Projecting hydropower production for the future : modelling challenges ... and open questions

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Introduction

Review of climate change impact assessment on hydropower production (**HPP**), Schaefli, 2006:

➔ From climate change impact to climate-vulnerability assessment

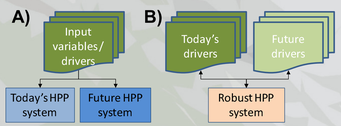


Fig. 1: Inversion of the assessment framework from impact assessment (A) to vulnerability assessment (B) to understand which future drivers can be handled by a robust system rather than to make highly uncertain projections of future system states.

Simulation framework

Most HPP climate change impact assessments simulate part of the complete model chain (Fig. 2):

- ➔ Management model often missing or unrealistic
- ➔ Studies with ecosystem Evolution: extremely rare
- ➔ Studies with sediment modeling: very rare

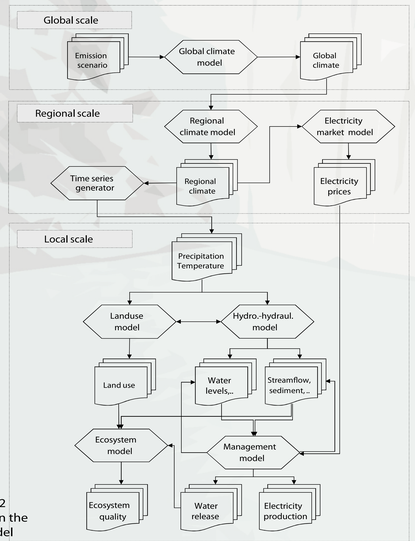


Figure 2: Sketch of the model chain for climate change2 impact simulation. Many more feedback loops between the models could exist. A complete HPP management model includes HPP operation as well as maintenance work.

Assessment framework

Simulation-based climate change impact assess. has 3 simulation phases & 4 analyis steps (Fig. 3).

Challenges

- ➔ Probability of occurence of climate change scenario ?
- ➔ Plausibility of climate models
- ➔ Natural (or internal) variability ?
- ➔ Hydro-hydraulic modeling uncertainty ?
- ➔ Calibrated models useful for future situations ?
- ➔ Missing feedbacks among system models ?
- ➔ Electricity market evolution ?
- ...

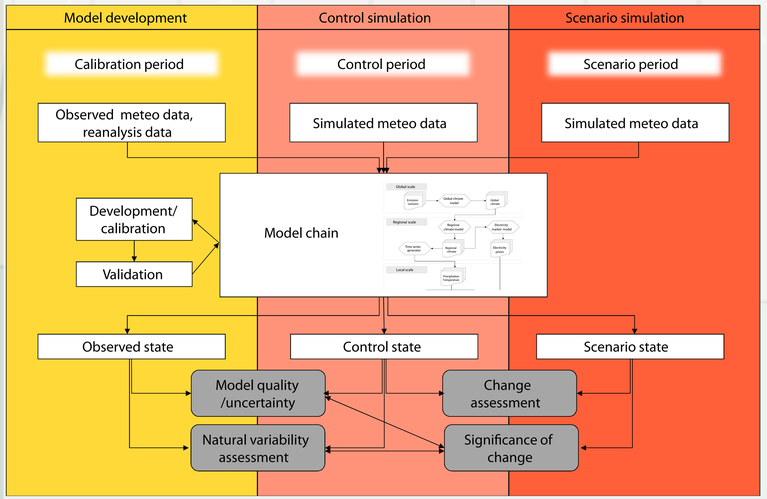


Figure 3: Sketch climate change impact assessment composed of three simulation phases (colour boxes) and of four phases of output assessment (grey boxes).

Results

Ensemble-based climate change impact projection:

- ➔ Range of possible future states
- ➔ Anticipate adaptation
- ➔ Robust conclusions for many snow-influenced basins (Fig. 3)

HPP impact depends on:

- ➔ HP production type (Fig. 5, 6, 7)
- ➔ Local climate, hydrol. regime
- ➔ *No* continental scale assessm.

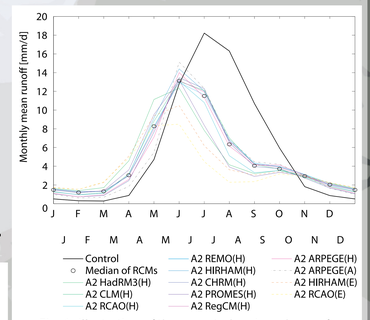
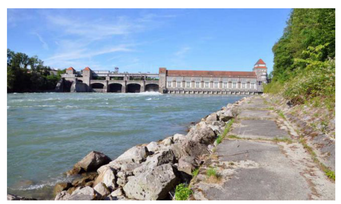


Fig. 4: Illustration of the expected regime change for snow-dominated Alpine catchments from Horton et al. 2006; shown is the regime during the 1961-90 control period and a range of future simulations (2070-99); the expected warming will result in earlier melt and higher winter base flow

Fig. 5: Grimsel Oberaarsee, a Swiss high head storage plant where actual hydro-power production cannot be deduced from hydrol. regime alone but requires insights into the electricity market. (Source: wikimedia)

Fig. 6: Laufenburg, oldest HP plant on the Rhine, a run-of-river scheme for which the HP production can be deduced from the flow-duration duration curve (source: pronatura.ch)



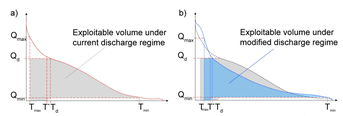


Fig. 7: Estimation of exploitable discharge volume for run-of-river HP under observed und assumed future discharge regime

Conclusion

Recommended focus change to

- Climate-vulnerability assessment
- Enhanced forecasting for HPP under future demand conditions

Reference: Schaefli, B.: **Projecting hydropower production under future climates**: a guide for (..) **WIREs Water**, Early View, 10.1002/wat2.1083, 2015.