Virtual soils: Identification of effective flow processes and properties using inverse modelling

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Introduction

Spatial heterogeneity of soil hydraulic properties within a field determines both the average hydraulic behaviour of the system and the variability of local observations. To analyse the influence of realistic structures in natural soils, the interdisciplinary research group INVEST performed water flow simulations in complex two- and three-dimensional virtual realities representing cultivated soils with spatial heterogeneity on multiple scales (Schlüter et al., 2012, Vadose Zone J.). From these simulations datasets of internal state variables mimicking real field measurements are used to analyse the influence of the soil structures on the variability of measurements and its consequences for the assessment of the water budget of a soil.

Questions

- How do within-field structures affect measurements of state variables water content and matric head?
- How do effective hydraulic properties estimated by inverse modelling depend on measurement location?
- Can the soil water budget of the 2D virtual realities be predicted with 1D effective hydraulic properties?

Virtual Soils

- 2D profiles representing cultivated soils in a typical moraine landscape, exhibiting heterogeneities on multiple scales
  - Geological facies:
    - Silt above sandy soil matrix with loam lenses
  - Tillage induced features:
    - Plow horizon
    - Seed bed
    - Dense plow pan
  - Soil compaction below tractor ruts
- Three soils with increasing complexity, consisting of 5 to 10 soil horizons

Effective 1D Simulation

Matric heads and volumetric water contents at the five observation depths obtained from soil B during the 2. cycle. Data points and fitted curves for 24 replications.

Soil Hydraulic Properties

Water retention and hydraulic conductivity curves estimated from the 24 replications of the whole 2. cycle for the three different soils. 24 replications, their range, and their arithmetic average. White space denotes the range, in which information from the measurements is given.

Effects on Soil Water Budget

Histograms of cumulative boundary fluxes during 2. cycle predicted with 1D simulations using the soil hydraulic properties estimated from the infiltration/redistribution phase of 2. cycle and the whole 2. cycle for the three different soils profiles. 24 replications in each case.

Conclusions

- Measurements differ considerably, depending on the horizontal position of the observation points.
- Estimated soil hydraulic properties strongly depend on the position of the observations.
- True soil water budget of the structured soil can on average be reproduced with effective soil hydraulic properties.
- Predicted soil water budget is strongly affected by the variability of the estimated soil hydraulic properties.

References and Acknowledgements


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