REVIEWER 1

Comments on Weiss et al.: "Modeling Indian Ocean circulation to study marine debris dispersion: insights into high-resolution and wave forcing effects with Symphonie 3.6.6" (first revised version)

I have carefully re-read the authors revisions and responses to the first round of comments a few times. While most minor issues and my previous General Comment 2 were thoroughly addressed, and reformulations helped to account for my previous General Comment 3, I still have concerns regarding the implementation and presentation of wave effects in relation to my previous General Comment 1.

We sincerely thank the reviewer for their time and valuable feedback, identifying the inconsistencies in our terminology and formulations. It has enabled us to present the physics more clearly and unambiguously. We are pleased that some of our responses have satisfied the reviewer's expectations, and we are continuing our efforts to clarify the representation of wave effects below.

Although the authors included formulas and adjusted their wording, the mathematical expressions and terminology remain imprecise, hindering a clear understanding of how wave effects were incorporated (General Comment 1). Moreover, these formulations appear inconsistent with the written response, from which I understood that the only wave effect included in the dispersal simulations is the modification of Eulerian currents via Stokes-Coriolis forcing. If that is indeed the practice the authors adopted, it deviates from established approaches in the peer-reviewed literature, and is not convincingly motivated (General Comment 2). Hence, I unfortunately still cannot complete my assessment nor recommend publication at this stage.

We agree that some wording in the previous version of the manuscript created ambiguities. We propose adjusting our wording and terminology in line with the literature, particularly the work of Couvelard et al. (2020).

General Comments:

1. Imprecise mathematical formulations and terminology still hinder understanding of the incorporation of wave effects

Equations (1)-(3) contain inaccuracies and partially contradict each other as well as the supporting text. As written, they do not allow the reader to understand how exactly Stokes drift enters the momentum and tracer equations. Please ensure the equations and descriptions are consistent, specify all terms affected by Stokes drift, and consider simplifying diffusion terms. Specifically:

In the first round of revisions, we misunderstood some comments of the reviewer, which led us to provide inadequate justifications or modifications.

- Eq.1: L. 158: Please use standard terminology, i.e., the Lagrangian velocity u (not the "total current") equals the Eulerian current velocity plus Stokes drift (not "Stokes velocity"). This distinction is important, as it helps to recognize the Eulerian velocity as a prognostic variable and to not misinterpret Stokes drift as a current.

First, we acknowledge that "Stokes velocity" was a poorly chosen term because, although it has the form and units of a current in a phase-averaged wave model, it does not exist as an Eulerian current in nature. Following the reviewer's suggestions, we have reinstated the standard terminology using the term “Stokes drift” throughout the manuscript, as stated in the first version and as commonly found in the literature.

What we called the “total current” is indeed referred to as the “Lagrangian velocity”, so we have reworded it. It is this Lagrangian velocity that is used for the advection of tracers and particles.

We rewrote the full set of wave-current interaction equations, providing explicit expressions for the modified Stokes-Coriolis terms, the advection operator, the free-surface equation, the tracer equation, the continuity-based vertical Lagrangian velocity.

- Eq. 2: The terms d/dt appear to be material derivatives and should be capitalized. For the purpose of the paper, I strongly suggest to write out the material derivatives to clarify which velocities enter the advection terms. In l. 165, it reads that d/dt includes the advection terms by the “total current”, and that “Lagrangian particles as well as Eulerian tracers are displaced consistently by the sum of the Eulerian current and the Stokes drift”. This would largely agree with established approaches discussed below.

Indeed, the material derivatives of the first term on the left side of the general equations use what was called “the total current”, now reworded as Lagrangian velocity in the advection terms. Following the reviewer’s recommendations, we now explicitly write the expression of the derivation operator and capitalize it as suggested to show more rigorously that all tracers and momentum components are advected by the Lagrangian velocity (Eulerian current + Stokes drift).

However, the response to my previous comments and the text explaining equation 3 suggest that Stokes drift was not explicitly included for the particle advection (see comments below). This direct contradiction could be resolved by accurately writing out the respective equations.

- Explanation Eq 3, L. 186-188: “*Lagrangian particles are advected by the Eulerian current fields dynamically modified online by wave forcing through the Stokes-Coriolis term, but without any explicit addition of Stokes drift in the Lagrangian advection scheme*”. This statement seems to be in direct contrast to the explanations added to equation 2. Please revise to ensure consistency.

Due to a misunderstanding in the first round of comments, the quoted statement is indeed incorrect. We felt that the reviewer asked if Stokes drift had been added a second time to the previously calculated total current field, in the offline Lagrangian simulations. Particles are advected by the same Lagrangian velocity as the tracers, the difference is that particles use averaged offline fields, whereas tracers are advected online by the sum of the modified Eulerian current through the Stokes-Coriolis force and the Stokes drift. We now understand that we were all referring to the same physics, but did not express it correctly.

All previous contradictory statements have been removed, in particular the sentence suggesting that Stokes drift was not explicitly used for the Lagrangian advection.

The new current-wave interaction section is now consistent with the equations and with the literature framework terminologies.

Furthermore, in response to my previous comments, nearly all occurrences of the term “Stokes drift” were replaced by alternative phrases. Please note that I never intended to argue for removing the term Stokes drift entirely, but just to differentiate clearly where it appears (i) directly as drift, versus (ii) indirectly via changes in the Eulerian fields through wave-current interactions in form of Stokes-Coriolis forcing. Please reinstate the term Stokes drift where appropriate, use the term "Stokes-Coriolis forcing" for impacts on Eulerian current fields, and consider using "wave impact" when discussing particle results that are influenced by both.

We misunderstood some of the first round comments. Following these last recommendations, we reverted to using the term "Stokes drift" throughout the manuscript when appropriate, as stated in the first version and as commonly mentioned in the literature. We also specified the Stokes-Coriolis force where necessary. Thank you for your careful comments and consideration.

2. The apparent inclusion of only Stokes-Coriolis forcing, without Stokes drift in advection terms, contrasts with established approaches and is not convincingly motivated

In the reply to my previous comments it reads "As the reviewer suggested, we only considered the wave effect on Lagrangian transport indirectly – i.e. […] through wave-induced modification of Eulerian currents, including anti-Stokes forces such as the Stokes-Coriolis force. In our simulations, the Stokes drift is not explicitly added to the Lagrangian advection scheme."

If Stokes drift is indeed omitted from the Lagrangian advection, this is at odds with established practices regarding the incorporation of wave effects in hydrodynamic models and dispersal simulations. In my review of the initial submission, I already referenced recent Lagrangian dispersal studies that highlight the relevance of including both, wave-impact on Eulerian currents (including Stokes-Coriolis forcing) and Stokes drift, for dispersal simulations. Regarding the general theory for the incorporation of wave effects in hydrodynamic models, Couvelard et al. (2020) note that "[b]ecause of geostrophy, it is obvious that the addition of the Stokes–Coriolis force requires the effect of the Stokes drift on the mass and tracer advection to be taken into account". Suzuki and Fox-Kemper (2016) outline how Lagrangian advection (including Stokes drift) and Stokes-Coriolis forcing act together (e.g., their equation 5, 6, and 7). Hence, the response to my previous comments that "the addition of Stokes drift in the Lagrangian module could have led to redundancy in the consideration of this effect" remains unconvincing. Are there publications or internal results supporting this statement?

Finally, we think that our method (the physics used) fully aligns with the reviewer recommendations and bibliographical references mentioned, and that the mistake lies only in our wording. We thus thank again the reviewer for carefully pointing this crucial inconsistency. We confirm that, in our simulations, both Eulerian tracers and Lagrangian particles are advected by the Lagrangian velocity and there is no omission of Stokes drift from the transport scheme.

After re-evaluating our initial response, we realized that we misinterpreted some comments from the first round of review. The confusion originated from our internal distinction between the online computation of the Lagrangian velocity for Eulerian flux-form advection, and the offline use of this fields by the particle tracking module. We mentioned a "redundancy', because our offline velocity field already considers the addition of the modified Eulerian current via the Stokes-Coriolis force and the Stokes drift. This misunderstanding arose from our point of view because some Lagrangian tracking studies using offline current fields use this additional method without considering the Stokes-Coriolis force.

Furthermore, based on the literature studies referenced by the reviewer, we only retained the Stokes-Coriolis force. The additional nonlinear terms (as detailed in Couvelard et al., 2020), which the authors mentioned to be less significant at this wave resolution, were therefore neglected. The low resolution of the wave product used for forcing (CMEMS WAVERYS 0.2°) justifies the simplification of the parameterization and the omission of the nonlinear terms based on Stokes drift gradients, which are either absent or very weak in a low-resolution wave forecast. We added "Besides, readers' attention is drawn to the fact that a similar but more precise parameterization with more terms is provided by Couvelard et al. (2020)."

Also, to clarify, note that our set of equations is a simplified presentation. It omits the sigma vertical coordinate system and curvilinear horizontal coordinates used in our configuration model. Numerical advection schemes that affect viscosity and diffusivity are not explained here (see Garinet et al., 2025, for example).

Specific Comments:

- L.17: Stokes velocity -> Stokes-Coriolis forcing : We think that here the seasonal effect in the Arabian Sea is rather attributed to the Stokes drift term, we thus replaced Stokes velocity by Stokes drift in this sentence. On the other hand, we have clarified L11 with " IndOc.HR-Sto uses the same resolution but includes wave forcing through both the Stokes-Coriolis force and the Stokes drift".

- Lns. 65-67: Maybe not the one-way vs two-way coupling is the important point here, but rather the complexity and number of wave processes included? Rühs et al. (2025) do not perform a two-way, but one-way coupling. : We rephrased such as "Different levels of complexity in representing wave effects have also been explored in the literature, from simplified parameterizations through one-way forcing to more comprehensive schemes that include multiple wave-induced processes and/or two-way coupling frameworks (Röhrs et al., 2012; Cunningham et al., 2022; Rühs et al., 2025; Bajon et al., 2023; Couvelard et al., 2020)."

- L. 151, L. 155: Stokes velocity -> Stokes drift : agreed and replaced by "the three-component Stokes drift vector"

- L. 153 ff: "In practice, the effect of Stokes drift is considered through the transport calculations in the model's Eulerian equations." This could be interpreted as if Stokes drift enters the advection terms in the momentum and/or tracer equations. But the reply to my previous comments reads as if that is not the case. If Stokes drift is not added to the advection terms, please clarify or delete this sentence. : to remove any ambiguity we have added the expression of the material derivative that includes the Stokes drift in the advection terms (Eq 1). We acknowledge that our response to your previous comments was not clear enough.

- L. 154: I do not understand what is meant with "in parallel" here. It sounds as if the practice described in this sentence is performed in addition to the implementation described in the last sentence. But I thought you are just adding Stoke-Coriolis forcing? This phrasing was indeed ambiguous. We replaced it with a clearer formulation explaining that Stokes drift affects advection and Stokes-Coriolis affects Eulerian momentum. These two effects are complementary but applied within a single consistent framework : "the model incorporates a simplified parametrization for the influence of waves on currents, retaining only the dominant terms in the right-hand sides of the momentum equations 2 and 3 below, i.e., the Stokes-Coriolis force (van Sebille et al., 2020; Jordà et al., 2007; Xu and Bowen, 1994). [...] The general wave-current equations of the SYMPHONIE model distinguish between the components (u, v, w) of the Eulerian current and the components (us, vs, ws) of the Stokes drift. The Stokes drift enters the Eulerian equations through the advection operator. The material derivative used in Eqs. 2 to 5 below includes the advection by the Lagrangian velocity (u + us, v + vs, w + ws), i.e. Eulerian current + Stokes drift"

- L. 171: "including Stokes velocity forcing to integrate the effect of surface waves on Eulerian currents via the Stokes-Coriolis term in the momentum equations" -> including the effect of waves on Eulerian currents via the Stokes-Coriolis term in the momentum equations : done

- L. 402, L. 404, L. 595: Stokes velocity forcing -> Stokes-Coriolis forcing : done

- L. 629, L. 653: Stokes velocity -> Stokes drift : done

- L. 643, L. 652, L. 669: Stokes velocity forcing -> waves (potentially includes changes in Eulerian currents plus Stokes drift?) : done