International Commission for the Hydrology of the Rhine Basin
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RheinBlick2050

Assessment of regional climate change impacts on discharge in the Rhine River Basin – Overview

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Structure of the presentation

- Motivation
- Goals
- Research framework
- **Climate change (CC) impacts**
- Conclusions

Motivation for the RheinBlick2050 project

- **Regional climate change** does and will **modify hydrological processes** and the water balance and **discharge** in the Rhine River basin and its tributaries
- This has **variable impacts**, depending on respective sectors' sensitivities and vulnerabilities
- Decision makers need **suitable information** to develop adequate adaptation strategies
- Existing publications / projects exist, albeit often either
  - **Small regional cc projection ensemble size**, potential undersampling of "true" bandwidth; difficult assessment of uncertainties (e.g. Hurkmans et al., 2010, J Climate)
  - Focus often **only on subcatchments**; methodologically difficult to combine, or (e.g. KLIWA, CCHydro, FLOW-MS)
  - Missing link to **stakeholders** (i.e. water managers)
- Need for **common coordinated discharge projections for the complete catchment**
- The **CHR** has a coordinating role in hydrological research in the Rhine River catchments (joint research; exchange of data, methods, information; development of standardized procedures)
- Close linkage to and cooperation with the **ICPR / AG-H / EG Klima**; CHR specifically mentioned in ICPR's tasks in Rhine ministers conference communiqué of 2007 under topic "Climate change and its consequences"

Project goals

- Overall objective: **Assessment of regional climate change impacts on discharge in the Rhine River basin** (“classical” hydrological impact study, no adaptation)
- Goals and results

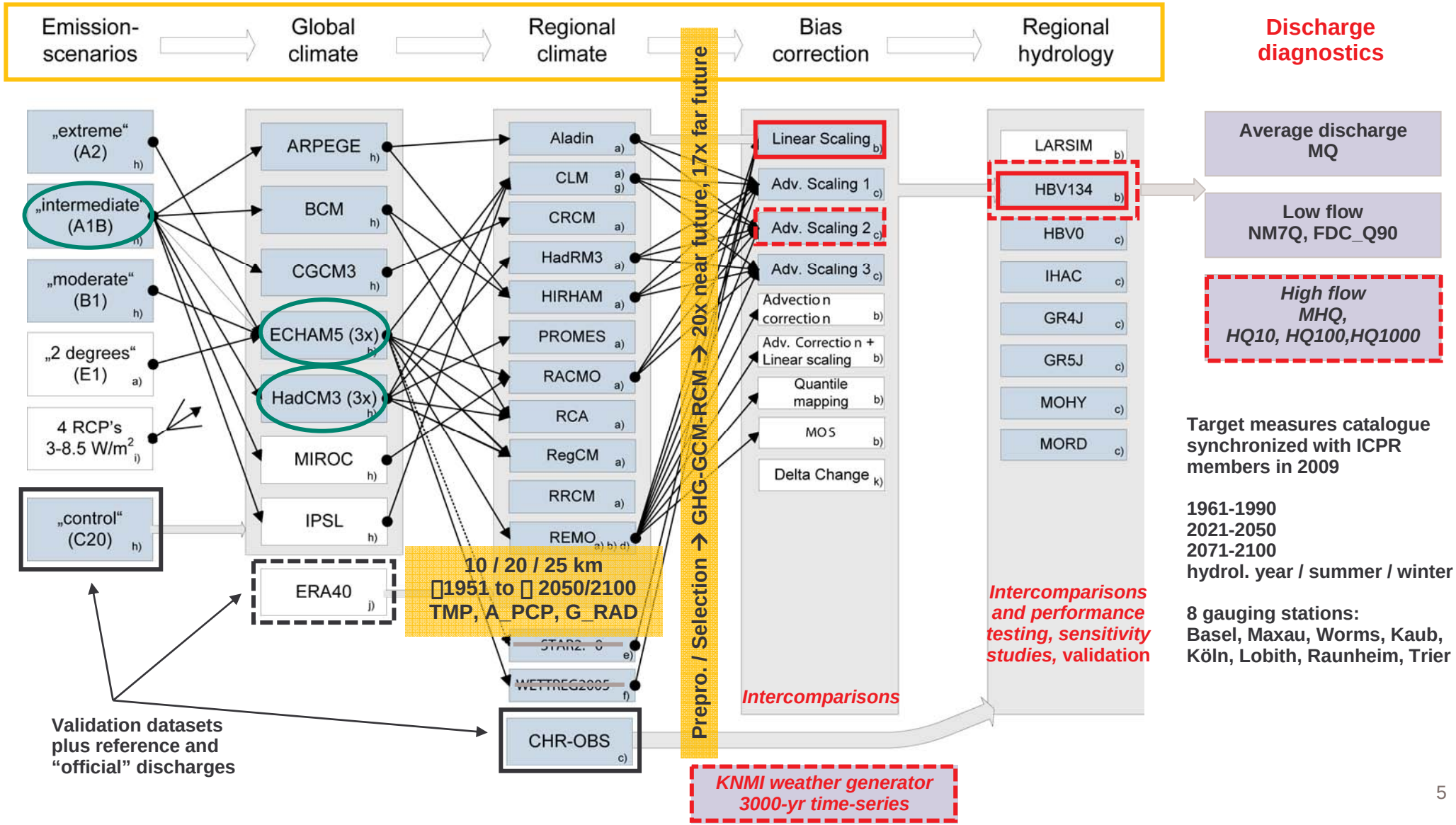
  1. Development of a **common, consistent research framework** across participating countries (5) and institutions (8); “common” = agreement on suitability of data, methods, models; “consistent” = data and models available for the complete catchment
  2. Creation (acquisition, pre-processing, evaluation, bias-correction) of state-of-the-art **regional climate change projection ensemble** for analyses and as forcing data to hydrological models to generate **specific discharge projections***
  3. Compilation of partly heterogeneous** information into **applicable information (synchronized with stakeholders) and quantifiable statements** through **scenario bandwidths and tendencies** of future changes in meteorological and hydrological **key diagnostics** (mean, low and high flow statistics) for **time-spans up to 2050 and 2100**

* macro-scale processes → complimentary to more regionalized projects

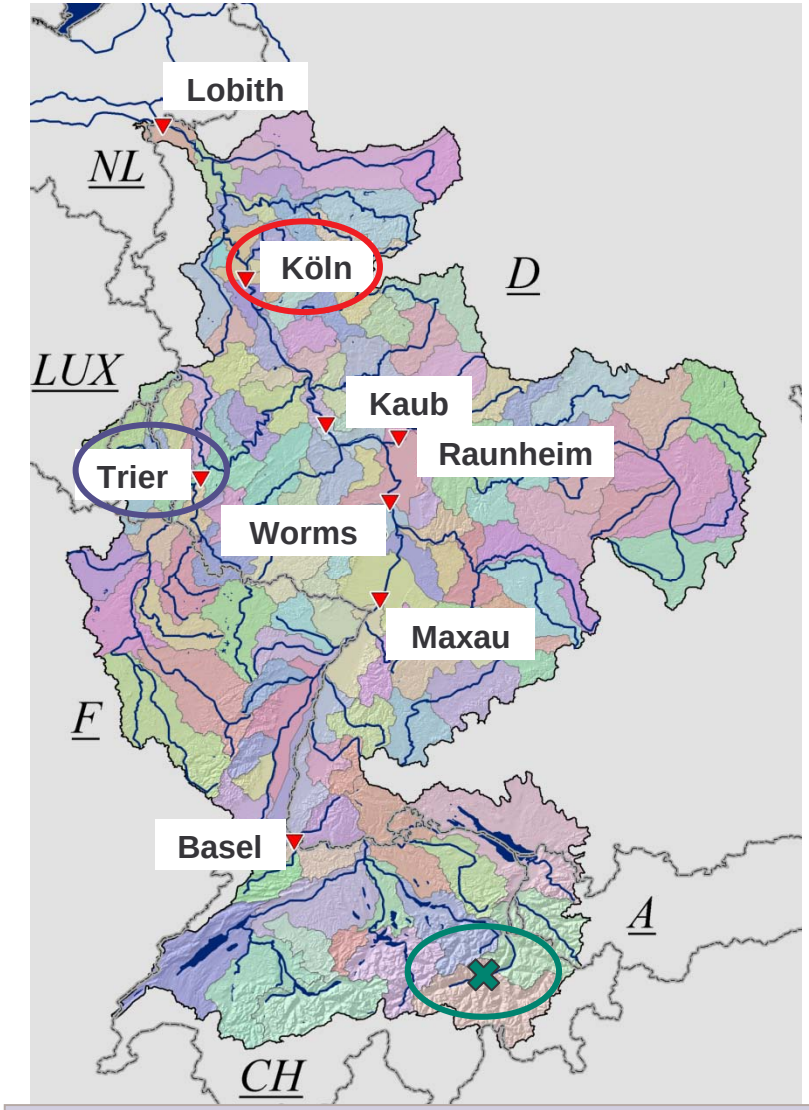
** “meta” project, based on existing ongoing projects, results and data of the partners (e.g. KLIWAS, CCHydro)

Research framework
Experiment design, data, modelling / processing chains

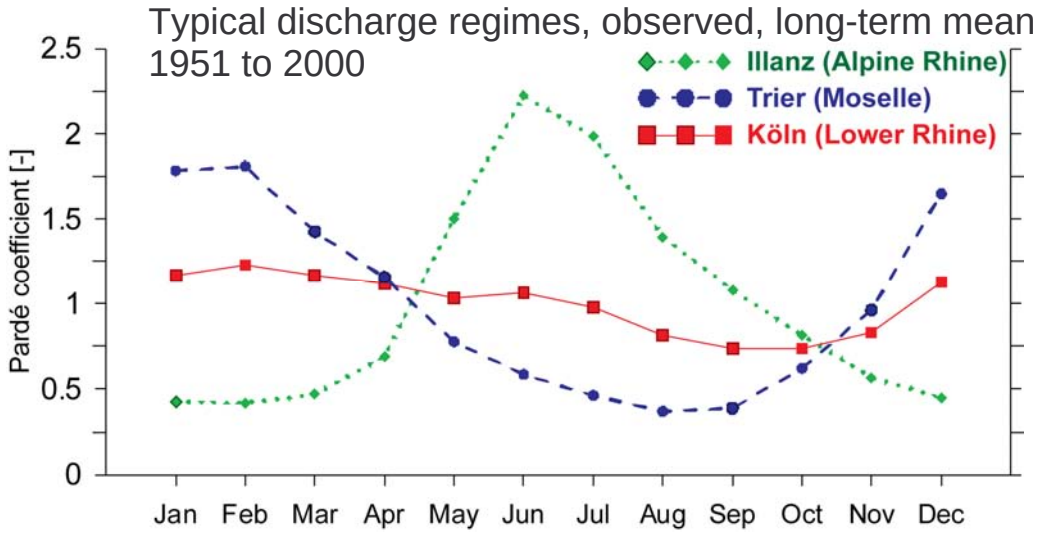
Ensemble of multi-model results shows an increasing bandwidth (*assessment of contribution to overall uncertainty*)



Research framework
Study area and setup of hydrological model HBV134



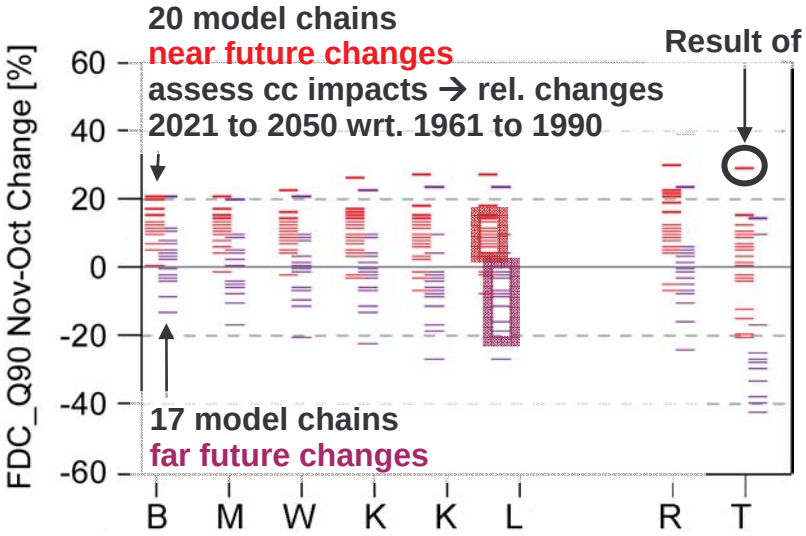
MACRO-SCALE PROCESSES → complimentary to small-scale projects



- HBV hydrological model for discharge projections
- Version: HBV-96, implemented by BfG and RWS-WD to Rhine River catchment, daily time-step
- Semi-distributed, 134 model catchments (HBV134)
- Inputs: precipitation, air temperature, potential evapotranspiration
- Limitation:
  - Hydrometeorological reference datasets
  - Linear description of base flow
  - No lake retention, not too sensitive
  - Flood routing, no hydraulic model, no overtopping of dikes → only with HQx

Research framework
Results evaluation: “Scenario bandwidths and tendencies”

- ... Discharge projections → specific diagnostics → how to evaluate and communicate bandwidth?
- → **scenario bandwidths and tendencies**; combining qualitative and quantitative measures
  - Tendency: **direction of change** (increase / no tendency / decrease / no conclusion), 80% of ensemble members point into same direction
  - Bandwidth: **bandwidth of change**, [%], 80% of ensemble members are within that span



Result of complete processing chain realisation

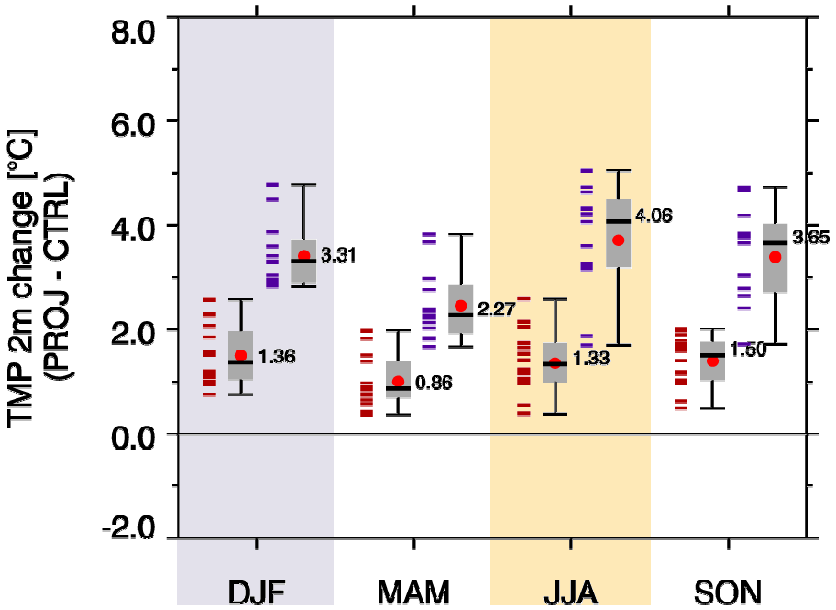
Gauging station	2021 to 2050	2071 to 2100
Basel	+5 to +15%	-5 to +15%
Maxau	+5 to +15%	+/-10
Worms	+5 to +15%	+/-10
Kaub	+5 to +15%	-10 to +5%
Köln	+5 to +15%	-10 to 0%
Lobith	+5 to +15%	-20 to 0%
Raunheim	+5 to +25%	+/-10
Trier	-5 to +15%	-40 to -25%

- Large bandwidth → but: clusters → derive scenario from projections (retain full information, narrow bandwidth, transparent, easy to apply / understand, adjustable, extensible)
- In line with “good practice“ recommendations of EU + checked with ICPR stakeholders

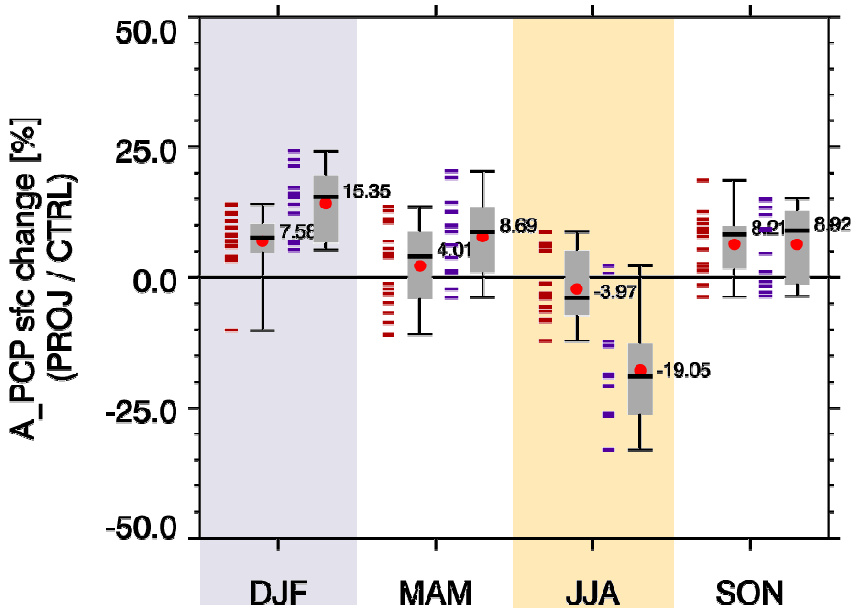
* Low-flow: 90th percentile of flow duration curve / discharge value undershot at 10% of days in time-span

CC impacts – Meteorological drivers, basin-wide

Air temperature changes, 30-yr seasonal means



Precipitation changes, 30-yr seasonal means

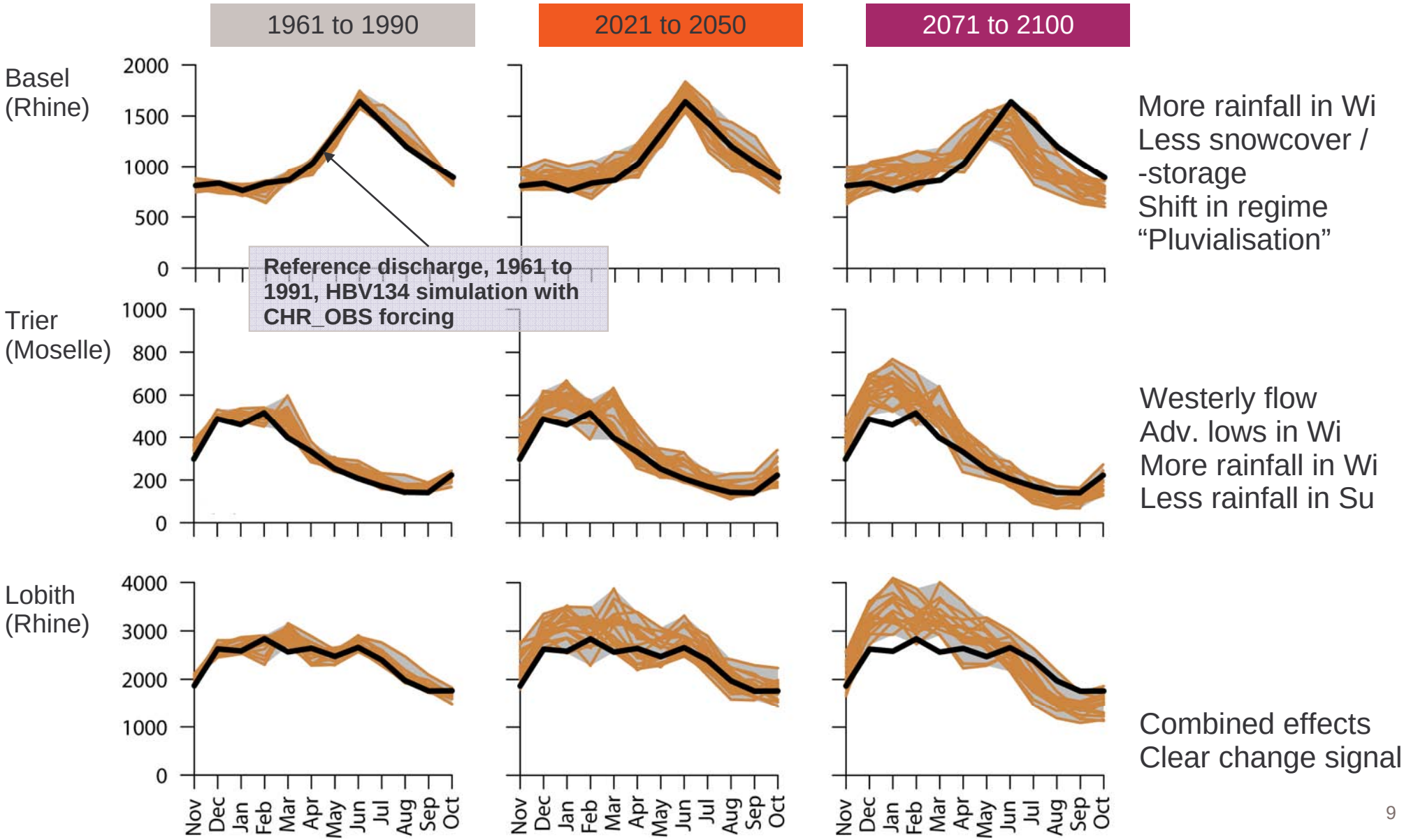


- **All seasons: increase of temperature, all spatial domains (slightly higher in South); more clearly defined in winter**
- **Wi: 0.5°C to 2.5°C near future; 2.5°C to 5.0°C far future**
- **Su: 0.0°C to 2.0°C near future; 2.5°C to 5.0°C far future**

- **Wi: increase of precipitation; 0% - 15% near future; up to 25% far future**
- **Su: decrease of 10% to 30% far future**
- **Sp/Su/Au: no clear tendency near future**
- **Spatially uniform in-/de-crease in near future; larger heterogeneity in South in far future**

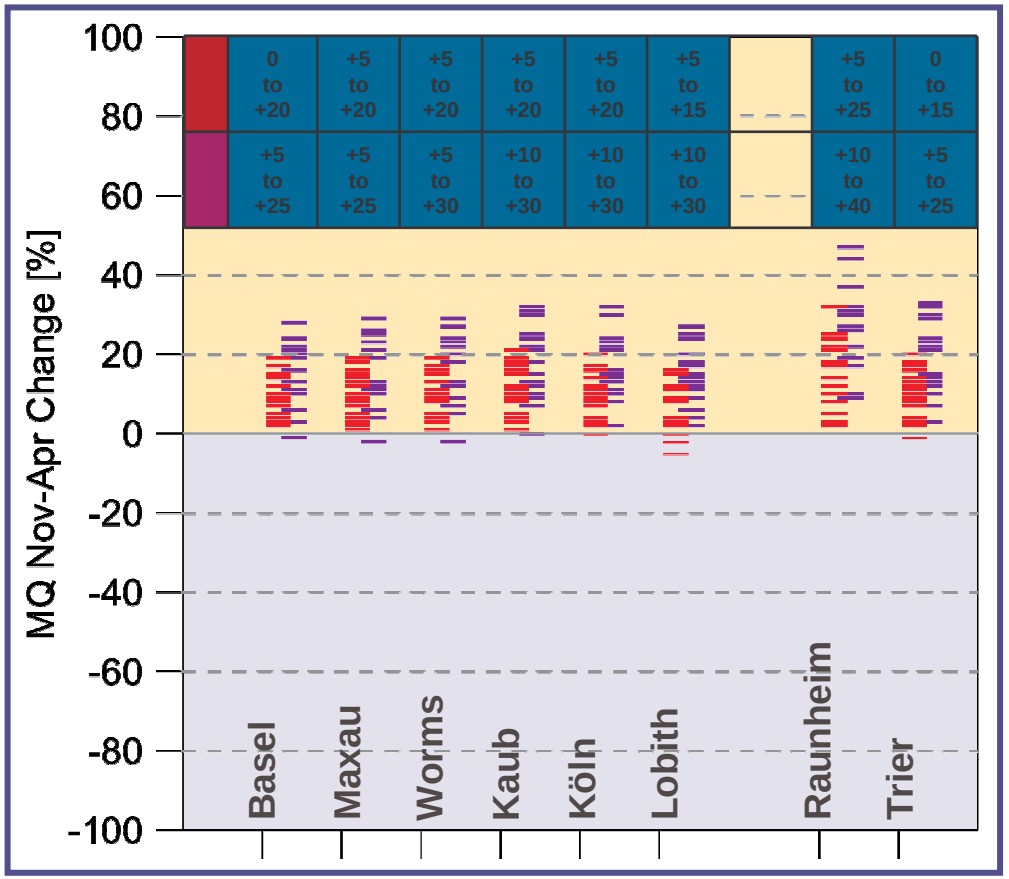
CC impacts – Mean flow changes
Modified discharge regimes throughout the basin

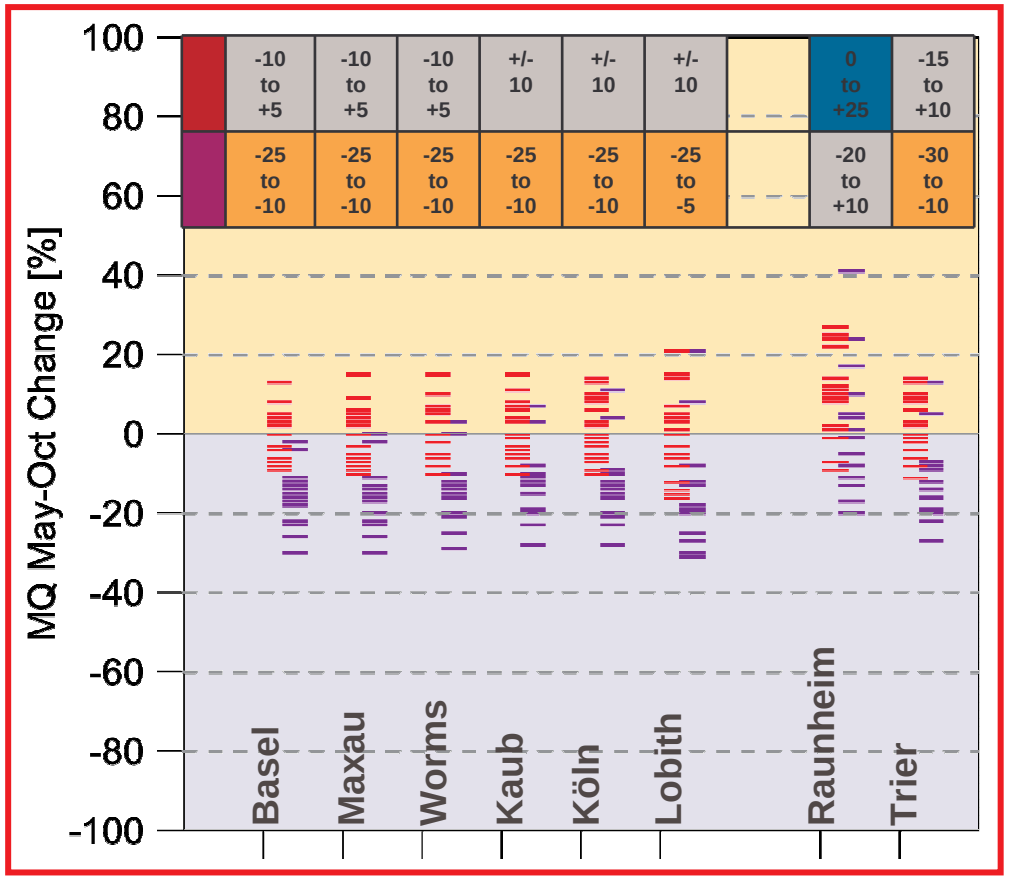
MQ [m³/s], 30-year long-term monthly mean discharge, annual cycles, Nov-Oct



CC impacts – ***Mean flow*** changes
MQ changes, hydrological winter and summer

Projected relative changes of 30-year long-term mean **hydrological winter / summer MQ** and scenario bandwidths and tendencies

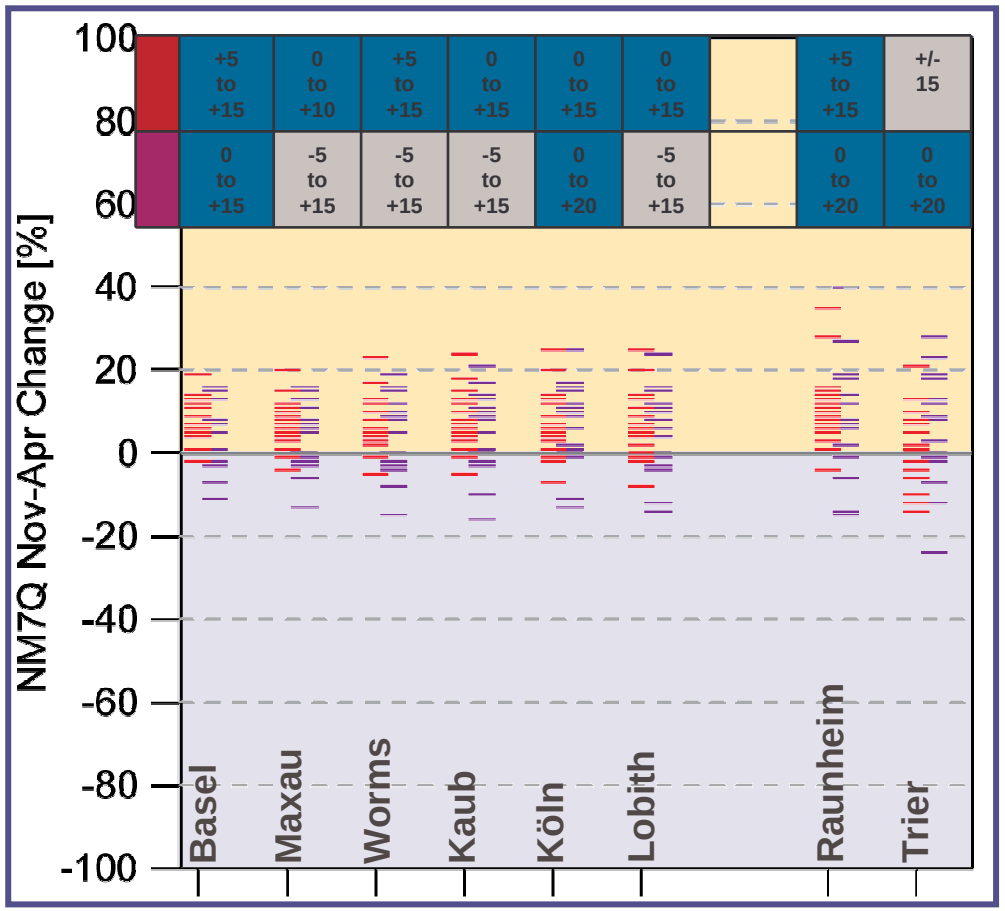


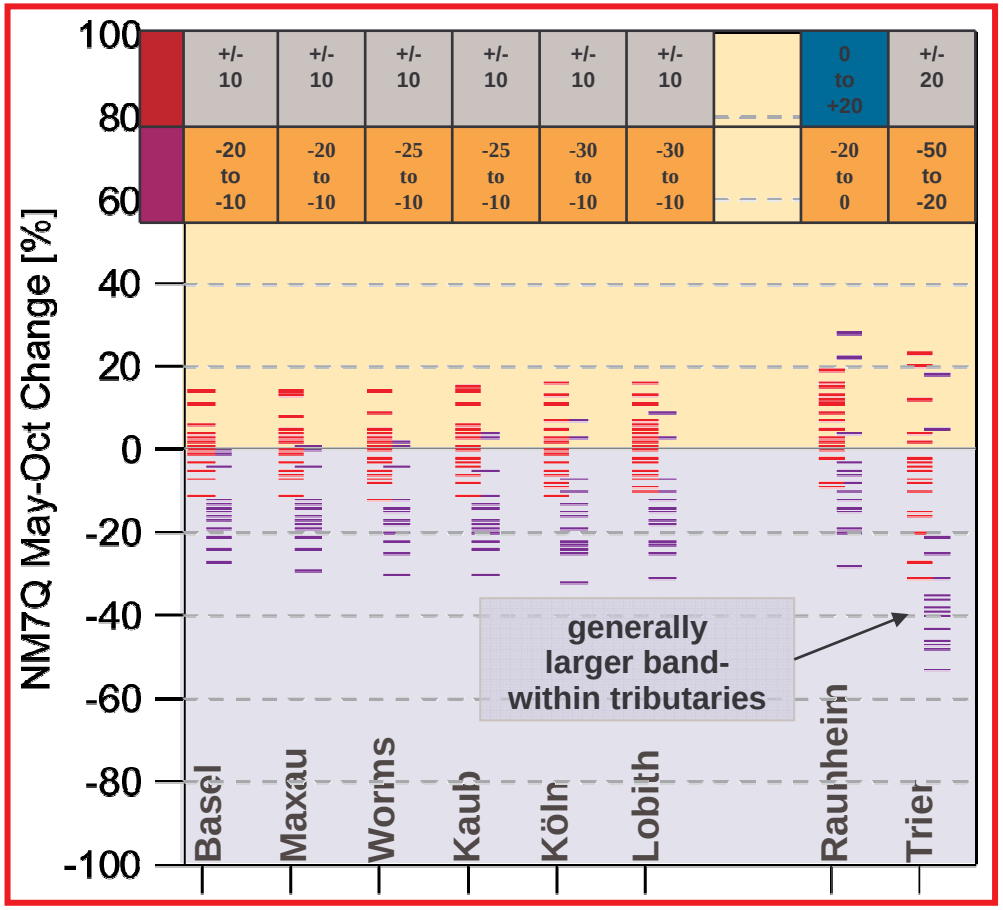


- **Wi: increase of mean discharge: near (0% to +25%), far (+5% to +40%) future**
- **Su: opposite tendency: decrease of 30% to 5% far future; upstream: more rainfall-dominated flow regime → more similar to regimes downstream; shift of maxima and minima**
- **Annual (not shown): increasing tendencies only for near future (Kaub, Köln, Lobith, Raunheim); in far future Wi and Su tendencies compensate each other**

CC impacts – *Low flow* changes
NM7Q changes, hydrological winter and summer

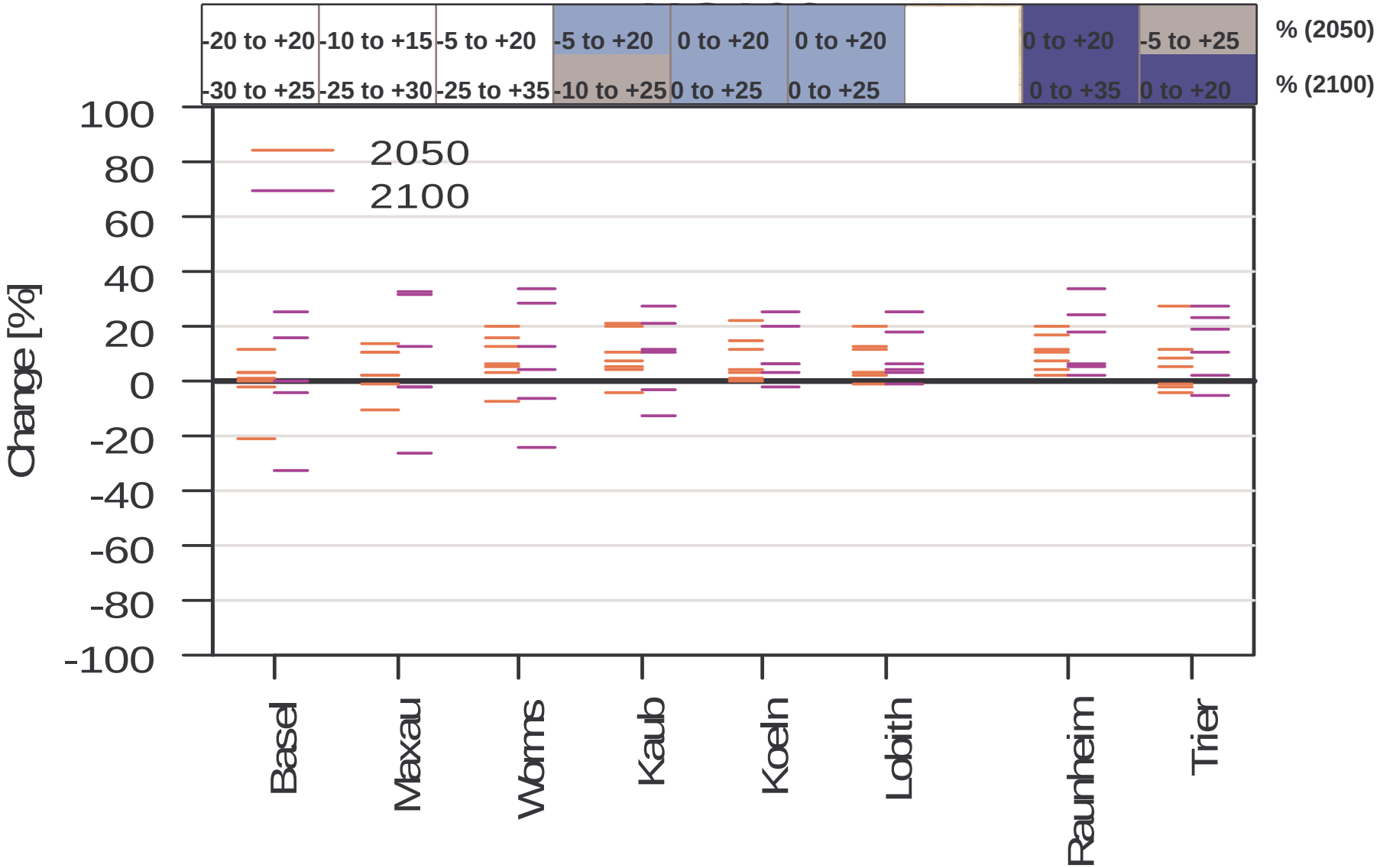
Projected relative changes of 30-year long-term mean **hydrological winter / summer NM7Q**
and scenario bandwidths and tendencies INCREASE = LESS SEVERE LOW-FLOW CONDITIONS





- **Wi: increasing tendencies for near / far future (0% to 15%)**
- **Su: decrease of seasonal lowest 7-day mean discharge in far future (-30% to -10%)**

CC impacts – ***High flow*** changes
HQ100 changes, hydrological winter and summer



Conclusions

- **Project goals are reached**, (**one of the first successful efforts of this kind** in an international river basin with many horizontal and vertical linkages)
- A **concerted, international view** of regional climate change impacts on the discharge regime in the Rhine River basin is derived (at **macro-scale**!) → in line / complimentary with other projects
- A common research framework / institutional network is developed and ready for further studies
- Changes in the regional climate system manifest themselves in the hydrology of river systems in the Rhine River catchment; direction and magnitudes (bandwidths) are consistently determined
- Individual results (**mean, low, high* flow**) have **different** magnitudes of **uncertainties and reliabilities** assigned
- Hydrological **projections and model chain components** are based on **a large proportion of currently available data**, based on current understanding of climate system and hydrology
- Many **uncertainties and limitations still exist** → projections rather than predictions or forecasts, but state-of-the-art of summer 2010
- Discharge analyses / **scenario bandwidths and tendencies** have been fed – among inputs from other projects – into the **political process at ICPR** where eventually **adaptation measures** shall be prepared among the riparian countries of the Rhine River
- **Not the only solution** of the “climate problem” – if there is one at all

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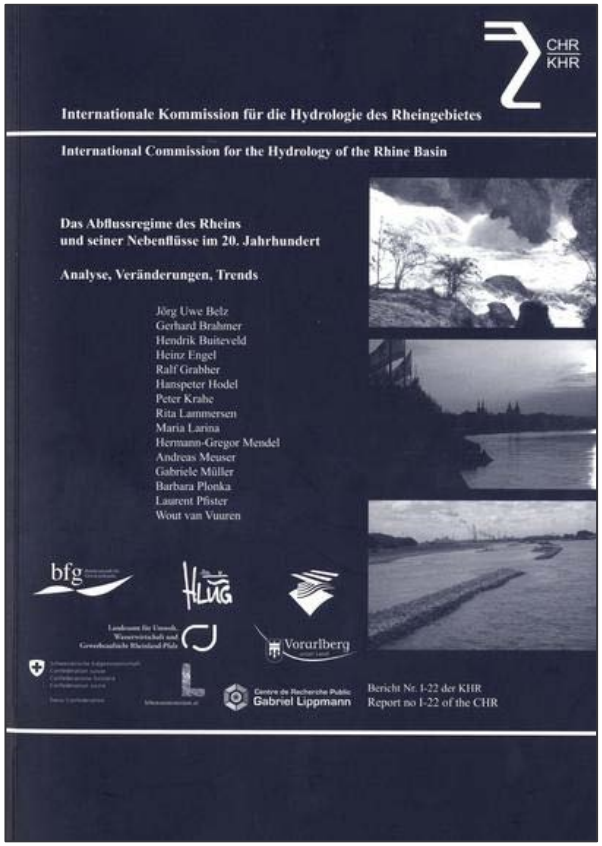
CHR Climate change related PDFs via http://www.chr-khr.org

First CC impacts report

CHR report I-16
Grabs et al. (1996)

Impact of climate change on hydrological regimes and water resources management in the Rhine basin

Observed changes



CHR report I-22
Belz et al. (2007)

Das Abflussregime des Rheins und seiner Nebenflüsse im 20. Jahrhundert - Analyse, Veränderungen, Trends

Future changes / RheinBlick2050

CHR report I-23
Görgen et al. (2010)

Assessment of Climate Change Impacts on Discharge in the Rhine River Basin: Results of the RheinBlick2050 project

RheinBlick2050

http://www.chr-khr.org > Projects > RheinBlick2050

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Delft, The Netherlands


amice
meuse
maas
This project has received
European Regional
Development Funding
through INTERREG IV B.
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INTERREG IVB

Climate change in Meuse river basin

- National climate scenarios

- AMICE climate scenarios

  - First set of common and shared scenarios for the Meuse river basin

  - However:
    - Based on a combination of national climate scenarios
    - Based on different climate datasets
    - Constructed differently (e.g. GCMs and RCMs used)
    - Limited with regard to effects on meteorological and hydrological extremes

Vue de Meuse

- **Idea:** Apply approach used in Rheinblick to the Meuse river basin
- **Goal:** Develop common state of the art climate and discharge scenarios for the international Meuse basin that can be applied for climate risk assessments and adaptation.

- **Why?**
  - Shared and common analysis on the whole river basin scale
  - Gives insight in uncertainties of effects of climate change on river flows
  - Suitable for extremes: drougths and floods

- **How?**
  - Use of Ensembles dataset
  - Shared hydrological modeling exercise and analysis

How further?

Meta-project like Rheinblick?

- Research approach → policy relevant results
- Participation from all Meuse basin countries
- Kick-off meeting early 2011 (?)