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The impact of connectivity on the modelling of water and nutrient fluxes within semi-arid environments

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The parameterisation of grid-based, physically-based hydrological and nutrient-transport models is a complex task in semi-arid and arid shrubland environments. These environments are commonly characterised by very heterogeneous spatial distributions of soil- and vegetation- related properties, which are highly sensitive model parameters. The objective of this study was the incorporation of the spatial variability of model input parameters and of their intrinsic connectivity under specific consideration of parameter scaling issues. It was hypothesised that if the spatial distribution and connectivity patterns of model parameters are preserved and thus the modelling scale corresponds to the observation scale of the field data, and the process descriptions are correct, then the model outcome should be accurate and acceptable.

This modelling study used the outcome of an extensive field campaign to derive the spatial distribution of sensitive model input parameters. For this purpose, various scaling tools for interpolation and extrapolation were employed to develop four parameterisation approaches for the numerical models with a very fine grid resolution of two metres and a spatial extent of the model domain of circa 0.2 km2. The various parameterisation approaches differed in their degree and detail of spatial parameter representation - and thus connectivity - and were based on the statistical and geostatistical properties of the field data and surrogate patterns derived from remotely sensed data and from Gaussian stochastic simulation procedures to incorporate patterns of parameter values. The ability of the parameterisation approaches to reproduce connected features within the spatial representation of model parameters was qualitatively assessed by using a leakiness index. This leakiness index describes how well

a landscape functions to retain or leak runoff and soil resources in the direction of dominant flow down the hillslope.

The applicability of the various parameterisation approaches were tested by comparing simulated with observed discharge data at various points within small shrubland catchments in the Jornada Basin, New Mexico. The outcome of the study was that connectivity (in the form of connected patterns of parameter values) plays a fundamental role in the parameterisation and the modelling of water and nutrient fluxes within semi-arid catchments. The modelling study enabled to relate a large leakiness index directly to the performance of the models: the larger the represented degree of connected features, the better the model performance. In contrast, the parameterisation approaches that did not contain connected patterns of parameter values performed very poorly.