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From groundwater to soil moisture to transpiration: do stable landscape patterns exist and when do they break down?

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Hydrological science still struggles with the fact that while we wish for spatially continuous images or movies of state variables and fluxes at the landscape scale, most of our direct measurements are point measurements. To date regional measurements resolving landscape scale patterns can only be obtained by remote sensing methods, with the common drawback that they remain near the earth surface and that temporal resolution is generally low. However, distributed monitoring networks at the landscape scale provide the opportunity for detailed and time-continuous pattern exploration. Even though measurements are spatially discontinuous, the large number of sampling points and experimental setups specifically designed for the purpose of landscape pattern investigation open up new avenues of regional hydrological analyses.

The CAOS hydrological observatory in Luxembourg offers a unique setup to investigate questions of temporal stability, pattern evolution and persistence of certain states. The experimental setup consists of 45 sensor clusters. These sensor clusters cover three different geologies, two land use classes, five different landscape positions, and contrasting aspects. At each of these sensor clusters three soil moisture/soil temperature profiles, basic climate variables, sapflow, shallow groundwater, and stream water levels were measured continuously for the past 4 years.

We focus on characteristic landscape patterns of various hydrological state variables and fluxes, studying their temporal stability on the one hand and the dependence of patterns on hydrological states on the other hand (e.g. wet vs dry). This is extended to time-continuous pattern analysis based on time series of spatial rank correlation coefficients. Analyses focus on the absolute values of soil moisture, soil temperature, groundwater levels and sapflow, but also investigate the spatial pattern of the daily changes of these variables. The analysis aims at identifying hydrologic signatures of the processes or landscape characteristics acting as major controls. While groundwater, soil water and transpiration are closely linked by the water cycle, they are controlled by different processes and we expect this to be reflected in interlinked but not necessarily congruent patterns and responses.