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Pushing the basins and squeezing the models

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In hydrology we have to deal with a multitude of processes, scales and unknowns. Most studies rely on past observations at gauges and point measurements. Some use singular experiments to test the hillslope or catchment reaction to forcing. To extend beyond that, we mostly need to rely on models.
At the same time these models have often been developed as engineering tools with given degrees of freedom and limited capabilities for self-organisation. Both aspects raise questions about getting trapped in circular reasoning, recovery of assumptions or ambiguity.

The future in water sciences could approach these known challenges in a more rigorous manner along the following alleys:
1. Experimental hypothesis testing needs to extend beyond monitoring of natural conditions at the plot and hillslope scale.
2. Complementary experimental setups can test the validity of methodological assumption of one observation technique through an other to reduce ambiguity.
3. A new generation of models which are capable for self-controlled process interaction and hypothesis testing.

To outline the possibilities of these paths we will present some preliminary examples for each aspect:
1. We conducted a hillslope scale sprinkler experiment with a sharp divide of the sprinkled area. It was accompanied by GPR (Ground Penetrating Radar) induced trenches for spatial and temporal recovery of rapid flow paths. Using this approach allows to test many hypotheses in situ.
2. We present findings from multi-tracer and 3D time-lapse GPR experiments at the plot scale. Here we highlight how the different methods deliver contradictory conclusions about the processes and how the combination may reduce uncertainty.
3. In addition we point out results from our echoRD model (eco-hydrological particle model based on representative structured domains) which treats water itself as particles on the plot scale. Special emphasis will be given on tests with different representations and parameterisations of macropore-matrix interaction related to the previous experiments.