

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

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* GENERAL COMMENTS This paper presents an interesting parameter sensitivity analysis of a global aerosol model. It is very well written and a pleasure to read. The uncertainty analysis is restricted to a subset of eight of the model's parameters, and the only model output variable whose parameter sensitivity is evaluated is the concentration of cloud condensation nuclei (CCN) across the globe, at just one of 31 simulated vertical layers, at one moment in time, July 2000. A further limitation of the sensitivity analysis is the use of uniform parameter distributions with arbitrary non-elicited minima and maxima. All these restrictions mean that the paper does not provide a thorough uncertainty analysis of the selected model, let alone provide any novel scientific information about aerosol dynamics. However, the authors do not claim to do so, and what they do provide is a very nice demonstration of the potential of sensitivity analysis in elucidating which parameters may be important in different parts of the globe. I also en-

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joyed reading their explanations, in clear physical terms, for the differences they found between regions in parameter sensitivities. The original model is slow, so the authors use Gaussian Process emulation to interpolate probabilistically between the model's CCN-predictions for 80 different parameter vectors, allowing them to examine many more combinations of parameter values. The same authors presented this emulation method, using the same model and based on the same 80 original model runs, in a previous paper (Lee et al., 2011). So this paper does not present novel methodology as such (Gaussian Process modelling is a well established technique in other disciplines anyway, such as climate modelling), except that in the current paper we see the sensitivities quantified across the globe, whereas the 2011 paper only showed them for two grid cells. It is useful to see the possibility to do such spatially distributed sensitivity assessment, afforded by the very high computational speed of the emulator compared to the original model. The paper thus convincingly shows further evidence for the potential of a specific methodology as applied to global aerosol modelling. I did find that the paper gave insufficient information about the aerosol model and about Gaussian Process emulation - and will return to that finding in the Specific Comments below.

* SPECIFIC COMMENTS - p. 14091, l. 21: Incorrect statement: model response to a single parameter can be nonlinear and an OAT sensitivity test can show that. What OAT tests can not do is account for interactions between parameters. - Section 2: The model description can be made clearer and more comprehensive. Explain the phrase "lognormal modes" which is common in aerosol modelling but not elsewhere and it conflicts with the statistical meaning of the term "mode" of a probability distribution. Also, how many parameters does the model have besides the 8 selected for sensitivity analysis? And which processes are included in the model that are not controlled by any of those 8 parameters? - Section 3: The description of the emulation method may easily be misconstrued: the suggestion is given, by consistently writing "the" emulator, that there is one single emulator just as there is one aerosol model. It thus seems that a model is replaced with a single emulator having as only input the values of the eight parameters and with the global spatial field of CCN as output. That is not the case: the

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authors build separate emulators for each of the 2^{14} grid cells. Those emulators are independent from each other so the collection of emulators is in no way constrained by considerations of, for example, keeping the same global or regional totals of CCN as the original model. That approach is inevitable because of current technical limitations of building emulators for multivariate outputs, but those limitations should be made clear and discussed. There should also be a much more in-depth analysis of the limitations of Gaussian Process modelling as applied to aerosol modelling, including the importance of prior assumptions about smoothness of the original model's CCN predictions. The reference to Lee et al. (2011) for evidence of "the" emulator's quality is clearly not sufficient, as in that paper the emulation process was only evaluated for two grid cells, and here we have about 16000 extra grid cells (i.e. extra emulators) for which we have no confirmation of emulator quality. - p. 14101, l. 9-10 "clear and testable assumptions": please make those assumptions explicit and show the test results. * TECHNICAL CORRECTIONS - Do not write "percentage" where the meaning is "fraction" (Figs 3, 5 and 7). - Explain what the white areas in Figs 1 to 6 represent. - p. 14100, l. 20: It is not 35% "of the uncertainty" that is being dominated by the parameter, but 35% "of the area" where that parameter happens to be the most influential. A similar incorrect statement is on l. 22-23. Correct statements are given on l. 21.

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