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High resolution regional climate simulations for hydrological impact studies in Germany

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Introduction

- An increased variability in precipitation and temperature for the warming future climate is expected.
- Climate impact studies, e.g. the assessment of changes in flood hazard for small and medium sized river catchments require regional climate simulations in high spatial resolution.
- Furthermore, the aspect of uncertainties of simulation results is crucial in this kind of impact studies.
- Therefore, **ensembles of coupled climate-runoff simulations** are performed for the assessment of changes in flood hazard for small and medium sized river catchments in Germany.
- Our ensemble includes 2 GCMs (ECHAM5, CCCma3) and for one GCM (ECHAM5) three realizations with different initial conditions, **2 RMCs (CCLM, WRF) with a final spatial resolution of 7km and 1 hour output timestep**, and at least two hydrological models for each catchment (see Figure1); in addition REMO simulations within the projects “UBA” and “BFG are included (Jacob et al., 2007).

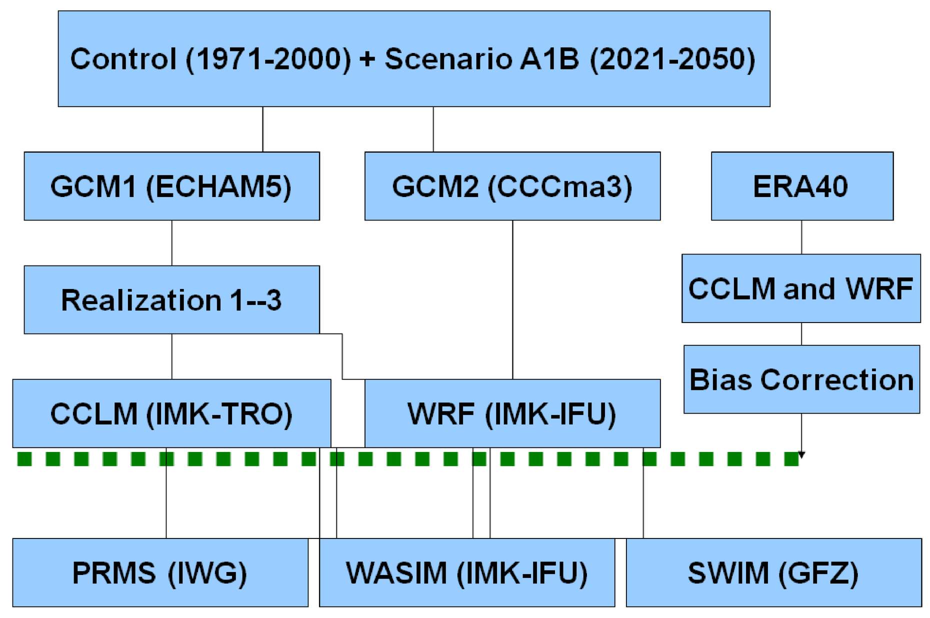
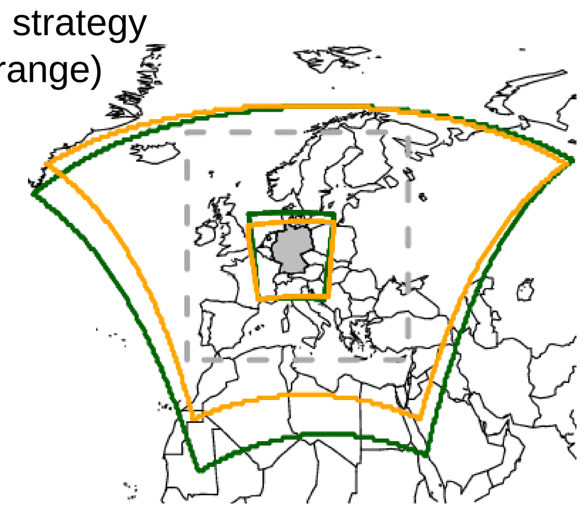


Figure 1: Schematic over the ensemble simulations strategy. The additional step of bias correction is included on the right side of the diagram

Figure 2: RCM double nesting strategy for CCLM (green) and WRF (orange)



Regional Climate Modeling Results

VALIDATION (1971-2000)

CLIMATE CHANGE SIGNAL (2021-2050 versus 1971-2000)

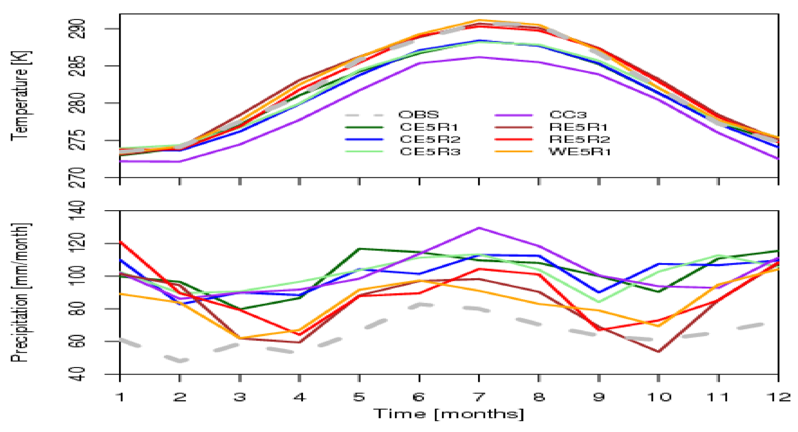
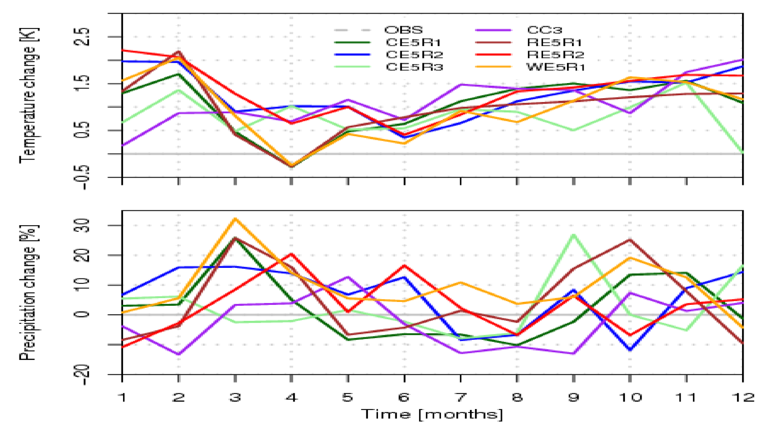


Figure 3
left: Annual cycles of temperature (top) and precipitation (bottom) for the 2nd nest CCLM, WRF and REMO control simulations (E520C) for realizations R1-3, plus an CCCma3 driven simulation with CCLM. Temperatures are compared to the E-OBS data set [Haylock et al., 2008], and precipitation to the REGNIE data set (DWD)
right: Climate change signal of the RCM simulations described above



Temperature

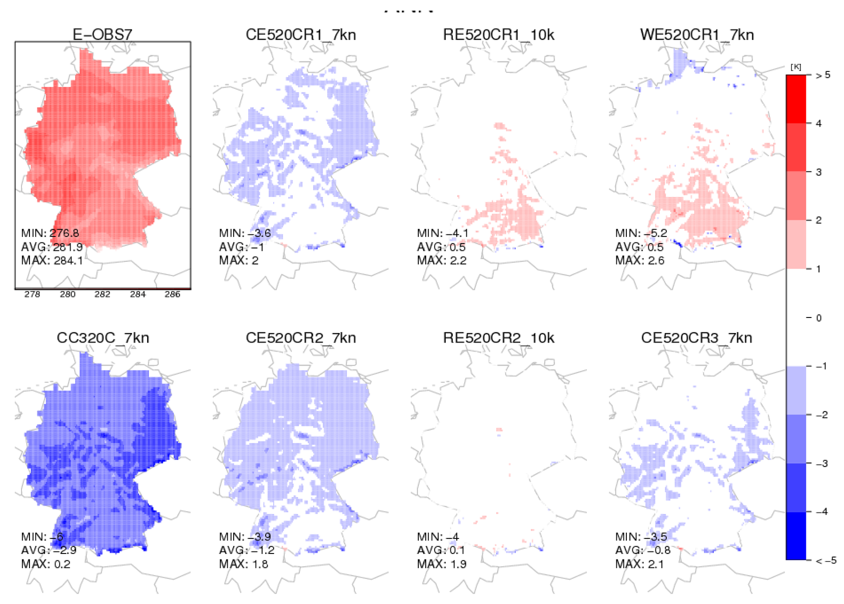
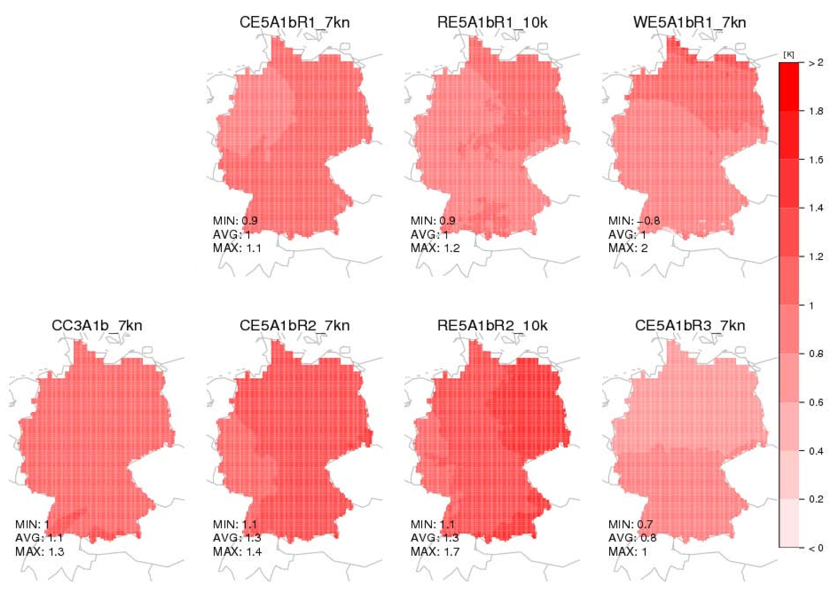


Figure 4
left: Spatial distribution of annual mean temperature bias for the CCLM, REMO and WRF control simulations (E520C) for realization 1 (top line) and CCCma3, CCLM R2, REMO R2, and CCLM R3 (bottom line)
right: Climate change signal of the RCM simulations described above



Precipitation

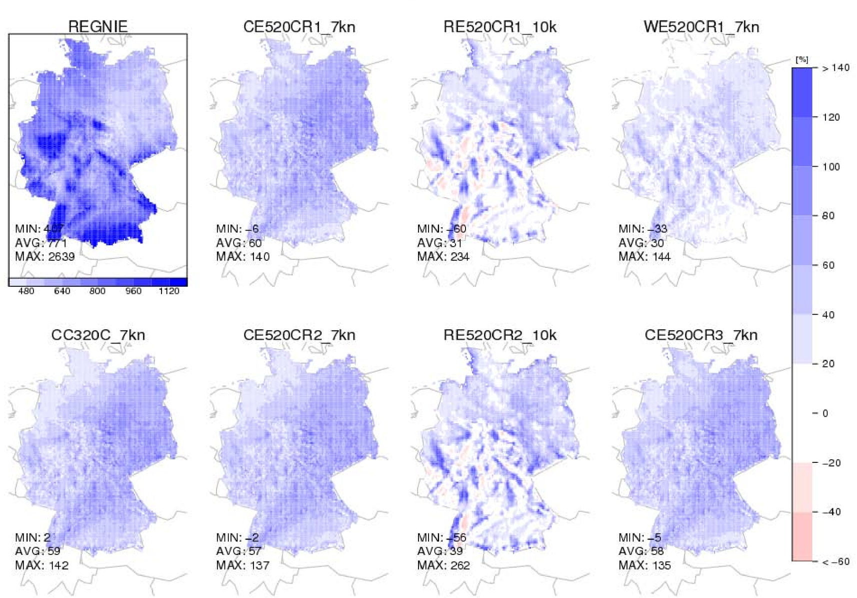


Figure 5
left: Spatial distribution of relative annual mean precipitation bias for the CCLM, REMO and WRF control simulations (E520C) for realization 1 (top line) and CCCma3, CCLM R2, REMO R2, and CCLM R3 (bottom line)
right: Climate change signal of the RCM simulations described above

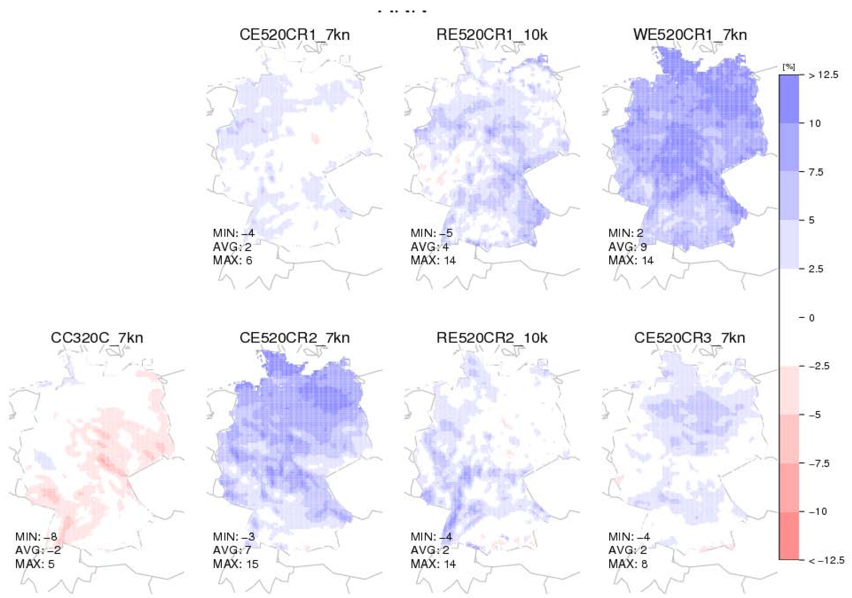
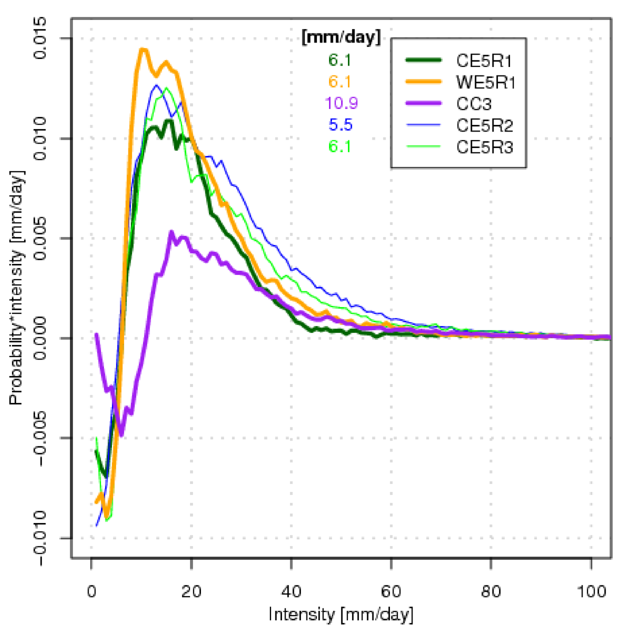
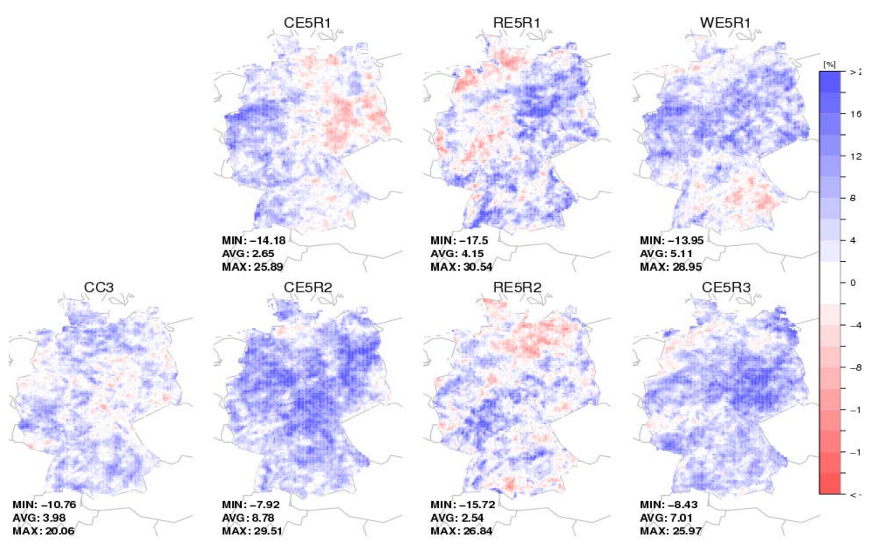


Figure 6
left: Wet day distributions of precipitation intensities for 2nd domain over Germany. The numbers next to the legend indicate the change point from a decrease in probability for low intensities to an increase for higher intensities
right: Climate change signal of 99 percentile of daily precipitation amounts [%] over Germany





Validation of RCM results:

- CCLM model is colder than observations by about 0.5 to 2 K.
- WRF and REMO have a warm bias of around 0.5 K.
- Precipitation is overestimated by all models (partially also due to GCM input).
- Wet bias is larger in winter for CCLM and WRF (not shown).

Climate Change Signals:

- Temperature increase between 0.8 and 1.3 K.
- Change of annual precipitation between -2% and 9%.
- Varying spatial distributions of annual precipitation for different GCM-RCM combinations.
- Probabilities of higher precipitation intensities increase.
- Precipitation extremes increase in general over Germany; spatial variability is high inclusive regions with decreasing extremes.

Bias correction of RCM results:

- Biases in the RCMs needs to be corrected before coupled to the hydrological modeling.
- Bias correction method: **quantile mapping**.

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