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On October 22, 2019, intense rains took place in Catalonia (292.6 mm in 24 hours at Prades), associated with a meteorological isolated depression at high atmospheric level (DANA in Spanish language). These rains caused a sudden discharge increase and a major flash-flood in the Francolí river (Tarragona, Catalonia, Spain). As a result, the river swept along a large quantity of vegetation, crops and infrastructures, such as bridges, roads, and houses. Unfortunately, the flood caused a considerable economic damage (exceeding 100 million euros), and a loss of six human lives. This area was also affected by the 1994 flood, which produced 10 fatalities and losses worth 17,000 million euros.

The Francolí river watershed has an area of 853 km$^2$ and a length of 59 km. The study area stretches for ~20 km along the upper basin, without regulatory infrastructures. It covers the localities of Vimbodí, L’Espluga de Francolí, Montblanc and Vilaverd, with a population of 12,463 people. Downstream Vilaverd, the river crosses the strait of La Riba at the west of the Prades mountains. The Francolí River has low water levels much of the year and a strong seasonal regime. It presents high sediment mobility and large transportation capacity.

Orthophotographs, LiDAR and field work data, including GNSS-RTK data of river sections, are fundamental for this hydro-geomorphic analysis. It is performed mostly through classical and stereo-anaglyph photo-interpretation and comparison of the 2019 (post-flood event), 2016 (pre-flood event), 1995 (after the 1994 flood) and 1945-56 orthophotographs (provided by the Geological and Cartographic Institute of Catalonia). The main effects considered are: a) channel migration, cuts or changes in the sinuosity of meanders; b) significant bank erosion; c) pull up and dragging of vegetation; d) channel widening and braiding; e) development of secondary active channels during the flood; f) significant erosive and sedimentary morphologies; g) extension of the flooded areas through ephemeral evidence. From the geomorphological effects of the 2019 and 1994 floods, the Active Band is determined and mapped. This characterization highlights that the Francolí river is, geomorphologically, very active. In consequence, when defining flood hazard...
zones, hydraulic modelling would not be able to capture the complexity of this system and would produce biased results.

Once the Active Band is determined and with the estimation of peak flows in crucial localities, the Preferential Flow Zone (PFZ) can be defined. PFZ is the envelope of the areas where the flow concentrates during major floods or, also, the most frequently flooded areas in minor floods. This zoning allows us to discriminate areas with high and low flow energies, and to identify the margins most prone to erosion. Accordingly, varying levels of flood hazard can be mapped, and flood areas classified.

This combined analysis of indicators allows us to characterize the flood hazard more precisely in the studied stretch. The method can serve to better understand and predict the flash-floods associated hydro-geomorphic hazards in these kind of geomorphologically active rivers.

The authors thank the financial support from PROMONTEC project (CGL2017-84720-R AEI/FEDER, UE), Spanish MINEICO.