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Uncertainties in climate projections and hydrological models for climate change studies in the Rhine basin

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Deltas in times of climate change
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Outline

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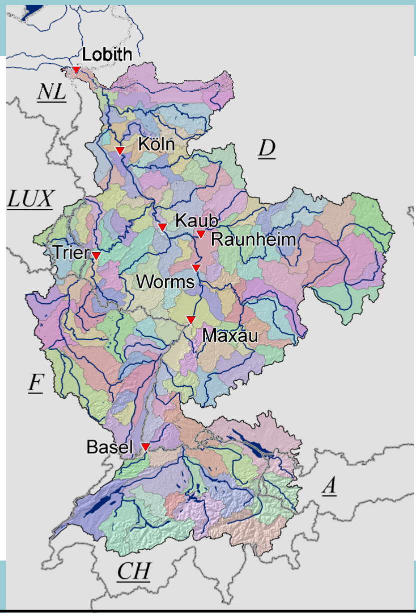
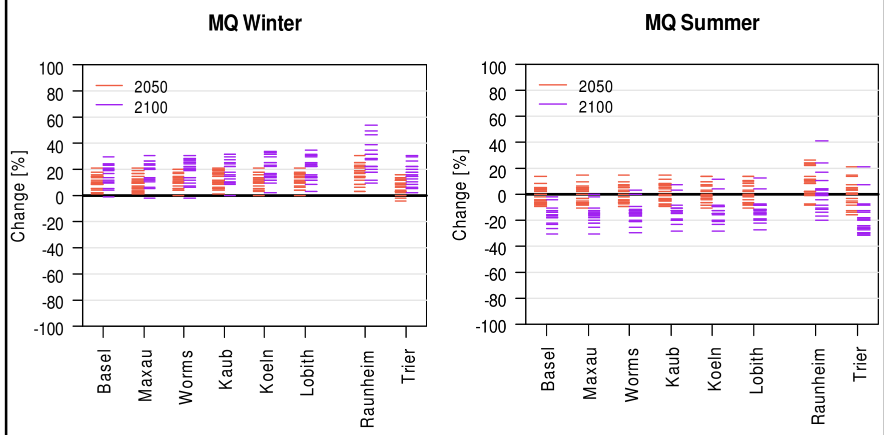
- Introduction
- Example: uncertainty in the change in the mean discharge (at Lobith)
- The modeling chain
- Uncertainties in the modeling chain
- Summary and conclusions

Introduction



Discharge projections for the Rhine

Example: MQ in 2050 and 2100 (RheinBlick)



The modeling chain

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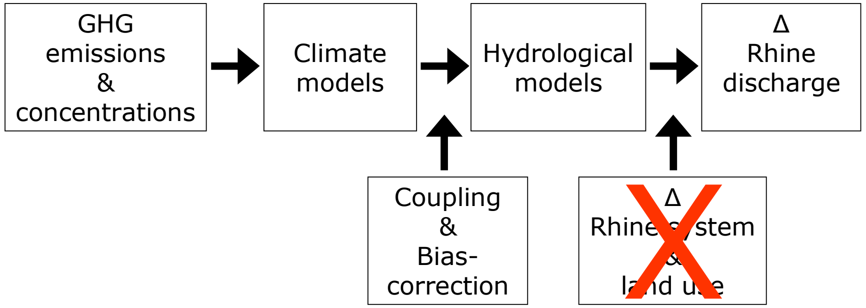

The modeling chain

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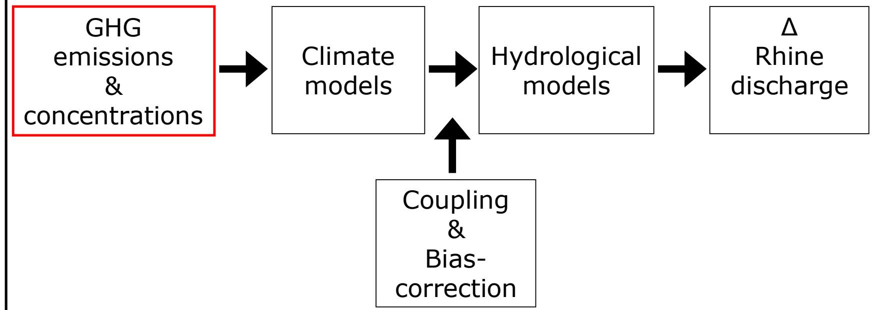

GHG emissions & concentrations
CO_2 concentration

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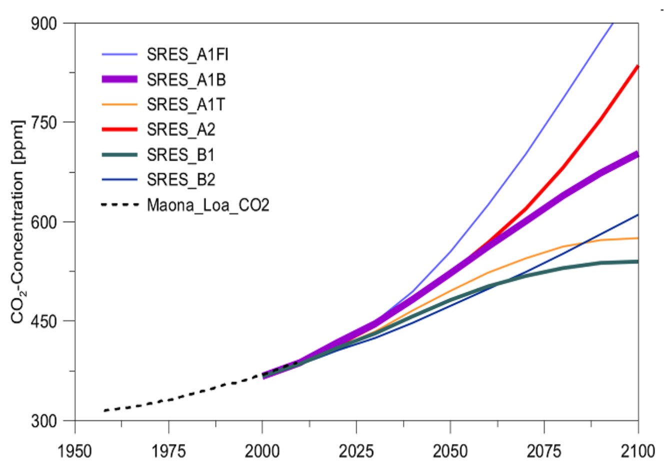

GHG emissions & concentrations
Major sources of uncertainty

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- Global population
- Global economy
- Technological development (transition of the energy system)
- Uncertainties in the carbon cycle (uptake by the ocean, rock and forests)

The modeling chain

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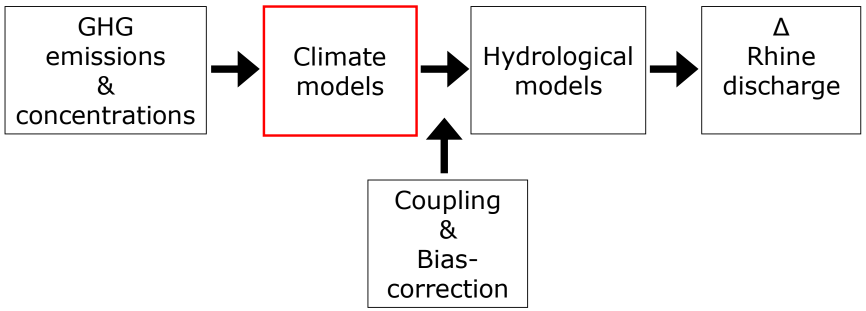

The modeling chain
Climate models

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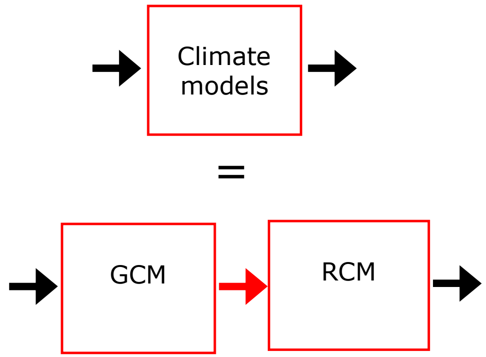

RCM has about factor 5 larger spatial resolution; better resolves land/sea contrasts and orographic effects

Climate models

GCM uncertainty in global temperature projections

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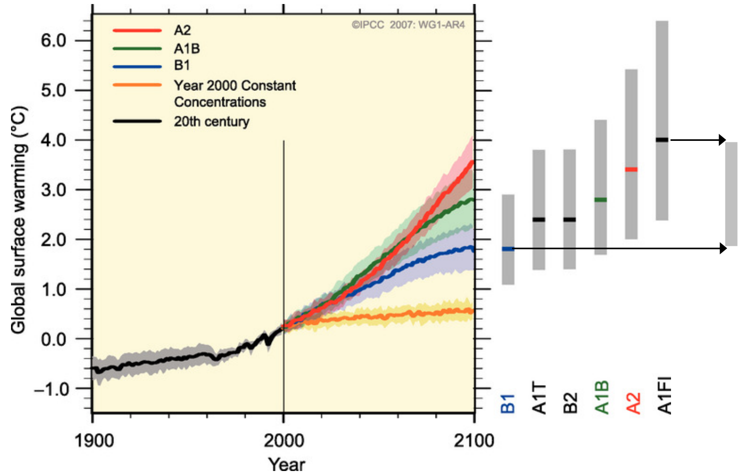

Climate models

RCM uncertainty in ΔT and ΔP in the Rhine basin (SRES A1B)

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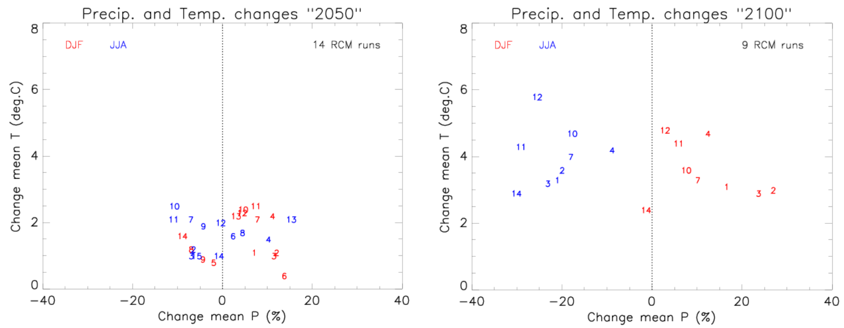
2050 = near future

2100 = far future



ΔT = 1 to 3ºC, ΔP = -15 to +15%

ΔT = 1 to 3ºC, ΔP = -15 to +15%

ΔT = 2 to 5ºC, ΔP = 0 to +30%

ΔT = 3 to 6ºC, ΔP = -30 to -5%

Climate models & scenarios
Major sources of uncertainty

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GCMs
- Climate sensitivity (overall effect of all positive and negative feedbacks)
- Cloud feedbacks
- Change of large scale atmospheric circulation (important for Western Europe because of sea climate)

RCMs
- Parameterization of small-scale processes (e.g. convection, extreme precipitation)
- Soil properties and local (hydrological) feedbacks (e.g. summer drying)

The modeling chain

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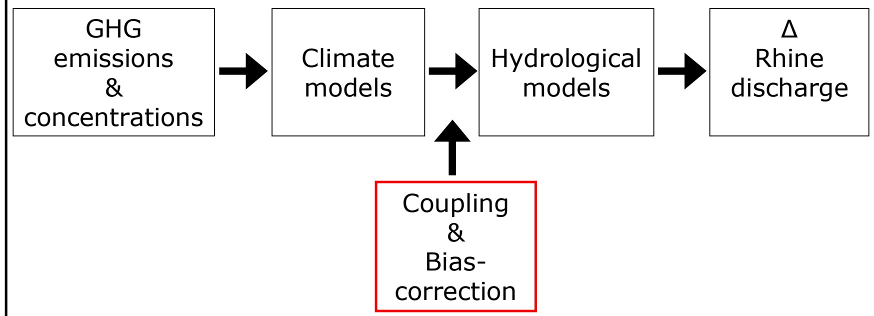

Bias correction
Example for the Rhine basin (RheinBlick)

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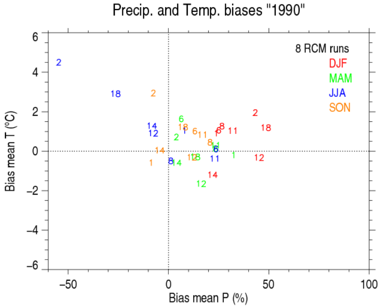
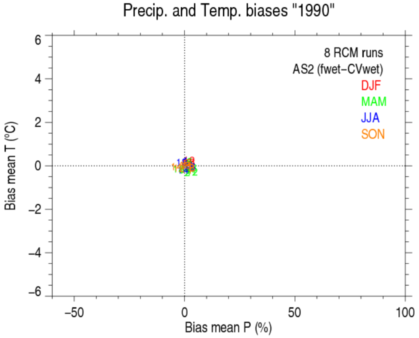


Bias T: between -2 and +4˚C

Bias P: between -50 and 50%



Bias correction
Uncertainty in summary

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- If a proper bias correction is applied the uncertainties from bias correction are small compared to those from emissions scenarios and climate models, and can be ignored
- The challenge is however to apply a suitable bias correction (e.g. one that also removes biases in extreme precipitation if changes in extreme discharges are studied)

The modeling chain

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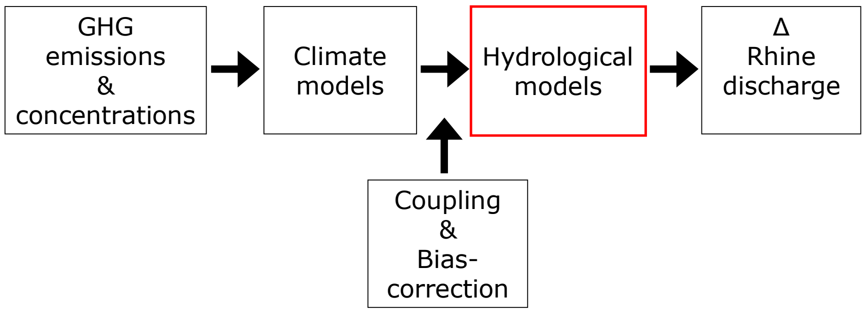

Hydrological models
Uncertainty in summary

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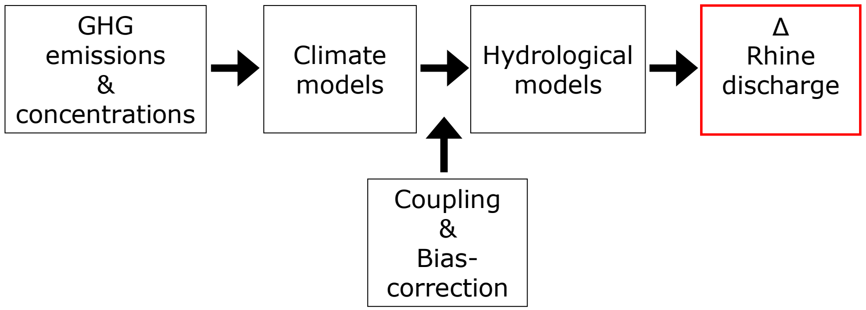
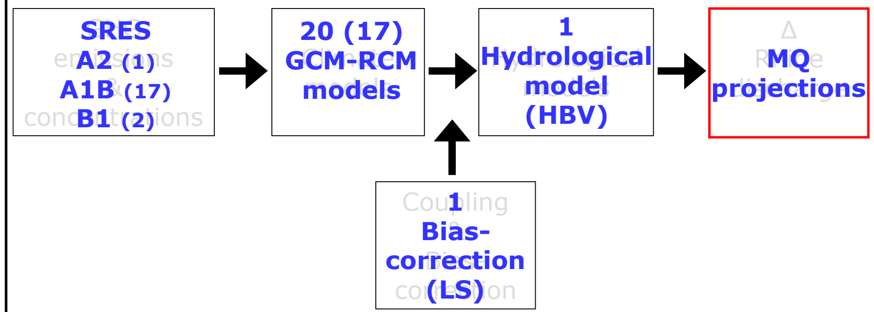
- Uncertainty in climate forcing (input) of the hydrological models is considered to be (much) larger than the uncertainty in the hydrological models themselves
- Uncertainty in hydrological models is largely related to uncertainty about the validity of the parameterizations of hydrological processes under (unprecedented) future climate conditions. (This validity is however difficult to asses since most hydrological models are conceptual models rather than physically based)
- In RheinBlick the hydrological model that performs best under current climate conditions is therefore used in the modeling chain

The modeling chain



Discharge projections for the Rhine

Example: MQ in 2050 and 2100 (RheinBlick)



Discharge projections for the Rhine
Example: MQ in 2050 and 2100 (RheinBlick)

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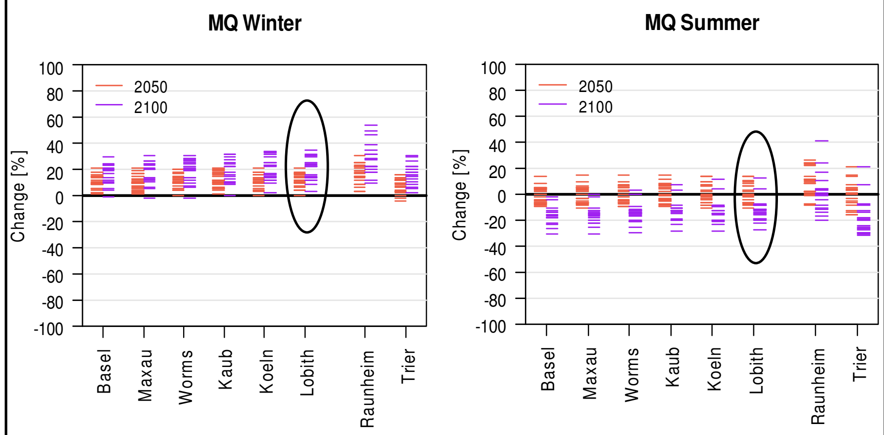

Discharge projections for the Rhine
Example: HQ1000 in 2050 and 2100 (RheinBlick)

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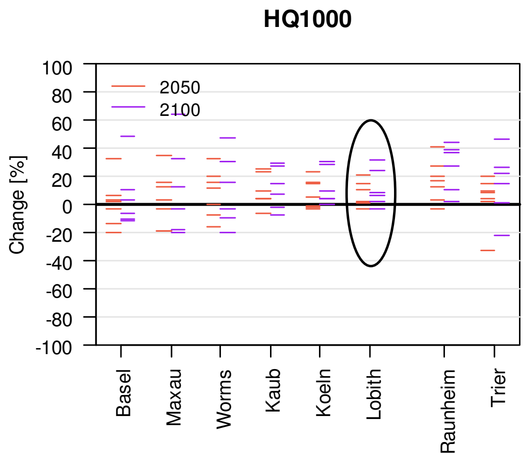

Summary

- There are large uncertainties in emission scenarios and climate models, and thus in climate model projections (for the Rhine basin)
- Uncertainties from bias correction (if properly dealt with) and hydrological models are relatively small and therefore not included in the modeling chain for RheinBlick
- Uncertainties from 'non-climatic' changes in the river system (e.g. changes in land use) are ignored

Conclusions

From the RheinBlick results it may be concluded that:

- Uncertainty in MQ projections is somewhat larger for the far future (2100) than for the near future (2050)
- For the far future, most projections show an increase in MQ in winter and a decrease in summer
- Uncertainty in extreme discharge projections (like HQ1000) is often larger than for MQ projections
- The uncertainty in discharge projections for the Rhine basin is large; except for a clear increase in MQ in winter in the far future, both increases and decreases are projected
- As a result, one should be careful considering only the ensemble mean change, the majority of the projections or single-model results since this ignores the fact that there is also a (small) probability for a change in the opposite direction
  → ***the full information is in the full range***