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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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The paper describes in detail an updated version of the GLOMAP global size-resolved aerosol microphysical model and provides a comprehensive qualitative evaluation of this model against a wide ranging variety of observational data sets. Given the interest and uncertainty in the effects on climate of aerosols, the subject matter is appropriate for GMD. The aerosol microphysical model as described follows the M7 model described in Vignati et al. (2004) very closely. The descriptions of the size distribution; hygroscopic growth; nucleation; coagulation; condensation and ageing, are as the authors acknowledge, effectively the same as those in Vignati et al. (2004). The authors

should therefore seriously consider defining GLOMAP-mode as GLOMAP+ "a version of M7", rather than presenting it as a new modal version of GLOMAP. The only substantive difference that I found was the use of 10 mono-layers of H2SO4 rather 1 in M7 as the ageing threshold.

Although there are similarities in the design of M7 and GLOMAP-mode, we feel it is important to point out the differences and to explain why we did not simply adopt M7 in our chemistry-transport model. Firstly, our aim in developing GLOMAP-mode has been to create a modal version of an existing bin (sectional) model (Spracklen et al., 2005, and many subsequent publications). We took this approach specifically so that the computationally more efficient mode model could be evaluated against the more complete bin model as a reference. Thus, many of the processes in GLOMAP-mode are handled in a very similar or identical way as in GLOMAP-bin. Thus, the heritage of GLOMAP-mode is more closely associated with GLOMAP-bin than it is with M7. The similarity between M7 and GLOMAP-mode is essentially in the definition of the modes (e.g., nucleation, Aitken, accumulation and coarse modes; the assumption of insoluble emitted modes plus aged mixed composition modes; and the use of two moments – mass and number – with a fixed mode width). However, the scope for variation of these choices, if one wants to minimise the number of advected tracers, is very limited, so there are inevitably similarities between the two models at that level of definition.

Secondly, the handling of processes in M7 and GLOMAP-mode is in many respect quite different. Whilst there are some processes in GLOMAP-bin (e.g. hygroscopic growth, ageing) which follow the same method as M7, the main approach to simulating the aerosol microphysics (nucleation, coagulation and condensation) is quite distinct from that in M7. One of the key differences is in the treatment of nucleation and condensation. Both the bin and mode versions of GLOMAP simulate the competition for condensable vapours (e.g. H2SO4 and SEC-ORG) using a number of shorter competition timesteps (usually 5) within each chemistry-timestep upon which the two processes are integrated process-split. In Vignati et al (2004), the method (as I un-

derstand it) is to first calculate the vapour production over the full chemistry timestep (DTC), then deplete the vapour according to H2SO4 condensation over the DTC and then calculate the nucleation rate.

Another important difference is that GLOMAP simulates the growth of particles due to the uptake of secondary organic material (SOM) via condensation of the species "SEC-ORG" whereas M7 (Vignati et al, 2004) does not simulate SOM and the related HAM model (Stier et al, 2005) only considers SOM as a primary emission whose mass flux is a fixed fraction of the terpene emissions. Consequently, the production of SOA in M7/HAM is not driven by the chemistry and also it adds additional particles to the system and does not contribute to the growth of existing particles. A third fundamental difference between the models is that the actual transported tracers in the model are different. GLOMAP-mode includes organic carbon (OC) in the nucleation mode (this is SEC-ORG condensing into the OC component) whereas M7 does not.

There are also a large number of other important differences between the approaches to microphysics in the two models. For example, GLOMAP-mode simulates the cloud-processing of particles from the Aitken-soluble mode to the accumulation-soluble mode (section 2.2.10) whereas M7/HAM does not include this process. Also, the expressions for important parameters like the coagulation kernel and the condensation coefficient in GLOMAP-mode are those used by GLOMAP-bin (see equations 33-36) and are different from the expressions in Vignati et al (2004) and Stier et al (2005).

Where approaches from M7 are used in GLOMAP-mode, they are clearly stated in the manuscript, as the referee acknowledges.

In the revised manuscript, we have added a paragraph at the start of the model description section which clarifies that the approaches used are those from GLOMAP-bin in the same aerosol dynamics framework as M7/HAM. Given the heritage of GLOMAP-bin and GLOMAP-mode we do not accept the suggestion that we should rename our model.

In any case, the authors should note that the M7 model on which this work relies is not a modal model per se. As the authors note, in a 3 moment modal algorithm (e.g. Whitby and McMurry, 1997), the mode standard deviation is a prognostic variable. In half-modal models with fixed sigma parameters (e.g. Binkowski and Shankar, 1995) the coagulation and condensation rates are calculated by integrating over the modes. In M7 and GLOMAP-MODE, as in half-modal models the sigma is fixed, but the coagulation and condensation rates are based on a single particle diameter (the geometric mean diameter). This is not dissimilar to mono-disperse models such as the original GLOMAP, The only difference is that the calculated mass and number are, after the fact, spread out across a lognormal distribution with an assumed sigma. Vignati et al. (2004) called this "pseudomodal" and the authors should consider doing so as well.

We have added a statement in the "Model Description" section clarifying that the modal approach is the "pseudomodal" approach as used in Vignati et al (2004).

Given the degree of reliance on the approach used in M7 in GLOMAP-MODE it would be appropriate for the authors to include the development and principal applications of the "pseudomodal" approach, as background in order to put their work in a proper context. They refer to its use in a GCM (Stier et al, 2005), but do not include CTM examples, either of the precursor to M7 (Wilson et al. 2001) or that of Vignati et al. (2010), which uses a very similar set-up to GLOMAP mode.

We have added references to Wilson et al (2001) and Vignati et al (2010) as examples of 2-moment modal aerosol schemes.

This paper reports BC burdens and lifetimes (6.2 days 0.14 Tg) that are very similar to those reported by the authors (6.6 days, 0.14 Tg), but uses a single H2SO4 monolayer aging threshold. One would expect the requirement of having 10 times more H2SO4 condensation for each aged particle would increase the BC lifetime and burden. That it does not implies that the condensation pathway is not as important as coagualation in ageing BC. Perhaps the authors would like to comment on this.

The ageing in GLOMAP-bin and GLOMAP-mode proceeds according to the uptake of soluble material including both H2SO4 and SEC-ORG. In Vignati et al (2010), the condensation of secondary organic material is not included in the ageing, so the ageing will likely be faster in GLOMAP-mode for an equivalent assumed monolayer thickness. This may be part of the reason why the BC lifetime for single monolayer ageing threshold in Vignati et al (2010) is similar to that found for a 10 monolayer threshold here. We have added reference to this in the text.

Regarding the use of aerosol observations from the Global Atmosphere Watch, I note that the WDCA and the scientists providing the data are acknowledged. Could the authors also confirm that they have contacted the scientists concerned and obtained their approval for the use and citation of the data in this manner, in accordance with the WDCA data citation conditions specified in each dataset.

As explained in the caption to Table 7, all the CN observational data from the GAW sites were downloaded from the World Data Centre for Aerosols webpage (http://wdca.jrc.ec.europa.eu/data/parameters/datacnc.html). As described in the text, these datasets are a sub-set of the CN observations used in the paper "Explaining global surface aerosol number concentrations in terms of primary emissions and particle formation" by Spracklen et al (2010) published in Atmospheric Chemistry and Physics. As several of the data PIs for the CN measurements (e.g. Dr. John Ogren, Dr. John Gras, Dr. Urs Baltensberger, Prof. Gerard Jennings, Dr. Rolf Weller) and four of this paper's authors (Spracklen, Carslaw, Mann, Pickering) were also co-authors on that paper, we felt that, since the comparisons essentially repeated that carried out for GLOMAP-bin, with GLOMAP-mode, an Acknowledgment, in this case, would be sufficient. However, when we submitted the manuscript, we had not contacted the data PIs again to check they are happy with the acknowledgment. We have now contacted all the data PIs to obtain their approval and received confirmations of approval. The Acknowledgement has been revised to specifically name the data PIs involved and their institutions. Acknowledgments for the EMEP, CASTNET and IMPROVE datasets have

also been added.

The paper's novelty is the coupling of the particular components TOMCAT+ GLOMAP + a version of M7, rather than presenting new concepts tools or ideas. Nevertheless such an approach is valid and contributes to advancing modelling science by demonstrating the reliability and robustness of the components.

The methods and assumptions made are valid and clearly outlined, subject to the comments above, and the results support the interpretations and conclusions made. The description is complete and precise. Again, subject to the comments above, work is properly credited. The title reflects the contents, the model number is not however reported.

We have added (at the end of the first part of the Model Description section) a sentence stating the model version that the description refers to (v1gm4c) and referring to its use in the results submitted to AEROCOM in October 2009 for the A2-CTRL simulation.

The abstract is sufficient and the overall presentation and language is well structured, clear and easy to read. The formulae and abbreviations are understandable I did not find any errors with units. The paper is clear and none of the material is surplus. Subject to the comments above, the references are appropriate. No supplementary material is provided.

Specific Comments.

1. I did not find the year or years of the met data used reported in the description of the model set-up. From some of the results it appears to be 2000 is this correct? 2. If a single year is used, would it be of interest to compare results with observations from that year where available?

The ECMWF re-analysis fields were for the year 2000. We have added a sentence to the "Model Description" section stating this.

Typos:

P701 line 27 ofr of

Corrected.

P701 line 31 Wilson, G. –> Wilson, J.

Corrected.

References:

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