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Geoscientific
Model Development
Discussions

Interactive comment on "Description and evaluation of GLOMAP-mode: a modal global aerosol microphysics model for the UKCA composition-climate model" *by* G. W. Mann et al.

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General Comments:

This paper describes and evaluates a mode version of GLOMAP. The manuscript is well-written and easy to read through.

We thank the Referee for their review of the manuscript.

However, the model description and evaluation are probably too long. Since the modal aerosol process treatment mostly follows the bin version of GLOMAP and M7 (Stier et al., 2005). Many process description can be simplified, such as 2.1.2.-Aqueous chem-

istry, 2.2.2.-aerosol dry deposition, 2.2.5- 2.2.7 nucleation/coagulation/condensation.

Although we accept that some of the model description could be shortened with reference to other previous papers, we prefer here to keep the descriptions as they are so that the document can serve as a complete description of the GLOMAP-mode model. We note that Referee 1 states with regard to the model description that "none of the material is surplus".

The authors should document the main differences between this modal version versus bin version (which has been well published in the literature), and aerosol microphysics treatment between this work and M-7 if there are any. I have also some technical comments below which need to be addressed.

We have added a section at the end of the Model Description which clearly states that the model uses the process descriptions from GLOMAP-bin within the "pseudo-modal" aerosol dynamics approach used by M7/HAM. The paragraph also clarifies commonalities/differences between GLOMAP-mode and GLOMAP-bin/M7.

Specific comments:

1. Page 653. Lines 18-20. Please be clear why the mass-only version unrealistically perturb cloud properties and precipitation. Do you mean that mass-only version gives too high droplet number? "precipitation autoconversion" should be "cloud droplet autoconversion".

We have added a few extra words to this sentence to clarify that we mean that the mass-only models cannot conserve particle number and thus may unrealistically perturb cloud properties via changes in CCN where models with aerosol microphysics would not.

2. It is not clear to me how you treat ammonium. What kind of formulation do you assume for sulfate (e.g., NH4HSO4 or (NH4)2SO4). Even though you don't treat ammonium, you need to account for ammonium amount for aerosol optical depth. Otherwise

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you will miss a significant amount of aerosol mass.

In this version of the model, we do not treat ammonium, with the model only calculating the anion concentrations. For water content, we calculate charge-balance assuming the sulphate is all in the form of sulphuric acid, and all sea-salt is in the form sodium chloride. As part of a PhD thesis (D. Ridley, University of Leeds, 2008), GLOMAP-mode simulated AOD has been thoroughly evaluated against AERONET and MODIS observations. However, in this paper we have not shown any model aerosol optical depth fields, leaving this for a separate paper.

3. Section 2.2.2. How do you differentiate dry deposition/sedimentation of aerosol mass versus aerosol number?

As explained in section 2.2.2. (page 664: lines 14-20, page 665: lines 1-3), we calculate 0th and 3rd moment averages for the gravitation settling velocity (VGRAV) and particle diffusion coefficient (DCOFF) following the expressions in Binkowski and Shankar (1995). These values are then used to give the dry deposition velocities for each modes number and mass concentrations using equations 7 to 18.

4. Section 2.2.3-Aerosol scavenging. Can you justify why you choose 103 nm dry diameter for nucleation scavenging? Do you assume soluble fraction is 1 for all soluble modes (i.e., all aerosol in soluble modes with size larger than 103 nm will be in cloud water)? For impaction scavenging by rain droplets, why do you use dry radius of the mode since aerosol will uptake water especially for sea salt.

The value of 103nm is not used in GLOMAP-mode – only in GLOMAP-bin – but we realise that the way we had written this sentence did not make this very clear. We also realise that it is 103nm dry radius not dry diameter. So we have reworded the sentence:

Only the soluble accumulation and coarse modes are subject to rainout similarly to GLOMAP-bin, where the process is applied to all particles larger than 103 nm dry diameter in the mixed (soluble) distribution.

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to instead say:

Whereas in GLOMAP-bin, the rainout is applied to all particles larger than 103 nm dry radius in the mixed (soluble) distribution, in GLOMAP-mode this approach is approximated by only allowing the soluble accumulation and coarse to be subject to the process.

Incidentally, the value of 103nm was chosen (see Spracklen et al, 2005b) as an intermediate value between that used by Adams and Seinfeld (2003) (0.03 and 0.082 microns for convective and stratiform clouds respectively) and that used by Capaldo et al. (1999) (0.250 microns).

5. Section 2.2.10-cloud processing. Why do you assume an activation dry radius at 37.5 nm while in the nucleation scavenging you use 51.5 nm dry radius (or 103 nm diameter)?

The 37.5nm value is for activation to cloud-droplets in low-level clouds, whereas the 103nm value (dry radius) is used in precipitating clouds. The larger value is based on the assumption that larger aerosol will form larger cloud droplets, hence in-cloud scavenging will preferentially remove the largest of the activated aerosol.

6. Page 683. Lines 6-8. You need to move this part on aerosol nucleation over Antarctica to the above just after showing Figure 9.

We prefer to leave these lines here as they refer to particle size.

7. Section 3.5. You evaluate aerosol number at several size ranges. I don't see here you evaluate size distribution (aerosol number vs. size: dN/dlogr vs r). Therefore, you can merge section 3.5 with section 3.4.

We have renamed section 3.4 to be "Evaluation of simulated CN and CCN concentrations" and section 3.5 to be "Evaluation of simulated size-resolved number concentrations"

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8. Page 693. Line 16. Number of aerosol tracers. Please move this part to the beginning of model description.

We prefer to leave this here as this first paragraph summarizes the model description as this is a key part of the paper.

9. Table 5. "Terpenes and condensing organics" need to be consistent with those in table 4 "MONOTER" and "SEC-ORG"

Done.

10. All lon-lat figures need to have lon-lat labels.

Figures 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 25 (all lon-lat figures) have been re-drawn with lon-lat labels added.

11. Figure 21. Please include error bars (uncertainties) of observations (Clarke and Kapustin data)

Figure 21 has been re-drawn with the dot-dashed adding on the positive standard deviation from Clarke Kapustin (2002) and the dashed line making the equivalent relative reduction.

12. Figure 22a) the line types are not correct.

Figure 22 has been re-drawn with the line types corrected to match the caption.

13. Figure 23. Please add error bars (uncertainties) of observations (Petzold data).

Figure 23 has been re-drawn with the dashed/dot-dashed lines representing the 25th/75th percentiles as in Lauer et al (2005).

Technical corrections:

1. Page 674. Line 7. "conistent" -> "consistent"

Done.

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2. Page 684. Line 3. "10-3" -> "10-3"

Done.

References:

Spracklen et al, 2005b, A global off-line model of size-resolved aerosol microphysics: II. Identification of key uncertainties, Atmos. Chem. Phys, 5, 3233–3250, 2005.

Interactive comment on Geosci. Model Dev. Discuss., 3, 651, 2010.