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Comparing droplet activation parameterisations against adiabatic parcel models using a novel inverse modelling framework

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Many previous studies have compared droplet activation parameterisations against adiabatic parcel models (e.g. Ghan et al., 2001). However, these have often involved comparisons for a limited number of parameter combinations based upon certain aerosol regimes. Recent studies (Morales et al., 2014) have used wider ranges when evaluating their parameterisations, however, no study has explored the full possible multi-dimensional parameter space that would be experienced by droplet activations within a global climate model (GCM). It is important to be able to efficiently highlight regions of the entire multi-dimensional parameter space in which we can expect the largest discrepancy between parameterisation and cloud parcel models in order to ascertain which regions simulated by a GCM can be expected to be a less accurate representation of the process of cloud droplet activation.

This study provides a new, efficient, inverse modelling framework for comparing droplet activation parameterisations to more complex cloud parcel models. To achieve this we couple a Markov Chain Monte Carlo algorithm (Partridge et al., 2012) to two independent adiabatic cloud parcel models and four droplet activation parameterisations. This framework is computationally faster than employing a brute force Monte Carlo simulation, and allows us to transparently highlight which parameterisation provides the closest representation across all aerosol physiochemical and meteorological environments.

The parameterisations are demonstrated to perform well for a large proportion of possible parameter combinations, however, for certain key parameters; most notably the vertical velocity and accumulation mode aerosol concentration, large discrepancies are highlighted. These discrepancies correspond for parameter combinations that result in very high/low simulated values of maximum supersaturation. By identifying parameter interactions or regimes within the multi-dimensional parameter space we hope to guide the future development of droplet activation parameterisations, as well as quantify where spatially the largest uncertainties from the underlying physical representation of droplet activation can be expected in a GCM.