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An innovative experimental design reveals the spatial correlation between landuse, irrigation properties, and bromide leaching

A. Schwen (1), Y. Yang (2), J. Walton (2), and O. Wendroth (2)

(1) Institute of Hydraulics and Rural Water Management, BOKU University Vienna, Austria (andreas.schwen@boku.ac.at),
(2) Department of Plant & Soil Sciences, University of Kentucky, Lexington/KY, USA

Understanding the relationship between leaching of pesticides and soil hydraulic properties under different land use conditions is critical to our understanding of the flow of water and solutes in soils and efforts to model these flow characteristics. One problem inherent in the measurement of solute leaching in field experiments is the considerable high natural spatial variability of flow-controlling soil properties. Thus, analyzing treatment effects based on the mean and the variance of observations can become obsolete if there is a huge inherent variance in the set of measurements. Moreover, no spatial range of influence can be derived from the observations.
To overcome this limitation, the spatial covariance and cross-variance between measurements was used as decision and quality criteria in the present study. This study aims to demonstrate that focussing on the spatial covariance of observations and considering their spatial process can provide a measure of spatial representativity or scale-specific variance.
We introduce a novel experimental scheme, where the treatments are arranged in a scale-dependent manner. In a field trial in Lexington, Kentucky, bromide leaching under two contrasting land use systems (no-till agricultural crops vs. pasture) was compared. After surface application of tracer solution (KBr), the experimental field was irrigated using different time-delays (1, 4 and 24 hours) as well as two different irrigation amounts and two different intensities. At the end, the KBr-concentration in the soil profile was determined using auger samplings. The data was correlated with the applied boundary conditions by spatial statistical methods such as semivariograms, cross-semivariograms and spectral analysis.
Our results show distinct differences in the leaching behaviour between the two analyzed land uses with an deeper infiltration in the no-till agricultural field. This can be partly related to a higher initial soil water content in this treatment. Besides, the effects of different irrigation amounts and intensities can be clearly seen in the leaching pattern. The bromide leaching-depth coincided positively with the amount of water applied and negatively with the rainfall intensity. A larger delay between tracer application and subsequent irrigation resulted in smaller infiltration depths. This may be due to exchange processes between the soil's intra-aggregate pores and coarser interaggregate pores contributing to a delayed appearance of bromide in tile drainage water.
The main outcome of this study is that different treatments could be applied at different scales and their impact was manifested in the variance behavior of leaching depth that showed common scales with treatments. Our result has strong implications not only for agricultural management experiments but also for large-scale hydrological and transport studies in landscapes and watersheds.