

The 2-3 November 2015 flood of the Sió River (NE Iberian Peninsula): a flash flood that turns into a mudflow downstream



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The night of 2-3 November 2015 torrential rains fell on the headwaters of the Sió River catchment; the subsequent flood caused four deaths in the town of Agramunt and many damages along the stream.

The Sió River is a left-side tributary of the Segre River, the main tributary of the Ebro River. The catchment (512 km²) has a westward orientation and headwaters on the Catalan Central Depression's between 700 and 900 m (Fig. 1); it has been largely modified by human activities and the main land use is dryland cereal farming.

A flow gauging station in the outlet operated from 1965 to 1992 (now out of use) recorded an average daily mean flow of 0.8 m³ s⁻¹ and a maximum peak flow of 16 m³ s⁻¹.

Our objective was to analyse the hydrological, hydraulic and sedimentary characteristics of this recent flood in order to gain a better insight on the characteristics of the major historical floods in the Sió and similar neighbouring catchments.

The rainfall height on the headwaters was between 136 and 146 mm in ten hours (Fig. 2), with a maximum intensity of about 32 mm·h⁻¹. In the rest of the catchment it rained much less (22-100 mm).

Peak flows were calculated with Manning's equation from the wet and mud marks and vegetal litter left by the flood. Suspended sediment load was estimated from the sediment quantity trapped in areas where water was hold back.

The peak flow in the headwaters (Oluges; Fig. 3) was 150 m³·s⁻¹ and diminished downstream: 45 m³·s⁻¹ in the centre of the catchment (Agramunt: Oluges + 27 km) and 8 m³·s⁻¹ in the outlet (Balaguer: Oluges + 63 km). Runoff volume diminished from 3 hm³ at Oluges down to 0.4 hm³ at the outfall (Fig. 4).

The suspended sediment load was 10-15% in volume in the headwaters and, judging from recorded images and eyewitnesses, and the decrease of the front's velocity (Fig. 5) it increased as the flow moved downstream, turning the flash flood into a mudflow. This concentration gain was most probably caused by the flood wave's loss of water due to the dryness of the riverbed and floodplains and translated in an increased viscosity that ultimately altered the hydraulic behaviour of the flow, slowing it down. This process of water loss has been observed in flash floods in dry riverbeds in arid and semiarid areas such as Negev (Israel) and Atacama (Chile). Historical floods in this and in neighbouring catchments (Ondara and Corb Rivers) are known to have had hyperconcentrated flows.

Our hypothesis is that the highly modified river geometry (an extremely diminished channel, Fig. 6) has forced most of the water to flow over very dry floodplains thus slowing it down and causing, at the same time, a major loss of discharge due to infiltration.

Acknowledgements

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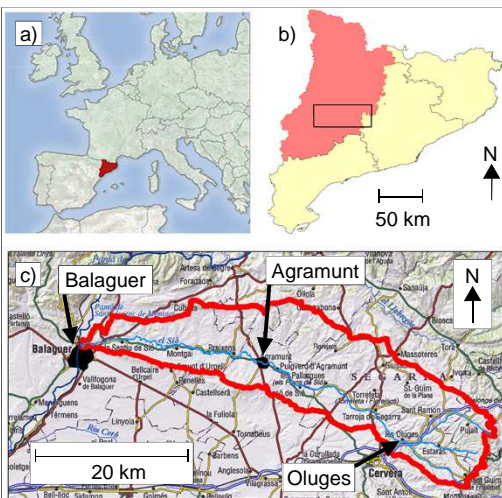


Figure 1. Location of the Sió River within Europe (a) and within Catalonia (b), and contour of its catchment (c)

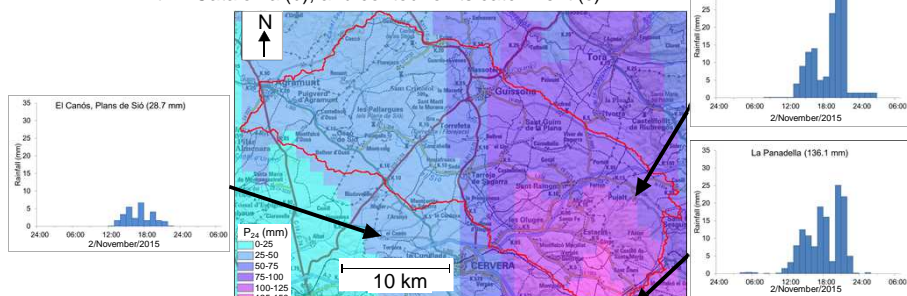


Figure 2. Event's rainfall fields in 24 h in the catchment at Agramunt (341 km²) and total rainfall at three locations within or near the catchment (Source: Servei Meteorològic de Catalunya)

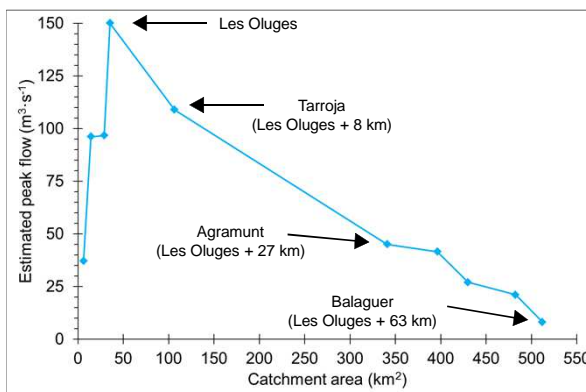


Figure 3. Estimated peak flow at different locations

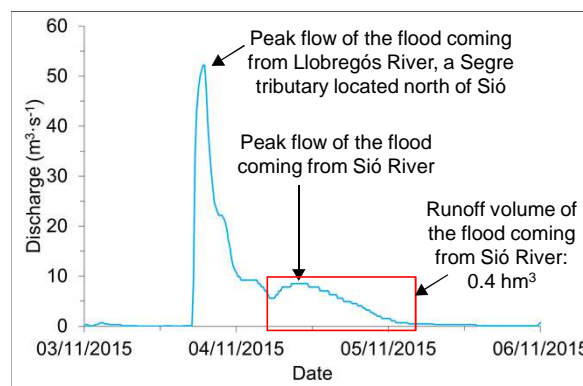


Figure 4. Hydrograph of the flood in the Segre River, 500 m downstream the junction with Sió River

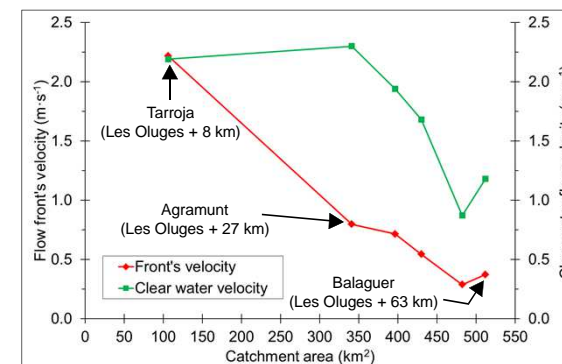


Figure 5. Flood's front velocity (calculated from its time of arrival) and velocity of a theoretical sediment-free water (calculated with Manning's equation) at different locations



Figure 6. Detail of the small section of Riera de la Vall (a tributary of Sió) at Tarroja. It can convey 3 m³·s⁻¹ whereas the peak flow was 26 m³·s⁻¹.



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