On the droplet spectral broadening numerics

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background

- super-droplet vs. bin μ-physics
- spectral broadening numerics:
  - bin (Eulerian-in-size):
    -numerical diffusion
    -no activation-related attr.
  - SD (Lagrangian-in-size):
    -spectral sampling issues
    -stiff equations (activation)
  - general:
    -incorporation of fluctuations

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    -incorporation of fluctuations
- trigger and focus for today: Morrison et al. 2018 (bin condensation using MPDATA vs. Lagrangian numerics)

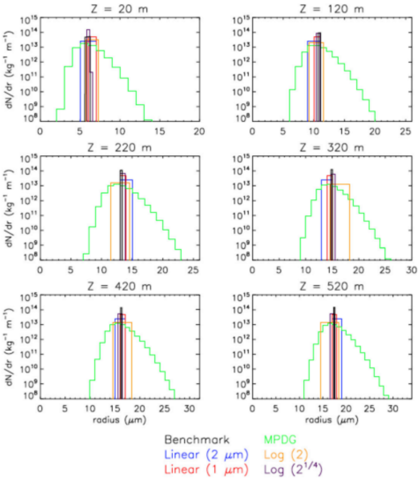


FIG. 7. Drop size distributions at various heights z from the Lagrangian microphysical benchmark (black) and the bin model simulations (colored lines) for the parcel test with a bulk drop number mixing ratio of 50 mg^{-1}. Different colored lines illustrate results using different bin mass grid configurations and growth methods, as listed in Table 1.

MPDATA & MPyDATA

https://github.com/atmos-cloud-sim-uj/MPyDATA

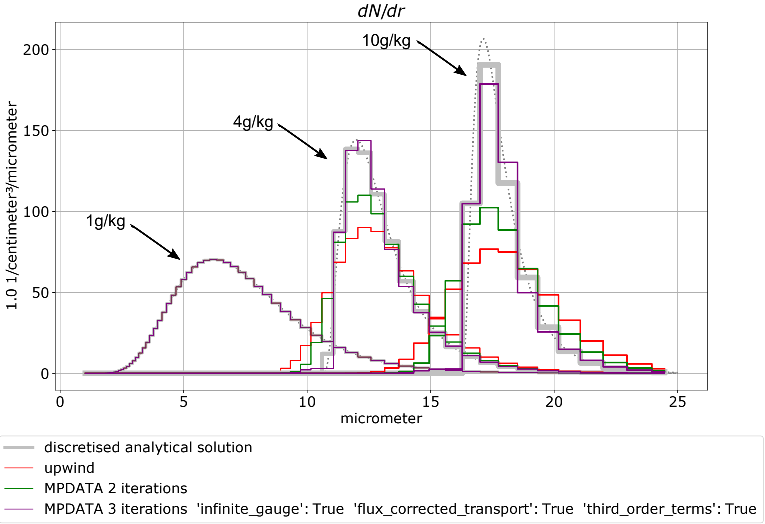
README.md

build passing coverage 70%

MPyDATA

MPyDATA is a high-performance **Numba-accelerated Pythonic implementation of the MPDATA algorithm of Smolarkiewicz et al.** for numerically solving generalised transport equations - partial differential equations used to model conservation/balance laws, scalar-transport problems, convection-diffusion phenomena (in geophysical fluid dynamics and beyond). As of the current (early) version, MPyDATA supports homogeneous transport in 1D and 2D using structured meshes, optionally generalised by employment of a Jacobian of coordinate transformation. MPyDATA includes implementation of a set of MPDATA **variants including flux-corrected transport (FCT), infinite-gauge, divergent-flow and third-order-terms options.** It also features support for integration of Fickian-terms in advection-diffusion problems using the pseudo-transport velocity approach. No domain-decomposition parallelism supported yet.

$$\partial_t(Gn_p) + \partial_x(\dot{x}Gn_p) = 0, \quad G(r) \equiv \det(Dp(r)/Dx(r)) = \frac{dp}{dx}$$



mass doubling grid: $p = \log_2(r^3)$, and surface-proportional coordinate: $x = r^2$

Lessons learned and prospects

- three-pass infinite gauge variant of MPDATA is a game-changer here
- proper handling of spectrum coordinate and grid layout matters
- next steps:
  - convergence analysis with different error measures
  - Lagrangian test case: ripening & fluctuations (PySDM)

End

Thank you for your attention!

To reproduce above plot (in the cloud) click in the link:
https://github.com/atmos-cloud-sim-uj/MPyDATA

MPyDATA ships with several demos that reproduce results from the literature, including:

- Smolarkiewicz 2006 Figs 3,4,10,11 & 12 launch binder
  (1D homogeneous cases depicting infinite-gauge and flux-corrected transport cases)
- Arabas & Farhat 2020 Figs 1-3 & Tab. 1 launch binder
  (1D advection-diffusion example based on Black-Scholes equation)
- Olesik, Bartman et al. 2020 (in preparation) launch binder
  (1D particle population condensational growth problem with coordinate transformations)
- Molenkamp test (as in Jaruga et al. 2015, Fig. 12) launch binder
  (2D solid-body rotation test)