Review of ICONGETM v1.0 – Flexible two-way coupling via exchange grids between the unstructured-grid atmospheric model ICON and the structured-grid coastal ocean model GETM

by Bauer et al.

This paper describes the implementation of the coupling between the atmospheric ICON model and the ocean GETM model using the ESMF/NUOPC coupling technology. It describes in particular the remapping between the unstructured atmosphere grid and the ocean structure grid, and vice-versa, using ESMF exchange grids available in ESMF regridding package. The impact of the two-way coupling is then analysed comparing in detail the results of two simulations of the central Baltic sea, one implementing two-way coupling and the other implementing only one-way coupling from the atmosphere to the ocean. It shows it particular that two-way coupling better represent the surface temperature as compared to the one-way coupling.

The paper is clearly written and easy to follow, and explanations are well illustrated. It represents a nice description of a coupled application and would deserve publication in GMD, but only, I think, if the following major comment is addressed.

Major comment:

In many places, you write that you implemented conservative interpolation between ICON and GETM, but from what I understood, I think this is not the case because of the non-matching sea-land masks in the two models. Let's take Figure 5 but considering fluxes exchanged from the atmosphere to the ocean. One problem is how to calculate the flux, for example, for the lower left GETM cell. If one normalizes the flux calculation by the whole lower-left cell area ("destarea" option in ESMF and SCRIP), then local conservation is ensured but non-physical values may result; if one normalizes by the intersected area ("fracarea" option in ESMF and SCRIP), then values will be physically sound but local conservation will not be ensured. For example, in Figure 5, it is clear that fluxes coming from the atmosphere in "case-2" regions would be lost as there is no corresponding ocean cell in GETM. The other problem is for the flux coming from case-2 atmosphere region; this part of the flux will not be transferred to any ocean cell and again local conservation will not be ensured.

The only way to set up a consistent atmosphere-ocean system and have a well-posed coupled problem, is to adopt the following best practice to defining coherent sea-land masks and sea fractions but it is applicable only if the atmosphere model can consider at least water and land sub surfaces. The original sea-land mask of the ocean model should be taken as is. For the atmosphere model, the fraction of water in each cell should be defined by the conservative remapping of the ocean mask on the atmospheric grid. Therefore, the atmospheric coupling mask should be adapted associating a valid/active index to cells containing at least a fraction of sea. This method ensures that the total sea and land surfaces are the same in the ocean and atmosphere models, allowing global conservation of sea or land integrated quantities.

Can you please comment on these important issues and clarify this in your manuscript?

Minor comments:

- p.1, l.20-21-22: I don't understand why you give the example of the precipitation over sea, while you start by talking about precipitation over land. I would just remove the "e.g. by precipitation over sea" which is confusing, I think.
- p.2, l.43: for the OASIS reference, please use also: Craig A., Valcke S., Coquart L., 2017: Development and performance of a new version of the OASIS coupler, OASIS3-MCT_3.0, Geoscientific Model Development, 10, pp. 3297-3308, doi:10.5194/gmd-10-3297-2017
- p.5, Table 1 captions: You write "If graupel, ice and hail are activated in ICON, then the corresponding contributions to precipitation must also be considered." but these are not explicit in Table 1 right? Maybe you should clarify this.

- p.5, Table 1 captions: You write “The humidity quantity is correctly identified by the name of the exchanged ESMF field” but I don't understand what this means. More on this should be provided in the text?
- p.5, Table 1 captions: You write “The exchange of flux data (3rd block) or state variables (last block) offers the comparison of different coupling strategies within the same model environment” but I don't understand what this means. More on this should be provided in the text?
- p.5, Table 1 captions: The last block is never exchanged as nothing appears in the last column? If so, why does it appear in the Table?
- p.13, l.239-240: Can you provide more precise numbers on the load balance obtained with 864 processes for ICON and 384 processes for GETM?
- p.14, l.251: can you describe and locate the “upwelling regions” more precisely?
- p.13, l.254: It could be relevant to mention Figure 9 when you write about the RV Meteor.
- p.13, l.255: It would be helpful to locate the island of Gotland on one figure.
- p.13, l.256-258: You state that “the values from the two-way coupled ICONGETM run are in the same range as the measurements and the temporal development also agrees much better with the observations “. I agree this is obviously the case after 10 days but not so obvious for the first days; can you better quantify the improvement, maybe by providing a correlation coefficient.
- p. 15, Figure 9: Which area is more precisely concerned, when you write “Easten Gotlan Basin”? Could you give the latitudes and longitudes of the region and maybe show it on one of the figures?
- p.15, l.269: Can you locate more precisely the “area east of Oland”?
- p.16, l. 274: can you give a definition of “central” and “upper” part of the boundary layer in meters so to refer to Fig. 12?
- p.16, l.277: you write “to the strengthening of the local land-sea circulation (cf. Fig. 11)”. I don't clearly see this, can you describe this in more details?
- p.17, l.295: You could refer to Figure 15 C and D.
- p.18, l.305: What does “cannot be switched off by minor changes” mean?
- p.18, l. 310-312: These sentences describe what should be implemented ideally. You should replace “can” by “could” (l.310) and “is done” by “should be done” (l.312)

<u>Other comments:</u>

- p.1, l.4: replace “The work achieved the development ...” by “We present here the development ...”
- p.1, l.19: add “but” before “later”
- p.1, l.20-21: Start the sentence with “However, for most ...” and remove it on line 21.
- p.2, l.31: Replace “show” by “have”
- p.2, l.34-35-36: These sentences use “The latter” and “They” and “them”; I suppose these designate the “coastally trapped waves” but it could be made more explicit for clarity.
- p.4, Figure 1 captions: replace “by arrows” with “by horizontal arrows”?
- p.4, l.95: consider rewriting the last part of the sentence as “... and only individual specification routines need to be implemented for the model and coupler components.”
- p.16, l.284: you talk about the surface heat flux, but these are not shown in any figure right? If so, you should add “(not shown)”.