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Editorial

On the need for catchment classification

The rapid growth in our ability to generate new descriptions of catchment heterogeneity, using both experimental and modeling approaches, is now outstripping our ability to use the knowledge effectively in theory and practice. Studies in experimental catchments have identified the idiosyncrasies of many river basins, and produced very complex, yet highly qualitative descriptions of catchment behavior. However, the sporadic attempts to regionalize those studies have been of limited value, because of the difficulty in producing concise, easily understood explanations of different basin behaviors. In a similar way, the variety of simulation models has continued to grow as new data sources and computing resources have become available, and new processes have been included in models. Some models have very detailed representations of processes which are difficult to validate except in the most intensively instrumented sites, while other models are simpler and easier to parameterize, but harder to validate against observations at the appropriate spatial scale. No clear guidance is available on which model or model structure is appropriate to any particular catchment type or management question. As a result, model structures often seem to be ad hoc. Similarly, no clear guidance is available on which dominant processes and mechanisms are operating in a given catchment type. As a result, the way that we instrument catchments and seek process understanding often also seems to be ad hoc.

We suggest that the underlying cause of many of our problems in catchment hydrology is the tremendous variability in space, time and process, which is present in natural hydrological systems all around the globe. It is enormously ambitious for a science as relatively young as hydrology to expect to understand so many levels of complexity in so many locations. Although it is well known that hydrological processes vary widely from one environment to the next, the science community has not developed an organized way of acknowledging and responding to that challenge. Hydrological science has successfully used both the hydrological cycle and the principle of mass conservation to provide unifying concepts that apply to any system, but these do not provide sufficient information on the partitioning of water among pathways, the relative importance of difference water storages, nor of the timescales of response of hydrological systems to discriminate among alternative possibilities. All of these properties are fundamental to our understanding.

One widely-used rational strategy for studying diverse systems in other disciplines is to use a globally agreed-upon broad-scale classification. Classification of phenomena is a standard first step in the process of scientific analysis and synthesis. Chemistry uses the periodic table to group together those elements which have similar chemical properties. In more complex, less well-behaved systems like biology, for example, the hierarchical Linnaean system of Species/Genus/Order/Class is used to classify organisms. Closer to hydrology, fluid mechanics uses the distinction between laminar and turbulent flow to distinguish fundamentally different flow regimes; limnologists classify lakes to distinguish different turnover rates or trophic status. While each class still contains tremendous internal complexity, classification groups together those systems that are similar, and thus limits the variability within classes.

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While not a panacea, classification may be a first step and one way to come at the challenges that catchment hydrology faces. It is a means to identify which might be the most important controls on water fluxes and pathways from the full range of processes and mechanisms present on the globe. At its most fundamental level, a classification scheme will need to have axes that describe fluxes, storages and response times, in order to provide broad and meaningful distinctions between catchments. Possible metrics might include: (i) a measure of climate dryness such as ratio of average annual potential evaporation to rainfall; (ii) the state in which water is predominantly stored: either frozen (snow and glaciers), or pore water (in soils, and rocks), or open water (lakes, wetlands, river channels); (iii) the response time of the dominant catchment storage (volume of storage which has the largest flux, divided by the flux).

Whatever form that it ultimately takes, a globally-agreed, broad-scale catchment hydrology classification system would provide an important organizing principle, complementing the concept of the hydrological cycle and the principle of mass conservation. It would help with both modeling and experimental approaches to hydrology, by providing guidance on the similarities and differences between basins, including locations for which only minimal data is available to characterize the site. A commonly-agreed classification would improve communication by providing a common language for regional, national and international discussions. It would also allow the rational testing of hypotheses about the similarity of hydrological systems from around the globe, as well as better design of experimental and monitoring networks, and better guidance in choosing appropriate models for poorly understood hydrological systems. In particular, classification would enable us to sort and group the tremendous variability in space, time and process, which is present in natural hydrological systems all around the globe.

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