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Seasonal and spatial variations of groundwater anionic composition at the hillslope scale: a new set of constraints for hydrological modelling

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Most hydrological and transport models at the watershed scale consider that groundwater chemical composition is steady at the scale of the hydrological year, and model calibration is usually performed on the observed variations of the stream chemistry. This strategy often leads to underdetermined systems and misestimation of the residence time of solutes in the system.

In this study, we propose a description and an interpretation of the spatial and temporal patterns of groundwater chemical composition, as an experimental basis for constraining hydrological models. We instrumented a head-water catchment with a network of 42 nested piezometers along a 200 m hillslope, monitored for hydraulic head and major anion composition at high frequency during 2 years. The observations showed that: i) the groundwater anionic composition of the first meter at the upper layer of the groundwater was much more variable than deeper parts, along the whole topographic gradient, confirming that this superficial layer constitutes a main compartment for the mixing of new recharge water and older groundwater, ii) deeper part of the aquifer exhibited seasonal variations, with hysteretic patterns, showing that mixing processes also occurred at depth, iii) the hysteresis amplitude decreased with depth, suggesting that the impact of groundwater recharge decreases with depth and iv) the hysteretic patterns were dampered from upslope to downslope, indicating the growing influence of lateral flow downslope.

The potential of these mixing hypotheses to account for the observed patterns across the hillslope section was tested by using a water flow and solute transport model (Hydrus-2D) using Richards equation coupled with solute transport model.