Geophysical Research Abstracts
Vol. 15, EGU2013-11125, 2013
EGU General Assembly 2013

The flash flood of October 2011 in the Magra River basin (Italy): rainstorm characterisation and flood response analysis

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On 25 October 2011, the Magra River, a stream of northwest Italy outflowing into the Ligurian Sea, was affected by a flash flood, which caused severe economic damage and loss of lives. The catchment covers an area of 1717 km^2, of which 605 km^2 are drained by the Vara River, the major tributary of the Magra River.

The flood was caused by an intense rainstorm which lasted approximately 20 hours. The most intense phase lasted about 8 hours, with rainfall amounts up to around 500 mm. The largest rainfall depths (greater than 300 mm) occurred in a narrow southwest – northeast oriented belt covering an area of approximately 400 km^2.

This flash flood was studied by analysing rainstorm characteristics, runoff response and geomorphic effects.

The rainfall fields used in the analysis are based on data from the Settepani weather radar antenna (located at around 100 km from the study basin) and the local rain gauge network. Radar observations and raingauge data were merged to obtain rainfall estimates at 30 min with a resolution of 1 km^2. River stage and discharge rating curves are available for few cross-sections on the main channels. Post-flood documentation includes the reconstruction of peak discharge by means of topographic surveys and application of the slope-conveyance method in 34 cross-sections, observations on the geomorphic effects of the event – both in the channel network and on the hillslopes – and the assessment of the timing of the flood based on interviews to eyewitnesses. Regional authorities and local administrations contributed to the documentation of the flood by providing hydrometeorological data, civil protection volunteers accounts, photos and videos recorded during and immediately after the flood.

A spatially distributed rainfall-runoff model, fed with rainfall estimates obtained by the radar-derived observations, was used to check the consistency of field-derived peak discharges and to derive the time evolution of the flood. The assessment of unit peak discharges confirmed the severity of the flood, with values up to approximately 20 $m^3 s^{-1} km^{-2}$ in catchments up to 10-20 km^2. The strong spatial gradients of the precipitation had a major influence on flood response, with large differences in peak discharge between neighbouring catchments. The magnitude of sediment transport processes, featuring as well a large variability among sub-basins, seems to have been controlled both by peak water discharge and by local geomorphological conditions affecting sediment supply, i.e. occurrence of large landslides connected to the channel network. A striking characteristic of the flood event was the recruitment and transport of large amounts of wood elements, deriving mostly from eroded portions of floodplains and islands along the main channels.