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Sequential planning of flood protection infrastructure under limited historic flood record and climate change uncertainty

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Flood protection is often designed to safeguard people and property following regulations and standards, which specify a target design flood protection level, such as the 100-year flood level prescribed in Germany (DWA, 2011). In practice, the magnitude of such an event is only known within a range of uncertainty, which is caused by limited historic records and uncertain climate change impacts, among other factors (Hall & Solomatine, 2008). As more observations and improved climate projections become available in the future, the design flood estimate changes and the capacity of the flood protection may be deemed insufficient at a future point in time. This problem can be mitigated by the implementation of flexible flood protection systems (that can easily be adjusted in the future) and/or by adding an additional reserve to the flood protection, i.e. by applying a safety factor to the design. But how high should such a safety factor be? And how much should the decision maker be willing to pay to make the system flexible, i.e. what is the Value of Flexibility (Špačková & Straub, 2017)?

We propose a decision model that identifies cost-optimal decisions on flood protection capacity in the face of uncertainty (Dittes et al. 2017). It considers sequential adjustments of the protection system during its lifetime, taking into account its flexibility. The proposed framework is based on pre-posterior Bayesian decision analysis, using Decision Trees and Markov Decision Processes, and is fully quantitative. It can include a wide range of uncertainty components such as uncertainty associated with limited historic record or uncertain climate or socio-economic change.

It is shown that since flexible systems are less costly to adjust when flood estimates are changing, they justify initially lower safety factors. Investigation on the Value of Flexibility (VoF) demonstrates that VoF depends on the type and degree of uncertainty, on the learning effect (i.e. kind and quality of information that we will gather in the future) and on the formulation of the optimization problem (risk-based vs. rule-based approach). The application of the framework is demonstrated on catchments in Germany.

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