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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Mapping the uncertainty in global CCN using emulation" *by* L. A. Lee et al.

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Dear Dr Booth,

Thank you for the detailed review of our manuscript. We have made some changes to the manuscript as detailed below where you will find your original comment in bold font and our response in normal font. Changes to the manuscript are in italic.

IPCC uncertainties estimates are radiative forcing estimates, where as what is emulated is the cloud condensating nuclei (CCN) in this study. The link between the two, first needs to be made (a key uncertainty within IPCC aerosol forcing estimates arises from indirect (aerosol-cloud micro-physics) effects – this study focuses therefore on CCN (a cloud property closely tied to these indirect effects)). I am not overly familiar with GLOMAP but assume that CCN was chosen

as GLOMAP has not yet been coupled to an atmospheric radiative scheme?
GLOMAP has not been coupled to an atmospheric radiative scheme in this study because the aim here is to understand the underlying aerosol physics before extending to radiation. The following text has been included in the abstract.
CCN is a key quantity for estimating the aerosol indirect radiative forcing effect.

The capabilities of this model need to be emphasised/contrasted with the existing/simpler schemes used in GCMs.
The following text has been included in the model description.
The GLOMAP-mode aerosol model is significantly more complex in its design than the models used in climate simulations. The main difference is that GLOMAP-mode simulates the evolution of the aerosol size distribution, while climate models typically simulate only the masses of the aerosol chemical components or assume a fixed size distribution. Thus, GLOMAP-mode requires many more parameters to describe the particle distribution as well as parameters defining the microphysical processes that control size-dependent particle growth, formation, coagulation, deposition, etc.

There are been a number of studies which have looked at model parametric uncertainty.
We apologise for not including these studies in the introduction to this paper. We included this literature review in Lee11 but realise that it should also be included here.
A number of studies have been carried out to assess parameter uncertainty in aerosol models. **?** *used probabilistic collocation to represent the computer model and carry out uncertainty analysis of the aerosol indirect effect.* **?** *used a general circulation model (GCM) to study the uncertainty in parameters determining atmospheric aerosol and its effect on the climate.* **?** *and* **?** *used the ECHAM model to study the parametric uncertainty in aerosol models and its effect on clouds but in both cases the number of parameters studied is limited by the method.* **?** *studied the effect of perturbations of 7 cloud-related parameters on the aerosol indirect effect with interactions identified by*

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the differences between OAT experiments and multiple parameter perturbation experiments. **?** *used a factorial design with 4 parameters to examine the effect of parametric uncertainty on clouds. In this study we illustrate the method of emulation to make statistical inferences about the relative effect of aerosol parameter uncertainties and their interactions on the cloud-related quantity CCN with 8 parameters using a sophisticated aerosol model. This method can easily be extended to more model parameters and outputs and different models.*

I am not familiar with these studies and question whether contrasting against OAT is that informative.
In aerosol modelling OAT tests are still modus operandi so the contrast against OAT here should be informative to the aerosol modelling community.

Is the guassian emulator making use of a nugget?
No nugget is used. Further text has been added to the emulator description to clarify this point.
The emulator provides an estimate of the model output at any previously untried point x *in the parameter uncertainty space with an associated "emulator" uncertainty; the emulator passes through every point in the training data with no uncertainty and uncertainty increases in a quantifiable way as the distance from the training data increases.*

Include North Atlantic region
The North Atlantic has now been added to the figure for interest but we do not make conclusions regarding this region. The North Atlantic region will be included in the next 28 parameter study.

Are the tails of the histograms an artefact of emulation or is there data in the tails?
There are data points in the tails of the distributions in the GLOMAP runs. The emulator is unlikely to extrapolate to give such long tails since weak prior distributions were

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used so the posterior distribution is mainly informed by the training data.

What is the "coefficient of variation"?
The coefficient of variation and its importance is discussed further in the text.
However, relative changes in CCN are more relevant for changes in cloud albedo and climate than absolute concentrations **?**. *In fact, changes in albedo are more sensitive to changes in CCN when concentrations are low, thus the absolute variance map will give a misleading impression of the importance of the uncertainty. To understand the relative uncertainty in CCN we define the coefficient of variation as* $\sigma_{CCN_{ij}}/\mu_{CCN_{ij}}$ *with* $\mu_{CCN_{ij}}$ *and* $\sigma_{CCN_{ij}}$ *calculated using the emulator for every grid box* ij.

In order to identify how the CCN can be better constrained is far too vague.
We have changed this sentence.
In order to identify which parameter uncertainties contribute to the CCN uncertainty in each region.

I don't see how an emission can be the dominant control on CCN but the CCN is insensitive variations around this emission.
Further discussion has been added to the results to clarify this.

This statement implies that this parameter (a representation of large area aggregate property) can be known exactly.
We have added a sentence to show that this conclusion is only true in theory since some parameters cannot be learnt precisely. The numbers here are important to show the relative contributions to uncertainty whether they are reducible or irreducible.
It may not always be possible to learn a parameter precisely in which case this is the uncertainty that is irreducible in the absence of fine scale process representation.

What I think is missed is whether this manuscript provides a step towards quantifying and reducing current aerosol forcing uncertainty raised in the first lines

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of the abstract?
Further text has been added to the conclusions.
To extend to aerosol forcing:
To extend this work to aerosol forcing the results of the GLOMAP runs can be directly fed into a radiative trasnfer code and the corresponding radiative effect quantities obtained. The emulators can then be built with the radiative effect quantities rather than the CCN following the same method.
Reducible versus irreducible:
Emulation of observable quantities such as CN and AOD will allow the comparison of emulated values against observations, which could reduce the parameter uncertainty by constraining the model output space. The results can be used to understand where parameter uncertainty is reducible and where it is irreducible.

Further changes have been made throughout the text to clarify other points made in the review. In particular, Figure 4 has been changed to have a better legend.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 14089, 2012.

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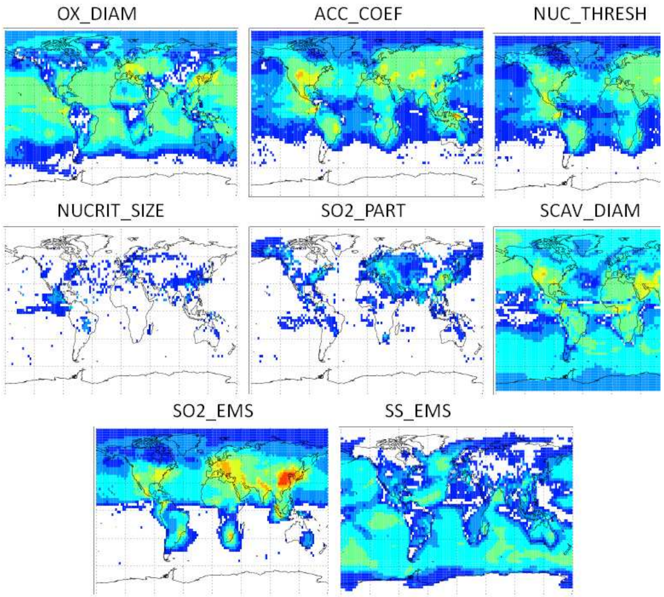

Fig. 1.

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