

Manuscript ID: egusphere-2024-2525

Original Title: *Improving prediction of particle size with a novel acoustic bedload monitoring system consisting of phased microphone arrays and accelerometer*

Authors: Zheng Chen et al.

Dear Reviewer #1,

We sincerely thank you for your positive and constructive feedback. We are grateful for your recognition of the novelty and potential of our acoustic bedload monitoring approach using phased microphone arrays. Following your suggestions, we have made moderate revisions to improve the clarity and completeness of the manuscript. All changes have been highlighted in the revised version, and detailed point-by-point responses are provided below.

Responses to the Comments from Reviewer #1

- **General comment 1:** I want to congratulate the authors on a novel experiment using a microphone array to improve impact-based bedload surrogate systems. Their work represents an incremental, but crucial, step towards an effective instream surrogate system. However, I believe that the manuscript, as written, requires some moderate changes before it is ready for publication. I have detailed those changes below with relevant line numbers.

The paper has a number of grammatical errors that should be corrected. I note some of them below in my line-specific comments but also wanted to add a general comment here. This is not at all a criticism of the lead author. Rather, I believe that the coauthors that are responsible for review and supervision should take a more careful review before resubmission of the manuscript. This is particularly noticeable in the introduction and methods sections of the manuscript.

Response: We fully agree with the reviewer's comments which are important and essential for improving this manuscript. After restructuring and revising the content, we will proofread the entire text carefully and perform a thorough grammar and language check before resubmitting it. We will pay particular attention to the Introduction and Methods sections.
- **General comment 2:** Many of the figures in the results section appear before they are referenced in the manuscript. It appears intentional, but it's not typically how papers are structured in my experience. I defer to the preference of the editorial staff, but would like to see the figures referenced in-text before the associated figure is shown.

Response: We thank the reviewer for this observation. In the original manuscript, some figures were placed before they were referenced to minimize page breaks between the text and the corresponding figures and thus improve readability during the review process. In the revised manuscript, we have adjusted the figure placements to ensure that all figures are referenced in the text before they appear.
- **General comment 3:** I think the discussion may benefit from some reorganization. My preference would be sections reorganized as follows: 4.4, 4.1, 4.3, 4.2. This would approximately match how the results are organized (number of microphones, microphone location, centroid frequency, grain size).

Response: We appreciate the reviewer's suggestion regarding the organization of the Discussion section. We

agree that rearranging the subsections in the order proposed (4.4, 4.1, 4.3, 4.2) improves alignment with the sequence of the Results section thereby enhancing the manuscript's logical flow. Accordingly, we have reorganized the Discussion section to follow this suggested structure in the revised manuscript.

● **General comment 4:**

In additional to general comment #3, I would appreciate some discussion of how this new system may perform under field conditions. How would the PMA system work with more than two impacts at once? In principal, the system should be able to better resolve these impacts based on your laboratory results, but I think a discussion of this is warranted. This technology is intended for deployment in the field to improve our understanding of actual bedload flux. A new subsection should recognize this, discuss the similarities and differences between systems already in place, and how this system may fair.

Response:

We thank the reviewer for this important and forward-looking suggestion. We fully agree that natural bedload transport often involves multiple particle impacts that occur simultaneously or nearly simultaneously, and that the PMA system's ability to resolve such conditions is critical for its future deployment in the field.

In response, we have significantly expanded the discussion in Sect. 4.3 ("Spatial resolution of the PMA system and multi-source detection") to address the system's ability to detect multiple, simultaneous impacts. In addition to the two-source simulations, we have now conducted numerical tests involving three and four concurrent impact sources under symmetric and asymmetric conditions, and will include the results in the text (see Appendix B). These results provide a more realistic assessment of the system's performance under multi-source interference.

Regarding the question to compare the PMA system with existing technologies, the signal response characteristics of the PMA and the Swiss plate geophone (SPG) systems are compared in Sect. 4.2, highlighting differences in sensor placement, signal type, and sensitivity to impact location.

We acknowledge that field deployment is the ultimate goal of the PMA-technology. To this end, we are designing systematic flume experiments that will include multi-particle impacts under active flow conditions. These tests will serve as an important intermediate step between idealized laboratory conditions and field deployment, allowing us to refine and validate the system in more complex and realistic environments.

We also add a forward-looking paragraph to the end of Sect. 4.4 ("Improved estimation of particle size, outlook to field application"), discussing the outlook for field deployment.

While the reviewer suggested adding a dedicated new subsection, we believe this topic is best integrated into the relevant existing sections for clarity and to avoid fragmentation. Therefore, the discussion of multi-source detection has been incorporated into Sect. 4.3, and a forward-looking paragraph on potential field implementation has been added into Sect. 4.4.

● **Specific comment 1:**

Lines 1-3: I think the title is a bit misleading. By my understanding, the improved particle size is just one of the improvements described in the manuscript. I would highlight the novelty of PMA system as a whole in the title.

Response:

We thank the reviewer for this helpful comment. We agree that the current title may place too much emphasis on the improvement in particle size prediction, whereas the manuscript introduces a more comprehensive innovation—the development and testing of a new PMA-based acoustic

monitoring system. Accordingly, we have revised the title as follows:

“A novel acoustic bedload monitoring system with phased microphone arrays and accelerometer for particle localization and size estimation”

- **Specific comment 2:** Lines 18-19: This sentence structure is a little confusing - is it a single regression or different regressions between impulses and the rest of the variables?

Response: Thank you for pointing out this ambiguity. To clarify, we performed separate regression analyses examining the relationship between particle size and each of the following signal characteristics: the number of impulses per particle mass, the signal amplitude, and the centroid frequency. In the revised manuscript, we have rephrased the relevant sentence to make this distinction clear.

- **Specific comment 3:** Lines 15-16: What is the 'conventional beamforming method'? - you describe it below so I think just referencing the section below is sufficient here.

Response: Agreed. We have revised the sentence in original lines 15–16 to include a reference to Sect. 2.3, where the conventional beamforming method is described in detail.

- **Specific comment 4:** Line 50: other studies have investigated the effect of grain size when using impact sensors, such as Halfi et al., 2021 or Stark et al., 2024

Response: Thank you for the suggestion. We agree that these studies are relevant to investigating bedload grain-size effects in impact sensor systems. We have added these references and cited them appropriately in the revised manuscript, where we discuss previous work on sensor type, particle size and signal characteristics.

- **Specific comment 5:** Lines 89-91: I don't think that specifying the manufacturer is necessary. Keeping it in would be fine though.

Response: Thank you for pointing this out. We have decided to keep the manufacturer information in this section, as this may help interested readers to identify and compare the specific equipment used in the experiments. This could make it easier to reproduce the experiments and explore similar instrumentation further.

- **Specific comment 6:** Lines 100-102: are these calibration coefficients universal across all systems, or is this established for every system prior to use?

Response: Thank you for raising this important point. The calibration coefficients provided in lines 100–102 of the original manuscript are manufacturer-specified constants for the specific sensor models used in our study. For sensors of the same model, these coefficients are generally consistent. However, small variations may occur due to manufacturing tolerances.

It is also important to note that these calibration coefficients are only valid within a specified frequency range. For example, the microphone sensor has a typical frequency response from 10 Hz to 20 kHz, whereas the accelerometer operates effectively within the range of approximately 0.5 Hz to 10 kHz. Outside of these ranges, frequency-dependent calibration curves may be required for accurate signal conversion.

We have clarified this point in the revised manuscript.

- **Specific** Line 113: The use of eccentric seems unusual here, but is technically correct. I think something

- comment 7:** like center and off-center may be more intuitive to the reader, rather than centric and eccentric, but accept that there is nothing wrong with the word choice. Still, I would appreciate you explicitly state what a centric and eccentric impact entails here, in the methods, rather than waiting to the results to define it.
- Response:** We appreciate this helpful suggestion. While the terms “centric” and “eccentric” are technically correct, we agree that they may not be immediately intuitive to all readers. To improve clarity, we have added a brief explanation to the Methods section. This specifies that a centric impact refers to a particle colliding at the center of the PMA plate and that an eccentric impact refers to an impact at a more off-center location. We have kept the original terminology throughout the manuscript, but have clarified its meaning when it is first used.
- **Specific comment 8:** Lines 113-114: You note that you conducted the experiments in both air and water, but it isn't clear in my reading of the results which you report. Is it both?
Response: Thank you for pointing this out. As mentioned in the Methods section, the experiments were conducted in both air and water. The water-based tests were intended as supplementary experiments. As the impact velocities in air were generally higher and produced stronger signal responses, we have chosen to present and analyze the results from the air experiments in the manuscript. This point has been clarified in the revised text.
 - **Specific comment 9:** Lines 125-126: Each section (such as this one) often begins with a statement of what the section is intended to accomplish. I don't think this is strictly necessary, and could be removed for brevity but if the authors feel strongly or prefer this, then I think it is fine to keep them!
Response: Thank you for this suggestion. As we looked into this, we realized that some of the introductory sentences could be more concise. While we have kept them for clarity, we have revised and shortened them to improve readability and flow.
 - **Specific comment 10:** Line 216: Are these all the relevant parameters or just some of them? It appears to be all, and if it is not, then the table should be expanded to include the parameter set used in the numerical simulations.
Response: We thank the reviewer for this careful observation. The parameters listed in Table 2 are the key parameters used in the numerical simulations. Other parameters—such as microphone element spacing and array arrangement—vary across different simulation scenarios and are therefore not included in the table.

To avoid confusion, we have revised the corresponding sentence in the manuscript to clarify that Table 2 contains only the key or representative parameters.
 - **Specific comment 11:** Line 257: Are centric and centroid frequencies the same thing? I don't think so, based on my understanding of the paper. Please ensure it is centroid frequency and centric impacts
Response: Thank you for pointing out this distinction. We have carefully reviewed the manuscript and revised the text to ensure consistent and correct terminology is used: *centroid frequency* refers to the frequency metric calculated from the signal spectrum, while *centric impact* refers to particle impacts at the center of the PMA plate.
 - **Specific** Lines 290-292: I think it would help the reader to include the microphone locations in Figure 6.

- comment 12:** Perhaps an inset or an overlay somehow? If not, you should reference the Appendix Figure showing the different arrangements here.
- Response:** We appreciate the reviewer's suggestion. To improve clarity, we have now added the locations of the microphone elements directly to Figure 6a–d as overlays. This allows readers to better understand how the reconstructed acoustic images correspond to different array configurations. We believe this change makes the figure easier to interpret.
- **Specific comment 13:** Line 296: Section 3.1.3 -- You only reference the multipole results a single time in your discussion. I do not think this is necessary to be included in this manuscript. To be clear - I think that multiple sources is critical for using this surrogate technology (detailed in another comment), but not necessary for this manuscript.
 - Response:** We thank the reviewer for this thoughtful suggestion. We agree that, while the multipole source simulations, while relevant to future applications, they are not essential to achieving the main objectives of this manuscript. These results were based solely on numerical tests, with no experimental validation. To improve focus and coherence, we have expanded this part of the analysis and moved the detailed results to the Appendix B.
The main text now includes a concise discussion of the implications of multiple simultaneous impacts, which are crucial for future field deployment. We believe that this approach helps to streamline the main text while ensuring that the results are still available for interested readers.
 - **Specific comment 14:** Line 298: fig 7 - Several grammatical errors in the figure caption.
 - Response:** Thank you for pointing this out. We have carefully reviewed and revised the caption of Figure 7, correcting grammatical errors and improving clarity.
 - **Specific comment 15:** Line 328: fig 8 - This caption contains discussion/results content and is unnecessarily long. I would revise it.
 - Response:** Agreed. We have revised the caption to make it more concise and to focus on describing the figure itself.
 - **Specific comment 16:** Lines 338–344: Much of this could be introduced in the methods section, rather than in the results in my opinion.
 - Response:** Thank you for this structural suggestion. The first part of the paragraph in lines 338–344, which describes the experimental setup and definitions, is indeed more appropriate for the Methods section. We have moved this content accordingly, keeping only the actual results in the revised Results section.
 - **Specific comment 17:** Line 408: I believe that figure 11 could be recreated to be more effective. I suggest plotting (a) and (b) by themselves in a vertical orientation, with (c) - (f) in a square orientation separated by a vertical line.
 - Response:** Agreed. Following your recommendation, we have redesigned the figure. Panels (a) and (b) are now arranged vertically to emphasize the results obtained using the entire signal packet. Panels (c) to (f), which are based on the first wave, are arranged in a 2×2 square layout with a vertical

dividing line. We believe that this new layout improves the clarity and interpretability of the figure.

- **Specific comment 18:** Line 471: Section 4.1.2 -- The discussion of k_{IMP} is extremely short, given that this is one of two primary functions of this technology. I think this is a critical part of the manuscript that is generally overlooked throughout. This could also be a section where you discuss how this new system might perform under field conditions.

Response: We appreciate this insightful comment. We agree that the coefficient k_{IMP} (impulses per particle mass) represents a fundamental output of our monitoring system that deserves a more thorough and comprehensive discussion.

In the revised manuscript, we have expanded Section 4.1.2 to provide a more detailed interpretation of the observed trends in k_{IMP} and to compare these with the results from the SPG system. We have also added a discussion on how the PMA system might perform in field conditions with respect to k_{IMP} estimation. We believe this addition strengthens the manuscript.

- **Specific comment 19:** Line 211-212: Awkward working of this first sentence.

Response: Thank you for pointing this out. We have revised the sentence for clarity and improved readability.

- **Specific comment 20:** Line 212: 'firstly' is incorrect

Response: This sentence was revised.

- **Specific comment 21:** Line 252: extra parentheses in see eq. 14

Response: Thank you for spotting this. We have removed the extra parentheses in the revised manuscript.

- **Specific comment 22:** Line 278: Mon. is already introduced as an abbreviation of monopole.

Response: Thank you. We have removed the redundant definition of “Mon.” in the revised manuscript.

- **Specific comment 23:** Line 305: Mul. is already introduced as an abbreviation of multipole

Response: Thank you. We have removed the repeated explanation of “Mul.” in the revised manuscript.

Additional clarifications

In addition to the above comments, spelling and grammatical errors pointed out by the reviewer have been corrected in the manuscript.

We look forward to hearing from you in due time regarding our submission and to respond to any further questions and comments you may have.

Sincerely,

Dr. Zheng Chen (on behalf of all co-authors)

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