representing in-cloud oxidation of sulfur in a particle-based cloud-microphysics scheme

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Institute of Geophysics
Faculty of Physics, University of Warsaw

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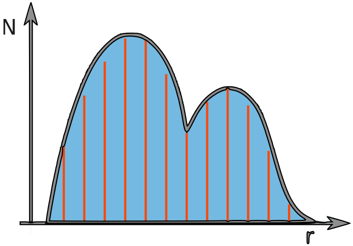
AMS, New Orleans, January 2016

Eulerian microhysics



- available liquid water is divided into histogram bins

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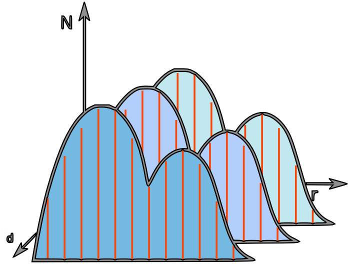

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- for aerosol - cloud interaction studies 2D histogram is created with "wet" and "dry" radius

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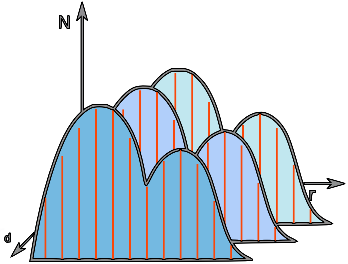

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- parametrisations of source and sink terms are applied to each bin

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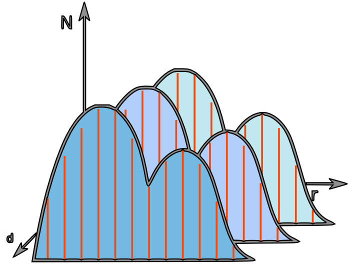
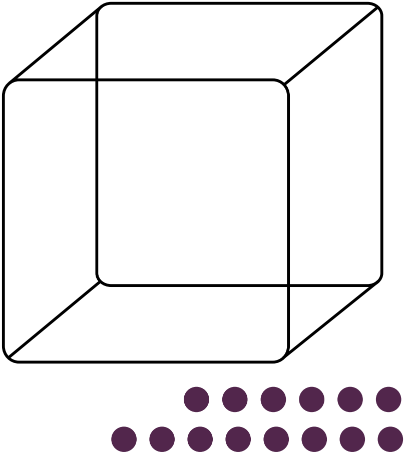


- available liquid water is divided into histogram bins
- for aerosol - cloud interaction studies 2D histogram is created with "wet" and "dry" radius
- parametrisations of source and sink terms are applied to each bin
- new histogram dimensions needed for chemical compounds...

Lagrangian microphysics

super-droplets in the domain



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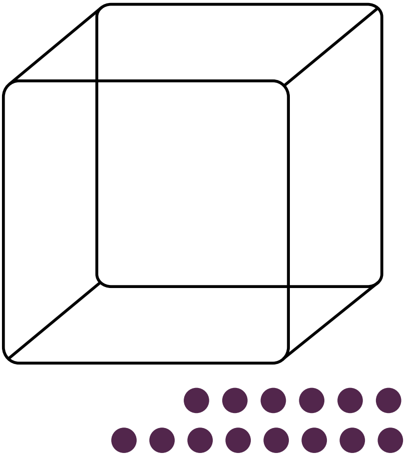

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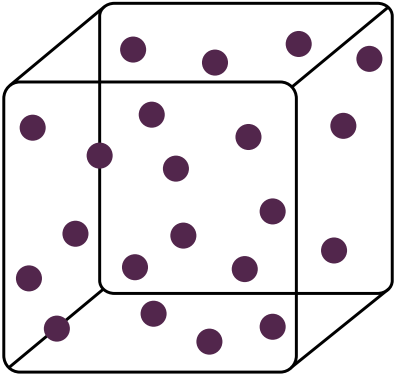

super-droplets in the domain

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- location

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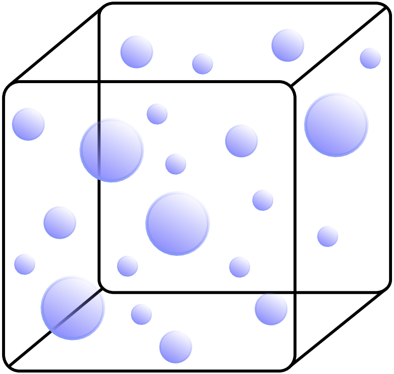
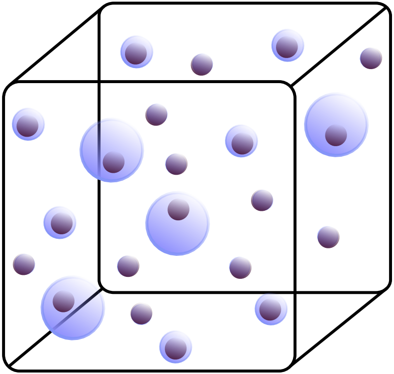


super-droplets in the domain

attributes:

- location
- wet radius

Lagrangian microphysics



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attributes:

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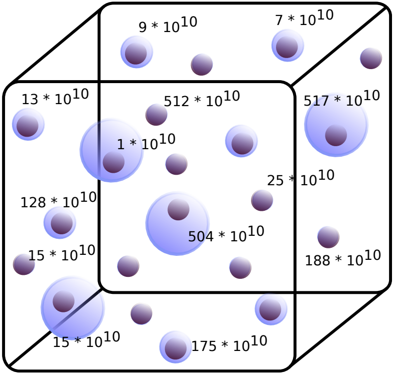

super-droplets in the domain

attributes:

- location
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- multiplicity

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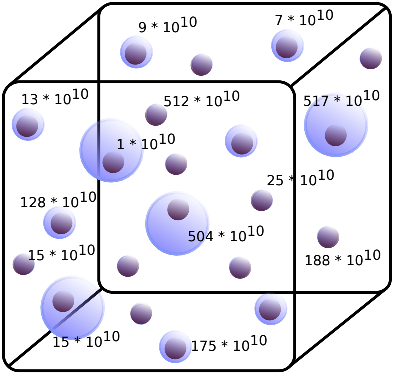

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Cloud microphysics

- Maxwell-Mason equation of condensational growth for each super-droplet using κ-Koehler parametrisation of higroscopicity (Petters & Kreidenweis, 2007)

- CCN activation
- condensational growth

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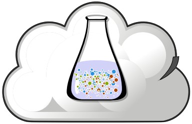

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- sedimentation of each super-droplet (Khvorostyanov & Curry, 2002)

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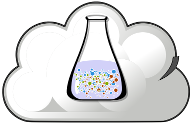

- collision - coalescence

- precipitation
- wet deposition
- droplet deactivation

Example results with collisions (2D kinematic set-up)

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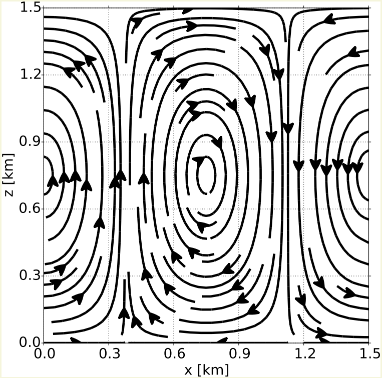

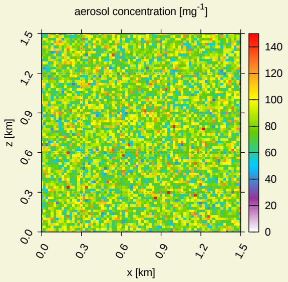

- set-up: Grabowski & Lebo (ICMW 2012)
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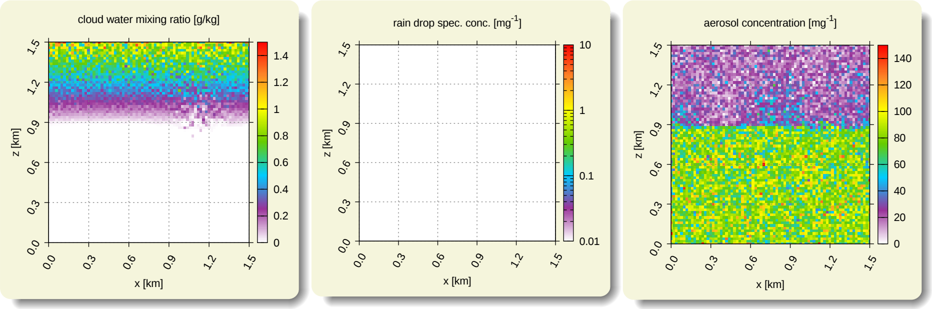

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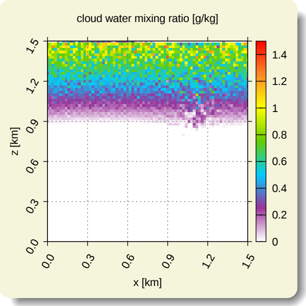
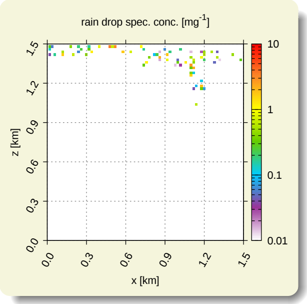
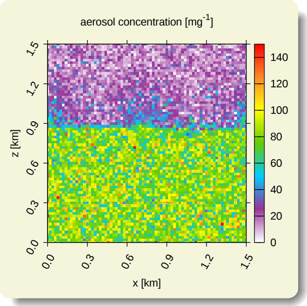
x o







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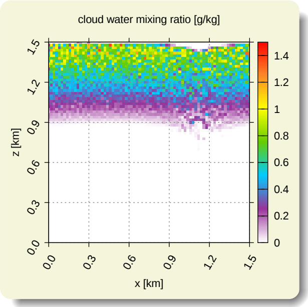

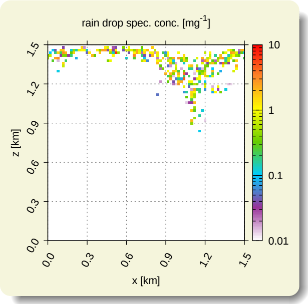

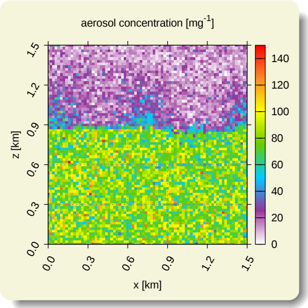

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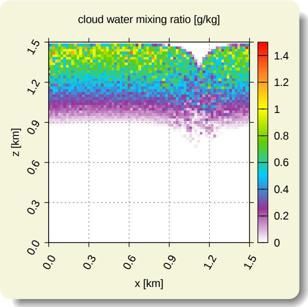

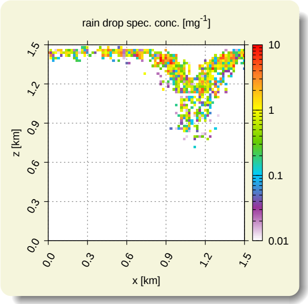

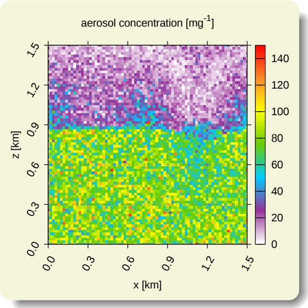

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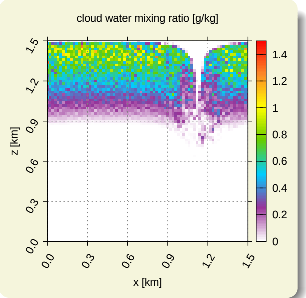
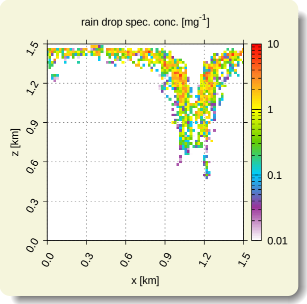
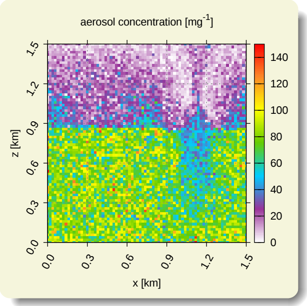
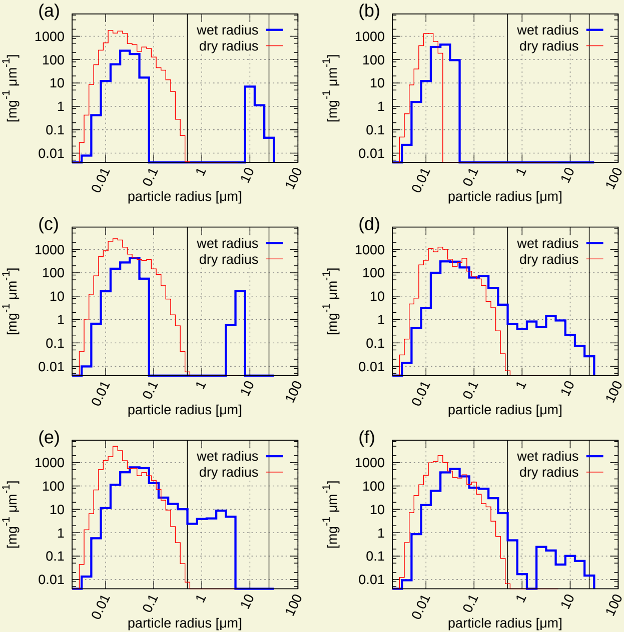
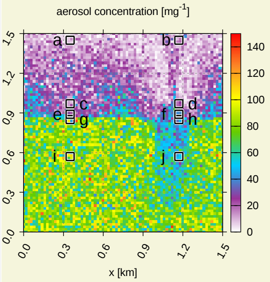






2×2 cell particle-derived spectra





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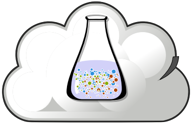

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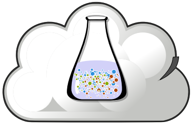

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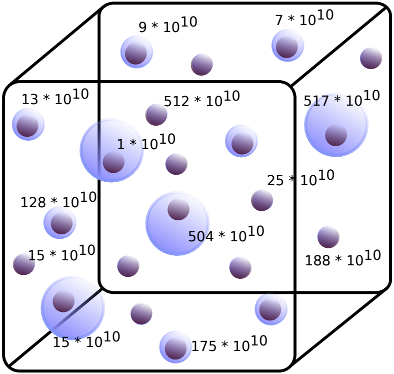
Lagrangian microphysics + aqueous chemistry



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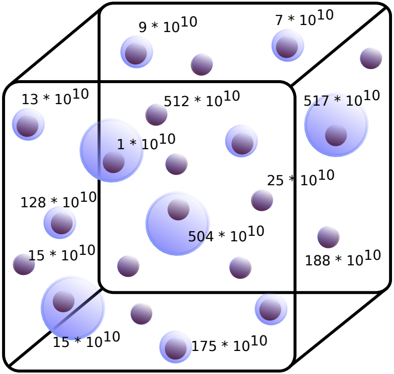

super-droplets in the domain

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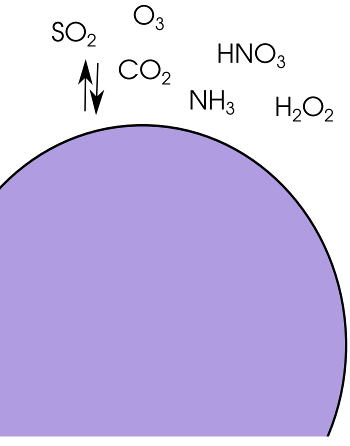
- mass of chemical compounds within droplets: $H_2O \cdot SO_2$, O_3, H_2O_2, $H_2O \cdot CO_2$, $H_2O \cdot NH_3$, HNO_3, HSO_3^-, SO_3^{2-}, HCO_3^-, CO_3^{2-} NO_3^-, NH_4^+, H^+, OH^-, HSO_4^-, SO_4^{2-}

Aqueous chemistry

- dissolving of trace gases



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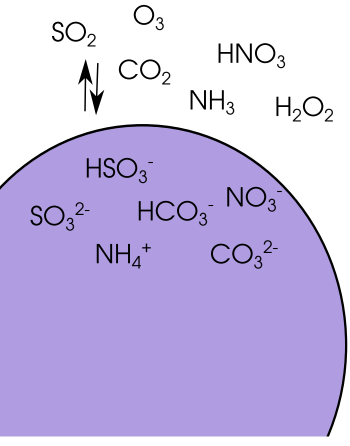

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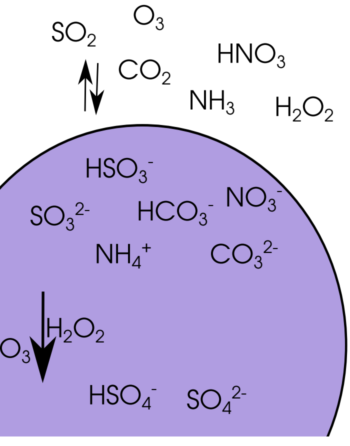

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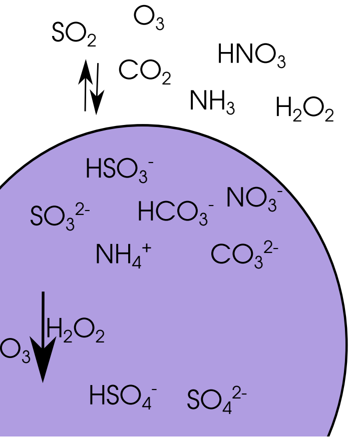

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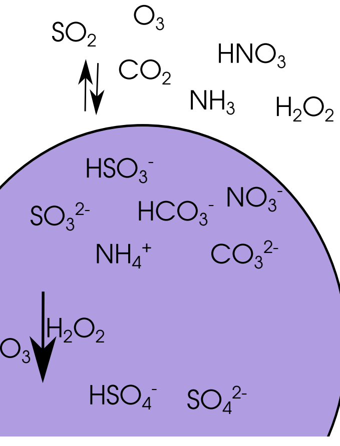

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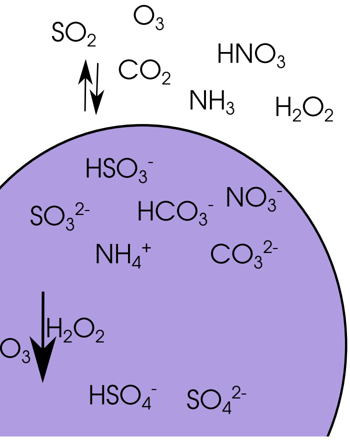

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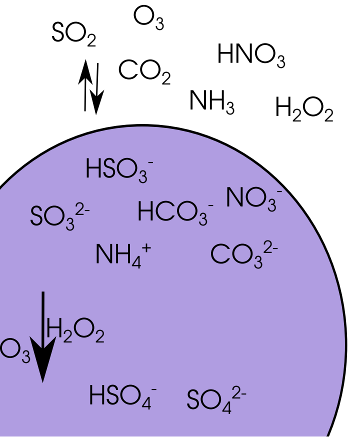

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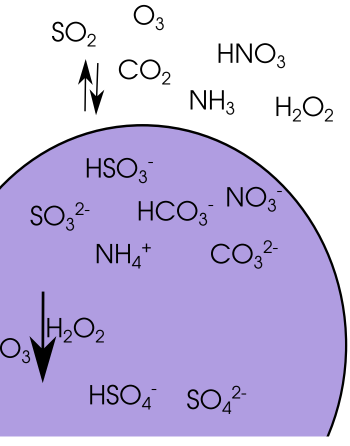

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- impacts condensation via dry radii, but no impact on κ (yet)

Validation of the chemistry module

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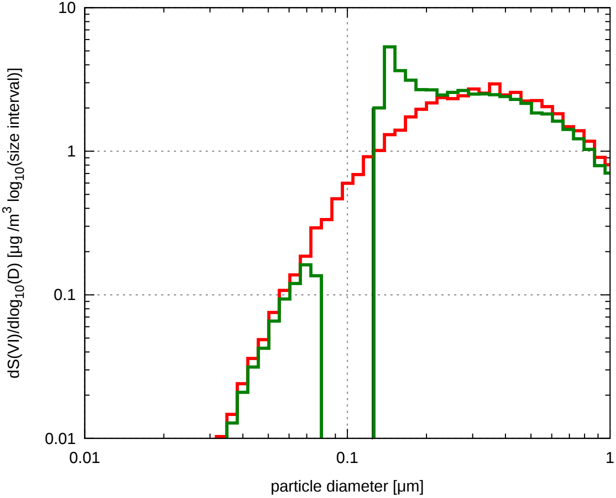

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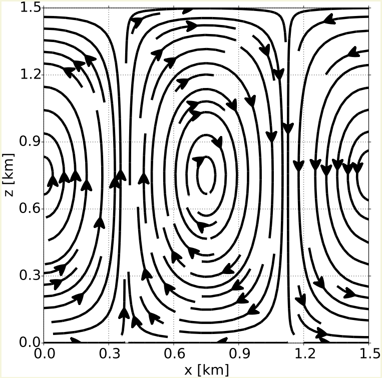

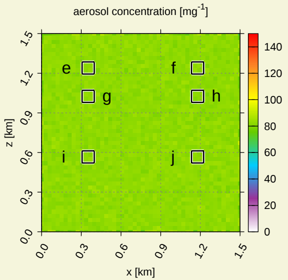

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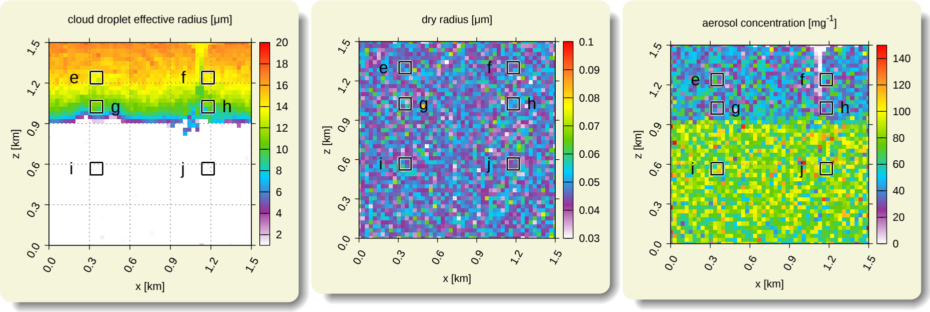

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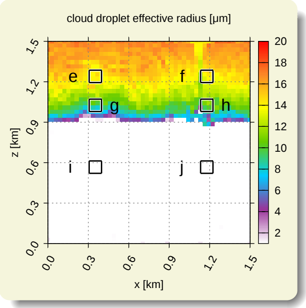

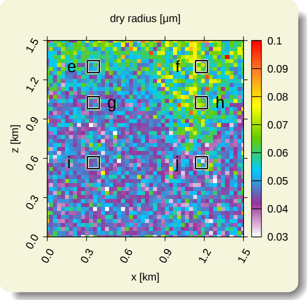

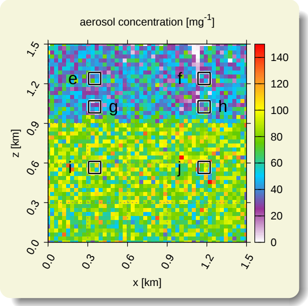

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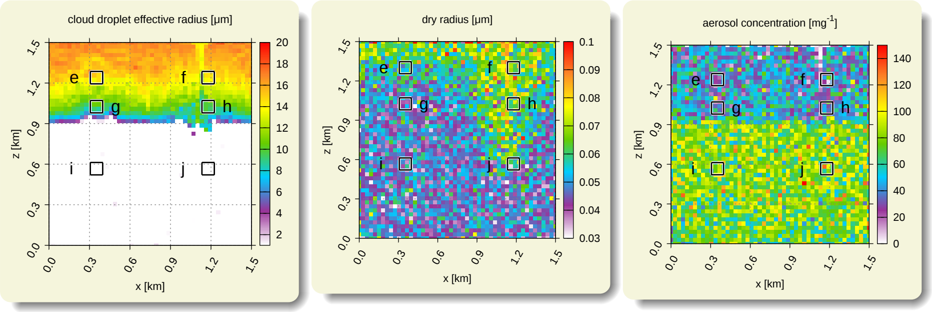

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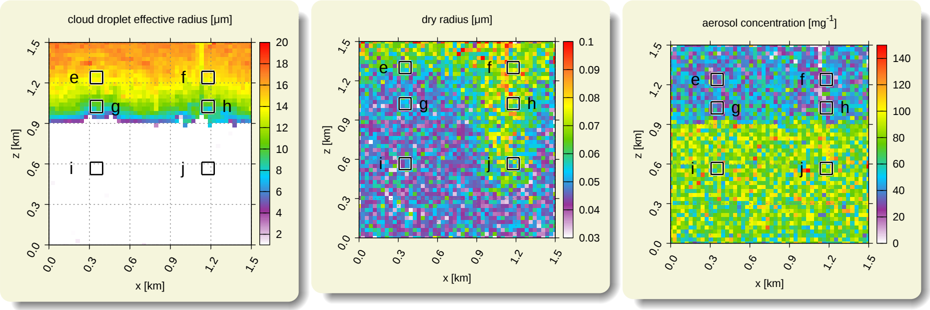

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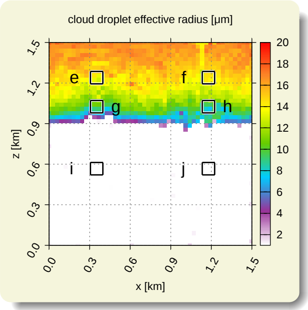

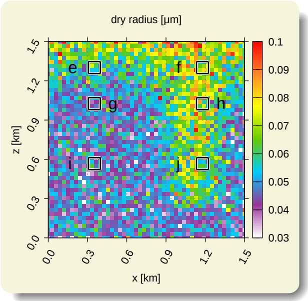

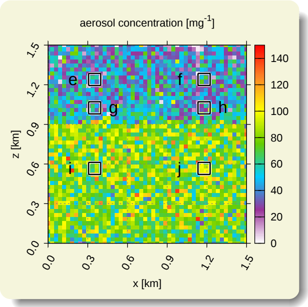

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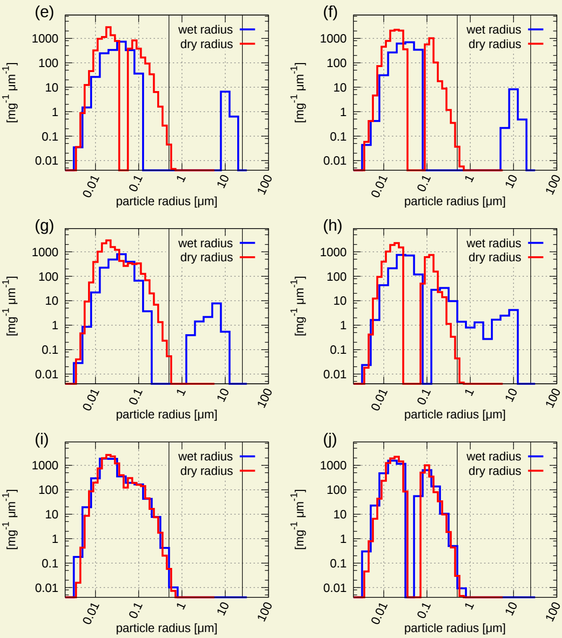

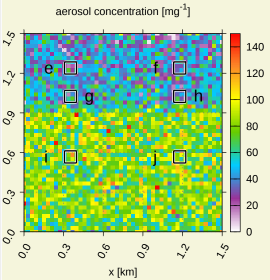

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- compact code (5000 lines of code)

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- Lagrangian scheme optionally GPU-resident (via Thrust)
- compact code (5000 lines of code)
- equipped with Python bindings

Final remarks

- available online as a part of **libcloudph++** library of cloud microphysics schemes
  http://libcloudphxx.igf.fuw.edu.pl/
- reusable:
  - design: no assumptions on dimensionality or dyn-core type
  - documentation: API described in the paper/manual
  - legal/practical matters: open source, GPL, hosted on github
- Lagrangian scheme optionally GPU-resident (via Thrust)
- compact code (5000 lines of code)
- equipped with Python bindings

- Thank you for your attention!