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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Subgrid-scale variability of clear-sky relative humidity and forcing by aerosol-radiation interactions in an atmosphere model" *by* Paul Petersik et al.

Anonymous Referee #2

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This study applied a stochastic parameterization of subgrid-scale variability of relative humidity (RH) to a global climate-aerosol model, ECHAM6-HAM2, and examined the impact of the subgrid-scale variability of RH on aerosol optical depth (AOD) and radiative forcing. The authors showed the subgrid-scale variability of RH increased global mean aerosol hygroscopic growth, AOD (by 7.8%), and effective radiative forcing (by 57%) due to the non-linear response of hygroscopic growth to RH.

Although this study showed a slight improvement of the estimation of AOD, I don't think this study is suitable for a paper of Atmospheric Chemistry and Physics because the scientific findings, methods, and analysis of this study are not enough as shown below.

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Discussion paper

Main comments.

1) Page 2, lines 7-27

These two paragraphs describe about previous studies. I understand from these paragraphs that the underestimation of radiative forcing by using the grid-box mean RH is already recognized well in previous studies. In addition, there are some global model studies focused on the subgrid-scale variability of RH previously. Due to these two points, it is hard to understand what was advanced scientifically in this study.

This study is new in ECHAM6-HAM2, but I feel that there is no clear advancement both scientifically and technically in the community of aerosol and cloud studies.

2) Section 2.2

Please explain why the stochastic treatment was used. Does this mean only single RH value is calculated by Eq. (6) and used in each grid box and each time? I think considering the full range of RH (shown in Figure 1) in each grid box and time is not so difficult, for example by using 5-10 RH bins between RHcls - delta RHcls and RHcls + delta RHcls. This will not increase the computational cost of the model so much.

If a random RH is used in the model, does it assure the repeatability of model simulations? For example, when the authors make two simulations which use completely the same inputs and model setups, can the authors obtain the same results from the two simulations?

3) Treatment of aerosol absorption

How does the model calculate aerosol absorption? Please describe the method and the treatment of absorption enhancement by water. The treatment of absorption enhancement of black carbon by water will be a key in the calculations of single scattering albedo and radiative forcings. The authors show negative values of radiative forcings, but I suspect the authors do not consider the positive forcings by the absorption enhancement. The absolute values of radiative forcings will be smaller when the absorp-

tion enhancement is treated properly, and the total effect of the subgrid-scale variability of RH will be less important.

Other comments.

Page 1, lines 23-24:

I think Ginoux [2017] is for mineral dust only. References for primary and secondary organic aerosols and aerosols from biomass burning should be added.

Page 2, line 7:

“However” is better to move to the next sentence (before “General circulation”).

Page 2, lines 34-35:

I cannot understand what the authors mean in this sentence (“RHcls is chosen. . .”) and next sentence (“That means, . . .”). I don’t think “aerosol-radiation interactions are negligible in the cloud part”. Some studies (e.g. Jacobson) have shown the importance of this issue.

Page 3, line 28:

I don’t think “age due to internal mixing” is good explanation. Did the authors mean that internally-mixed particles are made by aging processes such as condensation and coagulation?

Page 4, line 15:

Because the authors used “usually” here, it looks there are some previous studies considering the subgrid-scale variability.

Page 4, Line 25:

The values of cs, ct, and nx should be given after the equation (2) (at line 8).

Page 5, line 2: What is “RHcls,old”?

Page 6, line 6:

"c" values (Equation (9)) are not useful in the current manuscript. Discuss more or remove from the manuscript.

Page 6, line 13:

How important the different growth factors between CS/AS and KS/NS modes is?

Page 6, line 18:

Why did AOD increase especially in the tropics?

Page 6, line 25:

Why don't you show the results of "c" by using a figure?

Page 6, line 29:

"w" means single scattering albedo?

Page 6, line 32:

The alpha change shown here is for wet particles? Please clarify. Please show the percentage of this change.

Page 7, line 14:

Did the authors show the definition of ERFaer? What is the difference between ERFaricls and ERFaer? The effect of total and anthropogenic aerosols is shown, respectively?

Page 7, line 15:

Why did cloud cover increase in PD simulations but decrease in PI simulations?

Page 9, line 13:

The authors focus on sulfate and sea salt here, but how about nitrate, ammonium, and secondary organic aerosol? How does the global model treat these aerosol species?

Page 10, lines 1-5:

Please show the simulation results obtained by the authors rather than citing previous studies.

Page 10, line 8:

Please explain why the function of height is used. The authors explain the treatment in the cloud scheme but do not explain whether the treatment is realistic.

Page 10, line 11:

“Eq. (Equation 1)” should be “Eq. (1)”.

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