Reply on RC1

Alessandro Anav et al.

Author comment on "The ENEA-REG system (v1.0), a multi-component regional Earth system model: sensitivity to different atmospheric components over the Med-CORDEX (Coordinated Regional Climate Downscaling Experiment) region" by Alessandro Anav et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-248-AC1, 2021

Response to RC1:
We would like to thank the reviewer for the time taken to read and comment on this manuscript. The comments have been very helpful to improve the manuscript. We will follow your suggestions in addressing these changes in the revised version. Please find below (in bold) our responses to the reviewer's comments.

The manuscript describes and evaluates a new regional Earth System Model (ESM), the ENEA-REG system. The system's main components are a regional ocean model, the MITgcm, a river routing scheme, the HD, and two choices of atmospheric models, the RegCM and the WRF. The description paper for ENEA-REG, version 1.0, is certainly needed, and the GMD is the proper journal for this. But, there are a few issues the authors should work on before the final publication.
It is an advantage to have the possibility to choose between two atmospheric models in the ESM. This possibility allows a, as it is tried in the manuscript, fair comparison and investigation of the impact of different atmospheres on the, e.g., ocean circulation. But, both atmospheric models itself have many options available. For example, WRF can choose from various land surface schemes, microphysics schemes etc. Therefore, there are already many different atmospheric forcings to be got from different WRF setups. Why using two different models, which will, e.g., increase the challenge of future support? This decision should be more strongly motivated in the introduction.

Certainly regional climate models offer several schemes and parameterizations. However, it is also well recognized that models are flawed and some numerical schemes poorly perform locally or over some regions. For these reasons models with relevant skills in simulating climate in some regions of the World could produce large local biases in other regions. In principle, using a combination of different models allows to overcome this issue as users can select the model to be used depending on the study area and the skills of the model over the region of interest. We have further clarified this into the introduction.

The discussed simulations were driven by ERA-Interim reanalysis. WRF was nudged, i.e. not only driven at the domain boundaries, to ERA-Interim. It has been shown before that nudging improves the simulation quality, but only if nudged to reanalysis data. It is probably not helpful to nudge against any global climate projection, which is far less good

than any reanalysis, as nudging imprints the driving models deficits on the nested simulation (e.g. Leps et al. 2018). And, RegCM was not nudged. I would prefer to see a comparison with both atmospheric components not nudged. Perhaps, the simulation results would be more similar. On the other hand, the different atmospheric results force the ocean differently, which shows the impact of different atmospheres more clearly.

We agree with the reviewer on comparing not nudged atmospheric components; for this reason we reshaped the manuscript replacing WRF results with those from the non-nudged simulation. Further details can be found in the revised version of the manuscript. The comparison with the nudged simulation has been however discussed in the conclusion paragraph of the revised manuscript.

I additionally would like to get a bit of information about the computational costs. WRF is more expensive than RegCM? The ocean MITgcm cost is negligible?

**In the present configuration a straightforward comparison of computational costs was not possible as atmospheric models have different horizontal and vertical grids. Anyhow, the atmospheric components are slower than the ocean model because of the larger amount of processes to be simulated (i.e. radiation, clouds, processes taking place at land surface, soil hydrology). In addition, in order to respect the CFL conditions the physical timestep of the atmospheric component is about 10 times smaller compared to the ocean model.
Overall, for the present domains the average CPU time for one year of simulation is around 1 day. A detailed benchmark of RegESM performances is given by Turuncoglu (2019).**

Turuncoglu, U. U.: Toward modular in situ visualization in Earth system models: the regional modeling system RegESM 1.1, Geosci. Model Dev., 12, 233–259, https://doi.org/10.5194/gmd-12-233-2019, 2019.

The authors often used the reanalysis ERA5 as a reference, e.g., for 10-m wind over the sea. It should be made clear that ERA5 over the Mediterranean Sea might be off too and should be taken cautiously.

Thanks for pointing this out; we clarified in the text that ERA5 should be used cautiously over the Mediterranean Sea.

The statement on page 10, line 279, "no single combination of parameterizations yields optimal results" is a bit misleading. This statement is used as an explanation of a temperature bias larger than 4°C, which is quite substantial. It is true that no parameterization, and no combination of parameterizations, can be perfect, but still there are successful global climate simulations. I would avoid using this excuse here.

We apologize for the misunderstanding: the sentence "no single combination of parameterizations yields optimal results" is not an excuse to explain the large bias found in temperature but the outcome of a different sensitivity study where the authors performed several experiments changing WRF set-up and finding no optimal combination able to remove the winter cold bias in the North-Eastern Europe (i.e. Mooney et al. 2013). We reshaped the sentence to better reflect results of other studies where this bias is analyzed and discussed.

The language of the paper should be improved. A few examples are:
Titel: ".", perhaps a "-"?

We improved the language correcting a few typos and errors.

Abstract: line 21: "remarkable biases are relevant for some variables" -> relevant for processes, seen in simulated values of different variables?

We reshaped the sentence.

page 17, line 514: "estimation .... has been faced" -> "the challenge of estimation ... has been faced"

We changed as suggested.

page 26, line 785: "climate constraint by coupling" -> the simulated climate is modified by the actively coupled Med. sea or similar. The coupling itself cannot change the climate, and the Med. sea cannot constrain but modify the European climate.

Thanks for the suggestion, we reshaped the sentence.

Leps, N., Brauch, J., & Ahrens, B. (2019). Sensitivity of Limited Area Atmospheric Simulations to Lateral Boundary Conditions in Idealized Experiments. Journal of Advances in Modeling Earth Systems, 11(8), 2694–2707. https://doi.org/10.1029/2019MS001625