Towards an Objective Model of Catchment Hydrology

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The internal structure of catchment hydrologic models remains one of the most subjective elements of coupled hydrologic and biogeochemical models, despite the recognized sensitivity of model predictions to the chosen structure. Hillslope hydrologic studies indicate the high degree of complexity in transport processes at this spatial scale (e.g., variably saturated media, macropore-dominated transport). How can the complexities observed at the hillslope scale be translated into a general catchment model with modest data requirements, yet retain structure that is defined objectively by data? Observations from a hillslope trench study at Panola Mountain Research Watershed (GA, USA) suggest that residence time of water within a landscape unit may be the single most important physical characteristic determining the observed chemistry. We contrast the chemistry of the saturated zone in the hillslope with stream chemistry at various basin scales in three catchments across a range of residence times. Stream chemistry at the catchment with the shortest residence time is most similar to the hillslope chemistry, suggesting that a simple model structure, with few reservoirs, may be appropriate at this site. By contrast, at the site with the longest residence time, the greatest difference is observed between stream and hillslope chemistry, suggesting that more reservoirs are needed to model the catchment. The organizing principle in designing the structure of coupled hydrologic and biogeochemical models is to choose reservoir size that matches residence time with the rate of kinetically constrained biogeochemical reactions.

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