Hydromorphological restoration of the Upper Drac River (Hautes-Alpes, France)

Restauration hydromorphologique sur le Haut Drac (Hautes-Alpes, France)

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RÉSUMÉ

Le Haut Drac, dans la vallée du Champsaur, a fait pendant une longue période – depuis la fin des années 1960 jusqu'à récemment – l'objet d'une activité d'extraction de granulats importante. Ces extractions ont considérablement affecté la morphologie du cours d'eau, passant d'une tresse à un chenal unique divagant, et montrant une incision rapide dans d'anciens dépôts d'argiles lacustres. Pour stopper cette incision, un projet de restauration a été conduit entre novembre 2013 et avril 2014 afin de recréer un nouveau patron en tresses, à la bande active large et aux chenaux peu profonds. Un volume de 355 000 m^3 de sédiments a été réintroduit. Dans le cadre du projet HyMoCARES, un suivi de la réponse géomorphologique a été prévu sur un linéaire de 3,7 km en amont du village de Saint-Bonnet-en-Champsaur. Il repose d'une part sur la répétitivité de campagnes de mesures sur le terrain dont les acquisitions sont réalisées par drone à l'aide d'appareils photographiques numériques et par LiDAR aéroportés. Ces acquisitions sont exploitées pour produire une cartographie diachronique haute résolution des changements morphologiques. D'autre part, un suivi de particules à l'aide de puces RFID actives UHF a été conduit pour évaluer les distances de transport.

ABSTRACT

The Upper Drac River in the Champsaur valley has been highly impacted by intensive gravel mining since the late 1960s until recently. Gravel mining dramatically altered the channel morphology of the Drac River, which rapidly shifted from a braided to a wandering pattern, and which has been affected by an accelerated channel incision within ancient clay deposits. In order to stop channel incision, a restoration project was implemented between November 2013 and April 2014, and allowed the self-recovering of a new wide braided channel corridor, with shallow channels. A volume of 355,000 m^3 of coarse sediment was introduced. The physical monitoring program, implemented within the HyMoCARES Alpine Space project, will be applied to capture the geomorphic responses along a 3.7 km reach on the Upper Drac River, close to Saint-Bonnet-en-Champsaur. The physical monitoring is based on repetitive high-resolution topographic surveys conducted with camera embedded on UAV and with airborne LiDAR data. These datasets are used to produce diachronic, high-resolution maps of morphological change. Moreover a bedload tracing program using active ultra-high frequency RFID technology has also been conducted to assess transport distances.

KEYWORDS

Geomorphic responses, Physical monitoring, Restoration project, Sediment reintroduction, SfM photogrammetry

1 INTRODUCTION

1.1 General presentation of the study site

The Upper Drac (Hautes-Alpes department) is a gravel-bed braided river draining 1) the southern flank of the Écrins Massif, a geological unit belonging to the Alpine outer crystalline massif, 2) the northern flank of the Dévoluy Massif, which is part of the sedimentary Southern Prealps, and 3) the Flysch thrust zone, composed of Cenozoic sedimentary rocks. The Drac River is one of the major Alpine tributary of the Isère River, with a confluence at the city of Grenoble. The study reach (Table 1) is located close to St-Bonnet-en-Champsaur, downstream from the Champsaur leisure centre, at an elevation of 1000 m above sea level. This reach drains a 340-km² upland catchment with a maximum elevation of 3441 m. Imprints from the Last Glacial Maximum (LGM) are widespread in the catchment, with important till deposits on hillslope, and paraglacial sediment in the valley floor (lacustrine deposits related to the obstruction of the valley by the Séveraisse Glacier during Würmian phases of glacier recession). These clay deposits are covered by the thin contemporary alluvial fill of the Drac River. The climate is characterised by a mean annual rainfall of ~950 mm. The hydrological regime is influenced by a strong spring snowmelt and severe low flows in fall or winter.

Table 1. Main physical features of the Drac River at the restoration site

Drainage area (in km²)	340
Location	44°39'17''N, 6°6'23''E
Length of the study reach (in km)	3.7
Active channel width (in m)	110
Channel slope (in m/m)	0.01
Planform morphology	Braided pattern

Like most of Alpine braided rivers in France, the Upper Drac, in the Champsaur valley, has been highly impacted by intensive gravel mining since the late 1960s. This activity stopped only in 2012, near the confluence with the torrent-d'Ancelle, located upstream the restored read. In a general context of sediment supply decrease from the catchment, reinforced by historical channel corrections and modifications in the alluvial floodplain, gravel mining dramatically altered the channel morphology of the Drac River, which rapidly shifted from a braided to a wandering pattern, and which has been affected by an accelerated channel incision. One of the most damaging consequences of channel downcutting was the outcropping of ancient lacustrine clay deposits, very sensitive to erosion, which likely accelerated the lowering rate of the channel.

1.2 The hydromorphological restoration project

In order to stop channel incision and prevent damages on infrastructure (national road, isolated buildings, leisure center, agricultural fields), an ambitious restoration project was implemented between November 2013 and April 2014, and consisted in the creation of a new wide and shallow channel, a braided channel corridor, using more than 355,000 m³ of coarse sediment (Fig. 1).

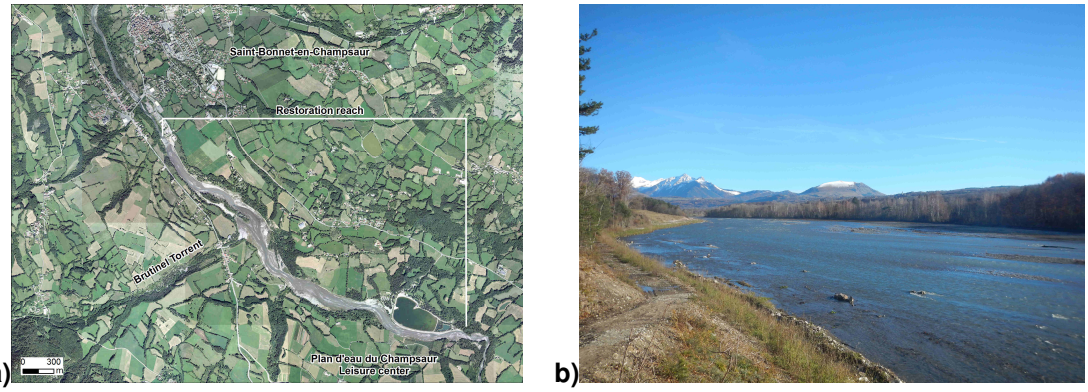

Figure 1. The restored reach of the Upper Drac River: **a)** Location near St-Bonnet-en-Champsaur (©BD Ortho 2017, ©IGN); **b)** view of the restored reach looking upstream (©Irstea).

2 MONITORING ACTIVITIES

An intensive physical monitoring program of the restored reach started in 2016, in parallel with the

monitoring of the ecological response of the reach (HyMoCARES Alpine Space project). The main objective of the physical monitoring program is to capture the geomorphic responses of the newly created channel morphology along a 3.7 km reach on the Upper Drac River, close to St-Bonnet-en-Champsaur, and to provide a record of the expected self-recovering towards a braided corridor. The physical monitoring combine (i) repetitive high-resolution topographic surveys of the restored reach, based on a combination of UAV-SfM surveys and airborne LiDAR data (Table 2), (ii) a bedload tracing program using active ultra-high frequency RFID technology, (iii) a high-frequency qualitative survey of channel changes using time-lapse cameras, and (iv) ancillary field surveys for specific data analysis (e.g., bedload transport computation, calibration of imagery-based data processing).

Table 2. High-resolution elevation data of the Drac River restoration project.

Date of the survey	Type of survey	Data source	Before/after restoration
02/08/2011	airborne LiDAR	CG05 / Sintegra	pre-restoration
10/15-28/2013	airborne LiDAR	CLEDA / Vinci	pre-restoration
04/11-17/2014	dGPS terrestrial survey	CLEDA / Vinci	post-restoration
09/10/2015	airborne LiDAR	CD05 / Sintegra	post-restoration
09/22/2016	airborne LiDAR	CLEDA / BURGEAP / Sintegra	post-restoration
09/04-05/2017	UAV+SfM surveys	Irstea	post-restoration

Field campaign data (GPS points and photos) were used to generate a high resolution DEM and orthophoto with the SfM photogrammetry method (Fig. 2).

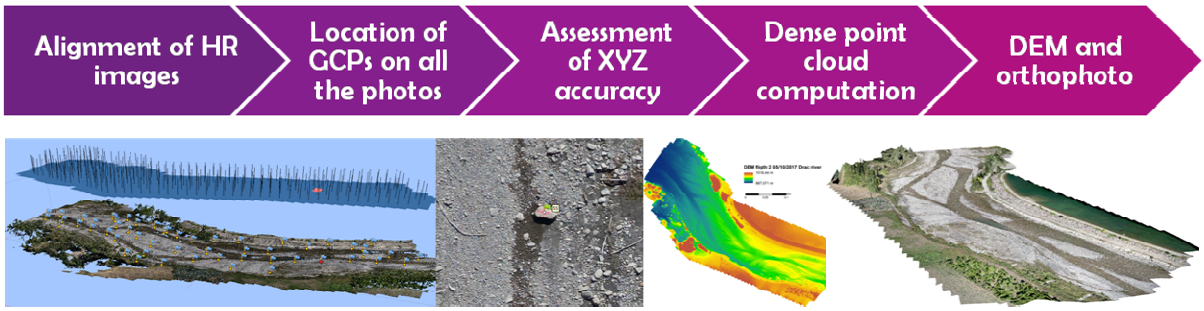

Figure 2. Processing of field-work data for producing a HR DEM and orthophoto.

Preliminary results of this monitoring program, mainly the assessment of relief variation with sequential 3D point clouds, allow us to evaluate the first morphological effects of the restoration project (Fig. 3).

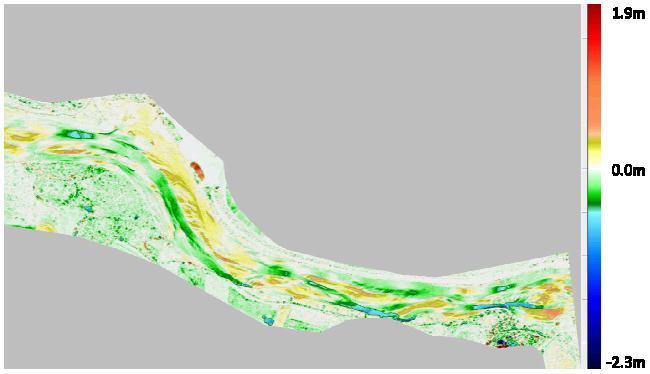

Figure 3. DEM of difference between 2015 and 2016 LiDAR datasets (©Sintegra).

3 CONCLUSIONS AND OUTCOMES

High resolution LiDAR and SfM 3D point clouds will be used to extract several morphological variables and to quantify different geomorphic processes along the restored and the reference reaches Hydrological records from the Ricous gauging station will be used for the interpretation of geomorphic change detected by repetitive surveys. Two other objectives of this study is to characterise the superficial grain size on gravel bars based on roughness metrics (correlation with some field-work measurements) and to test the potential of SfM technics to characterise elevation in submerged areas of the active channel by comparing results with bathymetric measures done in the field with a DGPS.