

Review for egusphere-2024-4111, title: A physical model for mean river discharge calculation: from riverside seismic monitoring experiments in a low flow river, China

The manuscript by Xiaoyue Zhou and co-authors investigates the relationship between flow discharge and seismic data along a natural reach of the Jiuqu River, a tributary of the Meishui River in China. Using seismic geophones alongside flow depth and velocity measurements, they link flow phenomena to seismic signals generated by forces acting on the riverbed during a one-day monitoring period. Their analysis distinguishes between noise from human activity and seismic signals related to stream flow, identifying turbulence as the primary contributor to seismic waves at frequencies below 10 Hz. They test whether seismic power can be used to estimate stream discharge (Figure 11) and propose an empirical equation that incorporates contributions from various environmental sources. By calibrating their model on part of the data, they determine a coefficient that allows them to predict flow using unseen data. Their model performs well across three experiments, aligning closely with discharge measurements (Figure 13). The study underscores the potential of continuous microseismic monitoring for quantifying river processes and isolating turbulence signals, even in low-flow conditions.

While the manuscript shows potential for enhancing discharge predictions using seismic data, it currently lacks several key components that must be thoroughly addressed before it can be considered for further evaluation and publication. Below, I outline my main concerns, followed by specific comments and line references from the main text that can guide the authors in revisiting the manuscript.

1. The manuscript, in its current form, lacks a clear motivation. Throughout the text, the authors' objectives are not sufficiently articulated. What is the main purpose of the project? Why were the experiments conducted? What was the rationale behind the choice of station locations? Additionally, why was the monitoring period limited to just one day? Please also refer to the last paragraph, after point (5).
2. The structure of the paper is not well organized, which distracts the reading process. This may be partly due to an insufficient definition of the paper's scope (see my above point 1). The Introduction section lacks clear organization, with discussions of seismic methods interspersed throughout and paragraphs lacking coherence. Additionally, the focus on the actual flow phenomena is insufficient and should be given more emphasis (see my comments on the first paragraph of the introduction). Moreover, many methodological details are only introduced in the Results and Discussion sections. I recommend a thorough reorganization of the manuscript, beginning with an introduction to flow phenomena and possibly a brief discussion on sediment transport. The authors can then identify research gaps and explain how environmental seismology can address these gaps. The research gaps must be then connected to the authors' current work.
3. The figures are not evenly distributed throughout the manuscript and require revision. For example, the first three figures could be combined into a single, more cohesive figure. They should also better support the main text by helping the reader understand the rationale

behind the seismic experiments. Additionally, schematic representations should be replaced with aerial or field photos (see my specific comments below).

4. The empirical model used by the authors (Equation 8) closely resembles the one proposed by Roth et al. (2016), and this should be acknowledged. Additionally, the main title ("A physical model for...") does not align with the empirical nature of Equation 8. The authors should either provide a justification for why this model can be considered physical, or revise the title to more accurately reflect the empirical nature of the model and the main message of the paper.
5. The justification for the hydrological perspective needs to be strengthened. The authors introduce the field settings and describe the low-discharge regime during the survey period. They then calibrate their empirical model (Eq. 8) and apply it for discharge predictions. However, they should explicitly present the range of discharge values measured (or estimated using their approach) on the survey day. Specifically, what was the observed discharge range during the seismic and hydrological survey? If the fluctuations remain within a narrow range (e.g., within a factor of 1, meaning no substantial deviation from the average), then applying the model within the same range, even to unseen data, may have limited value. To address this, the authors should first present their discharge time series and then assess whether their model is applicable over that range. This clarification is crucial for strengthening the manuscript's narrative and overall scientific rigor.

In light of the above points, I believe the manuscript has not yet reached a stage where a brief revision would suffice. Major or thorough revisions are necessary, particularly due to the lack of a coherent key message and a clear demonstration of the uniqueness of the approach. Specifically, and this is a critical point of my review, the manuscript needs to clarify how this work advances our understanding of monitoring flow phenomena using seismic tools, especially in comparison to previous studies (e.g., Gimbert et al., 2014; Schmandt et al., 2013; Lagarde et al., 2021; Roth et al., 2016). Once the key message is clearly established, the manuscript should be reorganized for better clarity, to more effectively present the arguments, objectives, and overall scope.

Specific comments

Introduction

I believe the Introduction section needs better organization. The current presentation of the motivation for flow monitoring - specifically, flow velocity and bedload transport - is unclear, and the rationale for using seismic monitoring is missing.

I suggest restructuring the introduction, e.g., as follows:

1. First paragraph: Introduce the key phenomena of river flow and bedload transport, emphasizing their importance and the need for improved understanding.
2. Second paragraph: Introduce environmental seismology as a remote sensing technique that mitigates risks associated with direct measurements of these processes. Briefly mention the key studies published in the realm of fluvial seismology, categorizing them by their focus (e.g., studies on flow, studies on bedload transport).
3. Third paragraph: Use specific examples (e.g., Schmandt et al., 2013; Burtin et al., 2011; Roth et al., 2016) to provide a foundation for later discussions in the manuscript.
4. Fourth paragraph: Identify the key research gaps that remain in the field and explain how the current study contributes to addressing these gaps. Emphasize how the manuscript provides a scientific evaluation of the proposed approach and its implications for advancing the understanding of river dynamics.

This restructuring will improve the logical flow and strengthen the manuscript's narrative.

Lines 33-35: I suggest to include an opening sentence which can then be used to argue for the importance of river monitoring.

Lines 34-35: there is also an empirical approach, where equations are used (e.g., for bedload transport and flow velocity).

Lines 38-39: For the purpose of your argument, I would change the references of Roth, Cook and Larose, since these are directly Environmental Seismology studies, while your opening paragraph discusses river monitoring.

Lines 40-42: The introduction of the seismic methods comes without a scope and I think you should first establish the reasoning for the use of seismic signals to infer river activity.

Lines 43-36: Sentence is redundant, and I don't see how it contributes to your arguments in this paragraph. Either reformulate or omit.

Line 46: "microseismic" – since this term repeats in your manuscript, and since it is used differently in most (if not all) the environmental seismology-related papers, I propose to either

change it to “seismic signals” or to define what is “microseismic signal” (as opposed to a “seismic signal”).

Line 49: “water surface”.

Line 52: what do you refer to by using “This”? be specific.

I also find that your reasoning here lacks a strong argument, that is, “This demonstrated that ... can not only aid in studying...”, but the above sentence is not convincing enough. I propose to revise the sentences between lines 46 and 52 to better present the arguments (using the studies you mentioned – Schmandt and Diaz) leading to the motivation of using seismic instruments to understand river flow.

Lines 57-59: A meaningless sentence. If the purpose of this paragraph is to elucidate the different seismic signatures obtained by various authors, maybe you should begin with a different sentence, emphasizing the main features of the seismic signal (frequency, Power Spectral Density – PSD).

Lines 57-69: Since you are using previous references that using seismic signals to demonstrate it can be applied as a passive tool to infer flow and bedload phenomena, it would be worthwhile mentioning both field-based (e.g., Schmandt et al., 2013; Roth et al., 2014; Burtin et al., 2011, and several more) as opposed to theory-based (i.e., Tsai et al., 2021; Gimbert et al., 2014; Luong et al., 2024) studies.

Lines 71-78: The entire paragraph reads detached from the rest. You begin with “warning systems...”, then you go on discussing the general method of analysis (“by analyzing the time-frequency...”). but it feels a more general description of the method, so it needs to come earlier, where you introduce environmental seismology.

Line 80: “This study focuses on the monitoring...” – I am lacking a motivation description to your study. This should come in the above paragraph. In what way does your experiment adds on previous experiments that conducted field experiments with flow and seismic measurements? Is it related to the flow regime in your study sites? Is it related to the number of your monitoring sites? Explain.

In addition, in this stage of the intro you should have already laid out the objective to your study, what were your aims? It is not clear by reading this paragraph what were you aiming to do.

2 Experiments

Line 89: I propose to change the title from “Experiments” to “Methods”.

Line 91: “We studied the Jiuqu River, a tributary of...”

Lines 92-93: Instead of refereeing to “Meishui town”, refer to either the river or the catchment itself.

Line 93: what is a relative height? Do you mean Relief?

Lines 94-95: Is the description of lithology important to your scientific work presented here? If it does not serve an important information, I propose to remove it.

Line 97: either “four field monitoring experiments”, or “four field experiments”

Line 98: what are current meters?

How do these measure flow velocity of the flow when situated on the banks?

Line 99: “for this experiment”, what do you mean by “this?”

Line 102: I am unclear what is a drainage canal.

Line 104: when describing grain size, please refer to standard jargon, for example, using its axis (axis a, b and c).

Line 105: I think you would benefit from reporting the averaged length of axis b itself, rather than the volume.

Line 106: Was your sediment concentration meant for the purpose of evaluating sediments travelling in suspension? Clarify?

From what elevation above the bed were these measurements conducted?

Line 108: “which classifies it as a low-flow river” – according to what standards? Please give reference, or revise\emit.

I am unclear how the reference to Figure 2 in line 108 established the argument for a low flow.

Line 119: “seismic ambient noise was collected” – the noise was not collected. Measurements were taken, or seismic noise was monitored. Please revise.

Lines 119:121: “Seismic instruments offer a variety of...” – delete this sentence.

Line 122: why is it important to mention what instruments are categorized? You are not reviewing seismic methods. You use a relatively well established method, so use a reference for that.

In general, I find that the paragraph starting in line 119 and ending at 132 can be reduced to one simple, concise sentence.

Line 134: not seismic stations, but seismic instruments.

Line 139-140: I do not understand the sentence (one of which was an integrated ...”). Revise or emit.

Paragraph encompassing lines 134 – 145 is too informative. Reduce and leave only the most important information.

Line 150: “Match 17” – the monitoring period was for one day? What was your purpose in conducting an experiment for one day? How long within that day did your experiment last?

Lines 150-151: move this to the beginning of the Method section to emphasize your objectives.

Line 158: what is the second experiment? I find it a little bit challenging to find my way within the introduction of your method section structure. For example, when you write “For the second experiment...” would imply for a reader that there are a few experiments. In such a case, you need to introduce them properly, before you delve into explaining them in detail.

Line 160: “Specifically, S2 was...” – it make a little sense to explain about S2 when you did not introduce it. Begin with a proper introduction of the experiments, and the stations.

Line 163: Why did you use four stations? In Figure 3, it seems that the stations are very close to each other. What were your aims in deploying for, and not only one stations? This needs to be justified.

Lines 163 – 169: I find this paragraph more suitable for the Results section.

Line 180: “calculating river flow” – what is river flow? Please specify, is that discharge (e.g., in units of m^3/s) or is it flow velocity (e.g., in units of m/s)?

Line 186: again, I think you mean here “discharge” rather than “river flow”.

Line 193: the title feels detached. Revise to make clear what you are doing.

Lines 213-214: please fix the equation so that it is presented near its number (7).

Line 218: “tests” – do you mean experiments? Please be consistent with the terms you use.

3 Seismic ambient noise

Line 220: change title to “Results”. It was not clear from the title that this is the results section, and I was reading a substantial part of this section believing it is still the methods (see comments below).

Lines 221-222: This comment applies specifically to the mentioned sentence but can be generalized to similar instances throughout the manuscript. It is crucial to maintain a clear distinction between the Introduction, where you present the state of the science, previous studies, and relevant fields, and the Methods, where you concisely describe the techniques used, ensuring they are theoretically reproducible. For example, in this case, rather than directly explaining the seismic ambient noise method, lines 221–231 primarily serve to justify the approach. However, such rationale belongs in the Introduction rather than the Methods section. Ensuring this distinction throughout the manuscript will improve clarity and logical structure.

Line 239: please specify the distance of the road from the experimental sites.

Figures 1, 2 and 3:

I believe the manuscript would benefit from a more integrated and visually informative representation of the experimental sites. Instead of separate schematic cross-sections and contour-like maps, I suggest merging Figures 1, 2, and 3 into a single figure with multiple panels. This would provide a more comprehensive overview of the study area by: (1) including a small inset map to show the study location within a broader China map for geographic context, (2) using an aerial or satellite image to display the experimental sites along the river, (3) incorporating photos of the different study sites to highlight their distinct morphological characteristics, and (4) ensuring a clearer depiction of station locations within the field setting, as the current photo in Figure 3 does not make their placement evident.

Additionally, the sensors in Figure 3 appear wired to cables - are these temporary? More details on the station setup, location, and monitoring period would improve clarity. Lastly, the red sensor between S2 and S4 lacks a label— - please clarify its designation. This restructuring will improve the figure's effectiveness and enhance the manuscript's clarity.

Figure 5:

In the figure's caption, please explain all the variables you mention in the figure.

Figure 6:

I believe this figure is redundant in the main text as it is secondary to your main analysis. Therefore, I propose to move it to the supplementary information.

Line 255: What is "still water flow"?

Lines 256-257: please specify "experiment" and "test". Are there differences between these terms? Are these the same?

Lines 257-260: This sentence is redundant. Delete.

Line 260: "A clear broadband seismic response" – in what way it is clear? That is subjective. I would try to reformulate the sentence to a more objective one.

Lines 272-280: This entire paragraph is an interpretation, not a result. Please move it to the discussion if needed.

Figure 8:

“Acceleration power spectral” – why do you use acceleration rather than velocity?

“PSD plots” – I think these plots would be better called “seismic spectra”.

Why do you choose to exhibit three curves and not all of the curves that you have as data sets?

Lines 293-299: Again, this paragraph belongs to the introduction. Remember that you are now introducing your results, so at this stage the reader should already be informative of the fact that “geophones can detect elastic waves generated by processes...”. In fact, you already wrote this previously, so it is a repetition. In this manner, the allocation of Figure (9) is not well suited

Lines 300-302: You are mixing pure results (e.g., the measurement showed that...) with discussion, which is meant to bring forth your interpretation of the results (e.g., “the deployed microseismic stations can receive these signals and record them as”).

Lines 310-312: You introduce the fourth experiment, but this should already have been done previously in the methods section.

4 Seismic interpretation and river discharge calculation

Line 340: please change this title to “Discussion.

Lines 342-354: this entire paragraph also reads detached from the text. As this is the beginning of the discussion, you should more pronounced focus on bringing forth your results and discussing them with respect to previously published science in this field.

Lines 356-364: Same comment as above. This paragraph should be deleted. The information is interesting, but it is not related with your specific work. The focus should be on interpreting the results, not the methods, which are probably massively discussed elsewhere in the literature.

Lines 367-368: The sentence is superfluous.

Lines 368-370: It is too early to state that. You should begin with you aim, proceed with what you did as a test (as you begin in line 370, “for verification”), then conclude with something in the form of “as a result, we propose that the frequency range within 2 and 10 Hz records seismic signals generated form turbulence...”.

Alternatively, you could write something along the lines of: “We hypothesize that the low-frequency... in the experimental ... is related to flow turbulence within the stream”. To validate our hypothesis, we plot...”.

Figure 11:

This figure should be within the results, not discussion. The discussion can pick this up by discussing in what ways does this plot reinforce (or not) your hypothesis that turbulence dominates the < 10 Hz frequency band.

5 Results and discussion

Line 394: it does not make much rationale to include both results and discussion in the same section. Logic would say to include them as separate sections.

Lines 395-396: “a linear test..” – this belongs to the method section.

Line 397: what do you mean by “mechanical effect”?

The entire paragraph starting from line 395 and ending at 422 needs to be moved to the methods section.

Line 402: in what way it is “inverted”? please specify this term within the scope of your methods.

Lines 406-407: what is the difference between passing vehicles (P_v) and environmental noise (P_N)?

Line 413: Equation (8). This is an interesting approach. However, I suggest you reference and cite Roth et al. (2016; <https://doi.org/10.1002/2015JF003782>), as they proposed a very similar model. Additionally, it is important to clearly state that P_f represents the total contribution of all seismic sources. Moreover, you should explicitly mention your key assumption that is currently implicit: the total seismic PSD, representing the seismic data at a given time and frequency, is assumed to be the linear sum of the PSDs of the contributing sources. This assumption underpins your presentation of Eq. (8), which, as it stands, is a reorganized form of this principle. This connection is not immediately evident from the text but is critical to understanding your approach (see Eq. (1) in Roth et al., 2016). Implicit as well in your Eq. (8) is that bedload transport did not occur during the monitoring period. While this is plausible, it should not come implicitly and as a surprise to the reader. Therefore, please add a sentence before introducing the equation, where you explicitly mention this. Lastly, please define the coefficient a_f .

Line 416: what do you mean by “highest turbulence signal to ratio”; what is “highest”? how is it defined?

Line 418: grammar is incorrect, please revise sentence.

Line 420-421: you mention the Green’s function, but you assume that your audience is familiar with it, while it comes with no introduction. Introduce it, or delete.

Figure 12:

I propose to switch the axes, so that frequency is at the horizontal, while the coefficient is the vertical.

What is the meaning of the three panels? What is the difference between them and what do they represent in your scientific context?

Line 429: “After regressing... the first 10 minutes of...” I find the description of the monitoring period unclear at this stage of the manuscript. By this point, the reader should have a comprehensive understanding of the monitoring timeline, but that is currently not the case. I believe this issue stems from how the experiments were introduced earlier in the text. Please revisit and address my comments in the Methods section to provide a more detailed and transparent explanation of the experimental setup and monitoring period.

Line 432: in what way do the flow velocity measurements integrate into this part of your analysis? I do not seem to be able to follow your reasoning.

Figure 13:

Panel b: The 3-dimensional representation of the results is unclear and may be difficult for readers to interpret effectively. I recommend replacing it with a 2D plot, which would likely provide a clearer and more straightforward visualization of the data.

Line 479: “We cannot establish a correlation...” On what analysis is this statement based? Please refer explicitly to the relevant analysis or figure. If you are referring to Figure 11, I would argue that the measured discharge somewhat resembles the North component of the seismic power. However, this observation lacks a statistical criterion that would allow for an objective evaluation and support such a judgment.

Lines 483-485: “Real-time monitoring of the turbulence process...” This statement feels somewhat overstated in relation to your findings. While you have successfully established a quantitative correlation between a hydrodynamic parameter and seismic data, I believe it is not fully justified to claim that this enables “real-time monitoring” of the turbulence process. Based on the evidence presented, it seems that your work has not yet revealed specific features of the turbulence phenomena itself. I suggest revising this claim to better reflect the current scope and implications of your results.

Lines 487-501: This paragraph currently serves as a summary of the analysis and findings. However, I recommend revising it to go beyond summarizing and focus on highlighting the broader implications of your research. Specifically, you could emphasize the new avenues this

work opens for further exploration, as well as its potential relevance and applications beyond the context of your specific local findings. This would help underline the significance of your work and its contribution to the field.

References

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