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Supplement of

Modeling collision–coalescence in particle microphysics: numerical convergence of mean and variance of precipitation in cloud simulations using the University of Warsaw Lagrangian Cloud Model (UWLCM) 2.1

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S1 Box simulations: Moments of the initial DSD

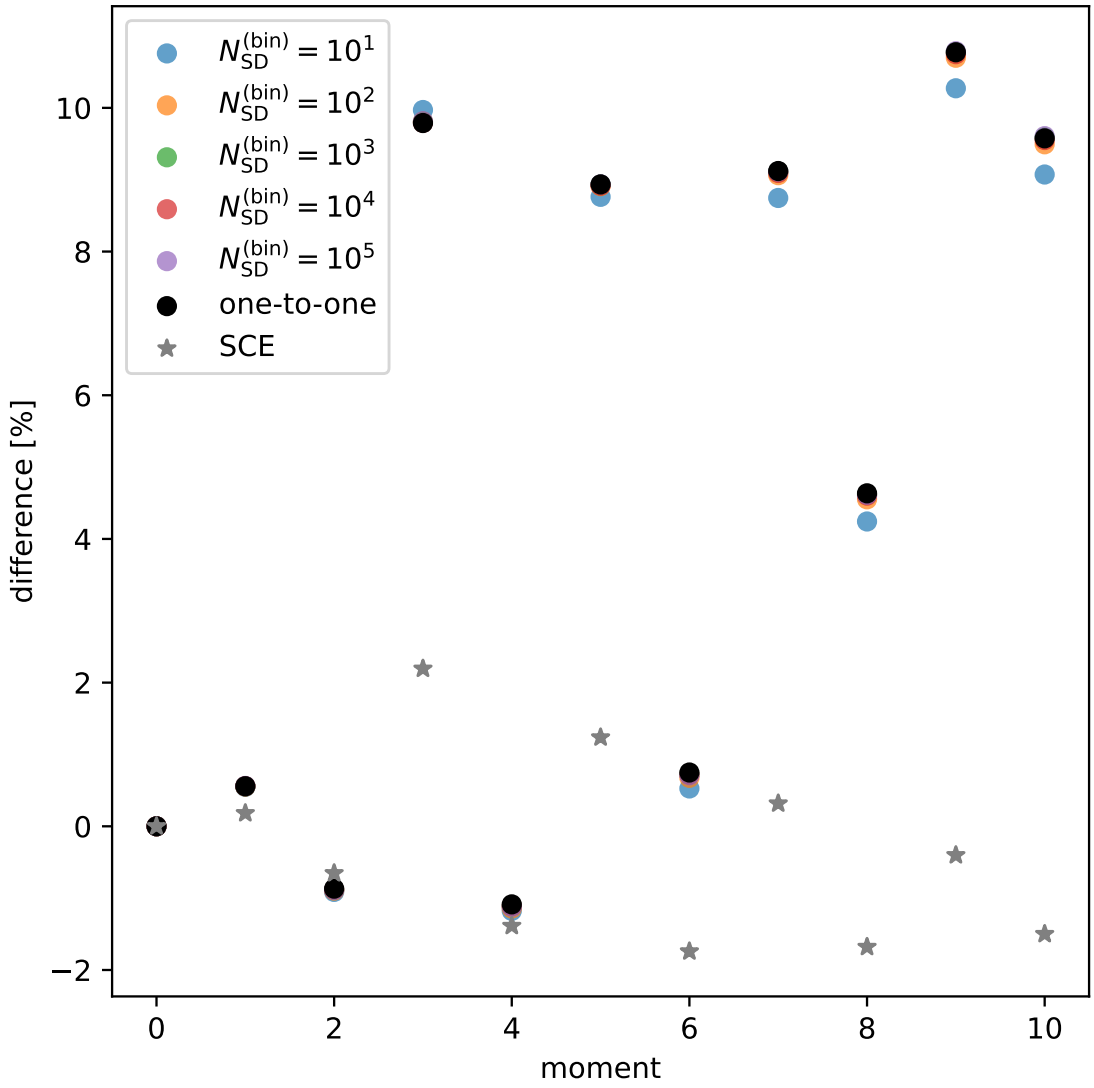

Fig. S1. Moments of the average initial number distribution function in box simulations and in the numerical solution of the SCE, relative to the moments calculated directly from the prescribed distribution. The number distribution function $n(r)$ is such that $n(r)dr$ is the concentration of droplets with radii between r and $r+dr$. The 0-th and the 1-st moments are raw, higher moments are central.

S2 CC simulations: Time Series

In this section, we discuss temporal development of general cloud properties in the LR, MR, HR and D scenarios. In this supplement, this is done in a more expanded version than in the paper to give the readers the whole overview of how the modeled cloud develops. Time series of cloud top height (CTH), cloud cover (cc), cloud water path (CWP), rain water path (RWP) and surface precipitation (surf. precip.) are plotted in the following figures. In case of figures for cloud scenarios with coalescence solver turned off, the subplot showing the precipitations is omitted due to the fact that in those cases there are no precipitation at all. The results are ensemble averages for all cases with the coalescence solver turned on as well as for the D scenario with the coalescence solver turned off. For kinematic scenarios, there is no difference between simulations within the same ensemble while the coalescence solver is turned off; that is why the presented plots are based on a single result for each $N_{\mathrm{SD}}^{(\mathrm{bin})}$.

A brief description of each subplot is as follows:

(a) Cloud top height is the vertical position of the topmost cloudy cell;

(b) Cloud cover is the fraction of columns with at least one cloudy cell;

(c) Cloudy cells are cells with cloud water mixing ratio greater than 10^{-5};

(d) Cloud droplets are droplets with $0.5\,\mu\mathrm{m} \leq r_w \leq 25\,\mu\mathrm{m}$;

(e) Rain drops are droplets with $25\,\mu\mathrm{m} \leq r_w$;

(f) Surface precipitation, cloud water path and rain water path are domain averages divided by cloud cover in order to obtain values representative of the cloudy area.

S2.1 Scenario: LR

S2.1.1 With coalescence

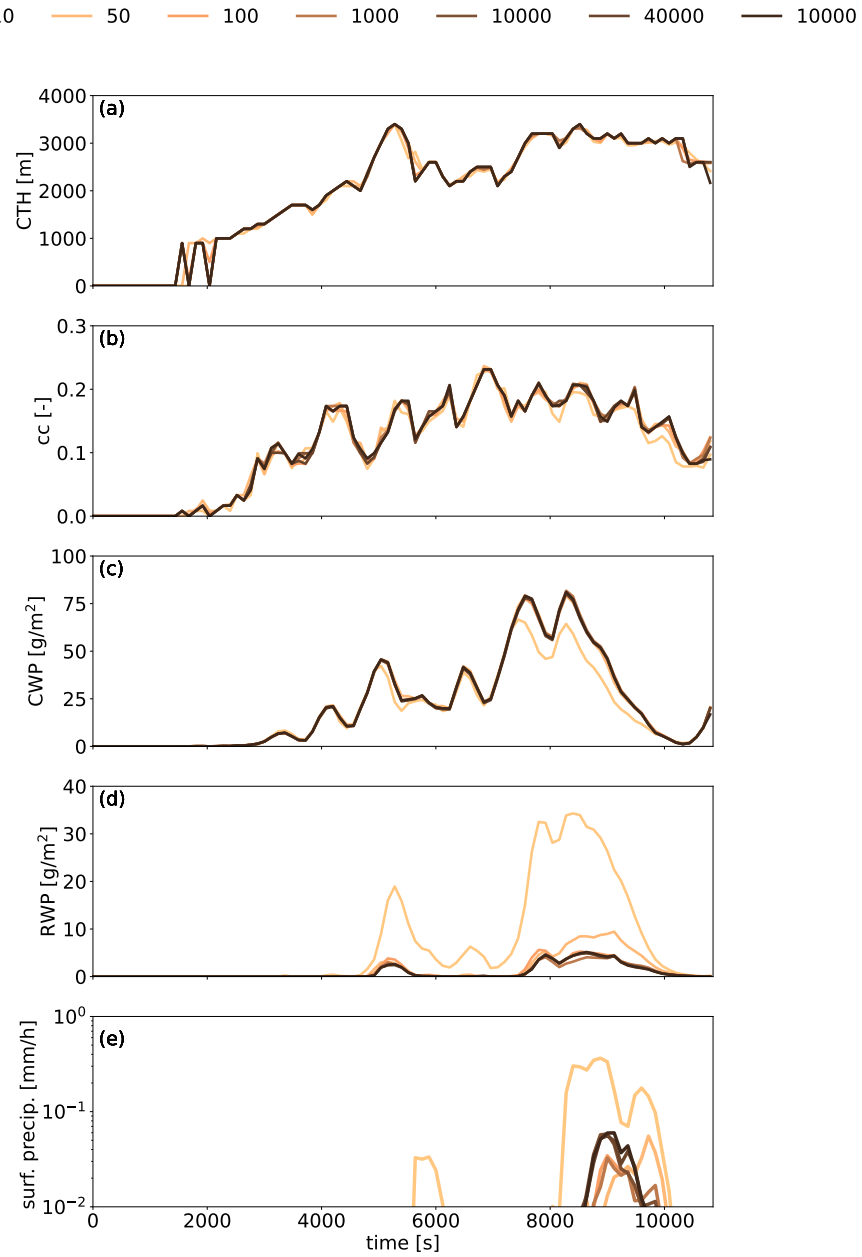

Fig. S2. Time series of ensemble averages of cloud top height (CTH), cloud cover (cc), cloud water path (CWP), rain water path (RWP) and surface precipitation (surf. precip.) for LR scenario with $N_{\mathrm{SD}}^{(\mathrm{bin})} = \{10, 50, 100, 1000, 10000, 40000, 100000\}$.

S2.1.2 Without coalescence

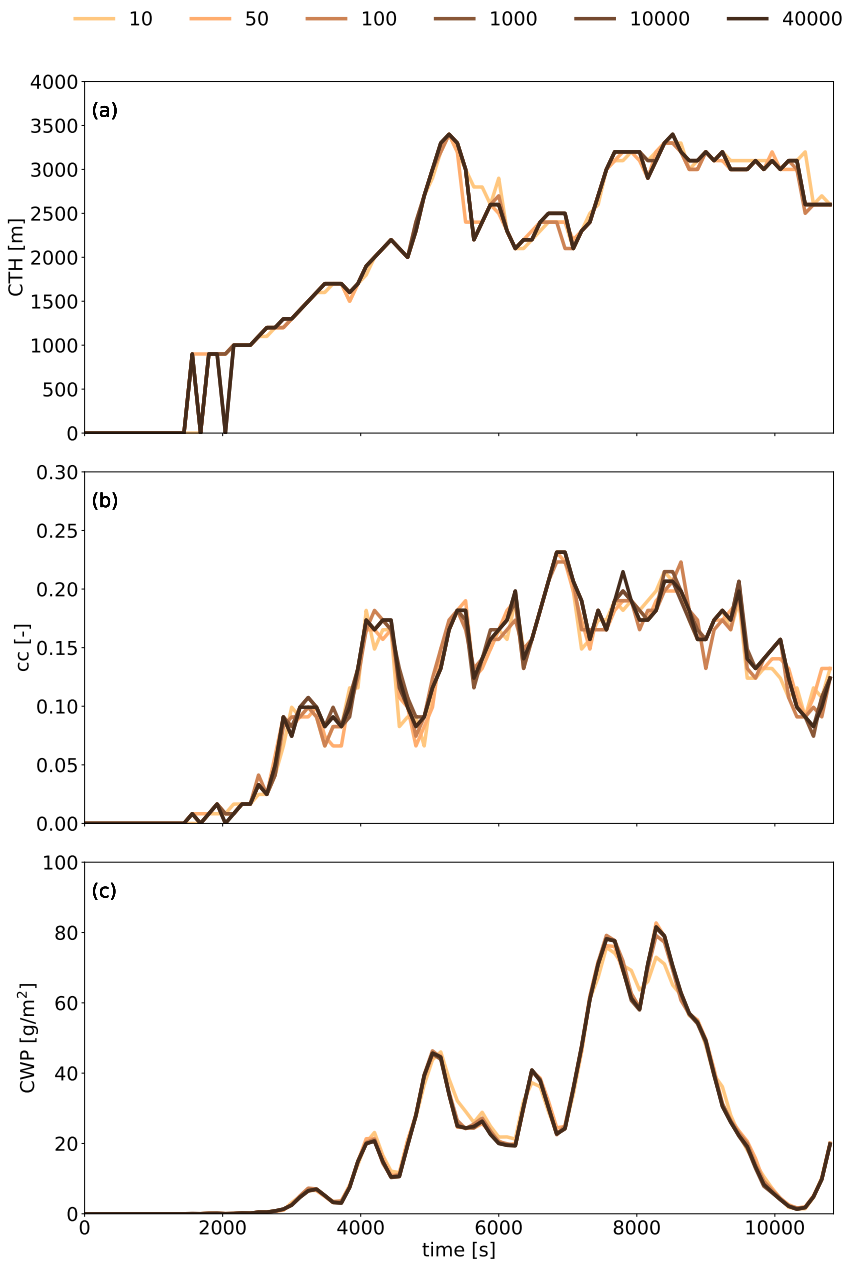

Fig. S3. Time series of ensemble of cloud top height (CTH), cloud cover (cc), cloud water path (CWP) for LR scenario with $N_{\mathrm{SD}}^{(\mathrm{bin})} = \{10, 50, 100, 1000, 10000, 40000\}$ for the coalescence solver turned off.

S2.2 Scenario: MR

S2.2.1 With coalescence

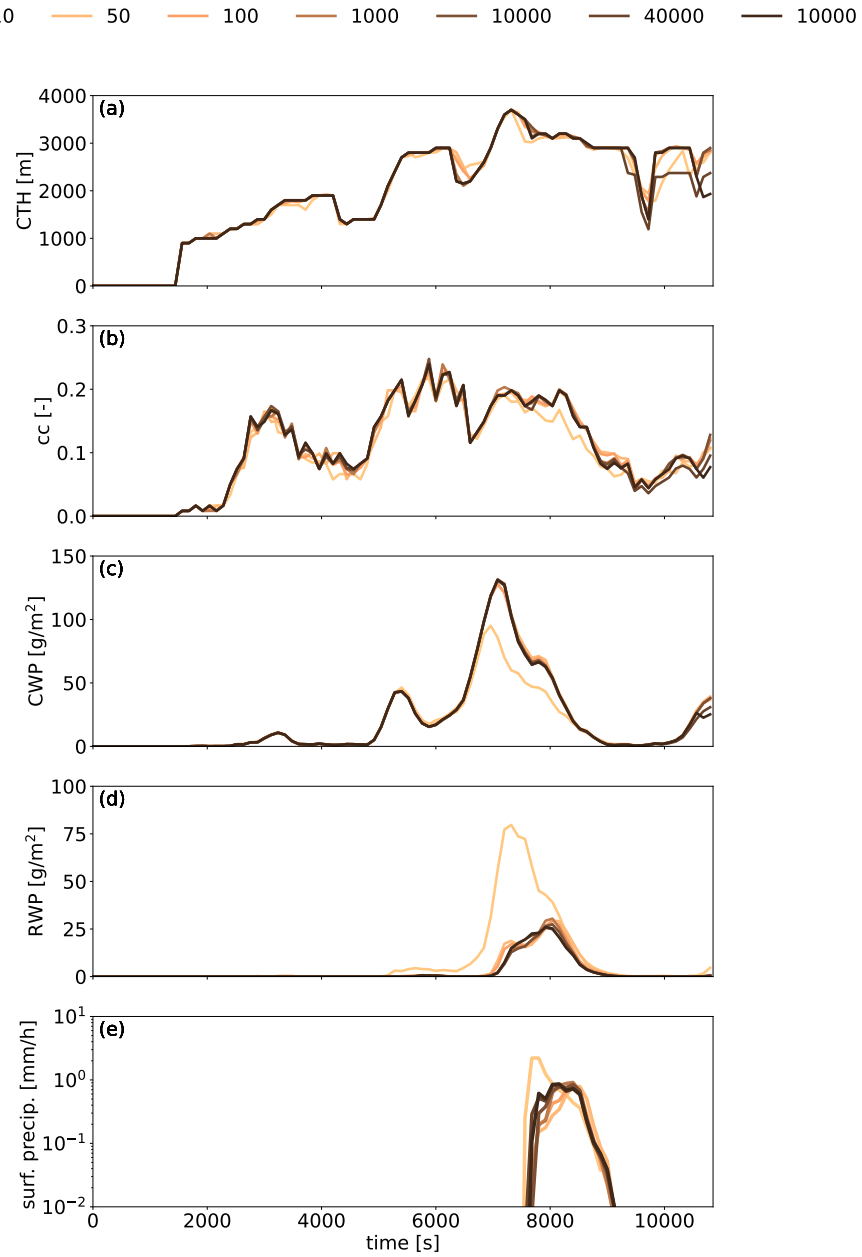

Fig. S4. Time series of ensemble averages of cloud top height (CTH), cloud cover (cc), cloud water path (CWP), rain water path (RWP) and surface precipitation (surf. precip.) for MR scenario with $N_{\mathrm{SD}}^{(\mathrm{bin})} = \{10, 50, 100, 1000, 10000, 40000, 100000\}$.

S2.2.2 Without coalescence

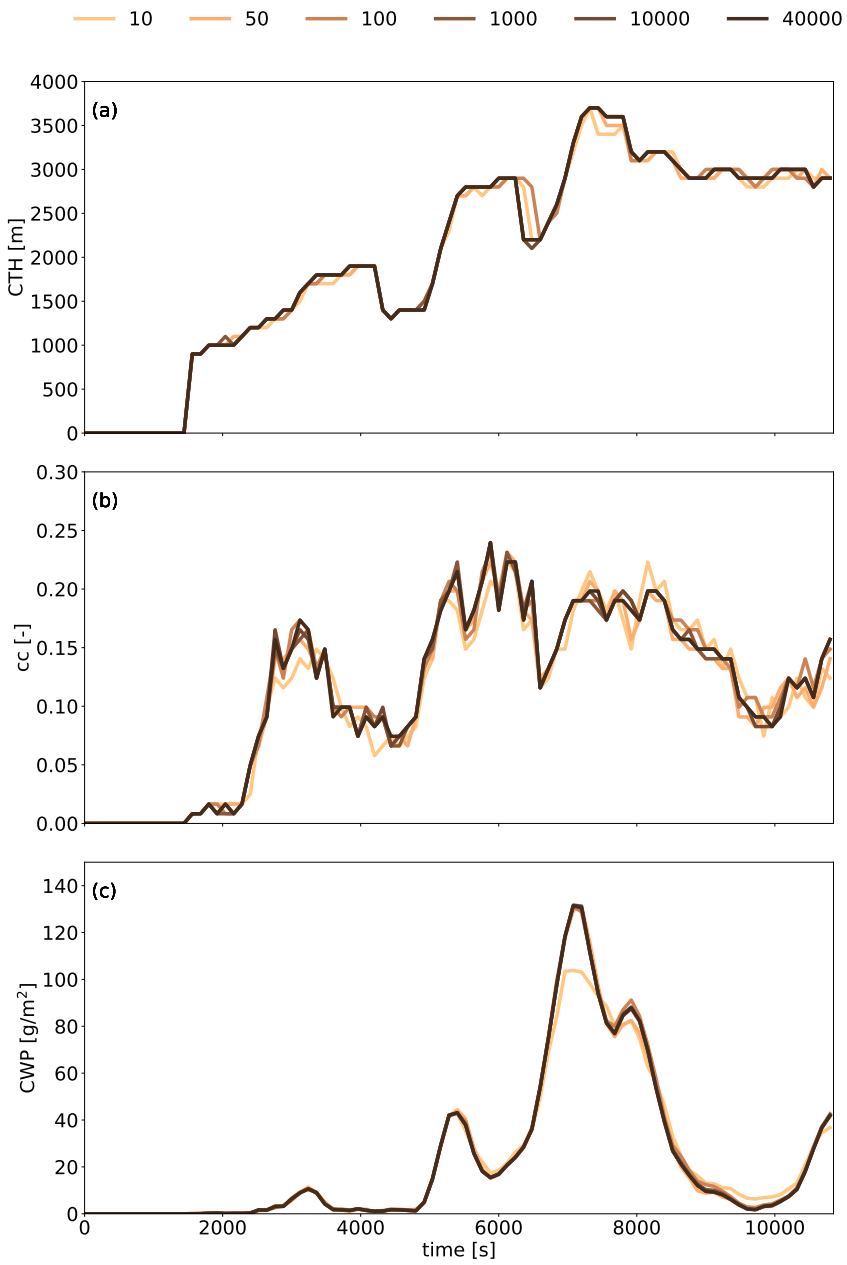

Fig. S5. Time series of ensemble of cloud top height (CTH), cloud cover (cc), cloud water path (CWP) for MR scenario with $N_{\mathrm{SD}}^{(\mathrm{bin})} = \{10, 50, 100, 1000, 10000, 40000\}$ for the coalescence solver turned off.

S2.3 Scenario: HR

S2.3.1 With coalescence

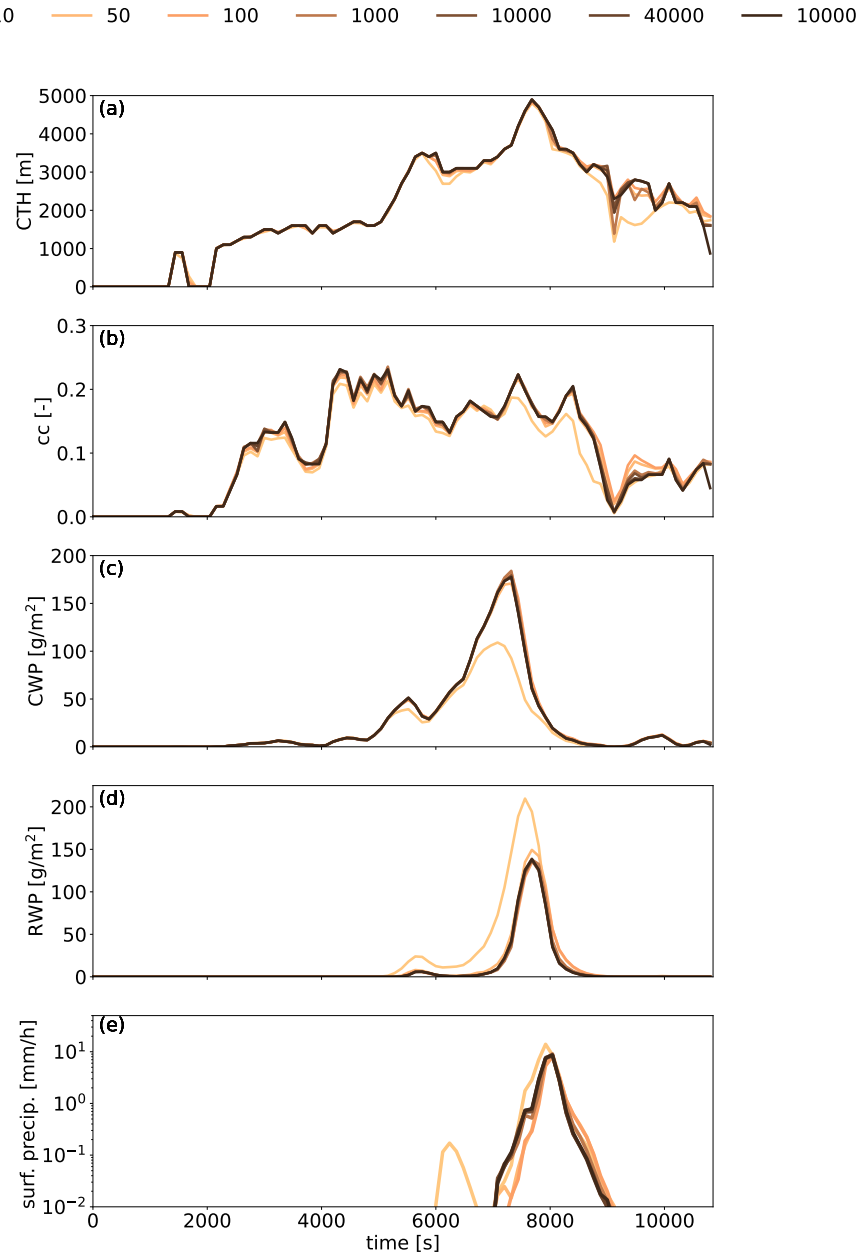

Fig. S6. Time series of ensemble averages of cloud top height (CTH), cloud cover (cc), cloud water path (CWP), rain water path (RWP) and surface precipitation (surf. precip.) for HR scenario with $N_{\mathrm{SD}}^{(\mathrm{bin})} = \{10, 50, 100, 1000, 10000, 40000, 100000\}$.

S2.3.2 Without coalescence

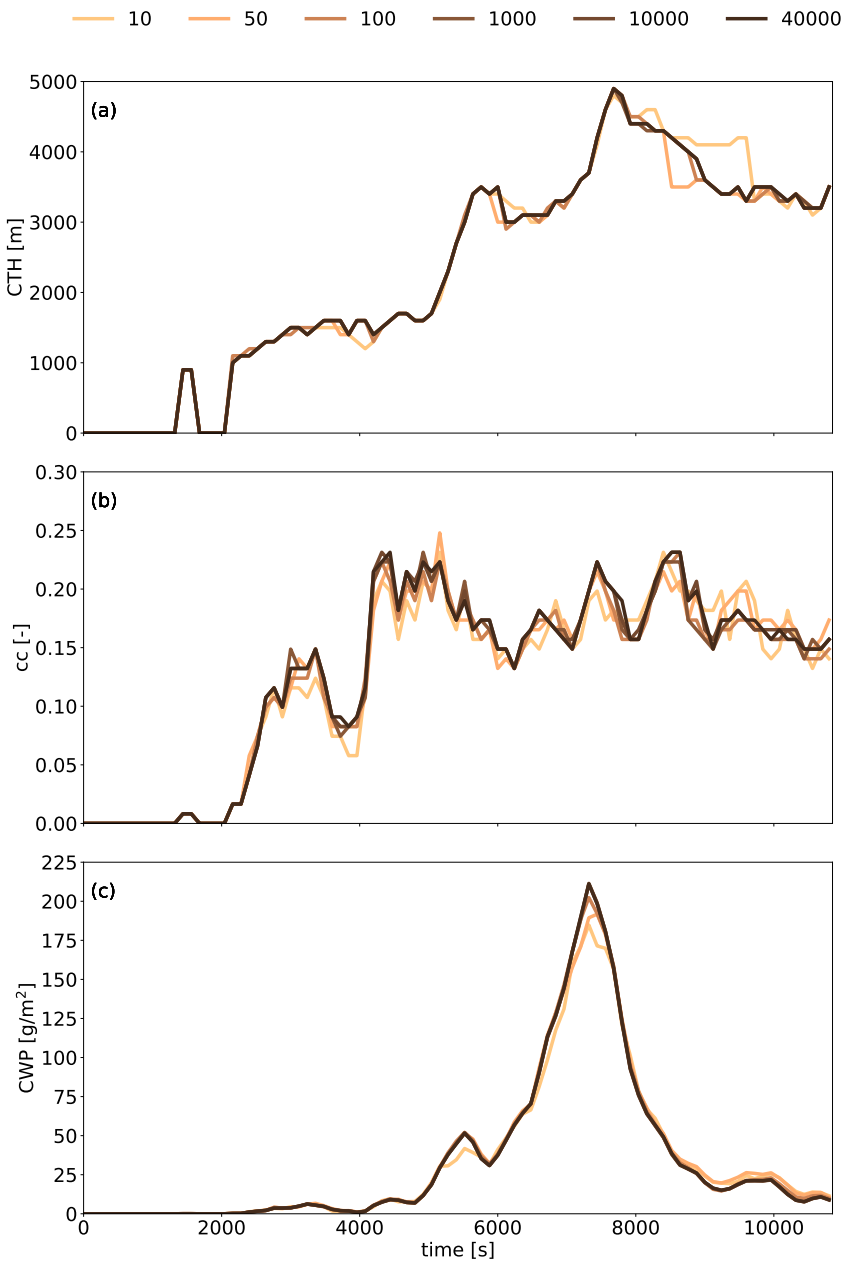

Fig. S7. Time series of ensemble of cloud top height (CTH), cloud cover (cc), cloud water path (CWP) for HR scenario with $N_{\mathrm{SD}}^{(\mathrm{bin})} = \{10, 50, 100, 1000, 10000, 40000\}$ for the coalescence solver turned off.

S2.4 Scenario: D

S2.4.1 With coalescence

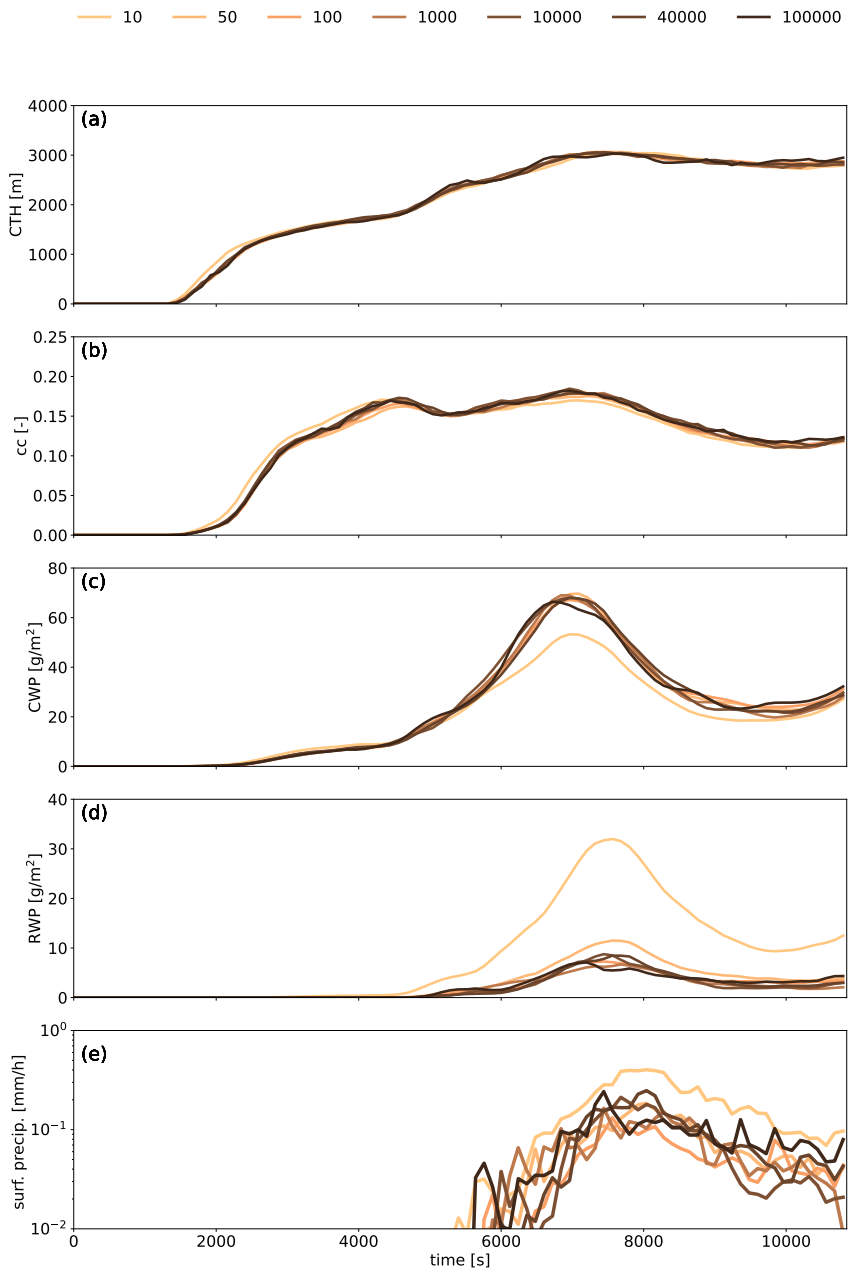

Fig. S8. Time series of ensemble averages of cloud top height (CTH), cloud cover (cc), cloud water path (CWP), rain water path (RWP) and surface precipitation (surf. precip.) for D scenario with $N_{\mathrm{SD}}^{(\mathrm{bin})} = \{10, 50, 100, 1000, 10000, 40000, 100000\}$.

S2.4.2 Without coalescence

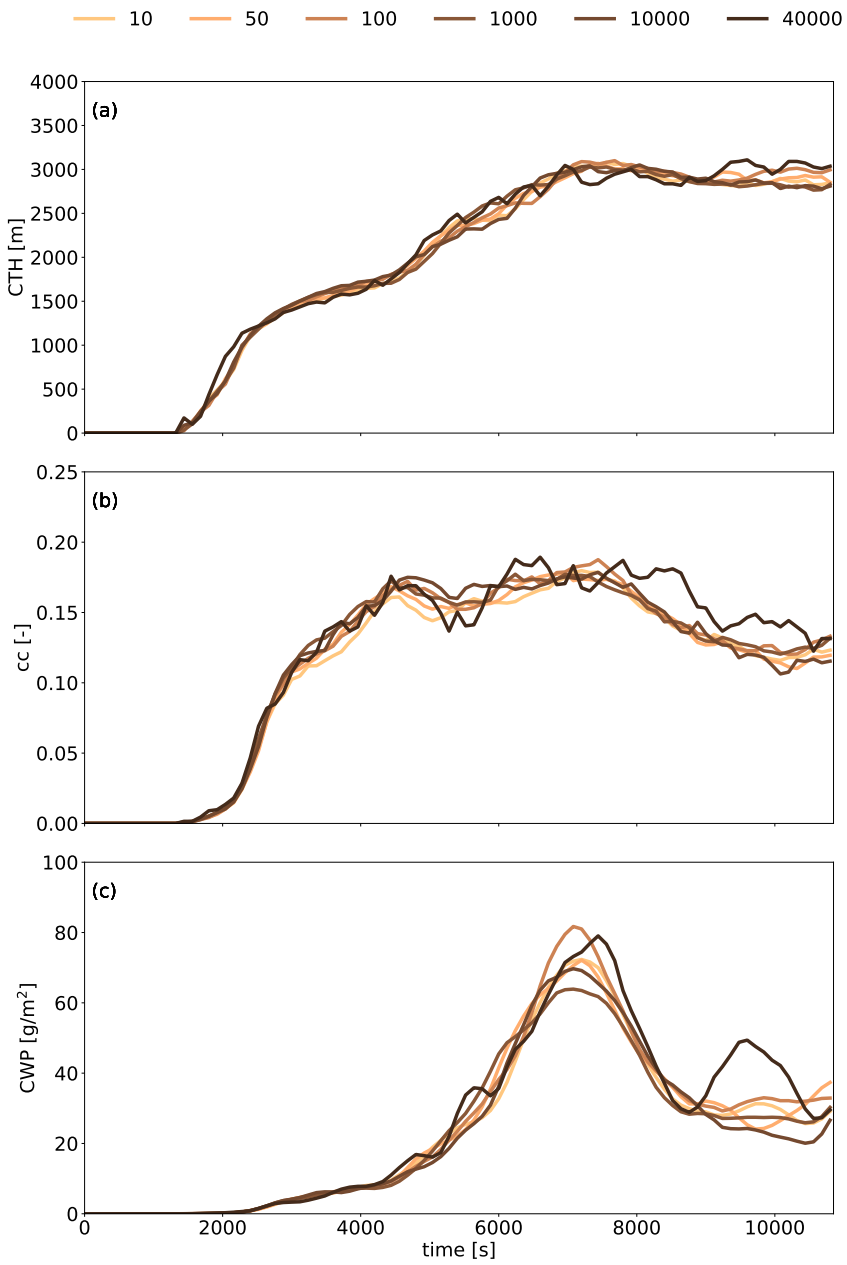

Fig. S9. Time series of ensemble of averages cloud top height (CTH), cloud cover (cc), cloud water path (CWP) for D scenario with $N_{\mathrm{SD}}^{(\mathrm{bin})} = \{10, 50, 100, 1000, 10000, 40000\}$ for the coalescence solver turned off.

S3 CC simulations with SGS SD motion

S3.1 Profiles

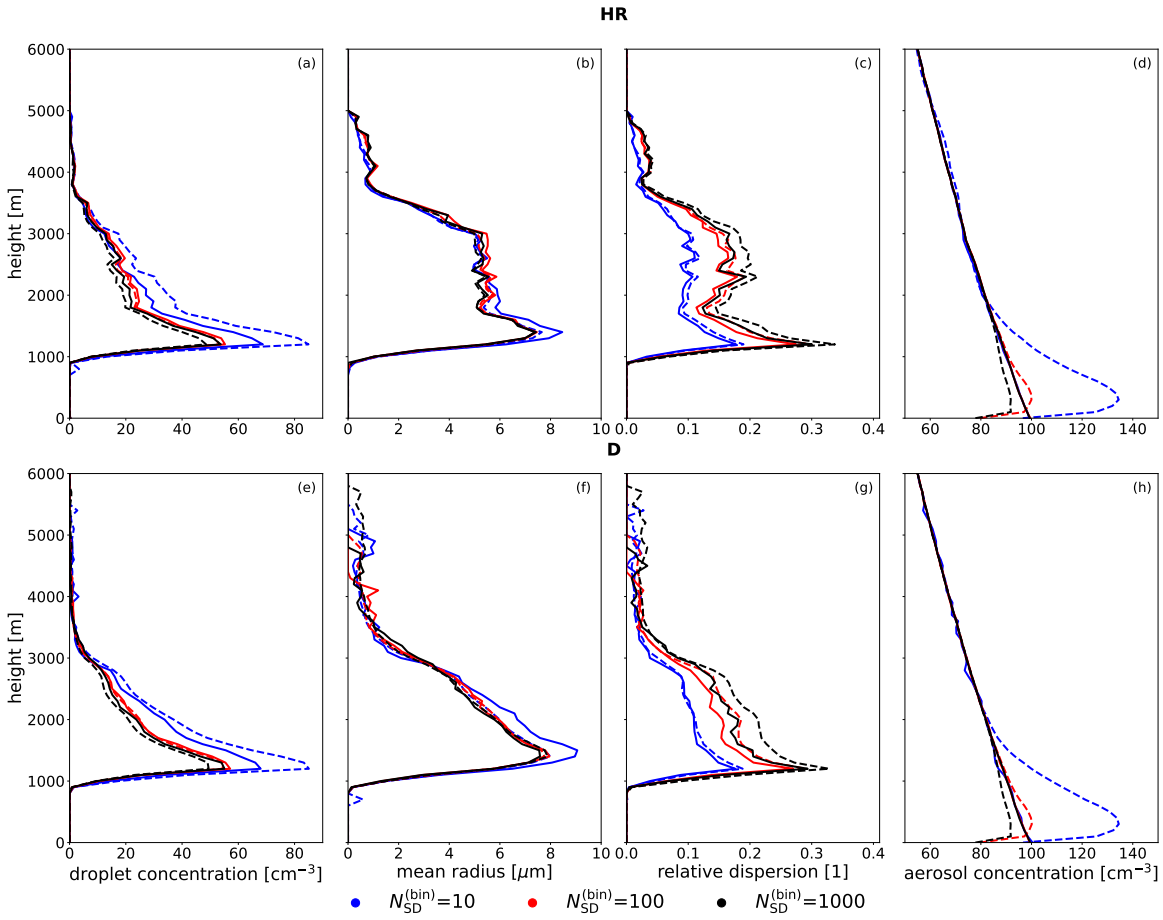

Fig. S10. Profiles of cloud droplet concentration, their mean radius and its relative dispersion, and aerosol concentration in D and HR simulations with (dashed lines) and without (solid lines) SGS motion of SDs. Profiles are averaged over the time interval between 1800 s and 9600 s, over the simulation ensemble, and over all (aerosol concentration) or cloudy (other profiles) cells.

S3.2 Spatial distribution of SDs

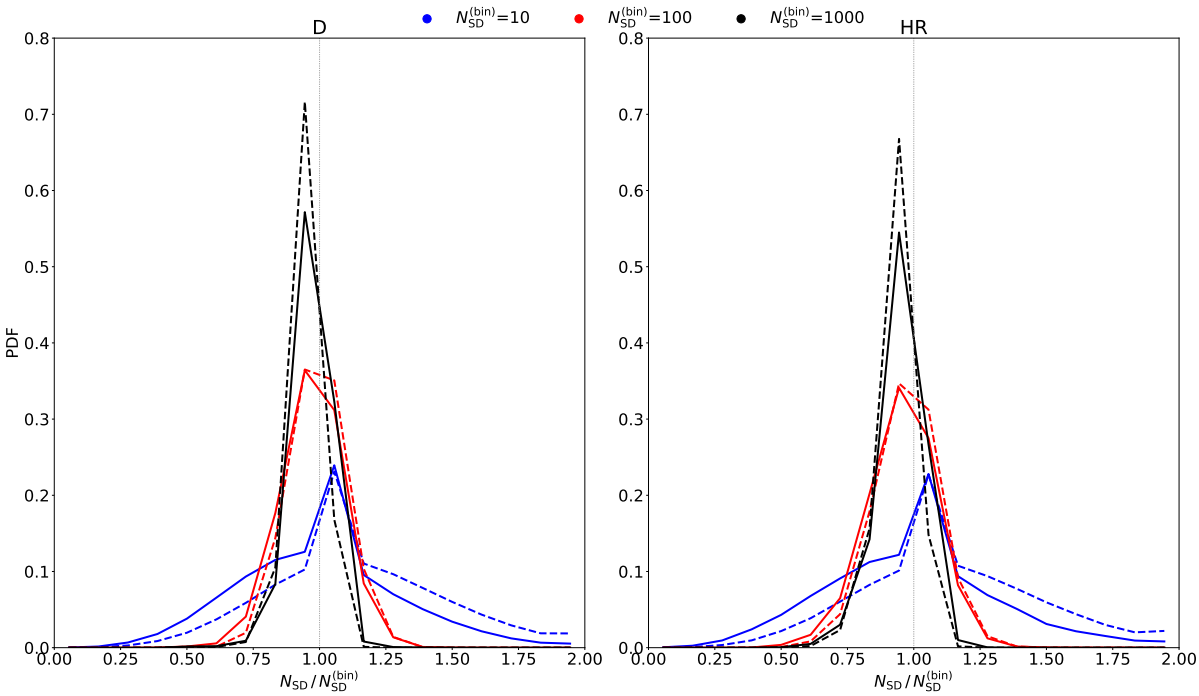

Fig. S11. Probability density of the number of SDs in a grid cell in D and HR simulations with (dashed lines) and without (solid lines) SGS motion of SDs. Calculated over the time interval between 1800 s and 9600 s and over the simulation ensemble.