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HYDROLOGICAL AND WATER QUALITY MODELING OF THE ATHABASCA RIVER BASIN USING SWAT

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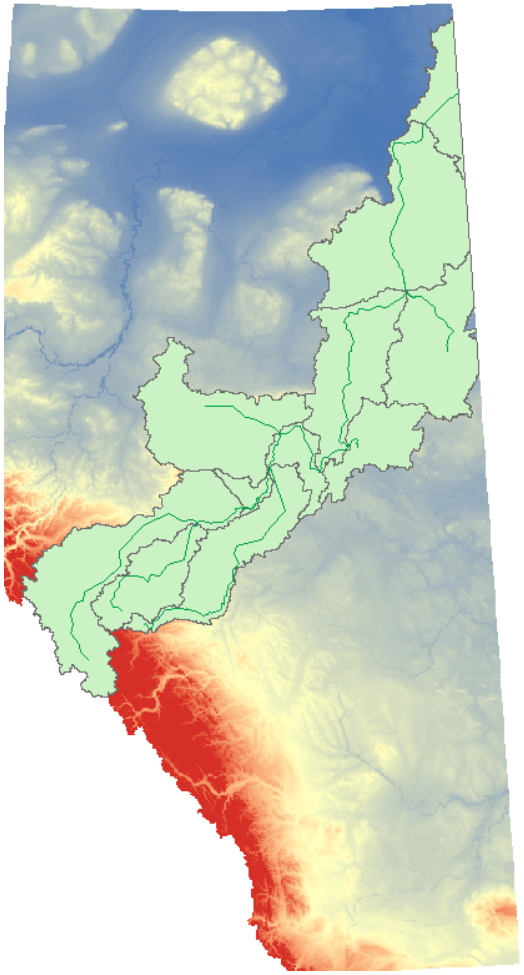
Outline

- Introduction
- Objective
- Data & database
- Modeling
- Results
- Conclusion

Introduction

- The river begins from the Columbia Glacier and drains into Lake Athabasca
- The basin covers 24% of Alberta
- It had about 5% of the provincial population
- Contributes to the provincial economy



Introduction

- Main activities in the ARB:
  - pulp and paper
  - coal mining
  - oil and gas
  - agriculture
  - municipal
- Environmental problems in the ARB
  - Water abstractions
  - Effluent discharges
- This could pose ecological and human health risks

Introduction

- Research gaps:
  - Impacts on water quality and quantity
  - Pathways of contaminant from source to receiving environment
  - Management practices to reduce transport of contaminants
- River basin modeling assists to:
  - understand processes in a basin
  - make decision for system view

Objectives

- To develop a modeling framework using Soil and Water Assessment Tool (SWAT) to simulate hydrological and water quality processes
- Specific objectives:
  - To collect weather, landuse, soil, and water quality
  - To setup soil, plant, and weather databases
  - To build hydrological and water quality models, and calibrate and validate them

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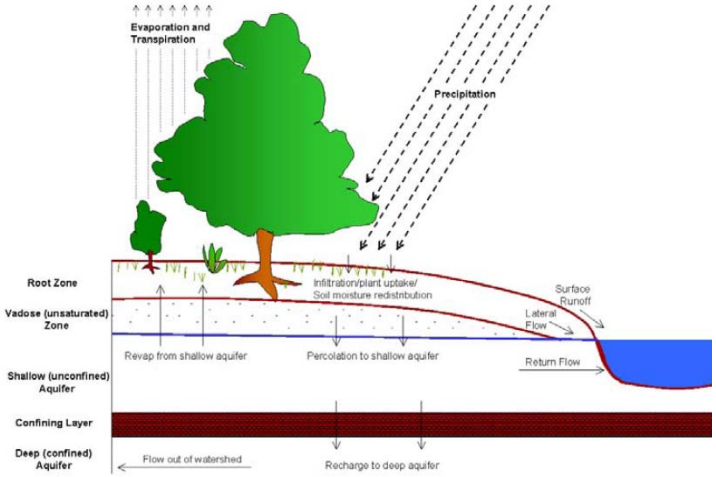
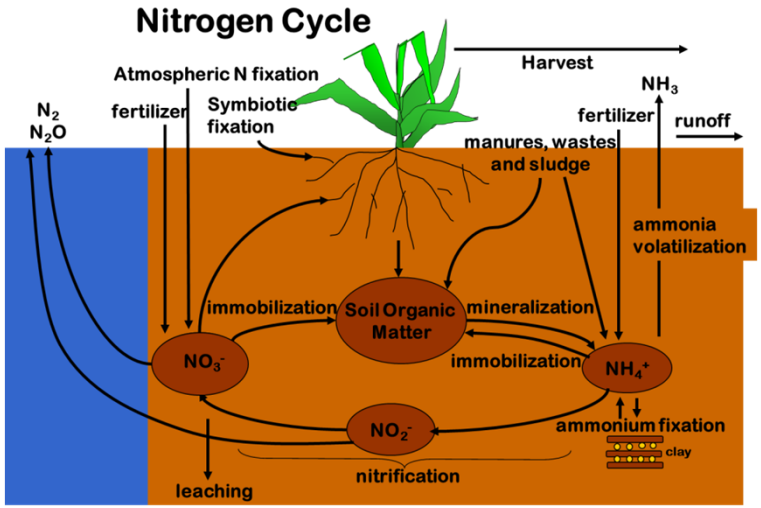
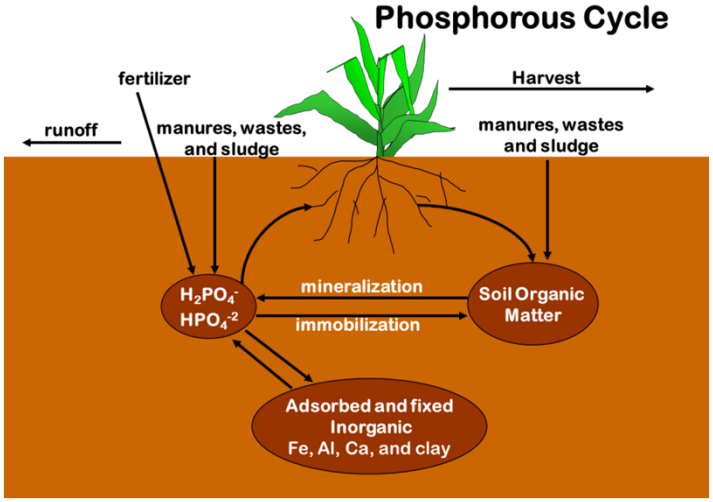
SWAT description







Source: SWAT theoretical manual (2012)

Data collection

Data	Description	Resolution	Source
Digital Elevation map	Topography	90 m	SRTM
Landuse map	Land cover classifications	30 m	NRC
Soil map	Soil types	500 m	AAFC
Weather	Precipitation and temperature	Daily	EC
Flow	River flows	Daily and monthly	EC
Water quality	Nitrogen and phosphorus	Monthly	EC

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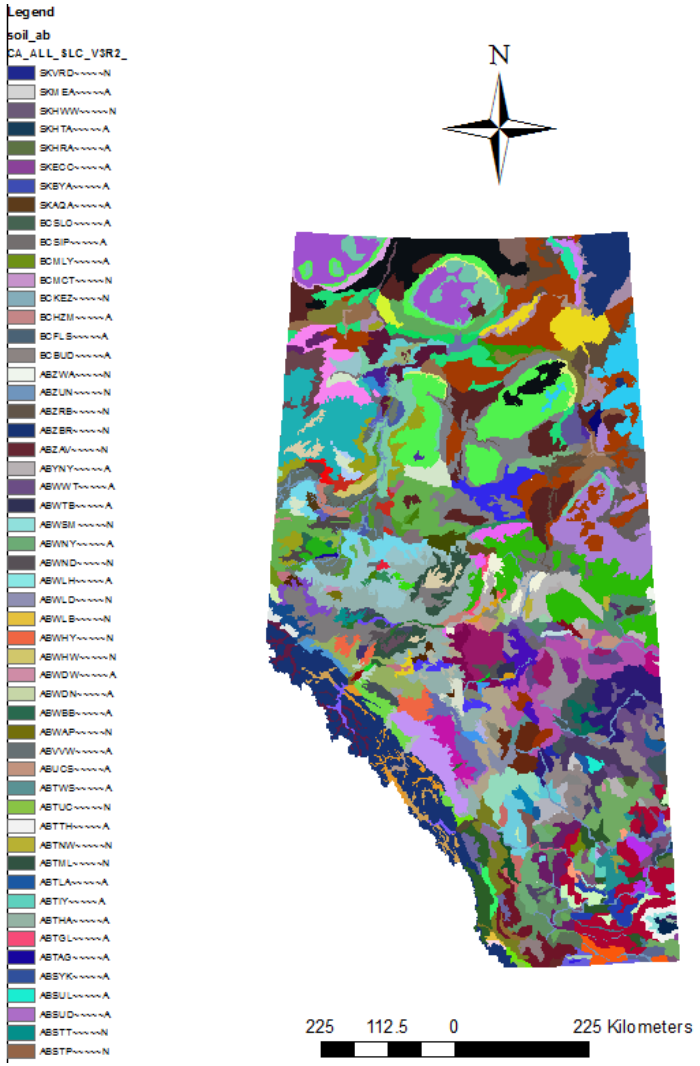
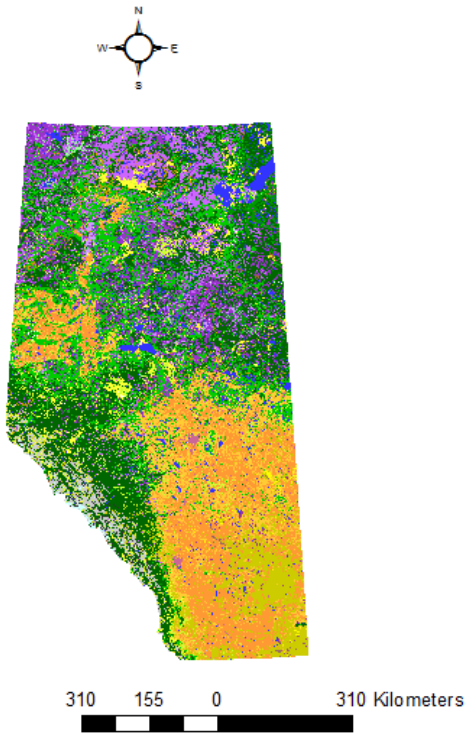
Soil and landuse maps





Databases

Plant database

CPNM	BIO_E	HVSTI	BLAI	FRGRW1	LAIMX1	FRGRW2	LAIMX2	DLAI	CHTMX	RDMX	T_OPT
CNGR	35	0.1	5	5	0.05	50	0.99	0.54	0.7	1.3	25
PAST_GETNET	30	0.9	5	5	0.05	49	0.95	0.85	1.5	2	25
ASPN	30	0.76	5	0.05	0.05	0.4	0.95	0.99	7.5	3	30
WSPR	15	0.76	5	0.15	0.7	0.25	0.99	0.99	10	3	30
BSPR	15	0.76	5	0.15	0.7	0.25	0.99	0.99	10	0.6	30
LDGP	15	0.76	5	0.15	0.7	0.25	0.99	0.99	10	3	30
CEDR	16	0.01	12	20	0.2	99	0.99	0.99	12	3.5	30

Soil database

usersoil

SOL_Z1	SOL_BD1	SOL_AWC1	SOL_K1	SOL_CBN1	CLAY1	SILT1	SAND1	ROCK1	SOL_ALB1	USLE_K1	SOL_EC1	SOL_Z2	SOL_BD2	SOL_AWC2	SOL_K2
0.1	1	20	300	40	0	0	0	0	0.16	0	0	80	1.45	8	300
150	1.25	11	100	2.5	30	20	50	30	0.23	0.15	0	310	1.4	11	100
110	1.15	11	100	3.3	30	20	50	30	0.23	0.15	0	310	1.4	11	100
150	1.25	10	100	2.5	23	15	62	30	0.23	0.15	0	310	1.4	11	100
110	1.15	9	300	3.3	23	15	62	30	0.23	0.15	0	310	1.4	11	100
130	1.25	15	100	3.7	30	45	25	5	0.3	0.18	0	200	1.35	15	100
150	1	14	100	6.2	31	50	19	0	0.02	0.2	0	430	1.35	17	100
130	1.25	15	100	3.7	30	45	25	5	0.3	0.18	0	200	1.35	15	100
0.1	1	20	300	40	0	0	0	0	0.3	0	0	130	1.15	14	100
100	1.25	13	100	3	20	35	45	3	0.02	0.17	0	120	1.35	11	100
170	1.25	13	100	4	20	35	45	3	0.02	0.17	0	230	1.35	11	100
170	1.25	13	100	4	20	35	45	3	0.02	0.17	0	230	1.35	11	100
170	1.25	13	100	4	20	35	45	10	0.02	0.17	0	230	1.35	11	100
170	1.25	13	100	4	20	35	45	3	0.02	0.17	0	230	1.35	11	100
170	1.15	12	300	5.2	20	35	45	3	0.02	0.17	0	230	1.35	11	100
140	1.15	13	100	1.5	16	60	24	10	0.3	0.21	0	370	1.35	18	10

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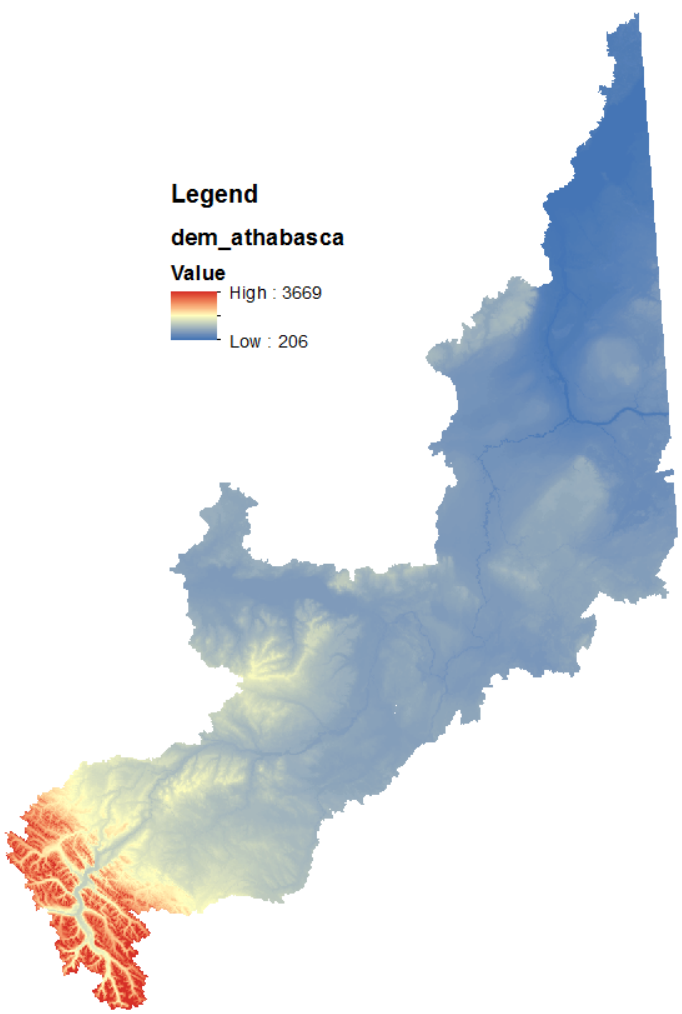
Model setup



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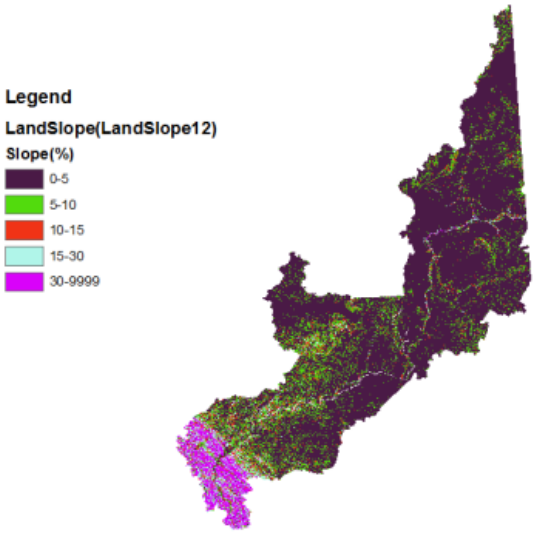

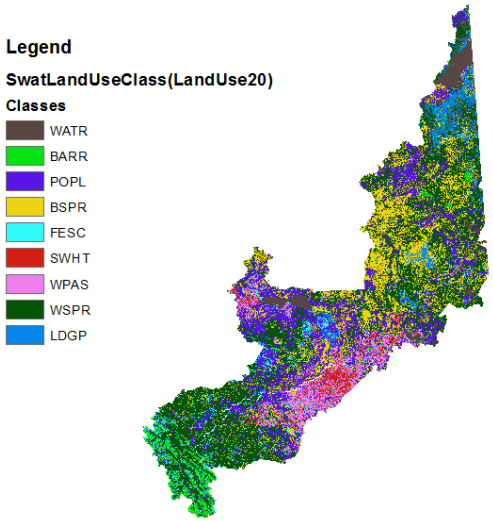

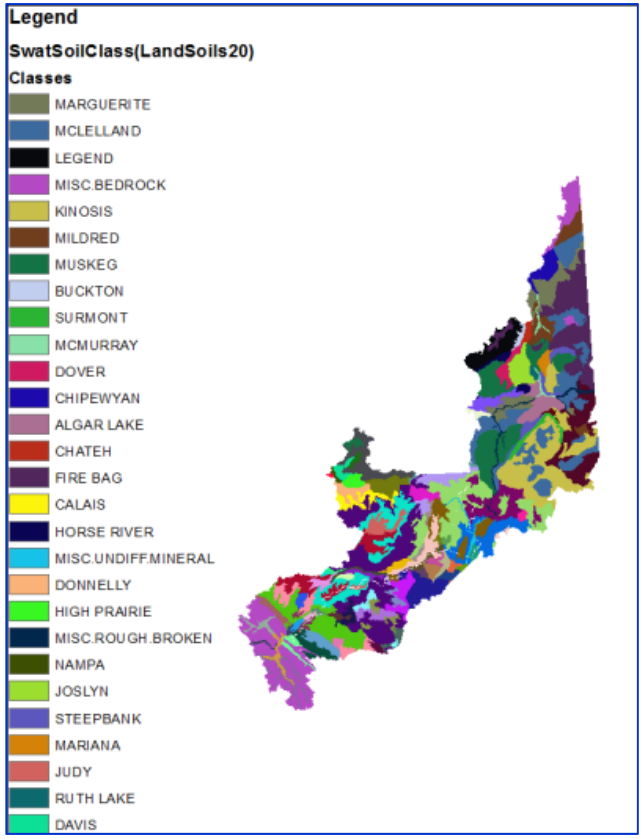

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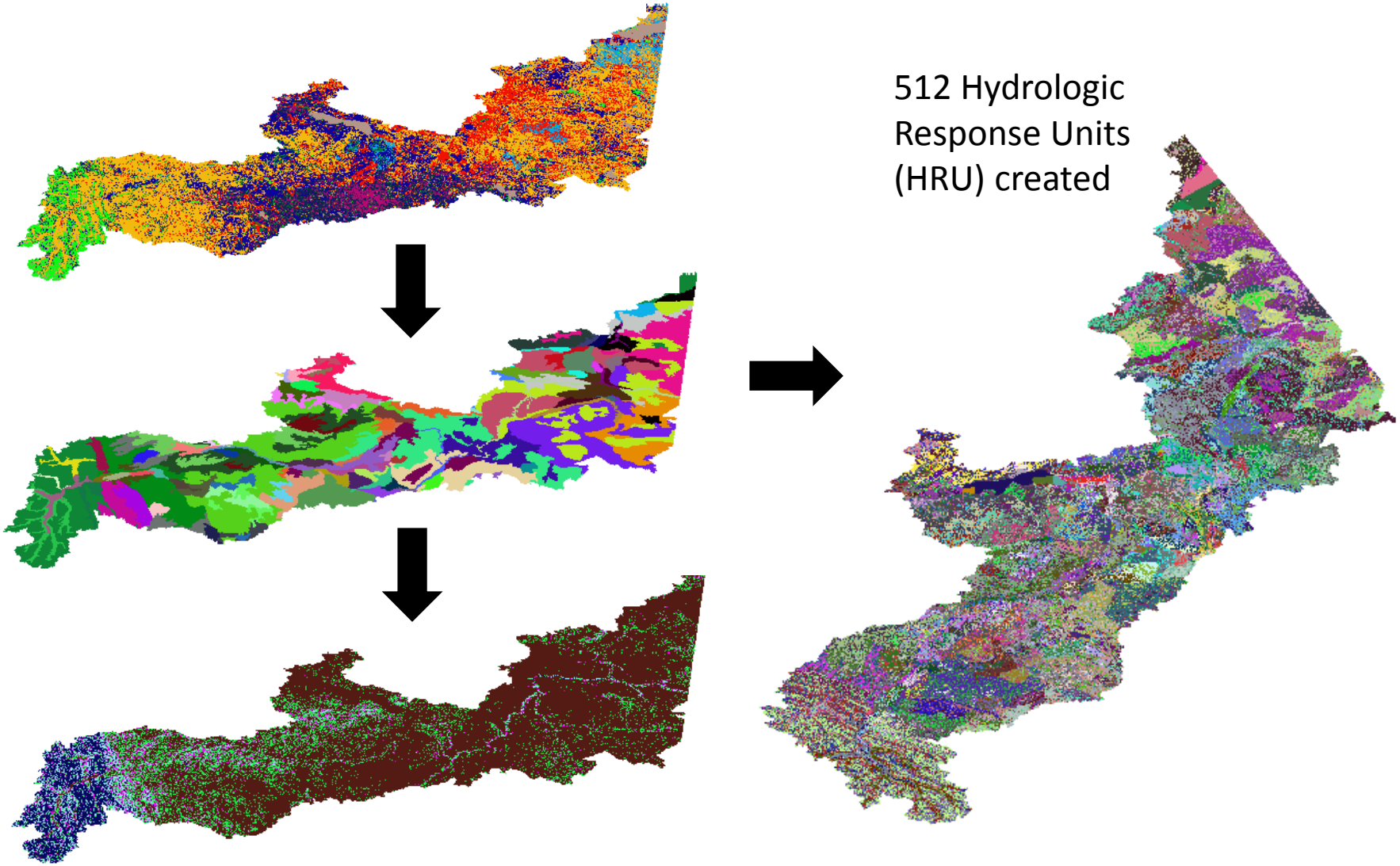
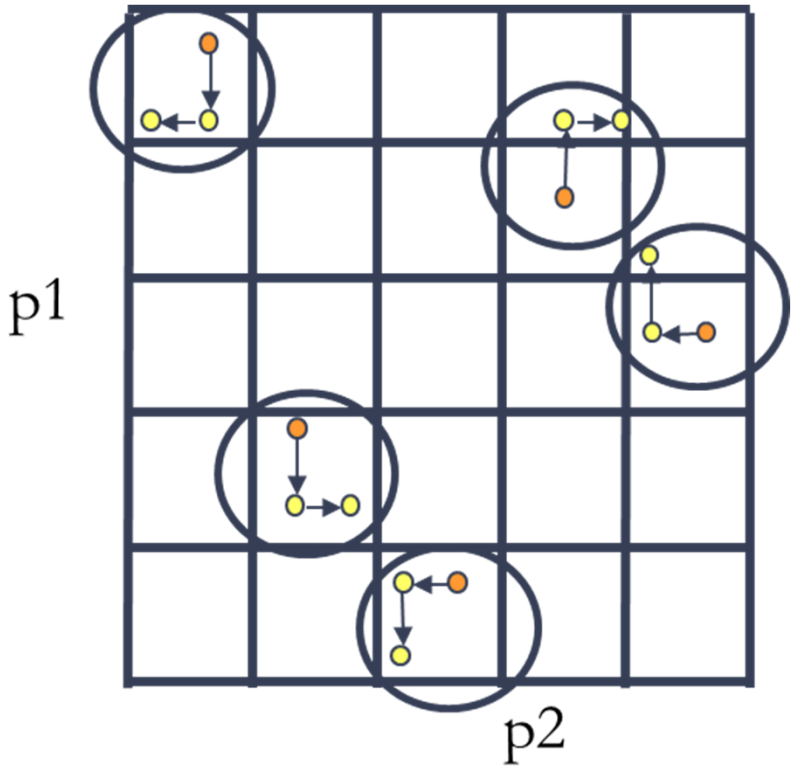
Model setup



512 Hydrologic Response Units (HRU) created

Model Development

- Model is setup
  - 1979-2012
- Warmup period
  - 1979-1981
- Calibration period
  - 1982-1996
  - LHOAT
  - SUFI2
- Validation period
  - 1997-2012



Model Evaluation

- To measure the robustness of a model

$$\mathrm{NSE} = 1 - \left[\frac{\sum_{i=1}^{n} \left(X_i^{\mathrm{obs}} - X_i^{\mathrm{sim}} \right)^2}{\sum_{i=1}^{n} \left(X_i^{\mathrm{obs}} - X^{\mathrm{mean}} \right)^2} \right]$$

- NSE > 0.5 indicates acceptable flow simulation

Sensitivity result

Parameter_Name	Fitted_Value
V__SMTMP.bsn	3.010351
V__SMFMX.bsn	1.04569
V__TIMP.bsn	0.081897
R__CN2.mgt	-0.469061
R__SOL_Z(..).sol	0.122765
V__ALPHA_BF.gw	0.012511
V__GW_DELAY.gw	15.12498
R__SOL_BD(..).sol	-0.810234
V__REVAPMN.gw	121.176529
V__GWQMN.gw	327.328308
V__CH_N2.rte	0.062229
V__N_UPDIS.bsn	78.959007
V__ERORGN.hru	4.266926
V__NPERCO.bsn	0.009494
R__ANION_EXCL.sol	-0.031612
V__SHALLST_N.gw	-853.466248
V__PSP.bsn	0.783254
V__PHOSKD.bsn	99.42643
V__P_UPDIS.bsn	17.300001
V__PPERCO.bsn	11.2225
V__ERORGP.hru	4.245

11 flow parameters

5 nitrogen parameters

5 phosphorous parameters

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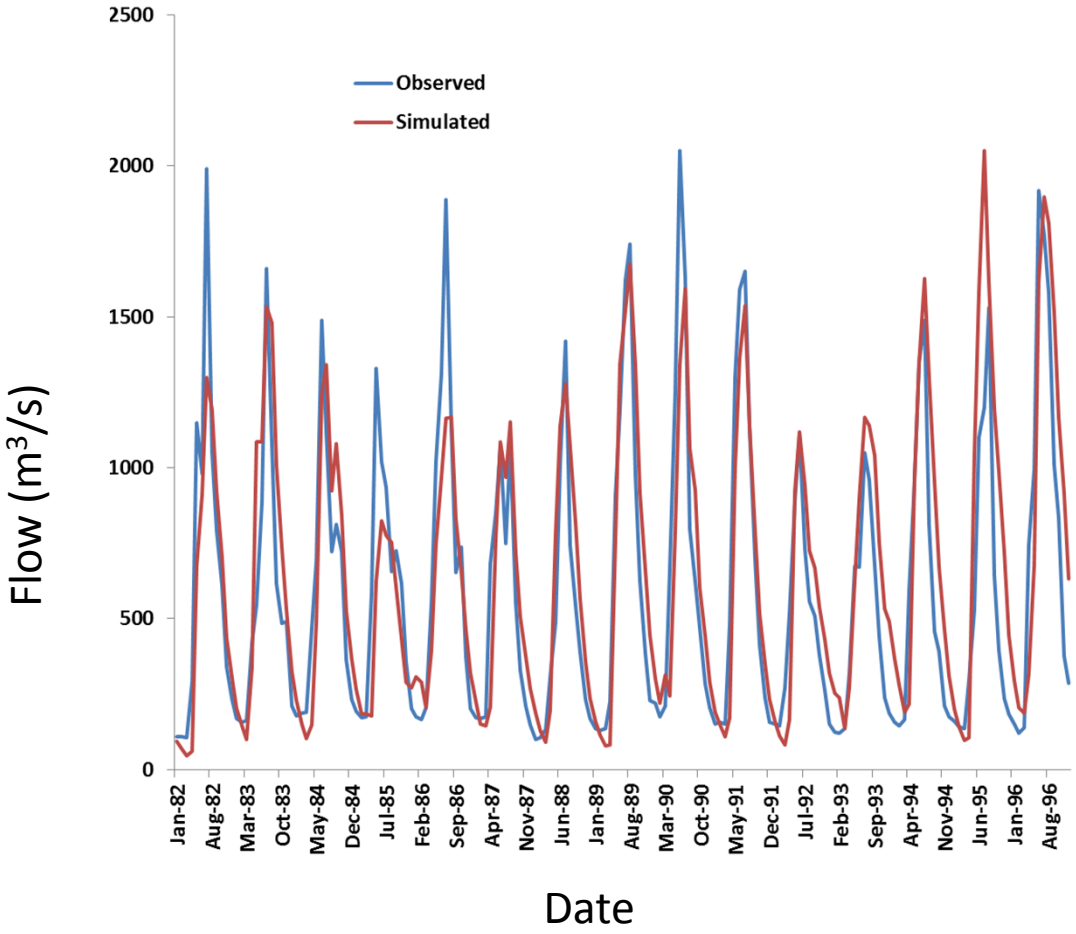
Monthly flow calibration



NSE = 0.72

Peak flows are captured except 4 years

Low flows are captured

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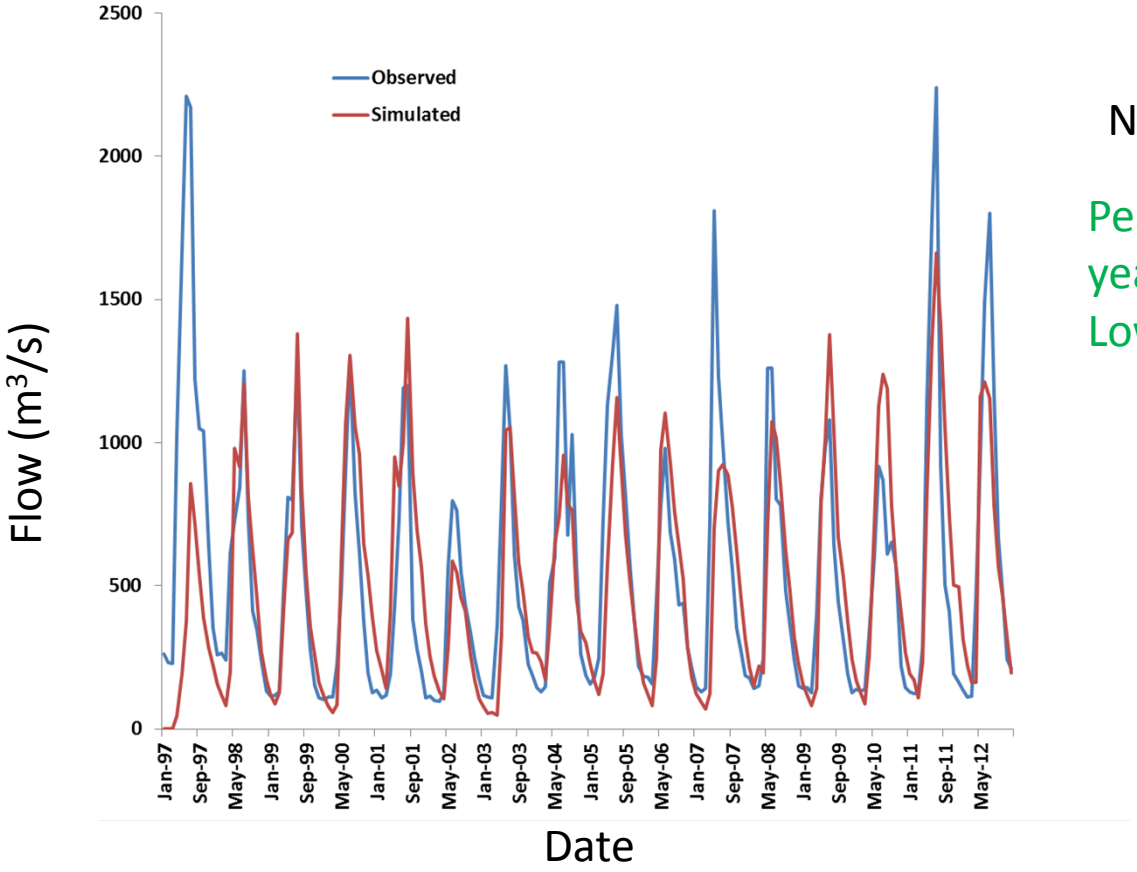
Monthly flow validation



NSE = 0.51

Peak flows are captured except a few years

Low flows are captured

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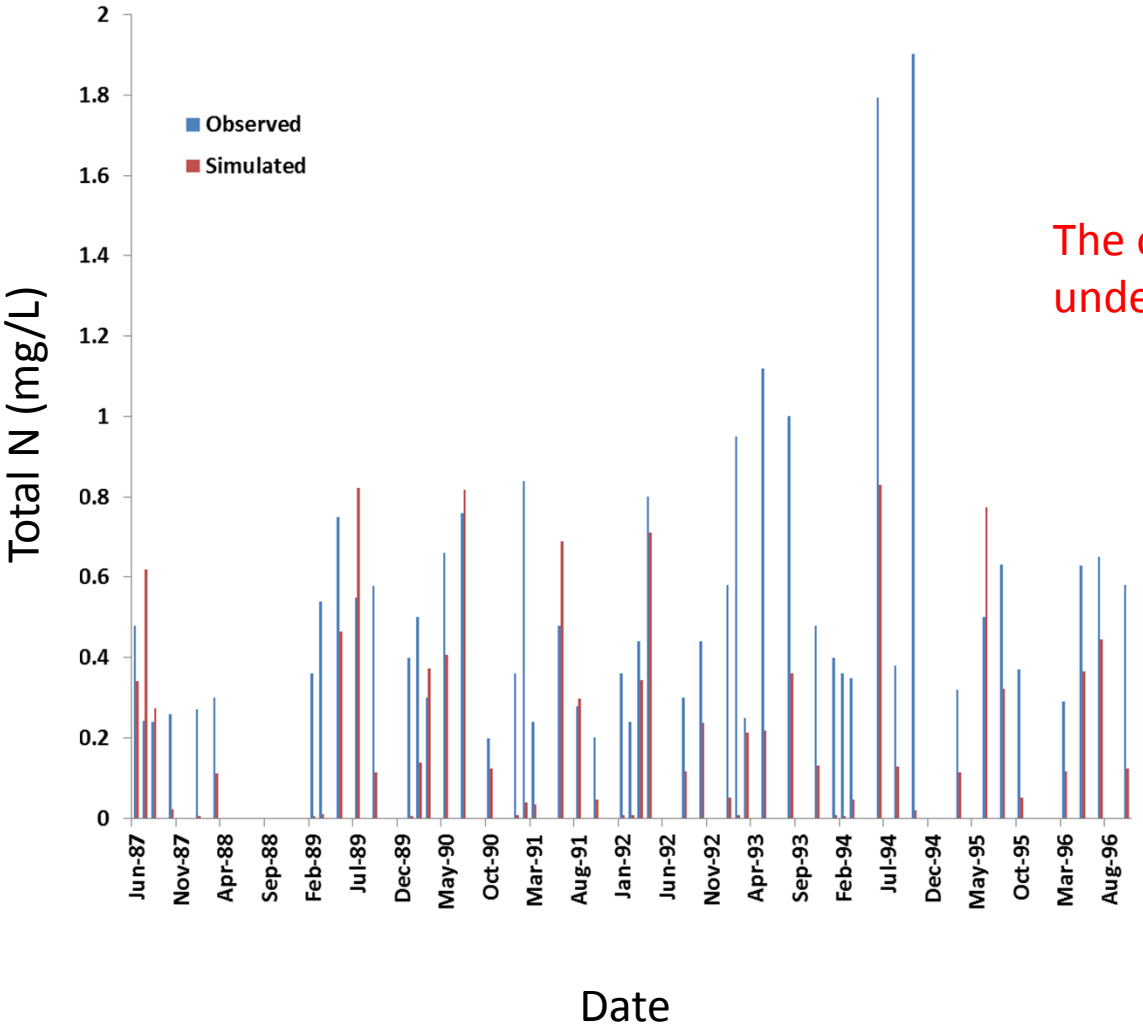
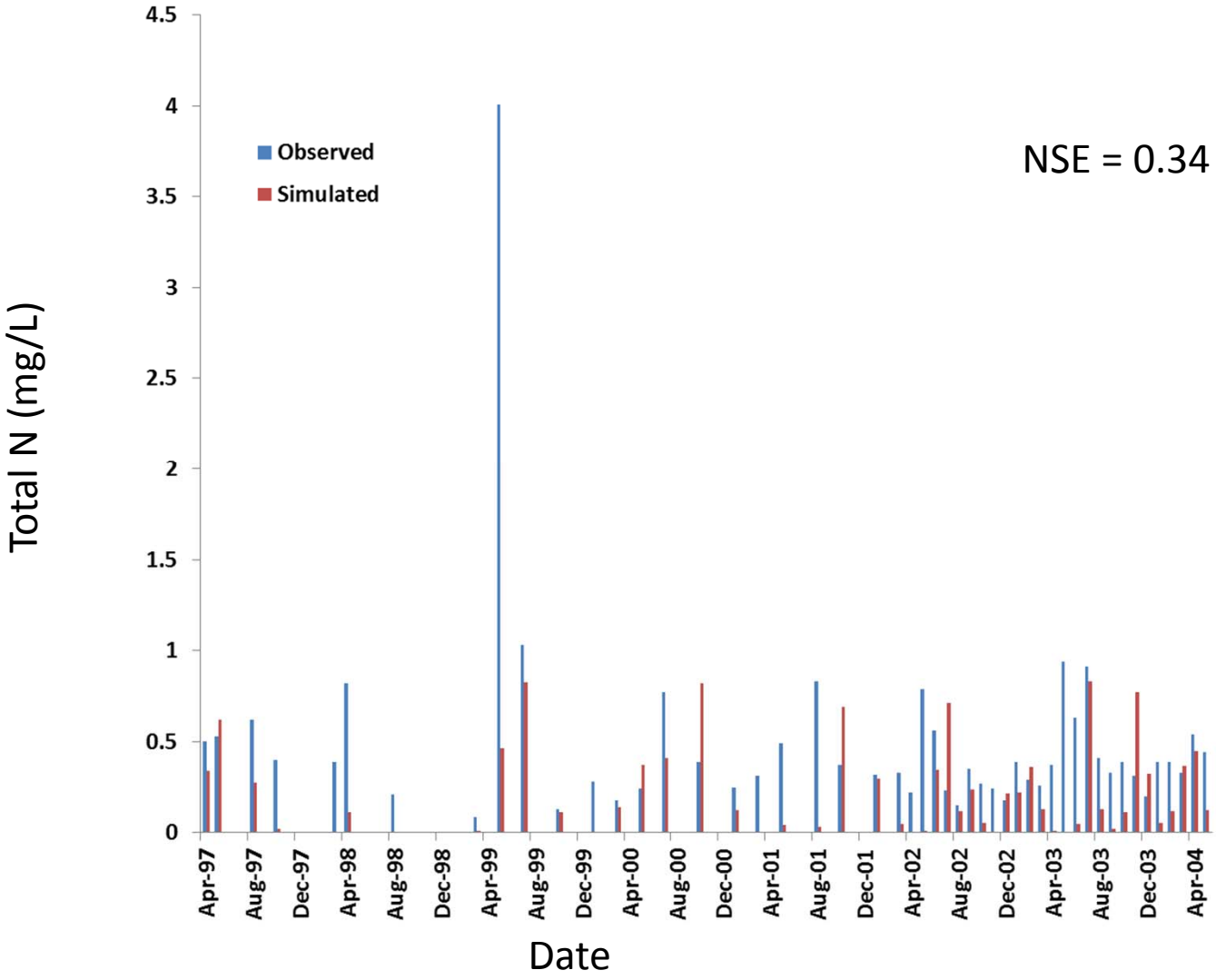
Monthly nitrogen calibration



NSE = 0.50

The observed Total Nitrogen is underestimated

Monthly nitrogen validation



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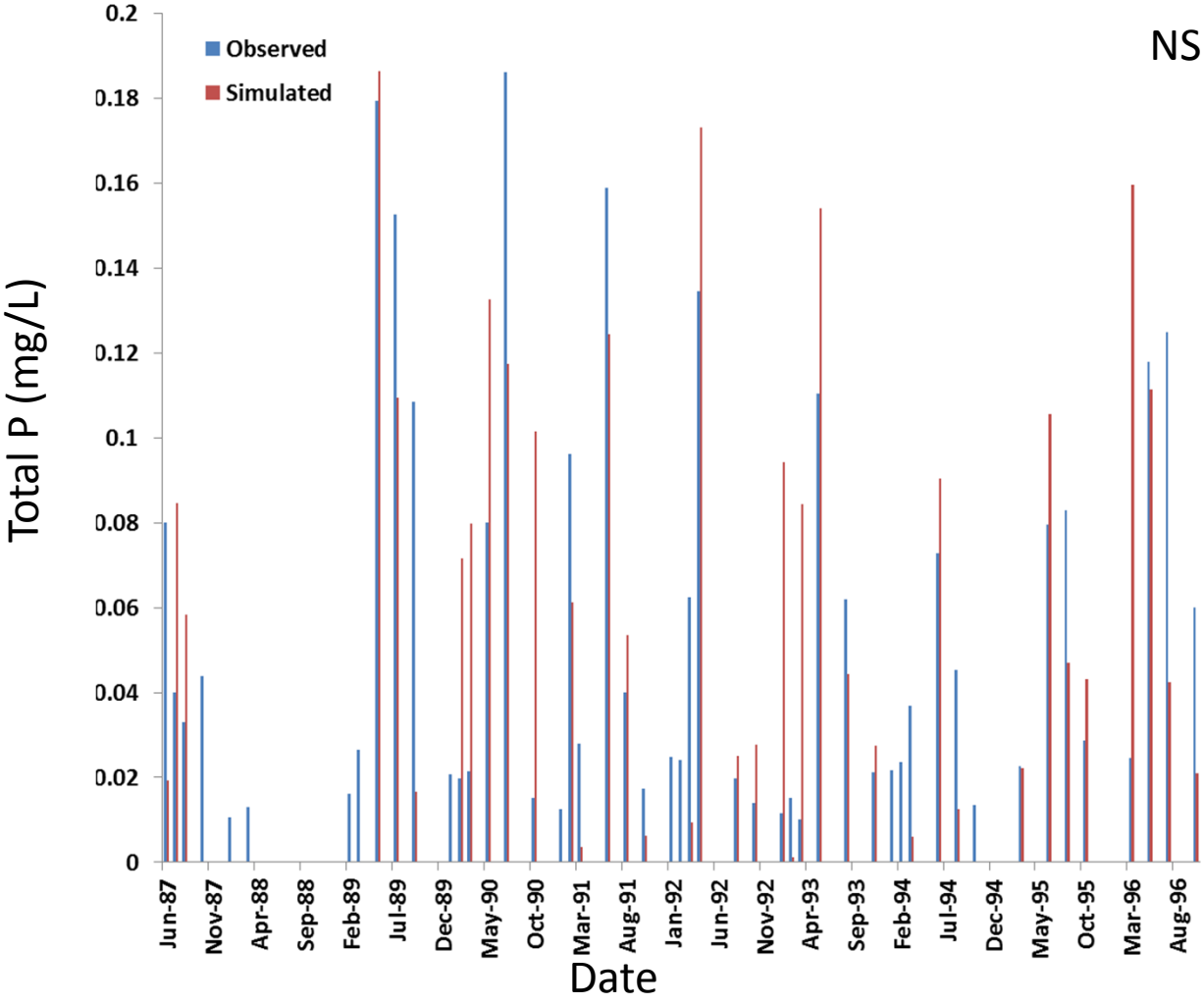
Monthly Phosphorus calibration



NSE = 0.69

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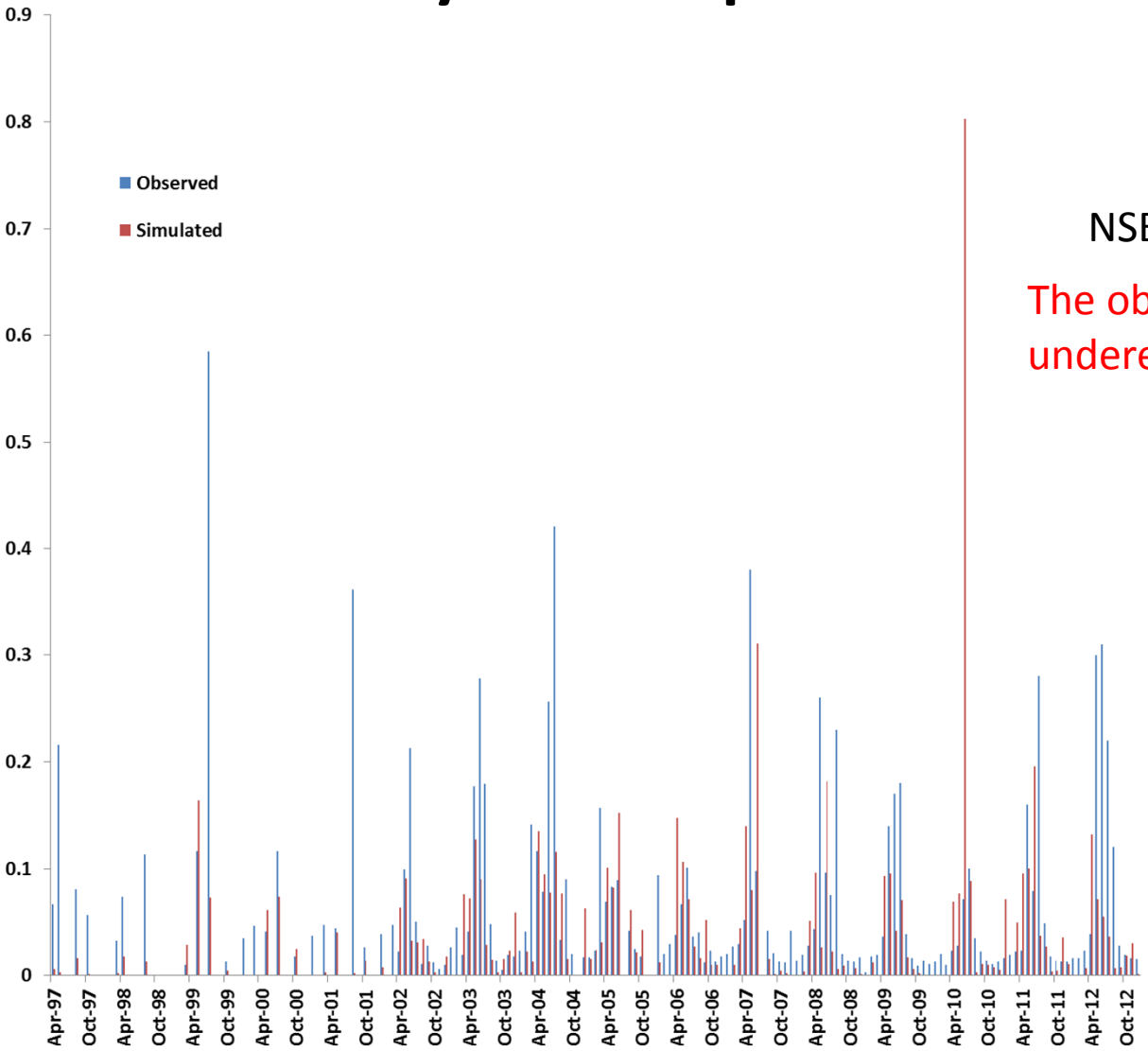
Monthly Phosphorus validation



NSE = 0.23

The observed Total P is underestimated

Conclusion

- Databases for hydrological and water quality developed
- Hydrological and water quality models setup
- The hydrological model performance is good
- The water quality model needs to further improvement
- The results indicate SWAT could be used to understand hydrological and water quality processes and make decisions in the ARB

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Acknowledgement

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Thank you!

Questions/comments:

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