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Regional Climate Change

REKLIM Helmholtz-Verbund Regionale Klimaänderungen

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Topic 6: Extreme events - How will the magnitude and frequency of extreme weather events change in a future climate?

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An ensemble assessment of the climate change impact on flood hazard for three small to medium sized catchments in Germany

CEDIM

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Introduction

- Aim: quantification of the climate change impact on changes in flood discharges for the near future.
  ⇨ Important for the adaptation of flood management.
- Scenario assessments based on only one combination of global climate model (GCM), regional climate model (RCM) and hydrological model (HM) might be misleading.
  ⇨ Ensemble approach: based on 2 GCMs, 2 high-resolution RCMs (7km) and 3 HMs.

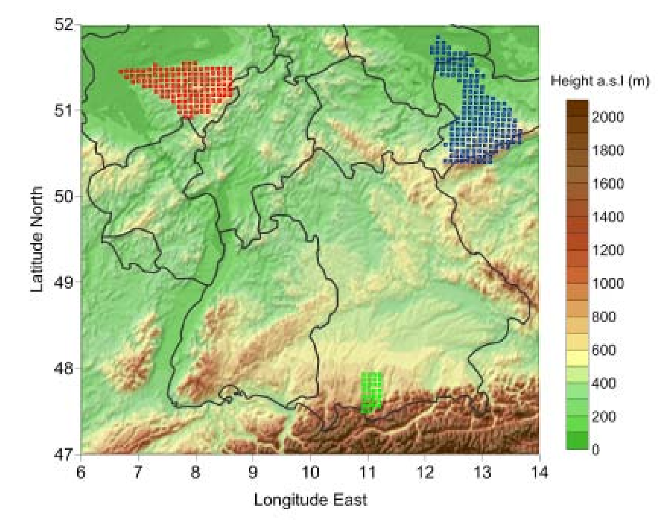

Figure 1: Locations of the three selected catchments.

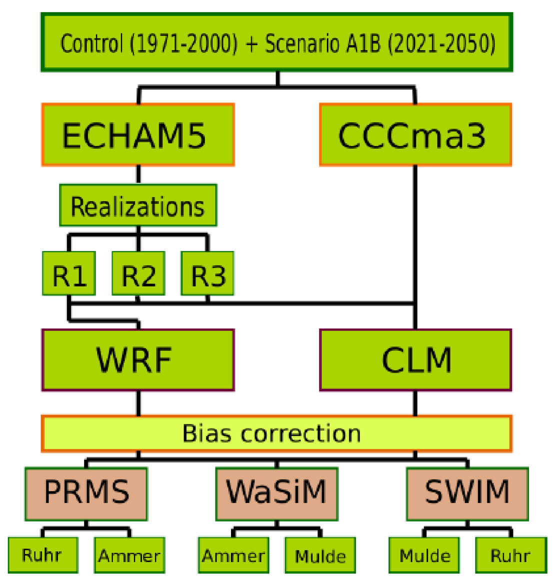

Figure 2: The ensemble approach.

Methods: study area, climate input, hydrological models

Study area: Selection of three catchments representing different flood regimes in Germany: Ruhr (4485 km², winter floods), Mulde (6171 km², floods in winter/spring, but also in summer), Ammer (710 km², summer floods).

Ensemble:

- Emission scenario: A1B; only one scenario, as other projects already showed that the emission scenario has only a smaller impact for the near future (2021-2050).
- GCMs: The climate projections are based on three realizations of ECHAM5 and one realization of CCCma3.
- RCMs: All GCM simulations are downscaled by the RCM CLM, and one realization of ECHAM5 is downscaled also with the RCM WRF.
- HMs: In each of the catchments two of three selected HMs (PRMS, SWIM and WaSiMETH) are applied.

Results

Projected changes in meteorological input:

- Temperature: shows an increase (on average +1.1 C, range 0.8-1.5 C) in all catchments and for all ensemble members.
- Precipitation:
  Only in the Ruhr catchment all ensemble members project a change in the same direction.
  In the other two catchments, the ensemble mean indicates an increase, but some ensemble members show decreases.

Hydrological modeling results control period:

- Despite bias correction of temperature and precipitation, there are still some deviations between simulations with observed climate input and climate input from the RCMs (Fig. 3, left column).
- Caused by: - differences in the precipitation data sets used as model input and for bias correction
  - deviations in climate variables which are not bias corrected (radiation and humidity).

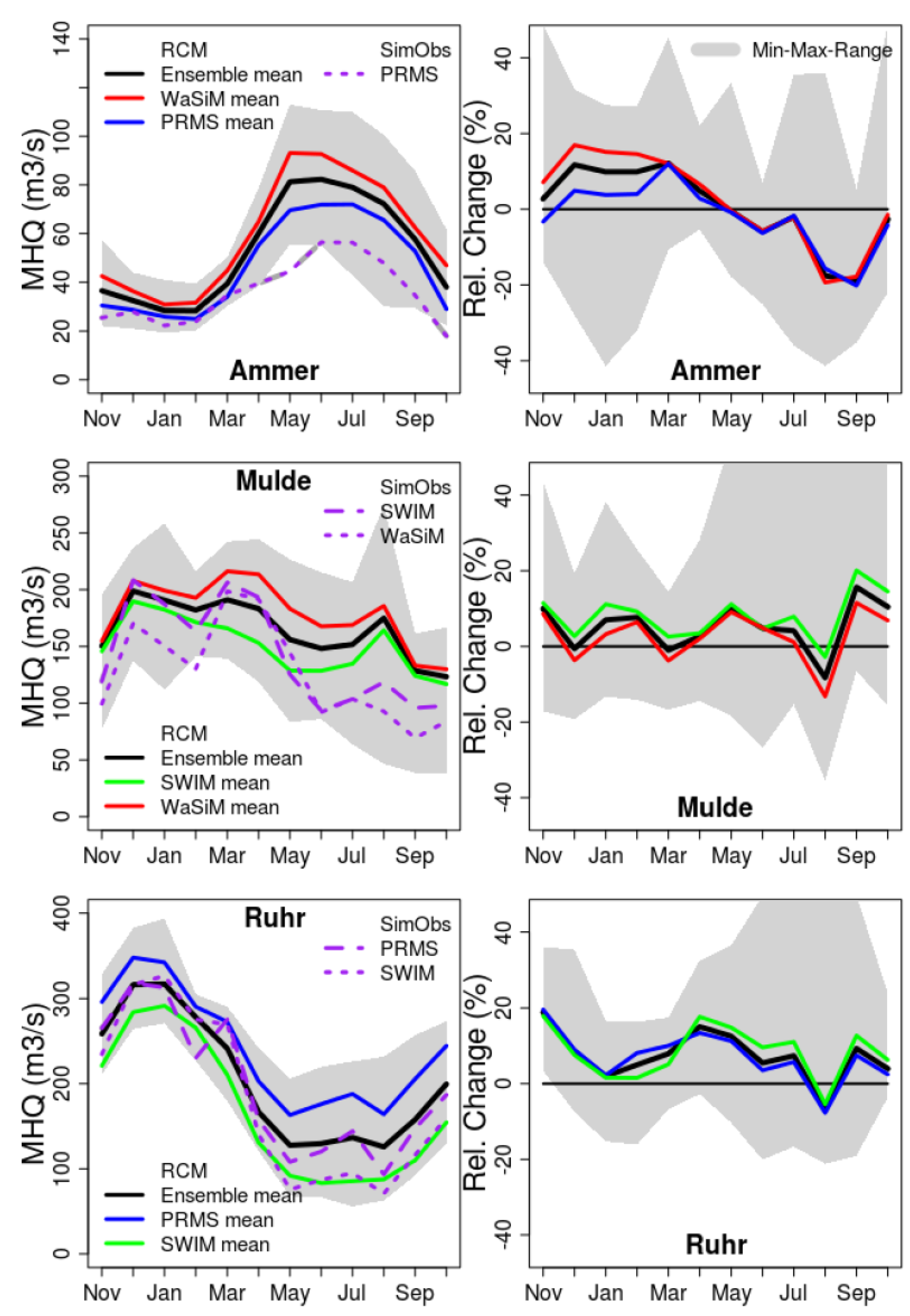

Figure 3 Left : Simulated MHQ for the control period 1971-2000 with climate input from observations (SimObs) and the RCMs.
Right : Percentage change of MHQ between the scenario (2021-2050) and control (1971-2000) period. The gray shaded areas mark the range of the individual model projections.

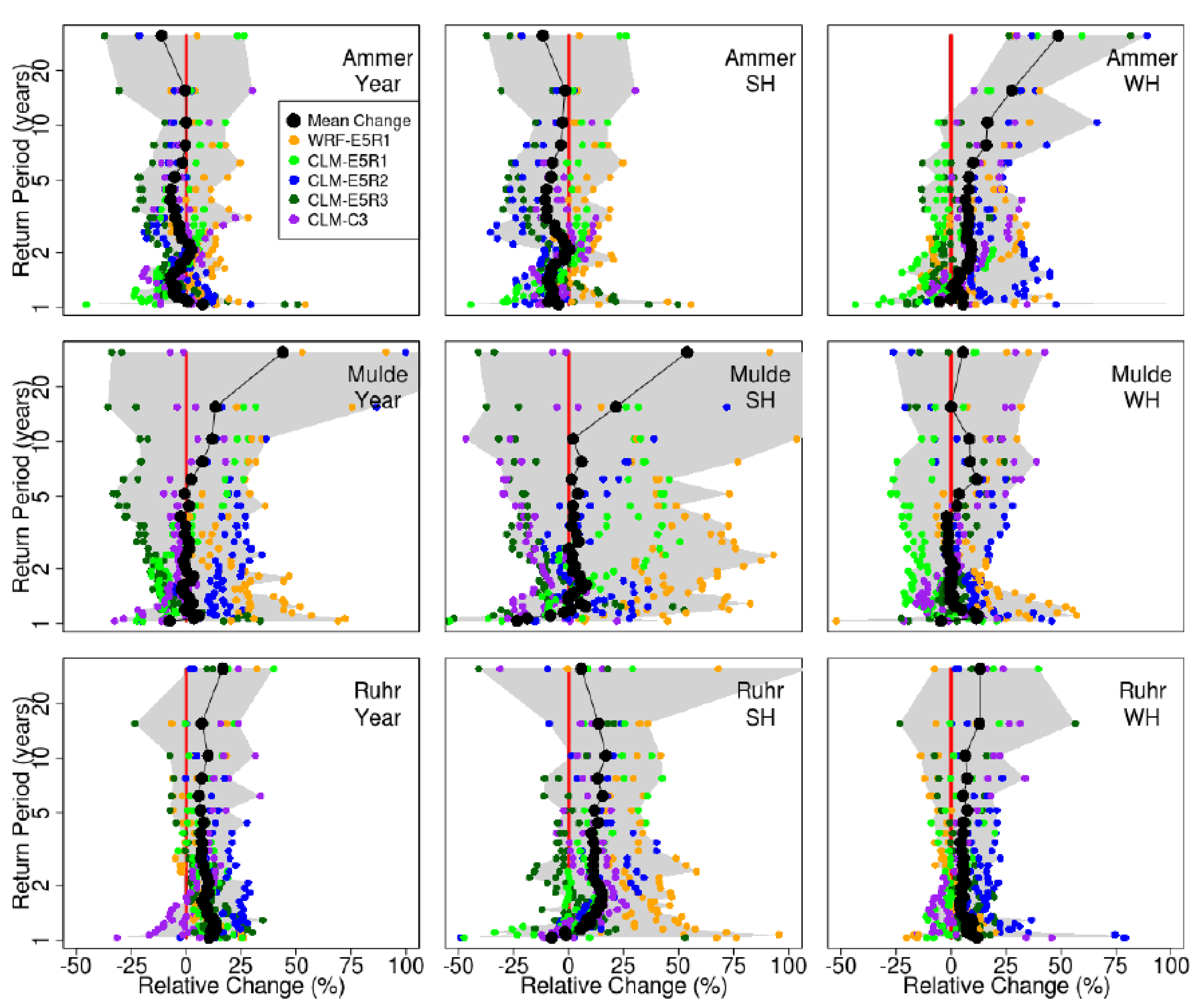

*Figure 4: Changes in discharge for given return periods. Values are based on the change of the 2*30 maximum annual, summer (SH) or winter (WH) values for the period 2021-2050 versus 1971-2000. R1-3: Realizations of ECHAM5. The gray shaded areas mark the maximum range of the single ensemble members. One color implies both HMs.*

Hydrological modeling results scenario period:

- Large spread of changes in mean monthly maximum discharges and return values in all three catchments (Fig. 3+4, gray area).
- Ammer: the ensemble mean indicates a change in the seasonality with higher flood discharges in winter and lower flood discharges in summer (Fig. 3+4, top row).
- Mulde: no overall trend towards increasing or decreasing flood discharges can be observed (Fig. 3+4, middle row).
- Ruhr : the changes in mean monthly maximum discharge and return values, suggest increasing flood probabilities (Fig. 3+4, bottom row).

Conclusions

- The ten member ensemble based on 2 GCMs, 2 high-resolution RCMs and 2 HMs demonstrates large uncertainties for the possible impact of climate change on flood hazard in the near future.
- Largest contributions to the overall uncertainty are from the different RCMs in the summer half year, and the different GCMs and their realizations in the winter half year.
- Implications: water infrastructure needs to be planned and designed with these uncertainties, for example by planning water infrastructure in an adaptable way.

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