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Behavioural modelling: a new theoretical framework for hydrological prediction

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Catchments 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 will present a new theoretical framework called behavioural modelling not just to describe and/or understand catchment behaviour but to also make hydrologic predictions. The key to behavioural modelling is to acknowledge the existence of the most probable system behaviour conditioned by system evolution and inferable (in a Bayesian sense) at different moments, places and scales based on organizing principles (the likelihood function) and observed behaviour. The relative importance of local uniqueness as compared to (possibly universal) organizing principle(s) ultimately governs predictability. Behavioural modelling presents a whole new language: behaviour includes both system structure, and system response that is conditioned by structure, which in turn conditions the evolution of structure. Structure refers to the spatial or temporal arrangement of mass and/or energy within the system, and response refers to changes in time and/or in space. Behaviour is observed at a given point of the time-space-scale domain. Part of system behaviour is unobserved; prediction is about making probabilistic statements about unobserved system behaviour either explicitly, or implicitly (encoding of system behaviour in hydrological models) on the basis of observed behaviour and the identified organizing principle(s). We will provide an outline of the steps involved in implementing behavioural models, illustrating how they combine with and complete existing models. We finally discuss the benefits of behavioural modelling for hydrological predictions and for the design of new observatories.