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Quantifying the origin of different sediment types in a catchment of the Southern French Alps by combining hydro-sedimentary records and fingerprinting

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Soil erosion and subsequent sediment supply to rivers are particularly massive and episodic in mountainous environments, such as in the Southern French Alps. Those processes typically lead to an increase in water turbidity and a rapid filling of reservoirs in downstream areas. This situation is particularly problematic in regions where reservoirs are used to provide clear water to hydroelectric power plants. Sediment source areas must first be delineated and sediment fluxes between hillslopes and the river system must be better understood to implement efficient sediment management.

We therefore combined traditional monitoring techniques (i.e. installation of river gauges and sediment samplers in several subcatchments) and sediment fingerprinting using elemental geochemistry and fallout radionuclides as potential discriminant properties to quantify the supply of sediment provided by different lithological sources (i.e. black marls, marly limestones, conglomerates, Quaternary deposits) to the River Bléone (905 km^2). Those analyses were conducted on different material types collected within the catchment (i.e. suspended and riverbed sediment), and at the catchment outlet (i.e. on a sequence of sections of a 3-m long sediment core).

Sediment exports at the river catchment outlet (330±100 t km-2 yr-1) were mainly driven (80%) by the occurrence of widespread rainfall events (long duration, low intensities). In contrast, heavy, local and short duration storms generated high peak discharges and suspended sediment concentrations, but they were restricted to small upstream torrents. Our study (2007-2009) confirmed the important contribution of black marls (up to 70% at the flood scale) to sediment transported in rivers, although this substrate only occupies c. 10% of the total catchment surface. However, the contribution of other lithological sources varied at both intra- and inter-flood scales. Sediment exports generated by local convective storms were dominated by black marls/marly limestones. In contrast, widespread flood events that generate the bulk of annual sediment supply at the outlet were characterized by a more stable lithologic composition and by a larger contribution of limestones, Quaternary deposits and conglomerates, which corroborated the analysis of riverbed sediment.

Finally, we found that black marls and marly limestone sources provided the main fraction of sediment analysed throughout the outlet core sequence (40 and 22 %, respectively, for the period 1962-2009). However, we also found evidence for the occurrence of major floods carrying large quantities of sediment originating from Quaternary deposits and conglomerates (25 and 16 %, respectively). The variability of sediment sources throughout the sequence may reflect the spatial variability of rainfall within the catchment, which in turn reflects its origin. This study emphasizes the importance of using archival data to validate the results of sediment fingerprinting studies conducted during short contemporary monitoring programmes.