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Interactive comment on "Reallocation in modal aerosol models: impacts on predicting aerosol radiative effects" *by* T. Korhola et al.

Anonymous Referee #1

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Review of "Reallocation in modal aerosol models: impacts on predictions aerosol radiative effects".

The paper quantifies how typical modal aerosol microphysics schemes may have errors in climate-relevant properties due to the assumptions made in the modal schemes. This is a very important exercise since many 3D atmospheric models are using modal schemes to predict aerosol climate impacts. While models with modal schemes are often evaluated against observations, they may be getting "good" predictions for the wrong reasons and may not accurately predict the sensitivity of aerosols to changes in the system. I feel that this paper is within the scope of GMD and deserves to be published once the authors have addressed several points that will make the paper clearer.

P4208 L17: Please say what ACI is in the abstract

P4209 L22-26: The description of the M7 (or similar scheme) is a bit confusing here (e.g. "(containing several compositions for internal mixing)"). Please expand to make this more clear.

P4209 L29: "standard deviation and composition ... are known" or *assumed*! The standard deviation is never "known" with the modal schemes, it is always assumed.

P4210 L14-: This paragraph confused me at first. Specifically because it started with "In modal models" and never mentioned anything about *spatial* finite differencing. I thought you were talking about finite differencing in the aerosol size distribution. It would be better to say "In 3D aerosol models, the aerosol properties are usually described across space using a finite difference...".

P4211 L7: "The larger mode also decreases *in size* due to..."

P4211 L22: Please describe what the ACI is qualitatively (e.g. the sensitivity of CDNC to a change in aerosol number (keeping the shape of the size distribution the same)).

P4212 L3: Why does only EC (I'm assuming elemental carbon, but not explicitly defined) count towards uncertainty in the direct forcing. Shouldn't scattering aerosols contribute to this too?

P4212 L18: Can you explain how the threshold diameters work? There will always be a tail of a lognormal mode that will go above these sizes (to infinity). Also, on P4215, you say "The emission mode mean diameter is also $\sim$50 nm larger than the largest allowed average diameter for the Aitken mode." Since the emissions diameter is 80 nm, this implies that the largest allowed average diameter is 30 nm. How does this fit with the 100 nm threshold diameter? This is not clear.

P4214 Eqn 3: Since your sectional model is being used as your "truth", shouldn't you take the difference from just that simulation?

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P4215 L11: Please describe what the background aerosol is.

P4216 L8: This overestimation is not shown... all values are negative in Figure 2.

P4216 L29 (and several other places shortly after including the labels of Figures 3 and 4): You discuss the difference between the reallocating modal model and the unrestricted modal model. However, on P4215 L13 you mention that you will only compare the reallocating modal model to the sectional model for this part of the paper. I realize that the sectional model and unrestricted modal models give the same solution here, but for consistency it would be better if you referred to your "truth" model as the sectional model as you established on P4215 L13.

Section 3.2: Can you include a size-distribution-timeseries figure similar to Figure 8 for the experiment in this section? Figure 8 was really useful for visualizing why the 3 schemes diverged in the nuc/growth experiment, and I think it would be useful here too.

Equation 4 (and discussion surrounding it): I found a number of things about this equation confusing. You refer to it as a injection rate, but give it "C" like it is a concentration. For C0, you don't provide units (at least initially), which would clear this up. The term "injection concentration" doesn't clarify this either. Later you say "2.6 x 10^8 molecules cm-3", which makes me thing that this value is C0 (it matches the value given earlier) and that C is a concentration, and not an injection rate (as initially stated) in any way. Additionally, when you say "The decreasing injection concentration in the presence of a condensation sink leads in (–typo, I think–) to quickly decreasing H2SO4 concentrations...", does the "T-t/T" term represent the loss of C due to the condensation sink, or is the condensation sink and losses explicitly resolved (e.g. the condensation sink will be changing during you simulation as the size distribution changes)? If it were a fixed condensation sink, should the expression be C_SA=C0*exp(-t/Tau) rather than a linear decay? (I'm not sure this matters for illustrating your point, but readers will likely be confused in a number of places). Overall, this paragraph is very confusing.

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End of page 4218: “causing the Aitken mode to grow by 45 nm” 45 nm above which size?

P4219 L26: “particle *number* concentration.”

P4221 L8: “by *the* reallocating model”.

P4221 L29: “to *the* sectional one”

P4222 L10: “For the *initial* accumulation mode”. Same on line 17

Does anyone use unrestricted modal aerosol schemes in 3D models? It would be good to explicitly state what the purpose of this scheme is in this paper. Is it strictly to show an intermediate step between the sectional model and the typical, reallocating modal scheme, or are these unrestricted modal schemes more common than I think?

I think the paper would benefit from the addition of some discussion of the implications of the findings in this study to 3D modal aerosol models. It seems like there are large uncertainties that may be being buried in the global models (and maybe there is a cancellation of errors?). Perhaps there should be a call to evaluate these models (e.g. reproducing growth and survival probability during nucleation events).

Interactive comment on Geosci. Model Dev. Discuss., 6, 4207, 2013.