PySDM: current/future features and how to get involved as a contributor!

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PySDM contributors:
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Jan 26 2024

Columbia University, New York

context: aerosol-cloud-precipitation interactions (scales!)

"Cloud and ship. Ukraine, Crimea, Black sea, view from Ai-Petri mountain"

(photo: Yevgen Timashov / National Geographic)

Confronting the Challenge of Modeling Cloud and Precipitation Microphysics

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AGU ADVANCING EARTH AND SPACE SCIENCE
Journal of Advances in Modeling Earth Systems 10.1029/2019MS001689

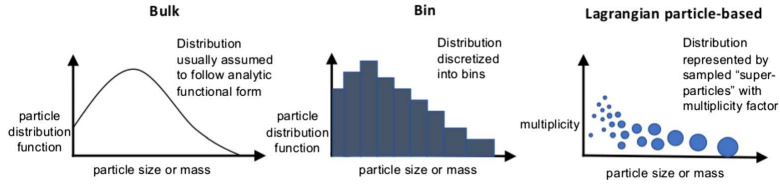


Figure 3. Representation of cloud and precipitation particle distributions in the three main types of microphysics

super-particles: example 2D kinematic Sc test (Morrison & Grabowski '07)

2D flow field

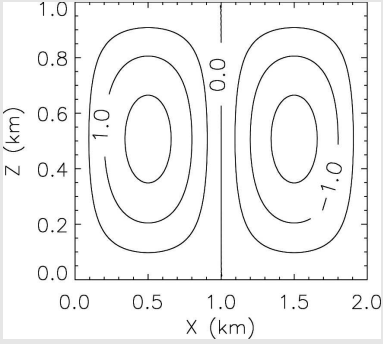
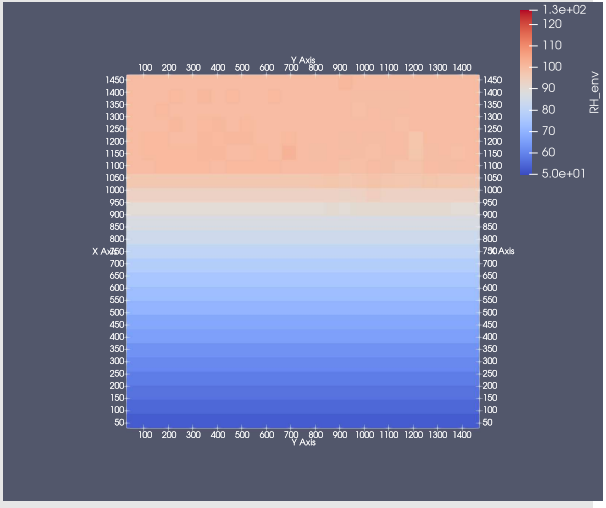
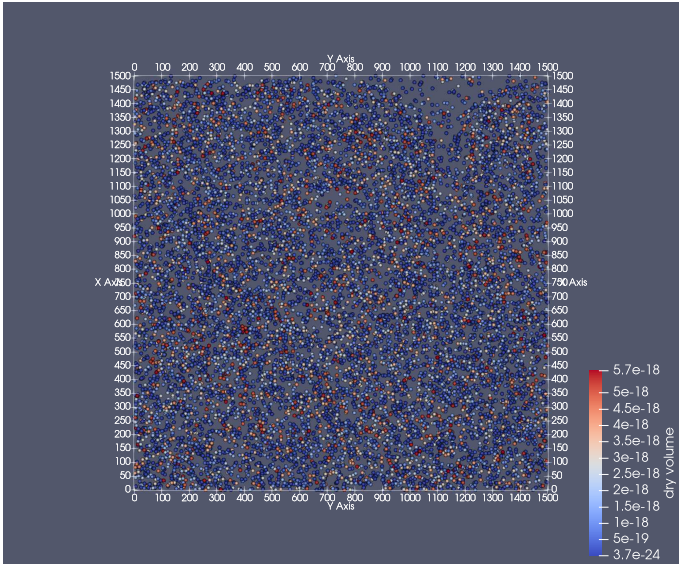


FIG. 1. Time-invariant vertical velocity for the stratocumulus case (contour interval is 0.5 m s^{-1}).

RH profile at t=0



super-particle attribute initialisation: dry/wet volume



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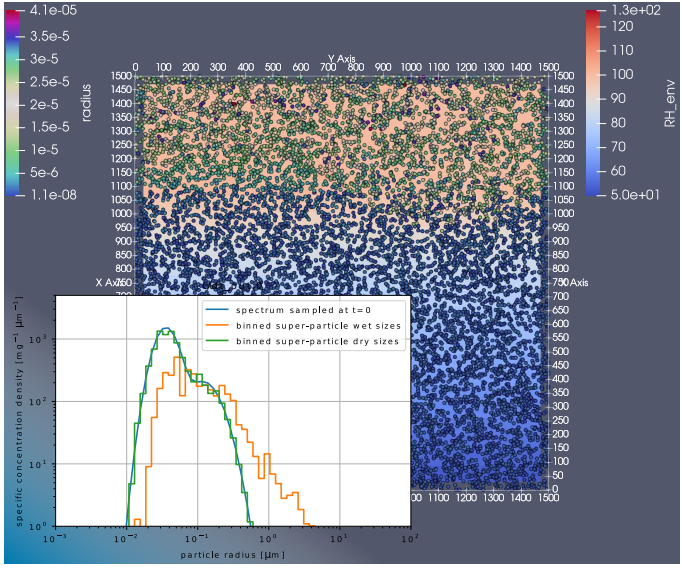
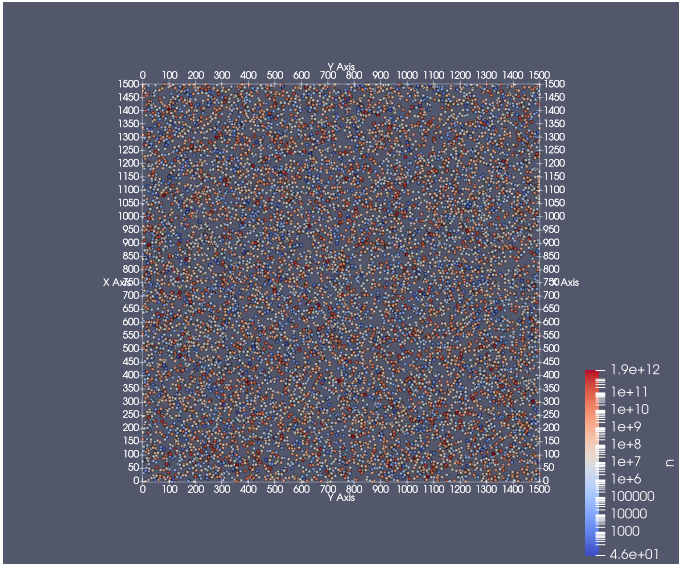
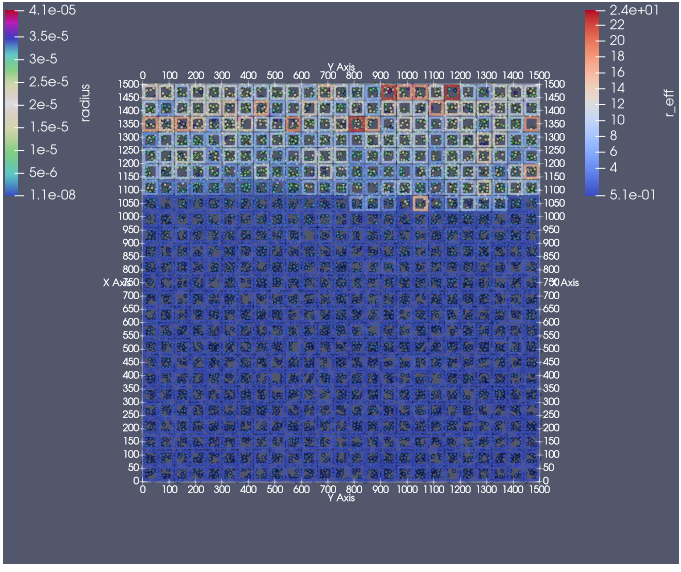


super-particle attribute initialisation: multiplicity



super-particle attribute evolution (droplet radius) and "products"



SDM

PySDM

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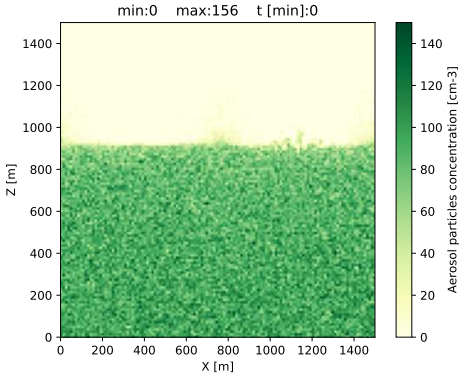
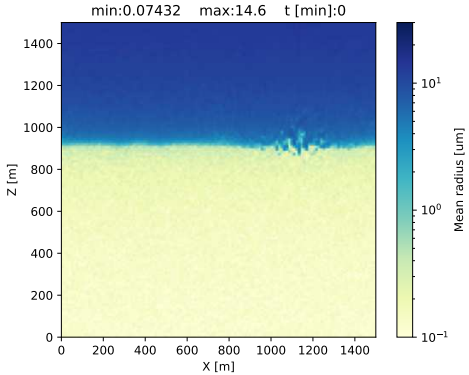
  KPI: instant and anonymous execution on commodity environment

sample aerosol-cloud-precipitation interactions simulation

Computational grid: 128x128

Computational particles: 2^{21}





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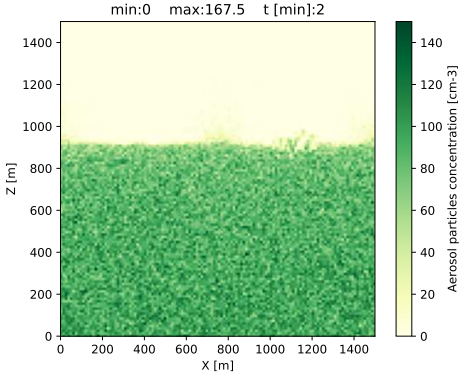

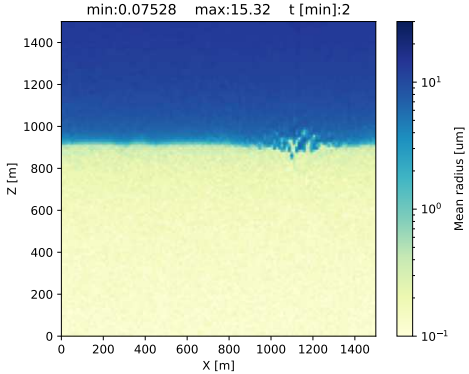

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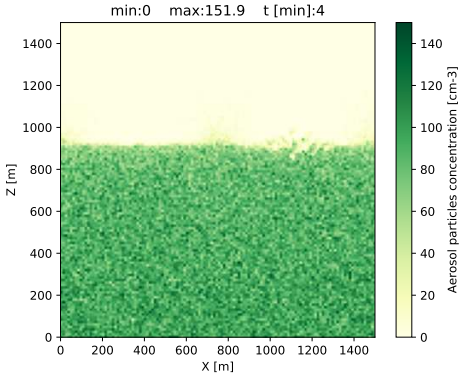

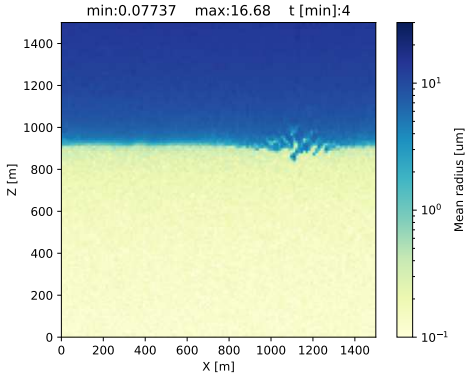

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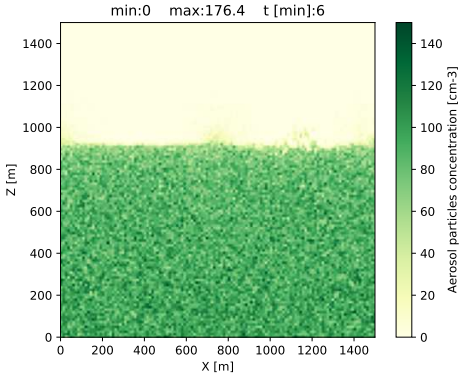

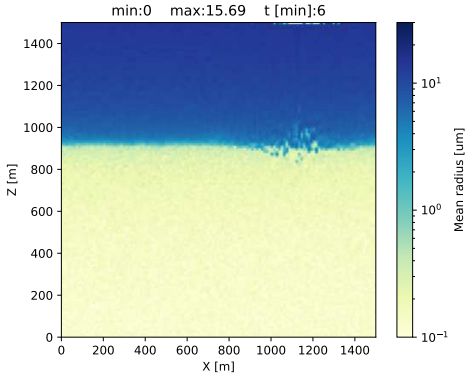

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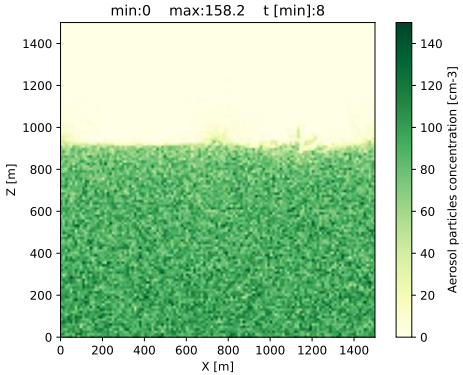

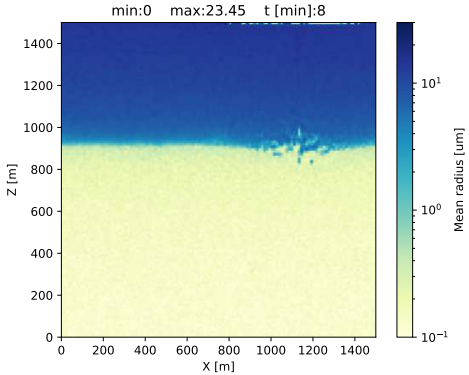

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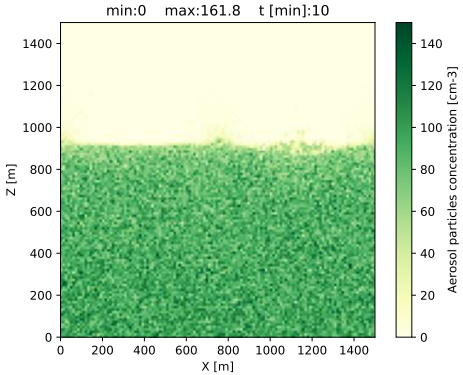

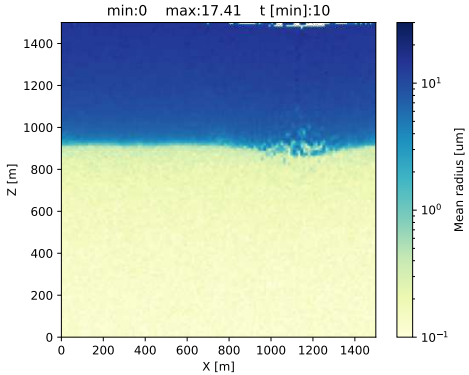

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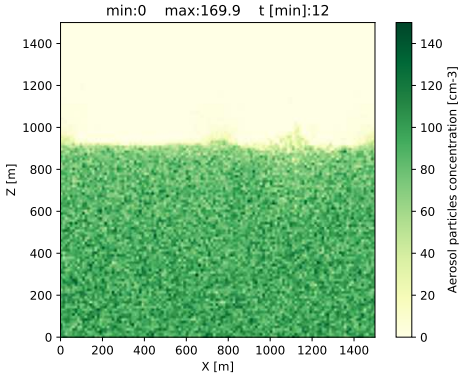

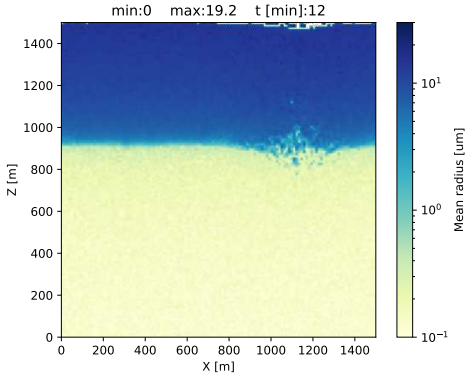

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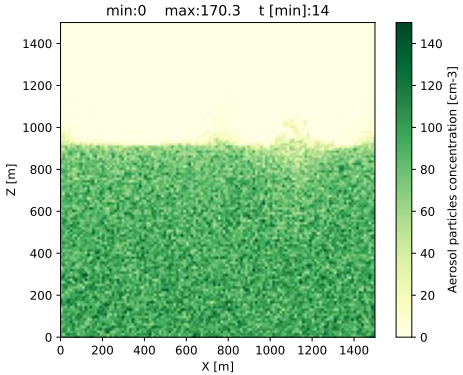

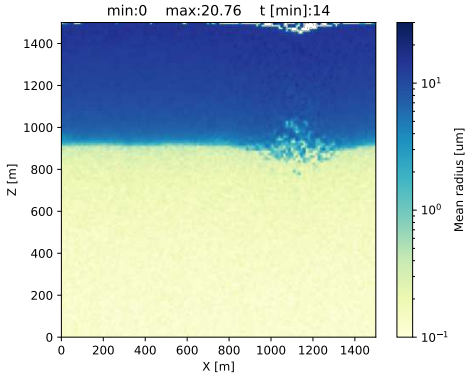

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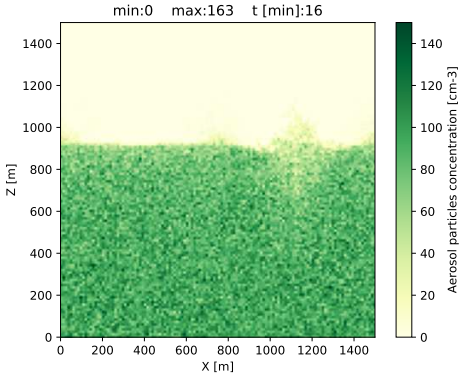

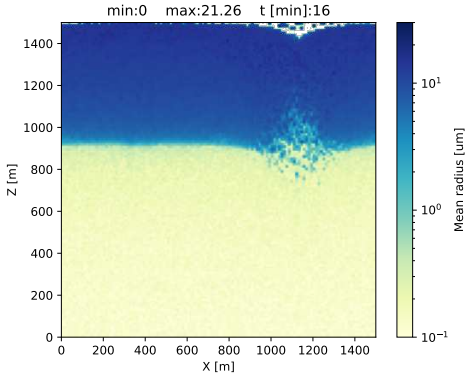

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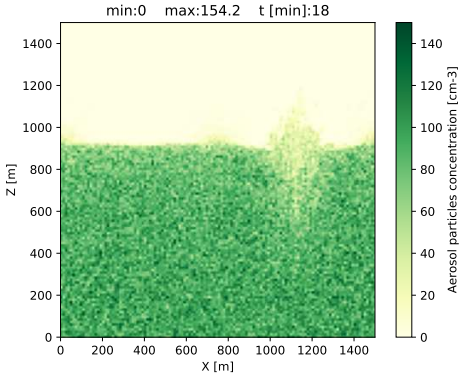

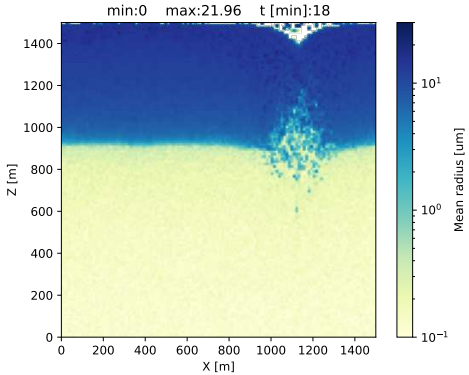

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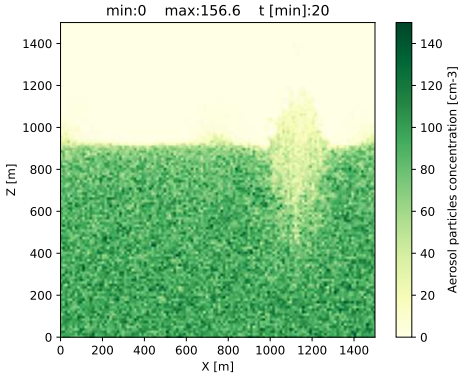

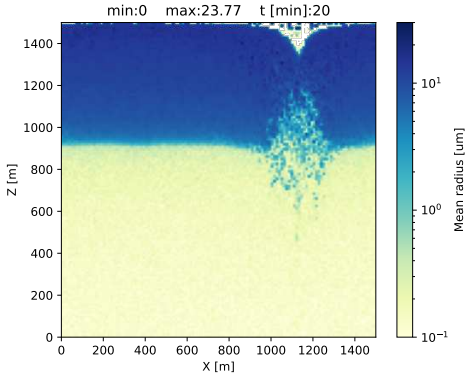

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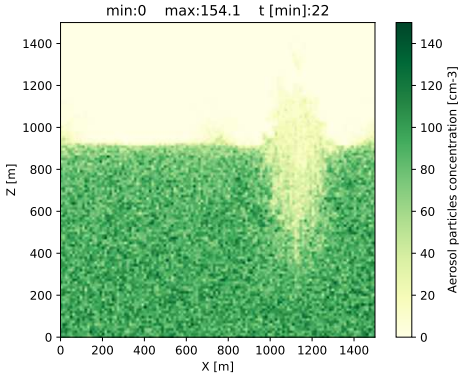

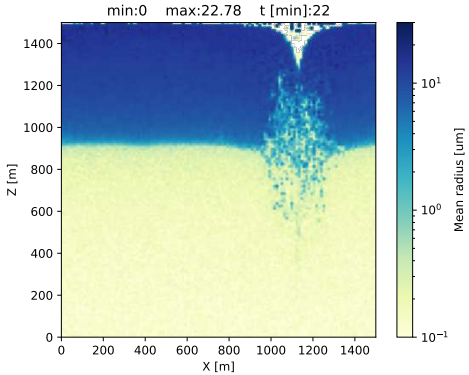

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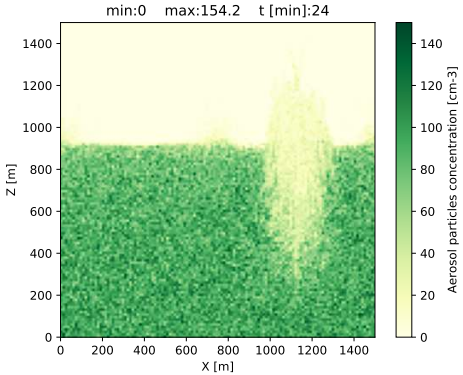

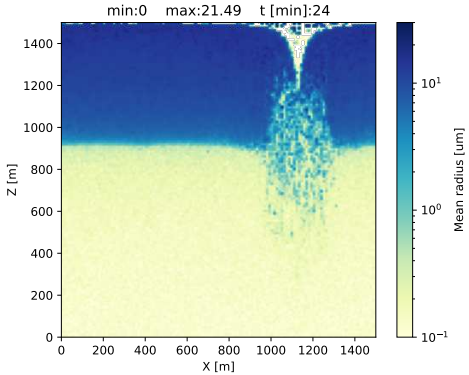

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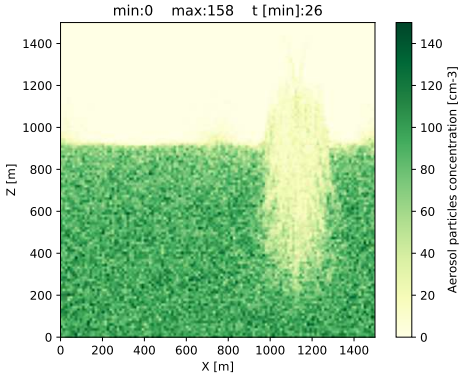

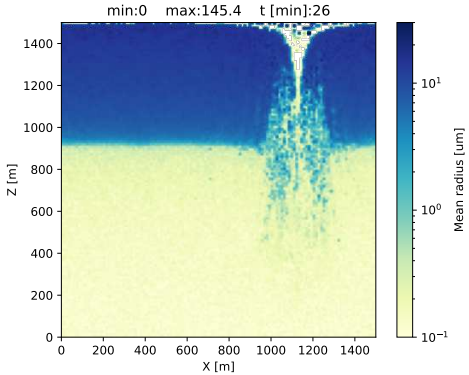

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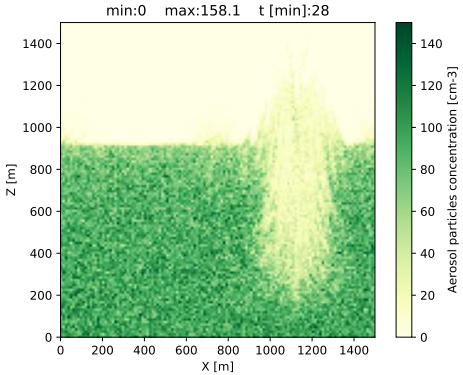

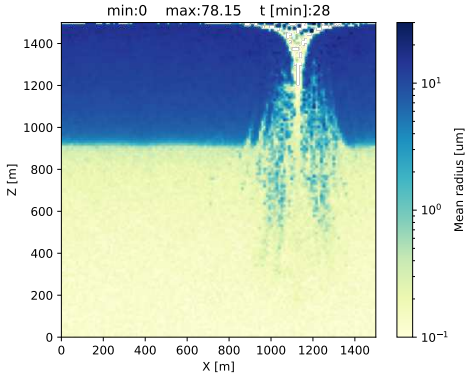

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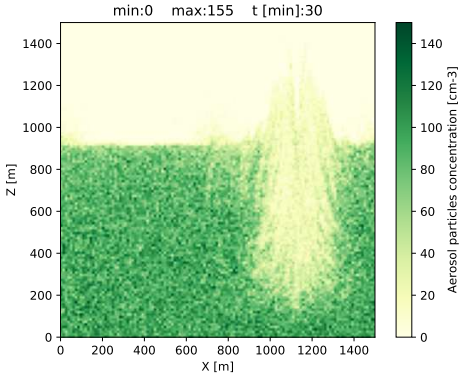

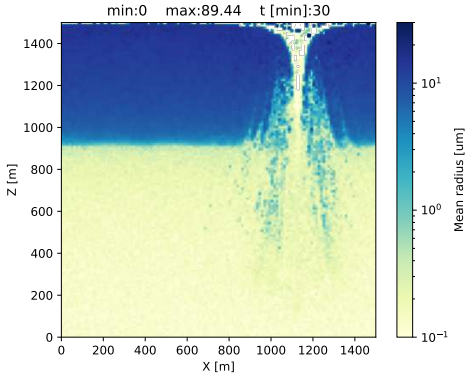

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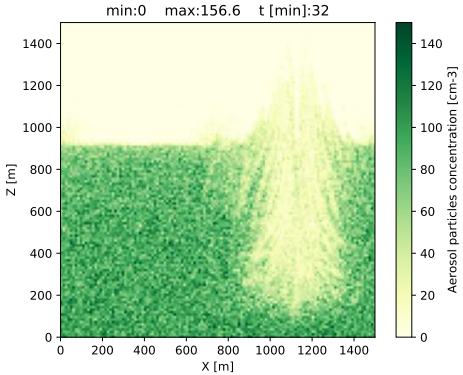

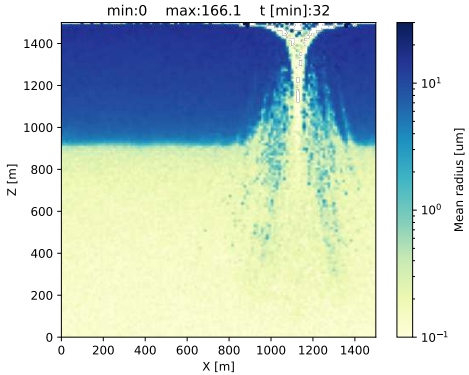

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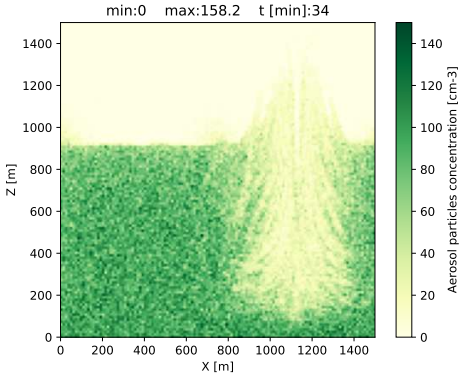

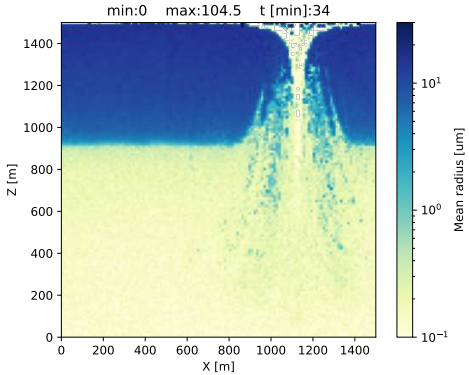

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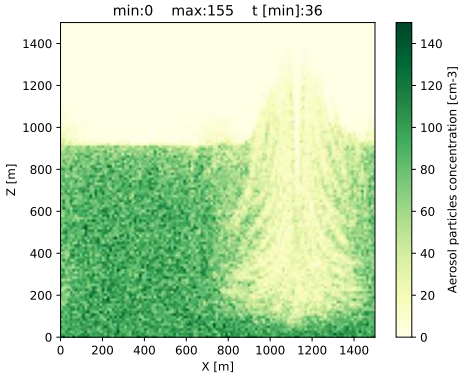

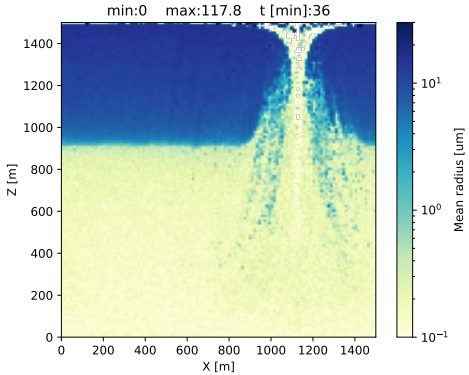

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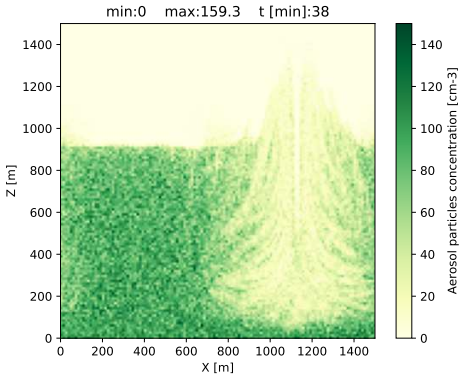

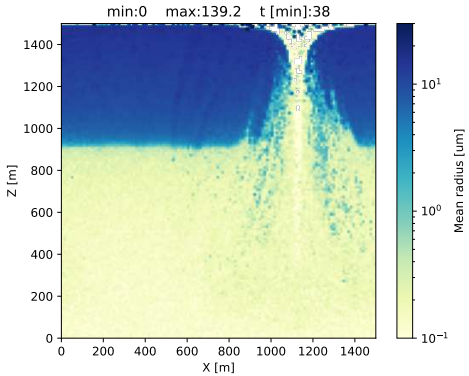

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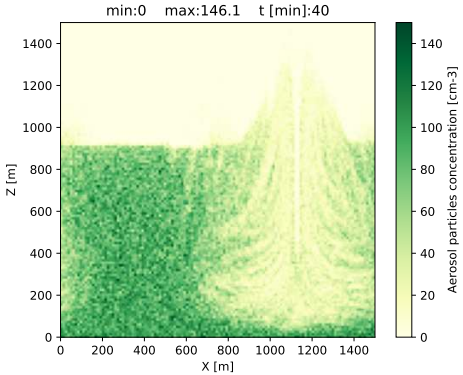
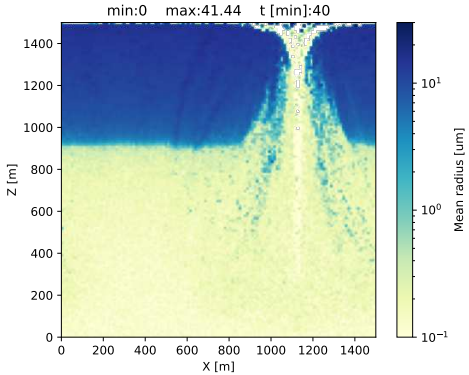
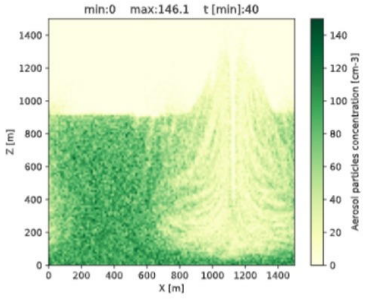
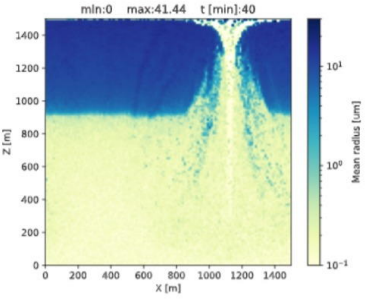




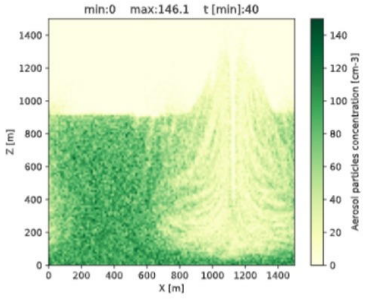
PySDM:

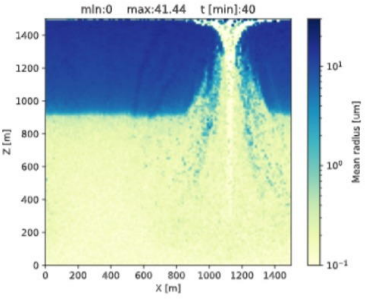

min:0 max:146.1 t [min]:40
Z [m]
X [m]
Aerosol particles concentration [cm-3]


min:0 max:41.44 t [min]:40
Z [m]
X [m]
Mean radius [μm]

PySDM: Pythonic

```
[3]   1 simulation.run()
```





PySDM: Pythonic, Jupyter-friendly

demo.ipynb

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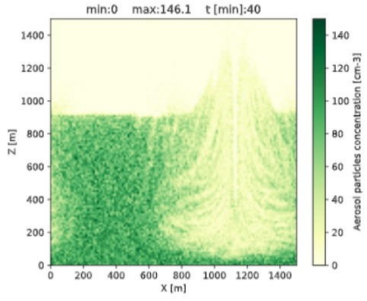
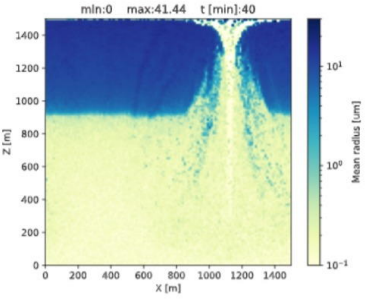
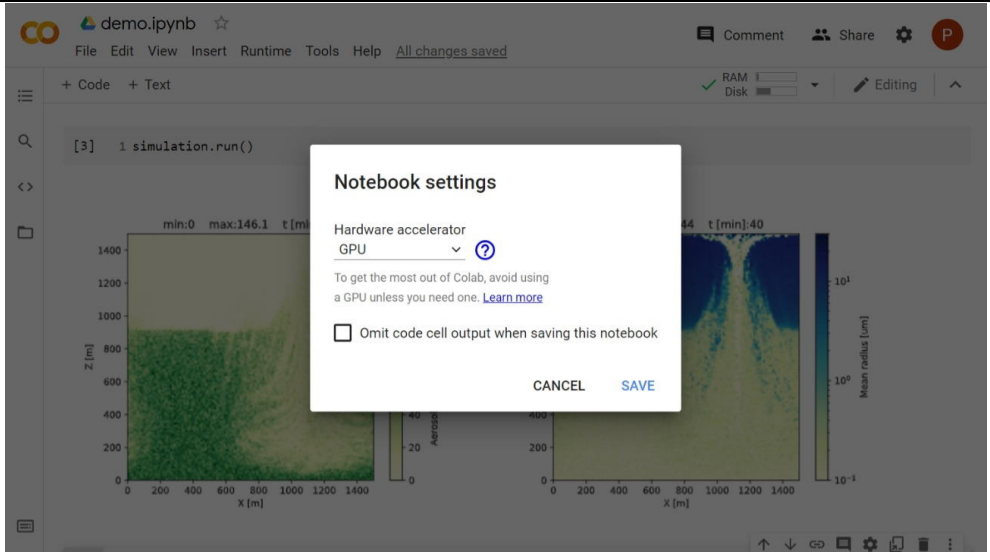
```
[3]  1 simulation.run()
```

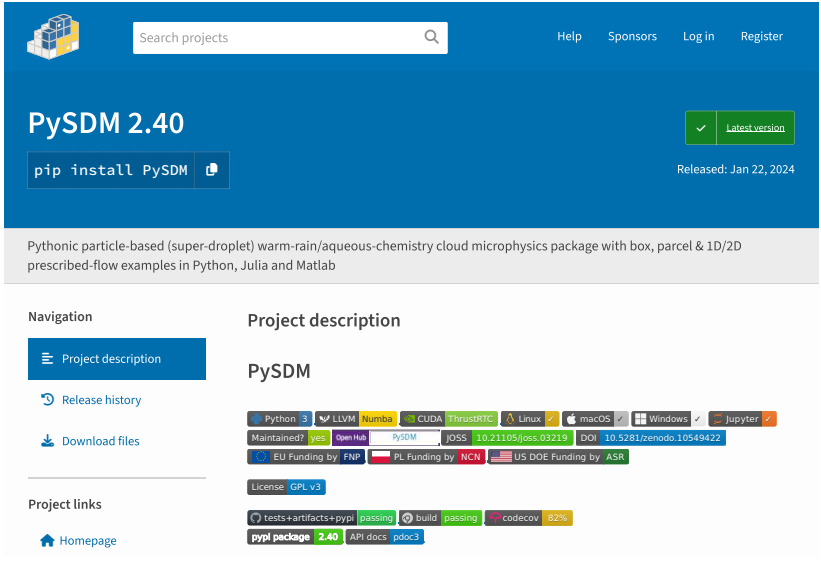




PySDM: Pythonic, Jupyter-friendly, GPU-enabled



PySDM: packages



PySDM: users

PySDM v1: particle-based cloud modelling package for warm-rain microphysics and aqueous chemistry

Search within citing articles

An Efficient Bayesian Approach to Learning Droplet Collision Kernels: Proof of Concept Using “Cloudy,” a New *n*-Moment Bulk Microphysics Scheme

M Bieli, ORA Dunbar, EK De Jong… - Journal of Advances …, 2022 - Wiley Online Library

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PyPartMC is a Pythonic interface to PartMC, a stochastic, particle-resolved aerosol model implemented in Fortran. Both PyPartMC and PartMC are free, libre, and open-source …

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E de Jong, JB Mackay, A Jaruga, S Arabas - EGUsphere, 2022 - egusphere.copernicus.org

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

S Arabas, JH Curtis, I Silber, A Fridlind… - arXiv preprint arXiv …, 2023 - arxiv.org

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Spanning the gap from bulk to bin: A novel spectral microphysics method

EK De Jong, T Bischoff, A Nadim… - Journal of Advances in …, 2022 - Wiley Online Library

Microphysics methods for climate models and numerical weather prediction typically track one, two, or three moments of a droplet size distribution for various categories of liquid, ice …

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coupling with an external CFD code (Oleksii Bulenok) (https://github.com/CliMA/ClimateMachine.jl/pull/2244)

PySDM and ClimateMachine coupling examples in Kinematic setup #2244

Code

Open **abulenok** wants to merge 16 commits into `CliMA:master` from `abulenok:ob-pysdmachine`

Conversation 32 | Commits 16 | Checks 10 | Files changed 17 | +2,528 −1

abulenok commented on 27 Oct 2021 — Contributor

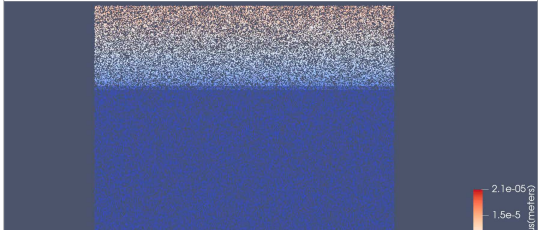
This PR includes a coupling logic for ClimateMachine.jl and PySDM.

PySDM is a particle-based aerosol/cloud microphysics package written entirely in Python.
This PR depicts how Python modules can be leveraged within ClimateMachine.jl including the continuous integration setup.

The initial set of tests included here is based on the kinematic 2D example previously used as a test case in both PySDM and ClimateMachine.jl. In the tests added in this PR, ClimateMachine.jl handles air motion and total water transport, while PySDM handles representation of aerosol and liquid water transport as well as phase changes leading to formation of cloud water.

Output from PySDM is handled using VTK files. Example animation with an evolution of radius computed from particle properties is shown below:

output.mp4



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slayoo
charleskawczynski
claresinger
jakebolewski
edejong-caltech
tapios

Assignees
trontrytel

Labels
Microphysics

Projects
None yet

Milestone
No milestone

Development
Successfully merging this pull request may close these issues.
None yet

Literature Reference	Cond/Evap	Collisions	Isotopes	Breakup	Transport	Chemistry	Freezing	Comments/keywords
no-environment								
Pierchala et al. 2022			×					theoretical curves for a lab experiment
OD box environment								
Shima et al. 2009		×						Golovin kernel example
Berry 1967		×						Several different kernels
Bieli et al. 2022		×		×				
de Jong et al. 2023		×		×				
Alpert & Knopf 2016							×	
OD parcel environment								
Kreidenweis et al. 2003	×					×		"Hoppel" gap
Jaruga & Pawlowska 2018	×					×		"Hoppel" gap
Lowe et al. 2019	×							surfactants
Yang et al. 2018	×							ripening (depending on the definition)
Graf et al. 2019	×		×					
Grabowski and Pawlowska 2023	×							ripening (not named so in the paper)
Arabas and Shima 2017	×							monodisperse, activation/deactivation cycle
Abdul-Razzak & Ghan 2000	×							parcel vs. activation parameterisation
1D single-column kinematic env.								
Shipway & Hill 2012	×	×			×			KiD 1D
deJong et al. 2023 (figures 6-8)	×	×		×	×			
2D prescribed-flow environment								
Arabas et al. 2015	×	×			×			includes GUI
Arabas et al. 2023 (figure 11)	×	×			×		×	Paraview script example

contributions welcome!

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- new examples (incl. "smoke tests")

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- last but not least: logo :) (also for PyMPDATA)
- could we organise a PySDM hackathon/workshop/school/...?

Thank you!

github.com/open-atmos/PySDM

Funding:

- Foundation for Polish Science
- Polish National Science Centre
- DoE ASR
- Eric and Wendy Schmidt & Heising-Simons Foundation
- ...