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Impact of the ratio between subbasins and climate stations on the performance of SWAT in the Rhine basin

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Overview

The setup and application of a hydrological model on the European Continent

Overview

The setup and application of a hydrological model on the European Continent

- Main aim is the setup up of SWAT for the European continent
- Calibration and validation with focus on water quantity
- Future scenarios of climate and land-use changes

Contribution to GENESIS – 7th Framework EU project

GENESIS
groundwater and dependent ecosystems

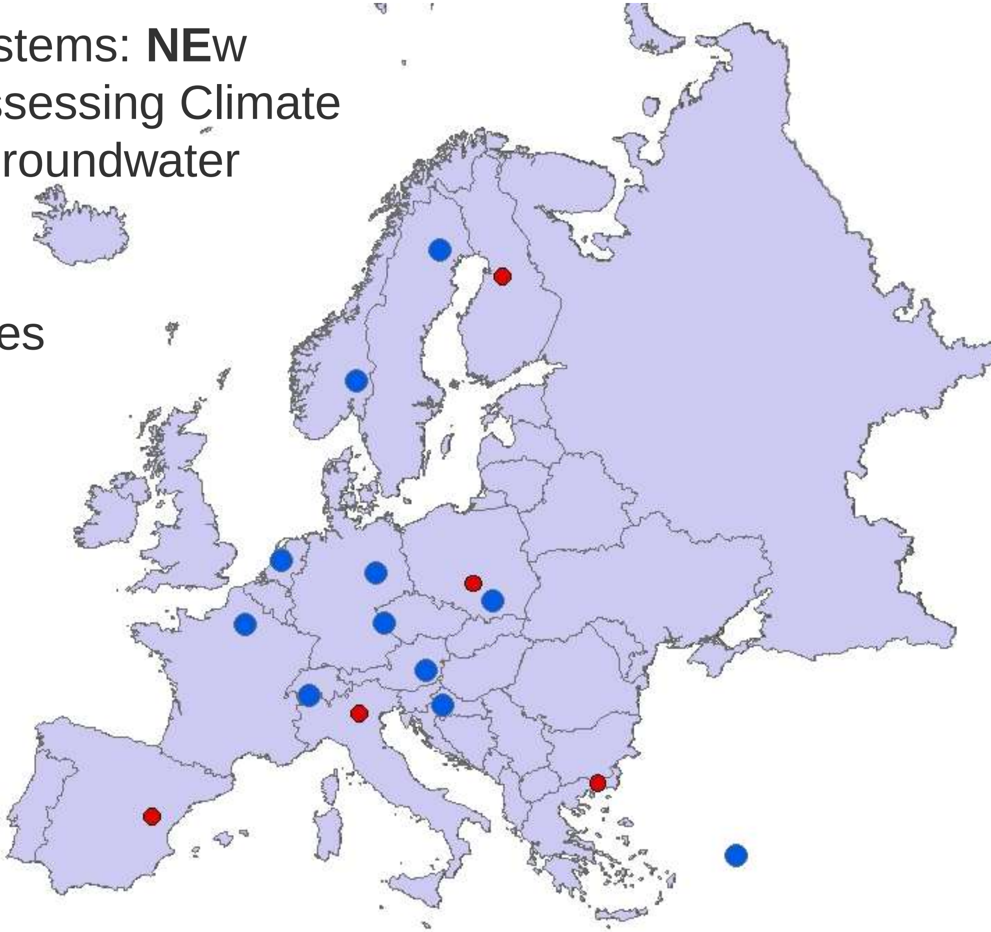
SEVENTH FRAMEWORK PROGRAMME

- **G**roundwater and Dependent **E**cosystems: **NE**w **S**cientific and Technical Bas**IS** for Assessing Climate Change and Land-use Impacts on Groundwater Systems

- 25 Partners from 17 different countries

- 16 case study sites

- Our contribution:
  Derive estimates of groundwater recharge on a continental scale using SWAT
  Application of land-use and climate change scenarios



Introduction

Climate data in a SWAT project

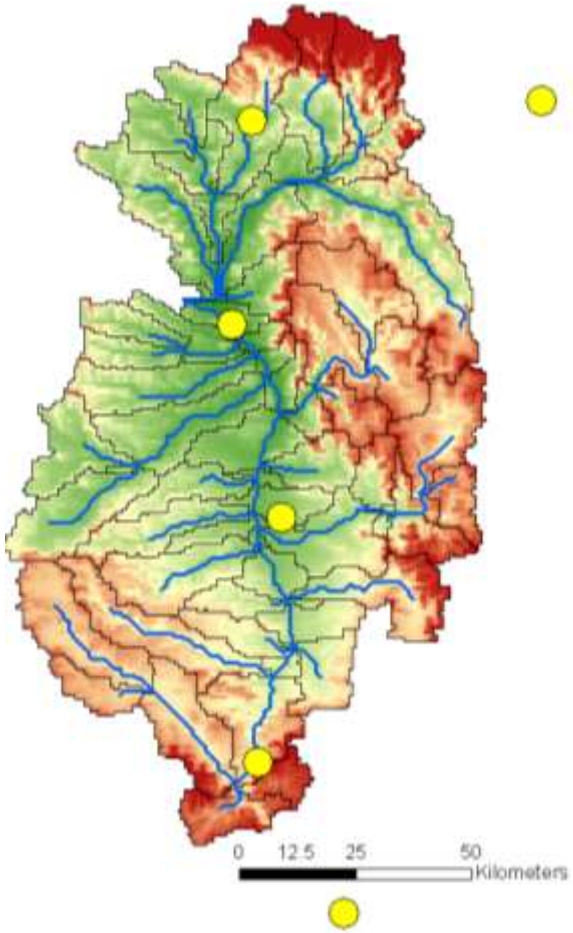
- Climate data is the main driver of a hydrological model

  So we need to consider…:

  - …Source
  - …Quality
  - …Spatial resolution

  of the climate dataset(s).

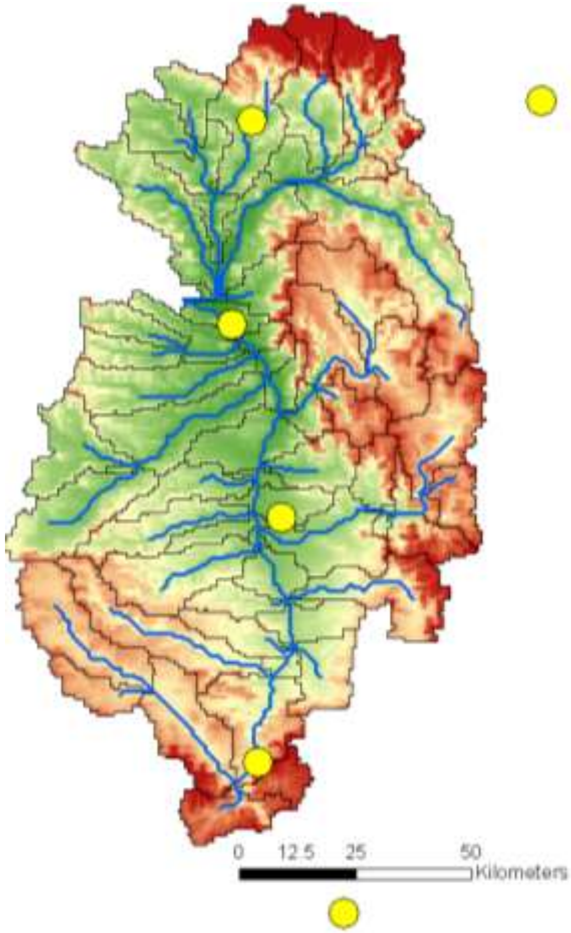
- SWAT: 1 climate station for 1 subbasin



Introduction

Climate data in a SWAT project

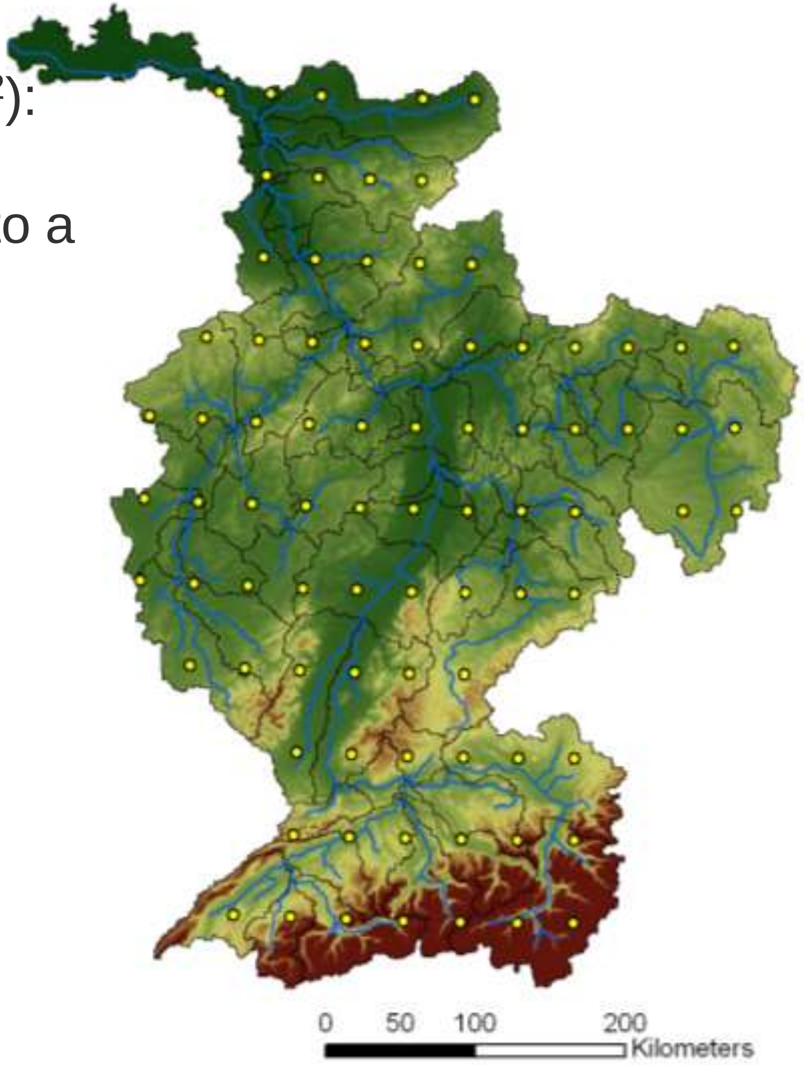
- Smaller SWAT projects in the magnitude of $10^3 – 10^4 km^2$:
- Number of subbasins >> number of climate stations
- Size and number of subbasins usually depends on the diversification of the river network



Introduction

Large Scale modeling

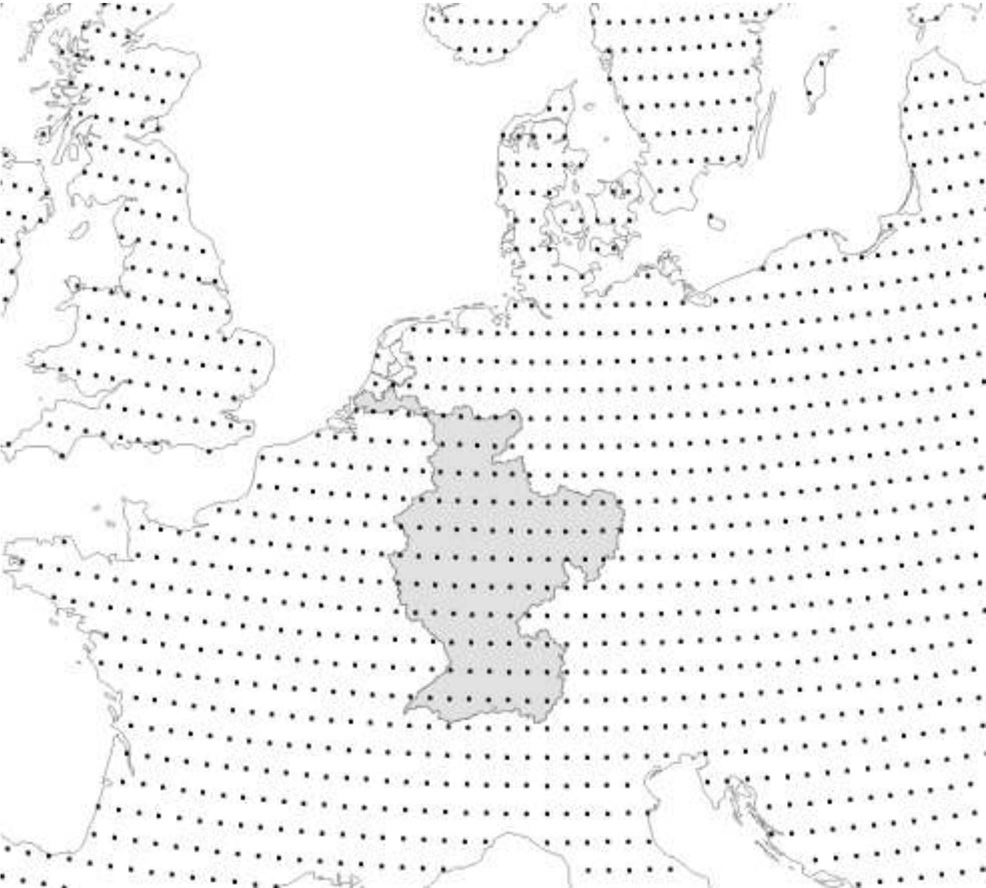
- Large scale application ($10^5 – 10^7 km^2$):
- Size of subbasin increases, typically to a magnitude of $10^3 – 10^4 km^2$
- Gridded climate datasets might be available for study area
- Choice of climate dataset and spatial extend of subbasin while considering limits of computational resources?!



Introduction

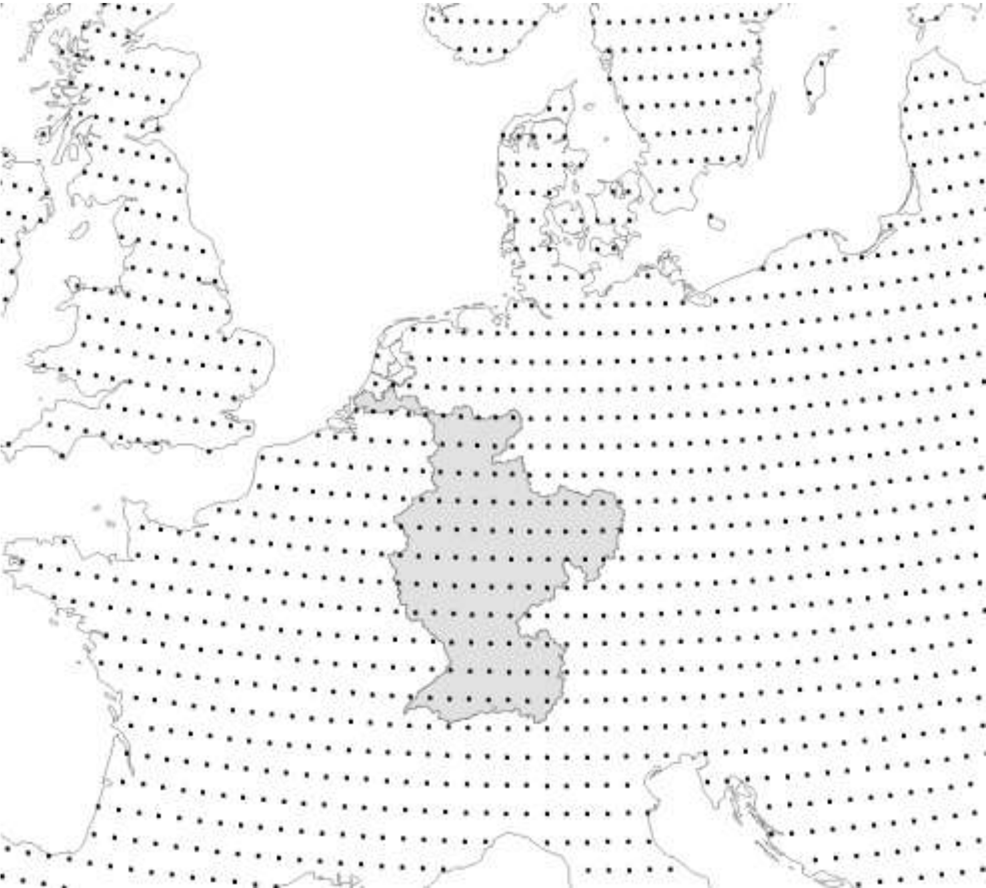
- Aim is to test the sensitivity of SWAT to the ratio between subbasins and climate stations on a large scale project

- Comparing the results using two different delineation thresholds



Introduction

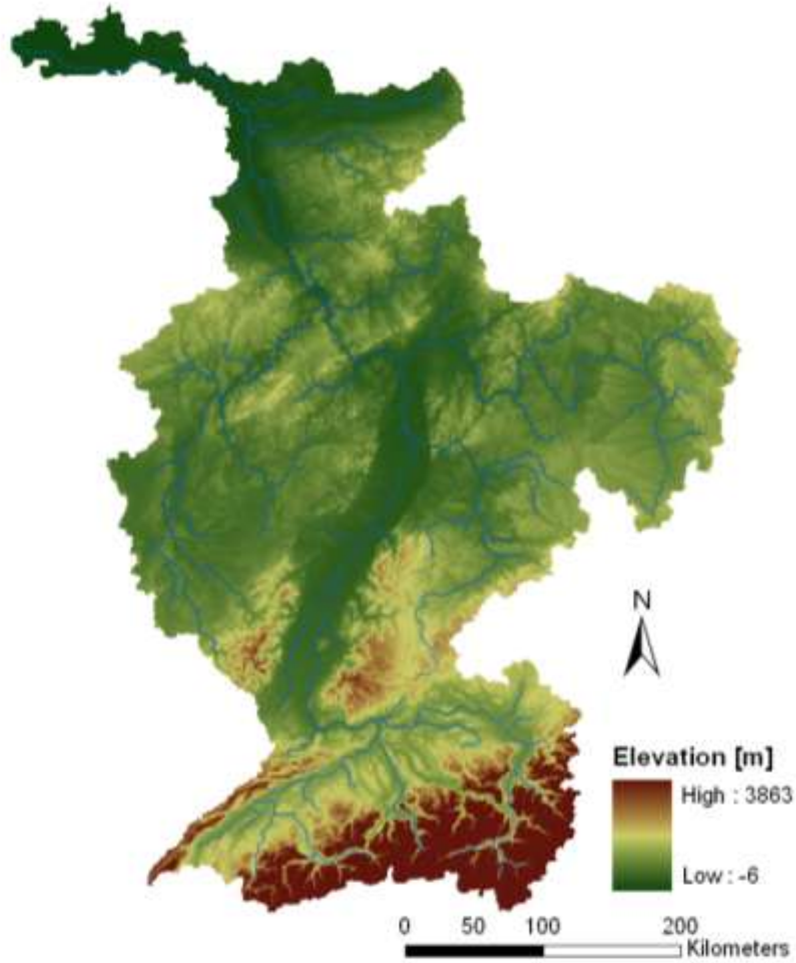
- Aim is to test the sensitivity of SWAT to the ratio between subbasins and climate stations on a large scale project
- Comparing the results using two different delineation thresholds
- Rhine Basin
- CRU TS3.0 gridded climate dataset on a 0.5° resolution



Model setup

Rhine catchment

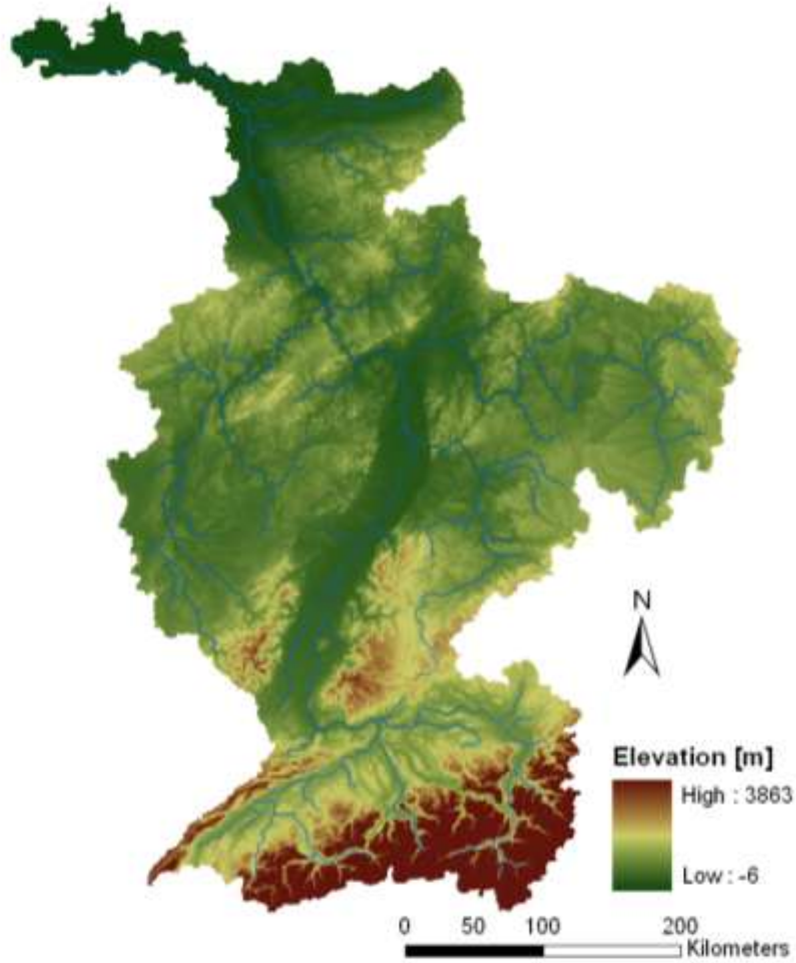
Characteristics	
Area	170’000km2
Topography	
Below 1000m	91.37%
Above 1000m	8.63%
Above 1500m	4.98%
Above 2000m	2.65%



Model setup

Rhine catchment

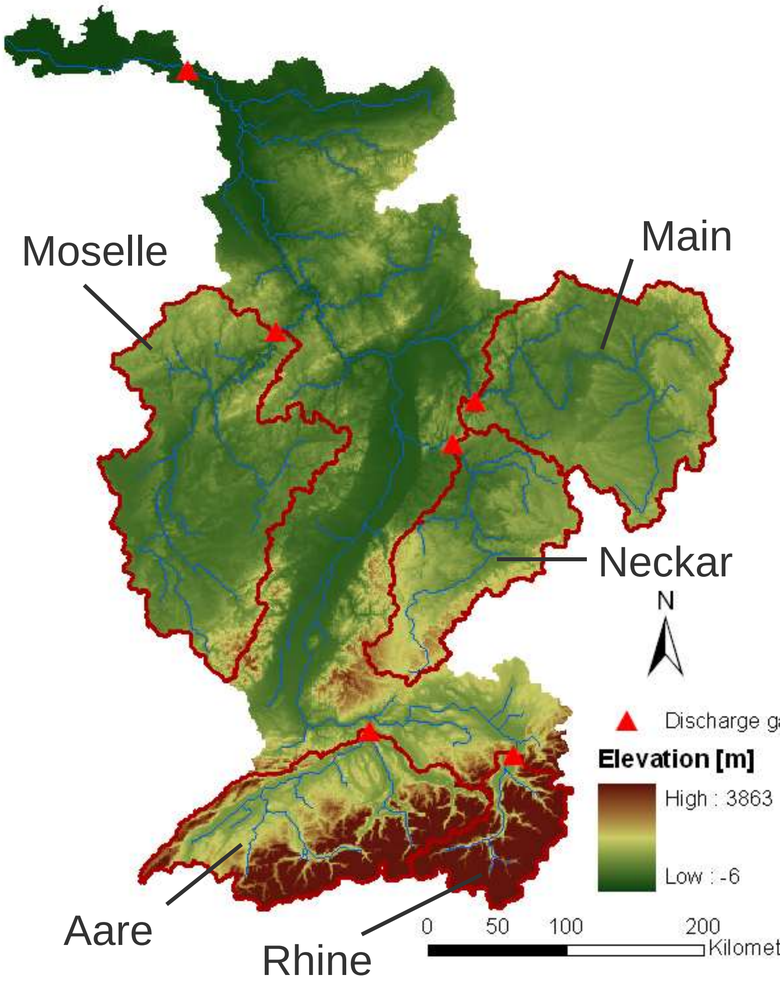
Characteristics	
Area	170’000km^2
Land-use	
Agriculture	45.78%
Forest	37.07%
Pasture	10.69%
Residential, tundra/bare ground, waterbodies/wetlands, industrial/urban	6.46%



Model setup

Rhine catchment

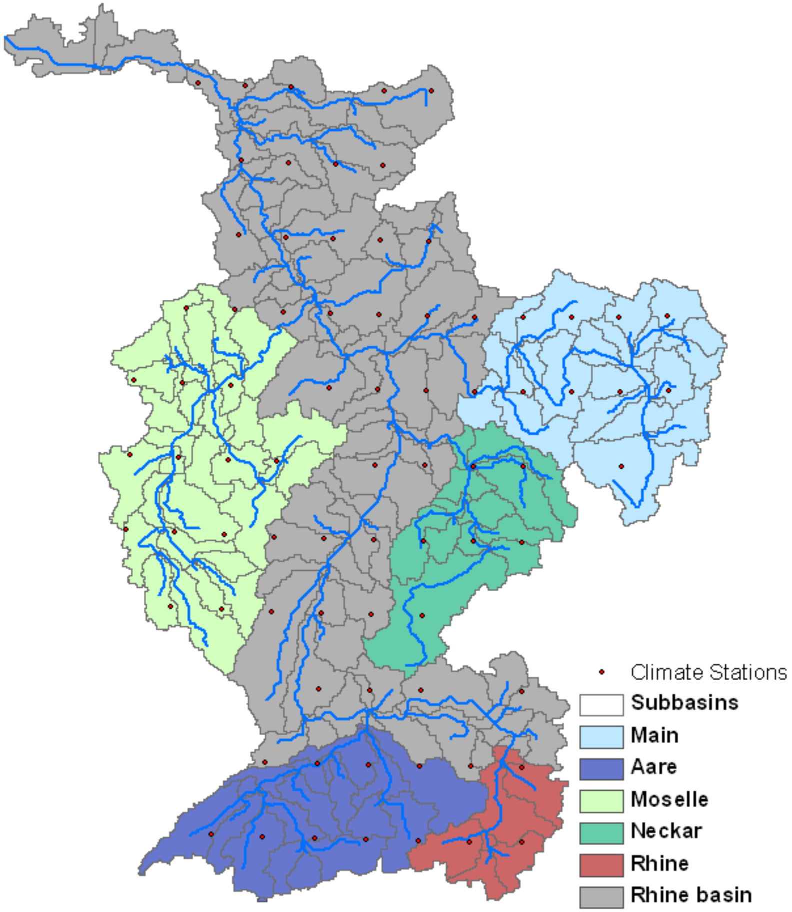
Subcatchments	Area
Rhine upstream	6’000km2
Aare	17’000km2
Neckar	14’000km2
Main	22’000km2
Moselle	28’000km2



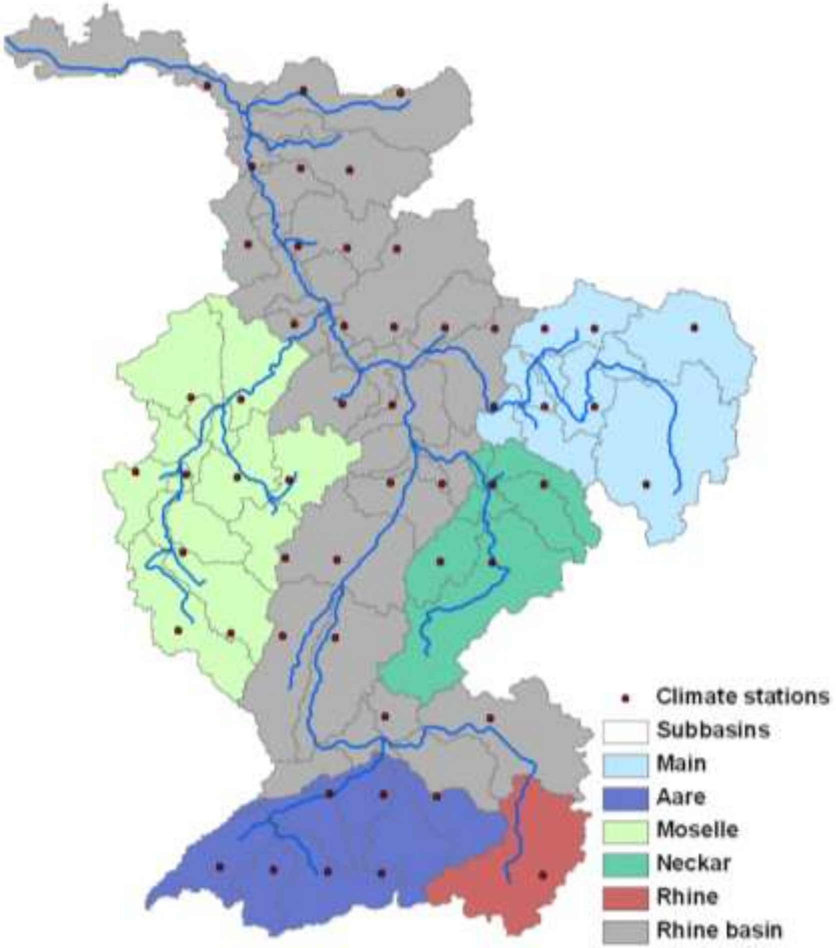
Model setup

Delineation thresholds

50’000ha: 170 subbasins



150’000ha: 73 subbasins



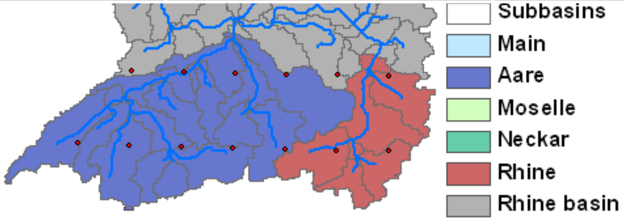
Model setup

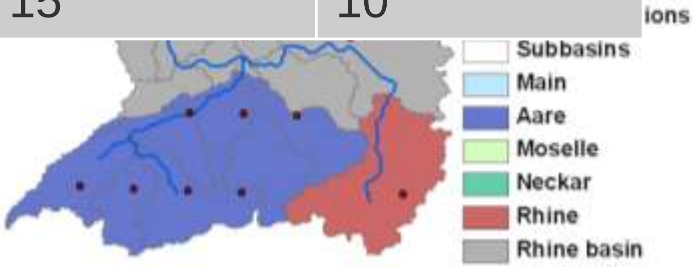
Delineation thresholds

50’000ha: 170 subbasins

150’000ha: 73 subbasins

	High resolution		Low resolution	
	Subbasins	Climate stations	Subbasins	Climate stations
Rhine	170	77	73	53
Rhine upstream	7	3	1	1
Aare	18	9	7	7
Neckar	12	6	6	4
Main	23	10	10	7
Moselle	32	14	15	10





Model setup

Delineation thresholds

~2.4 (+24 Stations) **~1.3**

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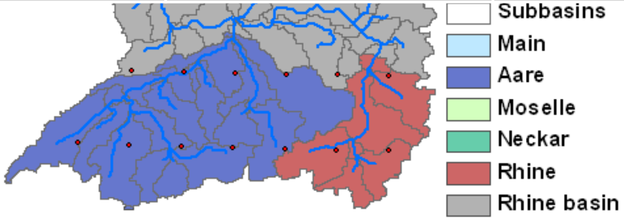

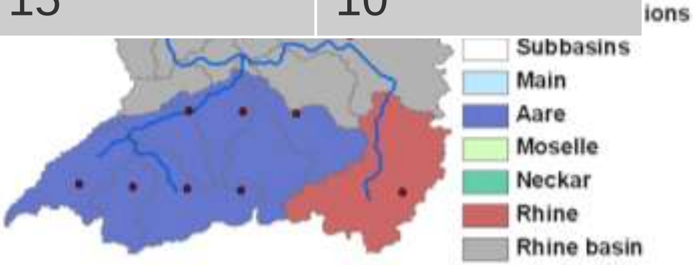

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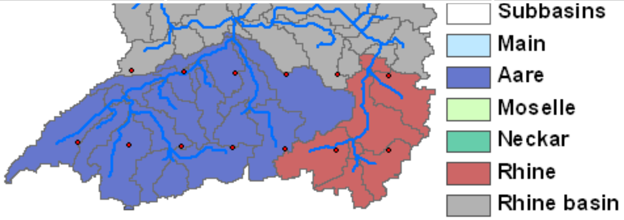
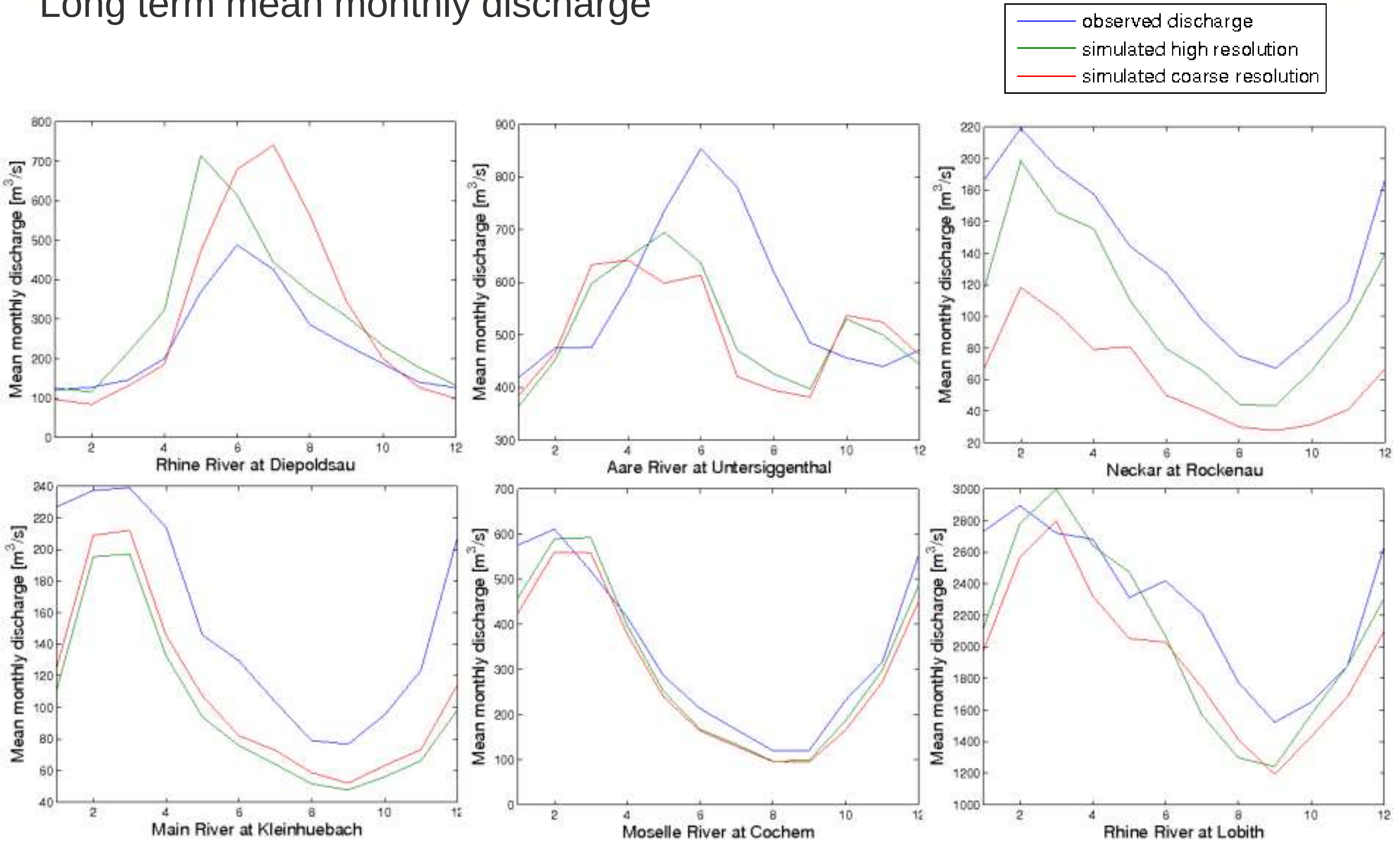


Model setup

Simulation Setup	
Simulation Time	1970-1992
Spin up time	3 years
Elevation bands Bandwidth T-lapse	1000-4000m 500m -6.5°C
ET calculation method	Hargreaves

Results

Long term mean monthly discharge



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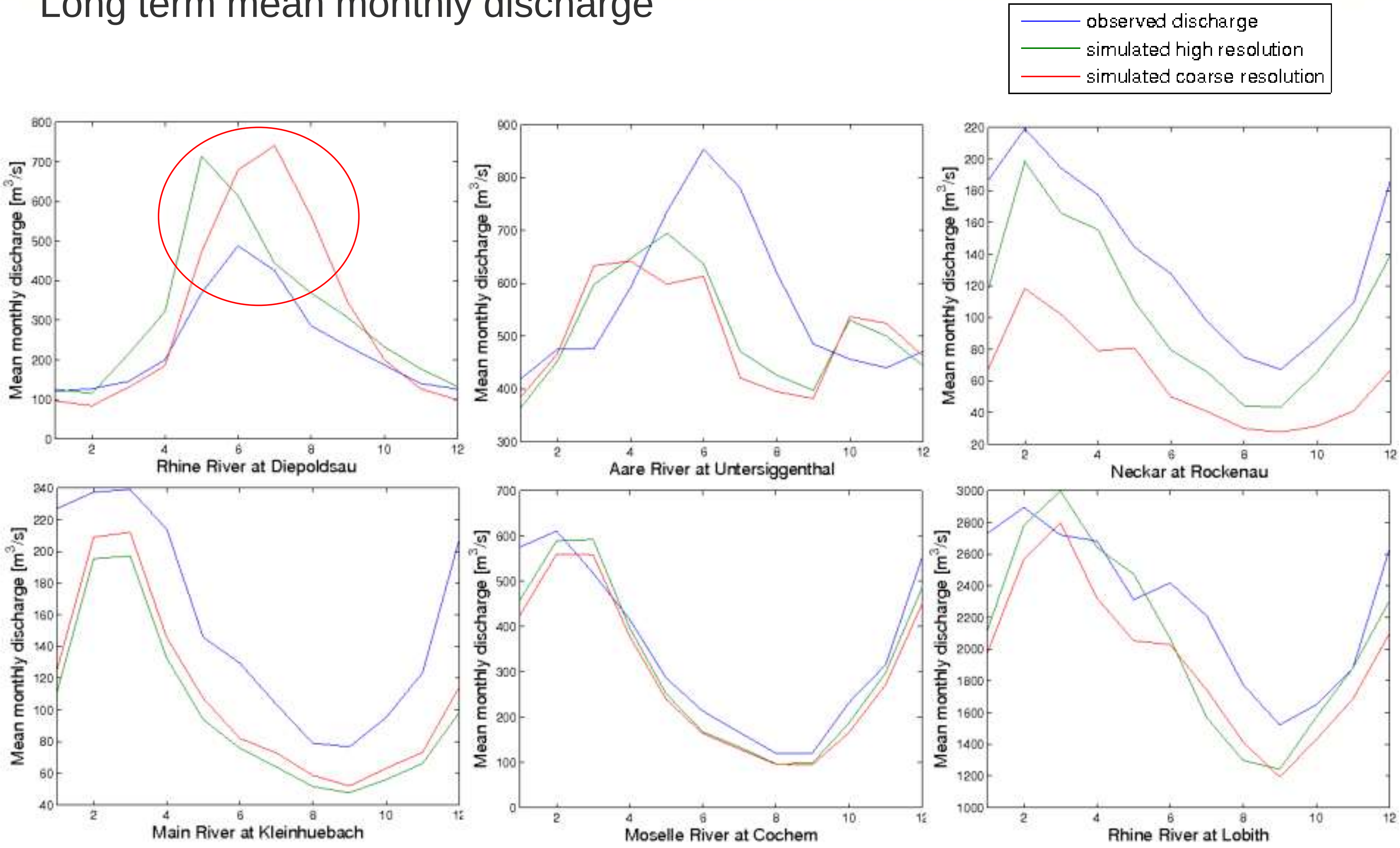

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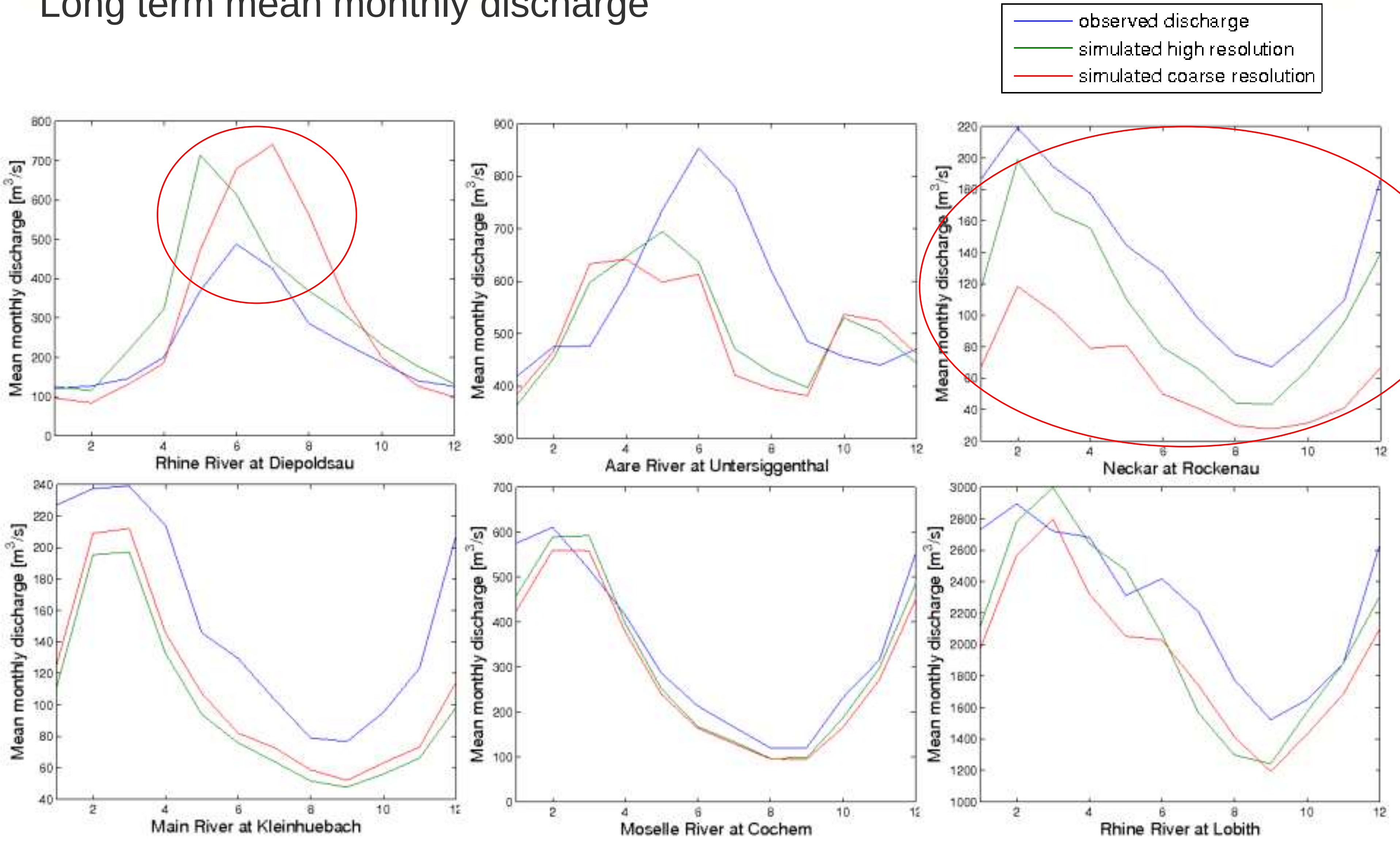

Results

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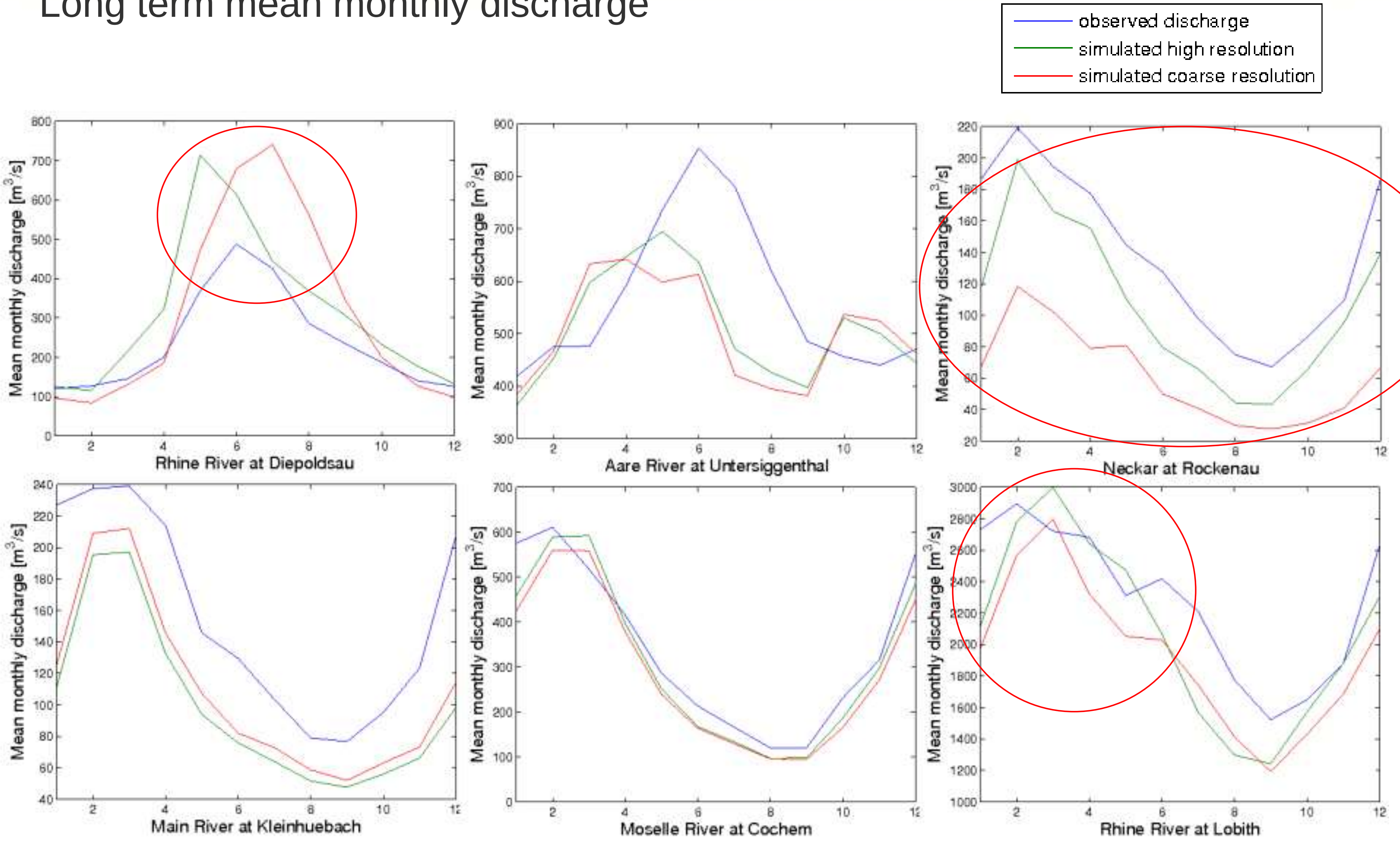

Results

Long term mean monthly discharge – Nash Sutcliffe Efficiency

Catchment	NS		
	High	Low	Difference
Upper Rhine	-0.62	-0.56	0.06
Aare	-0.13	-0.37	0.24
Neckar	0.4	-0.27	0.67
Main	-0.05	0.05	-0.10
Moselle	0.66	0.65	0.01
Rhine downstream	0.21	0.29	-0.08

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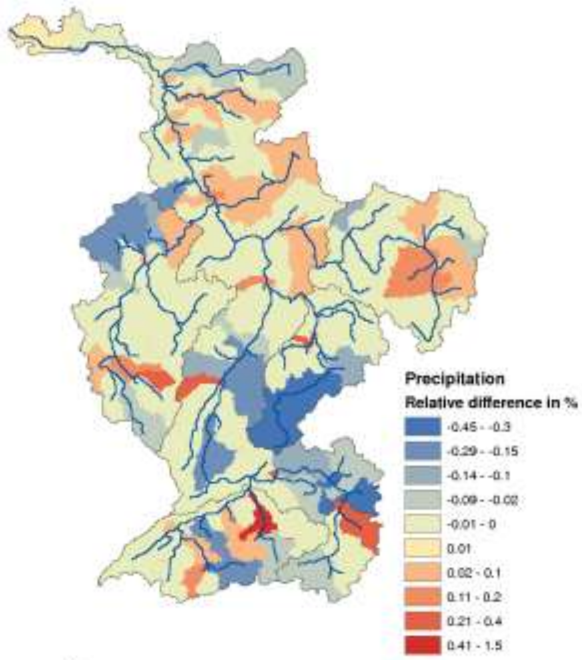
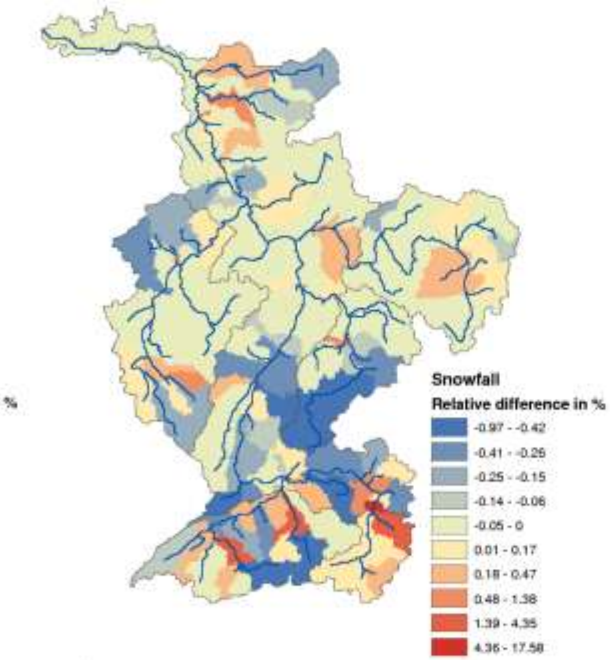
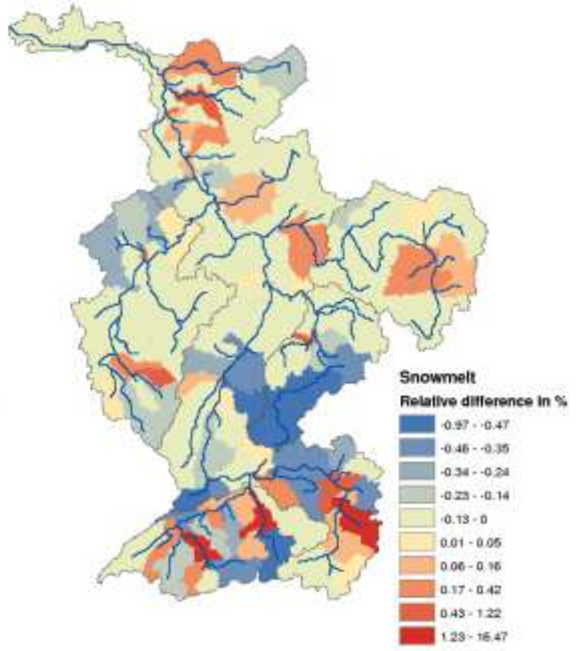
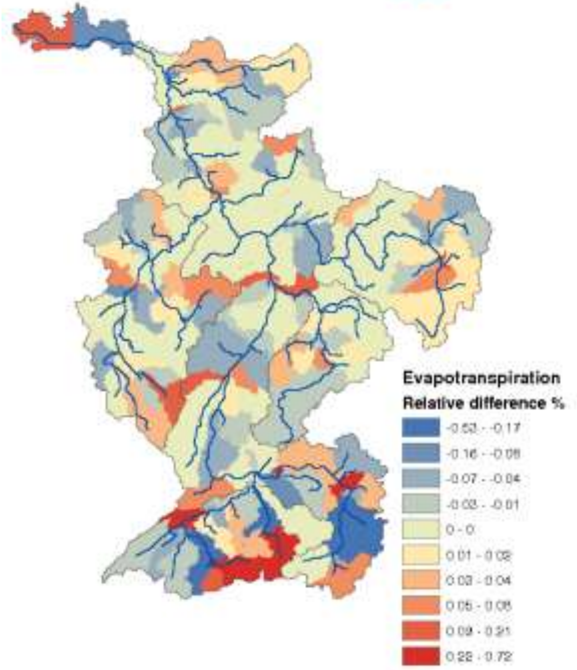
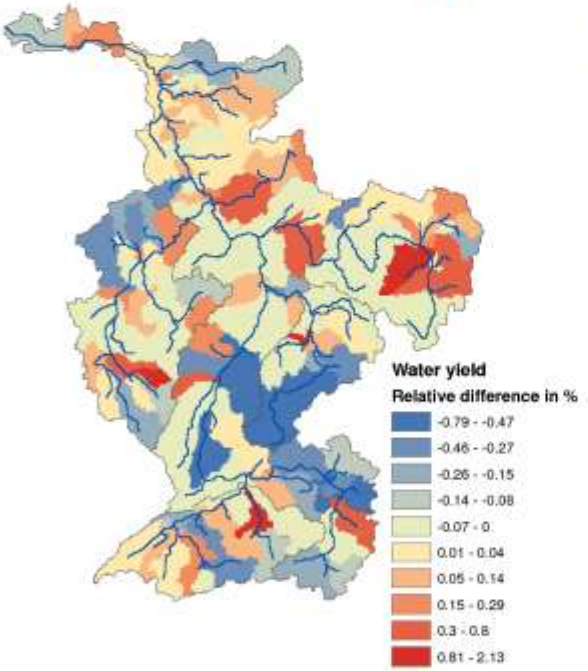
Relative difference of long term mean annual values: (low – high) / high

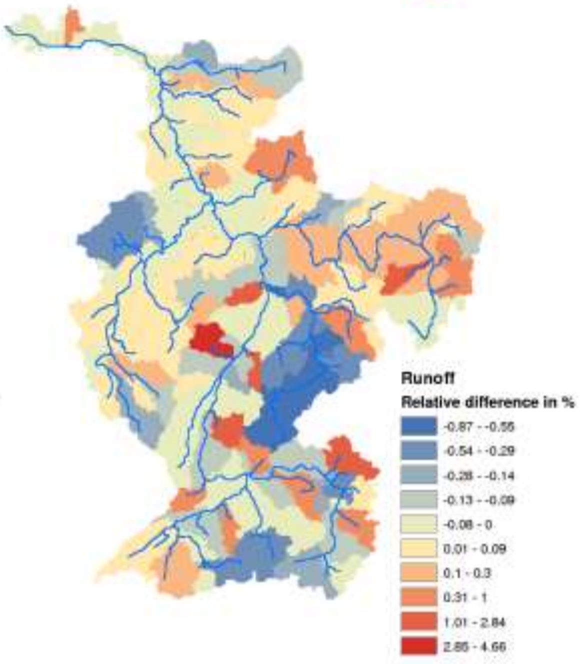




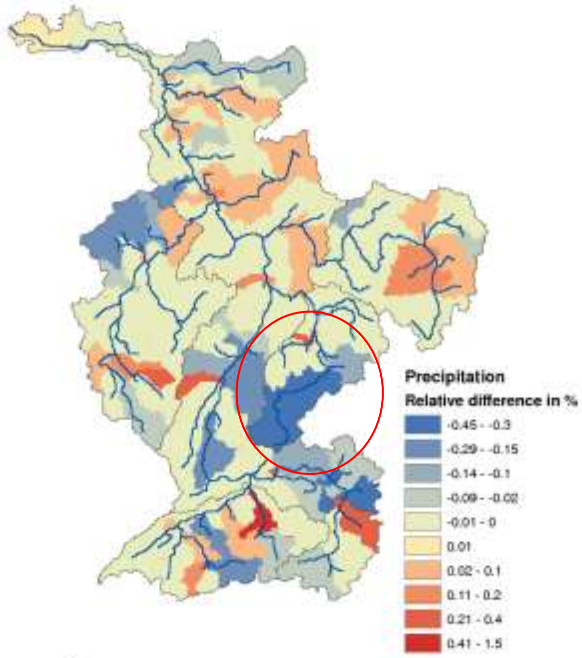


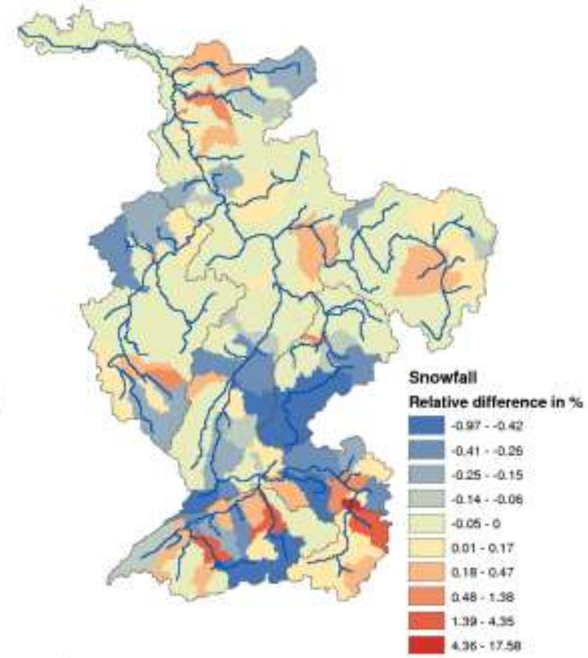


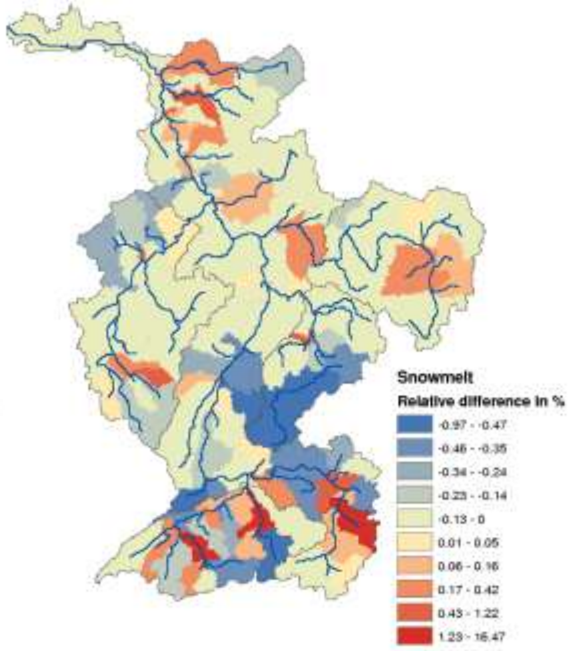


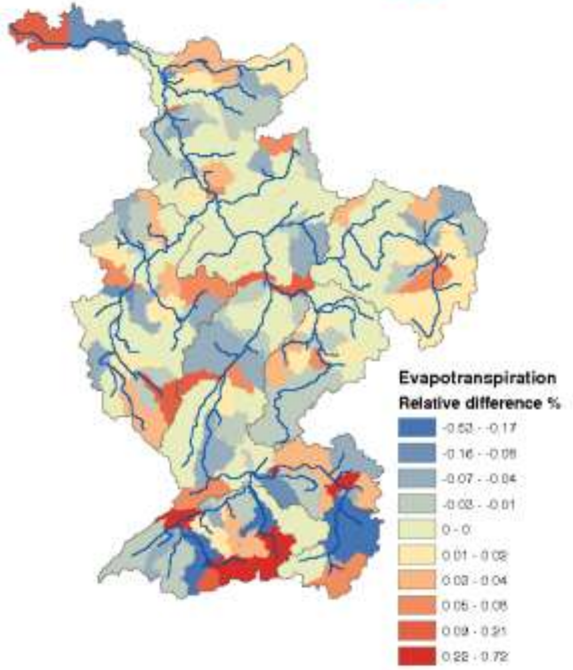


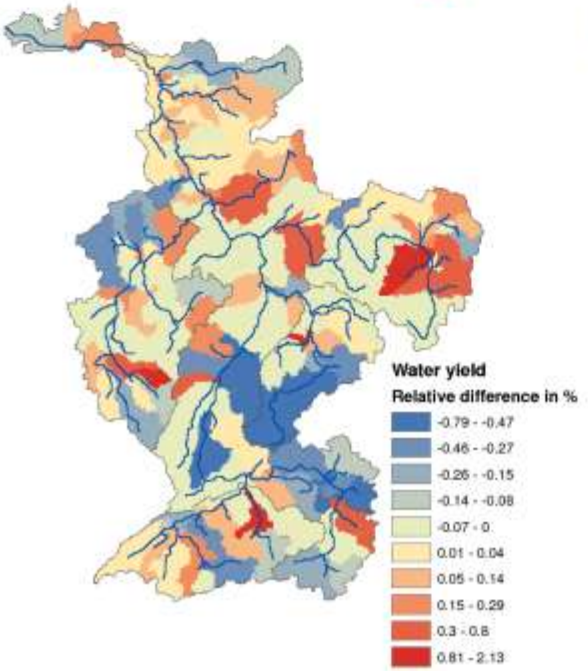
Relative difference of long term mean annual values: (low – high) / high

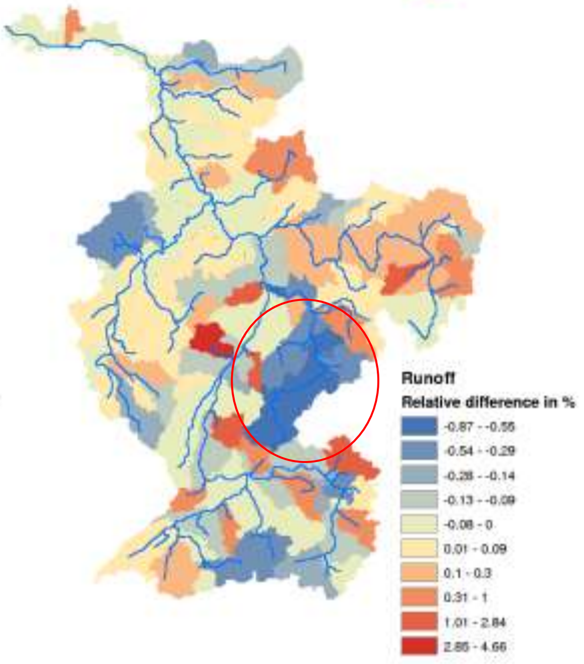












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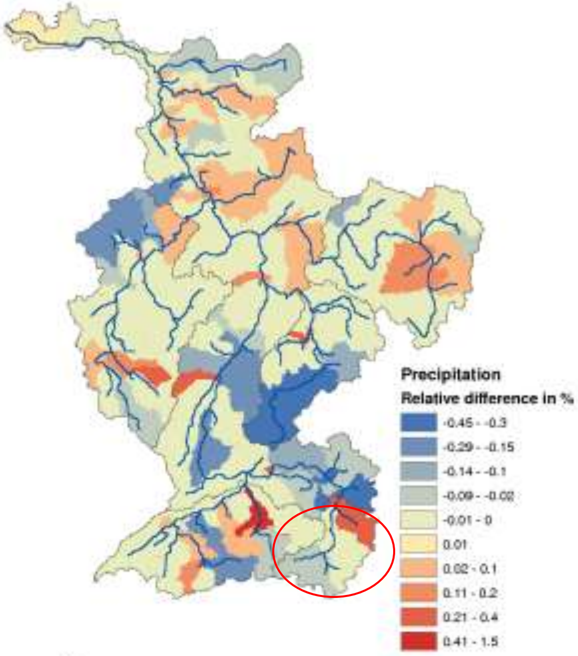

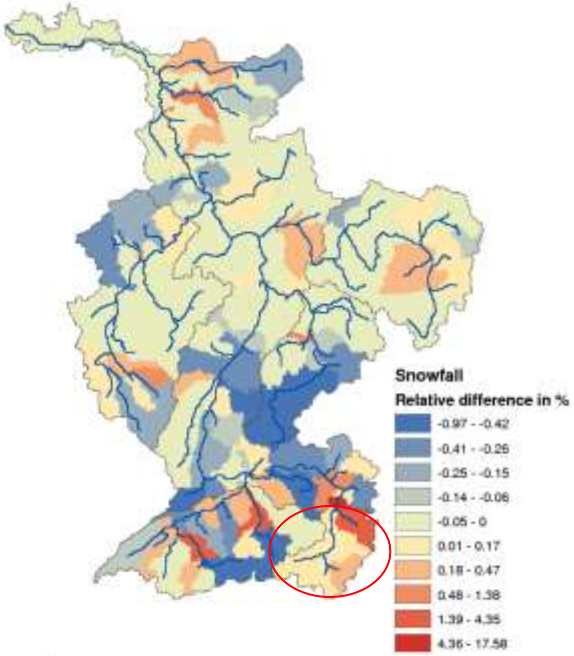

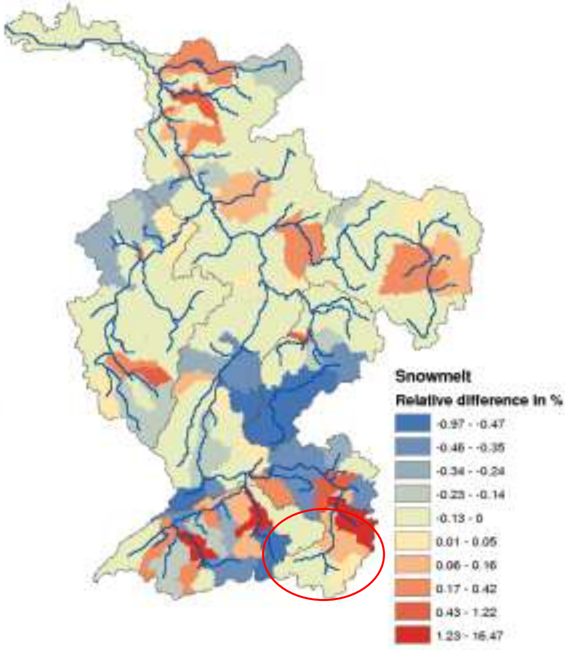

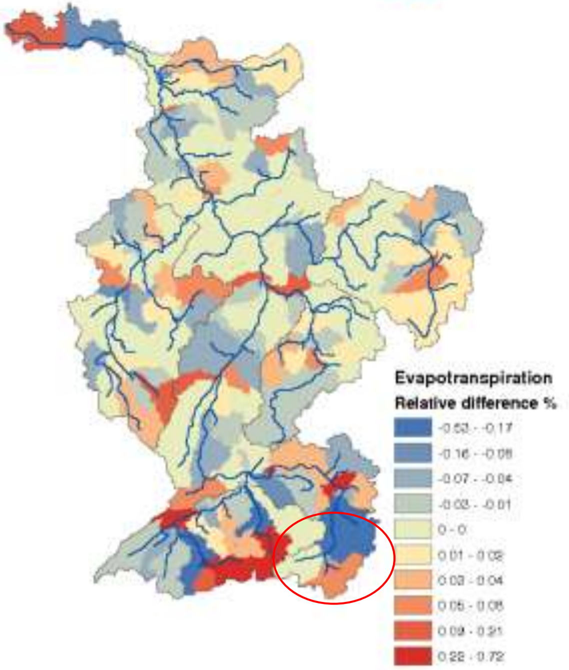

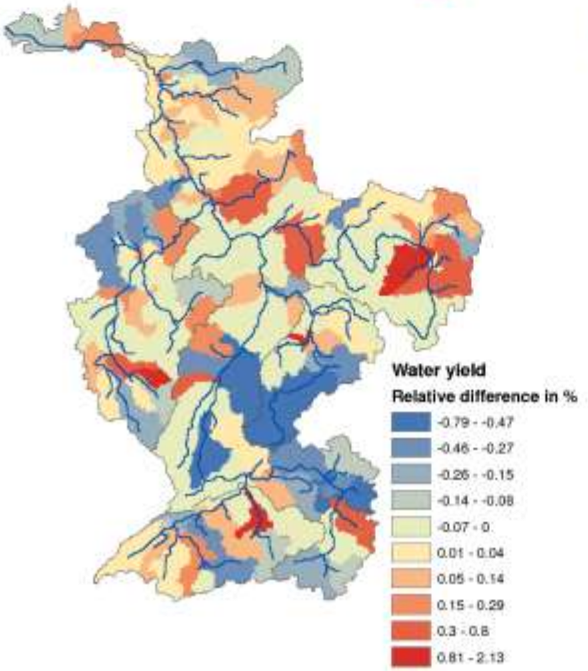

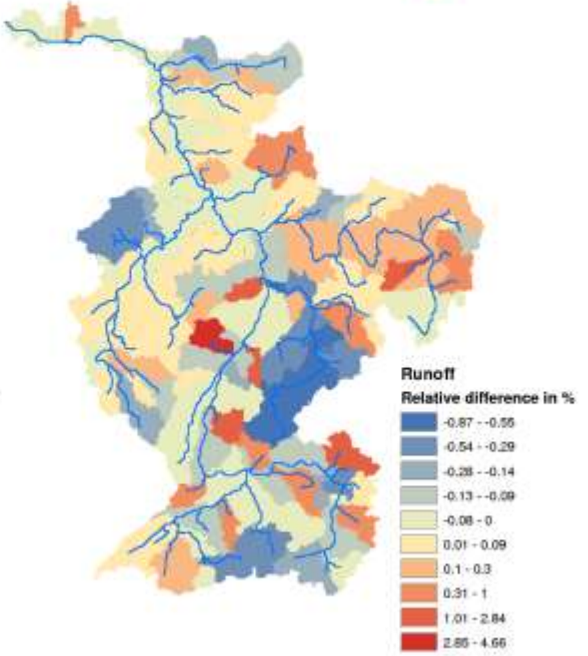

Conclusions

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Conclusions

- Size of subbasin does matter as the allocation of climate stations to subbasins may change

- But a significant signal at a tributary river in a comparable small catchment decreases further downstream which, indicates the higher importance of subbasin size on the local scale than on a large scale

- Even on the local scale: the higher resolution does not necessarily lead to the better model performance, as the ratio between subbasins and climate stations should not exceed 1 by far

- Choice of spatial extend of subbasins should be based on the available climate data resolution and the size of the project vs. the computational resources

Thank you for your attention!