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Effects of large floods on channel width: recent insights from Italian rivers

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Variations of channel morphology occurring during large flood events (recurrence interval $>$ 50-100 years.) are very often the cause of damages to buildings and infrastructures, as well as of casualties. However, our knowledge of such processes remains poor, as is our capability to predict them. Post-event campaigns documenting channel changes and linking them to hydrological and morphological factors thus bear an enormous value for both the scientific community and river management agencies.

We present the results of an analysis on the geomorphic response associated to 4 large floods that occurred between October 2011 and September 2015, affecting several catchments in Northern Italy (Magra-Vara, Trebbia, Nure rivers) and Sardinia (Posada and Mannu di Bitti rivers), characterized by different climatic, lithological and geomorphological settings. The analysis considered more than 400 channel reaches characterized by a drainage area ranging from 39 to 1,100 km^2 and featuring a wide range of lateral confinement, mostly within the partly- and unconfined conditions.

The approach to flood analysis encompassed: (i) hydrological and hydraulic analysis; (ii) analysis of sediment delivery by landslides to the channel network; (iii) GIS-based and field assessment of morphological channel modifications. For the Nure River flood event (September 2015) a quantitative assessment on average bed level variations was also carried out. Return period for maximum hourly rainfall intensities and peak water discharges exceeded in all basins 100 yr, in some cases even 300 yr. Very high unit peak discharges were estimated, reaching 8.8 m^3 s^{-1}km^{-2} in the Nure River (205 km^2) and up to 30 m^3 s^{-1}km^{-2}in few Magra River tributaries (5-10 km^2).

Notable channel widening (post-flood width / pre-flood width $>$ 1.1) occurred in 83% of studied reaches, and it was found more relevant in the channels with narrower initial width, i.e. along the relatively steep tributaries. For these tributaries, the ratio between post-flood and pre-flood width presents an average value of 4.2, with a maximum approaching 20. In the main river channels, due to the presence of wider sections and lower slope, the ratio resulted $<$ 5, on average 1.3.

The analysis of width ratio vs. flood peak unit stream power shows that the minimum unit stream power required to cause relevant widening was about 500 Wm^{-2}. Nonetheless, some reaches affected by unit stream power as high as 4,000 Wm^{-2} exhibited limited or no widening at all. Indeed, a statistical analysis on the relationship between widening and both morphological and hydraulic controlling factors indicates that unit stream power and confinement index were the most relevant variables, whereas sediment input from mass wasting processes seems to have a localized influence. Remarkably, the analysis of subset referring to Trebbia and Nure basins showed that channel widening is strongly associated to bed aggradation, and that steeper tributaries underwent higher aggradation despite their larger sediment transport capacity. These results points out that geomorphic changes due to large floods are controlled by several factors that induce a highly variable pattern of change even within the same river basin.