Geophysical Research Abstracts
Vol. 21, EGU2019-1643, 2019
EGU General Assembly 2019

Investigation of the effect of Loess Soil Vertical Heterogeneity on Estimation of Unsaturated Water Flow and Chloride and Nitrate transport

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There is an increasing trend in applying the Richards equation and the advection-dispersion equation (ADE) for regional studies of groundwater recharge and vadose zone nitrate transport. These equations require detailed knowledge of the soil hydraulic properties (SHP) and their spatial distribution. While the horizontal spatial variability of the SHP is considered in most studies to some degree, the vertical heterogeneity is often neglected. Deep soil profiles may display significant variation in soil texture that might affect estimated fluxes, however, including multiple layers in the model domain, at the regional scale, is challenging. Previously, regional groundwater recharge and nitrate fluxes for the Loess Plateau of China (LPC) were investigated by implementing the Richards equation and the ADE using a multiple 1D column approach. This model exploits an extensive database of soil properties derived from recent intensive soil profile sampling over the LPC, together with climate, vadose zone thickness, and land use data. However, the vertical variability of the vadose zone was not included. Recently, five deep (50 – 200 m) soil profiles were sampled across the LPC under different land-uses and climate conditions. Soil properties such as bulk density, particle size distribution (PSD), soil organic carbon, soil water content (SWC), nitrate concentrations and chloride concentrations were analysed in 0.5 – 1 metre intervals along these profiles. Additionally, the retention and hydraulic functions were measured at the top 10 cm of the soil, which allowed the direct estimation of the van Genuchten- Mualem (VGM) parameters. Different unsaturated model setups were examined by calibrating against the SWC, chloride and nitrate observations. Initially, the measured VGM were prescribed to the models. In cases where a poor fit between simulations and observations was encountered, an additional adjustment was conducted for the measured soil parameters. For the other setups, the vertical variability of the soil profiles were introduced to the models with Miller scaling coefficients for the retention curves that were estimated according to the PSD. In addition, the scaling coefficients of soil hydraulic conductivity functions were estimated according to the soil bulk density. Vadose zone layers were explicitly included in the model as a last resort. In some cases, an additional adjustment was conducted for the measured soil parameters to attain better fit. The calibrated models facilitate the comparison between fluxes that were predicted by a simplistic one-layer model and models with detailed variability (layering and scaling factors). This comparison reveals the bias in temporal and magnitude of recharge and solute fluxes estimated by the different models. The vertical variability will be introduced to the regional model to investigate if there is a significant effect on groundwater recharge and nitrate spatial distribution.