Simulating idealized supercells with the newest P3 v5 scheme

Recoupling a microphysics scheme with ICON in an open & sustainable way

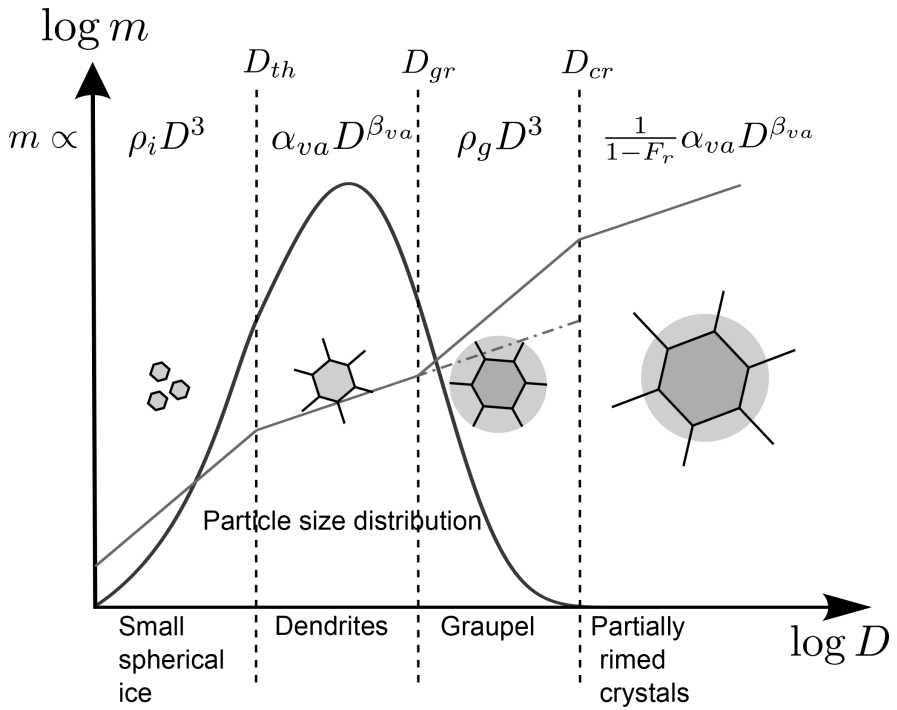
1) Marco Wurth, IMKTRO, KIT

2) Corinna Hoose, IMKTRO, KIT

3) Jason Milbrandt, ECCC

4) Melissa Cholette, ECCC

5) Hugh Morrison, NCAR



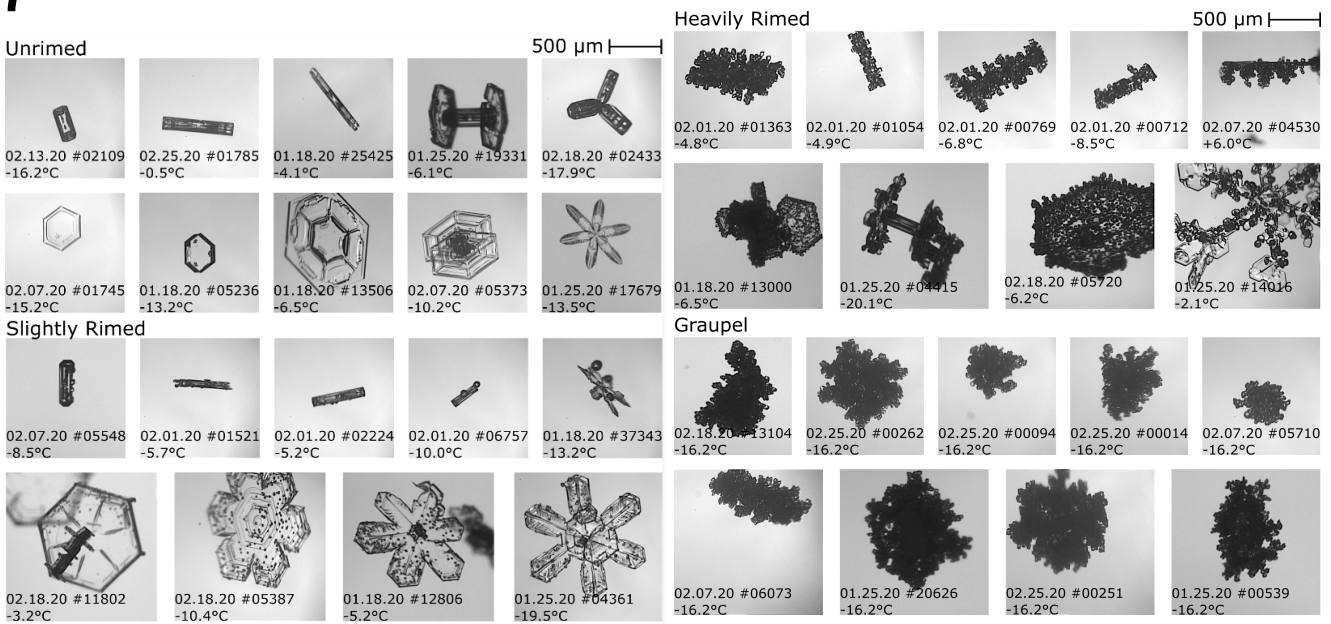
Multi - category

Liquid fraction

3-moment mixed-phase

Different Approaches in Describing the Ice Phase

Describing the ice **particle collective** with a few variables



[Waitz et al., 2022, ACP]

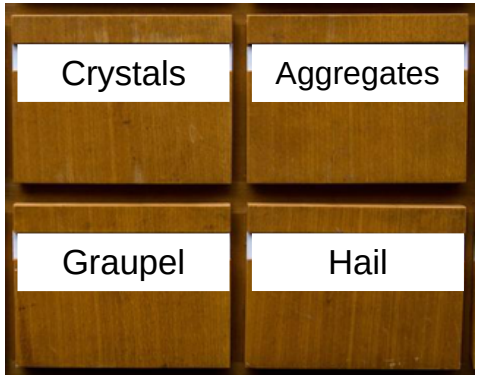
Different Approaches in Describing the Ice Phase

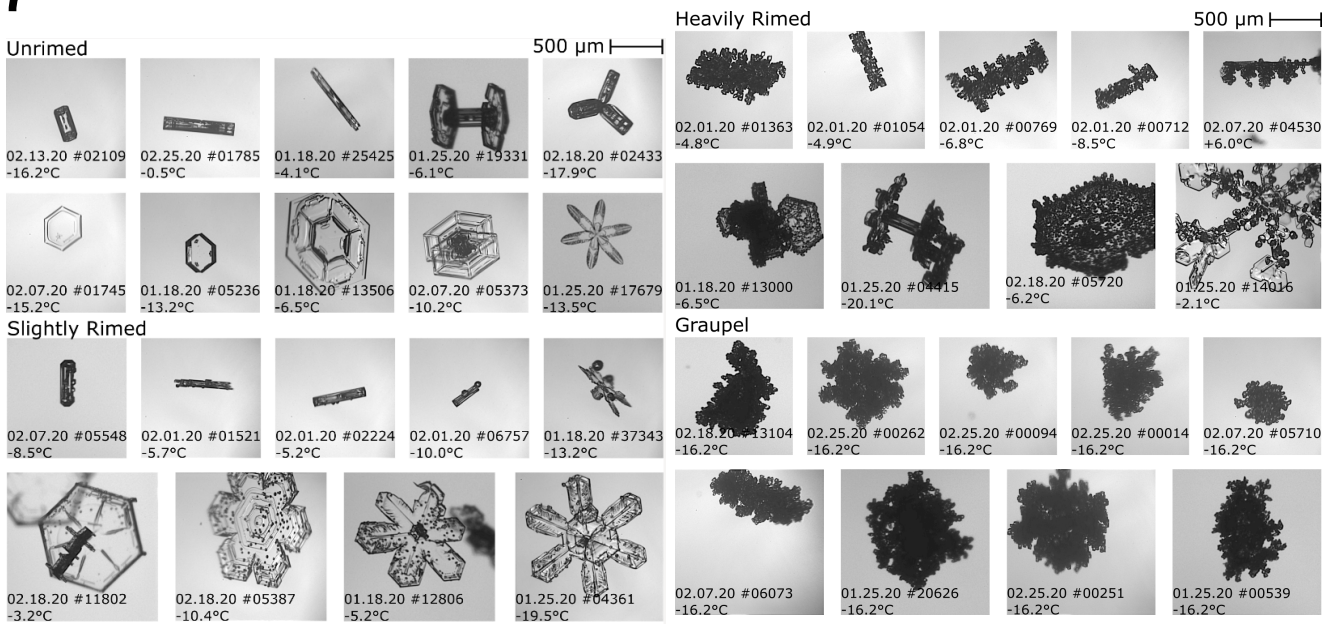
Classical 2-Moment Scheme

Classify

Describing the ice **particle collective** with a few variables

- Different ice types with fixed properties
- Flexible: number & mean size





[Waitz et al., 2022, ACP]

Different Approaches in Describing the Ice Phase

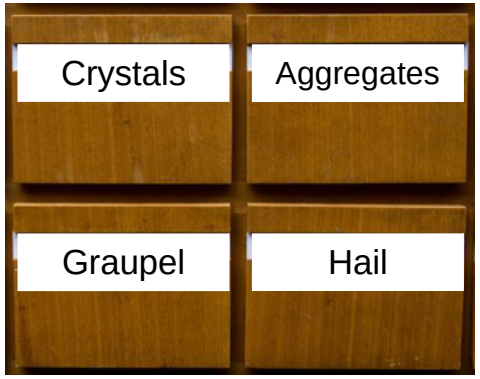
Describing the ice **particle collective** with a few variables

Classify → Classical 2-Moment Scheme

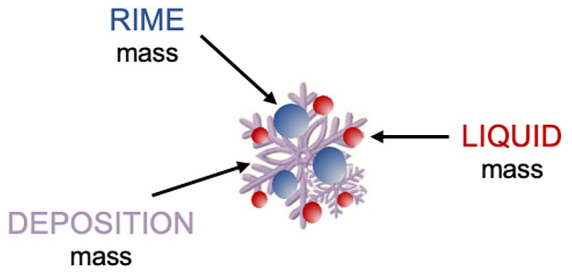
- Different ice types with fixed properties
- Flexible: number & mean size

Describe → Predicted Particle Properties (P3) Scheme

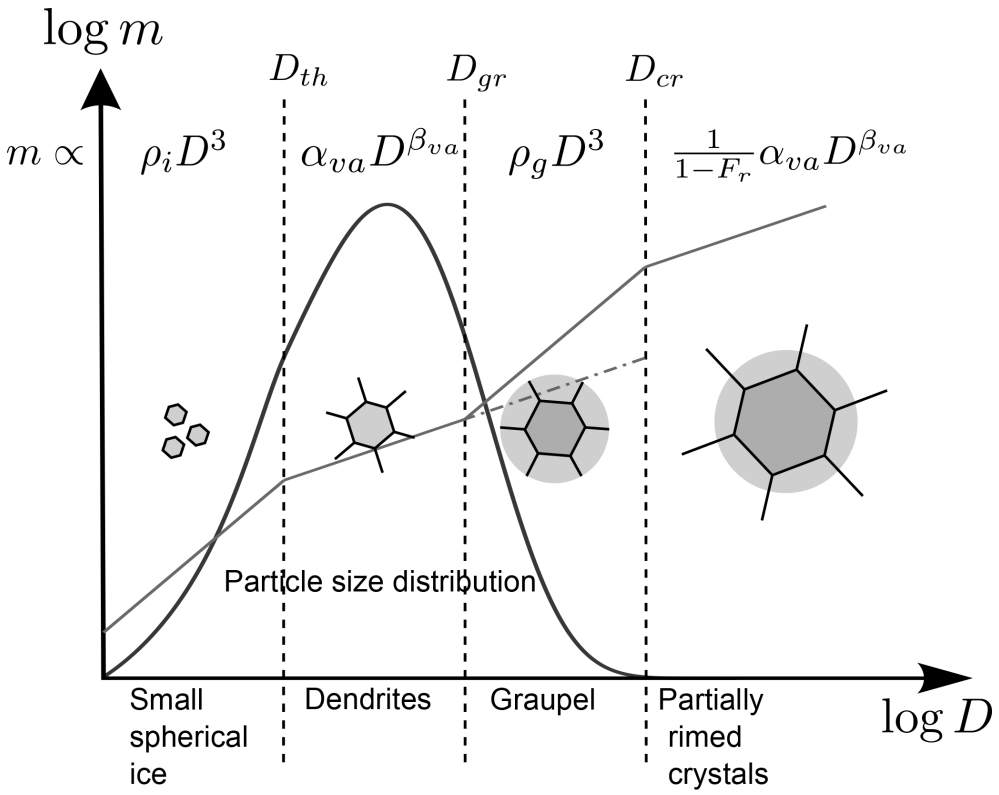
- “Free” ice
- Flexible: number & mean size + distribution shape + rime mass + rime density + liquid mass on ice [+ aspect ratio]



[Waitz et al., 2022, ACP]



P3's Approach in Describing the Ice Phase



[Dietlicher et al., 2018, GMD]

Predicted Particle Properties (P3) Scheme

- "Free" ice
- Flexible:
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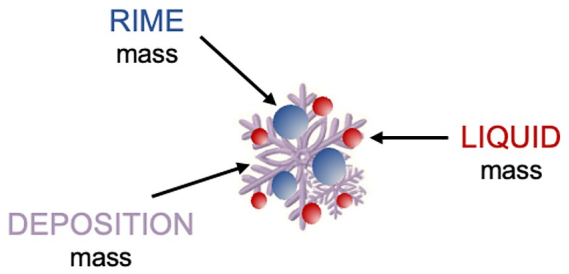
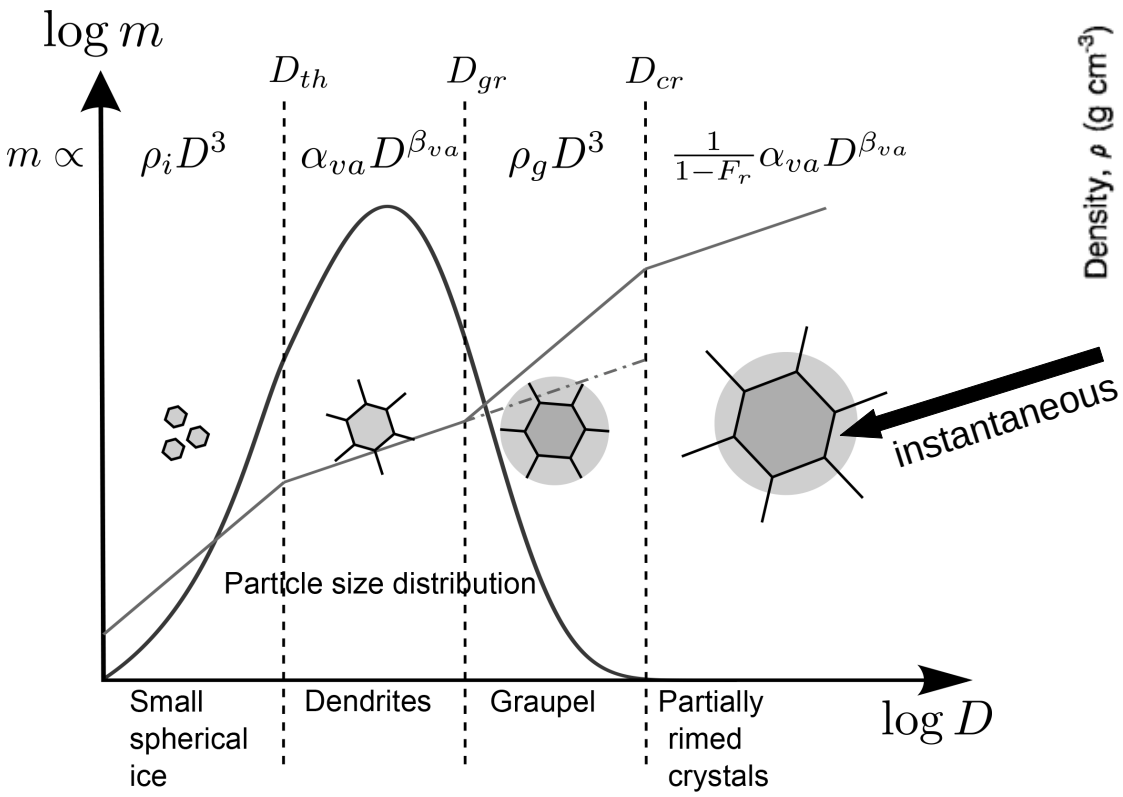
  [+ aspect ratio]

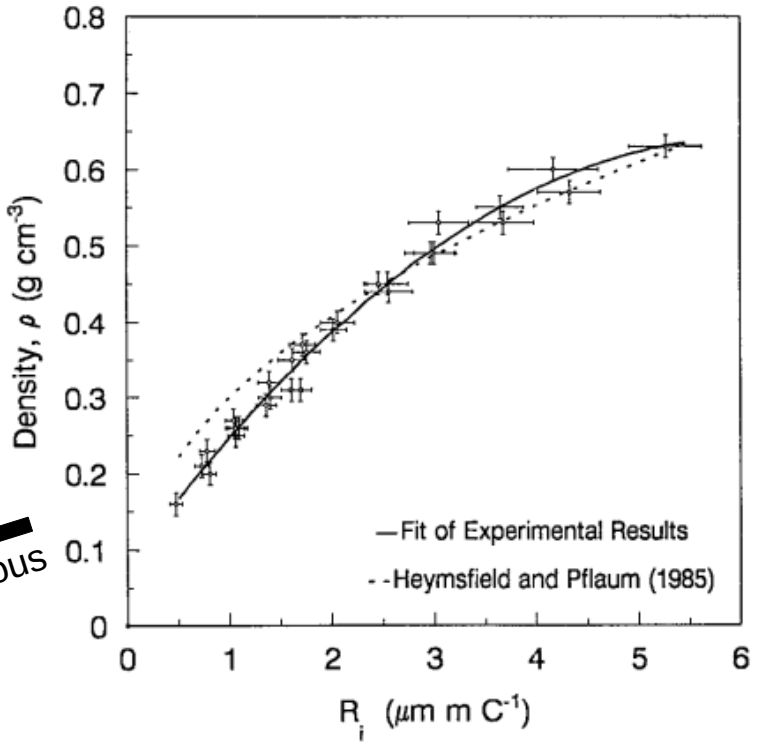


P3's Approach in Describing the Ice Phase



[Dietlicher et al., 2018, GMD]

[Cober and List, 1993, JAS]



instantaneous

$$R_i = -\frac{r_m V_i}{T_s}$$

Predicted Particle Properties (P3) Scheme

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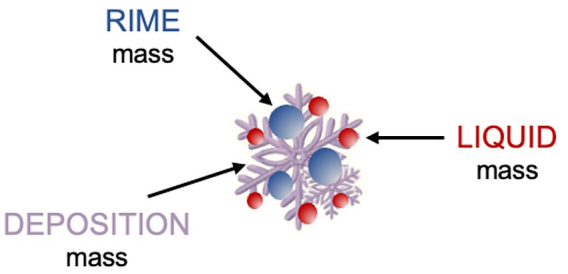

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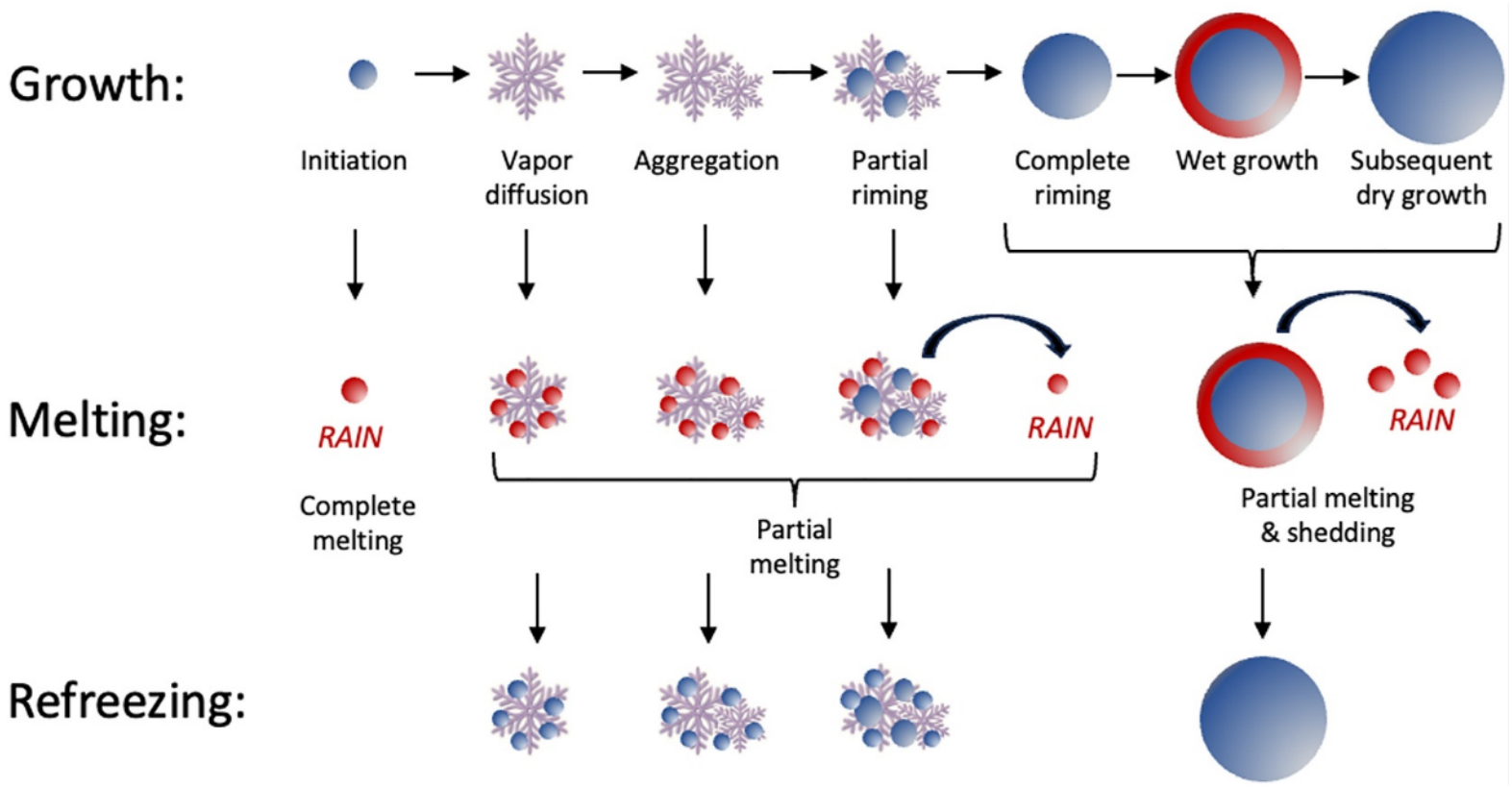

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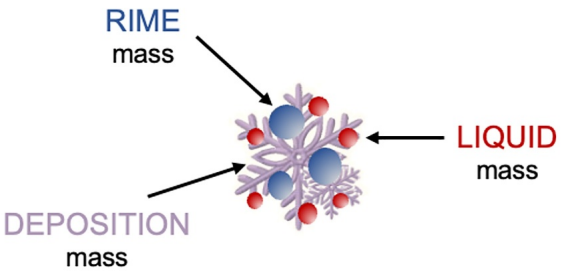


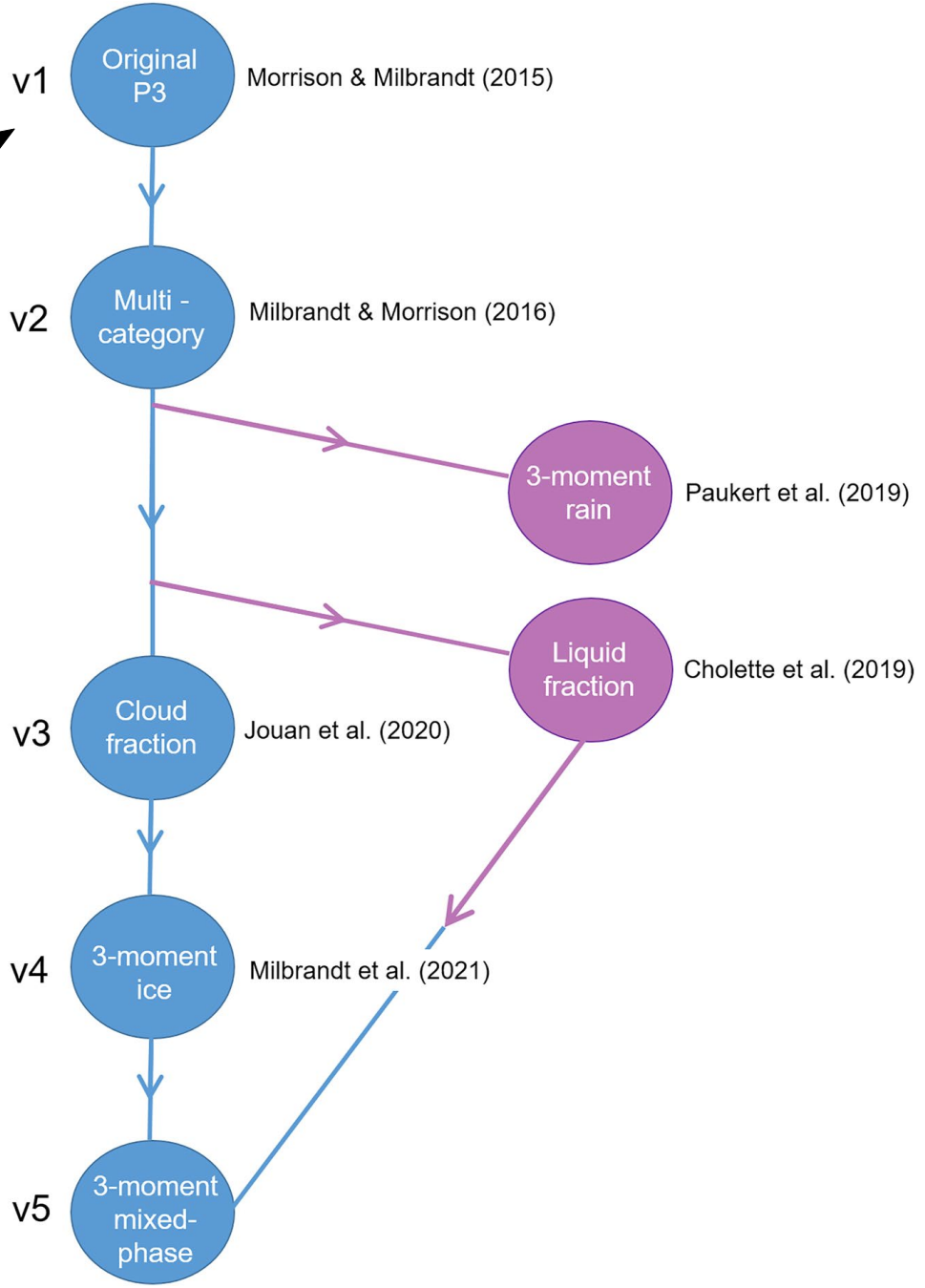
ICON + P3 v1 before

Juha Tontilla, Andrew Barrett (2016-2022):

→ Integration of P3 v1 into ICON in private branch

→ New P3 and new ICON versions

→ Reintegration needed



ICON + P3 v5 now

Juha Tontilla, Andrew Barrett (2016-2022):

→ Integration of P3 v1 into ICON in private branch

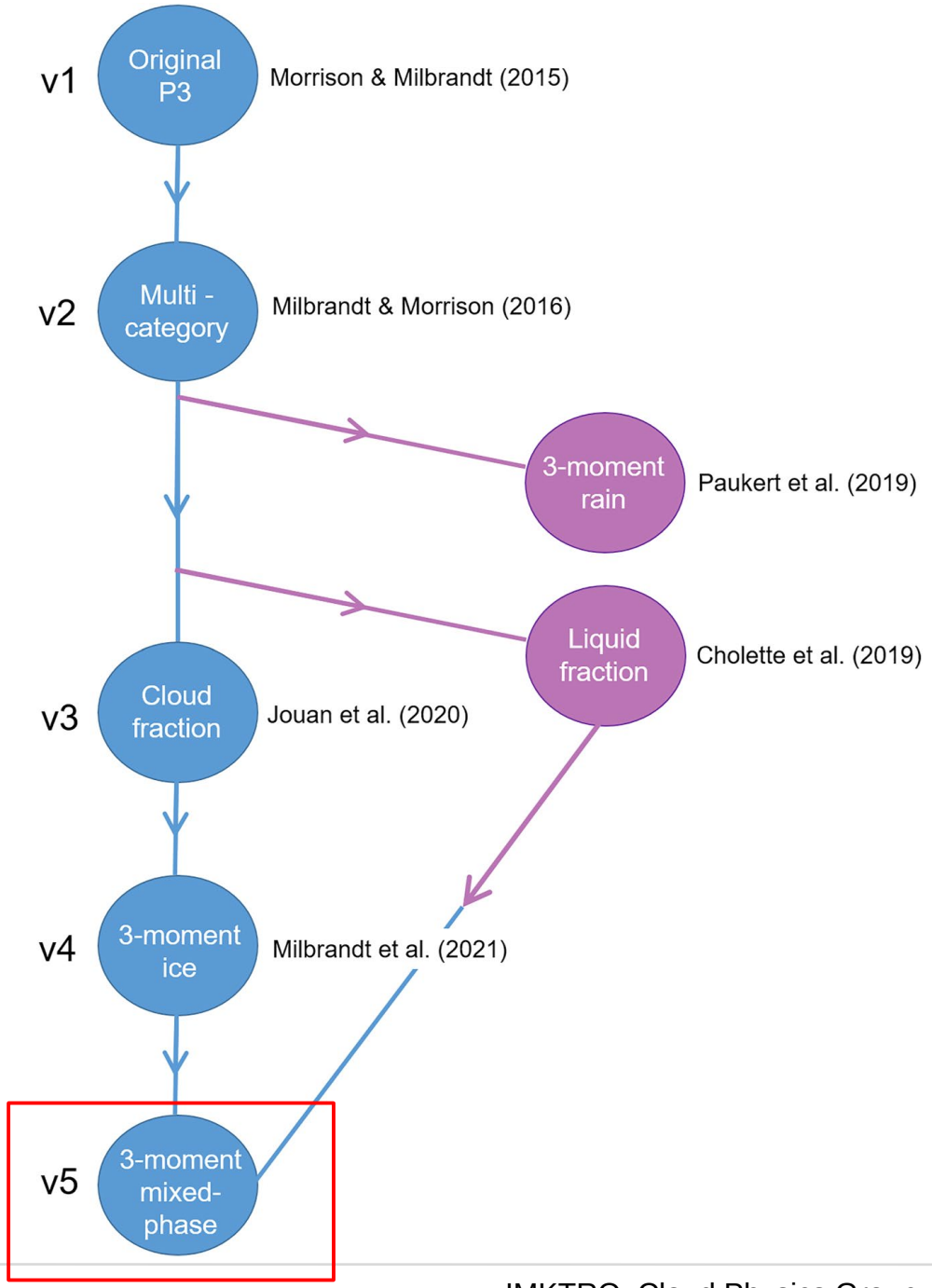
→ New P3 and new ICON versions

→ Reintegration needed

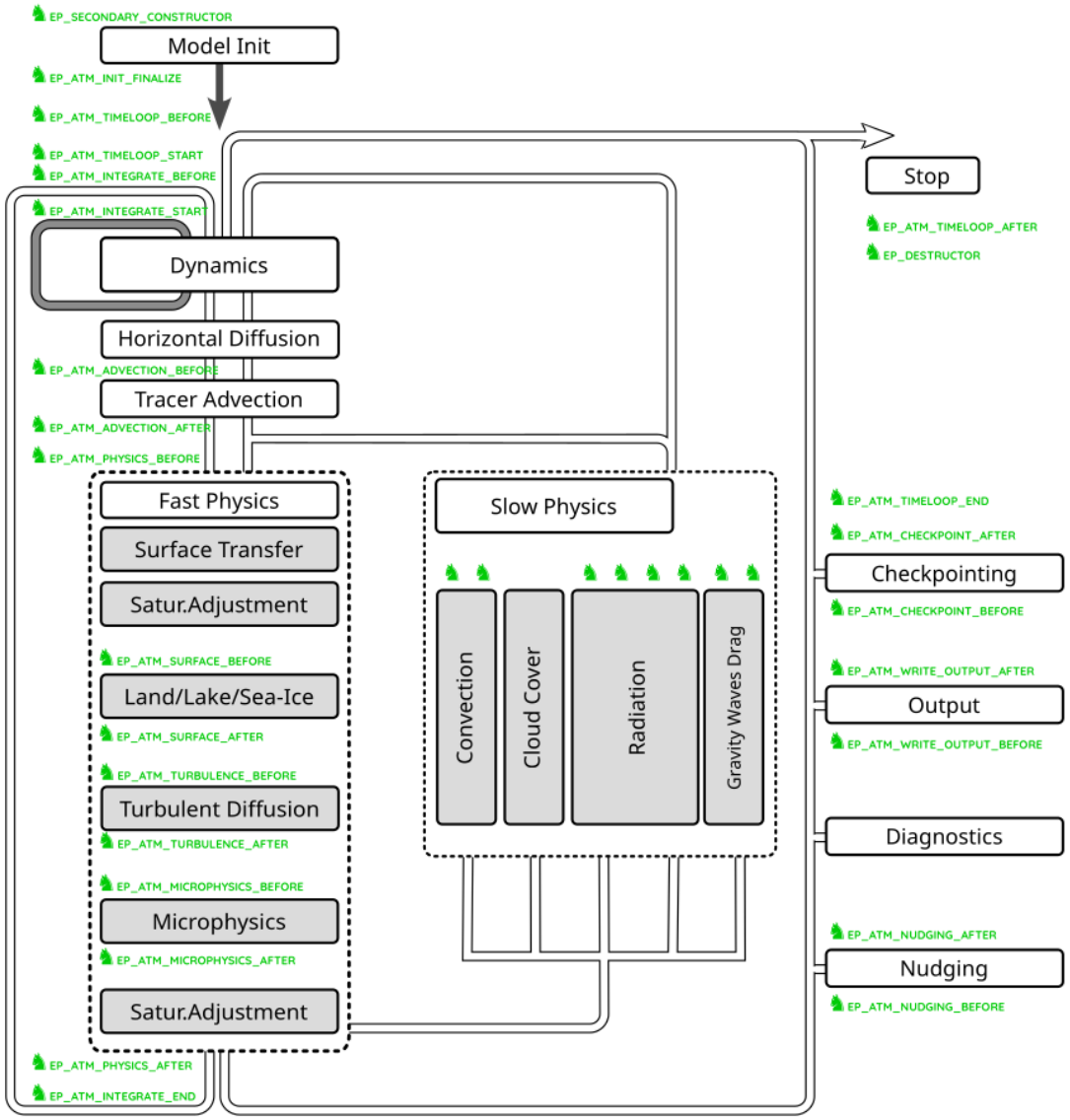
→ More sustainable integration desired

Merge into P3 codebase

github.com/P3-microphysics

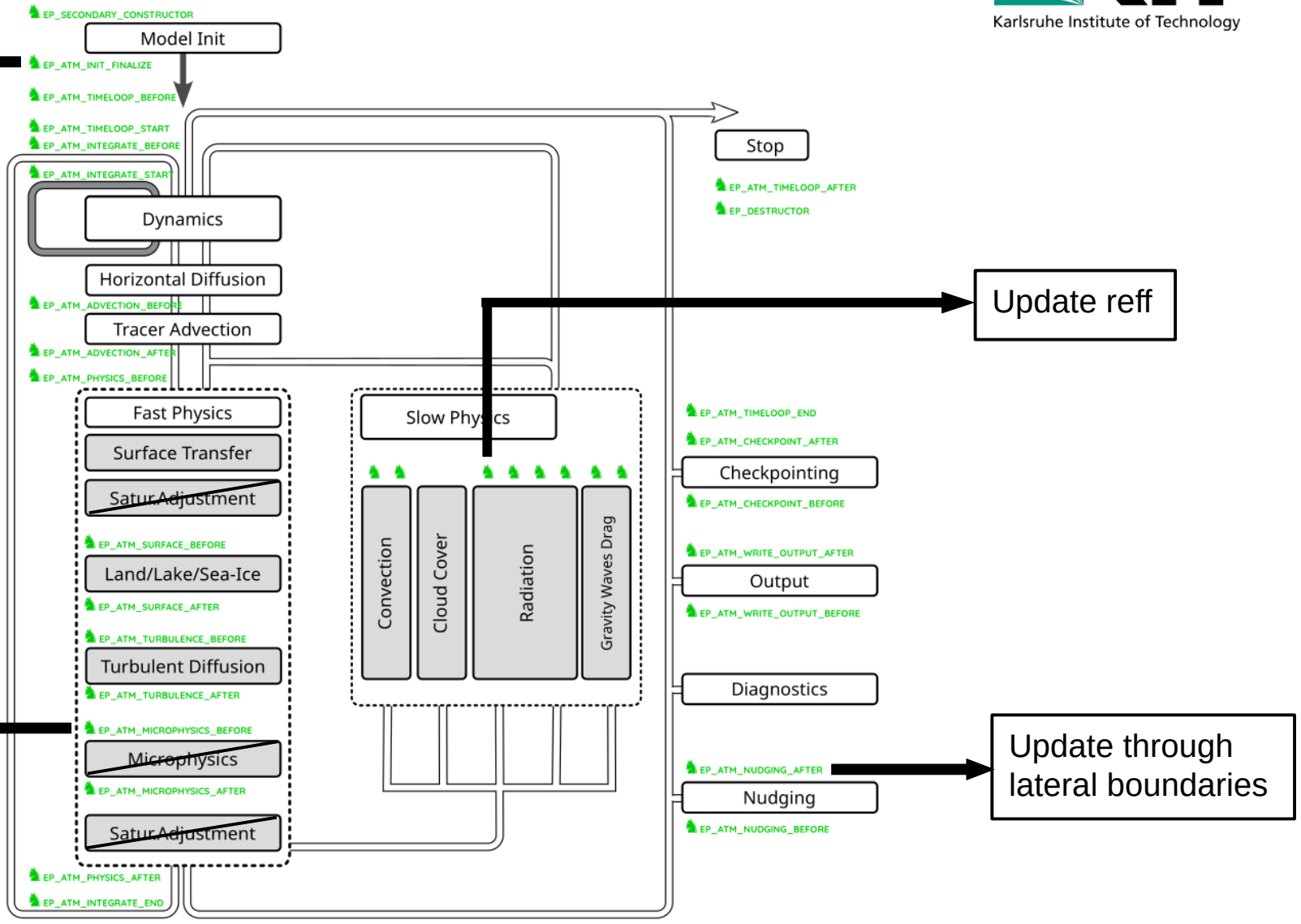


Coupling P3 to ICON with ComIn



Coupling P3 to ICON with ComIn

- Call p3_init() that loads LUTs
- Initialize P3 tracer fields



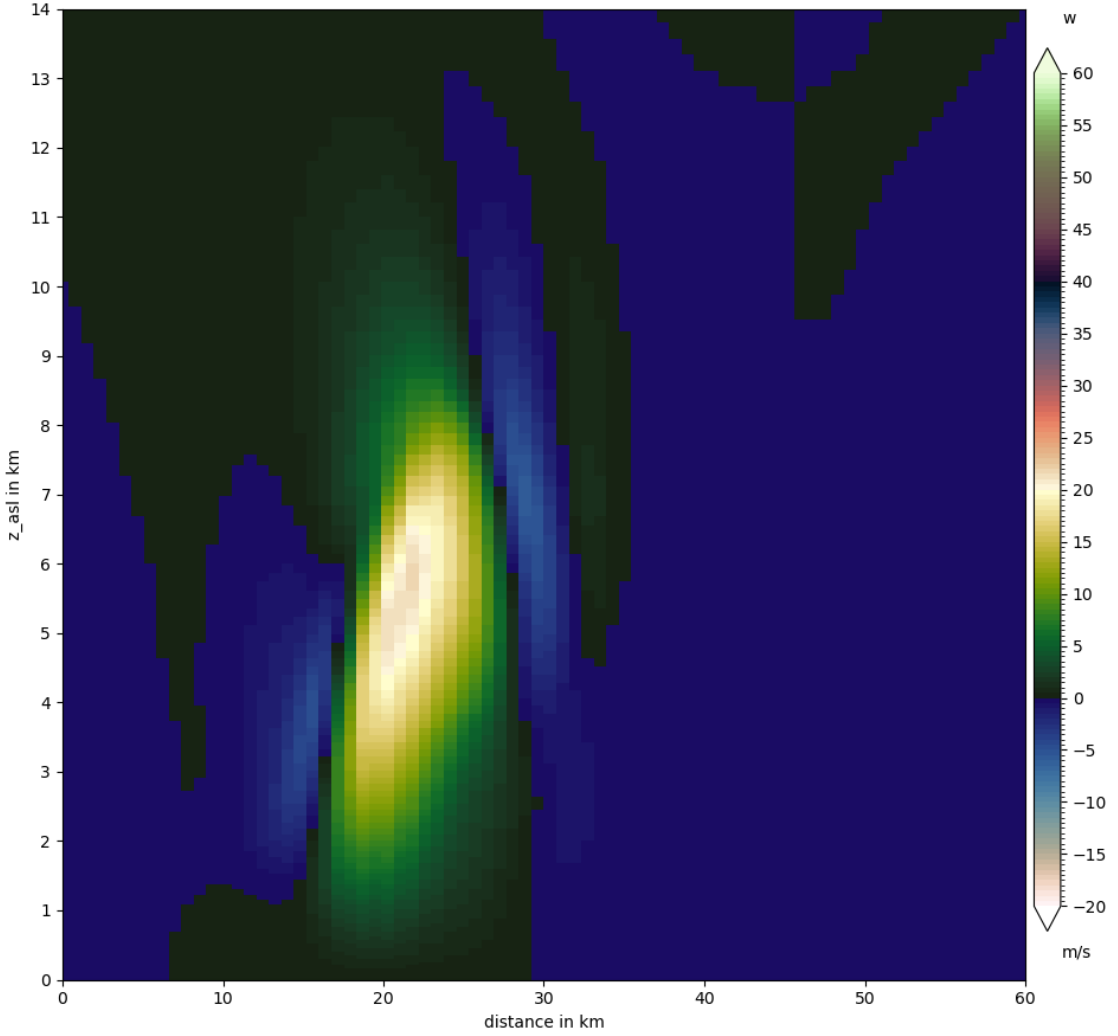
Update reff

- Call p3_main()
- Update ICON's precipitation vars
- Merge and save reff

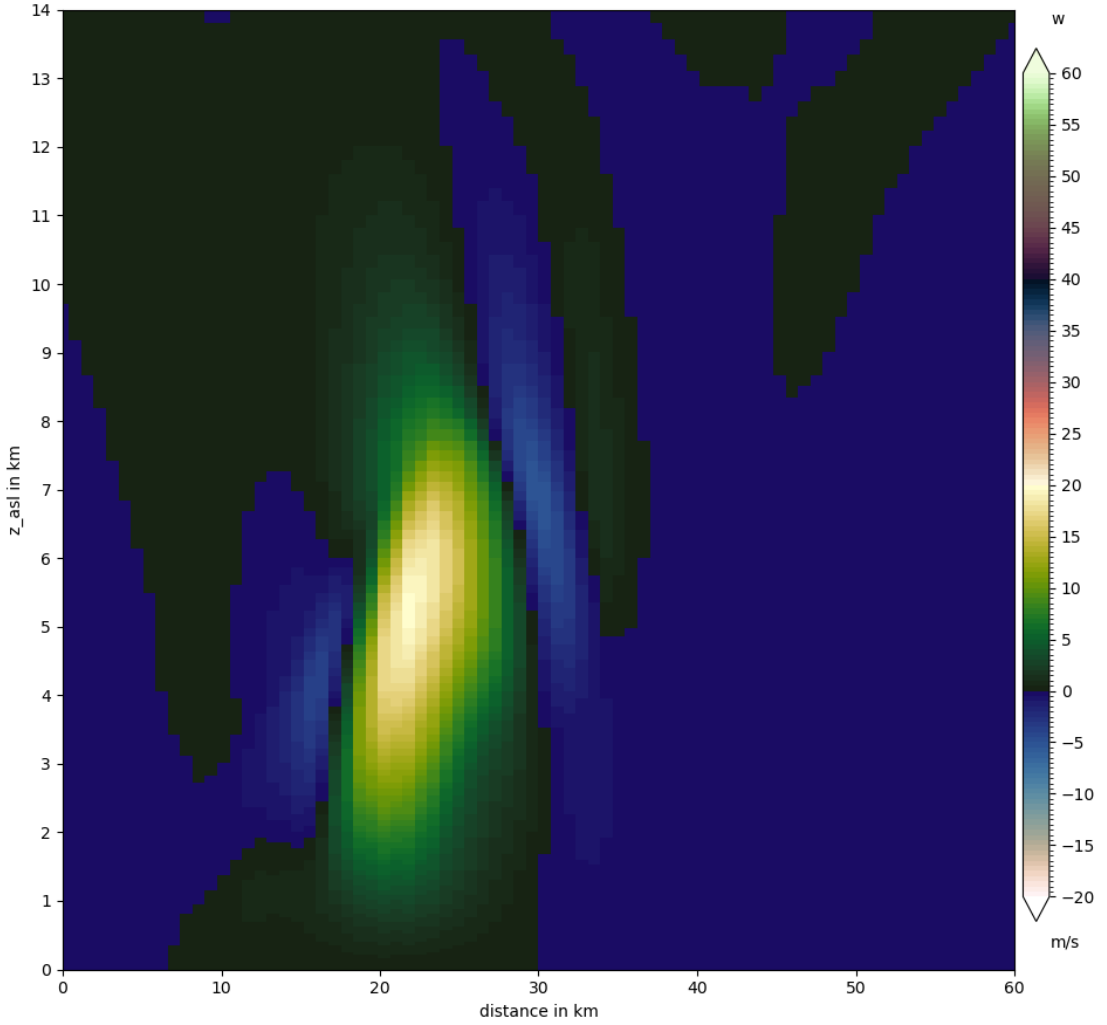
Update through lateral boundaries

Coupling tests: Initial updraft after 16min

2-Moment Scheme

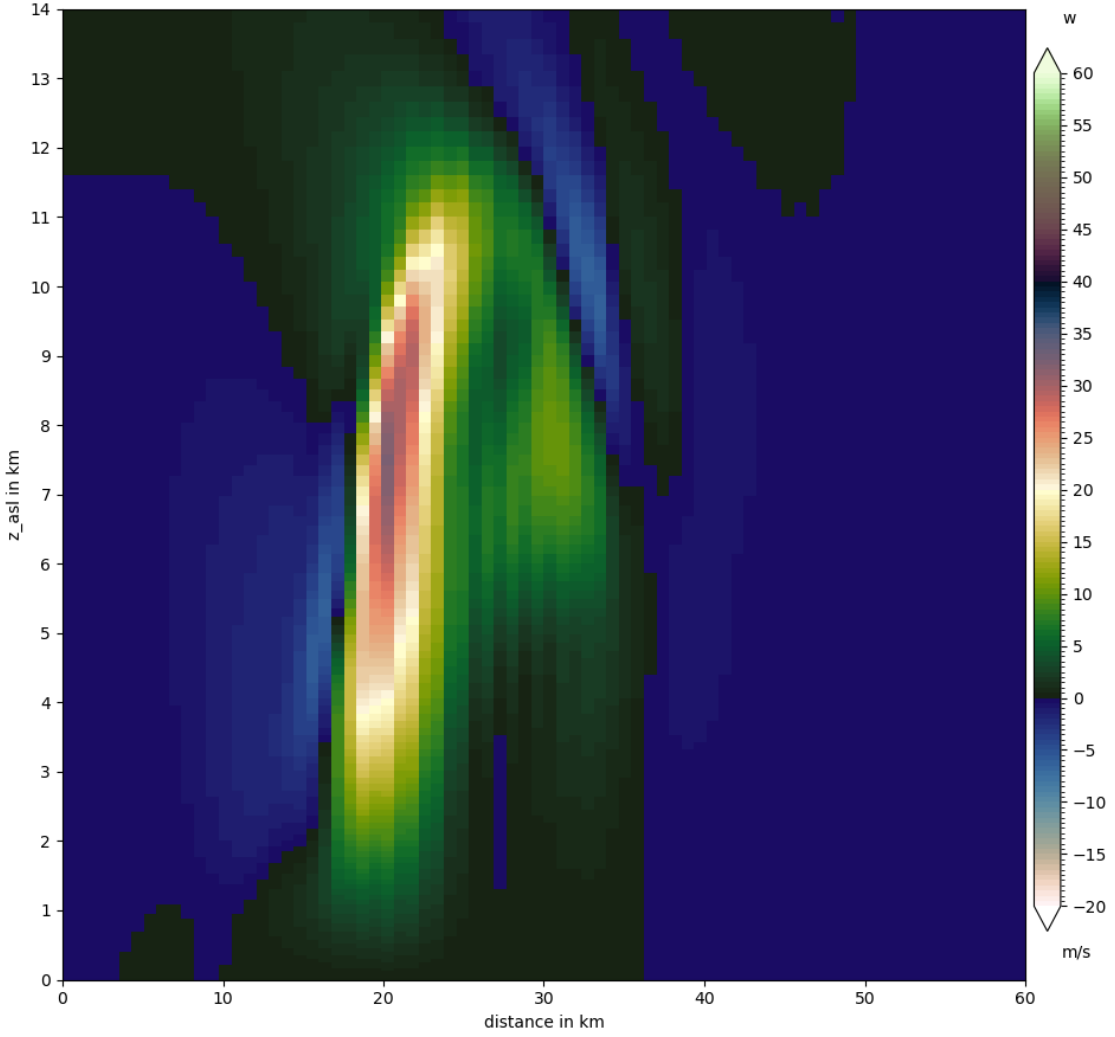


P3 Scheme (2Cat., 3M)

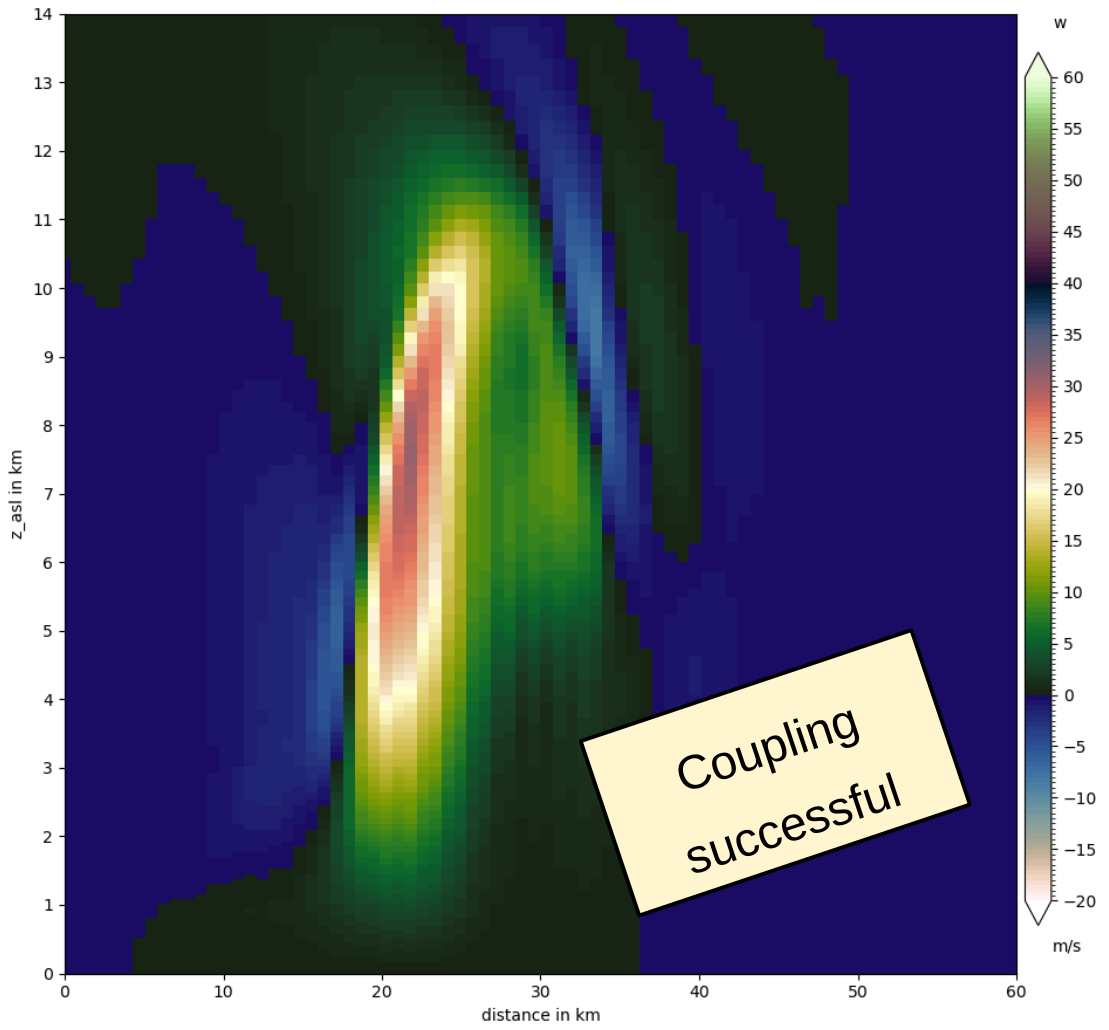


Coupling tests: Initial updraft after 22min

2-Moment Scheme

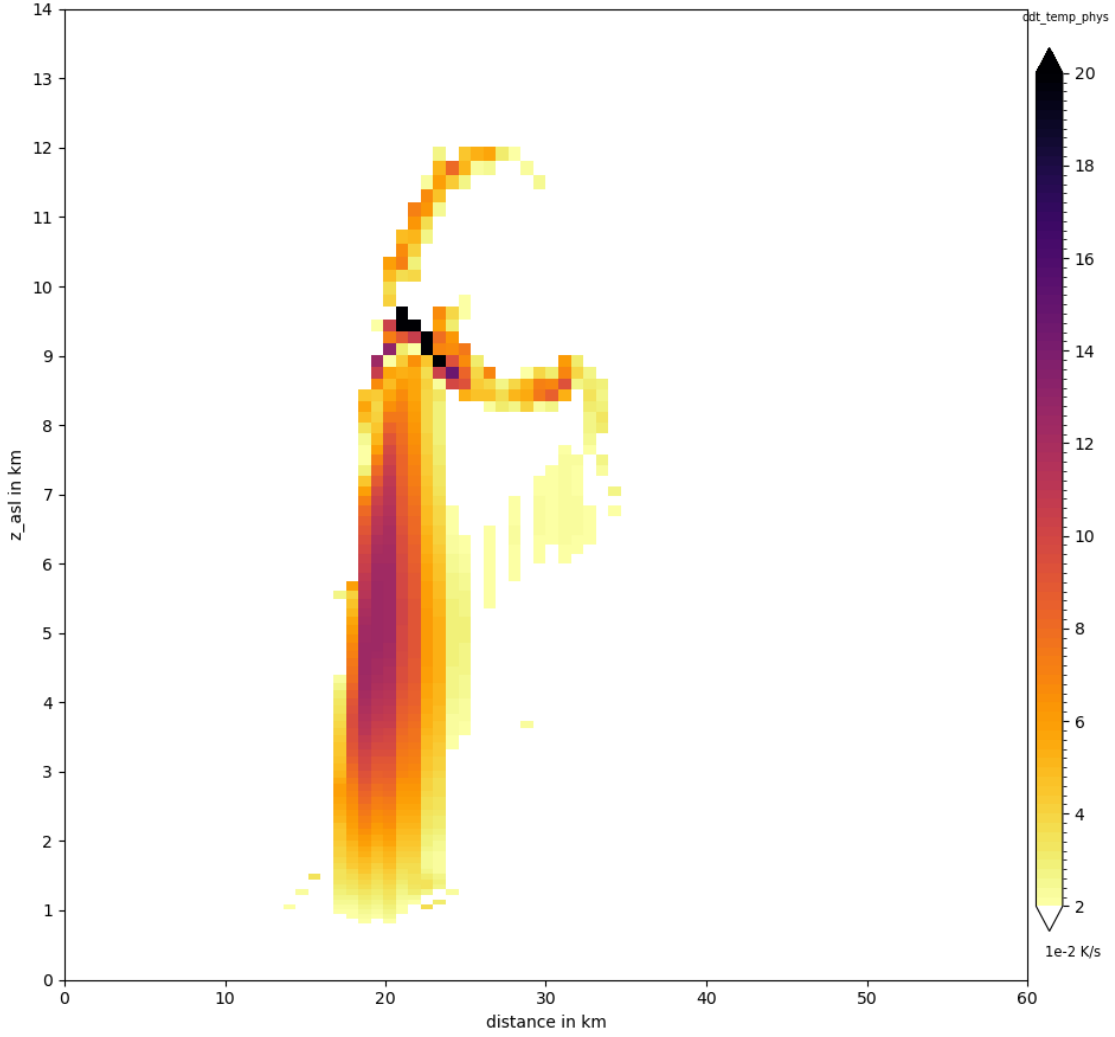


P3 Scheme (2Cat., 3M)

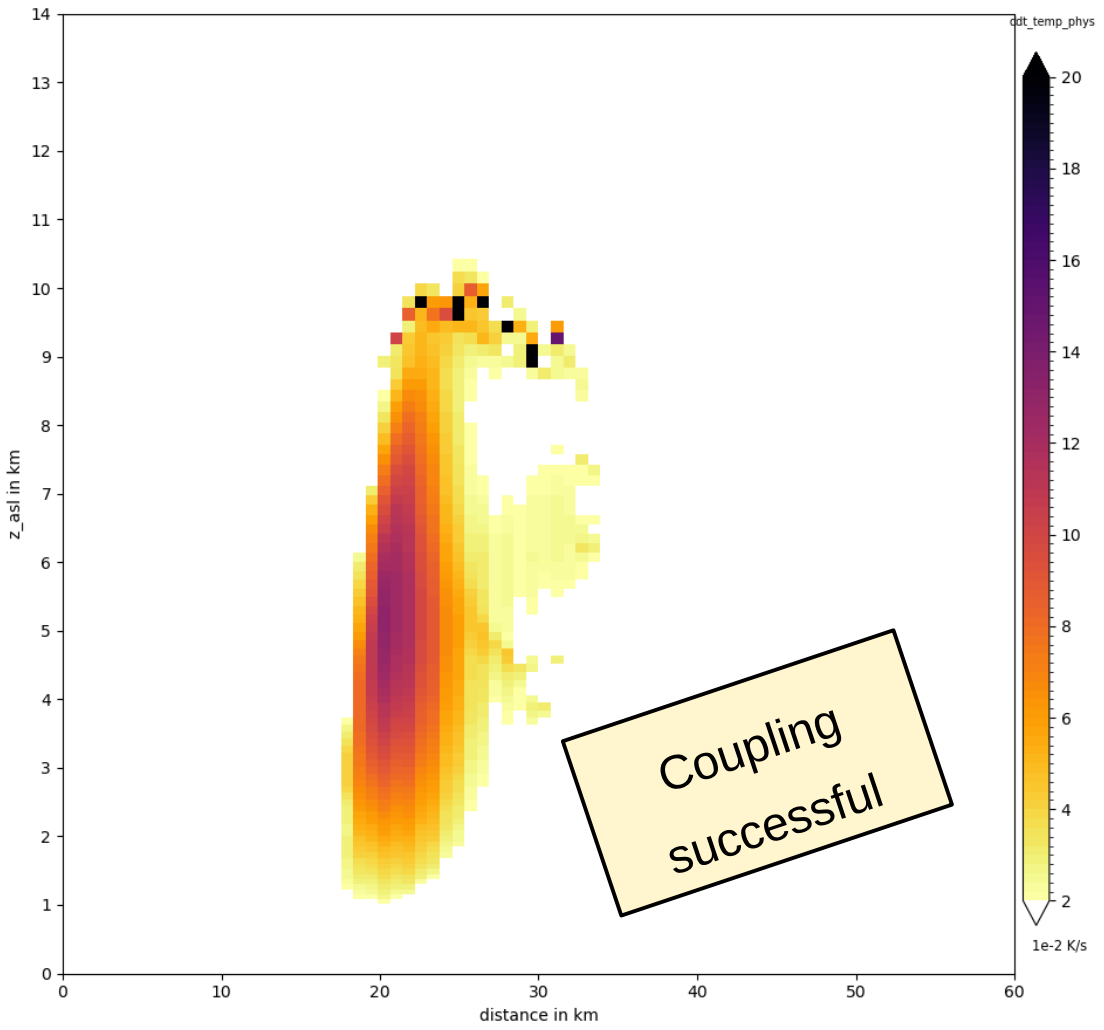


Coupling tests: Microphysical heating rate after 22min

2-Moment Scheme

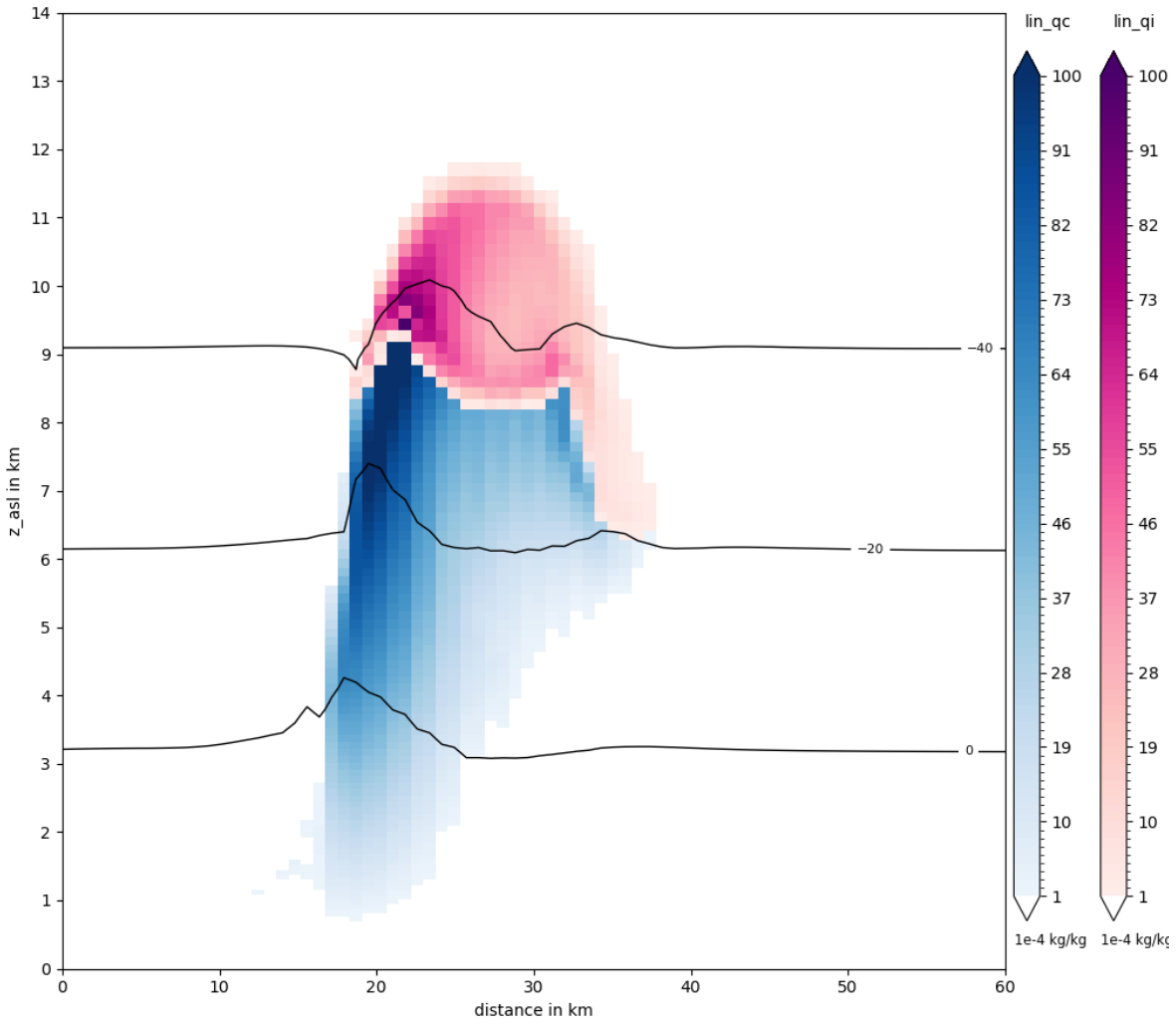


P3 Scheme (2Cat., 3M)

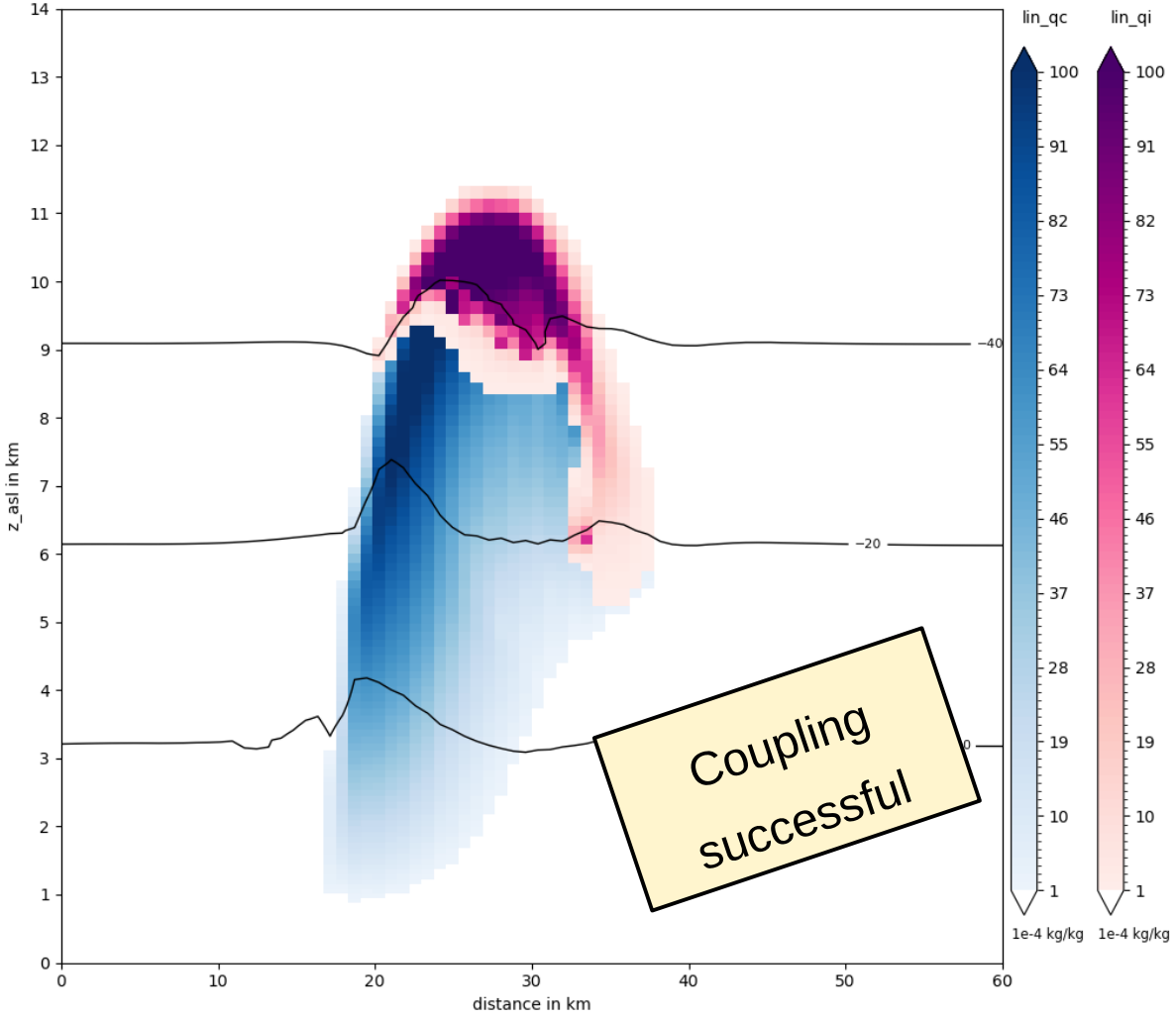


Coupling tests: Hydrometeors after 22min

2-Moment Scheme

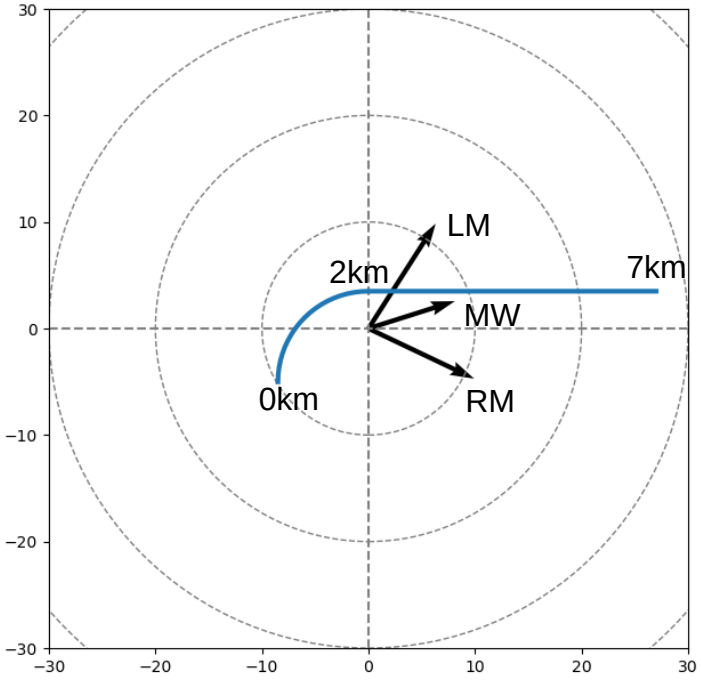


P3 Scheme (2Cat., 3M)

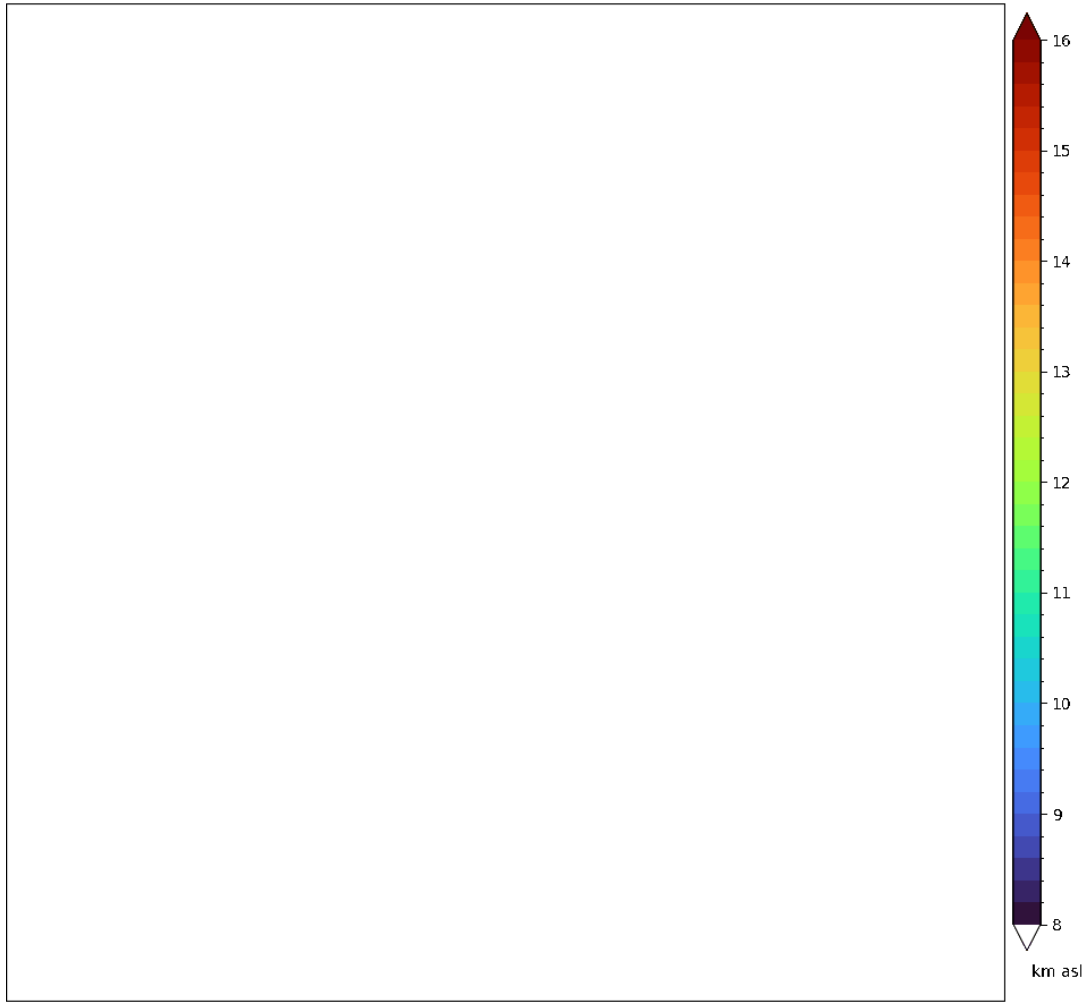


Idealized Test Case: Quarter-circle WK profile + Warm bubble

- Torus Grid: Double periodic boundaries
- Homogeneous Weisman-Klemp (1982) profile with qv=14 g/kg
- Hodograph from WRF test case implementation
- 2K warm bubble in boundary layer
- No surface scheme, no radiation
- Resolution: 1km, 5s
- Simulation time: 2h
- P3 without liquid fraction / no mixed phase particles
- Custom CCN activation with 1300 cm-3

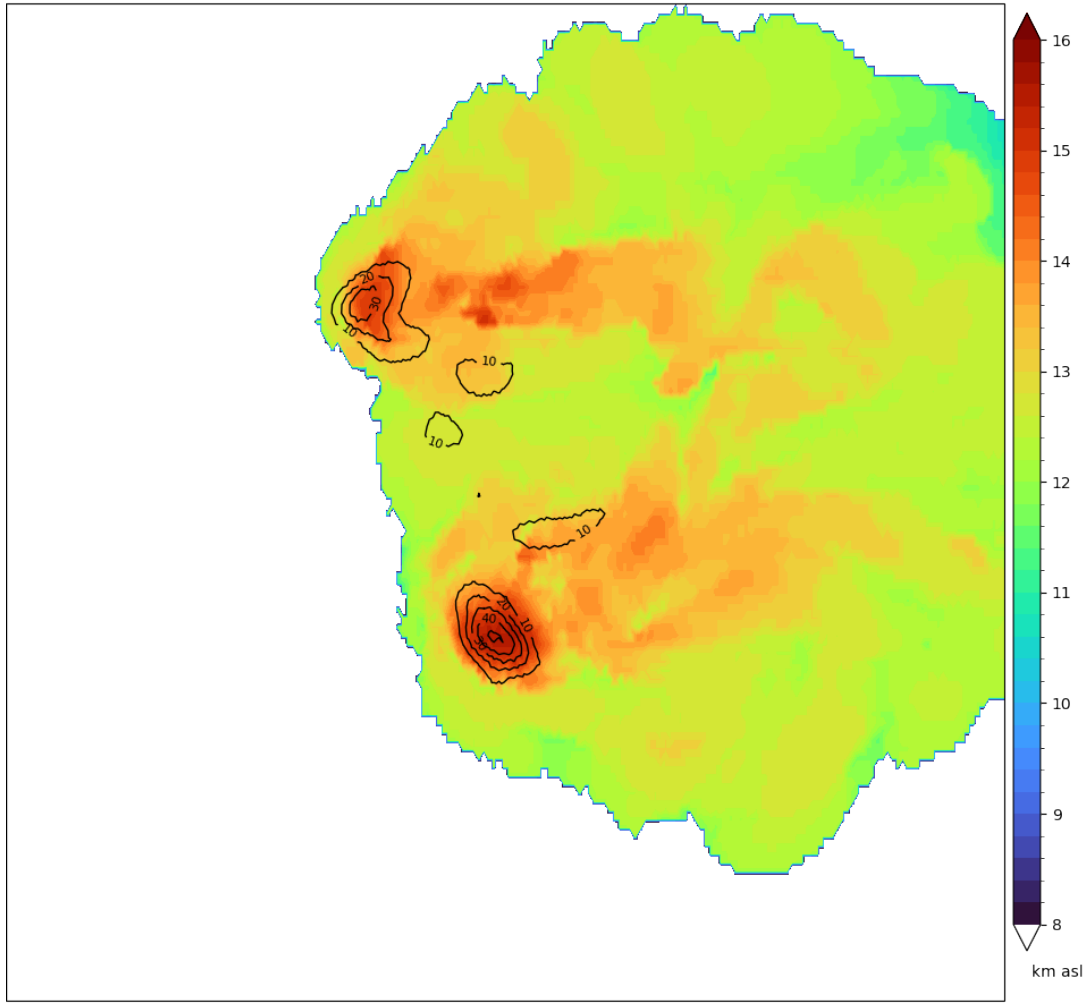


Idealized Test Case: Splitting supercells



P3 Scheme (2Cat., 3M)

Idealized Test Case: Splitting supercells

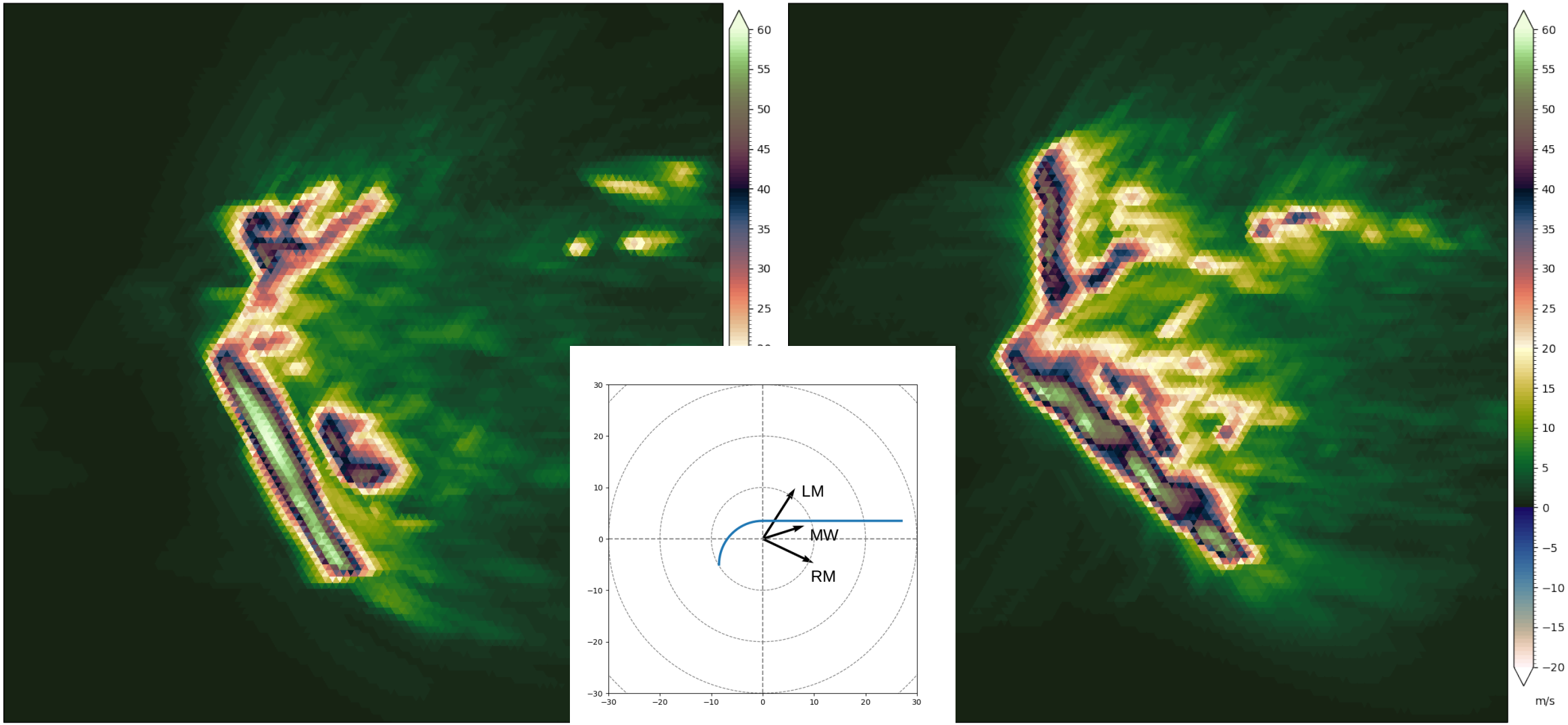


P3 Scheme (2Cat., 3M)

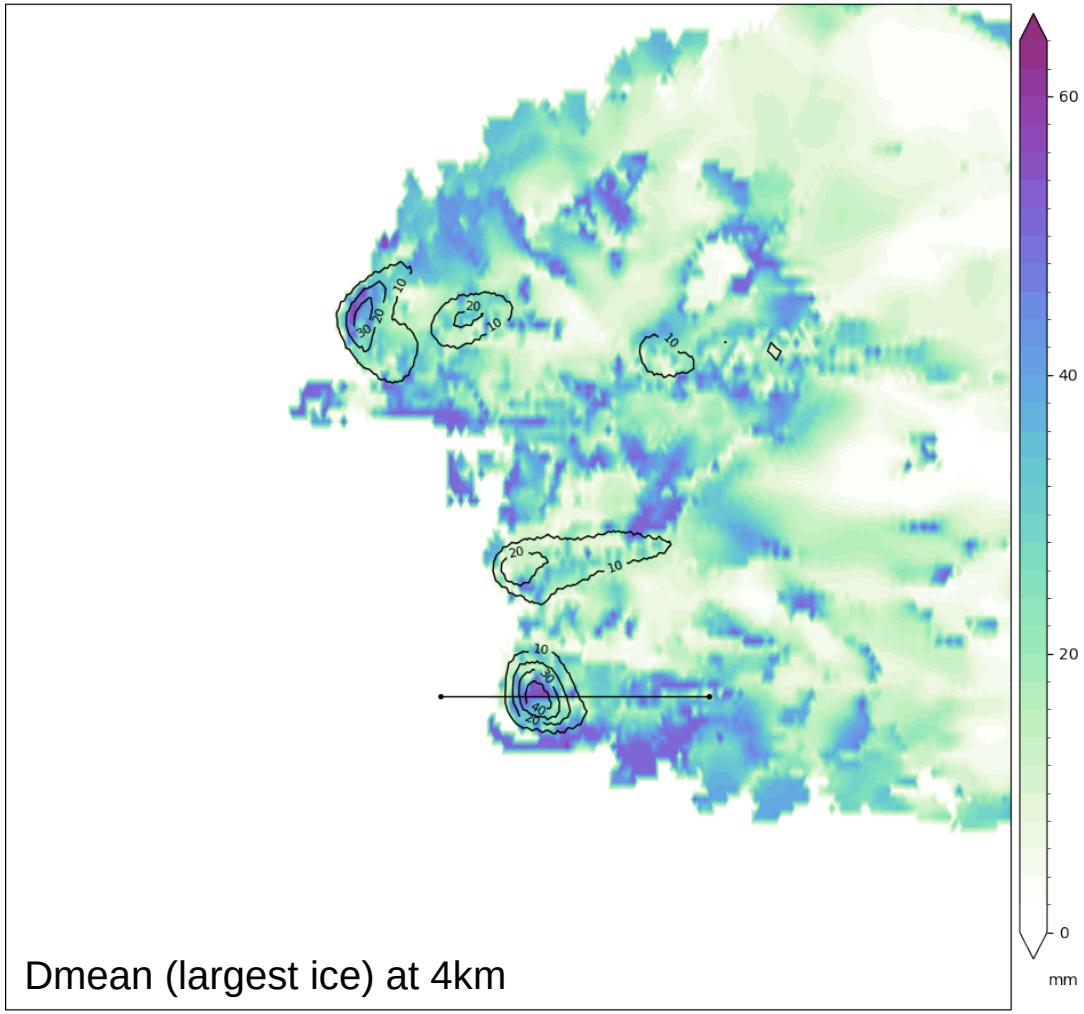
Scheme Comparison: Updraft tracks

2-Moment Scheme

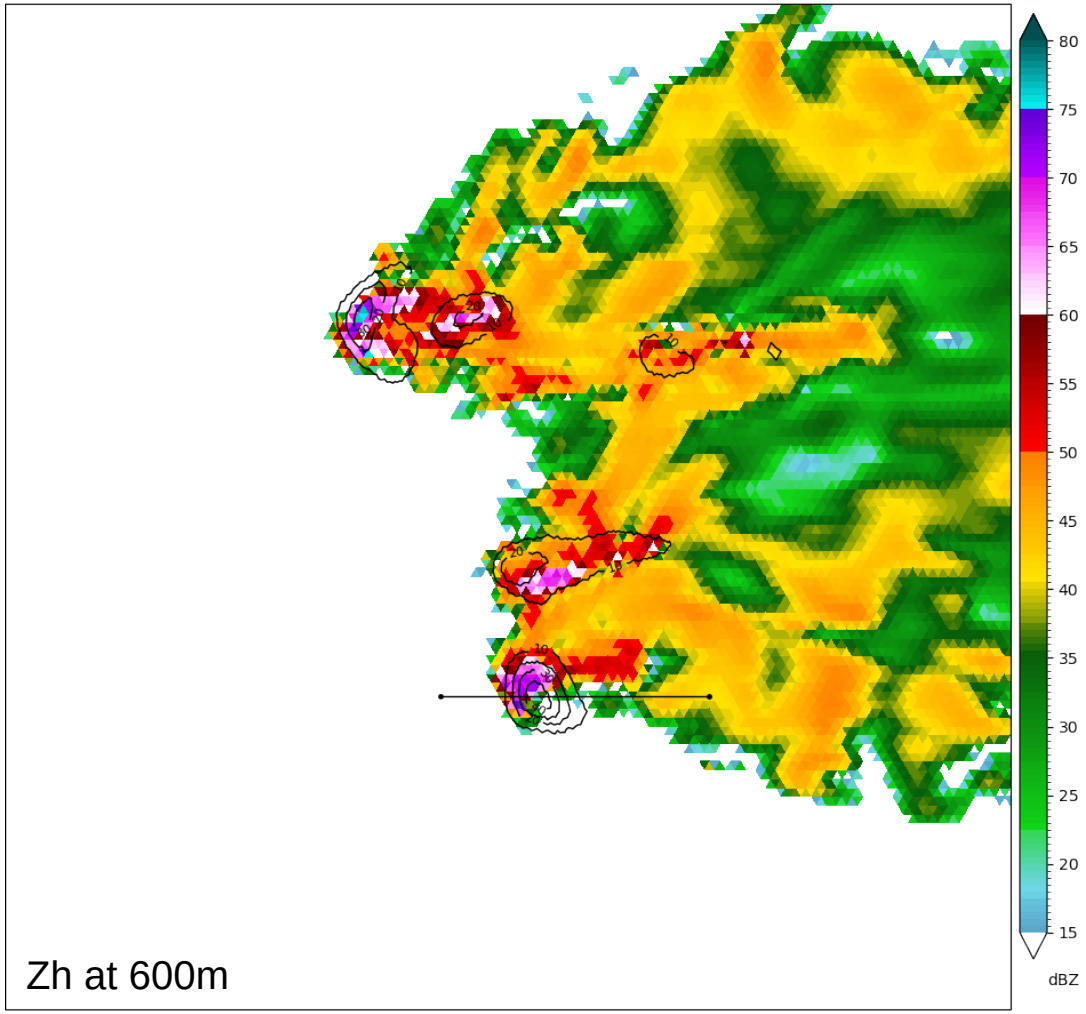
P3 Scheme (2Cat., 3M)



Idealized Test Case: Hail core



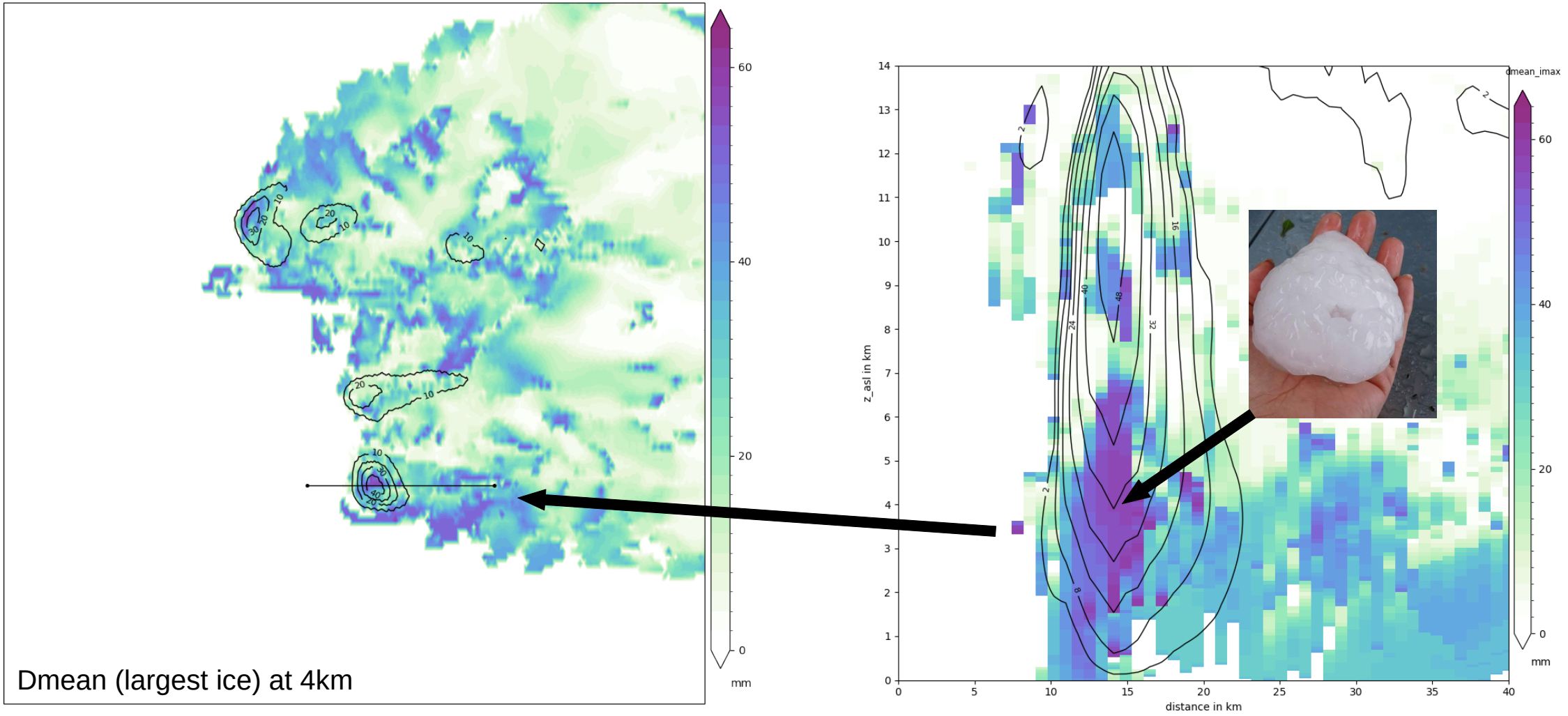
Dmean (largest ice) at 4km



Zh at 600m

P3 Scheme (2Cat., 3M)

Idealized Test Case: Hail core



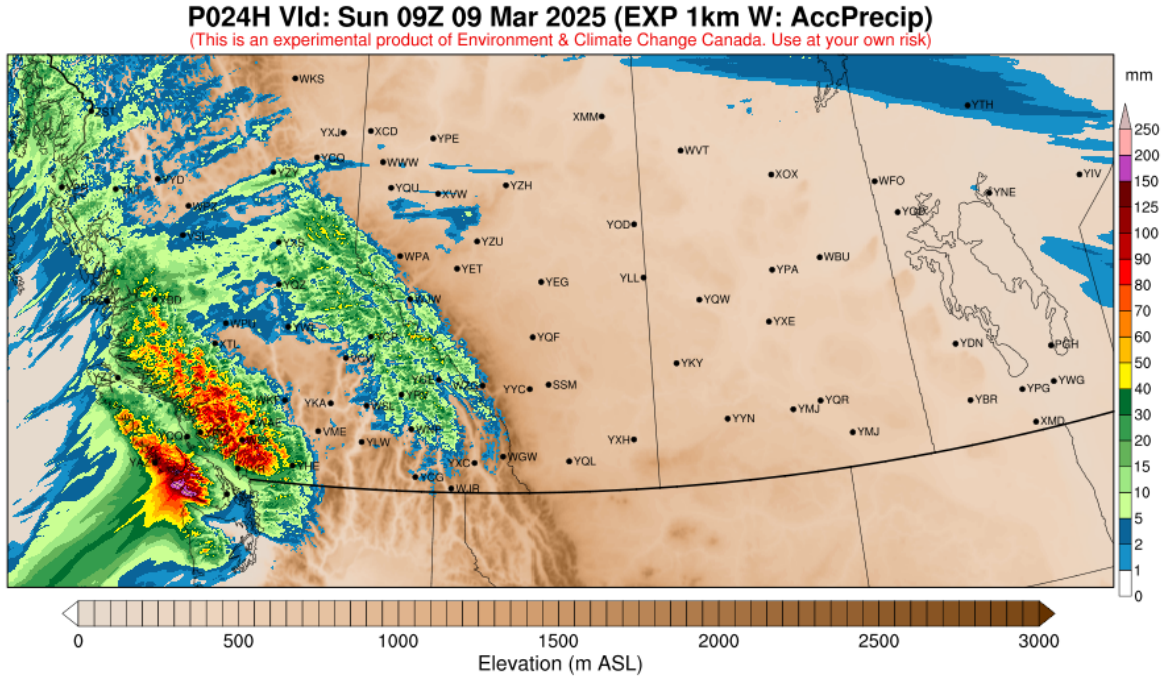
P3 Scheme (2Cat., 3M)

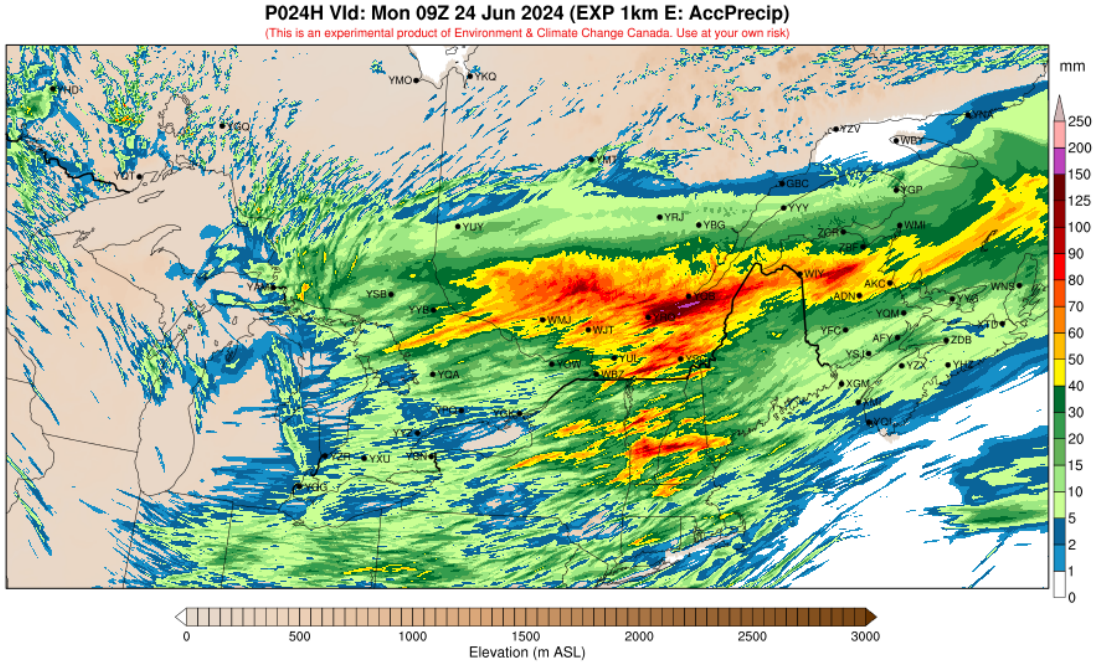
Conclusions & Outlook

- Successfully re-coupled P3 v5 with ICON using ComIn
- Latent heating feedback very similar in both schemes (under high CCN)
- First tests of idealized splitting supercells done: got expected storm motions
- In P3 (2Cat., 3M, no Liqfr) clear hailcore simulated with baseball-sized hail
- Many areas to explore now: Liquid fraction processes, SIP, riming parameterization

- Paper for GMD in work
- Plugin will be made available soon until merging into official P3 main code done
- Investigate realistic case hail cells of RELAMPAGO-CACTI campaign

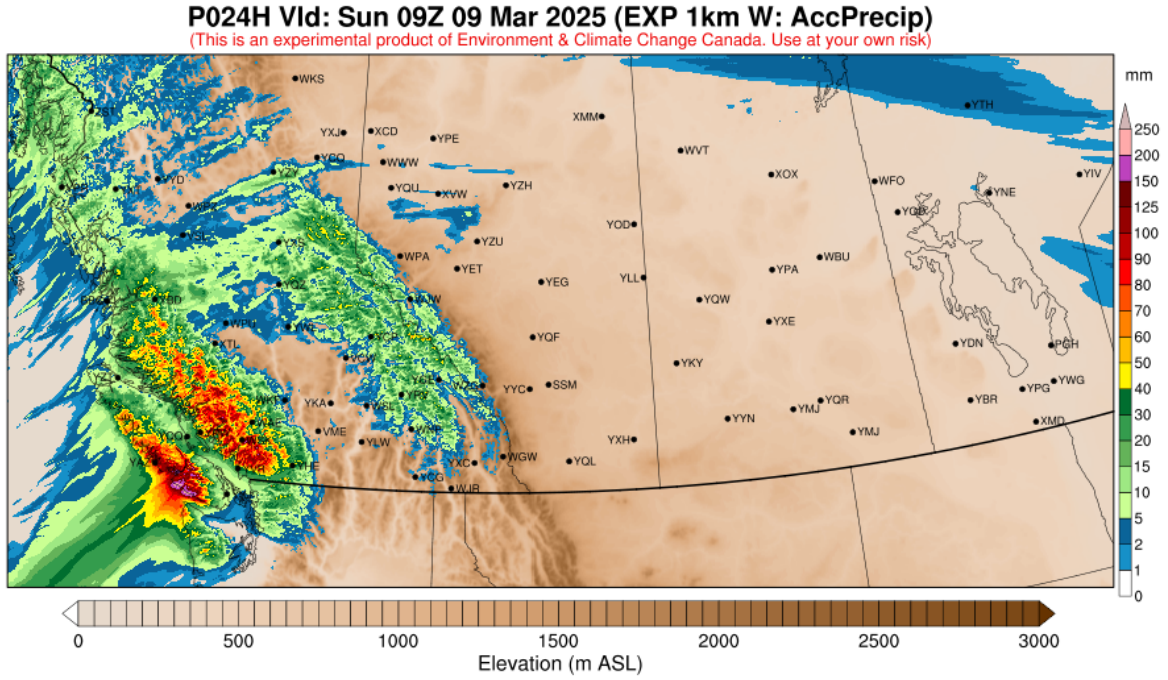
Semi-operational GEM+P3 domains

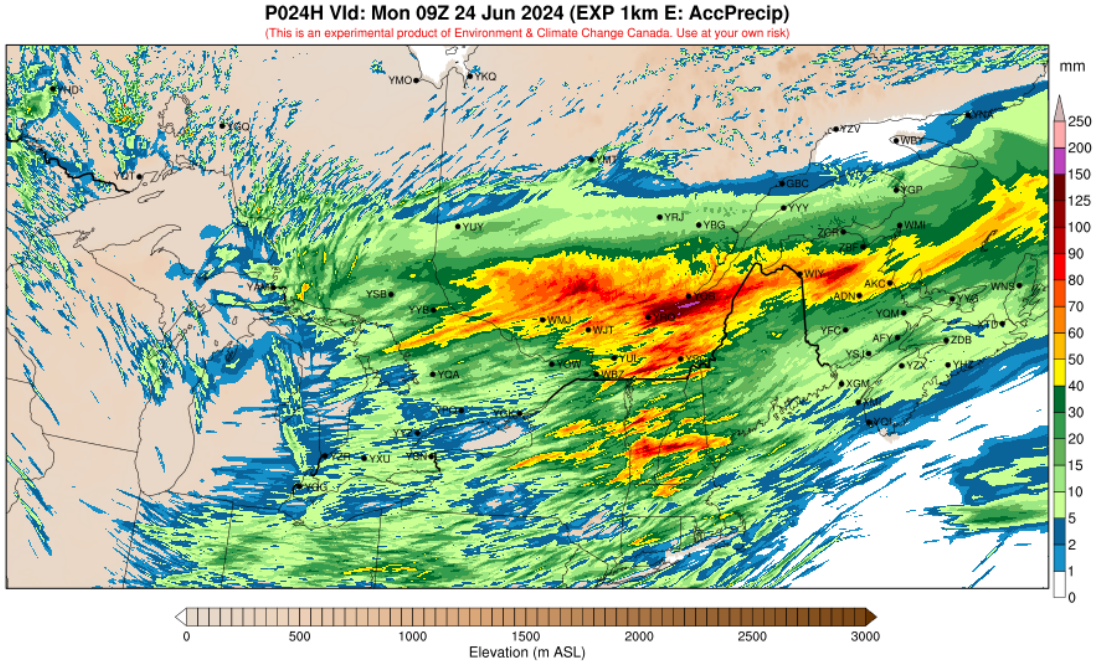




https://hpfx.collab.science.gc.ca/~rum001/exp_1km/exp_1km_e/current/index.html

Thanks & Questions





Break the traditional category boundaries, free the ice and use ICON+P3!