Coping with challenges in the application of SWIM in a heavily managed lowland region in Central Europe

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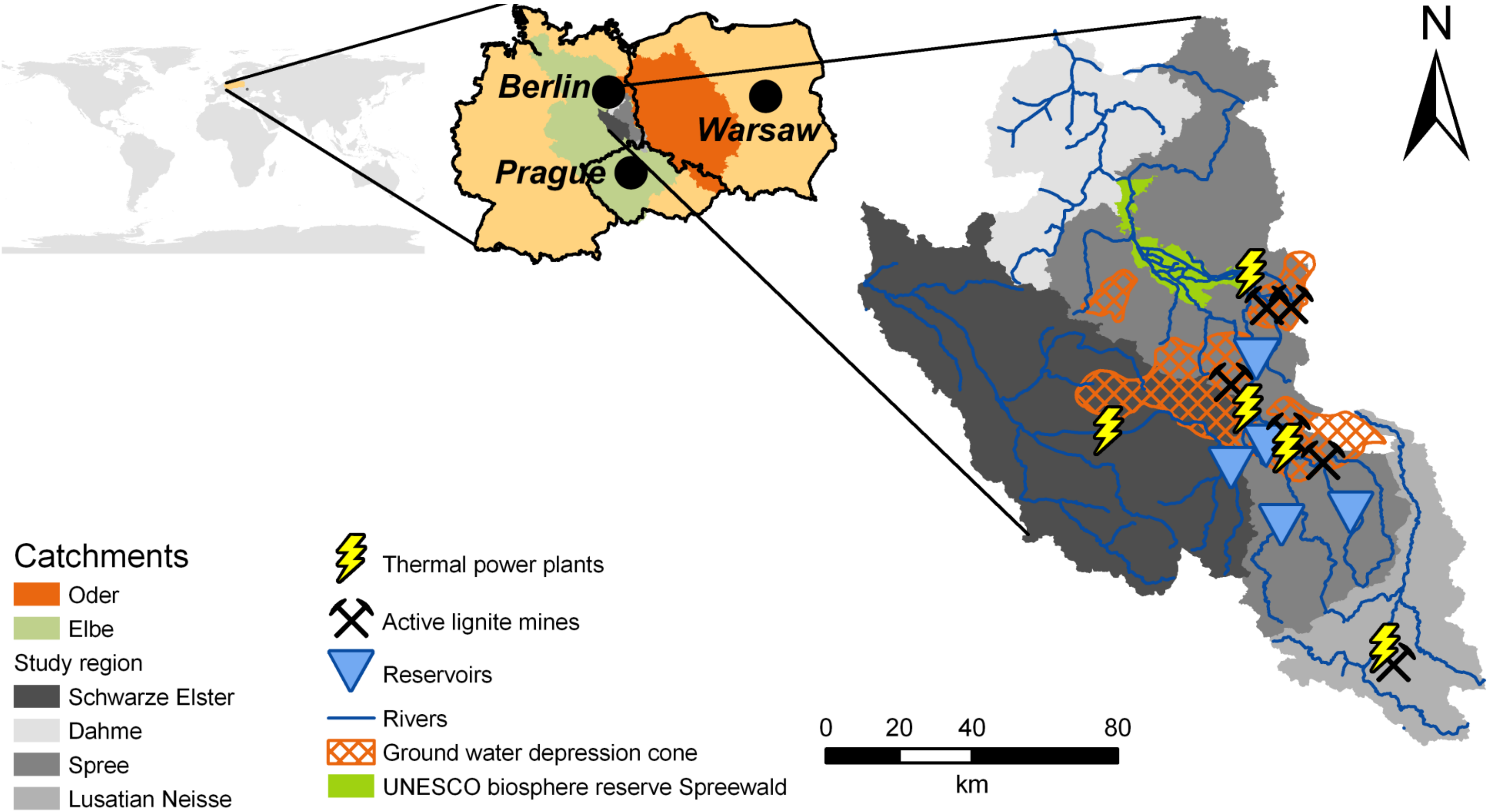
Background

Lusatia – a heavily managed lowland region in Central Europe



Background

Lusatia – a heavily managed lowland region in Central Europe

Impacts on the water balance

Lignite mining:
Ground water table lowered prior and during mining operation
➔ **Ground water depression cone**
➔ **River discharge strongly increased**
(Cottbus 32 m^3/s instead of natural 12 m^3/s)

Welzow open pit mine,
Picture: www.fotos-aus-der-luft.de

Background

Lusatia – a heavily managed lowland region in Central Europe

Water management - general challenge for large scale hydrological modelling

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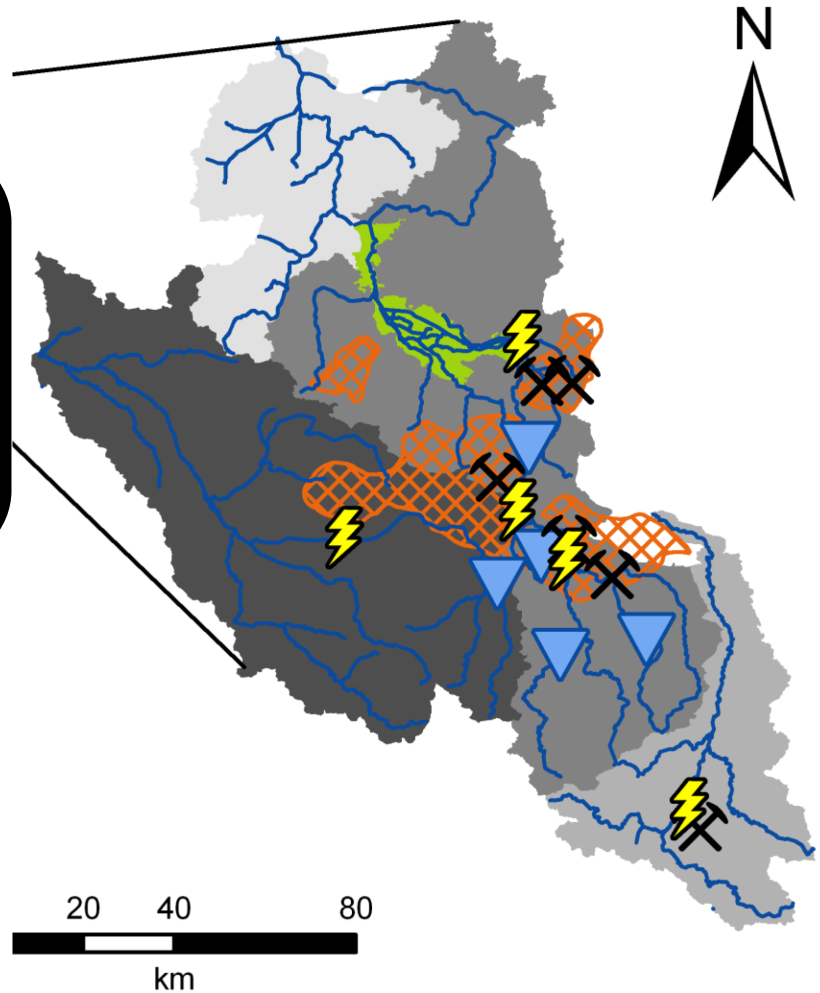

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Electricity production:
Withdrawal of cooling water

Boxberg power plant
Picture: www.wikipedia.de

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Electricity production:
Withdrawal of cooling water

Water management:
Reservoir operation, transfer via channels
➔ **Interannual variability evened out**

Aim of the study

- Model set up and parameterization of the Soil and Water Integrated Model SWIM (Krysanova et al., 1998, 2000) which is based on SWAT (Arnold et al., 1994) and MATSALU (Krysanova et al., 1989) to simulate natural water balance components in the region

➔ Basis for climate and land use change impact study

➔ Prerequisite for climate change adaptation

Challenges in the application of SWIM

in a heavily managed lowland region in Central Europe

- **Trinational catchment ➔ data availability**
- **Heavily managed ➔ model parameterisation by calibration using observed discharge constrained**

Model parameterization

Calibration for selected subcatchments
(all hydrological model parameters)

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Calibration for selected subcatchments
(most sensitive hydrological model parameters)

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Regionalization: physical similiarity and spatial proximity
(entire catchments)

↓

Comparison with observed long term pre-mining discharges
and simulation results of other models

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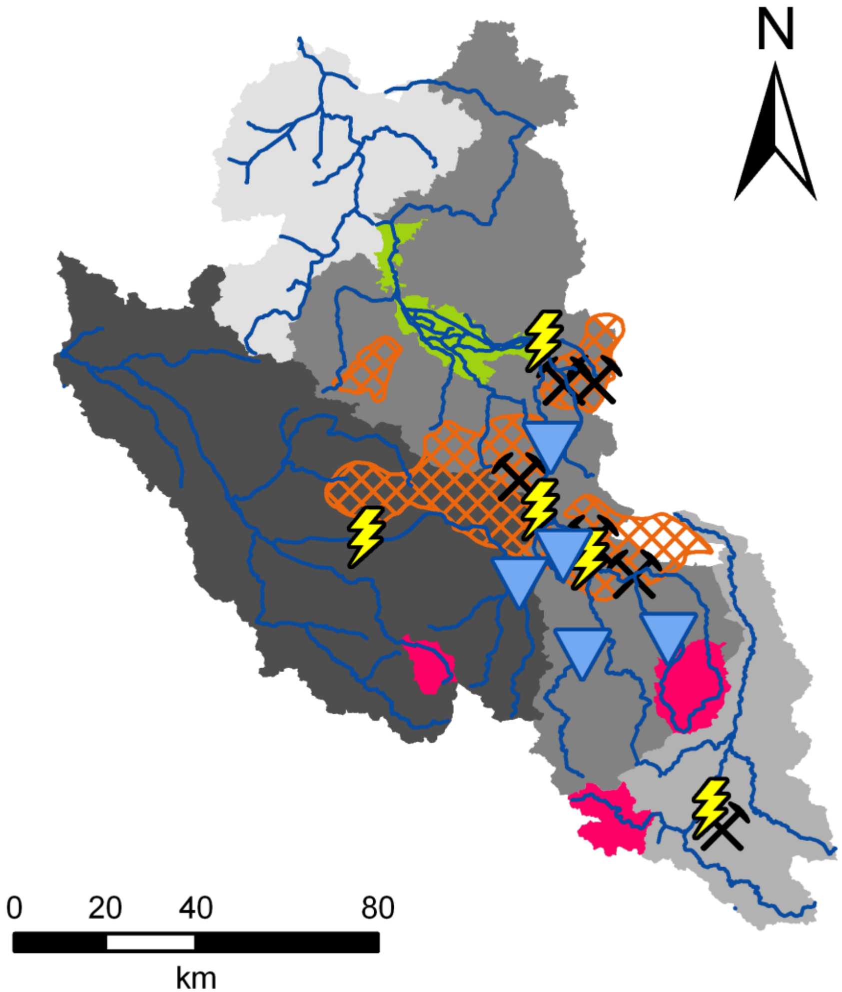
Calibration for selected subcatchments (all hydrological model parameters)

Multi-objective calibration, focus on low flow

Calibration Period (C)	1998-2001
Validation Period (V)	2002-2006

Relative Volume Error	**RVE**
Nash-Sutcliffe Efficiency	**NSE**
Nash-Sutcliffe Efficiency for log(Q)	**NSE_{log}**
Pearson‘s r^2	**r^2**
Volume Efficiency	**VE**



Calibration of all hydrological model parameters

Model parameterization

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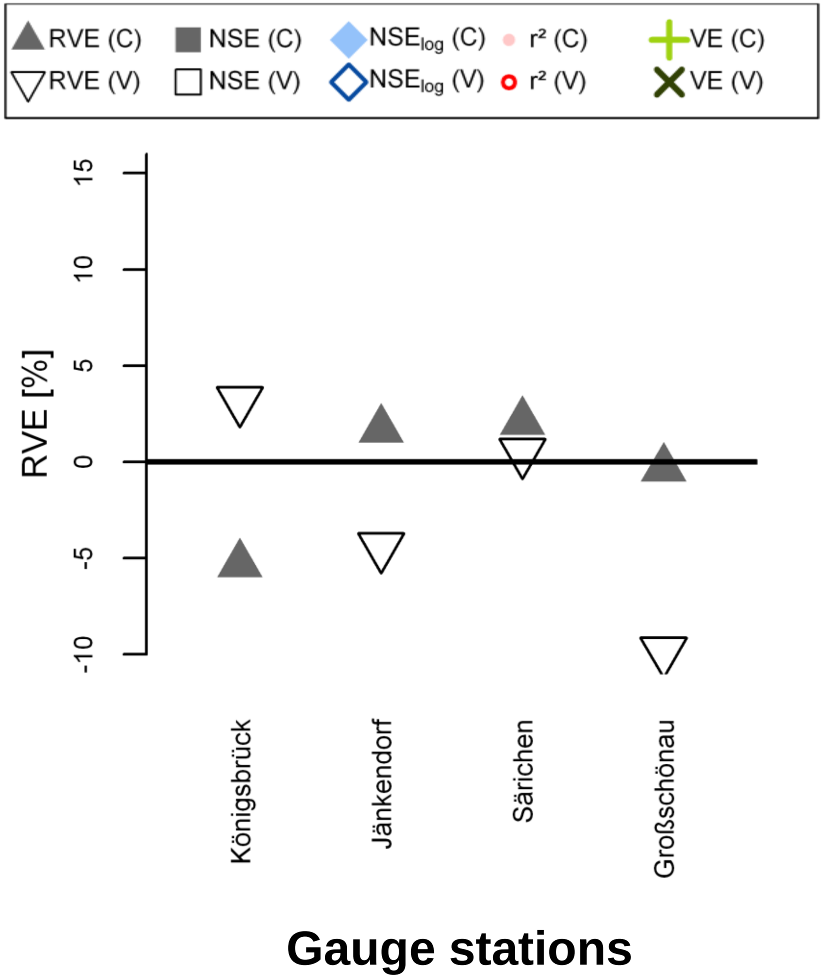

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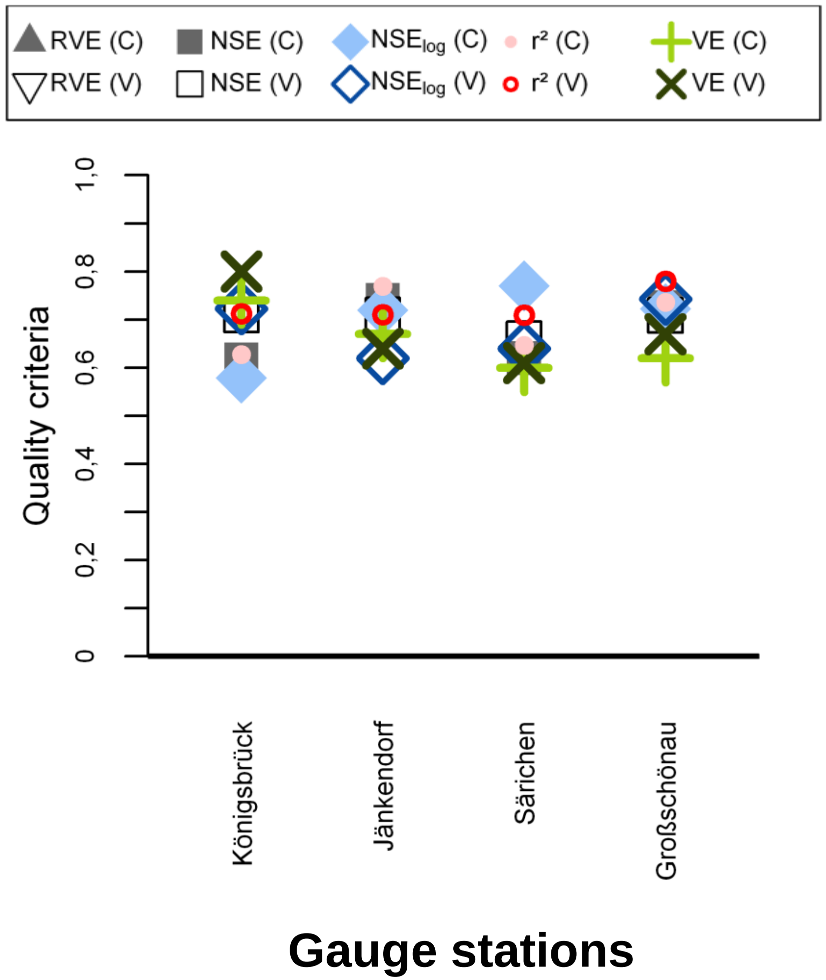

Model parameterization

Calibration for selected subcatchments (all hydrological model parameters)

Parameters		Königsbrück	Jänkendorf & Särichen	Großschönau
bff	Base flow factor	0.3	0.3	0.4
cnum1 /cnum2 /cnum3	Curve numbers	50 / 60 / 50	55 / 60 / 60	50 / 55 / 55
ecal	Correction of ETP	1	1,24	1
gwq0	Initial ground water flow	0.2	0.02	0.2
abf1 / abf2	Ground water recession rates	0.018 / 0.0002	0.023 / 0.00007	0.012 / 0.005
del0	Ground water delay	5.5	2.5	1.5
roc2 / roc4	Routing coefficients	1 / 1	1.1 / 1.2	1.1 / 1.1
sccor	Correction of saturated hydraulic conductivity	10	9	2
tsnfall	Snowfall temperatur	0.2	0.1	0
tmelt	Snowmelt temperature	3.6	3	2
smrate	Snowmelt rate	2.3	3.3	2.5
pcfacts	Riparian zone parameter	1	1	1

Model parameterization

Calibration for selected subcatchments (all hydrological model parameters)

Parameters		➔ Normalized values for parameters
bff	Base flow factor	
cnum1 /cnum2 /cnum3	Curve numbers	
ecal	Correction of ETP	
gwq0	Initial ground water flow	
abf1 / abf2	Ground water recession rates	
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roc2 / roc4	Routing coefficients	
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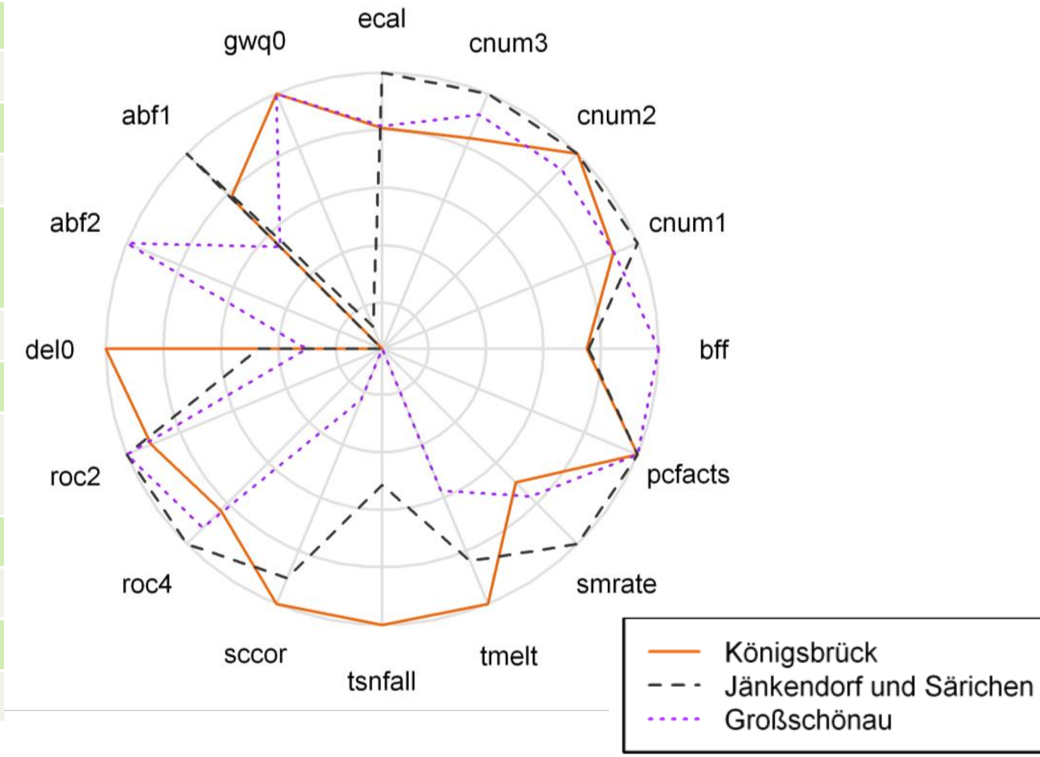

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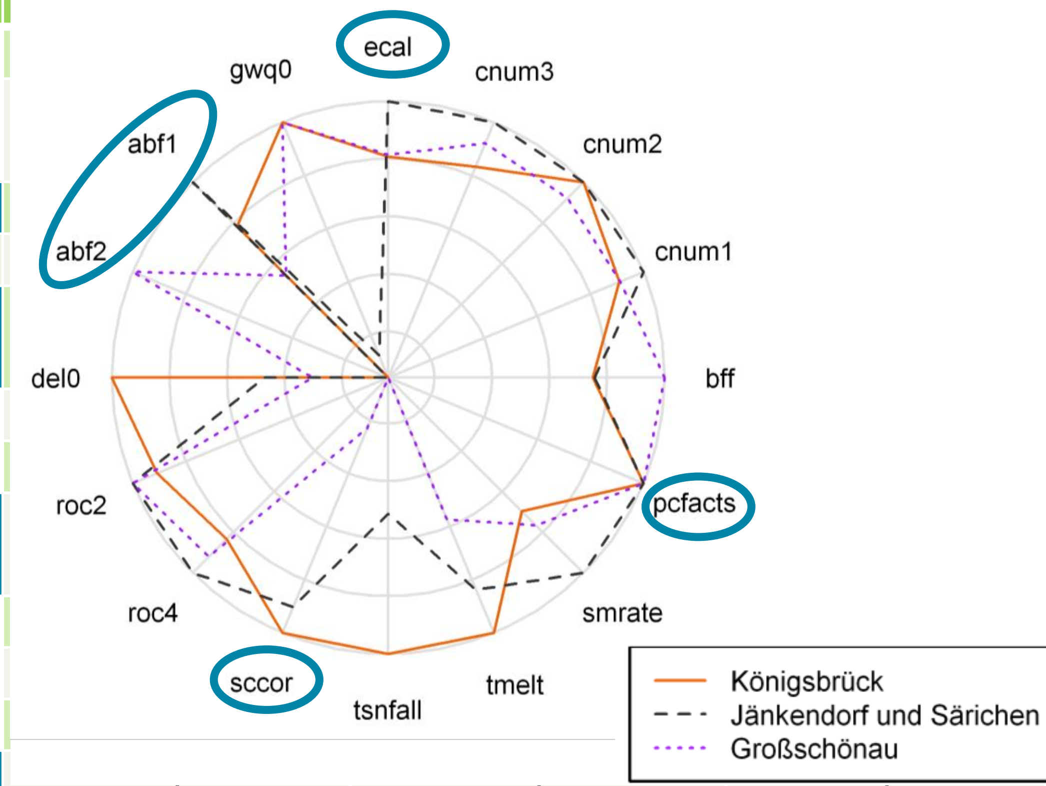

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Calibration for selected subcatchments
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Regionalization: physical similiarity and spatial proximity
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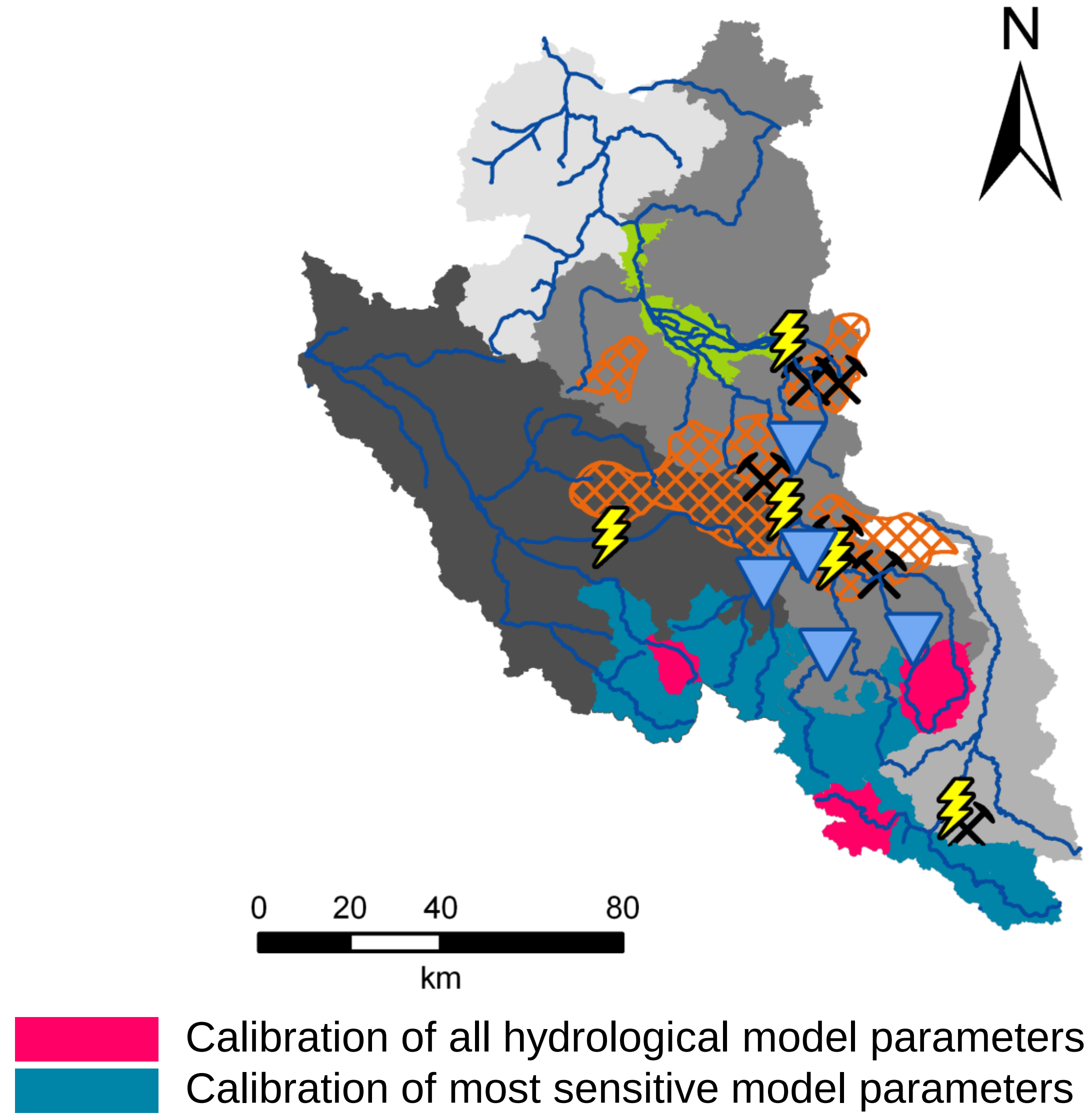

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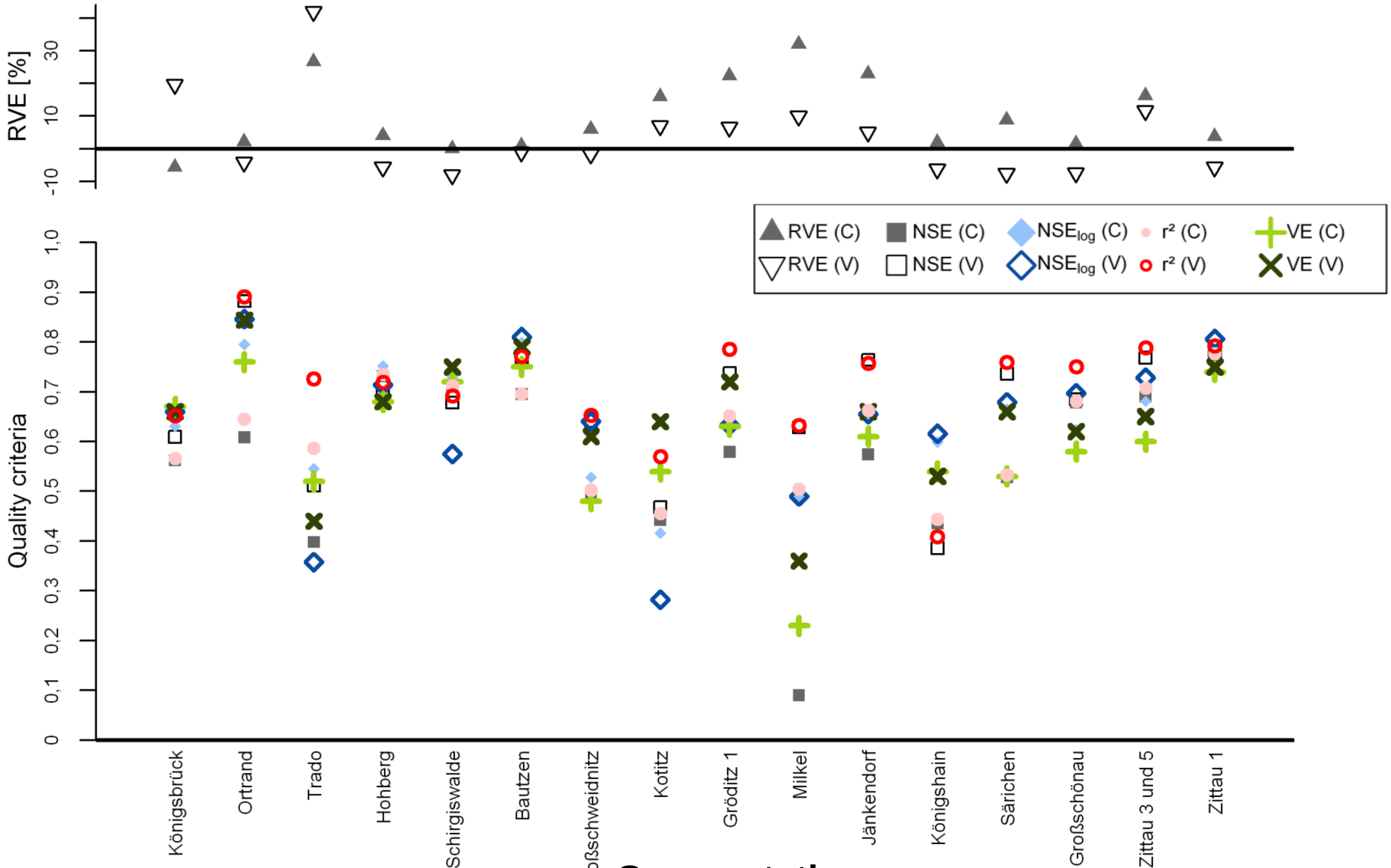

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Regionalization: physical similiarity and spatial proximity (entire catchments)

Correction of ETP: calibration in hilly areas, only small correction in lowland areas

Groundwater recession rates: higher in lowland than in hilly areas, relation 1/20

Correction of hydraulic conductivity: calibration in hilly areas, mean values in lowland areas

Riparian zone parameter: higher in hilly areas, lowest in the Spreewald Biosphere Reserve (wetland with channels)

Model parameterization

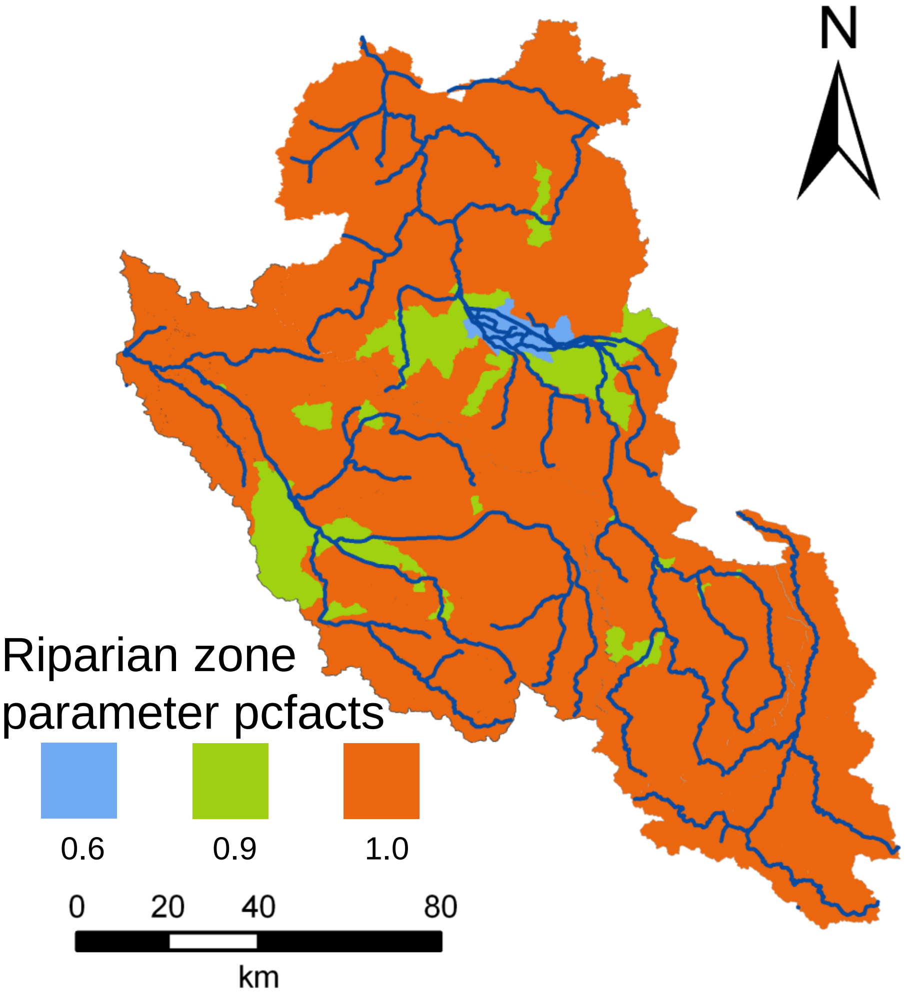
Regionalization: physical similiarity and spatial proximity (entire catchments)

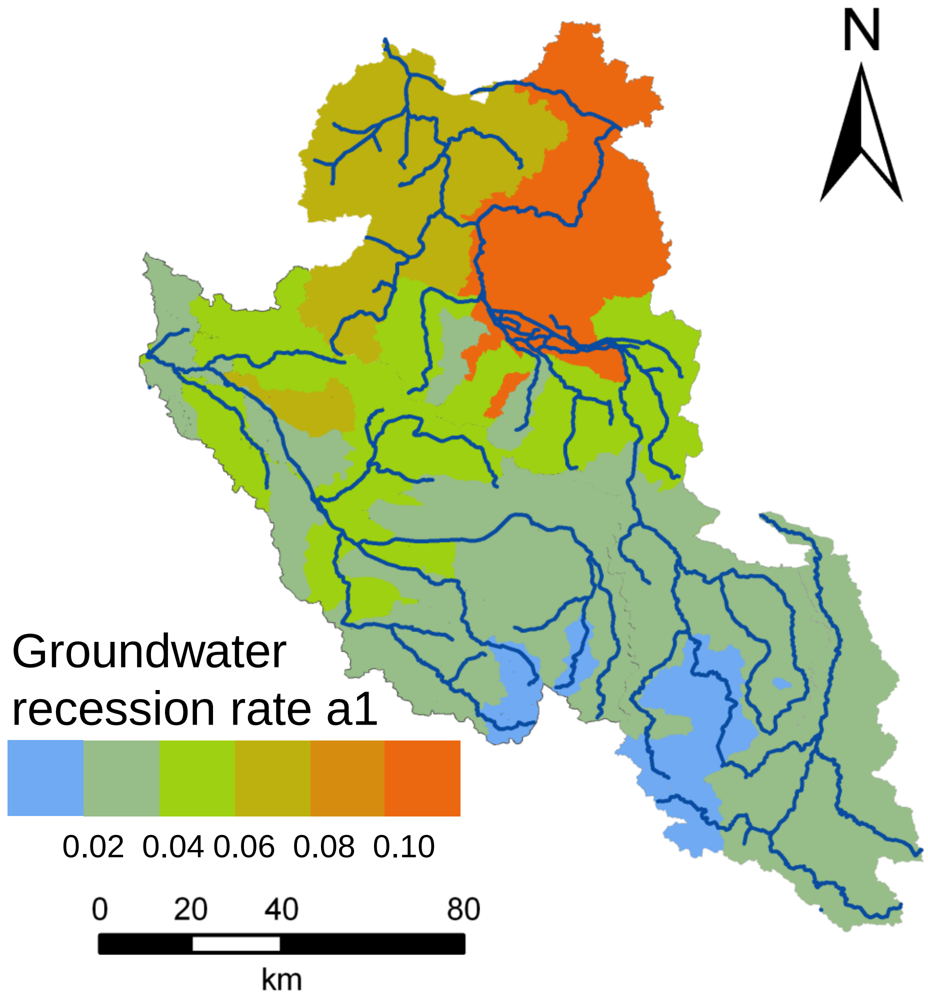
➔ **Model parameter values / ranges for the entire catchments**

Parameters		Value (Global)	Range (catchment specific)
bff	Base flow factor	0.3	
cnum1 /cnum2 /cnum3	Curve numbers	50 / 55 / 55	
ecal	Correction of ETP		0.85 – 1.35
gwq0	Initial ground water flow	0.02	
abf1 / abf2	Ground water recession rates		0.01-0.12 / 0.0005 – 0.006
del0	Ground water delay	5.5	
roc2 / roc4	Routing coefficients	1 / 1	
sccor	Correction of saturated hydraulic conductivity		1 – 14
tsnfall	Snowfall temperatur	0.3	
tmelt	Snowmelt temperature	1.2	
smrate	Snowmelt rate	2.2	
pcfacts	Riparian zone parameter		0.6 – 1.0

Model parameterization

Regionalization: physical similiarity and spatial proximity (entire catchments)





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Comparison with observed long term pre-mining discharges
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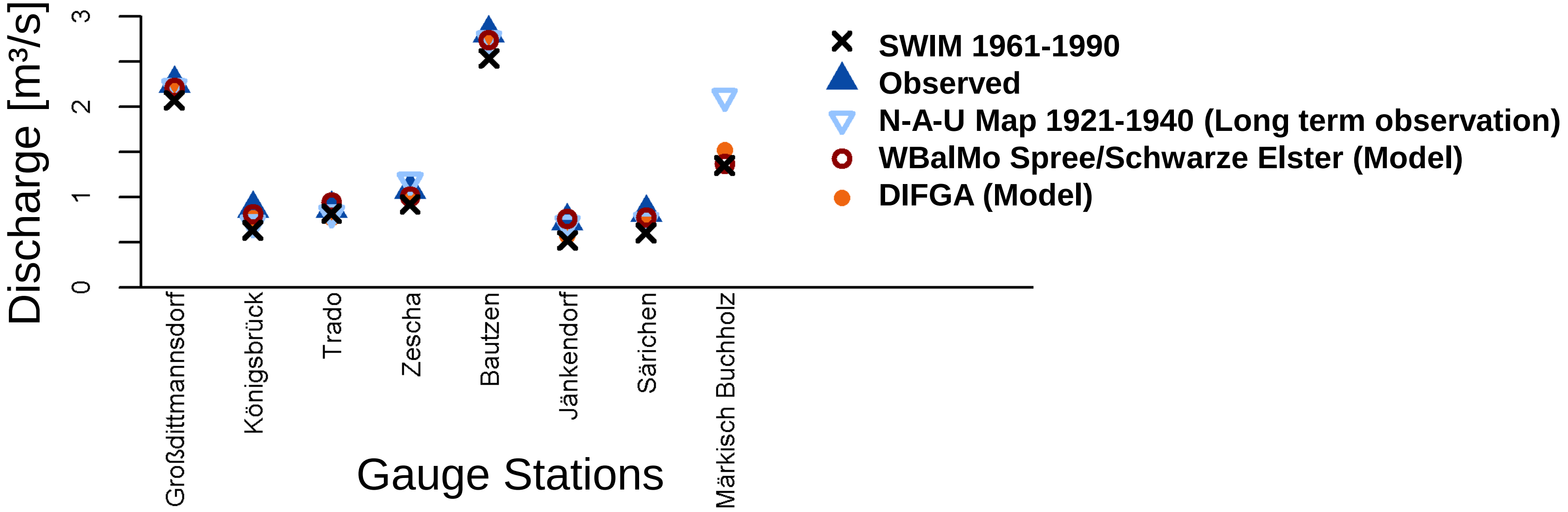
Model parameterization

Comparison with observed long term pre-mining discharges and simulation results of other models

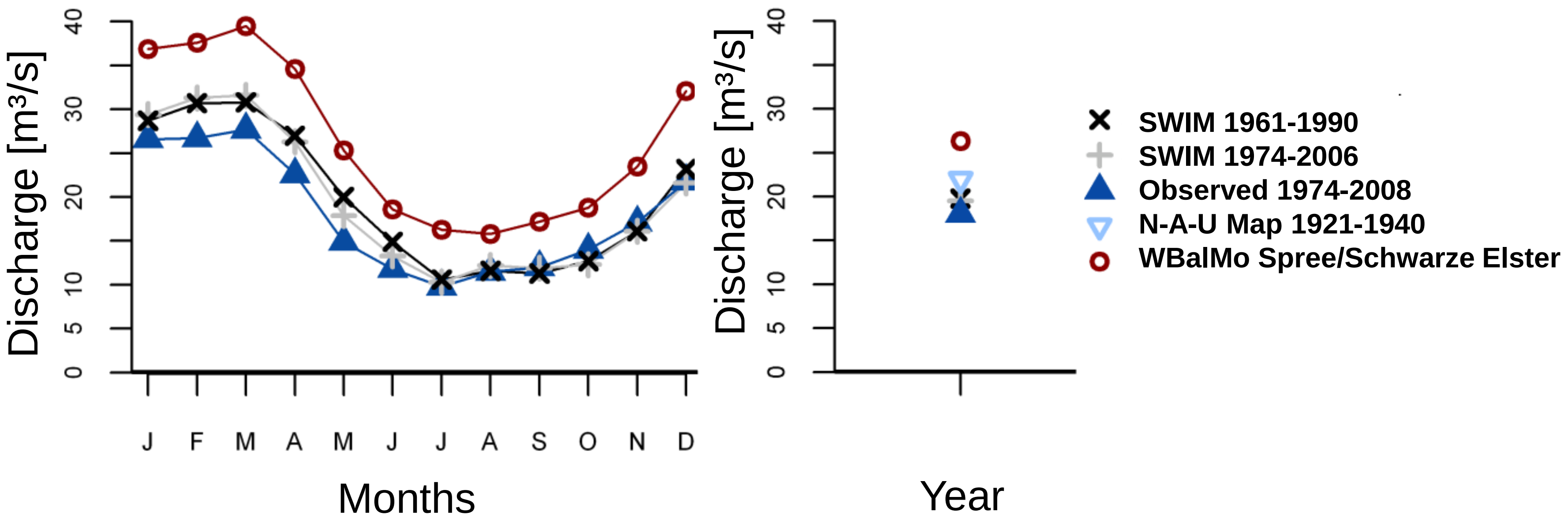
Long term discharge



Model parameterization

Comparison with observed long term pre-mining discharges and simulation results of other models

Long term discharge at the Löben gauge station (Schwarze Elster)



Summary and conclusion

Calibration for selected subcatchments (all hydrological model parameters)

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Calibration for selected subcatchments (most sensitive hydrological model parameters)

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Regionalization: physical similiarity and spatial proximity (entire catchments)

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Comparison with observed long term pre-mining discharges and simulation results of other models

Successful model set up + parameterization of SWIM to simulate natural water balance components in the region

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General approach also applicable to other catchments

Outlook

- Models are used in a combined climate and land use change impact study (Pohle et al. 2014 a)
- Mining discharge, cooling water demand of the power plants and water management are considered and adaptation measures are discussed (Pohle et al. 2014 b)
- Analysis of potential climate change impacts on mining related water quality issues

- **Model comparison SWIM - WaSiM-ETH - HBV-light:**
  Presentation of Anne Gädeke, „Comparing the eco-hydrological model SWIM to conceptually different hydrological models for climate change impact assessments on low flow“ (Friday)

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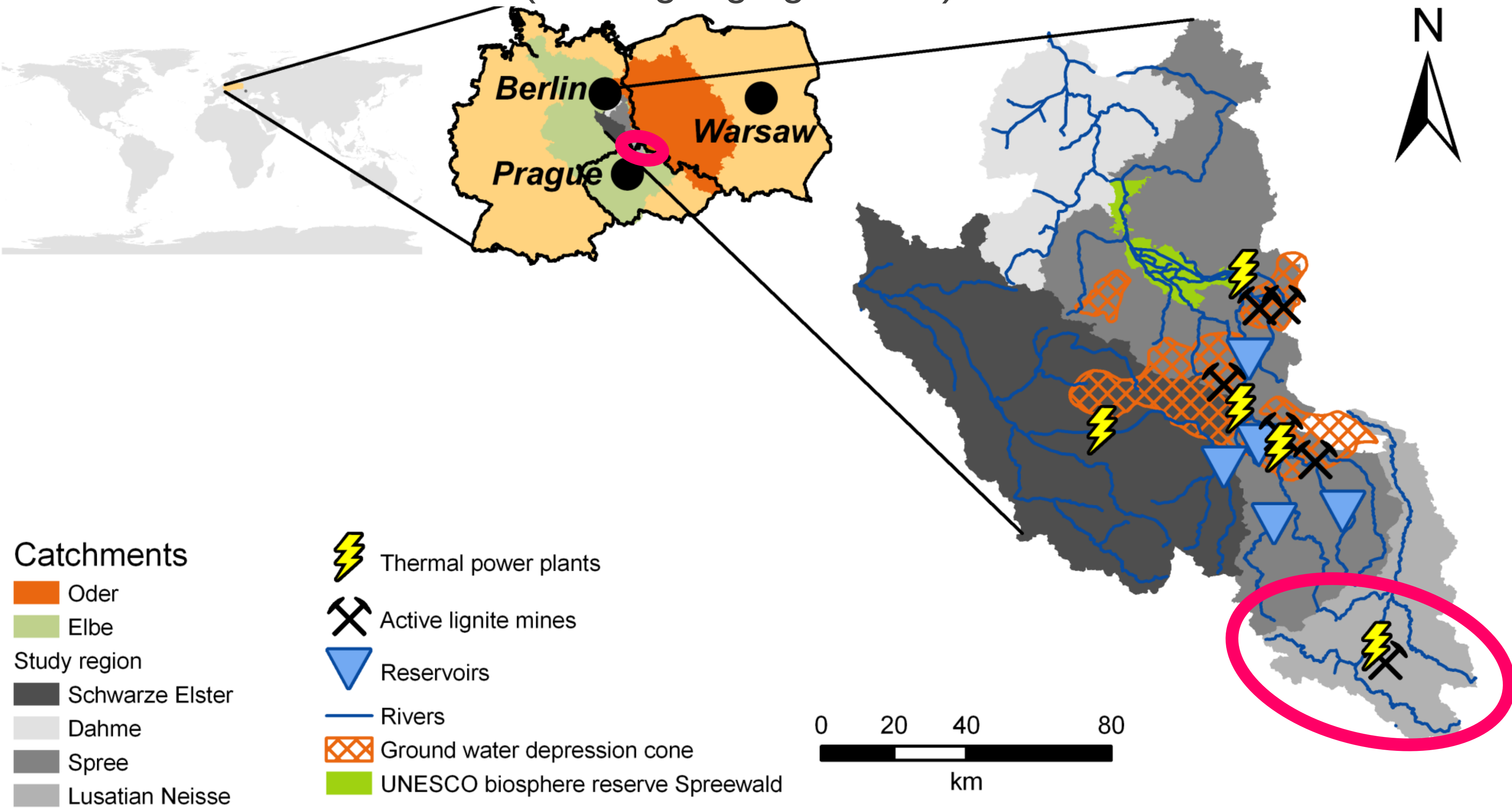
THANK YOU!!

Post-mining lake Klinge, picture: Radke, LMBV

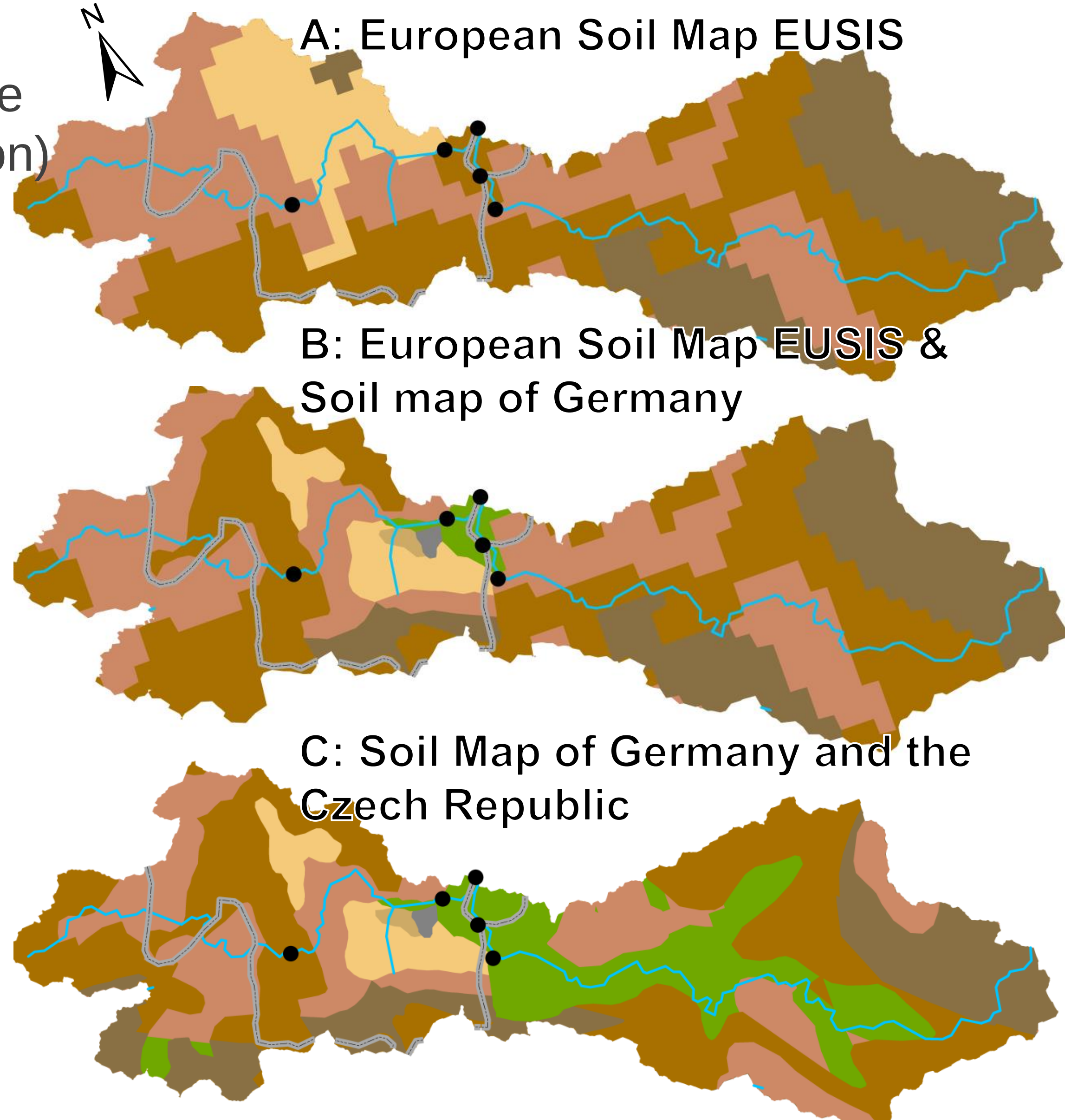
Influence of data availability (soil data)

Lusatian Neisse catchment (Zittau gauging station)



Influence of data availability (soil data)

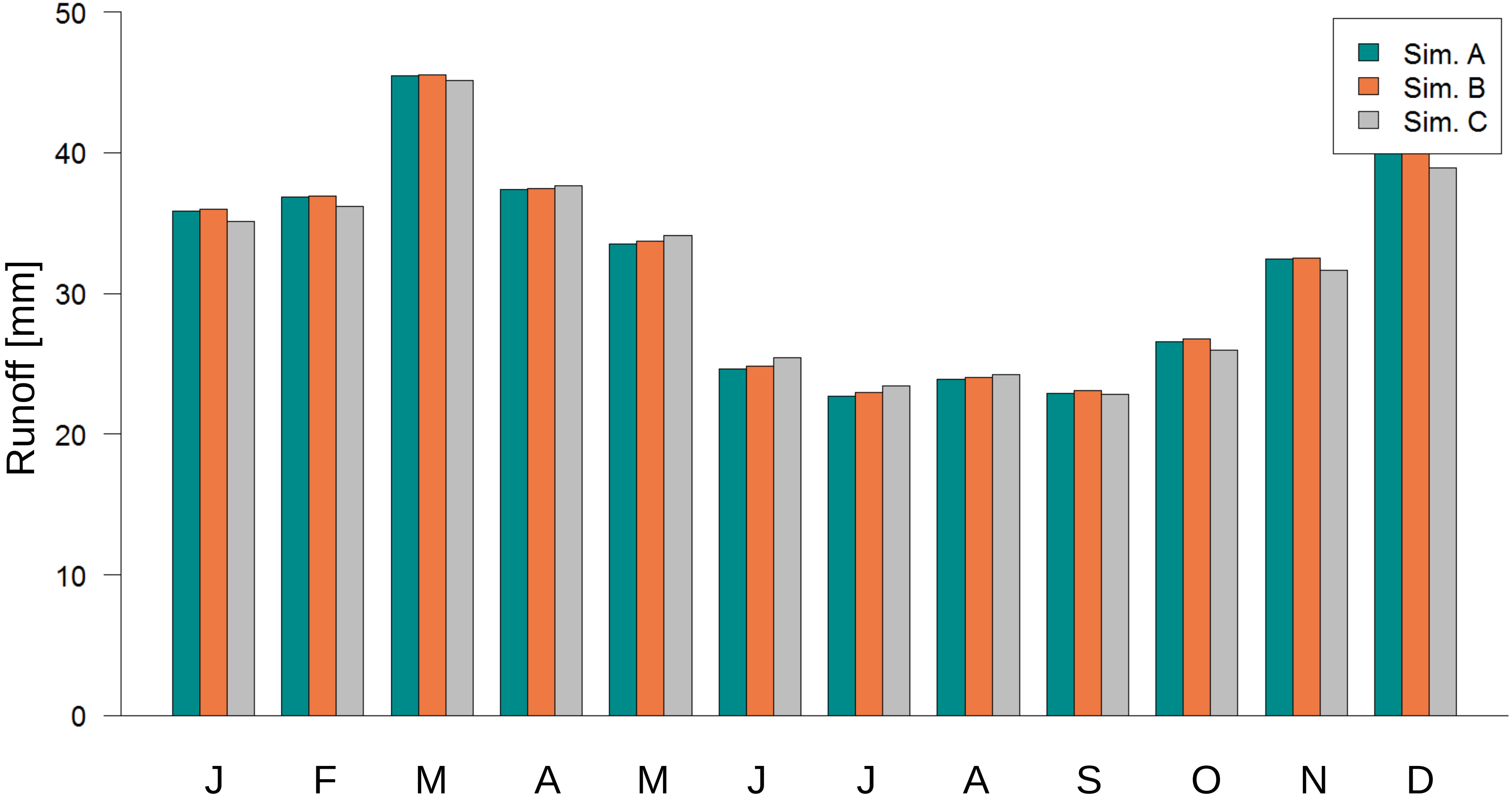
Soil maps of the Lusatian Neisse catchment (Zittau gauging station)



0 1,5 3 6 9 12

Influence of data availability (soil data)

Long term monthly discharge at the Zittau gauge station using 3 different soil maps (1961-1990)



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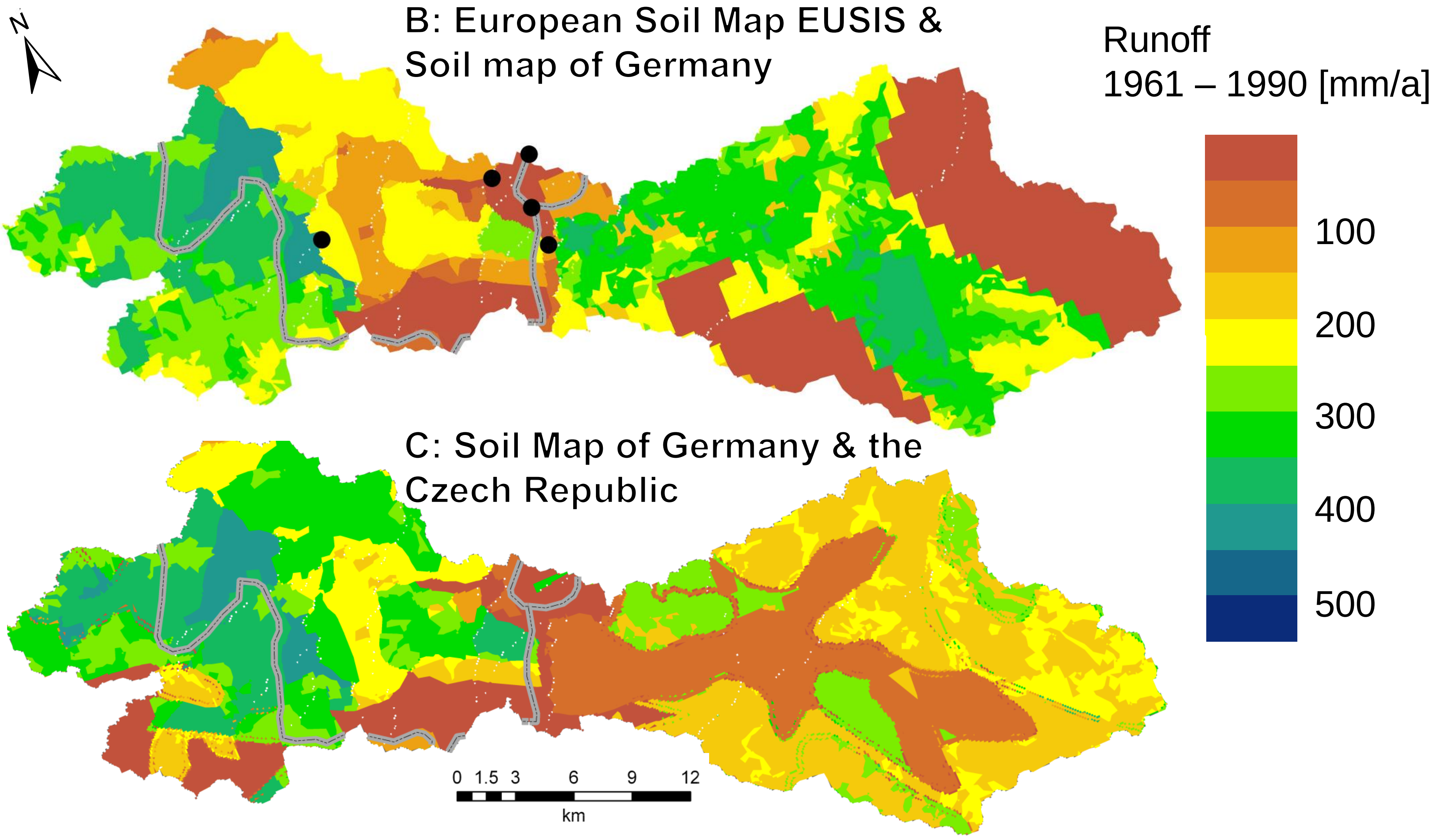

Influence of data availability (soil data)

- Different soil maps ➔ similar results at the gauge stations can be gained due to parameter calibration
- But: very different results of spatially discretisiced water balance components

➔ Good results for the wrong reason?

➔ In the end the most detailed soil map was chosen for each country

Background

Lusatia – a heavily managed lowland region in Central Europe

- Climate: average temperature ca. 9°C, annual precipitation ca. 600-650 mm
- Topography: mountain ranges and hilly areas in the south (max. 1000 m), mostly lowland areas in the north
- Land use: mainly cropland and forest
- Large – scale open pit lignite mining
- Size of the study region: 16 300 km²