**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Monte Carlo-based subgrid parameterization of vertical velocity and stratiform cloud microphysics in ECHAM5.5-HAM2" *by* J. Tonttila et al.

Anonymous Referee #1

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SUMMARY COMMENTS: Overall, this is a well-written manuscript that combines two interesting methods to better understand the role of sub-grid vertical velocity on CDNC using: (i) a stochastic representation of sub-grid vertical velocity; and (ii) the Monte Carlo Independent Column Approximation for radiative transfer. The ideas and approach are clearly described by the authors. There is great value in being able to couple the sub-grid scale cloud radiative effects and cloud condensate amount in a consistent manner.

The introduction and methodology in Sections 1 through 4 are very well written, however, from Section 5 (Results), and onwards, the presentation of ideas is not as clear

and the depth of analysis was rather 'light'. The analysis in Section 5.1 and 5.2, especially, needs to be deeper. It would be nice to explain the processes linking the changes in CDNC to cloud amount, LWC and SW CRE. Simply stating and increase or decrease in LWC isn't enough. For example, are the large changes to SW CRE purely due to changes in cloud optical properties or was there also a decrease in low-level cloud amount?

Still, this very interesting work and the conclusions are clearly presented. The results seem relevant and useful to the community.

COMMENTS: - Abstract - The sentence "promotes changes ...cloud radiative effects" is too ambiguous. Can you link the (significant?) changes to the SW CRE to the changes to the LWP or LWC?

- Abstract - Consider eliminating "and might thus have implications ... " from the last sentence. The abstract is for a summary of the work done and conclusions, not a place for speculation. Instead, it would be helpful to reiterate that the decrease in CDNC induced a stronger auto-conversion of cloud water to rain here.

- Section 3.1 - Q_{nucl} and Q_{aut} are non-linear - Consider presenting the formula for Q_{aut} since you show Q_{nucl} and you talk about it later.

- Section 3.1 - Please elaborate on the "ensemble of sub-column CDNC will be adjusted, accordingly". How do you adjust it?

- Section 3.3 - Could you please state explicitly how $N_{act}(j,k)$ is related to $\langle N_{act}\rangle(k)$. How do you go from the max. num. of activated droplets from all the sub-columns $N_{act}(j,k)$ to grid-box $\langle N_{act}\rangle(k)$?

- Section 4 - It would be nice if the 'generalized' overlap method could be summarized in a sentence here.

- Section 5.1 Cloud Properties: "... autoconversion yields the depleted LWC seen ..." - Replace with "autoconversion depletes the LWC in the SUBW experiment."

- Section 5.1 Last Paragraph: It would be helpful to the reader if you mention rain when you speak of autoconversion here, otherwise it is odd that you only speak of it in the conclusions.

- Section 5.1 - Changes to low-level cloud cover ought to be considered, especially since you will show large changes to SW CRE yet state that total cloud cover did not change.

- Section 5.1 - Can you explain what causes the global decrease in LWC? The link between CDNC, LWC and SW CRE in the marine stratocumulus region is interesting and merits a few more sentences, especially since the 'marine' areas do not show the same pattern everywhere.

- Section 5.2 - The reason for the largest changes in SW CRE are not discussed - a discussion linking these changes to changes in the LWC would be useful. Furthermore, is the change in SW CRE low-level cloud amount / low-level cloud cover or a change to the low-level clouds optical depth?

- Section 5.2 - There is very little difference in LW CRE - was this expected?, why?, etc ...

- Section 5.2 - Did you discuss/demonstrate/quantify how the direct coupling with McICA with sub-grid cloud properties influenced the CRE vs. the avg. of sub-grid cloud properties back to GCM scale?

- Section 5.2 Radiative Balances: "... CDNC deflects the total radiative budget..." - The use of 'deflects' in this context is very odd. It is recommended to find another word.

- Section 5.2 In the sentence "... subsequent removal of cloud condensate ...", does this mean there is a loss of low level clouds? Is this due to the stronger autoconversion or the reduction in CDNC? Please be more specific, otherwise the current formulation may lead to mis-interpretation.

- Conclusions: Reiterate SW CRE is affected more than LW CRE.

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