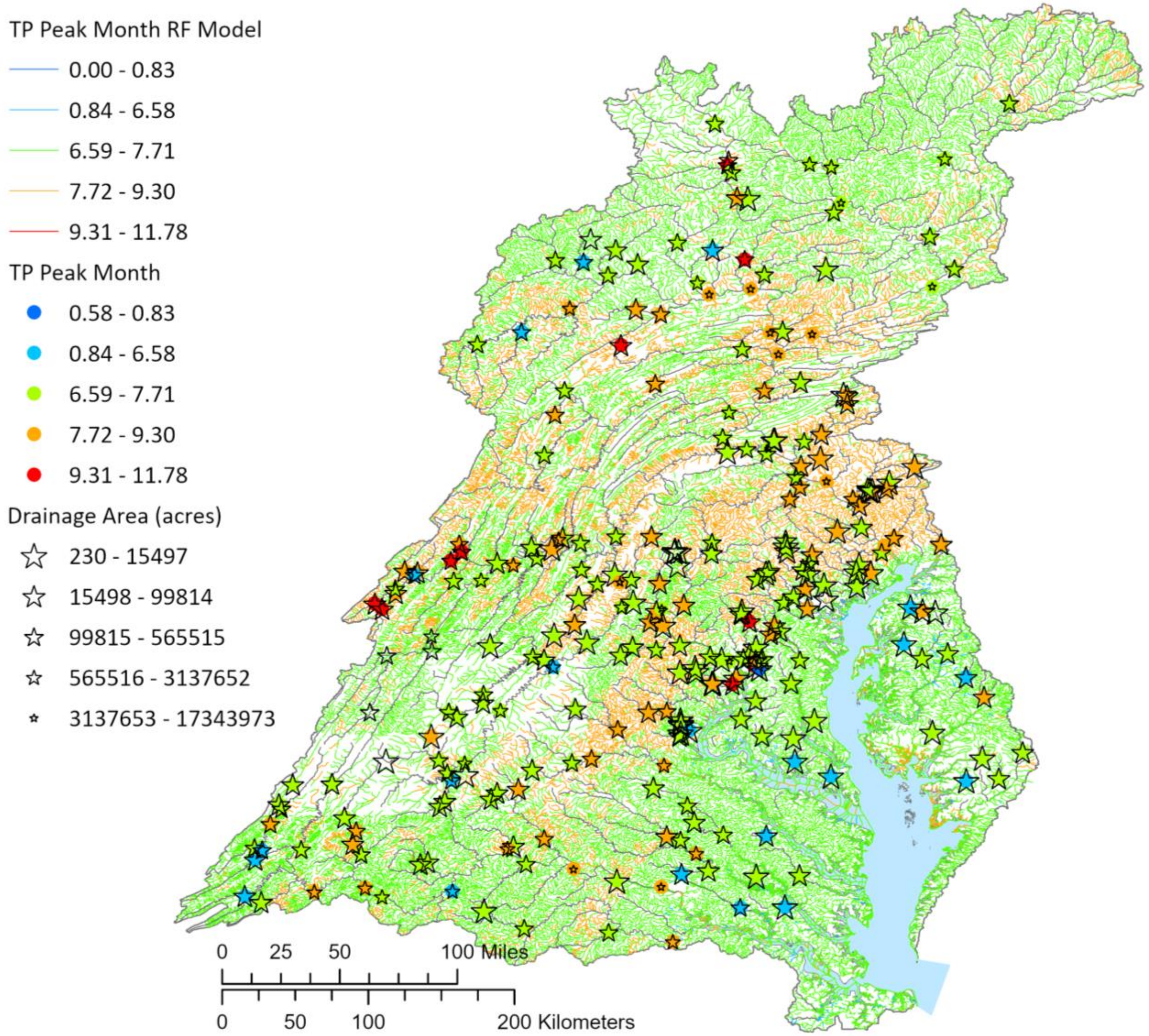
Nitrogen seasonal variability, β_3 & β_4



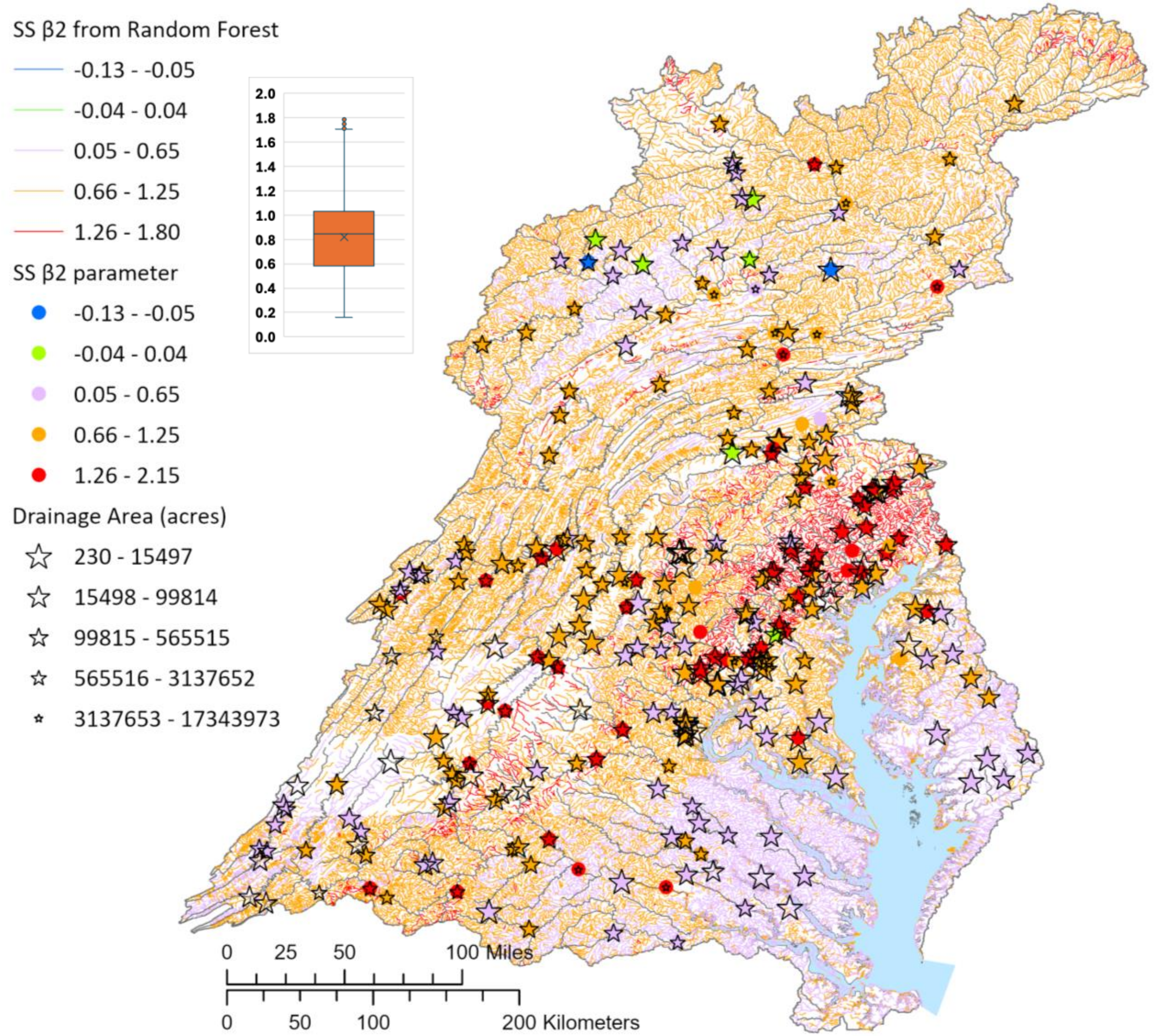
Phosphorus flow variability, β_2



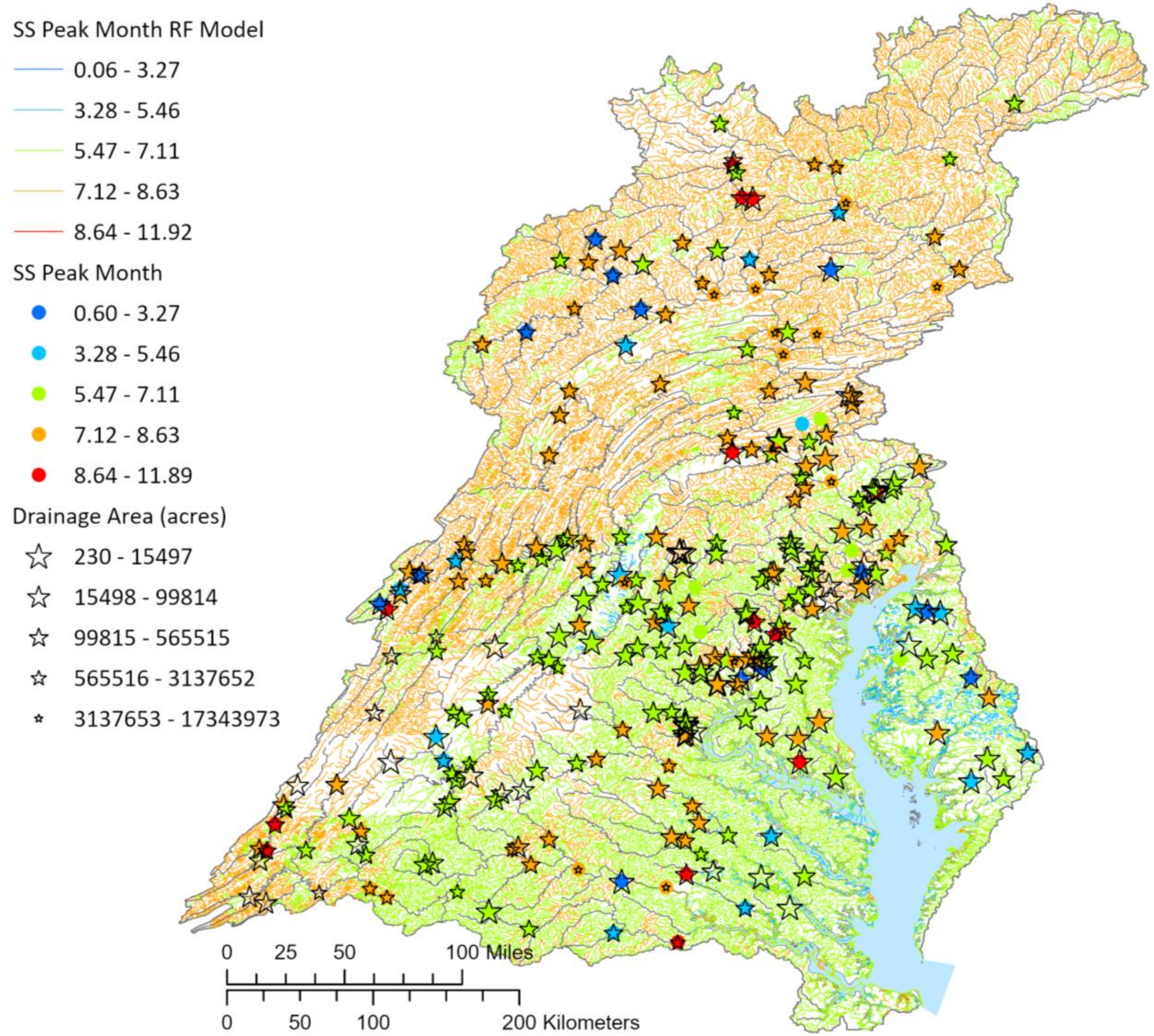
Phosphorus seasonal variability, β_3 & β_4



Sediment flow variability, β_2



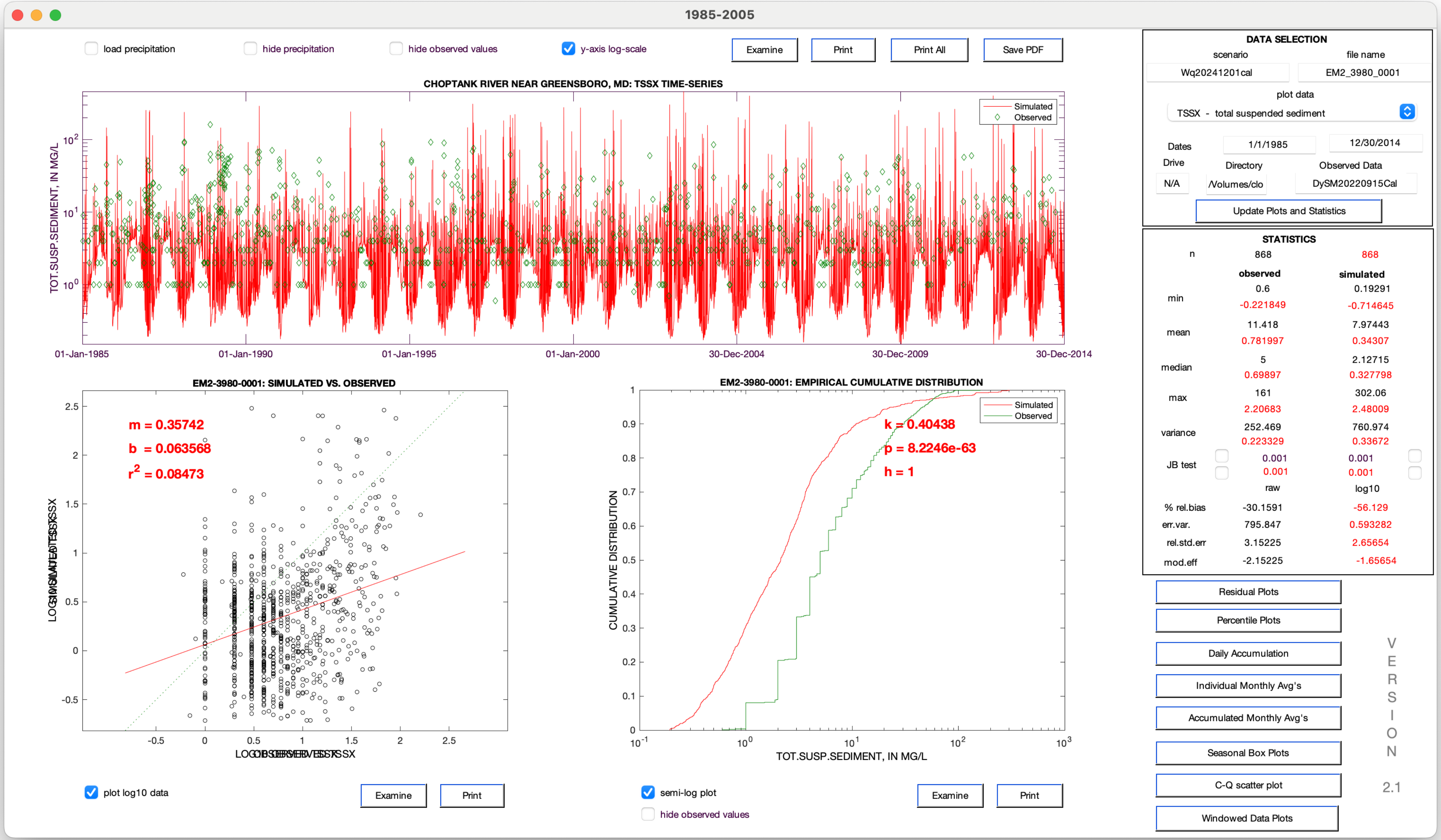
Sediment seasonal variability, β_3 & β_4



HSPF Calibration Constrained by CalCAST

Choptank River Near Greensboro, MD

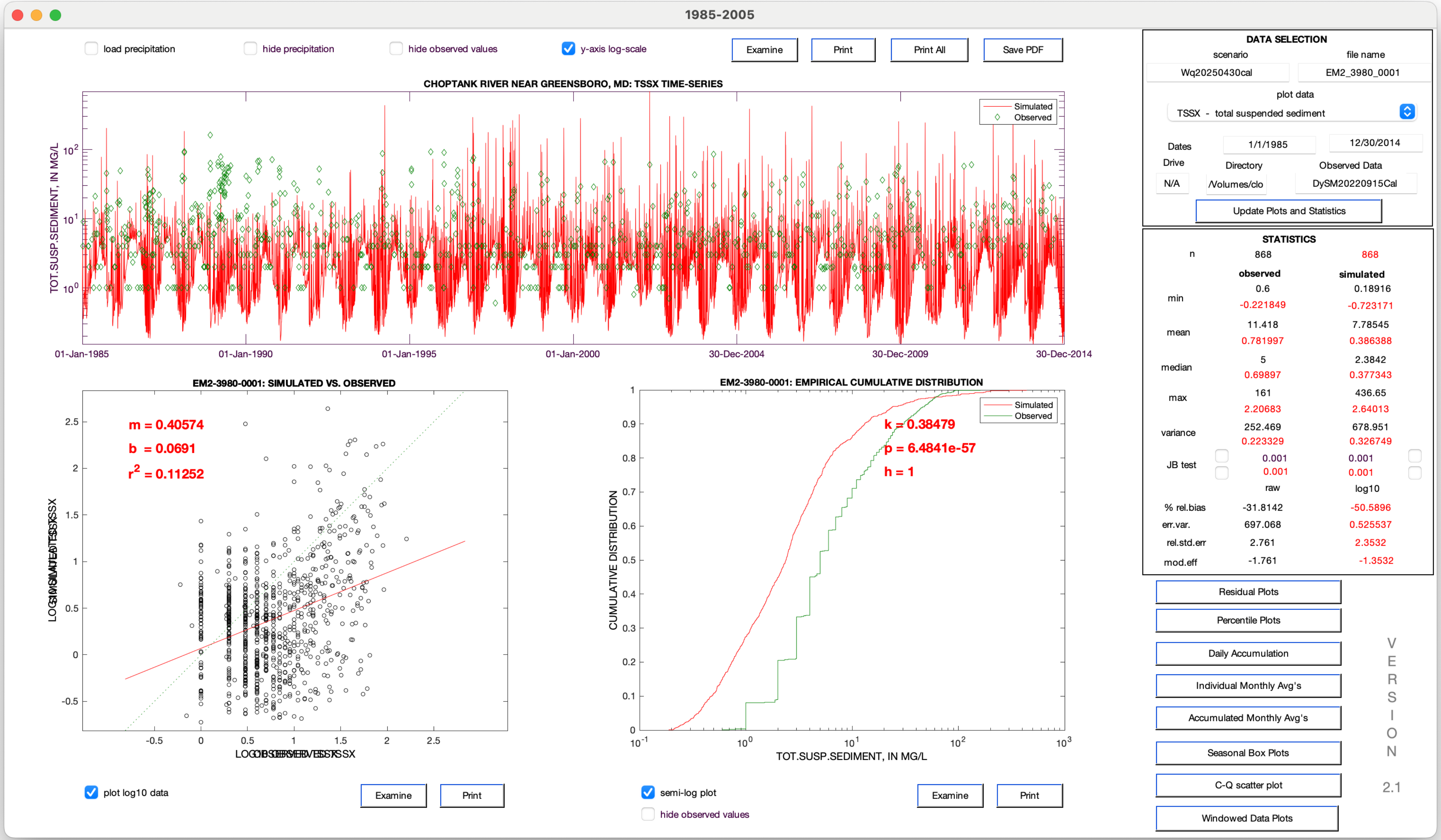
Sediment



HSPF Automated Calibration (April Beta)

Choptank River Near Greensboro, MD

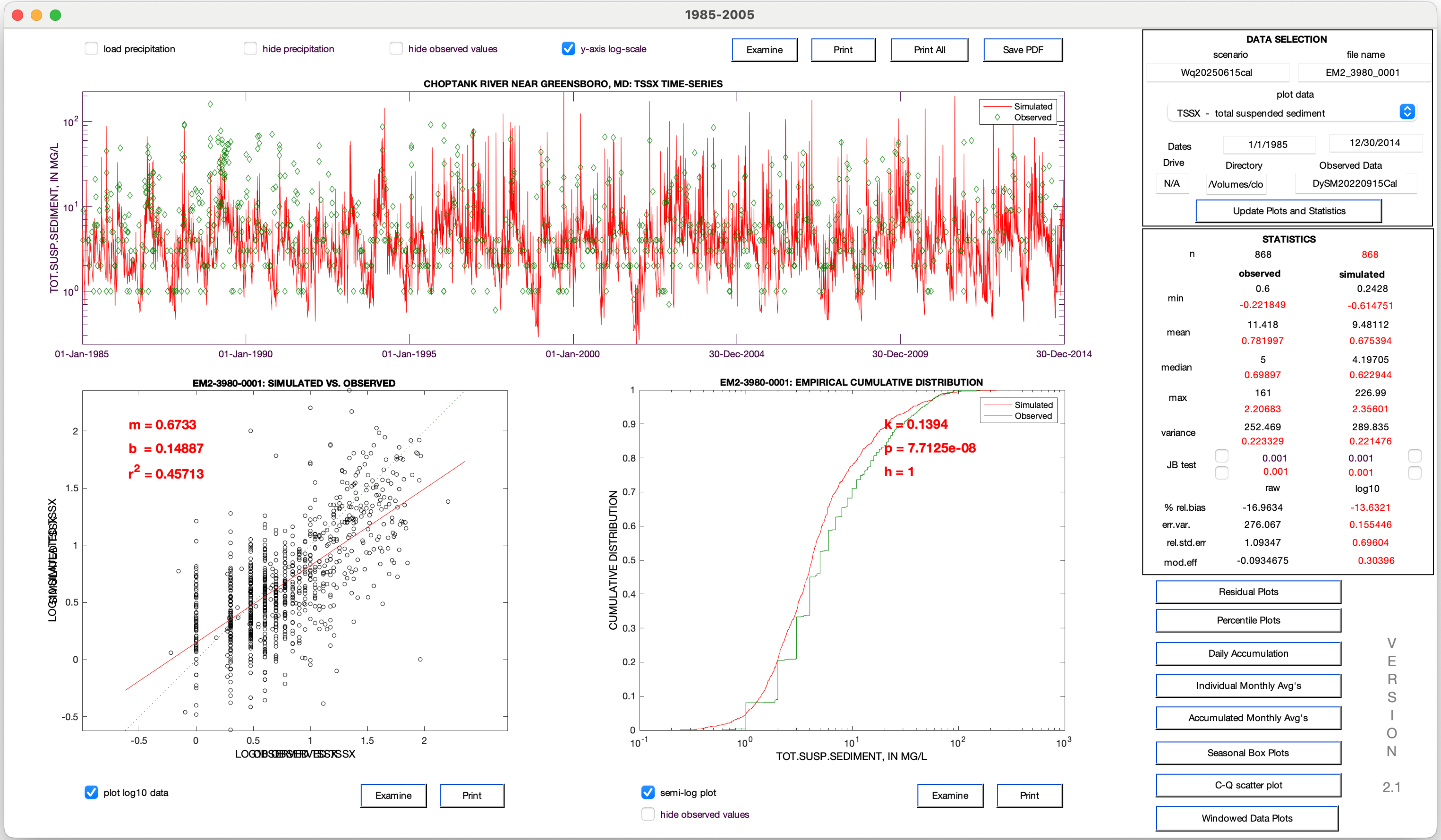
Sediment



HSPF with Stream routing & Beta parameters

Choptank River Near Greensboro, MD

Sediment



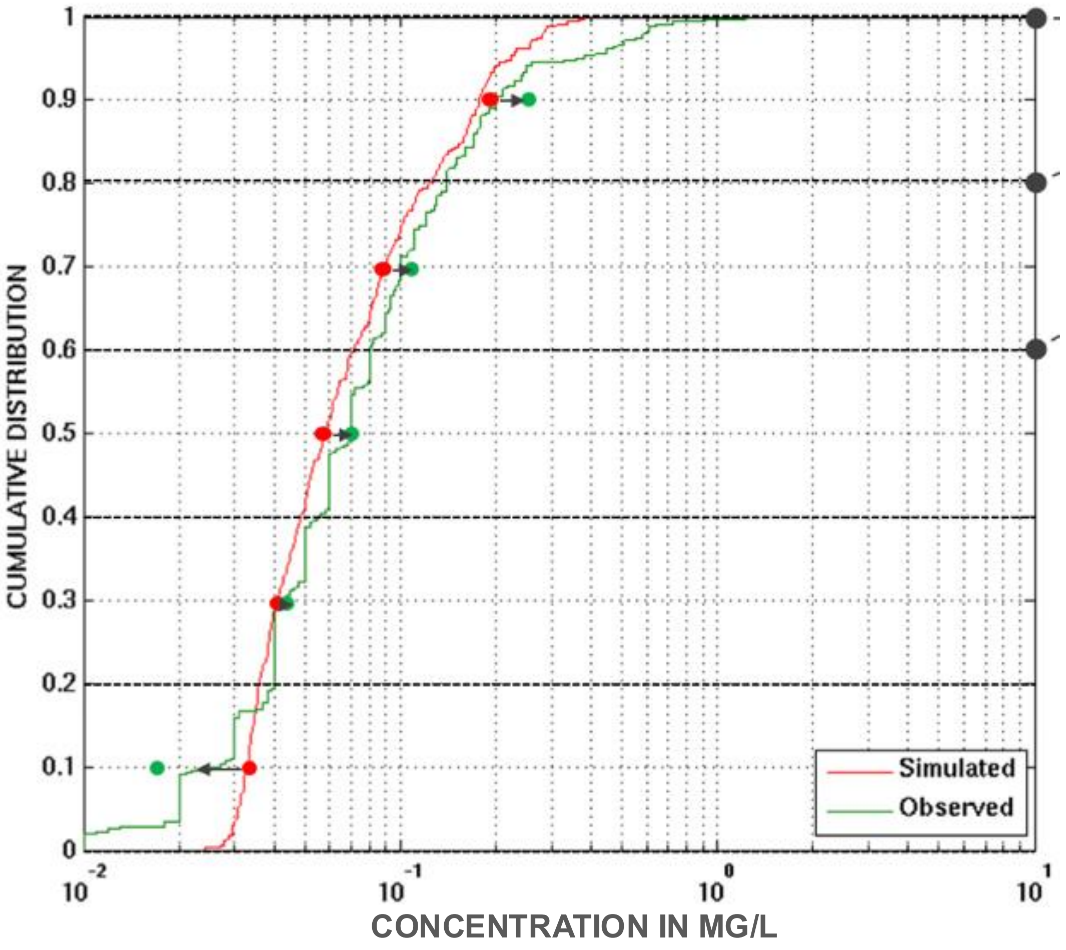
Water quality calibration methods

We calibrate DWSM/HSPF water quality parameters to improve agreement in cumulative frequency distribution (CFD) of observed and simulated concentrations.

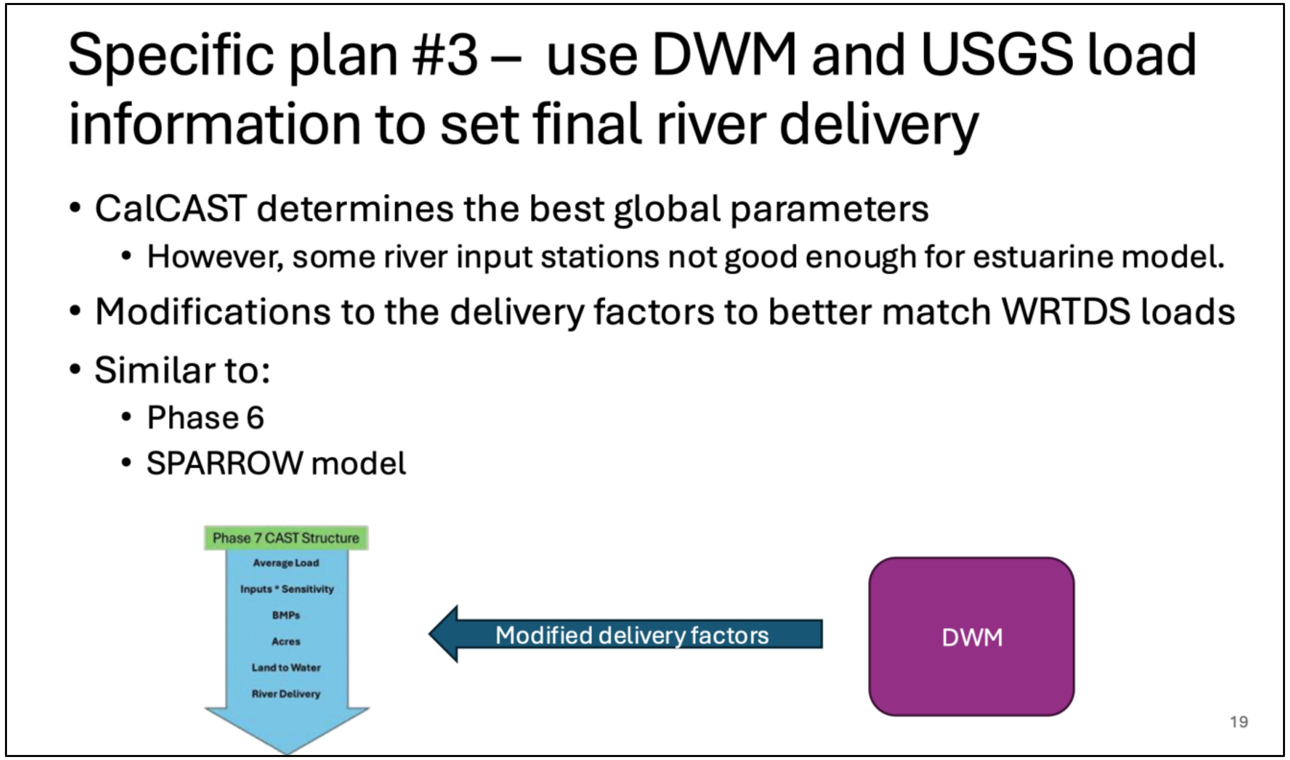
→ Information available for the calibration of model parameters:

- Observations of daily concentrations for nutrient species at monitoring stations
- Transport factors for TN, TP, and SS for each river mainstems (CalCAST)
- **WRTDS estimated loads**
- QC relationships (generalized β parameters for river mainstems)

Figure: Cumulative distribution of concentrations at a monitoring station



Water quality calibration methods

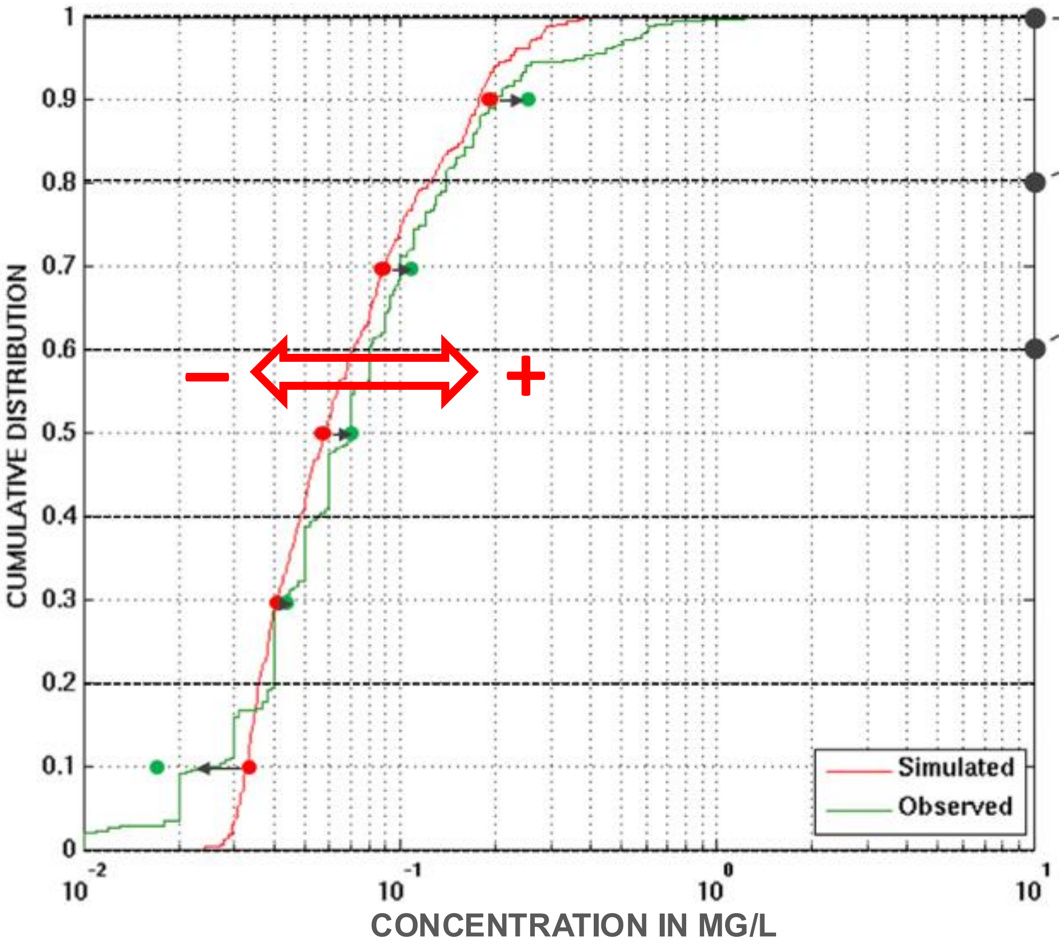


January & April 2025 MW (Shenk, G.)

Slide 19: https://www.chesapeakebay.net/files/documents/940-2025-01-07-Overall-P7-Plan-MWG-gshenk.pdf

Slide 12-14: https://www.chesapeakebay.net/files/documents/930_2025-04-01-Overall-P7-WSM-Plan-MWG-gshenk_update.pdf

Figure: Cumulative distribution of concentrations at a monitoring station



→ We incorporated "adjustment factor" that nudges the simulated CFD within the automated calibration.

- adjustment factor shifts the CFD during each calibration iterations

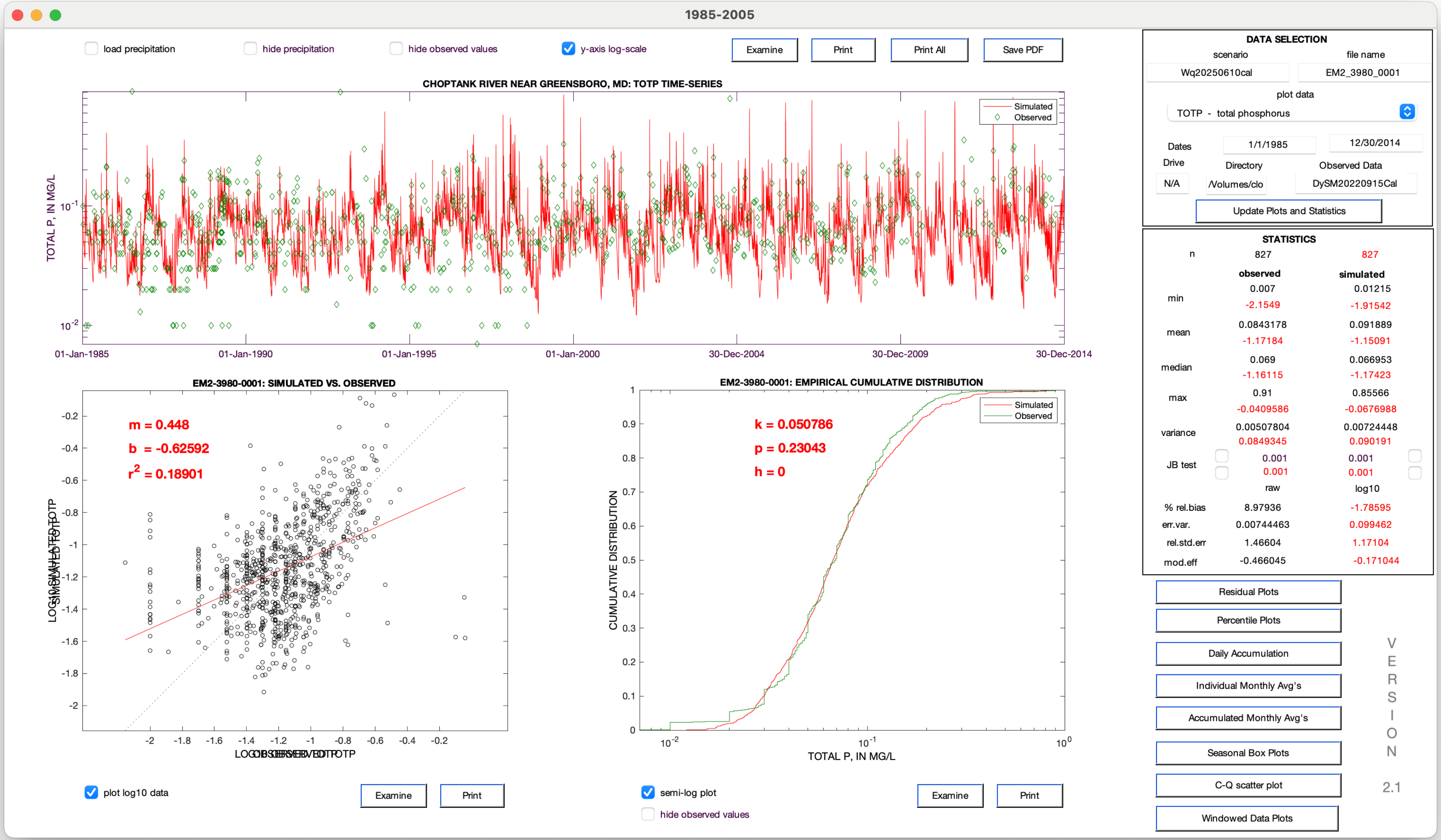
We implemented and tested a few calibration approaches...

[1] April 2025	PRISM precipitation; N-speciation; Constrained by CalCAST
	Wq20250430cal
[2] June #01	Automated HSPF WQ calibration for river mainstems
	Wq20250601cal
[3] June #02	Beta parameters estimated by Random Forest Models
	Wq20250610cal
[4] June #03	Constrained using best available loads (WRTDS)
	Wq20250615cal

June #01: Automated HSPF WQ Calibration

Choptank River Near Greensboro, MD

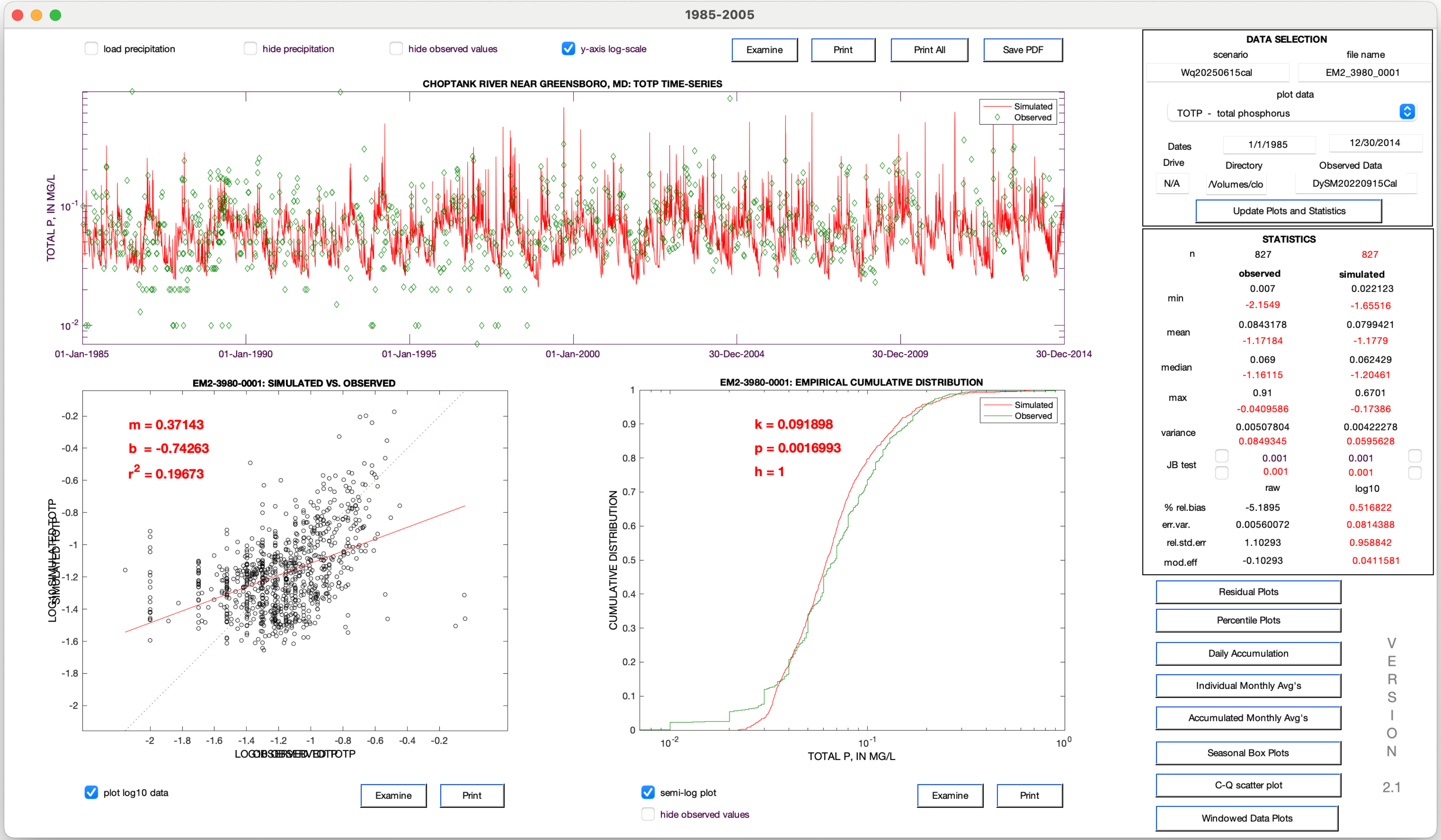
Phosphorus

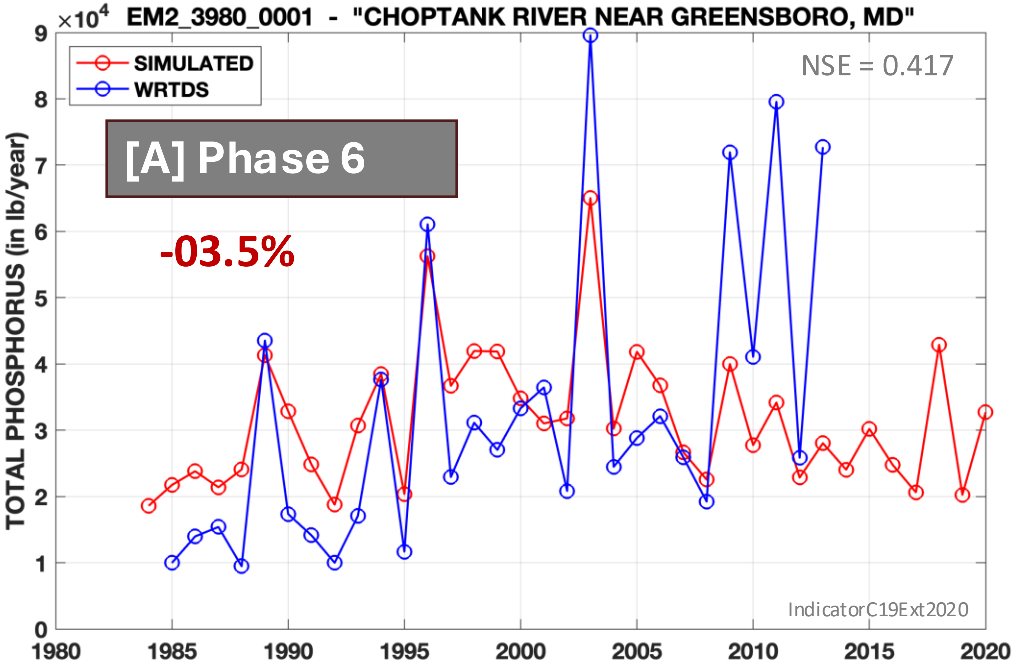


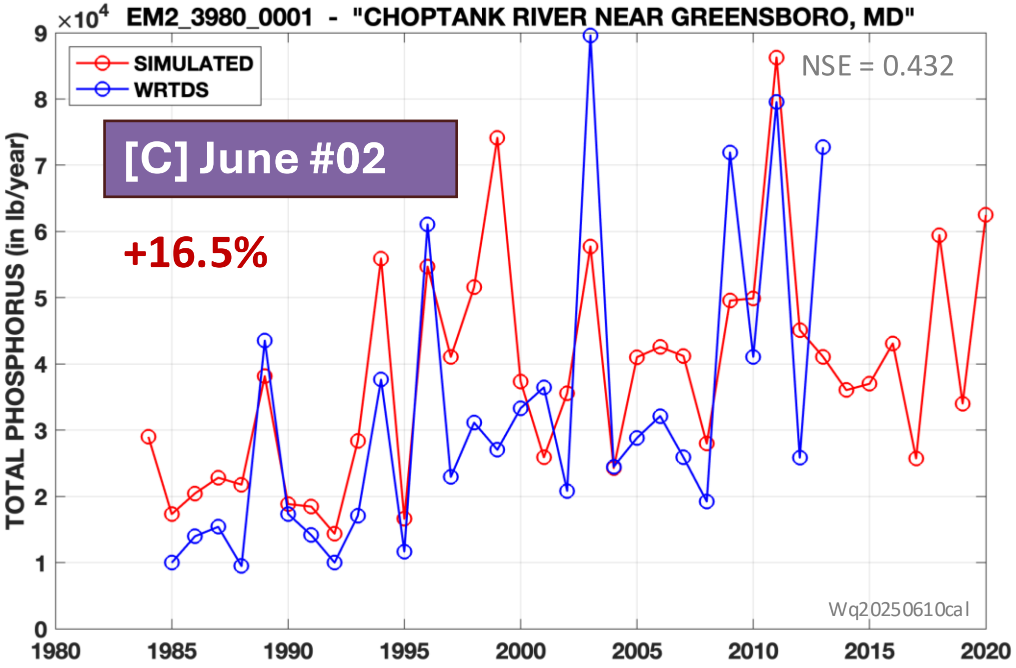
June #03: β-params & Constrained by WRTDS

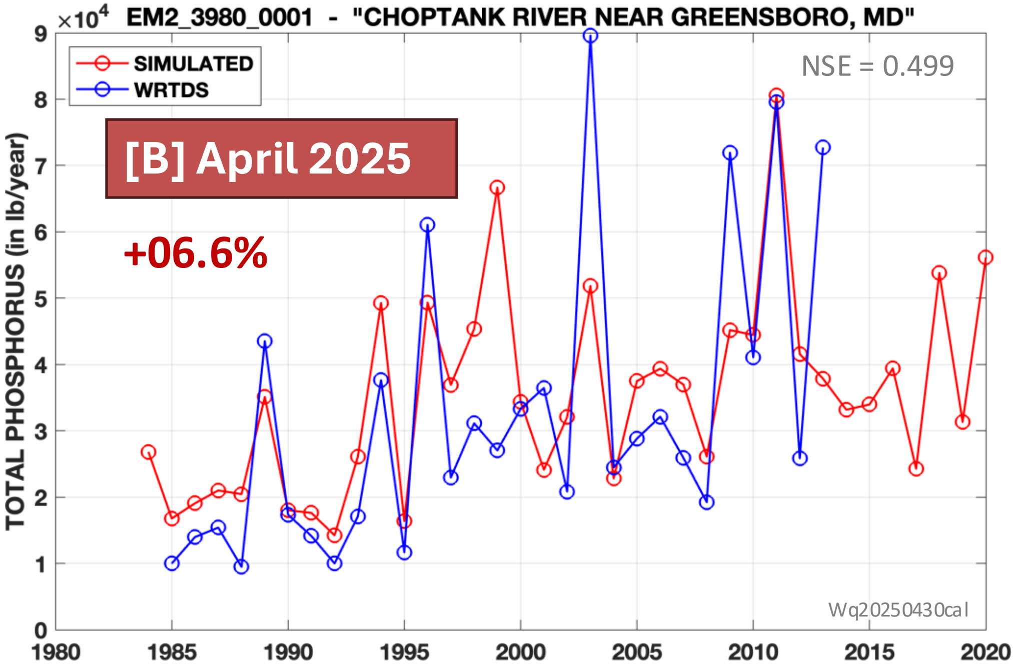
Choptank River Near Greensboro, MD

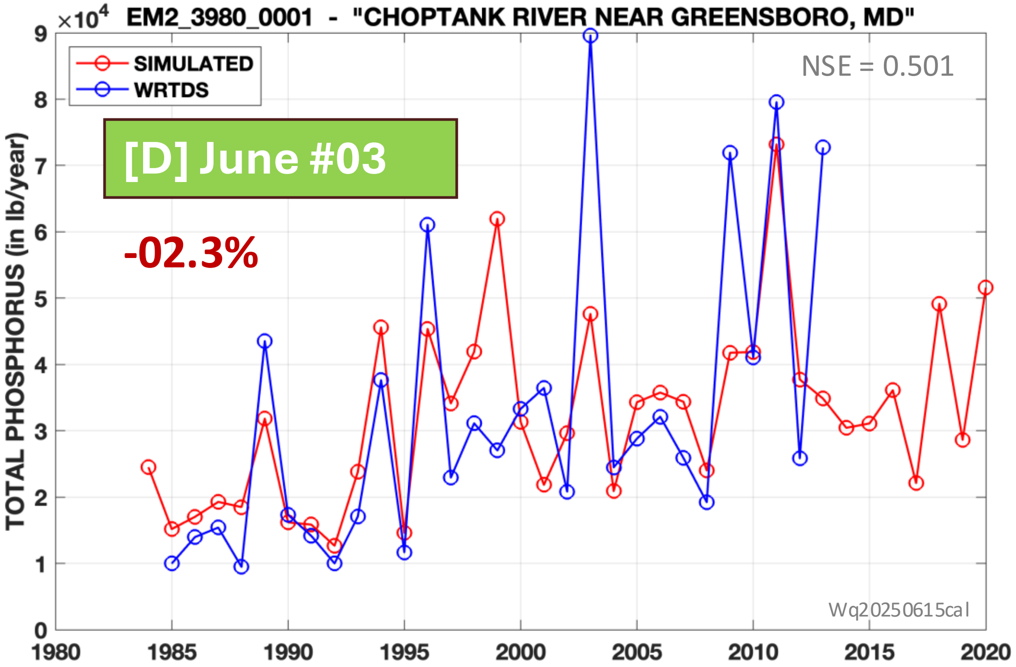
Phosphorus




EM2_3980_0001 - "CHOPTANK RIVER NEAR GREENSBORO, MD"
SIMULATED
WRTDS
NSE = 0.417
[A] Phase 6
-03.5%
IndicatorC19Ext2020
TOTAL PHOSPHORUS (in lb/year)
$\times 10^4$


EM2_3980_0001 - "CHOPTANK RIVER NEAR GREENSBORO, MD"
SIMULATED
WRTDS
NSE = 0.432
[C] June #02
+16.5%
Wq20250610cal
TOTAL PHOSPHORUS (in lb/year)
$\times 10^4$


EM2_3980_0001 - "CHOPTANK RIVER NEAR GREENSBORO, MD"
SIMULATED
WRTDS
NSE = 0.499
[B] April 2025
+06.6%
Wq20250430cal
TOTAL PHOSPHORUS (in lb/year)
$\times 10^4$


EM2_3980_0001 - "CHOPTANK RIVER NEAR GREENSBORO, MD"
SIMULATED
WRTDS
NSE = 0.501
[D] June #03
-02.3%
Wq20250615cal
TOTAL PHOSPHORUS (in lb/year)
$\times 10^4$

RIM stations: Phase 7 Nitrogen loads vs. WRTDS

(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

Rivers	[1] April 2025	[2] June #01	[2] June #02	[2] June #03
Susquehanna Conowingo MD	-09.2% (+0.665)	-14.2% (+0.571)	-20.7% (+0.410)	-01.1% (+0.723)
Susquehanna Marietta PA	-09.9% (+0.687)	-12.6% (+0.630)	-12.8% (+0.626)	+01.1% (+0.776)
Potomac Washington, DC	-20.9% (+0.670)	-17.0% (+0.724)	-17.3% (+0.719)	-01.6% (+0.817)
James Cartersville, VA	-22.8% (+0.632)	-23.7% (+0.607)	-24.3% (+0.599)	-01.2% (+0.902)
Rappa. Fredericksburg, VA	-05.7% (+0.853)	-00.4% (+0.868)	-04.2% (+0.860)	-05.8% (+0.854)
Appomattox Matoaca, VA	+10.2% (+0.702)	-09.1% (+0.785)	-08.0% (+0.792)	-12.0% (+0.755)
Pamunkey Hanover, VA	+04.9% (+0.786)	+11.8% (+0.724)	+11.0% (+0.722)	-07.4% (+0.771)
Mattaponi Beulahville, VA	+19.9% (+0.378)	+21.4% (+0.301)	+20.5% (+0.317)	-10.2% (+0.655)
Patuxent Bowie, MD	-01.6% (+0.308)	+15.2% (-0.029)	+14.3% (+0.044)	-04.0% (+0.300)
Choptank Greensboro, MD	-03.1% (+0.732)	+09.2% (+0.708)	+08.0% (+0.726)	-04.4% (+0.722)

→ *some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period*

RIM stations: Phase 7 Phosphorus loads vs. WRTDS

(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

Rivers	[1] April 2025	[2] June #01	[2] June #02	[2] June #03
Susquehanna Conowingo MD	+18.2% (+0.763)	+12.9% (+0.757)	+13.1% (+0.794)	+02.2% (+0.783)
Susquehanna Marietta PA	-13.9% (+0.789)	+00.1% (+0.833)	-00.9% (+0.824)	+04.4% (+0.840)
Potomac Washington, DC	-05.5% (+0.541)	+29.8% (-0.636)	+29.1% (-0.409)	+06.9% (+0.226)
James Cartersville, VA	-21.8% (+0.615)	-12.6% (+0.749)	-20.2% (+0.774)	+01.9% (+0.850)
Rappa. Fredericksburg, VA	-11.3% (+0.732)	+24.9% (+0.276)	+30.6% (+0.059)	-03.4% (+0.680)
Appomattox Matoaca, VA	+12.8% (+0.713)	+38.4% (-0.096)	+37.9% (-0.182)	-06.2% (+0.739)
Pamunkey Hanover, VA	+04.2% (+0.506)	+42.2% (-0.628)	+39.7% (-0.485)	-02.0% (+0.243)
Mattaponi Beulahville, VA	+11.2% (-0.035)	+11.5% (-0.021)	+13.3% (+0.221)	-07.3% (+0.237)
Patuxent Bowie, MD	-11.8% (+0.348)	+49.2% (-2.156)	+23.8% (-0.636)	-07.0% (-0.015)
Choptank Greensboro, MD	+06.6% (+0.499)	+19.1% (+0.412)	+16.5% (+0.432)	-02.3% (+0.501)

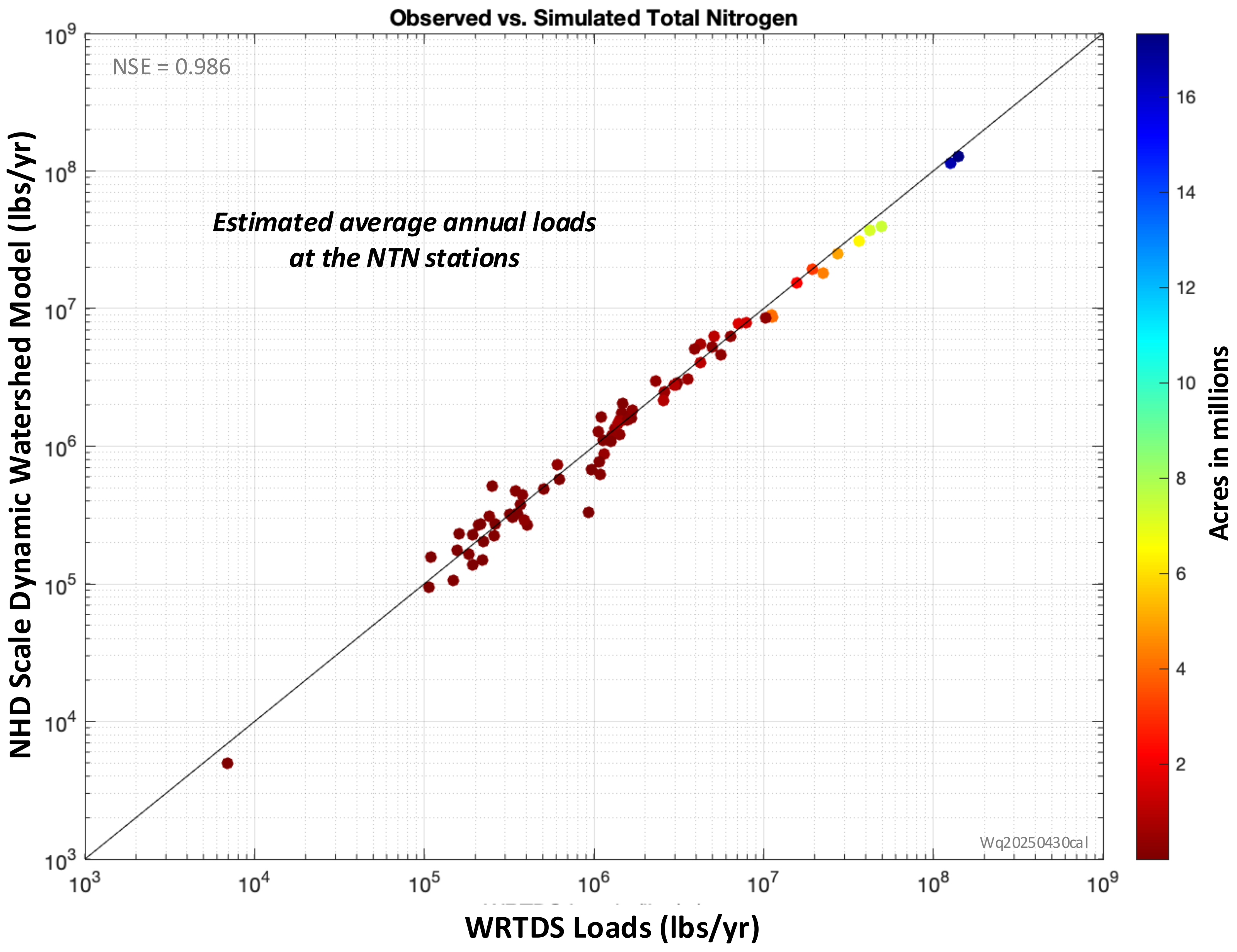
→ *some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period*

RIM stations: Phase 7 Sediment loads vs. WRTDS

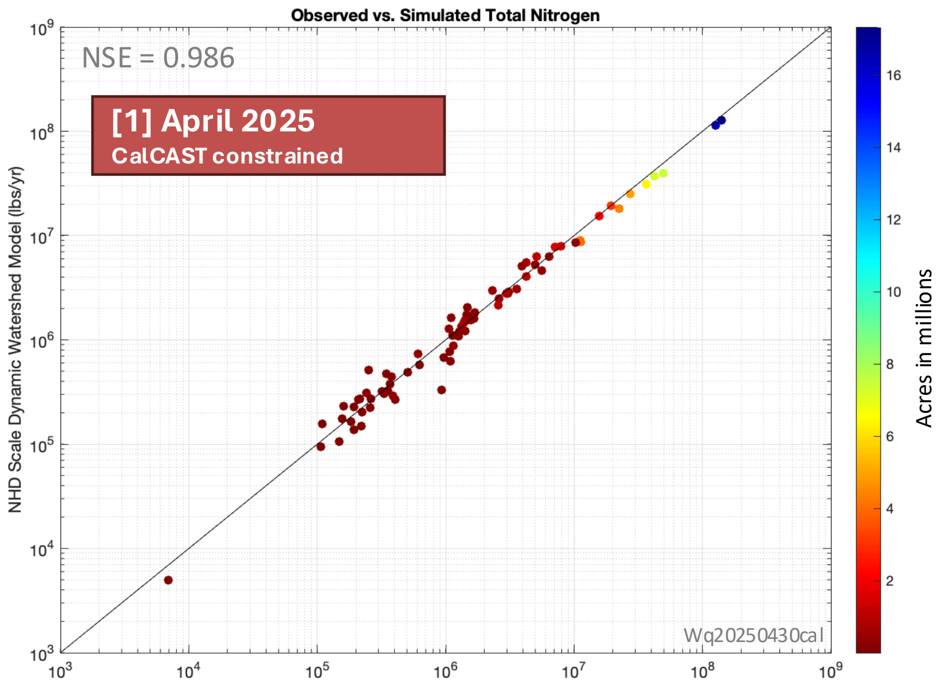
(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

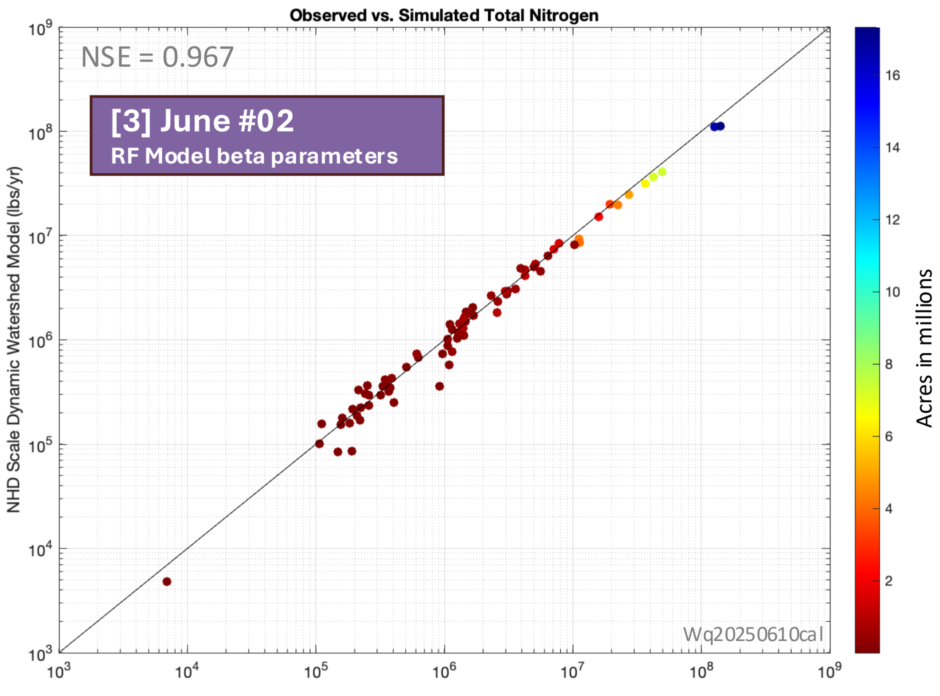
Rivers	[1] Dec 2024	[2] June #01	[2] June #02	[2] June #03
Susquehanna Conowingo MD	+18.0% (+0.433)	-32.7% (+0.535)	-19.6% (+0.681)	+04.3% (+0.808)
Susquehanna Marietta PA	+02.6% (-0.115)	-08.3% (+0.731)	-04.9% (+0.629)	+07.9% (-0.047)
Potomac Washington, DC	-08.4% (-0.503)	-03.1% (-0.041)	+06.5% (-0.509)	+10.1% (-0.623)
James Cartersville, VA	-36.0% (+0.627)	+05.0% (-1.844)	+05.9% (-1.850)	+08.0% (-2.613)
Rappa. Fredericksburg, VA	-41.9% (-0.750)	+07.9% (+0.320)	+27.7% (-0.583)	-04.1% (+0.474)
Appomattox Matoaca, VA	-32.7% (+0.534)	+10.1% (+0.244)	+31.1% (-0.650)	-06.4% (+0.449)
Pamunkey Hanover, VA	-44.2% (+0.229)	+48.8% (-3.345)	+38.3% (-2.303)	-02.4% (-0.024)
Mattaponi Beulahville, VA	+101.3% (-10.342)	+42.8% (-3.929)	+31.3% (-1.670)	-09.4% (-0.533)
Patuxent Bowie, MD	+28.7% (+0.501)	+51.7% (-1.685)	+47.4% (-2.124)	-11.0% (-0.134)
Choptank Greensboro, MD	-19.4% (+0.116)	-03.8% (-0.594)	-06.2% (-0.763)	+01.5% (-0.805)

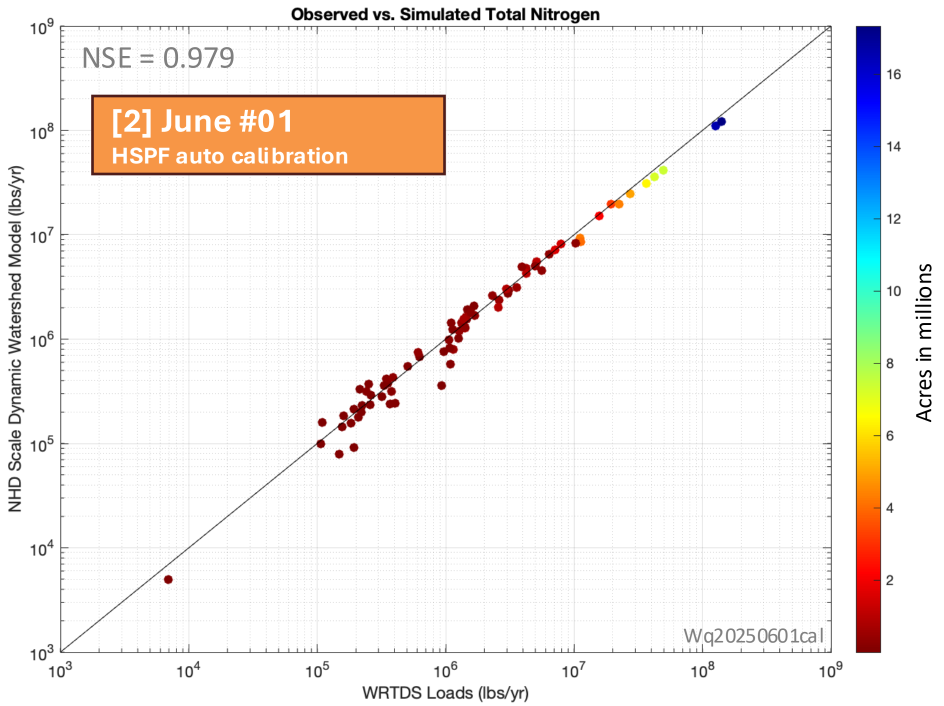
→ *some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period*

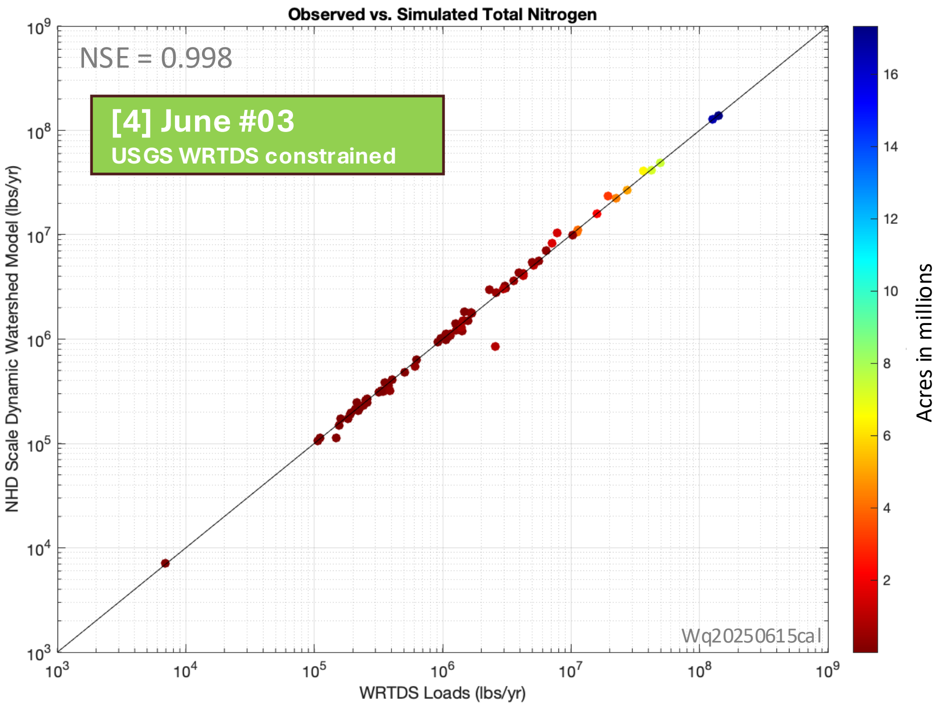


Observed vs. Simulated Total Nitrogen
NSE = 0.986
Estimated average annual loads
at the NTN stations
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions
Wq20250430cal

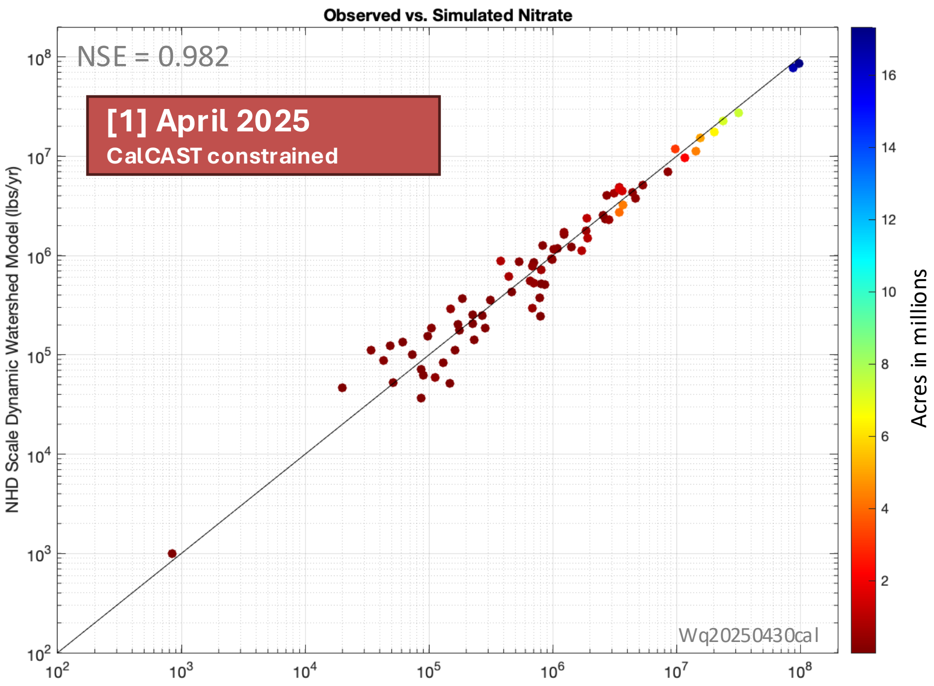

Observed vs. Simulated Total Nitrogen
NSE = 0.986
[1] April 2025
CalCAST constrained
NHD Scale Dynamic Watershed Model (lbs/yr)
Acres in millions
Wq20250430cal

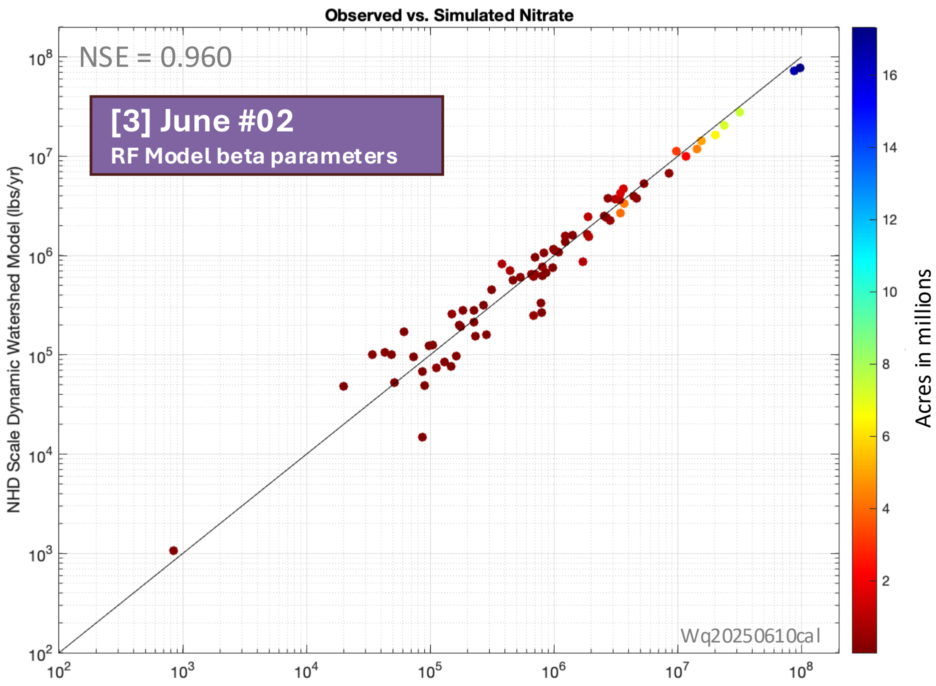

Observed vs. Simulated Total Nitrogen
NSE = 0.967
[3] June #02
RF Model beta parameters
NHD Scale Dynamic Watershed Model (lbs/yr)
Acres in millions
Wq20250610cal

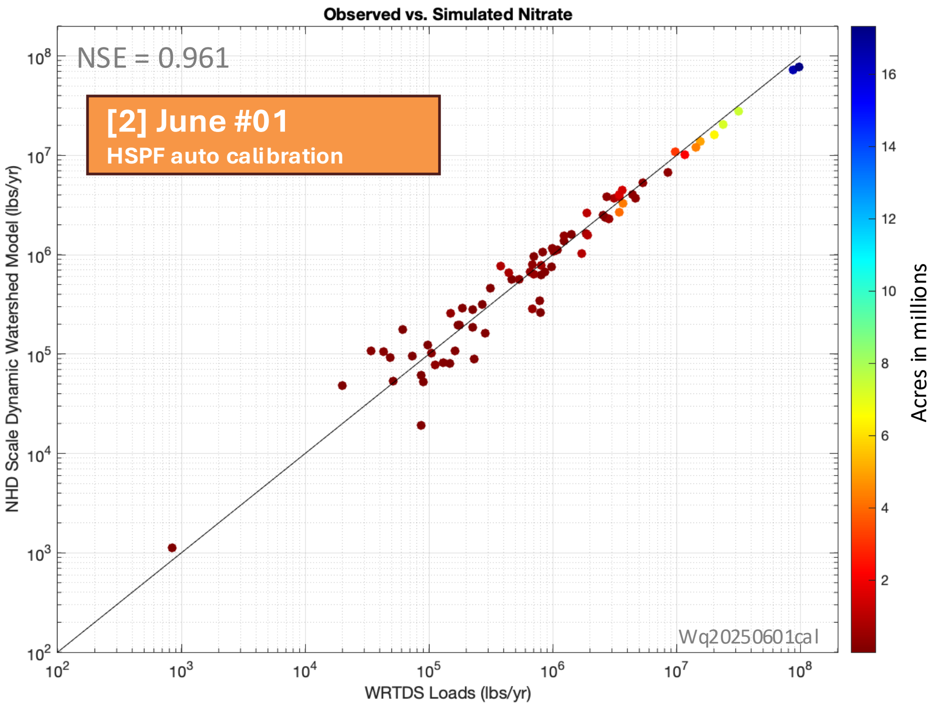

Observed vs. Simulated Total Nitrogen
NSE = 0.979
[2] June #01
HSPF auto calibration
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions
Wq20250601cal

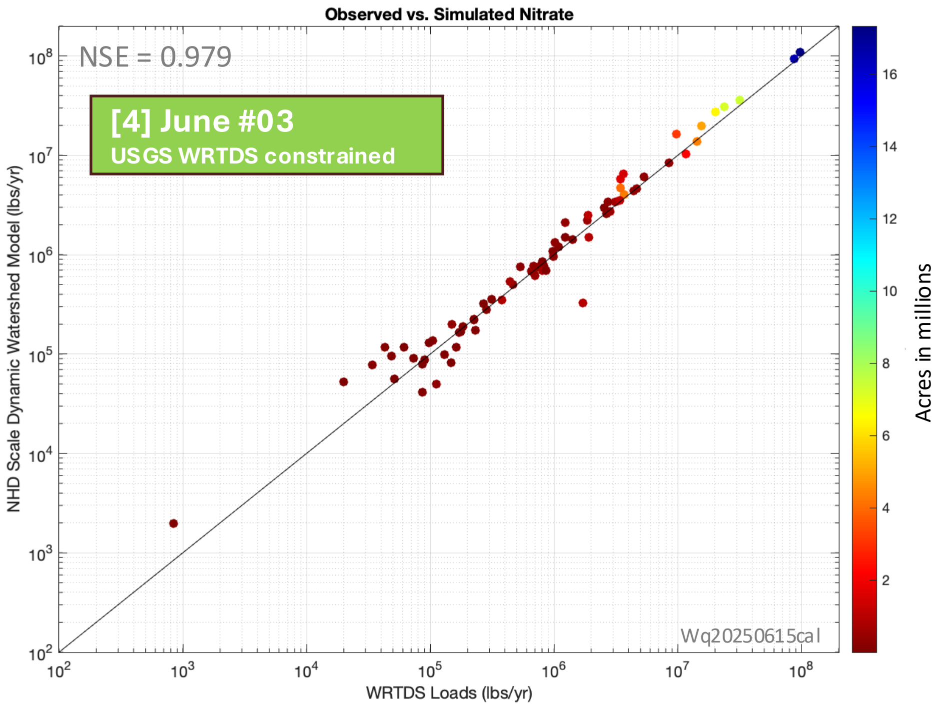

Observed vs. Simulated Total Nitrogen
NSE = 0.998
[4] June #03
USGS WRTDS constrained
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions
Wq20250615cal

Nitrogen

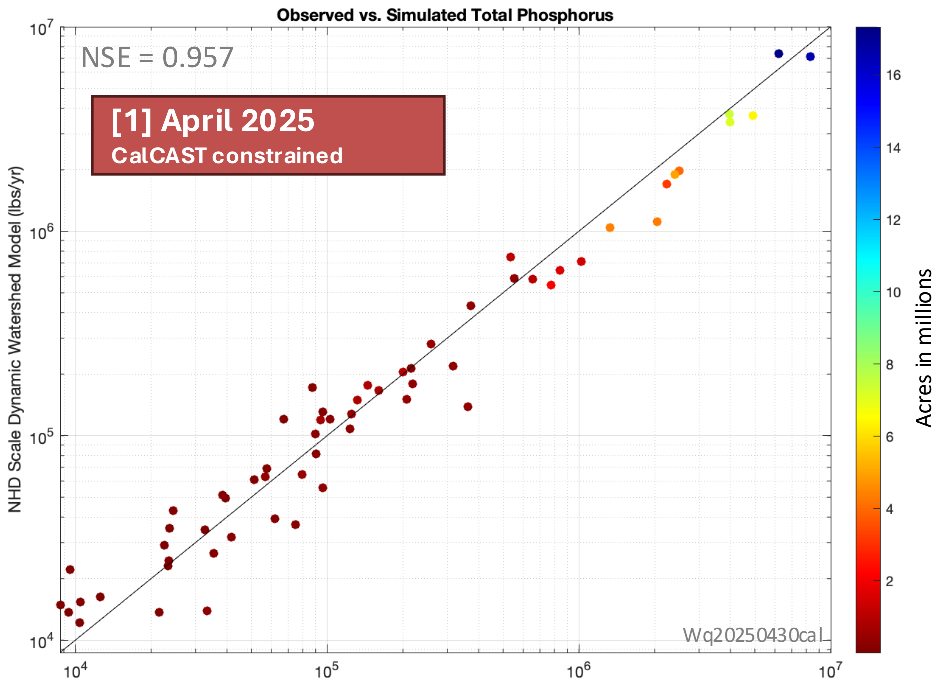

Observed vs. Simulated Nitrate
NSE = 0.982
[1] April 2025
CalCAST constrained
NHD Scale Dynamic Watershed Model (lbs/yr)
Acres in millions
Wq20250430cal

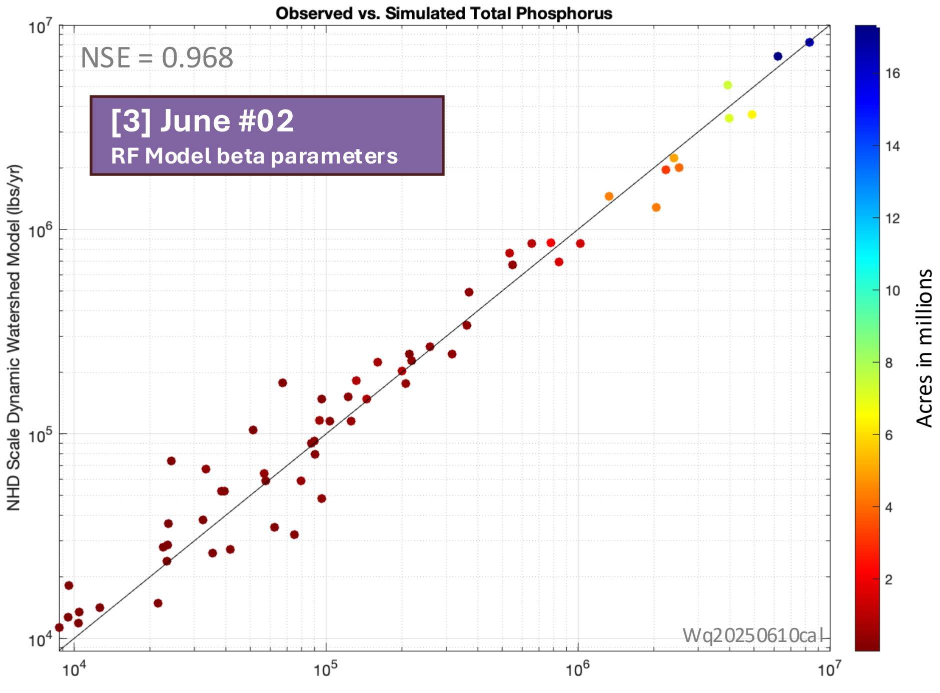

Observed vs. Simulated Nitrate
NSE = 0.960
[3] June #02
RF Model beta parameters
NHD Scale Dynamic Watershed Model (lbs/yr)
Acres in millions
Wq20250610cal

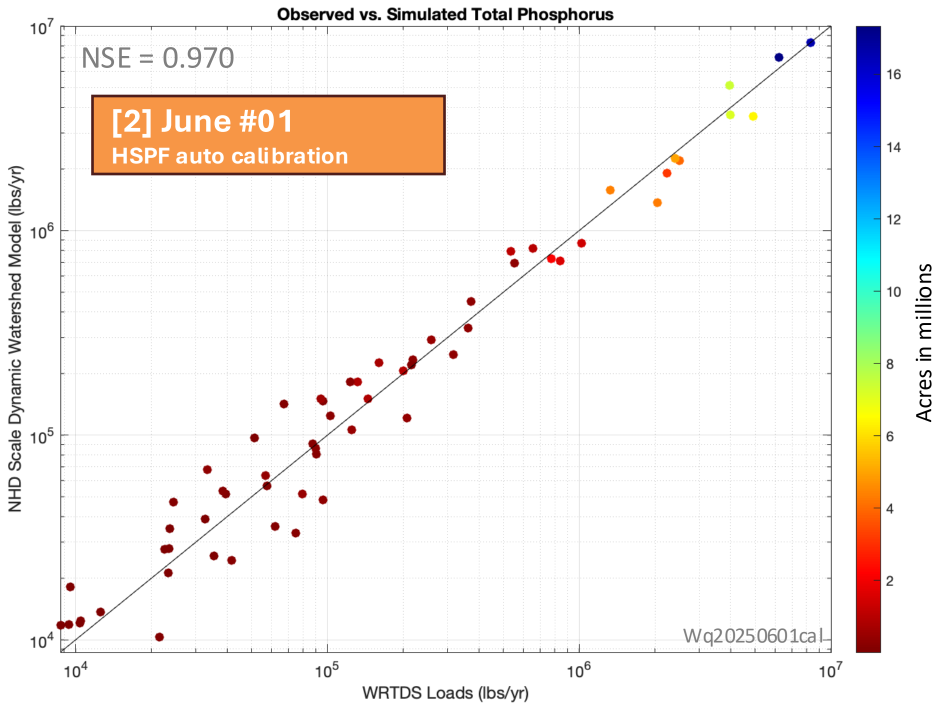

Observed vs. Simulated Nitrate
NSE = 0.961
[2] June #01
HSPF auto calibration
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions
Wq20250601cal

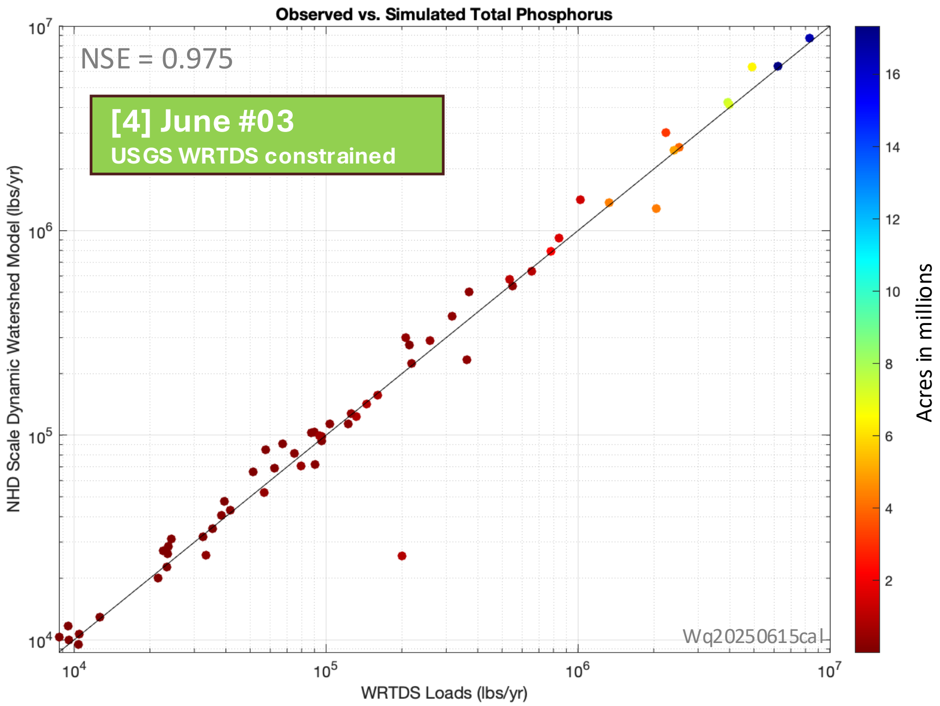

Observed vs. Simulated Nitrate
NSE = 0.979
[4] June #03
USGS WRTDS constrained
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions
Wq20250615cal

Nitrate


Observed vs. Simulated Total Phosphorus
NSE = 0.957
[1] April 2025
CalCAST constrained
NHD Scale Dynamic Watershed Model (lbs/yr)
Acres in millions
Wq20250430cal

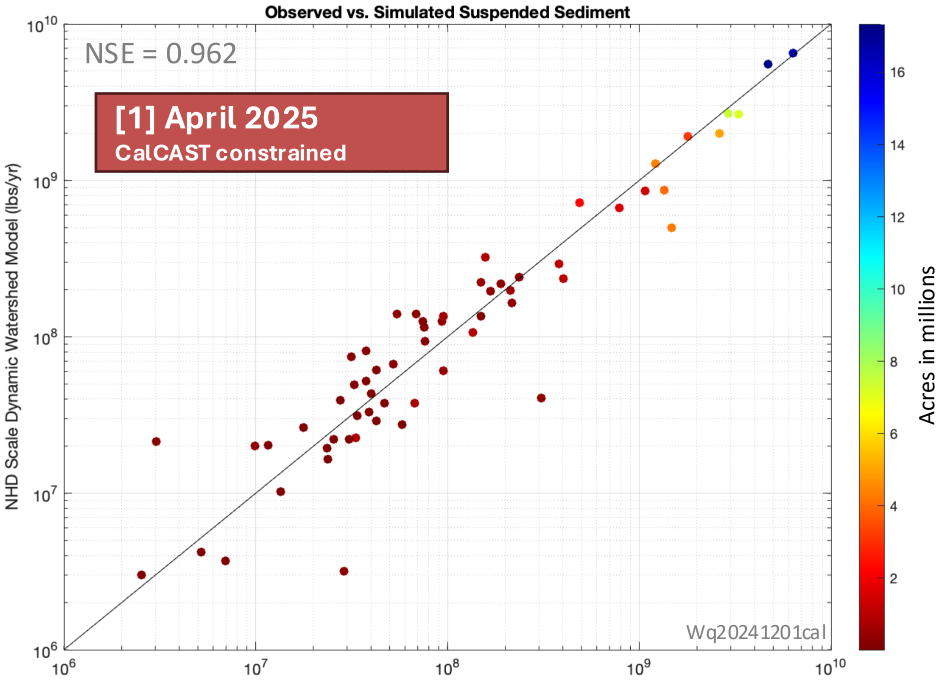

Observed vs. Simulated Total Phosphorus
NSE = 0.968
[3] June #02
RF Model beta parameters
NHD Scale Dynamic Watershed Model (lbs/yr)
Acres in millions
Wq20250610cal


Observed vs. Simulated Total Phosphorus
NSE = 0.970
[2] June #01
HSPF auto calibration
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions
Wq20250601cal

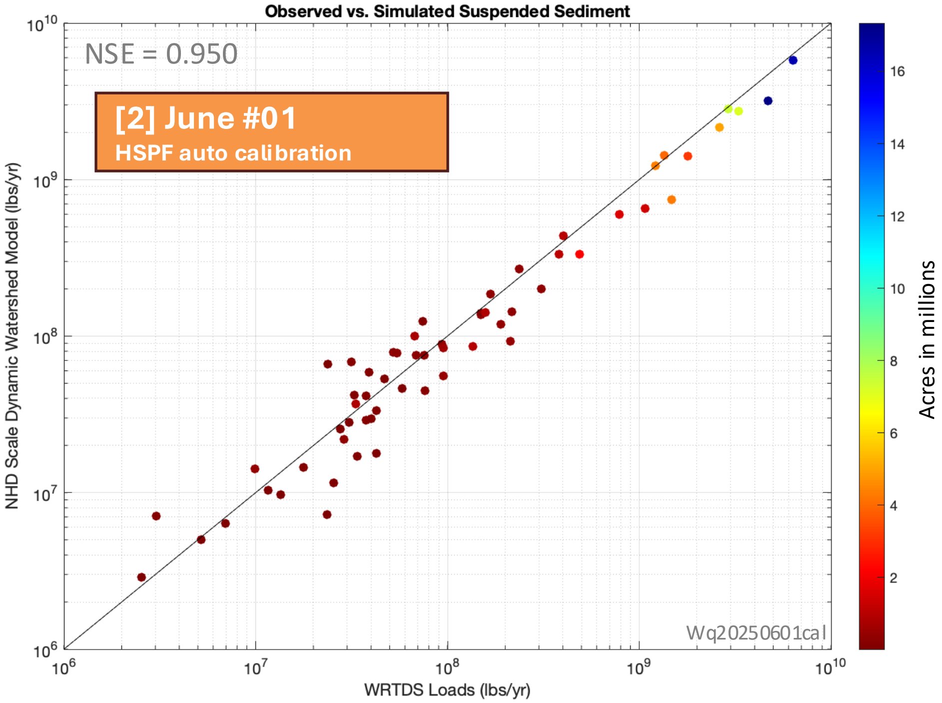

Observed vs. Simulated Total Phosphorus
NSE = 0.975
[4] June #03
USGS WRTDS constrained
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions
Wq20250615cal

Phosphorus

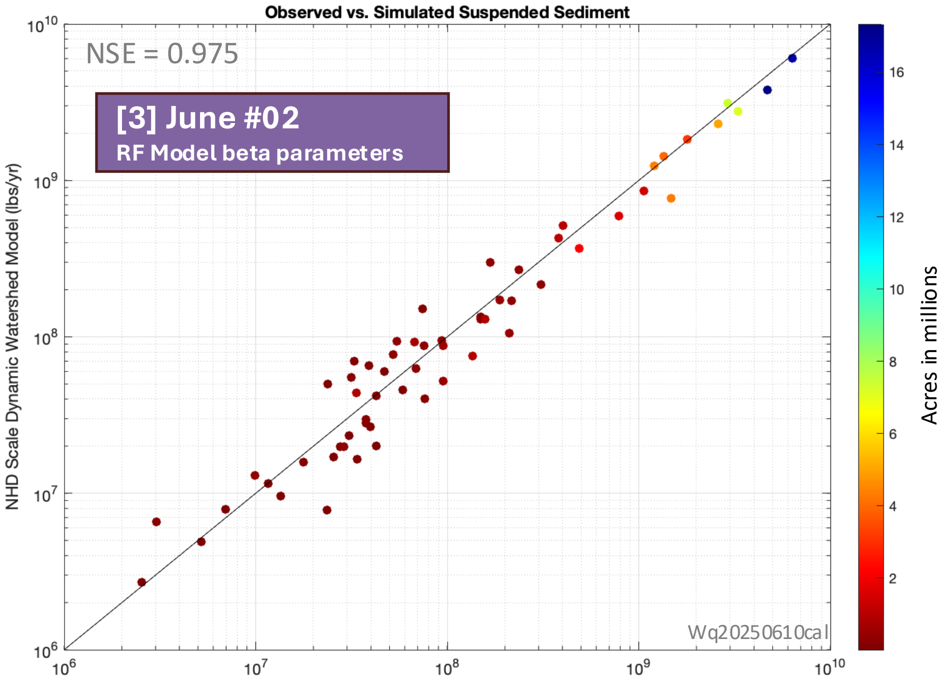
S e d i m e n t



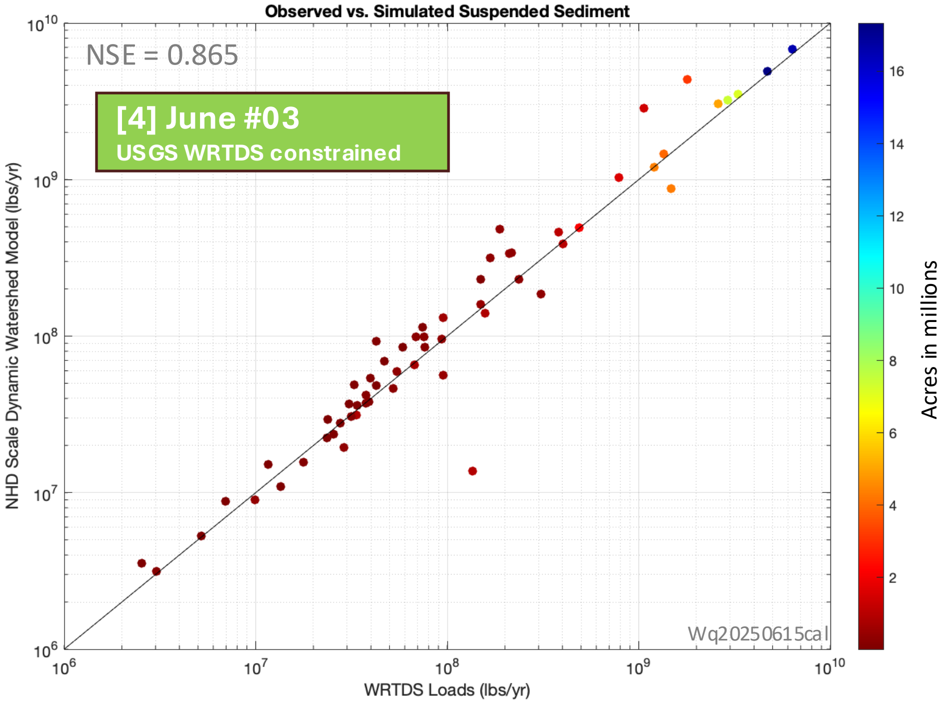
Observed vs. Simulated Suspended Sediment
NSE = 0.962
[1] April 2025
CalCAST constrained
Wq20241201cal
NHD Scale Dynamic Watershed Model (lbs/yr)
Acres in millions



Observed vs. Simulated Suspended Sediment
NSE = 0.950
[2] June #01
HSPF auto calibration
Wq20250601cal
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions



Observed vs. Simulated Suspended Sediment
NSE = 0.975
[3] June #02
RF Model beta parameters
Wq20250610cal
NHD Scale Dynamic Watershed Model (lbs/yr)
Acres in millions



Observed vs. Simulated Suspended Sediment
NSE = 0.865
[4] June #03
USGS WRTDS constrained
Wq20250615cal
NHD Scale Dynamic Watershed Model (lbs/yr)
WRTDS Loads (lbs/yr)
Acres in millions

Summary

1. We updated beta versions and linkage of incrementally refined watershed model flows and loads with the estuarine model.

- E.g., hydrology model recalibration and PRISM precipitation; simulation of nitrogen speciation; RF model estimated beta parameters; routing module for small stream sediment; refinements to calibration methods;

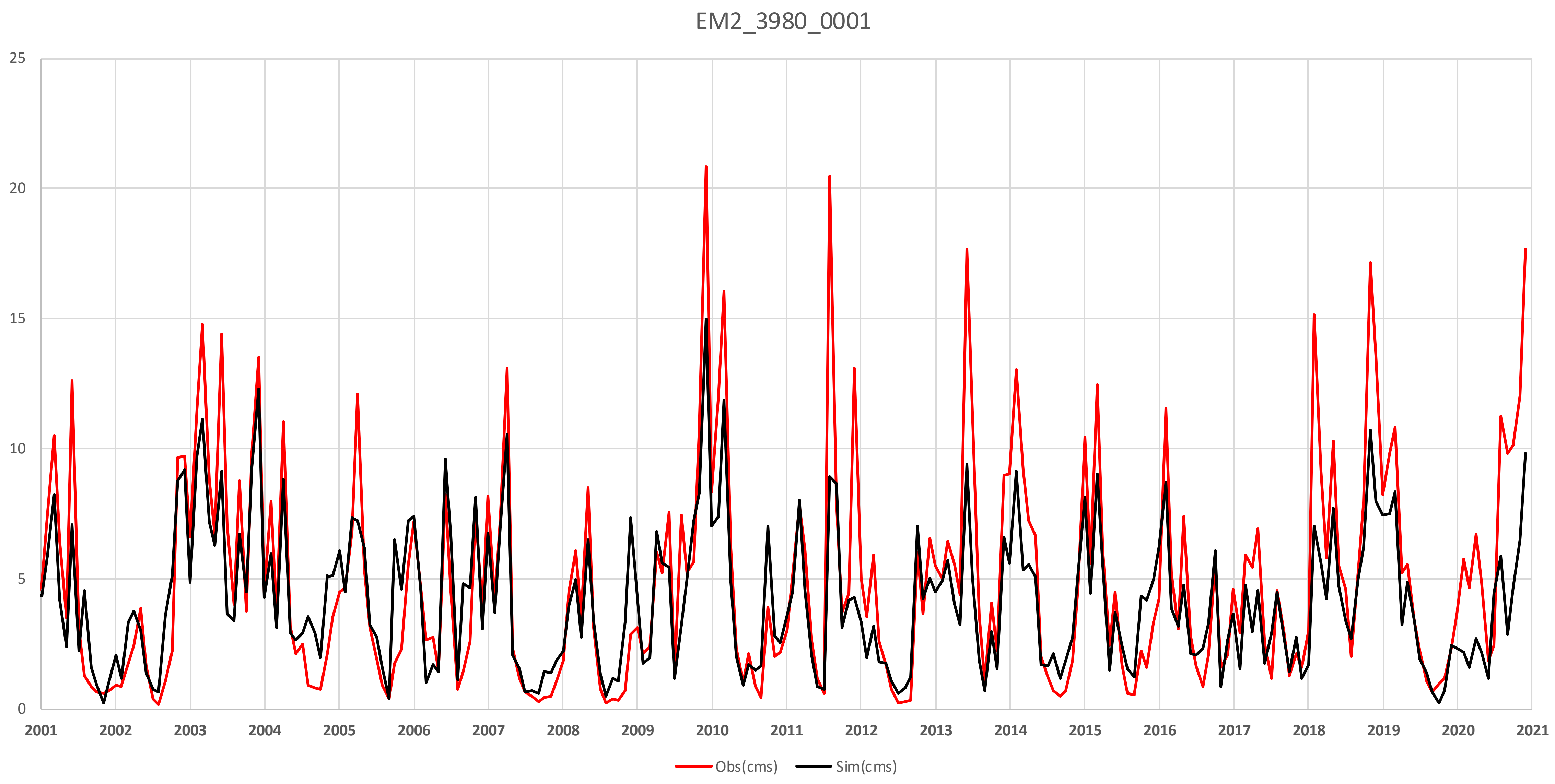
>> Next Steps for the Phase 7 Dynamic Watershed Model (DWSM)

2. We have shifted towards completeness of the model: (a) model parameters (beta parameters); (b) calibration methods (RIM loads); (c) incorporation of inputs (BMPs; afo/cfo loads); (d) linkage with the MBM and MTMs (atmospheric inputs, tracking progress).

Appendices

Monthly time series

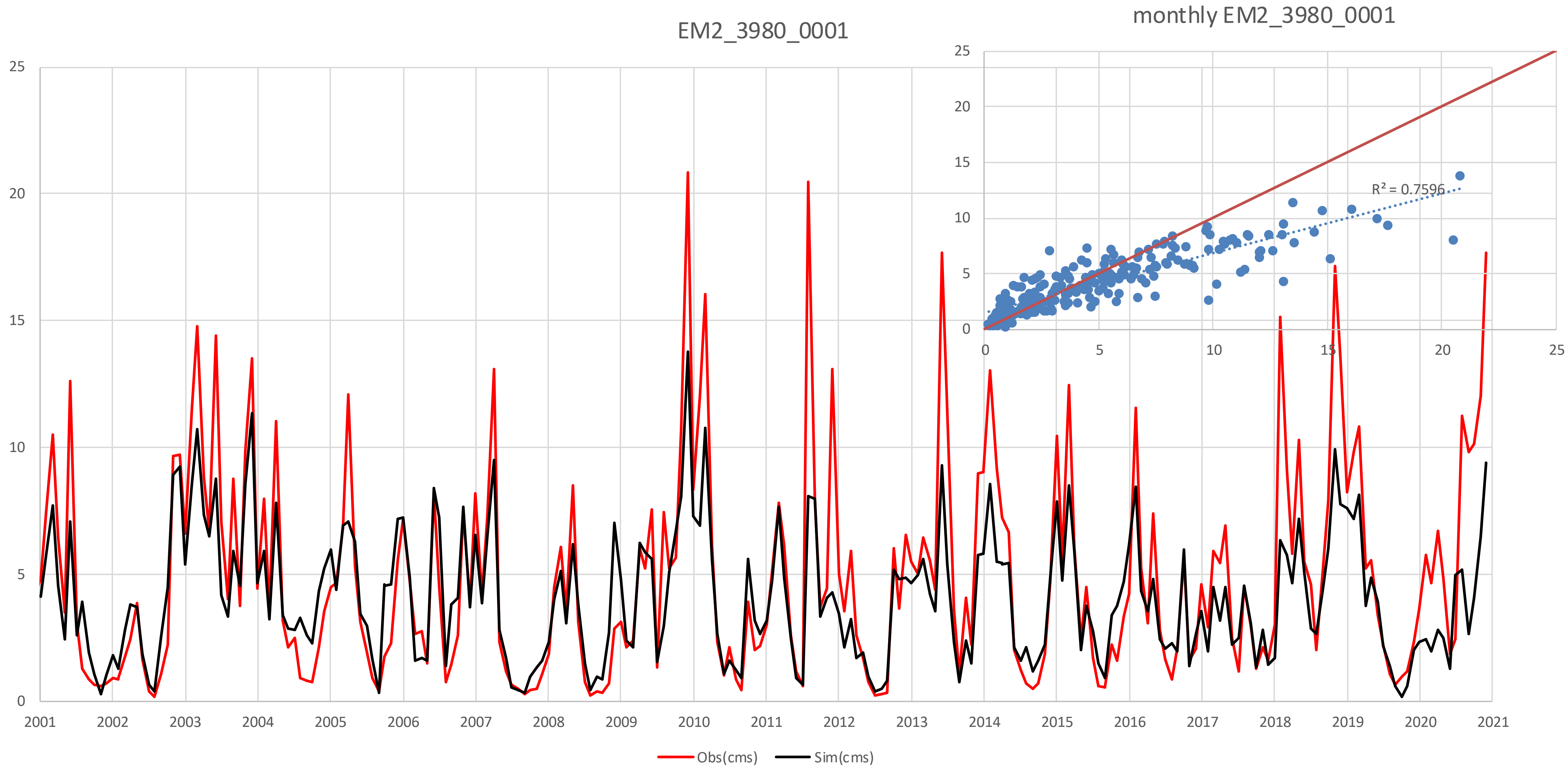
Phase 6



Simulated flow is -15% as compared to observed.

Monthly time series

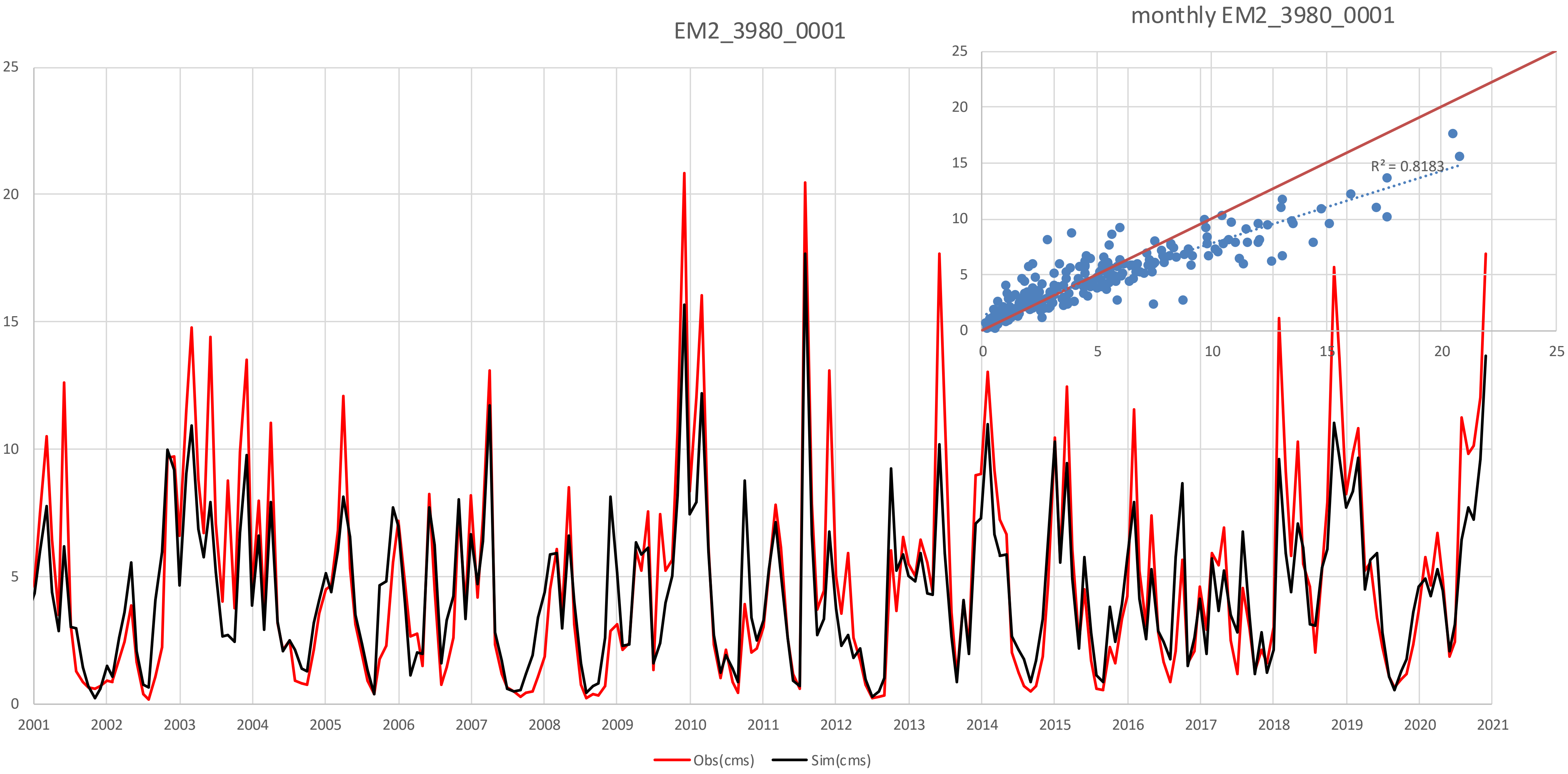
Phase 7



Simulated flow is -17% as compared to observed.

Monthly time series

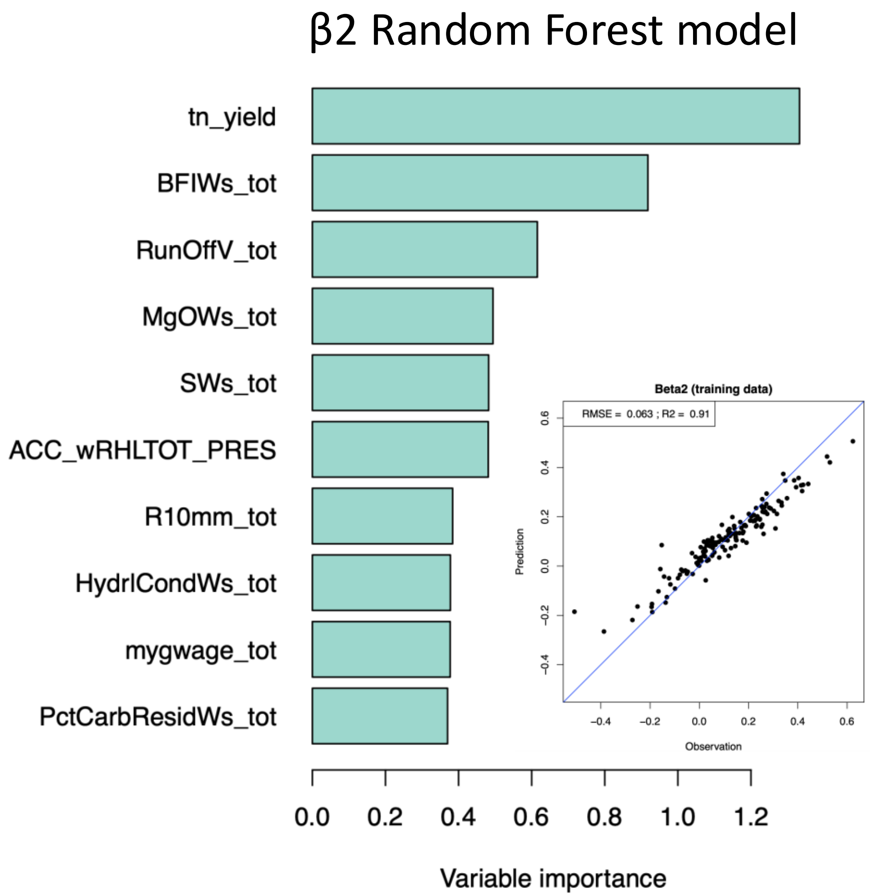
P7 PRISM

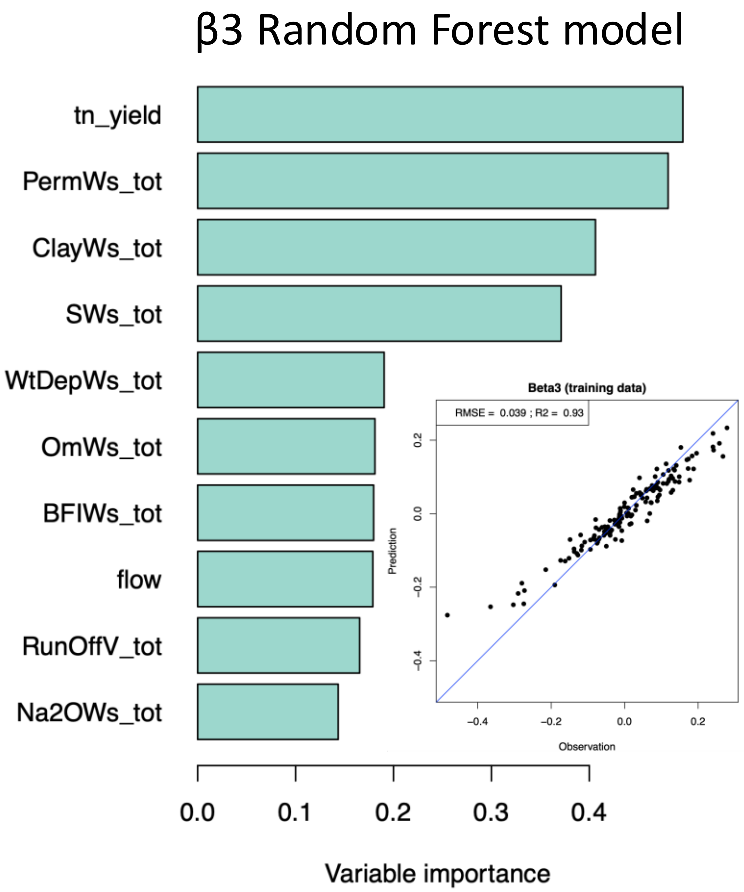


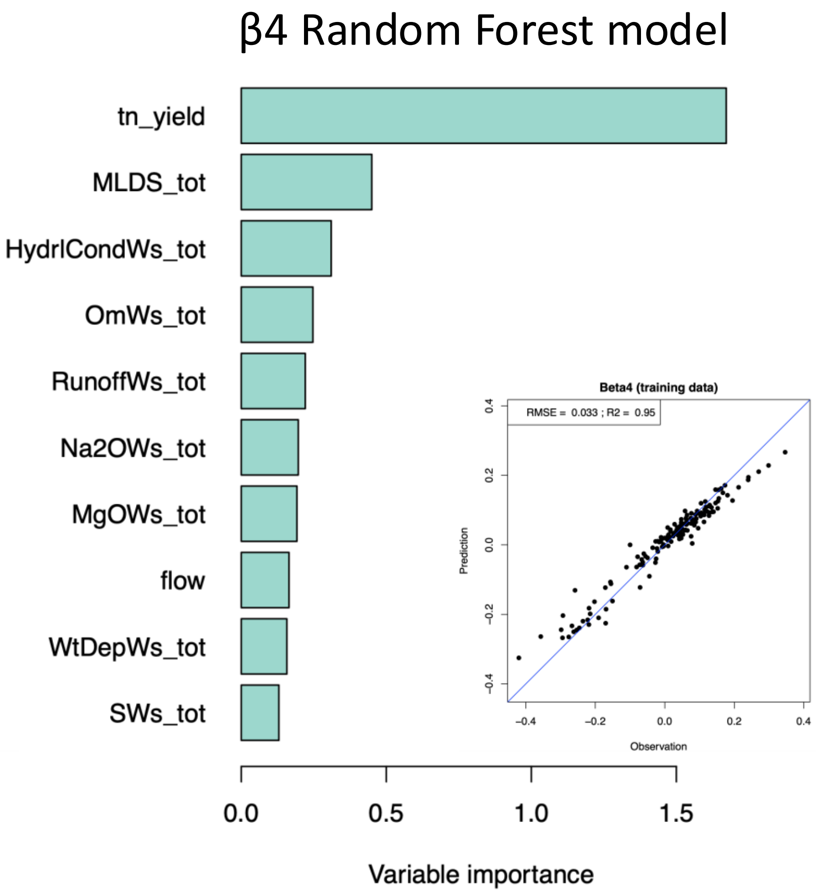
Simulated flow is -8% as compared to observed.

Generalization of β parameters

with contributions of Qian Zhang & Isabella Bertani







$$ln(c) = \beta_o + \beta_1 t + \boldsymbol{\beta_2}\, ln(Q) + \boldsymbol{\beta_3} sin(2\pi t) + \boldsymbol{\beta_4} cos(2\pi t) + \varepsilon$$

P6 Nitrogen (auto calibrations Oct-Nov 2017)

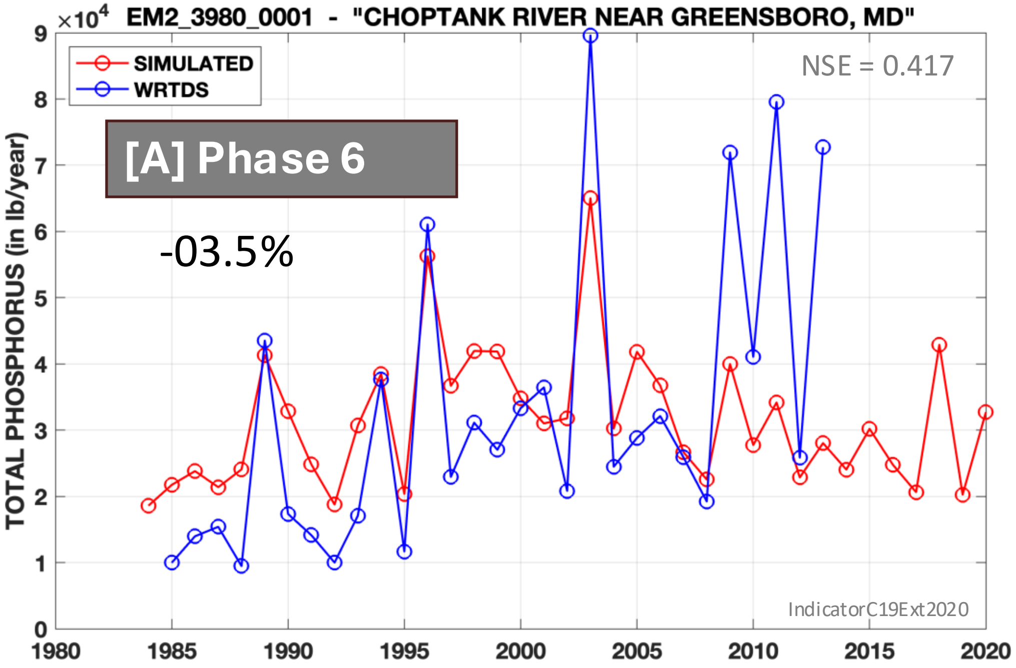
BASIN	June Auto	#A	#B	#C	#D	#F
SUSQ	-03%	-01%	-04%	-04%	-07%	-07%
POTO	-26%	-22%	-21%	-22%	-21%	-14%
JAME	-20%	-30%	-25%	-26%	-25%	-13%
RAPP	-11%	-14%	-20%	-20%	-18%	-07%
APPO	-07%	-09%	-02%	-02%	-02%	00%
PAMU	00%	-09%	-01%	-02%	-02%	06%
MATT	23%	13%	19%	25%	16%	16%
PATU	06%	07%	07%	06%	07%	08%
CHOP	43%	14%	18%	28%	25%	19%

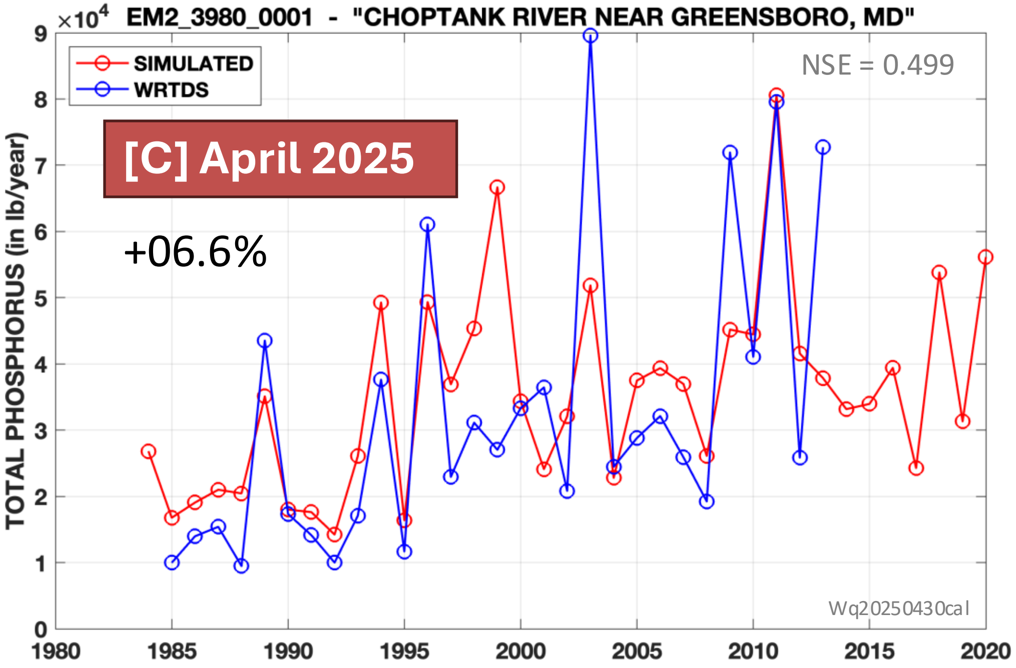
P6 Phosphorus (auto calibrations Oct-Nov 2017)

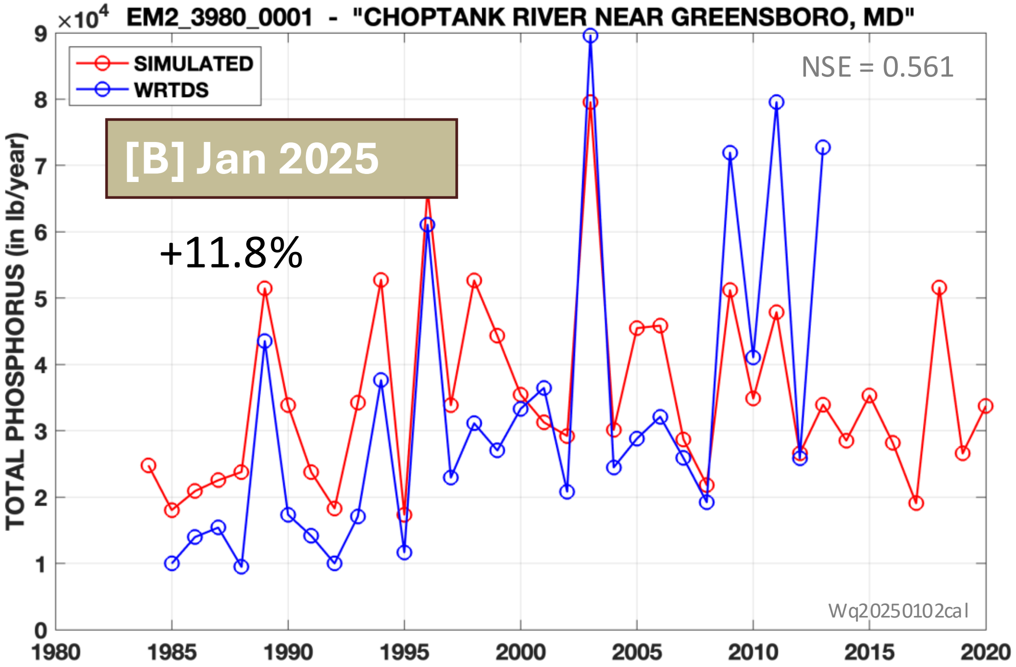
BASIN	June Auto	#A	#B	#C	#D	
SUSQ	14%	20%	20%	17%	16%	
MARI	05%	06%	05%	04%	-03%	
POTO	-18%	-17%	-17%	-17%	-10%	
JAME	-01%	-08%	-11%	-20%	-17%	
RAPP	01%	19%	16%	14%	18%	
APPO	13%	17%	11%	18%	08%	
PAMU	21%	31%	28%	23%	17%	
MATT	-14%	-17%	-19%	-16%	-20%	
PATU	11%	14%	12%	11%	12%	
CHOP	13%	-17%	-19%	10%	-20%	

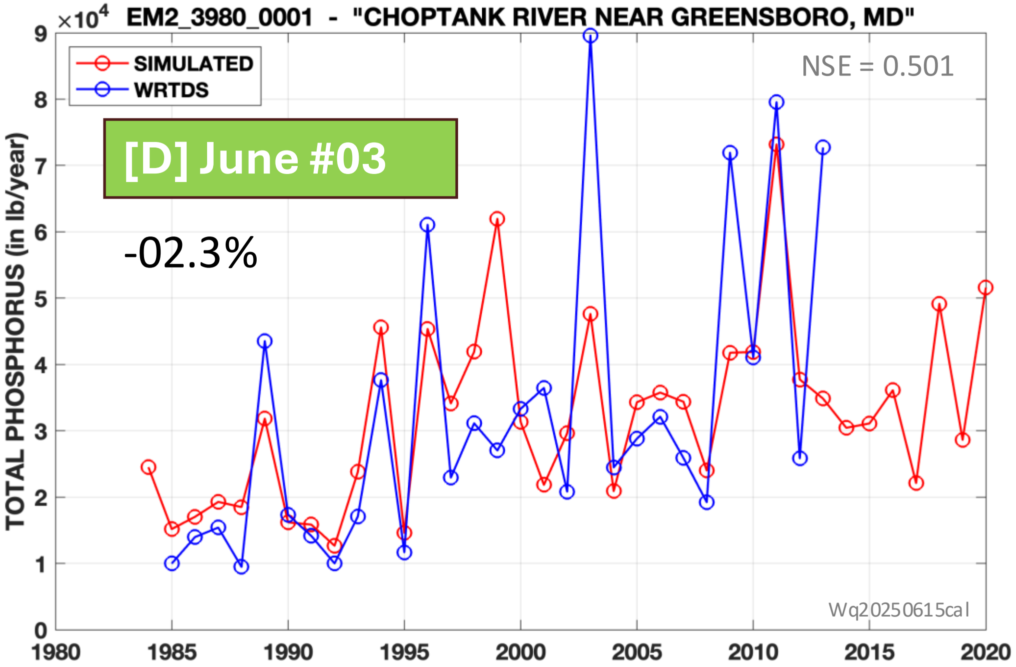
P6 Sediment (auto calibrations Oct-Nov 2017)

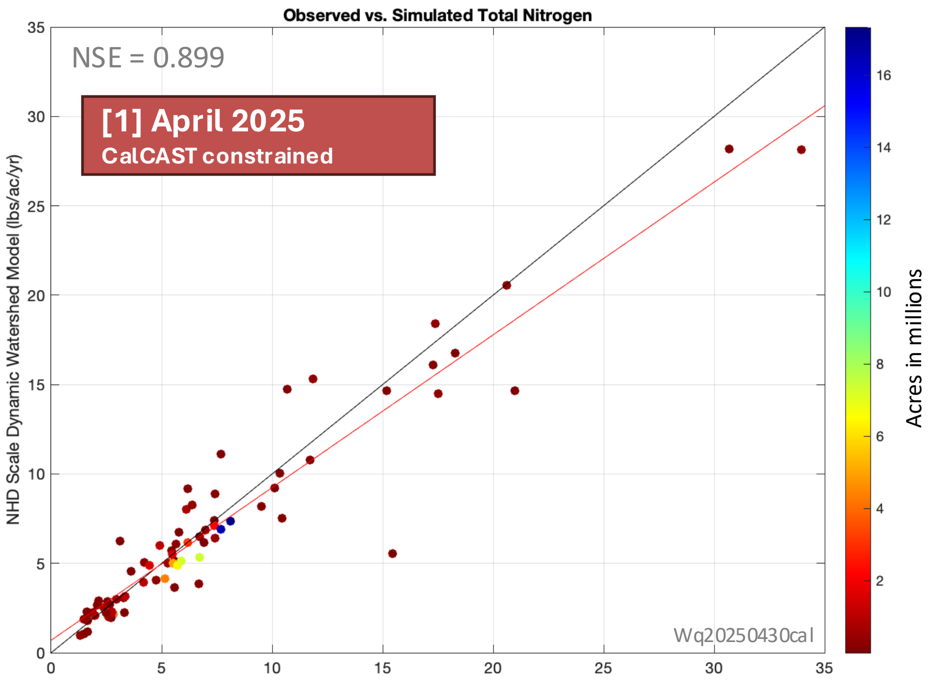
BASIN	June Auto	#A	#B	#C	#D	#F
SUSQ	-23%	-14%	-14%	-15%	-14%	
MARI	-01%	-05%	-05%	-04%	-01%	
POTO	-31%	-31%	-30%	-31%	-06%	
JAME	-14%	-02%	-14%	-10%	05%	
RAPP	-04%	09%	01%	08%	05%	
APPO	36%	26%	17%	25%	09%	
PAMU	40%	65%	58%	48%	36%	
MATT	91%	35%	35%	142%	41%	
PATU	53%	58%	53%	77%	61%	
CHOP	171%	07%	07%	352%	06%	

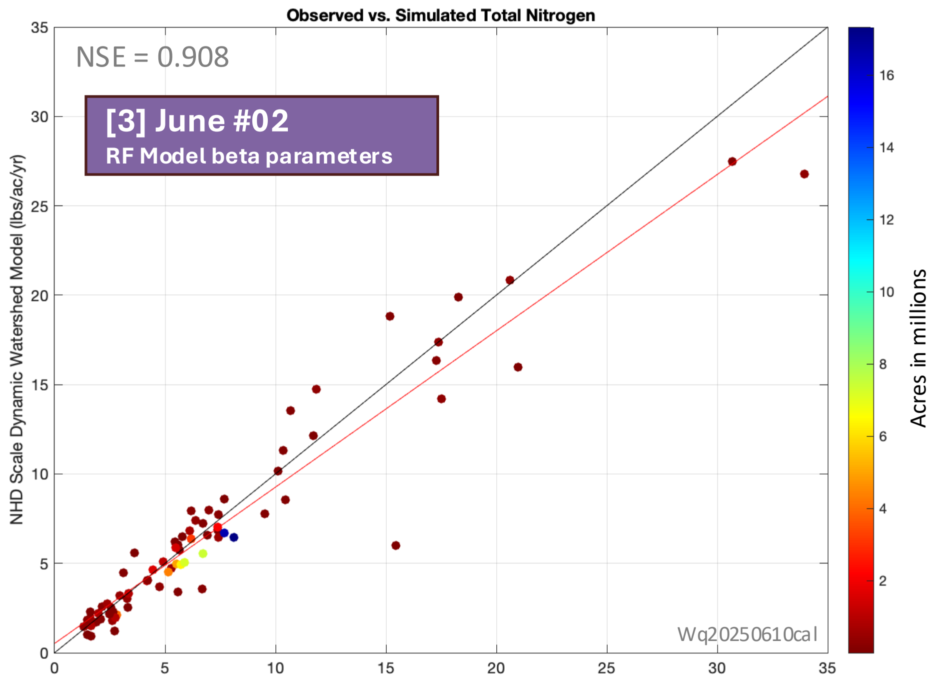

×10^4 EM2_3980_0001 - "CHOPTANK RIVER NEAR GREENSBORO, MD"
SIMULATED
WRTDS
NSE = 0.417
[A] Phase 6
-03.5%
TOTAL PHOSPHORUS (in lb/year)
IndicatorC19Ext2020

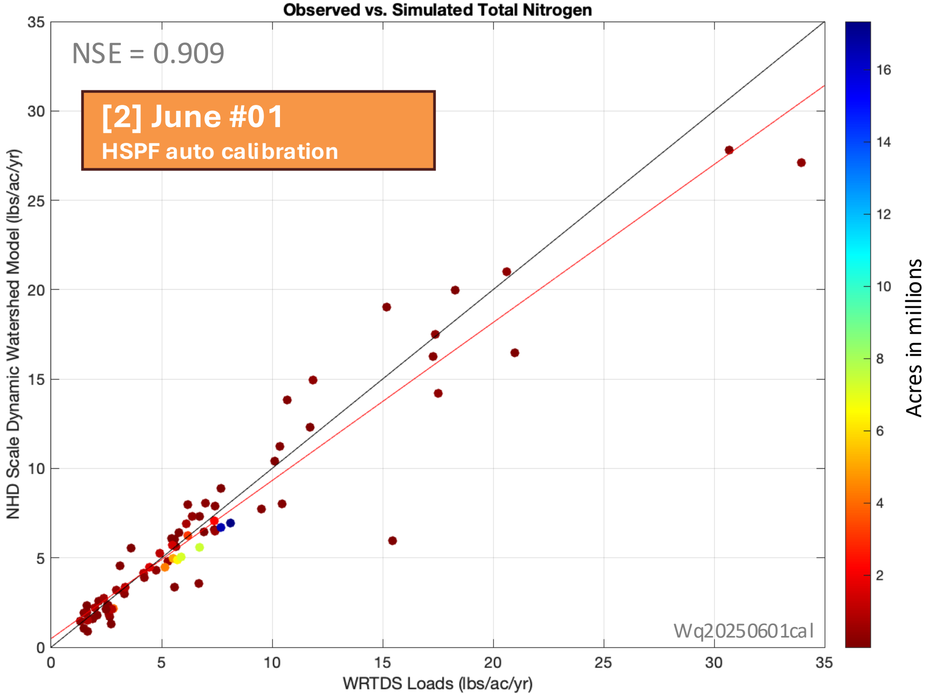

×10^4 EM2_3980_0001 - "CHOPTANK RIVER NEAR GREENSBORO, MD"
SIMULATED
WRTDS
NSE = 0.499
[C] April 2025
+06.6%
TOTAL PHOSPHORUS (in lb/year)
Wq20250430cal

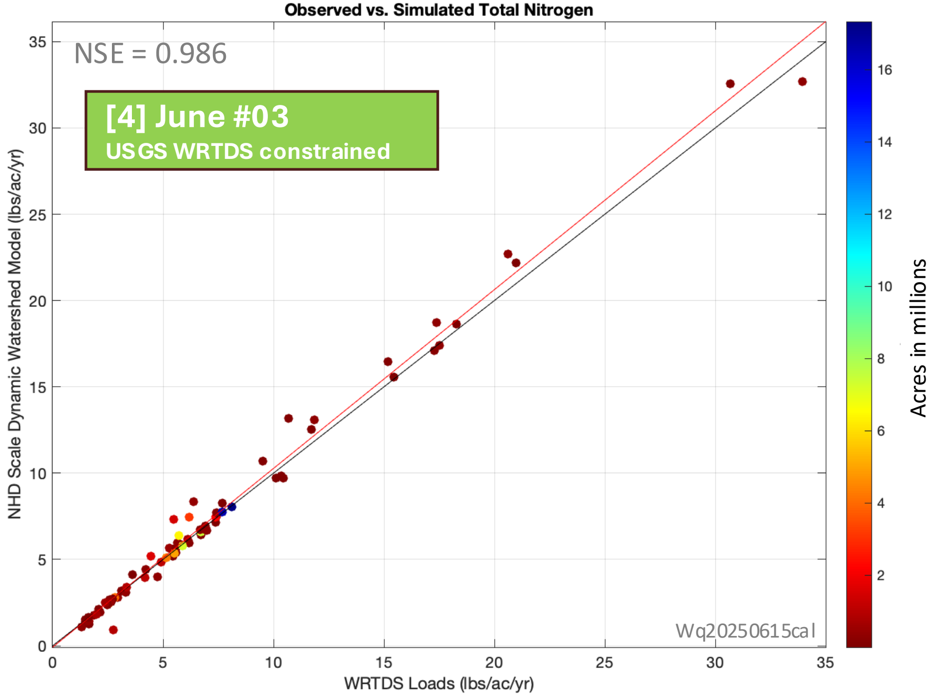

×10^4 EM2_3980_0001 - "CHOPTANK RIVER NEAR GREENSBORO, MD"
SIMULATED
WRTDS
NSE = 0.561
[B] Jan 2025
+11.8%
TOTAL PHOSPHORUS (in lb/year)
Wq20250102cal

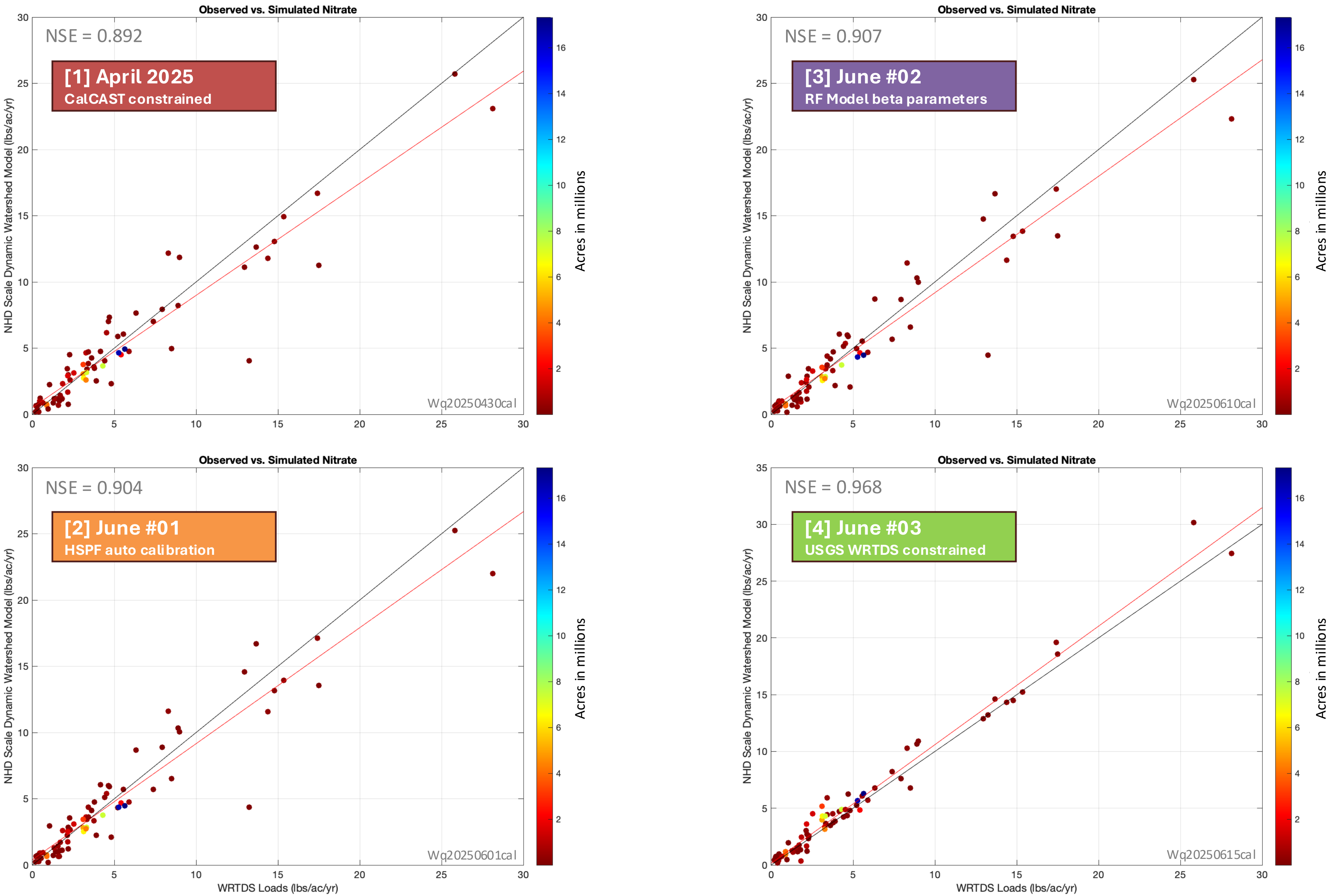

×10^4 EM2_3980_0001 - "CHOPTANK RIVER NEAR GREENSBORO, MD"
SIMULATED
WRTDS
NSE = 0.501
[D] June #03
-02.3%
TOTAL PHOSPHORUS (in lb/year)
Wq20250615cal


Observed vs. Simulated Total Nitrogen
NSE = 0.899
[1] April 2025
CalCAST constrained
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
Acres in millions
Wq20250430cal

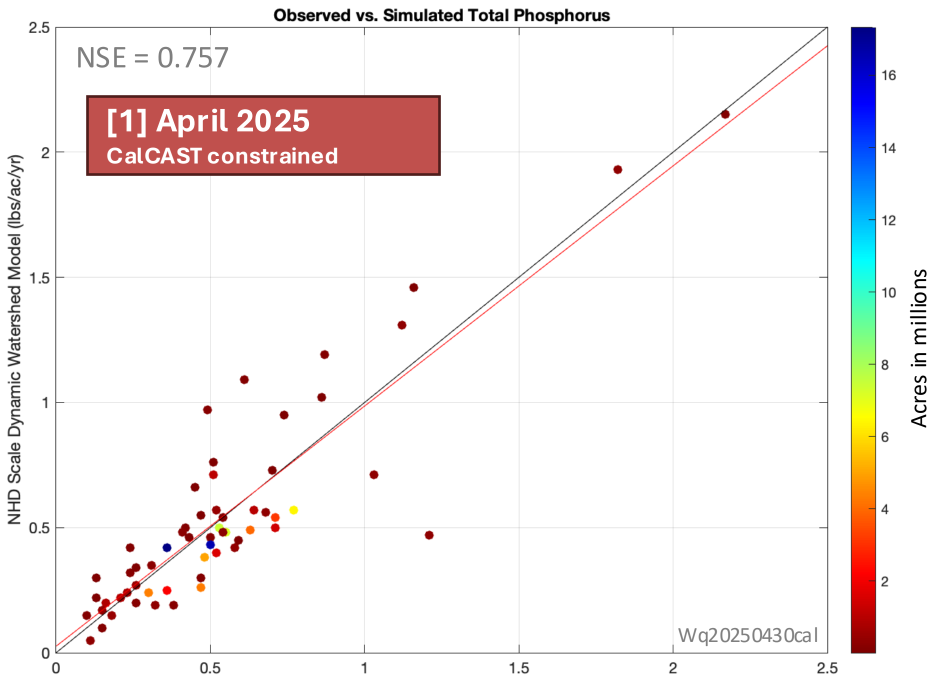

Observed vs. Simulated Total Nitrogen
NSE = 0.908
[3] June #02
RF Model beta parameters
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
Acres in millions
Wq20250610cal

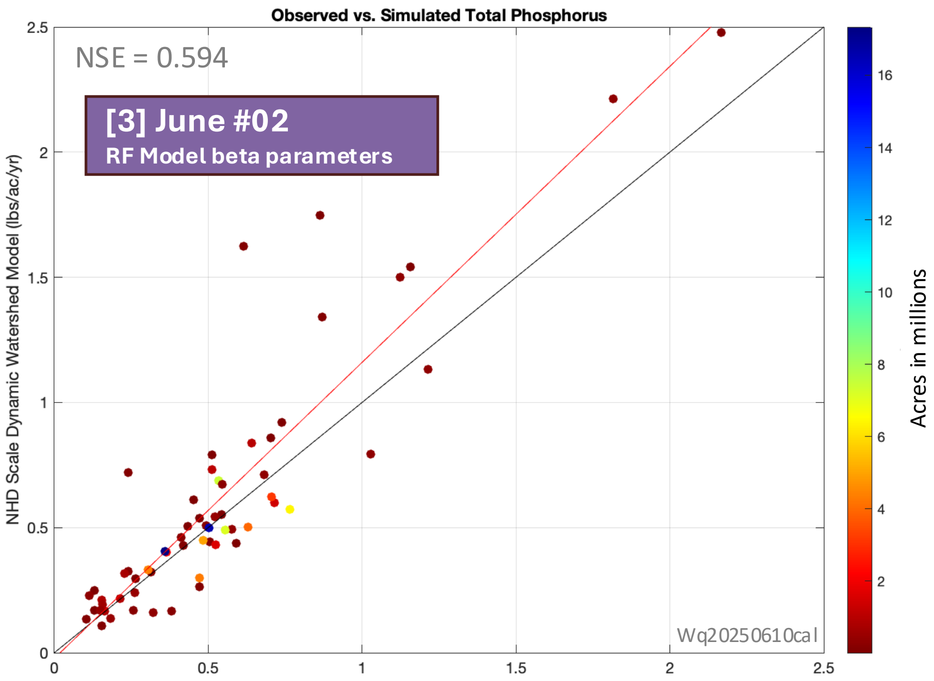

Observed vs. Simulated Total Nitrogen
NSE = 0.909
[2] June #01
HSPF auto calibration
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
WRTDS Loads (lbs/ac/yr)
Acres in millions
Wq20250601cal

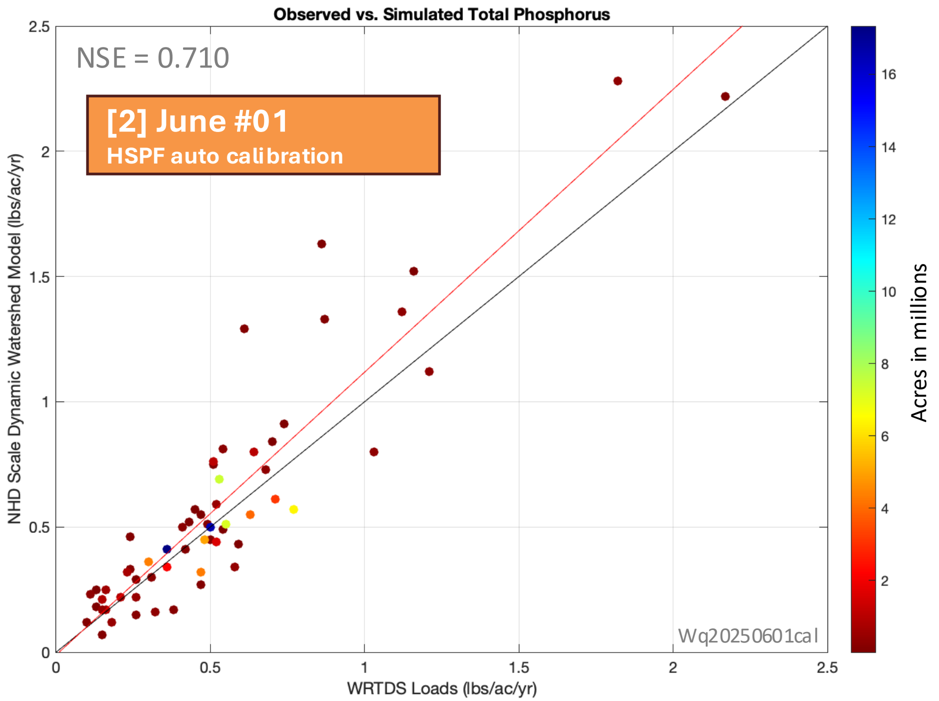

Observed vs. Simulated Total Nitrogen
NSE = 0.986
[4] June #03
USGS WRTDS constrained
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
WRTDS Loads (lbs/ac/yr)
Acres in millions
Wq20250615cal

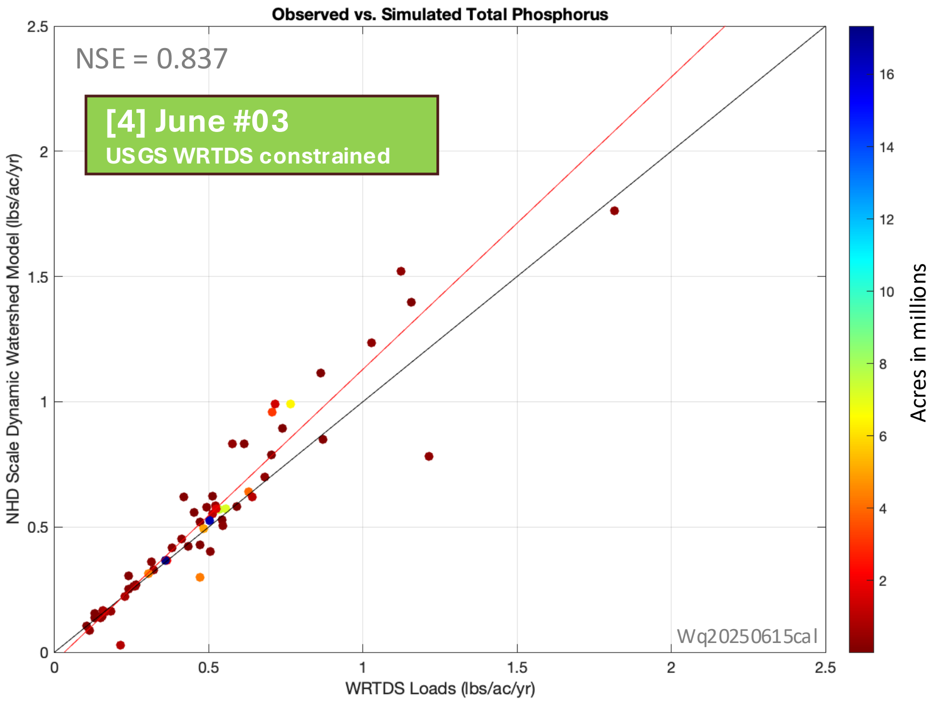


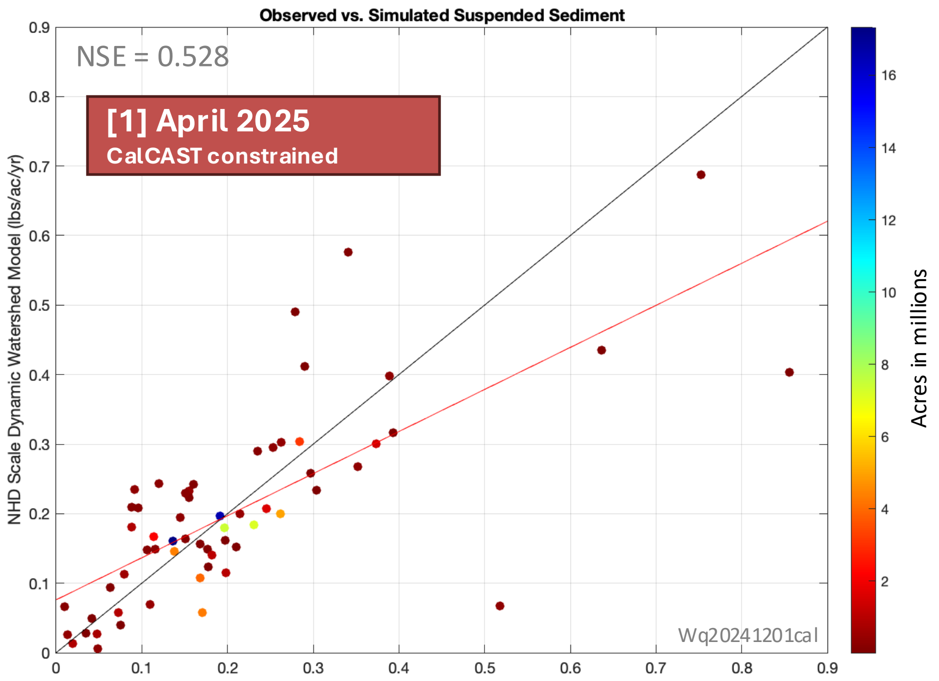
Observed vs. Simulated Nitrate
NSE = 0.892
[1] April 2025
CalCAST constrained
Wq20250430cal
NSE = 0.907
[3] June #02
RF Model beta parameters
Wq20250610cal
NSE = 0.904
[2] June #01
HSPF auto calibration
Wq20250601cal
NSE = 0.968
[4] June #03
USGS WRTDS constrained
Wq20250615cal
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
WRTDS Loads (lbs/ac/yr)
Acres in millions

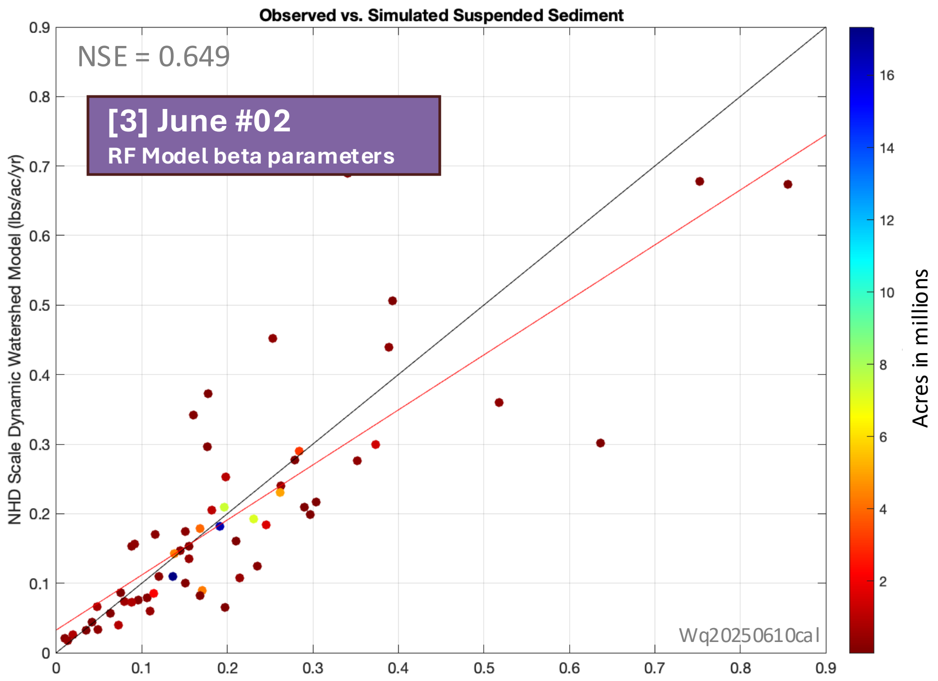

Observed vs. Simulated Total Phosphorus
NSE = 0.757
[1] April 2025
CalCAST constrained
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
Acres in millions
Wq20250430cal

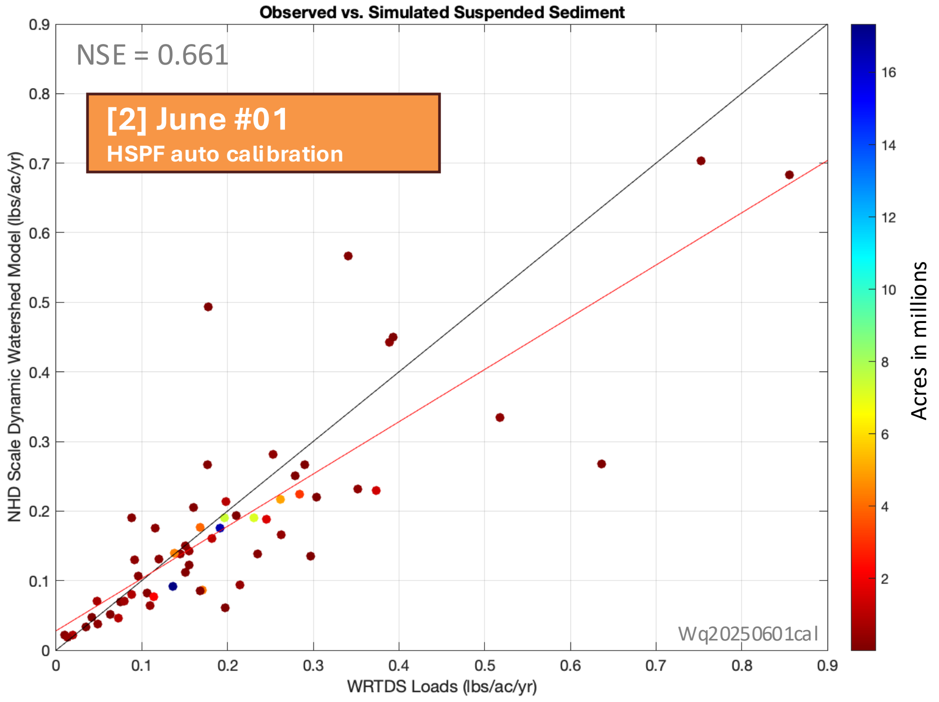

Observed vs. Simulated Total Phosphorus
NSE = 0.594
[3] June #02
RF Model beta parameters
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
Acres in millions
Wq20250610cal

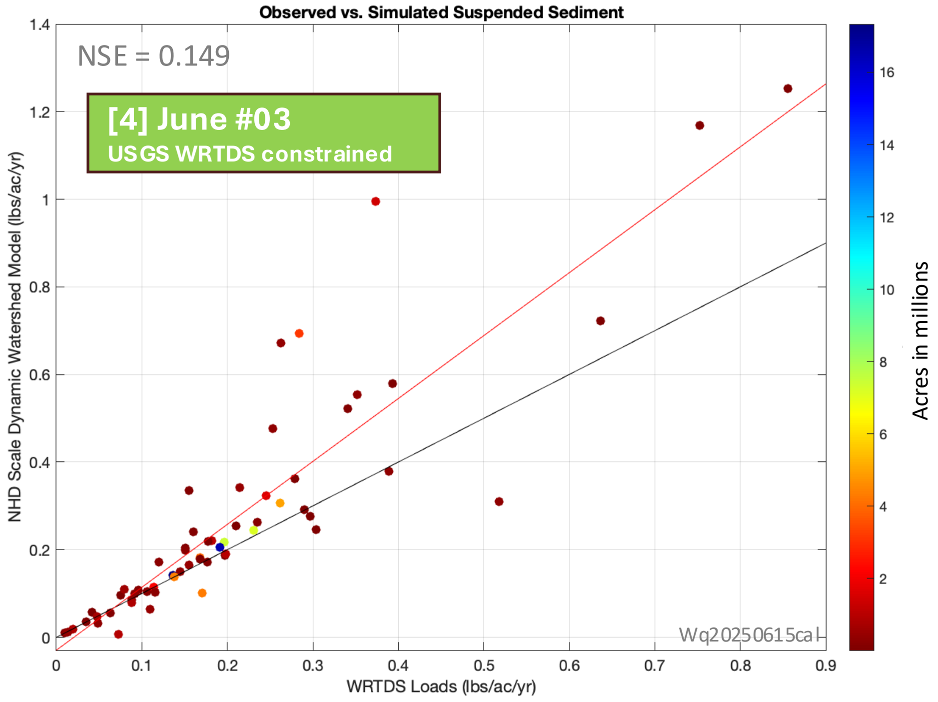

Observed vs. Simulated Total Phosphorus
NSE = 0.710
[2] June #01
HSPF auto calibration
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
WRTDS Loads (lbs/ac/yr)
Acres in millions
Wq20250601cal


Observed vs. Simulated Total Phosphorus
NSE = 0.837
[4] June #03
USGS WRTDS constrained
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
WRTDS Loads (lbs/ac/yr)
Acres in millions
Wq20250615cal


Observed vs. Simulated Suspended Sediment
NSE = 0.528
[1] April 2025
CalCAST constrained
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
Acres in millions
Wq20241201cal


Observed vs. Simulated Suspended Sediment
NSE = 0.649
[3] June #02
RF Model beta parameters
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
Acres in millions
Wq20250610cal


Observed vs. Simulated Suspended Sediment
NSE = 0.661
[2] June #01
HSPF auto calibration
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
WRTDS Loads (lbs/ac/yr)
Acres in millions
Wq20250601cal


Observed vs. Simulated Suspended Sediment
NSE = 0.149
[4] June #03
USGS WRTDS constrained
NHD Scale Dynamic Watershed Model (lbs/ac/yr)
WRTDS Loads (lbs/ac/yr)
Acres in millions
Wq20250615cal