Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-896-RC3, 2017

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Effects of 3D Thermal Radiation on Cloud Development" *by* Carolin Klinger et al.

Anonymous Referee #2

Received and published: 6 January 2017

This manuscript addresses an important yet poorly understood topic by examining the impact of 3D longwave radiative processes on cloud development for small cumulus clouds. The methodology is appropriate and I believe the paper will make a valuable contribution to the community, but the presentation needs significant improvement before publication. Please find below a list of specific comments. In compiling the list I tried to avoid repeating earlier comments made in the interactive discussion, but some inadvertent repetitions may occur.

General comments:

The paper should comment on whether the results are likely to be affected in a significant way by any inaccuracies in its 3D radiation scheme, the Neighboring Column Approximation.

The summary section should mention that examining additional LES scenes is a key topic for follow-up studies (alongside with incorporating solar radiation, etc.), as the representativeness of current results can be established only by examining further scenes.

Specific comments:

Page 1, Lines 9-10: The meaning of "slab-averaged applications" is not clear to me. Also, the comma after "profile" in Line 11 is not needed.

Page 1, Lines 16-17: It would be important to clarify right at the first mention what is meant by "organization" and/or "organization effects" (e.g., fewer but larger clouds).

Page 5, Lines 6-7: It would help to point out that averaging is over the entire scenes, including even cloud-free grid cells. (This is clarified in the last sentence of Page 13, but readers may wonder well before that.)

Page 5, line 11: I suggest deleting the sentence "The overall cooling in a modeling domain is generally stronger in case of 3D thermal NCA radiation", as the results are discussed and explained later, while this section discusses only the experimental setup.

Page 6, Line 6: I wonder in what sense does cooling compensate for the temperature perturbation.

Figure 3 and most subsequent figures: Using longer dashes in all figures would really help, as I could distinguish dashed lines from solid ones only after strong zooming.

Figure 5 caption: It is not quite clear to me what "bottom" and "middle" mean in "bottom right axis" and "middle left axis."

Page 10, line 6: It might be worth pointing out that relative humidity is lower in interactive simulations even though the temperature is also lower, because the liquid water mixing ratio is higher.

Figure 10-11 captions: For clarity, I suggest replacing "as an 3 hour averaged" by "and as 3 hour averages centered" (perhaps using "starting" instead of "centered").

Page 12, Lines 27-29: It seems worth mentioning that the issues of cloud organization and the size-dependence of cloud lifetime are closely related, as smaller clouds dying and larger clouds growing will result in fewer but larger clouds and in longer correlation lengths. Also, it seems worth pointing out explicitly that it is the same entrainment-invigoration due to 3D interactive radiation that reduces cloud diameter for the cylindrical cloud and erodes small-size clouds for the LES cumulus scene (if this is correct).

Page 13, Lines 7-8: I don't quite understand the sentence "The separation into moist and dry regions is stronger in the simulation with a coarser resolution.", and so clarification would be helpful.

Page 13, Line 18: The comma after "both" can be deleted.

Page 13, Lines 27-29: It seems more important to emphasize the behavior before (rather than after) 20 hours, as that is the time period for which cloud organization results are presented (Figures 13 & 14). The time after 20 hours may be mentioned in passing, but the key point is that in the first 20 hours, clouds are larger in the interactive runs.

Page 14, Lines 17-18: The sentence ". . .it is not certain that we would ever reach the stage where clouds organize in the averaged radiation simulations, but we may reach the stage in the interactive ones" is confusing, because the paper discussed cloud organization in Section 3.2.2 and did not find it negligible in the interactive simulations. Page 14, Lines 3-5 also talk about significant cloud organization.

Page 14, last sentence of summary: This is a very important sentence, and even I suggest directly pointing out its main implication, that the impact of 3D effects comes from changing the spatial distribution (and not the mean value) of cooling.

Figure 19 is very helpful and I would even consider bringing it earlier, accompanied by some discussion of the key processes involved. For example, it could help to point out that the difference between 3D averaged and 3D interactive simulations is deter-

mined by the balance of two competing processes. In interactive runs, the stronger entrainment caused by cloud side cooling shrinks clouds, while the lack of cooling in the middle of updraft pockets leads to stronger updrafts and helps clouds grow. The balance of these two processes varies with the perimeter to area ratio of updrafts, and so the first process can be expected to win for small clouds, and the second one for large clouds. Finally, a minor point is that it would help to include a title for each panel or to specify in the caption what the top and bottom panels are for.

Appendix: I don't think there is a need for a separate Appendix, as the current Appendix contains only the two tables that could easily be moved into the main body. Also, it would be important to clarify what is meant by "vertical stretching".

Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-896, 2016.