

LES with Particle Microphysics: Mean and Variance of Precipitation

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Motivation

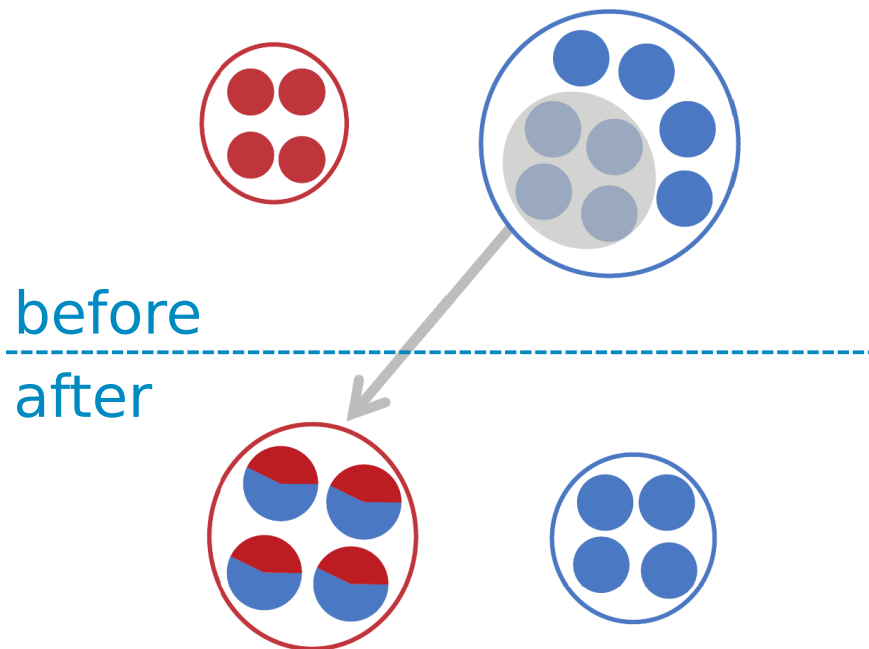
- How „lucky droplets“ affect precipitation?

Motivation

- How „lucky droplets“ affect precipitation?
- Numerical convergence test of collision-coalescence modeling in particle microphysics.

Collision-coalescence in particle microphysics: all-or-nothing (AON) algorithm

Collision of a pair of SDs (stochastic):



- Correct mean number of collisions:

$$\langle coll \rangle^{(SD)} = \langle coll \rangle$$

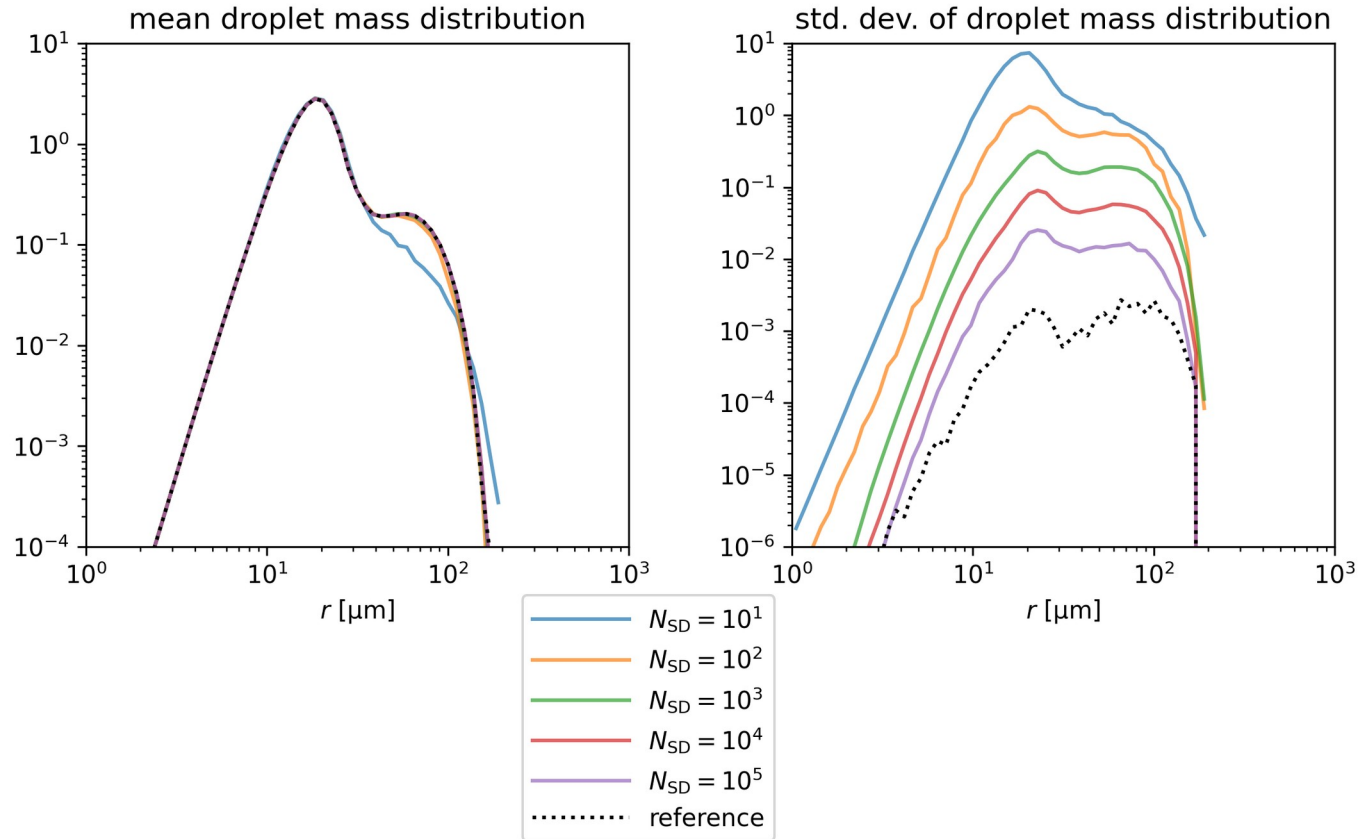
- Too high standard deviation:

$$\sigma(coll)^{(SD)} \approx \sqrt{\frac{N}{N_{SD}}} \sigma(coll)$$

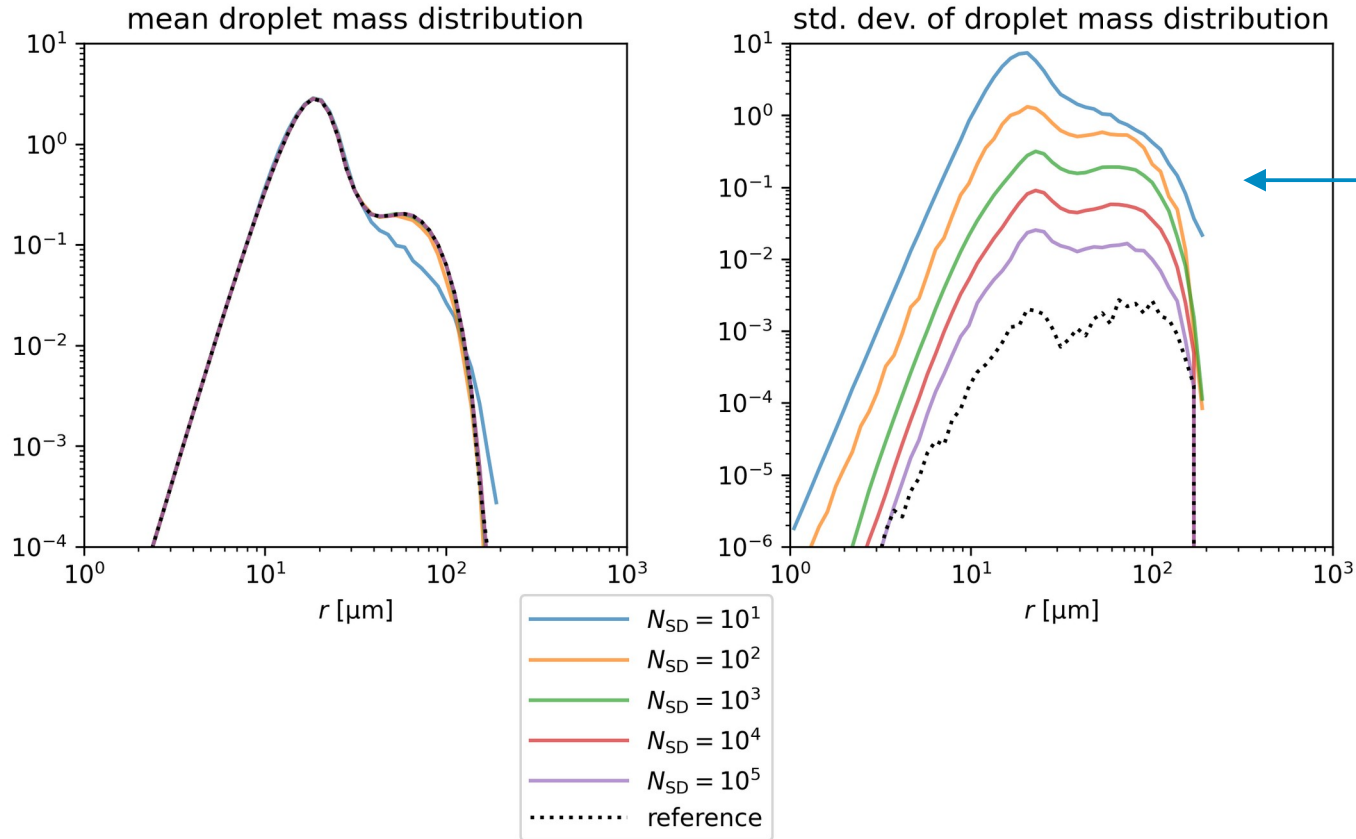
N - number of droplets

N_{SD} - number of super-droplets

Collision-coalescence in a box model



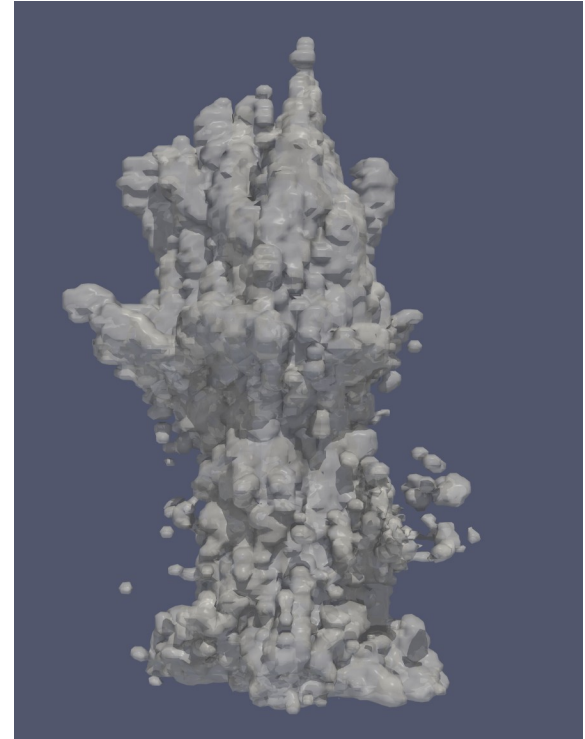
Collision-coalescence in a box model



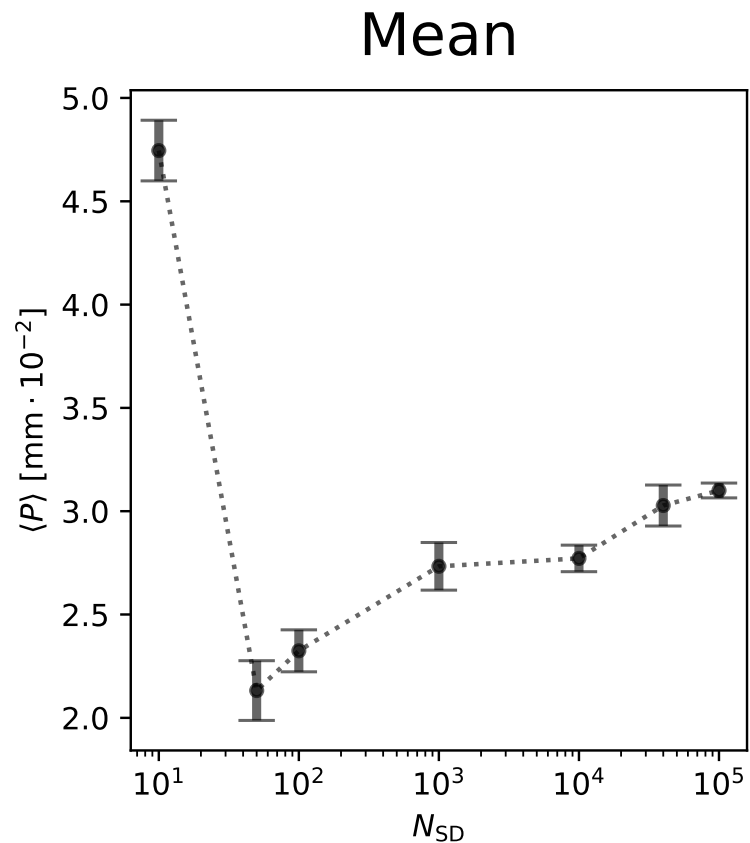
What does it mean
for precipitation in
LES?

Collision-coalescence in LES: strategy

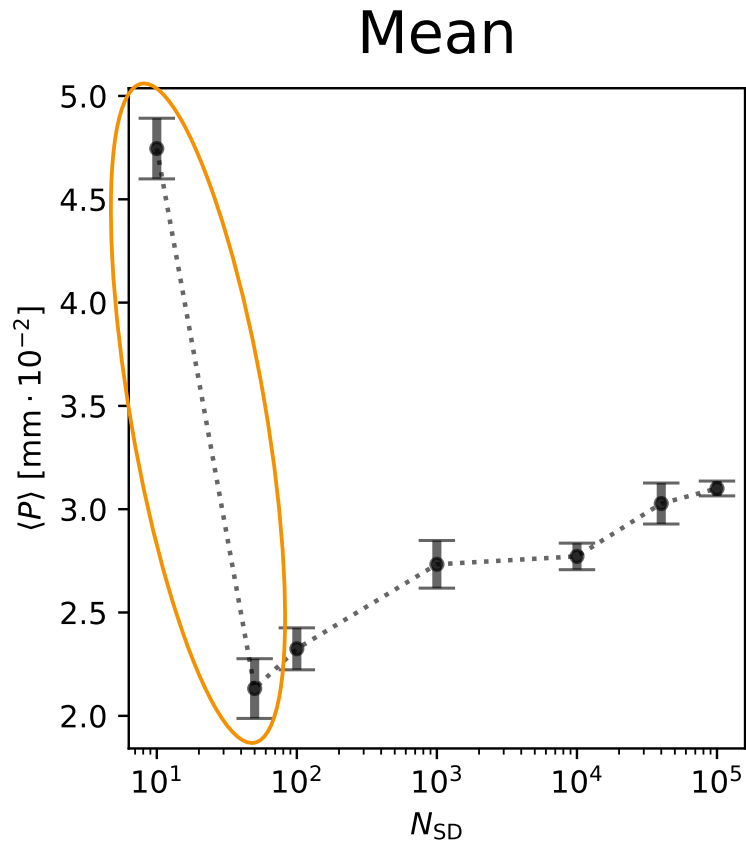
- Isolated cumulus setup
- Ensembles of simulations for differing N_{SD}
- 2D simulations to allow large N_{SD}
- Eliminate randomness other than collision-coalescence:
 - Same initial conditions in all simulations
 - Same flow field in all simulations
- Done with the UWLCM model



Collision-coalescence in LES: mean accumulated precipitation vs N_{SD}



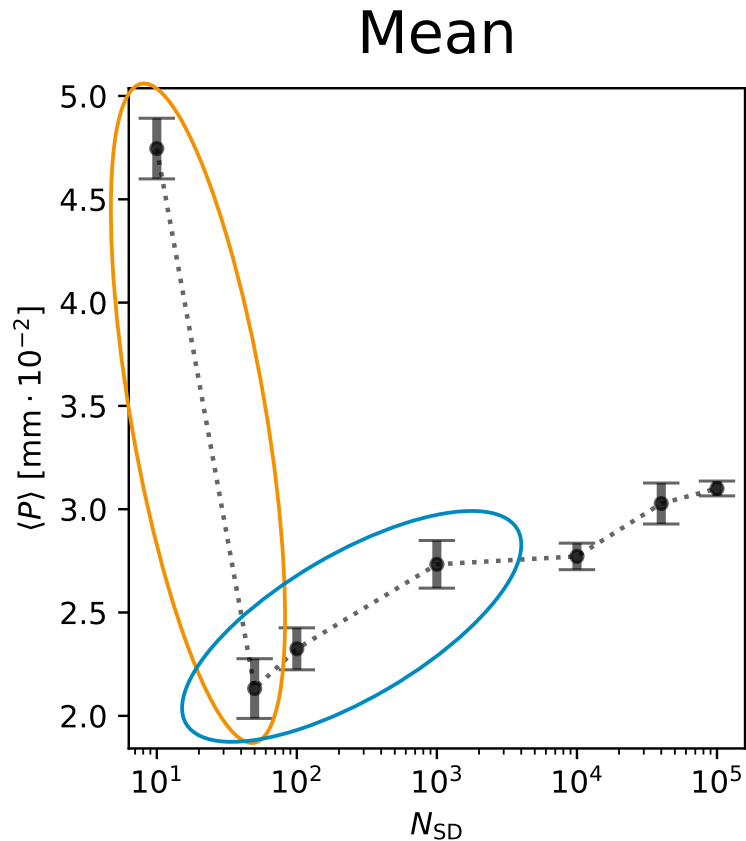
Collision-coalescence in LES: mean accumulated precipitation vs N_{SD}



Decrease consistent with:

- Collision-coalescence in box model
- LES with condensation only

Collision-coalescence in LES: mean accumulated precipitation vs N_{SD}



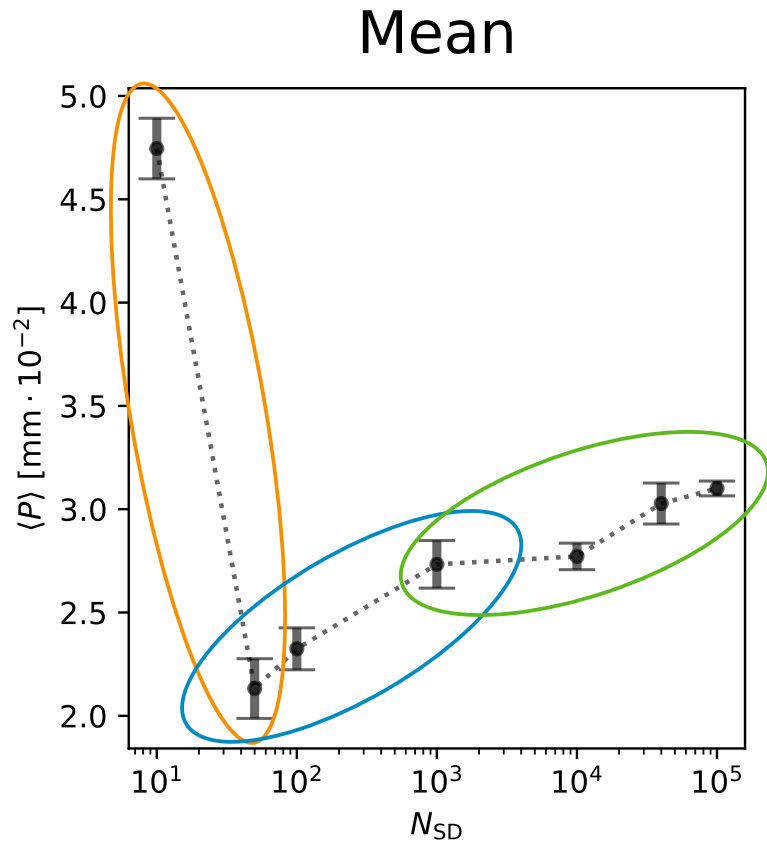
Decrease consistent with:

- Collision-coalescence in box model
- LES with condensation only

Increase consistent with:

- Collision-coalescence in box model

Collision-coalescence in LES: mean accumulated precipitation vs N_{SD}



Decrease consistent with:

- Collision-coalescence in box model
- LES with condensation only

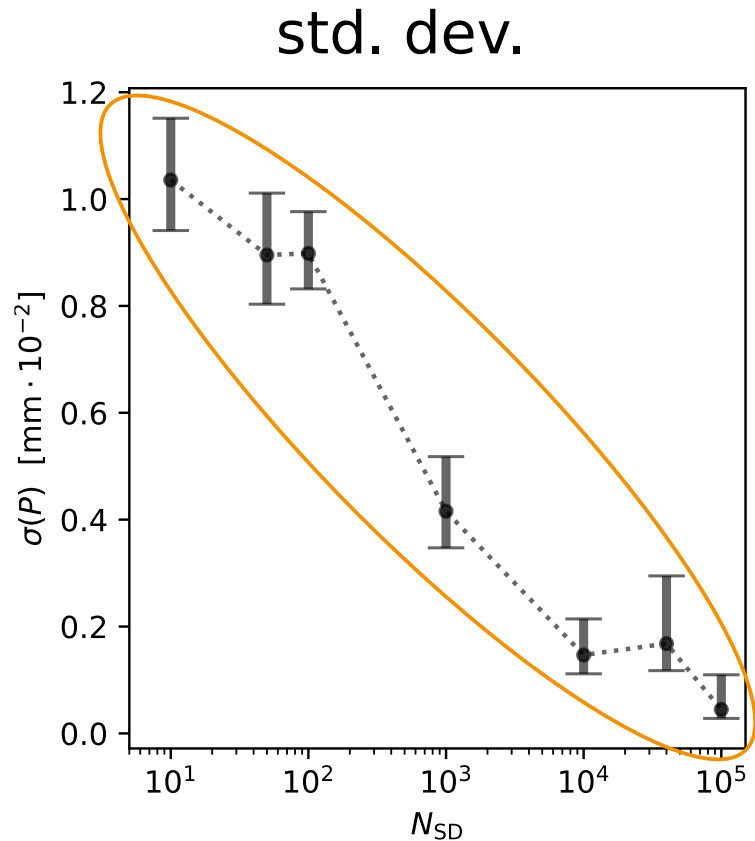
Increase consistent with:

- Collision-coalescence in box model

Is there an increase?

- Numerical convergence (discretization)?
- „Lucky droplets“ (variance)?

Collision-coalescence in LES: std. dev. of accumulated precipitation vs N_{SD}



Decrease consistent with:

- Collision-coalescence in box model

There is no decrease if flow field is not prescribed (i.e. different realizations of collision-coalescence result in different flow fields).

Tentative conclusions

- Precipitation in LES does not converge for up to 10^5 super-droplets per cell.
 - A matter of discretization of the DSD?
 - A matter of variance of the DSD?
- Too large variance in collision-coalescence in particle microphysics does not give too large variance of accumulated precipitation in LES, because differences in flow field are more important.