Geophysical Research Abstracts
Vol. 14, EGU2012-2001, 2012
EGU General Assembly 2012


# Sensitivity analysis of a global aerosol model to understand how parametric uncertainties affect model predictions

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Global aerosol contributions to radiative forcing (and hence climate change) are persistently subject to large uncertainty in successive Intergovernmental Panel on Climate Change (IPCC) reports (Schimel et al., 1996; Penner et al., 2001; Forster et al., 2007). As such more complex global aerosol models are being developed to simulate aerosol microphysics in the atmosphere. The uncertainty in global aerosol model estimates is currently estimated by measuring the diversity amongst different models (Textor et al., 2006, 2007; Meehl et al., 2007). The uncertainty at the process level due to the need to parameterise in such models is not yet understood and it is difficult to know whether the added model complexity comes at a cost of high model uncertainty. In this work the model uncertainty and its sources due to the uncertain parameters is quantified using variance-based sensitivity analysis.

Due to the complexity of a global aerosol model we use Gaussian process emulation with a sufficient experimental design to make such as a sensitivity analysis possible. The global aerosol model used here is GLOMAP (Mann et al., 2010) and we quantify the sensitivity of numerous model outputs to 27 expertly elicited uncertain model parameters describing emissions and processes such as growth and removal of aerosol. Using the R package DiceKriging (Roustant et al., 2010) along with the package sensitivity (Pujol, 2008) it has been possible to produce monthly global maps of model sensitivity to the uncertain parameters over the year 2008.

Global model outputs estimated by the emulator are shown to be consistent with previously published estimates (Spracklen et al. 2010, Mann et al. 2010) but now we have an associated measure of parameter uncertainty and its sources. It can be seen that globally some parameters have no effect on the model predictions and any further effort in their development may be unnecessary, although a structural error in the model might also be identified. The sensitive parameters are shown to change regionally due to the local aerosol properties. The quantification of the relative sensitivities allows modellers to prioritise future model development in order to reduce prediction uncertainty. For example, we show that model predictions would be improved over polluted regions if the size and rate of particulate emissions could be better constrained. The result is a complete understanding of the model behaviour, the effect of increasing the model complexity and the uncertainty introduced.