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Study of the contribution of groundwater to hydrosedimentary processes in two Mediterranean mountainous watersheds using the high frequency conductivity signal as a tracer of water origin

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Understanding erosion and sediment transport is essential for the sustainable management of water and soil resources in the critical zone. Soil erosion is considered as the main threat to soils and poses food security problems. Given these significant challenges, it is important to understand and prioritize the processes that control erosion dynamics and sediment transfers within watersheds.

However, these dynamics exhibit strong spatio-temporal variability, as illustrated by the wide dispersion of relationships between suspended sediment concentrations and liquid discharge (Q) at catchment outlets. However, these dispersions are often interpreted based on the variability along the sediment axis (e.g., origin and availability of particles), while very few studies have focused on the variability along the discharge axis (water origin). In particular, the interactions between groundwater flow and sediment transport have been little studied.

The aim of this study is to assess the impact of groundwater flow on sediment transport dynamics in two headwater catchments (respectively 1.07 km² at Brusquet and 0.86 km² at Laval) of the Draix-Bléone observatory with different vegetation cover rate (respectively 80% at Brusquet and 30% at Laval). The work first involved developing an EMMA (End-Member Mixing Analysis) method for decomposing flood hydrographs and separating the respective contributions of groundwater flow and surface runoff for each flood using the high-frequency conductivity signal, highly correlated to sulfate concentrations, as a tracer discriminating these two water compartments.

This EMMA method was used to calculate groundwater contributions during 120 floods between 2015 and 2020 in the Laval catchment and 116 floods between 2013 and 2020 in the Brusquet catchment. Analysis of the results of these decompositions revealed seasonal variations in groundwater contributions in both catchments, with winter and spring floods showing higher groundwater contributions than summer and autumn floods. These decompositions made it possible to examine the dynamics of fine sediment transport during floods as a function of surface runoff rate and to identify the impact of groundwater on hydrosedimentary processes (effect of dilution or of remobilization of riverbed sediment). By comparing the results of the decompositions from the two catchments, it was possible to assess the impact of vegetation cover on the contribution of groundwater to flood and on each catchment sediment dynamics.

Overall, this study suggests that the use of high frequency conductivity signals as tracer of water origin offers a promising approach to performing high frequency decompositions of flood hydrographs. The results of the decompositions highlight the importance of groundwater flows for understanding hydrosedimentary processes in headwater catchments (~km²).