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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Comparing the impact of environmental conditions and microphysics on the forecast uncertainty of deep convective clouds and hail" *by* Constanze Wellmann et al.

Anonymous Referee #3

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Review of "Comparing the impact of environmental conditions and microphysics on the forecast uncertainty of deep convective clouds and hail" by Wellmann at al.

The study identifies model input parameters describing environmental conditions and cloud microphysics that lead to large uncertainties in the prediction of deep convective clouds and precipitation, by conducting statistical emulation and variance-based sensitivity analysis of the simulated deep convective clouds in an idealized setup of a cloud-resolving model. They showed some interesting results that could be useful in guiding the improvement of forecasting. However, the results could be very dependent of microphysics scheme, model setup (such as idealized vs. real, nesting vs non-nesting), and

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even convective case. This discussion would be necessary. Particularly, the two moment microphysics schemes with saturation adjustment for condensation/evaporation calculation could lead to very different CCN impacts on latent heating and precipitation rate compared with more explicit microphysics schemes such as bin scheme as detailed in a review article (Fan et al., 2016, JAS). This could change the conclusion related to the diabatic heating rate. Another major problem of this manuscript is that the authors only described what the figures show, and did not interpret the results by connecting with physics properties/processes. See my specific comments for Section 4 and 5. The paper also have quite a bit confusing statements that need to be clarified. Therefore, a major revision is recommended to improve the paper before it is accepted for publication.

Specific comments

The title has a grammatic error: it should be “Comparing . . . to (or with). . .”

Abstract:

Need some detailed background about how change of environmental conditions affect deep convective cloud properties. P1, L8-9 I think the results section showed that fall speed of graupel even contributes more than the fall speed of hail. In the last sentence, suggest rewrite or add sentence to show what parameters impact hail.

Introduction:

1. P1, L16, Fan et al., JGR, 2009 and Qian et al., JGR, 2015 are the studies focusing on wind shear impacts on convective clouds. 2. P2, L5, Change the second “for” to “with”. 3. P2, L22-23 The sentence “However, the impact on precipitation is not identified as the investigated clouds are non-precipitating” needs to be rewritten. I have no idea what you want to say here. 4. P2, L25, The sentence “because of its higher fall velocity immediately falls out of the cloud leading to reduced convection intensity” has grammar errors and also confusing. 5. Need to change the strong tone in some statements.,

for example, (1) “There are only a few studies including Lee et al. (2008) and Storer et al. (2010) where the effect of several parameters is analyzed”, you do not need to say only a few studies since there are a significant number as far as I Know. If indeed just a few, all of them are needed to be cited here. (2) “The only previous studies of multiple interacting uncertainties in deep convective clouds are our own previous study (Wellmann et al., 2018) and Johnson et al. (2015).”

Model Setup:

1. Since the open lateral boundaries are used, need to specify how the boundaries are set up, i.e., what are used for the boundary conditions? 2. P4, L20 How did you define cloudy points? 3. P4, L34-35, the recent progress about CCN impacts on convective clouds is Fan et al., (2018, Science). 4. P5, L15-16, this is confusing, how can you specify the wind velocity to be constant in all simulations since wind is a prognostic field?

Sections 4 and 5:

1. I think some brief introduction to the case is needed before discussing the results from uncertainty quantification (UQ), which would help understand the UQ results . For example, I would like to know the relative amount of each hydrometeor mass to understand if this is a hailstorm case or not (i.e., hail mass is dominant compared with graupel mass). This would help me understand why graupel fall speed is the largest contributor to the uncertainty of integrated hydrometeor mass. 2. In both Section 4 and 5, there is a problem that the authors only describe the figures, but do not interpret the results from physics perspective. For example, in describing Fig. 1, it is better to understand why graupel fall speeds and CCN have the largest impacts on integrated hydrometeor mass but not on the hail mass? Why CCN have a large contribution to integrated hydrometeor mass but not to diabatic heating? 3. I have a hard time to physically understand the contributions shown in Figure 2. At the maximum heating around 3-6 km, the latent heating should be dominated by condensation, which

should be strong affected by CCN. Bout because saturation adjustment is used for condensation and evaporation, the CCN effect on condensation is not shown here. This problem should be discussed. In addition, How does graupel and rain fall speed contribute to the heating uncertainty? Above 10 km, the major contributors are CCN and graupel fall speed. I think it is because they affect how much amount of condensate mass are being transported to the upper levels. This kind of discussion is important to connect with cloud physics. 4. P12, L18-20 Figure 3 shows the largest contribution is graupel and hail fall speeds, which is different from what is described here. 5. P12, L20-21, need to discuss the possible physical mechanisms of how CCN affect the large hailstones. There are literature studies about this. 6. P15, the first three paragraphs, need some discussion in connecting with cloud physics to understand why. For the third paragraph, how to explain the contrasting contribution of hail fall speeds to hydrometeor mass and precipitation? 7. P17, "Dennis and Kumjian (2017) specify in their work that process rates are not an essential factor causing discrepancies in the formation of hail for different model setups", not sure what this means, since microphysical process rates directly determine the budget. 8. Section 5.3, need clearer introduction here to state the purpose of this part. I was not understanding the purpose of this part until I got to the summary (last paragraph of page 20). 9. P18, L12-21, all of the magnitudes described in these two paragraphs are different from what is shown Figure 6. For example, the maximum value plotted is 0.01 mm-1m-3, but you got values of 0.4 and 3.4 mm-1m-3 in the text. Need to check what is going on. 10. P18, L15-16, the sentence is confusing and need clarifications.

Section 6:

1. The relevant summary (the first three paragraphs) needs to be revised accordingly by adding physical explanations. 2. For "The controlling parameters of the combined input parameters are the INP concentration and the fall velocities of graupel and hail, hence a combination of parameters describing environmental conditions and micro-physical parameters", the logic of the sentence is wrong. All the parameters described

here are only microphysical parameters.

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