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Evaluation of methods for computing decadal water-quality loads

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Water Quality Load Evaluation - Background

- Studies indicated the potential for biased load computations when using standard USGS methods
  - Stenback et al. (2011) indicated that the LOADEST 7-parameter model produced positively biased nitrate loads in many Iowa Rivers
  - Richards et al (2012) indicated bias in TN and TP loads produced by FLUXMASTER (used in SPARROW)
- The USGS formed a workgroup to begin to evaluate the accuracy of load estimation methods
- Hirsch (2014) found WRTDS to be more resistant to causes of extreme bias in LOADEST methods
- Lee et al. (2016) evaluated an expanded set of methods for computing decadal loads

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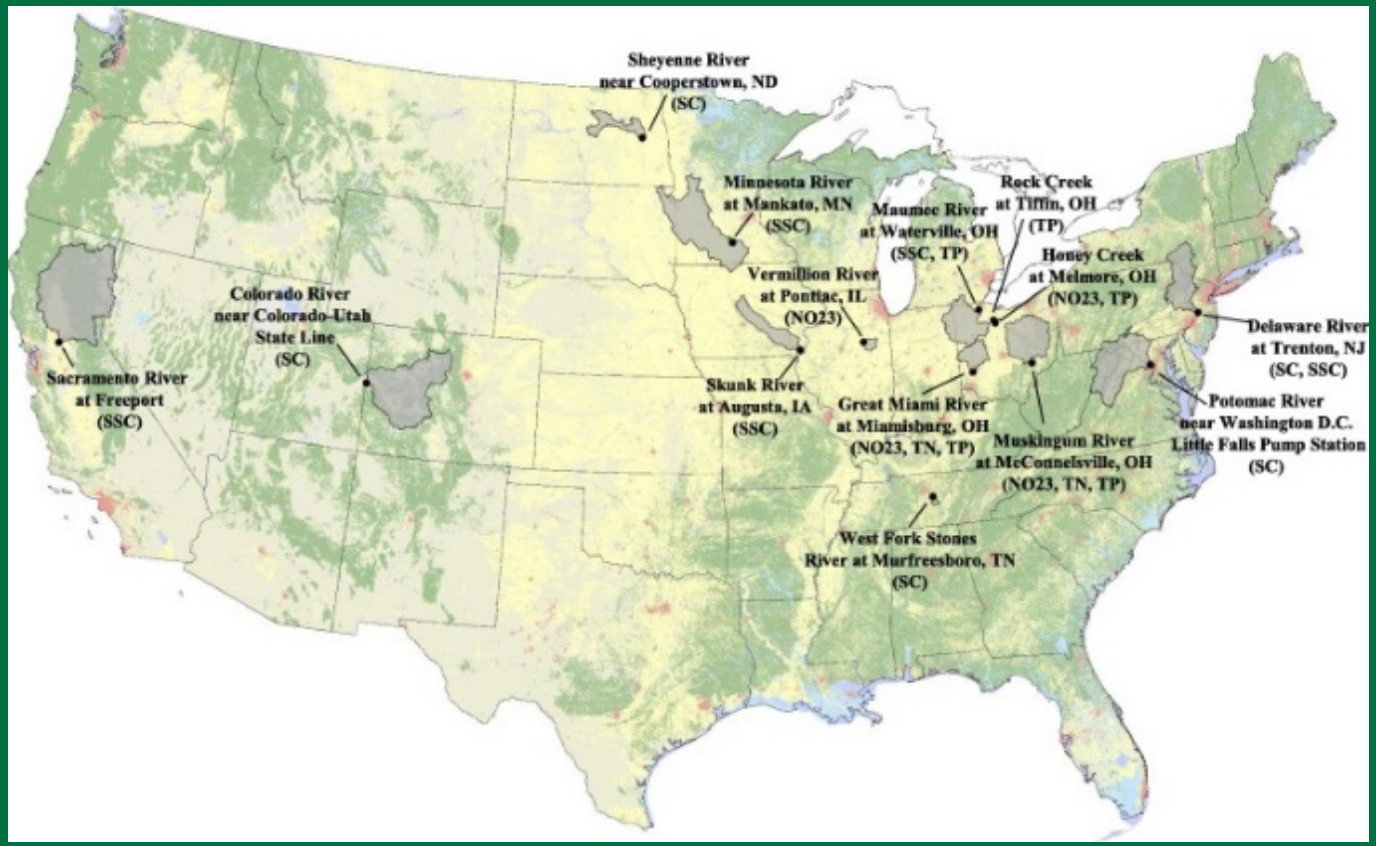
Methods

- **Used near-daily specific conductance, nutrient, and suspended-sediment data collected over ten-year periods as “truth”**



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Methods

- Used near-daily specific conductance, nutrient, and suspended-sediment data collected over ten-year periods as “truth”

- Methods considered:
  - Simple interpolation
  - A version of Beale’s ratio estimator
  - Standard LOADEST methods, including 5 parameter, 7 parameter, and best model selection
  - LOADEST composite method, LOADEST 5 parameter with flow squared and cubic terms
  - FLUXMASTER 5 and 7 parameter models
  - WRTDS
  - A generalized additive model with Kalman smoothing

- Methods were evaluated among WQ constituent, sampling strategy, sampling frequency, record completeness, and sites

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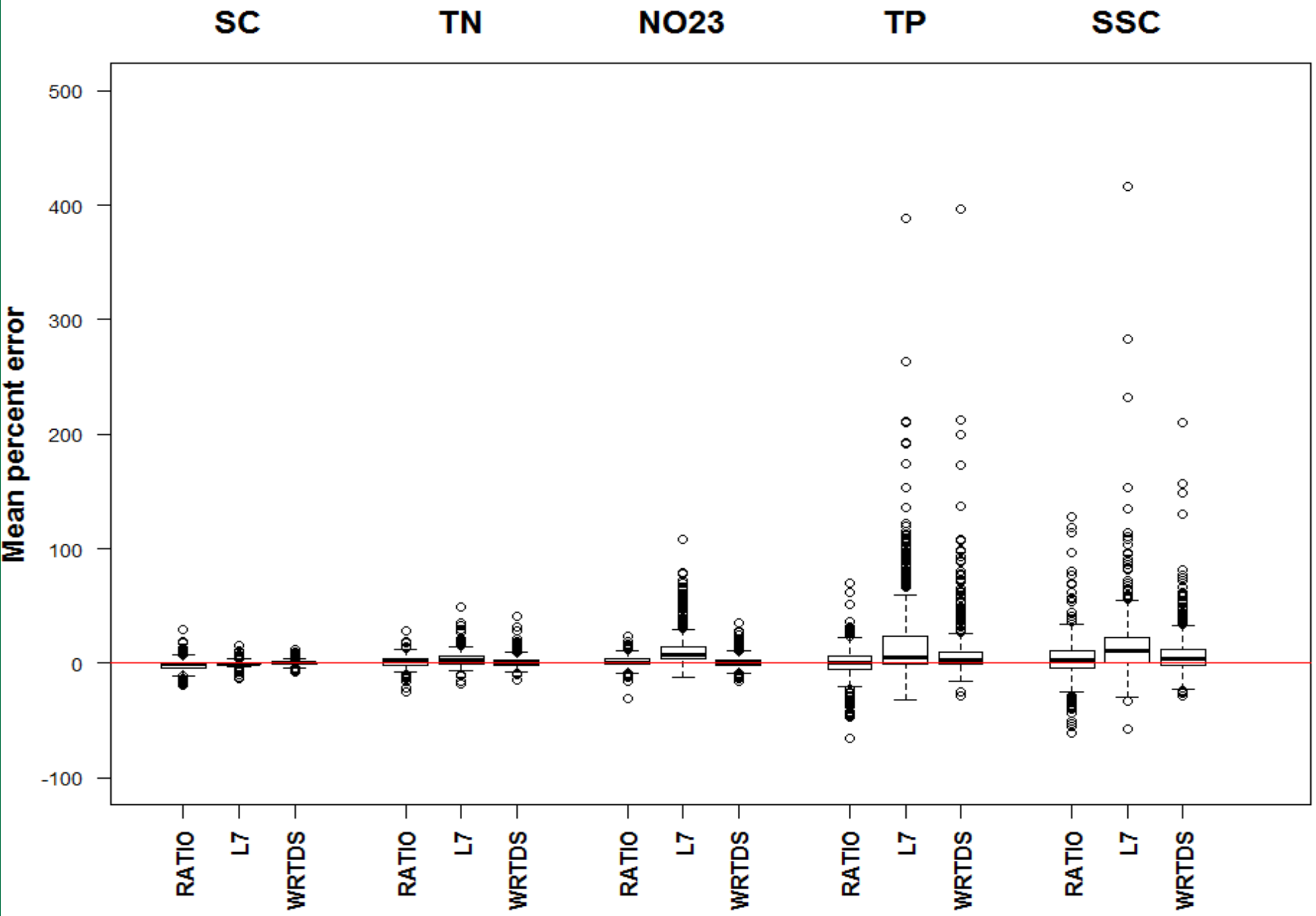
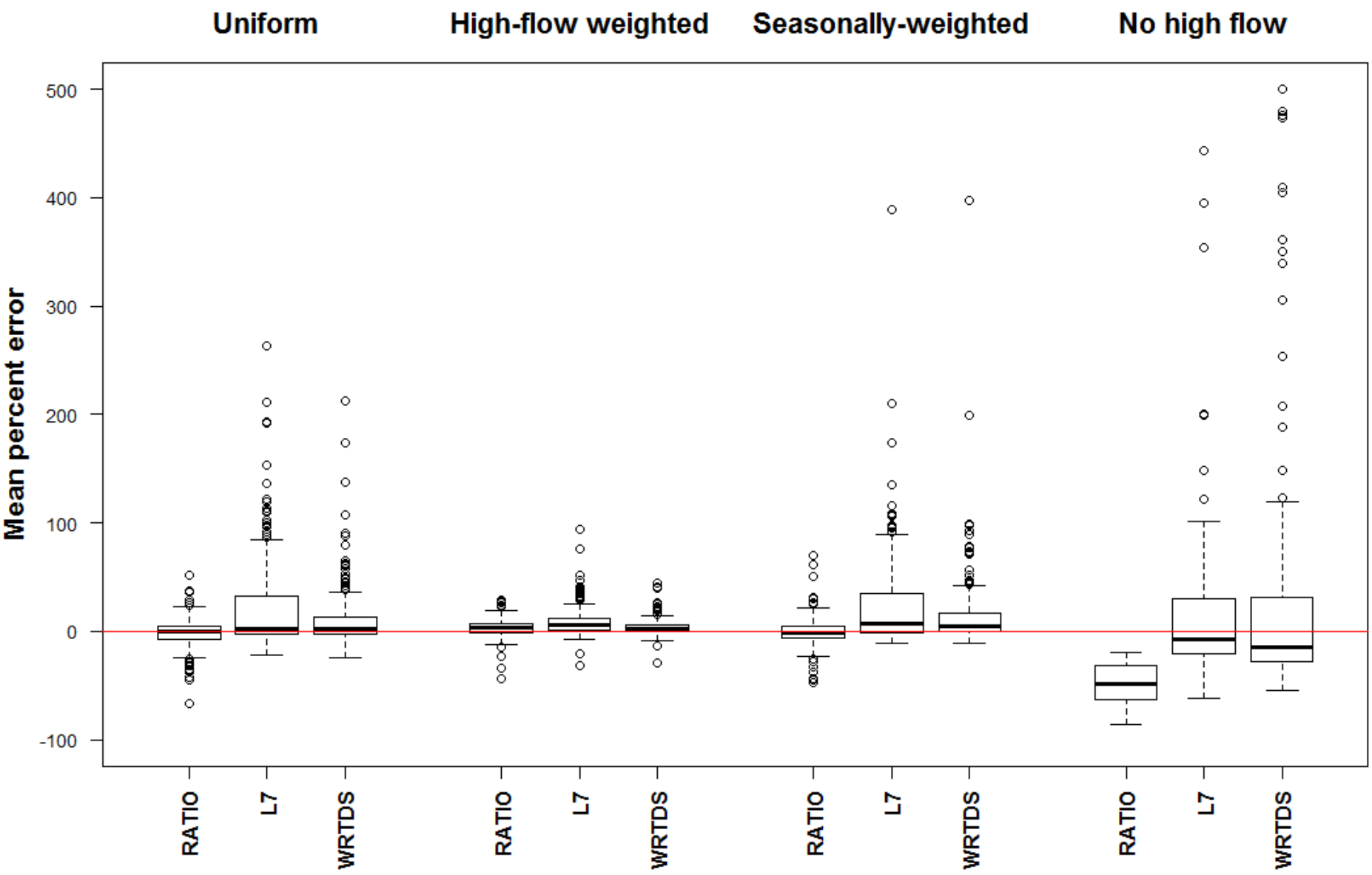
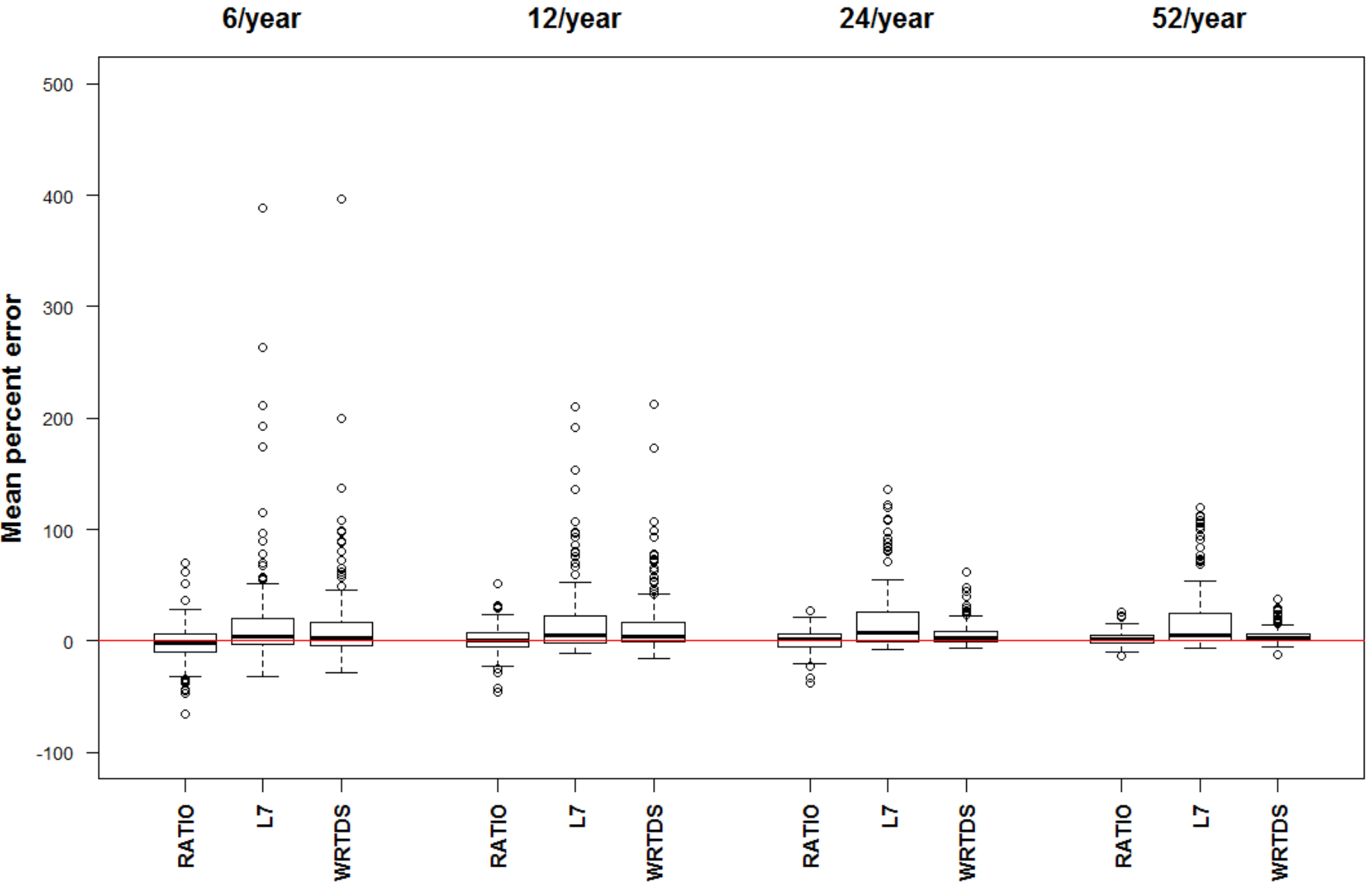
Performance – Among Constituents



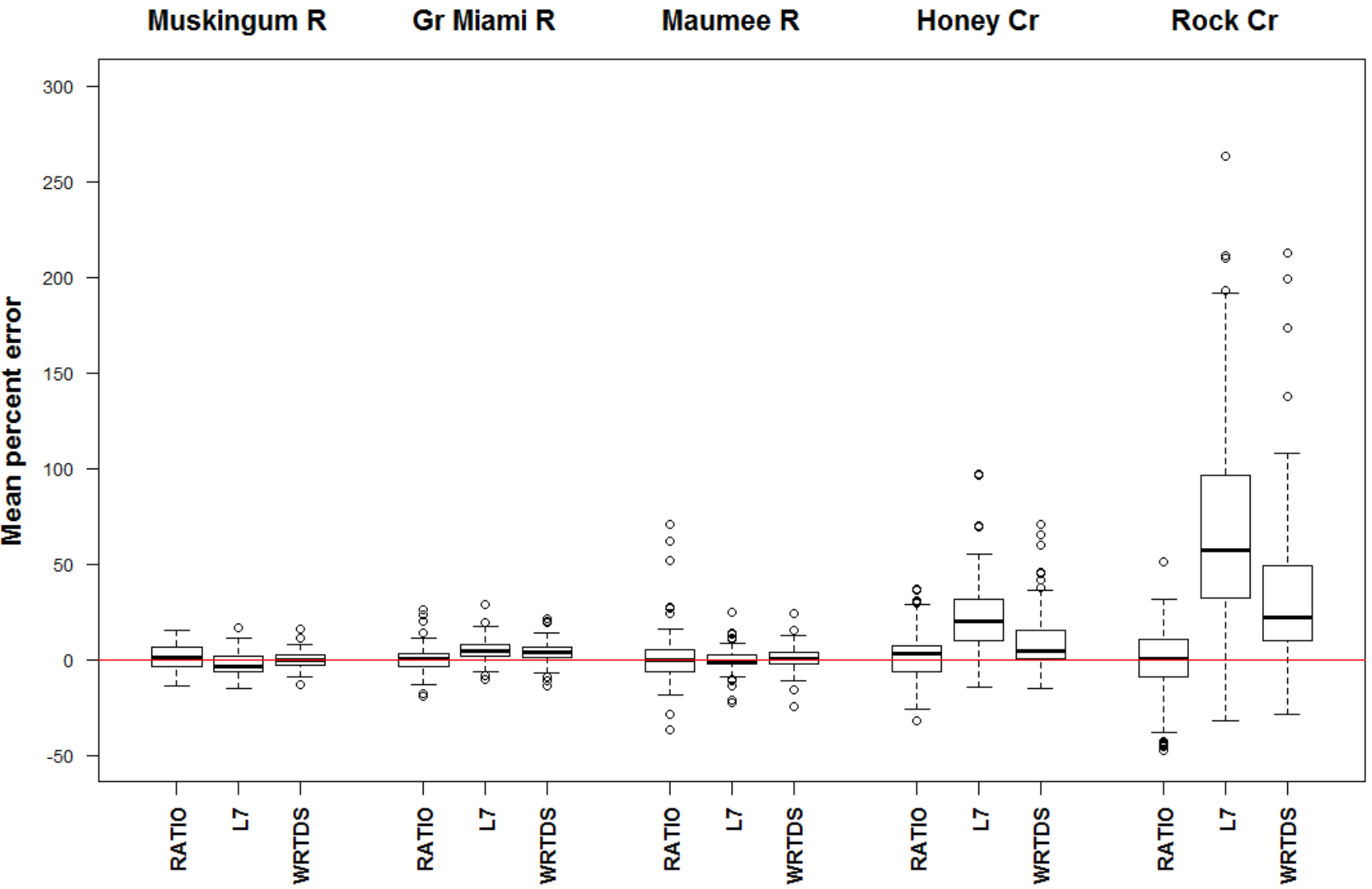
Performance - Among Sampling Strategies - TP



Performance – Among Sampling Frequencies - TP

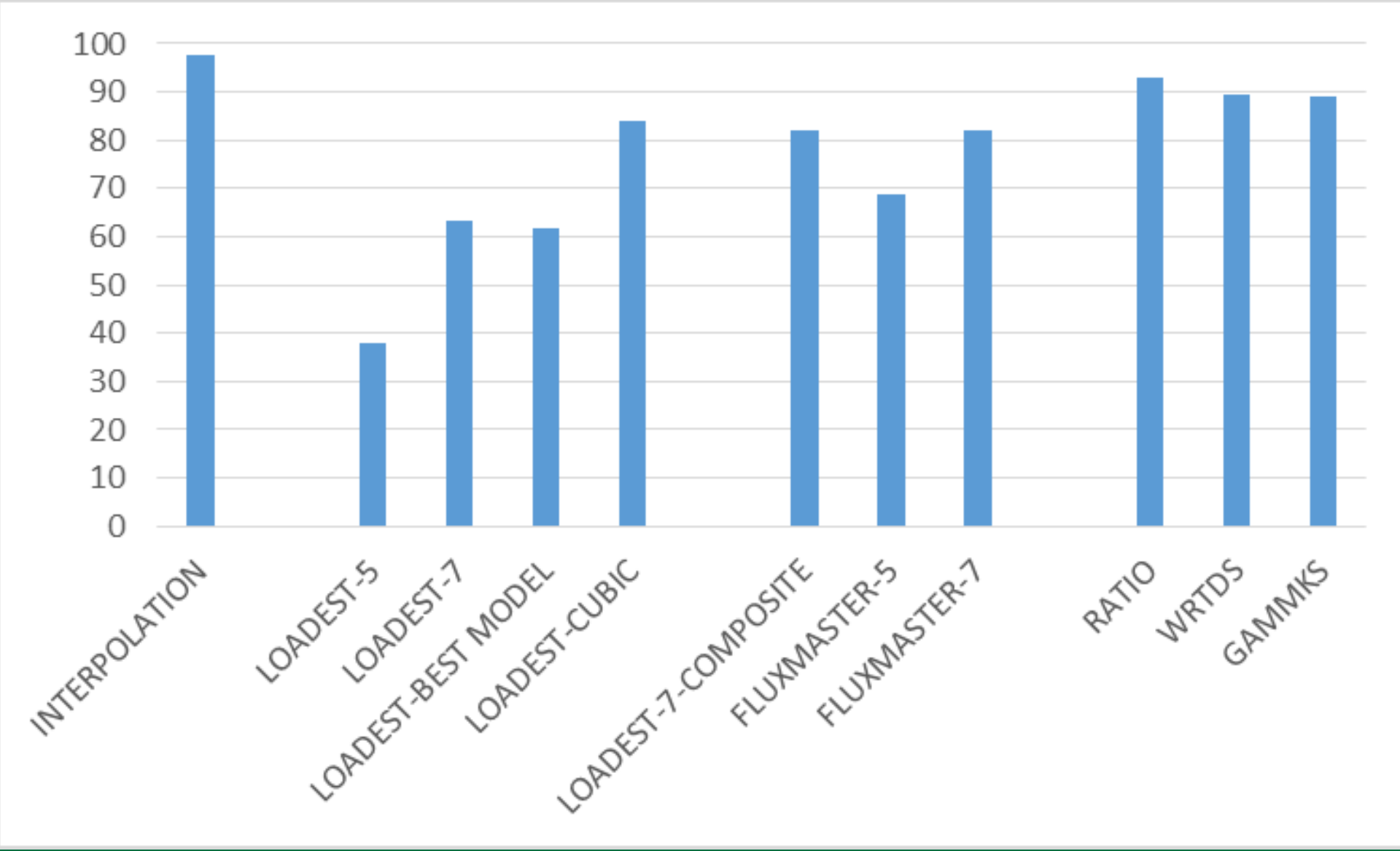


Performance – Among Sampling Sites - TP



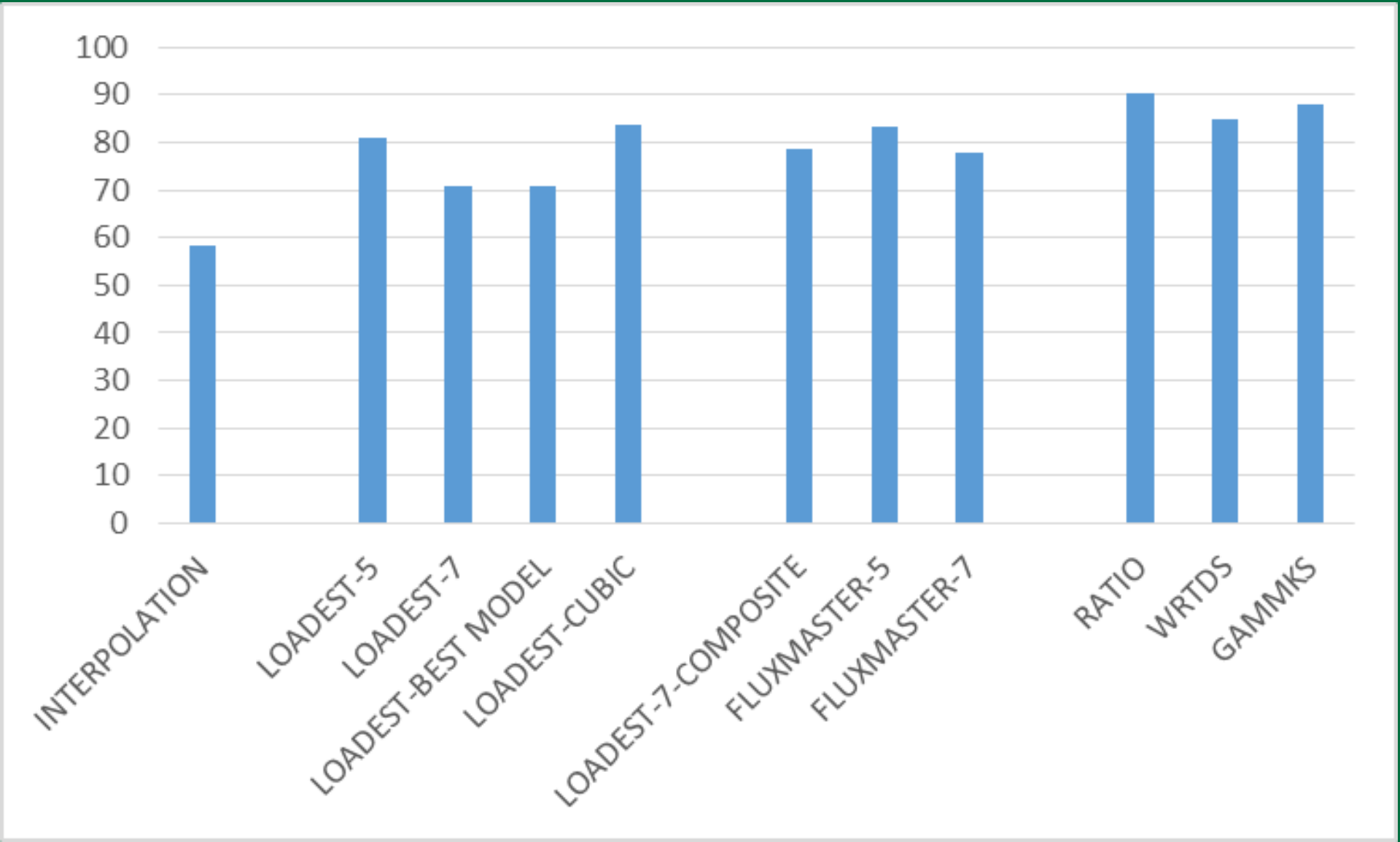
Performance among methods – Nitrate

Percent within +/- 10% of observed loads

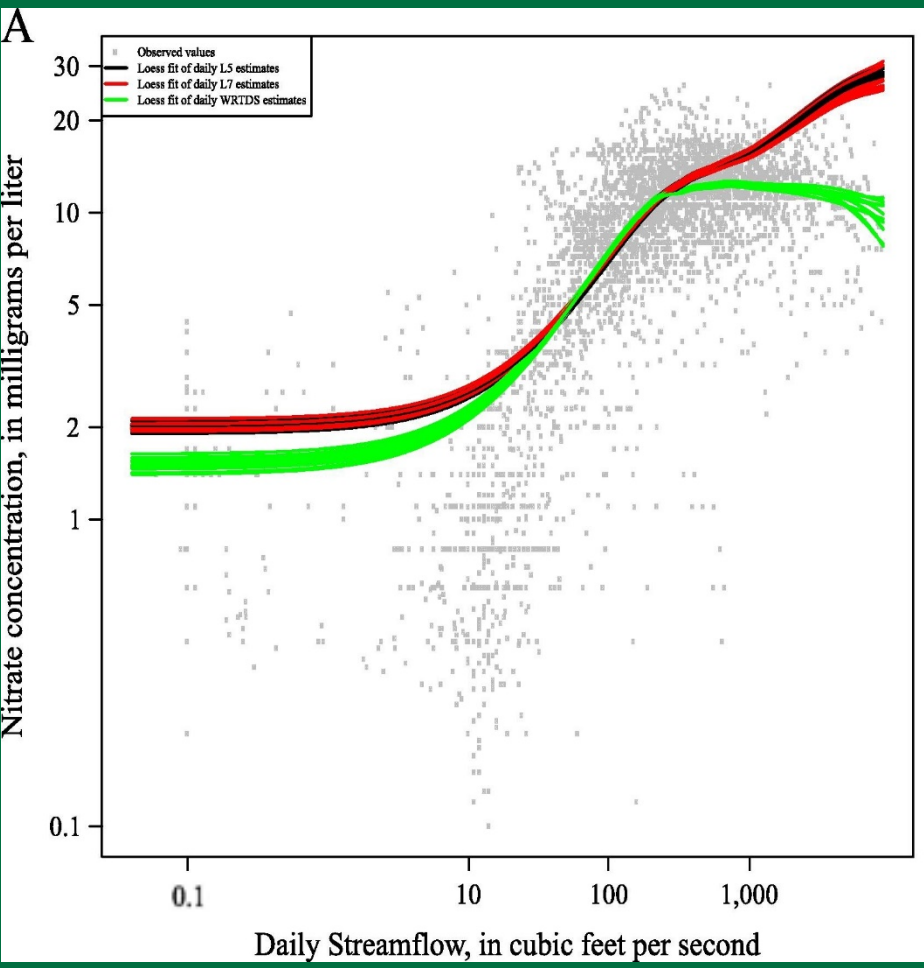


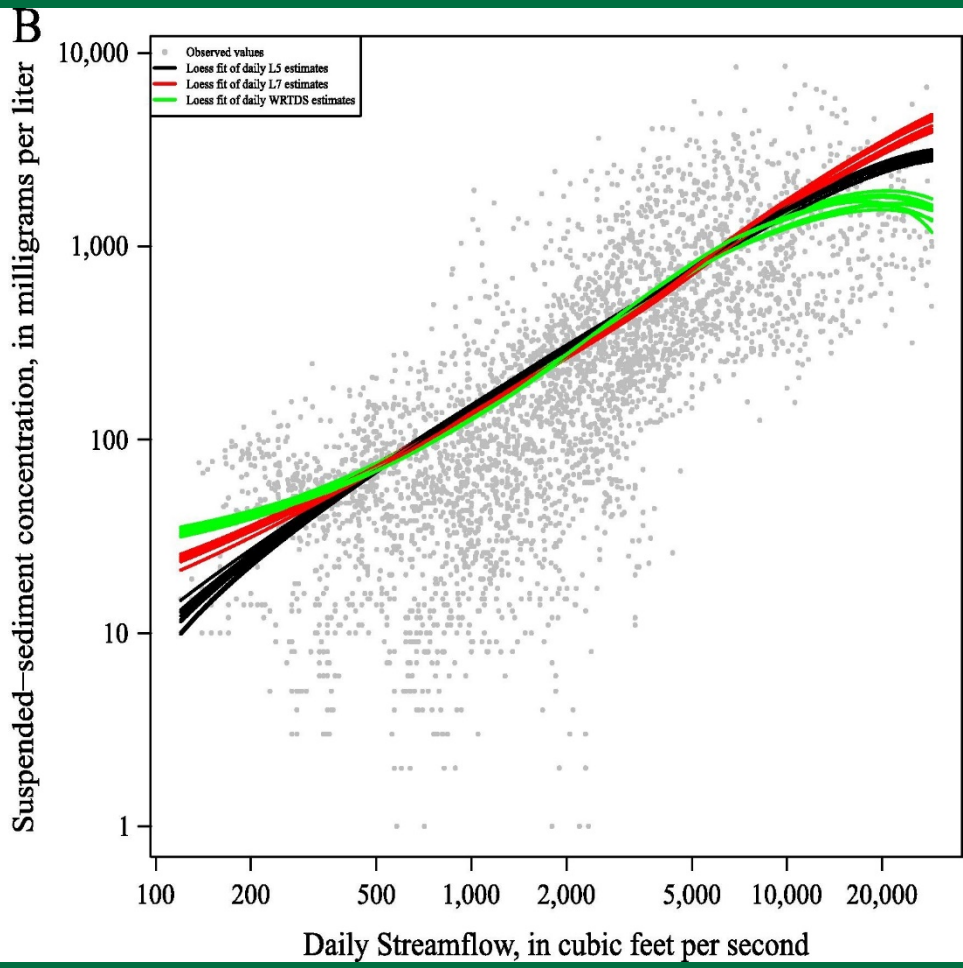
Performance among methods – TP

Percent within +/- 20% of observed loads



Example: LOADEST v. WRTDS





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Take aways

- Practitioners need to inspect residual plots before computing loads
- High flow sampling is necessary
- Nitrate, TP, and SSC are progressively more difficult to estimate
- Use of the “best model selection” tool in LOADEST generally does not improve estimate accuracy
- Correction for local departures from measured values tended to improve estimates
- The flexibility of RATIO and WRTDS tended to improve decadal load estimates
- SPARROW now uses the adapted Beale’s Ratio Estimator

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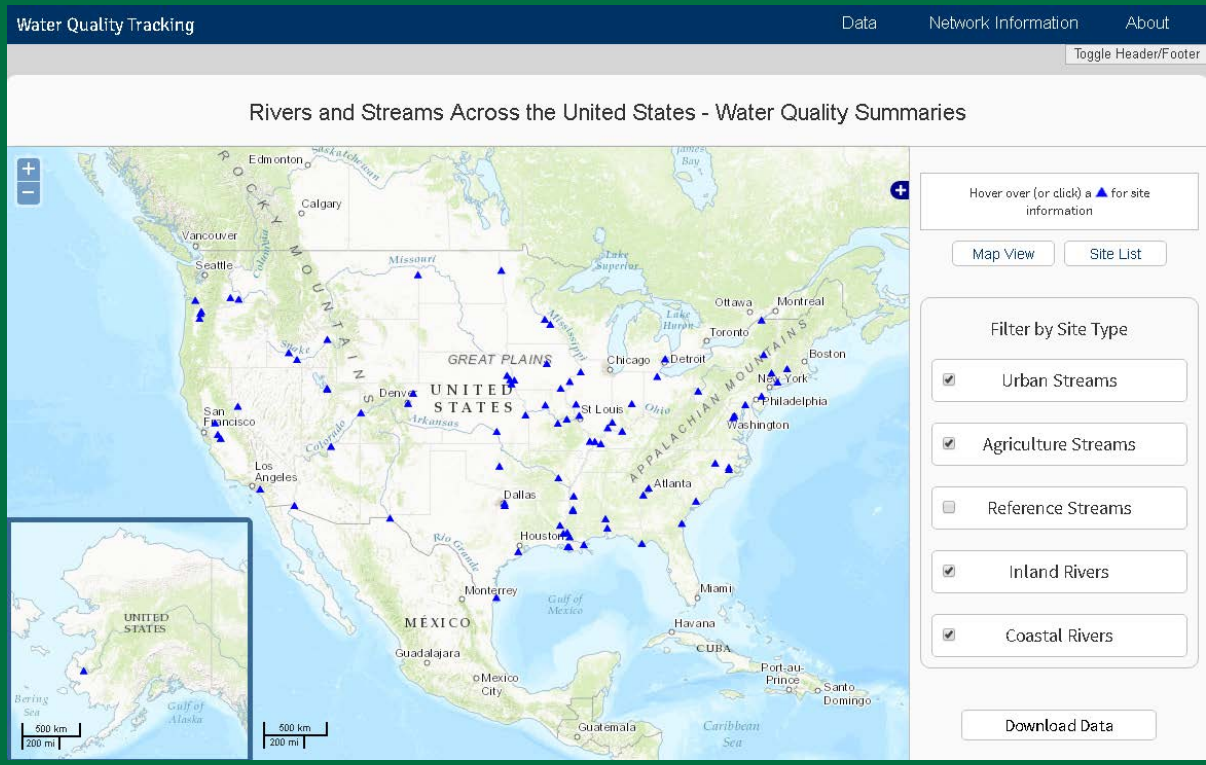
Future directions

- USGS National Water Quality Network (NWQN)
- Loads are computed using an adapted LOADEST method
- Plan to add WRTDS loads at all sites in 2018



https://cida.usgs.gov/quality/rivers/home

- An evaluation of NWQN and other methods for computing annual loads is in progress
- We are looking for opportunities to expand the NWQN

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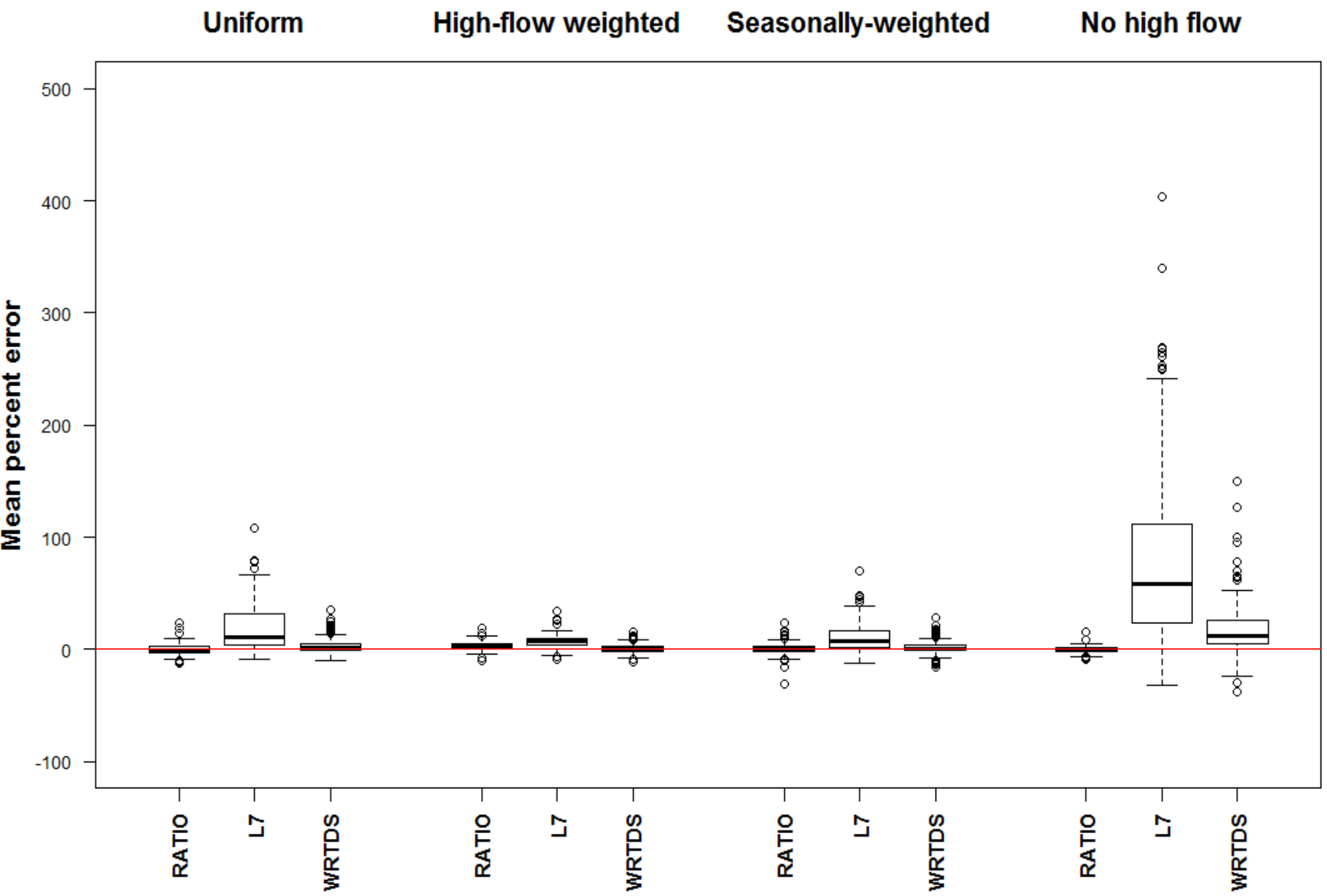
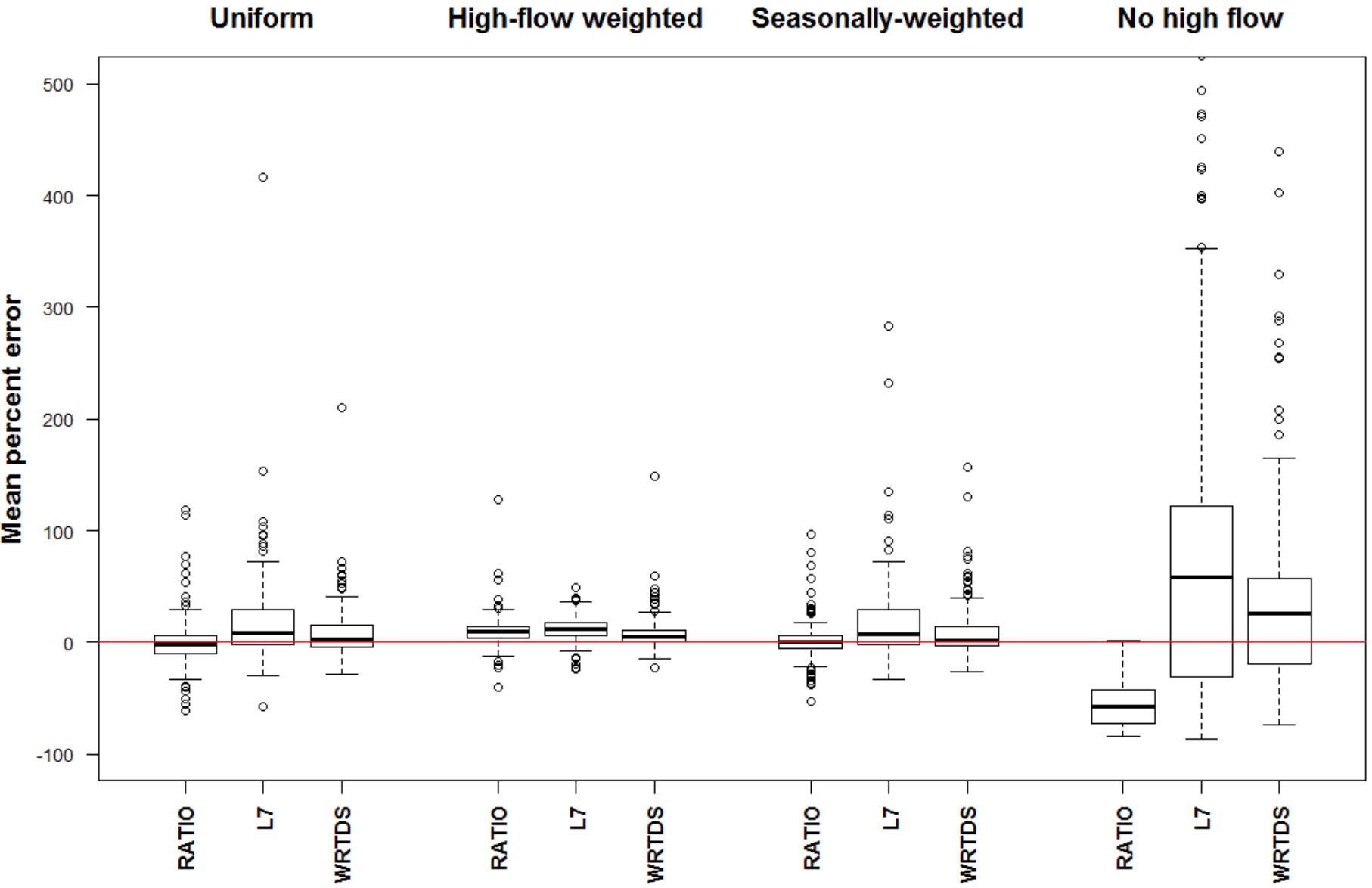
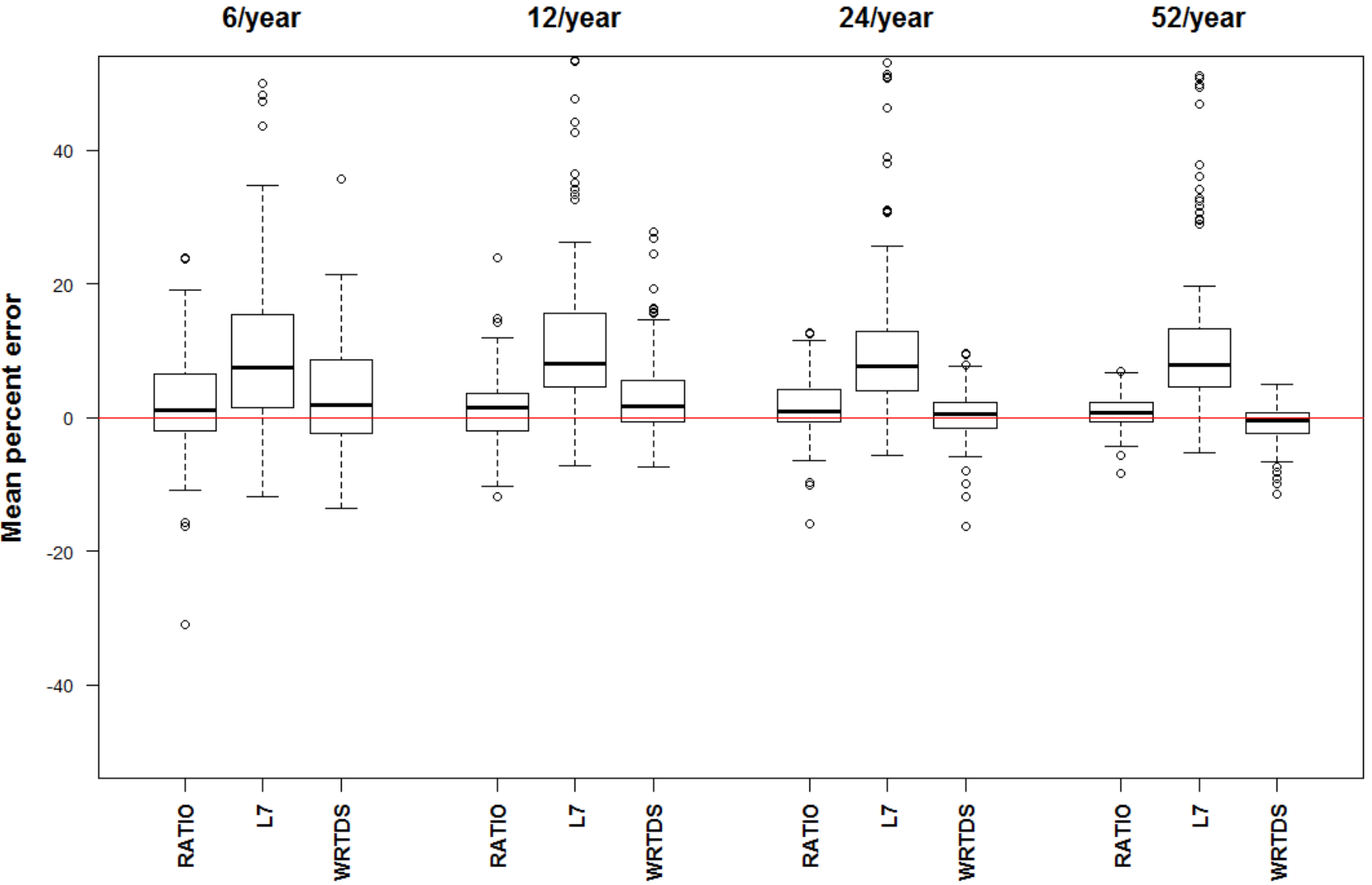
Performance - Among Sampling Strategies - Nitrate



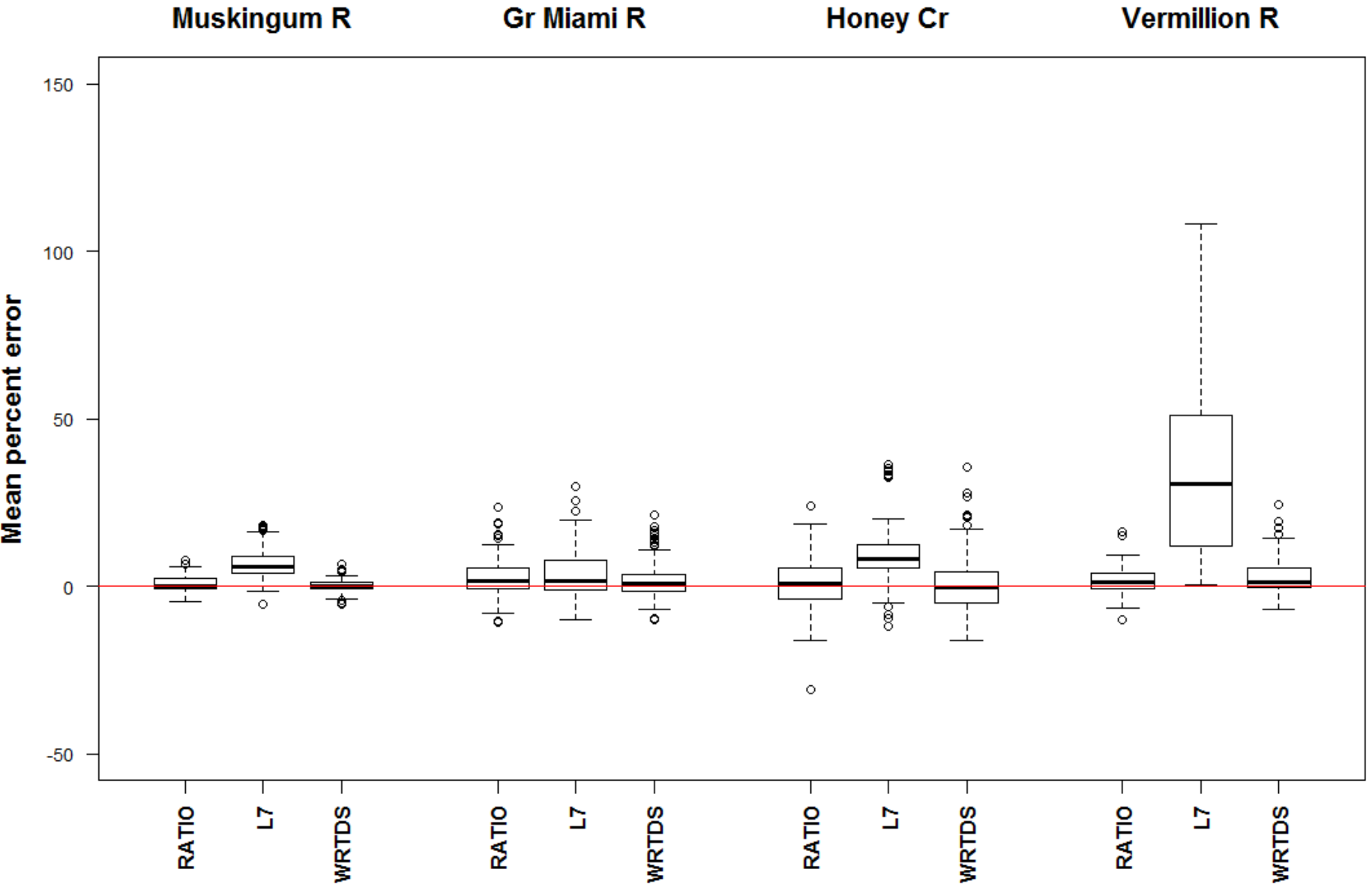
Performance – Among Sampling Strategies - SSC



Performance – Among Sampling Frequencies – Nitrate



Performance – Among Sampling Sites - Nitrate



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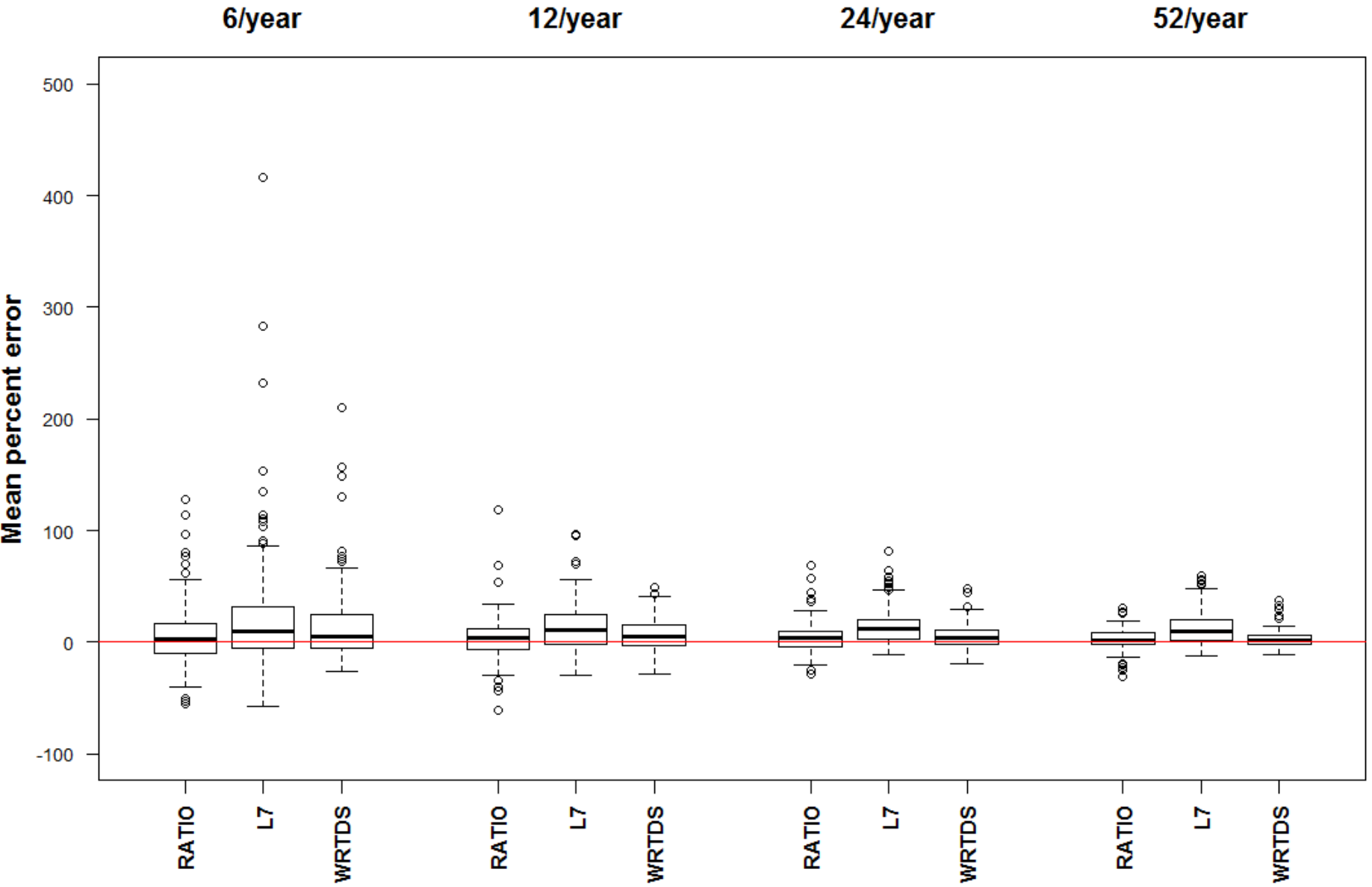

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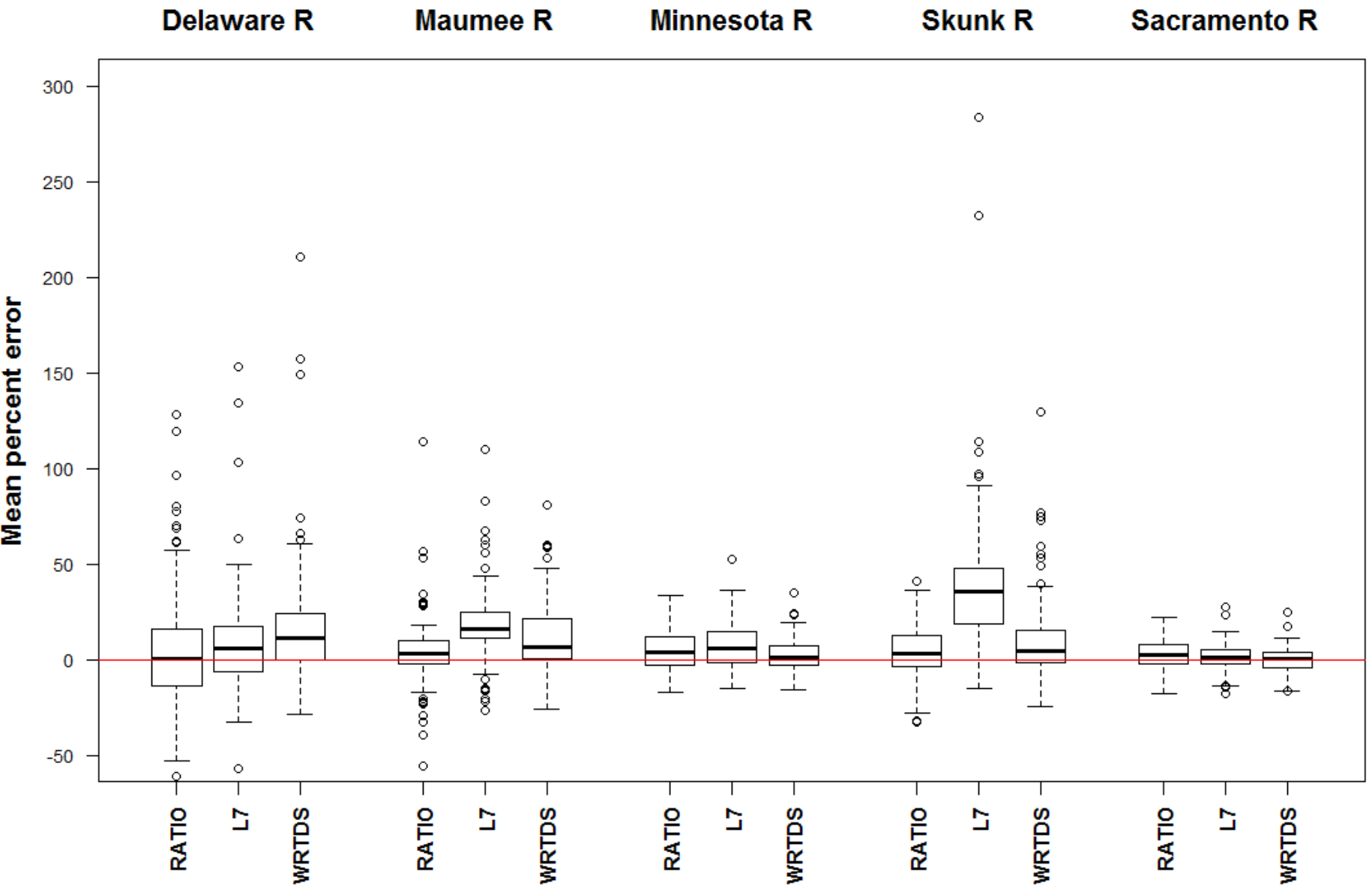
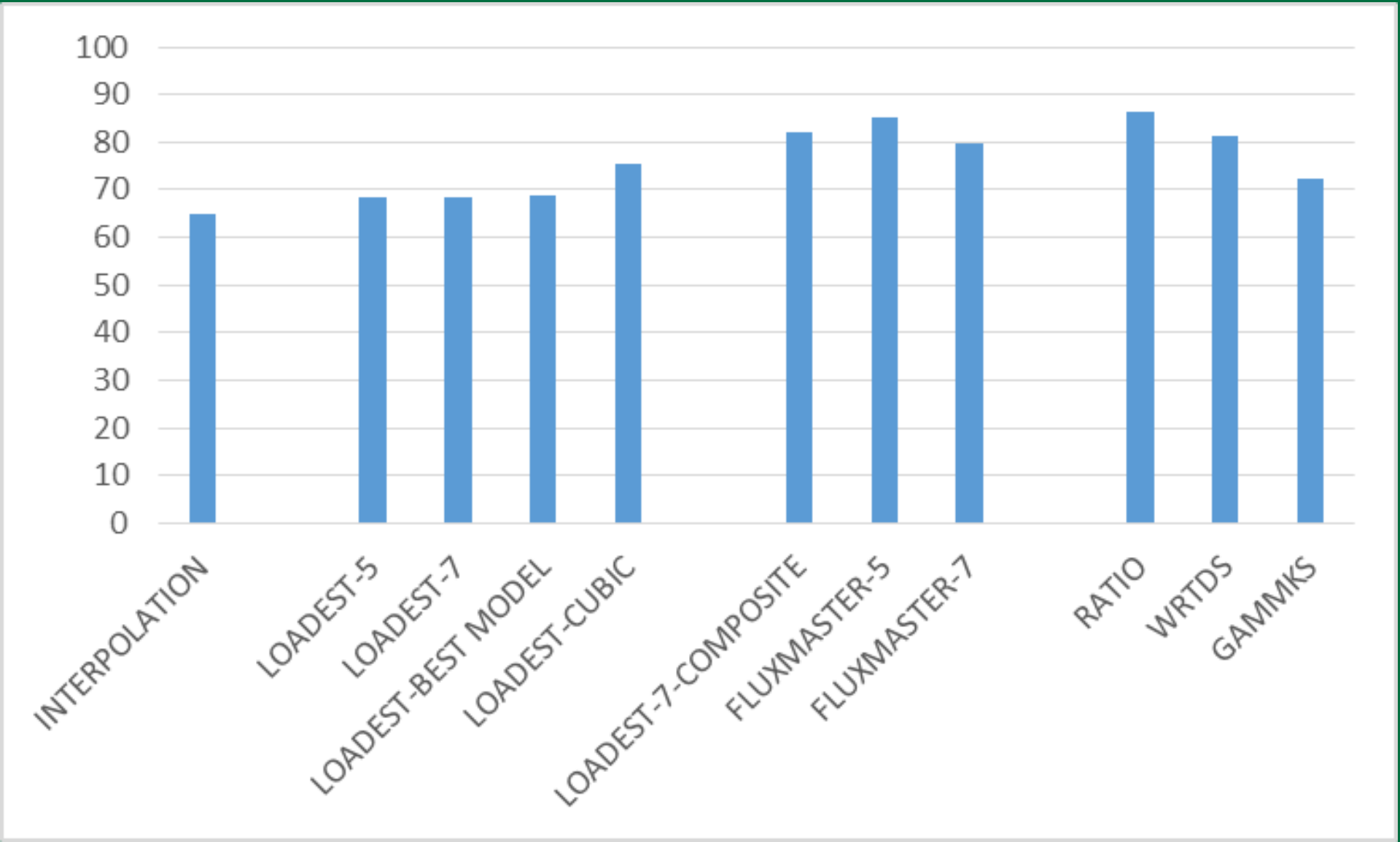


Performance among methods – SSC

Percent within +/- 20% of observed loads



Limitations

- Only applicable to decadal loads
- Limited to sites where near-daily data were available
- “Observed” daily data do not always represent actual concentrations

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Performance – Among Methods

	NO23 (±10%)	NO23 rank	TP (±20%)	TP rank	SSC (±20%)	SSC rank	Rank among all constituents
INTERP	98	1	58	11	65	11	8
RATIO	93	2	90	1	86	1	1
LOADEST-5	38	11	81	6	68	10	11
FLUXMASTER-5	69	8	83	5	85	2	7
LOADEST-CUBIC	84	5	84	4	76	6	4
LOADEST-7	63	9	71	9	69	9	9
LOADEST-7-COMPOSITE	82	6	79	7	82	3	4
FLUXMASTER-7	82	7	78	8	80	5	6
LOADEST-BEST MODEL	62	10	71	9	69	8	10
WRTDS	89	3	85	3	81	4	2
GAMMKS	89	4	88	2	72	7	3

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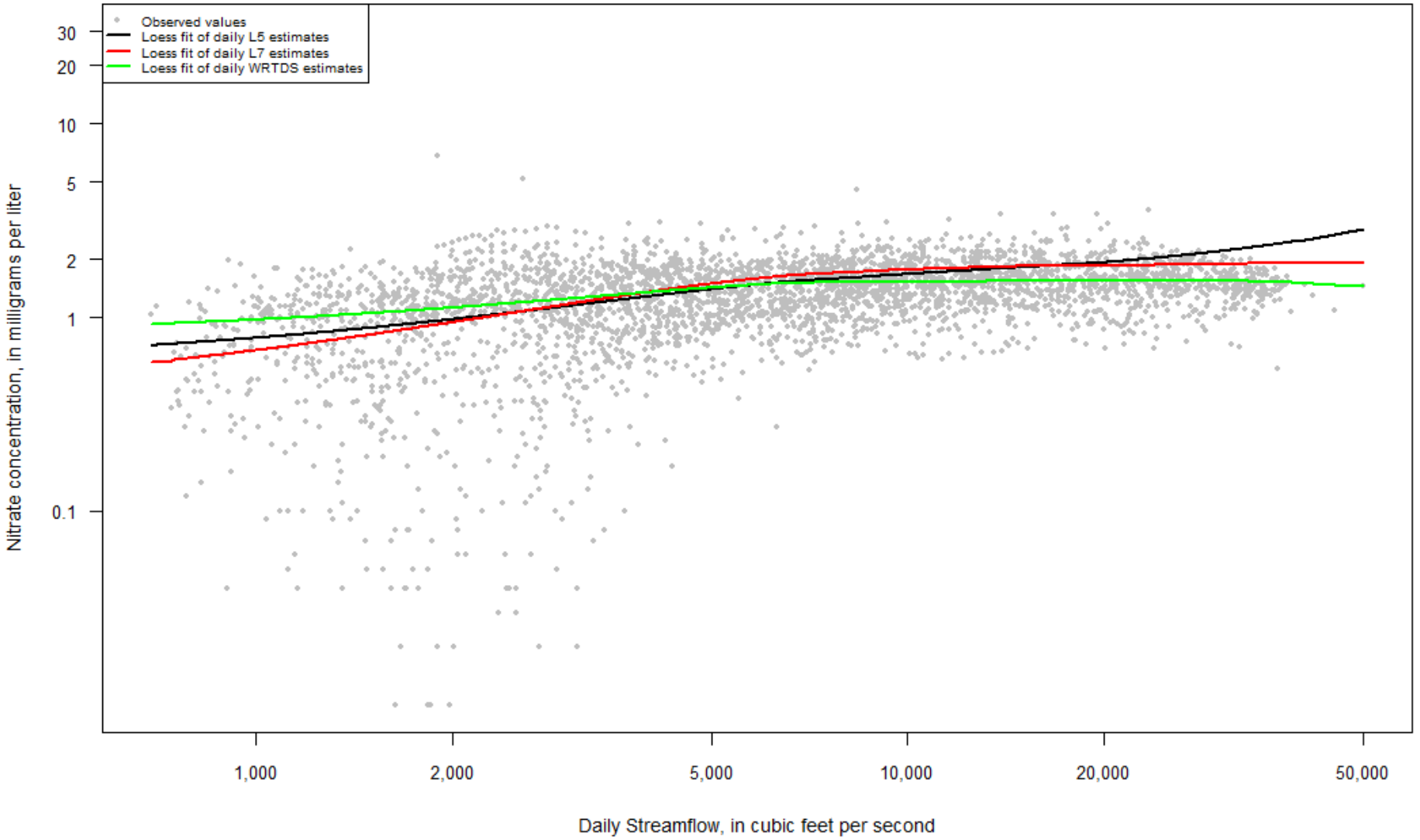
Nitrate Muskingum



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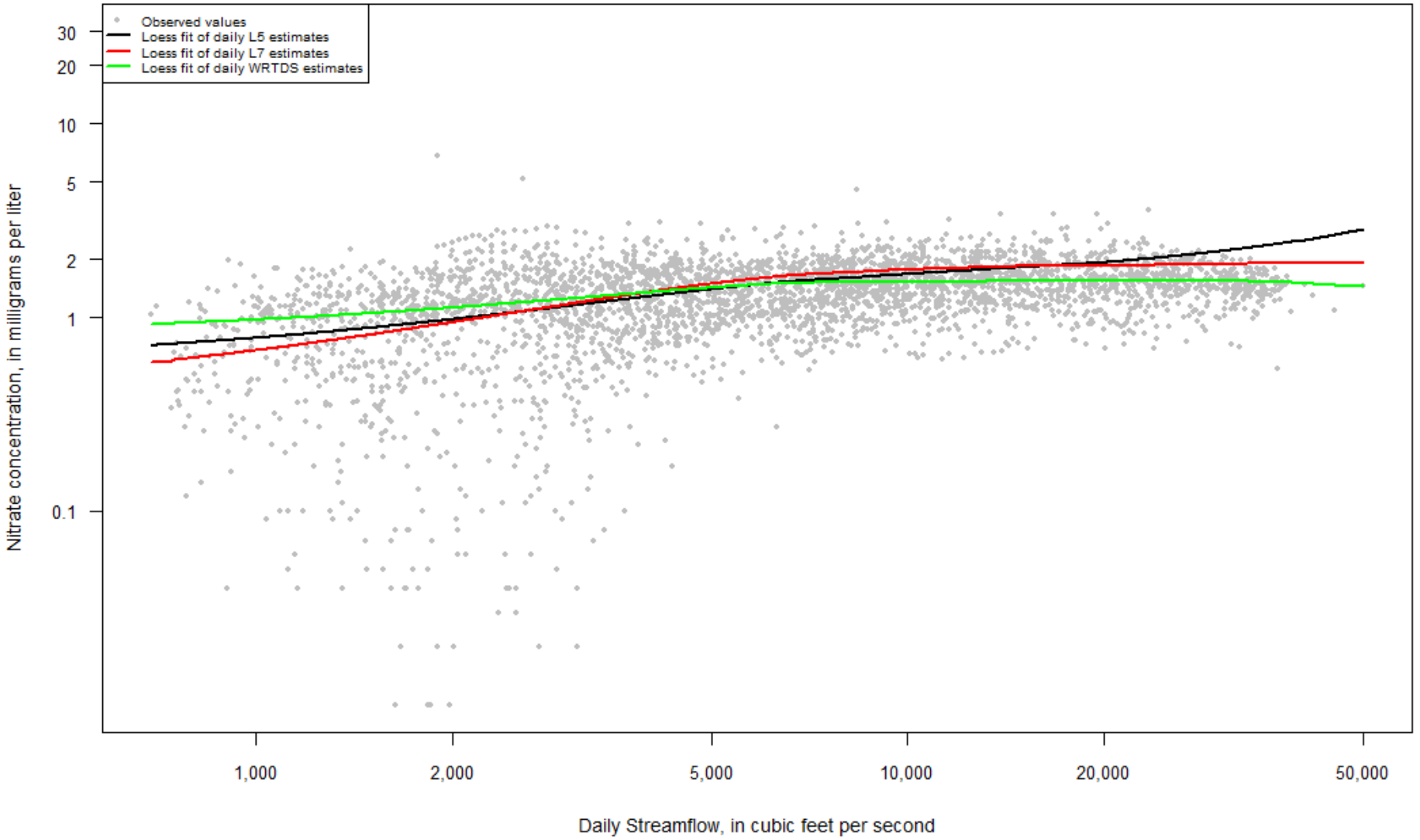
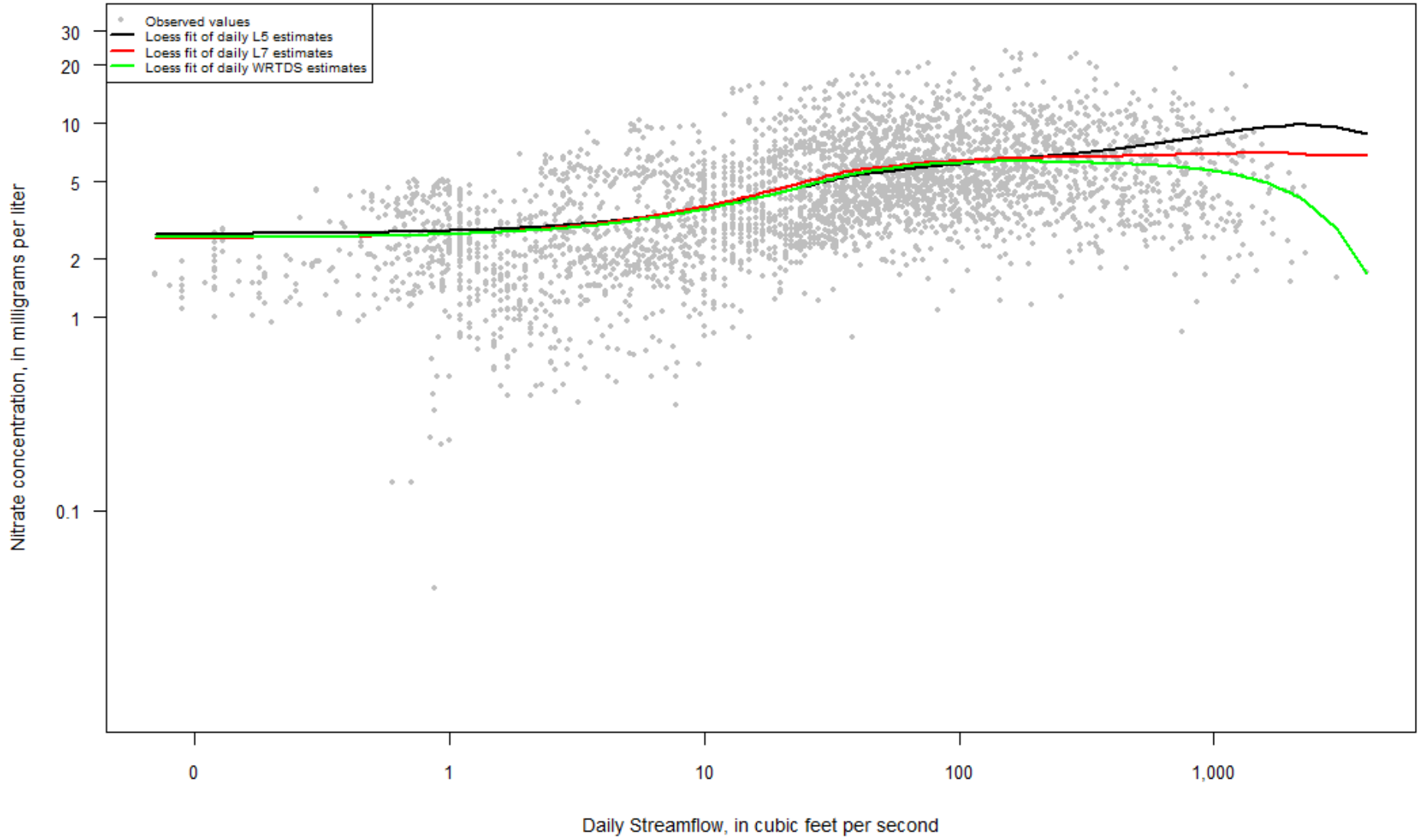
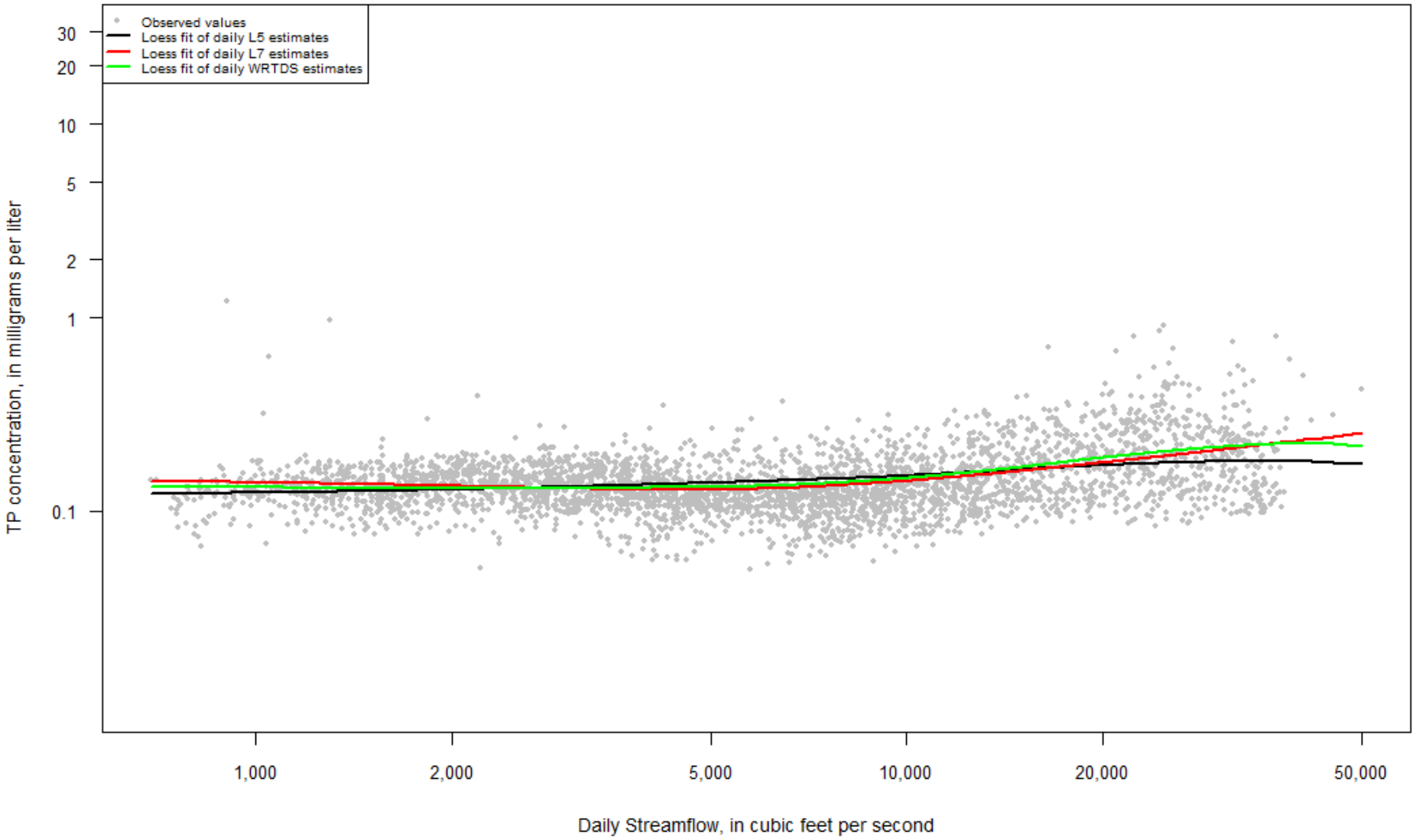


Nitrate Honey Creek



TP Muskingum



TP Rock Creek