Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2022-120

Anonymous Referee #1

Referee comment on "Grid refinement in ICON v2.6.4" by Günther Zängl et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-120-RC1, 2022

<General comments>

This paper described a method of grid refinement as a form of lateral two-way nesting for the ICON system which is employed in the operational DWD global and regional models. This paper also showed that the performance of the suggested methods by the results of ideal experiments with dynamical core only and NWP case studies with full-physics. The authors presented that the suggested methods worked fine, numerical disturbances due to the nesting are enough to small, and feedback from child models give positive impacts to the parent model's forecasts.

As far as I know, this is the only operational global NWP system (targeted for short-to-medium range forecasts) which employees a two way-nesting method as grid-refinement. (Specifications of operational global NWP systems as of 2021 are seen in the WGNE website: http://wgne.meteoinfo.ru/wp-content/uploads/2021/11/wgne_table_2021_v4.xls)

In addition, the suggested two-way nesting method makes use of characteristics of the triangle mesh generation efficiently. Even though there is a constraint that the mesh size of a child domain should be "twice" finer than that of the parent domain, this could make the model 's source code simple and contribute to well maintainability. From these points, the methods described in this paper are unique and this paper is worth publishing. This paper also could be important as one of the reference papers for the DWD's operational global NWP system.

The structure of this paper basically looked fine, however, the results showed in this paper are limited to make following author's message persuasive:

* "the numerical disturbances induced at the nest boundaries are small enough toã□□be negligible for real applications." (L14-15 of the manuscript)

and

* "a regional refinement over Europe has a significant positive impact on the forecast quality in the northern hemisphere" (L16-17 of the manuscript)."

More evident results such as plots of difference between two experiments, forecast snapshots, and error propagation on maps in the NWP case studies are necessary for publishing.

In addition, several figures which show not exact but acceptable mass conservation of the parent model due to feedback from child models, could be important to persuade practicality of the suggested two-way nesting method.

From above, I suggest publishing this paper after major revisions.

Please see the detail in the specific and technical comments.

<Specific comments>

L8-10: This is a little too technical to write on the abstract. The relevant description is not written in the main part of this paper but in Appendix. As another comment from a different point of view, this description appears some techniques of vectorization. In my understanding, this is of course important for DWD' system as the center uses the NEC's supercomputers. However, these techniques may not be generally effective to other supercomputers.

L123: "or convection can be reduced by stronger entrainment… "… I understand that enhancement of entrainment, particularly for deep convection, can weaken the effects of convective parameterization. However, it does not mean reducing the convection itself. This description could mislead readers who are not familiar with convective paramterization. I suggest "or effects of convective parametrization can be weakened by enhancement of entrainment for deep convection" as alternative.

L224-225: It should described that how much is the magnitude of the diffusive coefficient is and how the magnitude was determined.

L280: I agree with that the feedback operator does not guarantee the mass conservation, as mentioned in this line. In a pragmatic point of view, how much the feedback operator loses the mass conservation could interests readers. If authors put some figures to respond to the interests, this manuscript could be improved.
For examples, comparison of total mass of the child domain between parent model with/without two-way nest, and child model as a function of forecast lead time in JW test (Section 3) and/or NWP case studies (Section 4)

L388: The multi-nesting using the recursive approach sounds interesting, however, the rest of this paper does not present any results from the multi-nesting experiments. Section 2.4 should be shortened and moved to Section 4 as future work, or should be moved to Appendix.

L437-440: It is difficult to see the difference in phases from Figure 4. Difference between E2orE3 and E1 should be shown.

L440-442: It is difficult to see the difference in phases from Figure 4. Difference between E2 and E3 should be shown.

L467: For readers who are not familiar with icosahedral grids, some references are necessary to describe "well known regular wavenumber-five disturbance pattern characteristic for icosahedral grids".

L471-473: It is natural that the nested run has the larger errors than those in the non-nested run since the nested run has more source of numerical disturbances.
The authors should explain the reason why the disturbances due to the boundary are not problematic in fine meth models or NWP cases.
For examples, the authors could emphasize following points more clearly.
(1) the JW's steady state test is initialized from a baroclinically unstable basic state, hence the result is very sensitive to small perturbations. The basic state in the JW's experiment is highly idealized to extract model's characteristics.
(2) disturbance error due to the nesting is smaller as the meshes are finer.
(4) These are the reasons why kinds of errors in Figure 6 are not obvious in fine mesh models or NWP cases

L501-502: It is not clear that "Spurious disturbances" means "Spurious disturbances against the analytic solution" or "Spurious disturbances against the reference". "the uppermost quasi-hydrostatic wave crest and trough, and to the leeward propagating wave signal" are also seen around the regione where x > 20km in the reference (Figure 7 (a)).

L511-517: I am not sure that
(1) whether the parent model is more consistent with the reference than the model without vertical nesting. Because the result from the model without vertical nesting is not shown.
(2) whether the more consistent result with the reference becomes closer to the truth (the analytic solution). Because the leeward wave propagation is not obviously seen in the analytic solution (e.g. Fig (1) of Klemp (2003), MWR,
https://doi.org/10.1175/1520-0493(2003)131<1229:NCOMTI>2.0.CO;2)

L519 (general comment on Section 4): From experience of nested runs of regional models, errors due to boundary conditions may be visualized by hydrological parameters such as clouds, precipitations, etc. If the authors attempt to present that spurious disturbances are not clearly seen, showing some figures of forecast snapshots from the parent model could be necessary.

L561: It is very interesting that impacts of EU-nesting propagate downstream with a delay over the ASIA region. It could be more persuasive if the authors can show the propagation of error diff. on the maps. (e.g. RMSE diff. of sea level pressure on the map at day1, day2, …, and day5 etc.)

L610: I suggest that the authors write down possible future works or plans of this study in the end of Section 4. Propagating the impacts of the two-way nesting downstream is the interesting and gives important implication. This finding implies the possibility of another nested domain upstream from the EU region for improving medium-range forecast over the EU region. This point could be a future prospect of this study in addition to muti-ways nesting described in 2.4.

<Technical comments>

L13: The order of description should be consistent with that in Section 3 (3.1 for JW tests and 3.2 for Schar's mountain wave tests)

Figure 1: White integers which indicate the indexing edged are a little bit difficult to read. For an example, black characters in white circles could make the figure more reader-friendly.