We thank Reviewer #1 for providing constructive comments and suggestions for the manuscript. As a general comment, the Reviewer suggested adding more in-depth analysis of the results and the reasons behind them. Therefore, we have made significant changes and additions to Section 5. We have added more thorough explanations to what is causing the results we present in sections 5.1 and 5.2, and we made slight adjustments to the order of presentation in section 5.1 to make it easier to follow. Moreover, Section 5.2 has been divided into two sub-sections 5.2.1 and 5.2.2, where the first gives the original 5.2 and the latter has been added for comparison with CERES-data as suggested by Reviewer #2.

Below we present our answers to the specific comments given by the Reviewer, which will also cover further changes made in the manuscript (with Reviewer comments in *italics*).

1.
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?

Yes, the most significant changes in shortwave cloud radiative effects coincide with the most relevant changes in CDNC and/or LWC. It is now said in the Abstract:

“The strongest reduction in CDNC and cloud water content over the continental areas promotes weaker shortwave cloud radiative effects (SW CRE) even after retuning the model. However, compared to the reference simulation, a slightly stronger SW CRE is seen e.g. over mid-latitude oceans, where CDNC remains similar to the reference simulation, and the in-cloud liquid water content is slightly increased after retuning the model ”.

2.
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.

We agree with the comment and have removed the from this sentence abstract. Following the Reviewer's comment the following has been added to the Abstract instead:

“The primary impact of the new parameterizations is to decrease the CDNC over polluted continents, while over the oceans the impact is smaller. Moreover, the lower CDNC induces a stronger autoconversion of cloud water to rain”.

3.
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.

We prefer not to go into details about the autoconversion process in Section 3, since we haven't modified the basic parameterization in ways other than to apply it in individual subcolumns. However, the basic equation according to Khairoutdinov and Kogan (2000) has been added to Section 5.1, where we specifically comment on its operation and it is the only place where that formula is needed (3rd paragraph in Section 5.1 and Eq. (8)).

4.
Section 3.1 - Please elaborate on the "ensemble of sub-column CDNC will be adjusted, accordingly". How do you adjust it?

After each process affecting only the GCM-scale mean CDNC, the subcolumn values are scaled with the relative change in the mean, so that the GCM-scale mean is always equal to the subcolumn ensemble mean value. The sentence has been replaced with the following one in the last paragraph of Section 3.1:

"It is assumed that the fractional change in CDNC caused by these processes is equally large for all subcolumns. Thus, the subcolumn CDNC values are scaled with the fractional change in the GCM grid mean, so that the subcolumn ensemble mean always matches the GCM-grid mean".

5.
Section 3.3 - Could you please state explicitly how N_act(j,k) is related to <N_act>(k). How do you go from the max. num. of activated droplets from all the sub-columns N_act(j,k) to grid-box <N_act>(k)?

A simple ensemble mean using the in-cloud subcolumns is computed for each GCM grid-cell. An extra equation (Eq. (6) in the revised manuscript) has been added in Section 3.3 to clarify this.

6.
Section 4 - It would be nice if the 'generalized' overlap method could be summarized in a sentence here.

The description of overlap assumptions was moved to Section 3.4 dealing with radiation. Moreover, the following text has been added there:

"The cloud overlap is described by the generalized overlap method (Hogan and Illingworth, 2000; Räisänen et al., 2004), which is employed when the vertical cloud profiles are created in SCG. In generalized overlap, the degree of overlap changes gradually from maximum towards random overlap with increasing distance between layers. The relative contribution between these two basic overlap assumptions depends on decorrelation lengths defined for cloud fraction and cloud condensate (assumed 2 km and 1 km, respectively)".

7.
Section 5.1 Cloud Properties: "... autoconversion yields the depleted LWC seen ..." - Replace with "autoconversion depletes the LWC in the SUBW experiment."

This sentence was eliminated when reformulating the examination concerning the coupling between CDNC and LWC in Section 5.1.

8.
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.

We now mention the autoconversion to act as a drizzle and rain forming process in the 3rd paragraph of Section 5.1.

9.
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.

Low level cloud fraction is now commented in the 3rd paragraph of Section 5.1, yet we did not add new figures. There are slight differences in low level cloud fraction, basically following the changes in low-level LWC, which is expected since the changes in cloud water content affect the prognostic statistics in the Tompkins cloud cover scheme. The differences in cloud fraction between different simulations are mostly rather small, and affect radiation to the same direction as the changes in the in-cloud properties.

10.
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.

We have extended the discussion about the interactions between subgrid variability in both the CDNC and LWC and the autoconversion process. It seems reasonable that the behaviour in SUBW can be explained by these terms. The main reason, as stated before, is the overall reduction in CDNC, which on average promotes stronger autoconversion at least in the polluted environments. Otherwise, considering the strong non-linearity of the autoconversion process in LWC and CDNC, just by introducing subgrid variability in either one of these variables (keeping the mean values constant) likely increases the average autoconversion rate, and thus the decrease in LWC can be even more widespread than what could be expected based merely on the decreased grid-mean CDNC. Similar explanation has been added to the 3rd paragraph in Section 5.1.

11.
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?

We have added discussion about the changes in cloud conditions, including cloud fraction, leading to the differences seen for SW CRE. As stated in the response to comment #9 above, the changes in cloud fraction follow the changes in LWC and in general affect the radiative budget to the same direction as the changes in cloud optical properties. So the main driver for the changes in radiation lies in the microphysics and, thus, the optical depth, but changes in low-level cloud fraction still certainly contribute to SW CRE. Discussion about this point has been added to Section 5.2.1 (1st and 2nd paragraph) in the revised manuscript.

12.
Section 5.2 - There is very little difference in LW CRE - was this expected?, why?, etc

As we looked mainly at the LW fluxes at the top of the atmosphere (TOA), this was not very surprising, since the LW fluxes at TOA are mainly influenced by high-level clouds such as cirrus clouds. The new subgrid parameterization components in general affect mainly low-level warm clouds, which do not affect the outgoing LW radiation that much since their temperature is

relatively close to the temperature of the surface of Earth. Discussion on this has been added to the 4th paragraph of Section 5.2.1.

13.
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?

To illustrate the effect of direct subgrid-scale coupling with radiation, we performed an experiment where the subcolumn values of CDNC and LWC were replaced by their GCM-scale in-cloud mean for the radiation calculations, while keeping the subgrid description of activation and microphysics intact (identical to SUBW). The model was run with identical closure parameter setup as in SUBW. For the longwave CRE the difference is rather small as expected (as explained in the previous comment). For the shortwave, a clearly stronger CRE is seen for the new experiment compared to SUBW. The global mean SW CRE is about 1.7 W m-2 stronger than in SUBW. No significant differences are seen e.g. in the mean cloud characteristics. These results are reported in the last paragraph in Section 5.2.1.

14.
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.

The sentence has been reformulated as "...sets the total radiative budget off balance ..." in the first paragraph of Section 5.2.1.

15.
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.

In this case, the reduction of the in-cloud liquid water content was intended. The sentence has been reformulated as:
"...and the induced stronger removal of liquid water from clouds due to enhanced autoconversion" in the first paragraph of Section 5.2.1.

16.
Conclusions: Reiterate SW CRE is affected more than LW CRE.

We have added the following in Section 7 (2nd paragraph):

"While the impact on the longwave cloud radiative effect was quite weak, somewhat more pronounced differences were seen in the shortwave radiative effect".