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Regional estimation of catchment-scale soil properties by means of streamflow recession analysis for use in distributed hydrological models

Olivier Vannier (1), Isabelle Braud (2), and Sandrine Anquetin (1)

(1) LTHE, UMR 5564 – Université de Grenoble, BP53, Grenoble Cedex 9 F-38041, France (olivier.vannier@ujf-grenoble.fr),
(2) IRSTEA, UR HHLY (Hydrology-Hydraulics), 5 Rue de la Doua, CS 70077, 69626 Villeurbanne cedex, France

The estimation of catchment-scale soil properties, such as water storage capacity and hydraulic conductivity, is of primary interest for the implementation of distributed hydrological models at the regional scale. This estimation is generally done on the basis of information provided by soil databases. However, such databases are often established for agronomic uses and generally do not document deep weathered rock horizons (i.e. pedologic horizons of type C and deeper), which can play a major role in water transfer and storages. Here we define the Drainable Storage Capacity Index (DSCI), an indicator that relies on the comparison of cumulated streamflow and precipitation to assess catchment-scale storage capacities. The DSCI is found to be reliable to detect underestimation of soil storage capacities in soil databases. We also use the streamflow recession analysis methodology defined by Brutsaert and Nieber (Water Resources Research 13(3), 1977) to estimate water storage capacities and lateral saturated hydraulic conductivities of the non-documented deep horizons. The analysis is applied to a sample of twenty-three catchments (0.2 km^2 – 291 km^2) located in the Cévennes-Vivarais region (south of France). In a regionalisation purpose, the obtained results are compared to the dominant catchments geology. This highlights a clear hierarchy between the different geologies present in the area. Hard crystalline rocks are found to be associated to the thickest and less conductive deep soil horizons. Schist rocks present intermediate values of thickness and of saturated hydraulic conductivity, whereas sedimentary rocks and alluvium are found to be the less thick and the most conductive. Consequently, deep soil layers with thicknesses and hydraulic conductivities differing with the geology were added to a distributed hydrological model implemented over the Cévennes-Vivarais region. Preliminary simulations show a major improvement in terms of simulated discharge when compared to simulations done without deep soil layers.

KEY WORDS: hydraulic soil properties, streamflow recession, deep soil horizons, soil databases, Boussinesq equation, storage capacity, regionalisation