Response to reviewer 1

We first want to thank you for paying very careful attention and spending time to review our work; we hope these modifications make the manuscript clearer and improved it sufficiently to render it worth publishing.

The article describes an application of the integrated MARS3D-AGRIF model for two-way nested coastal modelling, particularly for estimation of environmental indicators.

Major points:

1. The article looks like a project report as technical details and data information take quite a lot of space. It is a bit short of novelty but an extended application of existing model techniques. As the authors have stated that the AGRIF software has already been implemented into the MARS3D model and two-way nesting has been reported by Debreu et al (2012). Authors may try to restructure the article and clarify what has been done before and what is done in this study, minimising duplication of published materials.
We synthetize the technical details to avoid the "project report" aspect of what was written in the first submission and develop the numerous novelties that have been implemented in the systems since the cited papers. Despite the fact that AGRIF has been developed for years (almost decades) and has been implemented in a couple of models such as ROMS-AGRIF (Debreu et al., 2012), NEMO (Biastoch et al., 2018), MARS3D (Dufois et al., 2014), the model MARS3D V11.2 with AGRIF and the applications performed illustrated new capabilities and open rooms for future conceptual developments. It may be first worth to stress the fact that the approach relies on the development of a code-independent library (AGRIF), suited for structured grids and finite differences/ finite volumes methods, and weakly intrusive into codes (Debreu and Blayo, 2008). In that way, it offers a generic capability implementable in any code fulfilling the prerequisites nevertheless requiring a good knowledge of code numerical aspect (time stepping, advection scheme, mode splitting).
As a matter of fact, the coupling reported by Debreu et al. (2012) relies on the ROMS-AGRIF model. In many ways ROMS-AGRIF differs from MARS3D: mostly it is a split explicit free surface model (Shchepetkin and McWilliams, 2005) whereas MARS3D is a split semi-implicit free surface model (Lazure and Dumas, 2008). The use of the Alternate Direction Implicit (ADI) which is a global solver, solving a full row or column of the grid in one step induces many tricks especially in the two-way implementation that have been addressed since the first application of Muller et al. (2009). Theses aspects has been developed in the reviewed manuscript.
Here we can mention specifically what has been added or better highlighted:

- The reformulation of the ADI scheme to solve the barotropic mode,
- The update method between a given child grid and its parent grid, that insure momentum and mass conservation,
- The communication between overlapping child grid of the same level of the hierarchy,
- Some specific point related with the wetting and drying capability.

As you noted, an older version of the AGRIF library was already implemented in MARS3D V6.0 and used in Muller et al. (2009) and Dufois et al. (2014). This implementation solely assured the mass conservation with one-way nesting. The MARS3D-AGRIF V11.2 code gathers numerous developments. We understand it could be a bit confusing as it represents nearly a continuous 5-years period of development. Considering this remark and your next suggestions, the article was restructured to better identify what is new in MARS3D model, AGRIF library and the two-ways nesting technique implementation. The Sect. 2 is now devoted to innovative developments with reference to previously published studies.

2. Whether this technique is suitable for coastal marine application is still a question though the authors have claimed it is 'well suited'. There are three reasons for this questioning:
a) The two-way interaction is only built between the mother grid and each child grid. Although it could create a chain of child grids along coastlines and some child grids may even overlap, there is no direct interaction among the child grids, neither two-way nor one-way. This casts a doubt on whether the child grids could really represent the coastal processes as whole. The mixed effects reported by the article may be evidence.
The requirement pointed here is very relevant and we paid much attention to it despite the fact it was apparently not sufficiently described in the first version of the manuscript. It led to a misunderstanding and thus we clarify the manuscript. The child grids are indeed enabled to exchange information thanks to the overlapping areas as it was explained in paragraph L208-215 (subsection 2.2.4). We extended the description of this interaction between grids of the same level through their common parent grid. Without these interactions at the same hierarchical level, choosing to pave the coastal domain with rectangular shapes such as in the regional configuration would have been an inadequate solution. The overlapping areas are necessary to apply a weighted-average operator between child grids.

b) AGRIF is designed for adaptive refinement in open ocean, may not be a good approach for coastal refinement. The final example of 3-level refinement with 1 mother grid at 2 km, 19 grids at 1 km and 61 grids at 500 m resolutions is complicated as a coastal model. Nevertheless, the 3-level refinement may not be enough for coastal models. For instance, the 500 m fine resolution may not

be enough to resolve the 1.8 km wide 50 m deep narrow channel (Goulet de Brest). The 2 km mother grid may not be suitable for a large regional model to cover key regions desired for far-reaching effects. It looks the software may struggle if more levels are required.
You are totally right that the example given is not refined enough in coastal areas. Resolution below hundred meters is now an order of magnitude to study coastal physical or biological processes. Actually, the pavement was described as “a simple example” to illustrate the capability of geographic domain splitting. Nevertheless, the MARS3D-AGRIF system is able to cope with more complex grid hierarchy: We provide here an example with two levels of grid refinement but there is formally no limit on the number of levels in the grids hierarchy. We could have built a hierarchy with three, four even more levels to downscale up to any given resolution. So far, the main problem raised by such an approach relies more in the postprocessing (of numerous file results) than in the building nor the computation. This problem is being addressed for a next generation of our approach.
On another hand for biological studies where more than 20 tracers are simulated (Ménesguen et al., 2018), this example configuration (already tested for a short period) still represents a suitable opportunity to pave the French coast at reduced computation cost without jeopardizing the final objectives.
Because this development is still an on-going perspective, we decide to reduce it with just a short mention.

c) Although the AGRIF software has removed the burden to save boundary files for the child grids, there is still a requirement to save the output from these child grids. Otherwise, the enhancement by the refinement will be lost. The duplication of data over same areas (as the mother and child grids overlap) also increases disk demand, not to mention that some child grids may also overlap, and the rectangular domain shape wastes some disk spaces for land areas.
We completely agree: a new structured output data needs to be elaborated, to avoid duplicated writing data at different refinement scales over the same geographic areas. An INRIA team is developing such output design bearing in mind the compatibility with processing software (Python, Paraview…) to easily interact with. It is based on different merges of grids at same level without keeping data where there is a subgrid level. Another solution would be to use the same as unstructured model’s output file with 1D list containing geographic position, hierarchical grid level and spatial relations with adjacent cells. This issue was already mentioned in L628-630 so we emphasize it by explicitly telling that further improvements are still required.
Concerning the disk space used for land areas, the rectangular domain shape waste remains minimal as all land values are declared as a missing value thanks to the _Fill_Value attribute of the NetCDF norm. With the classic on-the-fly compression using zlib (https://zlib.net) integrated into the NetCDF4 library, the output file’s final size is largely reduced, almost as if these points do not exist. One may even think to mask in a parent grid all the areas overlapped by a child grid (not yet performed in our system).

3. Parallelization is an important feature of large models, like this coastal application. The article does include some description of parallelization but may extend it to give more details, at least, to clarify some results as given in section 3.1.
We do agree; some words were given in the section 2.2.3 but certainly not sufficient regarding the importance of this aspect. We extend the description of the parallelization and we comment in further details the results in section 3.1.

Minor points:

L40-51: This paragraph stated that it is difficult for unstructured grids to handle adaptive refinement both temporally and spatially but failed to clarify that the present application is not adaptive as well though the AGRIF software is originally designed for adaptive mesh refinement. There is also multi-resolution unstructured grid, such as the spherical multiple-cell grid (Li 2021), which can offer static coastal refinement and prevent the finest cell CFL restriction from spilling over the entire grid.
We do agree and are thankful for the reference that help to mitigate our initial statement. Our point is mostly focused on the temporal refinement which is very easy to manage from one grid to another (one may notice it is constant on a given grid). We did not intend to address here the problem of the spatial adaptive refinement which is, as you underline, out of the scope of this study where we use static grid hierarchy. We are more in line with Li (2021) approach to better fit a fixed geometry rather than tracking a dynamic feature (such as an oceanic eddy, a river plume, a frontal instability). We also add that to our (almost comprehensive) knowledge AGRIF is not use for application with its spatially adaptive capability relevant to follow dynamical patterns of a flow.

L53: It is a bold claim that overlapping grids would be "well suited" for coastal applications.
You are right. The overlapping is compulsory to exchange information between child grids and might not be claim as “well suited”. We underline this and temperate what might appear as a “bold claim”.

L75: The section title is ambiguous. Using the sub-section titles directly may be good enough.
As mentioned earlier, we split Sect. 2 into two parts: the first one is dedicated to innovative model developments and the second one is focused on both realistic configurations and timescale indicator description. Thus, Sect. 2 is now named “Innovative developments for two-way nesting”.

Section 2.1: An important feature of a 3-D marine dynamical model is the vertical discretisation or vertical coordinate scheme. The sigma coordinate used in the MARS3D model is better to be mentioned in this section rather than quite later in section 3.1. Authors may simplify the MARS3D model description, such as shortening the description of the C-grid as it is well documented, and concentrate on any update for this study, such as any modified equations or changed schemes.
We do agree with you. We dramatically simplify these parts with only the newest developments and remind that MARS3D is based on sigma vertical coordinate framework (itself rather common and well documented but worth to be mentioned).

Section 2.2: Similar as comment for section 2.1. Is the two-way nesting algorithm differ from Debreu et al (2012) one? If so, what is new in this model implementation?
Yes, it is significantly different as some fundamental numerical aspects of these two models differs noticeably, especially the time stepping and the baroclinic/barotropic coupling. The main one relies on implementation in split explicit free surface model (ROMS-AGRIF as in Debreu et al. (2012)) *vs* split semi-implicit surface model (never performed before to our knowledge). We think it is worth presenting it as long as the ADI (*ie* semi-implicit) solver used in MARS3D is quite popular among coastal modelling community (Chakraborty et al., 2021; De Goede, 2020; Parsapour-Moghaddam and Rennie, 2017) concerning model as widely spread as Delft3D or Mike21. As said earlier, the recent developments have now been highlighted in the Sect 2.

Sub-section 2.2.3: Parallelization is an important feature of large models. Better start a new section for it and explain a bit more about it.
According to your rightful suggestion, we create a new subsection 2.3 dedicated to the parallelization option and give more details.

L195: Do you mean distributing the MPI processors among all child grids?
Yes, it is exactly what we meant. We replace the term "between each" with "among all".

Sub-section 2.2.4: Is this part of the two-way nesting algorithm? If so, better merge it into sub-section 2.2.1.
The definition of a sponge layer applied in the child grids is indeed a part of the two-way nesting algorithm. Following your suggestion, we merge it with subsection 2.2.1. The second part of the initial subsection was dealing with the interaction between child grids at the same hierarchical level; we keep it in a special subsection to highlight this important issue (as you underlined above in your second major point).

Section 2.3 and 2.4: These sections could be reduced to essential information, so they are just enough for demonstrating the two-way nesting effect.
We decided to create a new section with these subsections. We have reduced the description of forcing and data validation as recommended and avoid the "project-report-like effect" it gives.

L227: Move the 3 in 'm3' to a superscript.
Ok.

Section 3.1: May change the section title to: Computing cost. It may serve as part of the model parallelization. Explain more on how many runs are used for the computing time average and clarify the computing node usage, particularly for the hybrid one.
We gather a part of this section with the parallelization section. We also clarify the paragraph and correct the wrong usage of term node. Five simulations were run sequentially to determine the average computing time.

L368: "computing coast" should be computing cost".
Ok

Table 2: what do you mean 56 MPI nodes with 8 OMP each? Do you mean the total number of nodes are 56x8? Better to clarify in terms of MPI ranks and OMP threads as number of processors on one computer node may vary from machine to machine. Reducing the runtime to 1/4 with 8 times of computing resources in hybrid mode is a good result.
OK. We definitely need to clarify this part as we made some confusion with the term "node" instead of using "ranks". The supercomputer DATARMOR is composed of 396 nodes with 28 cores each. When we were saying "56 MPI nodes with 8 OMP each", it should have been "56 MPI ranks with 8 OMP threads, for a total number of 448 cores". We modify Table 2 according to this terminology. Indeed, the hybrid mode is efficient to reduce the computing time. We highlight this remark in the manuscript.

Section 3.2-3.4: Limited by my knowledge about coastal models and environment indicators, I could not comment much on these sections.

Section 4. Would it be better to merge the discussion with the result section?

We sum-up the description of the results to avoid the project report as you mentioned earlier. Nevertheless, we think it is better to keep separated the results from the discussion. Thus, the reader can draw more easily conclusions during the discussion.

L616-630: The paragraph for possible multi-resolution approach with AGRIF library may be shortened as it is not part of this study. Fig.10 gives readers a false impression that the 3-level configuration has been tested. It is better removed.
Yes, because this development is still an on-going perspective, we decide to reduce it with just a short mention.

L700: Better not quote conference abstract with a broken web link.
Actually, the link https://ui.adsabs.harvard.edu/abs/2016EGUGA..1815272D is not broken. We have checked again that all the links provided in the bibliography are functional.

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