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# Analysis of soil moisture patterns in arable land and grassland using Empirical Orthogonal Functions

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Soil moisture is one of the fundamental variables in hydrology, meteorology and agriculture. Nevertheless, its spatio-temporal patterns in agriculturally used landscapes affected by multiple natural (rainfall, soil, topography etc.) and agronomic (fertilisation, soil management etc.) factors is often not well known. The aim of this study is to determine the dominant factors governing the spatio-temporal patterns of surface soil moisture in a grassland and an arable land test site.

One test site represents a typical grassland area (32 ha) within a low mountain range of Western Germany, the other an intensively used agricultural area (41 ha), where crops are grown on slight slopes. Surface soil moisture (0-5 cm) has been measured in a 50 x 50 m grid at 14 and 16 dates (May 2007 to November 2008) in both test sites, respectively. Moreover, soil moisture in two depths (10 and 30 cm) in up to seven locations and meteorological and water flux data have been measured. To analyse spatio-temporal patterns of surface soil moisture an Empirical Orthogonal Function (EOF) analysis was applied, decomposing the measured data into a series of time-invariant spatial patterns (EOFs) and associated, temporal varying coefficients (ECs). The EOFs and ECs were later on correlated with parameters derived from topography, soil, vegetation, land management and meteorology.

For the grassland test site the analysis results in one significant spatial structure (first EOF), which explains about 57.5% of the spatial variability and has a highly significant correlation with the existence of an impermeable soil layer and topography. The effect (or weight) of the first spatial EOF is stronger on wet days, because the associated EC is positively correlated to the average spatial soil moisture. For the arable land test site it is more difficult to interpret the EOF results, because of the increase of temporally uncorrelated spatial patterns (e.g. crop rotation). However, the analysis yields two significant spatial structures, the first EOF, explaining 37.5% of the spatial variability, has a highly significant correlation to soil properties (coarse alluvial deposits). The second EOF explaining 25.4% of the spatial variability slightly correlates to differences in land management.

In general, the EOF analysis combined with information regarding topography, soils, vegetation, meteorology and land management appears to be a suitable, objective method to identify the dominant drivers of spatio-temporal patterns in soil moisture data sets.