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Probabilistic graphs as a conceptual and computational tool in hydrology and water management

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Originally developed in the fields of machine learning and artificial intelligence, probabilistic graphs constitute a general framework for modeling complex systems in the presence of uncertainty. The framework consists of three components:

1. Representation of the model as a graph (or network), with nodes depicting random variables in the model (e.g. parameters, states, etc), which are joined together by factors. Factors are local probabilistic or deterministic relations between subsets of variables, which, when multiplied together, yield the joint distribution over all variables.

2. Consistent use of probability theory for quantifying uncertainty, relying on basic rules of probability for assimilating data into the model and expressing unknown variables as a function of observations (via the posterior distribution).

3. Efficient, distributed approximation of the posterior distribution using general-purpose algorithms that exploit model structure encoded in the graph.

These attributes make probabilistic graphs potentially useful as a conceptual and computational tool in hydrology and water management (and beyond). Conceptually, they can provide a common framework for existing and new probabilistic modeling approaches (e.g. by drawing inspiration from other fields of application), while computationally they can make probabilistic inference feasible in larger hydrological models. The presentation explores, via examples, some of these benefits.