Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 9, 1339-1356, 2009
www.atmos-chem-phys.net/9/1339/2009/

Uncertainty in global CCN concentrations from uncertain aerosol nucleation and primary emission rates

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Abstract. The indirect effect of aerosols on climate is highly uncertain and limits our ability to assess anthropogenic climate change. The foundation of this uncertainty is uncertainty in the number of cloud condensation nuclei (CCN), which itself stems from uncertainty in aerosol nucleation, primary emission and growth rates. In this paper, we use a global general circulation model with aerosol microphysics to assess how the uncertainties in aerosol nucleation, emission and growth rates affect our prediction of CCN(0.2%) concentrations. Using several nucleation rate parameterizations that span six orders of magnitude of globally averaged nucleation rates, the tropospheric average CCN(0.2%) concentrations vary by 17% and the boundary layer average vary by 12%. This sensitivity of tropospheric average CCN(0.2%) to the nucleation parameterizations increases to 33% and 20% when the total primary emissions are reduced by a factor of 3 and the SOA condensation rates are increased by a factor of 3.5, respectively. These results show that it is necessary to better understand global nucleation rates when determining CCN concentrations. When primary emissions rates are varied by a factor of 3 while using a binary nucleation parameterization, tropospheric average CCN(0.2%) concentrations also vary by 17%, but boundary layer average vary by 40%. Using the fastest nucleation rate parameterization, these changes drop to 3% and 22%, respectively. These results show the importance of reducing uncertainties in primary emissions, which appear from these results to be somewhat more important for CCN than the much larger uncertainties in nucleation. These results also show that uncertainties in nucleation and primary emissions are more important when sufficient condensable material is available to grow them to CCN sizes. The percent change in CCN(0.2%) concentration between pre-industrial times and present day does not depend greatly on the nucleation rate parameterization used for our base case scenarios; however, because other factors, such as primary emissions and SOA, are uncertain in both time periods, this may be a coincidence.

Final Revised Paper (PDF, 1460 KB) Discussion Paper (ACPD)

Citation: Pierce, J. R. and Adams, P. J.: Uncertainty in global CCN concentrations from uncertain aerosol nucleation and primary emission rates, Atmos. Chem. Phys., 9, 1339-1356, 2009. Bibtex EndNote Reference Manager