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Exploiting hysteretic relationships and tracer data for multi-criteria calibration of a conceptual hydrological model in mountain catchments

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Hysteretic relations between several variables are very common in hydrology. Analyzing hysteretic relations for different rainfall-runoff events and differences in patterns of hysteretic loops among basins can reveal crucial information about hydrological dynamics. This, in turn can lead to improvements in the performance of hydrological modelling. Despite this importance, including hysteresis in hydrological modelling is generally underrepresented.
This study aims to test a stepwise multicriteria calibration approach for a simple rainfall-runoff model able to simulate streamflow and hysteresis loops between streamflow and groundwater level, as well as the stream water isotopic composition. The model is applied to two basins with similar area but different climatic and physiographic characteristics: the 2-ha Ressi basin, a forested catchment located in the Italian pre-Alps (600m a.s.l.), and the 14-ha Bridge Creek basin, covered by grassland and located in the Alps (2000m a.s.l.). Both catchments are instrumented with a v-notch weir, pluviometer, lysimeters, piezometers, soil moisture sensors. Moreover, water isotopic data are available for the Ressi basin. A set of 117 rainfall-runoff events were selected from the long-term datasets (from year 2012 to 2016) for Ressi, while 36 rainfall-runoff events are available for Bridge Creek (2011-2012).
The model includes three conceptual storages representing the hillslope zone, the riparian zone and groundwater storage, and is applied to each rainfall-runoff event. For each event simulation and model parameter set, combined performances measures are computed taking into account the simulation of the hydrometric and tracer response, as well as the hysteretic pattern. This approach allows us to develop a stepwise calibration procedure used to select the level of model complexity supported by field data. Ongoing work shows that i) including analysis of hysteretic patterns provide indications on the realism of the simulations with varying event durations, and ii) multi-criteria evaluation using ensembles of performance measures provides a much more comprehensive assessment of the model performance than single efficiency statistics, which alone, could be misleading.

Keywords: hysteresis index; model calibration; streamflow; groundwater level.