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Integrating multi-component aerosol responses into general circulation models

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A parameterization of internal mixing between sulphate and sea-salt aerosol has been successfully integrated within the Hadley Centre General Circulation Model (GCM). The results of this combined parameterization indicate a significantly reduced role, compared to previous estimates, for sulphate aerosol in cloud droplet nucleation, and consequently, in indirect radiative forcing. However, in this bi-component system the cloud droplet number concentration, N_d, is a smoothly varying function of the sulphate aerosol loading.

In subsequent studies, we have included a third component, biomass aerosol, in addition to sulphate and sea-salt, in a detailed microphysical parcel model that accounts for the particle's hygroscopicity and age. We find that biomass smoke can significantly perturb the activation and growth of both sulphate and sea-salt particles, leading to a much more complex relationship between these aerosol components and the number of cloud droplets activated. The intuitive variation of N_d with sulphate mass that is observed in a sulphate–sea-salt system breaks down under certain conditions and demands a more complex, but computationally efficient, algorithm for use in GCMs.

The method employed to parameterize this complex non-linear response of N_d to the aerosol mass loadings was the Shepard interpolation method. This provides a global three-component parameterization which can be adapted in order to study climatic responses in multi-component aerosol domains. Also, this method is more suitable than the series of polynomial interpolations valid only through specific slices in the activation domain that were previously employed. The results obtained show that the method gives meaningful and realistic results for wide ranges of aerosol mass loadings and dry aerosol sizes.