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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Global error maps of aerosol optical properties: an error propagation analysis" *by* K. Tsigaridis et al.

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We would like to thank Svante Henriksson for his comments. Detailed answers to the explicit points mentioned follow:

1) Compared to reality there are also many other sources of uncertainty, for which although most briefly mentioned, the expected consequences should be treated in the paper. The paper studies variations within one model and no comparison to observations or other models is made. The range of validity and scope of applicability of the results remain unclear in the current formulation.

Following this comment and some comments from the anonymous reviewer #1, we decided to include a comparison with measurements, although this does not affect much the error propagation analysis presented in this work. We also decided to include ra-

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diative forcing calculations, in order to show an application of the present work. Please note that this work is willingly intended to explore the partial uncertainty resulting from just one part of the parameter space. In view of the difficulties to disentangle the influence of all possible factors on the resulting global AOD (see for instance the AeroCom efforts to understand the diversity in AOD among models) it seems to us timely to document one part of the sources of error within just one model.

2) Aerosols are modelled as two lognormal modes with fixed standard deviations for the radii. Optical calculations are based on Mie theory. This part is very clear and also the propagation of uncertainty from the varied input properties to the results is explained well based on aerosol physics. Aerosol transport, removal, chemistry are not described and uncertainty in these might well be the source of problems I'll describe later in the text.

These model-dependent uncertainties were not intended to be addressed in this paper, since our target was to study the partial uncertainty due to some selected aerosol microphysical properties. The wording 'partial uncertainty' will be defined and introduced in the text to better guide the reader. As already mentioned in the manuscript, Liu et al. (2007) has studied how meteorology affects aerosols in a global model. Please see also our comments to reviewer #1.

3) In section 2.3. the uncertainty calculations are described. I want to ask the authors on what basis the variation intervals of -20% - +20% for the aerosol radius and -50% - +50% for the aerosol water volume were chosen while mentioning at the same time that uncertainty ranges in e.g. the AEROCOM experiment are much larger?

In conjunction with the comment from reviewer #1, point #15, we chose to use a fairly narrower distribution than all models calculate, in order to show that even small uncertainties can play a major role in the error propagation. However, we agree with the reviewer that the range can be larger.

4) On page 16043 a comparison to the AEROCOM B experiment, which included many

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different models, is made. The reference case of the paper has a global annual mean AOD of 0.083, which is at the very low end of AEROCOM results. For most models the global annual mean AOD is between 0.11 and 0.14. AERONET remote sensing data from ground gives 0.135 and remote sensing from space (satellite composite) gives 0.15. The difference is attributed to an underestimation on the humidity growth of aerosols, which according to the authors is not expected to affect much the relative error. This point to explain the very large discrepancy is non-trivial and an explanation or reference is needed.

We will redo the calculations assuming that the reference simulation has triple aerosol water compared to the original model output, and then disturb that amount to propagate the error. This will show that a) the mean AOD will increase substantially, and b) the relative error calculated is not so strongly dependent on the absolute amount of aerosol water assumed as a reference, but its relative uncertainty.

5) Specific clarifying question concerning page 16043, lines 13-14: Was the global annual mean AOD really the same (0.083) for all choices of mixing state, aerosol size and aerosol water content?

What we meant here is that the ensemble of calculations for the different mixing state, aerosol size and aerosol water content gave a median AOD value similar to the mean AOD value of the ensemble, which was again similar to the reference AOD value and equal to 0.083. This was expected, since the reference case is in the middle of the cases studied. We will clarify this to the revised manuscript.

6) Looking at the results, it seems that relative AOD uncertainty tends to be largest where the AOD values themselves are large, while for g and SSA the situation is opposite. I would find possible explanations for this phenomenon interesting although not obligatory.

When AOD is high due to high load of fine aerosols (strong scatterers) the change in aerosol associated water and size alters their extinction capabilities substantially,

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having a major effect on AOD. Changing the radius of large particles, although their extinction properties do not change much (for the given wavelength), their total mass changes a lot, hence their AOD.

For aerosols with radii above 0.1um, the asymmetry parameter and SSA are not affected that much, as this can be seen in Figures 2 and 3. For that reason, the uncertainty range of these two properties is narrow when AOD is high (very small particles, although strong scatterers, do not contribute much to the total AOD due to low mass loads). At low AOD though, the aerosols are either negligible (thus insignificant) or extremely small (thus low scatterers). For the latter case, again as can be seen in Figures 2 and 3, these extremelly small particles are calculated to have a higher variability concerning their asymmetry parameter and SSA, thus are calculated to have a higher variation on these properties.

We agree that the explanation for this is interesting and will include it in the revised manuscript.

7) Specific clarifying question concerning page 16046, lines 4-6: Specifically how do you think this uncertainty analysis could be used to estimate the error introduced to the radiative forcing calculated by models?

Since our work is just exploring the partial uncertainty in the optical properties, it would require further systematic documentation of similar error maps as a function of refractive index, transport and removal, emissions, humidity fields, albedo, cloud fields to be able to combine them. Our error maps are intended to be compared to other error estimates to better understand the sources of diversity across models.

8) The paper is ambitious and interesting reading but it's significance for further science is unclear to me. It is well known that there are large differences between results of different models and models are not strongly validated against observations. In general what lacks in the paper is a comparison to observations and a treatment of uncertainties other than those coming from varying the three aerosol properties in the one

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model. As such the study does not give convincing uncertainty estimates for aerosol optical properties in nature. Perhaps by expanding on the GEMS-ECMWF aerosol assimilation system mentioned in the text and the conclusions the application of the results at least to this specific case could be justified.

As already answered to the reviewer #1, point #4, a comparison with measurements will be made in the revised manuscript. The treatment of uncertainties other than the aerosol microphysics will not be addressed, since it is outside the scope of the present work. Nevertheless, the approach followed here can be easily implemented to any other model, as we had already mentioned. Further, the calculation of the radiative forcing uncertainty that will be included in the revised version will hopefully show one more reason why this paper is significant.

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