WARP
WAtershed Regressions for Pesticides

ESTIMATING PESTICIDE CONCENTRATIONS IN UNITED STATES STREAMS FROM NATIONALLY AVAILABLE WATERSHED CHARACTERISTICS

U.S. Geological Survey

National Water Quality Assessment Program

Pesticide National Synthesis Project

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Context for Model Development

- Managing the risk of pesticides in water requires knowledge of concentrations in water supplies.
- Concentrations can be directly measured by monitoring or estimated with a model.
- Models are inexpensive alternatives to monitoring if they are sufficiently reliable.

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What is WARP?

- WARP is an empirical, regression-based approach that statistically relates pesticide concentrations in streams to watershed characteristics using national data.
- Independent regression models are developed for nine selected percentiles of the frequency distribution of pesticide concentrations and for the annual mean.
- The goal is a tool for estimating pesticide concentrations in streams that have not been monitored.

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POTENTIAL PREDICTORS:
Explanatory Variables Evaluated

Pesticide Use
- Use intensity

Physical Basin Characteristics
- Drainage area
- Average slope
- Average annual runoff
- Elevation

Other Basin Characteristics
- Land Use
- Population

Weather/Climate
- Average annual precipitation
- Average annual temperature
- Average storm intensity
- Average storm duration
- Average interstorm period

Soil Properties (STATSGO)
- Available water capacity
- Sand, silt, clay composition
- Hydrologic group
- Organic matter
- Permeability
- USLE parameters

Hydrologic Parameters (TOPMODEL)
- Total overland flow
- Dunne overland flow
- Horton overland flow
- Subsurface contact time

Agricultural Management Practices
- Irrigation
- Artificial drainage
- Conservation tillage

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Atrazine Model

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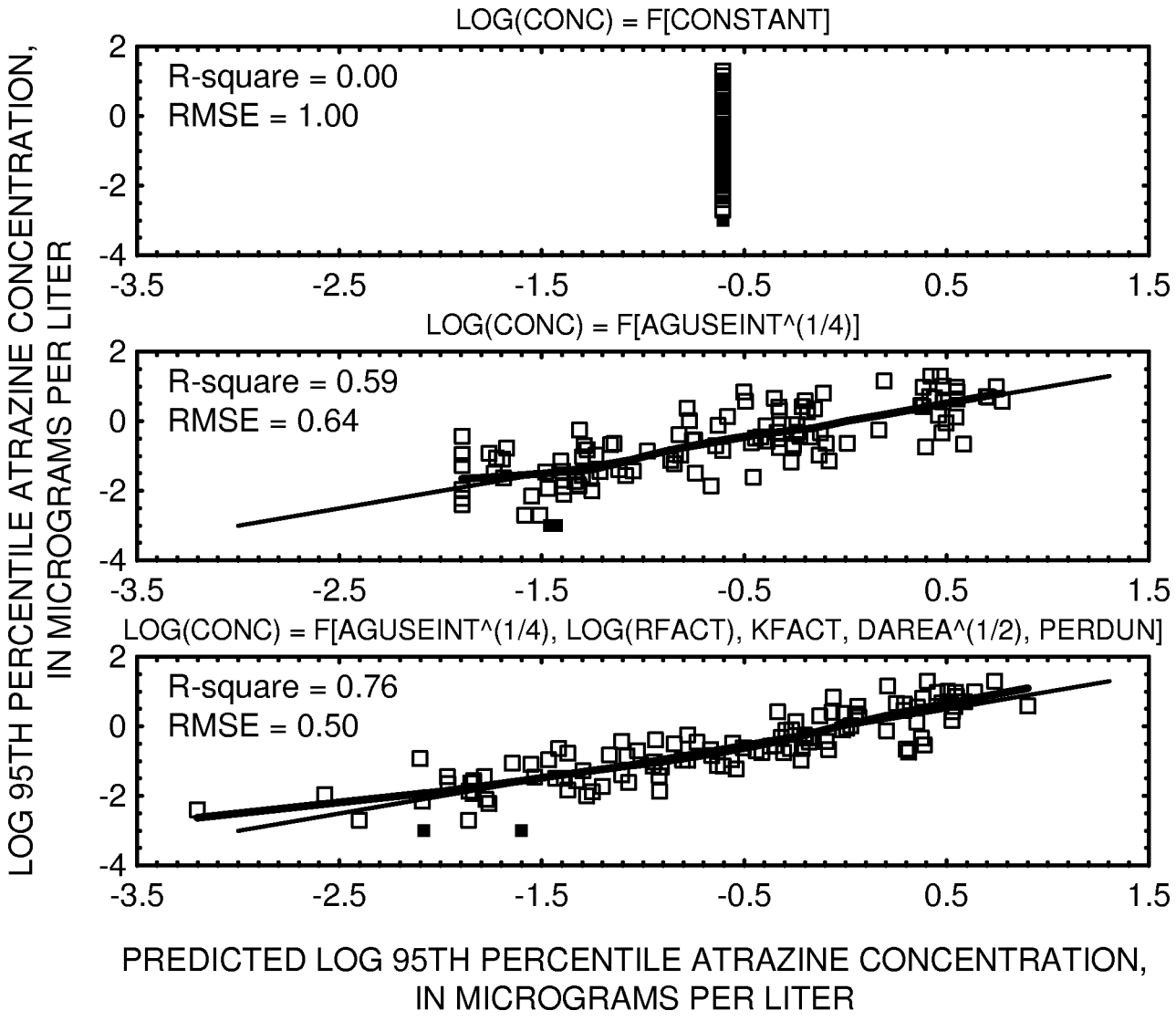
LOG(CONC) = F[CONSTANT]
R-square = 0.00
RMSE = 1.00
LOG(CONC) = F[AGUSEINT^(1/4)]
R-square = 0.59
RMSE = 0.64
LOG(CONC) = F[AGUSEINT^(1/4), LOG(RFACT), KFACT, DAREA^(1/2), PERDUN]
R-square = 0.76
RMSE = 0.50
2
0
-2
-4
-3.5
-2.5
-1.5
-0.5
0.5
1.5
LOG 95TH PERCENTILE ATRAZINE CONCENTRATION, IN MICROGRAMS PER LITER
PREDICTED LOG 95TH PERCENTILE ATRAZINE CONCENTRATION, IN MICROGRAMS PER LITER

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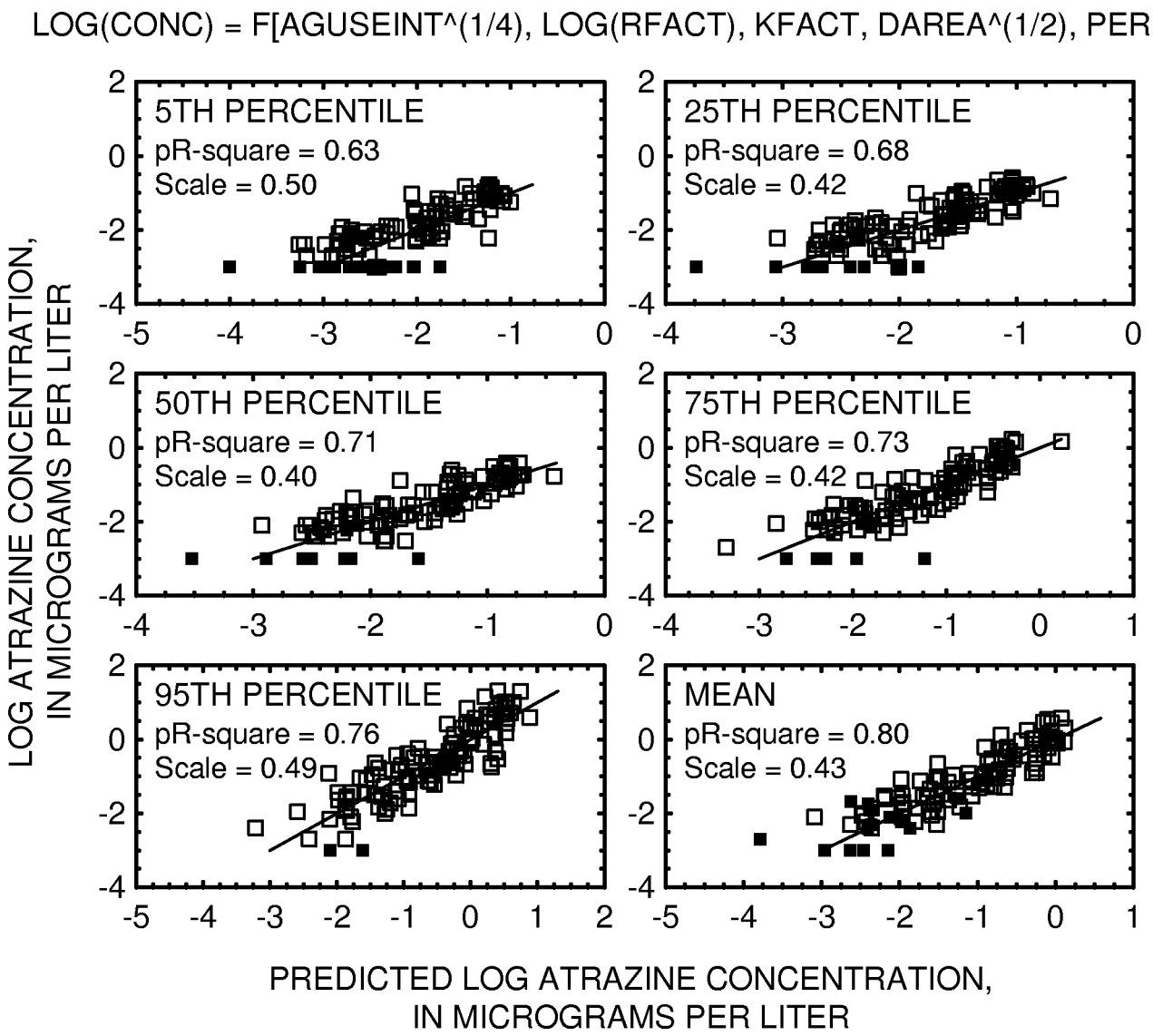
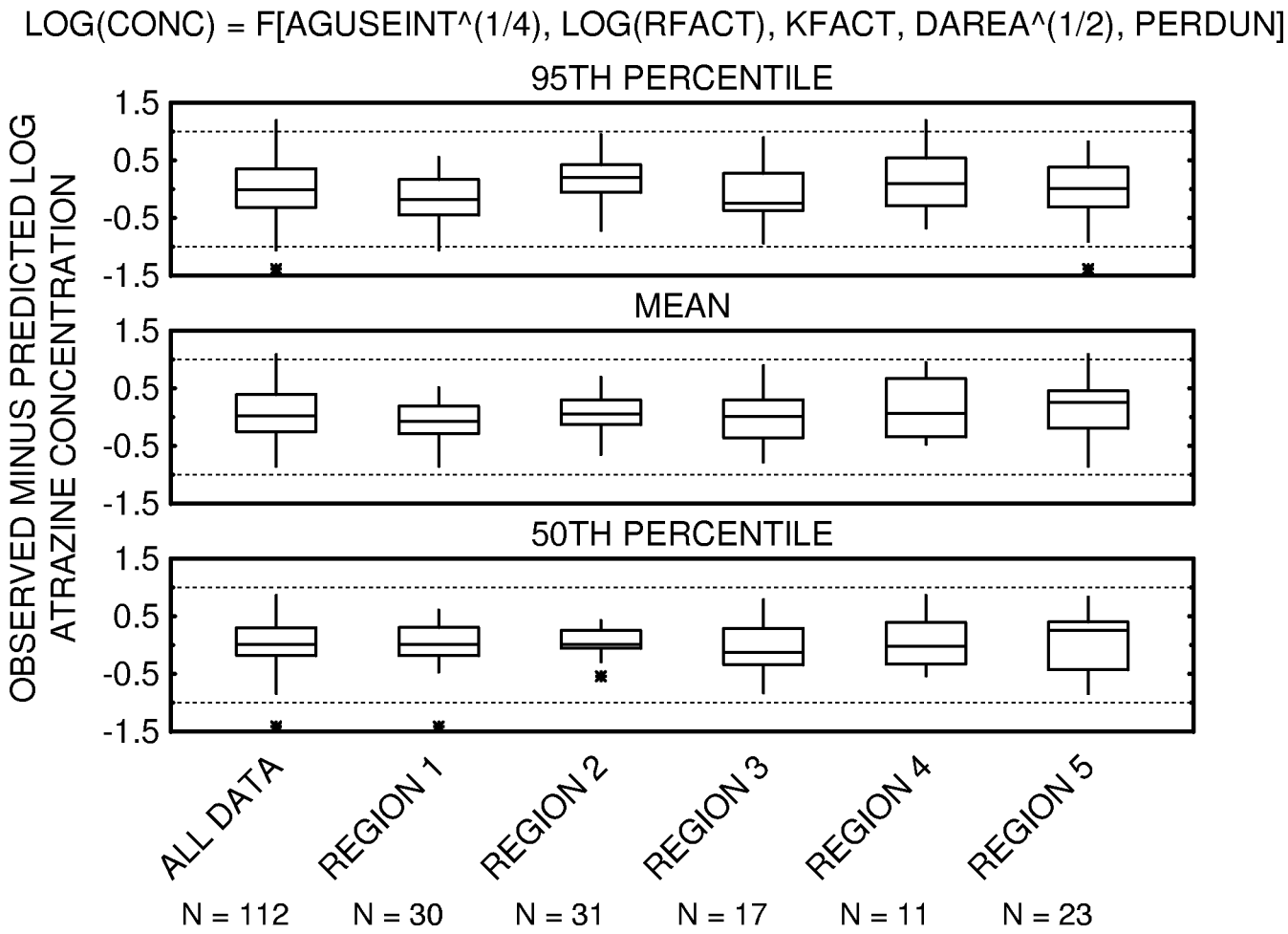
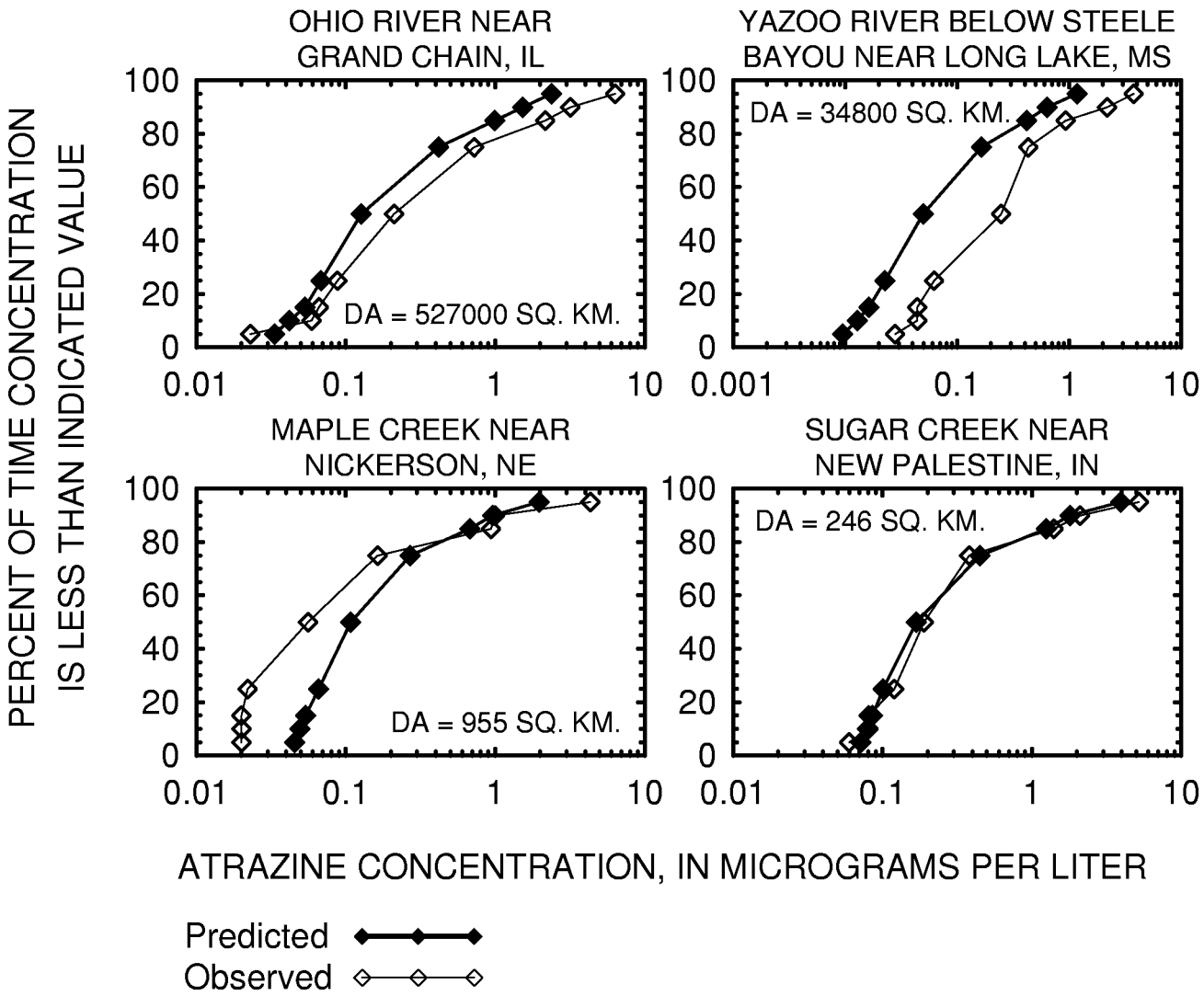

LOG(CONC) = F[AGUSEINT^(1/4), LOG(RFACT), KFACT, DAREA^(1/2), PERDUN]
5TH PERCENTILE
pR-square = 0.63
Scale = 0.50
25TH PERCENTILE
pR-square = 0.68
Scale = 0.42
50TH PERCENTILE
pR-square = 0.71
Scale = 0.40
75TH PERCENTILE
pR-square = 0.73
Scale = 0.42
95TH PERCENTILE
pR-square = 0.76
Scale = 0.49
MEAN
pR-square = 0.80
Scale = 0.43
LOG ATRAZINE CONCENTRATION, IN MICROGRAMS PER LITER
PREDICTED LOG ATRAZINE CONCENTRATION, IN MICROGRAMS PER LITER


LOG(CONC) = F[AGUSEINT^(1/4), LOG(RFACT), KFACT, DAREA^(1/2), PERDUN]
95TH PERCENTILE
MEAN
50TH PERCENTILE
OBSERVED MINUS PREDICTED LOG ATRAZINE CONCENTRATION
1.5
0.5
-0.5
-1.5
ALL DATA
REGION 1
REGION 2
REGION 3
REGION 4
REGION 5
N = 112
N = 30
N = 31
N = 17
N = 11
N = 23

LOG(CONC) = F[AGUSEINT^(1/4), LOG(RFACT), KFACT, DAREA^(1/2), PERDUN]



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Models for Other Pesticides

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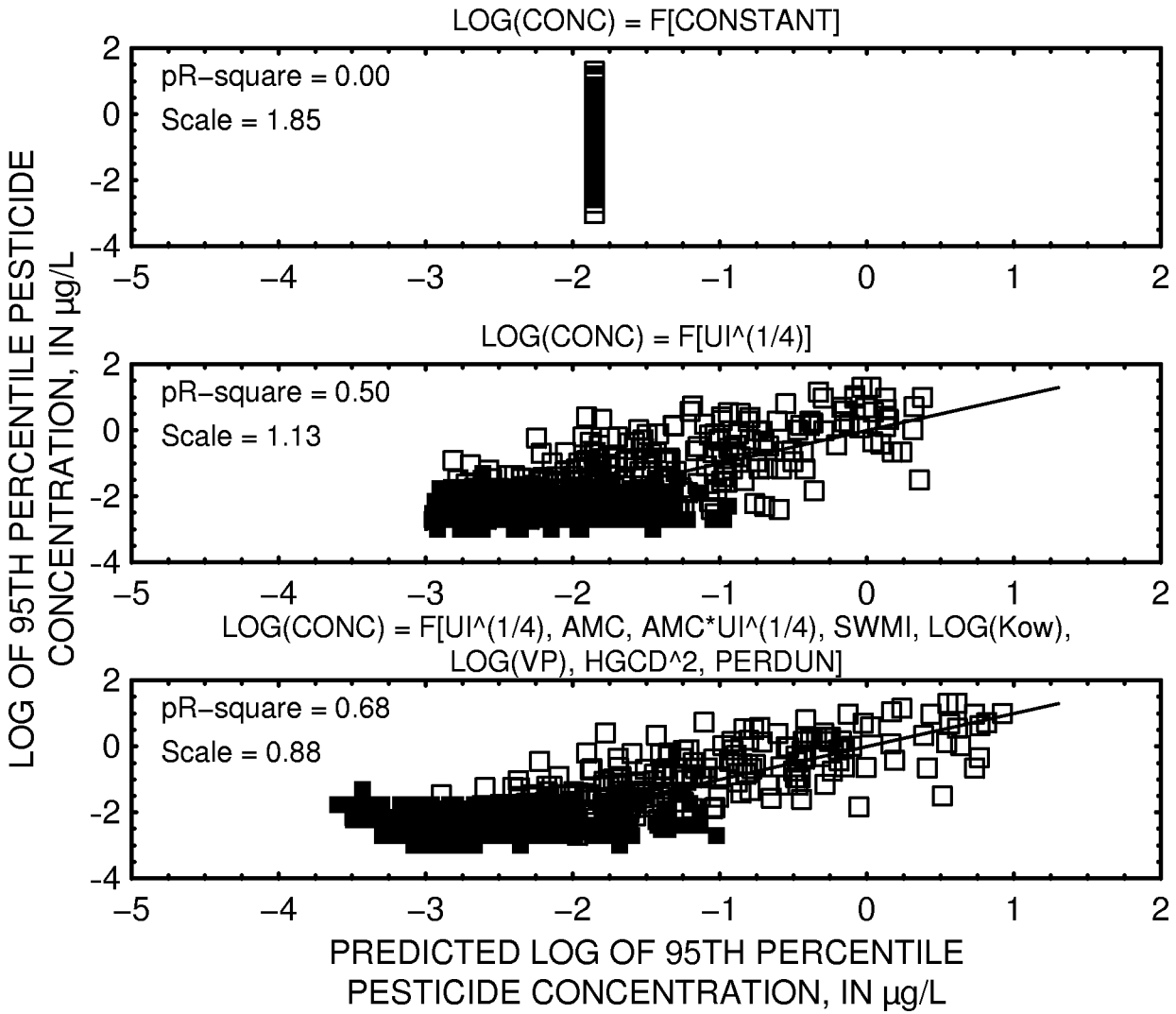
LOG(CONC) = F[CONSTANT]
pR–square = 0.00
Scale = 1.85
LOG(CONC) = F[UI^(1/4)]
pR–square = 0.50
Scale = 1.13
LOG(CONC) = F[UI^(1/4), AMC, AMC*UI^(1/4), SWMI, LOG(Kow), LOG(VP), HGCD^2, PERDUN]
pR–square = 0.68
Scale = 0.88
LOG OF 95TH PERCENTILE PESTICIDE CONCENTRATION, IN µg/L
PREDICTED LOG OF 95TH PERCENTILE PESTICIDE CONCENTRATION, IN µg/L
2
0
-2
-4
–5
–4
–3
–2
–1
0
1
2

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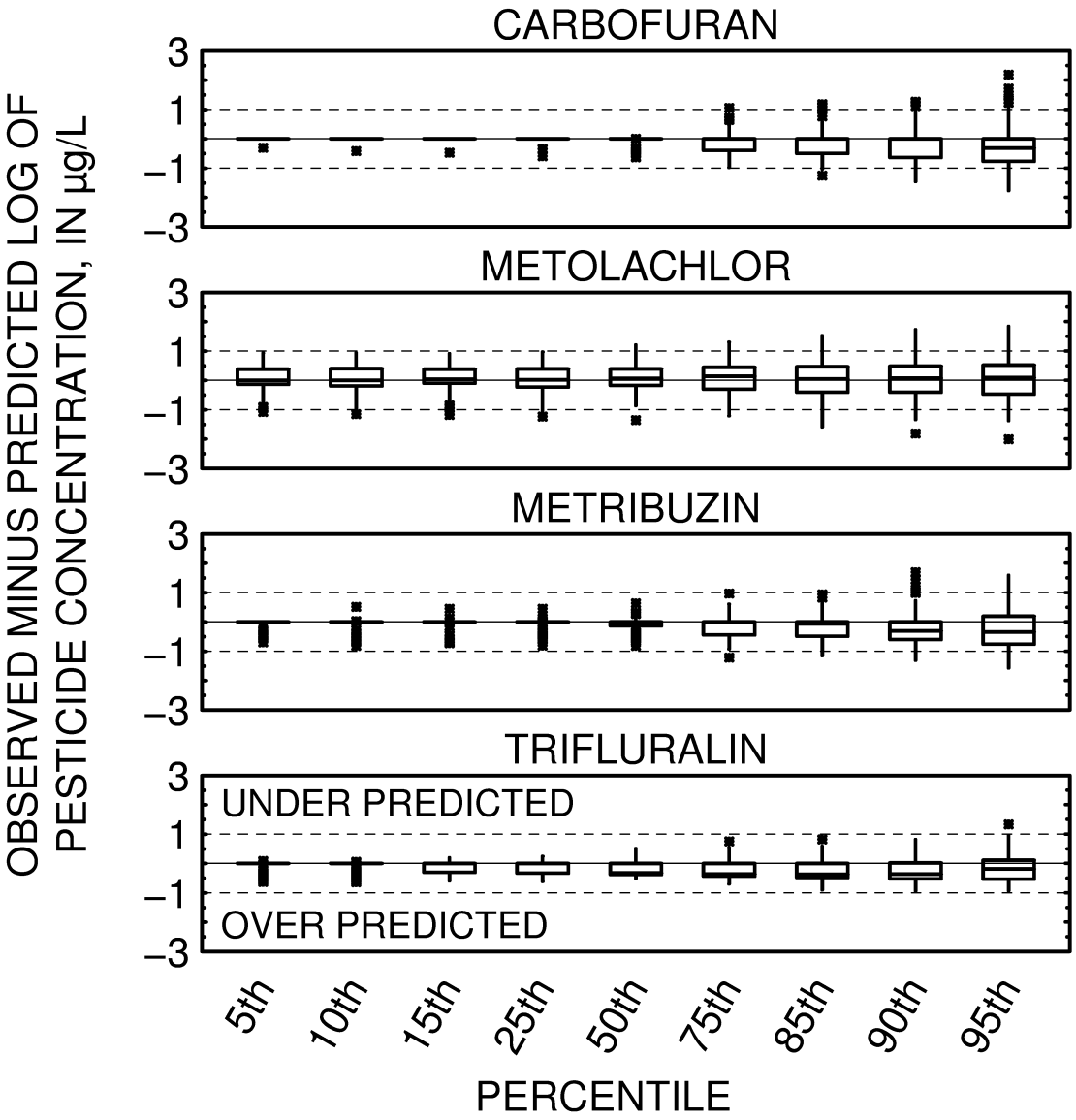
CARBOFURAN
METOLACHLOR
METRIBUZIN
TRIFLURALIN
3
1
−1
−3
UNDER PREDICTED
OVER PREDICTED
OBSERVED MINUS PREDICTED LOG OF PESTICIDE CONCENTRATION, IN µg/L
5th
10th
15th
25th
50th
75th
85th
90th
95th
PERCENTILE

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What WARP Can Do

- WARP can directly estimate chronic and acute exposure in individual watersheds.
- It can estimate the range of pesticide concentration distributions likely to occur within a region of the United States.
- It can be used to substantiate simulated concentrations (i.e. from PRZM-EXAMS).
- It can be used to determine where additional monitoring data might be needed (i.e. areas where high concentrations are predicted).
- WARP can take advantage of new monitoring data and can use these data to update the models.

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What WARP Cannot Do

- Directly generate a daily time series of pesticide concentrations for a stream location (it has no temporal component).
- Estimate the co-occurrence of multiple pesticides.
- WARP is an empirical modeling method based on nationally available data sets. It can't incorporate factors for which there are no such data sets (i.e. buffer strips).
- WARP is based on historical data. It can't address factors that significantly change the relationships underlying WARP models without new data that reflect the changes. The recent registration changes in diazinon are an example of this.

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