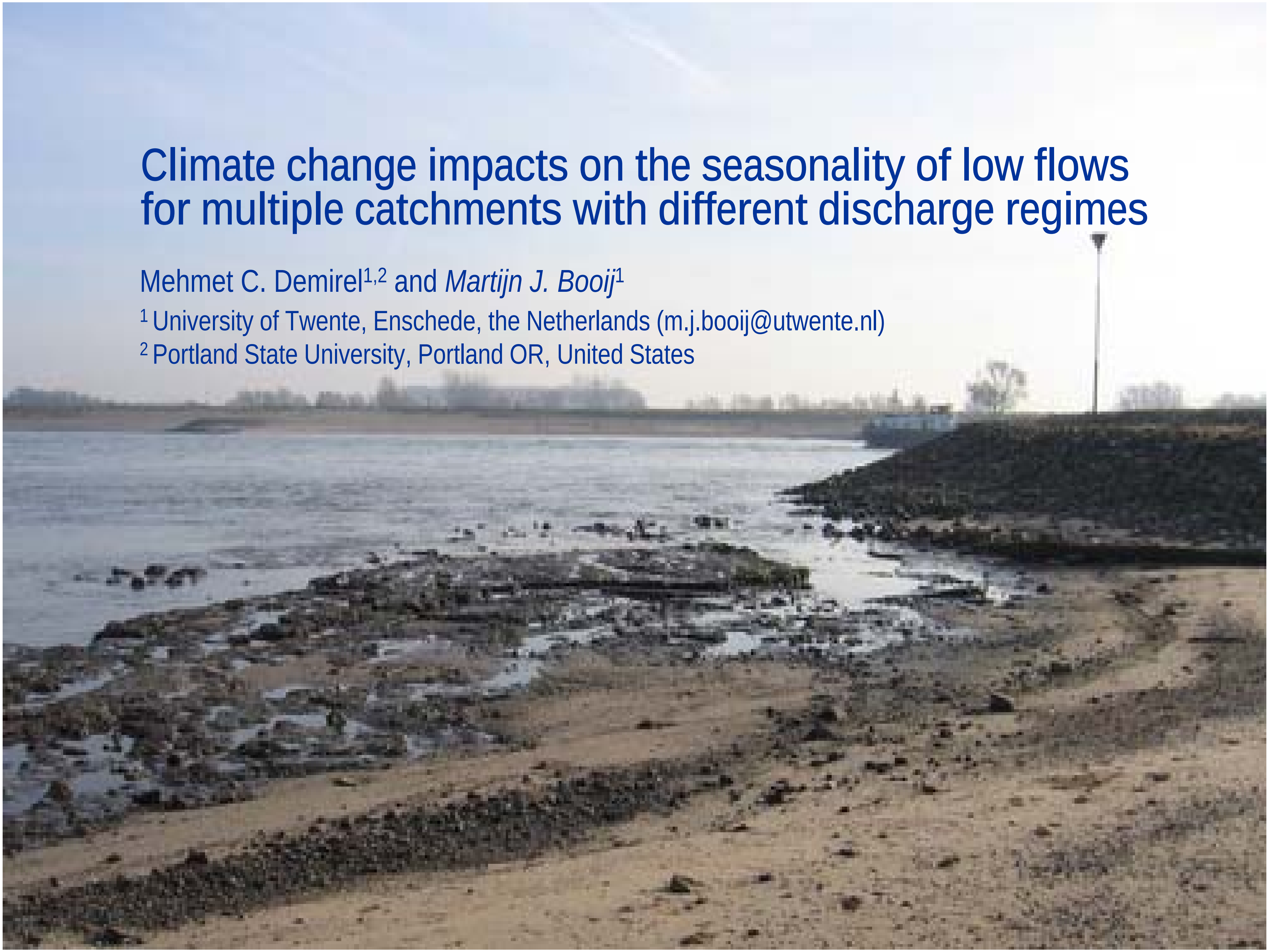

Climate change impacts on the seasonality of low flows for multiple catchments with different discharge regimes

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Outline

- Introduction
- Study area and data
- Methods
- Results
- Conclusions

Introduction (1)

Low flows in rivers may cause severe problems

Navigation

Power supply

Water supply

Water quality

Introduction (2)

Important to provide information on low flows:

- forecasts (short, medium and seasonal term)
- *climate change impacts* (long term)
- effects of land use and cover changes, river engineering works, etc.

Motivation

- growing concern that occurrence of low flows will intensify due to climate change
- impacts of climate change on the seasonality of low flows hardly assessed

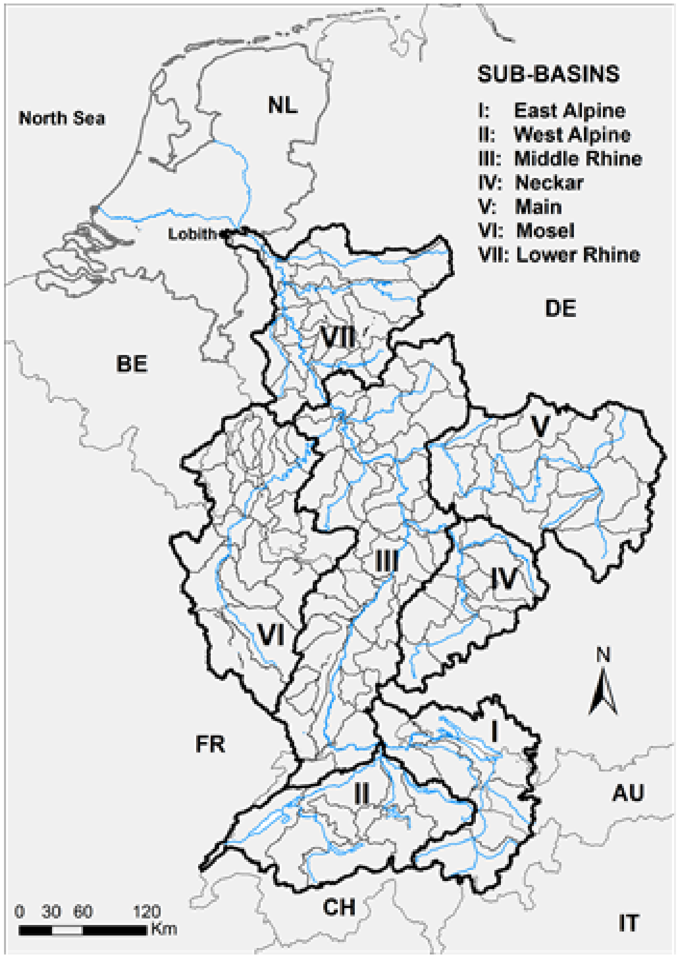
Study area and data (1)

Rhine river upstream of the Netherlands

- surface area: 185 300 km^2
- average discharge Lobith: 2300 m^3/s
- minimum discharge (1929): 575 m^3/s

Two spatial scales:

- seven sub-basins
- 134 sub-catchments



Study area and data (2)

Observed data

- daily precipitation, temperature and evapotranspiration (sub-catchment averaged)
- daily discharge (101 sub-catchments)

Climate model output for seven combinations (current and future climate):

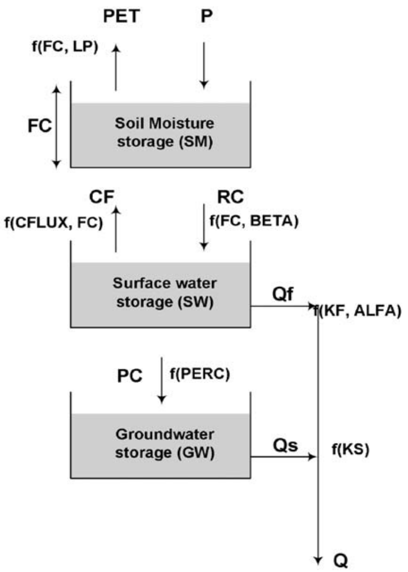
- four Global Climate Models (GCMs)
- four Regional Climate Models (RCMs)
- three greenhouse gas emission scenarios (A1B, A2, B1)
- bias-corrected

Methods (1)

Three indices:

- seasonality ratio (summer low flows/ winter low flows) - SR
- weighted mean occurrence day – WMOD
- weighted persistence (inter-annual variability of WMOD) – WP

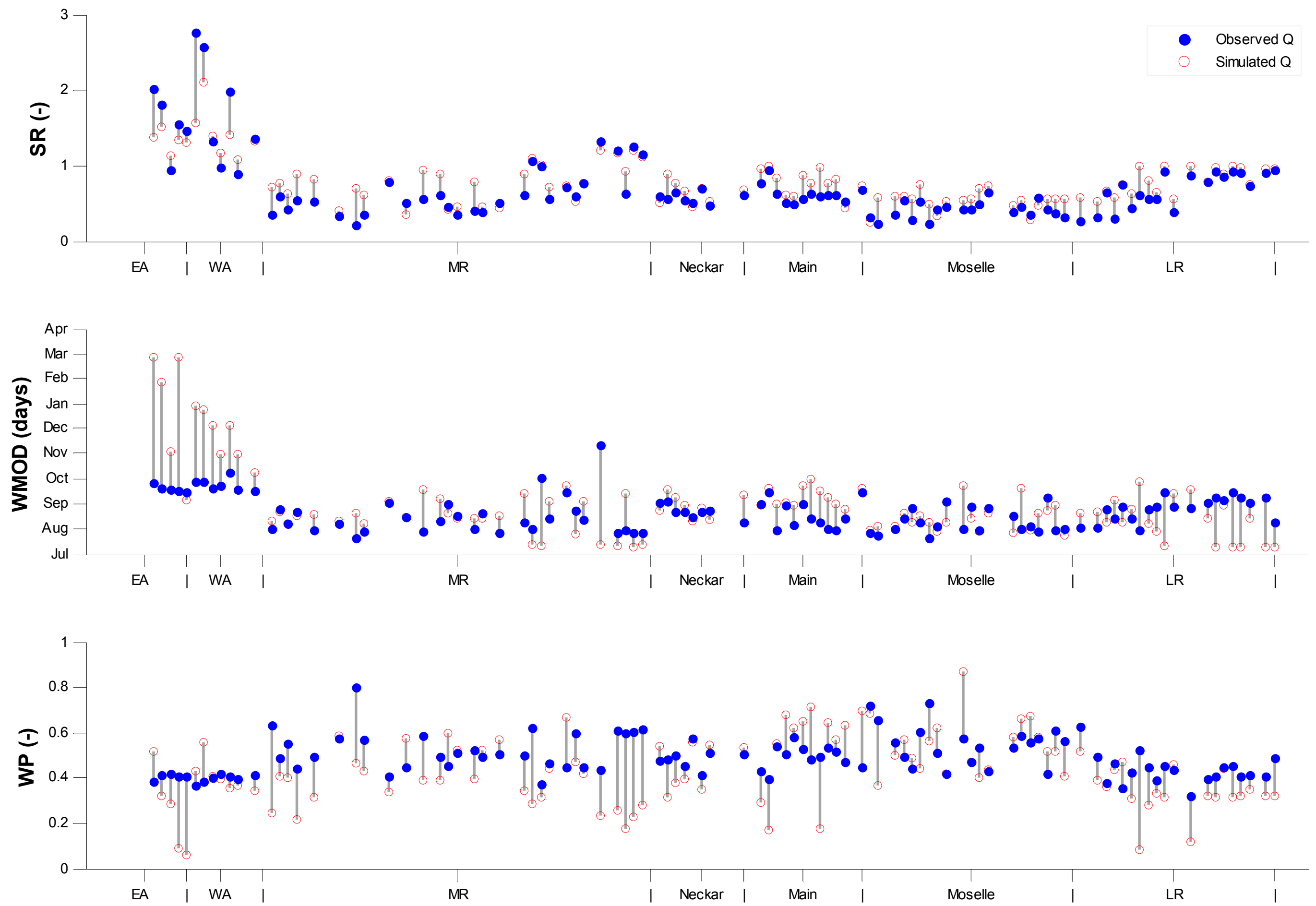
Hydrological model HBV for 134 sub-catchments of the Rhine



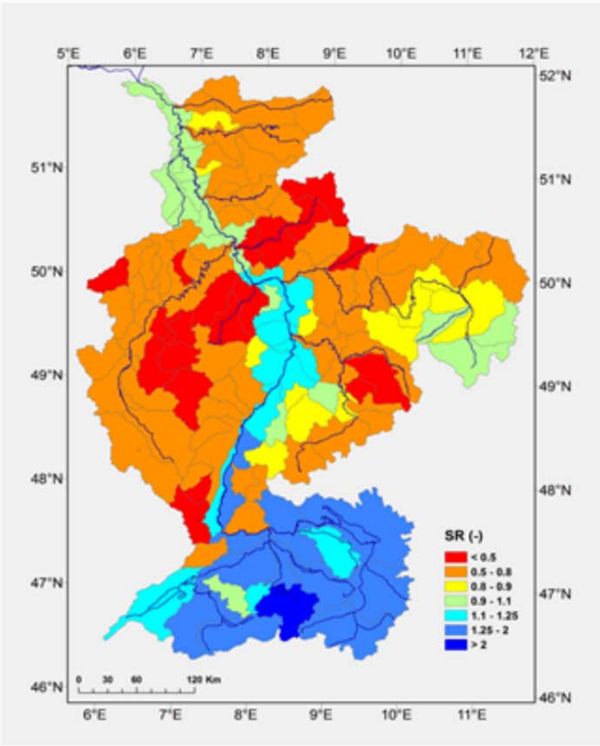
Methods (2)

Case number	Number of calculations	Description of calculations
1	1	The three indices are based on observed discharge series with varying lengths
2	1	The three indices are based on simulated discharge using observed climate for 1964–2007 as input
3	7	The three indices are based on simulated discharge using simulated climate for 1964–2007 as input
4	7	The three indices are based on simulated discharge using simulated climate for 2063–2098 including three emission scenarios as input

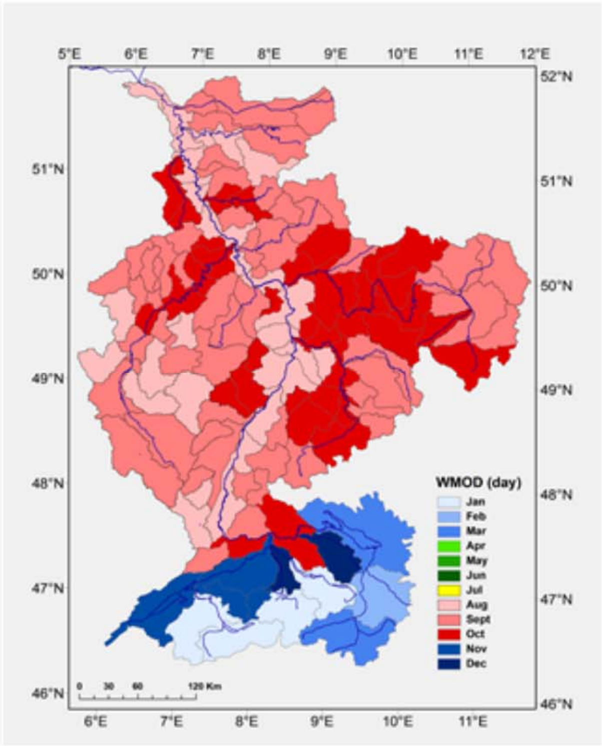
Results (1) | observed vs. simulated discharge (no. 1 vs. 2)



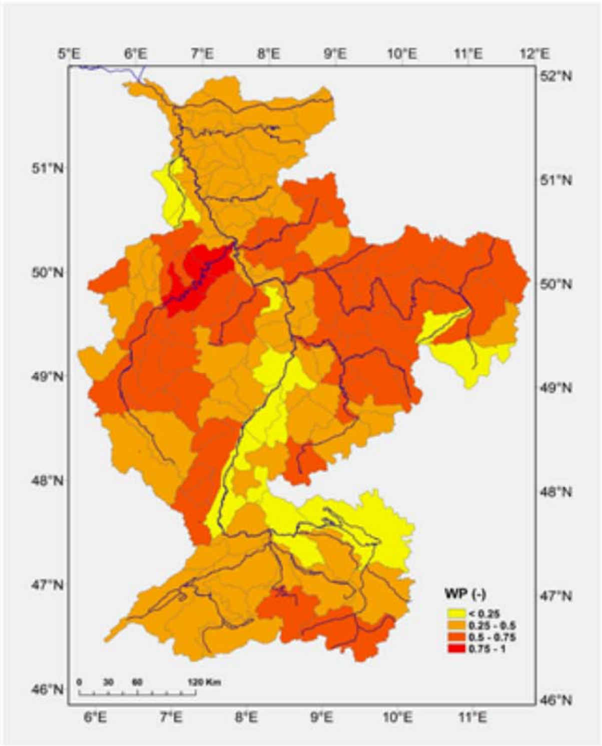
Results (2) | simulated discharge (no. 2)



SR

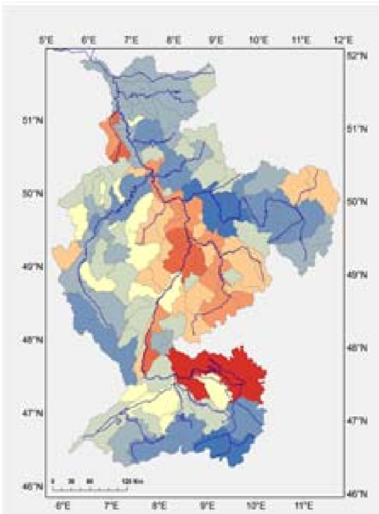


WMOD

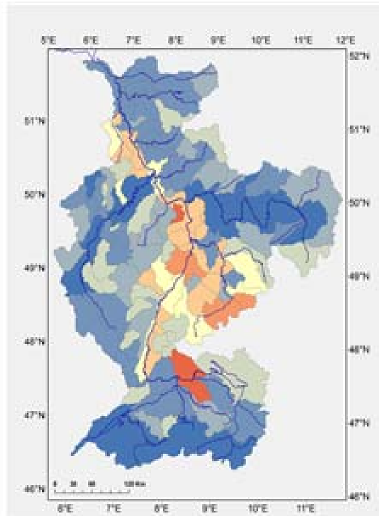


WP

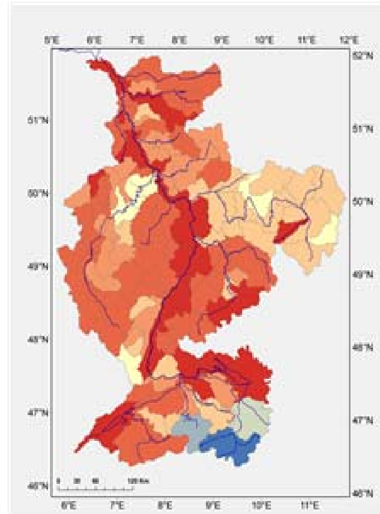
Results (3) | observed vs. simulated input (no. 2 vs. 3)



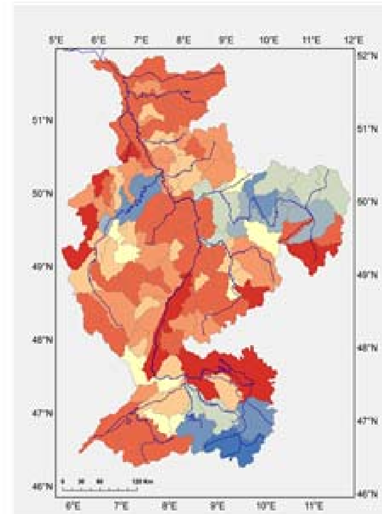
Climate Scenario 1



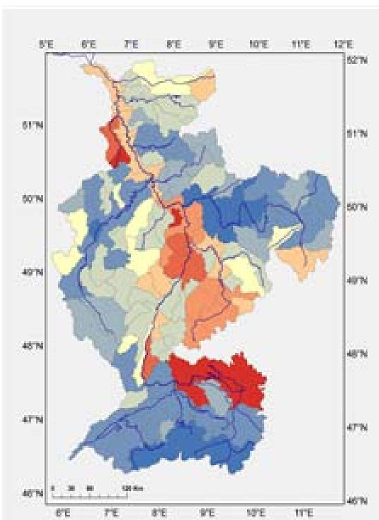
Climate Scenario 2



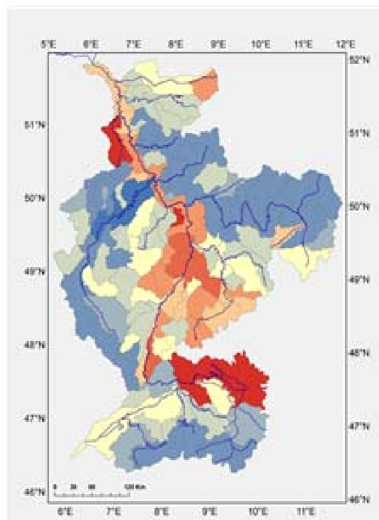
Climate Scenario 3



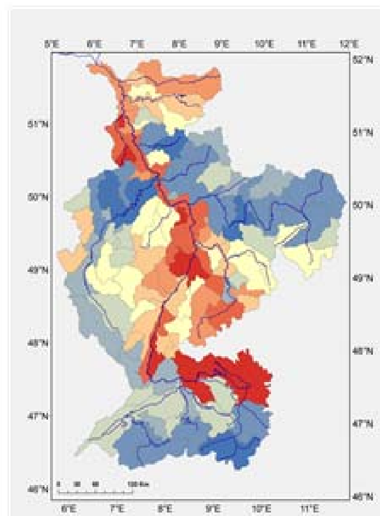
Climate Scenario 4



Climate Scenario 5



Climate Scenario 6



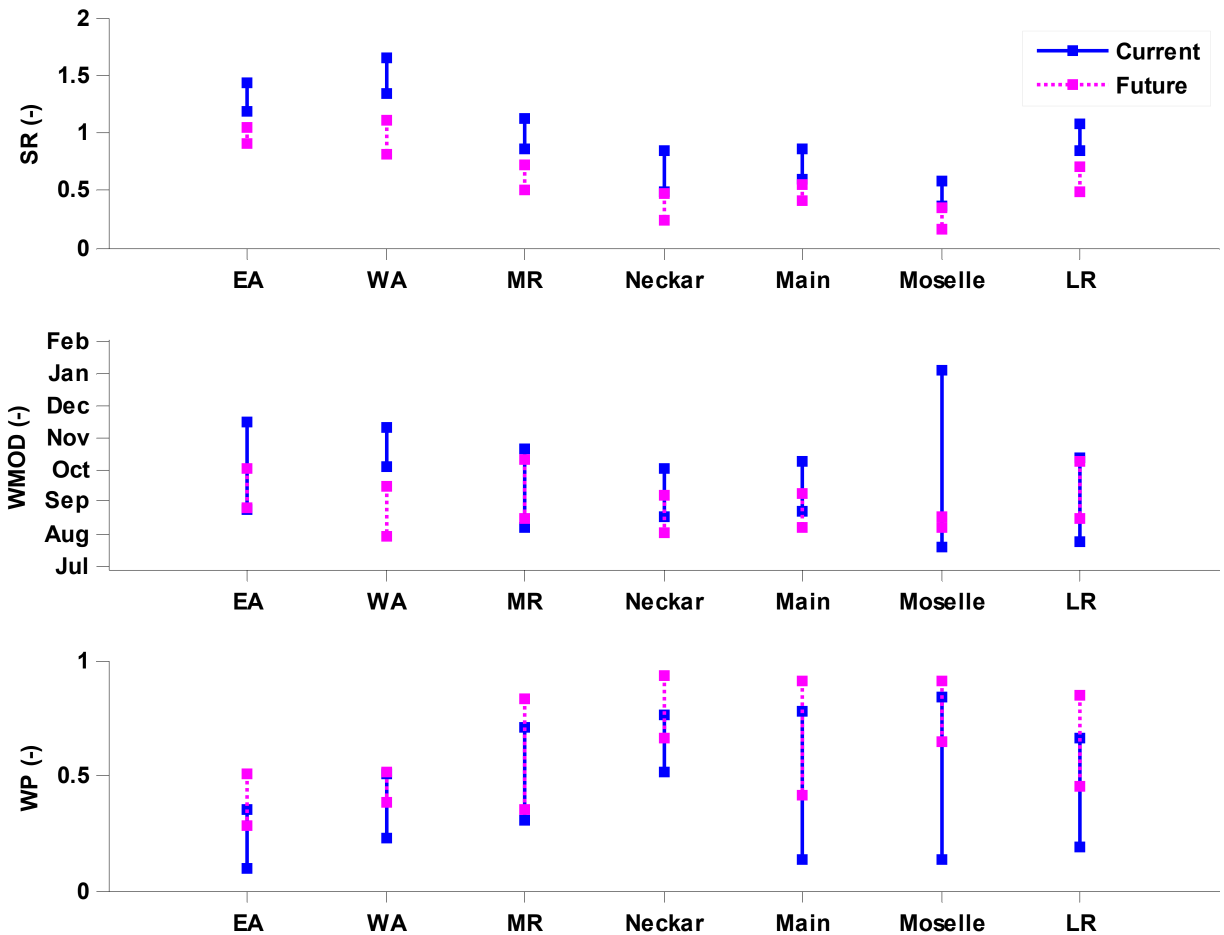
Climate Scenario 7

Difference in persistence (%)

- < -60
- -60 to -30
- -30 to -20
- -20 to -5
- -5 to +5
- 5 to 20
- 20 to 40
- 40 to 90
- > 90

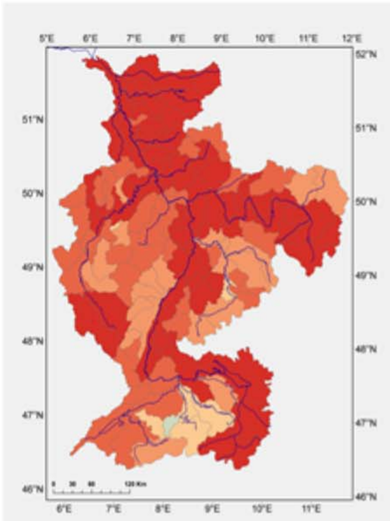
no. 3-2

Results (4) | current vs. future (no. 3 vs. 4)

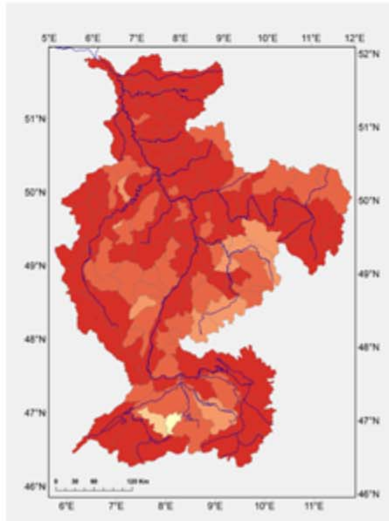


Results (5) | current vs. future (no. 3 vs. 4)

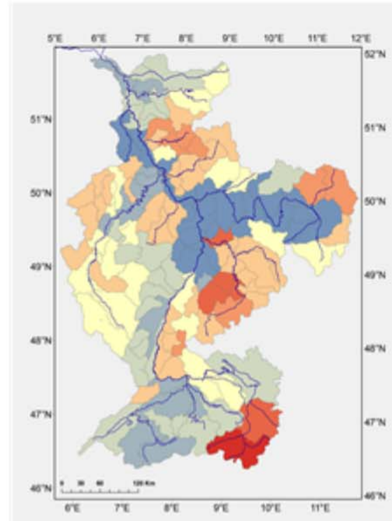
Results (6) | current vs. future (no. 3 vs. 4)



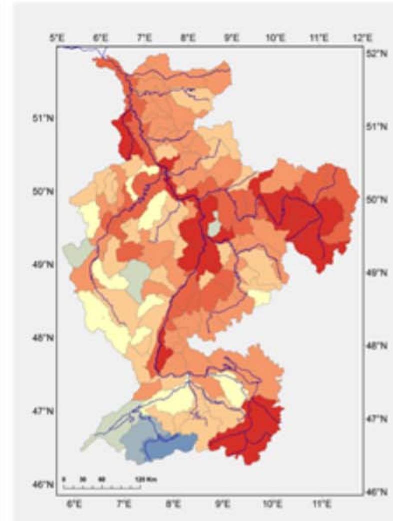
Climate Scenario 1



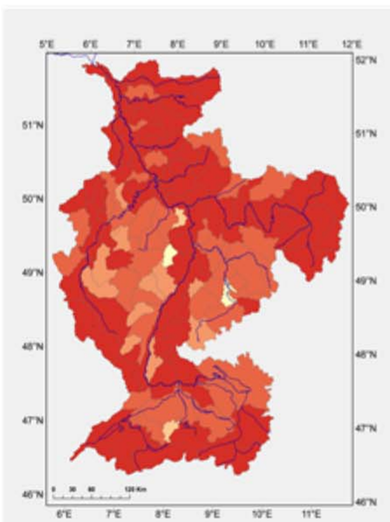
Climate Scenario 2



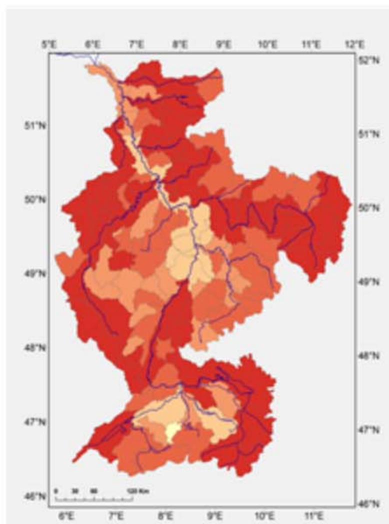
Climate Scenario 3



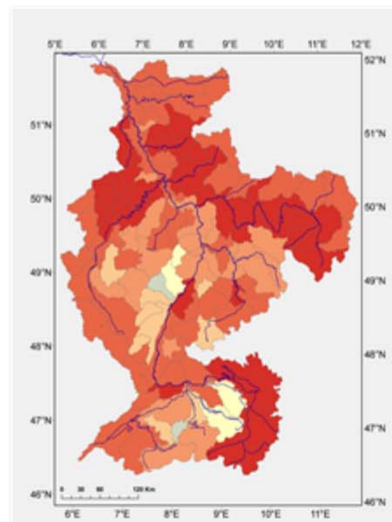
Climate Scenario 4



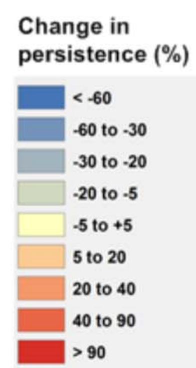
Climate Scenario 5



Climate Scenario 6



Climate Scenario 7



Conclusions

- significant differences between seasonality indices based on observed low flows and simulated low flows with observed climatic input
- small differences for SR for all subbasins (except Moselle) and large differences for WMOD and WP based on observed inputs and simulated inputs
- SRs significantly decrease in all subbasins by 2063-2098 (substantial change in low flow regimes; a regime shift from winter low flows to summer low flows is likely in two Alpine subbasins)
- WMODs of low flows tend to be earlier than for the current climate in all subbasins except for the Middle Rhine and Lower Rhine subbasins
- WPs slightly increase showing that predictability of low flow events increases

Thank you for your attention!