Three Overarching Research Questions in Hydrologic Uncertainty

Scope: This document was developed by American Geophysical Union's (AGU's) Technical Committee on Hydrologic Uncertainty (www.hydrouncertainty.org) at the request of the AGU-Hydrology Section President in May-June 2018, to outline the three biggest research questions around hydrologic uncertainty.

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The Technical Committee (TC) on Hydrologic Uncertainty is transdisciplinary, as uncertainty is an intrinsic property of a wide range of modern hydrological sciences and beyond. Therefore, this TC is focused on bringing together research efforts that tackle uncertainty from various areas and promoting them at an overarching level. In particular, this TC addresses methodological issues to handle uncertainty in support of modelling (process understanding, forecasting, and prediction), and decision making (scenario analysis). Its big research questions have already had substantial attention, but still need substantial efforts to obtain widely accepted and sufficiently nuanced answers.

1) How to improve the credibility and computational efficiency of approaches and tools for characterizing uncertainty in both natural and engineered hydrologic processes?

The challenge for characterizing uncertainty in hydrologic systems is twofold. First, a core concern is adequate representation of what is known and unknown to enable effective reasoning about uncertainty. This becomes more complicated and sometimes intractable in the presence of 'deep' and 'epistemic' uncertainties, requiring frameworks for representing highly uncertain factors and unknown unknowns in human-water systems. Second, uncertainty in real-world problems typically has to be addressed numerically which can be computationally intensive, requiring highly efficient algorithms and software programs. Such problems are often high-dimensional, with a multitude of uncertain factors that need to be characterized. These challenges become further complicated when considering human interventions into natural systems and the resulting collective human-hydrologic behaviours. Therefore, the identification and characterization of dominant controls of uncertainty is key to advancements of hydrologic sciences, thereby reducing uncertainty.

2) How to reduce uncertainty in understanding, modelling, and predicting the future of coupled human-hydrologic systems?

Research towards reducing uncertainty, informed by efforts for characterization of uncertainty and its dominant controls, faces major challenges due to lack of adequate data and information in support of process understanding and modelling. More effective data-model integration is needed for improved data-informed model development (reducing uncertainty in model structure) and model-informed experimental design (obtaining more useful data). On this basis, development and implementation of more systematic strategies for data collection and unification that target the 'right' types of data on dominantly controlling variables of both natural and human-driven processes is essential. This should include identifying new and overlooked data sources (including citizen science) and integrating them across scales. Better data will improve the representation and incorporation of hydrologic and human-hydrologic processes and their feedback mechanisms into models, thereby reducing predictive uncertainty on the future of water resources that can more effectively support decision making.

3) How to better communicate about uncertainty in support of decision and policy making to best achieve societal objectives?

Uncertainty management in practice makes use of methods for characterization and reduction of uncertainty, but differs in approaches between different sub-disciplines of Earth sciences and different policy making contexts. Communication particularly needs work in mixed science-management-stakeholder setting. This would benefit from better integration of uncertainty measures in decision support software as well as better handling of deep uncertainties and epistemic uncertainty. It also requires greater awareness of the need to reconcile differences in the paradigms guiding uncertainty management in different contexts in science and practice. As such, proper communication and consideration of uncertainty is essential in helping us minimize regrets in decision making when the future deviates from the assumptions we typically hold about it.