

Dear Claire Masteller,

Thank you very much for your extensive editing of our paper and for your scientific comments and suggestions. We took them into account in this new version of our paper.

You will find here the answer to your comments and a new version of our paper. We include also, as requested, a version that shows the changes we made.

Hoping that this new version is suitable for publication, best regards,

Pascal Allemand for the Authors

1- I would suggest adding a broader motivating sentence to articulate why this new method is needed/important/represents an advance. And 2 - Repetitive to first sentence. again would suggest a final sentence to place results in the broader context of the field.

Following your suggestion, we have added several sentences both at the beginning and at the end of the abstract. (Lines 8 to 20 – line numbers refer to the version on which changes are indicated).

3 - It feels like there is a paragraph missing to bridge the gap between measuring bedload transport more broadly and the importance/specific issue of measuring boulder transport. I think it would benefit this manuscript to make this distinction somewhere in the introduction to better scope the work presented in the paper.

We fear that there is some misunderstanding about the use of the word « boulder » in our paper. We are not interested in boulders *per se*. Neither are we suggesting that boulders would be transported in a different manner than the rest of bedload particles. The reason why we focus on boulders is practical: the resolution of our images does not allow us to observe particles smaller than 0.10 to 0.15 m. We therefore restrict our analysis to sediment of size between 0.5 and 0.75 m — i.e. boulders — which are easier to track. However, the method we propose could be extended to smaller grains, given the appropriate optical resolution. We have added several sentences in the text — starting with the introduction — to clarify this point. (Lines 63 to 65)

4- This statement is very vague and is a bit disconnected. Overall, I feel this paragraph could better articulate why the specific questions that are posed remain open. What are the reasons that these questions remain - in particular, why are the methods that have been outlined in the previous paragraphs insufficient to address these questions or limit what can be learned?

We clearly write now that bedload transport is a process that combine stochasticity and intermittency. (first and second paragraphs of the introduction)

5- This is fairly vague - be more specific about what aspects of the composition

We have modified the paragraph and hope that the new version provides more information about this geochemical method (Lines 78 – 80).

6- This sentence is a bit jarring - seems out of place, I would suggest adding this definition in the previous sentence. I think this entire section could be slightly revised to be more clear/applied. I would reorganize to first discuss the georeferencing and accuracy of the orthoimages. I would then introduce the idea of superimposing orthoimages from different campaigns and to what end this is being done. I would then provide the additional detail that due to warping due to differences in georeferencing/construction of the orthoimages using photogrammetry (there is literature out there that focuses on this type of warping for photogrammetric models) how the orthophotos were modified to be compared/measured.

Thank you. We modified the description of the technique we use following your suggestions. References concerning georeferencing and image warping have been added. (Lines 115 to 135)

7- This is a bit unclear - what surface? what kind of error is computed here?

A is the exposed area of a boulder. We estimate that the uncertainty on the exposed area, A , of the smaller diameters is between 15 and 20 %. (Line 132)

8- This is a style difference, but in order to streamline the narrative it may be useful to remove this sentence and only focus on the analysis of the orthoimages.

Thank you for your comment. We use now the present tense in the active form.

9 - Is there a figure or quantitative metric that supports this or is this just from visual inspection? It would be good to clarify.

There is no quantitative metric that support this. We have modified the text. (Line 156)

10 - Is this that you don't have enough observations OR that because these boulders are smaller, that they are likely able to move in smaller flows, and therefore you cannot directly quantify their transport frequency since the observational data integrates over many floods? be clear of the limits of your data in this case.

We have only one dataset per year and we associate the maximum value of water discharge to the largest entrained or deposited boulder. So we do not have direct measurement for the smaller boulders which are the most numerous. (Lines 198 to 202)

11- Note that you've already used S as a variable for surface density. Revise and modify one of these for clarity.

Thank you. That is done.

12 – Line 233 to 235

There seems to be a bit of a logical leap here that may be hard for the reader to follow. As I understand it, you are taking your data points from figure 5 and back-calculating the shields stress that best matches those observations under the assumption that these largest boulders move under the maximum discharge.

Once you've calculated the associated critical shields stress, you then use that as a constant in equation 2 and modify D to solve for the threshold discharge for the transport of the smaller boulder class to determine how frequently those boulders may be entrained across the observational period.

As written, I am not sure that a casual reader would be able to readily follow this so I suggest that you make this more explicit by expanding this section.

The figure 5 has been simplified. We hope that now our presentation is clearer. We now limit our explanations to one value of water discharge and we indicate that the Shields stress value we use results from the fit to the data. (Line 220)

13 - What informs the bounds of this calculation? The bounds of D or some bounds on the threshold shields stress that you input into the equation, or both? It is unclear from the text why the Shields number is called "intermediate".

From our measurement and using the simple model we develop, we found that 0.032 is the best fit for our data set. More-over, this Shields value is in the range of the values found in literature. The adjective "intermediate" is suppressed now. The new version of figure 5 takes your comments into account.

14- Make clear that this is based on your calculation only, you do not directly measure/confirm this threshold in your dataset.

Now the text is: "In the previous section, we calculated that boulders of size 0.5 to 0.75 m move only when the river discharge exceeds the threshold value of $45 \text{ m}^3\text{s}^{-1}$." (line 220)

15- It is unclear why a range of threshold discharges is presented for this size class above but the effective transport time is only calculated for the $45 \text{ m}^3/\text{s}$.

We end the chapter 3.3 indicating that we choose the value of $45 \text{ m}^3/\text{s}$ as representative of the threshold for the range 0.5 to 0.75 m. We limit our consideration to only a value of threshold to avoid confusion. We are aware that is a limit of our method.

16 - 17 -18 This section is fairly confusing and it is difficult to parse what is being calculated using the simple model vs. what is being measured from the data directly.

I suggest revising to more clearly separate these efforts in the organization of this text. Further, additional details can be provided such as: the range of values observed across the observational period, what factors relevant to the dataset or the assumptions may influence the result, etc.

It seems like there are missing details here. Are you monitoring the number of the original boulders through time? From Figure 7, this is what I would guess, but it is not clear from the text.

It would be helpful to describe the number of boulders in the starting population and the criteria used to remove boulders - any indication of transport? disappearance from the bar completely? Etc

This is not entirely clear. Are you looking at the change of boulders on the annual scale or the change in the boulder population across the record at annual intervals? Or some combination of both, such that you look at the total number of boulders entrained over the course of a year between any two years on record, then the total number entrained over 2 year periods, so on and so forth?

I suggest that this section is revised to provide additional details for reader clarity

This section has been completely revised according to your suggestions (Lines 238 to 254). We describe first the evolution of the oldest population of boulders, i.e. the one which was present in 2011. Then we describe the evolution of the other populations and conclude that they follow the same evolution. (Lines 238 to 254)

19 - I agree with reviewer comments that this section can be expanded considerably to better place these results in the context of the general state of knowledge regarding sediment transport and similar work.

In particular, some discussion of boulder burial and sediment supply effects, as explored by Yager, would be appropriate to discuss here.

Further, a more thorough discussion of the potential sources of uncertainty or the limitations of this approach could be appropriate here. It appears that there can be quite a range of values surrounding the central trend highlighted in Fig 7.

In particular, individual years appear to plot above or below exponential fit, such that for a cumulative time of 30 hours, it appears that 30%-60% of boulders would move depending on the year. Some discussion of what additional factors may introduce variability around this generalized relationship (such as sediment supply differences and associated differences in boulder protrusion) would be appropriate to include here.

We have completely rewritten the discussion- conclusion section and added a paragraph that discusses the limits of the approach we propose. We hope that this new version is to your satisfaction.

The figures have been redrawn and their captions rewritten according to your recommendations.