Sand dynamics at the Isère-Rhône confluence

Dynamique du sable à la confluence Isère-Rhône

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RÉSUMÉ

La confluence entre l'Isère et le Rhône est un système complexe fortement anthropisé. La Basse Isère est en effet aménagée avec six retenues au fil de l'eau et débouche sur le canal d'amenée de l'usine de Bourg-lès-Valence, lui-même muni du barrage Isère permettant d'évacuer partiellement les flux de l'Isère vers le tronçon court-circuité du Rhône lors d'une crue. Un protocole de chasse est établi sur la Basse-Isère selon des consignes dépendant du débit de l'Isère en crue et du débit du Rhône. Du fait d'une hydrologie défavorable, seule deux chasses ont pu être effectuées ces 15 dernières années (2008 et 2015) et ont eu pour conséquence d'importants dépôts sableux au niveau de la confluence Isère et du canal d'amenée. Nous proposons ici une étude de la dynamique des sables sur la confluence Isère-Rhône sur la base d'une analyse des dépôts et de leur reprise pour les événements de 2008 et 2015, des mesures de flux sableux réalisés lors de l'événement de 2015 ainsi qu'une modélisation numérique bidimensionnelle de ce dernier. Cette étude a pu montrer que la capacité de transport des sables a été largement atteinte lors de ces deux événements démontrant une sédimentation importante de ces sables dans les retenues de la Basse-Isère sur la période inter-chasse et que ces sables se déposaient directement à la confluence créant un dépôt progressant initialement vers l'amont. Des mesures complémentaires sont aujourd'hui mises en place en vue d'une évolution du protocole de chasse amenant une occurrence de chasse plus forte.

ABSTRACT

The Isère-Rhône confluence is a complex system largely engineered. Six run-of-river dams were built in the downstream part of the Isère River. It meets the Rhône River at a bypass canal 5 km upstream the Bourg-lès-Valence hydropower plant. The Isère dam located in the middle of this reach allows a derivation of the Isère waters to the Old-Rhône in case of floods. A protocol for the Isère river dam flushing was set depending on both Isère and Rhône river discharge. Due to an unfavourable hydrology, only two flushing events occurred these last 15 years, in 2008 and 2015, respectively. Both events led to large sandy deposits at the Isère-Rhône confluence and in the bypass canal. We present here a study of the fine sand dynamics at the Isère-Rhône confluence based on an analysis of the bathymetric data achieved during the 2008 and 2015 events, sand fluxes measurements made in 2015 as well as 2DH modelling of the system for the latest event. Main conclusions are that a large input of sand from the dam reservoir was observed for these two events allowing the river to reach its sediment transport capacity. Most of the sediments settled at the confluence creating a large deposits progressing upstream. Complementary measurements are organised at present to better estimate sand fluxes and bed evolution in order to propose a new flushing protocol that prevents from large deposit formation.

KEYWORDS

Sand dynamics, Isère-Rhône confluence, Dam flushing event

1 INTRODUCTION

The Isère-Rhône confluence is a complex system largely engineered. Six run-of-river dams built in the downstream part of the Isère River need to be flushed regularly in order to keep their reservoir capacity and to respect the 2006 regulation, which stipulates that a sufficient sediment transport should be released. The Isère meets the Rhône River at a bypass canal 5 km upstream the Bourg-lès-Valence hydropower plant (Figure 1a). The Isère dam located in the middle of this reach allows a derivation of the Isère waters to the Old-Rhône in case of floods. A protocol for the Isère river dam flushing was set depending on both Isère and Rhône river discharge. The Basse-Isère river dams are flushed during the decreasing phase of an Isère flood (larger than 1000 m^3/s). Dam reservoir are flushed for approximately one week (Fig. 1b: flushing phase); and then, they are successively close and refilled, the most downstream dam (Beaumont-Monteux) being closed after three weeks (Fig. 1b: dam filling phase). Due to an unfavourable hydrology, the two last flushing events since 2001 occurred only after seven years, in 2008 and 2015, respectively. They both led to large sandy deposits at the Isère-Rhône confluence and in the bypass canal that endangered navigation and increased the flood risk. The purpose of this work is to better estimate the total sand fluxes and dynamics along this system. The study is focused on the 2015 event based on bathymetric measurements, hydro-sedimentary stations along the Isère River and numerical modelling (Naudet et al., 2015, 2016).

(a) (b)

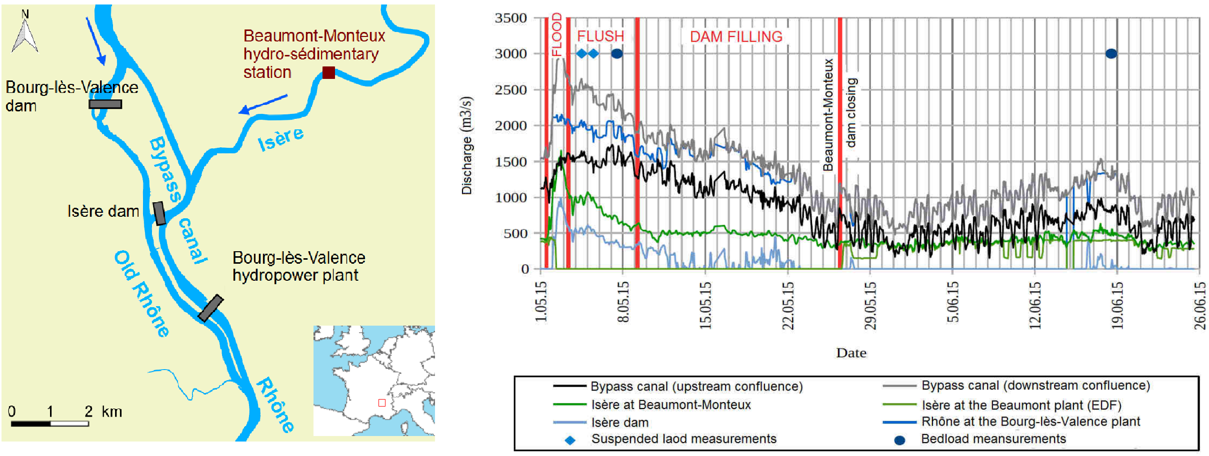

Figure 1: Location of the study site (a) and discharge time series of the 2015 flushing event (b).

2 ANALYSES ET RESULTS

2.1 Sediment budget

A sediment budget was made based on bathymetric measurements achieved by CNR on the downstream part of the Isère River and on the bypass canal (spring and June 2015), and by EDF on the five most downstream dams (2014 and summer 2015). A sediment budget on the reach including the five dams was made based on the measured Suspended Sediment Matter (SSM) fluxes at two hydro-sedimentary stations: Tullins and Beaumont-Monteux (BM). Two difficulties were encountered: (i) the conversion between volume and mass for deposits since a large uncertainty exists in the estimation of the fine sediment mixture density; (ii) hydro-sedimentary stations measure turbidity on the side of the river and so do not include sands that are mainly transported close to the bed (bedload or graded suspended load). The final budget is presented in Tab. 1.

From both hydro-sedimentary stations, one can observe that a net output of 5.2 M tons of fines was provided by the dam reservoirs. If we add the 5.3 M tons of sand deposited at the confluence, we can conclude that approximately 10.5 M tons of sediments were eroded from the reservoir (50% of which are sand), which corresponds to the maximum value estimated from the bathymetric measurements uncertainties included. A simple model was proposed and calibrated to estimate the instantaneous sand flux at the Beaumont-Monteux station (Camenen et al., 2014). To be able to reach to 5 M tons of sand, we made the hypothesis that the sediment capacity was reached during the flood and flush phases since the BM dam was opened (but with regulated water depths during the flood phase). During the filling phase, an exponential decrease of the sediment capacity was assumed to be consistent with the two bedload campaigns achieved on 7th and 18th May (Fig. 2a).

Table 1 : Sediment budget of the downstream part of the Isère River after the 2015 flushing event.

Site	Type of sediments	Volume (M m^3)	Mass (M tons)	Uncertainties
Hydro-sedimentary station (Tullins)	Fines		2.4	0.5 (20%)
Bathymetry Isère River dams	Fines + Sands	4.8	7.5	2.5 (30%)
Hydro-sedimentary station (BM)			7.6	1.5 (20%)
Bathymetry Isère-Rhône confluence	Sands	3.3	5.3	1.0 (20%)

2.2 Numerical modelling

A 2DH numerical model of the Isère-Rhône confluence was built to model the 2015 flushing event (using Rubar20TS developed at Irstea Lyon). The BM station was used for the upstream boundary condition for the Isère River together with the model for sand transport described above. It provided good results for the flushing period on the downstream part of the Isère reach showing that sand started to settle at the mouth of the Isère River. Eventually, the sand deposit got bigger and progressed upstream (Fig. 2b). Thanks to these results, dam managers agreed to focus on bathymetric measurements at the mouth of the Isère River for the future flushing event to prevent from a critical deposit size and provide a stop signal for the flushing event.

(a) (b)

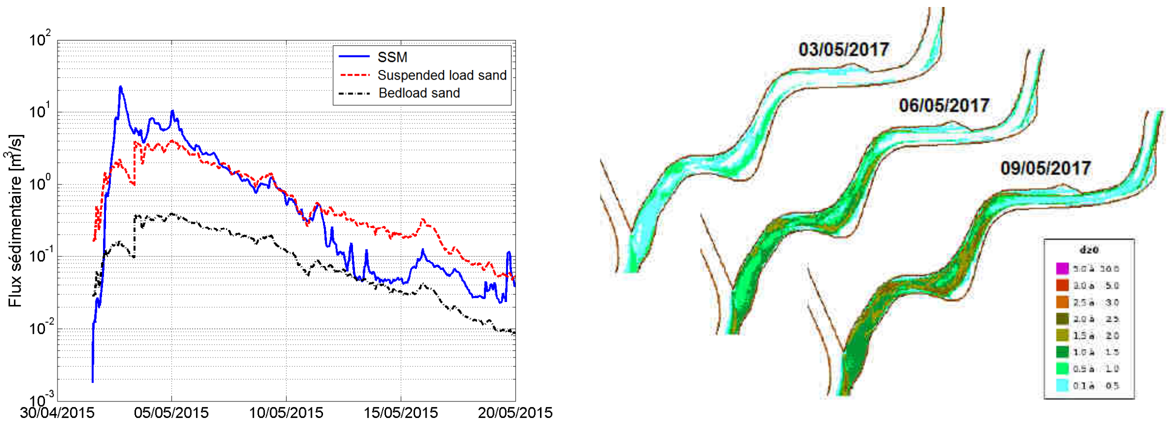

Figure 2: Estimation of the SSM and sand flux at BM (a) and deposits at the downstream part of the Isère River observed during the flushing period (beginning: 03/05 to end: 09/05) thanks to 2DH modelling (b).

3 CONCLUSIONS & PERSPECTIVES

Measurements and estimation of sand dynamics remains quite difficult in rivers. We presented a specific case where dam reservoirs largely influence the sand dynamics, which is reduced to flushing events. If these events are seldom, it may lead to large deposits at the Isère-Rhône confluence and so largely affect the Rhône River management. The 2DH modelling provided interesting results that give a base for implementing new monitoring strategies for the future flushing events. It was however not possible to model the bypass canal since 3D phenomena occurred: the denser waters of the Isère River plunged below the Rhône waters forming a two-layer flow until the Isère dam. The next challenge will be to model such phenomena using a quasi 3D model (Telemac).

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