Using tracers and hydrological hysteresis analysis to assess process consistency in a catchment conceptual model application

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Assessment of process consistency in hydrological modelling is crucial to get reliable model responses under conditions beyond the range of prior data availability. This is even more important in the case of conceptual catchment models because the assessment of process consistency may drive the selection of the degree of parsimony, which is warranted in a certain model implementation.

This study aims to analyse process consistency description for a simple conceptual rainfall-runoff model, by using water isotopic data and by the analysis of hysteretic relations. The continuous hydrological model conceptualizes the catchment dividing it into hillslope and riparian zone. A third conceptual tank represents the groundwater storage. The precipitation is used as input to the hillslope and the riparian areas, that are linked dynamically through a simple linear equation.

The model was applied to a headwater forested catchment located in the Italian pre-Alps (598-721 m a.s.l.), where rainfall, discharge, soil moisture and shallow groundwater level were monitored continuously. Moreover, samples for isotopic analyses were collected monthly and during selected rainfall-runoff events from rain and stream water, soil water and shallow groundwater. We applied an index for quantifying hysteresis between streamflow (independent variable) and groundwater level (dependent variable) at the rainfall-runoff event timescale. The index provides information on the direction, the extent and the shape of the loops. A set of 114 rainfall-runoff events were available from 2012 to 2016, to apply the model and compute the hysteresis index. The comparison of observed and modelled hysteretic relations was used to calibrate the hydrological model.

This model consistency analysis allowed us to investigate the goodness of the model in capturing the complex hydrological dynamics, keeping the number of parameters to be conditioned at the minimum. In particular, hysteresis analysis allowed to identify model parametrizations, which permitted an adequate mimic of the system-internal processes. Preliminary results show that the combined tracer analysis and examination of the hysteretic patterns provided indications on the degree of internal consistency of the model representation, making the model application more robust when extended beyond the range of data availability for model conditioning.