Flood hazard in a changing climate

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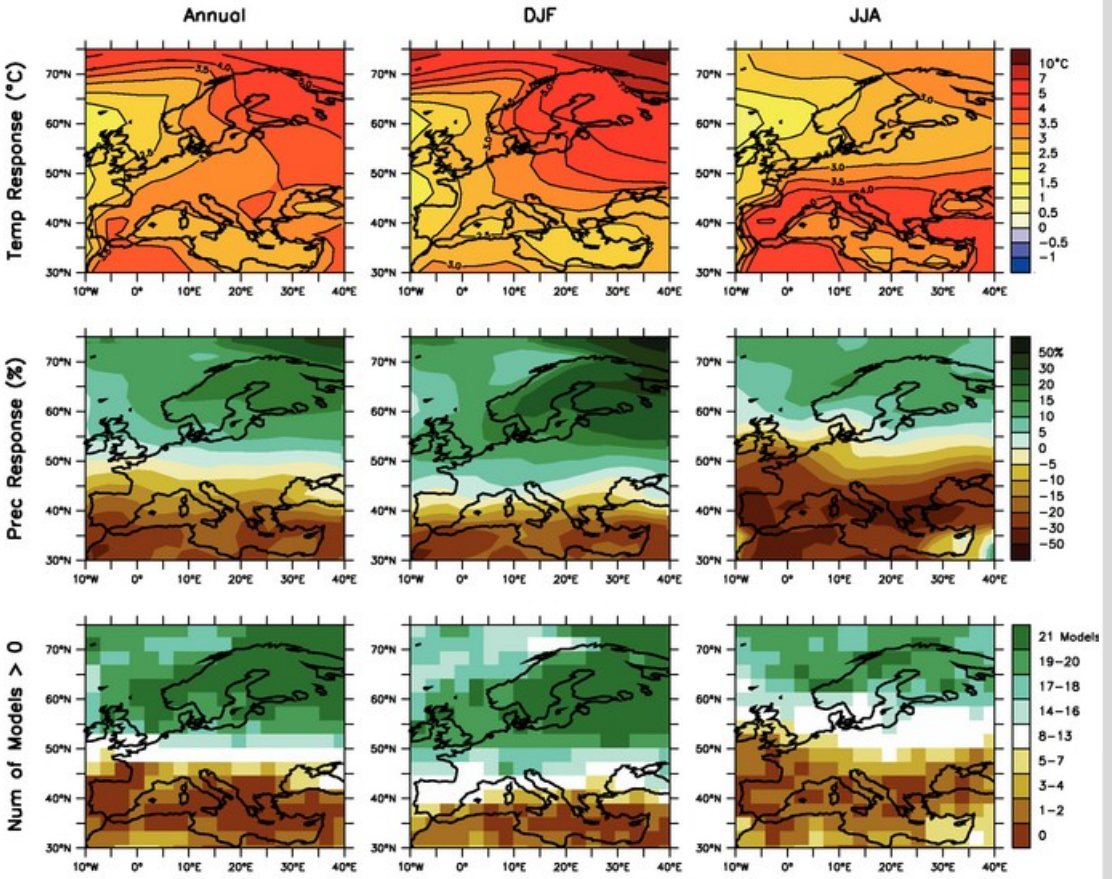
Flood hazard in a changing climate

- How will the characteristics of flood events in smaller river catchments in Germany be affected by a changing climate?
- How large are the uncertainties in projections of future climate? These uncertainties include not only future emission scenarios, but also uncertainties in the whole chain of models needed to make projections
- In this project we combine the expertise from four institutes (IMK-TRO and IWG in Karlsruhe, IMK-IFU in Garmisch-Partenkirchen and GFZ in Potsdam) to address these questions

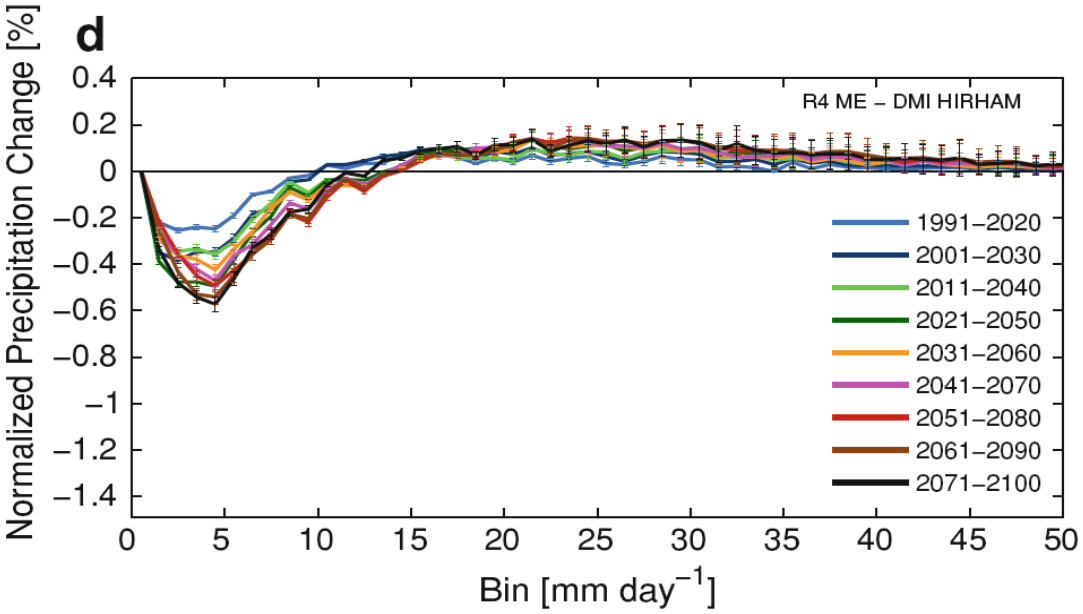
Flood hazard in a changing climate

- IPPC GCM projections for the end of the 21st century
  - Temperature increase all over Europe
  - Precipitation amount increases in Northern Europe and decreases in Southern Europe
  - Large uncertainties for central Europe and disagreement of the sign of the change between the models

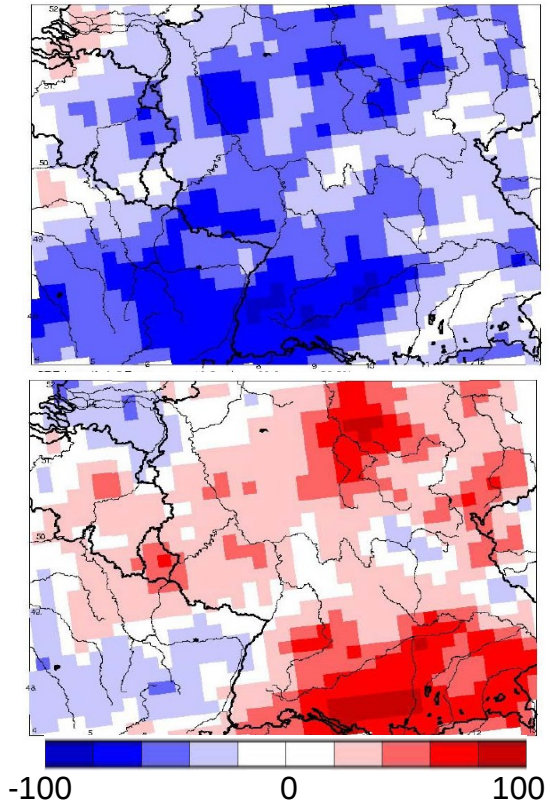


Flood hazard in a changing climate

- Studies of European precipitation changes show a change to more frequent extreme precipitation events for future scenarios



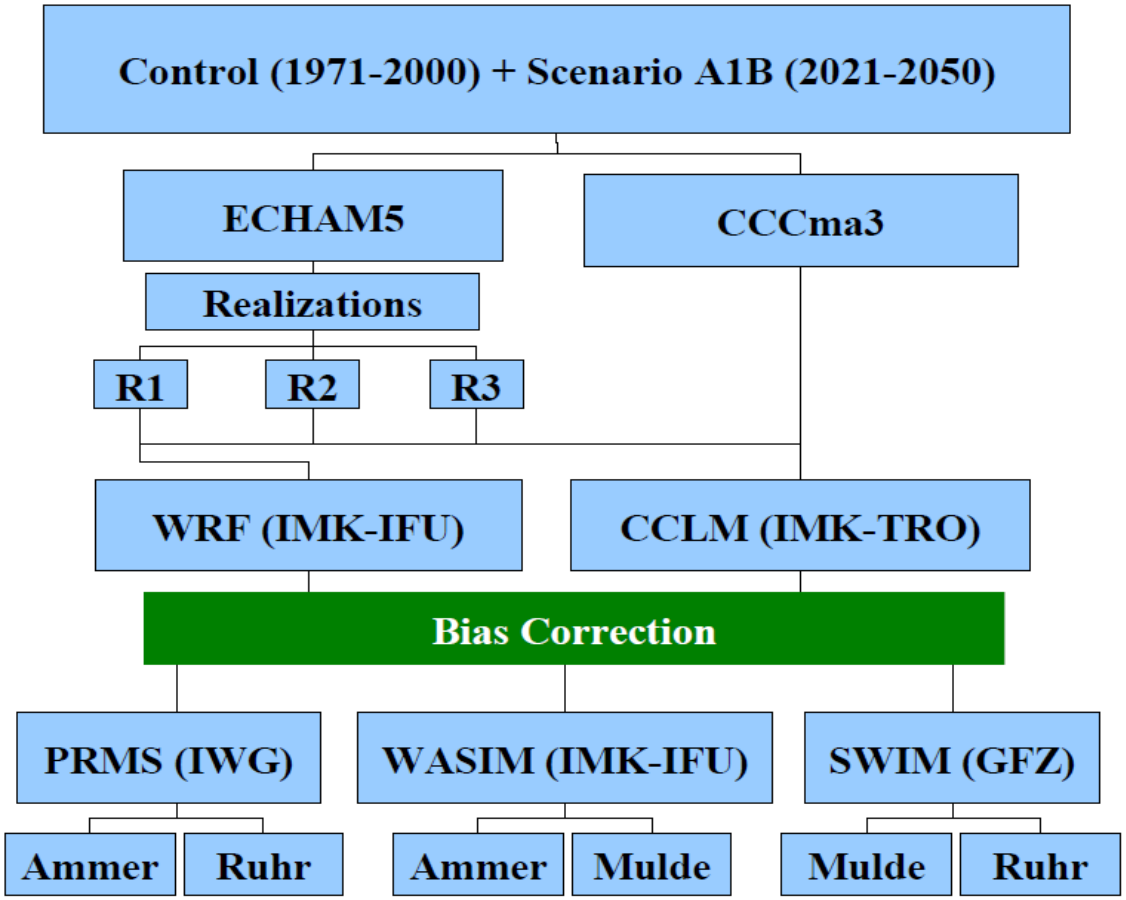
[Boberg, Berg, Thejll, Gutowski, and Christensen, Vol 35, Clim Dyn, 2010]



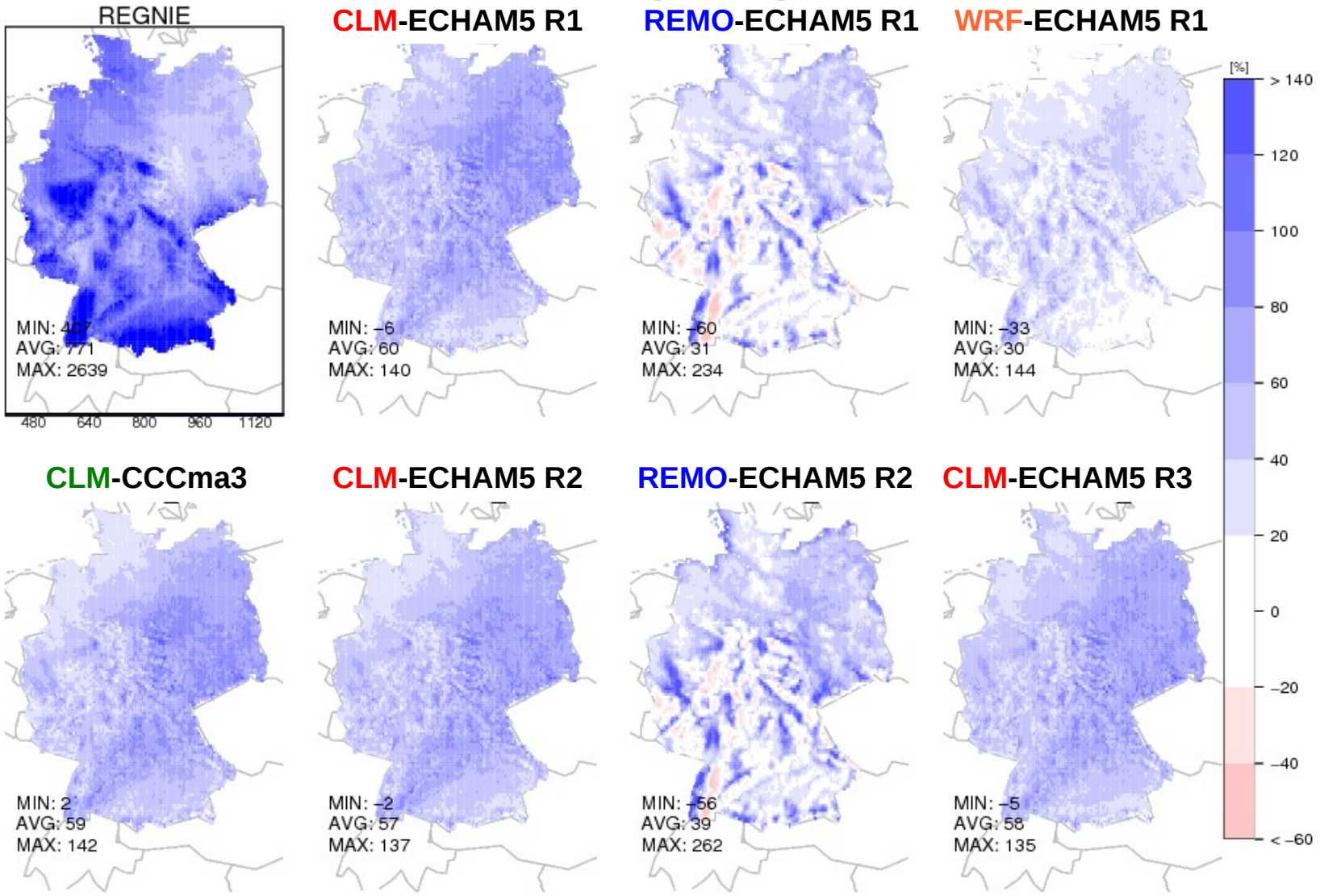
Relative change in the number of dry intervals of length 1—5 days (top) and 16—20 (bottom) [Schädler et al., 2010]

Flood hazard in a changing climate

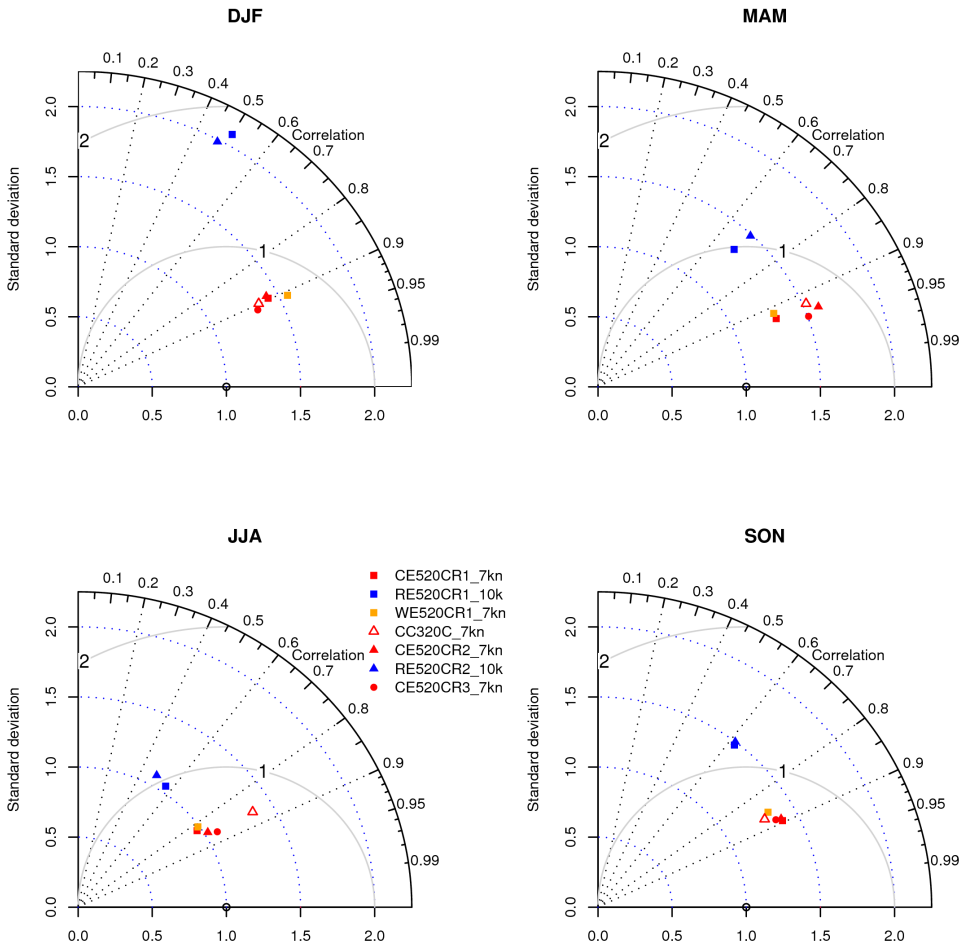
- In order to assess multiple uncertainties, we are constructing an ensemble of atmospheric and hydrological simulations
- In the base are two GCMs forced with SRES greenhouse gas scenarios
- These are then downscaled to a high resolution over Germany with two RCMs
- After an intermediate step of bias correction, the data is used to force a set of three HMs



Results of RCM simulations, control period relative differences in annual precipitation



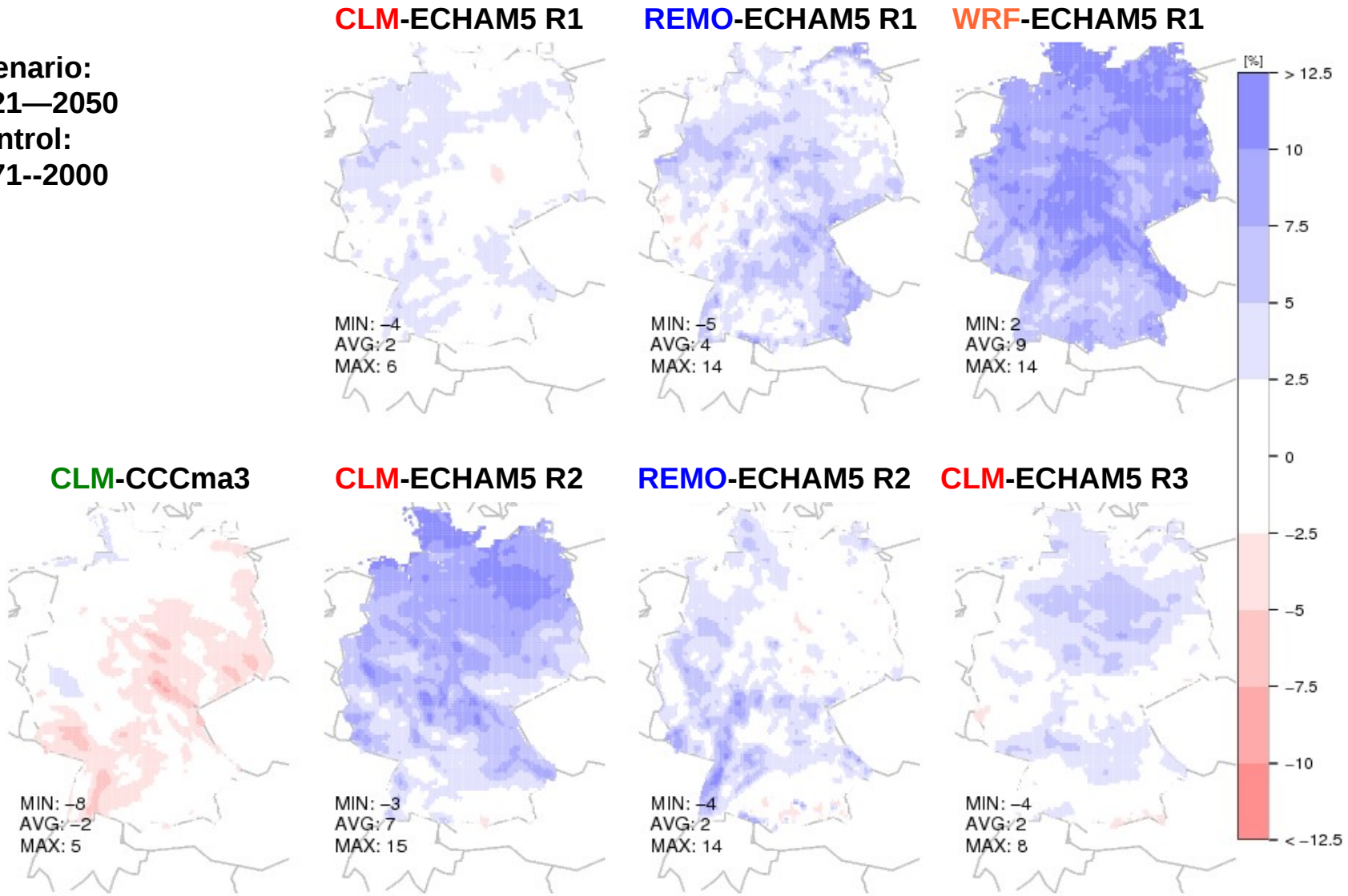
Results of RCM simulations, control period
Seasonal Taylor diagrams



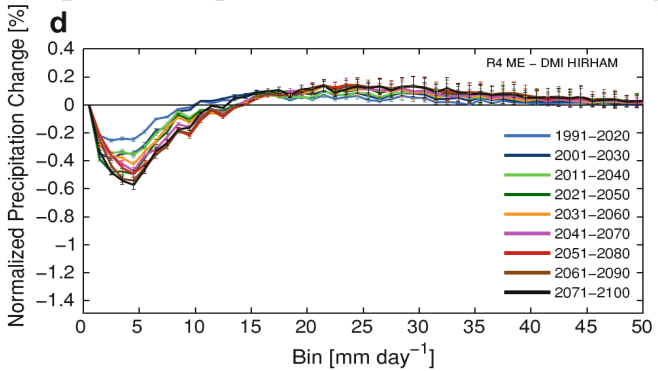
- The Taylor diagram shows the spatial correlation (bow) and the standard deviation in comparison to an observational data set
- Both **CLM** and **WRF** show a high spatial correlation of the precipitation pattern to observations throughout the year, while **REMO** has problems due to the shift of orographic induced features

Results of RCM simulations, scenario-control relative differences in annual precipitation

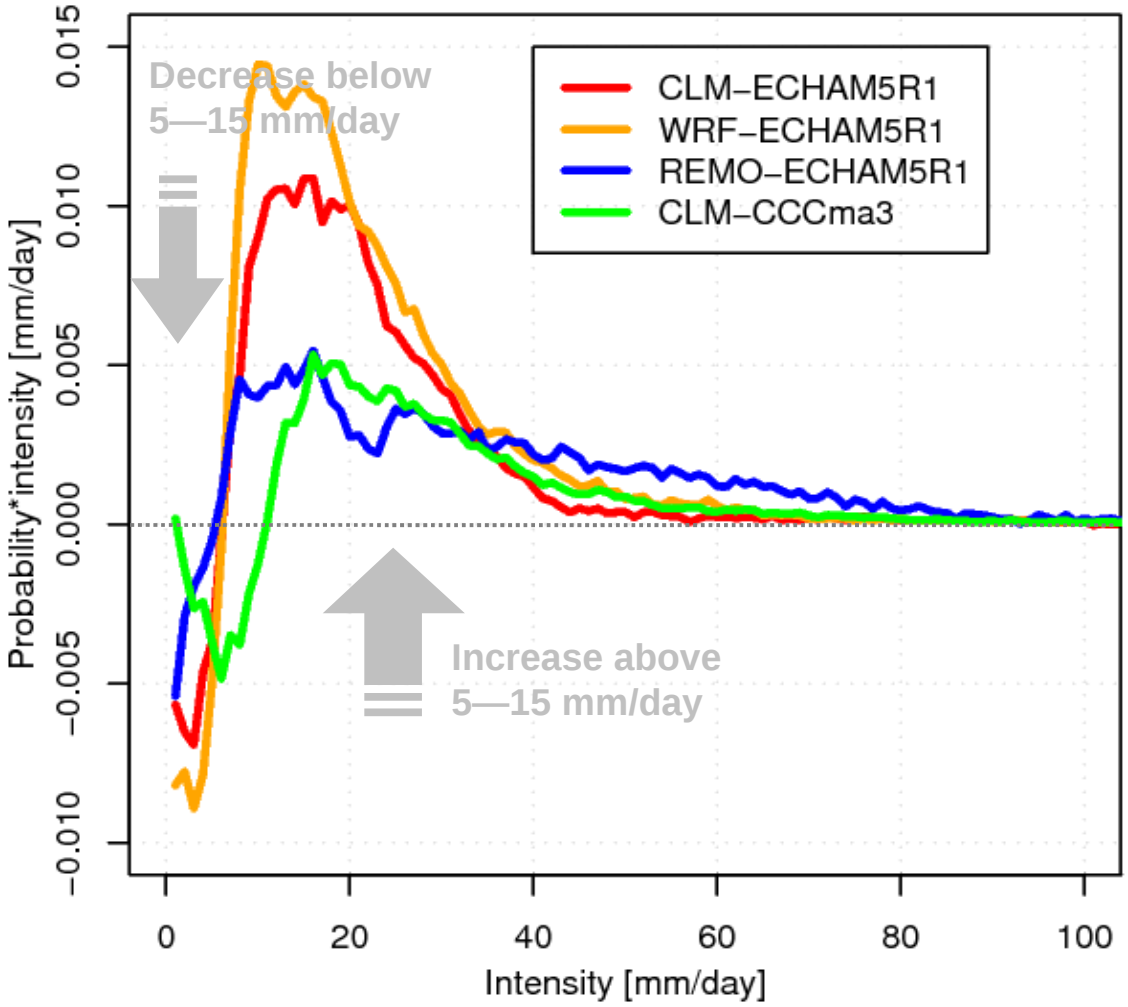
Scenario:
2021—2050
Control:
1971--2000



Results of RCM simulations, scenario-control precipitation density distribution

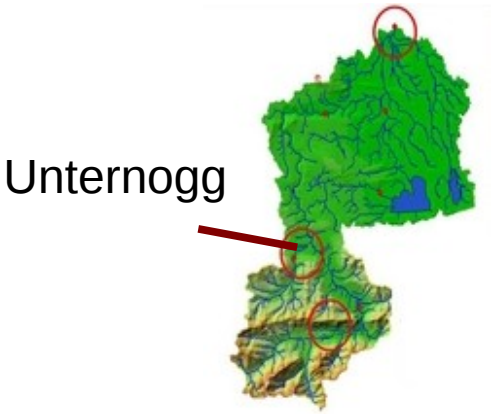


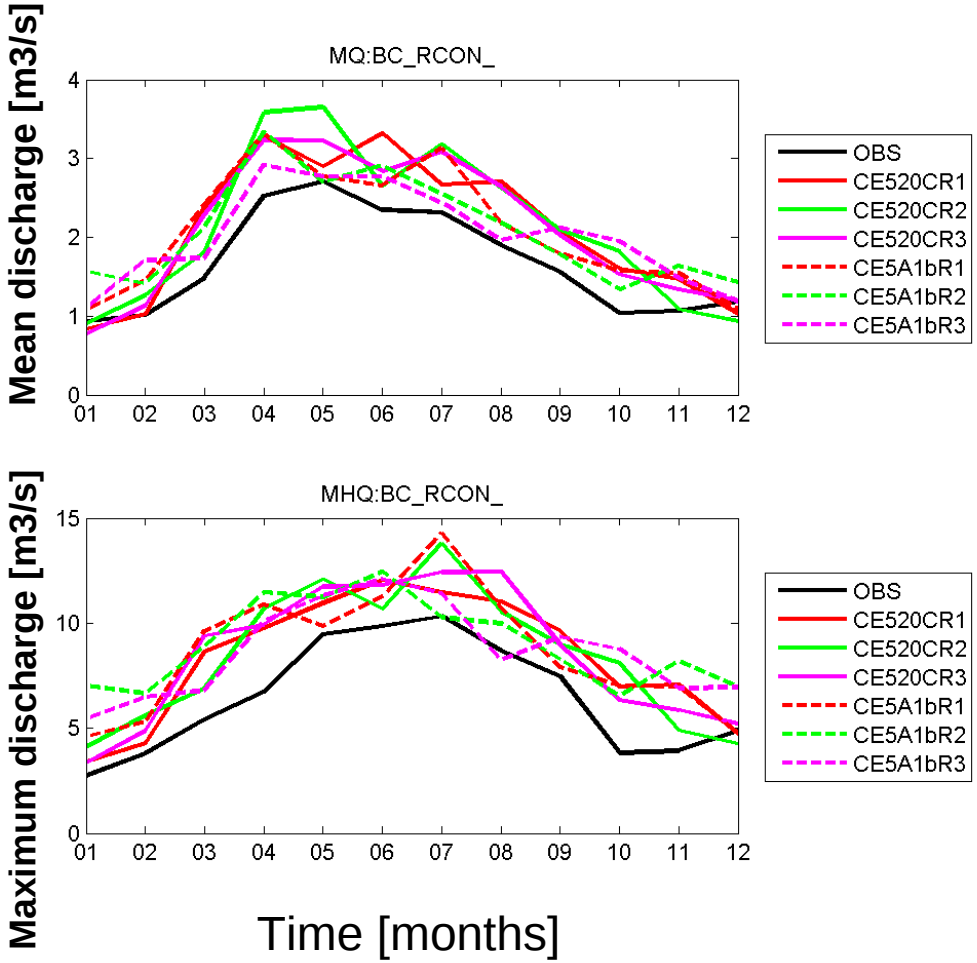
- The different RCMs produce a robust shift of precipitation toward more extreme events already for the near future
- A similar shift is also seen when forcing with a different GCM (CCCma3), however with slightly different characteristics



Results of HM simulations, control period simulated discharge in the Ammer catchment

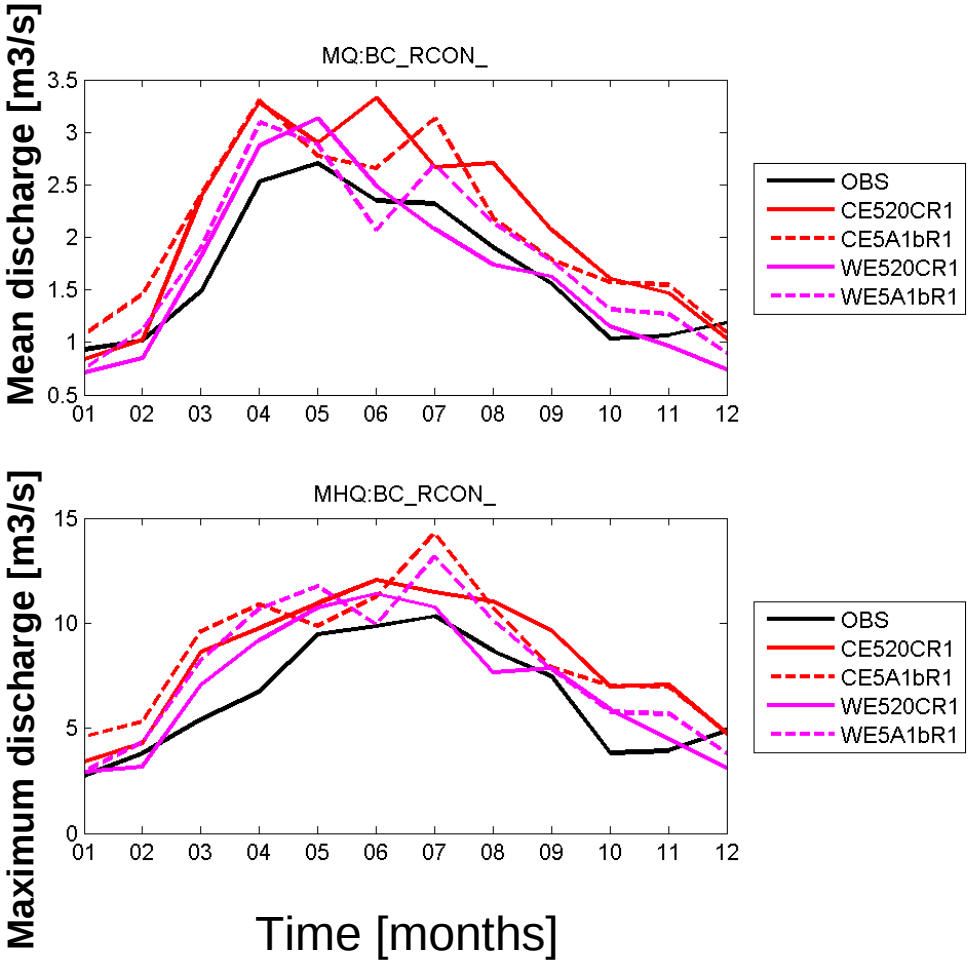
- The different realizations of the **CLM**-ECHAM5 data, get the annual cycle correct, but over-estimate the discharge





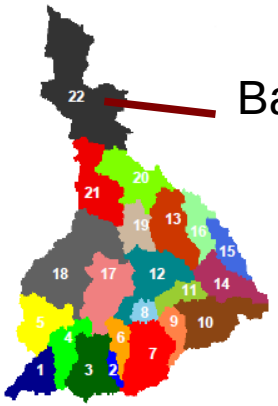
Results of RCM simulations, control and scenario period

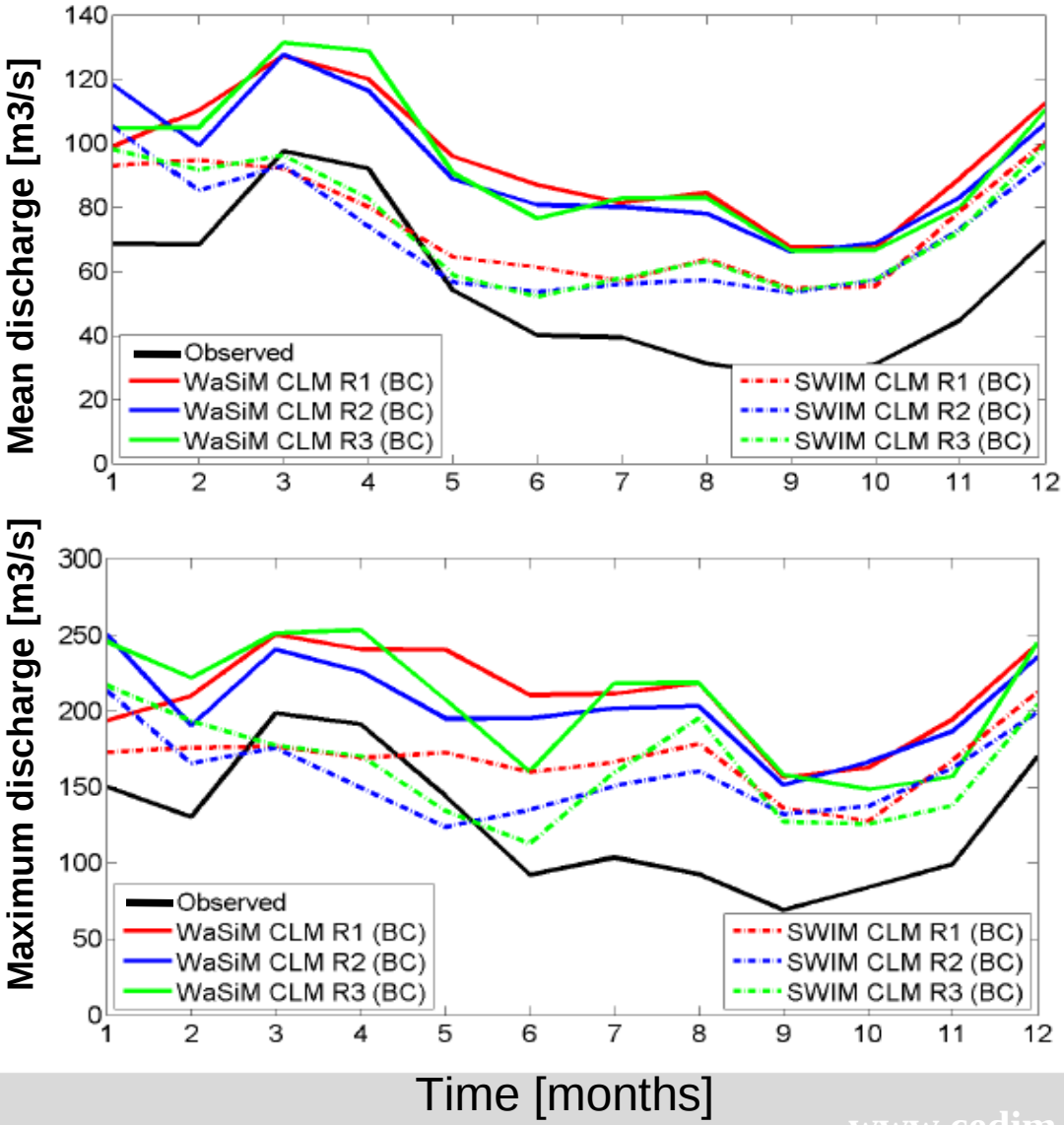
- The simulations with **CLM**-ECHAM5 data and **WRF**-ECHAM5 data agree well with each other, and the spread between forcing models and different realizations with one model are comparable



Results of HM simulations, control period simulated discharge in the Mulde catchment

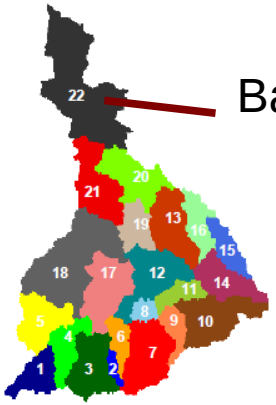
- Forced by **CLM**-ECHAM5 data, both SWIM and WaSiM over-estimates mean and maximum discharge
- SWIM is performing slightly better than WaSiM



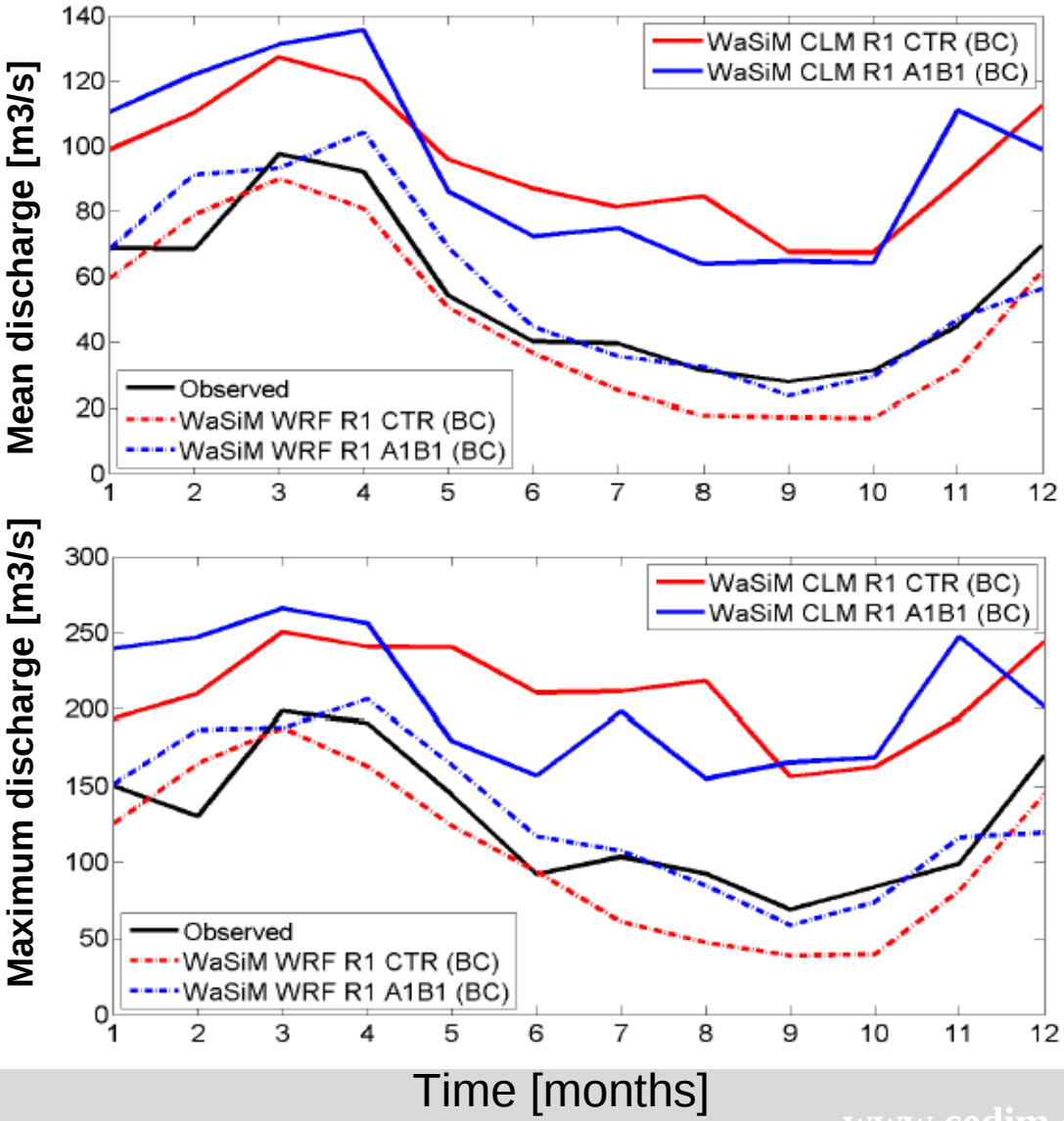


Results of RCM simulations, control and scenario period

- Forced by **WRF**-ECHAM5 data, WaSiM is performing better than with CLM-ECHAM5 data and is very close to observations
- The sign of the future changes differs between the RCMs



Bad Düben



Summary

- **RCM simulations and bias correction** step has been completed
- Some climate change statistics, such as the shift to more extreme precipitation, are **robust** for all simulations, while there are notable **differences in both sign and magnitude for other statistics**
- The **variability in the results for different RCMs**, depending on the forcing data and the realization of the GCM simulation, shows the **importance of using ensemble methods** in assessing uncertainties in future projections and not just rely on single models
- The different HMs have been **carefully calibrated** and tested against observed discharge also at many **sub-catchment gauges** and with respect to **high flow conditions**. The final simulations are being carried out.
- The HMs seem to **respond differently to different RCM forcing data**, and the complete set of simulations will show a clearer picture of how the different models respond.

Dissemination of results

- A **final report** including all work performed will be available at the end of October
- Writing of **scientific papers** and presentation at various **conferences**, such as DKKV forum and Tag der Hydrologie, Acqua Alta, EGU, etc.
- There is an initiative to make some of the RCM data and other results freely available in a **“CEDIM”-data base**
- The RCM simulations has drawn interest from other groups and agencies such as **KLIWA, BFG, Wasserwirtschaftsamt and Landesamt für Umwelt in Bavaria**, etc. **Collaborations** between IMK-TRO and e.g. KLIWA and BFG have already been **initiated** in exchanging methodologies and data
- Hydrologists are in close contact with **local water management**, e.g. **Ruhrverband**, and other local agencies

Outlook

- Within this project, a unique data set of high resolution climate simulations has been constructed
- Methodologies for coupling the RCM data to different HMs have been developed, including bias correction which can be expanded to additional variables and catchments in Germany
- An ensemble of simulated hydrological data for the three catchments is available for further use
- The topic of droughts could furthermore be studied within the available ensemble
- These data and methodologies should be built upon in future hydrological and other impact modeling within CEDIM