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Flowpath acceleration vs flowpath activation: how do hydrologic systems respond to dynamic inputs and changes in storage?

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The response of catchments to rainfall or snowmelt can be understood in terms of the propagation and dissipation of a wave of fluid energy, and in terms of the translation of fluid parcels in space. The first determines the amount of flow in a stream, and the second determines the age composition of that streamflow. However, these are not distinct phenomena, but two aspects of the integrated catchment scale hydrologic response.

Previous work has shown that catchment storage is the dominant state variable controlling both the magnitude of the flow response and the age composition of that flow response. Here, I will present a succinct framework that unifies the flow and transport properties of a watershed, and their relationship to storage. This framework further extends rank StorAge Selection (rSAS) function theory.

The framework suggests that the hydrologic response of a watershed to inputs can be understood to consist of two modalities: flowpath acceleration and flowpath activation. In the first case, additional potential energy drives an acceleration of flowpaths, so that water of all ages moves more quickly toward the catchment outlet. In the second case, the additional new water moves toward the outlet along newly-activated flow paths without modifying the velocity of water previously in the watershed. Real hydrologic systems may exhibit some combination of both modalities across their age-ranked storage.

The proposed framework allows the dominant modalities of a given hydrologic system to be explored with few a priori assumptions. Data from several hydrologic systems will be used to demonstrate the method, and gain insights into the sensitivity of catchment flow and transport in variable climatic conditions.