High-frequency monitoring of debris-flows and flash floods in the French Alps

O. Navratil[1], F. Liebault[1], D. Laigle[1], H. Bellot[1], J. Theule[1], V. Segel[2], M. Ficquet[3]

INTRODUCTION

The general aim of this study is to **improve the understanding of sediment responses** during **flash floods** and **debris flows** in small French Alpine torrent catchments (2.3 – 48.7 km²) by means of **high frequency monitoring** of water and sediment fluxes (200ms – 5 min). This study is part of two European research programs (RiskNat-Interreg and Paramount).

This poster presents the main characteristics of five **study sites** installed in 2010, the **material used** and the **monitoring system** through the example of the Real Torrent observatory.

STUDY SITES

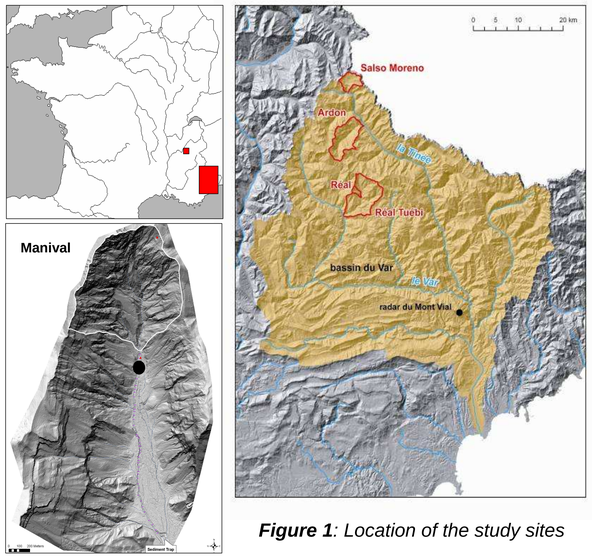

***Figure 1**: Location of the study sites*

Five study catchments were instrumented in the **Northern and Southern French Alps** (Fig. 1, Tab. 1). At these sites, **flash floods** observed are generally triggered by intense rainfall events. Most of the time they generate very high bed load transport with severe erosion from source areas and significant deposits in the downstream areas. Every years, several **debris flows** can be also observed on the smallest headwater catchments (Tab. 1). They generally occur following **violent thunderstorms** in spring and summer.

All sites (except the Réal Tuébi) are regularly monitored after flood events with high-resolution **topographical survey** of the channel and the sediment trap (with Lidar and/or theodolithe stations). These data allow calculating sediment yields from the catchments and estimating the processes of erosion/deposits in the river network (for the Mannival and Real torrents).

Socio-economical stakes mainly involve the infrastructure safety (roads) and the security of villages located downstream.

Torrent	Drainage area (km²)	Elevation ASL (m)	Sediment transport		Socio-economical stakes	Monitoring material			
			Bed load	Debris flow		Water level	Geophones	Camera	Rain gauges
Ardon	35.7	1139-2829	X	O	Saint-Etienne-de-Tinée village	Pressure sensor	0	0	1
Réal (3 sites)	2.3	1218-2069	X	X	Péone village	Radar and ultrasonic sensor	9	1	4
Réal Tuébi	48.7	779-2582	X	O	Péone, Guillaumes villages	Pressure sensor	0	0	3
Salso Moreno	12.6	1639-2868	X	X	Le Pra village, road RD64	Flood scale	0	0	1
Manival	3.6	570-1738	X	X	St Nazaire les Eymes, N90	Ultrasonic sensor	3	1	2

***Table 1**: Study sites characteristics*

Acknowledgement: This research is funded by the RiskNat-Interreg (Alcotra) and Paramount projects (Alpine Space)

Contacts: oldrich.navratil@cemagref.fr; frederic.liebault@cemagref.fr
(1)CEMAGREF, ETNA; (2) RTM-ONF; (3) Conseil General des Alpes Maritimes (06)

AN ILLUSTRATION: THE REAL TORRENT OBSERVATORY

Three gauging stations were installed in the Real torrent catchment (Tab. 1; Fig. 2). The distance between each station (R1, R2, R3) is c.a. 800 m. The processes of sediment erosion from source areas and the upstream debris flow initiation are monitored at R1 station. R2 station provide quantitative information about the transfer of sediment, but also the processes of initiation of debris flows in the main channel, i.e. attributed to a remobilisation of past floods deposits. R3 station is located just upstream of the confluence with the Tuébi in a depositional area.

Ultrasonic and radar sensors (Paratronic®) provide the water-sediment elevation at the surveyed cross-section (Fig. 2). At each site, three geophones (GS20DX0 from Geospace®, natural frequency of 8Hz) are distant of about 100m along the channel. They are coupled with an electronic conditioner to provide the envelope of the soil vibration signal during the flood at each location. Signal analysis thus allows estimating the **front debris flow velocity** at each site. The water level and geophone signals are continuously recorded every 200 ms with a Campbell® CR1000 and a 4Go memory extension (autonomy: 80 days). These data allow us estimating the **water-sediment discharges and volumes** **events**.

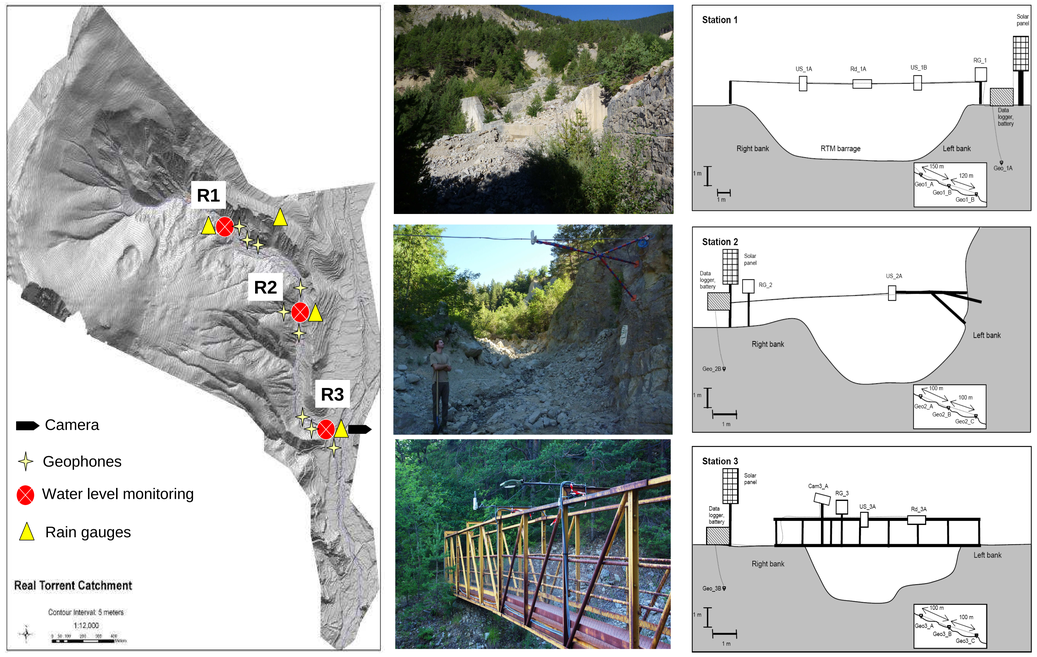

***Figure 2**: Real stations (R1, R2 and R3) and instrumentation: US, Rd, RG, Cam and Geo referred to as respectively, the ultrasonic sensor, the radar, the rain gauge, the camera and the geophones*

Rainfall volumes are recorded every 5 min at four locations. A camera (Campbell® CC640) placed at R3 is triggered by the geophones and the raingauge to provide images during the events (every 10s; resolution, 680*540 pixels). The power is supplied by a battery (12 V, 80 Ah) and a solar panel (55 Wcc). The stations are checked every 3 weeks by local governmental agency (RTM).

CONCLUSIONS

The combination of (1) **high-frequency sediment fluxes monitoring** during floods and (2) **high-resolution topographical monitoring** after each flood would provide valuable information to better understand the processes involved during flash floods and debris flows in mountainous catchments: from their **initiations** near the sources areas, their **transfer** (erosion/deposits) in the main channel, to their downstream **deposits** in sediment trap or their **release** in the fluvial network.

Two study sites (the Mannival and Real stations) will be soon equipped with high-resolution camera and video-camera. These images are expected to validate the results obtained from the monitoring stations, and to provide additional quantitative and qualitative information, as for instance the maximum sediment size transported or the type of water-sediment flow (mud flow, viscous or granular debris flow).