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Influence of soil structure on unsaturated water flow including root uptake

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The development of effective irrigation strategies is of great importance as the scarcity of water during extended dry periods in aride areas leads to limited water uptake by roots and thus to restricted growth and eventually to wilting of plants. To approach this goal a broad understanding of the factors which influence the distribution of the water potential and the interactions with root uptake is crucial. Soil structure is supposed to have a large impact on water flow especially under dry conditions when the variability of soil parameters is increased. For field applications, predictions of the water flow are needed for large scales where the scarcity of measurements leads to a high level of uncertainty about the detailed distribution of soil parameters. Thus stochastic methods in which heterogeneity of soil is described by a random parameter field are used.

In this presentation, the interrelation of root uptake and heterogeneity is analyzed using numerical simulations. Random parameter fields with Gaussian and non-Gaussian dependence were parameterized according to the Las Cruces Trench Site dataset and used as input for the numerical model. Transpiration is considered in a macroscopic way as a sink term with a prescribed potential extraction rate at each node, determined by the density distribution of the plants and with restricted uptake due to unfavorable conditions as lack of water and oxygen (modeled according to the Feddes - Function).

With this basic model, water flow in two dimensional random fields has been investigated under dry conditions. It was observed that dry spots - regions in which roots dry up to the wilting point form when the structure shows isolated high extreme values in conductivity. In these dry regions, roots take up a decreased amount of water such that the total potential demand is not met anymore. This seems rather unrealistic as sufficient water is available at other locations of the domain. Thus two other approaches are analyzed in comparison to the basic model where additionally optimizing mechanisms as preferential uptake in wet domains or redistribution of stressed conditions to unstressed regions are included. With this setup the influence on the hydraulic variables and total root uptake term is investigated in order to gain a deeper understanding of the joint effect of soil structure and root uptake using the example of the Las Cruces Trench Site dataset.