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Defining hydrological connectivity from a position of knowledge: A particle tracking experiment on contrasting hillslopes

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Looking at terrestrial-aquatic interactions through the lens of hydrological connectivity can be of value for understanding and managing human impact on surface water quality. Connectivity has proven itself a versatile basis for conceptualizing controls on runoff generation and water quality. Diverse as the literature is however, much of it takes a binary approach to connectivity: What is, or is not connected to the stream at any point in time. This may be sufficient for some purposes but it can also miss much of the spatial and temporal variation in the phenomenon of connectivity. To use connectivity, or any other simplification of a complex phenomenon to try to build up an understanding of systems can risk curtailing rather than furthering discussion. The concept of connectivity becomes more useful the better we know the system we are applying it to. That allows us to define what it is we want to classify from a position of knowledge, rather than from ignorance. Models have the power to provide this by going beyond our understanding of specific details that can be observed at discrete locations, such as a water table, or the concentration of a tracer, to a complete description of the hydrological system that maintains conservation of energy and mass. Although the model may not be correct, it can help in characterizing the phenomenon of connectivity and suggest better ways to test key hypotheses. In this presentation we use a semi-analytical model representation that tracks water particles as a basis for discussing what could be meant by terrestrial-stream connectivity and the search for appropriate metrics that describe connectivity. The model defines the daily hydrological response to 30 years of precipitation on an instrumented hillslope. Two different representations of the hillslope were made that differ only in their vertical profile of the saturated hydrological conductivity (Ks). In one case this is homogeneous, in the other case Ks changes with depth. Even though the two representations reproduce the stream flow and water table dynamics similarly well, the patterns of water flow pathways, velocities and residence times are markedly different. This provides a background for defining metrics of connectivity that can capture these differences. Compilations of the catchment transit time distribution of streamwater each day provided less information about connectivity than the residence time distribution of water in the hillslope. We argue that spatially distributed time-scales of transit time and velocity are appropriate indices for defining terrestrial-stream connectivity in this system. Such metrics can stimulate both theory building and guide further field investigations.