

**Comment on** "The Secondary Organic Aerosol Processor (SOAP v1.0) model: a unified model with different ranges of complexity based on the molecular surrogate approach"

I sincerely appreciate the authors' efforts responding to comments and applaud them for revising the manuscript to its current state. Indeed, many of the criticisms that I had before were simply from details left out of the text. Thank you for adding the text to section 2.3.2 regarding the solid morphology factors. I have a much better understanding now of the goals and procedure of that aspect of this work. Section 3.4 and Table 9 are also very informative and interesting; I am glad the authors added this nice element. I still have some issues left at various levels that I would appreciate having addressed.

### **Conceptual Issues:**

1. Page 12, line 16: I am afraid I find this second assumption seriously flawed considering the goal of the model. The authors use the word "layer" almost exclusively to discuss these regions of each particle that are separated from each other in the model. However, the only sense they are "layered" can be found in the parameterization of their diffusion timescales, which are based on their volumes, not their order. In my opinion, a critical aspect of their "layered-ness" is from inner layers being shielded from the gas-phase by the outer layers. If I'm not mistaken, the authors have now implicitly defined their layers to be detached regions, each one pseudo-connected to both the gas phase and the core. At the same time, they assert that the particles are axially symmetric. Although I disagree with this concept, they have made it clear in their discussion what the model assumes, and the reader can make up their own mind. It seems like an alternative could be achieved where the mass transfer due to condensation/evaporation in an inner phase is inhibited not just by its diffusion but also by the layers outside of it.
2. There is still an unresolved issue with section 2.3.8. I mentioned previously that if the authors are assuming that the "surface of particles is probably covered partially by both the organic matter and partially by the aqueous phase", then I would expect an angular-dependent concentration gradient to emerge in the gas phase at the surface of the drop. This would not affect the bulk gas-phase concentrations (as the authors interpreted my statements previously), but would have an affect near the surface where vapor pressure and  $D_{\text{air}}$  control the steepness or shallowness of the gradient moving away from the surface to the bulk phase. For this simple model, this approximation may not hurt much, but I think it is worth mentioning in the text.
3. In Figure 2, why is the magnitude of the morphology factor less for layer 3 than for layer 2? I assume here that layer 1 is the closest to the core, and layer 3 is the furthest, but this could be wrong. In any case, I would expect the layers to have consistently increasing or decreasing effect depending on which order they fall in the particle. I suspect this has to do with how big the individual layers are?
4. I do not see a change to Figure 3, but looking at it again, I am able to understand it better. How about changing the name of the box on the left to "Calculate Evolution for Species with Characteristic times lower than  $t_{\text{eq}}$  (assume equilibrium)" and the box on the right to "Calculate Evolution of Species with Characteristic times higher than  $t_{\text{eq}}$  (assume dynamic)". This is if I understand the boxes correctly. I still do not get why the dynamic box has a box for

"equilibrium" inside it. Is it for calculating particle-phase transfers during the time step? Again, no output arrow.

### **Technical Issues:**

p3, 12-3: Please add reference for human health, visibility and climate change impacts of particles.

p6, 13: It may be worth adding a little more information here for the reader. Specifically, does the model require every size section to have the same number of layers available to it?

p14, eq 31: Please define  $\alpha_{\text{layer}}$  after this first introduction of it. Can the authors give some description of what it is exactly? If I understand it right, it is proportional to the effect the organic phase has on the bulk  $D_{\text{org}}$ .

p15, 17: Too many significant figures for the values of  $\alpha$ .

p25, 13: For how long should the mass of layers must stay constant? Across a time step? Throughout the simulation?

Tables 1 and 3.: Perhaps my pdf is malfunctioning, but this does not appear to be a table.

p28, 114: What size distribution features were used for these test cases? How many bins, etc?

p33, 11: Perhaps replace "interesting" with "compelling"?

### **Grammatical Issues:**

p2, 125: ...some compound"s"

p3, 117: "or" no phase separation.

p4, 13-4: It's hard to understand this sentence exactly.

p5, 19-10: I recommend removing "if for example, the ... negligible" since the information in parentheses following seems to make the point perfectly clear.

p10, 15: ...hydrophobic (condense "into" both phases).

p12, 122: May I suggest reqrting "interface with the gas phase" to "gas-phase interface"?

p13, 13: Please remove "of" to read "no kinteic transfer of compounds"