natESM

DKRZ DEUTSCHES KLIMARECHENZENTRUM

JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

DKK Deutsches Klima Konsortium

Federal Ministry of Education and Research

Sprint 14

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

Clara Bayley (MPI-M), Wilton Jaciel Loch (DKRZ)

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

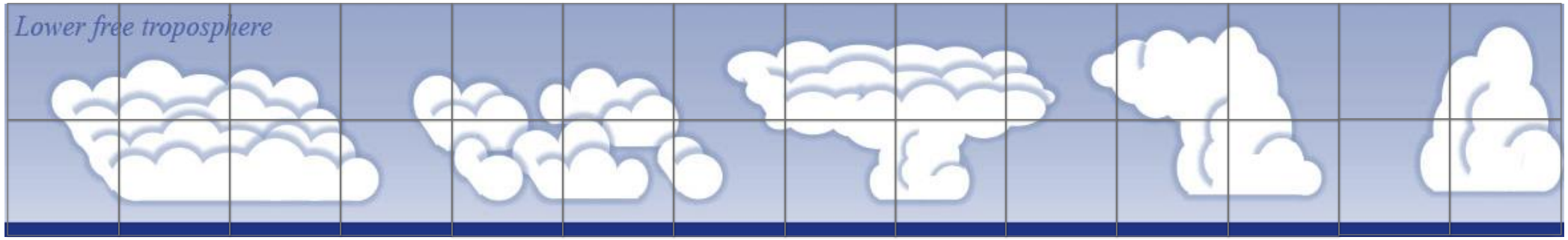
CLEO is a super-droplet model (SDM) for warm-cloud microphysics

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

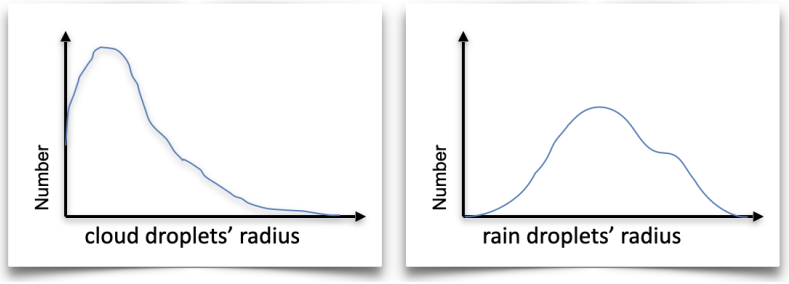
What is CLEO? What is a Super-Droplet Model (SDM)

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

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



Adapted from Cesana et al. 2019, CC BY 4.0



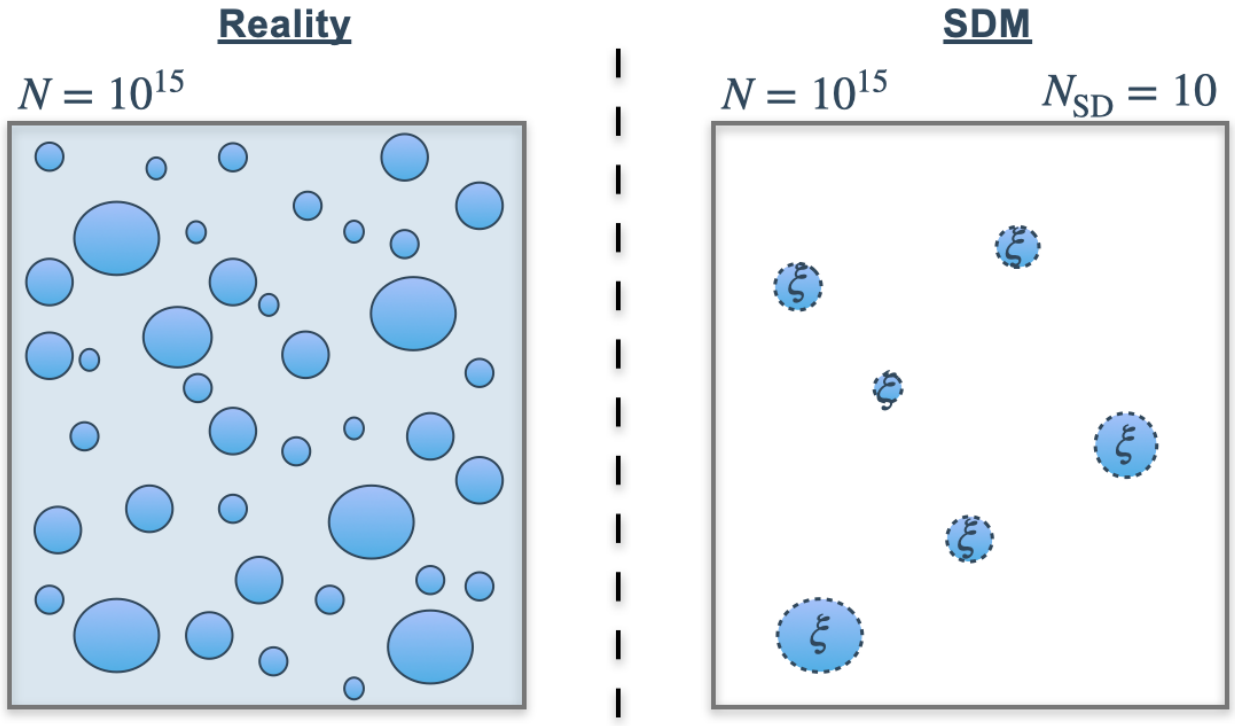
Including…

- Numerical diffusion
- Approximate size distributions and droplet theory

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

CLEO is a SDM for warm-cloud microphysics

Adapted from Cesana et al. 2019, CC BY 4.0

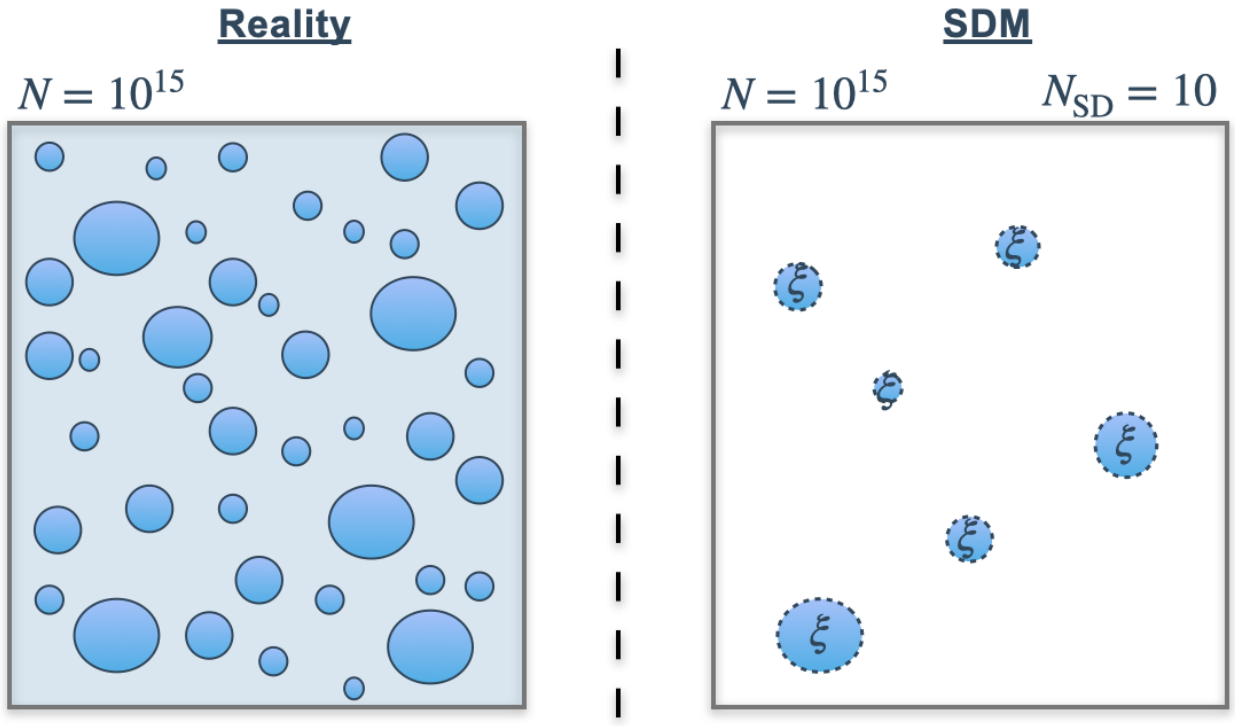


Shima et al. 2009

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

CLEO is a SDM for warm-cloud microphysics

Adapted from Cesana et al. 2019, CC BY 4.0



Shima et al. 2009

Each superdroplet has its own multiplicity, ξ,

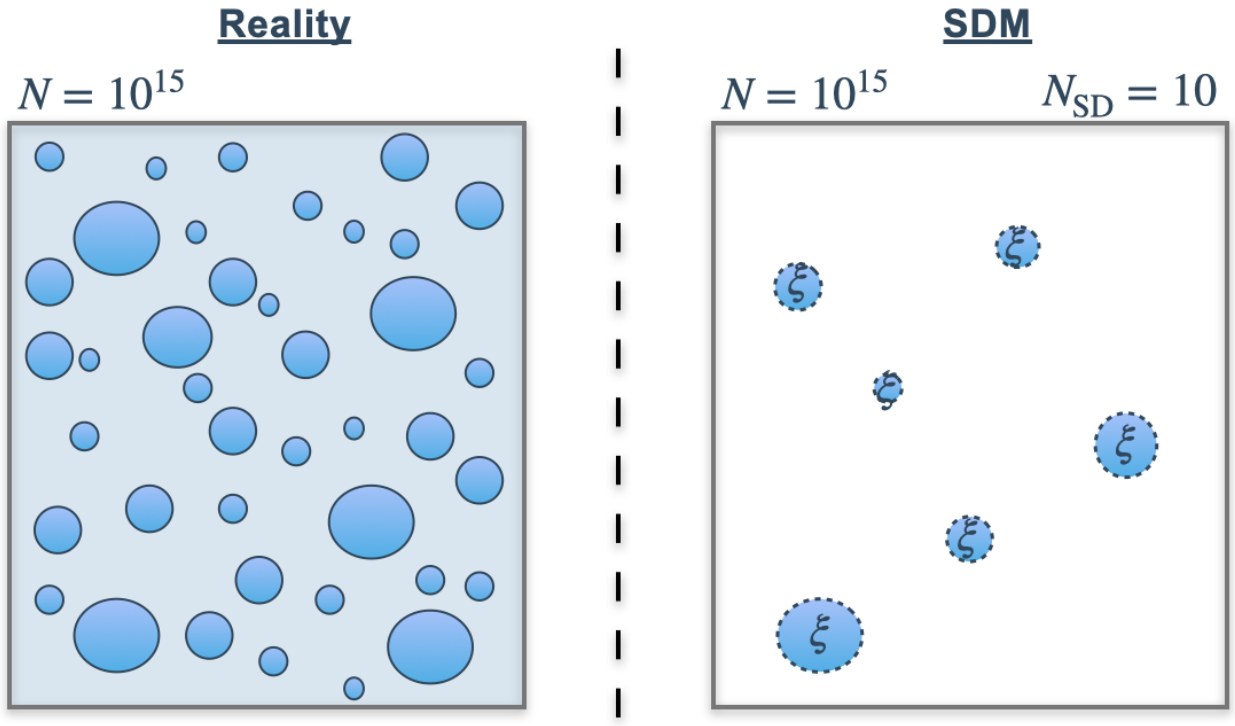
$\xi = 1, 2, 3, \ldots \xi$

1 superdroplet = ξ real droplets

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

CLEO is a SDM for warm-cloud microphysics

Adapted from Cesana et al. 2019, CC BY 4.0



Shima et al. 2009

Each superdroplet has its own multiplicity, ξ,

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

1 superdroplet = ξ real droplets

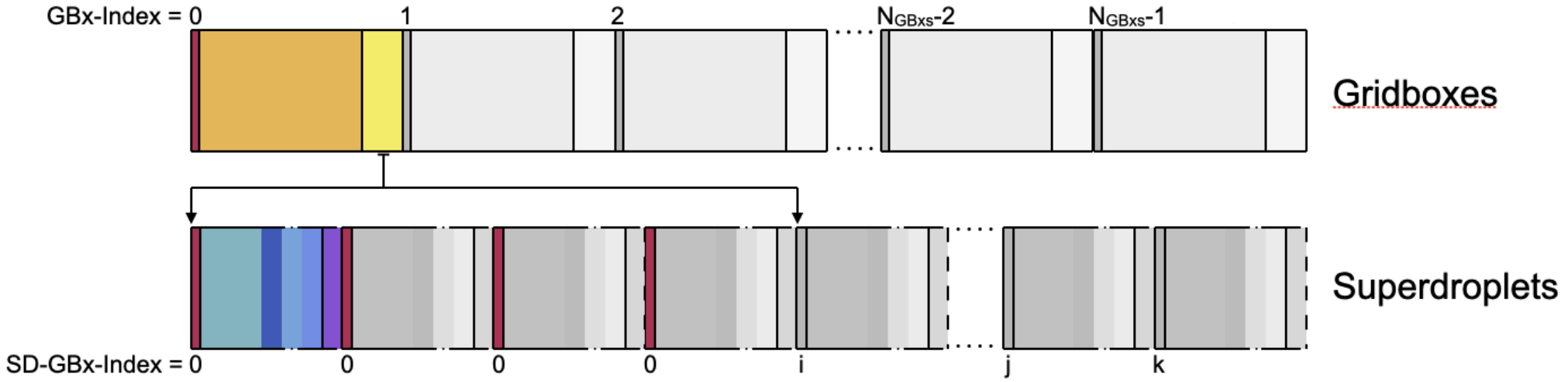
- Lagrangian c.f. Eulerian
- Useful convergence properties
- Highly parallelizable

The Goals of the CLEO-YAC-ICON sprint

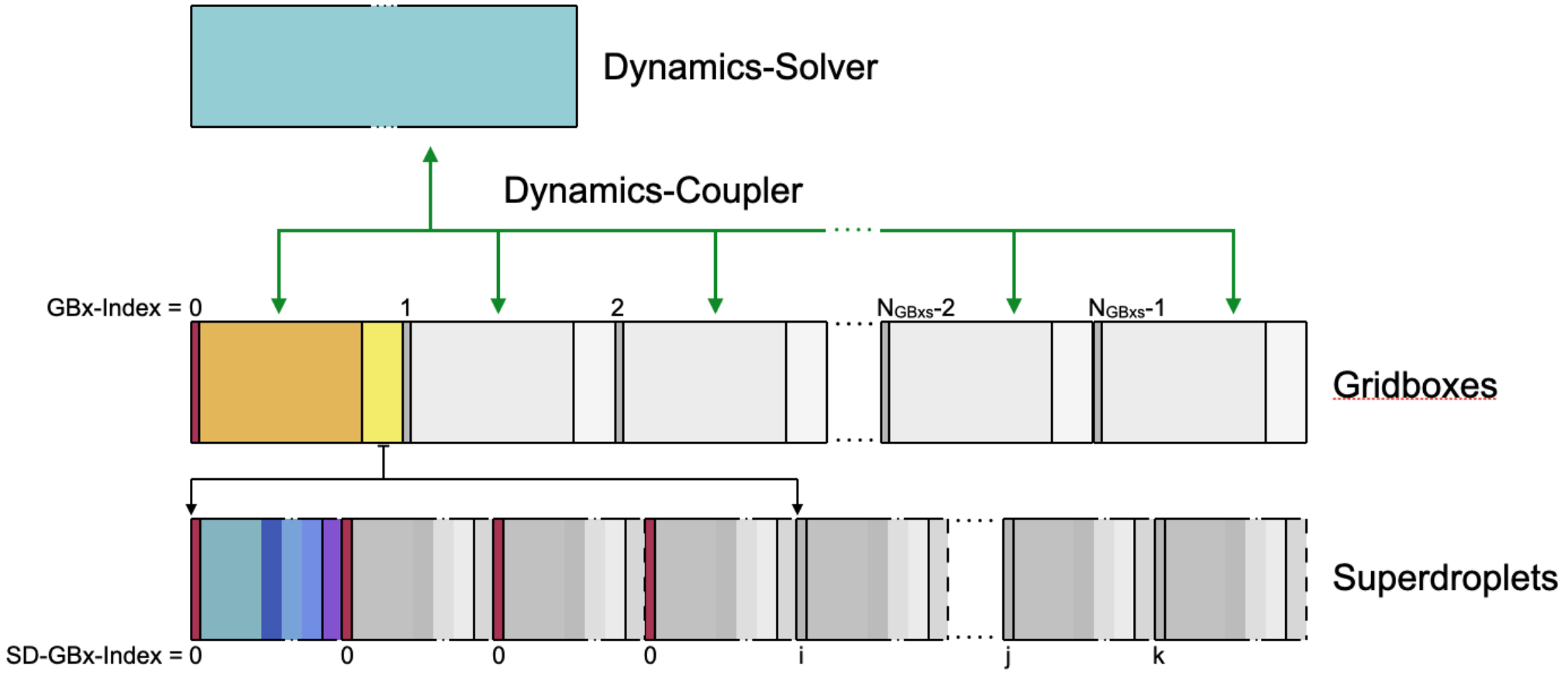
Assist the development of the SDM CLEO, to use as a microphysics scheme in ICON

1. Couple CLEO to ICON via YAC
2. Implement MPI Domain Decomposition

Developing CLEO's Computational Structure

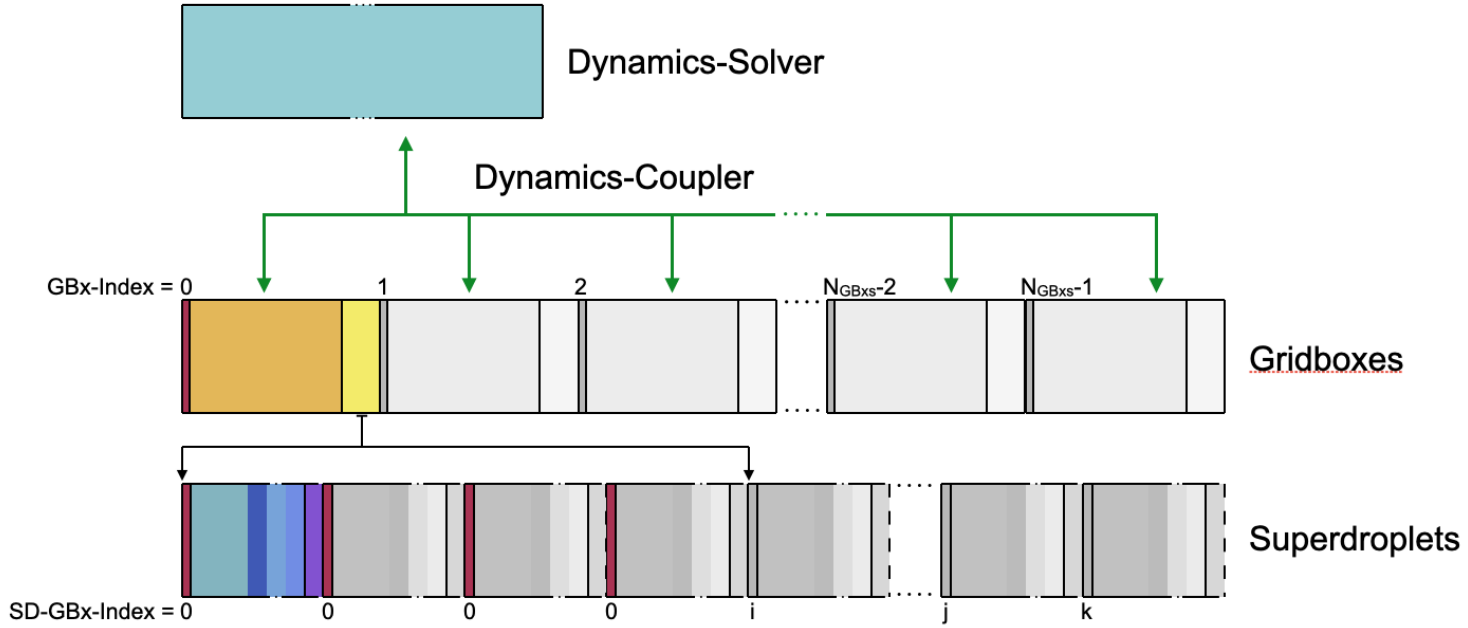


Developing CLEO's Computational Structure



The Goals of the CLEO-YAC-ICON sprint

1. Couple CLEO to ICON via YAC
2. Implement MPI Domain Decomposition

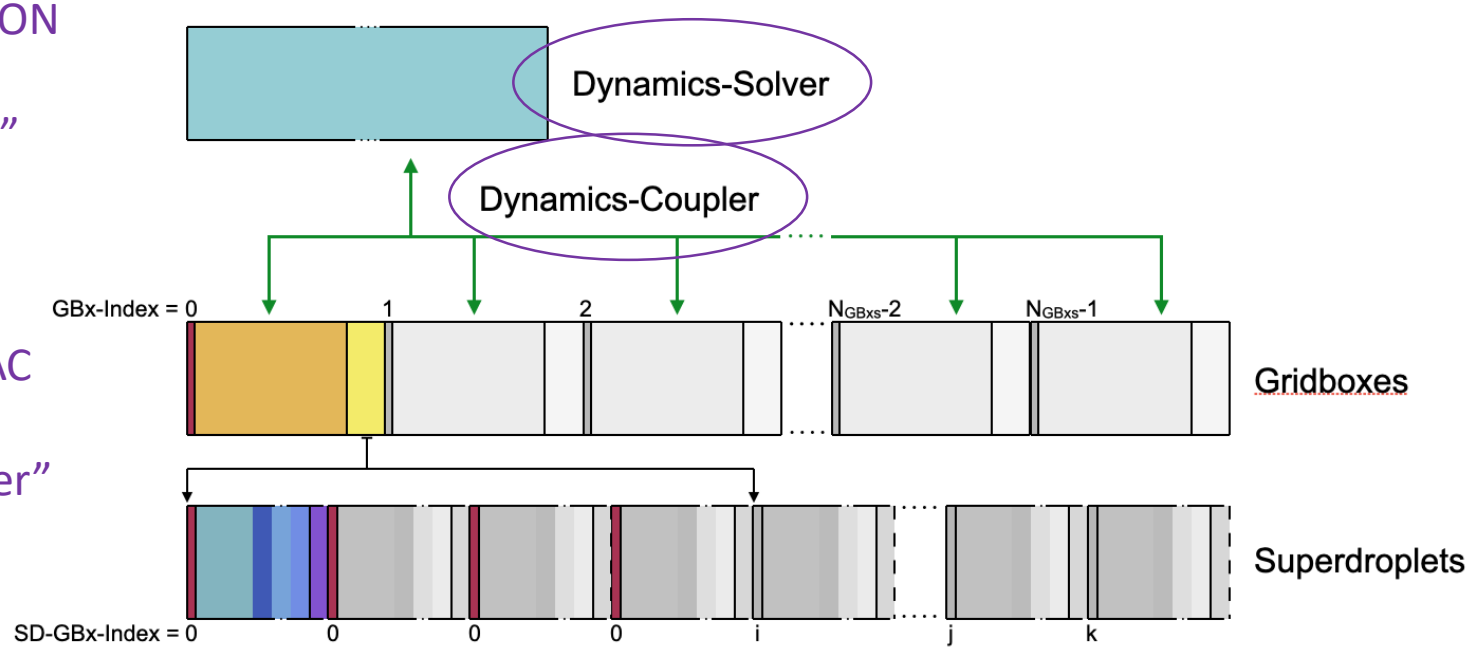


The Goals of the CLEO-YAC-ICON sprint

1. Couple CLEO to ICON via YAC

a) Create type for ICON satisfying the “Dynamics-Solver” concept

b) Create type for YAC satisfying the “Dynamics-Coupler” concept



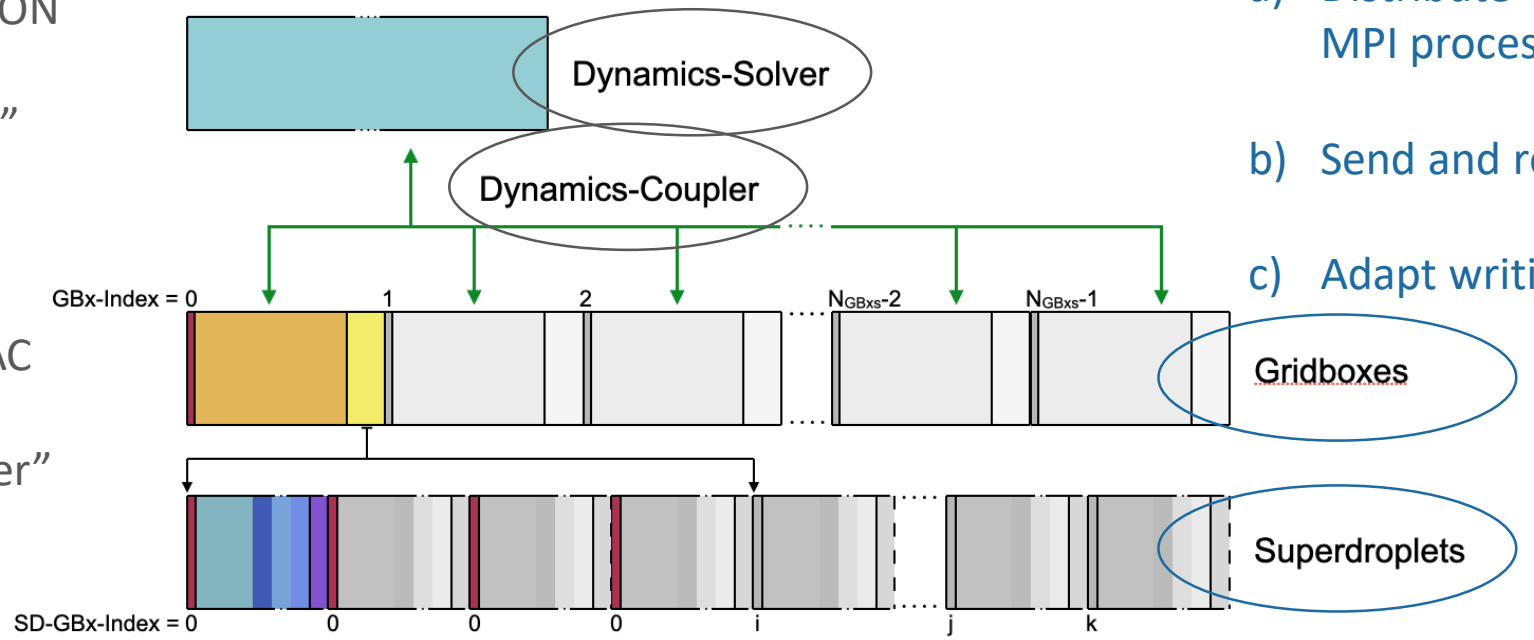
2. Implement MPI Domain Decomposition

The Goals of the CLEO-YAC-ICON sprint

1. Couple CLEO to ICON via YAC

a) Create type for ICON satisfying the "Dynamics-Solver" concept

b) Create type for YAC satisfying the "Dynamics-Coupler" concept



2. Implement MPI Domain Decomposition

a) Distribute Gridboxes across MPI processes

b) Send and receive superdroplets

c) Adapt writing of output

Challenges of the CLEO-YAC-ICON sprint

Ambitious! Sprint comprehensively covered CLEO and integrated it with other software

- Sub-divide goals into smaller tasks, e.g. testing coupling with dummy data before ICON
- Work simultaneously on independent goals to be more efficient

Challenges of the CLEO-YAC-ICON sprint

Ambitious! Sprint comprehensively covered CLEO and integrated it with other software

- Sub-divide goals into smaller tasks, e.g. testing coupling with dummy data before ICON
- Work simultaneously on independent goals to be more efficient

Hard to implement MPI incrementally

- CLEO wasn't so prepared for MPI as for the YAC coupling, harder to identify sub-tasks
- Sub-tasks were more co-dependent
- Very large pull request at the end conflicted with other code developments unlike smaller, more frequent requests

Challenges of the CLEO-YAC-ICON sprint

Ambitious! Sprint comprehensively covered CLEO and integrated it with other software

- Sub-divide goals into smaller tasks, e.g. testing coupling with dummy data before ICON
- Work simultaneously on independent goals to be more efficient

Hard to implement MPI incrementally

- CLEO wasn't so prepared for MPI as for the YAC coupling, harder to identify sub-tasks
- Sub-tasks were more co-dependent
- Very large pull request at the end conflicted with other code developments unlike smaller, more frequent requests

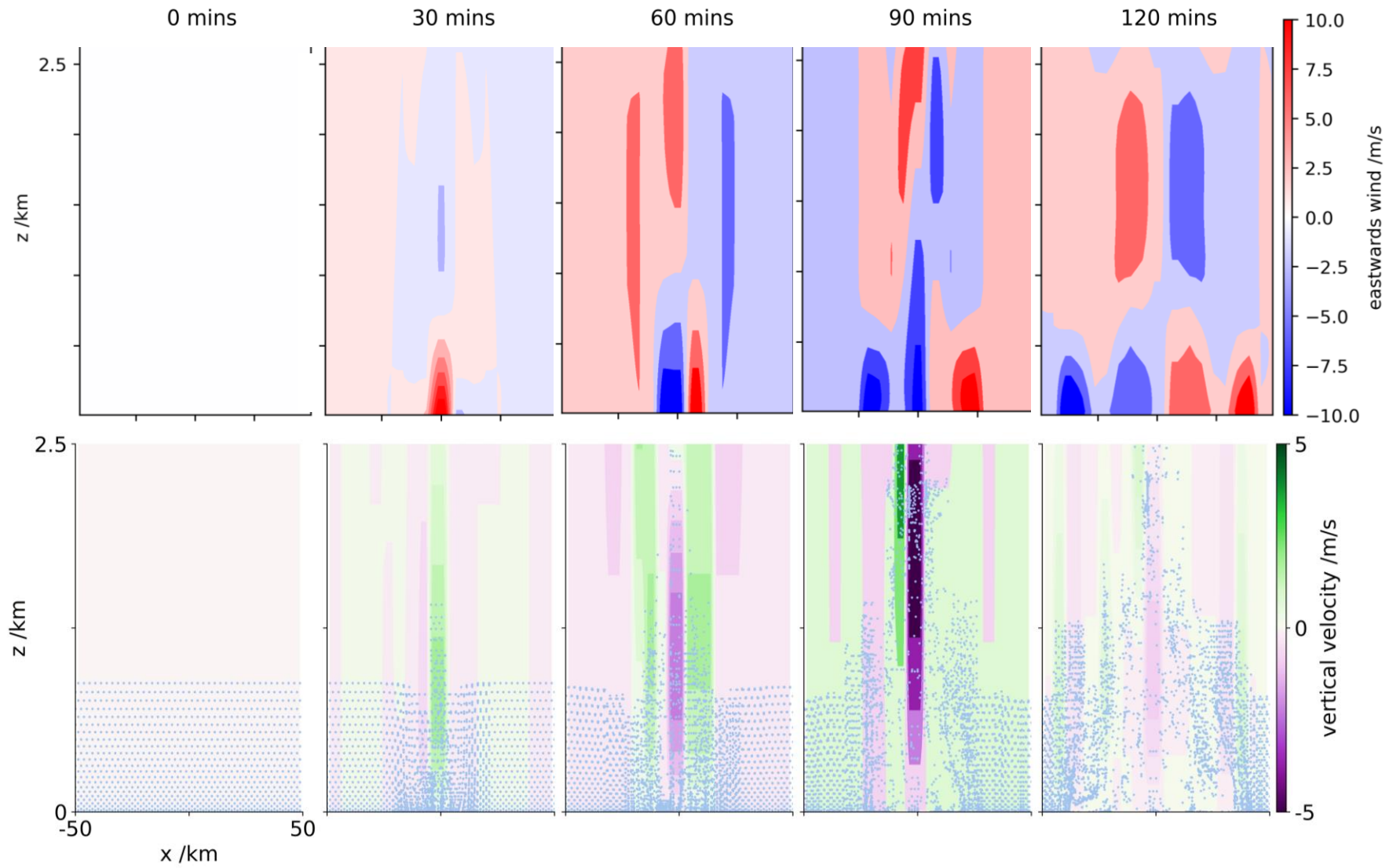
YAC documentation is not a user-guide

- Essential to have communication with Moritz Hanke
- Clara struggles to understand, modify or debug the YAC coupling

Results of the CLEO-YAC-ICON sprint

- Very smooth and enjoyable project with good communication
- A number of byproducts!
  - New working group developing ICON's microphysics schemes
  - Dissemination of better software practices, e.g. version control, documentation, commit messages, standardized code formatting and linting, …
- Completed one-way coupling from ICON to CLEO via YAC
- Completed first implementation for MPI domain decomposition

Completed One-Way coupling of CLEO to ICON via YAC



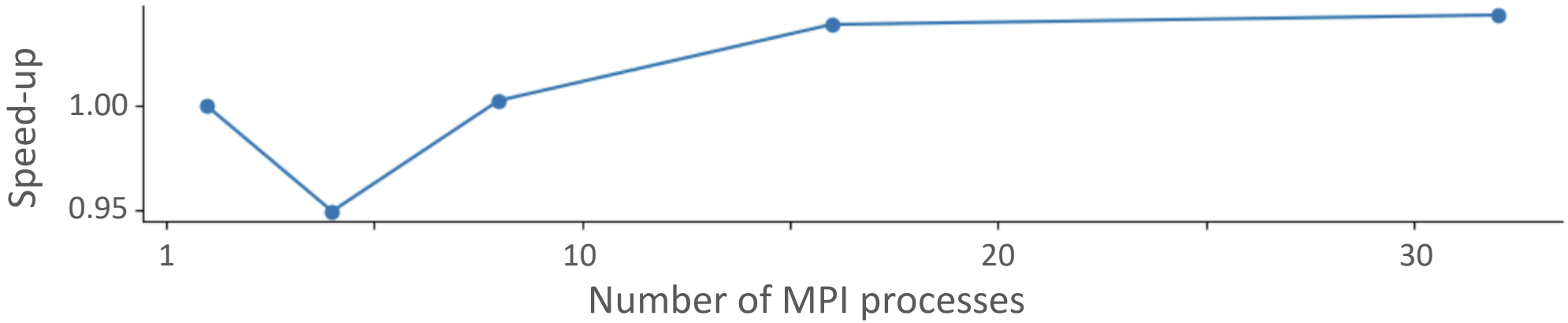
Completed CLEO's first MPI Domain Decomposition

- New "DomainDecomposition" structure to manage global to/from local indexing
- New functions in superdroplet and Gridbox initialization to select process-specific data
- New functions during superdroplet motion to send and receive superdroplets
- New version of "Dataset" structure for writing data from many processes via one

Completed CLEO's first MPI Domain Decomposition

- New "DomainDecomposition" structure to manage global to/from local indexing
- New functions in superdroplet and gridbox initialization to select process-specific data
- New functions during superdroplet motion to send and receive superdroplets
- New version of "Dataset" structure for writing data from many processes via one

There's still work to be done!



Outlook and Open Questions

We've applied for another sprint! (request currently under review)

With special thanks to Wilton Loch!

- For ICON-CLEO-YAC coupling:
  - Implement two-way coupling
  - Submit pull requests into ICON (compatible with our microphysics working group's refactoring)
- For CLEO's MPI Domain Decomposition:
  - Resolve (small) incompatibilities between coupling and MPI domain decomposition
  - Profile performance of specific test-cases
  - Improve load balancing, identify apparent bottlenecks, resolve if time permits

Striving towards ICON simulations with a fundamentally different model for warm-cloud microphysics, providing a new tool to understand cloud organization and precipitation!