Atmos. Chem. Phys. Discuss., 13, C11239–C11243, 2014
www.atmos-chem-phys-discuss.net/13/C11239/2014/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Intercomparison and evaluation of aerosol microphysical properties among AeroCom global models of a range of complexity" *by* G. W. Mann et al.

Anonymous Referee #2

Received and published: 18 January 2014

This paper discusses the differences in particle size distribution simulated by twelve global aerosol microphysical models when model results are compared with observations.

The paper is quite comprehensive and covers a lot of ground. However, while it shows comparisons with data, it does not quantify well the error of the models versus the data, and errors are obscured by logarithmic plots. As such, I would recommend a better quantification of errors for each plot provided (e.g., provide a statistic). In addition, the discussion of potential causes of model errors is missing. It is not so useful just to show that the models result in errors versus data, it is necessary to examine why this

might occur. Along those lines, it is important to clarify the weaknesses and identify what is missing in the models examined for understanding why the models might result in errors. Finally, the literature survey on aerosol modeling could use improvement.

Below are specific comments.

". . .observed number size distributions in a range of environments showing two distinct peaks, generally found in the 10 to 100nm and 100 to 1000nm dry diameter range (Raes et al., 2000)." There is another peak below 10 nm near roadways due to combustion emissions. Please clarify and cite a reference.

The authors discuss global models treating sectional schemes. They are missing Jacobson (2001), which was the first model to treat multiple interacting aerosol size distributions each with a sectional representation on the global scale.

The authors state, "Since AR4, many climate modelling centres have incorporated new aerosol modules that include size-resolved aerosol microphysics. This represents a major shift in model sophistication (Ghan and Schwarz, 2007) and improves upon previous "first generation" aerosol schemes in which aerosol optical properties and cloud droplet concentrations were based on the simulated mass of several externally mixed aerosol types, each assigned a prescribed size distribution. The microphysical aerosol schemes calculate and transport the number concentration and component mass in several size classes of particles and can also represent both external and internal mixtures. Separate transport of size-resolved number and mass allows growth processes such as condensation and aqueous sulphate production to realistically conserve particle number while adding mass, and enables new particle formation and coagulation to provide explicit sources and sinks for particle number, which has been shown to be important in capturing changes in aerosol in response to changing emissions (Bellouin et al., 2013)."

The authors are stating this as if these aerosol modules or treatments are new. However, this representation has been included in other global models for over a decade

ACPD
13, C11239–C11243, 2014

(e.g., Jacobson, 2001; Adams and Seinfeld, 2002). Please clarify.

The authors then state, “The microphysics models explicitly simulate the evolution of the particle size distribution, and use this to determine aerosol optical properties and cloud condensation nuclei concentrations. In so-doing, they represent aerosol interactions with clouds and radiation consistently with the underlying physics of the fundamental aerosol processes.”

True, however, the authors should clarify that the fundamentals of cloud physics is not treated in these models, as their cloud treatments are largely empirical (e.g., cloud water is often an empirical function of CCN concentration and/or some other parameters), and only one updraft is often assumed to occur in each grid column. The major weakness of these models is the treatment of clouds. As, such, the authors should focus on specifying what these weaknesses are so that readers can understand better the limitations of the models and why results may not always be so accurate.

One reason the treatment of clouds in these models is so critical for this paper is because the paper wants to propose multi-model mean size distributions for use in further analysis. However, aerosol size distributions in the presence of clouds are significantly affected by the size distributions of cloud and precipitation particles and the physical interactions of aerosol particles of different size with such cloud and precipitation particles of different size (Jacobson, 2003). As such, it is not realistic to expect a model that treats aerosol sizes explicitly but parameterizes cloud interactions with aerosols to obtain the aerosol size distribution within or below clouds before or after precipitation occurs. Parameterization of cloud treatment in these models may partly explain the model errors versus data seen in Figures 18 and 19 of the present paper, for example.

Table 1. Please clarify in the text or table whether each model treated one aerosol size distribution only. In other words, was it possible to have two particles of the same size but different composition in any model? Please state so explicitly.

Table 1. Please clarify whether the tracers are all components within aerosol particles

ACPD
13, C11239–C11243, 2014

of each size, or are some of the tracers present in only some sizes, or are some of the tracers gases?

Table 2. Why do none of the models treat the combustion mode of emissions (< 10 nm). Please discuss.

Table 2. What about organic carbon emissions, especially in the nanoparticle range?

Figures 1ff. Please define “diversity.”

Figure 3. It would be useful to see how the mean vertical profiles from the models compare with HIPPO data.

Figures 5. Are the same 8 models used for all observation locations, or are the best 8 models chosen separately for each location? The plot should show the same 8 models used at all locations; otherwise, the results are meaningless since you would not know if even a single model could predict the data well consistently.

Figure 5 and other figures. What does Dp > 3, 10, 14 nm mean? Does it mean that the data at some stations are > 3 nm and at others, > 14 nm? If so, please say so.

Figures 6, 7, 8, 9. Are the same 2/3rds of models used each month, or are the best 2/3rds of all models selected a month at a time? I hope the same 2/3rds of models are used each month.

Figures 10, 11, 12. Are the same 8 models used at all sites?

Figure 18, 19. The model mean size distributions do not compare well with the data. Please discuss the potential reasons in terms of missing or simplified model processes, that might explain the errors. Right now, in Section 3.2.5, the text only describes some of the errors but no reasons for the errors.

For Figures 18 and 19, please quantify the magnitude of the error (e.g., provide an RMS error over all sizes). Finally, please state, based on the results, whether the models can, therefore, be used reliably to predict aerosol size distribution.

ACPD

13, C11239–C11243, 2014

Similarly, for other comparison plots, please provide the magnitude of error. Are we talking about factors of < 2 or factors > 10 or something in between. A better quantification of error is needed throughout the paper.

Also, there is little discussion of the causes of error. A section of the paper should be devoted to this. In this discussion, the limitations of the models should be discussed in detail. In the end, readers should be able to tell whether these models are reliable or not and the magnitude of their reliability. Also, what percent of the models are reliable?

It would be useful to have a table or figure identifying the location of all the surface sites.

References:

Adams, P. J., and Seinfeld, J. H., Predicting global aerosol size distributions in general circulation models, J. Geophys. Res., 107, 4370, doi:10.1029/2001JD001010, 2002.

Jacobson, M. Z., Strong radiative heating due to the mixing state of black carbon in atmospheric aerosols, Nature, 409, 695-697, 2001

Jacobson, M. Z., Development of mixed-phase clouds from multiple aerosol size distributions and the effect of the clouds on aerosol removal, J. Geophys. Res., 108 (D8), 4245, doi:10.1029/2002JD002691, 2003

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 30841, 2013.