Titre : Study of the hydrological processes in four small and medium-scale Mediterranean catchments by performing flood hydrograph decompositions using graphical methods

Laboratory : Institut des Géosciences de l'Environnement, Grenoble

Supervisors : O. Fischer (ophelie.fischer@univ-grenoble-alpes.fr), C. Legoût (cedric.legout@univ-grenoble-alpes.fr), G. Nord (guillaume.nord@univ-grenoble-alpes.fr), C. Le Bouteiller (caroline.le-bouteiller@inrae.fr)

Duration : 5 or 6 months

Level : M1 or M2

Context :

Suspended sediment fluxes (organic and inorganic materials smaller than 63 micrometers) in watersheds are essential natural processes for landscape structuring, maintaining ecosystem health, and transporting nutrients within watersheds (Owens 2020). Suspended sediment (SS) constitute the dominant type of sediment generated by watersheds, representing 70% of the annual sediment export by rivers to the ocean (Vercruysse, Grabowski, et Rickson 2017). However, despite their crucial role in the river systems ecology, SS are also associated with numerous environmental and economic issues (redistribution of contaminants, degradation of the quality of riparian environments and aquatic life, threat for water quality, the food security, reservoirs siltation, damage during flash floods). Given these significant challenges, it is important to understand and prioritize the processes that control erosion dynamics and sediment transfers within watersheds during storms. However, despite decades of research, the spatial and temporal variabilities of the processes generating SS transport have not yet been fully understood (Vercruysse, Grabowski, et Rickson 2017).

Storm events are key moments during which sediments and nutrients are mobilized (Lloyd et al. 2016). During such events, the impact of precipitation tends to dislodge unconsolidated particles from slopes. These detached sediments are then either transported by overland flow to the nearest watercourse and exported out of the watershed, or deposited within the watershed before or after reaching the watercourse, where they may later be remobilized. The sediment transport rate primarily depends on discharge (Q) in the first instance, but many other factors influence sediment dynamics, which exhibit strong spatial and temporal variability (Onderka et al. 2012). Most studies examine sediment dynamics by linking suspended sediment concentration (SSC) to the total flow at the watershed's outlet and often observe significant dispersion in the Q-SSC relationship. However, water at the watershed outlet is a mixture of water coming from different compartments (mainly overland flow and subsurface/groundwater flow), which play different roles in the sediment export processes. Overland flow actively contributes to the detachment of particles from slopes and their transport to the hydrological network (Tolorza et al. 2014), whereas subsurface/groundwater provides clear water to the hydrological network, which can dilute sediments and/or contribute to the remobilization of riverbed sediments (Bača 2008). Therefore, the total discharge at the watershed outlet is not the best variable for understanding and identifying sediment production processes in a watershed. Decoupling the overland flow and subsurface/groundwater compartments during floods should lead to a better understanding of primary erosion (i.e., detachment of soil particles from slopes) and secondary erosion processes due to the arrival of subsurface/groundwater in the river, which limits sediment deposition by sustaining flow transport capacity and can contribute to the remobilization of previously deposited particles in the hydrological network.

Water compartments at the watershed outlet during floods can be separated by performing hydrograph decompositions. Hydrograph decomposition is based on the assumption that the streamflow at the watershed outlet is the result of a mixture of a finite number of different identified

water sources (Pelletier et Andréassian 2020). Many methods have been developed to decompose flood hydrographs. The oldest and most basic ones are graphical methods, and primarily rely on the difference in transfer time between water compartments (often baseflow and quick flow) ((Pelletier et Andréassian 2020), (Szilagyi et Parlange 1998)). Later, low-pass filtering methods were developed for base flow separation, assuming that baseflow produces the low-frequency components of the hydrograph ((Eckhardt 2005 , (Eckhardt 2008)). Several studies have conducted graphical hydrograph decompositions to investigate the dynamics of suspended sediment concentration in watersheds ((Bača 2008), (Walling et Webb, s. d.), (Andermann et al. 2012)). All these studies have highlighted the dilution effect of subsurface/groundwater by showing that the dispersion of the SSC/Q relation is reduced when considering only overland flow discharge. However, no such study has been conducted in small and medium-scale Mediterranean watersheds, which are known to have very high erosion rates ((Francke et al. 2014), (Klotz et al. 2023), (Nord 2016)).

Therefore, the objective of this internship is to analyze the hydrological processes of four Mediterranean watersheds by performing graphical hydrograph decompositions over several hydrological years. The studied catchments are part of French observatories of the OZCAR network : three of them (Laval, Brusquet and Galabre) belong to the Draix-Bléone observatory (located in the Southern Alps near Digne-les-Bains, south-east of France, (Klotz et al. 2023), (Legout et al. 2021)) and the Claduègne catchment is in the OHMCV observatory ("Observatoire Hydro-Météorologique Cevennes Vivarais", located in Ardeche in the south of France (Nord 2016). These watersheds have different sizes (0.86 km^2 for Laval, 1.07 km^2 for Brusquet, 20 km^2 for Galabre, 43 km^2 for Claduègne), different land uses (Brusquet, Laval, and Galabre watersheds are minimally anthropized with vegetation cover rates of respectively 80%, 30%, and 80% ; Claduègne watershed is more anthropized with approximately 40% of forest and the rest occupied by agriculture). These watersheds are all equipped with a hydrological station where high-frequency measurements of rainfall and discharge have been conducted for several years.

This internship is linked to an ongoing PhD project, which aims to analyze the impact of groundwater input on the hydrosedimentary processes of these watersheds. As part of this PhD, hydrograph decompositions have already been carried out in the two small watersheds (Laval and Brusquet), by using a different decomposition method based on the chemical composition differences of the various water compartments. This internship will therefore allow the comparison of the results of several flood hydrograph decomposition methods based on different principles.

The different steps planned for the internship are:

- Conduct a literature review on the various graphical hydrograph decomposition methods and select the most relevant one(s) for the studied watersheds.
- Perform hydrograph decompositions during the available flood events in the data from the four hydrological stations and develop a method to estimate uncertainty in the results.
- Compare the hydrological responses during floods in the four watersheds, particularly in terms of surface runoff generation processes. Try to link the observed variations in these processes to differences in flood types, vegetation cover, size, geology, rainfall spatial variabilities and human activities between the watersheds.

The internship may also involve participating in fieldwork missions on the different watersheds as part of the regular maintenance of the hydrological stations.

Required skills: As the internship is focused on the analysis of large datasets, it is necessary to be comfortable with at least one programming tool (R, Python, or MATLAB). A basic knowledge of hydrology is desirable.

Application: Send a CV and cover letter by email to the supervisors.

Bibliography:

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