



Uncertainty assessment of water flow and nutrient **Loads** under future **Climate Change** **Conditions (UnLoadC³)**

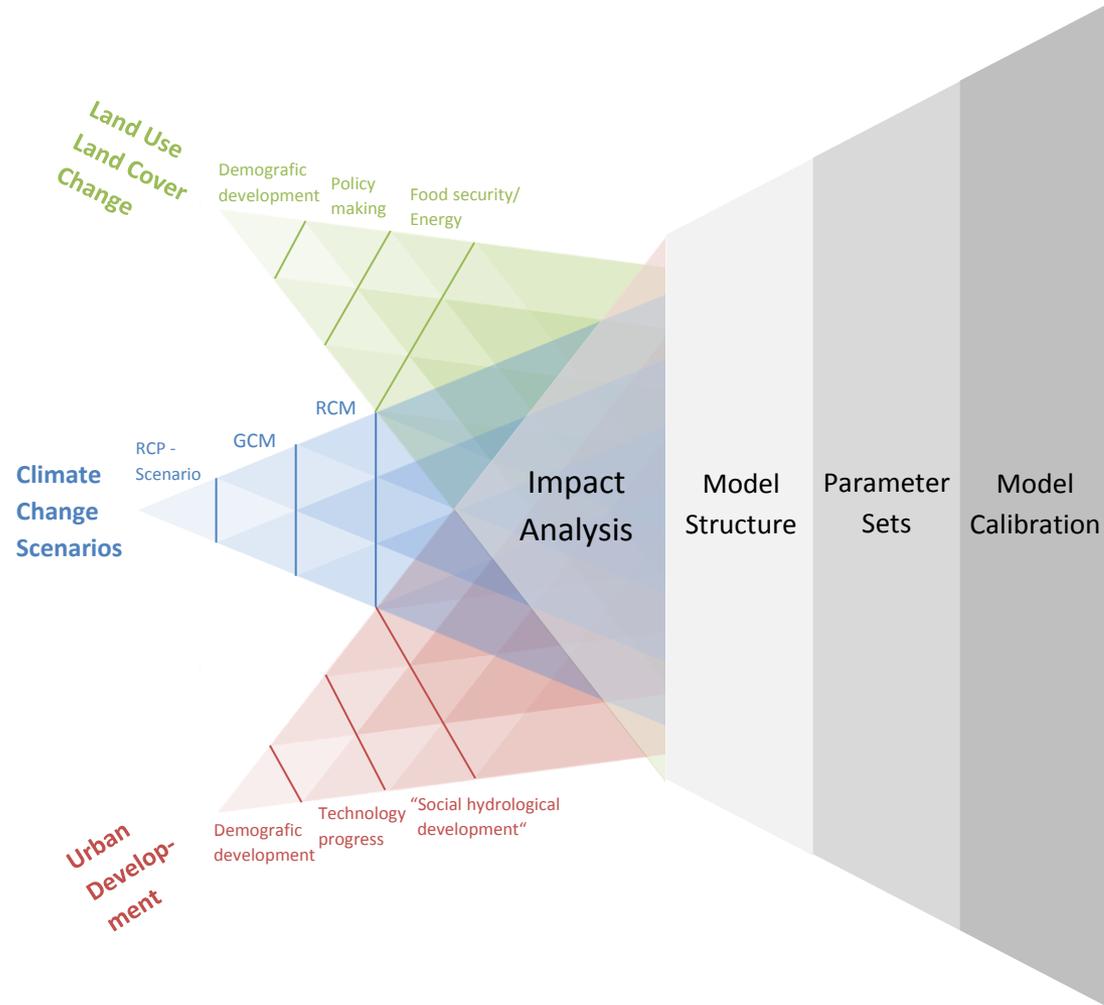
Karsten Schulz¹, Christoph Schürz¹, Bano Mehdi¹, Thomas Ertl², Alexander Pressl², Christoph Matulla³ und Brigitta Hollosi³

¹ IWHW BOKU

² SIG BOKU

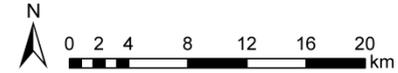
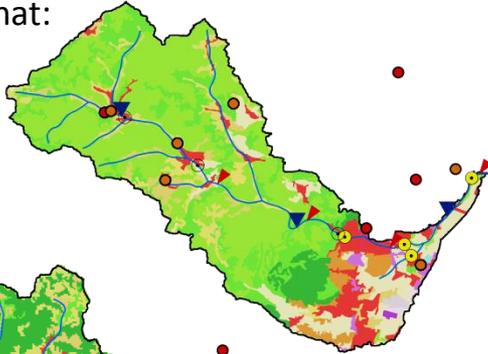
³ ZAMG

Einleitung

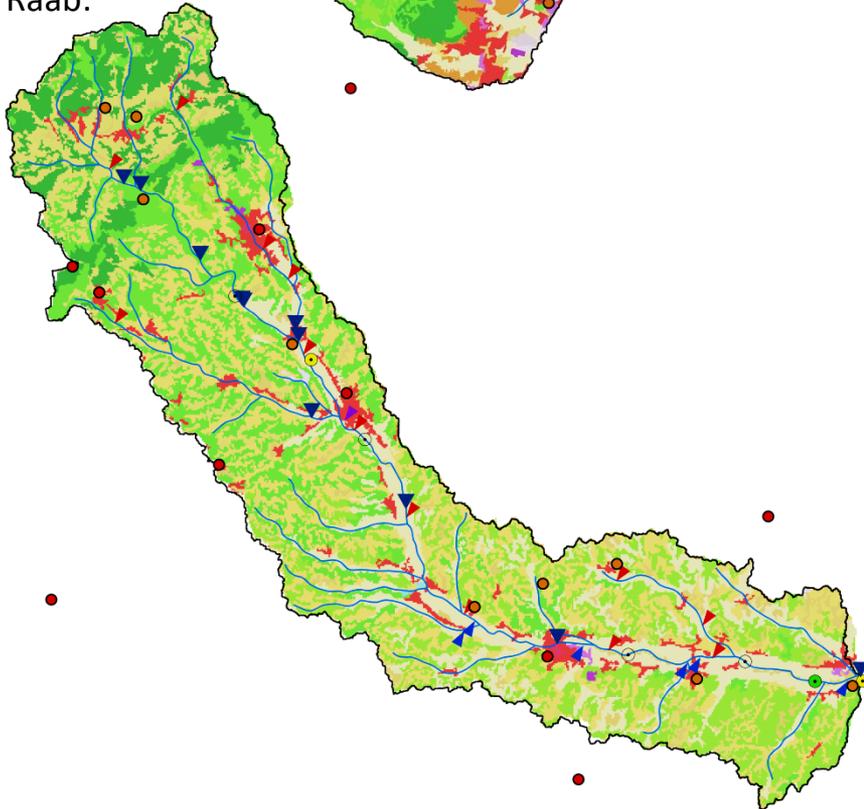


Übersicht der Einzugsgebiete

Schwechat:



Raab:



Measurement stations

- ▼ Discharge gauge, eHyd
- Weather station, ZAMG
- Precipitation gauge, eHyd
- Water quality online monitoring, IMW3, Raab mon.
- Water quality monitoring (in operation), GZÜV
- Water quality monitoring (not operating), GZÜV

Point sources

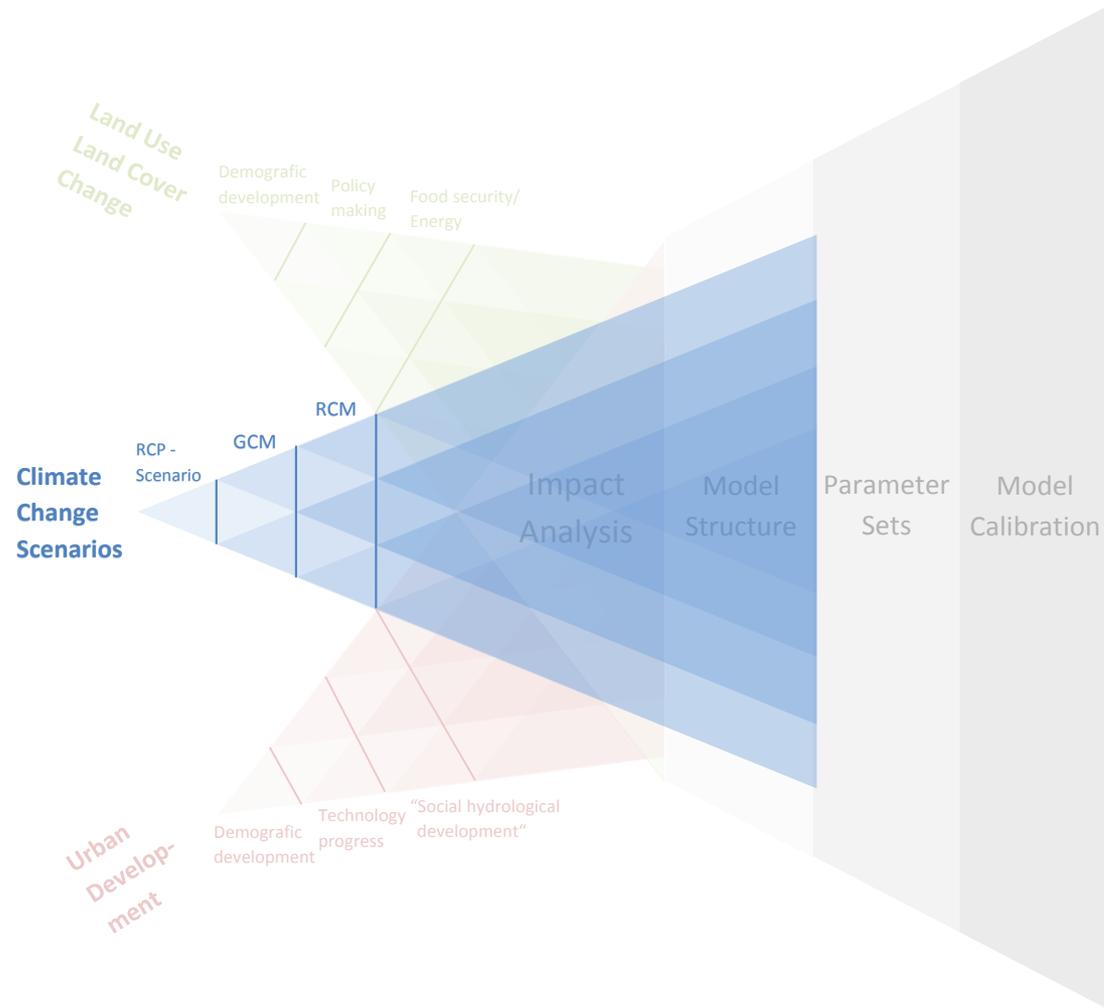
- ▶ Waste water treatment plant > 2000 PE (municipal)
- ▶ Waste water treatment plant (industrial)
- ▶ PRTR plant (Pollutant Release and Transfer Register)

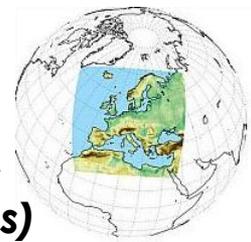
— Water course □ Basin boundary

Land use

- | | |
|-----------------------------|---------------------|
| ■ Settlement, dense | ■ Pasture |
| ■ Settlement, light | ■ Complex patterns |
| ■ Industry, Infrastructure | ■ Deciduous forest |
| ■ Mining | ■ Coniferous forest |
| ■ Urban green areas | ■ Mixed forest |
| ■ Non irrigated Agriculture | ■ Natural grassland |
| ■ Viniculture | ■ Water bodies |

Klimaszenarien





Klimadaten

Beobachtungsdaten (Spartacus, GPARD):

- Minimum (*tasmin*), Maximum (*tasmax*), mittlere Lufttemperatur (*tas*) und Niederschlag (*pr*)
- Zeitraum: 1971-2000 (tägliche Auflösung)
- Horizontale Auflösung: 1km

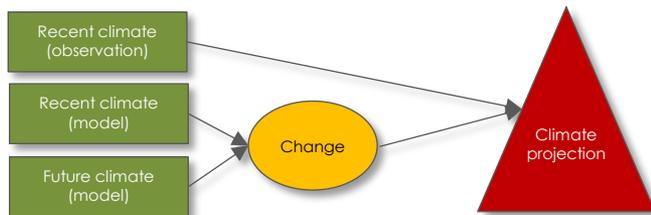
Modelldaten (EURO-CORDEX):

- Minimum (*tasmin*), Maximum (*tasmax*), mittlere Lufttemperatur (*tas*) und Niederschlag (*pr*)
- Zeitraum: 1971-2000, 2021-2050, 2071-2100 (tägliche Auflösung)
- Simulationen: RCP4.5 (13), RCP8.5 (13)
- Horizontale Auflösung: 12 km (skillful scale: ~80km)

Methoden

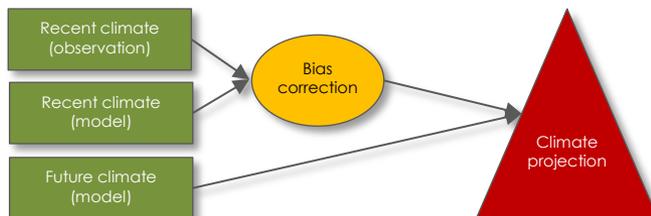
Delta Method

1.



Bias correction

2.



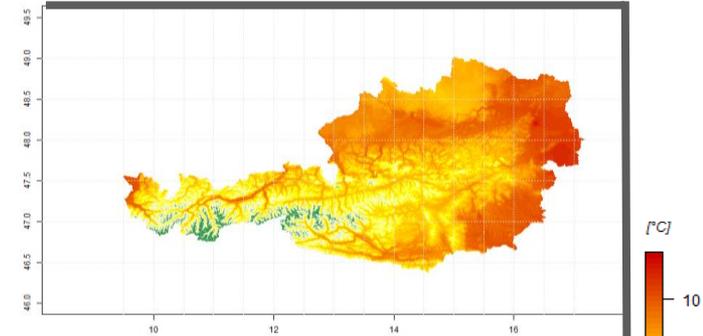
Gebietsmittel von **mittlerer Lufttemperatur (*tas*)**

1971-2000

Beobachtungsdaten

1km Auflösung

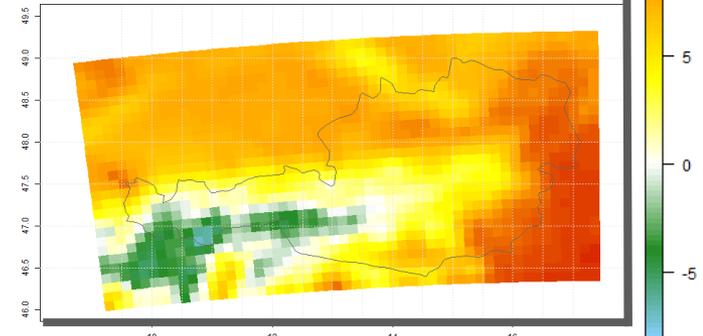
min = -7.4 °C
mean = 6.5 °C
max = 11.7 °C



CORDEX-Ensemble

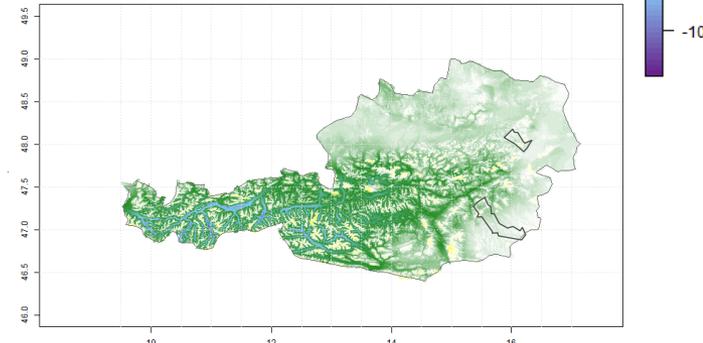
12km Auflösung

min = -6.9 °C
mean = 5.4 °C
max = 10.8 °C



Differenz zwischen Beobachtungsdaten und downgescalten CORDEX-Ensemble
1km Auflösung

Einfluss von Topografie (kleineres Bias im flacheren als im komplexeren Gebirgs Gelände)





Klimadaten

Beobachtungsdaten (Spartacus, GPARD):

- Minimum (*tasmin*), Maximum (*tasmax*), mittlere Lufttemperatur (*tas*) und Niederschlag (*pr*)
- Zeitraum: 1971-2000 (tägliche Auflösung)
- Horizontale Auflösung: 1km

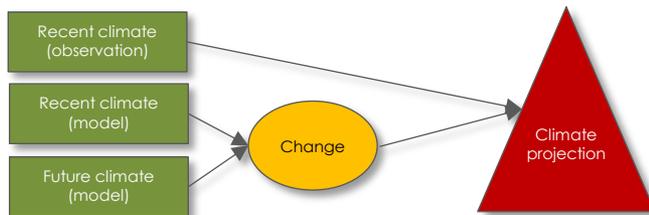
Modelldaten (EURO-CORDEX):

- Minimum (*tasmin*), Maximum (*tasmax*), mittlere Lufttemperatur (*tas*) und Niederschlag (*pr*)
- Zeitraum: 1971-2000, 2021-2050, 2071-2100 (tägliche Auflösung)
- Simulationen: RCP4.5 (13), RCP8.5 (13)
- Horizontale Auflösung: 12 km (skillful scale: ~80km)

Methoden

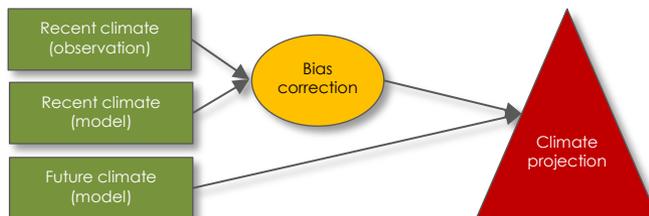
Delta Method

1.



Bias correction

2.



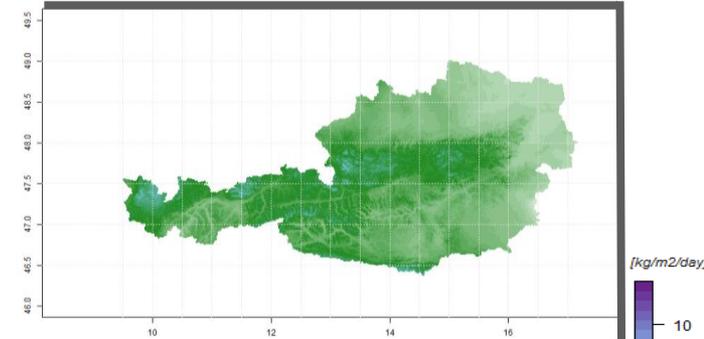
Gebietsmittel von Niederschlag (*pr*)

1971-2000

Beobachtungsdaten

1km Auflösung

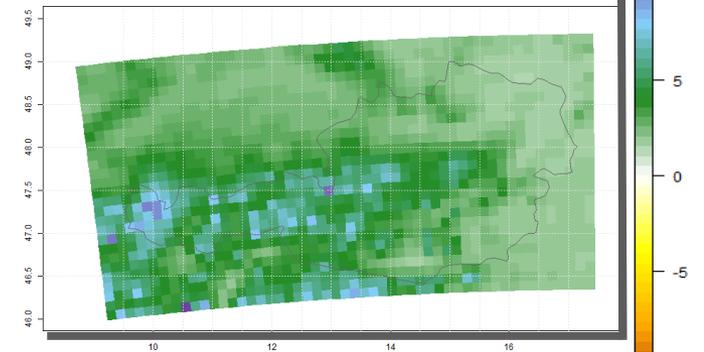
min = 0.7 mm/d
mean = 2.9 mm/d
max = 7.6 mm/d



CORDEX-Ensemble

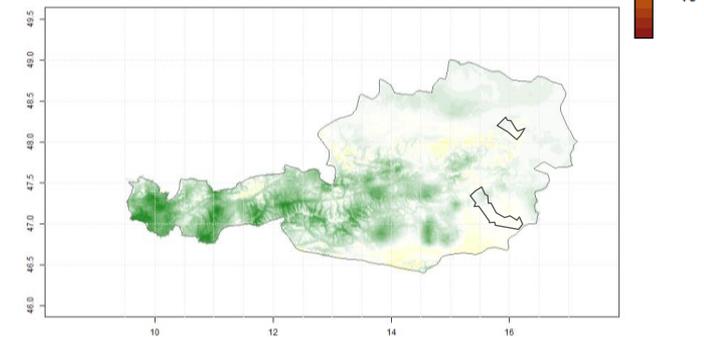
12km Auflösung

min = 1.5 mm/d
mean = 3.4 mm/d
max = 11.0 mm/d

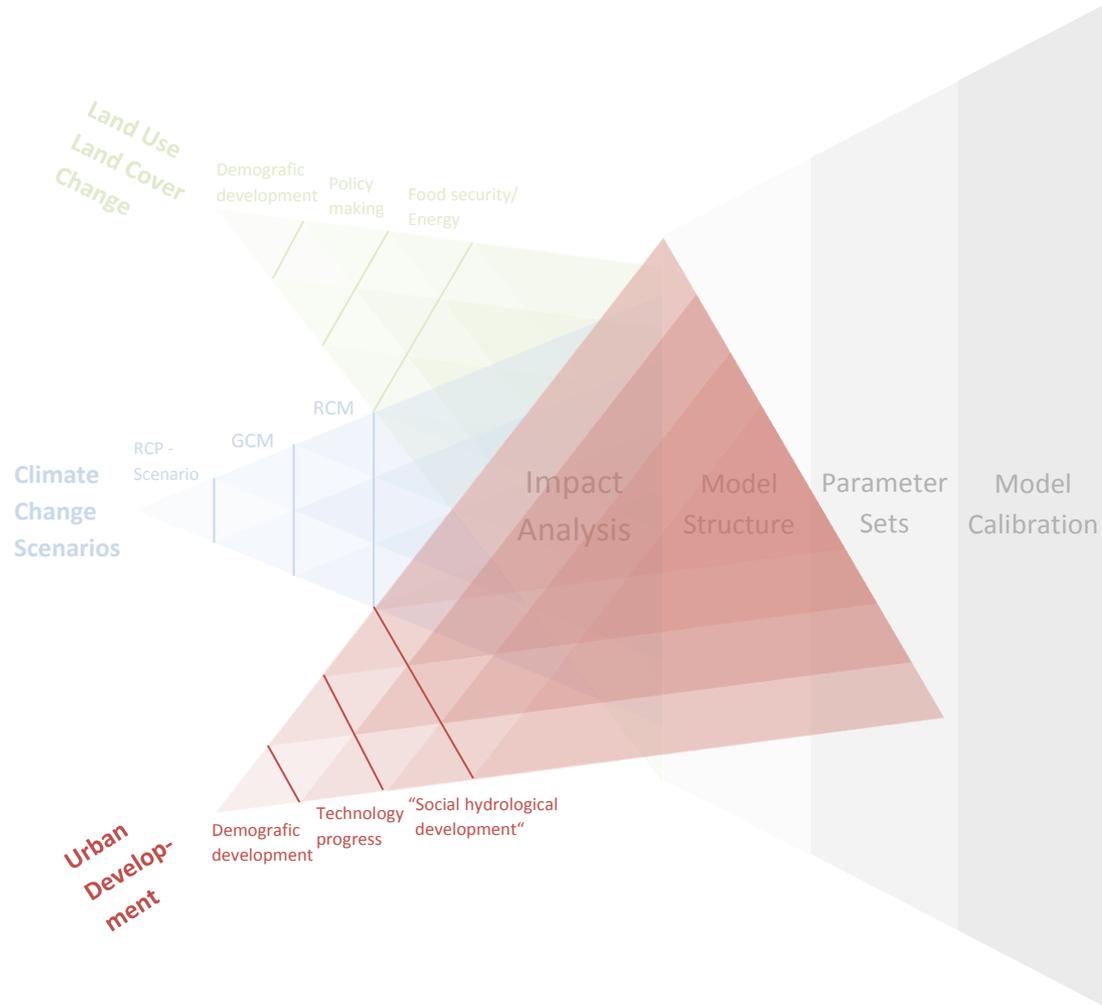


Differenz zwischen Beobachtungsdaten und downgescalten CORDEX-Ensemble
1km Auflösung

Einfluss von Topografie (kleineres Bias im Flachland als im komplexeren Gebirgs Gelände)

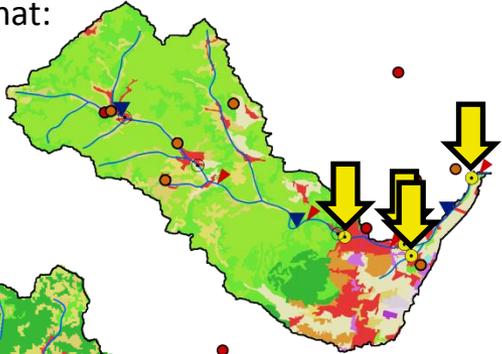


Siedlungswasserwirtschaft

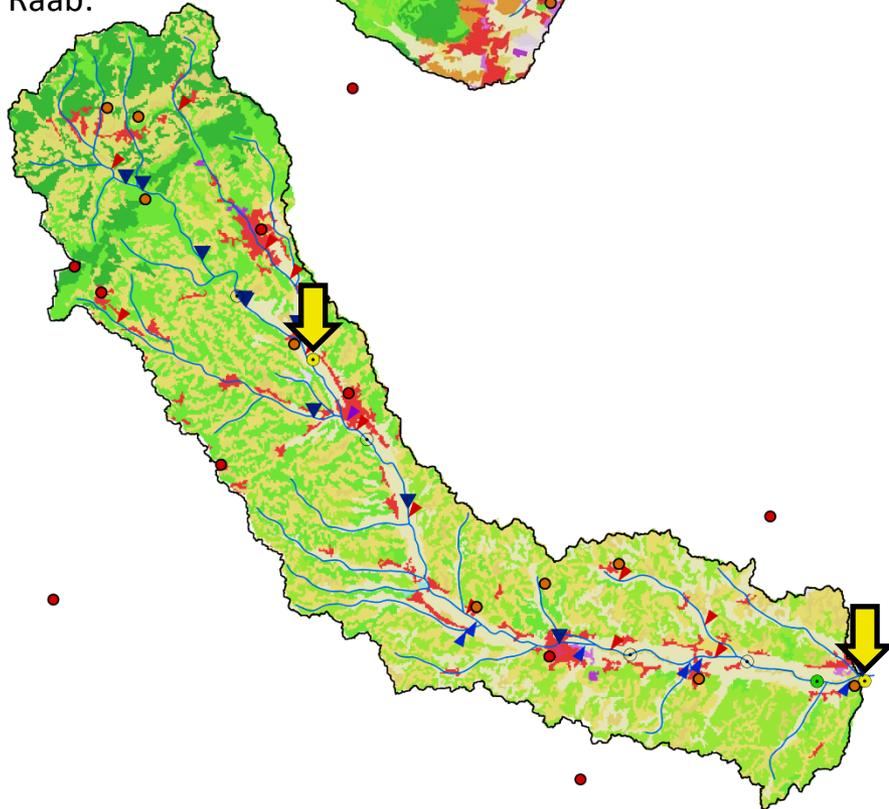


Datengrundlage Gewässergüte

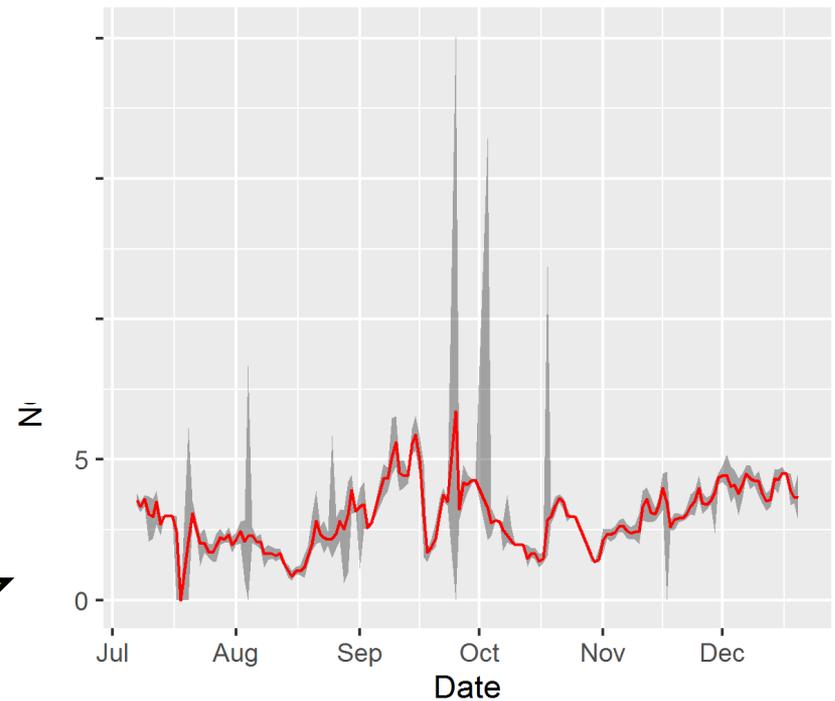
Schwechat:



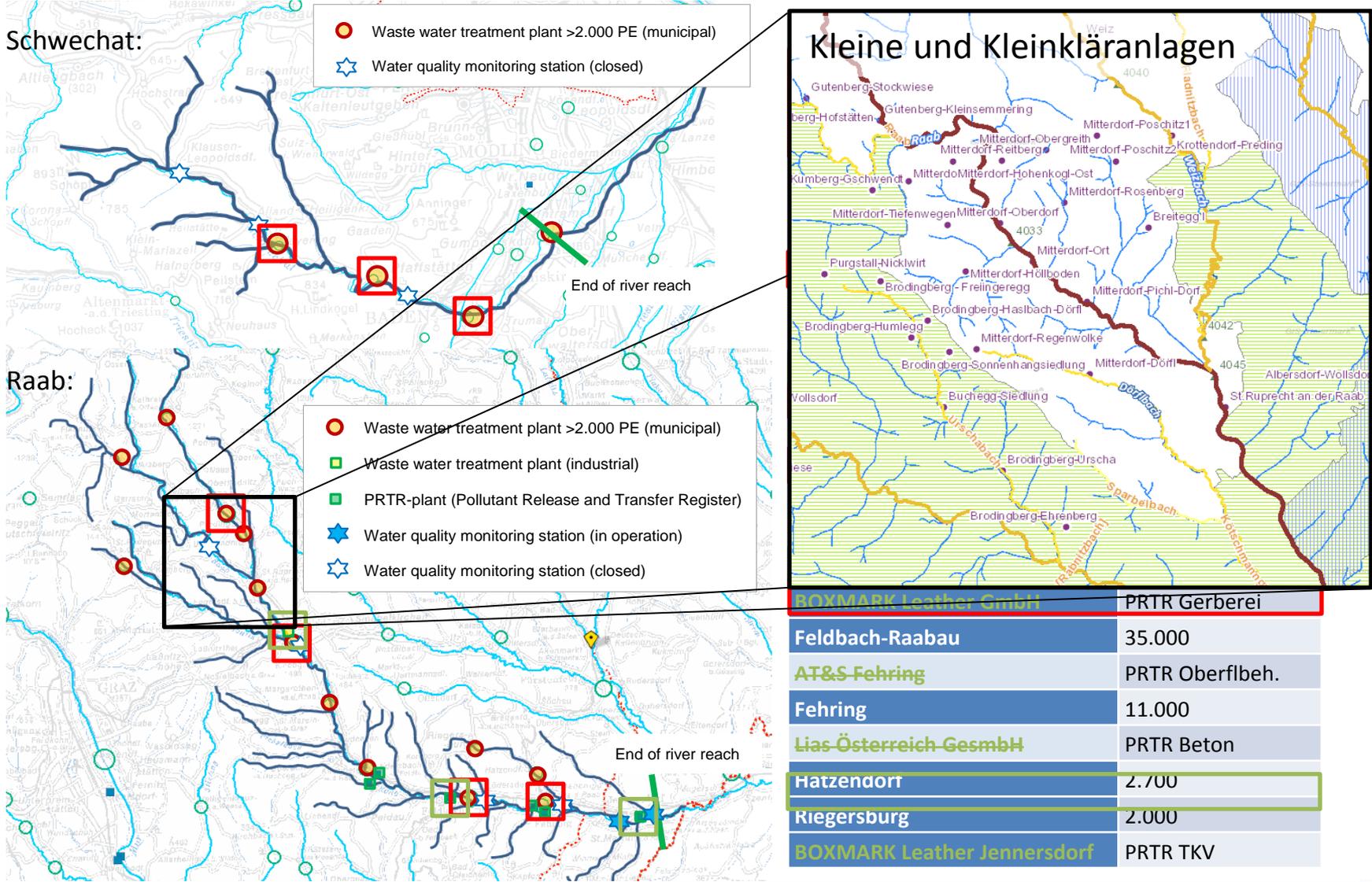
Raab:



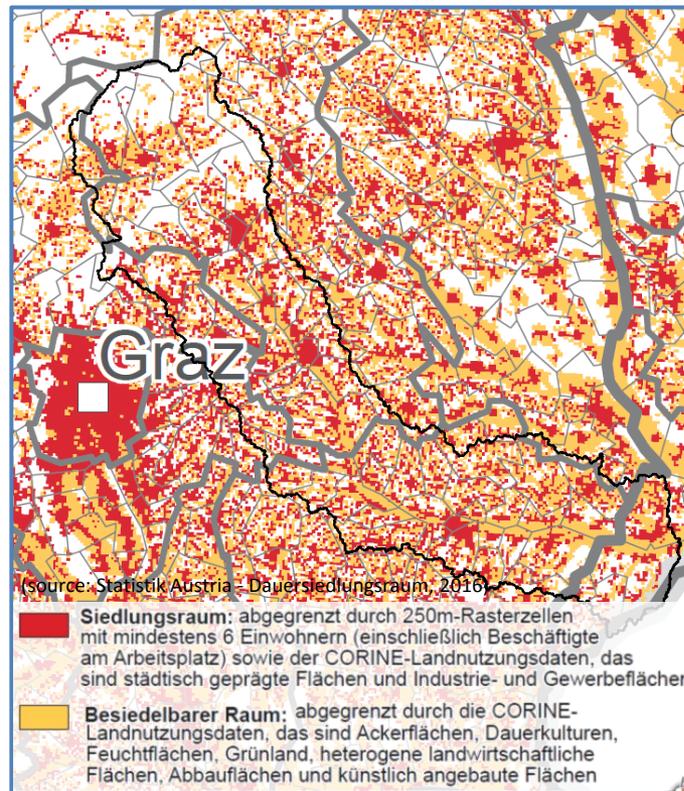
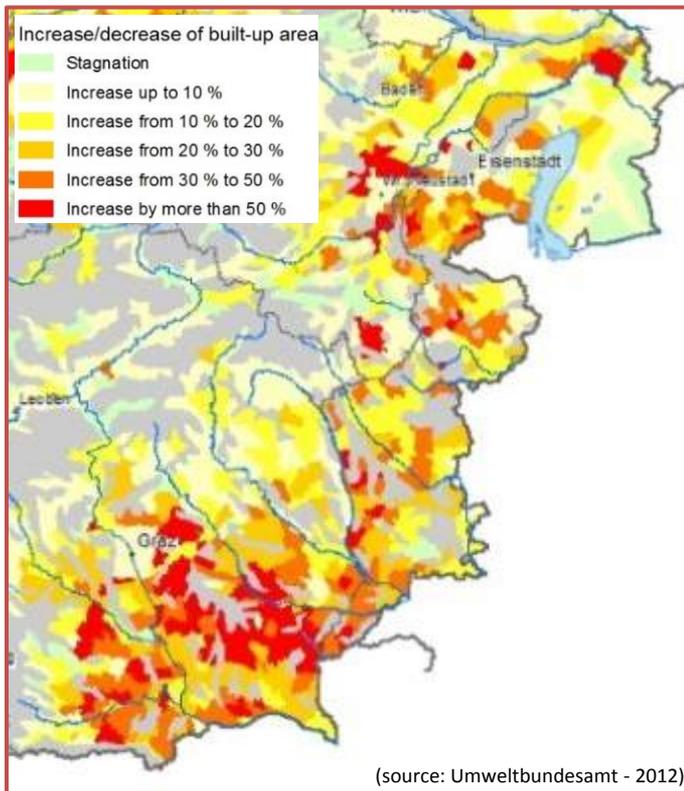
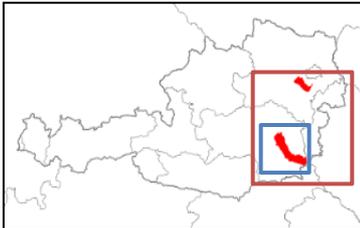
- Monitoring von $\text{NO}_3\text{-N}$ und $\text{NH}_4\text{-N}$ in 5 – 15 min Auflösung
- $\text{PO}_4\text{-P}$ und Ges-P monatlich



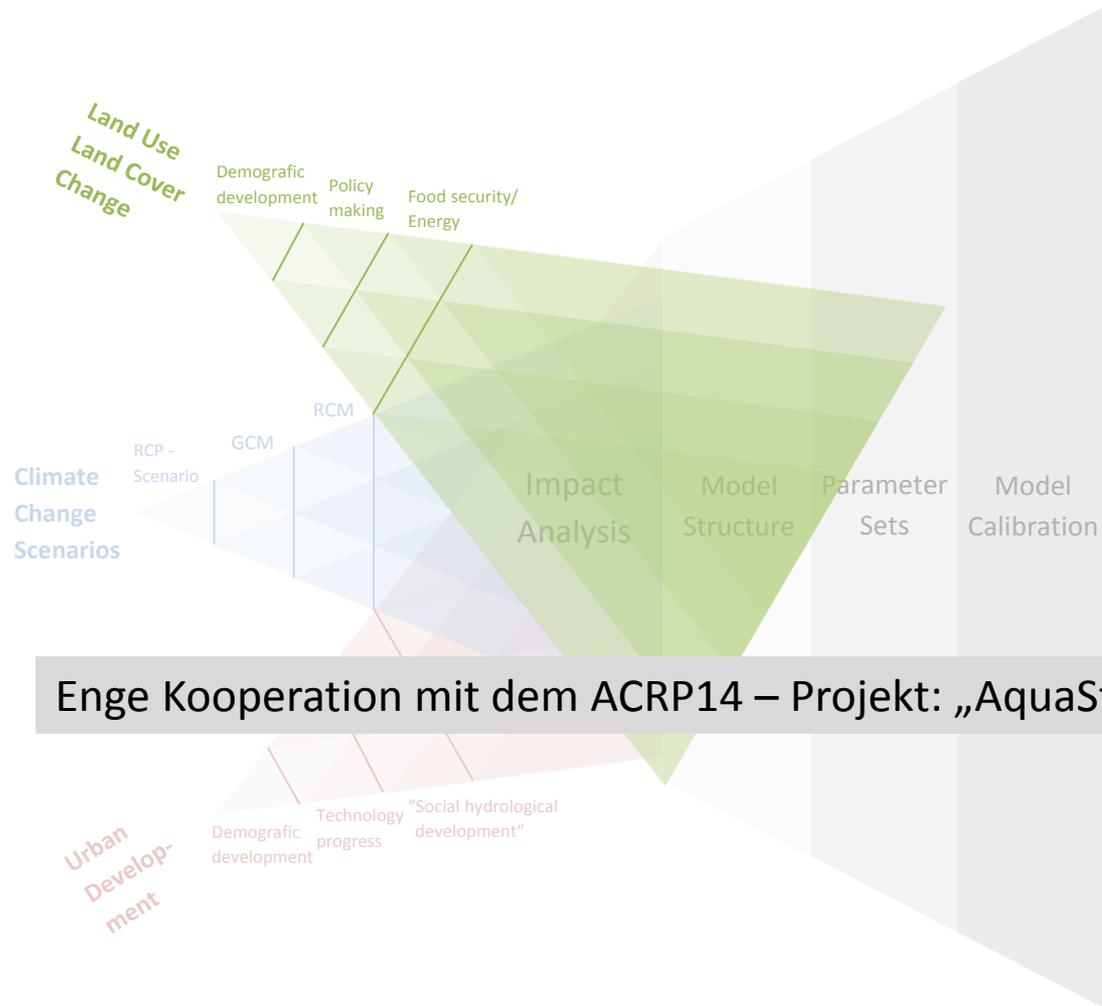
Daten Siedlungswasserwirtschaft: Punkteinleiter



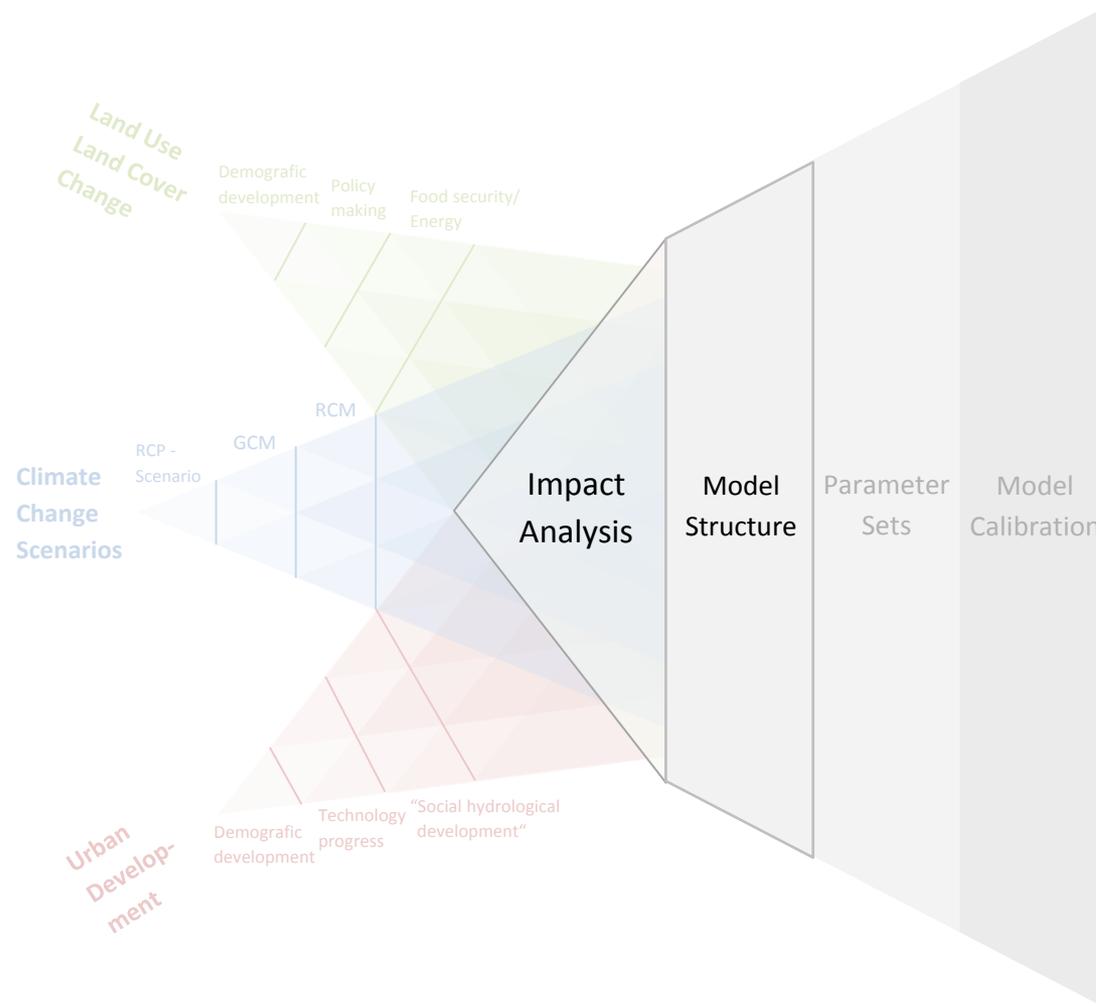
Siedlungswasserwirtschaftliche Szenarien



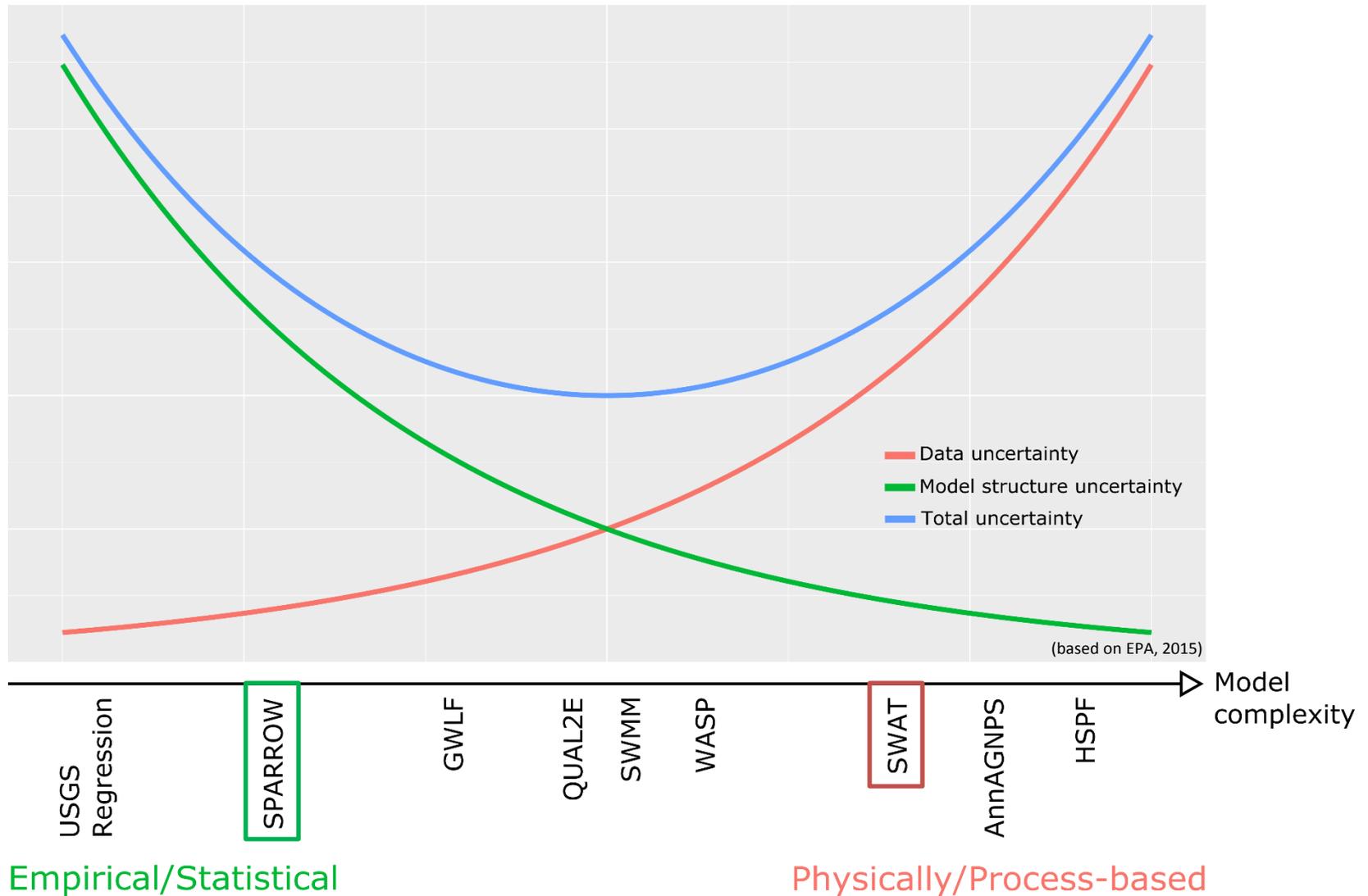
Landnutzungsänderungen



Modellstruktur



Modellstruktur



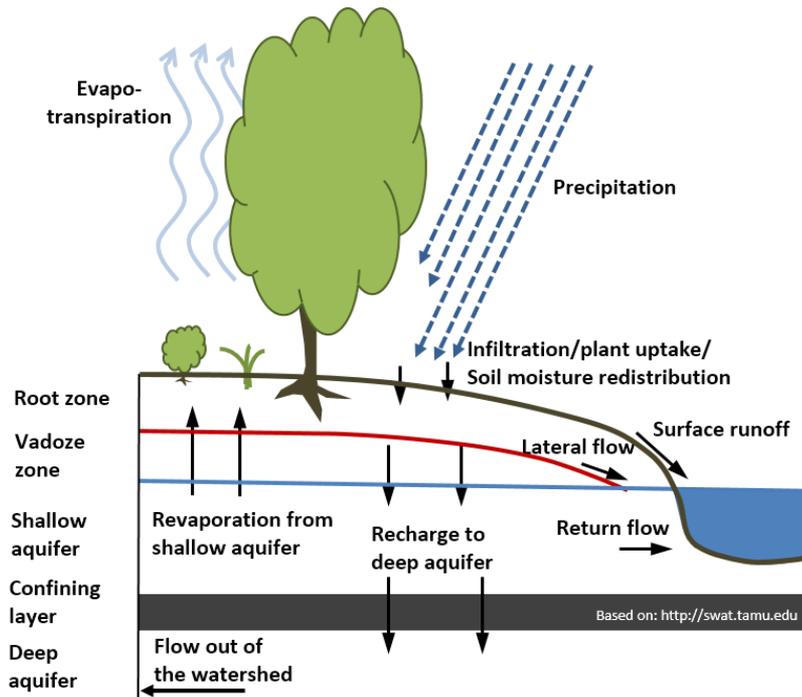
Empirical/Statistical

Physically/Process-based

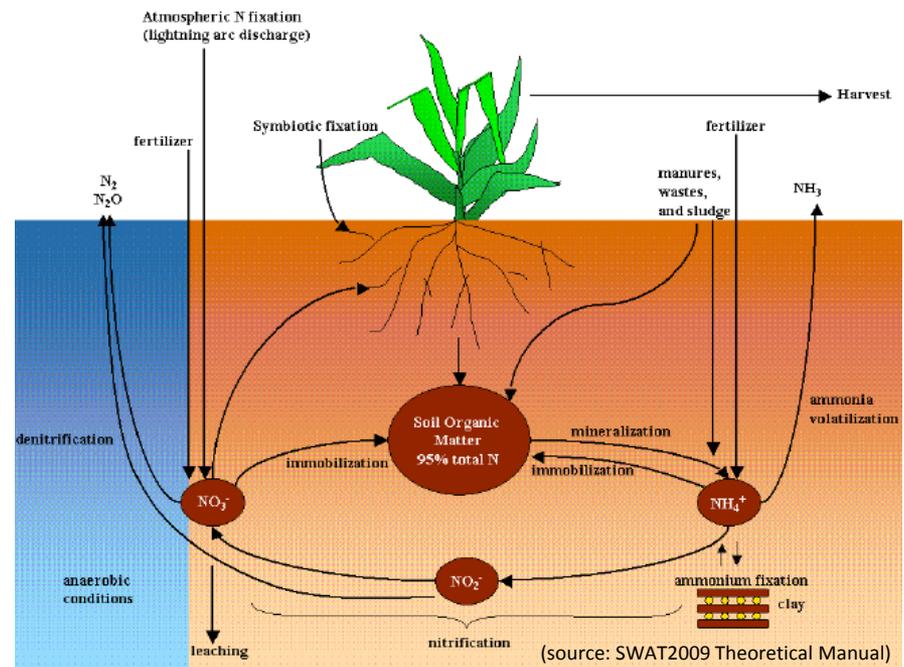
SWAT – prozessbasierte Modellierung

- Prozessbasierte Darstellung von hydrologischen und Nährstoff-Kreisläufen:

Wasser-Kreislauf:



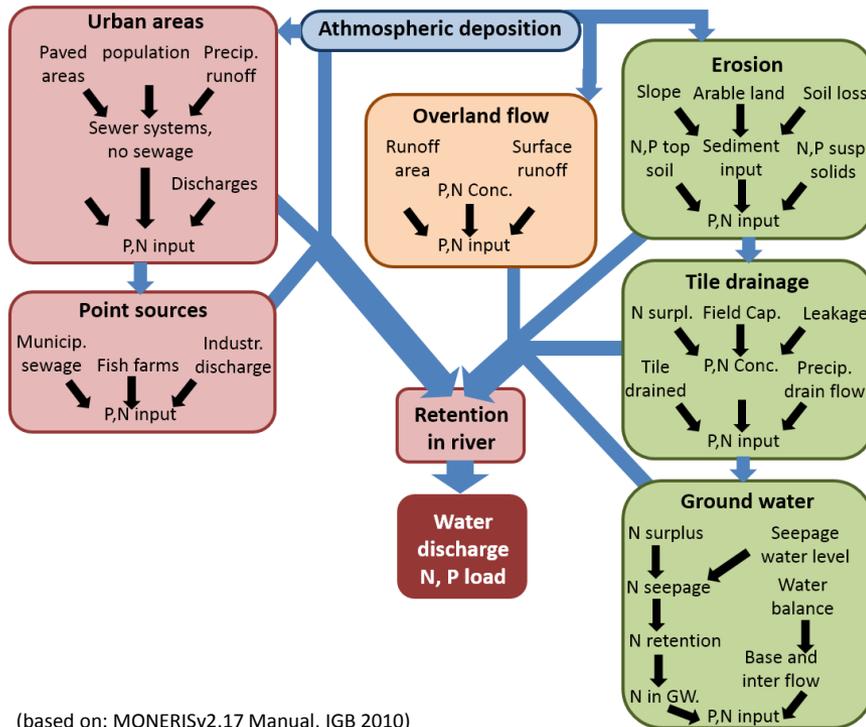
Stickstoff-Kreislauf:



Vergleich mit Modellen geringerer Komplexität

MONERIS:

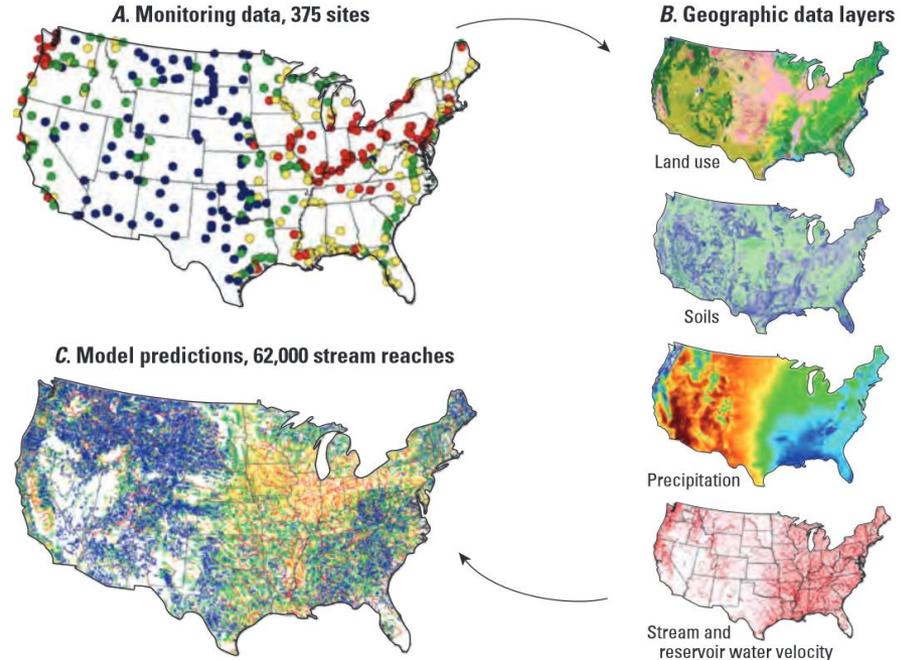
Bilanzierung aus verschiedenen Eintragspfaden



(based on: MONERISv2.17 Manual, IGB 2010)

SPARROW:

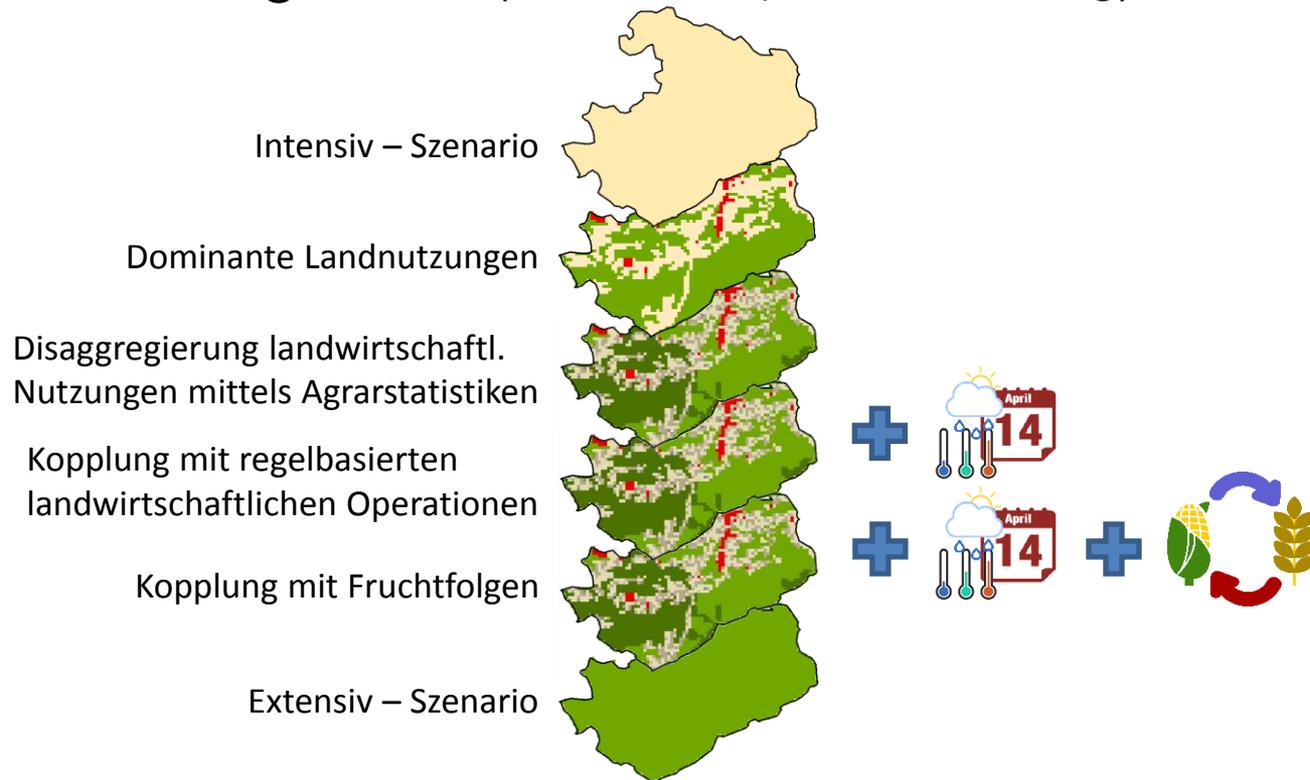
Regression von räumlichen Daten mit Stofffrachten



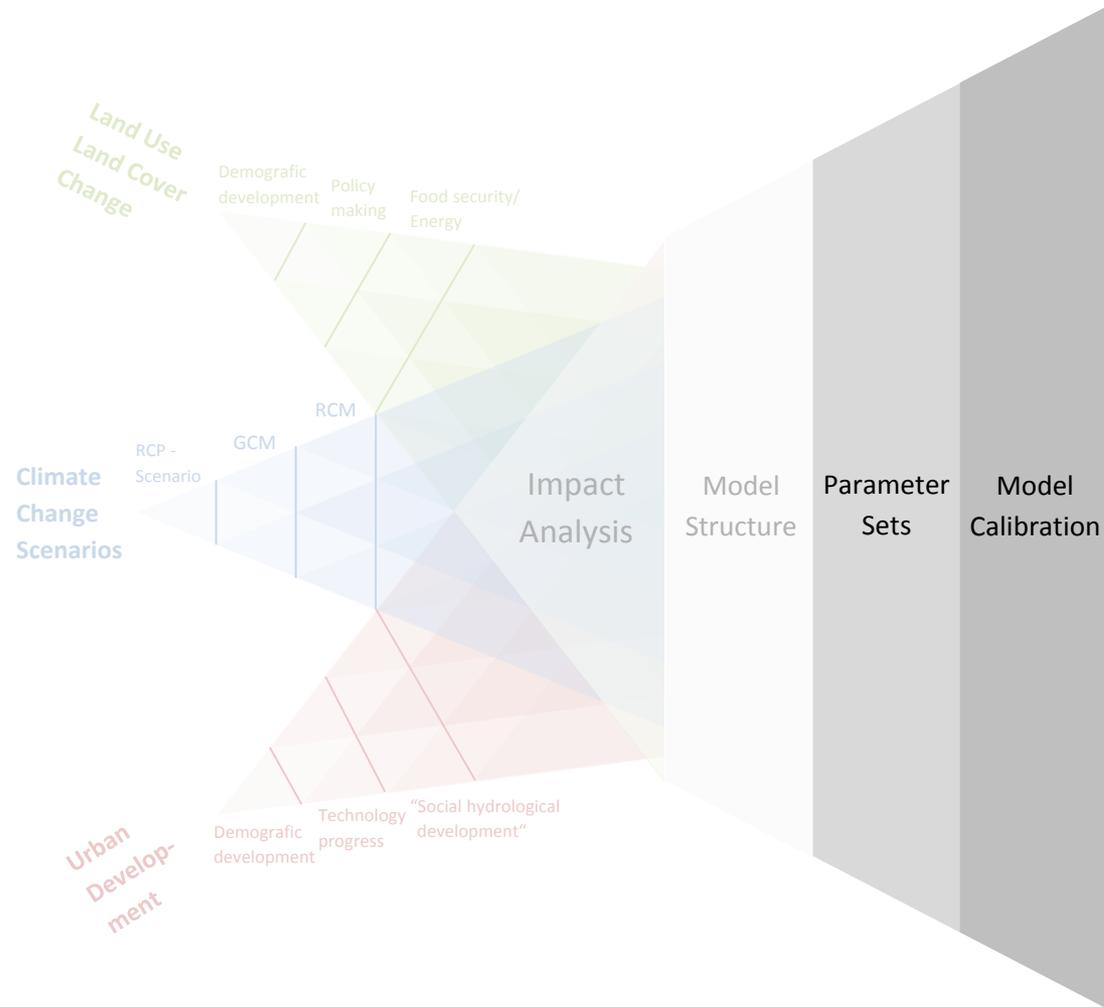
(source: USGS, <http://water.usgs.gov/nawqa/sparrow>)

SWAT – Datenaggregation

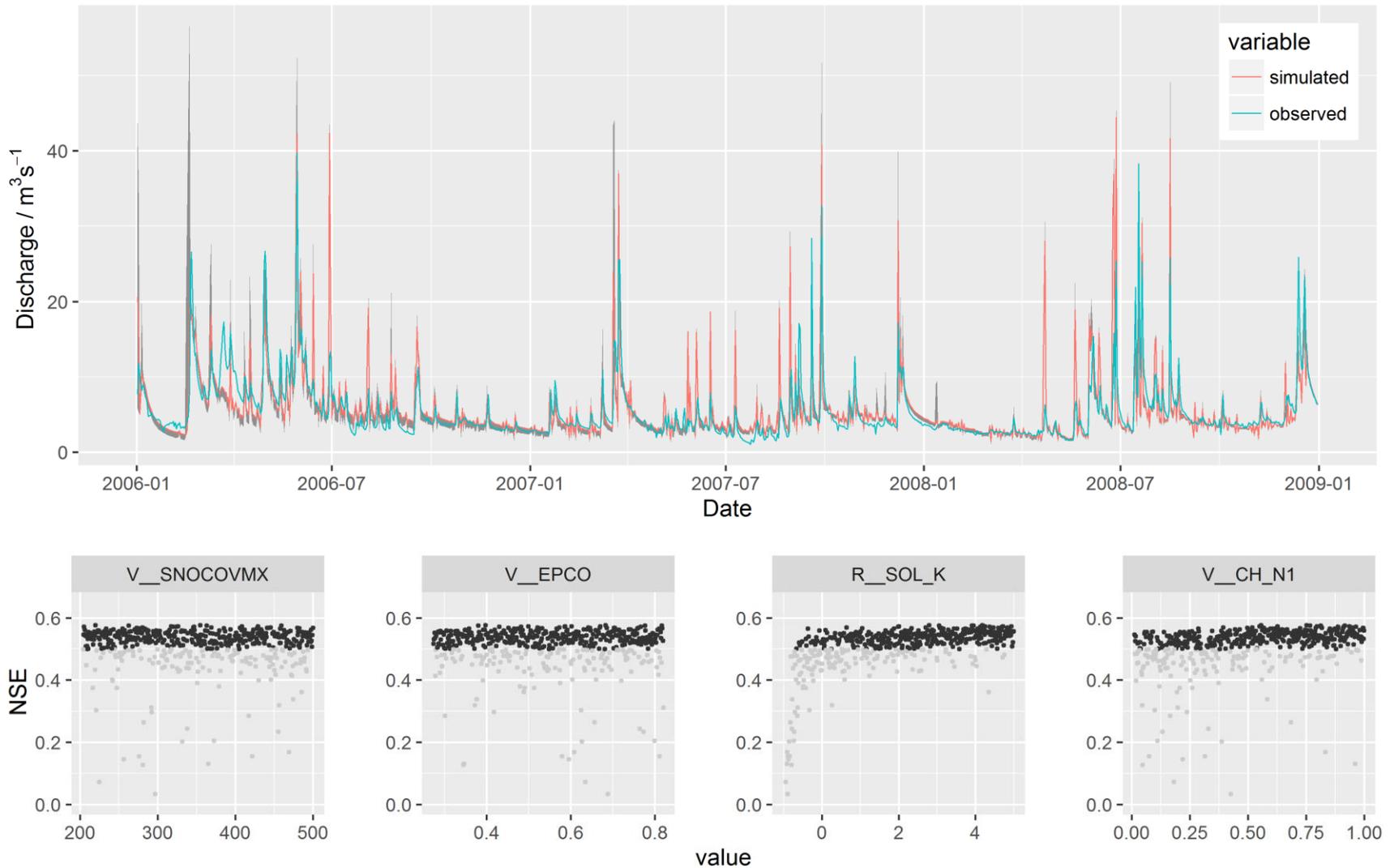
- Eingangsdaten sind in hohem Detailgrad gefordert.
- Mittels unterschiedlich komplexen Ansätzen entwickelt und in SWAT abgebildet (Hier am Beispiel Landnutzung):



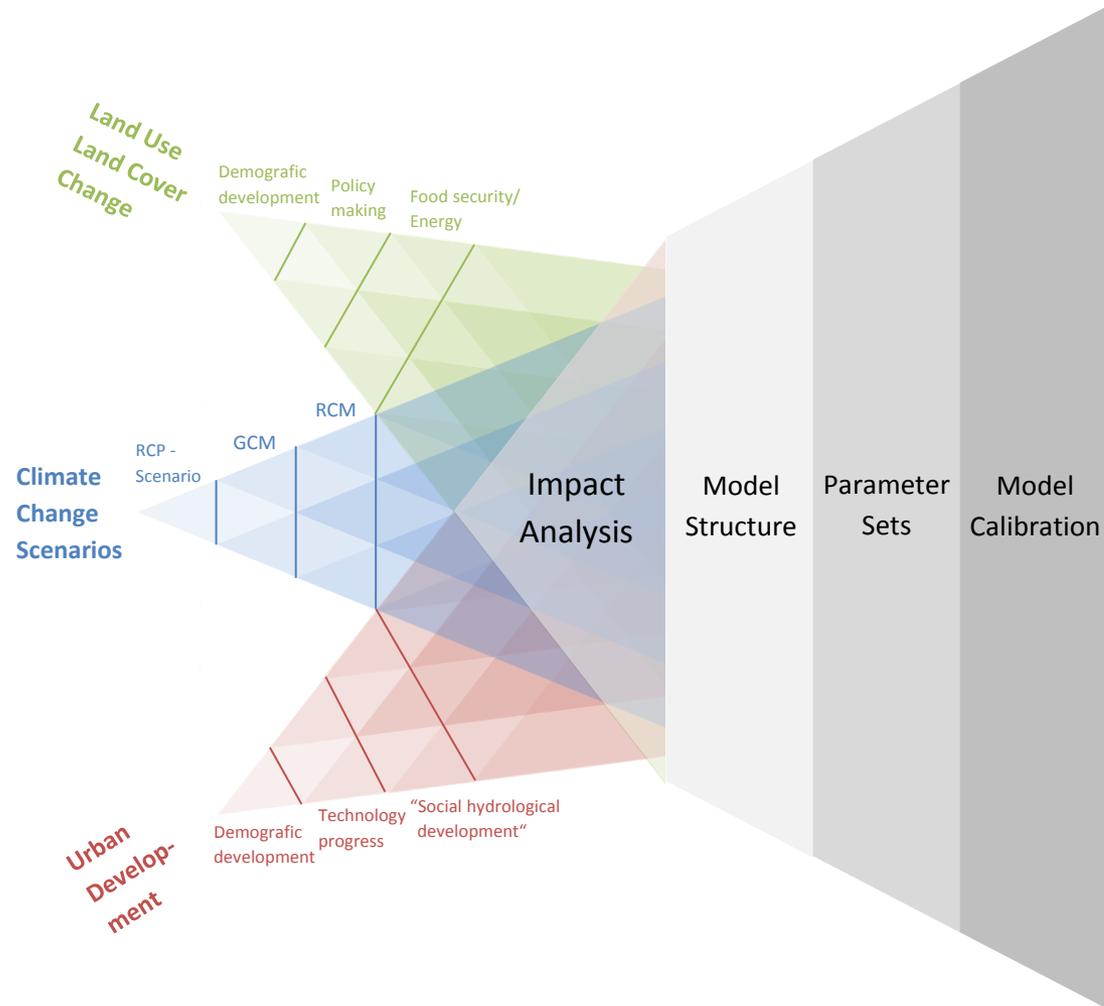
Parameter/Modellkalibrierung



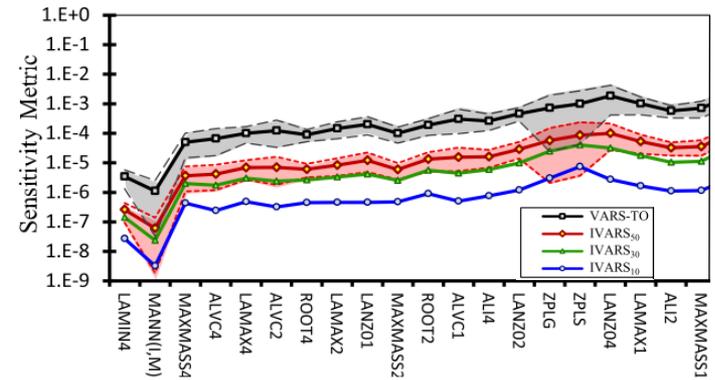
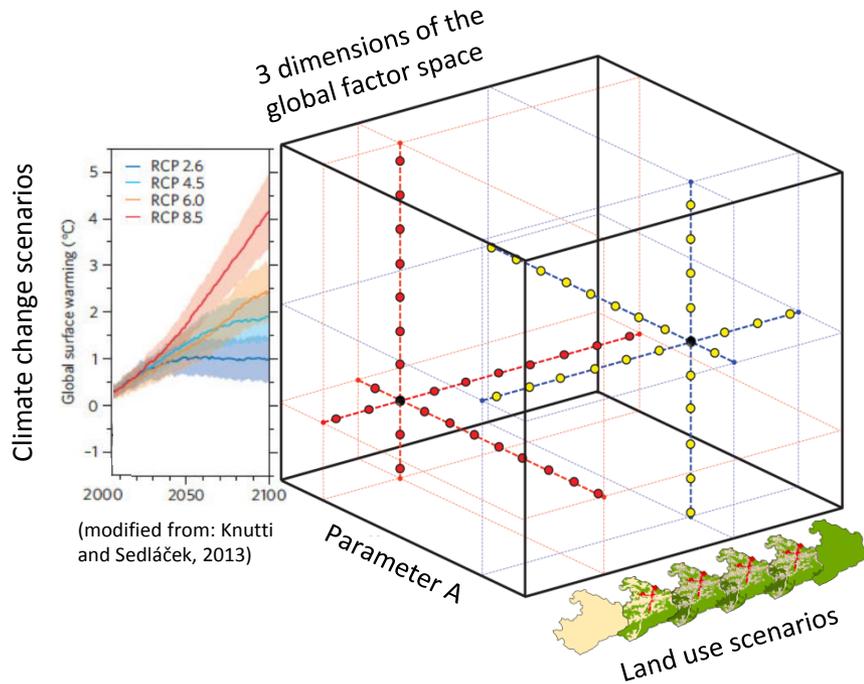
SWAT - Modellkalibrierung



Globale Sensitivitätsstudie



Globale Sensitivitätsstudie



(modified from: Razavi and Gupta, 2016)

ADVANCED TOPICS IN UNCERTAINTY ESTIMATION:

- ERROR PROPAGATION, MONTE CARLO

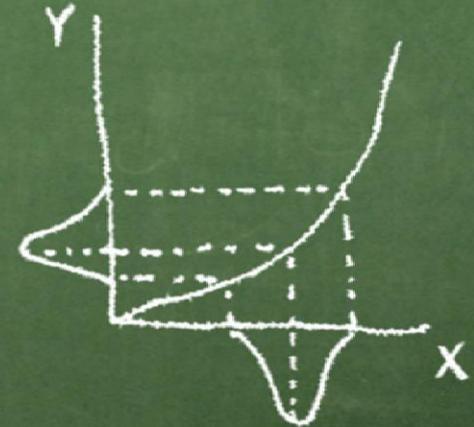
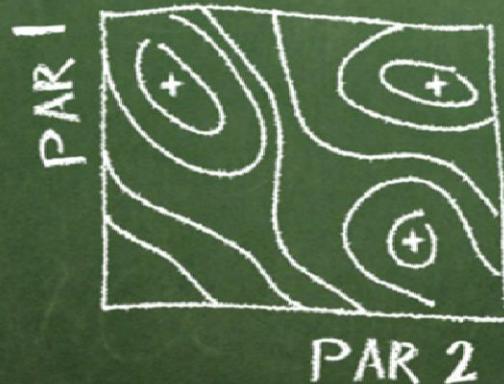
- NON LINEAR REGRESSION

- BAYESIAN APPROACH, MCMC

- GLUE

- DYNIA, SUFI

- DISCUSSION GLUE VS. FORMAL METHODS



$$s_y^2 = \sum \left(\frac{\partial y}{\partial x_i} \right)^2 s_{x_i}^2$$