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Review and rebuttal of the paper

Validation of Lagrangian particle movement in CFD for simulating passive object transport over weirs

Kaminski et al.

Editor handling the paper: Sebastien Erpicum

The reviewers remain anonymous.

1 Round 1

1.1 Reviewer #1 :

General comments:

The authors investigate particle and tracer transport using both physical and numerical models, employing the open-source solver *interFoam* in combination with particle tracking. This is a relevant topic within the field. While *interFoam* and particle tracking are commonly used tools, the authors have modified *interFoam* to include particle tracking capabilities, which are already available in other solvers. Therefore, this aspect cannot be considered a significant novelty. However, the simulations and their analysis, particularly those focused on particle trajectories, collisions, residence time, and behaviour within recirculation zones, are original contributions. These objectives are clearly outlined in the abstract, as well main conclusions.

A more comprehensive literature review is required to justify the adopted methodology. The assumption of treating fish as passive particles is not straightforward and appears somewhat forced. While the introduction references other studies using different modelling approaches, the rationale for selecting a Lagrangian particle framework is not sufficiently supported. For example, the choice over alternatives such as the Discrete Element Method (DEM) is not discussed.

The manuscript is carefully written and well-organized, free of typographical errors. The models and procedures are presented clearly. Figures and tables are of high quality and thoroughly analysed to support conclusions.

Detailed comments:

The title is somewhat unclear and widely avoid fish word. While the use of the term *validated* may be acceptable within the title, it is not suitable as a keyword.

The concept of two-phase flow, as introduced at the beginning of the introduction, is not clearly defined. On one hand, the *interFoam* solver models a water–air system; on the other hand, solid particles are also included in the simulations. This term "two-phase flow" creates confusion and should be clarified.

The statement, *"An underestimation of the dispersion by ANSYS FLUENT and an overestimation by OpenFOAM were found,"* is inappropriate for a scientific journal. ANSYS FLUENT and OpenFOAM, being respectively a commercial software and an open-source framework encompassing a wide range of models, cannot be evaluated as monolithic entities. Instead, the specific models or configurations responsible for these outcomes should be identified and critically discussed.

Authors reply

Thank you very much for your thoughtful and constructive review. We truly appreciate the time and effort you invested in providing detailed feedback. Your comments have been very valuable. We have taken them into careful consideration during the revision process, and where we were not able to fully implement a suggestion, we have provided a detailed explanation. Below, we provide detailed responses to your comments:

Detailed comments:

1. A more comprehensive literature review is required to justify the adopted methodology. The assumption of treating fish as passive particles is not straightforward and appears somewhat forced. While the introduction references other studies using different modelling approaches, the rationale for selecting a Lagrangian particle framework is not sufficiently supported. For example, the choice over alternatives such as the Discrete Element Method (DEM) is not discussed.

We agree that the assumption of treating fish as passive particles is a significant simplification and have therefore revised the introduction to more clearly articulate the rationale behind this approach.

In the revised manuscript, we now clarify in the introduction that the decision to use simplified, neutrally buoyant Lagrangian particles is primarily driven by the high complexity and uncertainty involved in realistically modelling fish. Fish vary widely in size and shape, and the current scientific understanding of species-specific behaviour—particularly during passage scenarios—is still limited. Accurately reproducing fish movement would require detailed biological and behavioural models that are not only challenging to develop but would likely only apply to one specific species, life stage, or even individual. Given the substantial inter- and intra-species variability, such highly detailed models would have limited general applicability. Therefore, a deliberately simple and generalised approach was chosen, abstracting fish as passive spherical particles. This allows for a scalable and transferable method that focuses on the hydrodynamic component of fish movement and enables robust statistical analysis of potential passage trajectories without relying on uncertain behavioural assumptions.

Regarding the choice not to use DEM, we have now clarified this in the manuscript (chapter 2.2.1 Lagrangian particles). Since the approach aims at a general, species- and size-independent representation of fish, focusing on the particle trajectories and not elaborate collision mechanics, detailed particle properties and interactions that DEM allows were not necessary. The capabilities of the simpler Lagrangian particles were sufficient for this work.

We hope this revised explanation addresses your concerns and improves the transparency of our methodological choices.

2. The title is somewhat unclear and widely avoid fish word. While the use of the term validated may be acceptable within the title, it is not suitable as a keyword.

We fully agree with the suggestion regarding the keyword “validation” and have accordingly removed it from the list of keywords.

Regarding the title, we understand and appreciate the suggestion to include a reference to fish. This was in fact a point of extended internal discussion, and earlier versions of the manuscript did include fish-related terms in the title. However, we received feedback that such wording could lead to confusion, as the study does not directly assess fish passage. Instead, it focuses on comparing the movement of neutrally buoyant particles in laboratory and numerical models as a means to evaluate the underlying numerical approach. While this method is ultimately intended for applications related to fish downstream migration, this lies beyond the scope of the present paper.

For this reason, and in consultation with our academic peers, we decided to retain a more neutral and technically precise title that highlights the core focus of the work: the comparison of particle trajectories. We hope this explanation makes our decision clearer and appreciate your understanding.

3. The concept of two-phase flow, as introduced at the beginning of the introduction, is not clearly defined. On one hand, the interFoam solver models a water–air system; on the other hand, solid particles are also included in the simulations. This term "two-phase flow" creates confusion and should be clarified.

Thank you for pointing out this confusing wording. The sentence has been amended to clarify that we are referring to a water-air system.

4. The statement, “An underestimation of the dispersion by ANSYS FLUENT and an overestimation by OpenFOAM were found,” is inappropriate for a scientific journal. ANSYS FLUENT and OpenFOAM, being respectively a commercial software and an open-source framework encompassing a wide range of models, cannot be evaluated as monolithic entities. Instead, the specific models or configurations responsible for these outcomes should be identified and critically discussed.

We fully agree, that this statement is not clearly worded. The statement from the cited paper has been shortened too much here. The sentence has now been revised to clarify that it was the specific modelling approaches applied within ANSYS FLUENT and OpenFOAM that led to the observed underestimation and overestimation of dispersion, respectively. We appreciate your valuable input in helping us improve the precision of our manuscript.

1.2 Reviewer #2

Major comments:

1. L52-L81: The paragraph is extremely long. It can be subdivided into two main topics (numeric vs experimental validation of flow L52-L62, ethohydraulic validation L62-L81). Also, sentences are not relevant to the rest of the manuscript. How do the mentioned studies connect with the work performed in this paper? What do they lack to justify choices made in this paper? This part (long paragraph) is crucial because it depicts the state of the art and therefore, the relevance and novelty of this paper.
2. L82 & L83: What is the species of interest? Different species can behave differently. Also, physical condition (length, mass) is extremely variable between species.
3. L93 – L104: Why these specific dimensions were chosen? What is the model scale? If any what are the potential effects on the results?
4. L128-L129: What reasons motivated the choice of this specific particle size?
5. L166: Why this specific discharge?
6. L222 – L248: Are the 7 equations which follow equation 5 (6-12) necessary to understand the findings?
7. L455 -L500: This part focuses on the study limitations. It's preferable to have it as the last point of the discussion (4.4) and start with 4.1. after a short summary of the main findings.

Minor comments:

1. L9 -L36: An abstract is preferably a (one) well developed paragraph. Is it possible to combine both paragraphs?
2. L22: Which species?
3. L27: What is the deviation value?
4. L42-43: Is it possible to add citations (examples)?
5. L48-L51: This paragraph can be combined with the previous one. It will avoid inconsistent length of paragraphs.
6. L87 -L91: This part can be deleted. It's not useful to the paper.
7. L152, L157, L163, L172-173: Where are the references?
8. L177: How many trajectories?
9. L222: Are the 7 equations which follow equation 5 (6-12) necessary to understand the findings?
10. L451-L453: A figure (bar plots) could significantly improve the readability of these results.

1.3 Authors reply:

Thank you very much for your thoughtful and constructive review. We truly appreciate the time and effort you invested in providing detailed feedback. Your comments have been very valuable. We have taken them into careful consideration during the revision process, and where we were not able to fully implement a suggestion, we have provided a detailed explanation. Below, we provide detailed responses to each of your points:

Major comments:

8. L52-L81: The paragraph is extremely long. It can be subdivided into two main topics (numeric vs experimental validation of flow L52-L62, ethohydraulic validation L62-L81). Also, sentences are not relevant to the rest of the manuscript. How do the mentioned studies connect with the work performed in this paper? What do they lack to justify choices made in this paper? This part (long paragraph) is crucial because it depicts the state of the art and therefore, the relevance and novelty of this paper.

We fully agree that subdividing the paragraph into two parts, as suggested, improves clarity and readability. This restructuring has been implemented accordingly.

Furthermore, we have enhanced the section to more clearly articulate the connection between the referenced studies and our work. Specifically, we now emphasize that while these prior studies generally demonstrate good agreement between numerical methods and experimental or field data, their approaches differ in various respects. Many of these works primarily focus on fish turbine passage, whereas our study is explicitly dedicated to the weir passage scenario.

Additionally, we underline the choice of using Lagrangian particles in our methodology and highlight that our main focus lies on the accuracy of particle motion prediction. In contrast, several other studies concentrate more on pressure variations as the key parameter. This distinction further justifies the relevance and necessity of our specific validation effort within the context of fish passage modelling.

We believe these clarifications better position our work within the state of the art and illustrate the rationale behind our methodological choices.

9. L22 & L83: Which species the model could be used for? What is the species of interest? Different species can behave differently. Also, physical condition (length, mass) is extremely variable between species.

We sincerely appreciate this important question and the opportunity to clarify our approach. The approach should not be limited to a specific species. Due to the considerable variability in behaviour and physical characteristics the deliberately simplified and generalised approach was chosen to represent passively moving particles in a way that is broadly applicable across species and sizes. This rationale has now been explicitly added in two sections of the manuscript — the Introduction and the Lagrangian particles chapter — to improve clarity. Thank you very much for highlighting this point.

10. L93 – L104: Why these specific dimensions were chosen? What is the model scale? If any what are the potential effects on the results?

We understand that this part wasn’t clear enough. The paragraph has been revised accordingly. The chosen dimensions are based on practical constraints of the laboratory flume and the need to ensure accurate visual tracking of particle motion. We have clarified that both the physical and numerical models operate at a 1:1 scale with identical geometries, and that no geometric scaling was applied. Therefore, potential scale effects are not considered to be relevant for this study.

11. L128-L129: What reasons motivated the choice of this specific particle size?

We appreciate your question. The particle size of 10 mm was chosen as a compromise between minimizing the size differences between laboratory and numerical model, and ensuring practical feasibility. This includes the ability to fabricate particles with sufficient dimensional accuracy, adjust their density to achieve neutral buoyancy, and guarantee their visibility during image-based tracking. A corresponding sentence has been added to the paragraph for clarification.

12. L166: Why this specific discharge?

The flow rate of 11 l/s was selected based on preliminary tests, which demonstrated that this discharge produces a stable hydraulic condition in the laboratory setup, minimally affected by minor external fluctuations. This stability was essential to ensure consistent and reliable experimental results. We have now added this explanation in the Methods section to clarify our choice.

13. L222 – L248: Are the 7 equations which follow equation 5 (6-12) necessary to understand the findings?

Whether these formulas are necessary is a good question, thank you very well for asking. The seven equations following Equation 5 (i.e. Equations 6–12) detail the specific formulations of the particle forces considered in the model. In our view, including these equations is necessary because the exact implementation of the force models plays a fundamental role in the central question of this study—namely, the movement of particles.

Simply listing the types of forces would not, in our opinion, provide sufficient transparency. To ensure full reproducibility and to allow readers to critically assess the numerical approach, we believe it is essential to include the mathematical formulations of the applied force models. We hope this explanation clarifies our reasoning.

14. L455 -L500: This part focuses on the study limitations. It's preferable to have it as the last point of the discussion (4.4) and start with 4.1. after a short summary of the main findings.

We greatly appreciate the effort and consideration behind this suggestion and have carefully reflected on it.

We understand and agree with the general convention that a discussion of the study's limitations is typically positioned at the end of the discussion section. However, in this specific case, we would like to clarify that the section in question is not intended to present general limitations of the study, but rather to describe fundamental and unavoidable differences between the numerical and the laboratory model. These differences, for example those related to flow field characteristics and starting velocities directly influence the interpretation of the particle motion in both systems and are repeatedly referenced in sections 4.1 to 4.3. For this reason, we believe that positioning this section at the beginning of the discussion is important to ensure transparency, facilitate understanding, and allow the reader to follow the comparison between experimental and numerical results in a meaningful way. It allows readers to understand the underlying conditions and constraints before delving into the detailed comparison of particle movements.

Nevertheless, we found this comment very valuable and it prompted us to critically review the structure of the discussion. We sincerely thank you for this input.

Minor comments:

11. L9 -L36: An abstract is preferably a (one) well developed paragraph. Is it possible to combine both paragraphs?

Thank you for the helpful suggestion. The two paragraphs have been merged as recommended.

12. L27: What is the deviation value?

We intentionally refrained from providing a specific deviation value at this point, as doing so would suggest a level of numerical precision that, in our view, is not justified. As explained in the following sentence, this particular deviation is at least partially attributed to methodological limitations—specifically, the smearing of the air–water interface inherent in the Volume of Fluid (VOF) method. This makes the deviation significantly larger than the others observed in the study. While we understand the desire for a concrete value, we believe that the key takeaway lies not in the exact numerical difference, but rather in the clear indication that this pronounced deviation is driven by model-related constraints.

13. L42-43: Is it possible to add citations (examples)?

You are absolutely right that citations are appropriate in this context. Relevant references have been added accordingly.

14. L48-L51: This paragraph can be combined with the previous one. It will avoid inconsistent length of paragraphs.

Thank you for the suggestion. The two paragraphs have been combined to improve consistency in paragraph length.

15. L87 -L91: This part can be deleted. It's not useful to the paper.

We agree that this summary of the paper structure is not essential and have removed it accordingly.

16. L152, L157, L163, L172-173: Where are the references?

The corresponding references to the product manuals (e.g. GoPro and Nortek) are included in the reference list. As these documents do not state a publication year, they are now cited as 'n.d.' (no date). The references to the used software (Python, OpenCV) was added as well.

17. L177: How many trajectories?

This point has been clarified in the revised manuscript. Approximately one quarter of the particle trajectories were manually reconstructed due to intermittent tracking gaps that prevented the formation of continuous paths.

18. L451-L453: A figure (bar plots) could significantly improve the readability of these results.

We appreciate the suggestion and agree that a bar chart would generally offer a more accessible visual representation. We have reconsidered this option; however, given the number of values that need to be presented (mean, median, minimum, maximum, and standard deviation for six variations with three subgroups each) we found that incorporating all this information into a single figure would compromise clarity. For this reason, we would like to retain the tabular format.

2 Round 2:

2.1 Reviewer #2:

After the suggested revisions, the manuscript content remains quite interesting for ecohydraulic and ethohydraulics. Most of my recommendations have been followed and where it was not possible, the authors provided explanations.

Nevertheless, the authors must proofread one more time the paper. Proofreading will help fixing small typos like these ones:

L181, L186, L192, L200, L202: No date is not acceptable. A little research on the manufacturer's website can easily provide the publication year of most hard and software.

L351 to L356 must be rephrased. Its current form is difficult to understand (calibration simulation or calibrated simulation), (initialisation simulation or simulation of initial conditions), (starting conditions or initial conditions).

L431: are within 1 cm (no of), etc.