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Extended Abstract

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SOURCING AND CHANNELLING INFORMATION FLOWS FOR HYDROLOGICAL PREDICTION

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1 The challenge of hydrological prediction

Hydrological engineering and science is tasked with providing predictions of the behaviour of various components of the hydrological cycle on various time scales. Since hydrological systems are vastly more complex than we could capture with the data we can normally collect, we are stuck in a situation of predicting from partial knowledge, and uncertainty is inevitable. Choices and trade-offs have to be constantly made between different options for monitoring network layouts (variables, locations, times, scales), as well as choices between model approaches and different model complexities (data-driven/physically based, lumped / distributed).

2 Theoretical framework: Information Theory

Information theory gives us a number of measures of information, which are based in probabilities. Due to the fundamental derivations from first principles (Shannon, 1948), these measures allow formulation of laws and principles that govern the flow of information as a fundamental measurable quantity, evaluated in “bits”. These measures, such as Shannon entropy, mutual information, relative entropy, and transfer entropy, allow us to look into contributions and interactions of various sources of information, without restricting assumptions on linearity of relations or Gaussianity of distributions. Diverse applications in hydrology have been pursued (Ruddell and Kumar, 2009; Alfonso et al, 2010; Nearing et al 2015).

3 The information-centered approach to hydrology and water resources management

In this presentation, we will give an overview of some recent work on the intersection of information theory and hydrology, done in the "hydro-info-theory" research group at UBC. The overarching aim of the research is to investigate approaches to increase the amount of useful information that our water management decisions are based on. Examples of elements that contribute to this aim are 1) better quantification of uncertainties (example on discharge); 2) sourcing hydrological information in more economic ways, that trade accuracy for spatial coverage (example on snow cover); 3) improving uptake of information into models by using an information-based approach to calibration and complexity control.

4 Discussion: The information-centered approach to hydrology and water resources management

We argue that elements 1 and 3, where the raw data (and thus its information content) is fixed, are questions of channeling information and should be lead by purely information-based and epistemic considerations, while element 2, which represents the choice of what information to collect, is a question of sourcing information, and should be guided by utility-based and economic considerations (Weijs et al, 2010).

5 Conclusion and Recommendations

Studying the dynamics of information in the process of learning from hydrological data can provide a useful avenue to inform choices that are essentially about optimizing the processing of the information in that data into predictions and decisions.

There are still many open questions surrounding the correct application of information theory to this field, which include dealing with numerical issues, false data, and translation of concepts and results from information theory in other fields to applications in engineering hydrology. Although many translations are possible, the challenge is to find those where the fundamental properties of information retain their significance and meaning in the application. Interdisciplinary exchange is key to advance these ideas.

References

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