HYDROLOGY AND EROSION PROCESSES IN SMALL MOUNTAIN CATCHMENTS: 25 YEARS OF OBSERVATION IN THE DRAIX EXPERIMENTAL SITE (FRENCH SOUTHERN ALPS)

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INTRODUCTION AND CONTEXT

The floods generated in small mountains basin are flash floods often devastating. Predicting runoff, erosion and sediment yield within mountainous catchments presents a strategic interest due to the consequences which arise from these phenomena and the need for natural hazard mitigation engineering. In the Southern French Alps, the Black Marls formation covers a large area. This formation is very susceptible to weathering and erosion. It results in "badlands" topography and high solid transport, bringing heavily loaded floods downstream and silting up reservoirs. These problems are particularly acute in the Durance basin where the erosion rates in the watersheds devoid of vegetation are among the highest values recorded in the world. The need to quantify the phenomenon and the effect of the restoration strategies led the Cemagref to monitor a group of little basins in this area. The main goal of this observatory is to improve the prediction of the runoff and erosion response of small mountain catchments to climatological inputs (precipitation and temperature), particularly for extreme events.

STUDY AREA AND MONITORED SITES

The Draix observatory is located 200 km South of Grenoble, near the little town of Digne (Fig. 1). Five basins have been equipped since 1983 for the measurement of rainfall, liquid discharge and solid transport. These basins have different areas, from 1300 m² to 1 km². Four are situated in denuded areas and the last one was reforested at the end of the last century, within the frame of restoration works. 87 % of its surface area is now covered with a pine forest (Tab. 1).

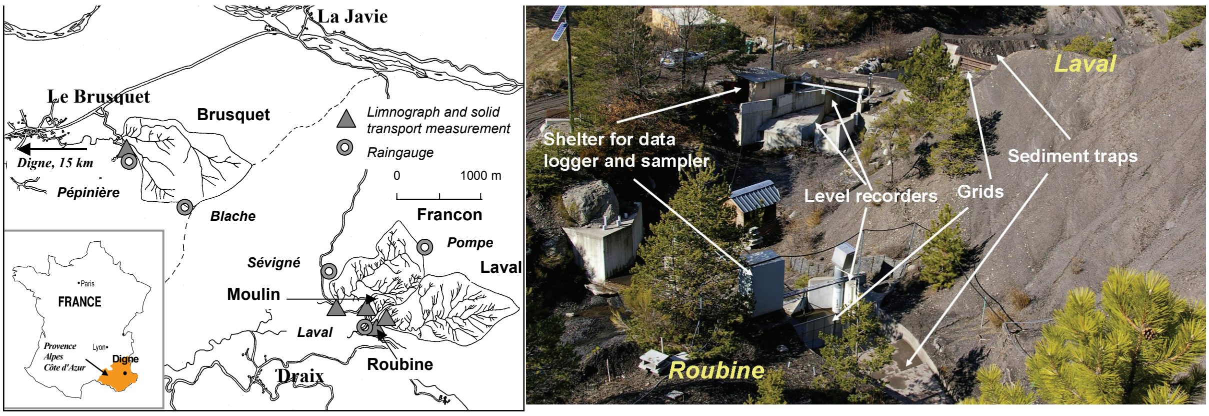

Fig. 1 Location of the study area and measurement devices at the outlet of the catchments

Seven rainfall recorders and a spectro-pluviometer measure the precipitation at different locations. At the outlet of the basins, a gauging station with level recorders, samplers, optical turbidimeters and sediment traps allow the measurement of discharge, suspended and bedload sediment fluxes. A climatological station records air temperature, humidity, solar radiation, wind speed and direction. Soil

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temperature is recorded in two stations with sensors at different depth, aspect and slope locations. Four soil hydrological stations with TDR, tensiometers, piezometers and humidity capacity probes are settled in different environmental contexts: abandoned rangeland, badlands slopes and landslide

Tab. 1 Main Characteristics of the monitored basins

Basin name	*Area* (ha)	Denudation rate (%)	Average slope (%)	Elevation min-max (m a.s.l)	Observed since
Roubine	0.133	79	75	850-885	1983
Moulin	8	54	30	850-925	1988
Francon	76	56	41	850-1140	1983-96 - 2008
Laval	86	68	58	850-1250	1984
Brusquet	108	13	53	800-1260	1987

MAIN RESULTS ON FLOOD GENERATION, EROSION AND SOLID TRANSPORT

Mean annual rainfall is 900 mm with 200 days a year without rain and only five days with rainfall depth exceeding 30 mm. Summer precipitation comprises very few rain showers: occasional storms providing 20–60 mm of precipitation. The periods of April-May and September-October are much rainier, with monthly rainfall reaching 100 mm, and October is usually the wettest month. The floods observed are violent with very high peak discharge. The highest flood monitored reached $20m^3/s$ as peak flow for only 0.86 km of basin area. The floods are very flashy on Laval, Roubine and Moulin. On Laval, the raising time is shorter or equal to 20 minutes. For the Laval catchment, within this time the discharge raise in the gauging station from zero up to 2 to 10 m^3/s. Constrasting responses are observed in the forested basin (le Brusquet) : the raising time is much longer (20 to 60 min), the peak flows 5 to 10 times lower.

The sediment supply occurs mainly during storm events. During the floods the measured sediment concentration for the Laval is frequently higher than 300 g/l and can reach 800 g/l (August 1997). The maximum measured concentration is 420 g/l for the Moulin and remains under 300 g/l for the Roubine. On the Brusquet, the maximum concentration is 35 g/l and for most of the floods, it remains under 10 g/l. The maximum deposit for one flood in the Laval sediment trap was 700 m3 and is frequently over 400 m^3. In the Brusquet sediment trap, the deposits for one flood are usually too small to measure. The annual volume in the trap ranges from only 5 to 35 m^3. However, for the 2 highest floods of the observation period, the deposits reached 12 and 17 m3. This shows the threshold effect in erosion processes of this basin: the higher discharges are able to transport much more sediment to the outlet. A scale effect was observed in the sediment production: at the Roubine scale, ablation on the slopes is the dominant process. At the Laval scale, the coarse material from the slopes and gullies is submitted to deposition, scouring and transport processes and the proportion of fine sediment gets higher.

The annual sediment yield reaches very high rates, 115 t/ha.year for the Laval, with an important variation from one year to another (minimum 44, maximum 220). A great part of the annual production is often due to only a few storms in the year. On the forested Brusquet basin, the variability from one year to another is much higher and the maximum value (1994) is ten times the minimum (1995).

CONCLUSION

The research carried out on this site highlighted the need to take into account the hydrological, geomorphological and phyto-ecological processes. In order to understand how suspended sediment fluxes are delivered to the river systems downstream, the monitoring of larger catchments were undertaken since 2008 with embedded catchments from 20 km² up to 900 km², within a research program conducted by the LTHE laboratory in Grenoble. Since 2010, the Draix observatory has been extended to this network and constitutes now the Draix-Bléone Observatory.

Keywords: Floods, Erosion, Solid transport, Sediment yield, Experimental catchments