Behavioral Modeling: A New Theoretical Framework for Hydrological Predictions

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Abstract. Watersheds are dynamical systems that are maintained by coupled biotic and abiotic processes, constrained by their evolutionary history, as reflected in certain organizing principles, as well as shaped by the unique historical circumstances of a given place. We present a new theoretical framework called behavioral modeling not just to describe and to understand watershed behavior but also to make hydrologic predictions. The key to behavioral modeling is to acknowledge the existence of the most probable system behavior conditioned by system evolution and inferable (in a Bayesian sense) at different moments, places and scales based on organizing principles (as expressed in a likelihood function) and observed behavior. The relative importance of local uniqueness as compared to (possibly universal) organizing principle(s) ultimately governs predictability. Behavioral modeling presents a whole new language: behavior includes both system structure, and system response that is conditioned by structure, which in turn governs the evolution of structure. Structure refers to the spatial or temporal arrangement of mass and energy within the system, and response refers to changes in time and in space. Behavior is observed at given points of the time-space-scale domain. Part of system behavior is unobserved; prediction is really about making probabilistic statements about unobserved system behavior either explicitly, or implicitly (encoding of system behavior in hydrologic models) on the basis of observed behavior and the identified organizing principle(s). We will discuss candidates for useful organizing principles and how to identify them, provide an outline of the steps involved in implementing behavioral models, illustrating how they combine with, and complete, existing models. We finally discuss the benefits of behavioral modeling for hydrologic predictions and for the design of new observation networks.