Atmos. Chem. Phys. Discuss., 15, C1837–C1844, 2015
www.atmos-chem-phys-discuss.net/15/C1837/2015/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Prognostic precipitation with three liquid water classes in the ECHAM5-HAM GCM" *by* V. Sant et al.

V. Sant et al.

vivek.sant@mpimet.mpg.de

Received and published: 23 April 2015

[pdftex,a4paper,11pt]article mathtext color

Reply to Anonymous Referee #2

Dear Reviewer
Thank you for your review of: "Prognostic precipitation with three liquid water classes in the ECHAM5-HAM GCM" by V. Sant et al. Please find responses to your comments below.
Best regards,
Vivek Sant

Specific responses to Reviewer comments:

Major Comments:

Page 7784, line 16. Run the model long enough or, better yet nudge winds to a common analysis, to improve statistical significance.

We will extend the model runs by a few years to see whether the variability decreases. The problem with nudging is that the model is not necessarily in radiative equilibrium anymore.

Since the aerosol optical optic depth is changed significantly, this could affect the aerosol radiative forcing ERFari. Please add a diagnostic radiation calculation without aerosol to partition the ERF into ERFari and ERFaci (e.g., Ghan, 2013).

This would be a possibility, but differentiating between ERFari and ERFaci is difficult as both effects act at the same time (cf. Lohmann et al, 2010, ACP).

The manuscript has far too many problems with the English for a reviewer to identify and suggest all corrections. I've identified twelve corrections and improvements for the only the first two pages. If the corresponding author cannot improve the English in the rest of the manuscript, the coauthors should get more involved.

We note that most of the corrections are related to the style of writing. We are sorry to hear that the reviewer finds the style inappropriate and we will improve the manuscript as a whole. We thank him/her for the suggested corrections.

ACPD
15, C1837–C1844, 2015

More clarity is needed in several places, including whether all microphysical modes contribute to cloud optical properties, and how those optical properties are represented.

If by microphysical modes, the different liquid and ice water classes, i.e. hydrometeor types, are meant, then some clarification can surely be added. The added prognostic drizzle, rain and snow classes are not added to the radiative calculations. We state that this would be part of future work. Consequently, cloud liquid and ice water are the only contributors to the cloud optical properties for both model versions presented. This has not been changed.

Minor Comments:

Page 7784, first sentence. I recommend reordering this sentence so the dependent phrase follows the main part of the sentence.

Done.

Page 7784, line 5. Insert comma after and.

Done.

Page 7784, line 8. Replace ”phase” with ”phases”.

No, this would change the meaning. We refer to the physical definition of phase, i.e. water being either in the liquid or the ice phase.

Replace ”the prognostic” with ”a prognostic”.

Done.

ACPD

15, C1837–C1844, 2015

Page 7784, line 10. Remove ”does”.

Done.

Page 7784, line 24. Remove ”the” after ”towards”.

Done.

Page 7785, line 6. Replace ”may” with ”whether”.

Done.

Page 7785, line 18. Replace ”in cloud droplets” with ”in the number and reduction in size of cloud droplets”.

Done.

Page 7785, line 19. Replace ”cloud” with ”in warm clouds”.

Here 'cloud' is used in conjunction with droplets, i.e. 'cloud droplets'.

Page 7785, line 20. Remove ”upon”.

Page 7785, line 21. Insert ”produces” before ”a significant”.

Page 7785, line 22. Remove ”is produced”.

Done.

Page 7785, line 28. Start new sentence at ”thus”. Start new paragraph that focuses on

ACPD
15, C1837–C1844, 2015

mixed phase clouds.

Done.

Page 7788, line 15. Citing Ghan and Easter, Mon. Wea. Rev. (1992) would be useful here.

Thanks. We will add this.

Page 7790, line 20 - Page 7791, line 12. While the distinction between cloud water, drizzle and rain has a basis in physical processes, the distinction is much less clear for frozen water (Morrison and Grabowski, JAS, 2008). This issue should be discussed here.

Has been included.

Page 7794, lines 19-20. Insert "the computational cost" after "reduces" and make clear how much of the model this refers to (collection, the whole atmosphere, the coupled system).

Done.

Page 7796, line 11. What does "large" mean? Significant (statistically)? If so, demonstrate it. Or just noticeable? Do these paths include drizzling and precipitating particles as well as cloud particles?

'large' refers to the discussion which follows the 7 % change in cloud liquid water path. In the next paragraph we use the word 'significant' (p. 7797, line 3, not used on 7796) in the sense of large or noticeable - as suggested. We will clarify these issues. Concerning the LWP and IWP, they only include the cloud water, i.e. the precipitating

ACPD
15, C1837–C1844, 2015

water is not included. This will be clarified by using CLWP and CIWP for cloud liquid water path and cloud ice water path, respectively.

Page 7797, line 1. Is the hydrologic cycle faster if the precipitation rate and total water path don't change? Since you're discussing condensed water, not total water, I would say the cloud lifetime is lower.

In our case, the CLWP (which is seen by the radiation) decreases, but the precipitation rate stays the same, leading to the conclusion that the hydrological cycle is faster. Naturally, this also means that the cloud lifetime is lower. We will quantify this in the revised manuscript.

Page 7797, line 3. How do you know the differences are significant?

We mean 'noticeable'. This will be edited (see answer for p. 7796, line 11).

Page 7797, line 10. How does cloud lifetime affect SWCRE? Do you mean cloud fraction?

As the incoming shortwave radiation is influenced by the amount of cloud water (i.e. its density), its fraction and its lifetime, we in principle mean all. As the largest change (7 % global decrease) is seen in the CLWP, this is the main contributor to the change in SWCRE. We will clarify this in the text.

Page 7797, lines 17-19. Does your model treat the contributions of drizzling and precipitating particles to cloud optical depth? It was found to be important in CAM5. You should describe how the optical properties are determined. Are the same shapes assumed for all frozen modes?

No, the precipitating particles do not contribute to the radiative calculations (see answer

ACPD
15, C1837–C1844, 2015

of major comment to the microphysical modes) and will be part of future studies. This will be emphasised. We are aware that the inclusion of the precipitating water path, especially for snow, has a large effect on model physics and dynamics. Thus we will consider this for future improvements.

Section 3.2.2. Do the ice and liquid water contents include contributions from the drizzling and precipitating modes?

No, this will be clarified (see answer for p. 7796, line 11).

Page 7802, lines 3-21. Further discussion of Morrison and Grabowski (2008) would be useful here.

We will add this.

Figure 13. Please show standard error about the mean values.

Is Figure 14 meant? It would make the figure even more crowded and the information gained would not be very relevant as we already show the spread of the data. Nevertheless, we will add the correlation coefficient of the regression line and the number of data points, which should give some idea of the statistical variability.

Page 7806, lines 16-24. This might be a place to mention Morrison and Grabowski again.

Thanks. We will do so.

References:

- Lohmann, U., Rotstayn, L., Storelvmo, T., Jones, A., Menon, S., Quaas, J., Ekman, A. M. L., Koch, D., and Ruedy, R.: Total aerosol effect: radiative

ACPD

15, C1837–C1844, 2015

forcing or radiative flux perturbation?, Atmos. Chem. Phys., 10, 3235-3246, doi:10.5194/acp-10-3235-2010, 2010.

ACPD
15, C1837–C1844, 2015