



Sprint 20

Challenges and results experienced during the ICON-YAC-CLEO2 sprint

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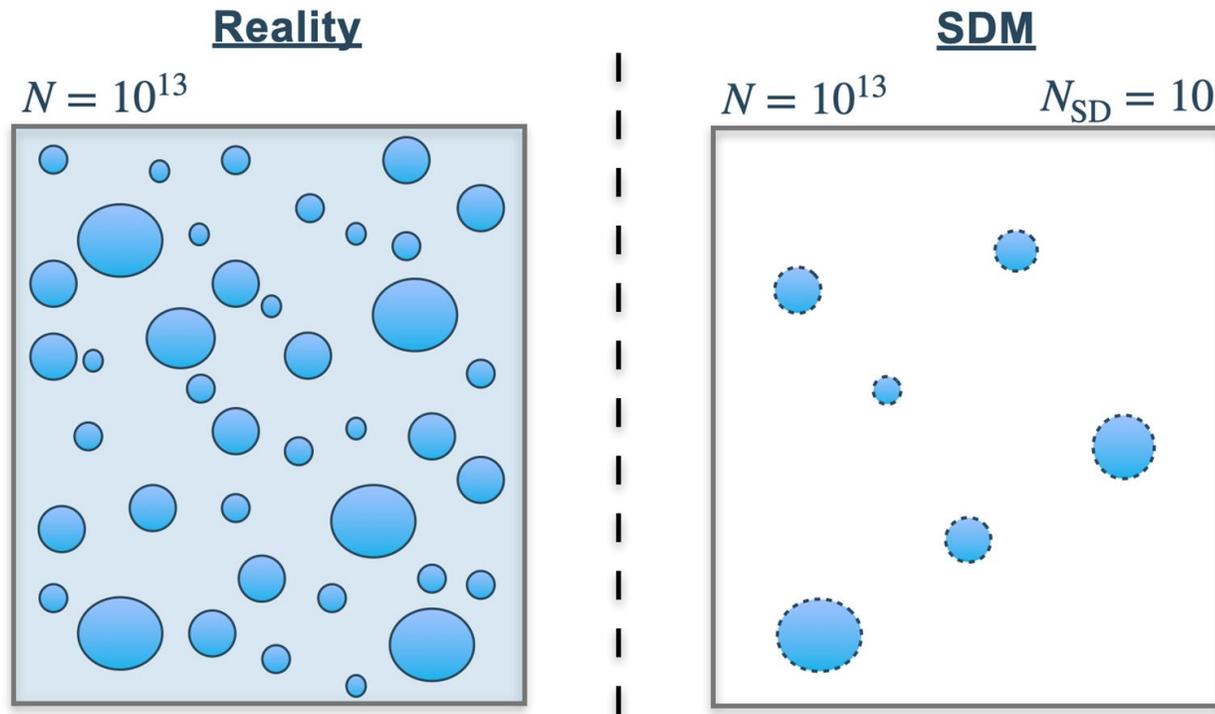
What is CLEO? What is a Super-Droplet Model (SDM)

CLEO is a super-droplet model (SDM) for warm-cloud microphysics

SDM is a fundamentally different model, which overcomes the intractable uncertainties of conventional bulk (one-/two-) moment models

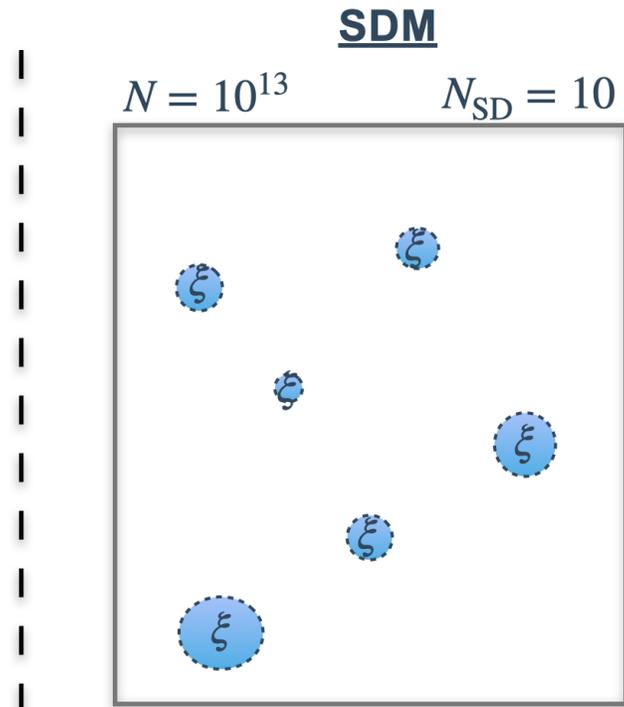
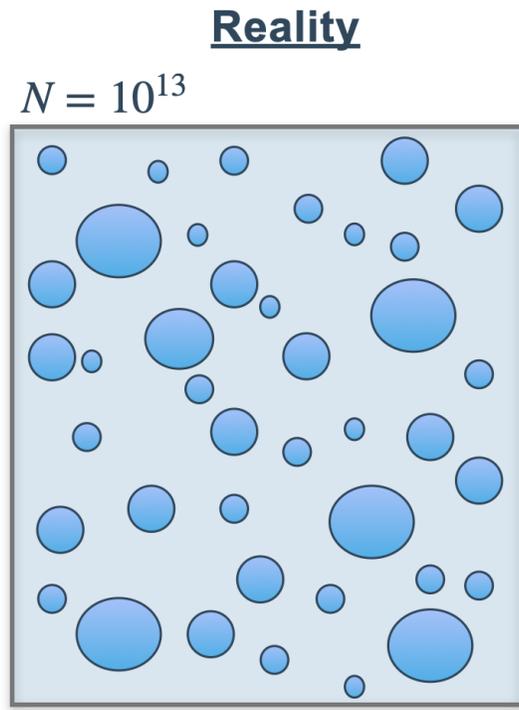
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(Shima et al. 2009)

Superdroplets are initialised from random sample of the “real” population, then evolve freely

Each superdroplet has its own multiplicity, ξ ,

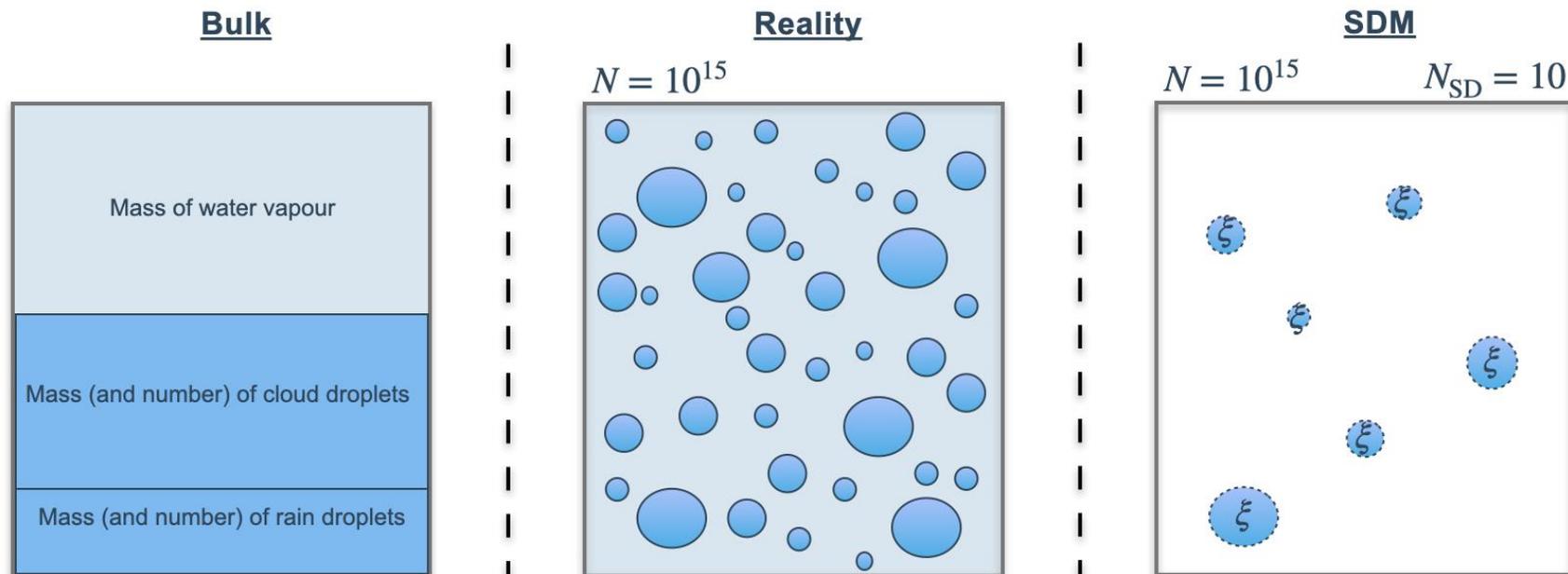
$$\xi = 1, 2, 3, \dots, \xi$$

1 superdroplet = ξ real droplets

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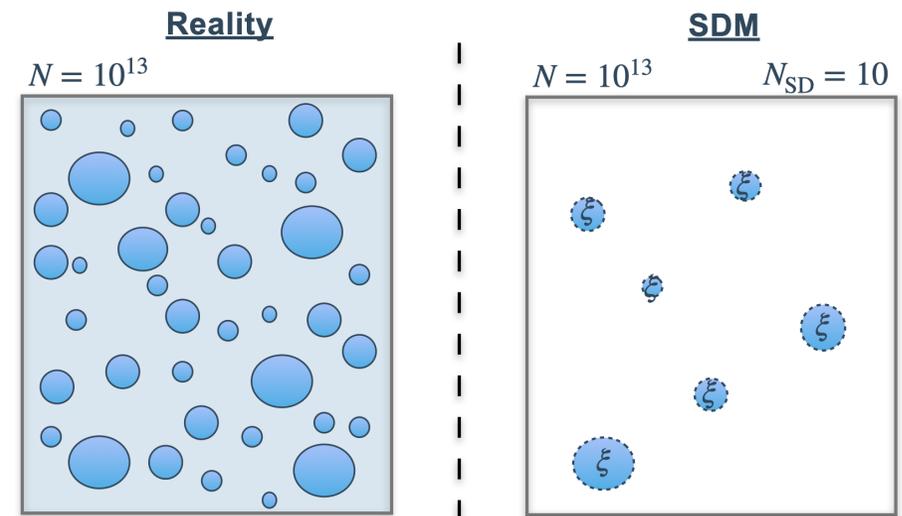
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SDM is Lagrangian rather than Eulerian:

- Greater fidelity to the underlying physics
- Insightful convergence property
- No numerical diffusion



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SDM is Lagrangian rather than Eulerian:

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And SDM is well-suited to HPC!

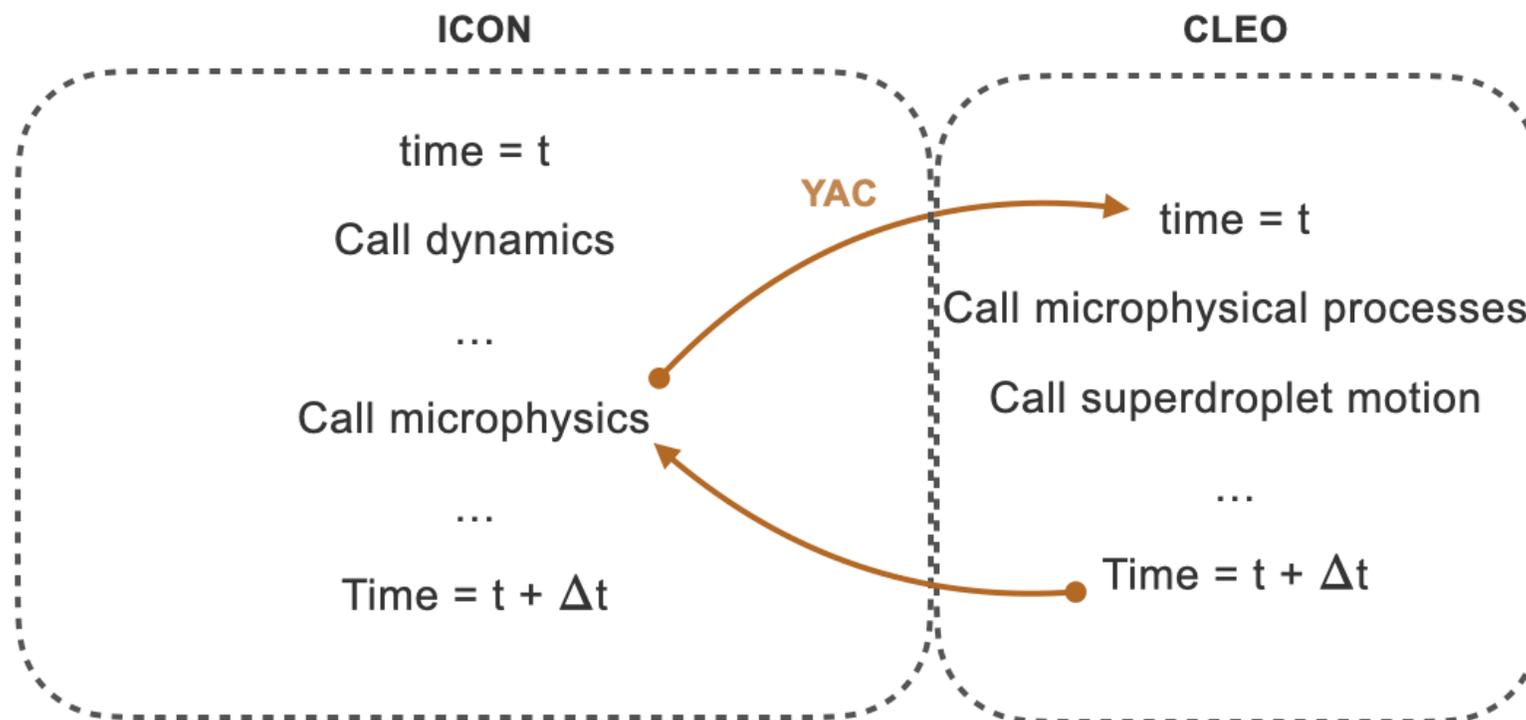
- Embarrassingly parallel
- Linearly increasing cost with increasing superdroplets and their attributes

What is the ICON-YAC-CLEO2 Sprint?

CLEO is motivated by the need to create a computationally efficient open-source, open-development SDM for the ICON cloud microphysics community

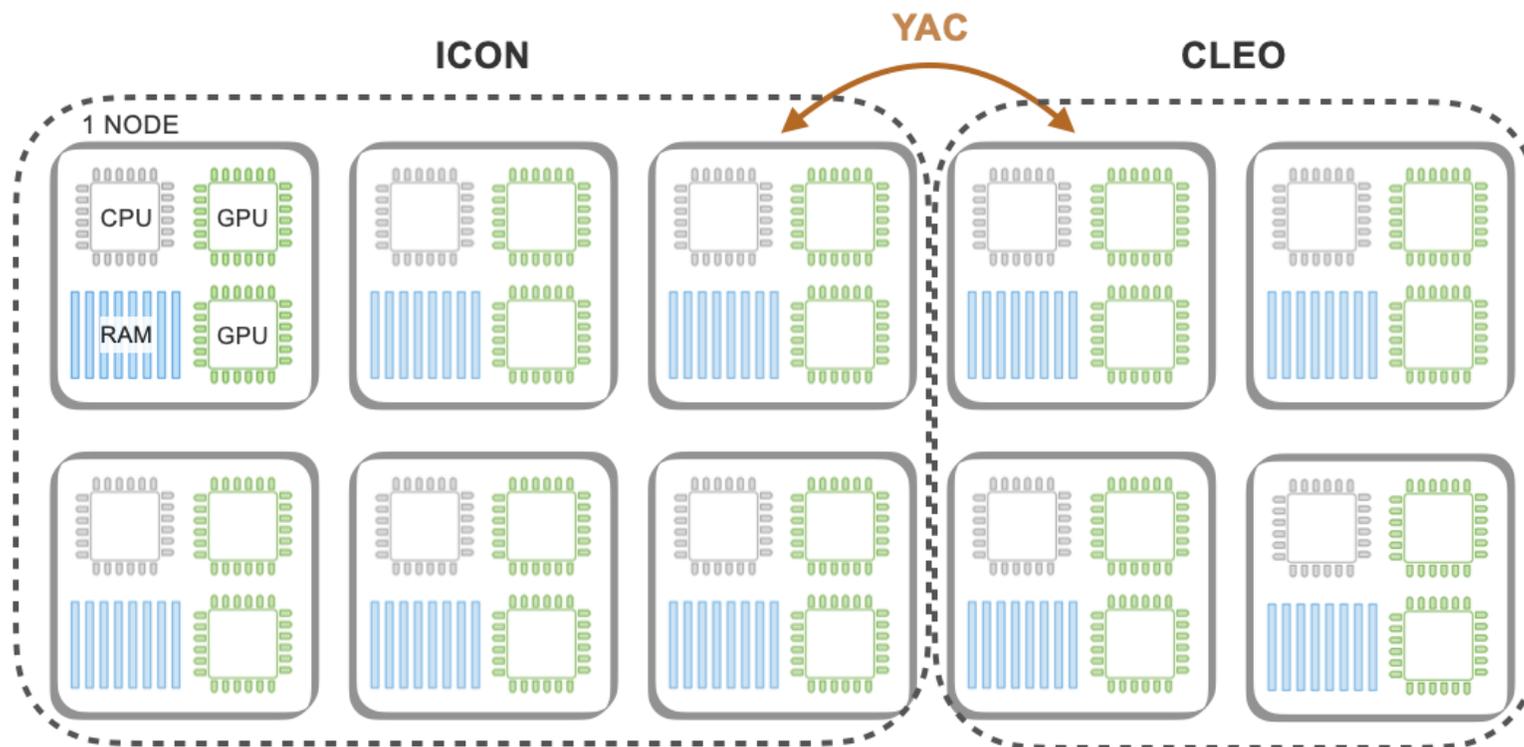
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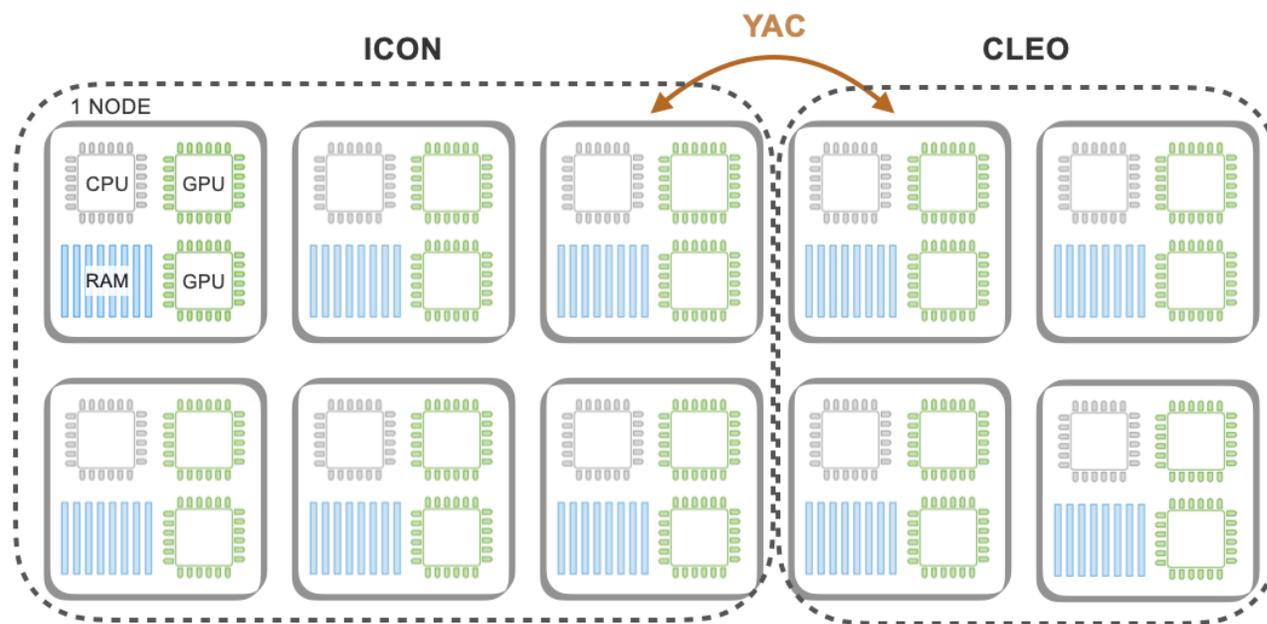


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Proposed help from NatESM for:

1. Coupling ICON and CLEO via YAC
2. Implementing MPI domain decomposition in CLEO



What is the ICON-YAC-CLEO2 Sprint?

CLEO is motivated by the need to create a computationally efficient open-source, open-development SDM for the ICON cloud microphysics community

In the first CLEO-YAC-ICON sprint:

1. Coupling ICON and CLEO via YAC

- Completed one way coupling from ICON to CLEO via YAC

2. Implementing MPI domain decomposition in CLEO

- Completed first implementation for MPI domain decomposition

Goals of the „ICON-YAC-CLEO2“ Follow-Up Sprint

1. Coupling ICON and CLEO via YAC

- Complete CLEO's two-way coupling to ICON.
- Make CLEO's MPI domain decomposition compatible with CLEO's coupling to ICON.

2. Implementing MPI domain decomposition in CLEO

- Identify major bottlenecks in the performance of CLEO's MPI domain decomposition, and potentially resolve them.

Goals of the „ICON-YAC-CLEO2“ Follow-Up Sprint

1. Coupling ICON and CLEO via YAC

- Complete CLEO’s two-way coupling to ICON.
- Make CLEO’s MPI domain decomposition compatible with CLEO’s coupling to ICON.

2. Implementing MPI domain decomposition in CLEO

- Identify major bottlenecks in the performance of CLEO’s MPI domain decomposition, and potentially resolve them.

Goals were divided into sub-goals, each aiming to fulfill different versions of the ICON “bubble” test-case or CLEO “from-file” test-case.

Overall Results of ICON-YAC-CLEO2

1. Coupling ICON and CLEO via YAC

Test-Case	Coupled to ICON via YAC	With MPI	Results
from-file (irregular)	no	yes	success
bubble	one-way and two-way	yes	Breaks, runs forever
bubble	one-way and two-way	no (1 process)	Runs successfully, but scientific plots are not right

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Made irregular-sized grid-boxes possible in CLEO's domain decomposition (to allow for irregular ICON vertical levels)

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Made “communicator class” to handle MPI communication for YAC and for CLEO’s domain

Overall Results of ICON-YAC-CLEO2

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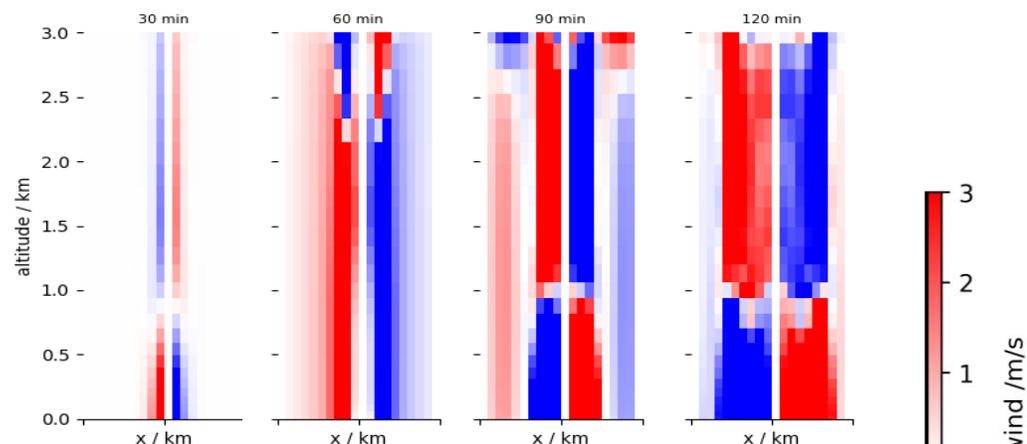
- Complete CLEO's two-way coupling to ICON.

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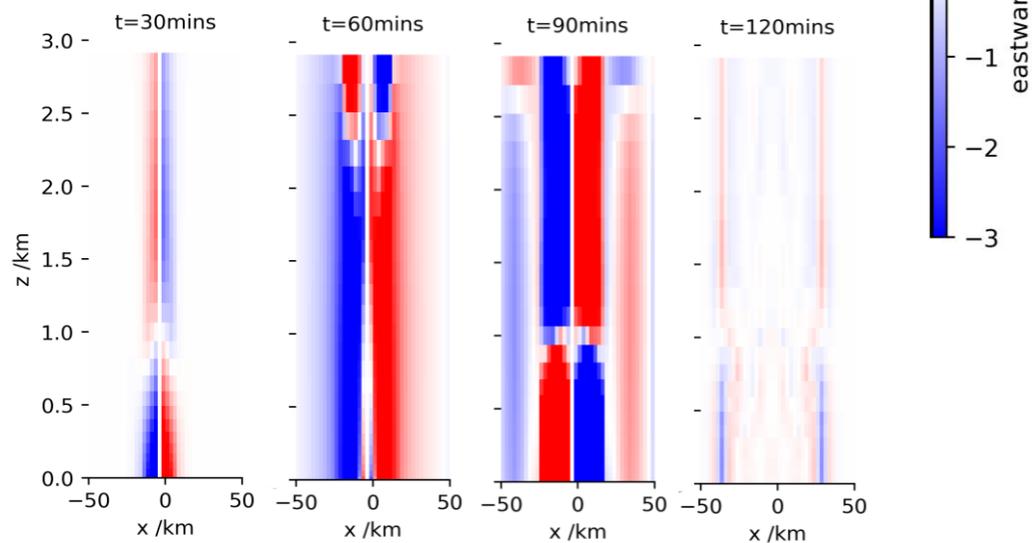
Implemented two-way coupling get/put calls

One-Way Coupled Bubble Test-Case

ICON



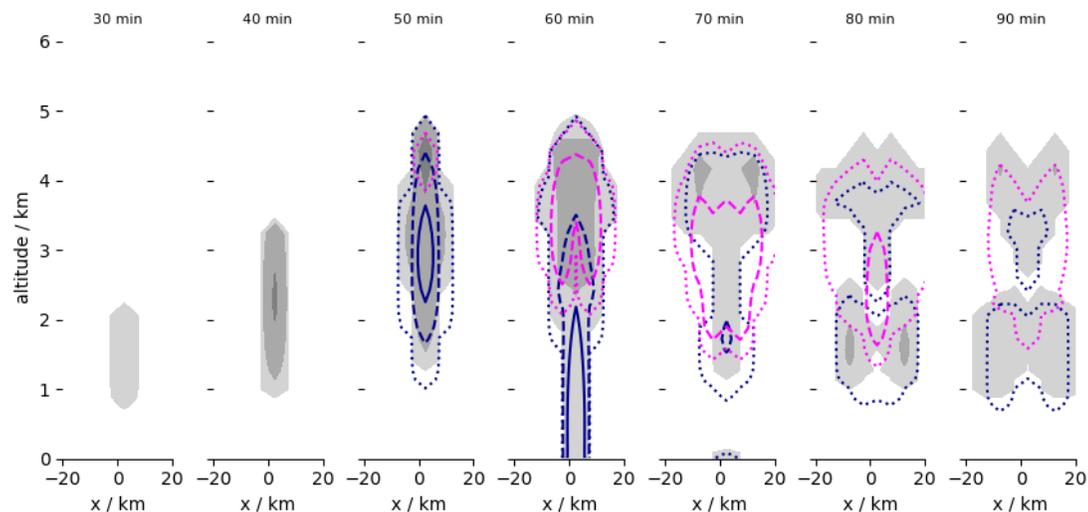
CLEO



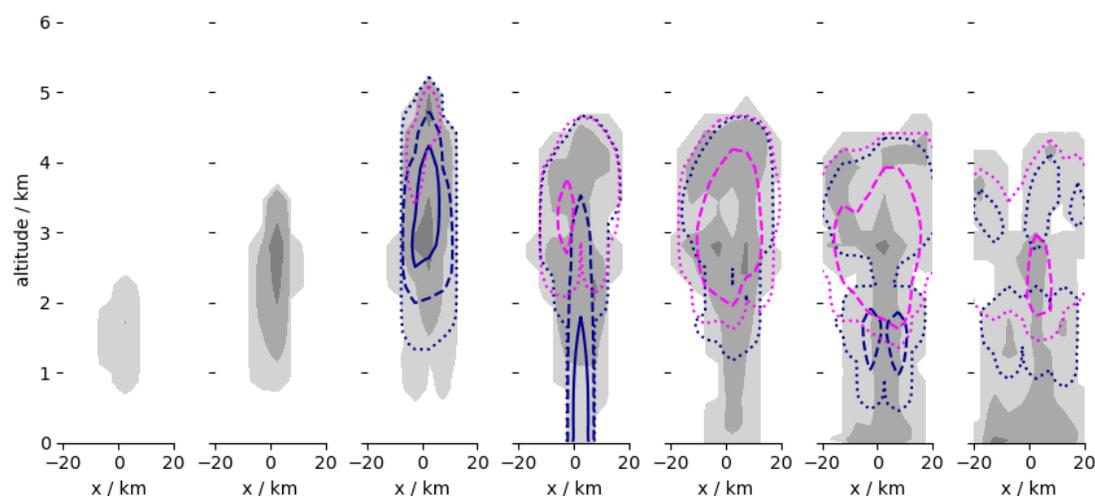
Everything correct
communicated except
that eastward wind is
flipped and last-timestep
is incorrect

Two-Way Coupled Bubble Test-Case

ICON 1-mom
not Coupled



ICON 1-mom
coupled to
CLEO without
microphysics



Deterioration of
interpolated fields over
time

Challenges

Common Coding Issues

- Choice how to handle GitHub repo, syncing forks, pull requests, and commits
- Debugging often takes an unknown length of time (hard to adjust timelines combined with little room for error on tight schedules)
- Unit tests in CLEO and ICON are lacking but would be very helpful

Hand-over of work at the end of the sprint

- Hard to hand over work-in-progress
- Needed more time for smoother transition
- Timing became particularly unfortunate as it coincided with the end of my PhD

Frequent meetings and oversight of previous RSE from last sprint worked well

Outlook & Open Questions

- Merge request in progress for CLEO's two-way coupling into ICON
- Debugging scheduled to resolve issues in one-way and two-way couplings and in compatibility with CLEO's MPI domain decomposition
- **Third sprint proposal in the pipeline!**
- **Other proposals in progress for extending CLEO's microphysics capacities,** steps towards providing community with tool for large ICON simulations with superdroplets

Thank you Aparna Devulapalli and Wilton Loch for your work on this sprint!