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Geostatistical and Fractal Characteristics of Soil Moisture Patterns from Plot to Catchment Scale Datasets

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Soil moisture and its spatio-temporal pattern is a key variable in hydrology, meteorology and agriculture. The aim of the current study is to analyze spatio-temporal soil moisture patterns of 9 datasets from the Rur catchment (Western Germany) with a total area of 2364 km^2, consisting of a low mountain range (forest and grassland) and a loess plain dominated by arable land. Data was acquired across a variety of land use types, on different spatial scales (plot to mesoscale catchment) and with different methods (field measurements, remote sensing, and modelling). All datasets were analyzed using the same methodology.

In a geostatistical analysis sill and range of the theoretical variogram were inferred. Based on this analysis, three groups of datasets with similar characteristics in the autocorrelation structure were identified: (i) modelled and measured datasets from a forest sub-catchment (influenced by soil properties and topography), (ii) remotely sensed datasets from the cropped part of the total catchment (influenced by the land-use structure of the cropped area), and (iii) modelled datasets from the cropped part of the Rur catchment (influenced by large scale variability of soil properties).

A fractal analysis revealed that soil moisture patterns of all datasets show a multi-fractal behavior (varying fractal dimensions, patterns are only self-similar over certain ranges of scales), with at least one scale break and generally high fractal dimensions (high spatial variability). Corresponding scale breaks were found in various datasets and the factors explaining these scale breaks are consistent with the findings of the geostatistical analysis.

The joined analysis of the different datasets showed that small differences in soil moisture dynamics, especially at maximum porosity and wilting point in the soils, can have a large influence on the soil moisture patterns and their autocorrelation structure.