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# Randomness in the amount of rain in LES with Lagrangian microphysics

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# University of Warsaw Lagrangian Cloud Model (UWLCM)

LES model with Lagrangian microphysics

## dynamics

- Eulerian
- Anelastic approximation
- MPDATA advection
- Calculated on CPUs
- Uses libmpdata++

## microphysics

- Lagrangian
  - Super-droplet method (SDM) (Shima et al. 2009)
  - Calculated on GPUs
- Eulerian
  - Single-moment bulk
  - Calculated on CPUs
- Uses libcloudph++

# Isolated cumulus congestus based on SCMS campaign

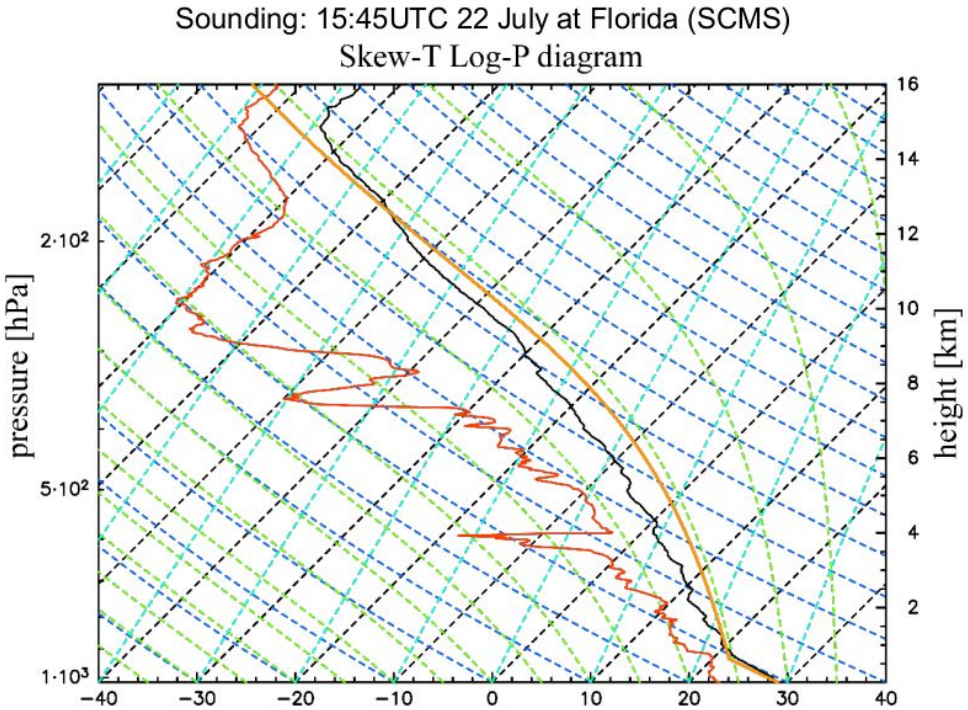



Figure from https://iccp2020.tropmet.res.in/Cloud-Modeling-Workshop-2020

The setup is almost the same as Lasher-Trap et al. (2005), which is based on the Small Cumulus Microphysics Study (SCMS) field campaign (Florida, USA, 1995).

Domain size and grid length:

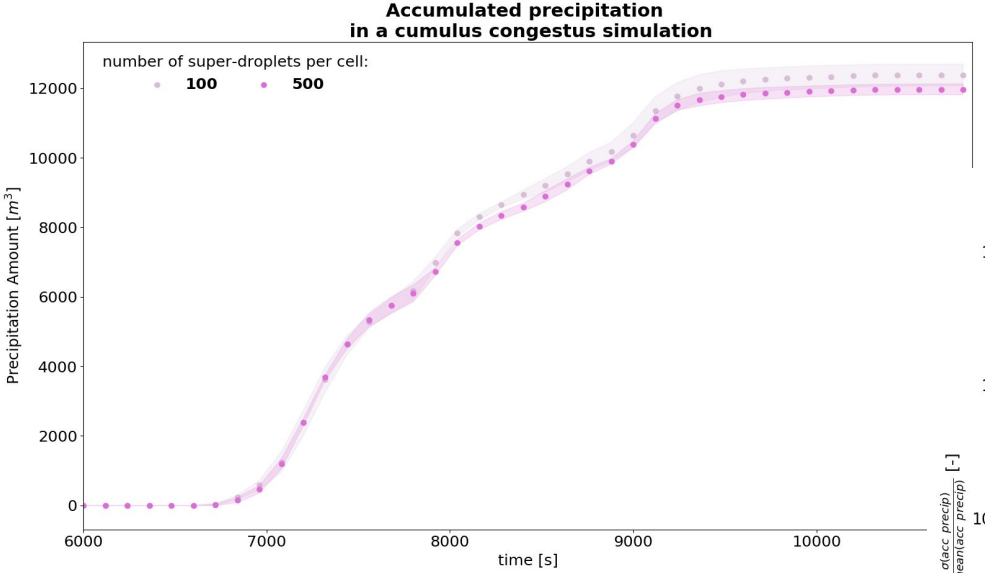
- 10 km x 10 km x 10 km
- $\Delta x=\Delta y=\Delta z$ = 100 m

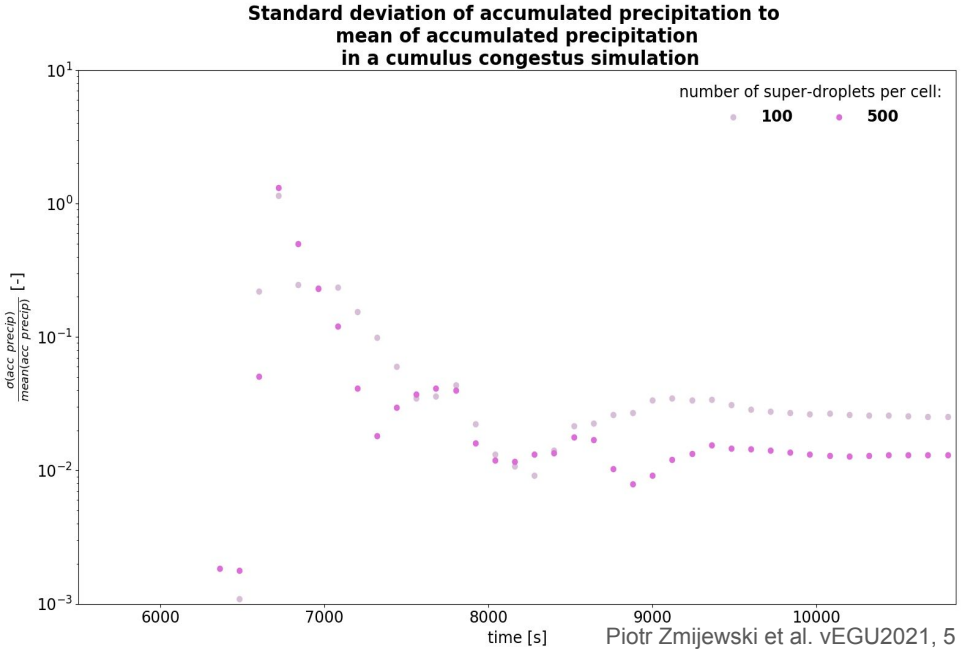
# Aerosol distribution

- The number concentration was 2 times bigger than that given in (van Zanten et al. 2011) for RICO intercomparison case.
- Tea aerosol particles are composed of ammonium bisulfate, and the number-size distribution is given by a bimodal log-normal distribution

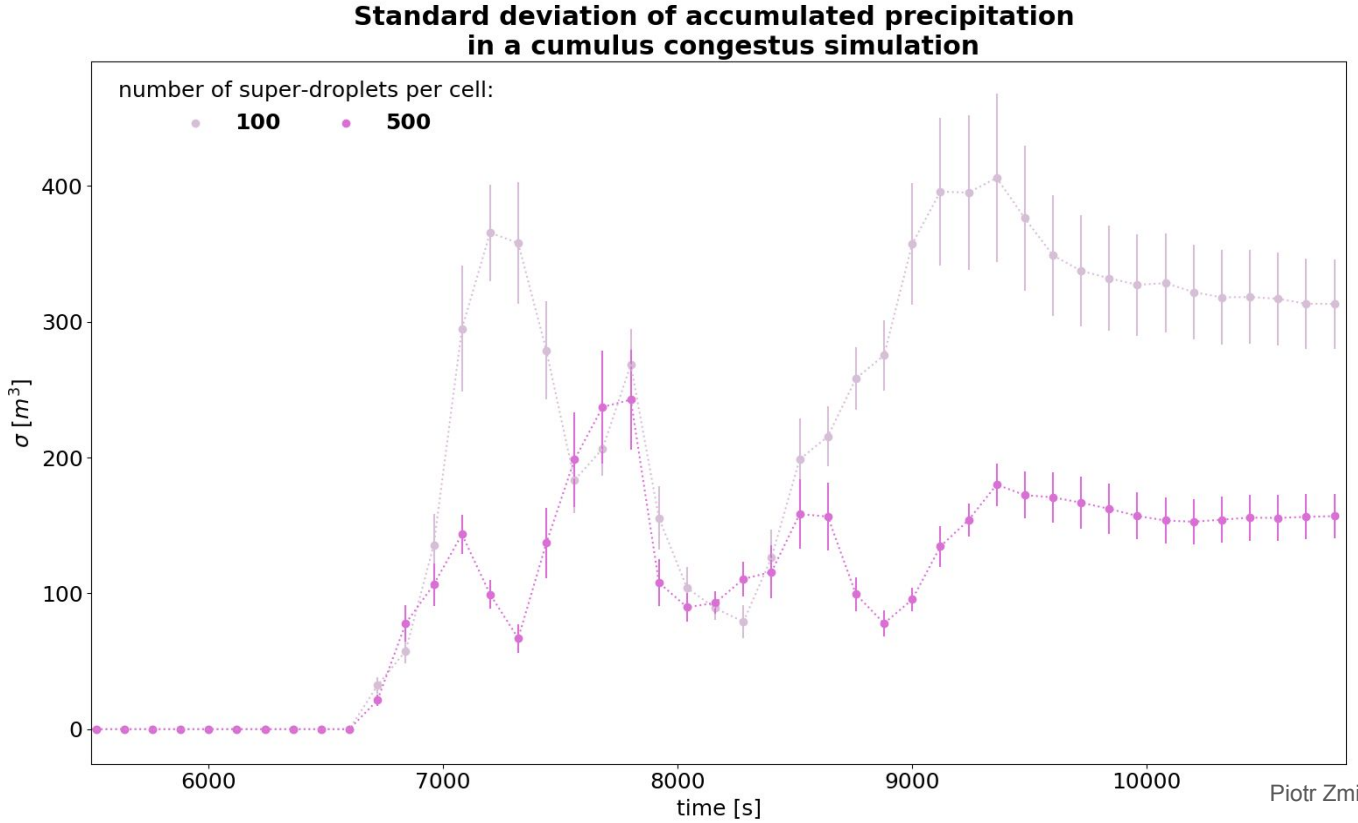
| **The particle number concentrations** | |
|---|---|
| $N_1 = 2 \times 90\ cm^{-3}$ | $N_2 = 2 \times 15\ cm^{-3}$ |
| $r_1 = 0.03\ \mu m$ | $r_2 = 0.14\ \mu m$ |
| $\sigma_1 = 1.28$ | $\sigma_2 = 1.75$ |

# Different realizations of the stochastic collision-coalescence algorithm, without feedback on dynamics, same initial conditions

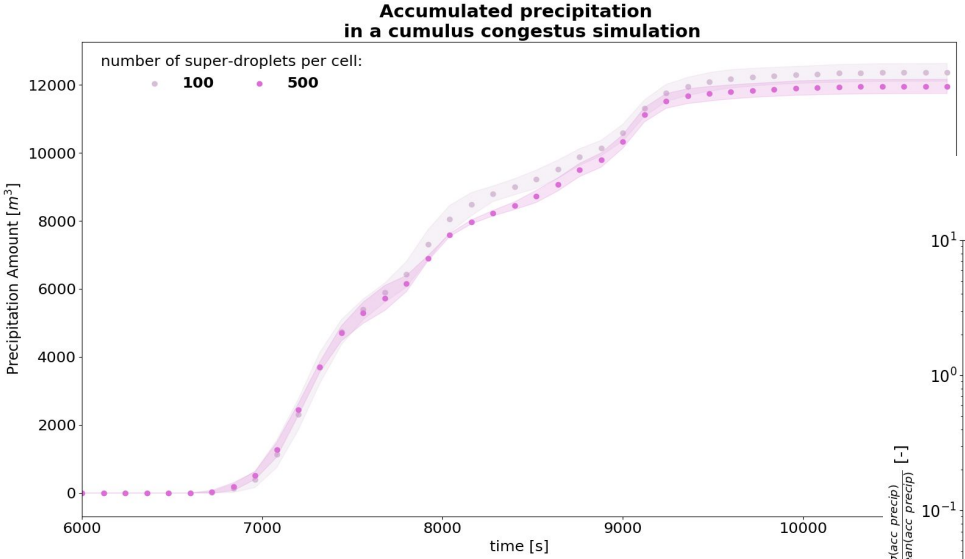


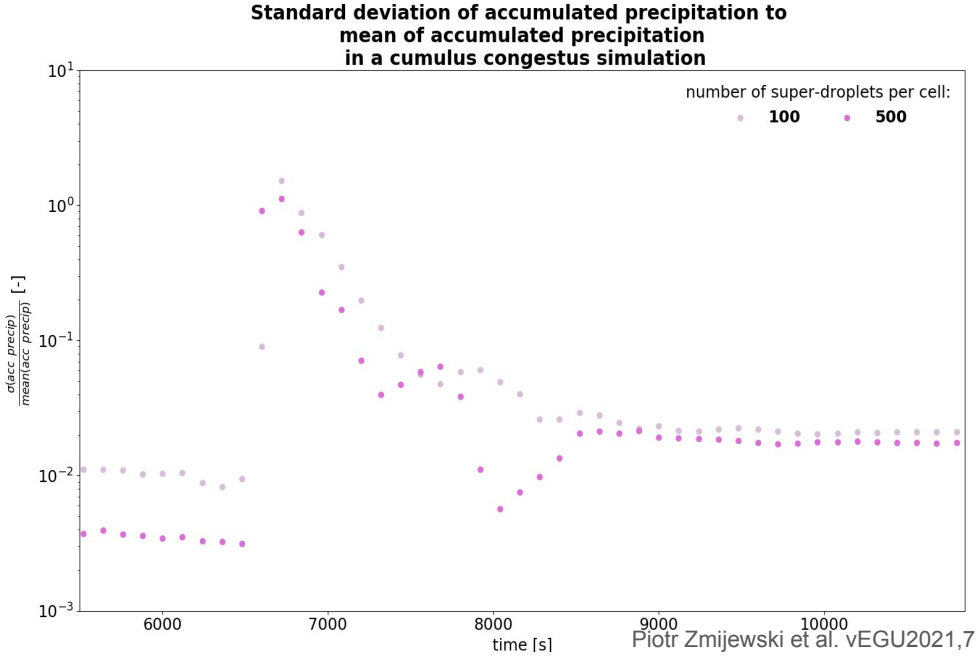



# Different realizations of the stochastic collision-coalescence algorithm, standard deviation of accumulated precipitation with standard error of the sample standard deviation



# Different realizations of the stochastic collision-coalescence algorithm, without feedback on dynamics, different initial conditions



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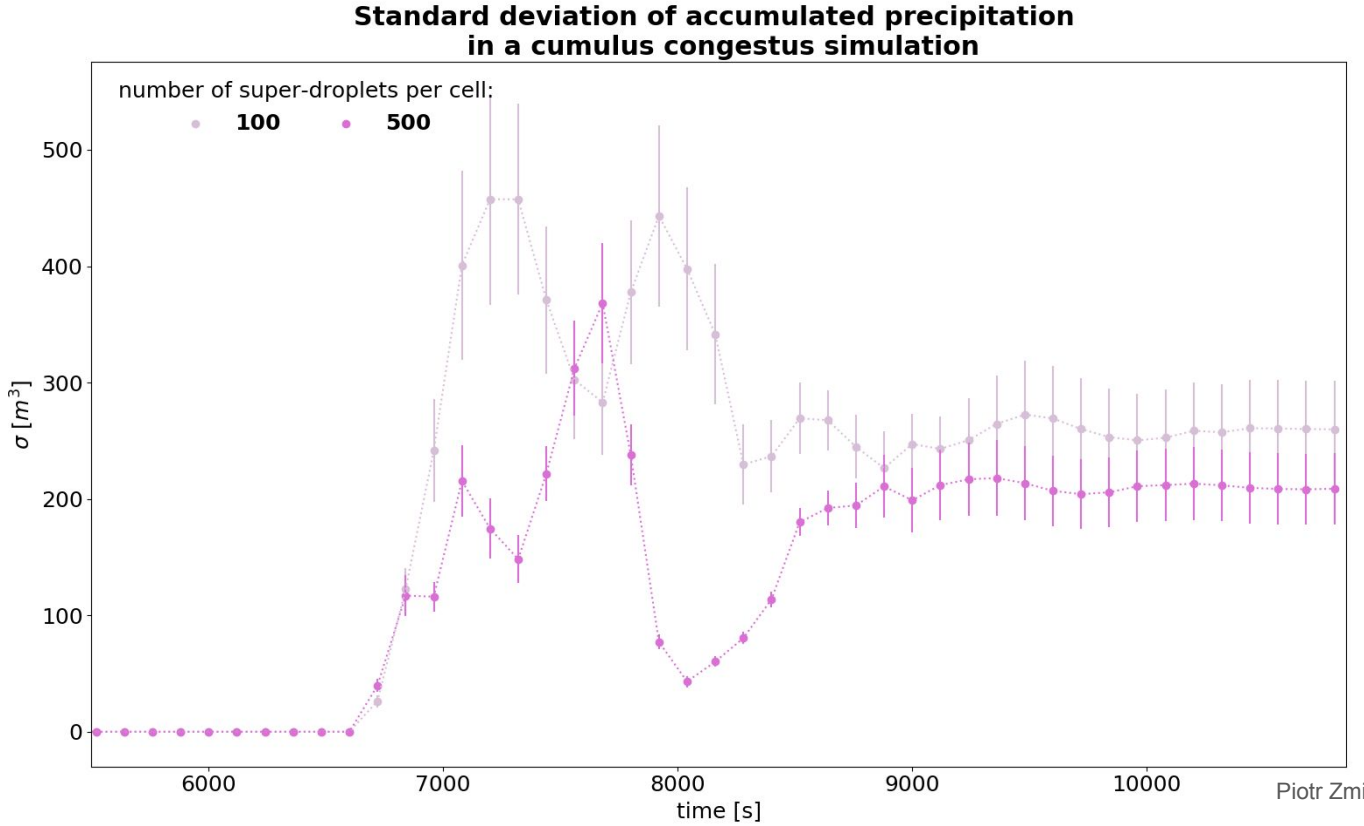


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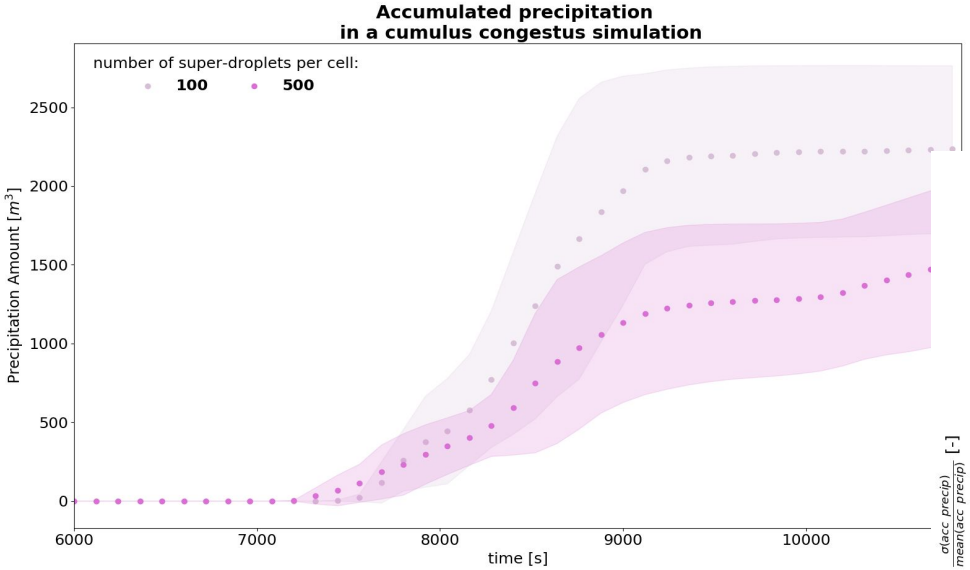
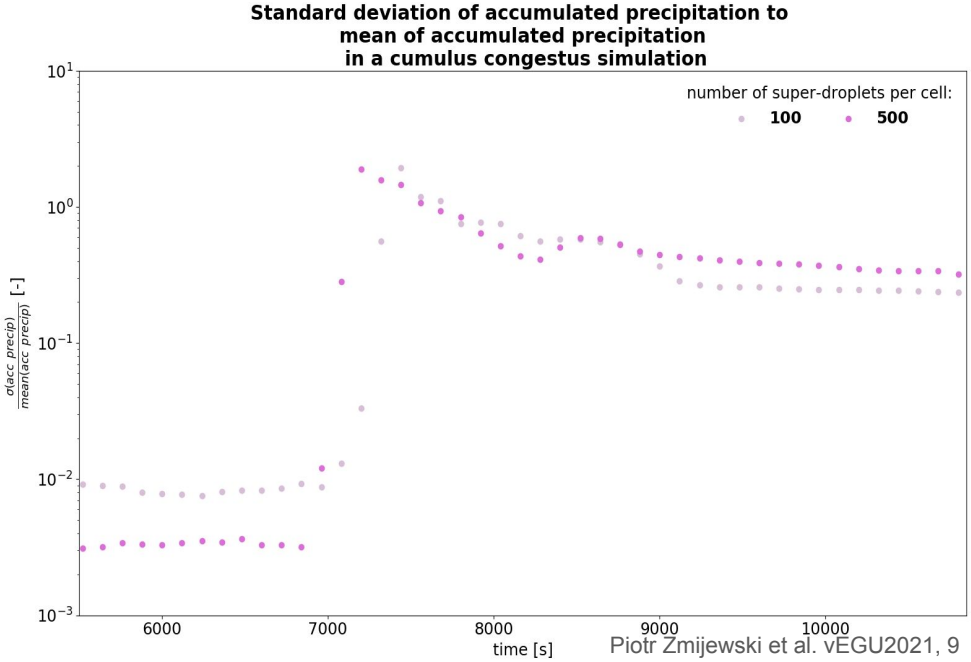
# Different realizations of the stochastic collision-coalescence algorithm, with feedback on dynamics, same initial conditions



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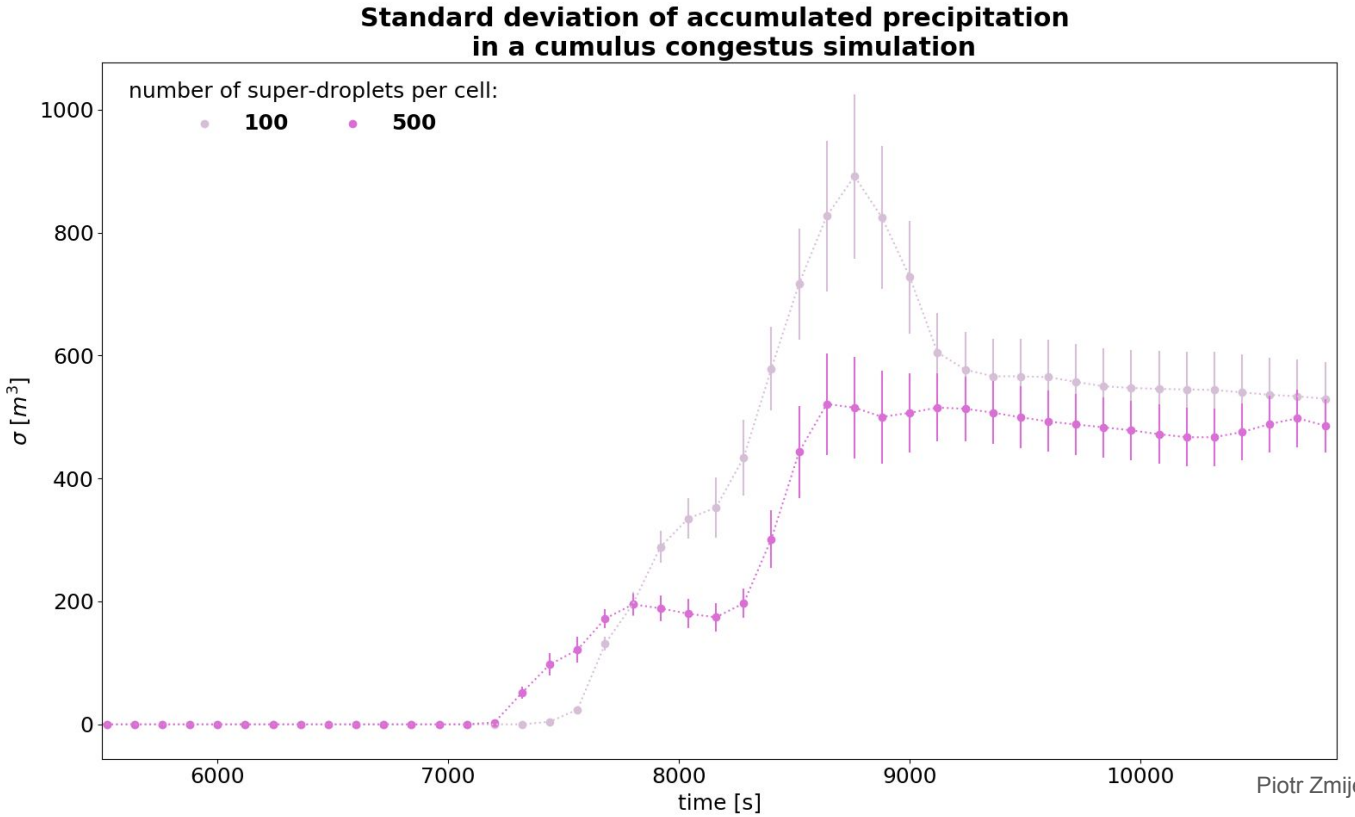


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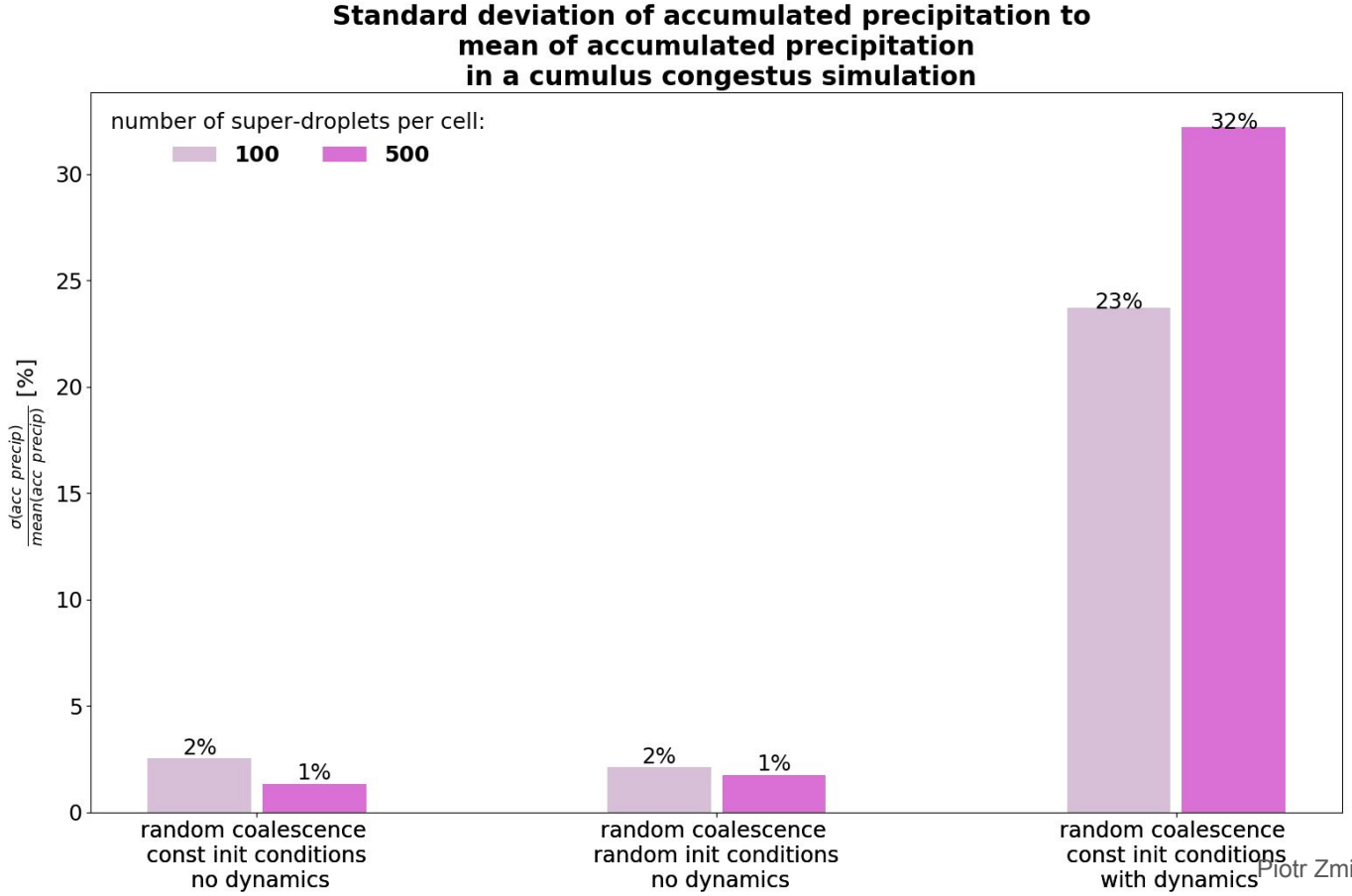
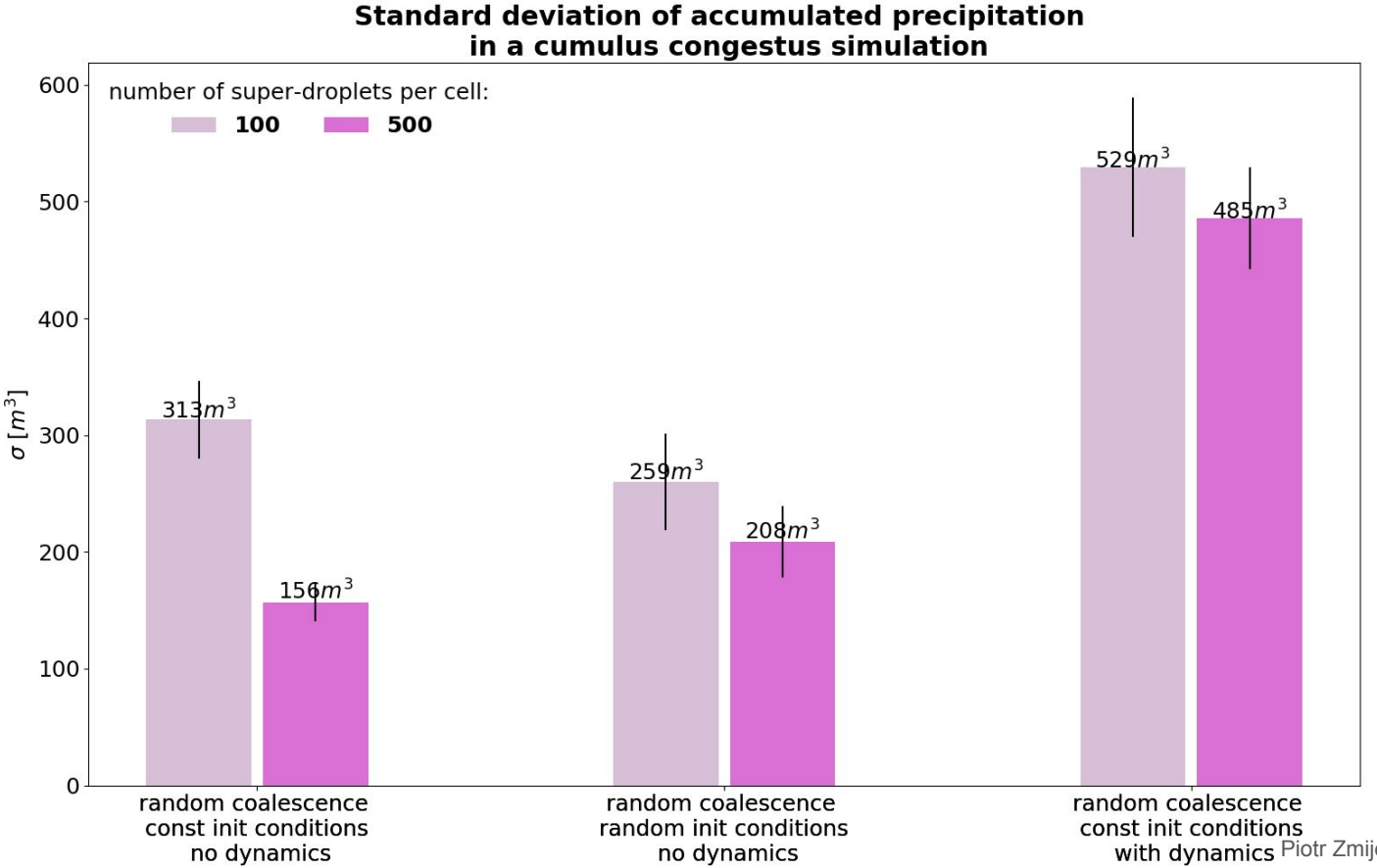
# Comparison of obtained results measured in ratio of standard deviation to mean value



# Comparison of obtained results measured in standard deviation

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# Conclusions

According to the commonly accepted theory standard deviation of accumulated precipitation in a collision-coalescence algorithm should be proportional to sqrt(no. of super-droplets). This appears to be true in case of simulations where the only source of randomness is the mentioned collision-coalescence algorithm. However, once randomness is allowed for initial conditions, and especially when one allows this randomness to affect the flow, the standard deviation of accumulated precipitation stays the same for both SD100 and SD500. Which means that randomness in the algorithm is not an issue.

**Thank YOU**