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The perceptual trap: Experimental and modelling examples of soil moisture, hydraulic conductivity and response units in complex subsurface settings.

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In order to discuss hypothesis testing in hydrology, the question of the solid foundation of such tests has to be answered. But how certain are we about our measurements of the components of the water balance and the states and dynamics of the complex systems? What implicit assumptions or bias are already embedded in our perception of the processes? How can we find light in the darkness of heterogeneity? We will contribute examples from experimental findings, modelling approaches and landscape analysis to the discussion.

Example soil moisture and the soil continuum: The definition of soil moisture as fraction of water in the porous medium assumes locally well-mixed conditions. Moreover, a unique relation of soil water retention presumes instant local thermodynamic equilibrium in the pore water arrangement. We will show findings from soil moisture responses to precipitation events, from irrigation experiments, and from a model study of initial infiltration velocities. The results highlight, that the implicit assumption relating soil moisture state dynamics with actual soil water flow is biased towards the slow end of the actual velocity distribution and rather blind for preferential flow acting in a very small proportion of the pore space.
Moreover, we highlight the assumption of a well-defined continuum during the extrapolation of point-scale measurements and why spatially and temporally continuous observation techniques of soil water states are essential for advancing our understanding and development of subsurface process theories.

Example hydraulic conductivity: Hydraulic conductivity lies at the heart of hydrological research and modelling. Its values can range across several orders of magnitude at a single site alone. Yet, we often consider it a crisp, effective parameter. We have conducted measurements of soil hydraulic conductivity in the lab and in the field. Moreover, we assessed infiltration capacity and conducted plot-scale irrigation experiments to analyse the apparent vertical soil water velocity for different soils and different measurement techniques. The results give rise to questions about the universality of the Darcy-scale assumptions and a scale-invariant assessment of hydraulic conductivity.

Example surface characteristics and subsurface processes: Hydrological models require the identification of some sort of response units based on available data. For this purpose many approaches relating surface properties to hydrological function have been developed. To test the coherence of surface characteristics and subsurface processes we contrasted in situ measurements, pedo-physical analyses of soil samples, an examination of the flow regimes and an investigation of GIS and remote sensing data. Our results show that landscape features and process characteristics do not necessarily align. Landscape classes and pedo-physical property means are not sufficient to define hydrologically functional units.