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Geoscientific Model Development Discussions

Interactive comment on "The upper-atmosphere extension of the ICON general circulation model" *by* Sebastian Borchert et al.

Sebastian Borchert et al.

sebastian.borchert@dwd.de

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Dear Dr. Añel,
Dear Referees,
Dear Commenter,

Thank you very much for handling our submission. A clean version of the revised manuscript and a version with the tracked changes will follow.

The major changes and improvements to our manuscript include:

- The title of the first version of our manuscript was missing a version specifier, as remarked by the commenter. We added this information to the title of the revised manuscript. Now, the title reads (with the addition in bold): "The upper-atmosphere extension of the ICON general circulation model **(version: ua-icon-1.0)**"
- Following a comment of referee 1, we significantly extended the review of existing general circulation models that extend into the upper atmosphere in section 1 ("Introduction") of the revised manuscript.
- Both referees remarked that the manuscript is too long. In order to reduce its length, we drastically abbreviated our arguments not to modify the dissipative terms of the governing equations for deep-atmosphere dynamics in section 2.1.1 ("Model equations"); we moved the technical details of the model initialization from section 2.1.3 ("Model initialization") to the appendix A, as suggested by referee 2; we drastically abbreviated our speculation on possible reasons for a numerical instability that occurred during one simulation of an idealized test case in section 3.1.2 ("Jablonowski-Williamson baroclinic instability test case") and removed a corresponding appendix.
- During the revision process, we found a flaw in the gas data that are required for the parameterization of the upper-atmosphere-specific radiative processes. This flaw has been removed and we repeated the climatological test case simulations presented in section 3.2, which make use of the upper-atmosphere physics (the two simulation variants named "UA-ICON" and "ICON(UA)"). The new simulation results presented in section 3.2.2 ("Comparison of simulated and observed climatologies") of the revised manuscript indicate, that the use of the corrected gas data results in an improved performance of UA-ICON (especially with regard to the mean temperature).
- Following a suggestion of referee 1, we included the results of a further climato-

logical test case simulation, named “UAphys-ICON” in our revised manuscript. It is identical to the test case “UA-ICON”, with its model top at 150 km and the upper-atmosphere physics switched on, except for the deep-atmosphere dynamics being switched off (i.e. the shallow-atmosphere dynamics are applied). Through the comparion “UAphys-ICON” $\leftrightarrow$ “UA-ICON”, we tried to quantify the effects of the deep-atmosphere modification of the dynamical core of ICON. The new results are presented in section 3.2.2 (“Comparison of simulated and observed climatologies”) of the revised manuscript.

- In the climatological test case simulations, whose results we presented in the first version of our manuscript, we were not able to apply the vertical variation of the gravitational acceleration as part of the deep-atmosphere dynamics, due to a numerical instability that resulted from too strong heating rates from the standard physics package. During the revision process, we were able to identify the problem in the code and removed it. The above-mentioned new simulations include the vertical variation of the gravitational acceleration, i.e. the complete deep-atmosphere modification of the dynamical core is applied.

We hope that we could address the concerns of the referees and the commenter adequately. With kind ragards, also on behalf of all co-authors,

Sebastian Borchert

Please also note the supplement to this comment:
https://www.geosci-model-dev-discuss.net/gmd-2018-289/gmd-2018-289-AC1-supplement.pdf

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