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Geoscientific Model Development Discussions

Interactive comment on "Aerosol specification in single-column CAM5" *by* B. Lebassi-Habtezion and P. Caldwell

Anonymous Referee #1

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GENERAL COMMENTS This study takes a close look at the role of aerosol in single-column model experiments with CAM5. By default, the model initializes the aerosol fields to zero, which is interpreted as being incorrect. Three alternatives are explored: specifying climatological aerosol, specifying observed aerosol, and fixing the droplet and ice numbers. Several typical SCM cases are used: marine stratocumulus (DYCOMS), Arctic stratus (MPACE), shallow convection (RICO), and deep convection (ARMSGP). Several interesting points emerge through the study. The microphysics desiccates the atmosphere and has a very strong impact on the LWP. This effect is deleterious in mixed phase clouds and is controlled by the Myers formulation for ice nucleation. There is a physical inconsistency associated with the microphysics removing so much water because cloud fraction is determined before this process, so CAM5 does not completely get rid of the old "empty cloud" problem previously reported for

CAM3/4. Convective cloud regimes are relatively insensitive to aerosol effects because of the simpler microphysics in the convection schemes, but near cloud-base activation still dominates the determination of droplet number so aerosol matters there while detrainment dominates the determination of droplet number at higher levels.

Although I appreciate the general approach of the study, I believe there are several major issues that should be addressed before it is suitable for publication. One is the framing of the problem. The whole study seems to hinge on the initialization of aerosol to zero in the default model being wrong. It is not a priori wrong to take this approach, and one could probably argue that it is as valid as any of the alternative approaches presented in this paper. The results show that there are probably ways to make the SCM better capture the observed cloud properties, perhaps supporting adoption of another aerosol specification. On the other hand, which of the approaches best matches the results from the full 3D model? The answer is not clear in this study, but probably should be considered as central in defining what the SCM should do. The first sentences of both the abstract and introduction indicate that SCMs are useful for model improvements, and therefore must (before all else) be representative of the full 3D model. Whether any of the aerosol specifications discussed here come closer to the full model is unclear. A second major issue is that there is a bit of a false dichotomy being presented in the comparison of the default model and the alternatives, and it comes down to the difference between the way the default model is initialized versus how aerosol is specified throughout the integration in the alternatives. The default model initializes the aerosol to zero and is subsequently driven by surface emissions, so the aerosol field (if I understand correctly) remains prognostic, but is erroneous because the only source is at the surface and vertical transport is the only way to populate the upper levels. In the alternative approaches, the initialization of the aerosol is likely to be inconsequent for the result. Instead it is the specification of aerosol fields through the column through the integration that matters. Connecting to my first point, it seems like the prognostic aerosol approach is most consistent with the 3D model, but the SCM would then require aerosol as part of the large-scale forcing, and

how to construct an appropriate aerosol forcing may be ambiguous. This distinction between the initialization problem and the specification problem may seem nit-picky, but I think it is fundamental to the study, and the issues are confused throughout the text. Third, the text presents the results of the default and alternatives, but never makes any recommendation for what would be the best method. From my vantage point, this lack of a clear recommendation is rooted in the previous points regarding how to think about and frame the problem of aerosol in SCMs. Finally, and related to the others, the text needs a substantial editing for grammatical errors, clarity, and concision.

SPECIFIC COMMENTS 1. The abstract is overly long and does not highlight the main results very well.

2. The first paragraph (pg 3-4) is a little hard to parse. The points get lost in all the call outs to the SCM studies. I think the paragraph could be cleaned up substantially by focusing on the themes that have emerged from these studies, rather than the specific conclusions from each one. It seems unnecessary to establish these results except to introduce the cases to be used later.

3. pg 4, line 19-21:What does it mean for aerosol to be handled "appropriately" in an SCM. This is not established, but would be a useful discussion for this paper. It should also be explained (here or in Section 2) what the default model actually does (initialize to zero and then use surface emissions in MAM).

4. The use of the word "fixes" for the alternative aerosol specifications seems informal on the one hand and misleading on the other. If these "fixes" actually fix the issue, then the study should determine what the default model behavior should be and make a recommendation. As mentioned above, there is also this issue about the difference between incorrect specification of the aerosol forcing (in the sense of the specified aerosol transport) versus initialization and actual physics. This comes back on page 5, lines 22-24: "As mentioned previously, this prognostic aerosol model in SCAM5 mode initializes the mass-mixing ratio of the different aerosol species to zero. Hence

we test other fixes to solve this problem as described below." This statement must be interpreted as one of an initialization problem, but none of the "fixes" is focused on initialization (and in fact, if the aerosol are still initialized to zero, it probably would not make any difference after the first time step).

5. pg 7, line 2 overstates the breadth of the cases. These cases are appropriate for the study, but do not cover the "full range of cloud types."

6. Section 2 could probably be streamlined by constructing a table with all the forcings and then the text could focus on the big picture of each case and any caveats (which are already there, e.g., the change in w for the MPACE case).

7. On pg 12, line 24, the 3D model result is referenced and is very different from the SCM result. What does this mean for interpreting the SCM as a cheap version of the full model? Could the difference in this case be due to sampling? Specifically, is the diurnal cycle in the long 3D run biasing the mean profile compared to the DYCOMS result?

8. Pg 13, line 10 blames the initialization of aerosol, but this is after hours of simulation. Is the problem that there isn't enough vertical transport of aerosol from the surface emissions?

9. Pg 15: "empty clouds" have been pointed out in previous versions of CAM. Are these empty clouds conceptually similar, or is the different microphysics responsible for a new kind of empty cloud error?

10. Pg 15-16: The three paragraphs ending this section should be combined and reduced. The third paragraph contains most of the useful information, so the other two should be turned into one or two supporting sentences in the third.

11. In the RICO case, how can the surface fluxes be so far off if the surface temperature and wind are prescribed?

12. I was surprised there was no discussion of precipitation in the RICO case. The

SCM results must be precipitating, right?

TECHNICAL CORRECTIONS

pg 3: First sentence of the paper is incomplete: insert "for" between tool and efficient. Also, it is the Community Atmosphere Model, not "Atmospheric." (http://www.cesm.ucar.edu/models/cesm1.2/cam/)

pg 3, sentence starting at line 13 is grammatically wrong. Perhaps it should just be "In another SCM intercomparison, simulations ... "

pg 3, the next sentence (line 16) is also wrong. Perhaps "The SCM intercomparison of ... "

pg 4, line 17: There is a problem with the tense. Maybe it should read: "As a result, developing aerosol parameterizations has become a high priority in the climate modeling community."

pg 4, line 18: This sentence reads awkwardly. First because it sounds like it is in the wrong tense ("had"), and second because the use of "break-through" is a bit aggrandizing of the aerosol model. It is a major development and adds capability, but for most applications it isn't a game-changer.

pg 4, line 20: The SCM is referred to as CAM5-SCM here, but as SCAM5 later. Choose one and be consistent throughout.

pg 5, line 14: "Brethorton" -> Bretherton

pg 5, line 25 versus pg 6 line 3, and also throughout the paper there is a lot of switching between tenses. It's distracting to the (or at least this) reader.

pg 5, line 26: "This case is the setup in default" is confusing, perhaps change to "This case is identical to the default"

pg 7, line 8 AND EVERY SUB-SECTION TITLE: the letter denoting the subsection is

repeated (e.g., a. a. DYCOMS RF02 case)

pg 8, line 21: delete "values"

pg 10, line 21: "The ARM95 included because" should be "The ARM95 case is included because" (?)

pg 11, lines 16-19: grammar fixes: "We also include cloud base, zb, which is computed by interpolating to the level at which cloud fraction first exceeds 0.5 and cloud-top height, zi, which is computed by interpolating to the highest level at which the total water mixing ratio drops below 8gkg-1."

-I think that zi is probably the lowest level at which q is below 8 g/kg, right?

pg 14, line 10: "not" -> "no"

pg 14, lines 22-24: This sentence reads very poorly, perhaps change to, "In PrescAero and ObsAero, the microphysics removes all the liquid water, but this feedback is removed in the FixHydro case by specifying constant droplet and ice numbers."

pg 14, line 28: "consistes" -> consists

pg 15, line 4: "the 10 years October 2004" What is this supposed to mean?

pg 16, line 22: the first "LHF" should be "SHF"

pg 16, line 24: "compared to LES, (0.19) and (19 g m2), respectively." -> "compared to LES (0.19 and 19 g m-2, respectively)."

pg 17, line 4: has -> have

pg 17, line 5: "was" probably is not correct tense

pg 17, lines 27-28: incomplete sentence (maybe need "is" between overestimation and due?)

pg 18, line 16: "every other day" what is meant by this?

pg 18, line 21: "Generally, SCAM over estimated LWP at all periods." -> "Generally, SCAM5 overestimated LWP during all periods." (If the past tense is to be used.)

pg 19, line 14-15: "formed when you have higher aerosol burden." -> "formed with a higher aerosol burden."

Figure 1: the global run isn't labeled.

Figure 4 caption: "3-D CAM values are 10 years July average global CAM extracted at the location of MPACE-B." -> "They cyan line shows the July average from a 10-year integration of the full 3D CAM at the MPACE-B location."

Figure 5: add legend for the observations

Figure 7: "No Aero" is the wrong color in the legend.

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