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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simulation of the chemical evolution of biomass burning organic aerosol" *by* Georgia N. Theodoritsi and Spyros N. Pandis

Anonymous Referee #2

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The Theodoritsi and Pandis manuscript reports on the predicted sensitivity of organic aerosol (OA) mass to biomass burning emissions, using a source resolved version of the chemical transport model, PMCAMX (PMCAMX-SR). Studies such as this one are important for understanding the potential air quality and climate effects of anthropogenic and biogenic biomass burning emissions, particularly since the representation of biomass burning-derived SOA is relatively undeveloped in most chemical transport models. The inclusion of biomass-burning derived SOA, particularly when including IVOC, leads to substantial contributions to total predicted OA. This study highlights the need to better constrain biomass burning emissions inventories, including the volatility distribution, and to better understand SOA formation potentials of those emissions.

This manuscript is likely to be of interest to the ACP community, and publication is recommended upon addressing the following comments.

Technical Comments

It is known that simulating the spatial and temporal distribution of OA, particularly SOA, can be challenging; compensating errors can obscure model performance. In the abstract and in section 7, in addition to the absolute performance statistics, it would be useful to report the change in performance with the expanded treatment of bb-OA (POA+SOA). Weaker performance in winter could be a function of the base simulation (emissions, chemistry, and/or meteorology) and not necessarily a function of the expanded treatment of bb.

Line 58: It is recommended that it be emphasized that bbOA is added as a third category, and is not explicitly considered anthropogenic or biogenic, though bb emissions are characterized in the manuscript as anthropogenic (ag. and heating) or biogenic (wildfire).

Line 111-113: How many model compounds are used to represent IVOCs and SVOCs, respectively? Was the SAPRC mechanism updated as part of this study? If so, the authors should provide further detail in the supplement. If not, a reference should be provided (may be the Environ reference, just needs to be moved).

Line 139: Was the May et al. volatility distribution applied to all bb emissions? The use of "wood burning" here implies only residential wood burning, but it is assumed that the bb volatility distribution was applied to all three categories of bb emissions. This needs to be modified/clarified.

Line 146: How does partitioning within this model framework depend on aerosol composition?

Lines 153-155: The description of the Lane et al. VBS scheme is confusing as written. Given the generally widespread use of the VBS SOA model, it might be clearer to

write that SOA is represented using 4 bins, and X number of VOC precursors that are tracked separately as either aSOA-v or bSOA-v. So the number of actual model surrogates seems like it would only be 4*aSOA-v,gas + 4*aSOA-v,p +4*bSOA-v,gas + 4*bSOA-v,p, and is not dependent of the number of VOC precursors (as implied by 4 surrogate SOA compounds per VOC).

Lines 162-170: The description of chemical aging is also somewhat confusing. It might be clearer to refer to the volatility bin, rather than “vapors” and ”semi-volatile SOA”. Do the POA and SOA aging reactions both result in an increase in OA mass (line 170)? Is this independent of the mass increase associated with a shift to a semi-volatile bin? Does the OA mass increase apply to the biogenic SOA aging, even though no change in volatility is assumed?

To clarify the volatility distributions and aging, a figure such as 5-2 in the CAMx user’s guide would be very helpful.

Section 2.2: It is recommended that the authors consider the publication by Alvarado et al. (2015), which also evaluated volatility distributions of bb emissions. It may be beyond the scope of the manuscript to repeat the model runs using the Alvarado volatility distribution, but it would be useful to consider it in the introduction and discussion, and include it in the Figure 1 panels. The Alvarado et al. study also attempted to account for IVOC emissions not included in two published volatility distributions (including May et al.). Overall, there is significantly more mass (or higher fraction of bb-POA emissions) in the 105 and 106 bins in the subject manuscript (base case) than in Alvarado et al.

Also, while scaling the anthropogenic POA EF by 1.5, which gives a sum of fractions >1, has been well described in current literature, it is not clear that the same rationale applies to the biomass burning emissions used in this work. While the IVOC bins are not constrained by data and thus absent in the published VBS distributions, this is not equivalent to missing mass in the bb-POA emissions totals. It seems that some scaling of the May et al. fractions may be needed to include the IVOC bins without giving a

sum of fractions >1 (e.g., as done in Alvarado et al.). This probably needs a bit more discussion/clarification in the methods, as the mass attributed to the IVOC bins has a significant effect on predictions of bb-SOA (as demonstrated by the sensitivity case). Reference: Alvarado et al., ACP, 15: 6667-6668, doi:10.5194/acp-15-6667-2015

Editorial Comments

In general, it is recommended that the authors check carefully for use of abbreviations. In many instances, an abbreviation is introduced but then not used consistently throughout the manuscript (e.g., organic aerosol (OA) in section 2.1). In a few cases, an abbreviation is introduced but not defined (e.g., AMS line 100).

Line 16: Oxidation products of the bbOA? Or of bb emissions? If the latter, sentence needs revision.

Line 22: Suggest removing “same” before contribution. It is a little confusing as written.

Line 50: What does “their” refer to?

Lines 54 and 57: Suggest using “or” rather than “and”, to indicate OA can be primary *or* secondary and of anthropogenic *or* biogenic origin.

Lines 217-232: The discussion about the emissions is a bit unorganized. Are the anthropogenic biomass burning emissions from a source other than GEMS or the Pan-European inventory? If not, recommend to add “including anthropogenic biomass burning emissions” (line 203 or 210). Line 218-219 is then not needed. It is also recommended to move line 217 to the previous paragraph in which the other emissions inventories are described (likely before the introduction of MEGAN).

Italicize variables in equations.

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