Riverwatching meeting

Bedload vs morphological active width: insights from lab experiments

Padova - 09/10/2024

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Questions

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1. How do bedload active width and morphological active width differ with the type of gravel-bed rivers?
2. How does active width change across different temporal scales at which it is measured?

I. Laboratory experiments and dataset

II. Bedload vs morphological active width

Results of experiments

Overview of some river investigations

III. Futur lab experiments

I. Laboratory experiments and dataset

I.1. Experimental design

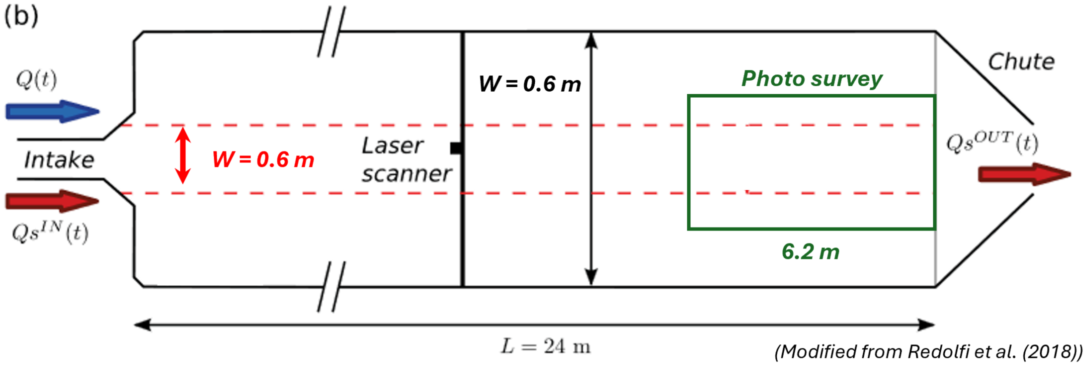
(a)

Parameters:

- *Width = 0.6 m*
- *Slope = 0.01*

run_code	Q [l/s]	Qsin (g/s)	Stream power *
q05_1	0.5	0.25	0.07
q07_1	0.7	0.39	0.11
q10_2	1.0	1.143	0.14
q15_2	1.5	2.46	0.2
q20_2	2.0	3.58	0.25

(b)

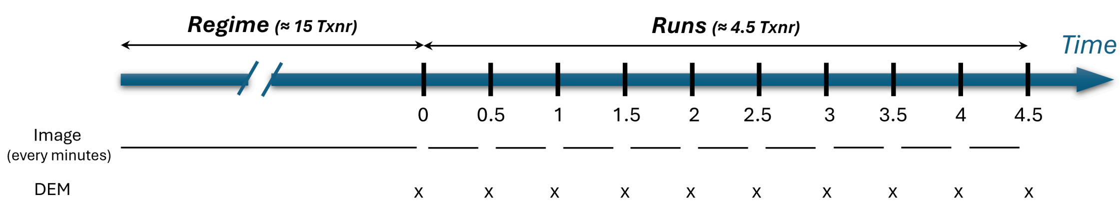


(Modified from Redolfi et al. (2018))

- The flume is 24 m long and 3 m wide
- For these experiments: Width = 60 cm
- Slope = 1%

- We performed 5 experiments increasing the water discharge from 0.5 l/s to 2.0 l/s and sediment flux from 0.25 g/s to 3.6 g/s.
- For q05 --> close to the threshold of motion
- To assess instantaneous bedload transport: performed photo survey and used time-lapse imagery technique (at the donwstream end of the flume)
- To quantify morphological changes : topographic surveys with a LiDAR

Exner timescale: $\boxed{T_{xnr} = \frac{D.W^2}{Q_s}}$

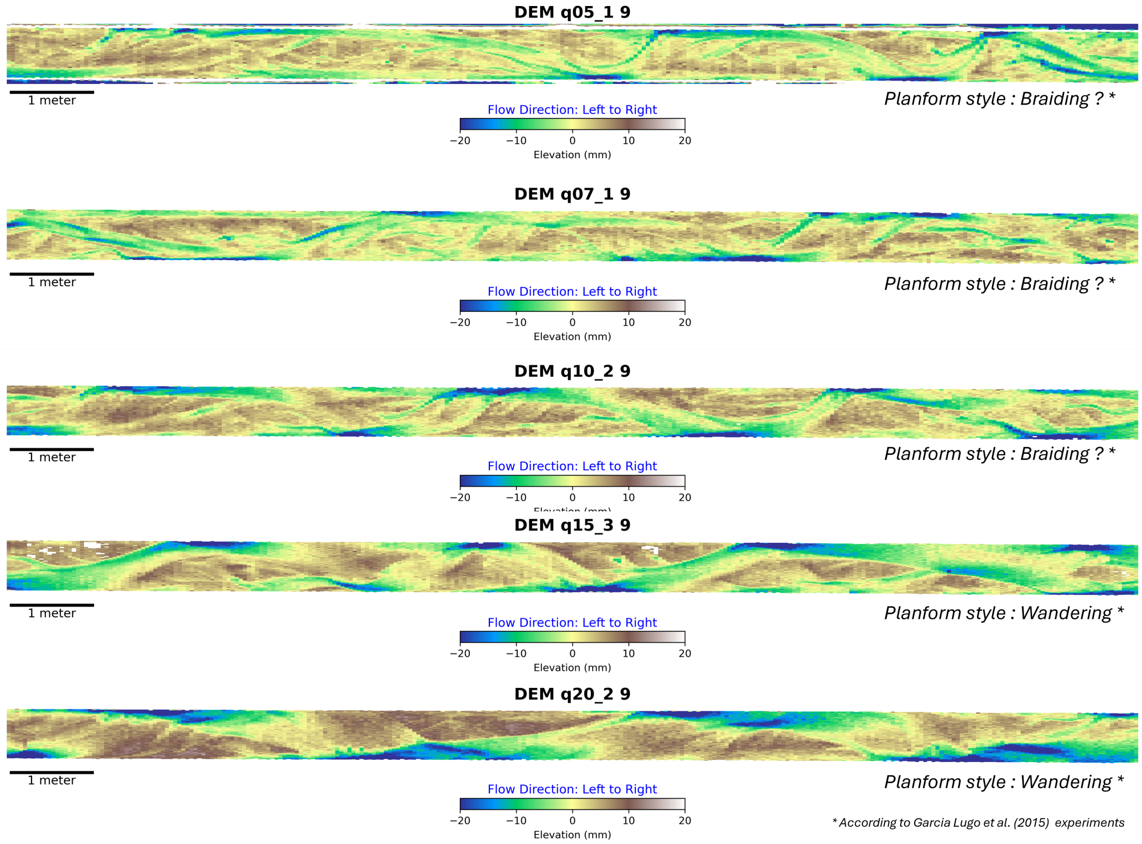


run_code	Q [l/s]	Qsin (g/s)	Txnr (min)
q05_1	0.5	0.25	109
q07_1	0.7	0.39	74
q10_2	1.0	1.143	48
q15_2	1.5	2.46	30
q20_2	2.0	3.58	20

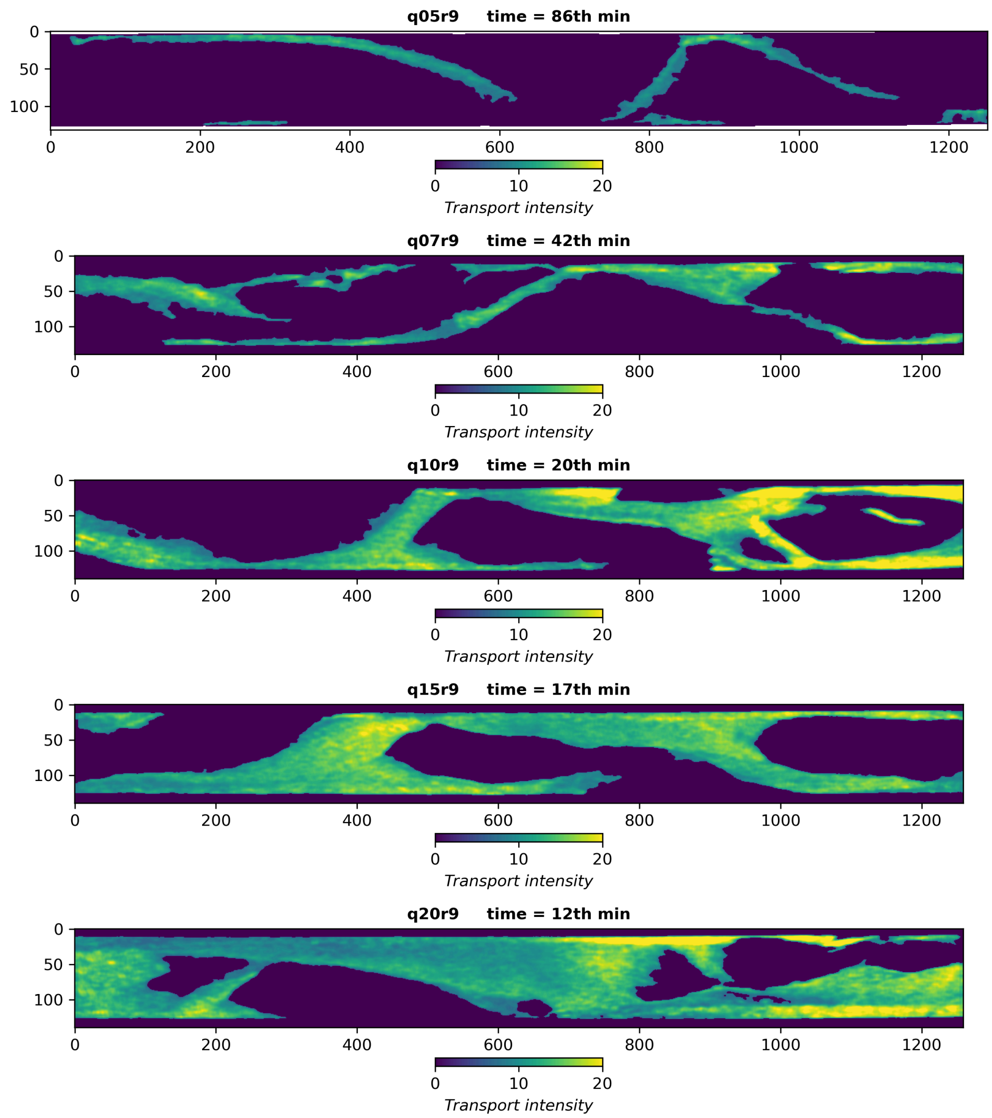
1 min q20_2 = 5.2 min q05_1

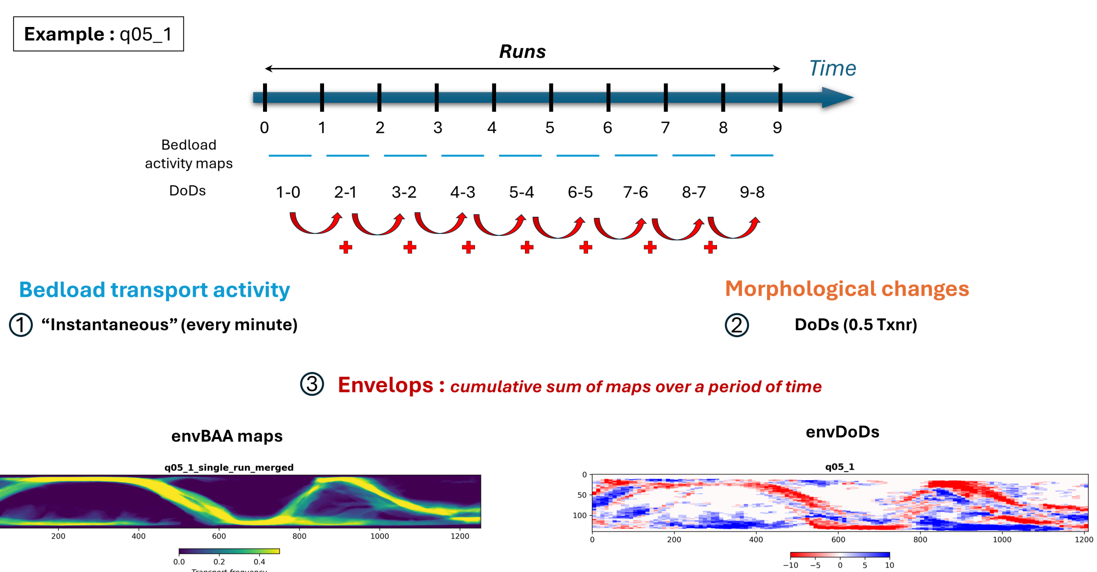
- How were the experiments designed?
- First: The duration was set with reference to the conservation of sediment mass equation (the Exner equation), to reproduce a similar time scale for morphological evolution of each experimental conditions.
- Describe the figure

I.2. Resulting dataset



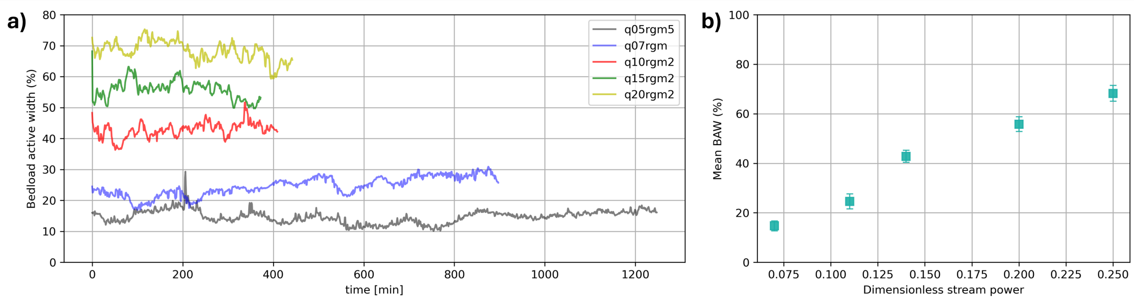
Bedload activity maps every minute (example)


q05r9 time = 86th min
Transport intensity
q07r9 time = 42th min
Transport intensity
q10r9 time = 20th min
Transport intensity
q15r9 time = 17th min
Transport intensity
q20r9 time = 12th min
Transport intensity


Example : q05_1
Runs
Time
0 1 2 3 4 5 6 7 8 9
Bedload activity maps
DoDs
1-0 2-1 3-2 4-3 5-4 6-5 7-6 8-7 9-8
Bedload transport activity
① "Instantaneous" (every minute)
Morphological changes
② DoDs (0.5 Txnr)
③ Envelops : cumulative sum of maps over a period of time
envBAA maps
q05_1_single_run_merged
Transport frequency
envDoDs
q05_1
Difference of elevation (mm)

II. Bedload vs morphological active width

I.1.1. Bedload active width through time

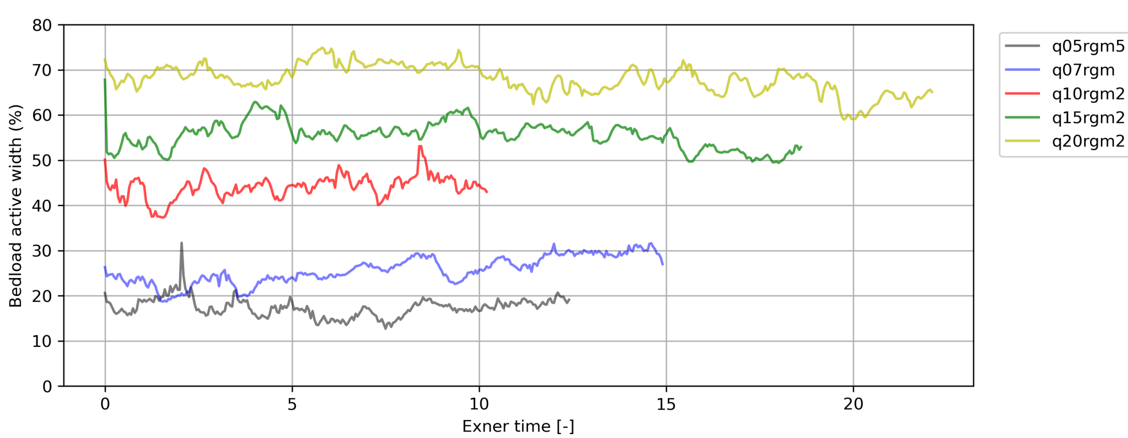


- This is the reach-averaged bedload active width evolution through time for each experiment (in min)
- It's important to note that it is the first time that the bedload active width is assessed continuously through time. Even among flume experiment study.
- The reach-averaged bedload active width increases with dimensionless stream power.
- We can observe that the variability is quite low (around 10%) and doesn't seem to change in function of the stream power --> confinement?

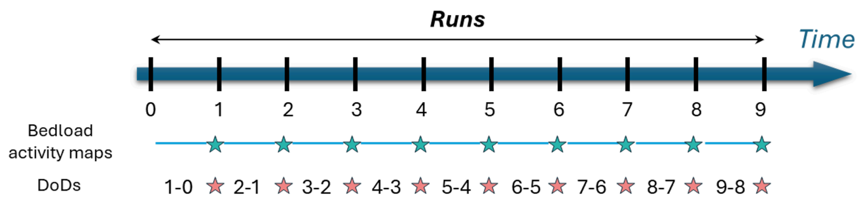
Exner timescale:

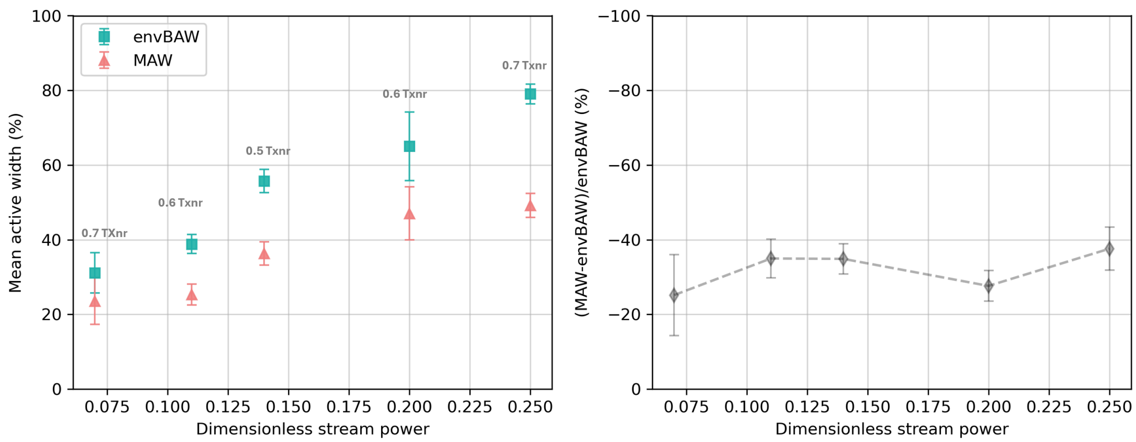
$$T = \frac{D \cdot W^2}{Q_s}$$

D: water depth (m); W: wetted width (m); Qs: Sediment flux (m3/s)



I.1.2. Mean active width - w* relationship

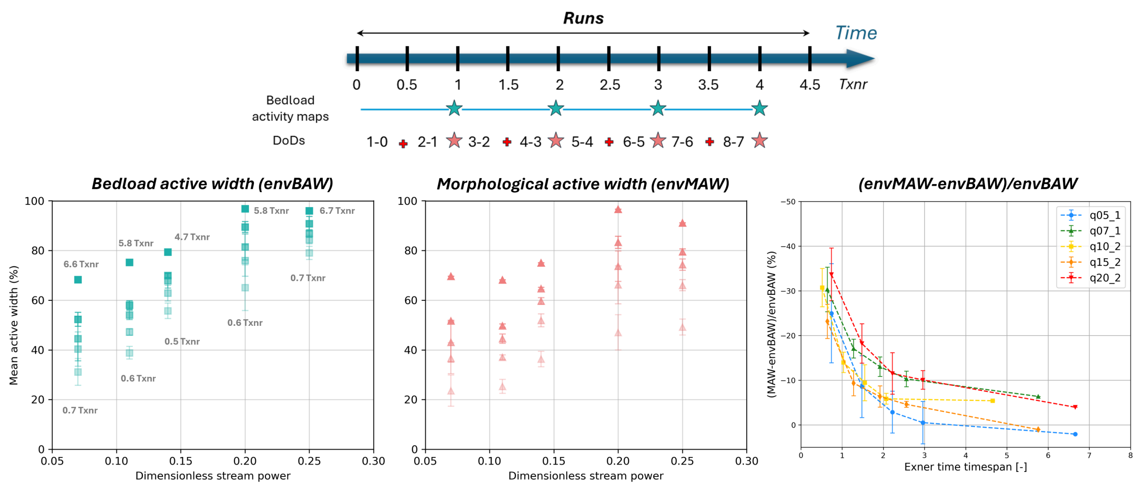




The morphological active widths is around ***30% lower than the envBAW.***

- These are both the reach_averaged bedload and morphological active width for a timescale of 0.5 Txnr.
- For BAW I computed the envelop from all the images in a run.
- The MAW also increases with stream power (except the last one)
- The MAW is always lower thant the envBAW (hopefully)
- The result differs from what has been proposed in the literrature that in braided rivers, most sediment transport induces morphological changes.
- This is the first attempt to quantify the 'missing' bedload transport from morphological changes.
- Comment: the q05 might appear higher because it is not 0.5Txnr but 0.7

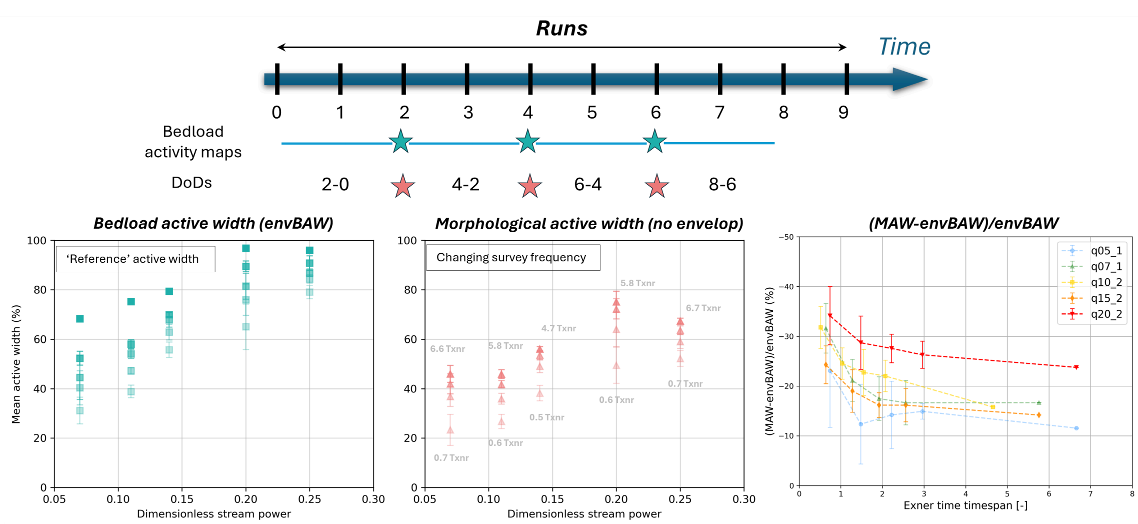
I.1.3. Cumulative mean active width - w* through time considering various exner timescales



The BAW can be acccurately assessed from MAW when integrated in time

- Explanation of the plots and cumulative time (example wit 1.Txnr)
- How the active width/area ?
- How long it takes for sediment transport to occur on the entire riverbed?
- The range of reach-averaged BAW decreases with stream power. This is due to the increase of the confinement with w*.
- This is not the case for MAW. 4 reasons for that: compensation, non morphological transport, travelling bedload and filtering processing.
- The difference between BAw and MAW decreases rapidly with the timescale of analysis. At 3 Txnr we are < 10%.
- No apparent trend with w*

I.1.4. Mean active width - w* changing the topographic survey frequency



- Explain the dataset used
- The range of MAW in function of w* is lower than the envMAW computed from the cumulative because we lost information with the increase of the survey frequency.
- It seems there is a limit in which the estimated MAW cannot be lower than 15% of the envBAW.

Conclusion

1. The active width estimated from morphological changes can be as high as 30% lower than the bedload active width for wandering and braided rivers.

2. This difference seems roughly constant with the dimensionless stream power.

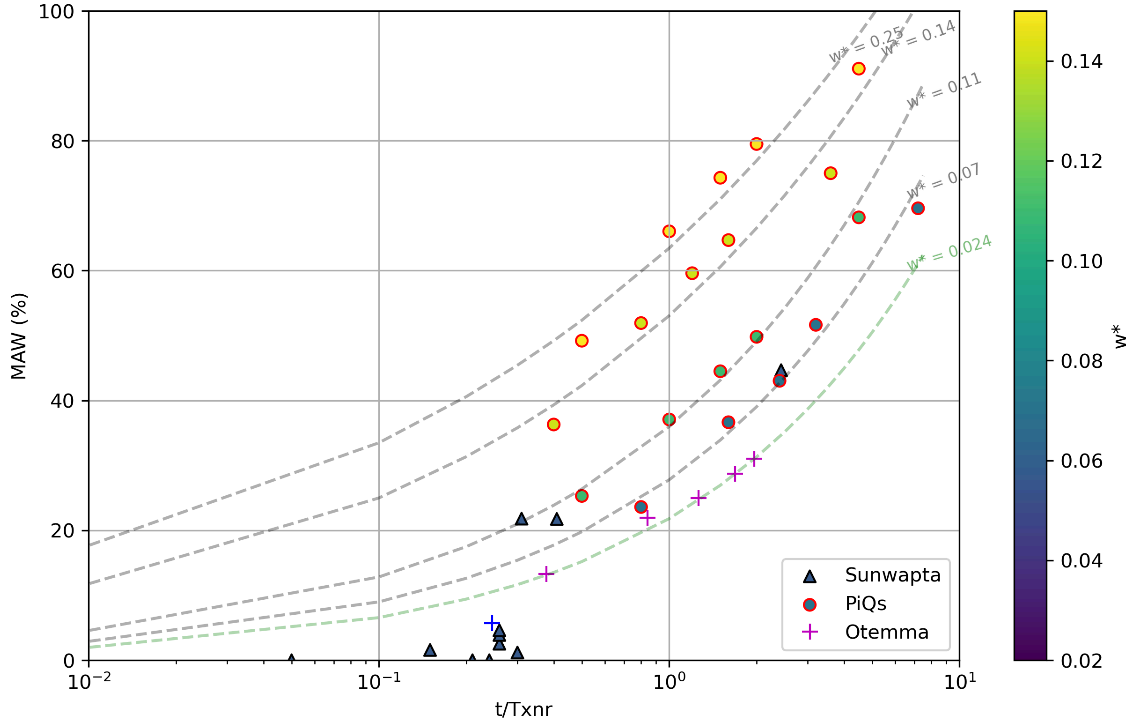
3. Increasing the survey frequency does not lead to more accurate estimation of the bedload active width at high temporal resolution. But it helps to better estimate it when integrated in time. This period of time depends on the dimensionless stream power.

Questions

1. What is the spatial pattern of both bedload transport and morphological changes? What is the link between morphological and transport processes ? (Enrico)

2. Can we observe a similar relationship between BAW-MAW and w* in function of the exner timescale in natural gravel-bed rivers? How can we link the result of the physical model with data from natural river systems?

I.2. Investigations of the MAW-w*-Txnr relationship on actual braided rivers: the cases of the Borgne, Sunwapta and Otemma rivers



II. Future lab experiments

Assessing bedload transport and morphological changes under unsteady water and sediment fluxes

Idea

issues

1. How to set the experiment/hydrograph duration with a continuously changing exner timescale?

2. How to scale the hydrographs with constant discharge experiments ?

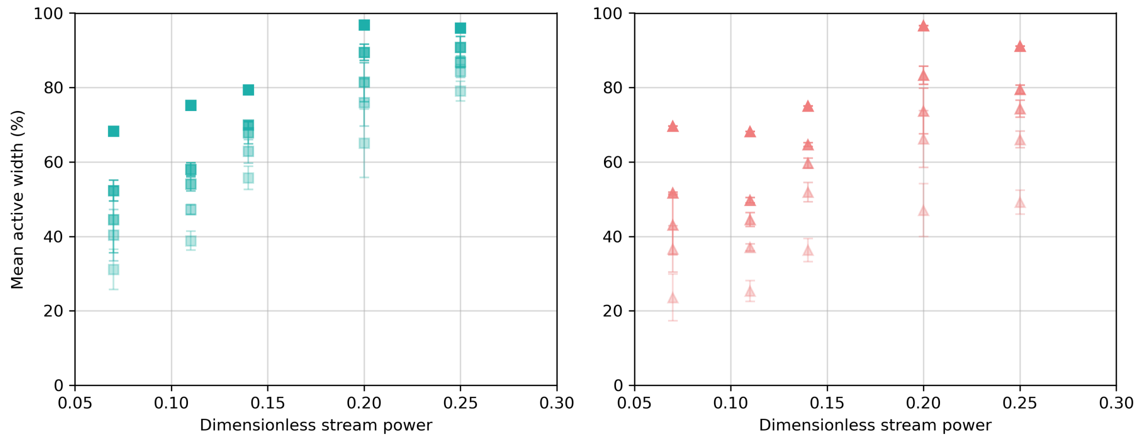
Tests

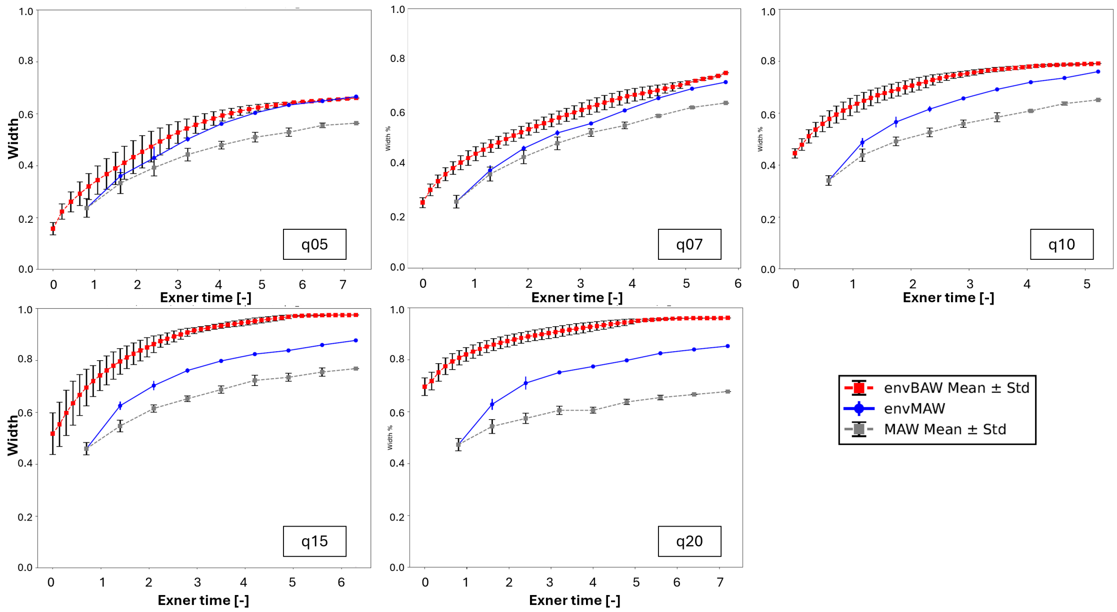
1. The output sediment flux need to be corrected from the water depth variation with discharge.

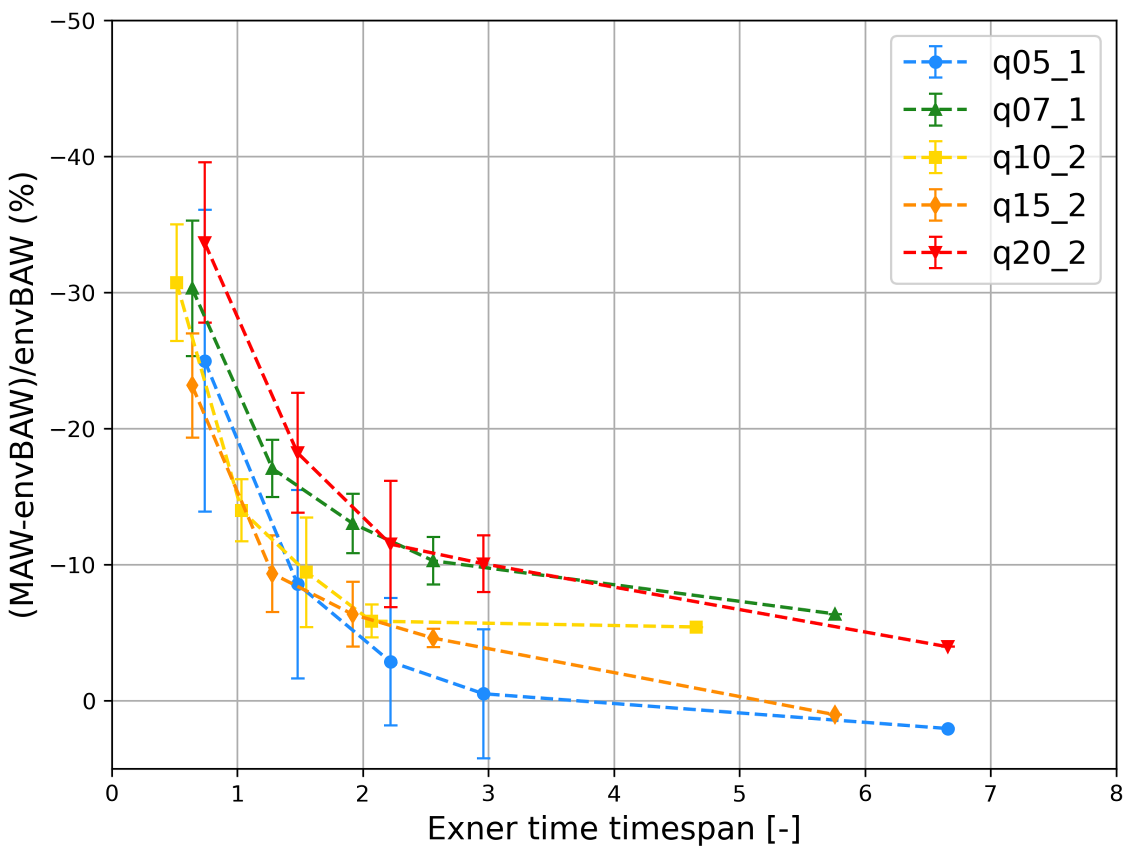
Test to ensure there good correlation between output water depth and discharge data. --> no dt

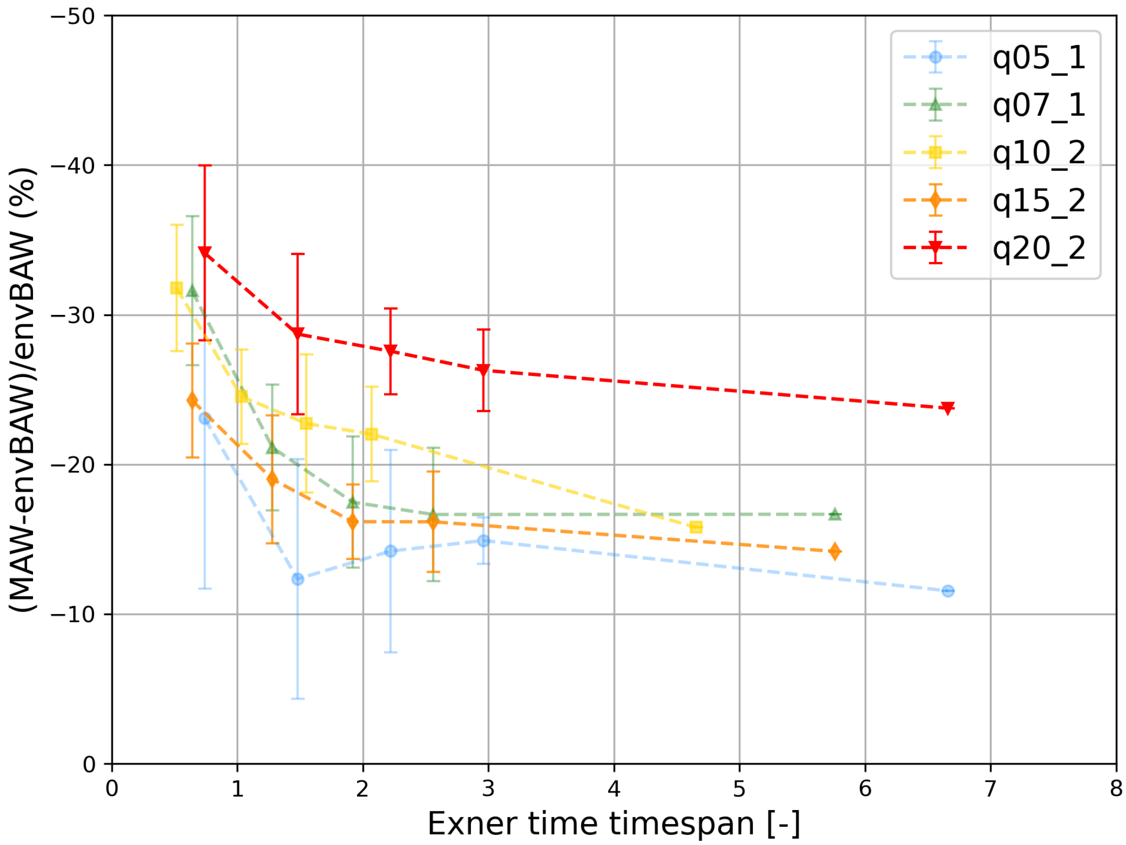
2. How the pump respond to a small increase in water discharge?

III. Supplements




Width
Exner time [-]
q05
q07
q10
q15
q20
envBAW Mean ± Std
envMAW
MAW Mean ± Std


(MAW-envBAW)/envBAW (%)
Exner time timespan [-]
q05_1
q07_1
q10_2
q15_2
q20_2



q05_1
q07_1
q10_2
q15_2
q20_2
(MAW-envBAW)/envBAW (%)
Exner time timespan [-]
−50
−40
−30
−20
−10
0
0
1
2
3
4
5
6
7
8

In [ ]: