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Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the characteristics of aerosol indirect effect based on dynamic regimes in global climate models" *by* S. Zhang et al.

Anonymous Referee #1

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The article investigates aerosol-cloud interactions and aerosol indirect radiative effects across a range of different climate models. The novel and very interesting aspect of the paper is that the large-scale dynamical settings are taken into account for the evaluation of aerosol-cloud interactions. The authors find a different sensitivity of the liquid water content to cloud condensation nuclei under different large-scale conditions, where regions of subsidence and strong monthly mean updraft are most sensitive. The comparison of different climate models indicates that models particularly strongly diverge in exactly these regimes. A further interesting finding is that the the model predictions of the aerosol effects varies much more if different large-scale conditions are taken into account than for global results.
Promoting the idea of binning aerosol-cloud interactions into different dynamical

settings is very helpful and an important aspect of advancing our understanding of aerosol-cloud interactions. The impact of large-scale dynamics on cloud-aerosol interactions has received only recently appropriate attention and this paper strongly contributes to highlight the importance of the large-scale dynamics. The large-scale (time and spatial) perspective taken in the paper allows to assess and compare a large number of large-scale dynamical regimes and helps to argue for the importance of large-scale dynamics. However, certainly more detailed work is required to understand the relation between large-scale dynamics, aerosols and cloud processes.
The following points should be addressed before final publication.

Specific issues

1. Please specify how monthly-mean GCM data for PI and PD is extracted from the models, i.e., time-slice experiments or average over specific time period (dates). If averages over a specific time period are used, it should be discussed what other changes in the state of the atmosphere could lead to changes in LWP coinciding with changes in aerosol number density. By just applying the eq. (1) these changes can project on the aerosol susceptibility although they are not physically related to aerosol-cloud interactions.

2. It would help to clarify the definition of "dynamical regime", if the characteristic spatial and temporal scales of the dynamic processes depicted by the chosen definition would be specified. It should also be discussed how relevant such a coarse definition is for aerosol-cloud interactions, particularly in regions with very transient dynamic systems as for instance in the extra tropics. It would be also helpful to include an additional figure showing the typical distribution of dynamical regimes as used in this study over the globe eventually for different seasons.

3. It should be specified how changes in LWP and CCN are computed: Are the values first binned according to ω_{500} in PD and PI runs and then subtracted or

are the grid point differences binned according to ω_{500} from either PD or PI runs? If the latter is used some justification is required, as the spatial pattern of ω_{500} may be different between PD and PI runs.

4. Are the LWP and CCN values for different ω_{500} arithmetic means for the values in each bin?

5. The summary is a bit fuzzy and hard to read, particularly the 3rd to 5th paragraph. Please try to reformulated these. The comparison to findings from previous studies should be more clearly described and potential reasons for discrepancies summarized. Further more a short statement on the impact of neglecting mixed-phase and ice-phase processes on the results should be included.

Minor issues Introduction

1. p. 23686, l. 15ff: Add a sentence with some references on the influence of aerosols on clouds by their potential to modify latent heating and cooling profiles.

2. p. 23686, l. 17: Give references to articles considering mixed-phase and ice phase clouds.

3. p. 23687, l. 8ff: Repeating the information from two sentences earlier. Also the next sentence is very long, please reformulate.

4. p. 23692, l.9: "that the frequency of the following sorted dynamic regimes": unclear please reformulated.

5. p. 23695, l. 18: replace "largest λ" with "largest global λ"

6. p. 23696, l. 14ff: sentence starting with "A major improvement ..." is unclear. Please reformulated.

7. p. 23697, l. 2: remove "where storm tracks prevail". This is not really required here and makes sentence hard to read.

8. p. 23697, l. 7: add "spatial" before "pattern"

9. p. 23700, l. 19: sentence starting with "By sorting into ..." is unclear. Please reformulate.

10. p. 23703, l. 18: "Despite the closer global means ..." unclear, please reformulate.

11. p. 23704, l. 24: "Results derived from large eddy ..." unclear, please reformulate.

12. p. 23705, l. 7: replace "can reduce" by "reduces", remove "only"

13. p. 23705, l. 9: replace by "total SCRE decreases in models with prognostic rain scheme compared to those with a diagnostic rain scheme"

14. p. 23705, l. 20: Monthly mean ω_{500} also does not necessarily represent the same conditions as also dynamical conditions may vary quite significantly on sub-monthly timescales.

15. p. 23706, l. 1: remove "A" from "Appendix A" since there is only one appendix.

16. caption of Tab. 4: replace "global regimes" by "all dynamical regimes".

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 23683, 2015.