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In-situ imaging of fluorescent tracer distributions in soils: Consideration of soil reflectance properties
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Abstract (590 words):
Properties of soils vary over fairly small distances. These small-scale heterogeneities can be of central importance for solute transport. A common procedure to asses the transport properties of a field soil consists in the application of a solute tracer followed by the sampling of the tracer along a vertical soil profile. The determination of the spatial tracer distribution can either be performed by soil coring and chemical extraction of the tracer or by analyzing the soil water collected by suction cups installed in the soil profile. The spatial resolution achieved by these methods however is insufficient to gain information on the transport mechanism of so-called preferential flow. In order to visualize solute flow paths on a small scale dye tracers can be used. Based on image analysis a semi-quantitative description of flow patterns can be obtained from color photos of the soil profile under investigation. Although valuable information are gained by this method it is limited to the application of only one dye tracer to the same soil at the same time. Once the soil profile is prepared no reference experiment with a second tracer, which differs from the first one, e.g., by its sorption properties, can be performed for exactly the same location.
In order to circumvent this disadvantage AEBY [1] recently developed a detection device and evaluation procedure for the simultaneous in-situ imaging of different fluorescent tracers on soil profiles. The device is based on a high-power xenon lamp (1 kW) for fluorescence excitation and a cooled CCD-camera system (1242 x 1152 pixel, 16-bit digitization) for fluorescence detection. Wavelength selection is accomplished by the use of optical filters. As fluorescent tracers brilliant sulfaflavine (BF), sulphorhodamine B (SB) and oxazine 170 (OX) were selected because of their favorable spectroscopic properties and their differing sorption characteristics. Within first field site and different laboratory experiments the capabilities of the in-situ fluorescence imaging technique have been impressively demonstrated.
In the present paper ongoing experiments using and improving the in-situ fluorescence imaging device as well as the evaluation procedure of the measured digital fluorescence images will be presented. So far the main interest was focused on getting a concentration map of the fluorescence tracer on the soil profile. In order to relate measured fluorescence intensities to tracer concentrations the optical properties of the soil surface have to be taken into account. In the context of remote sensing soil reflectance in the visible and near-infrared regions of the electromagnetic spectrum is used for soil characterization, classification and mapping.[2,3] Correlation of the soil reflectance signals measured in certain wavelength regions with, e.g., organic matter content, particle size, mineral composition, water content etc.[4] but also texture is one of the major goals. These parameters are likely to control the transport of solutes in soils. We therefore will improve our experimental setup with respect to the measurement of soil reflectances. Using the additional information we hope to get further insight into the mechanism of solute transport in soils. It is planned to test the approach at the hand of laboratory (preparation of model soil surfaces) but also field measurements.

[1] P. Aeby, Quantitative fluorescence imaging of tracer distributions in soil profiles, Ph.D. thesis, Swiss Federal Institute of Technologie ETH Zürich, Diss. ETH No. 12951 (1998).
[2] M.A. Mulders, Remote sensing in soil science, Developments in Soil Science 15, Elsevier, Amsterdam (1987).
[3] Theory and applications of optical remote sensing, G. Asrar (ed.), John Wiley & Sons, New York (1989).
[4] M.F. Baumgardner, L.F.Silva, L.L. Biehl, E.R. Stoner, Reflectance properties of soils, Advances in Agronomy, 38, 1-44 (1985).