Christian-Albrechts-Universität zu Kiel

How to improve the representation of nitrate processes and their dynamics in eco-hydrological models?

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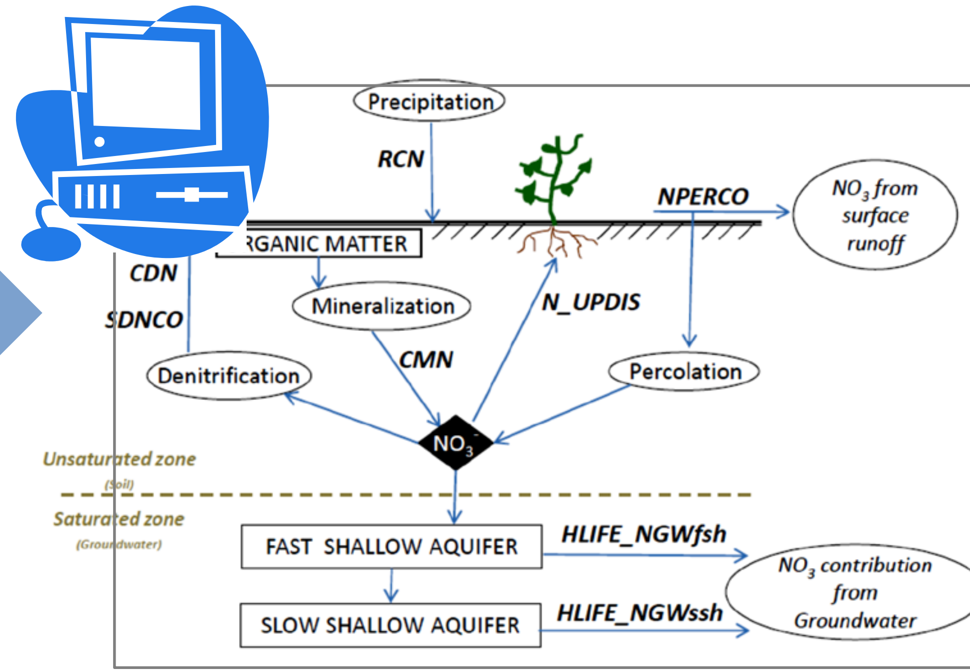
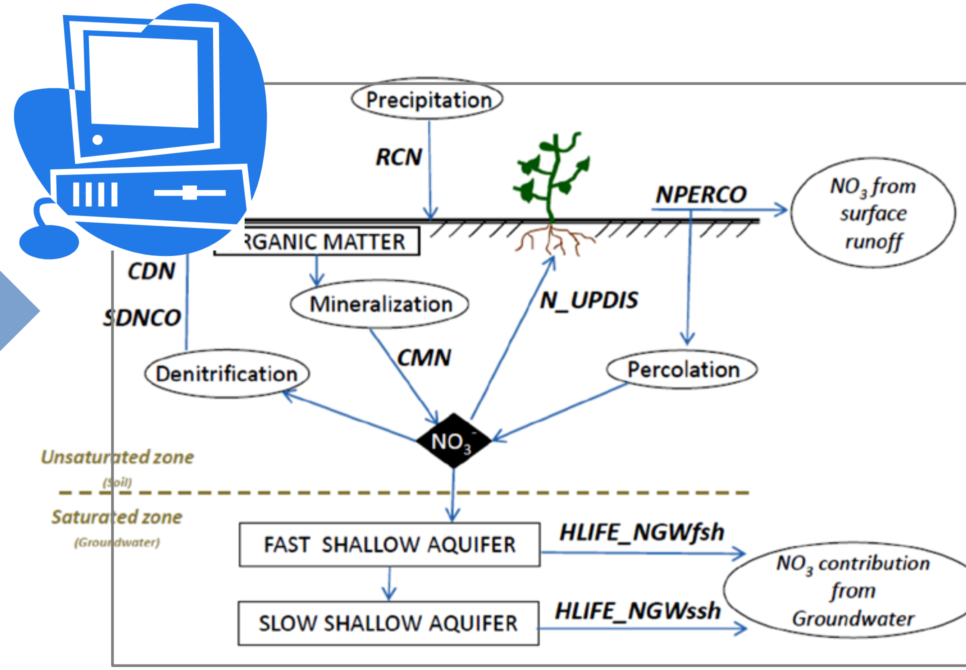
Motivation



- Nitrate entry in water bodies is one of the most pressing problems in agricultural watersheds.
- The process representation is highly complex and needs a sound parametrisation to develop realistic BMP‘s

Motivation

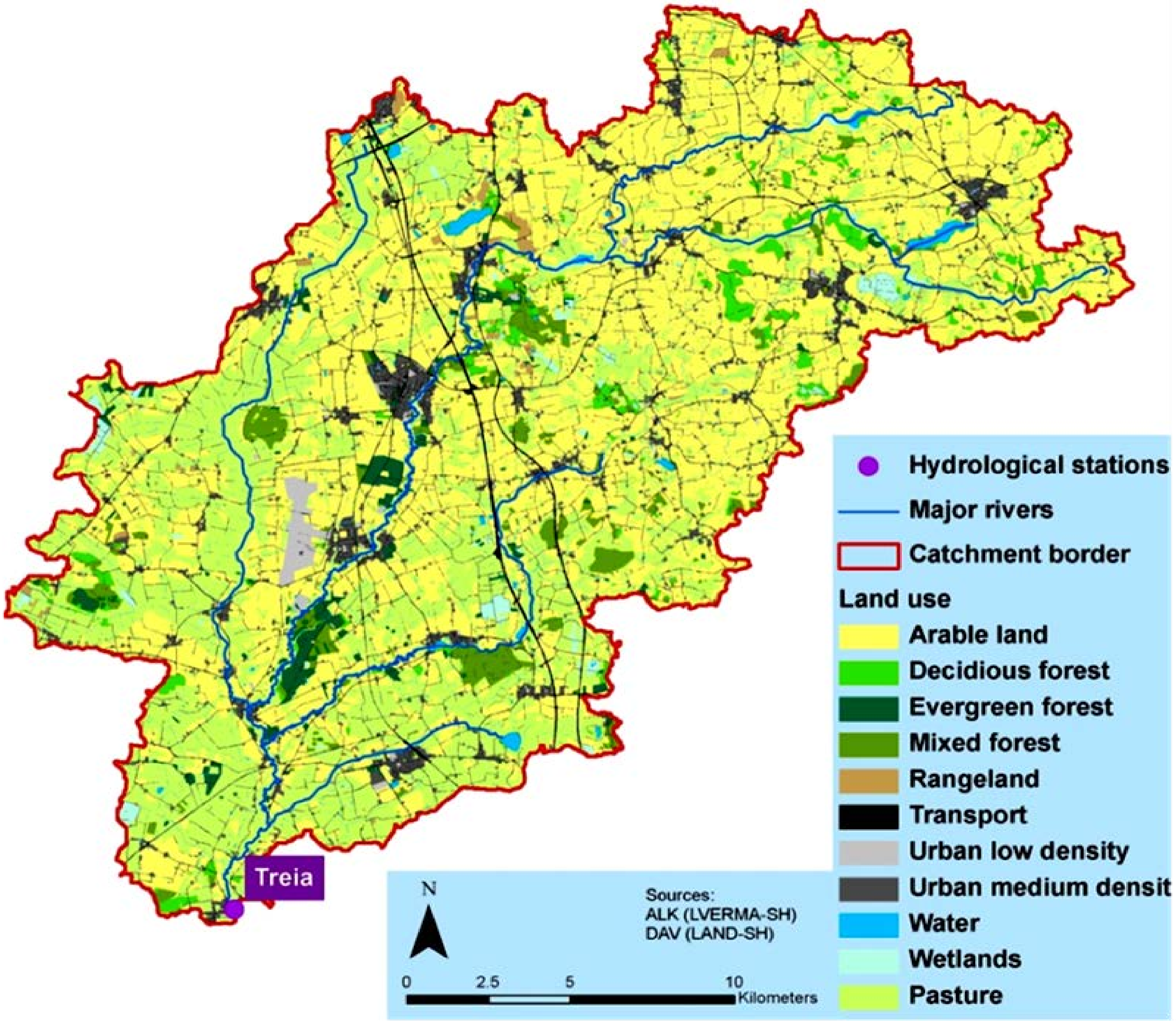


- Improved understanding of nitrate process representation by
  - Temporal sensitivity analysis of nitrate parmameters
  - Simultaneous calibration of runoff and nitrate processes
  - Adding information to the calibration process by using FDG and NDC

Test catchment: Treene river in Northern Germany

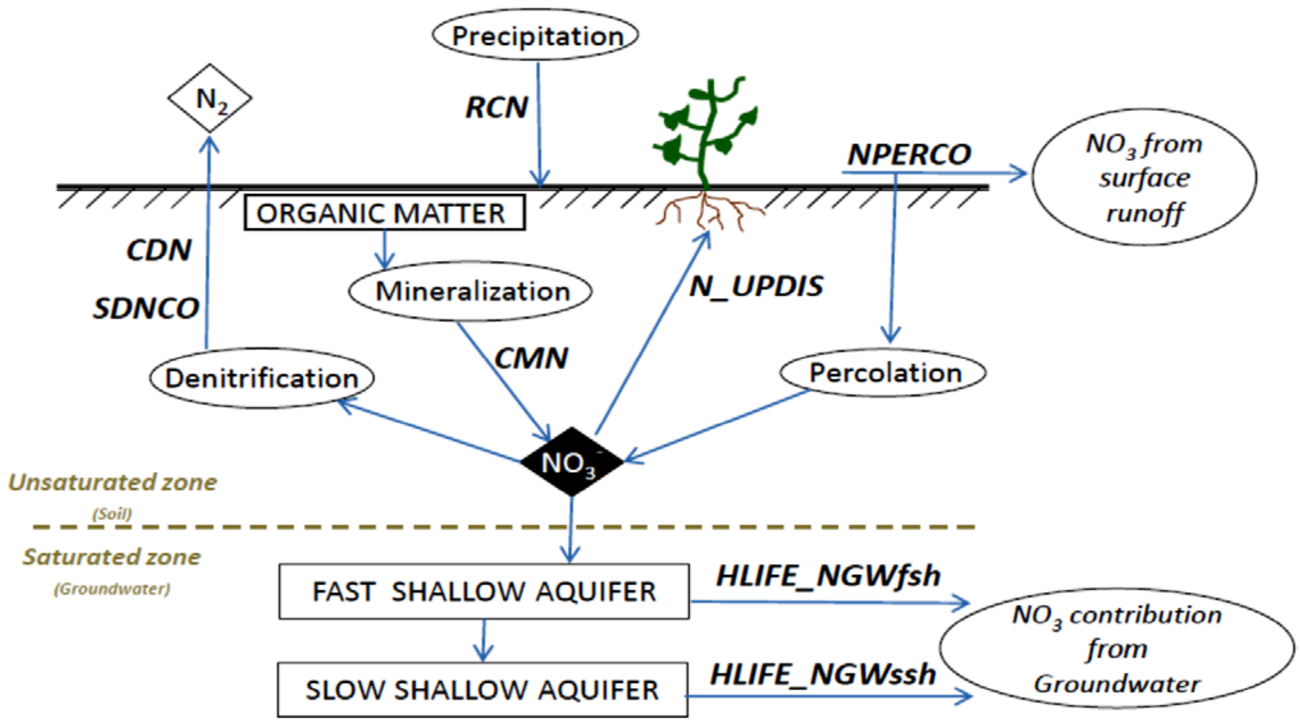
- 481 km²
- Treia
- Lowland catchment

- Dominated by agricultural land use



Quelle: LVERMA, 2004. *Aus Guse et al. (2014), adapt. von Haas (2015).*

Nitrate cycle in the SWAT-Model



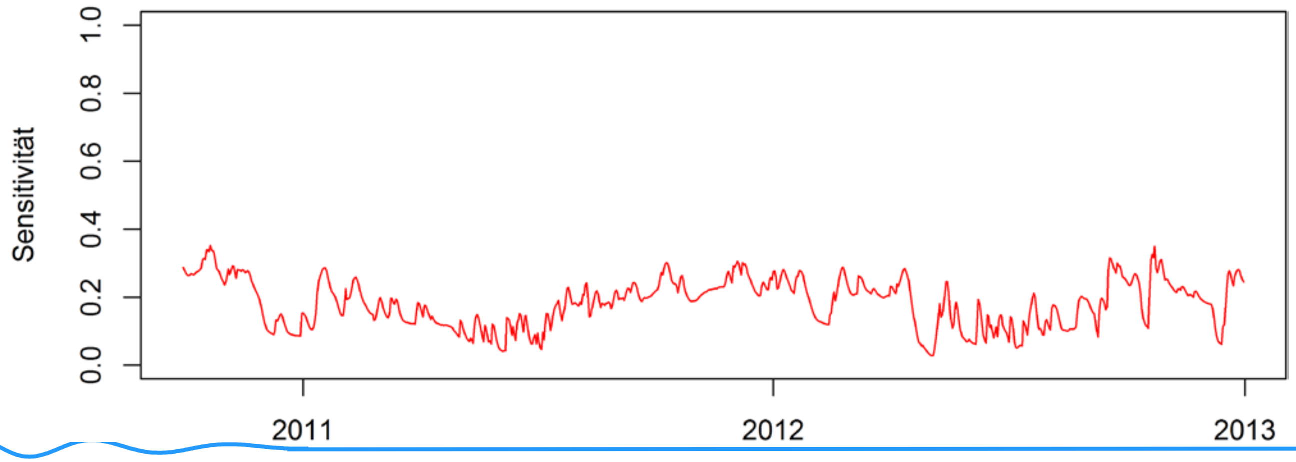
PARAMETER NAME	CODE
Concentration of nitrogen in rainfall	RCN
Nitrate percolation coefficient	NPERCO
Denitrification exponential rate coefficient	CDN
Denitrification threshold water content	SDNCO
Rate factor for humus mineralization of active organic nitrogen	CMN
Nitrogen uptake distribution parameter	N_UPDIS
Half-life of nitrate in shallow aquifer	HLIFE_NGWfsh
Half-life of nitrate in shallow aquifer	HLIFE_NGWssh

Haas et al. (2015).

TEMPORAL SENSITIVITY ANALYSIS

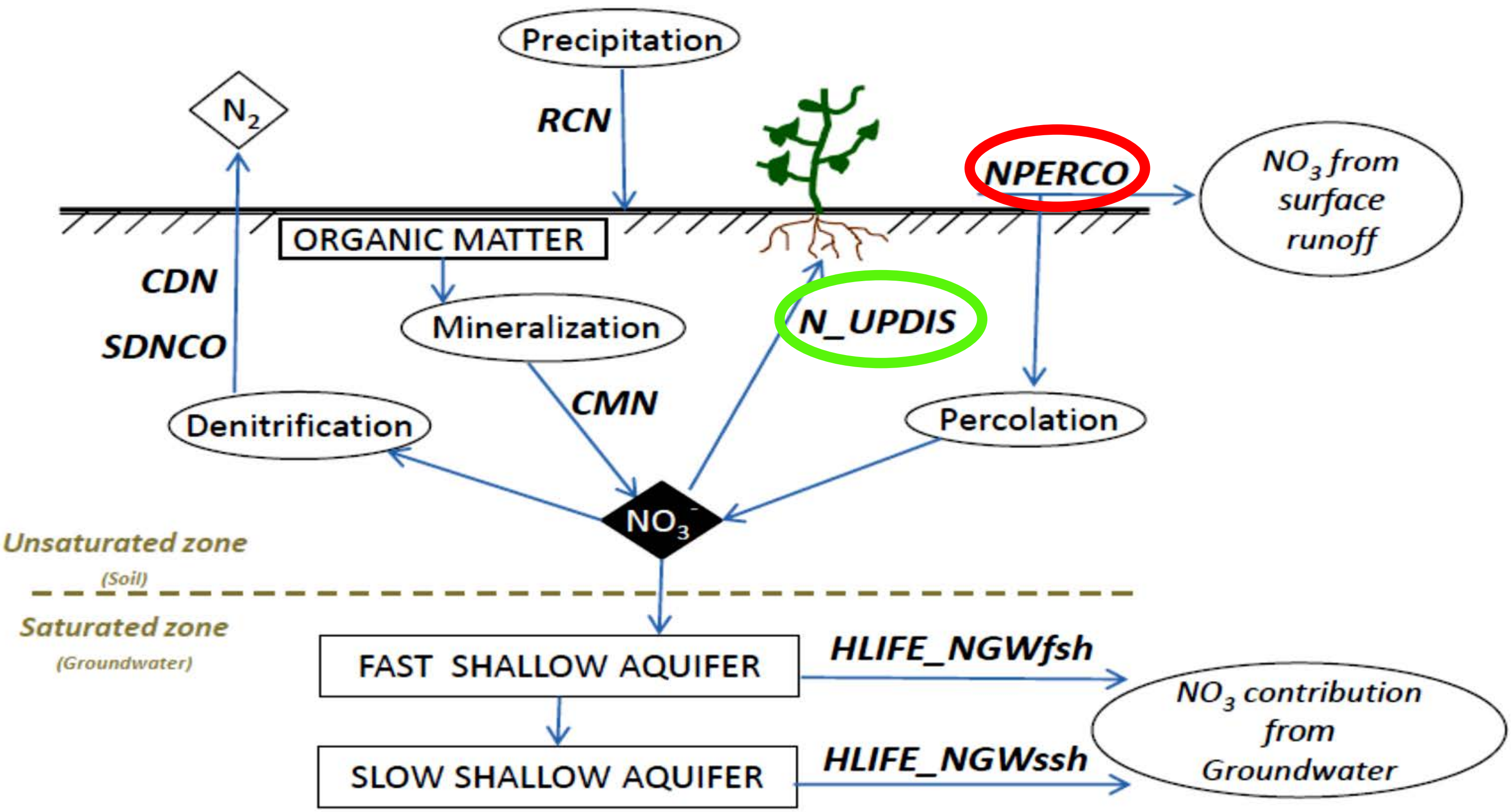
Temporal dynamics of nitrate prameters in a daily resolution

- Temporal dynamics of parameter sensitivity (TEDPAS), (Reusser et al., 2011; Guse et al., 2014)
  - Identification of the dominant nitrate parameter/process for every day
  - Global sensitivity analysis with the FAST-Method (Fourier amplitude sensitivity testing)
  - Sensitivity varies between 0 and 1

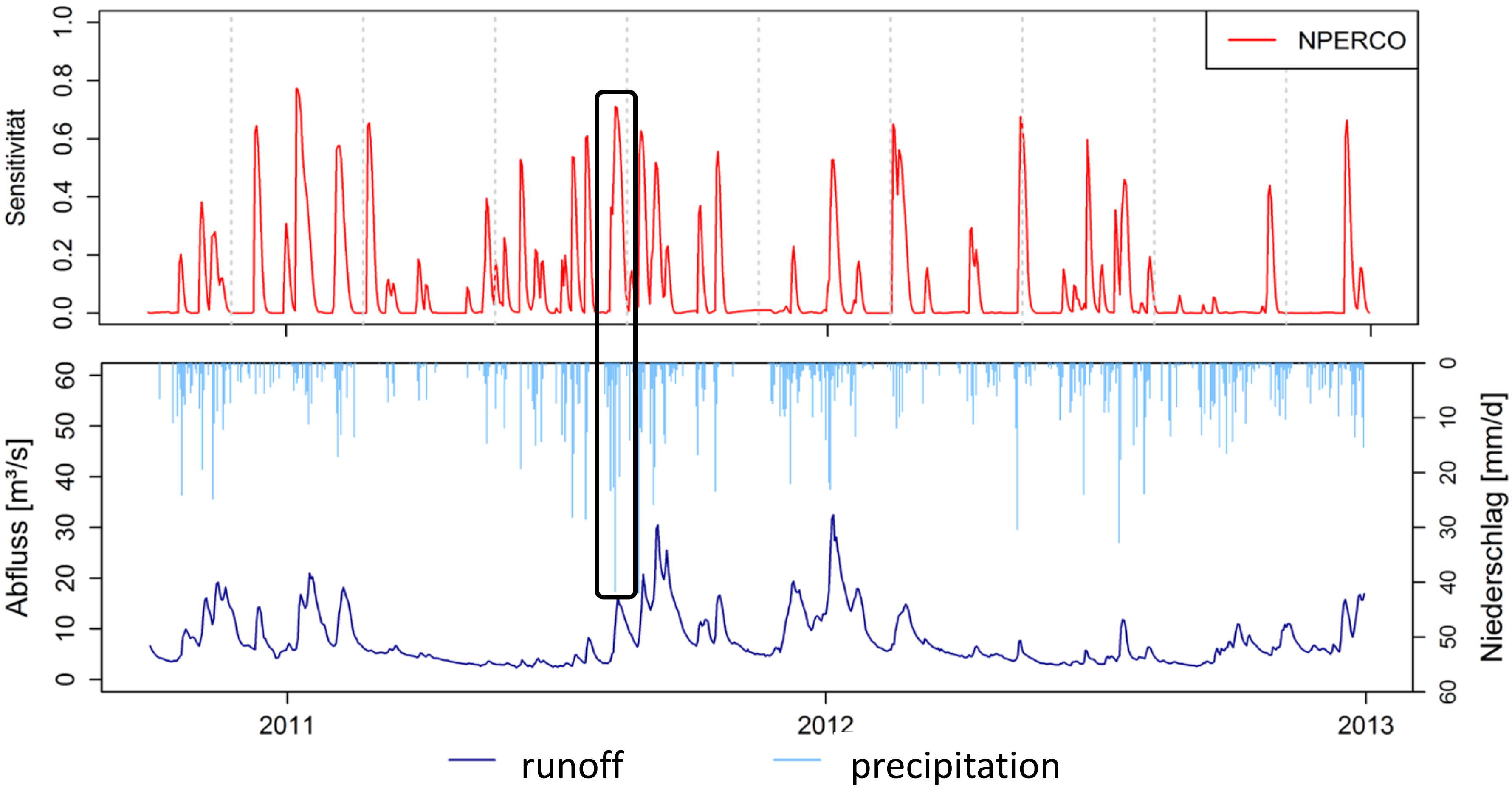


Nitrate percolation coefficient (NPERCO) and uptake by plants (N_UPDIS)

- NPERCO controls the share of seepage of nitrate and the share in surface runoff. N_UPDIS controls the plant uptake from the soil.



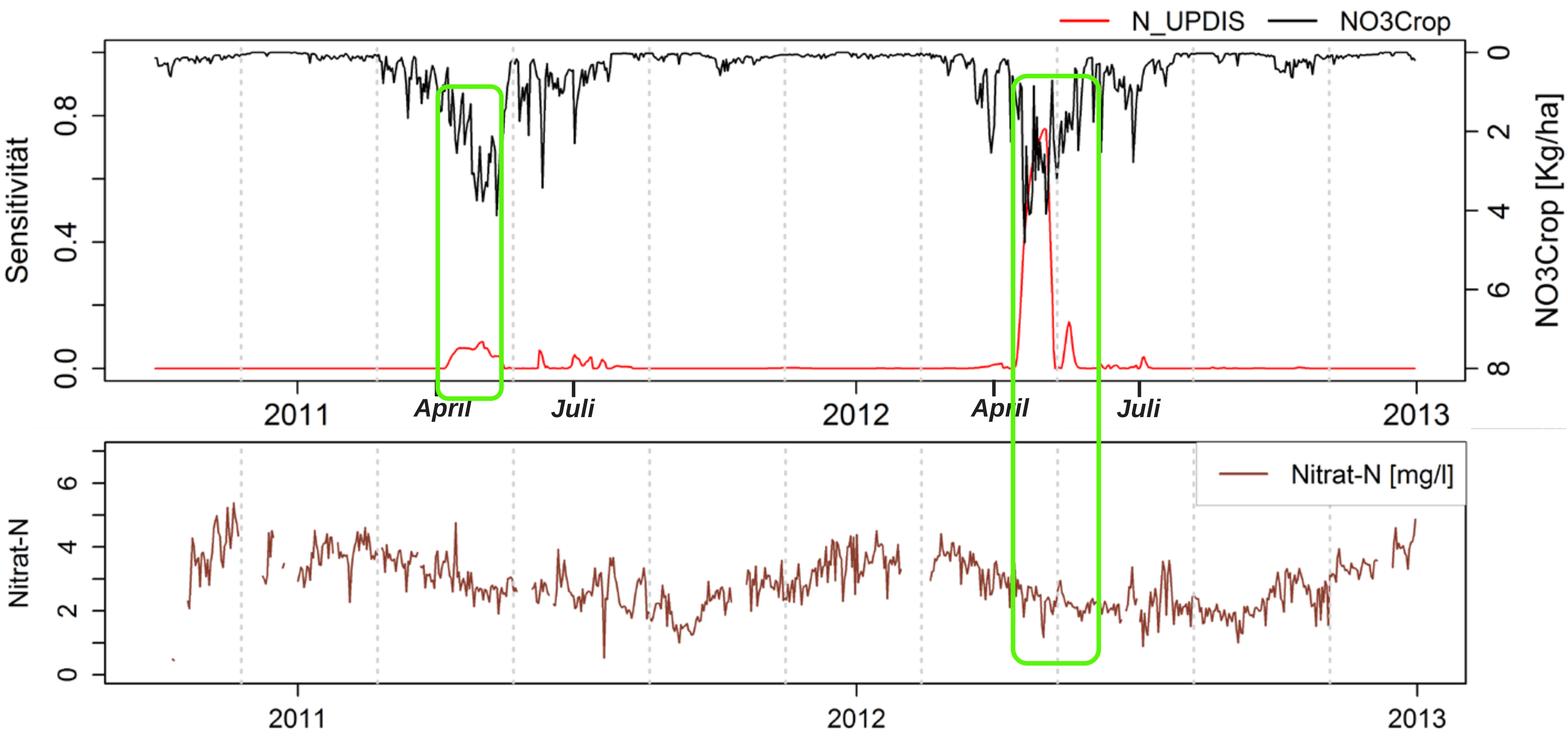
Temporal sensitivity of NPERCO (daily)



The sensitivity of NPERCO is linked to the rainfall/runoff pattern and is sensitive over all seasons

Aus Haas et al. (2015).

Daily sensitivity of N_UPDIS and Nitrate uptake of plants (*NO3Crop*)

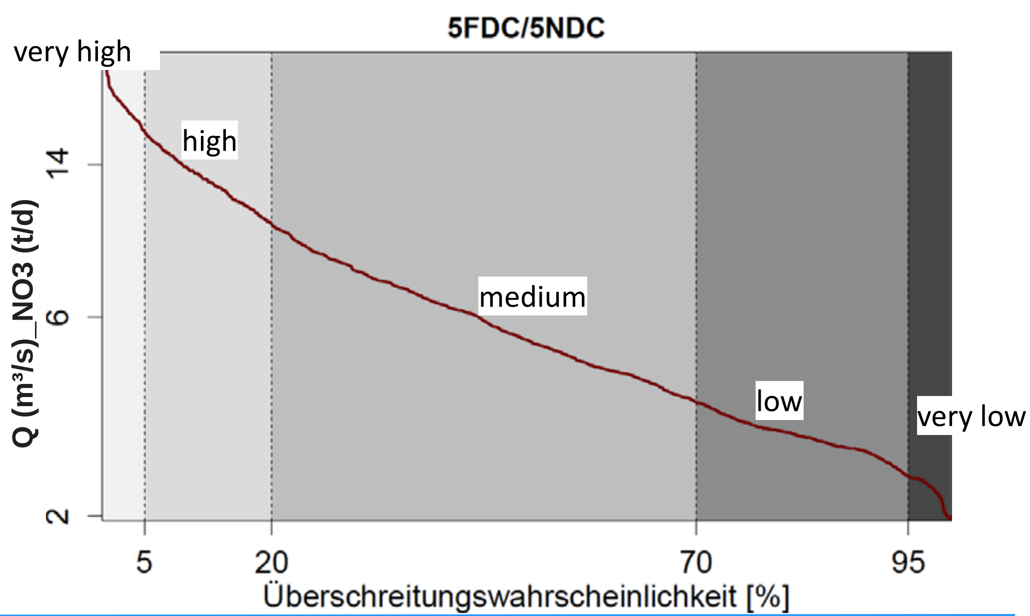


N_UPDIS is linked to plant growth and thus shows a strong seasonality.

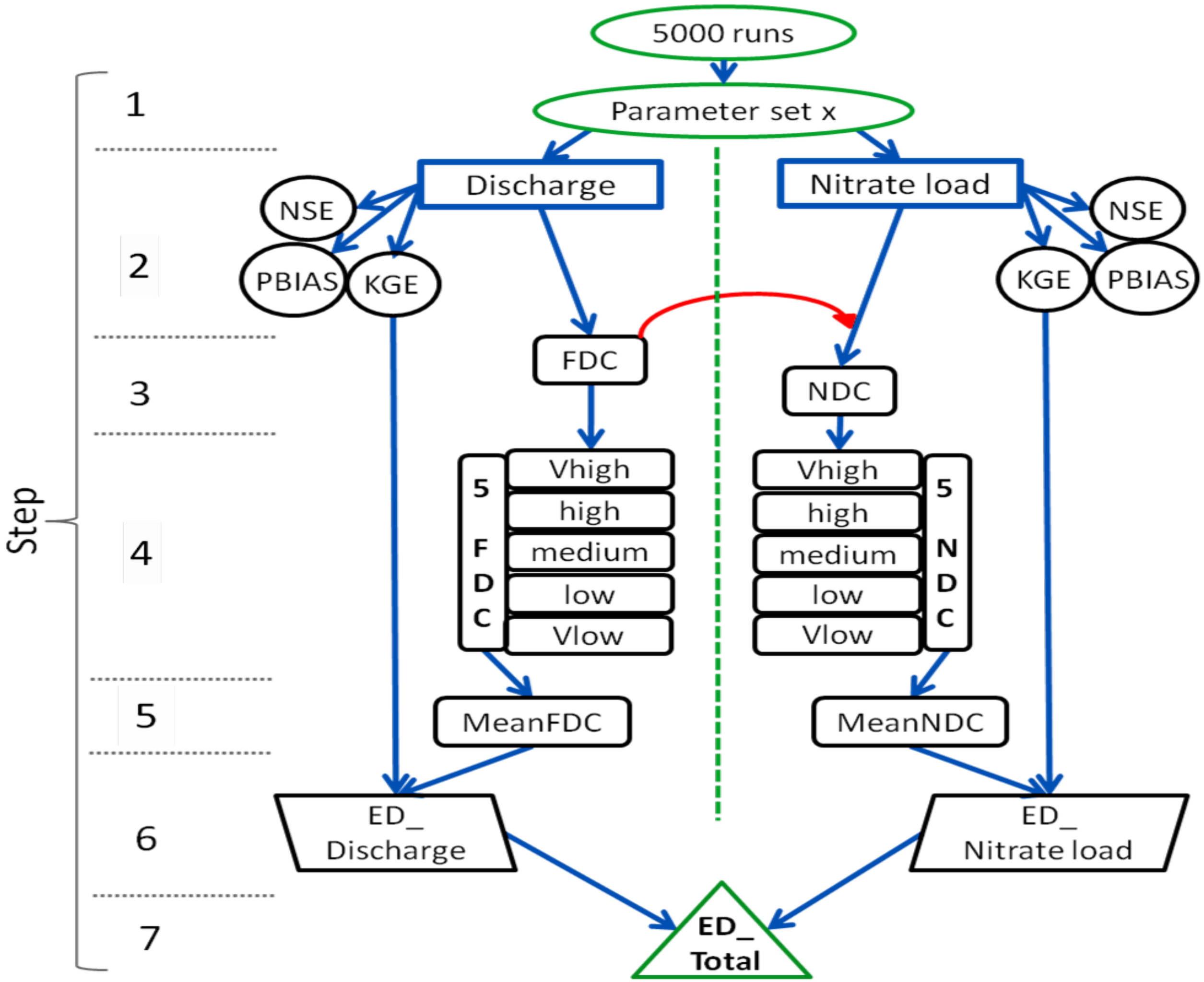
IMPROVED CALIBRATION PROCEDURE

Multivariable und multi-criteria calibration

- **<u>Multivariable</u>**: runoff + nitrate at the same time
- **<u>Multi-criteria</u>**: classical model efficiency measures + signature measures
- Flow duration curve (FDC) and nitrate duration curve
- (NDC)
  - **5FDC** Method (Pfannerstill et al., 2014):
    - Separate evaluation for every FDC segment
  - **5NDC** Method (Haas et al., 2016):
    - Efficiency measure calculated for every NDC segment



Multi-variable und multi-criteria calibration

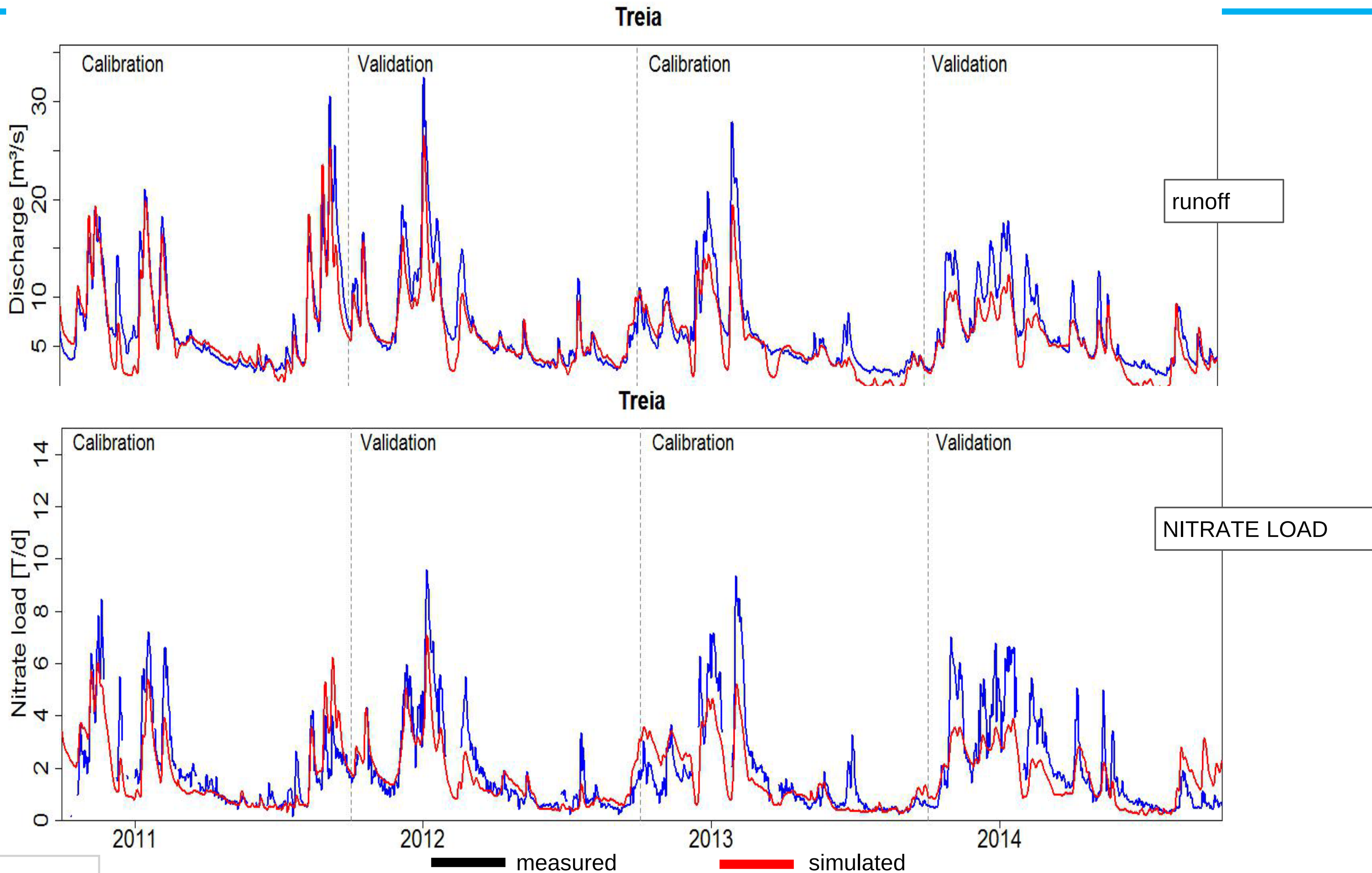


Haas et al. (2016, J.Hydrol.)

KGE = Kling-Gupta Efficiency (Gupta et al., 2009)

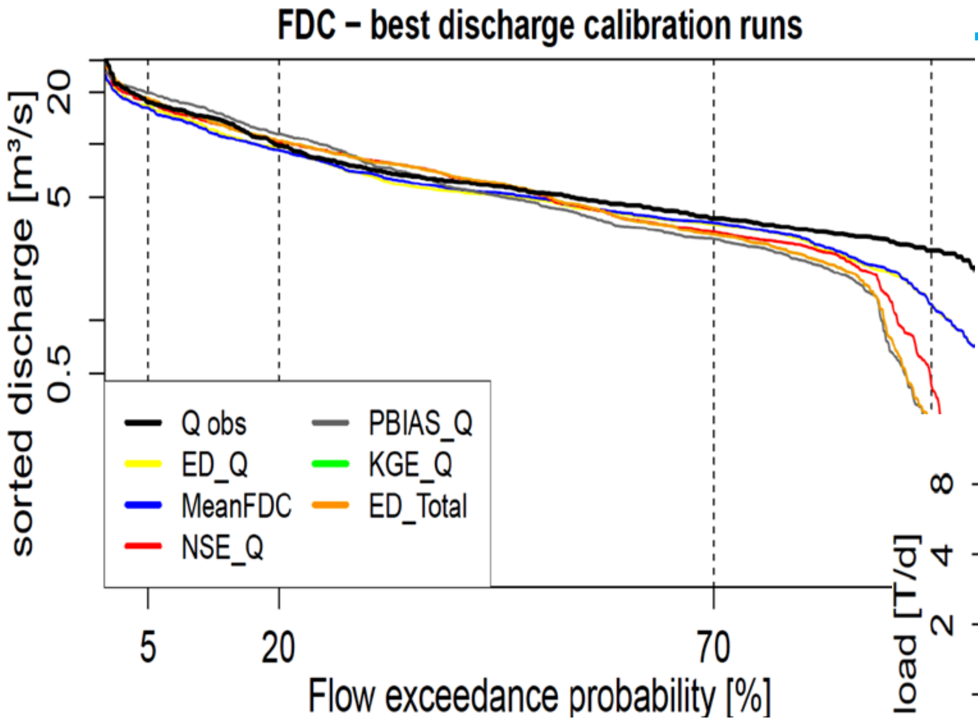
ED = Euklidic Distance

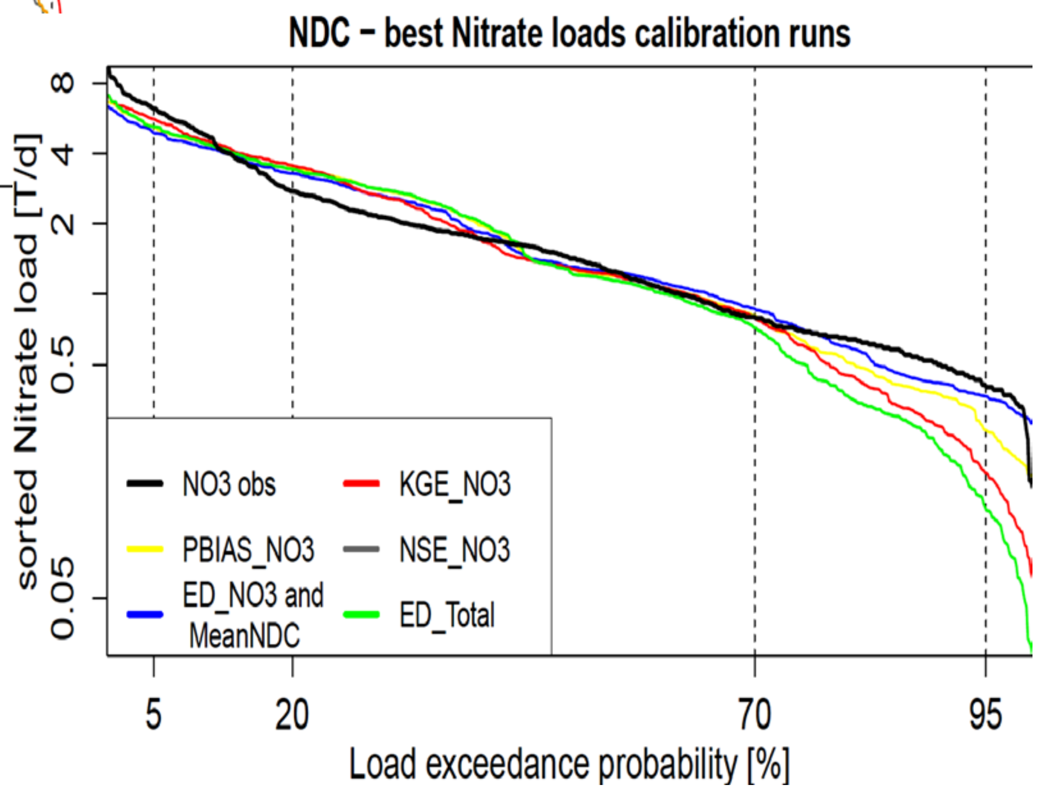
Best model (ED_Total) for runoff and nitrate load



Haas et al. (2016, J.Hydrol.)

Best model runs

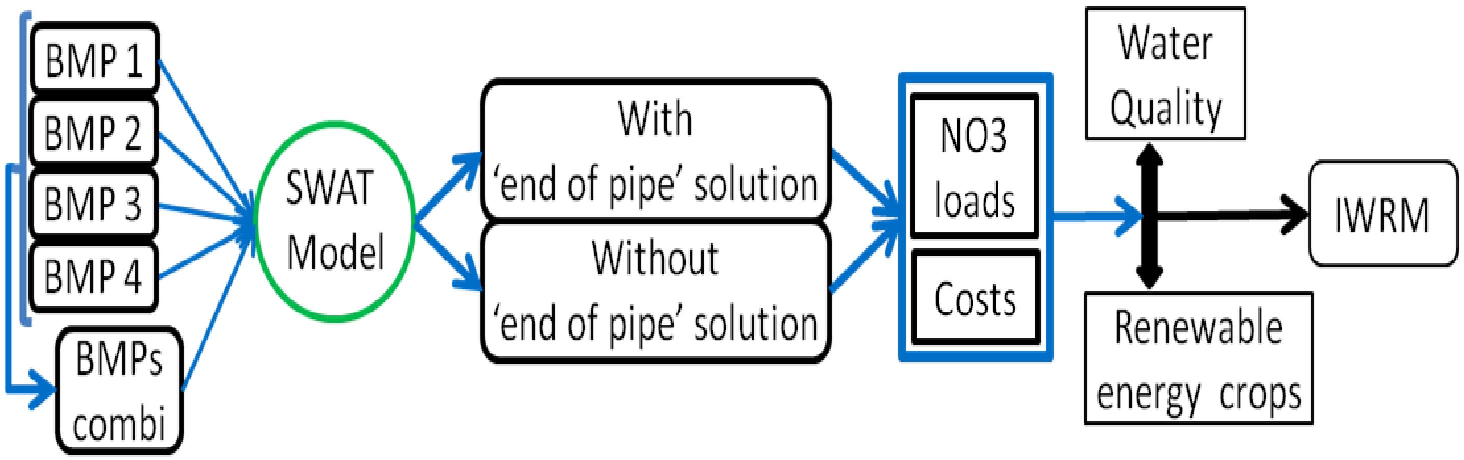




Haas et al. (2016, J.Hydrol.)


TEMPORAL ANALYSIS OF BMP‘S

Analysis of BMPs



Haas et al., 2017, JEMA

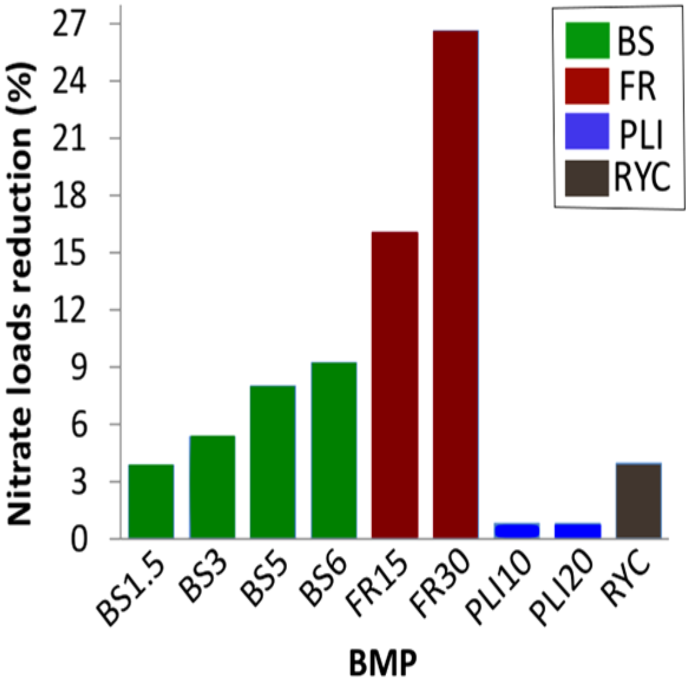
Reduction of nitrate by single BMPs

- Simulated BMPs
  - *Buffer strips* (BS)
    - 1,5 m; 3 m; 5 m; 6 m

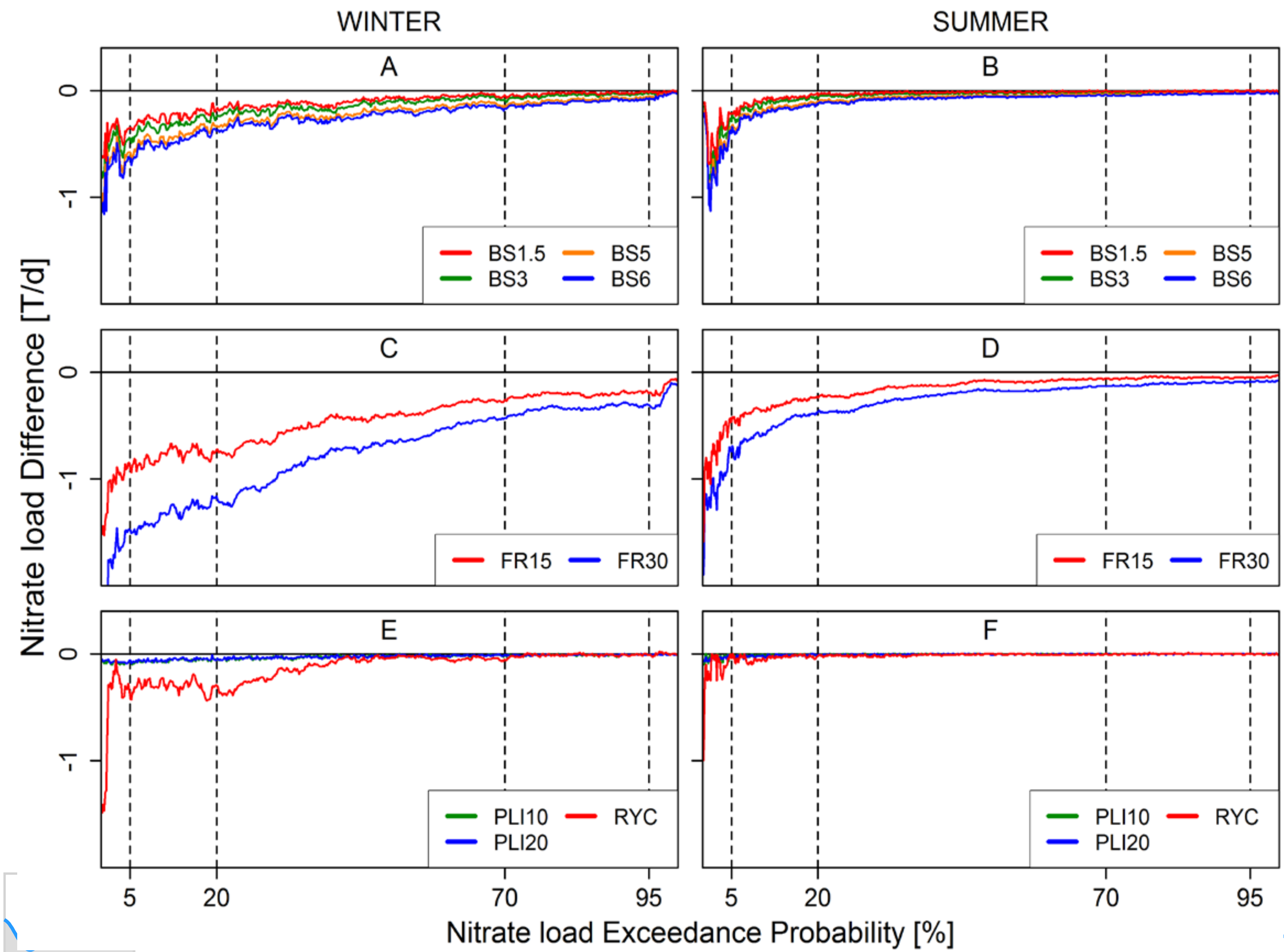
  - *Reduction of fertilizer* (FR)
    - -15% and -30%

  - *Increase of pasture* (PLI)
    - +10% and +20%

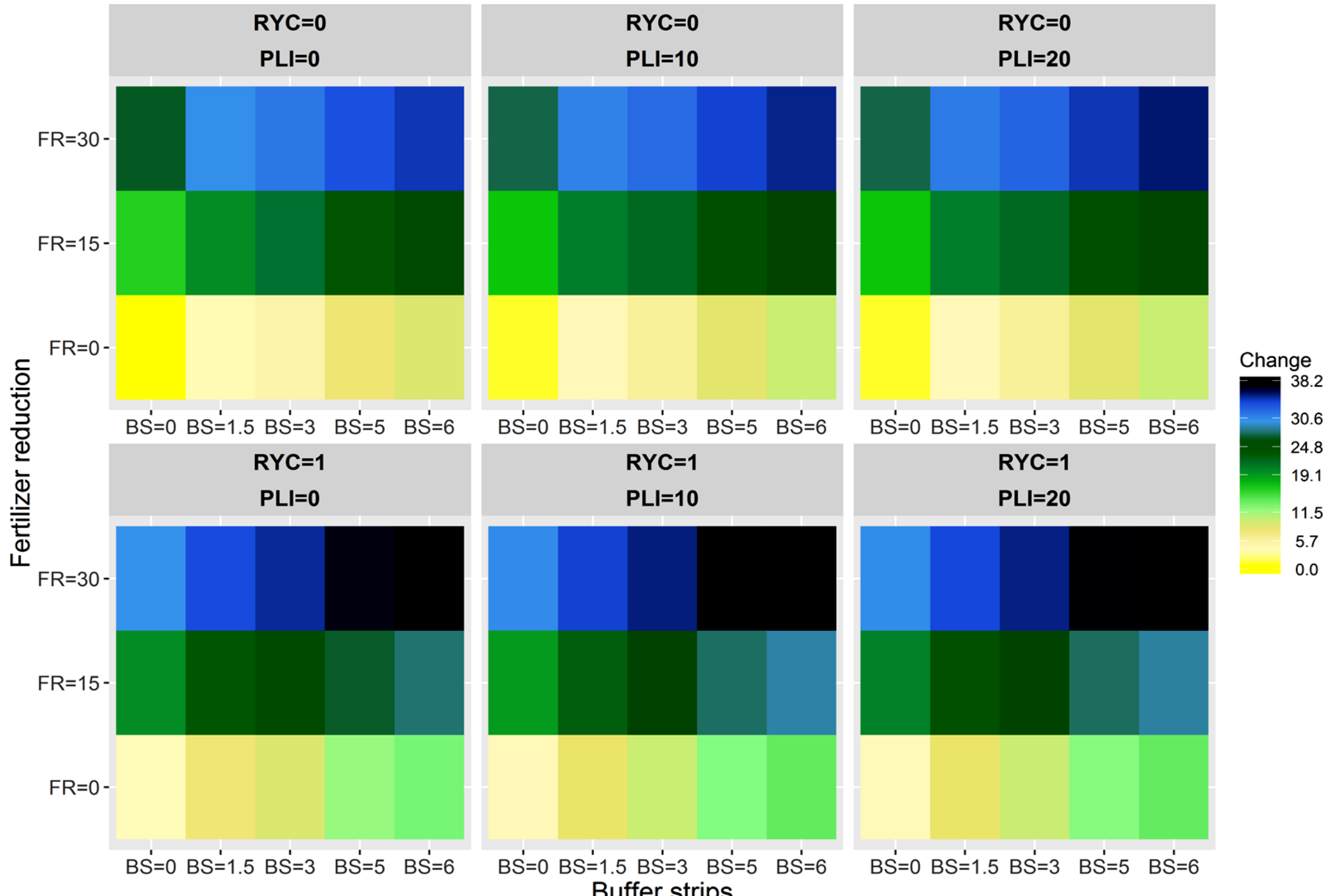
  - *less silage mais* (RYC)
    - -50%



Seasonal reduction of nitrate loads caused by BMP‘s



BMP combination matrix






BS = buffer strips	**FR** = fertilizer reduction	**PLI** = increase pasture	**RYC** = Alternative crop rotation

TEMPORAL ANALYSIS OF BMP'S

Main messages

- TEDPAS helps to identify WHEN a parameter is sensitive
- The application of different performance measures + signature measures (FDG/NDG) leads to a more balanced calibration
- NDC can be used to analyse the efficiency of BMPs
- Combination matrices of BMP's can support desicion making

Thank you for your attention!

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Haas, M., B. Guse and N.Fohrer, (2017): Assessing the impacts of Best Management Practices on nitrate pollution in an agricultural dominated lowland catchment considering environmental protection versus economic development. Journal of environmental management Volume: 196 Pages: 347-364 Published: 2017-Jul-01

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