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Supplement of

An investigation into the performance of four cloud droplet activation parameterisations

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Supplementary Material

Demonstration of Time Dependency in Model Simulations

Supplementary Figure 1 demonstrates the large amount of simulation time required by the parcel model in order to activate a fraction of large aerosol, 1000 nm.

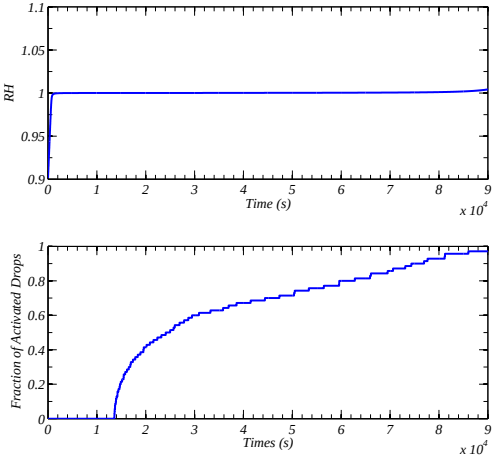

Fig. 1: Time series of peak RH (top panel) and fraction of activated drops (bottom panel) as calculated by ACPIM with initial conditions described in Table 1, aerosol number concentration 500 cm^{-3}, and mean aerosol diameter 1000 nm.

Single-Mode Experiment

Supplementary Figure 2 shows that the performance of the four parameterisations is generally good in single lognormal aerosol size distribution of small aerosol ($5 \leq d_m \leq 250$ nm) at high number concentration, 10000 cm^{-3}. However there is a tendency to underestimate the fraction of activated drops.

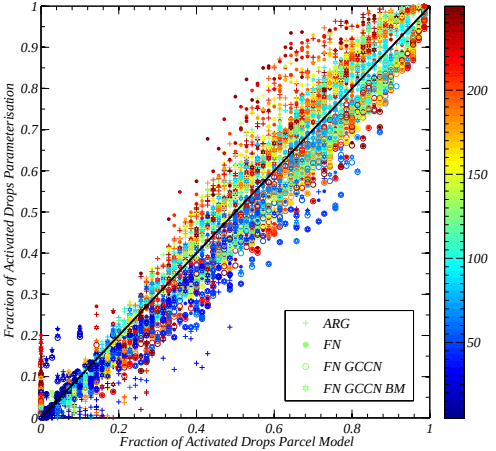

Fig. 2: Results from 1500 runs with 1 lognormal mode of ammonium sulphate aerosol, number concentration of 10000 cm^{-3}. Symobols are coloured by mean aerosol diameter (nm). The values for the following variables were randomly chosen within the stated ranges: $0.2 \leq \ln \sigma \leq 0.8$; median diameter, $5 \leq d_m \leq 250$ nm; updraft velocity, $0.01 \leq w \leq 10$ m s^{-1}. Initial conditions are detailed in Table 1.

Supplementary Figure 3 shows that the four parameterisations highly overestimate

the fraction of activated drops in single lognormal aerosol size distribution of large aerosol ($250 \leq d_m \leq 2000$ nm) at low number concentration, 100 cm^{-3}.

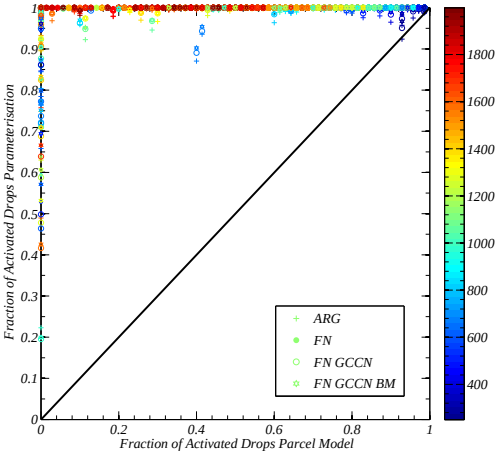

Fig. 3: Results from 1500 runs with 1 lognormal mode of ammonium sulphate aerosol, number concentration of 100 cm^{-3}. Symbols are coloured by median aerosol diameter. The values for the following variables were randomly chosen within the stated ranges: $0.2 \leq \ln \sigma \leq 0.8$; median diameter, $250 \leq d_m \leq 2000$ nm; updraft velocity, $0.01 \leq w \leq 10$ m s^{-1}. Initial conditions are detailed in Table 1.

Supplementary Figures 4 and 5 show the same results as Figure 2 with data points coloured coded by $\ln \sigma$ and aerosol number concentration respectively. There is no obvious relationship between the fraction of activated drops estimated by the parameterisations and variables mentioned.

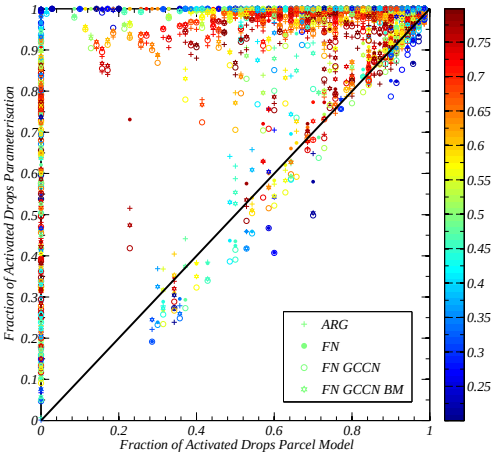

Fig. 4: Results from 1500 runs with 1 lognormal mode of ammonium sulphate aerosol and randomly sampled variables values as detailed in Table 2 and initial conditions described in Table 1. Symbols are coloured by $\ln \sigma$, see colour bar.

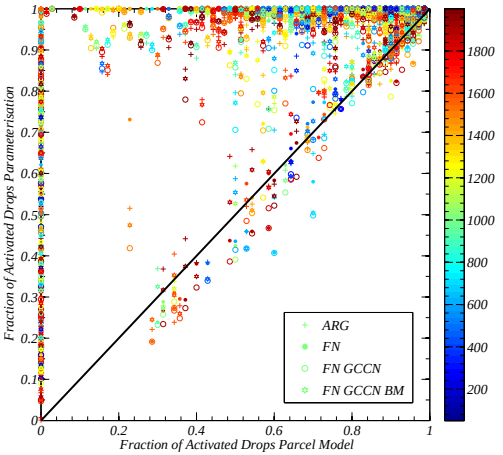

Fig. 5: Results from 1500 runs with 1 lognormal mode of ammonium sulphate aerosol and randomly sampled variables values as detailed in Table 2 and initial conditions described in Table 1. Symbols are coloured by aerosol number concentration (number cm^{-3}), see colour bar.

Dual-Mode Experiment

To avoid extreme conditions of very high concentrations of large or small aerosol the parameter space has been limited in the following cases. The range of updraft velocity has also been limited so that within the simulation time of the parcel model the “effective height” of the rising air parcel is more realistic, i.e between 0.4 km and 10km, where clouds form.

Using a smaller parameter space improves the results from the four parameterisations as can be seen in Supplementary Figure 6.

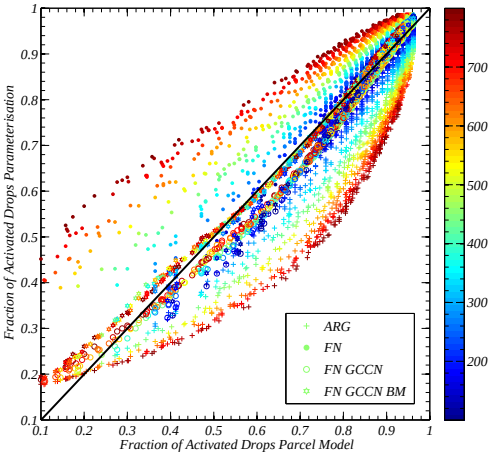

Fig. 6: Results from 1500 runs with bimodal aerosol size distributions, 500 cm^{-3} in the first mode and 100 cm^{-3} in the second. Only the median diameter of aerosol in the second mode and updraft velocity were changed between runs, within the ranges of $100 \leq d_m \leq 800$ nm and $0.2 \leq w \leq 5$ m s^{-1} respectively. Symbols are coloured by median diameter (nm) of the second mode, see colourbar. For initial conditions see Table 1.