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A method for mapping topsoil field-saturated hydraulic conductivity $K_{fs}$ in the Cévennes-Vivarais region using infiltration tests conducted with different techniques

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1. CONTEXT AND OBJECTIVES

Context:
Flash floods are natural hazards that affect the Mediterranean region. They are caused by intense rainfall events but catchment characteristics, and particularly topsoil field-saturated hydraulic conductivity $K_{fs}$, are also influential on the hydrological response. For distributed hydrological models, maps of $K_{fs}$ are useful, as $K_{fs}$ impacts Hortonian events, but they are difficult to obtain from point measurements.

Objectives:
- Propose a method to map $K_{fs}$ from GIS layers with application to the Cévennes-Vivarais region where infiltration measurements obtained with different methods were available (Fig. 1)
- Propose a method to pool available infiltration measurements obtained with various techniques in the region for regionalization

2. STUDY AREA AND DATA

Study catchment and available data (Fig. 1 and 2): Infiltration measurements performed using

- Guelph permeameter (GP) and Double Ring infiltration devices (DR) between 2002 and 2008 in the Gardon and Avène catchments
- Single Ring (SR) infiltration measurements in the Claudiége catchment (2012) and Yzeron catchment (2008, blue rectangle in Fig. 1)
- Tension Disk Infiltrometers (TI)

A two steps method for pooling $K_{fs}$ data from various methods:
- Pooling of GP and DR data by geology * land use (Desprats et al., 2010, Fig. 4) and conversion of GP data to equivalent DR data
- Pooling SR and DR + TI data (Fig. 5) to get a final set of homogenized equivalent DR + TI data set

3. POOLING INFILTRATION MEASUREMENTS

- Raw data show significant difference in distribution among methods (Fig. 3) so pooling the data requires specific treatments

4. MAPPING TOPSOIL $K_{fs}$

Mapping method
- Field data analysis show that geology and land use are significant explaining factors of $K_{fs}$ and one value is assigned by geology * land use class (Fig. 6)
- Geology and land use were used to produce a map of $K_{fs}$ (Fig. 7a) that is compared to a map derived from Rawls and Brakensiek (1985, RBB5) pedotransfer function (Fig. 7b) based on a pedology map with associated soil data base including information about soil texture

Comparison of maps
- A pattern more governed by land use resolution (30 m) for Fig. 7a and more related to the pedology map for Fig. 7b
- Lower range and lower absolute values with RBB5 pedotransfer function
- RBB5 values not representative of field in situ measurements (Braud et al., 2017)

5. CONCLUSIONS AND PERSPECTIVES

- A method was proposed to pool infiltration measurements of $K_{fs}$ obtained with different techniques
- Geology and land use were found to be discriminant factors explaining the variability of $K_{fs}$
- Geology and land use can be used to map $K_{fs}$
- Perspective: use the map in a distributed hydrological model to assess if flash flood simulation is improved as compared to the use of pedotransfer functions

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References:

Figure 1: Location of the study areas in France and simplified geology map of the Cévennes-Vivarais region. The dotted black rectangle corresponds to the location of the land cover map. The infiltration methods are Guelph Permeameter (GP), Double Ring (DR), Single Ring (SR) and Tension Infiltrometer (TI).

Figure 2: Photos of the various infiltration methods (a) GP; (b) DR; (c) SR; (d) TI where the disk has been removed from the tower (SDEC, SW 080 B); (e) Home-made TI from IGE.

Figure 3: Boxplot of original $K_{fs}$ data per method

Figure 4: Regression between log($K_{fs}$) (mm h$^{-1}$) for GP and DR infiltration methods. The points are mean values per geology * land cover classes and the horizontal and vertical lines correspond to one standard deviation.

Figure 5: Regression between log($K_{fs}$) (mm h$^{-1}$) for SR and DR + TI infiltration methods. The points are mean values per geology * land cover classes and the vertical and horizontal lines correspond to one standard deviation.

Figure 6: Bar plot of average log($K_{fs}$) (mm h$^{-1}$) plus one standard deviation for the different combinations of geology and land cover derived from the final homogenized data set.

Figure 7: Maps of log($K_{fs}$) for part of the Cévennes-Vivarais region using (a) the geology and land cover maps and the results of Fig. 6 and (b) the pedology map and Rawls and Brakensiek pedotransfer function RBB5.