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A new perspective on the spatio-temporal variability of soil moisture

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One of the key components controlling both the water and energy balance, is soil moisture. The characterization of its spatio-temporal variability is crucial to understand and predict processes in climate science and hydrology. A number of studies characterized the spatial variability and the rank stability (also called temporal stability) of the absolute soil moisture within a given network. These studies were generally based on short-term measurement campaigns and did not distinguish between the time invariant and time varying contributors of the absolute soil moisture. In the current study (Mittelbach and Seneviratne, 2012), we investigate this issue using measurements from 14 grassland sites of the SwissSMEX soil moisture network over a spatial extent of about 150x210 km and for the time period May 2010 to July 2011. The spatial variance of the absolute column soil moisture (integrated over 50 cm) is thereby decomposed over time in contributions from the spatial variance of the mean soil moisture at all sites (which is time invariant), and components that are related to soil moisture dynamics (which are time varying). These include the spatial variance of the temporal soil moisture anomalies at all sites and the covariance between the sites' anomalies to the spatial mean at a given time step and those for the temporal mean values.
The analysis illustrates that the spatial variance of the time invariant term contributes 50-160% of the overall spatial soil moisture variance at any point in time. On the other hand the spatial variance of the temporal anomalies, which is most relevant for climate and hydrological applications as it is directly related to the soil moisture dynamics, contributes at most 2-30% to the overall variance. This result suggests that a large fraction of the spatial variability of soil moisture assessed from short-term campaigns is time invariant and that the rank (or "temporal") stability concept when applied to absolute soil moisture, mostly characterizes the time-invariant patterns. Indeed, sites that best represent the mean soil moisture dynamics of the network are not the same as those that best reflect mean soil moisture at any point in time. Overall this study indicates that conclusions derived from the analysis of the spatio-temporal variability of absolute soil moisture do not necessary apply to temporal soil moisture anomalies, and hence to soil moisture dynamics.

Reference:
Mittelbach, H. and S.I. Seneviratne, 2012: A new perspective on the spatio-temporal variability of soil moisture: Temporal dynamics versus time invariant contributions. Submitted to HESS.