Review of GMD-2018-289
Title: The upper-atmosphere extension of the ICON general circulation model
Authors: Sebastian Borchert, Guidi Zhou, Michael Baldauf , Hauke Schmidt, Günther Zängl, and Daniel Reinert

1 General Comments

The authors present an extension of the ICON model to the upper atmosphere. This consists of both a change to the dynamics to simulate the deep atmosphere equations and augmentation to the physical parameterizations to represent important processes to the upper atmosphere that are missing in the standard model configuration. These changes are tested on two dry dynamical core tests and a climatological test. The paper is very detailed in the discussion and analysis of the dynamical core simulations which support the conclusions of the authors, the discussion of the climatological test is less conclusive and maybe more investigation and comparison could be performed here.

The contents of this paper is certainly of interest to the wider community and suitable to GMD, my main comment however is that I found the paper to be somewhat long, which in of itself is not a problem, but it is quite wide in its scope in both providing the modifications to the dynamical core, a detailed analysis of the dynamical cores tests, as well as broader descriptions of the extension of the parameterizations and the more complex climatological test. I think this paper could therefore benefit from re-factoring somewhat and tightening up.

I think this paper could be split into two papers, the first could detail the changes to the dynamical core to simulate deep atmosphere dynamics along with the results from Section 3.1 and the appendices of which I think there is enough material in this paper to recommend publication of as it stands. The second paper would detail the specification of ICON-UA, the extension of the parameterizations (Section 2.2) along with test case in Section 3.2. The changes to model initialization (Section 2.1.3) could be relevant to both areas and it is up to hte authors where they think this would best sit.

2 Specific Comments

In addition to the above I have a number of more specific, minor, comments for the authors:

1. Page 8, line 2. The equation in this line contains terms $\partial/\partial t$ referring to differentiation with respect to the tangential direction, whilst equations (8) & (9) use $\partial/\partial t$ for temporal differentiation. Could the authors change either of the symbols here to avoid confusion?

2. Section 2.1.3 I think that this change to initialization is problem many forecasting centers will have moving to the deep atmosphere equations with high lids and I am glad to see the authors address this, however I found the interaction of the different profiles $(T_B, T_F, T_\infty, T_{120km}, T_{IFS})$ a little hard to follow and think this could be helped by a simple diagram showing the regions in which each profile is used and the blending regions where they overlap.

3. Table 1. It would be useful if the authors could add the height at which these different processes (which is described in the text) are used into table 1.

4. Page 20, line27: "$\Delta t = \eta_1 \cdot 13.2s$ fits both the maximum magnitude..." It's unclear to me what is being said here. Do you mean that this timestep fits any CFL restriction of the model in both configurations? or something else?

5. Figure 4. The caption states that the isolines are the analytical solution but these appear very noisy in panels (a) and (b) (particularly the zero contour) which I would not expect from the solution given in the appendices. Is this correct?

6. Page 23. Line 14 How and why has the vertical grid been changed from the Ullrich et.al. paper? (Given the results from figure 7 it appears unlikely that this will have changed the answers but if possible could the formula (or reason) used here be given?

7. Figure 7 In order to condense the paper I think this figure could be removed and it simply stated that the test appears converged with regards to vertical resolution.

8. Page 26, Line 5: Replace "ragard" with "regard"

9. Page 28 Line 25: Replace “mentionde” with “mentioned”

10. Page 29 line 22: I think the authors are correct and this limitation will not affect results greatly but it would be better if they could quantify this belief somewhat instead of just assuming