Geophysical Research Abstracts
Vol. 14, EGU2012-2767, 2012
EGU General Assembly 2012

A metrics for soil hydrological processes and their intrinsic dimensionality in heterogeneous systems

G. Lischeid, T. Hohenbrink, and U. Schindler

Leibniz Centre for Agricultural Landscape Research, Institute of Landscape Hydrology, Müncheberg, Germany
(lischeid@zalf.de, +49-33432-82300)

Hydrology is based on the observation that catchments process input signals, e.g., precipitation, in a highly deterministic way. Thus, the Darcy or the Richards equation can be applied to model water fluxes in the saturated or vadose zone, respectively. Soils and aquifers usually exhibit substantial spatial heterogeneities at different scales that can, in principle, be represented by corresponding parameterisations of the models. In practice, however, data are hardly available at the required spatial resolution, and accounting for observed heterogeneities of soil and aquifer structure renders models very time and CPU consuming.

We hypothesize that the intrinsic dimensionality of soil hydrological processes, which is induced by spatial heterogeneities, actually is very low and that soil hydrological processes in heterogeneous soils follow approximately the same trajectory. That means, the way how the soil transforms any hydrological input signals is the same for different soil textures and structures. Different soils differ only with respect to the extent of transformation of input signals.
In a first step, we analysed the output of a soil hydrological model, based on the Richards equation, for homogeneous soils down to 5 m depth for different soil textures. A matrix of time series of soil matrix potential and soil water content at 10 cm depth intervals was set up. The intrinsic dimensionality of that matrix was assessed using the Correlation Dimension and a non-linear principal component approach. The latter provided a metrics for the extent of transformation (”damping”) of the input signal. In a second step, model outputs for heterogeneous soils were analysed. In a last step, the same approaches were applied to 55 time series of observed soil water content from 15 sites and different depths.

In all cases, the intrinsic dimensionality in fact was very close to unity, confirming our hypothesis. The metrics provided a very efficient tool to quantify the observed behaviour, depending on depth and soil heterogeneity: Different soils differed primarily with respect to the extent of damping per depth interval rather than to the kind of damping. We will show how that metrics can be used in a very efficient way for representing soil heterogeneities in simulation models.