

Interactive comment on “Regional and global modelling of aerosol optical properties with a size, composition, and mixing state resolved particle microphysics model” by F. Yu et al.

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The authors thank the referee for the constructive and useful comments. Our replies to these comments and our actions taken to revise the paper are given below.

General comments

We appreciate the referee's comments that “this work is very interesting and well presented” and “This paper has a strong potential to become very interesting and innovative”.

The referee has concerns about the computing cost and validation of model results.

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We feel that the referee might have misunderstood some portions of the present work:

Firstly, as we pointed out in the Introduction, the need for a sophisticated aerosol scheme in global models is well established as the optical properties and the climate impacts of atmospheric aerosols depend on a number of parameters such as particle size distribution, composition, hygroscopicity, refractive index, and mixing state.

Secondly, we would like to point out that the APM model, while sophisticated, is NOT “very CPU- expensive” at all. As we detailed in Yu and Luo (2009) and Luo and Yu (2011) and also pointed out in several places in this manuscript, GEO-Chem-APM and WRF-Chem-APM are computationally efficient and do not add much burden to the computing cost. For example, the incorporation of size-resolved full microphysics APM into GEO-Chem only doubles the computing cost although it increases the number of tracers from 54 to 127 (Yu and Luo, 2009).

Thirdly, the APM can provide many detailed information of aerosol properties (size distributions, number concentrations, mixing states, etc.) that a simple aerosol scheme can't provide. The referee claimed that he/she saw “no improvement here when compared with even the simplest aerosol models used by the scientific community”, however the referee didn't provide any details (or references) of previous studies that we can check.

Fourthly, the comparisons of particle microphysics simulations based on the APM model with a variety of relevant measurements have been reported in a number of previous publications (Yu and Luo, 2009, 2010; Luo and Yu, 2010, 2011, Yu et al., 2010, 2012).

Finally, the main objective of this work is to investigate aerosol optical properties based on size, composition, and mixing state resolved APM model. We have compared modelled AOD with those derived from AERONET, MODIS, and MISR measurements. We believe that the agreement “within a factor of two” is reasonable, considering the nature of comparisons and the uncertainties of measurements (as detailed in the manuscript).

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Specific comments

- 1) We have rephrased the second half of the abstract.
- 2) When we say “yyy coated on xxx” (mostly “secondary species coated on” various primary particles), “coated on xxx” is adjective used to describe yyy. To change it to “xxx coated by yyy” or “yyy coat xxx” will make the sentence harder to read. So we didn't make the suggested changes.
- 3) As we understand, “internally mixed” generally means that particles of all types are mixed together (i.e., in contrast to externally mixed). As we pointed out in the Introduction, APM treats particles of different types (secondary, BC, dust, sea salt, primary organic carbon (POC)) as semi-externally mixed, i.e., (1) it separates secondary and four types of primary particles, and (2) it explicitly predicts the spatiotemporal variations of the mass of secondary species coated on each type of primary particle as a result of coagulation, condensation, and equilibrium uptake. Coated aerosols are used to describe the externally mixed primary particles with secondary species coated on them.
- 4) We have minimized the repetition of figure description in the text.
- 5) Agree. Following the suggestion of Referee #1, we have deleted the whole sentence in the revised manuscript.
- 6) Details of the treatment of secondary organic and inorganic aerosols can be found in Yu and Luo (2009) and Yu (2011). This sentence has been added to the text.
- 7) Yes.
- 8) See our reply to comment #3.
- 9) We have deleted “should” from the sentence. If not, the solution has already been given in the end of the paragraph (i.e., “The range and resolution in each parameter space can be extended in the future if needed”).

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- 10) Our calculation indicates sea salt AOD at longwave ($> \sim 4 \mu\text{m}$) is negligible.
- 11) Changed “core” to “dust” in Table 2.
- 12) The purpose here is to show the dependence of optical properties on wavelength which is one of the dependent variables in the lookup table.
- 13) References added.
- 14) Following the suggestion of Referee #1, we have deleted the whole sentence in the revised manuscript.
- 15) The present model employs a combination of bins and log-normal modes (see second paragraph of section 3).
- 16) Detailed discussion of SOA treatment in the model can be found in Yu (2011).
- 17) The ISORROPIA II does not consider the water uptake of soluble SOA.
- 18) BC particles over tropical forests are also coated with some amount of secondary species although the amount is much less than that of BC over SE Asia. Competition with POC is one of the reasons for the difference, as POC emissions are much larger than BC emissions over tropical forests.
- 19) The κ values for the single components follow those given in Petters and Kreidenweis (2007). We have added this sentence at the end of the previous paragraph.
- 20) Around 20-30 km, based on the latitudes and longitudes of sites given in the figure legend.
- 21) The model results are for all sky (with and without clouds).
- 22) IMN of H₂SO₄-H₂O is based on the physics and thermodynamics. It should work in NE US as well and the differences in the conditions have been taken into account in the calculation of nucleation rates.
- 23) As already pointed out in the text, the nucleation scheme has been validated with

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state-of-art field measurements in the boreal forest (Yu and Turco, 2011).

24) Modified as suggested.

25) Modified as suggested.

26) In the figure, the refractive index of shell is given. No specific composition of the shell is needed.

27) To put the three sets of data together in Fig 7a can clearly show the difference of AOD from different platforms which is one of the purposes of the figure. For this consideration, we decide not to split Fig 7a.

28) For 4x5o horizontal resolution, our analysis indicates that the number of data point for CF<25% is not high enough for meaningful comparison.

Technical corrections

All corrected.

References:

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