Impact of subpollen particles on ice nucleation in clouds: A modelling study using ICON-ART

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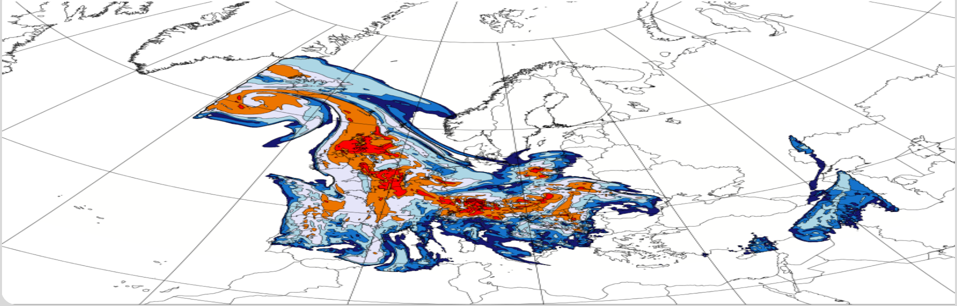

Pollens and biological ice nucleation

Biological IN (Hoose and Möhler 2012; Pummer et al. 2012)

- Form of heterogeneous ice nucleation
- Efficient: nucleation at high temperatures ($T > -20\,^{\circ}\mathrm{C}$)
- Ineffective: not considered in modelling

Pollens and biological ice nucleation

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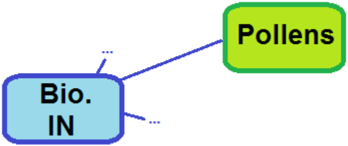

Pollens (Zhou 2014)

- biological ice nuclei
- Emitted by plants in a means of reproduction
- Large in size ($D \geq 20\,\mu$m)$\rightarrow$ ineffective IN

Pollens and biological ice nucleation

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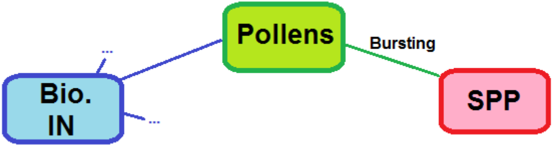

Sub**P**ollen **P**articles (O'Sullivan et al. 2015; Steiner et al. 2015)

- Material inside the pollens
- Humidity can trigger pollen bursting → SPP emission
- SPP: similar IN-efficiency, smaller and higher numbers

Objectives

- Effects of SPPs on biological ice nucleation
- Quantify SPP-effects on ice nucleation processes in clouds

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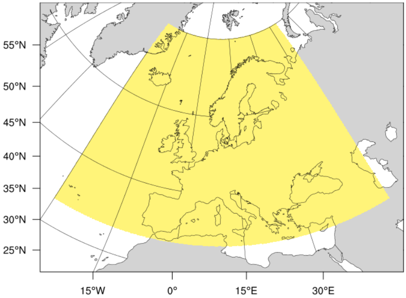
Model configuration

LAM-Simulation

- Model area: Europe
- Grid: R2B09 (approx. 5 km)
- Simulating 10 days
- Time step: 10 s



Ice nucleation

- Phillips et al. (2013)
- SPP as biological particles
- Simple mineral dust background ($10^6\,kg^{-1}$)

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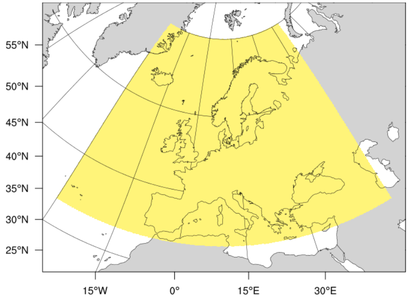
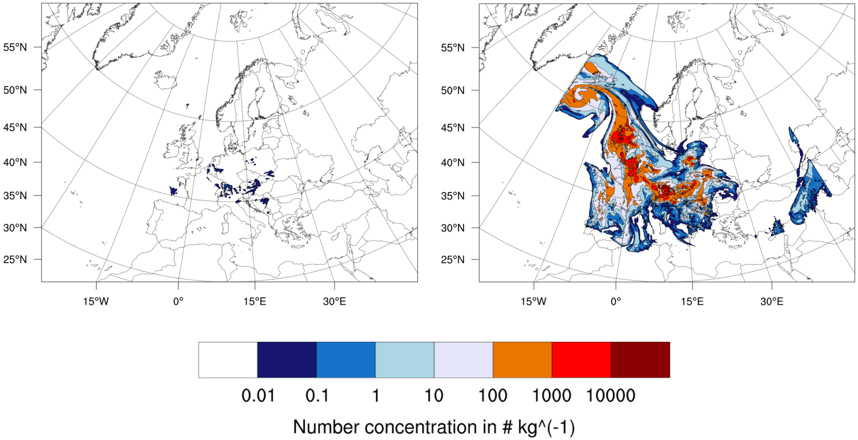
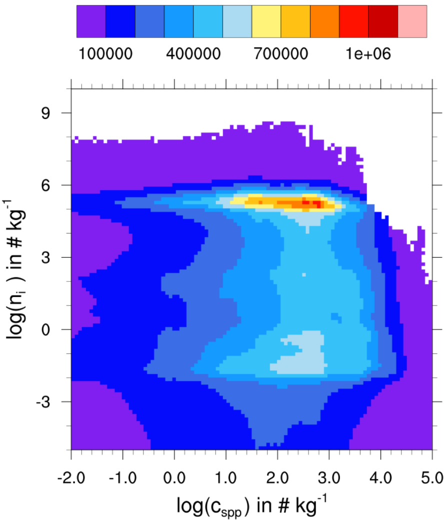


Horizontal distribution in 4000 m

Pollen SPP



Ice particle number density n_i - control



- Without biological ice nucleation
- Mode at high values of n_i

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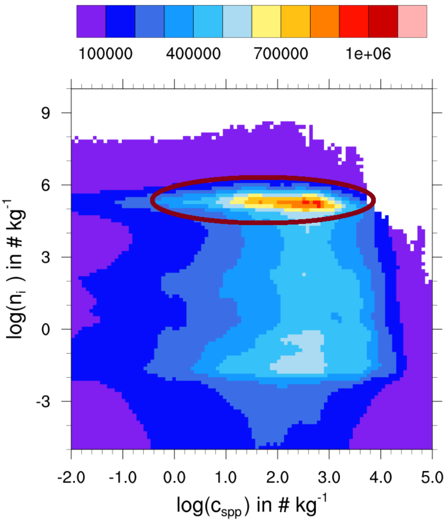

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Ice particle number density n_i - experiment

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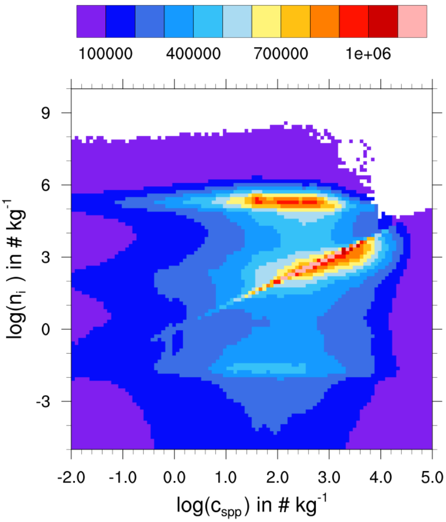

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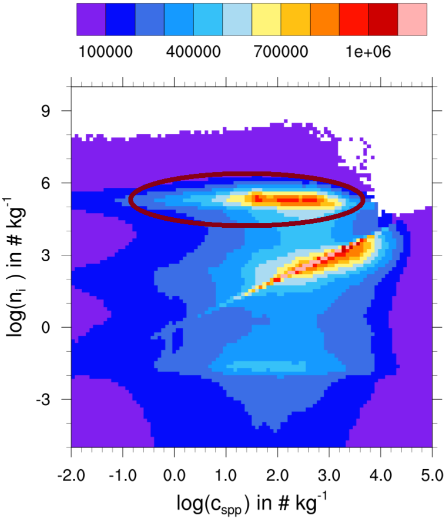

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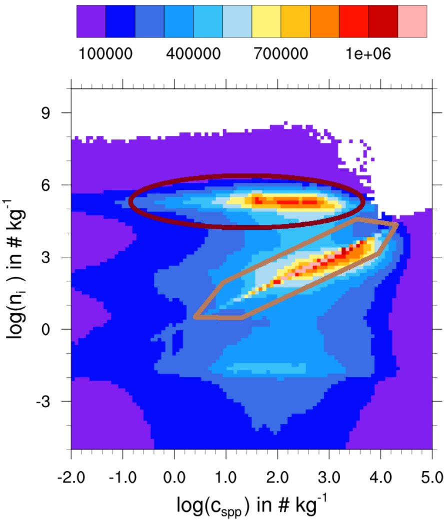

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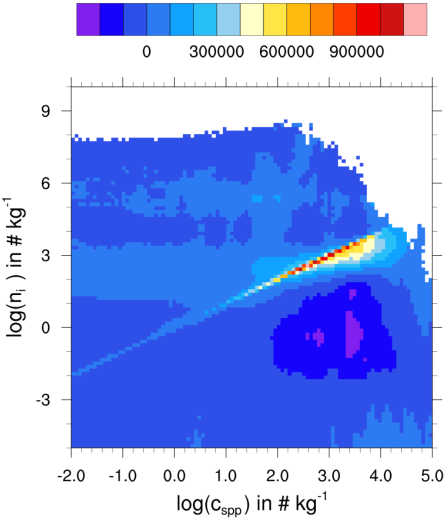
Ice particle number density n_i - difference



- Strong signal at lower n_i
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- weak signal at high n_i
  - Decrease in n_i

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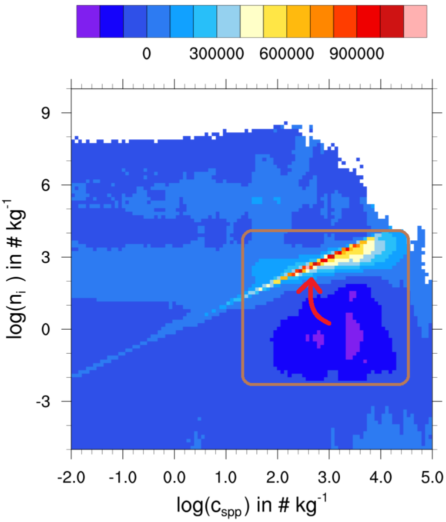

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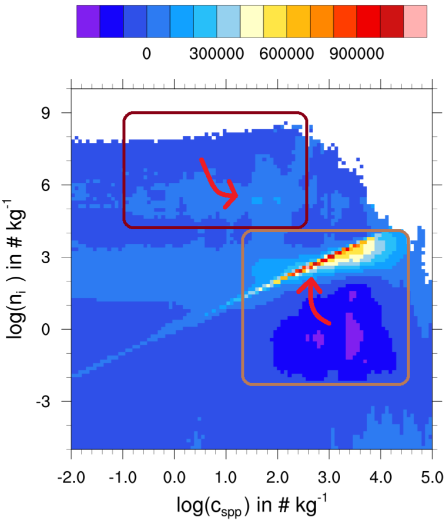

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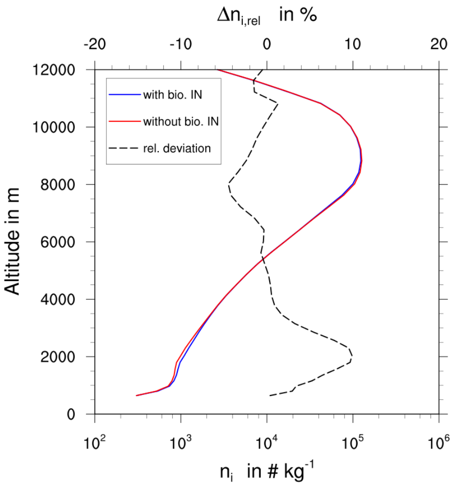
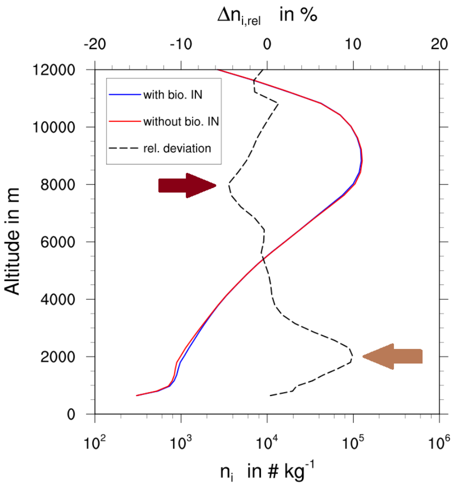
Ice particle number density n_i - profile



- Increase in n_i at warmer layers
- Decrease in n_i at colder layers
- Effect on cloud droplets?

Ice particle number density n_i - profile



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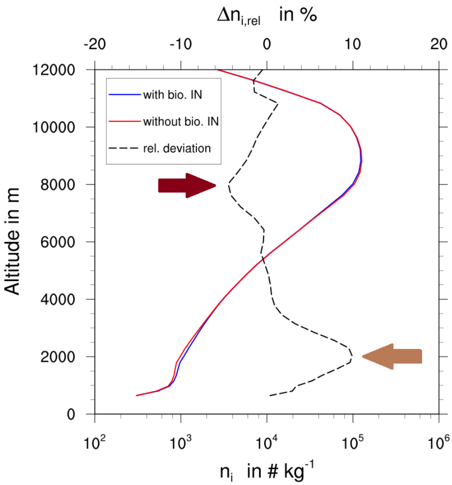

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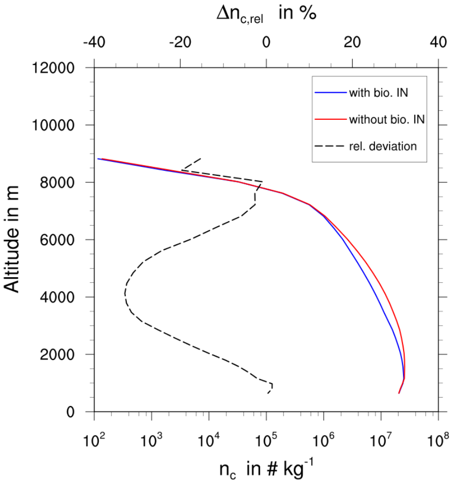
Cloud droplet number density n_c - profile



- Reduction in altitudes between 2000 and 7000 m
- $-35\,\%$ in about 4000 m

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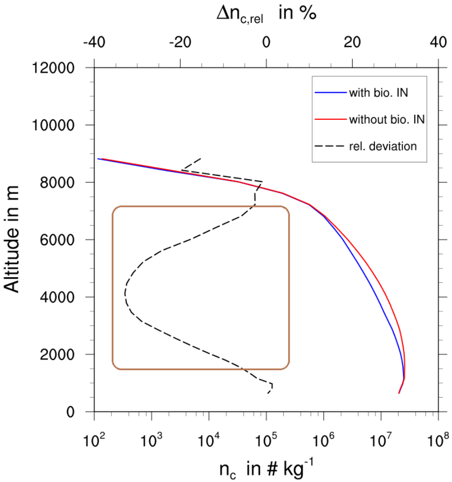

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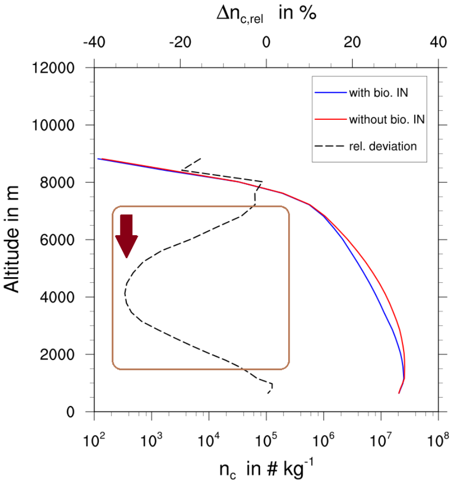

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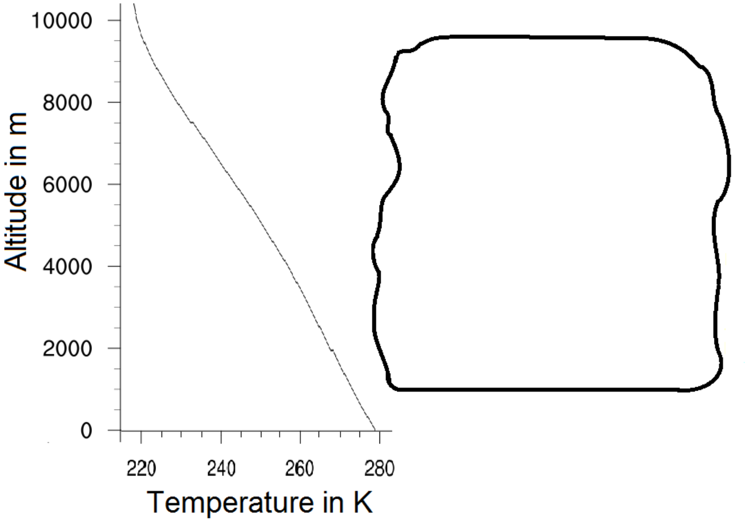
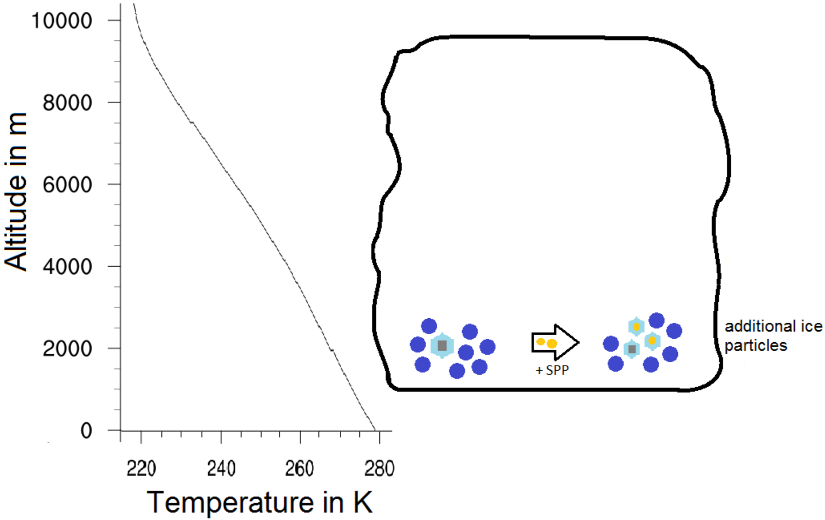


10000
8000
6000
4000
2000
0
Altitude in m
220
240
260
280
Temperature in K

Summary



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additional ice particles

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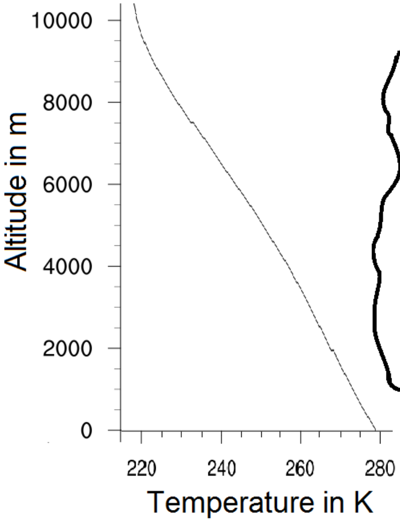

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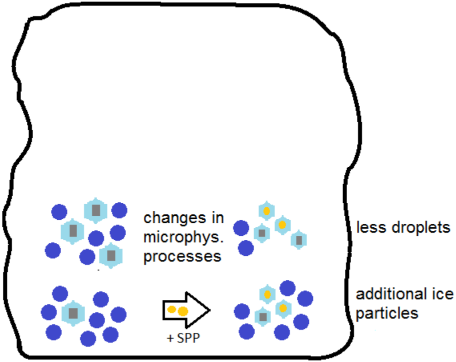

changes in
microphys.
processes
less droplets
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additional ice
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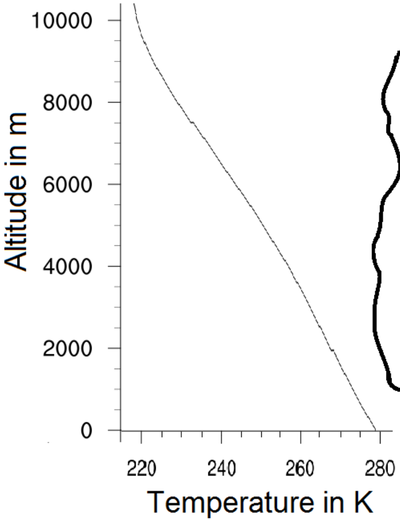
Summary



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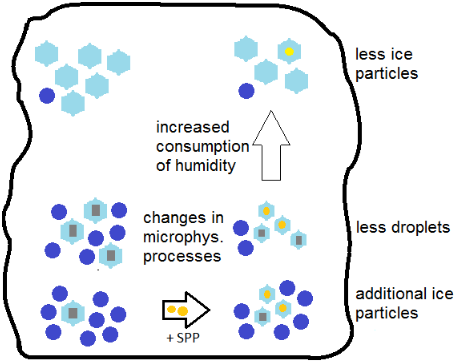
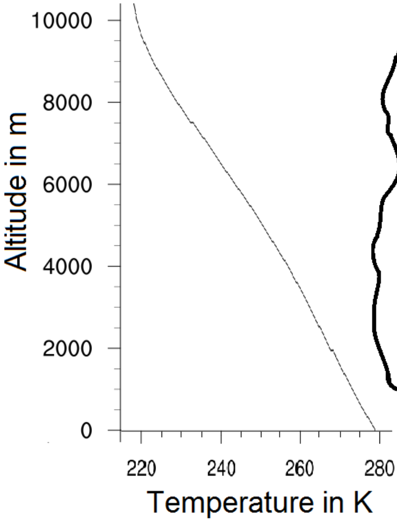
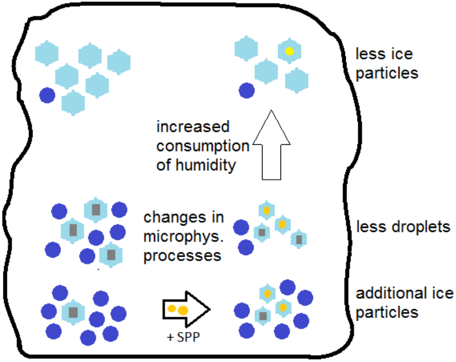


less ice particles
increased consumption of humidity
changes in microphys. processes
less droplets
+ SPP
additional ice particles

Summary





Impacting mixed-phase cloud composition

Literature I

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C. Hoose and O. Möhler, 2012. Heterogeneous ice nucleation on atmospheric aerosols: A review of results from laboratory experiments. *Atmospheric Chemistry and Physics*, **12(20)**, pp. 9817–9854.

D. O'Sullivan et al., 2015. The relevance of nanoscale biological fragments for ice nucleation in clouds. *Scientific reports*, **5**, p. 8082.

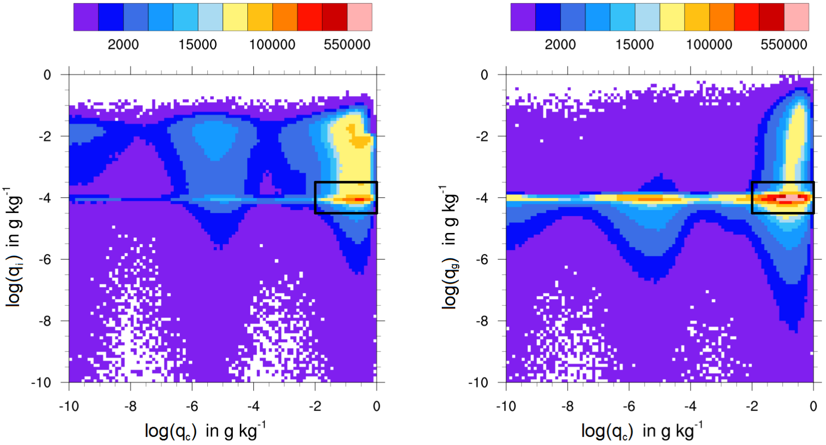
B. G. Pummer et al., 2012. Suspendable macromolecules are responsible for ice nucleation activity of birch and conifer pollen. *Atmospheric Chemistry and Physics*, **12(5)**, pp. 2541–2550.

Allison L. Steiner et al., 2015. Pollen as atmospheric cloud condensation nuclei. *Geophysical Research Letters*, **42(9)**, pp. 3596–3602.

Literature II

Qian Zhou, 2014. “Relative Humidity Induced Plant Pollen Grain Rupture and Conceptual Model Development”. PhD thesis. Washington State University, 2014.

Tracked 2D-histograms - with bio. IN



References
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