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Modelling conduit-matrix exchange processes in a karst aquifer

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The objective of this work is to identify the relevance of gradient exchange between karst conduits and fissured matrix for interpretation of karst spring responses. The numerical control volume finite element FRAC3DVS/HydroGeoSphere model (Therrien and Sudicky 1996) is used to simulate discharge and transport signals (^{18}O) at the karst spring Gallusquelle (Swabian Alb, South Germany) for a period of two years. The chosen double continuum approach accounts for saturated and unsaturated flow conditions in the karst system. Important model parameters were identified using sensitivity analyses. Model input was generated using a soil-moisture balance approach that accounts for evaporation, interception and snow storage (Geyer 2008). In general, karst aquifers are characterized by a dual flow system consisting of a low permeability matrix with high storage and a secondary system of highly conductive conduits with low storage. The interaction between both systems represents one of the characteristics of karst aquifers, displayed especially after recharge events, i.e. a characteristic rapid increase in discharge and slow recession. A further important indicator is the variation of isotopic spring signals, e.g. the relative abundance of ^{18}O in spring water. During long-term recession, a systematic decrease in ^{18}O was observed, which is interpreted as the release of isotopically lighter water, recharged during the winter period several years ago. It is believed that this behaviour can be related to: (1) gradient inversion during high recharge conditions and (2) storage in the matrix system and subsequent release of water.