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Geoscientific Model Development Discussions

Interactive comment on "A Consistent Prescription of Stratospheric Aerosol for Both Radiation and Chemistry in the Community Earth System Model (CESM1)" *by* R. R. Neely III et al.

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All author responses are in *italics*.

Anonymous Referee 1 Received and published: 4 January 2016

General comments The manuscript describes the prescription of the stratospheric aerosol for radiation and chemistry calculations in the Community Earth System Model (CESM1). The subject of the manuscript is appropriate to GMD, because it will help all CESM1 users to understand technical details of the new method. The authors illustrated the performance of the new scheme simulating the response of the atmosphere

and climate to Mt. Pinatubo eruption using SAGE-4lambda stratospheric aerosol data set recommended for the CCMI participants. The obtained results revealed much better agreement of the simulated global mean surface cooling and tropical lower stratosphere warming with observations, which makes the new approach interesting also for winder community. I think, the manuscript provides potentially interesting information and can be recommended for publication with moderate revisions.

Specific comments 1. Introduction should be extended to better review other methods used for the prescription of the stratospheric aerosol in the climate models. It is interesting to put the described approach into the context.

We understand the reviewers desire to add more context to this paper but we feel this is unnecessary for the main point of this paper (which is to describe CESM1's approach to prescribing stratospheric aerosols). The method described here should be of direct relevance to other models that use specified mass and surface area distributions to describe stratospheric aerosol and volcanic perturbations.

2. It is interesting which one of the introduced changes is responsible for the obtained major improvement. Is it the new SAGE dataset, new radiation codes implemented in CESM, introduced dependency of the aerosol property on particle size distribution or something else. This information will be highly appreciated by the modelling community, because it can show how to improve simulated response to volcanic eruptions.

We agree that this is an interesting aspect of this work and now have included a new Figure 3 (Figure 1 attached to this response) which illustrates the impact of the changes in both CAM4 and CAM5.

New Figure 3 Caption: Monthly times series comparison of the zonal mean SAOD after the 1991 Mt. Pinatubo eruptions for the old (panels a c) and new (panels b d) prescribed stratospheric aerosol scheme in CAM4 (panels a b) and CAM5 (panels c d).

In addition, we have added four 4 panel plots to the Supplement (Section S3; attached as a supplement to this response.) that separate the impact of the new SAGE dataset from the new radiation codes for both CAM4 and CAM5.

3. The authors illustrated their approach using the SAGE based dataset which includes effective radii. It should be discussed how to treat stratospheric aerosol for the simulation of the past/future climate when this information is not readily available.

We agree that limiting factor to prescribing the stratospheric aerosol is having an accurate forcing file for the period what you wish to simulate with CESM1. We have now added a section starting on page 7 line 30 discussing an extended forcing file that goes from 1850 to 2100.

Technical corrections 1. Page 10712, Line 9: Which global temperature is mentioned? I guess it should be explained.

We thank the reviewer for pointing out this ambiguous description. The sentence has now been changed to "In particular, the scheme used in the CMIP5 simulations by CESM1 simulated a global mean surface temperature decrease by a factor 2 larger than was observed by the GISS Surface Temperature Analysis (GISTEMP), NOAA's National Climatic Data Center and the Hadley Centre of the UK Met Office (HADCRUT4)."

2. Page 10715, Line 20: Rg is used, but explained only later.

This paragraph containing the explanation of Rg has now been modified to provide a clear explanation of Rg when it is first used. "As with CAM4, to interact with the radiative transfer scheme, CESM1(CAM5) calculates mass-specific properties over each spectral band of RRTMG. The calculations assume the size distribution of the aerosol to be a log-normal distribution with a geometric mean radius rg, that is allowed to vary as specified by aerosol forcing file, and a constant geometric standard deviation σg, specified as a constant 1.8 within the assumptions that are used to form the optical

parameters file. The result of the calculations are stored in a lookup table with both μ = ln(rg) and the RRTMG spectral bands as dependent variables. This is the main difference between the CAM4 and CAM5 when it comes to representing the impact of stratospheric aerosols. Instead of a one-dimensional look up table (i.e. just varying over spectral band) as CAMRT uses in CAM4, RRTMG utilizes a two-dimensional look up table that varies by μ and spectral band."

3. Page 10716, Line 6: What is asymmetric scattering? Probably asymmetry factor is better?

We agree and have now changed this accordingly in the text. The new text follows as"In CESM1(CAM5) the mass-specific aerosol extinction, scattering, and asymmetry factor are defined as:"

4. Page 10717, Lines 4-9: I do not understand this paragraph. Why Rg is equal 1.25? Which experiment is described here?

We agree that this paragraph was hard to follow and have now re-oragnised and reworded it as shown below. The main point we are trying to make in this paragraph is that, even though the code in CESM1(CAM5) allows for the variation in stratospheric aerosol size distribution, the standard configuration of the did not include the necessary information in the forcing file to take advantage of this new parameterization. Instead the same forcing dataset that was used in CESM1(CAM4) is utilized in CESM1(CAM5) with a constant size distribution for all times.

New text: "Similar to CAM4, the standard configuration of CESM(CAM5) uses the stratospheric aerosol forcing dataset over the period 1850 to 2010 from Ammann et al. [2003]. This dataset does not take advantage of the parameterization in CESM1(CAM5), as described above, to modulate the changes in stratospheric size distribution (i.e. variations in rg as described above). Instead, similarly to CAM4, the mass from the Ammann et al. [2003] dataset is assumed to be comprised of 75% sulphuric acid and 25% water and have a constant log-normal size distribution with a wet

effective radius of 0.426μm and a standard deviation (σ(ln r)) of 1.25. It should also be noted that the Ammann et al. [2003] is a zonally averaged dataset and, therefore, does not take advantage of CESM(CAM5)'s ability to utilize a zonally asymmetric forcing file."

5. Page 10719, Line 12: "The for original file was . . ." Something is wrong here. C3545

We agree that this was awkwardly worded and have now changed the line to the following: "The original file was modified slightly to form the new standard input file for CESM1 for period ranging from 1950 to 2012."

6. Page 10719, Line 26: needed?

This has been corrected.

7. Page 10724, Line 20: I think it is not allowed to use reference to the paper "in preparation". What potential reader should learn from this?

We agree and have now replaced this place holder with the actual citation.

Tilmes, S., Lamarque, J.-F., Emmons, L. K., Kinnison, D. E., Marsh, D., Garcia, R. R., Smith, A. K., Neely, R. R., Conley, A., Vitt, F., Val Martin, M., Tanimoto, H., Simpson, I., Blake, D. R., and Blake, N.: Representation of the Community Earth System Model (CESM1) CAM4-chem within the Chemistry-ClimateModel Initiative (CCMI), Geosci. Model Dev. Discuss., doi:10.5194/gmd-2015-237, in review, 2016.

Please also note the supplement to this comment:
http://www.geosci-model-dev-discuss.net/8/C4363/2016/gmdd-8-C4363-2016-supplement.pdf

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Interactive comment on Geosci. Model Dev. Discuss., 8, 10711, 2015.

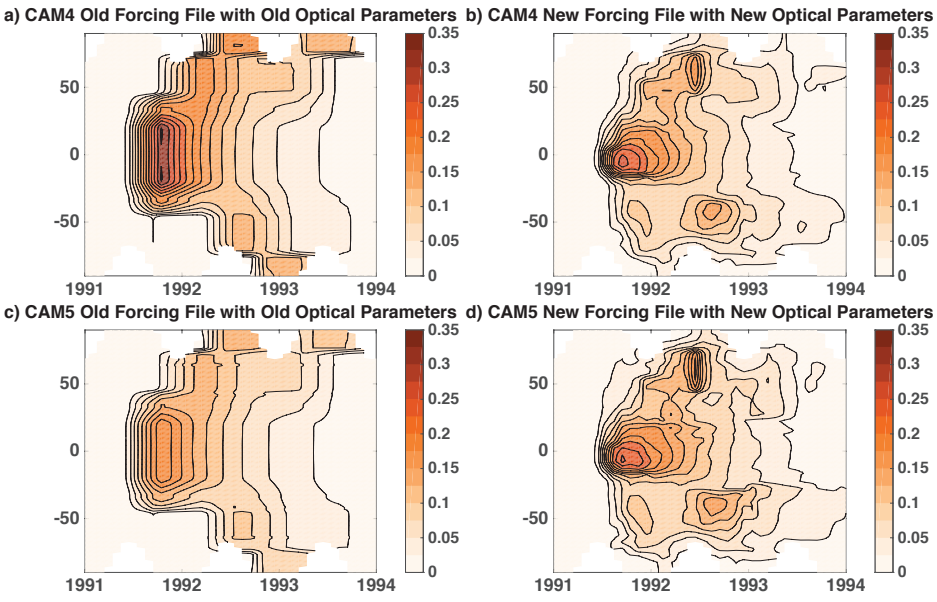

Fig. 1. New Figure 3 (Full Caption In Main Text)