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## **Comment on egusphere-2022-337**

Anonymous Referee #2

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Referee comment on "Using the two-way nesting technique AGRIF with MARS3D V11.2 to improve hydrodynamics and estimate environmental indicators" by Sébastien Petton et al., EGU sphere, <https://doi.org/10.5194/egusphere-2022-337-RC2>, 2022

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Review of 'Using two-way nesting technique AGRIF with MARS3D V11.2 to improve hydrodynamics and estimate environmental indicators' by Sébastien Petton, Valérie Garnie, Matthieu Caillaud, Laurent Debreu and Franck Dumas.

This manuscript describes the implementation of 2-way nesting into the 3D ocean model MARS3D using the AGRIF software package. The model is then applied to several domains to demonstrate its utility, specifically around the issue of residence times in coastal waters.

Major comments.

The manuscript is generally fairly well written (but with frequent grammatical errors), although it does seem to be conflicted about its focus. It's hard to discern what this is; is it to introduce the implementation of AGRIF into another ocean code, characterise the physics of the Bay of Brest region or further demonstrate the benefits of 2-way nesting. If the former two, then I think the paper falls short. If the latter, then this is not entirely new. The discussion section reads as if the object of the paper is indeed this improvement over 1-way nesting. However, the configuration chosen to make these comparisons is hardly unique, and the 1-way configuration to which the 2-way is compared seems set up to fail. Similar objectives of resolution placement and computational cost may be achieved by exercising the curvilinear capabilities of 1-way grid, for example, a polar-style curvilinear application may similarly achieve high resolution at the coast but decrease resolution at the seaward open boundaries. Such an application may provide equivalent dynamical advantages to the 2-way approach. Also, compared to the continuous resolution transition across scales afforded by unstructured models, the two-way approach presents a rather brutal interface that requires work (e.g., sponge zones, restriction

operators) to produce a viable solution. In this sense the unstructured approach is a more elegant and dynamically consistent approach. If benefits of 2-way nesting are the focus, it would be interesting to compare to, or at least consider, a tailored curvilinear grid or unstructured approach at the same resolution in the target area. My guess is the solutions would be similar in all cases if grid/meshes are carefully constructed, so benefits would come down to throughput. This would make for an interesting paper, but probably not within scope of what's tractable here. An important advantage of 1-way nesting is that once the open boundary files have been generated, then they can be re-used at no cost, whereas for 2-way nesting the parent must be also run every time the child is optimised, or an additional experiment performed. Since the child obviously runs faster than the parent+child, in terms of overall throughput this may be a more efficient system if many runs of the child are required. The re-use of child OBC conditions probably deserves consideration. Regardless, if comparative 1/2-way approaches are considered, then a more rigorous consideration of throughput could be included alongside dynamical benefits, and optimized 1-way configurations should be explored.

The system characterisation of the region comprises validation against tidal observations and T/S. The flushing time is then computed (using 1 and 2-way) for the Bay of Brest. Although the paper considers several flushing metrics, a variation of the non-stationary method (e.g., Tartinville et al., 1997) is used. The authors speculate on the physics responsible for the distribution of these flushing times, but I'm not sure this is a significant addition to previous studies of the region cited in Section 2.3.1.

The application of 2-way nesting is not new, neither is the implementation of AGRIF in coastal modes. In Section 2.2, it seems that AGRIF has previously been included in MARS3D (e.g., Dufois et al), so it seems that the MARS3D+AGRIF combination is not new either (?). One of the challenges of using AGRIF to orchestrate 2-way nesting previously has been the issue of coupling at the barotropic level. Since all ocean models are either mode split, or semi-implicit (as is this one), then to maintain stability and accuracy in 2-way systems it is generally required that information be exchanged between coarse and fine grids at every barotropic step in the case of the former and every iteration of the implicit solver in the latter. I'm unsure if AGRIF has been applied to semi-implicit models, as I believe the implementations in NEMO, ROMS and HYCOM use a mode-split approach. This potentially is a point of difference in this study that should be exploited, requiring better articulation of coupling at the barotropic level.

I'd suggest major revision to restructure the manuscript so as to consolidate its focus and highlight its unique aspects. This may come at the cost of jettisoning some components that don't support those aspects, and condensing information that has been previously addressed in other studies. Any numerical experiments presented should clearly support the unique aspect presented.

Minor comments.

P1. L15. 'institute for the exploitation', do you mean 'exploration'?

P1, L16. 'preserves some essential principles', suggest replace 'principles' with 'properties'.

P1, L16. 'constant preserving', do you mean preserving constancy condition, monotonic, positive definite? What are the 'induced constraints'?

P1, L22. 'the paper intends at comparing', suggest changing to 'intends to compare'.

P1, L23. 'how MARS3D-AGRIF tool', suggest 'how the MARS3D-AGRIF tool'. 'efficient way significantly', suggest 'efficient way to significantly'.

P1, L24. 'bring it biological issues'. What does this mean?

P1, L28. 'and surely for a long time', suggest changing to 'for a long time'.

P1, L31. 'grid on key-locations', suggest 'grid at key locations'. 'region can varies', suggest 'region can vary'.

P2, L36. 'solitary waves train', suggest 'solitary wave train'.

P2, L38. 'And then they', suggest changing to 'Then they'.

P3, L70. 'introduces shortly, suggest changing to 'introduces briefly'.

P3, L83. 'allows to enhance the', suggest 'allows the enhancement of'.

P4, L98. Perhaps for completeness explicitly specify the function G.

P4, Equation 2. Perhaps some introduction of eqn. 2 is required to make known its purpose; is this simply an expansion of eqn 1? For what purpose – what are you trying to show here?

P4, L115. Perhaps a brief overview of this is required. Either include the full equations or reference Lazure and Dumas and make it clear the above refers to the semi-implicit method (as opposed to explicit mode-split).

P6, Eq 5 & 6. These could probably be made clearer by a more explicit formulation.

P6, L162. Do the iterative strategies used by Haley, Martin mean that 2-way nesting has been previously used in semi-implicit models? If so, this probably needs to be stated earlier.

P7, L187-189. What about conservation for the fine grid using interpolated coarse grid variables? Is this interpolation conservative?

P9, L265. What are the 'classical open boundary conditions'? Sommerfeld radiation (which ones), Flather radiation, adaptive radiation, Dirichlet, upstream advection (characteristics)? The OBC used plays a key role in model accuracy and stability, and some further consideration here is probably warranted. These choices will likely impact the validation metrics in Section 3.2.

P10. L292-293. It'd be good to show the control domain on a diagram.

P10. L298. 'tracer concentration equal to 0'. This is for inflow – what about outflow concentrations?

P10. L299. 'between 95% and  $1/e$ '. Is it 95%, or  $1/e$  (which is  $\sim 36\%$ )?

P11. L303. 'To get rid of the initial conditions', what does this mean? 'the 13 tracers' – what are the 13 tracers? Perhaps clarify.

P12. L348. Change 'ODDYSEA' to 'ODYSSEA'.

P13. L356. 'according to the chosen boundary scheme'. What is the boundary scheme? These details are important.

P13, L368. Change 'computational coast' to 'computational cost'.

P14, L390. What about comparison to the low frequency component? This is a harder test for the model. The tidal component only really needs to be compared over a neap-spring cycle, whereas the low frequency component requires a much longer series.

P15, Table 4. I'm assuming the amplitude in cm is for the model, and the relative difference is the model-observation difference. If that's the case then some of the K1 metrics don't seem to line up (e.g. an observation of the 1-way amplitude overestimated by 9% doesn't seem commensurate with a 2-way amplitude of 8.8cm overestimated by 29%).

P15, Section 3.3. What are the specific improvements of 2-way nesting? Perhaps use this paragraph to better introduce Sections 3.3.1 and 3.3.2.

P15, L429. At what locations do the Taylor diagrams correspond to? Perhaps mention the gauges in Fig 4 here.

P16, L447. 'This could be explained by the nesting feedback that enables a more accurate temperature budget in the mother grid'. Perhaps if a high-resolution grid were designed with a polar curvilinear application that maintained high resolution at the coast but pushed the open boundaries further into the area occupied by the mother, then a similar result would be achieved to the 2-way approach. i.e., any difference may be a consequence of the configuration design due to shortcomings of the 1-way approach not being properly accounted for (in this case with open boundaries too close to the area of interest).

P16, Section 3.3.2. The Ushant front is stated to be due to tidal mixing. Table 4 indicates that, on balance, the 1-way approach has a better representation of the tidal height (although this is mainly due to K1, which appear to have some inconsistencies in their reporting). This comparison to sea level implies the barotropic currents (and hence tidal mixing) are similar (or better) for 1-way compared to 2-way models; i.e., the 2-way exchange of barotropic currents doesn't seem to improve tidal currents in the model interior over 1-way nesting. If this is the case, and resolution is the same in the 1 and 2-way Iroise zoom (500m), then why is the 1-way result worse in terms of the front? Some speculation around the dynamics causing this may benefit.

P18, L494. 'initially the flushing lag'. What is the flushing lag's value?

P18, L495. 'The same analysis....', is this analysis the Bay of Brest 50m model forced by the regional 250m model? Perhaps clarify.

P18, L498. 'The one-way nesting overestimates...', how do you know the 1-way is incorrect and the 2-way is the better estimate?

P18, L513. 'on behalf of various reasons', suggest changing to 'due to various reasons'.

P18, L515. 'AGRIF library as used for a split free surface ocean model'. Isn't the model semi-implicit rather than mode-split?

P18, L517. 'requires to write and store the 3D forcing file', suggest 'writing and storage of 3D forcing files'.

P18, L518. 'grid are picked up.', suggest changing to 'grid are supplied'.

P19, L519. 'high frequency writings', suggest 'high frequency output'.

P19, L520. 'other kind of issues', suggest 'other kinds of issues'.

P19, L521. 'Despite there are many improvements to deal with that question', suggest 'Despite the many improvements to deal with this question,'.

P19, L523. 'the cost of long-term storage of massive data.' Only data on the open boundaries need be stored, which may not be that massive, even at high frequency. Also, storing data enables reuse for the child only, without having to run both the parent-child.

P19, L525. 'sketched' – what does this mean in this context? Perhaps rephrase.

P19, L526. '... by performing them online at each time step....'. This is true, but there is no possibility of re-use, which may be a disadvantage in some cases.

P19, L530. 'consists in the', suggest changing to 'consists of the'.

P19, L537. 'constraints prevent from gravity issues', suggest 'constraints prevent the gravity issues'.

P19, L538. 'the same cares in the grid', suggest 'the same care in defining the grid'.

P19, L538-543. This argument is not particularly convincing as a burning issue. Perhaps rephrase or omit.

P19, L545. 'than the one reached with the tidal forcing prescribed at open boundary conditions', suggest changing to 'than the one achieved with the tidal forcing at open boundaries'.

P19, L547. 'For that kind of standalone grids', suggest 'For this type of standalone grid'.

P19, L548. 'they enables to represent accurately', suggest 'enabling the accurate representation of'.

P19, L549. 'thanks to adapted open boundary conditions algorithm', suggest 'via the open boundary condition algorithm'.

P19, L550. 'performed once for good', suggest 'performed only once'.

P20, L553-555. This is confusing and doesn't get the point across. Please rephrase. 'They are not straightforward..' – what does this mean?

P20, L557. 'maintains MARS3D good ability to', suggest changing to 'allows MARS3D to'.

P20, L559. 'exposed previously, suggest 'previously presented'.

P20, L565. 'large scales as the tidal forcing', suggest 'large scales such as the tidal forcing'.

P20, L570. 'boundary effect', suggest 'boundary effects'.

P20, L580. Why not make the standalone grid encompass the entire control volume, similar to the parent? Although, this would come at extra computational cost – would that be tolerable?

P20, L585. 'tidally flushed of the bay', suggest 'tidally flushed from the bay'.

P21, L590. 'conservative approach required', suggest 'conservative approach is required'.

P21, L587-591. A polar coordinate 1 -way nest may achieve the same result. Even better would be an unstructured coastal or bathymetry weighted mesh. Perhaps mention the 2-way solution is not unique.

P21, L592. 'the AGRIF library flexibility allows to specify', suggest 'the flexibility of the AGRIF library allows the specification of'.

P21, L594. 'of the different', suggest 'to the different'.

P21, L595. There is no reference to the seven-zoom grid apart from its layout. Without evidence it functions this should probably be removed.

P21, L592-593. This is an important advantage of 2-way nesting, and should be highlighted up front. Experiments demonstrating this would really bolster the case for 2-way nesting.

P21, L602. 'without additional task', suggest changing to 'without additional tasks'.

P21, L605. 'In situation where', suggest 'In situations where'.

P21, L606. 'checked once offline' – checked for what?

P21, L610. 'In such a perspective', suggest 'In such a case'.

P22, L623. 'with a refinement factor of 2 to 5'. Unstructured meshes have continuous resolution transition, and as long as this is sufficiently smooth, any refinement factor can be accommodated.

P21, L623-630. If the hierarchy has not been actively exercised, with results to show, then probably best not to include reference to it.

P21, L634. 'allows to reach', suggest changing to 'allows us to reach'.

P21, L640. 'to monitor marine environment', suggest 'to monitor the marine environment'.

P21, L641. 'the MARS3D model give the', suggest 'the MARS3D model provides the'.

Tartinville, B., Deleersnijder, E., Rancher, J.: 1997: The water residence time in the Mururoa atoll lagoon: sensitivity analysis of a three-dimensional model. *Coral Reefs*, 16, 193 – 203.