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Geoscientific Model Development Discussions
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# *Interactive comment on* "The co-condensation of semi-volatile organics into multiple aerosol particle modes" *by* Matthew Crooks et al.

**Anonymous Referee #2**

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Review of Crooks et al. "The co-condensation of semi-volatile organics into multiple aerosol particle modes. The authors have presented a new methodology and detailed set of non-linear equations to solve the co-condensation of organics into multiple modes. Although these mathematical equations and their derivations are presented in great details, their utility and atmosphere relevance is not clear. My major comment is that even after several reads, the paper mostly sounds like new and fairly involved algebraic mathematical formulations which are interesting, but why should atmospheric scientists care about these formulations? Below are specific comments that need to be addressed before the manuscript is considered for publication. 1. The condensation of semi-volatile organics on multiple modes is not a new formulation. This has been done in other models [e.g., Liu et al., 2012]. In the previous formulation [e.g., Liu et al., 2012], the sum of a semi-volatile organic partitioned to various modes equals the total



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aerosol particle fraction as determined by gas-particle partitioning theory. Therefore, it was not immediately clear how the authors work differs from multi-mode partitioning of semi-volatile organics in previous studies, except that it includes water and a non-volatile core. The authors need to clearly make this distinction between their work and previous multi-mode partitioning studies. 2. The title mentions co-condensation of semi-volatile organics. But it's actually co-condensation of organics and water on non-volatile core aerosol. The title needs to better reflect what is being presented. 3. What is the composition of the non-volatile core? Does it include inorganics such as sulfate, nitrate and also black carbon and non-volatile organic aerosol? The authors need to clearly define the composition of the core aerosol. 4. If the core aerosol includes inorganics, the authors are implicitly assuming that the inorganic core aids the partitioning of semi-volatile organics e.g. see equation 3, where the non-volatile core is included in the calculation of COA. How is this assumption justified? The absorptive partitioning theory assumes well mixed solution [Pankow, 1994]. How can a core-shell model be well mixed? Also, several studies suggest that secondary organic aerosols (SOA) are under many conditions highly viscous semi-solids [Cappa and Wilson, 2011; Vaden et al., 2011; Virtanen et al., 2010], so they cannot be assumed to be well mixed. The authors need to clearly specify where their current formulation is not atmospherically relevant in the context of these studies. 5. Section 7, page 18: The authors place large particles in the model first before adding small particles to improve the accuracy of their solution. How can this be applied in a regional or global 3D model, where many processes are happening simultaneously (such as nucleation, emissions, coagulation, condensation, transport etc.) so that at any time there are both small and big particles? 6. Finally, does the author's new formulation include organic-inorganic interactions especially for aqueous aerosols? For example, I did not see hygroscopicity of the core and other organics include anywhere in their equations. Please clarify how the differing hygroscopicities, activities and aqueous phase reactions would affect your equations and their solutions.

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mass spectra upon heating: implications for OA phase and partitioning behavior, Atmos. Chem. Phys., 11(5), 1895-1911. 2. Liu, X., et al. (2012), Toward a minimal representation of aerosols in climate models: description and evaluation in the Community Atmosphere Model CAM5, Geosci. Model Dev., 5(3), 709-739. 3. Pankow, J. F. (1994), An absorption model of the gas aerosol partitioning involved in the formation of secondary organic aerosol Atmospheric Environment, 28(2), 189-193. 4. Vaden, T. D., D. Imre, J. Beranek, M. Shrivastava, and A. Zelenyuk (2011), Evaporation kinetics and phase of laboratory and ambient secondary organic aerosol, Proc. Natl. Acad. Sci. U. S. A., 2190-2195. 5. Virtanen, A., et al. (2010), An amorphous solid state of biogenic secondary organic aerosol particles, Nature, 467(7317), 824-827.

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