Nitrogen Load Estimates in Central Germany using Hydrological Water Quality Modelling and High Resolution Monitoring

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Problem Statements

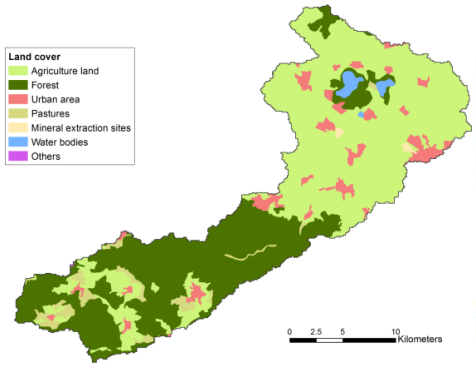
- Agriculture is responsible for the largest contribution of non-point source pollution (Eutrophication, blooms algae),
- Hydrological water quality modelling is increasingly used for water management and nitrogen leaching,
- Recently, high resolution water quality measurement is conducted temporally and spatially,
- Dynamical behavior is increasing in future due to the expected changes (land, climate, population),
- Good estimates of nitrogen load deponds on good measurement and prediction of discharge and nitrogen concentration,

Objectives

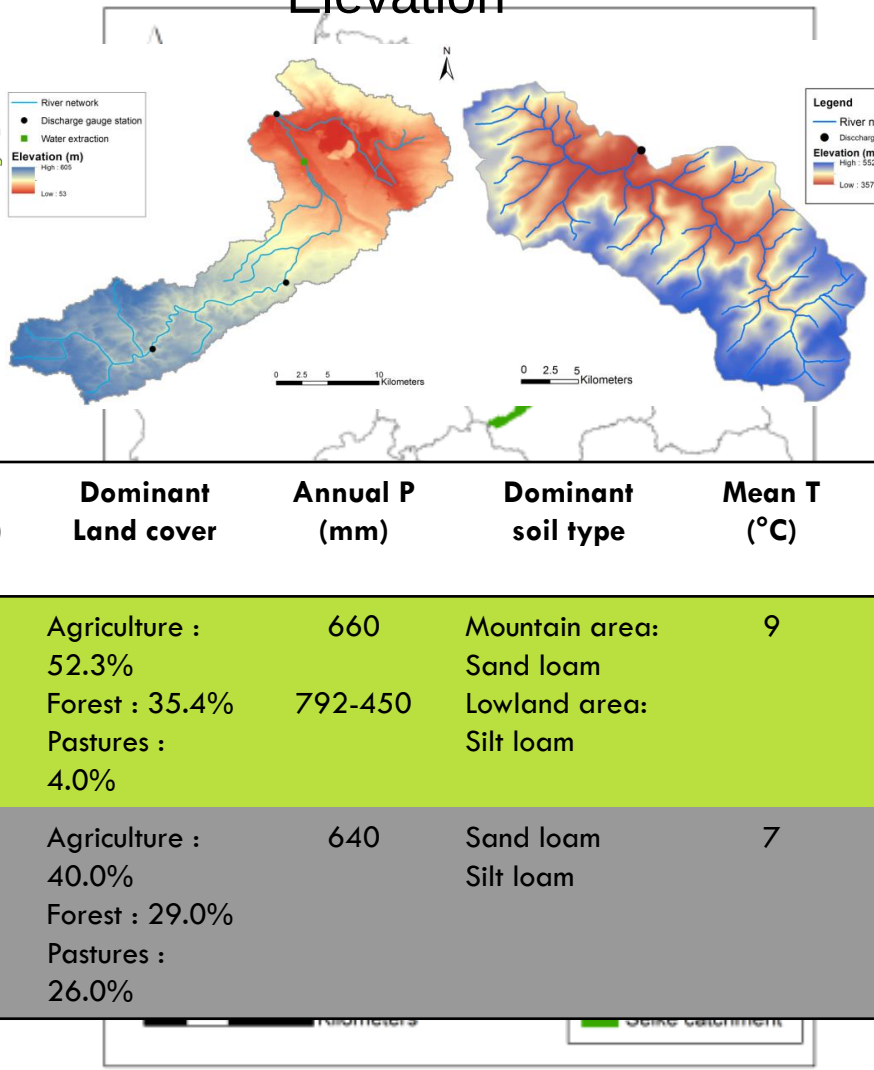
- Evaluate HYPE model applicability in central Germany (Selke and Weida),
- Estimates nitrogen load using hydrological modelling,
- Reconstruct the NO3 concentrations using Event Response Reconsctruction (ERR) approach using high resolution data,

Selke vs. Weida

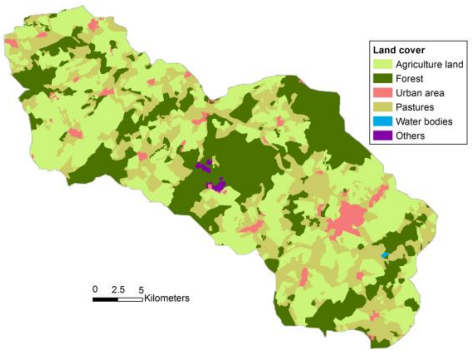
Land use



Elevation



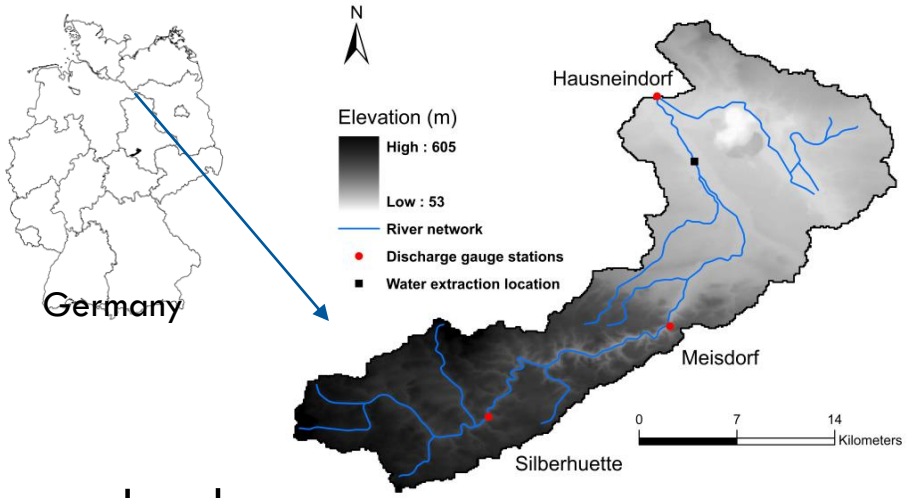
Land use



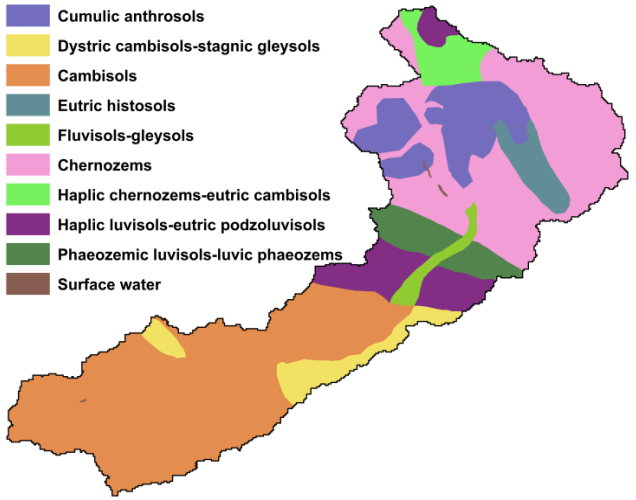
Catchment	DEM (m)	Area (km^2)	Dominant Land cover	Annual P (mm)	Dominant soil type	Mean T (°C)	Mean (IN) concentration (mg/l)	Mean Q (m^3/s)
Selke	53-605	463	Agriculture : 52.3% Forest : 35.4% Pastures : 4.0%	660 792-450	Mountain area: Sand loam Lowland area: Silt loam	9	3.91	1.54 Qs = 3.32 ($l/s/km^2$)
Weida	357-552	99.5	Agriculture : 40.0% Forest : 29.0% Pastures : 26.0%	640	Sand loam Silt loam	7	8.76	0.72 Qs = 7.23 ($l/s/km^2$)

Study area

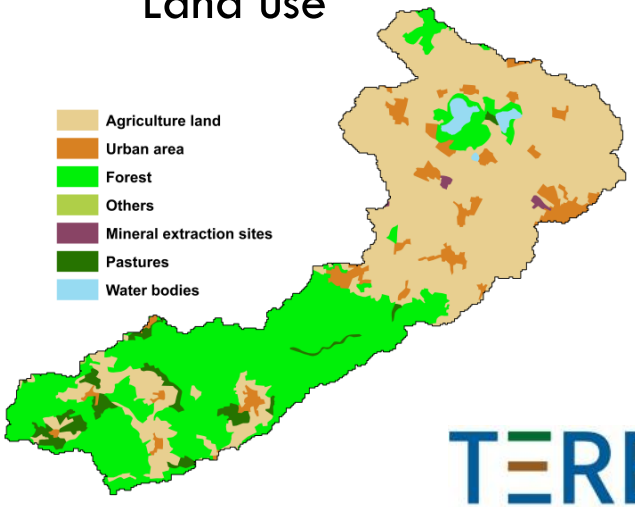
Selke catchment



Soil type



Land use



- Area: 463 km^2
- Elevation: 53-605 m
- Mean precipitation: 660 mm y^{-1}
- Mean temperature: 9 °C

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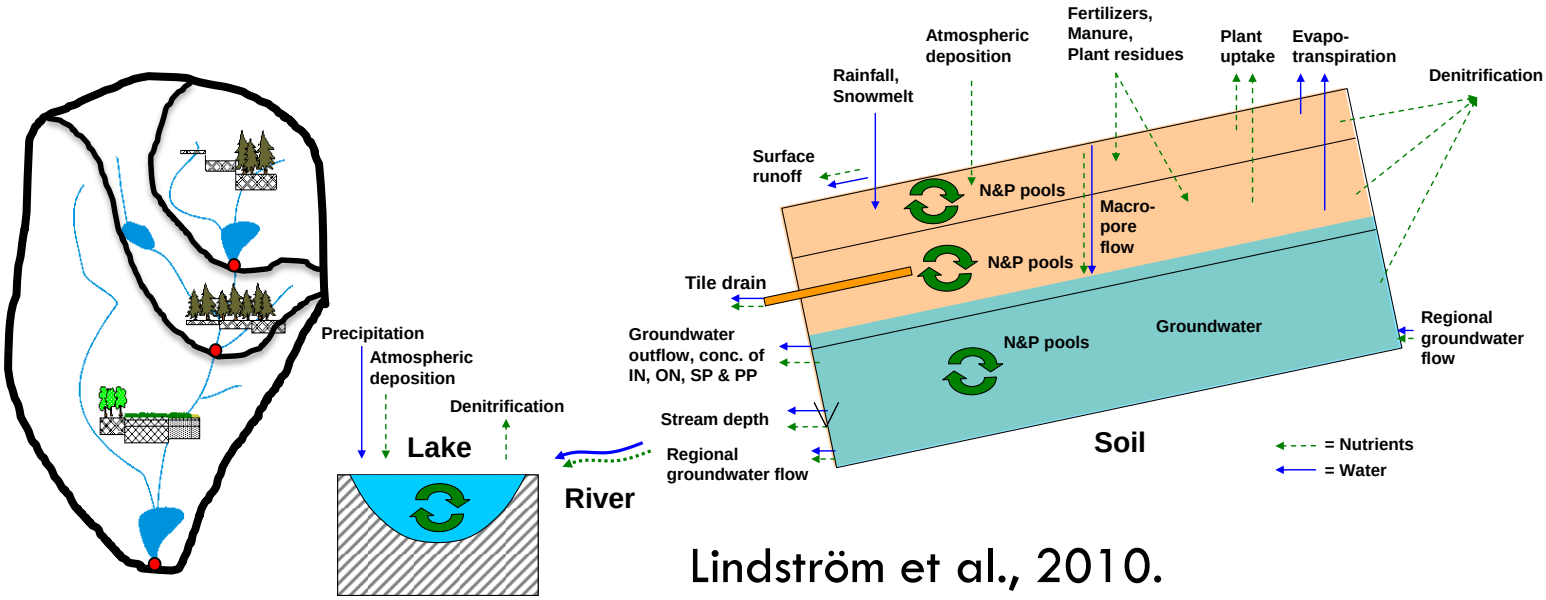
HYPE model



Lindström et al., 2010.

- Process-based semi-distributed hydrological water quality model
- Simulate runoff, nutrient (N and P) transport and transformation

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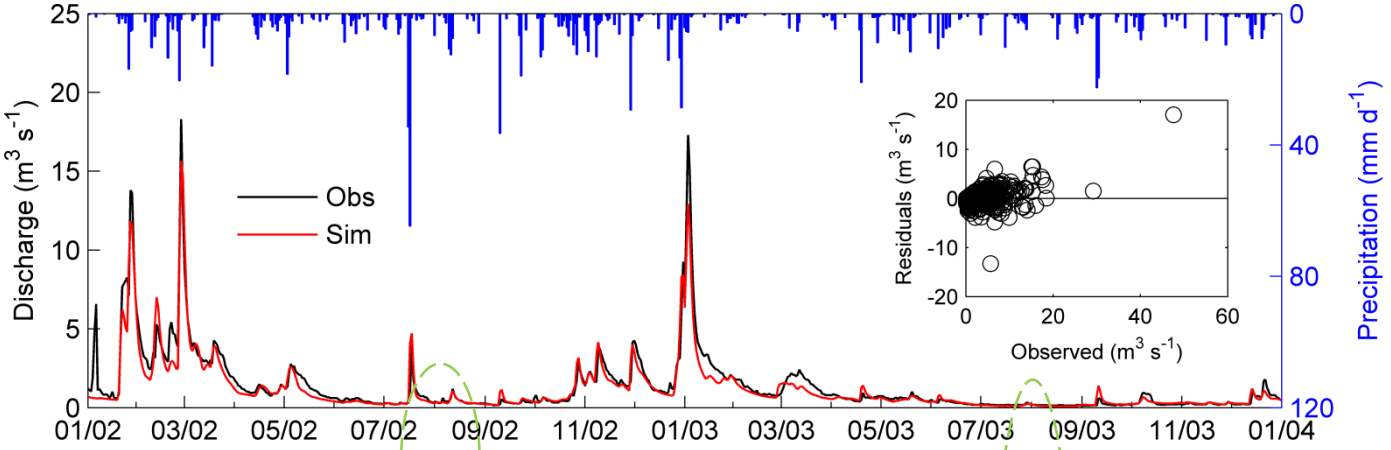
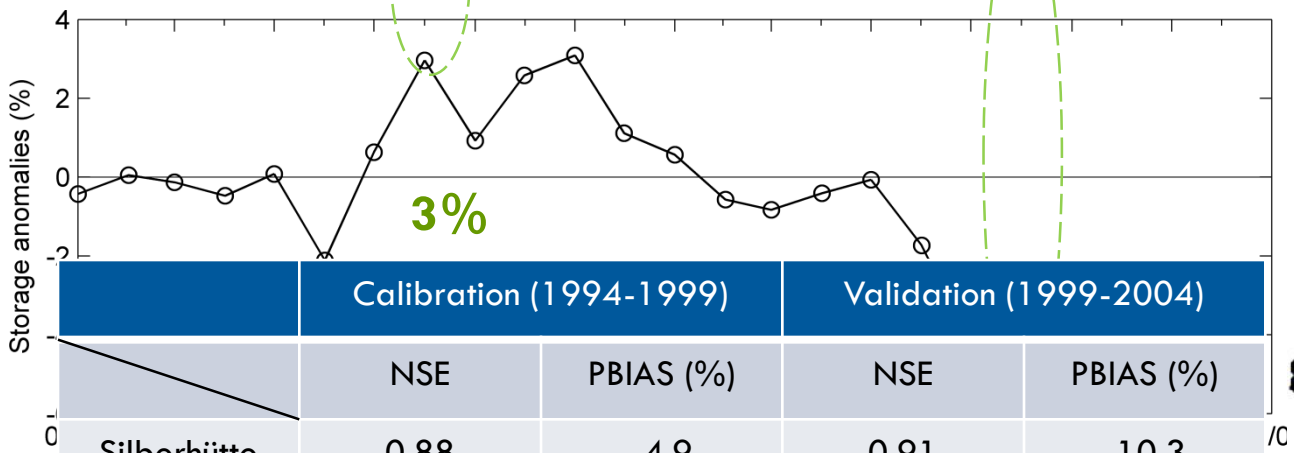
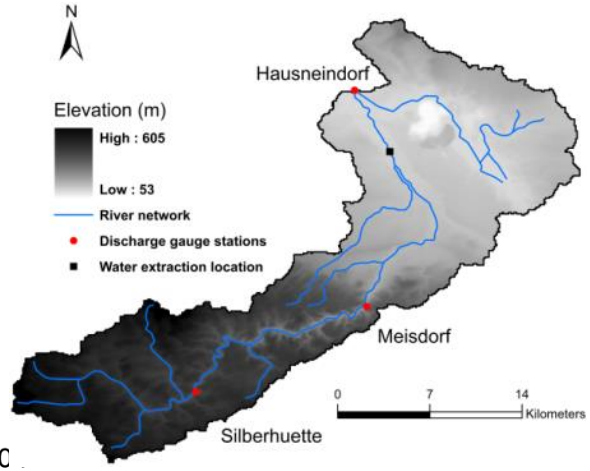
Discharge simulations (extreme events)





Multi-site & multi-objective calibration



	Calibration (1994-1999)		Validation (1999-2004)	
	NSE	PBIAS (%)	NSE	PBIAS (%)
Silberhütte	0.88	-4.9	0.91	-10.3
Meisdorf	0.88	-3.8	0.90	-0.7
Hausneindorf	0.86	2.6	0.86	14.3

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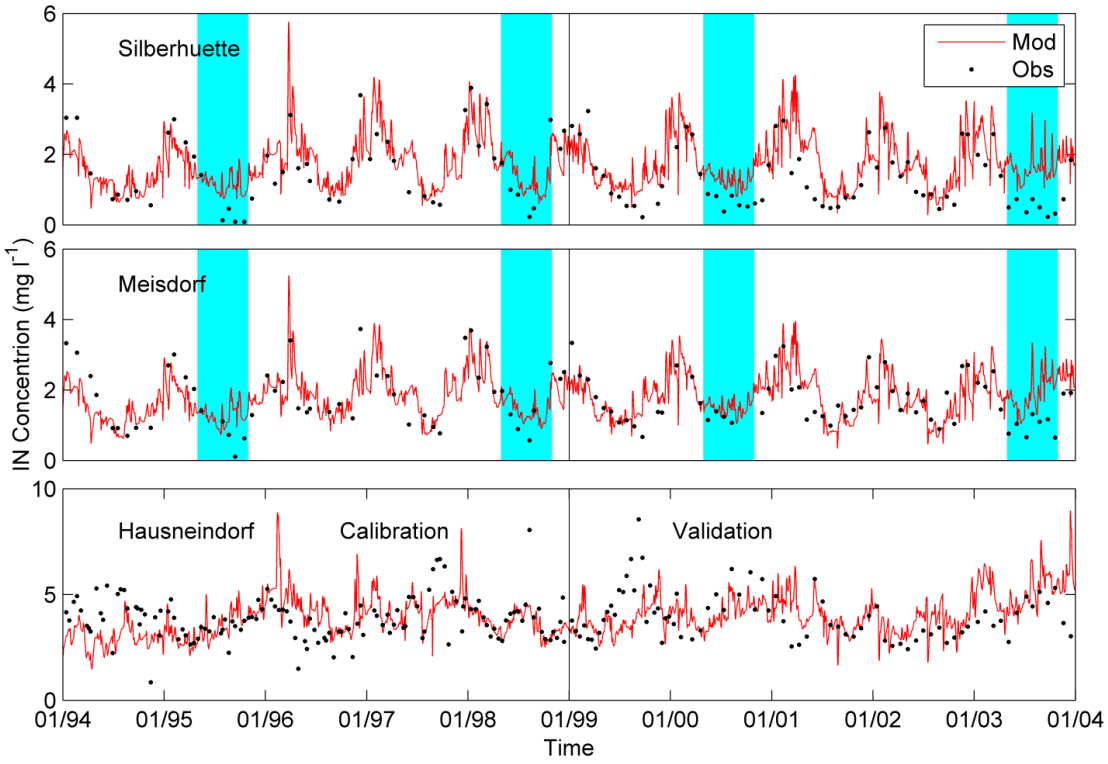
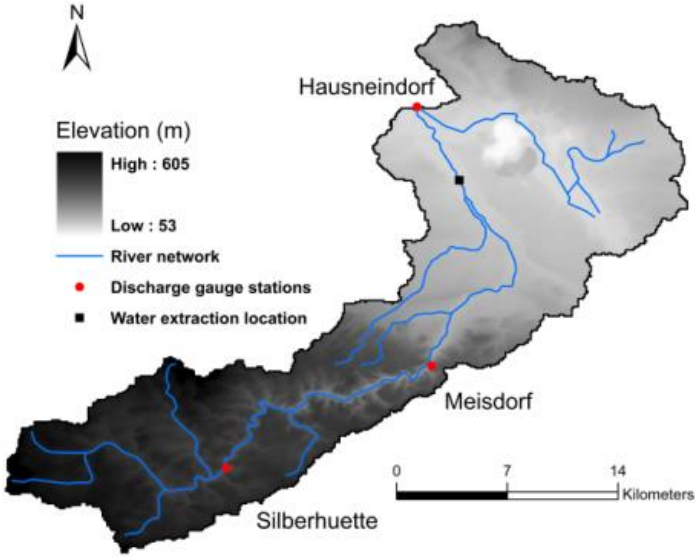
IN concentrations simulations





Lowest NS = 0.69

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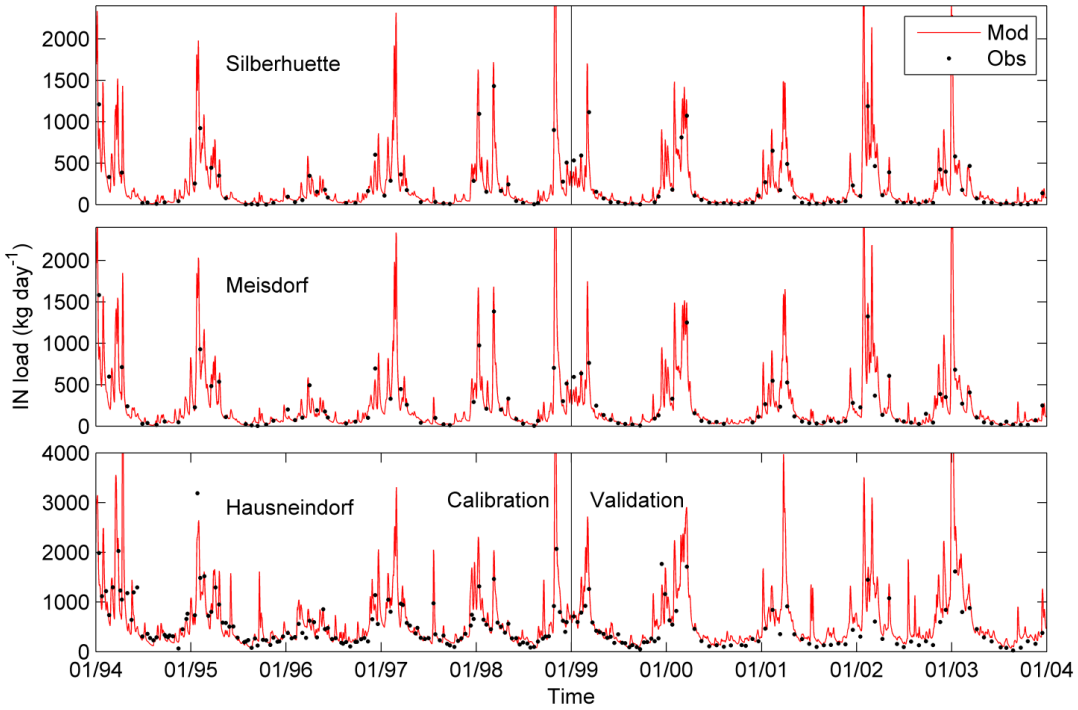
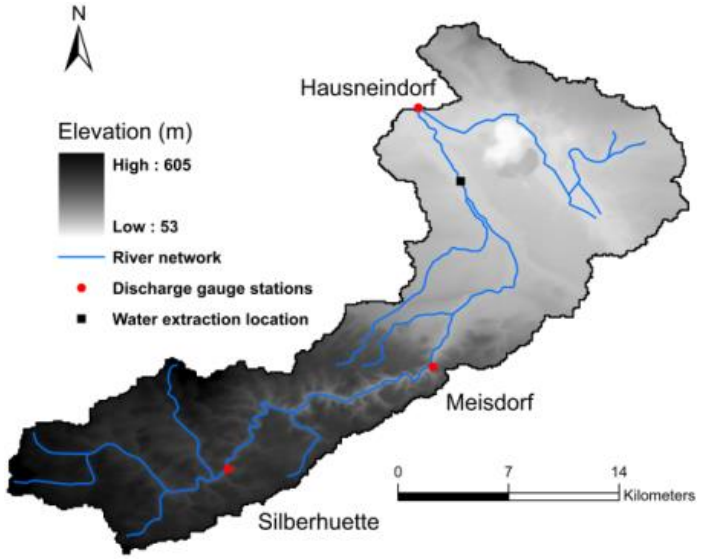
Daily IN load simulations





	Calibration (1994-1999)		Validation (1999-2004)	
Criteria / Station	NSE	PBIAS (%)	NSE	PBIAS (%)
Silberhütte	0.88	-11.4	0.83	0.5
Meisdorf	0.80	-15.3	0.89	8.1
Hausneindorf	0.70	4.3	0.46	40.3

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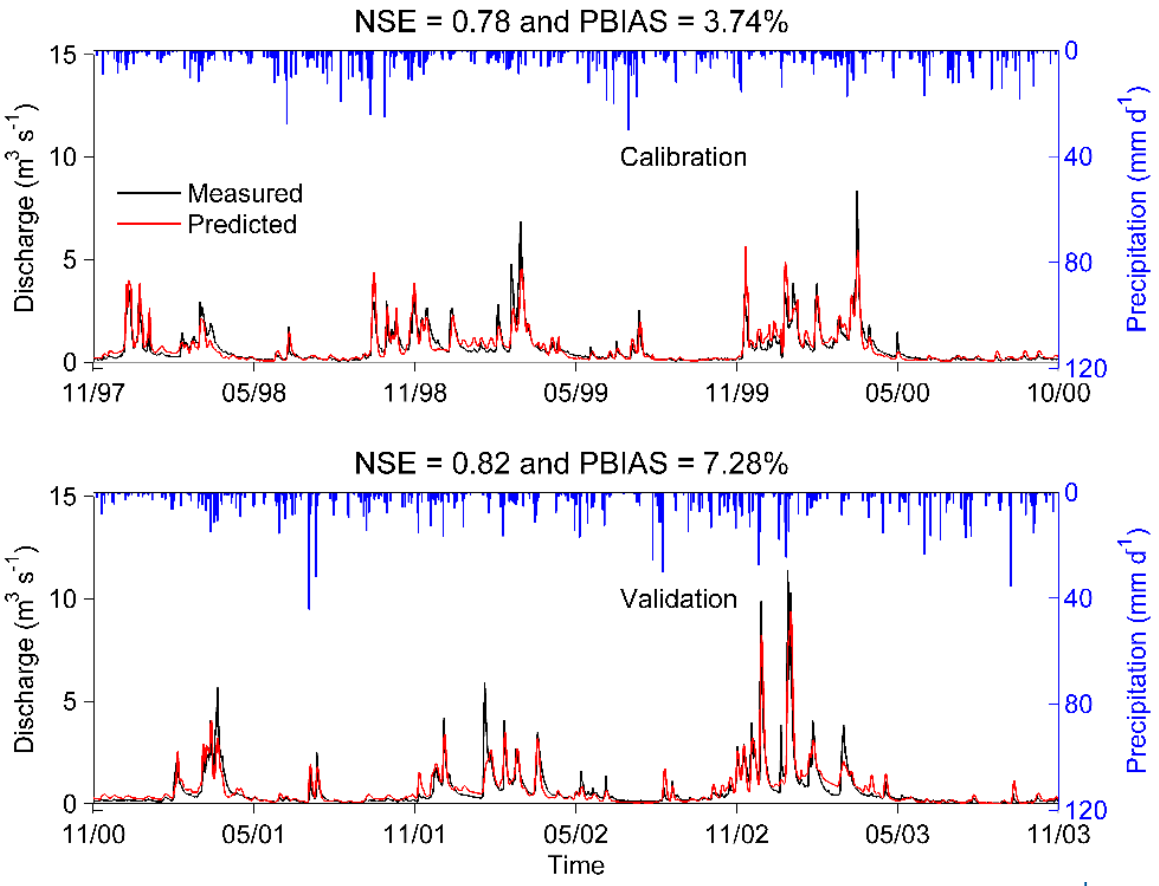
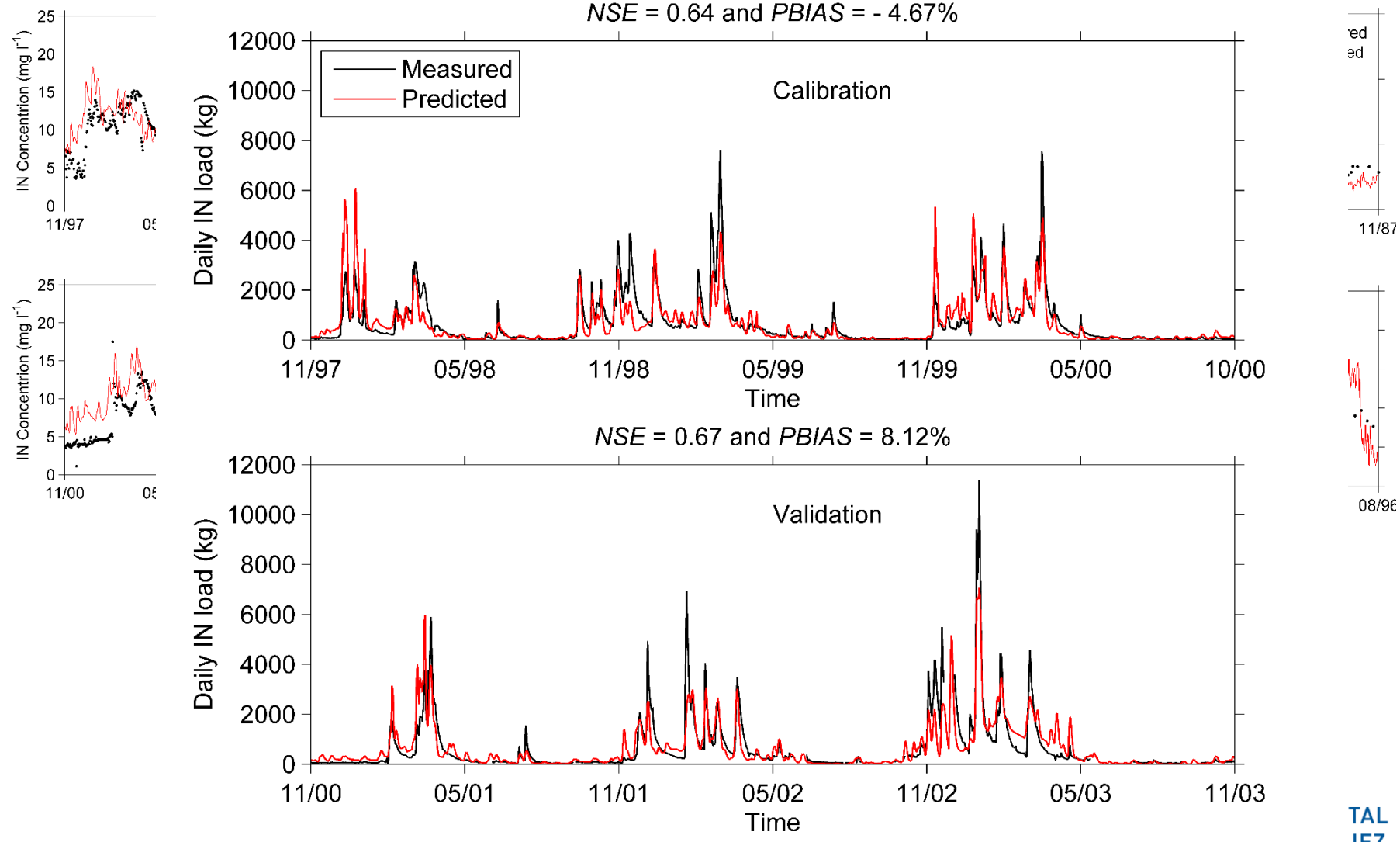
HYPE from Selke to Weida

→ The best optimized model parameters obtained from Selke could not reproduce the measured daily discharge of Weida (N



IN simulations and its temporal transferability



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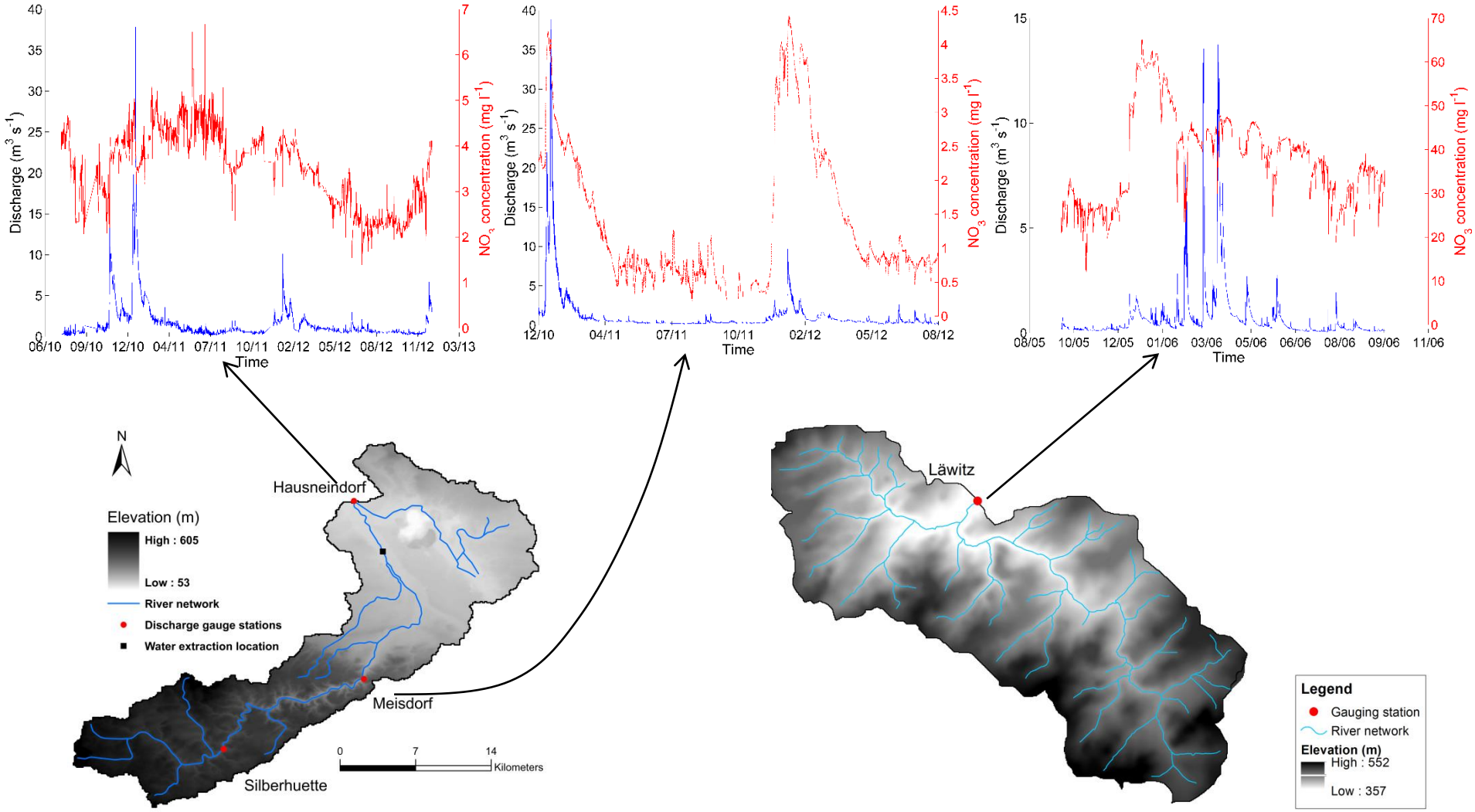
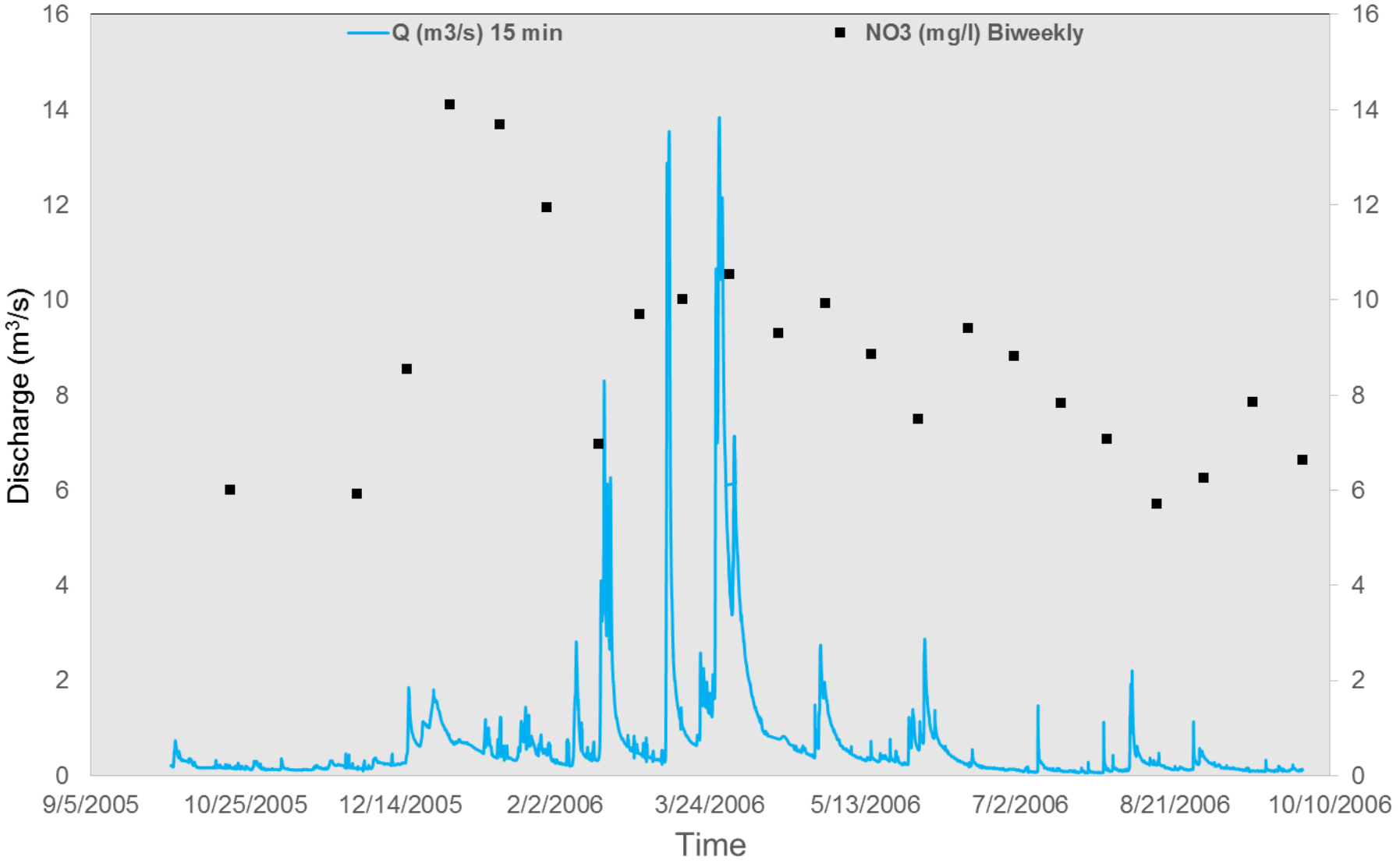
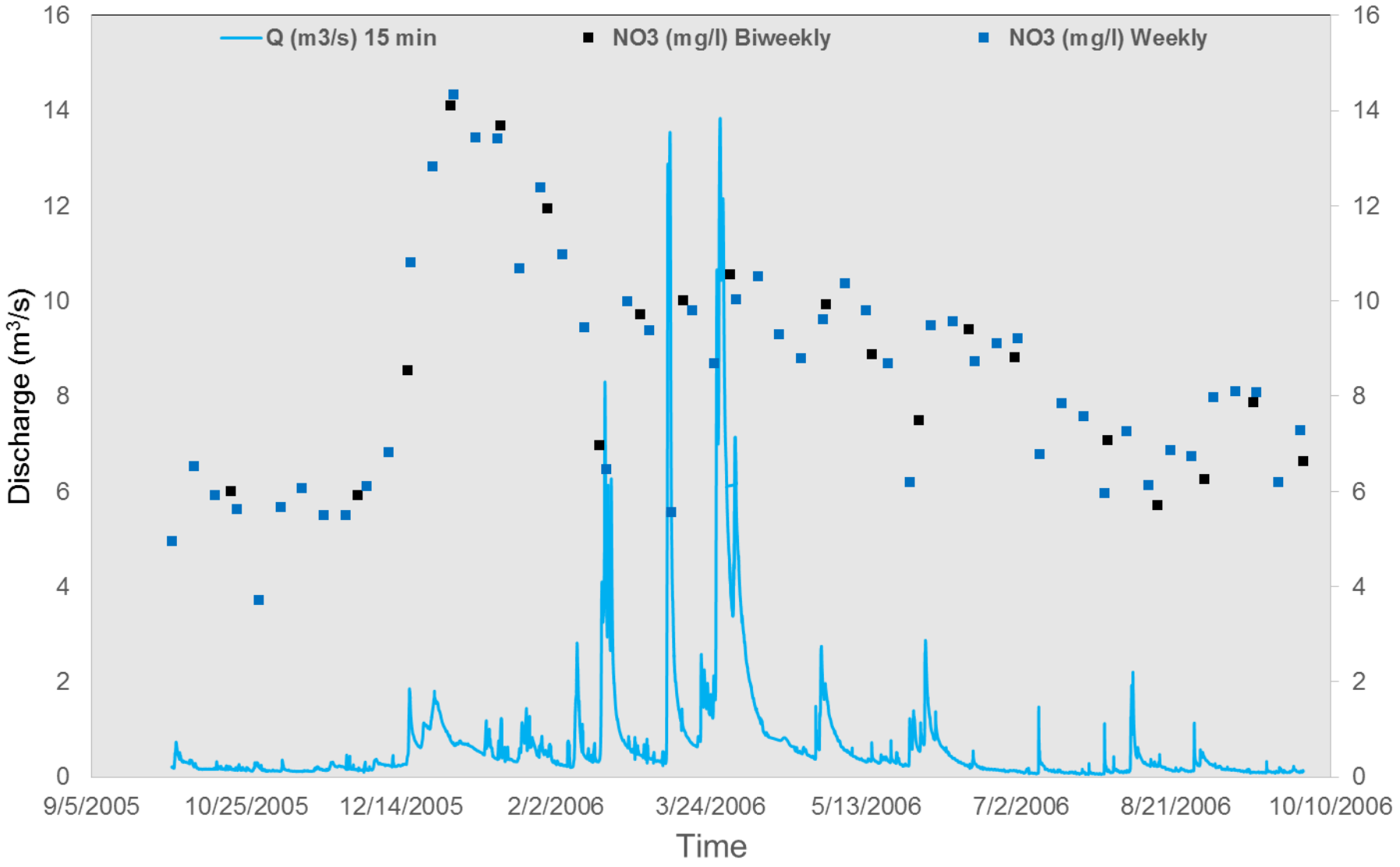
High resolution measurement : Model performance



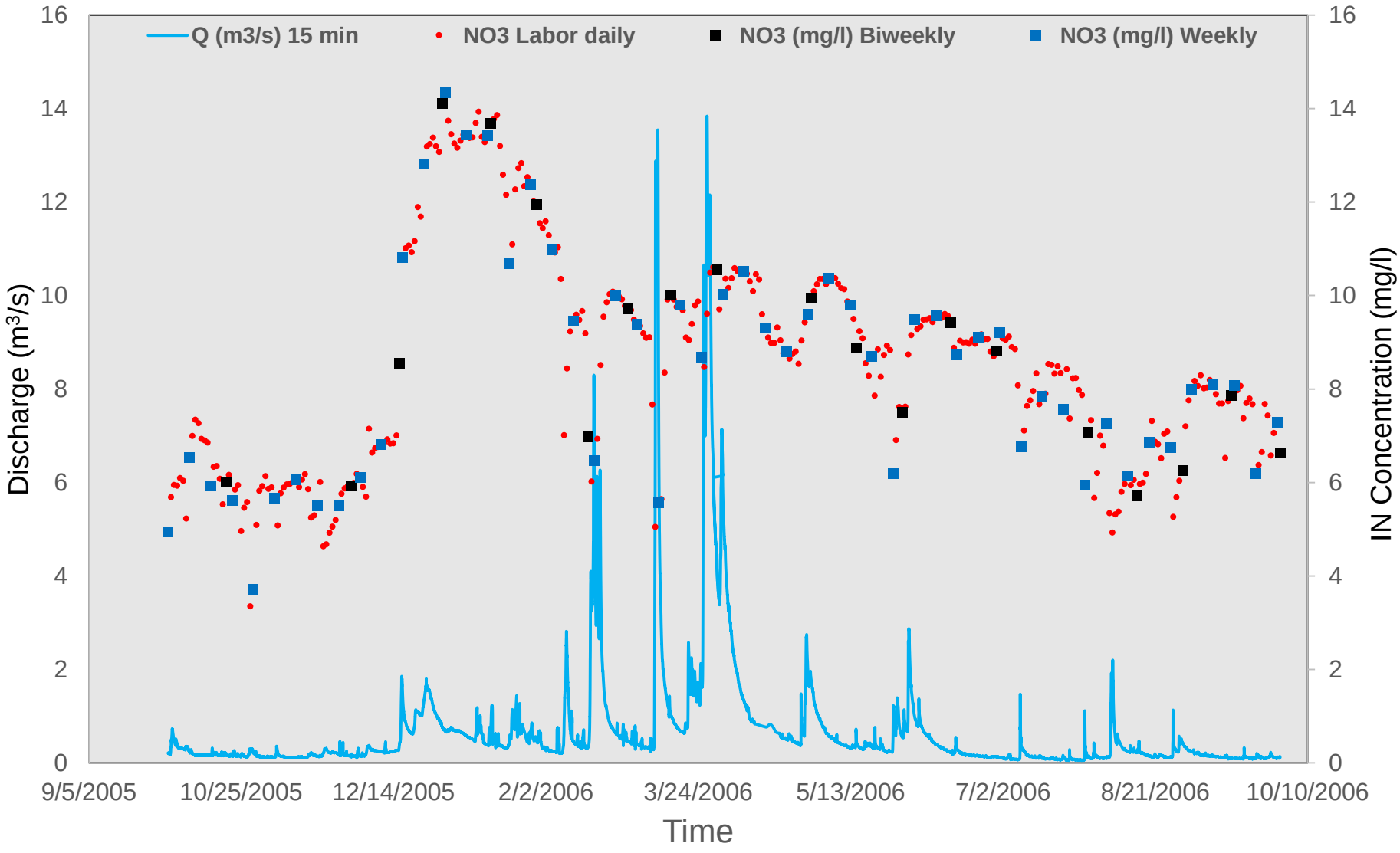
Dynamics vs. sampling frequency



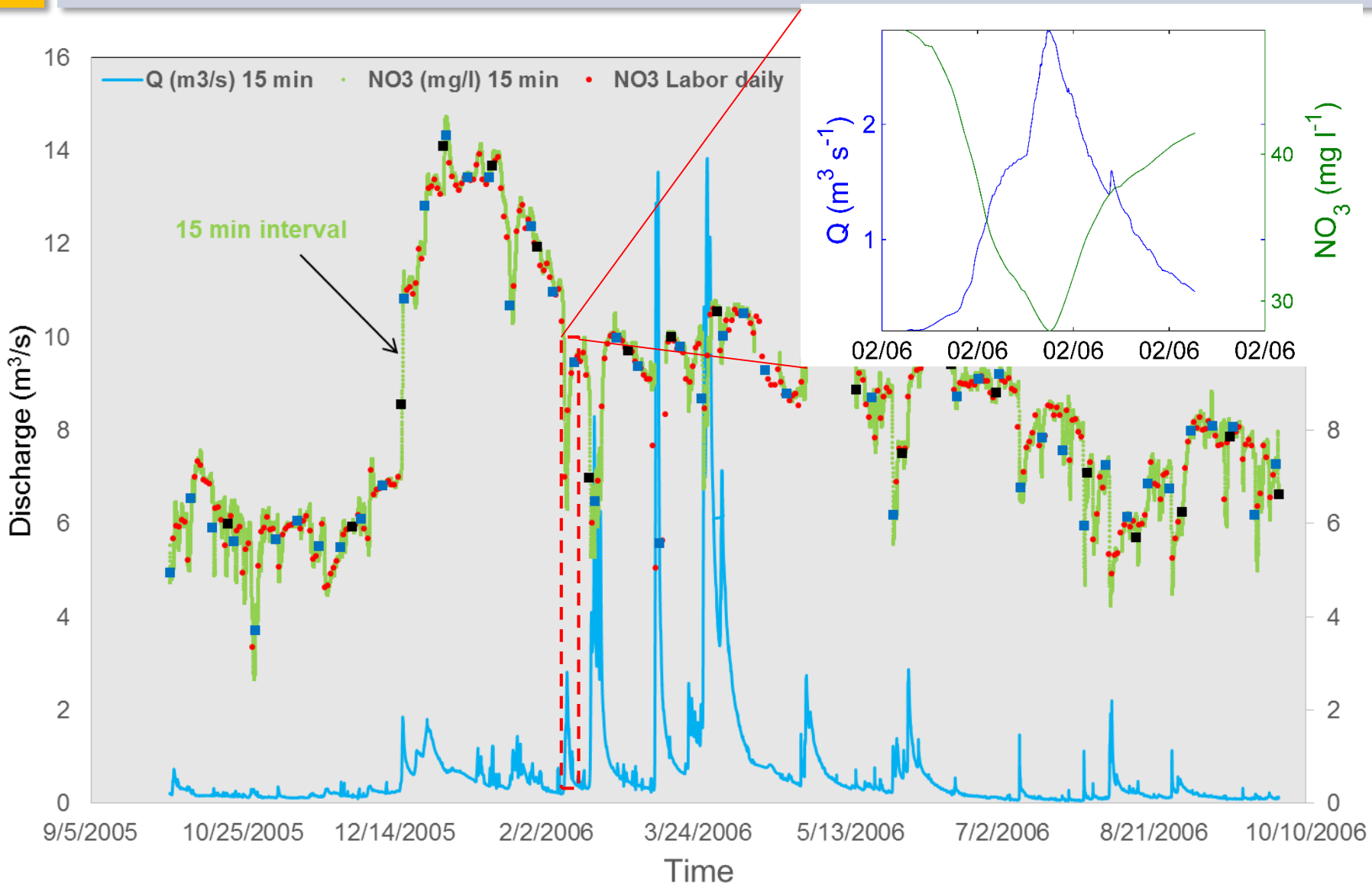
Weekly NO3


Q (m3/s) 15 min
NO3 (mg/l) Biweekly
NO3 (mg/l) Weekly
Discharge (m3/s)
0
2
4
6
8
10
12
14
16
9/5/2005
10/25/2005
12/14/2005
2/2/2006
3/24/2006
5/13/2006
7/2/2006
8/21/2006
10/10/2006
Time

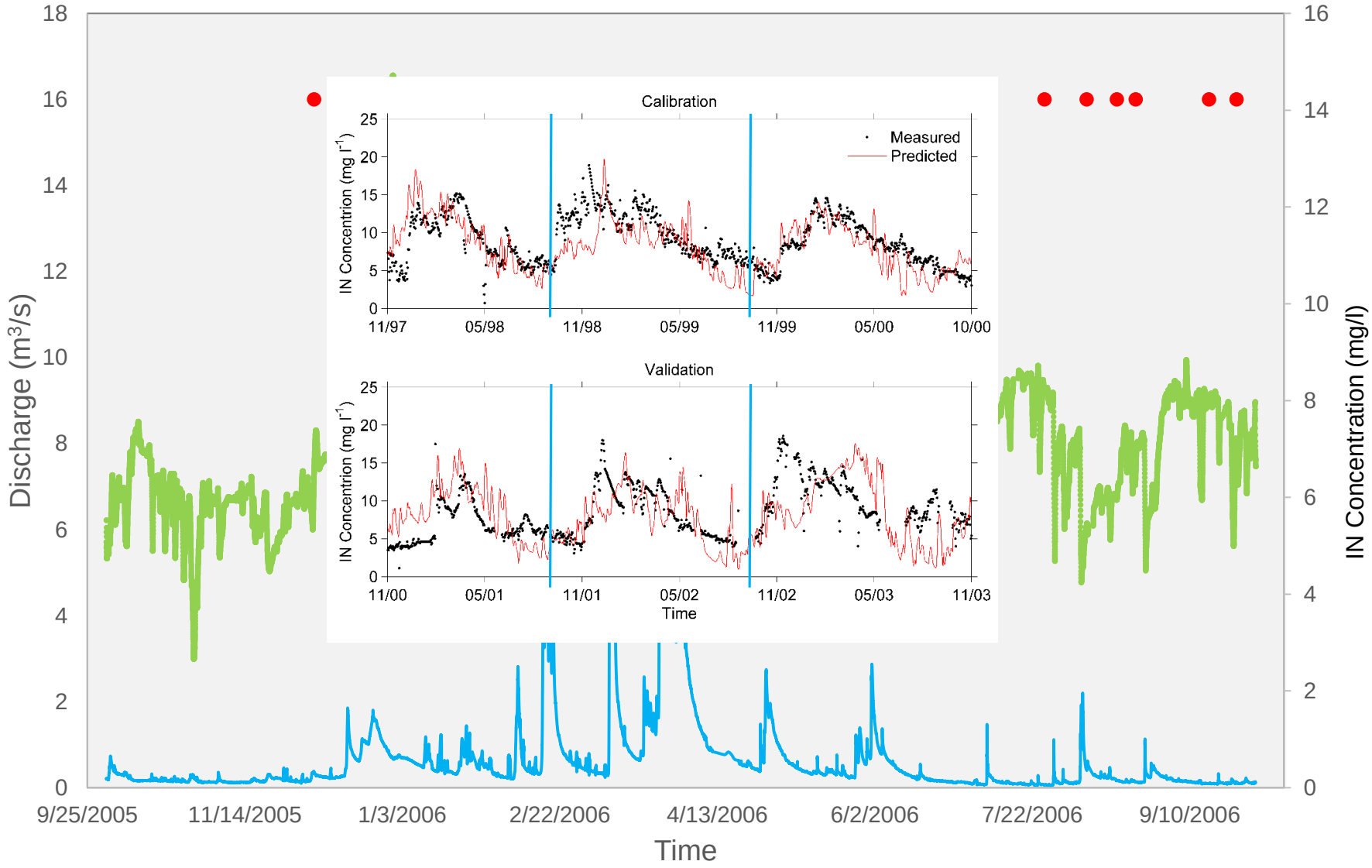
Daily NO3


Q (m3/s) 15 min
NO3 Labor daily
NO3 (mg/l) Biweekly
NO3 (mg/l) Weekly
Discharge (m3/s)
IN Concentration (mg/l)
0
2
4
6
8
10
12
14
16
9/5/2005
10/25/2005
12/14/2005
2/2/2006
3/24/2006
5/13/2006
7/2/2006
8/21/2006
10/10/2006
Time

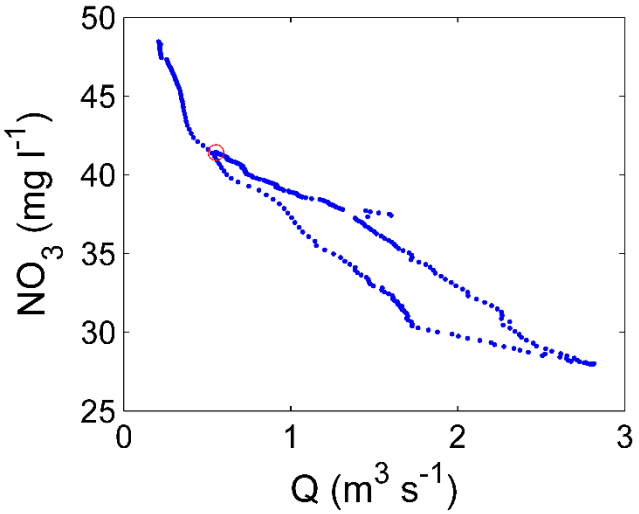
15 min interval

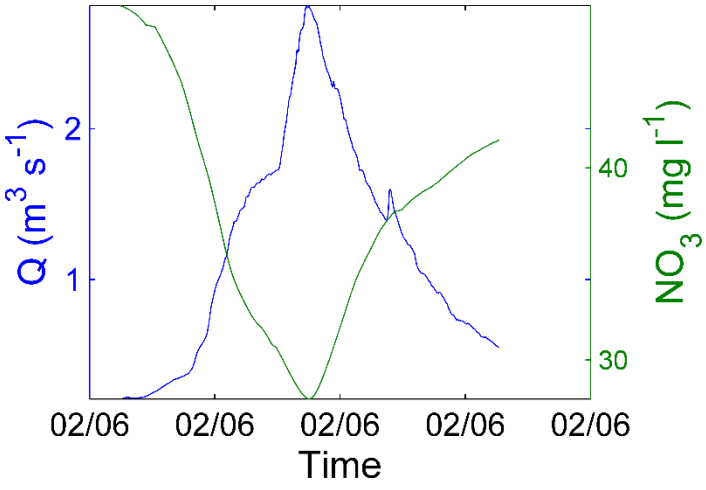


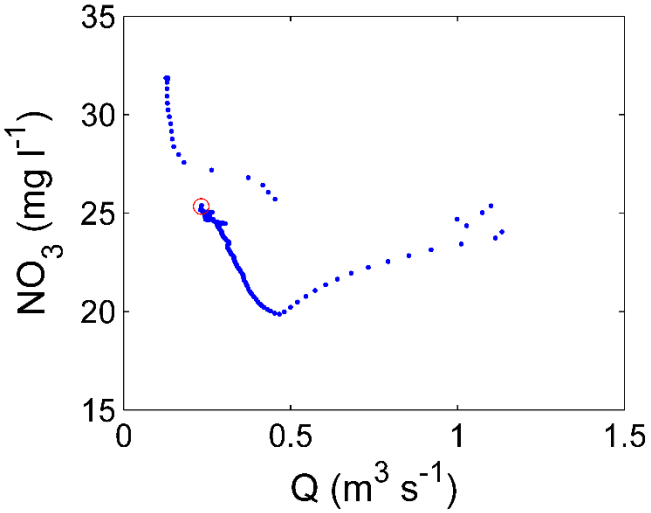
Selection of the events (31)

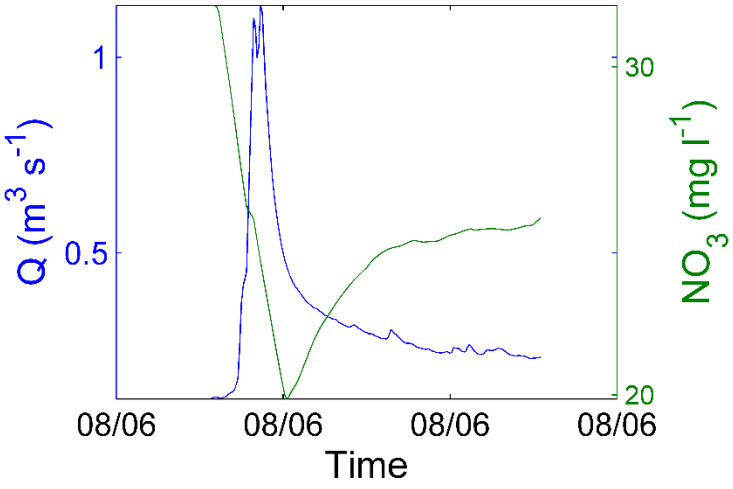


Events (Weida)









Explanatory variables

Discharge characteristics

- Discharge at start of event Qstart
- Max discharge during event Qmax
- Discharge change during event dQ
- Time to max discharge change TdQ
- Average slope rising discharge SQ
- Max slope raising discharge SQmax
- Time to max discharge slope TSQmax
- Recovery time discharge TQrec
- Total discharge Qtot
- Quick-flow percentage during event QFs
- Max quick-flow percentage during event QFmax
- Quick-flow percentage change event dQF

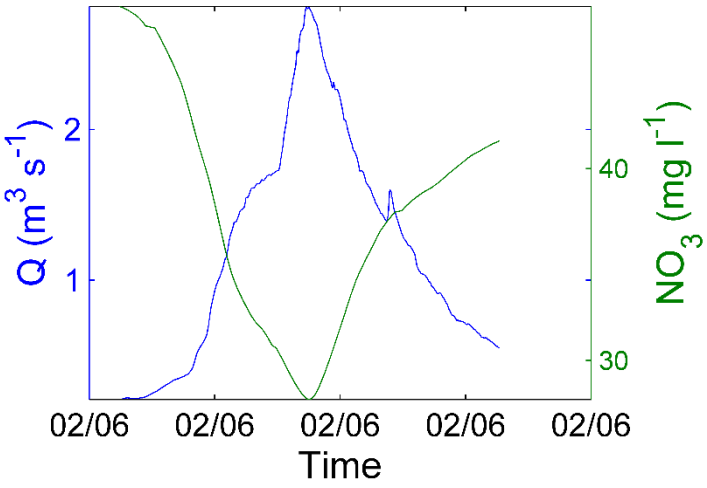
Rainfall characteristics

- Total rainfall Ptot
- Max rainfall intensity Pmax
- Antecedent precipitation index API

Explained variables

NO3 characteristics

- NO3 concentration at start of event NS
- NO3 minimum concentration during event Nmin
- NO3 relative concentration change during event rdN
- Time to max NO3 concentration change TdN
- Recovery time NO3 TNrec



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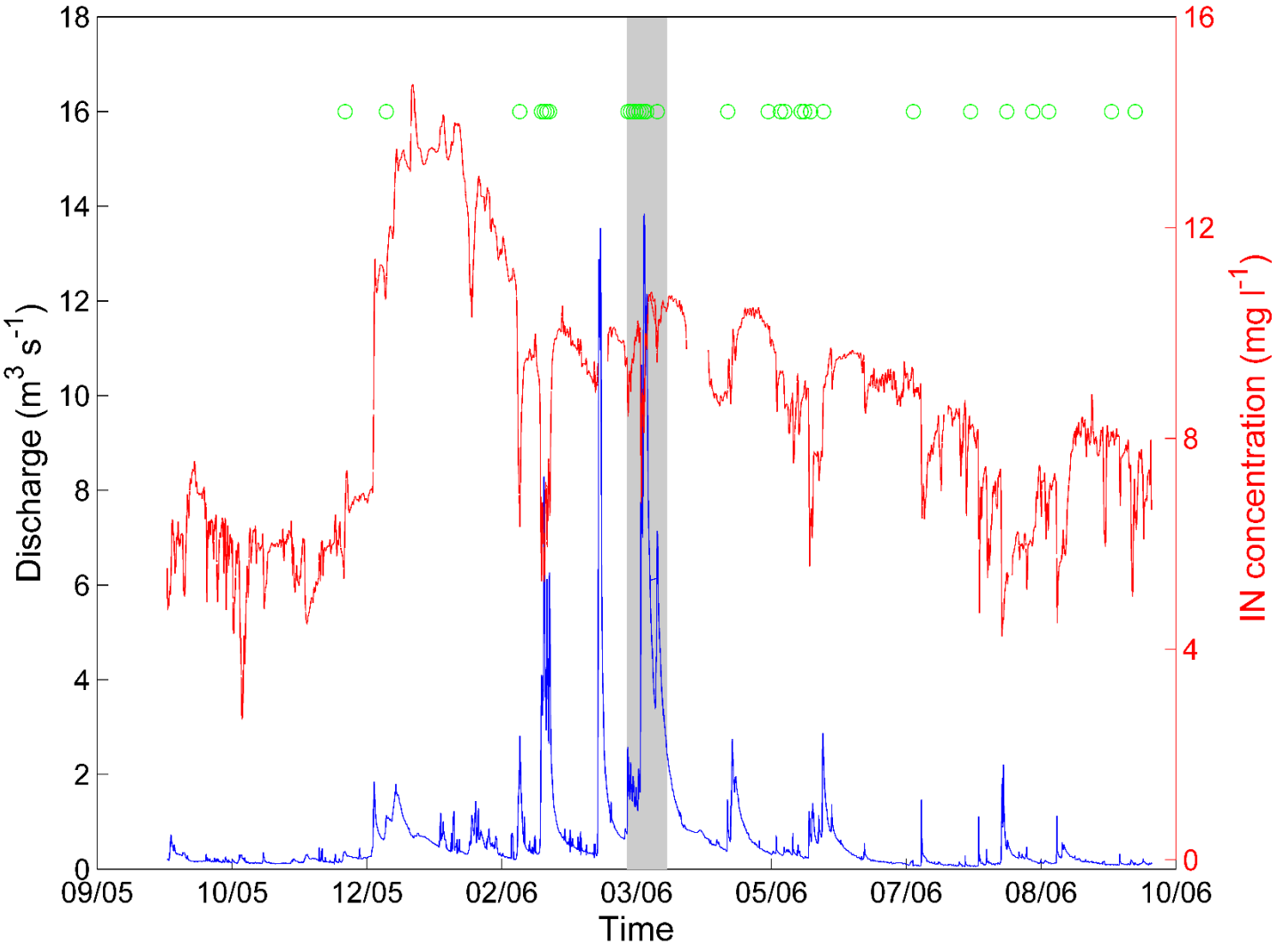
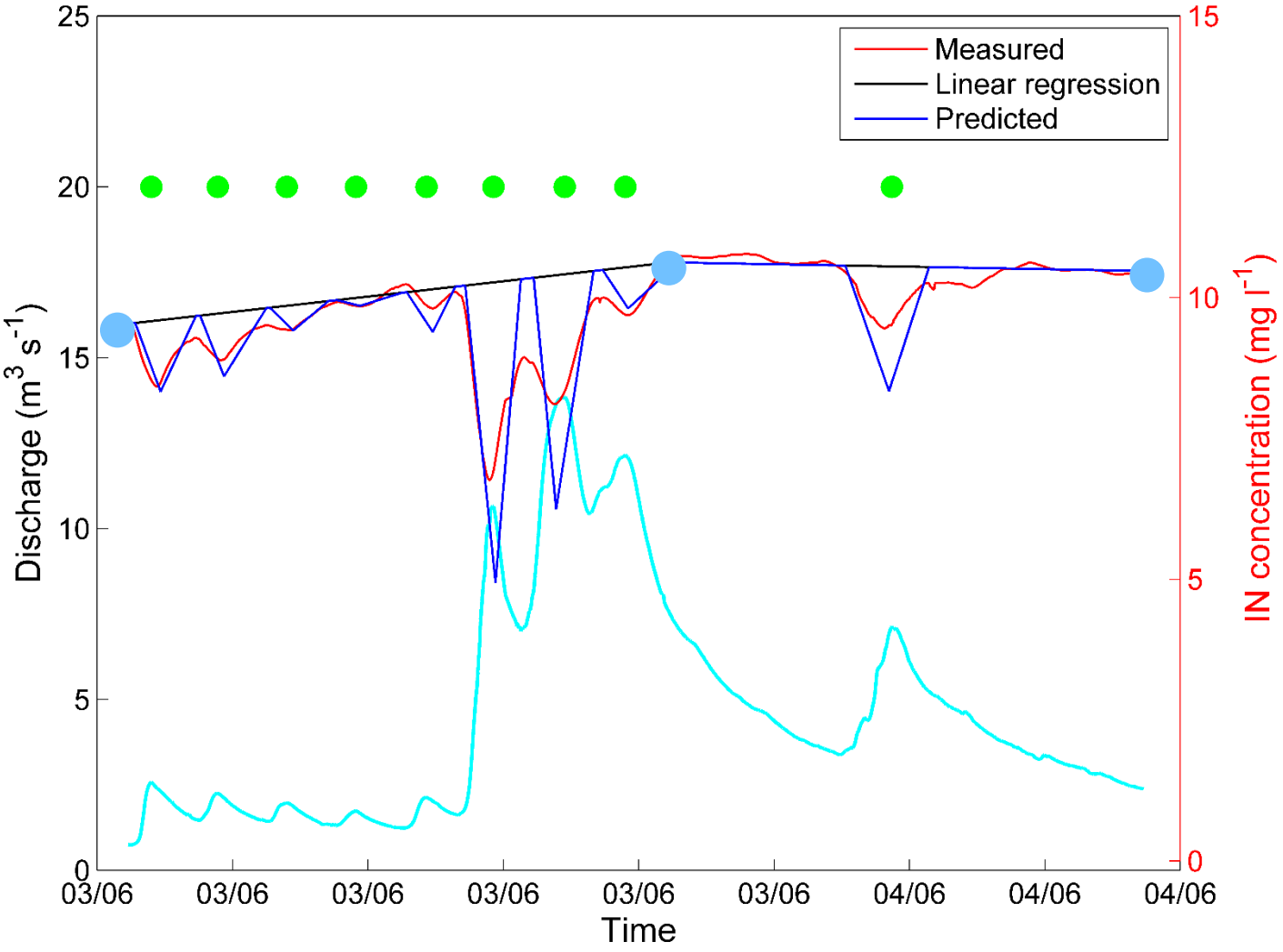
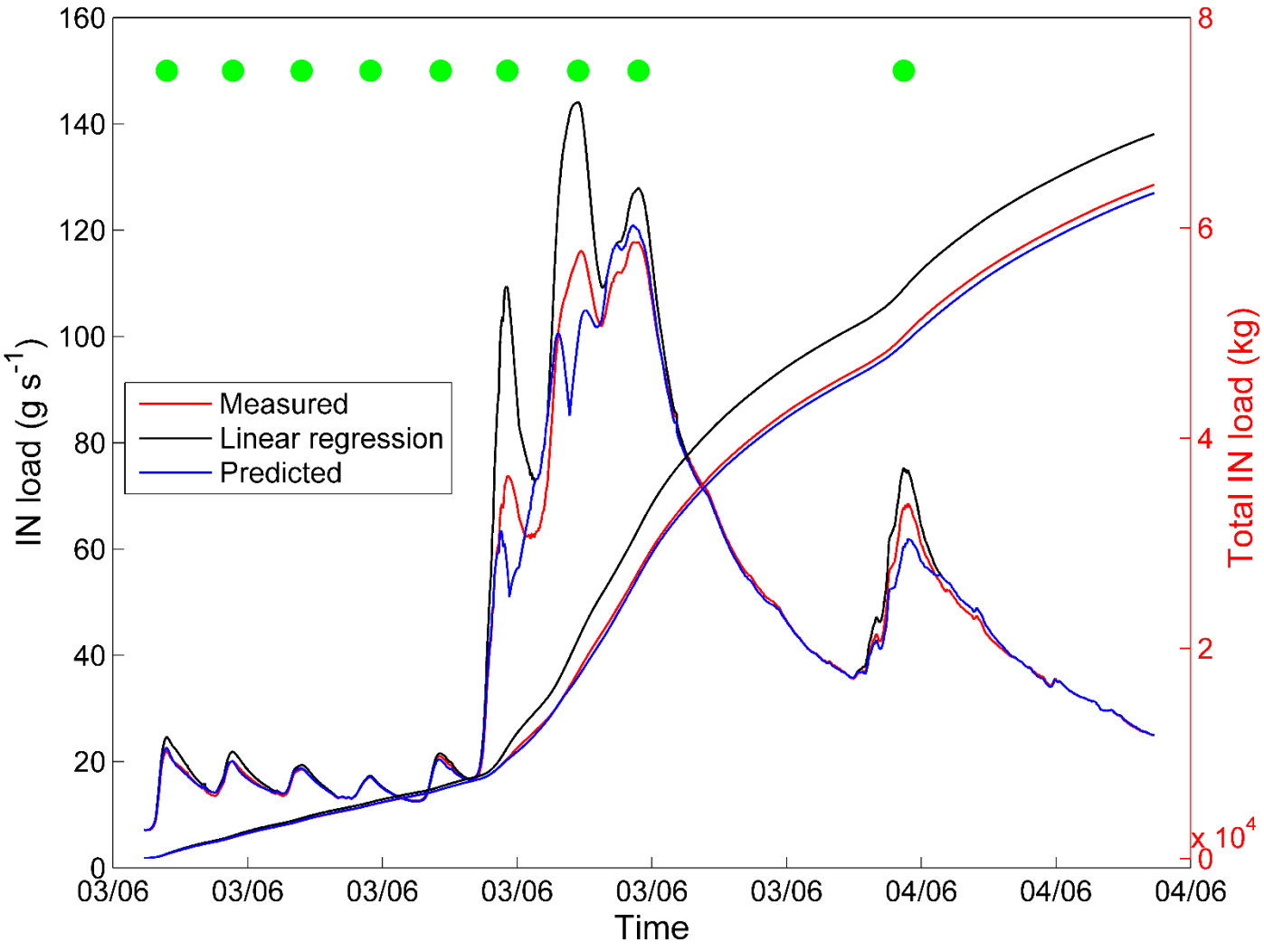
Calibration and validation events



Validation (9 events in 2 weeks)



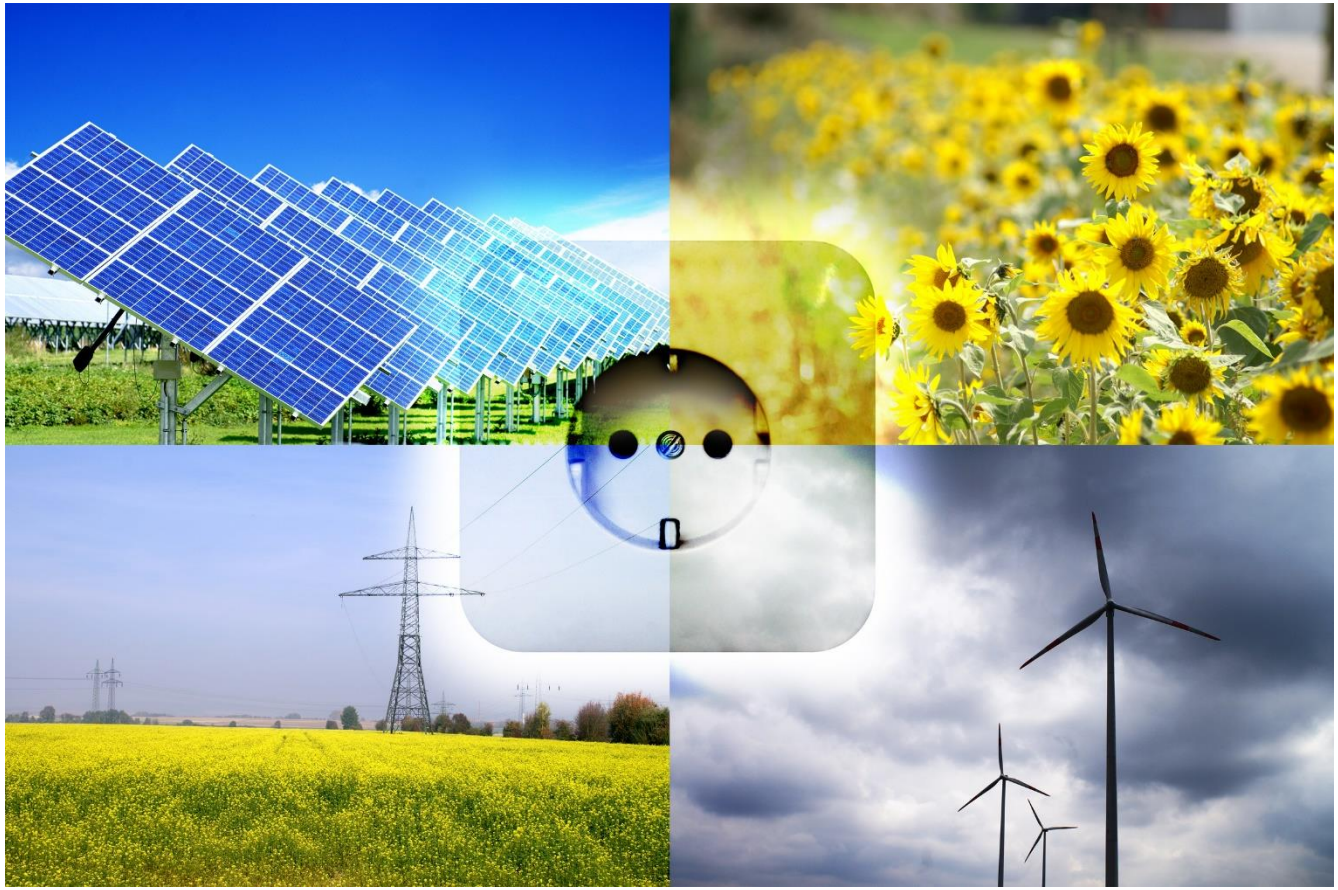
Validation (IN load in 2 weeks)



Conclusions and perspectives

- HYPE model was successfully validated;
- Catchment characteristics are the most controlling factors;
- Event Response Reconstruction approach is a promising technique for load estimates;
- Try to validate further the ERR approach to other sub-catchments such as Meisdorf,
- Test the ERR approach in dominant point source catchment.

Thank you for your attention



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