# Origin of sand suspension measured in the River Rhône at Lyon-Perrache during a flood

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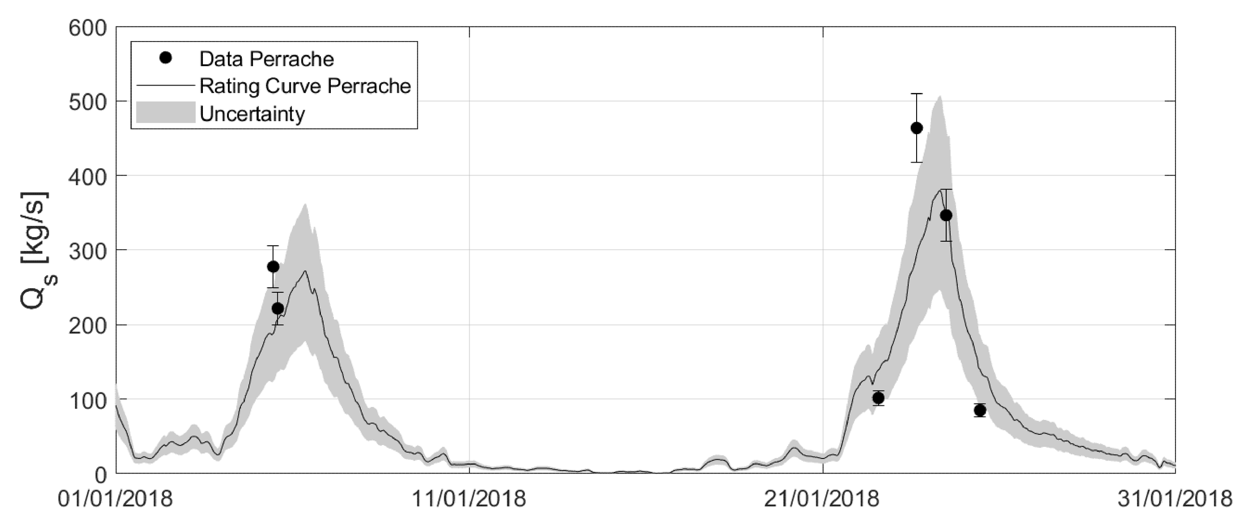
## Context of the study

The estimation of **sand transport in gravel bed rivers** is a complex task since bedload or suspended load may prevail depending on hydrodynamic conditions and because sediment transport capacity may be affected by an insufficient sediment supply. A challenge is first to sample suspended load due to strong vertical and lateral gradients and such direct sampling, though necessary, has a prohibitive cost and cannot provide high frequency estimates. A **sediment rating curve** may be applicable if the system is not supply limited. Dramais (2020) measured suspended load in the **River Rhône at Lyon-Perrache** during the **January 2018 flood**. He proposed a sediment rating curve model based on Bayesian inferring to evaluate continuously the suspended load. Eventually, he obtained a **total sand flux of 175 000 tons**. The object of this study is to understand where the stocks of fine sediment were to supply this system.




## Fine stock evaluation

Fine stocks available in the reach upstream of the measurement station at Perrache were evaluated using the Deng et al. (2023) methodology

Dry patch


Sieving at 10mm, 2mm, 500µm and 100µm with a volume $V$ of water → concentration $C$ of sediments finer than 100µm

Underwater patch (McNeil)


Local surface and subsurface stocks

$$S_s = \frac{M_{s,[0.1-2]mm}}{A_p}$$ in kg/m² — $A_p$ : sampling area

$$S_b = \frac{M_{b,[0.1-2]mm}}{A_p H_b}$$ in kg/m³ — $A_p$ : sampling area

## Fine stocks resupended during the flood

We use of a 1D model (Mage, INRAE) to evaluate the surface of the active width under water as well as the averaged bed shear stress. The erosion depth is evaluated such as (Pugh & Wilson,1999) : $\delta = 10 d_{90}\theta$

Based on a combination of GIS surface evaluation for each homogeneous zone (bar head, bar tail, secondary channel, etc.) and numerical modelling, one have :

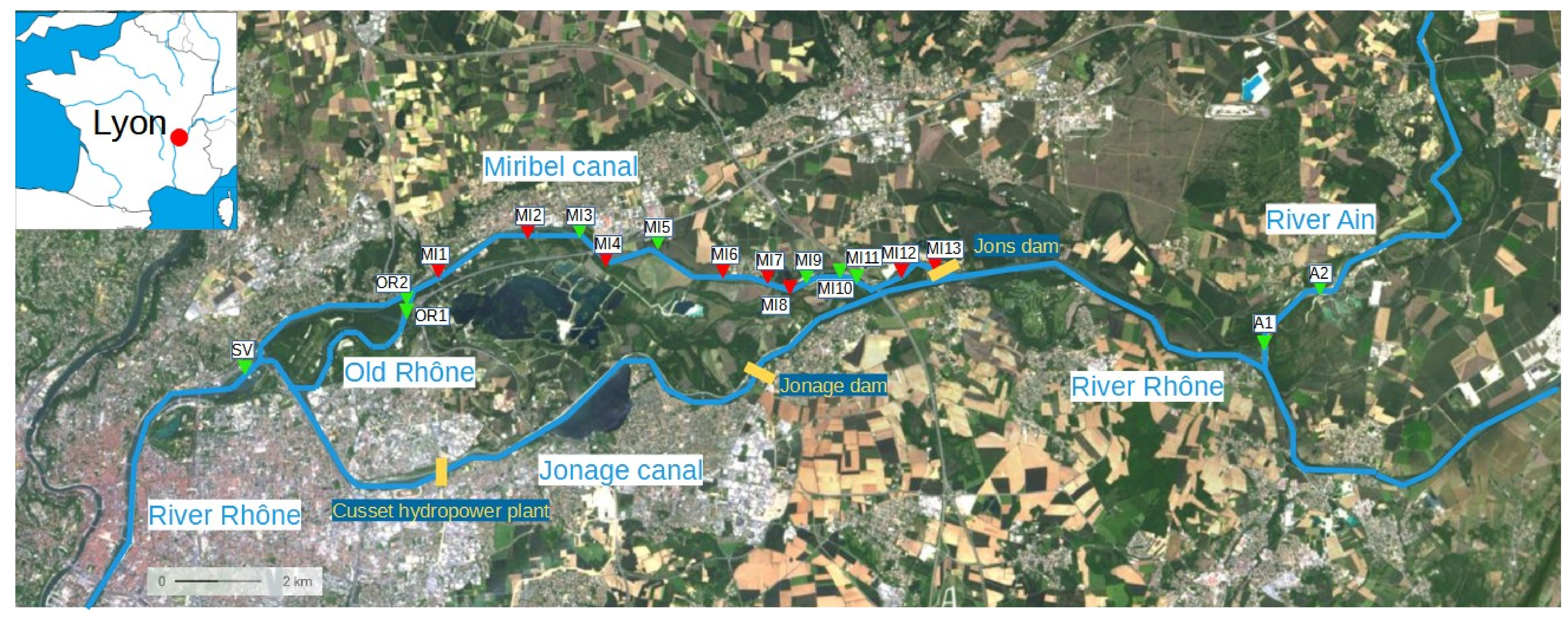
$$S_b = \sum_i \left(S_{s,i} A_i + S_{b,i} A_i \delta_i\right)$$

$S_{s,i}$, $S_{bi}$ : surface and sub-surface fines stocks for the homogeneous zone $i$
$A_i$ : surface area of the homogeneous zone $i$

Eventually, for a total surface area of approximately 30 ha investigated, a total stock of 1900 tons of sand was found, 1600 tons corresponding to the surface layer, which represents 1 % of the flux measured during the 2018 flood. The subsurface volume is however largely underestimated, especially for the River Ain that observed significant avulsion of the main channel.

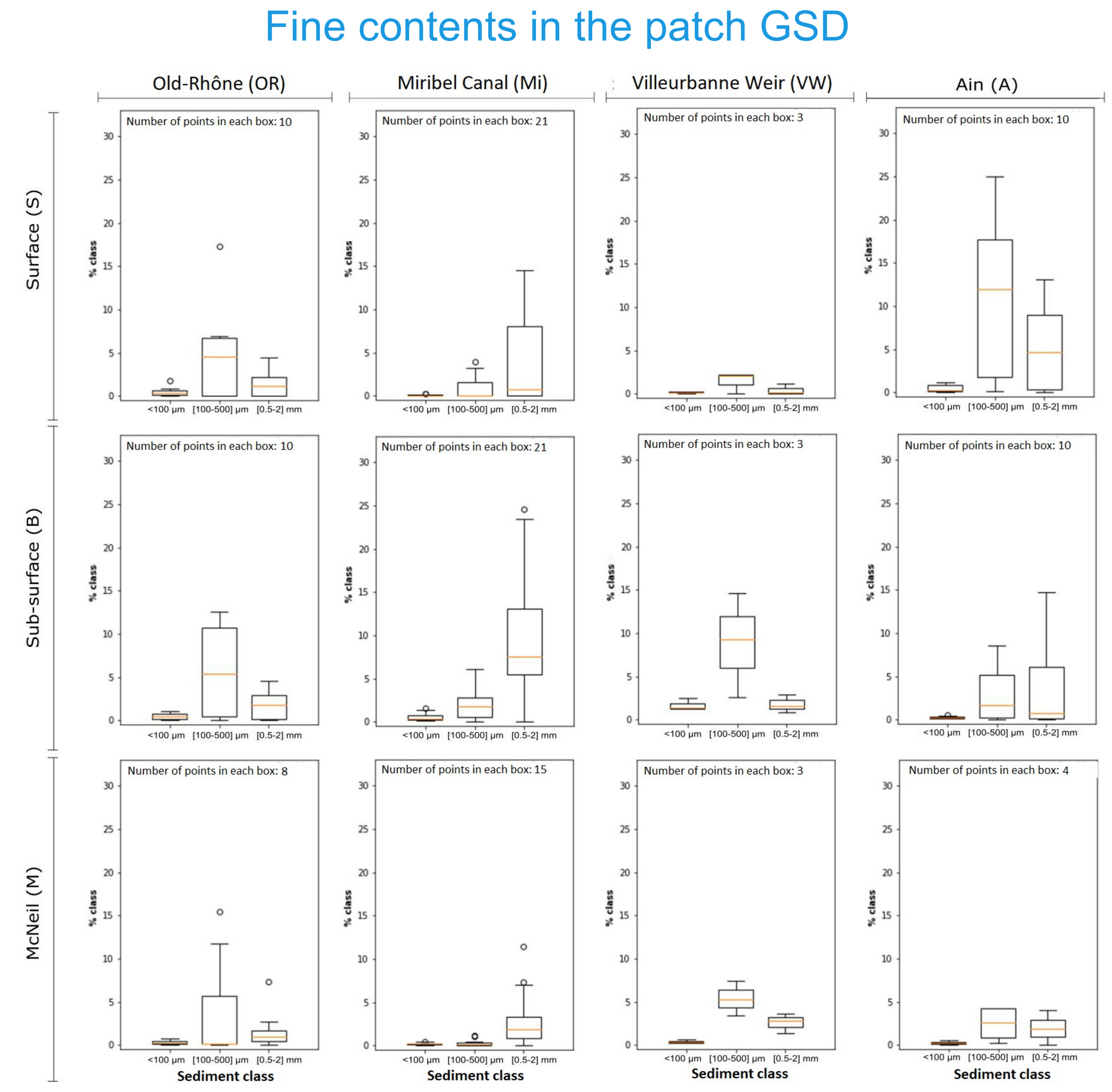
## Study site

The study site is on the River Rhône upstream of Lyon, France. It includes a multi-channel system (Miribel-Jonage) fully engineered. A hydropower plant is located on the Jonage canal (max discharge 640 m³/s). A minimum discharge (90 m³/s) is set for the Miribel canal ; in case of flood, all water that cannot be turbined goes to the Miribel canal.

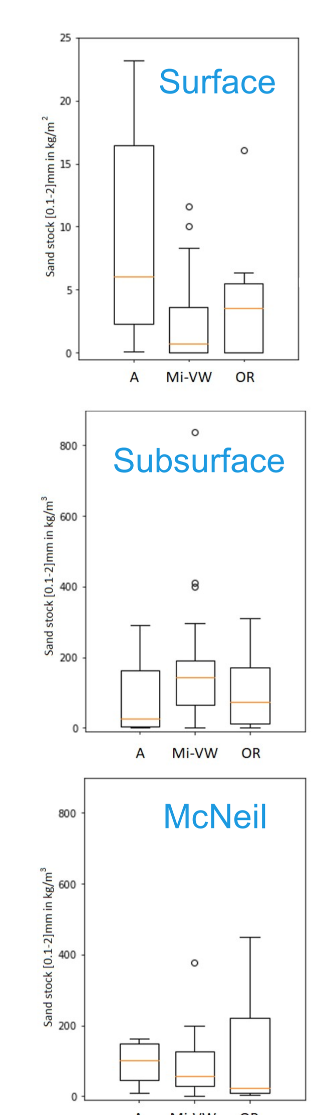



## Local patch results

Fine contents in the patch GSD



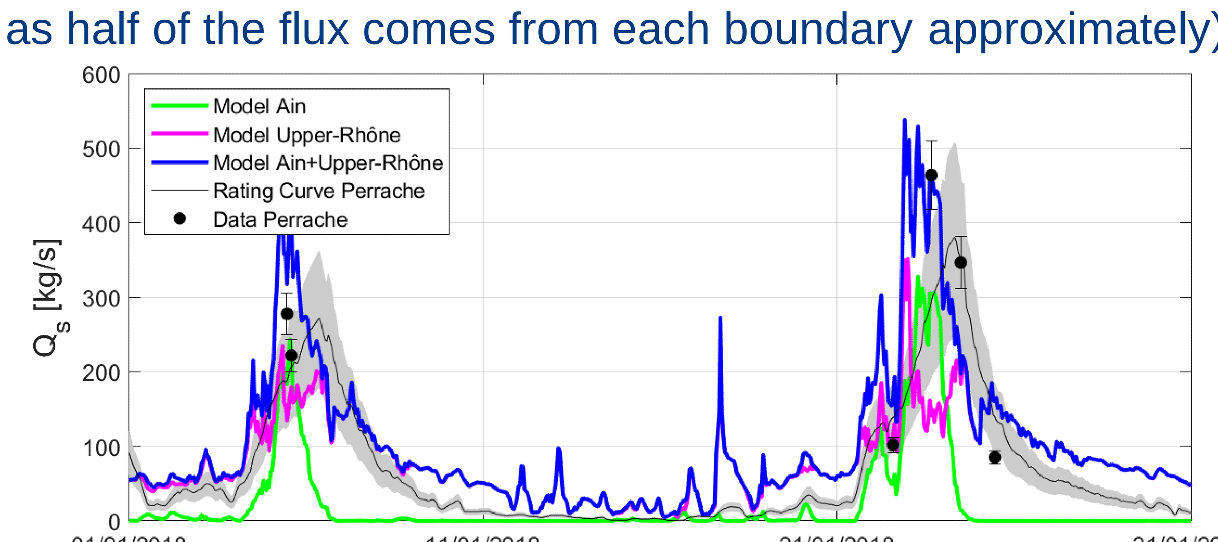

Fine stocks




The Old-Rhône, Villeurbanne weir and Ain sites are particularly rich in fine sands [100-500 µm] (~5%), Miribel sites include more coarse sands [500 µm-2 mm] (~5%). Potential stocks in surface larger for the Ain sites but equivalent in subsurface for all sites

## Numerical modelling

The hydro-sedimentary numerical model (Mage-AdisTS, Guertault et al., 2016) developped in the frame of the OSR (Rhône Sediment Observatory, Dugué et al., 2015) was used for simulating the 2018 flood. Water discharges from hydrometric stations (Port-Galland, River Ain ; Lagnieu, River Rhône) were used for the upstream boundary conditions. A sediment rating curve ($Qs=aQb$ with $b$=2 and $a$ fitted such as half of the flux comes from each boundary approximately).




The flood peaks were slightly smoothed due to floodplain inundation, which was not properly modelled. However, results remain consistent and show that a sediment rating curve established on the River Rhône at Perrache may underestimate the input from the River Ain, showing that the system is potentially supply-limited.

Centre
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## References

- Dramais, G. (2020). Observation et modélisation des flux de sable dans les grands cours d'eau [Observation and modelling of sand fluxes in large rivers]. PhD thesis, Claude Bernard University, Lyon 1, 313p. (in French)
- Deng, J., Camenen, B., Legout, C. & Nord, G. (2023). Estimation of fine sediment stocks in alpine rivers including the sand fraction. In revision for Sedimentology.
- Dugué, V., Walter, C., Andries, E., Launay, M., Le Coz, J., Camenen, B & Faure, J.-B. (2015). Accounting for hydropower schemes' operation rules in the 1D hydrodynamic modeling of the Rhône River from lake Genova to the Mediterranean sea. Proc. 36th IAHR Congress, paper 3366 : The Hague, The Netherlands
- Guertault, L., Camenen, B., Peteuil, C., Paquier, A. & Faure, J.-B. (2016). One dimensional modelling of suspended sediment dynamics in elongated dam reservoirs. Journal of Hydraulic Engineering , 142(10-04016033) : 1-9.
- McNeil, W. J. & Ahnell, W. H. (1964). Success of pink salmon spawning relative to size of spawning bed materials. US Department of the Interior, Bureau of Commercial Fisheries. Special Scientific Report-Fisheries, 469, 17.
- Pugh, F. J. & Wilson, K. C. (1999). Velocity and concentration distributions in sheet flow above plane beds. Journal of Hydraulic Engineering, 125(2):117-125.

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