Immersion freezing in particle-based aerosol-cloud microphysics: a probabilistic perspective on singular and time-dependent models

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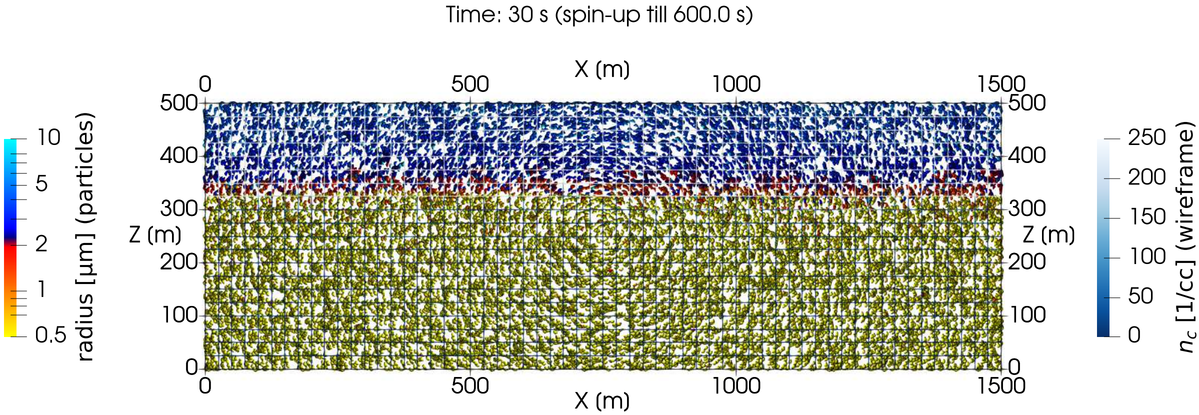
ASR Atmospheric System Research

2023 ARM/ASR Joint User Facility/PI Meeting, Rockville, MD

Breakout session: Primary and secondary ice production and impacts on mixed-phase and ice clouds

particle-based probabilistic aerosol-cloud μ-physics (super droplets)



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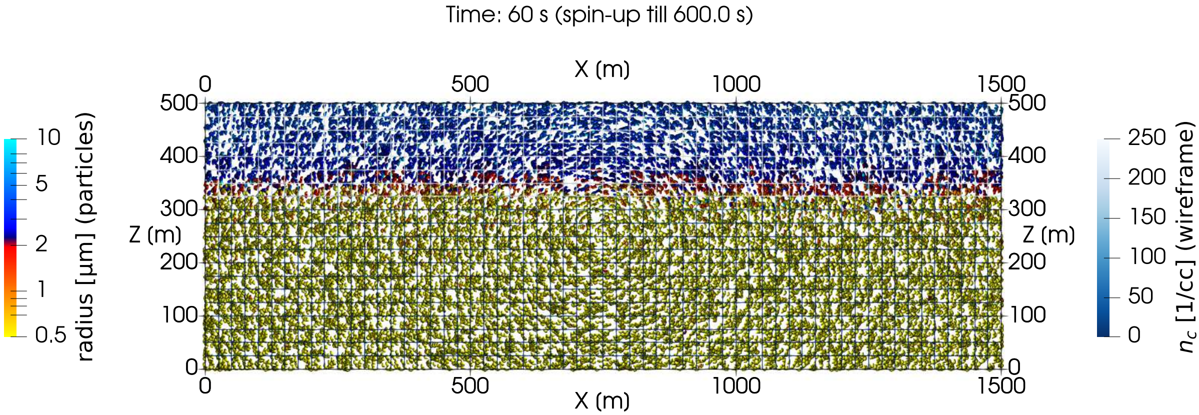

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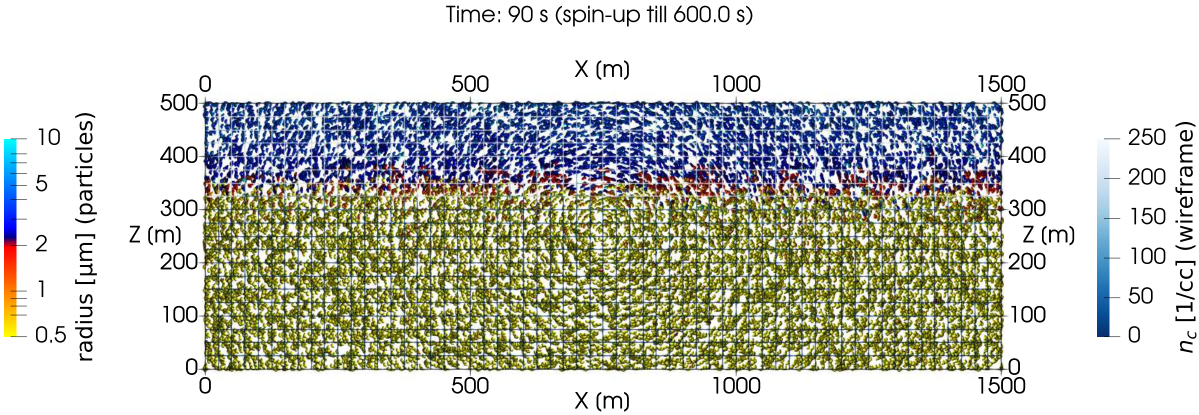

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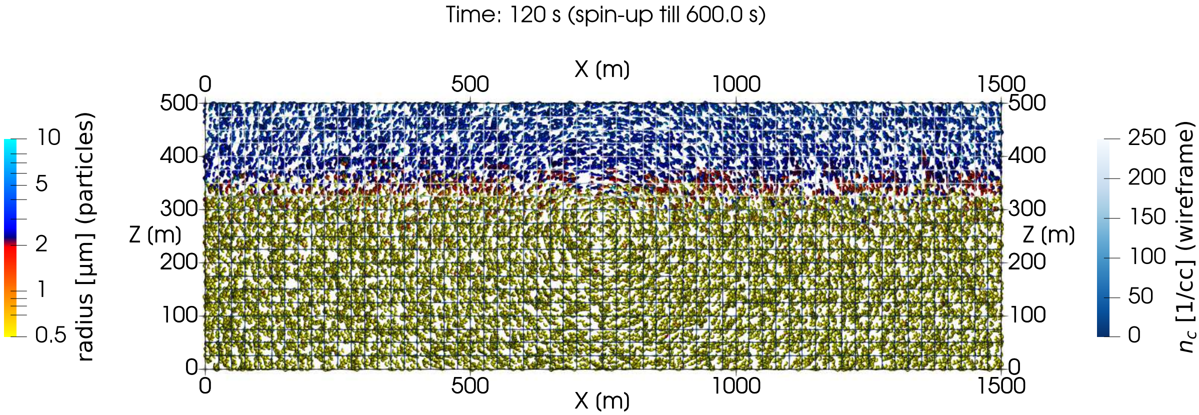

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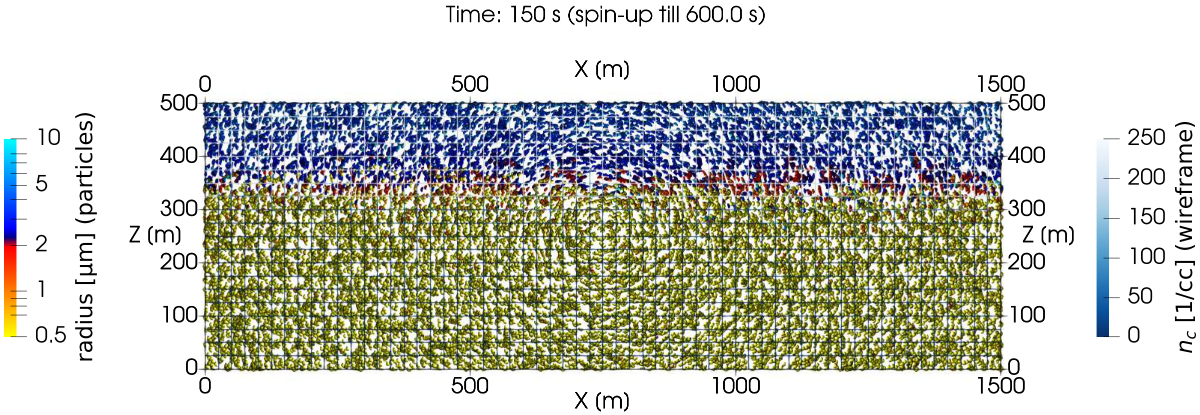

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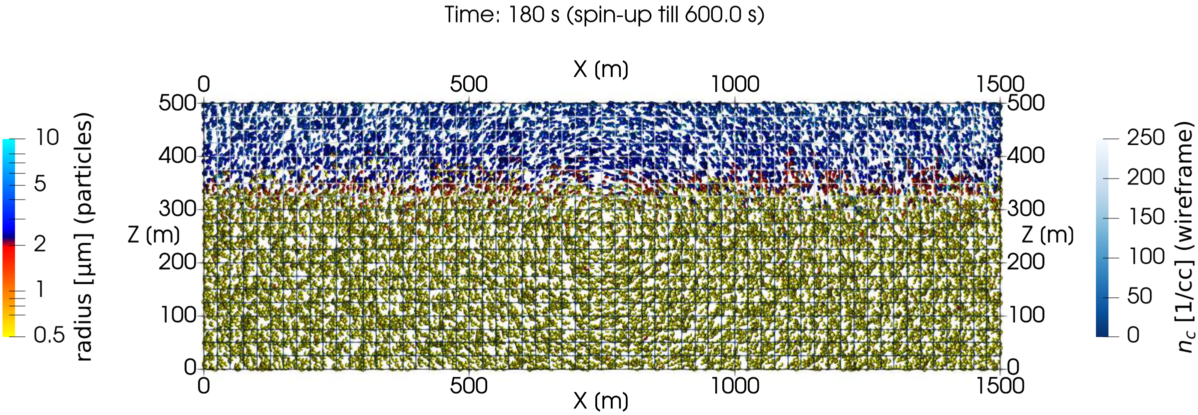

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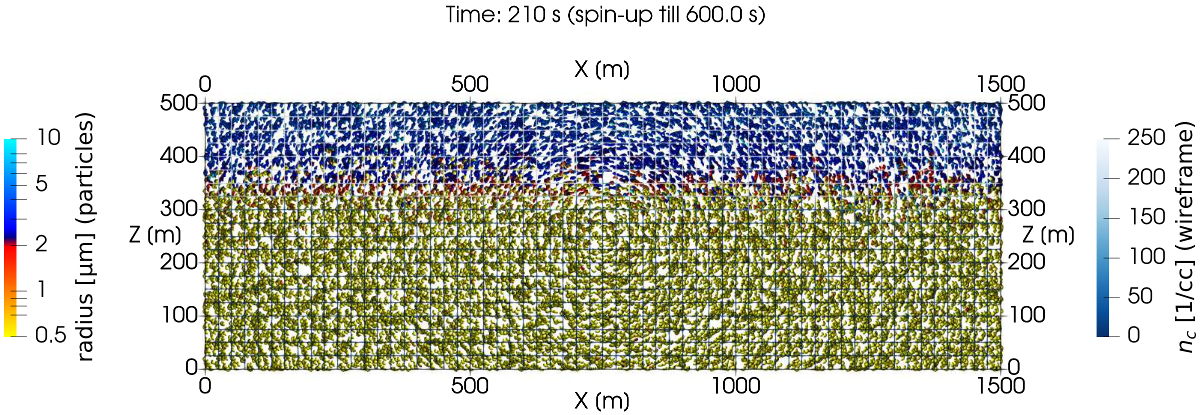

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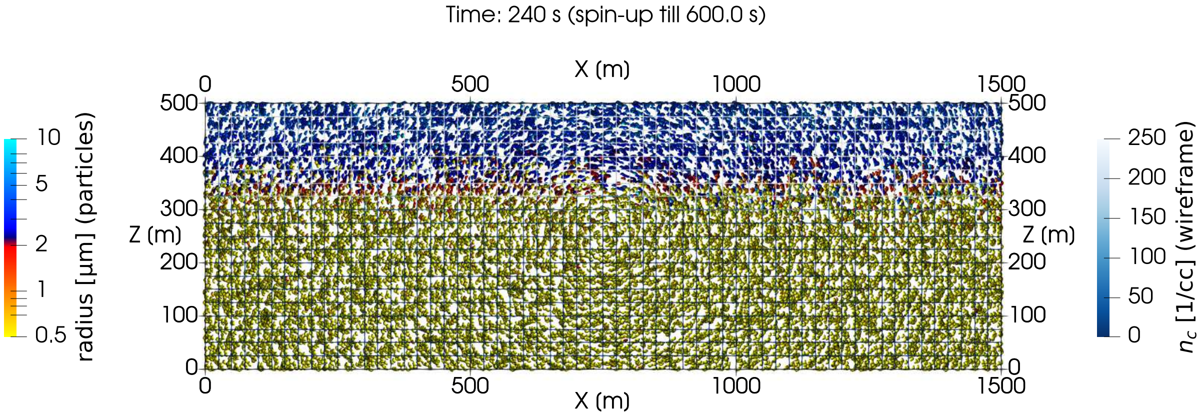

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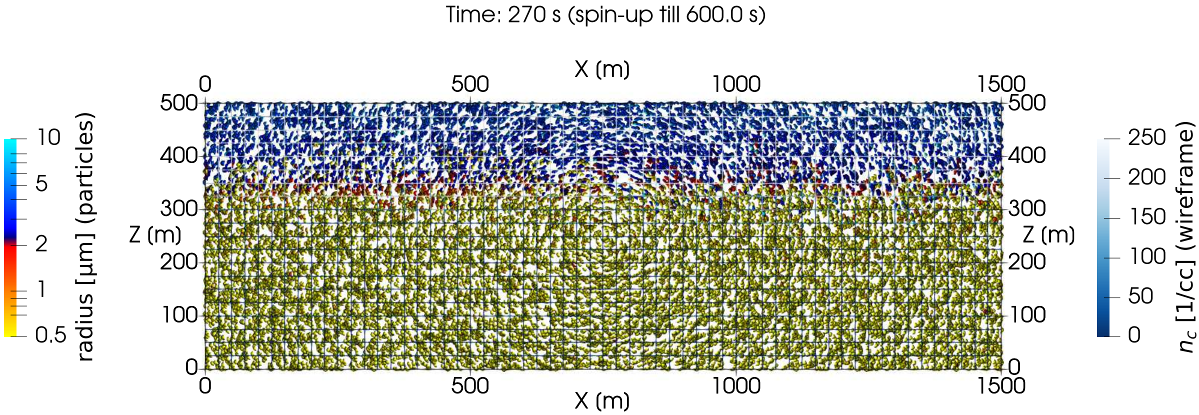

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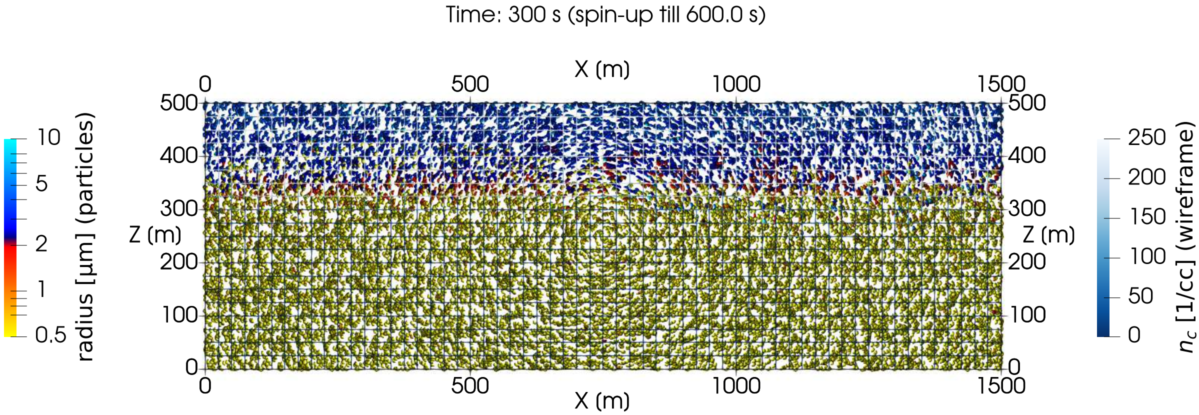

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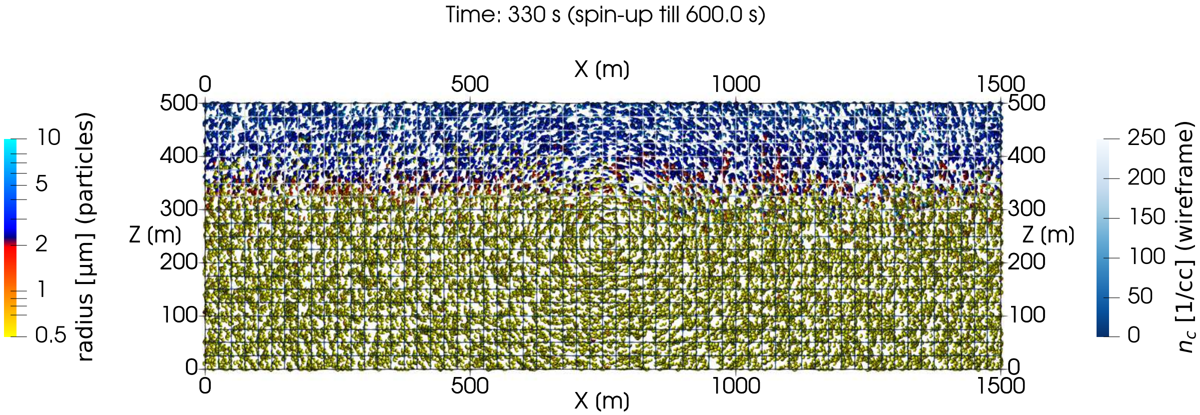

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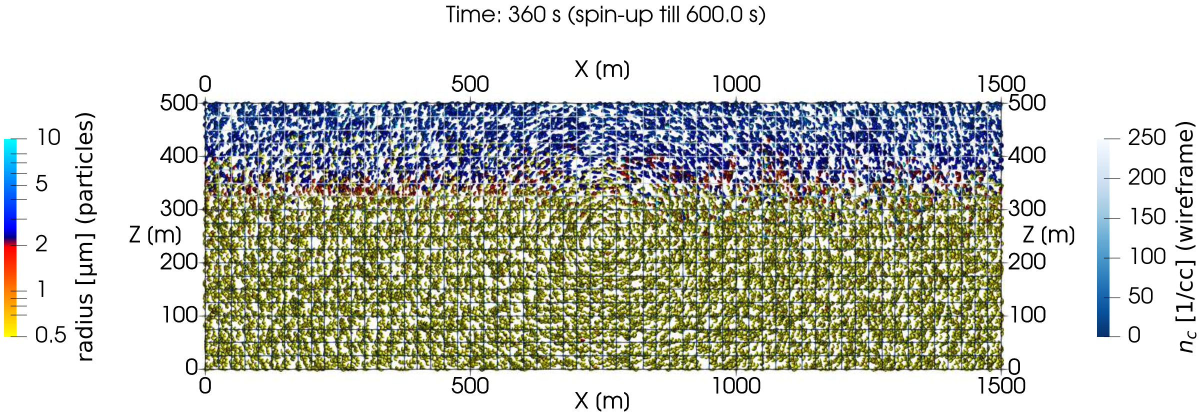

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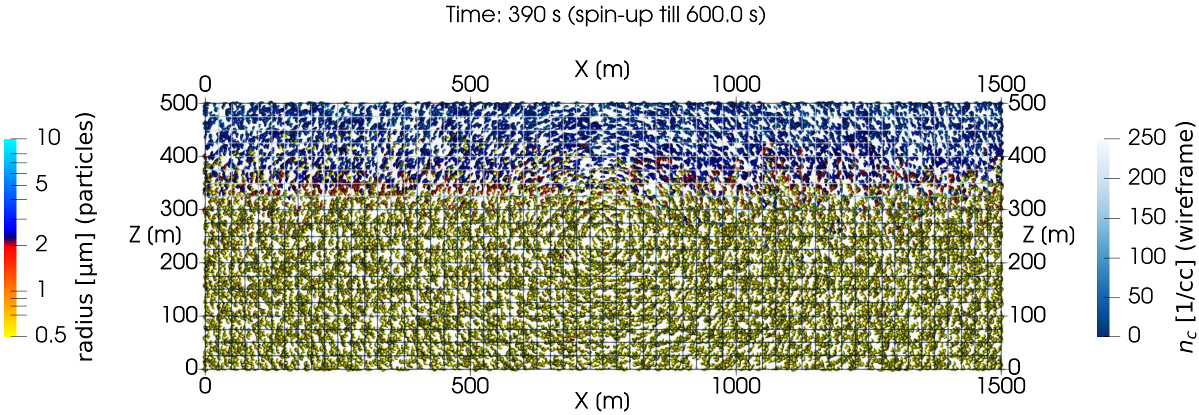

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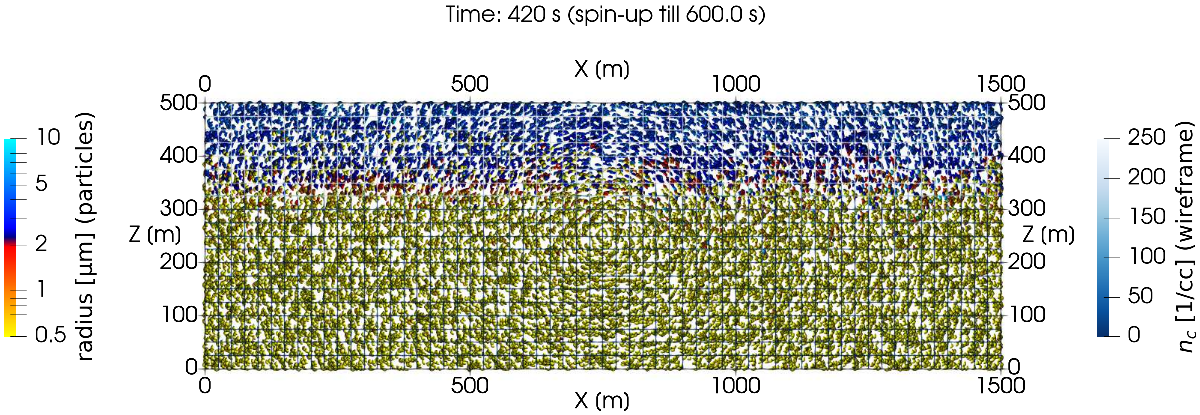

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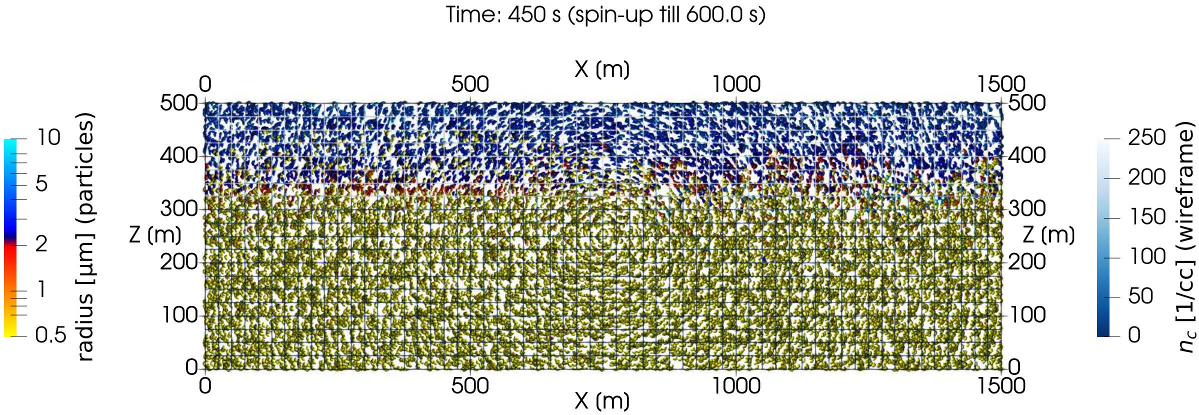

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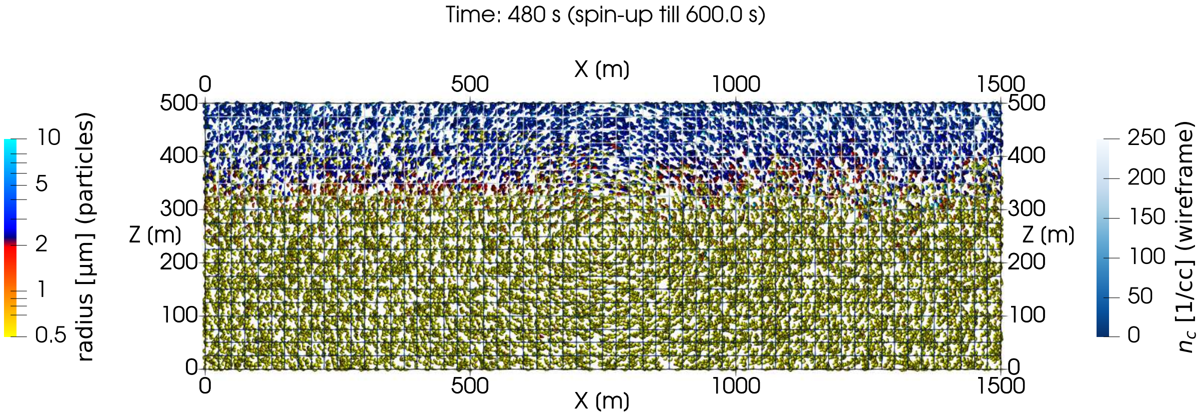

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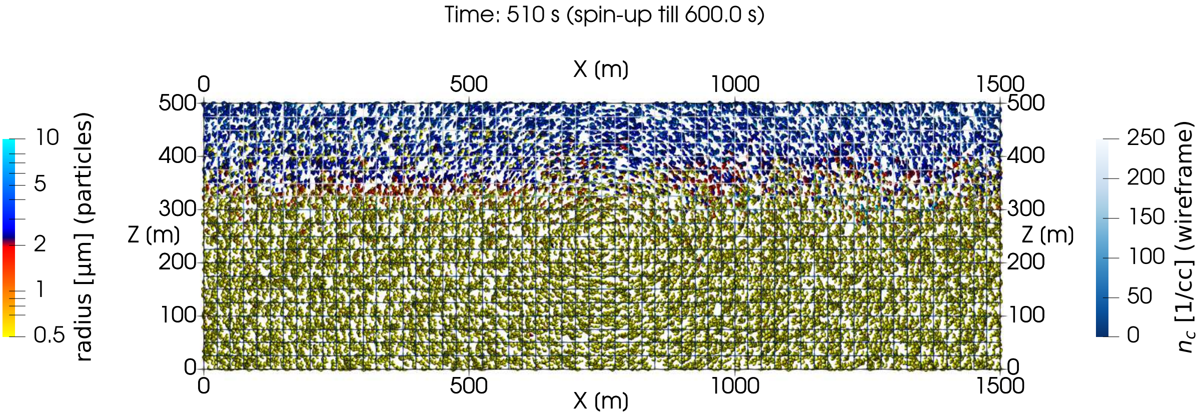

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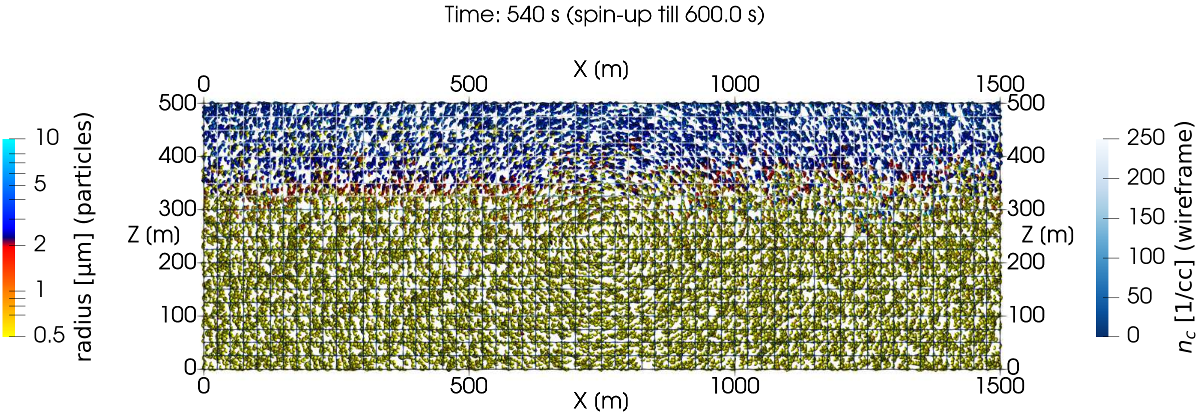

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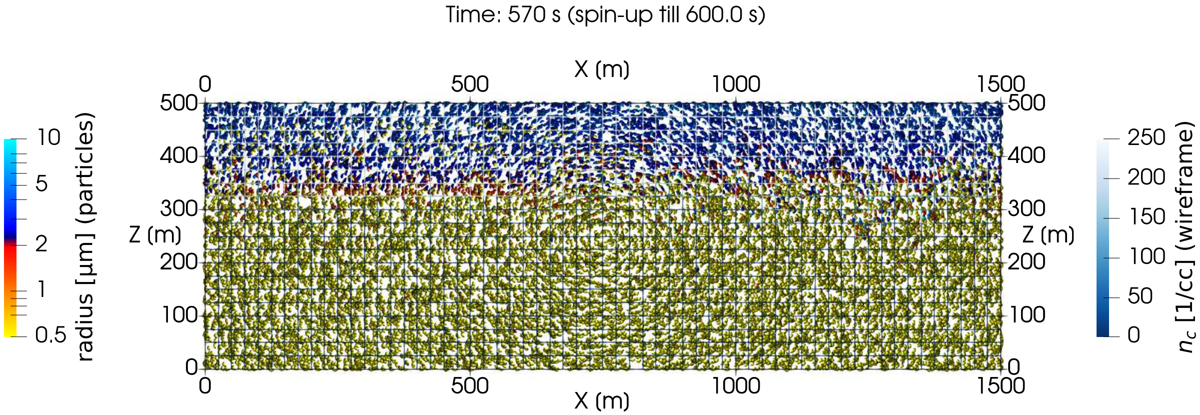

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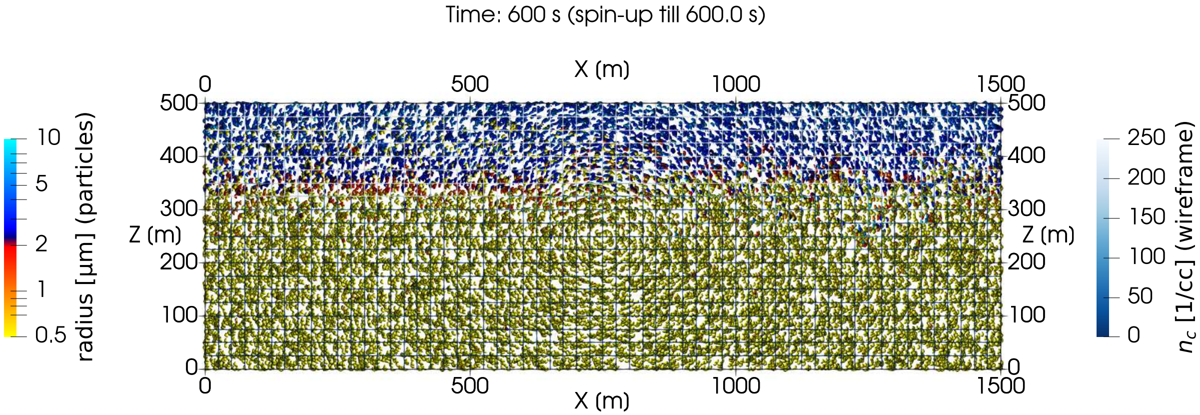

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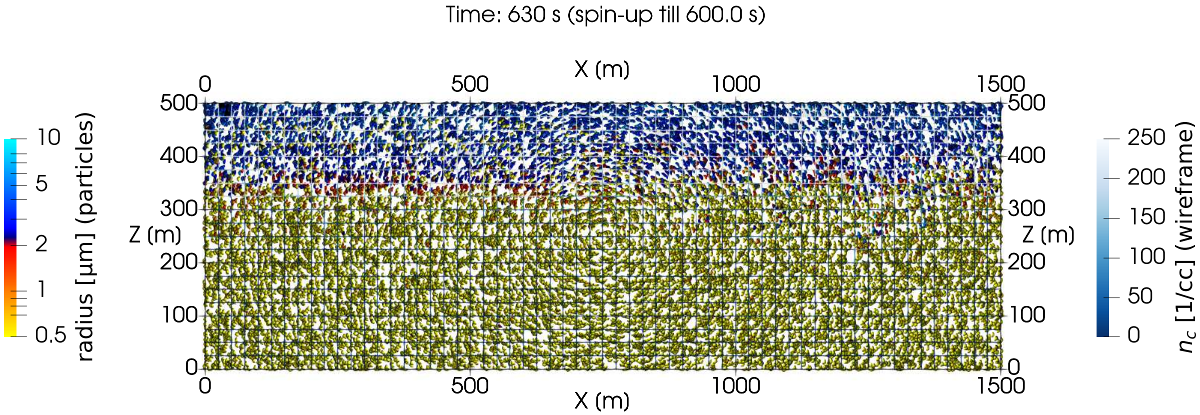

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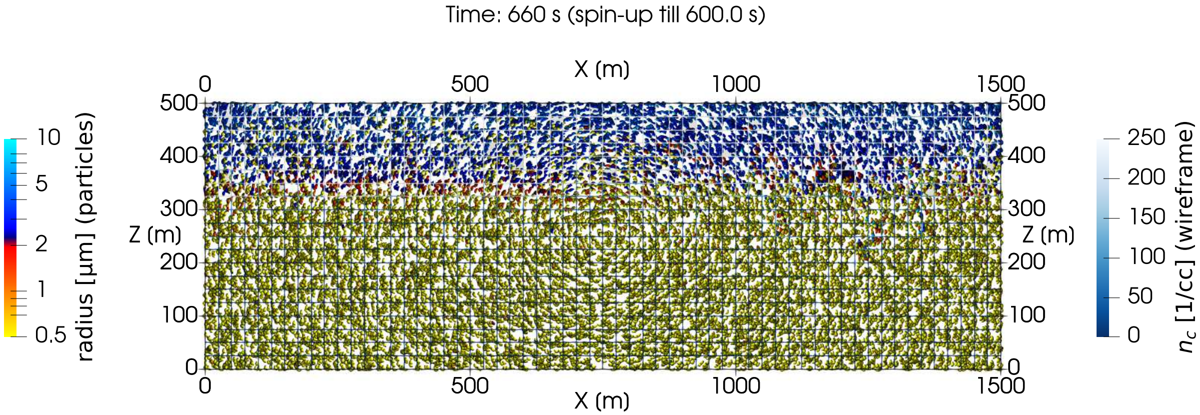

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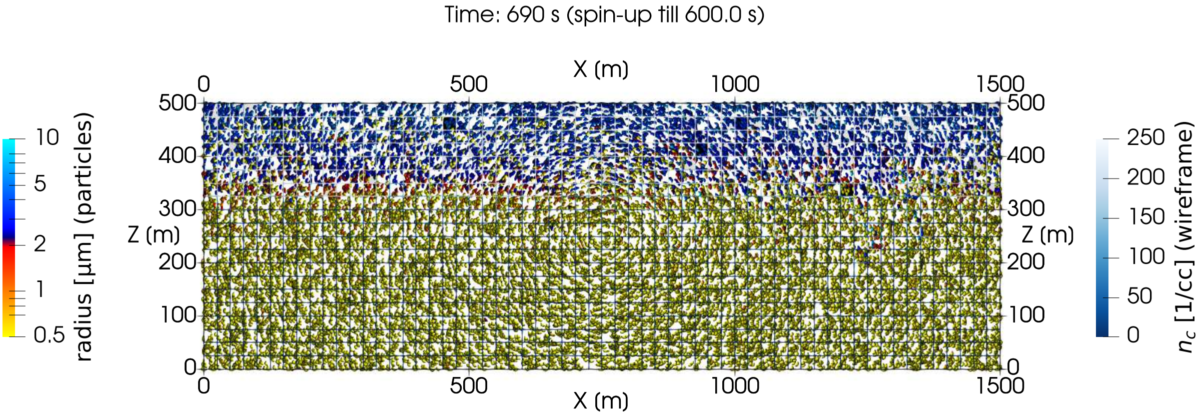

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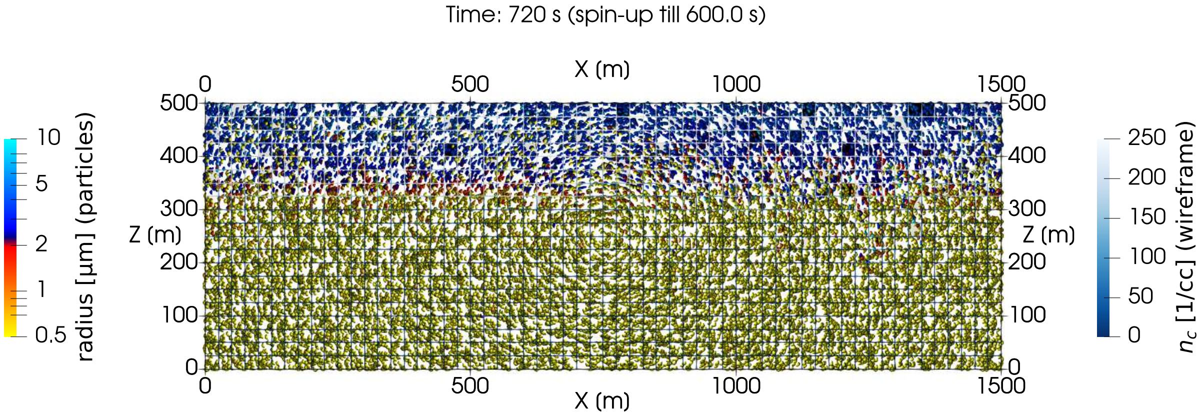

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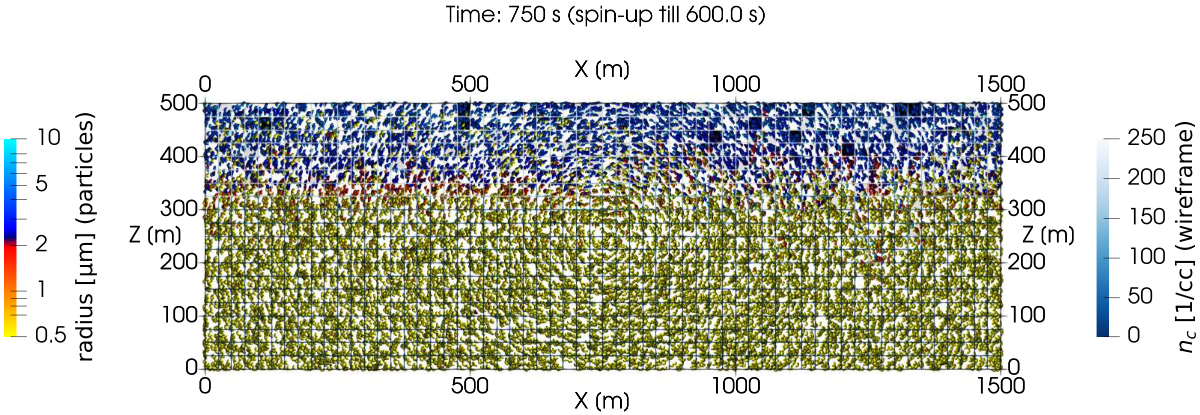

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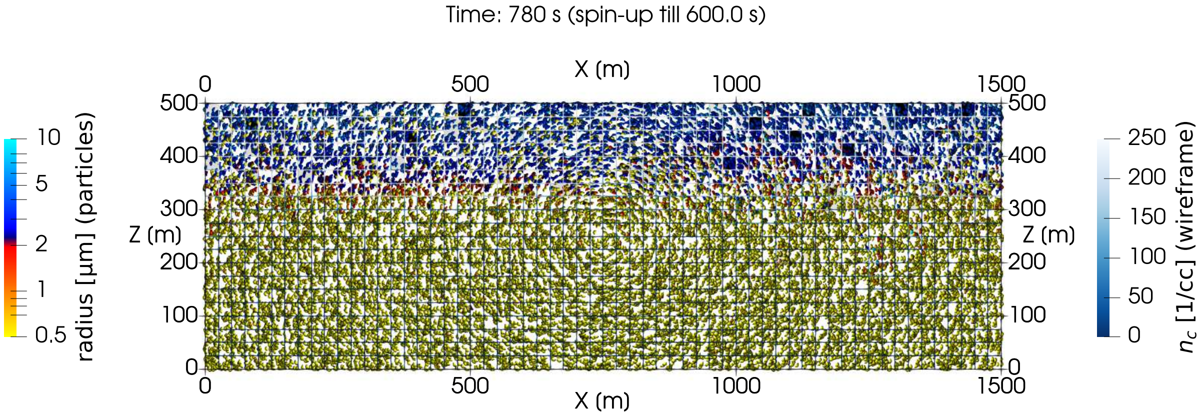

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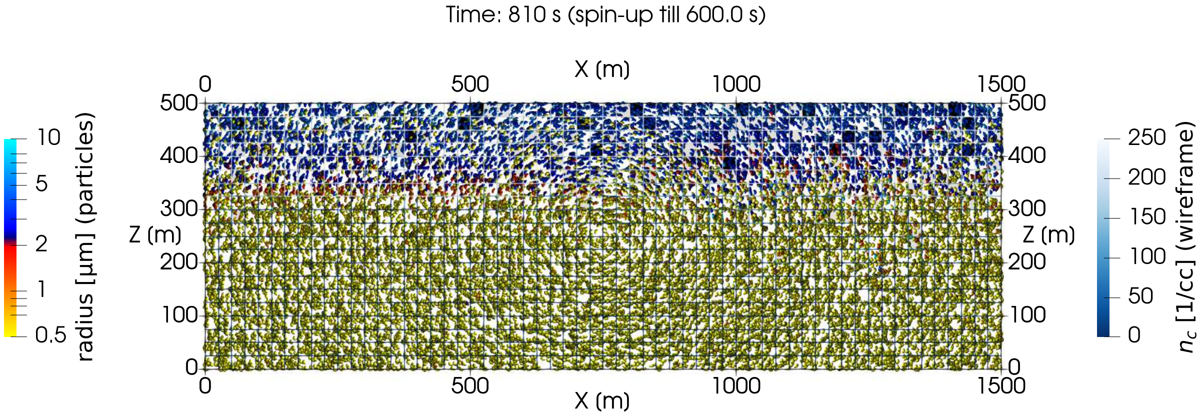

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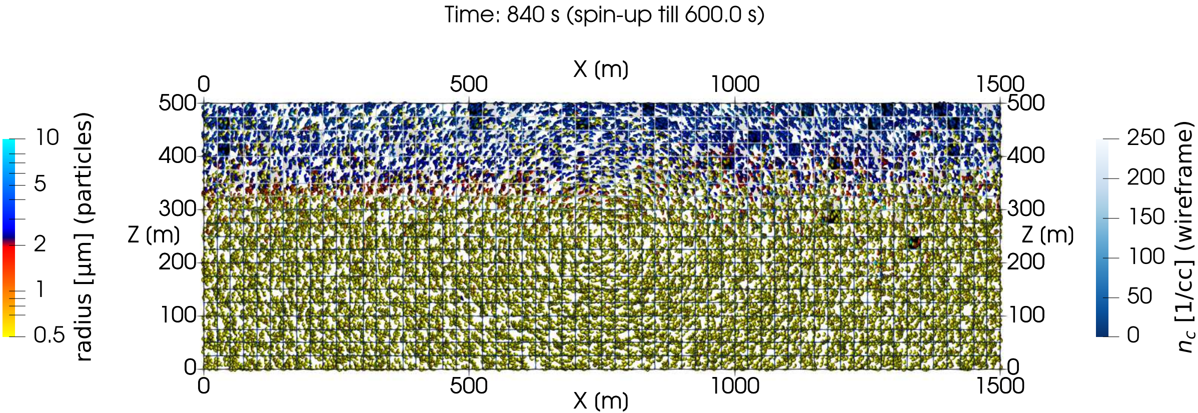

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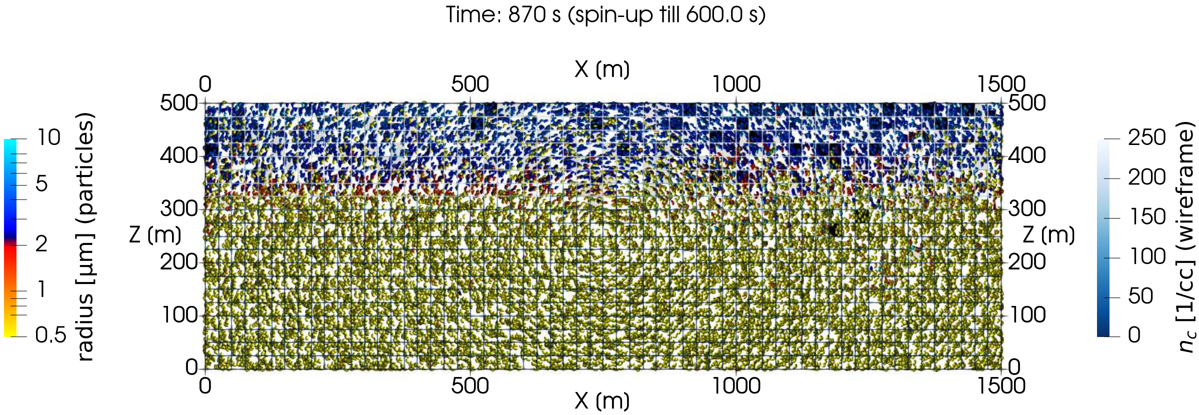

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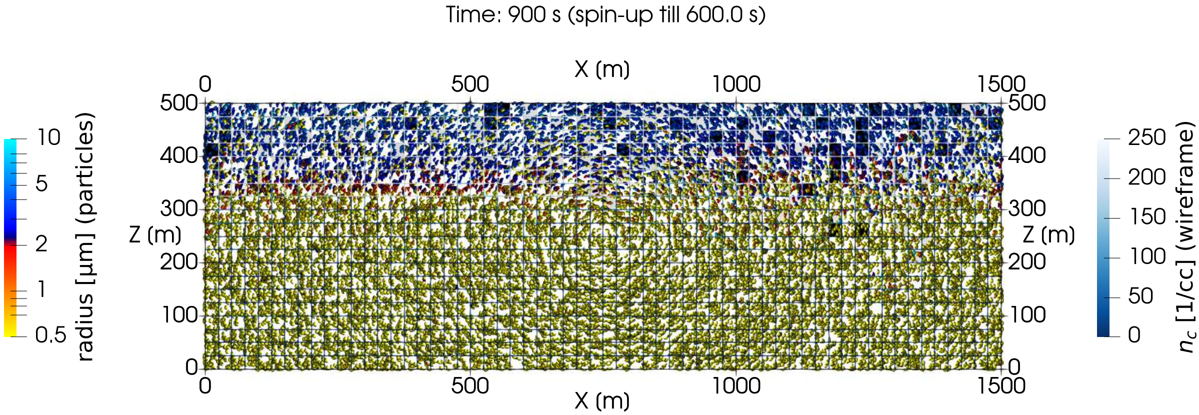

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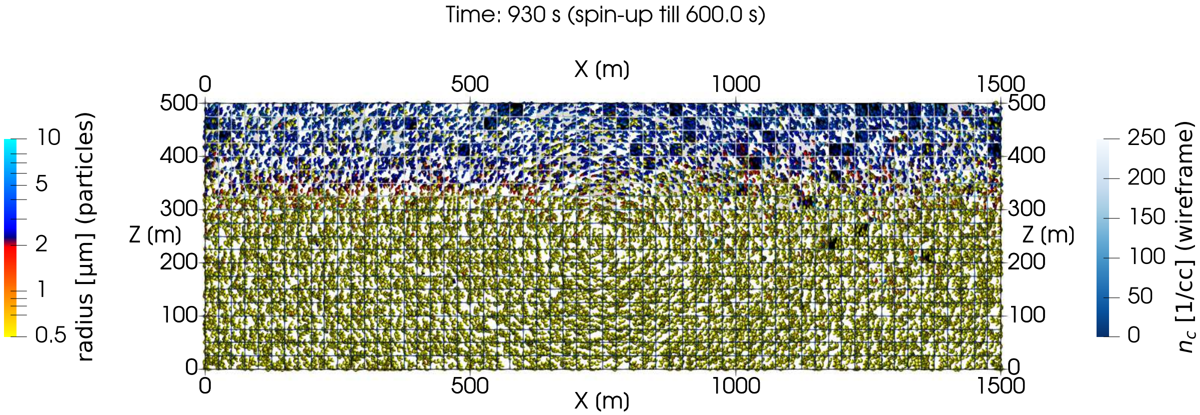

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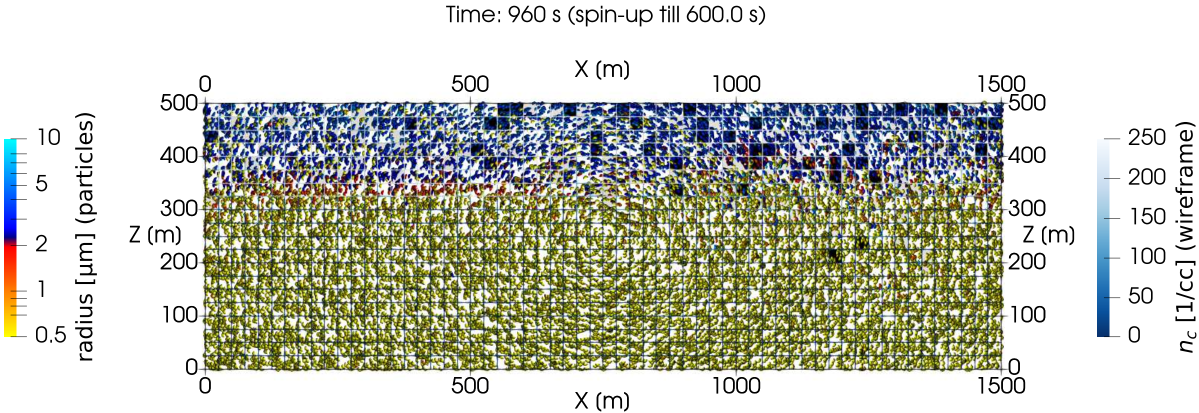

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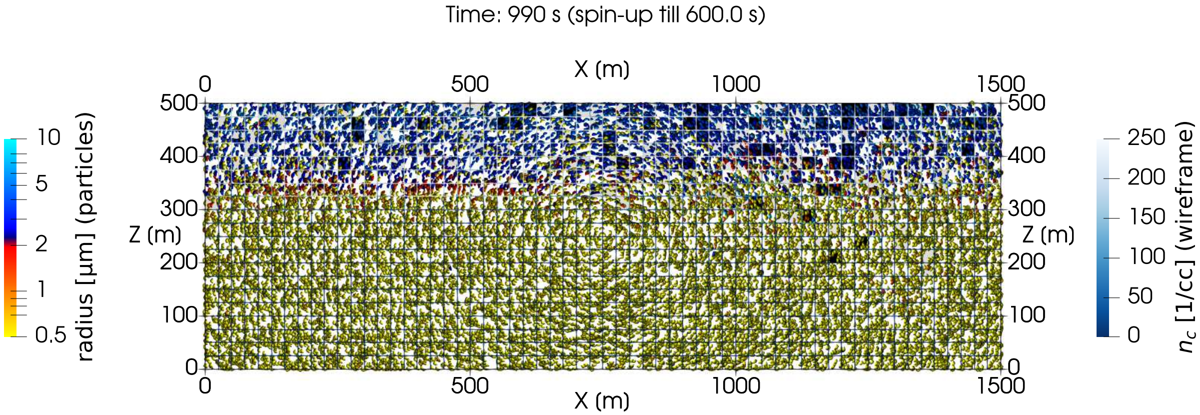

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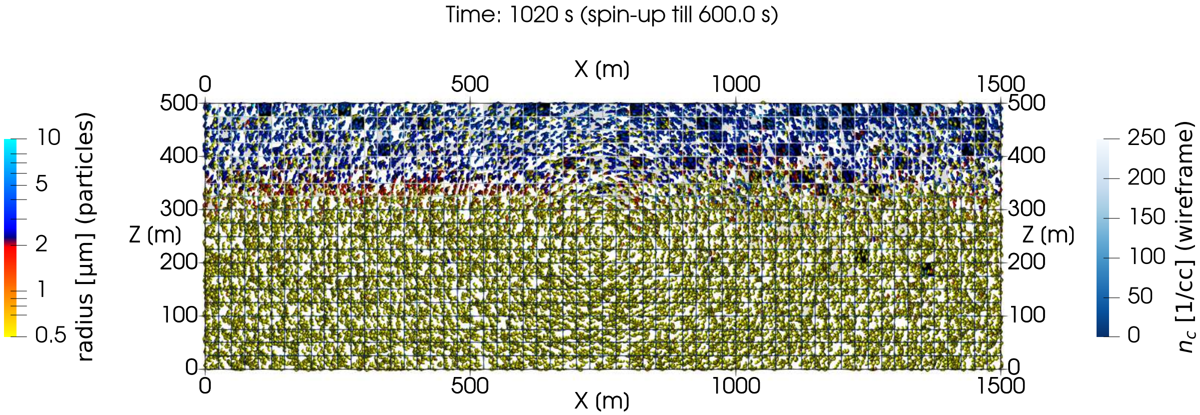

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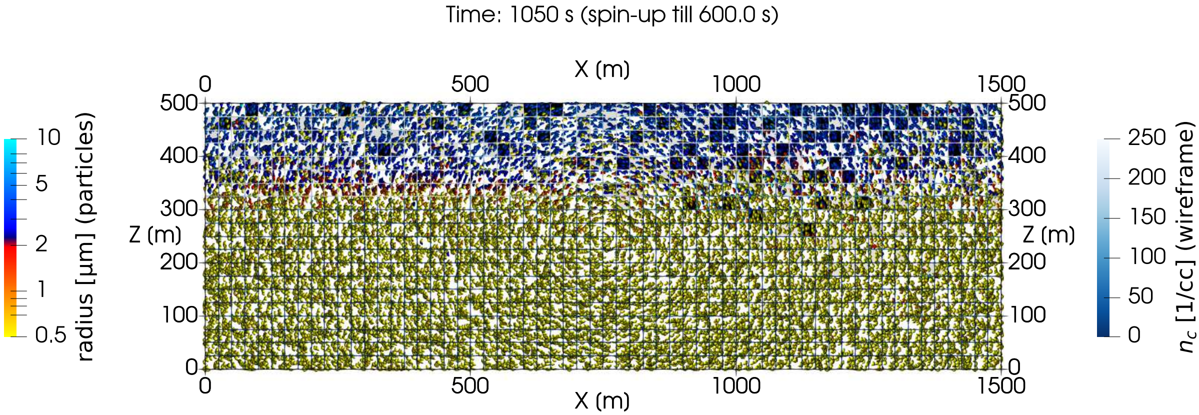

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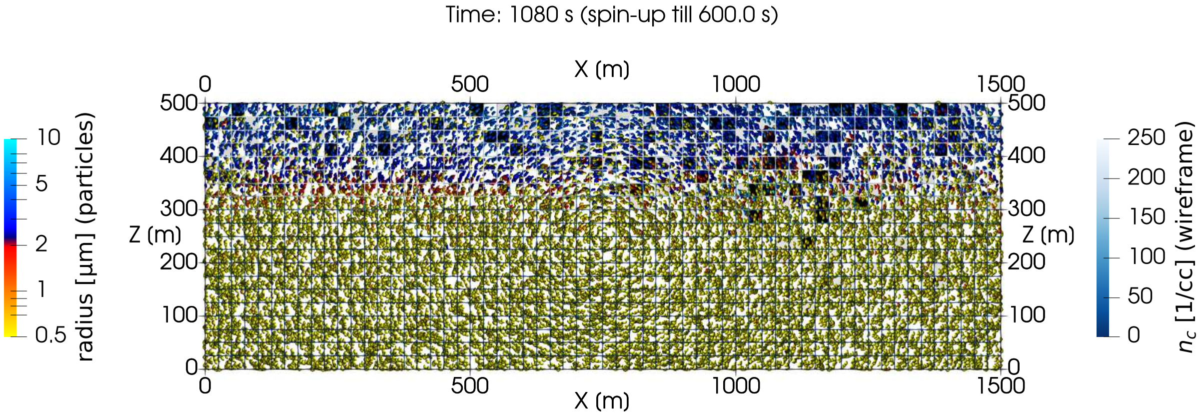

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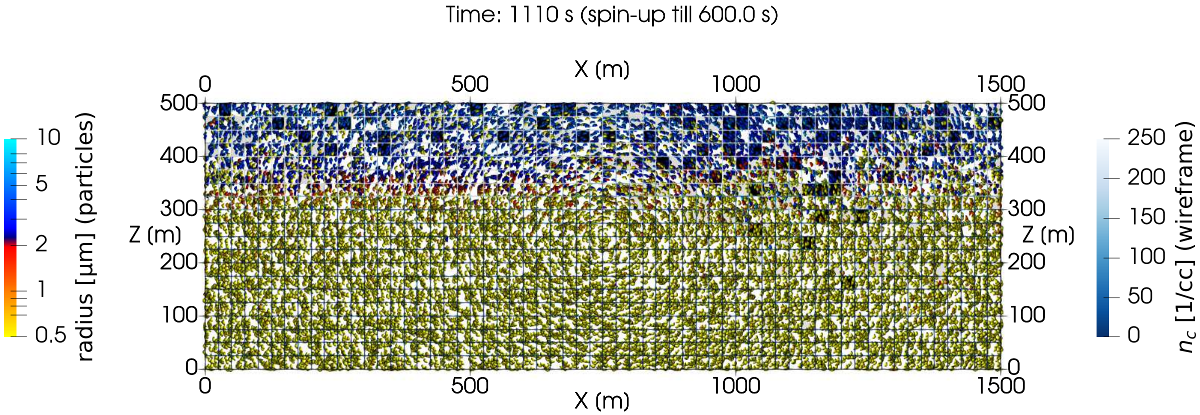

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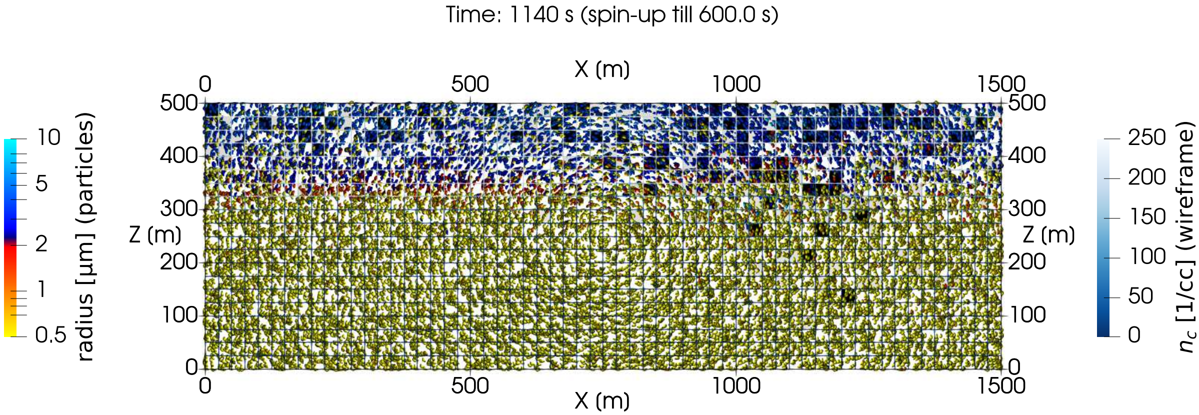
particle-based probabilistic aerosol-cloud μ-physics (super droplets)



16+16 super-particles/cell for INP-rich + INP-free particles

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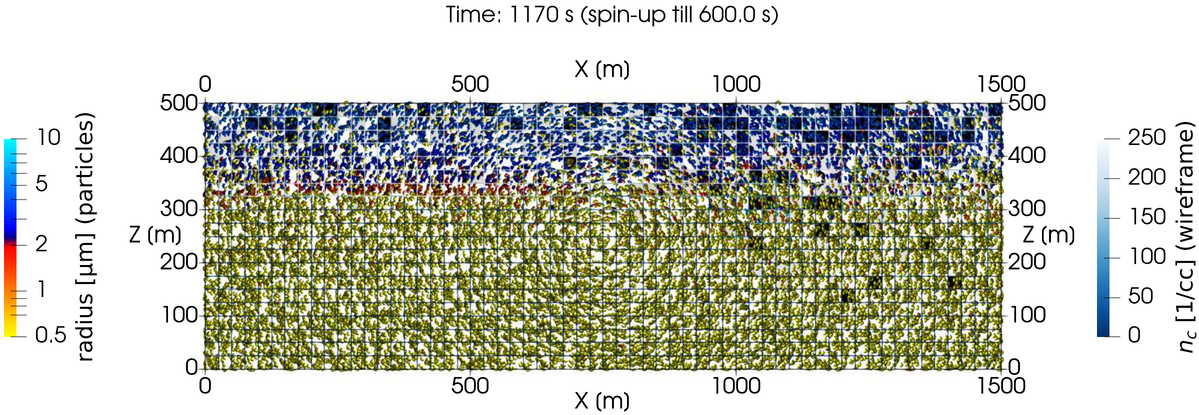

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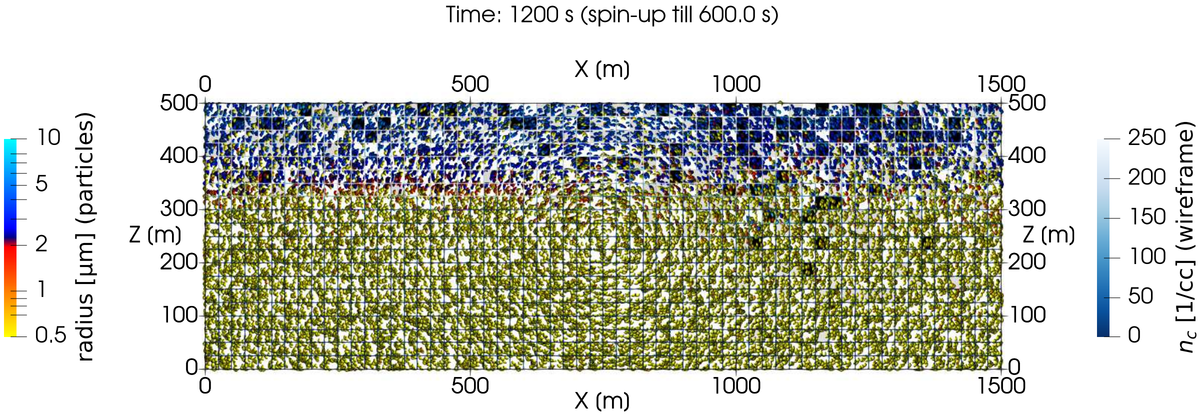

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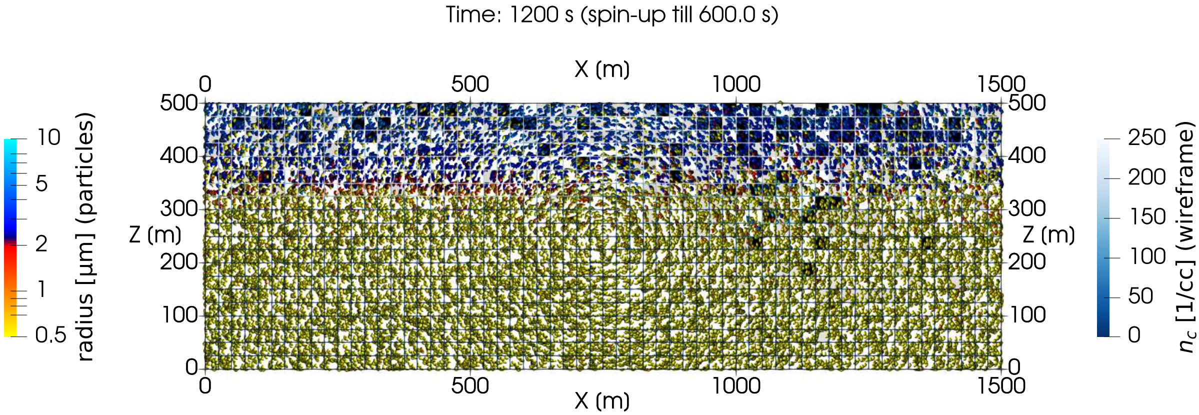
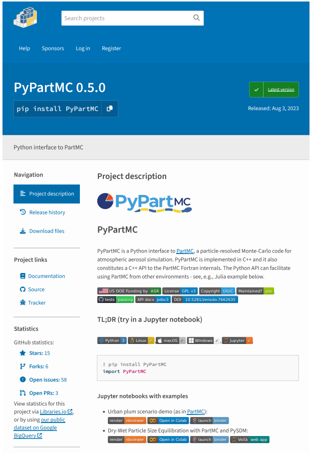


100% Python, 100% open-source, 100% runs "in the cloud" (Google Colab, jupyterhub, ...)

new open-source HPC Python packages



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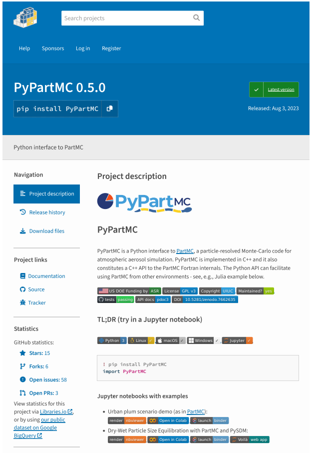


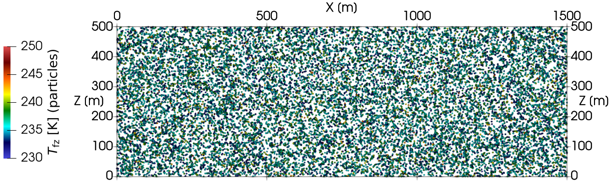
JAGIELLONIAN UNIVERSITY IN KRAKÓW

Caltech

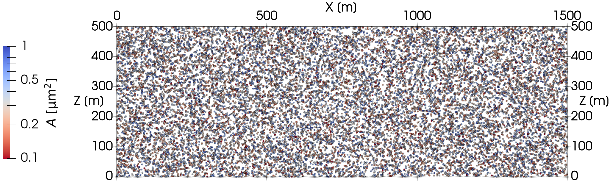
ILLINOIS

Monte-Carlo immersion freezing: singular vs. time-dependent

singular Monte-Carlo (as in Shima et al. '20)

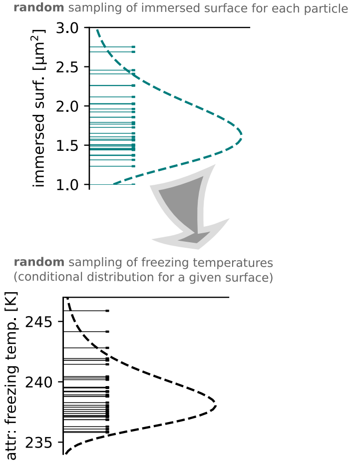


time-dependent Monte-Carlo (as in Alpert & Knopf '16)



Monte-Carlo immersion freezing: singular vs. time-dependent

particle attribute sampling



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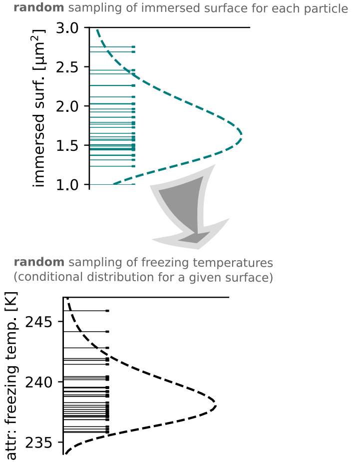
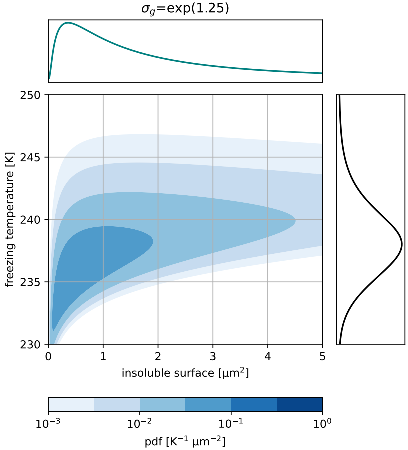
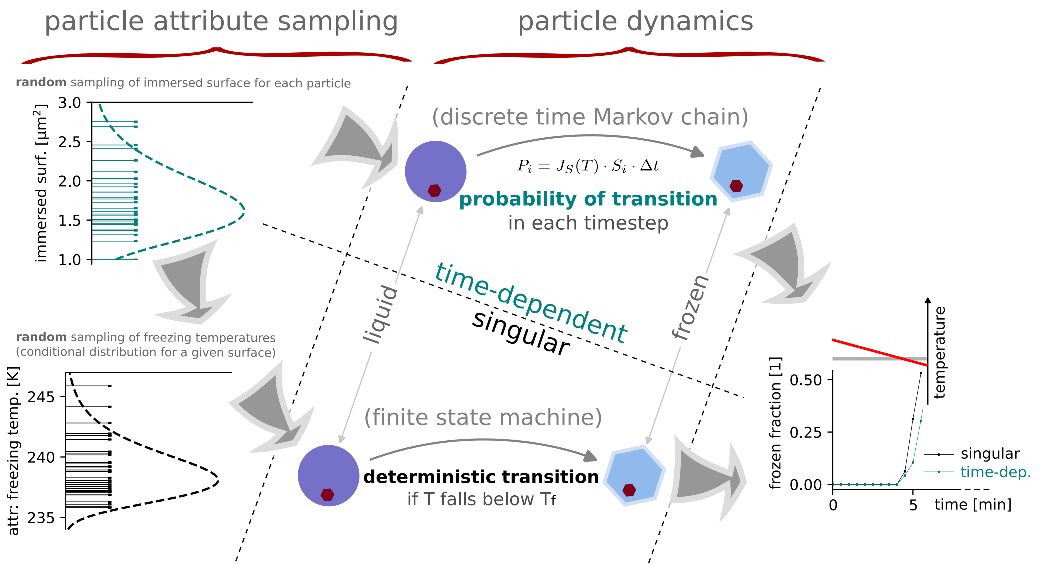


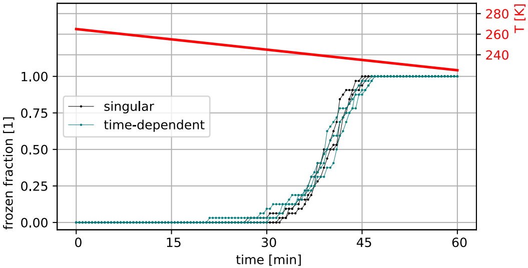
for singular: sampling from INAS-derived pdf

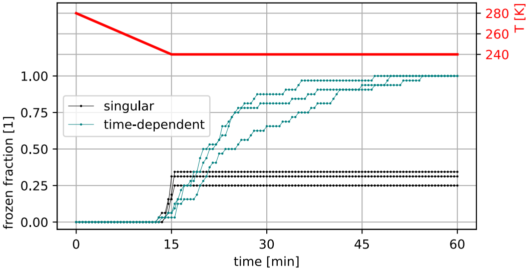


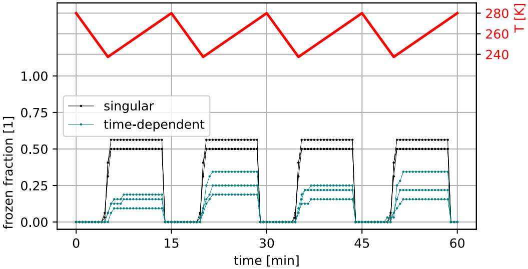
Monte-Carlo immersion freezing: singular vs. time-dependent



cooling-rate response (box model): singular vs. time-dependent

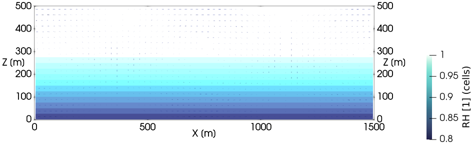






cooling-rate response (2D flow): singular vs. time-dependent

$w_{max} \approx 1/3$ m/s



$w_{max} \approx 1$ m/s

$w_{max} \approx 3$ m/s

cooling-rate response (2D flow): singular vs. time-dependent

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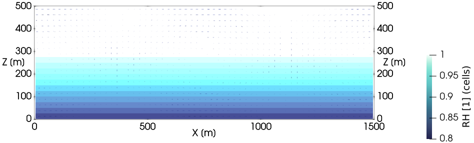

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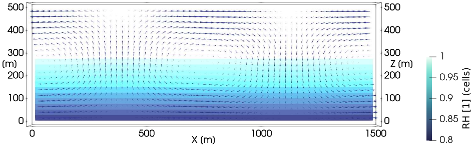

$w_{max} \approx 3$ m/s

cooling-rate response (2D flow): singular vs. time-dependent

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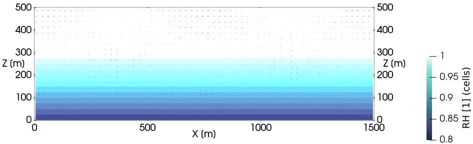

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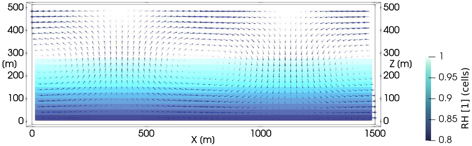
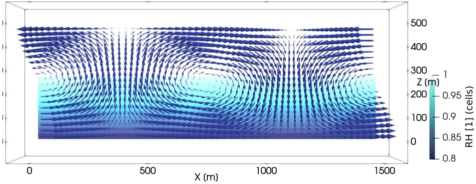
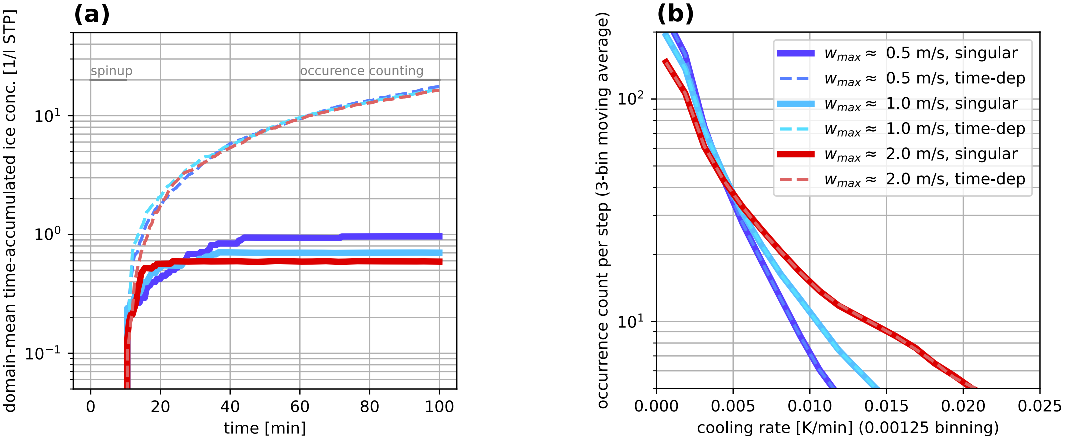


$w_{max} \approx 3$ m/s



cooling-rate response (2D flow): singular vs. time-dependent



- singular vs. time-dependent markedly different (as in box model for $c \ll 1K/min$)

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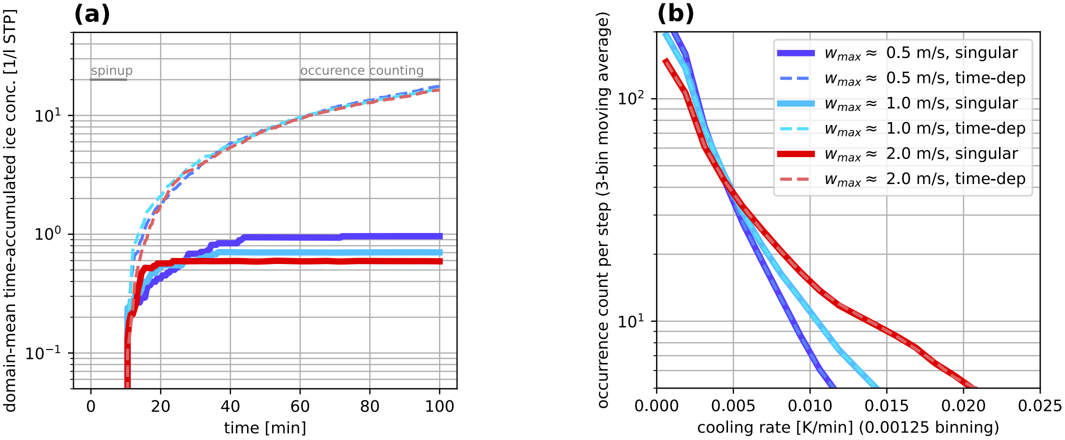

- singular vs. time-dependent markedly different (as in box model for $c \ll 1K/min$)
- diverse cooling rates even in a simple flow (far from $c \sim 1$ K/min for AIDA)

stay tuned: Arabas et al. 2023
(in prep.; e-print uploaded to arXiv)

100% Python & open-source: github.com/open-atmos

contact:
sylwester.arabas@agh.edu.pl