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Inverse modelling to estimate the profile of conductivity at saturation. A case study for a shallow layered soil

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An experimental field was installed in Summer 2012 in a mountain environment (Cividate Camuno, Oglio river basin, Central Italian Alps, 274 m a.s.l.) in order to investigate the soil–water balance and the effectiveness of the eddy correlation technique to measure the evapotranspirative fluxes in a complex topography. The soil is young, shallow and anthropized, grown on the debris of a power plant workings. The genetic sequence is given by A, C and D horizons, as it is common in many Alpine sites. USDA textural classes are silty loam (A, up to 9 cm depth), loam (upper C, 9 to 22 cm), silty clay loam (lower C, 22 to 28 cm) and silty loam (D, deeper than 38 cm), with increasing gravel fraction (pebbles) with depth. Due to the meaningful pebbles presence, the sampled soil cores were disturbed and considered reliable only for porosity, grains size distribution, water content and soil–water retention relationships. In the field a single ring infiltrometer was used to estimate the soil conductivity at saturation. Two infiltration tests were performed, in view of sampling the A–layer and the upper 10 centimeters of the C–layer.

The great soil heterogeneity in the upper layers does not merge the hypotheses of the classical approaches to determine the soil conductivity after infiltration tests, therefore a methodology based on inverse modelling was developed. After a preliminary estimate of the conductivities of the A–layer ($K_{s,A}$) and of the C–layer ($K_{s,C}$) based on the hypothesis of steady percolation at the end of the infiltration tests, a 2D axisymmetrical model was set up for both the tests with the FV–FD AdHydra code, which numerically solves the Richards equation. Then the two infiltration tests were used to iteratively fit both $K_{s,A}$ (first test) and $K_{s,C}$ (second test), using as an initial condition for the simulation of the second test the tensiometer–pressure potential map given as an output of the simulation of the first test. The procedure rapidly converged to comparable values to those obtained by preliminary estimates and, due to its sensitivity to the hydraulic conductivity, improved the deterministic reanalysis of the soil water balance.