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Influence of microscopic heterogeneities on static and dynamic hydraulic properties

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Soil hydraulic properties can be estimated using multi-step-outflow experiments (MSO) in combination with inverse modeling. One assumption implied, is that the sample is large enough to contain all microscopic heterogeneities in the sense of a representative elementary volume (REV). Hence, the measured properties are considered as 'effective' properties.
Through numerical simulation we studied the influence of microscopic heterogeneities on the parameter estimation. A two-dimensional heterogenous medium was generated as a standard gaussian field. The spatial distribution of hydraulic properties inside the medium was generated using Miller-similarity with prescribed mean properties.
Using Richards equation, we simulated a typical mso-experiment with small pressure steps. It can be well described by effective properties based on a classical van Genuchten/Mualem parameterization. However, the effective properties deviate considerably from the mean properties at the microscopic scale. We conclude, that Miller-scaling cannot be used to model heterogeneities at a smaller scale compared to the scale at which the properties are actually known. It may be applied, however, to model heterogeneities at a large scale. With respect to the effective hydraulic conductivity function, we demonstrate the sensitivity of the tortuosity parameter for the topology of the micro-structure. To investigate dynamic effects we increased the pressure steps and simulated a two-step outflow experiment within the same heterogeneous medium and the same pressure range. The simulated outflow dynamics was compared to the prediction based on the effective properties obtained from the mso-experiment. The significant deviations demonstrate that dynamic effects are produced by the microscopic structure of hydraulic properties in addition to those ascribed to pore scale processes.