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Static sampling of dynamic processes – a paradox?

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Environmental systems monitoring aims at its core at the detection of spatio-temporal patterns of processes and system states, which is a pre-requisite for understanding and explaining their baffling heterogeneity. Most observation networks rely on distributed point sampling of states and fluxes of interest, which is combined with proxy-variables from either remote sensing or near surface geophysics. The cardinal question on the appropriate experimental design of such a monitoring network has up to now been answered in many different ways. Suggested approaches range from sampling in a dense regular grid using for the so-called green machine, transects along typical catenas, clustering of several observations sensors in presumed functional units or HRUs, arrangements of those cluster along presumed lateral flow paths to last not least a nested, randomized stratified arrangement of sensors or samples. Common to all these approaches is that they provide a rather static spatial sampling, while state variables and their spatial covariance structure dynamically change in time. It is hence of key interest how much of our still incomplete understanding stems from inappropriate sampling and how much needs to be attributed to an inappropriate analysis of spatial data sets.

We suggest that it is much more promising to analyze the spatial variability of processes, for instance changes in soil moisture values, than to investigate the spatial variability of soil moisture states themselves. This is because wetting of the soil, reflected in a soil moisture increase, is causes by a totally different meteorological driver – rainfall - than drying of the soil. We hence propose that the rising and the falling limbs of soil moisture time series belong essentially to different ensembles, as they are influenced by different drivers. Positive and negative temporal changes in soil moisture need, hence, to be analyzed separately. We test this idea using the CAOS data set as a benchmark. Specifically, we expect the covariance structure of the positive temporal changes of soil moisture to be dominated by the spatial structure of rain- and through-fall and saturated hydraulic conductivity. The covariance in temporarily decreasing soil moisture during radiation driven conditions is expect to be dominated by the spatial structure of retention properties and plant transpiration. An analysis of soil moisture changes has furthermore the advantage that those are free from systematic measurement errors.