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Unlocking local knowledge production for global water systems analysis

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Global freshwater systems are critically threatened by environmental change and over-exploitation, stressing the need for novel, transformative solutions. As social-hydrological systems are diverse and complex, water-related risks and decision-making needs are often strongly embedded in a locally specific context. Therefore, such solutions need to be informed by solid scientific evidence while remaining tailored to local realities, knowledge, and practices. However, the current generation of global water system models struggles to produce evidence that is accurate, tailored, and actionable at the local scale.

Here we outline an approach to support local knowledge co-production and its integration with existing and emerging data sources in global water system models. We focus on three knowledge sources that are currently underrepresented in global modelling approaches: non-statutory monitoring, citizen observations, and local knowledge.

We show how data science methods such as semantic data models, distributed workflows, and machine learning can be leveraged to develop novel knowledge integration pipelines. These pipelines explicitly represent data provenance and track epistemic and aleatoric uncertainties across heterogeneous data sources. When combined with flexible modelling frameworks, this approach provides a blueprint for next generation simulation systems that bridge global modelling and local decision-making. Such systems enable the identification, prioritization, and targeted reduction of local knowledge gaps, thereby enhancing the relevance and legitimacy of global water assessments for regional and community-level action.