**Referee Report on** "*Modeling tsunami initial conditions due to rapid coseismic seafloor displacement: efficient numerical integration and a tool to build unit source databases*" by Alice Abbate *et al.*

The manuscript under review, authored by **Alice Abbate, José M. González Vida, Manuel J. Castro Díaz, Fabrizio Romano, Hafize Basak Bayraktar, Andrey Babeyko, and Stefano Lorito**, represents a significant contribution to the field of tsunami research. Hailing from esteemed institutions like the Istituto Nazionale di Geofisica e Vulcanologia, the University of Trieste, the University of Malaga, and the GFZ German Research Center for Geosciences, the team brings together a wealth of expertise. Their work focuses on improving the simulation of seismically-induced tsunamis through the numerical evaluation of the Kajiura filter integral for instantaneous vertical seafloor displacements, a topic of paramount importance for both academic research and practical applications in tsunami risk assessment and early warning systems.

The study's strong points lie in its innovative approach to the numerical integration of the Kajiura filter integral and the subsequent development of a tool for constructing tsunami unit source databases. The methodology proposed by the authors to approximate the initial sea level perturbation through a linear combination of elementary sea floor displacements is both efficient and accurate. This allows for rapid simulations of tsunami initiation, which is crucial for improving the timeliness and reliability of tsunami warnings. Moreover, the application of this methodology to the tsunamigenic Kuril earthquake doublet and the consideration of the horizontal contribution to tsunami generation represent notable advancements in the field. The provision of a tool to create tsunami unit source databases offers a valuable resource for the research community and practitioners alike.

However, the manuscript is not without areas that could benefit from further refinement. While the authors have clearly delineated their contributions to the field, the manuscript would benefit from a more comprehensive discussion of the implications of their findings for existing models of tsunami generation and propagation. Specifically, it would be advantageous to elaborate on how their approach compares with current methodologies in terms of computational efficiency, accuracy, and applicability to different seismotectonic settings. Additionally, the paper could be strengthened by addressing potential limitations of the proposed methodology, such as the applicability of their approach to complex bathymetric features and varying sea floor displacements. Furthermore, the manuscript would be enhanced by the inclusion of a more detailed exploration of how the tool for constructing tsunami unit source databases could be integrated into existing tsunami warning systems and risk assessment frameworks.

The manuscript also suffers from a lack of discussion regarding the sensitivity of their model to various parameters, such as the choice of truncation points in the numerical integration and the resolution of the underlying bathymetric data. Addressing these aspects would not only provide a clearer understanding of the robustness and reliability of their approach but also guide future research efforts in optimizing the model for different scenarios.

The authors assert in the abstract, "We verify that we can satisfactorily approximate the initial sea level perturbation as a linear combination of those induced by the elementary sea floor displacements." While this statement highlights a central aspect of the manuscript's methodology, it is worth noting that this outcome is inherently expected from a theoretical standpoint. This fact naturally follows from the Green's function integral representation of the solution to the Laplace problem for an incompressible and irrotational fluid, combined with the convergence properties of the selected quadrature formula. The linearity of the problem and the superposition principle justify the authors' approach to modelling the initial sea level perturbation. Thus, while the verification of this approach through numerical experiments is valuable for practical applications, the theoretical basis for expecting such a result should not be overlooked.

It is also noted that several relevant references are missing, which could provide a more comprehensive background and context for the study. Incorporating these references would not only enrich the literature review but also position the authors' contributions more clearly within the existing body of knowledge.

Furthermore, the authors mention in the Introduction, "The contribution of the horizontal component to the coseismic deformation can also be important in the presence of steep slopes in the bathymetry (Iwasaki, 1982; Tanioka and Satake, 1996), or in shallow earthquakes resulting in an additional uplift in the accretionary prism (Seno, 2000; Tanioka and Seno, 2001)." This acknowledgment of the significance of horizontal displacements in tsunami generation is crucial. It is pertinent to note that the influence of horizontal seabed movements on tsunami genesis has been previously investigated. For instance, Dutykh et al. (2012) in their study "On the contribution of the horizontal sea-bed displacements into the tsunami generation process" (Ocean Modelling, 56, 43–56, https://doi.org/10.1016/j.ocemod.2012.07.002) offer an early examination of this aspect. Moreover, the application of finite fault solutions to tsunami generation, akin to the methodology employed by Abbate et al., has been discussed in the literature, notably by Dutykh, D., Mitsotakis, D., Gardeil, X., & Dias, F. (2013) in "On the use of the finite fault solution for tsunami generation problems" (Theor. Comput. Fluid Dyn., 27(1–2), 177–199, https://doi.org/10.1007/s00162-011-0252-8). The inclusion of these references could provide a richer historical context to the current study, acknowledging the foundational work upon which the present methodology builds.

In their manuscript, the authors describe different methodologies for modeling the initial conditions of tsunami generation, noting, "Some approaches impose a delta function as the bottom velocity (Levin and Nosov, 2009; Saito, 2017) or transfer to the sea-level the last frame of a time-dependent earthquake rupture simulation (Saito, 2019; Abrahams et al., 2023)." This distinction between methodologies can also be framed within the context of "passive vs active generation" of tsunamis, as explored in the literature. Specifically, the concept is detailed in Dutykh et al. (https://doi.org/10.1007/978-3-540-71256-5_4), a reference already cited by the authors for other purposes. To enhance the accessibility and comprehensiveness of their discussion, it would be beneficial for the authors to include this terminology, referring to "passive" and "active" tsunami generation. This inclusion would not only align with established nomenclature but also potentially broaden the appeal of their work to readers familiar with these terms from existing literature on tsunami dynamics.

Additionally, from a typographic standpoint, the manuscript could benefit from a refinement in the presentation of mathematical expressions, particularly concerning the notation of (hyperbolic) trigonometric functions. Instead of representing these functions in plain text, such as "*cosh*," the authors should employ the corresponding function notations available in their document preparation system. This practice not only adheres to mathematical typesetting standards but also enhances the clarity and professionalism of the manuscript. Adopting this approach for all mathematical functions within the paper will ensure consistency and improve readability for the audience.

Regarding Figure 5, there is a significant opportunity for improvement in its visual presentation. The current excessively dark style of the figure does not contribute to its clarity or effectiveness in conveying the intended information. To enhance the readability and overall visual appeal of the figure, it is recommended that the authors remove the background grid. This adjustment would simplify the figure's appearance, making it easier for readers to focus on the key data and findings presented. Such a revision would align with best practices in scientific visualization, ensuring that figures serve as effective communication tools within the manuscript.

In conclusion, the manuscript "*Modeling tsunami initial conditions due to rapid coseismic seafloor displacement: efficient numerical integration and a tool to build unit source databases*" by Alice Abbate et al. presents a valuable contribution to the field of tsunami research. However, to fully realise the manuscript's potential as a fantastic scientific article, the authors should consider expanding their discussion of the implications, limitations, and sensitivity of their methodology. Additionally, addressing the issue of missing references will further strengthen the paper. Given these considerations, I recommend a revision of the paper, confident that the authors will address these points constructively, thereby significantly enhancing the value and impact of their work.