Progress Report

Research Objective 1:
Development of a Q3D MMF

The quasi-3D multi-scale modeling framework (Q3D MMF) is an attempt to include 3D cloud effects in a GCM without necessarily using a fully three-dimensional global cloud-resolving model (GCRM).

Joon-Hee Jung and Akio Arakawa

January 2011 CMMAP Team Meeting

A Q3D algorithm based on a "gappy" grid has been developed and evaluated

Presentations:

3rd International Workshop on Next-generation NWP Models
Aug. 29 - Sep. 1, Jeju

1st International Workshop on Nonhydrostatic Numerical Models
Sep. 29 - Oct. 1, Kyoto

ECMWF Workshop on Nonhydrostatic Modelling
Nov. 8 -10, Reading

A Q3D algorithm based on a "gappy" grid has been developed and evaluated

Publications:

Jung, J.-H., and A. Arakawa, 2010:
Development of a quasi-3d multiscale modeling framework: motivation, basic algorithm and preliminary results.
J. Adv. Model. Earth Syst., **2**, Art. #11, 31pp.

A. Arakawa, J.-H. Jung, and C.-M. Wu:
Toward unification of the multiscale modeling of the atmosphere
submitted to Atmos. Chem. Phys.

A. Arakawa, J.-H. Jung, and C.-M. Wu:
Toward unification of general circulation and cloud-resolving models
submitted to ECMWF conference proceeding

Ongoing Work: Parallelization of the Q3D model

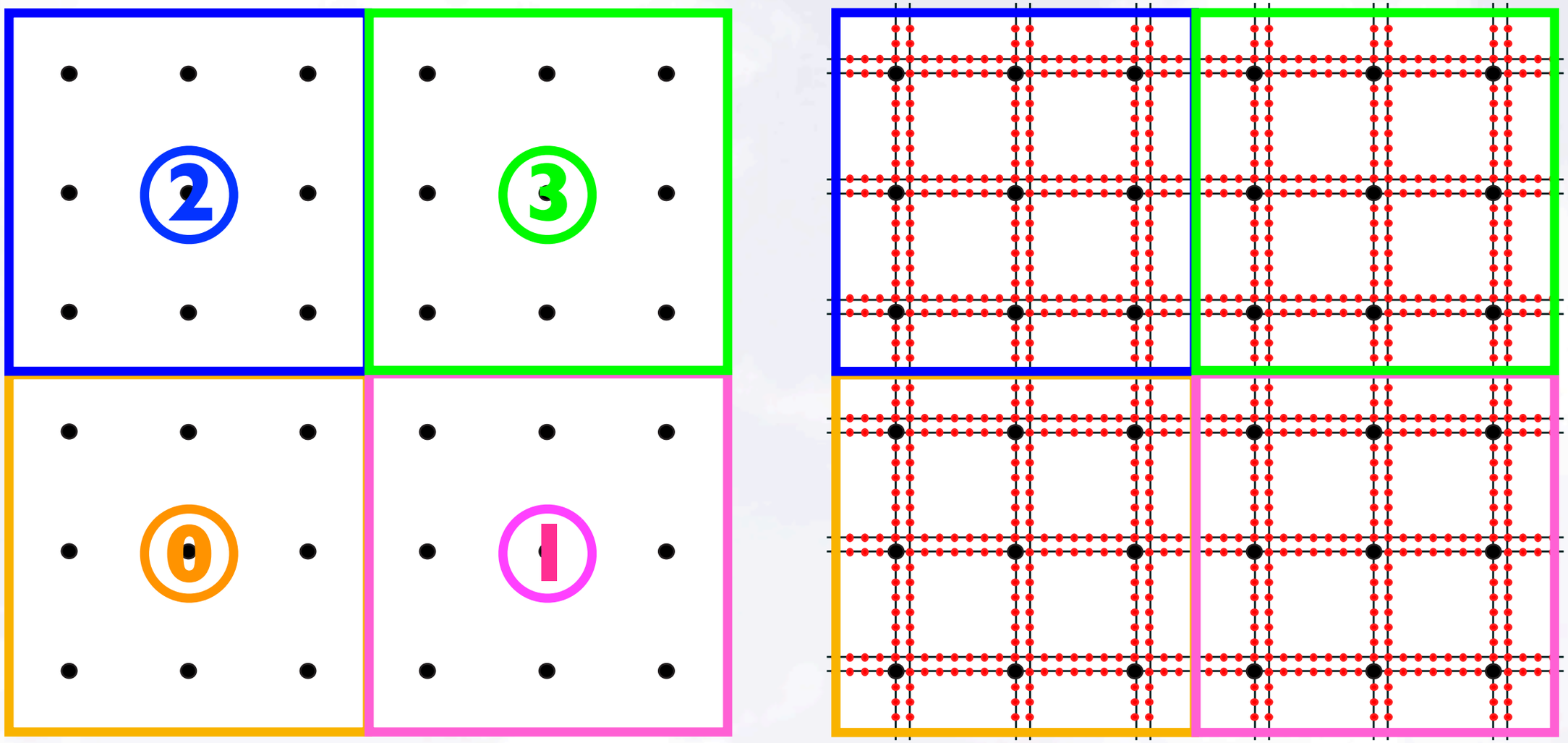
Prior to this work the code was Fortran 77 without parallelization

Component Codes of the Q3D model

- **GCM code (a toy version: coarse-resolution 3D CRM)**
  - Base model: 3D VVM (Fortran 90/parallelized by Don Dazlich)
- **Q3D CRM code (two sets of perpendicular channels)**
- Interface between GCM and CRM
- Preparation of initial conditions from BM (3D CRM) data
- Preparation of GCM values from BM data

Global horizontal domain is divided into rectangular subdomains of equal size

Subdomains are distributed among computer processors

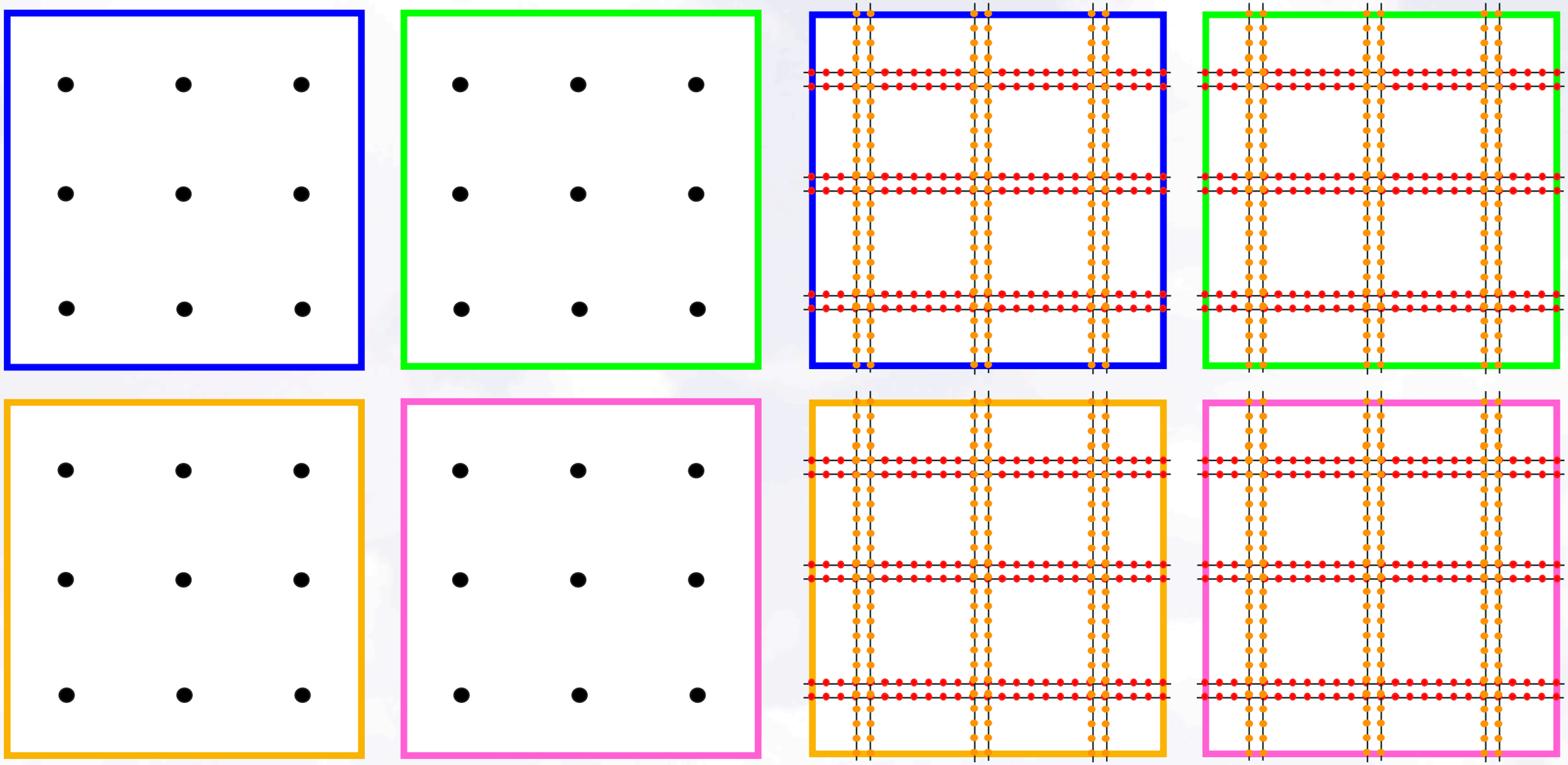


- GCM grid point
- CRM grid point

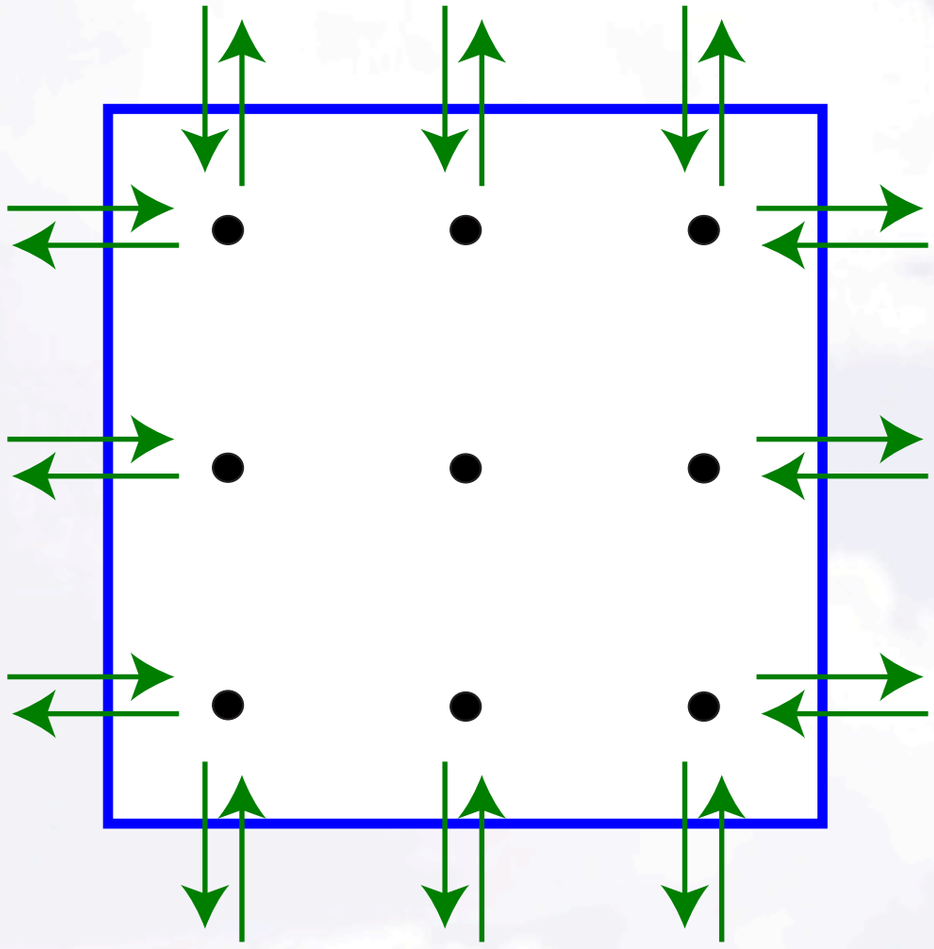
Each process simultaneously performs own calculation

GCM

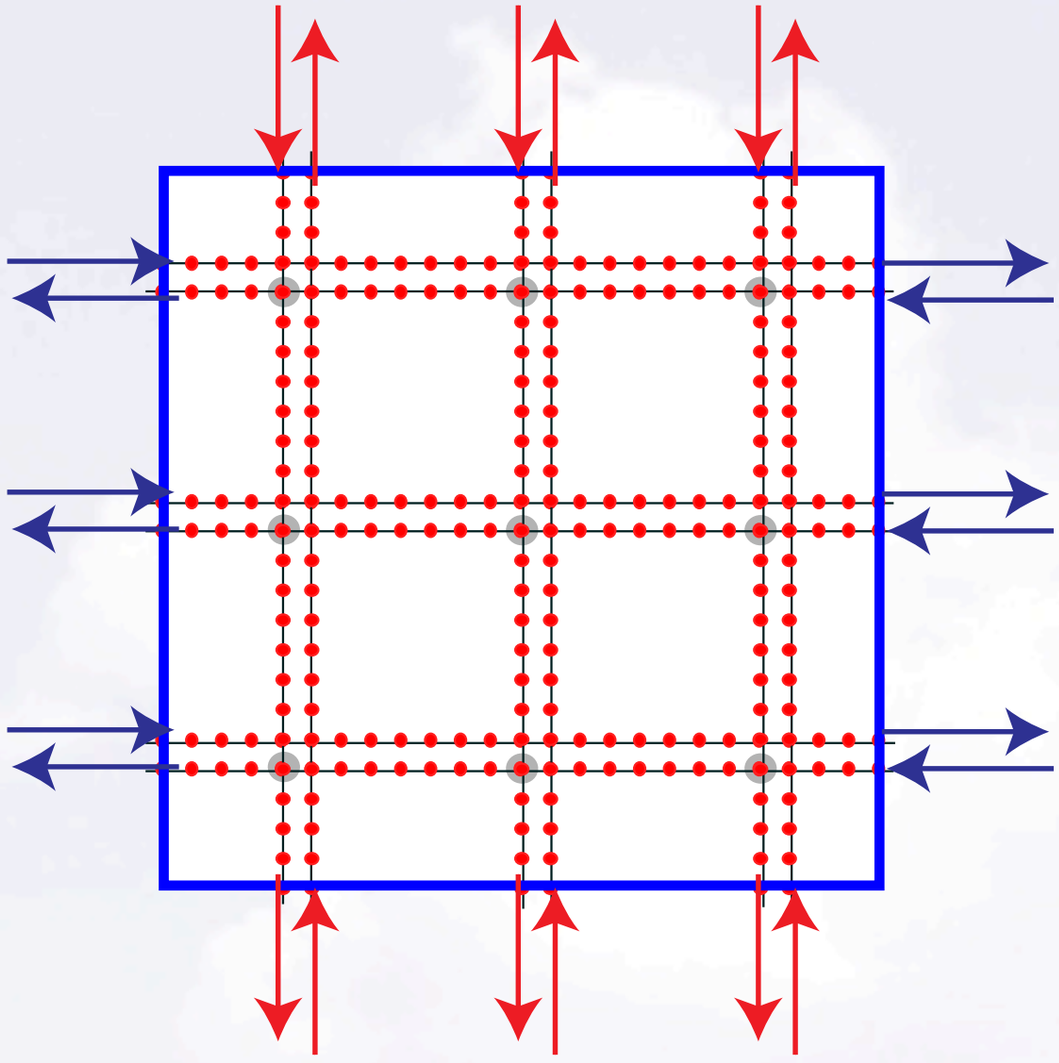
CRM



Communication between Neighboring Domains by Message Passing Interface (MPI)



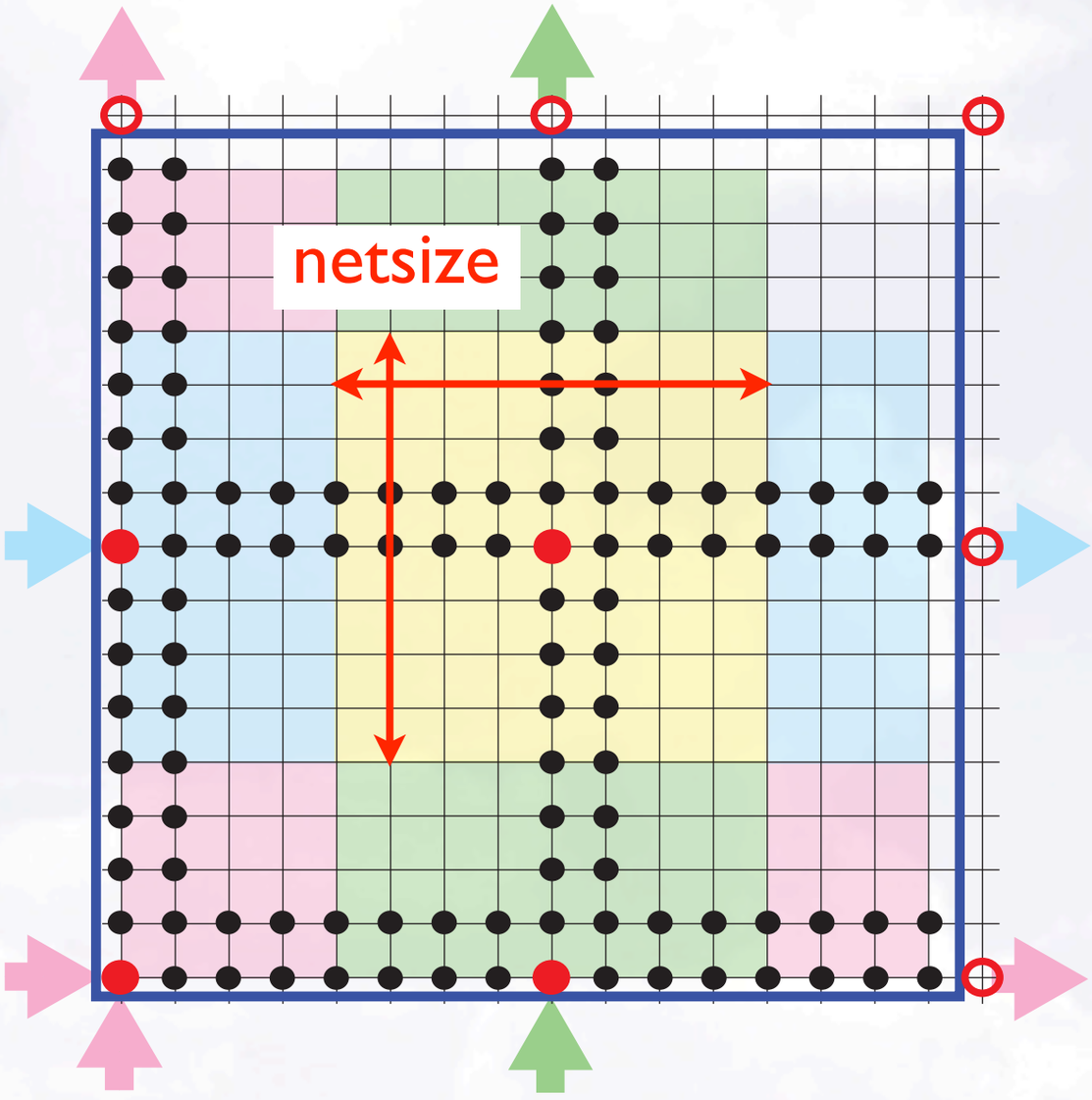
For GCM calculation, message passing involves two directions (e/w *and* s/n).



For Q3D CRM calculation, message passing involves only one direction (e/w *or* s/n).

Coupling of Perpendicular Channels

The channels are coupled through mutual relaxations of the potential temperature and water vapor mixing ratio ***averaged over the netsize segment*** of each channel.



Message Passing:
averaged values at GCM-points

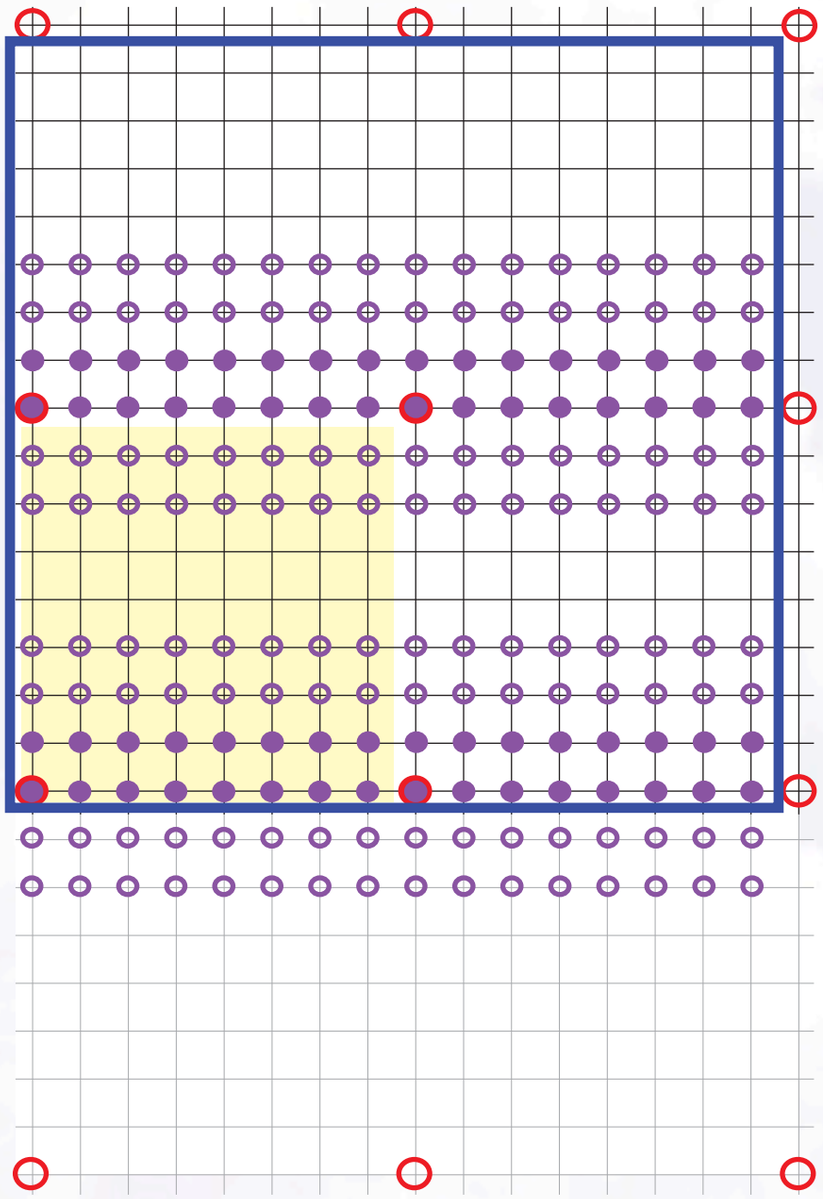
If necessary,
GCM values are obtained from
BM data in a similar way.

Use of Background Fields

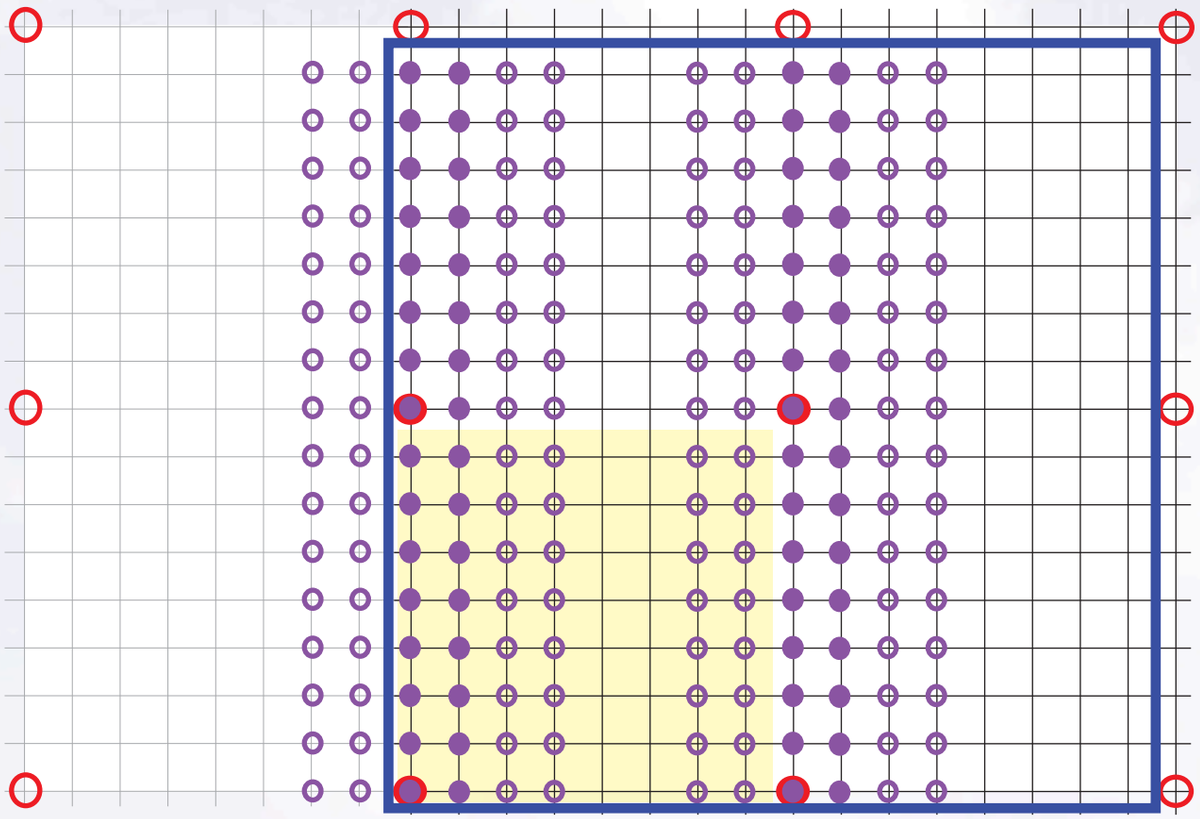
The background field at each CRM point is obtained by ***interpolation*** of the GCM variables.

q-point variable

x-channel



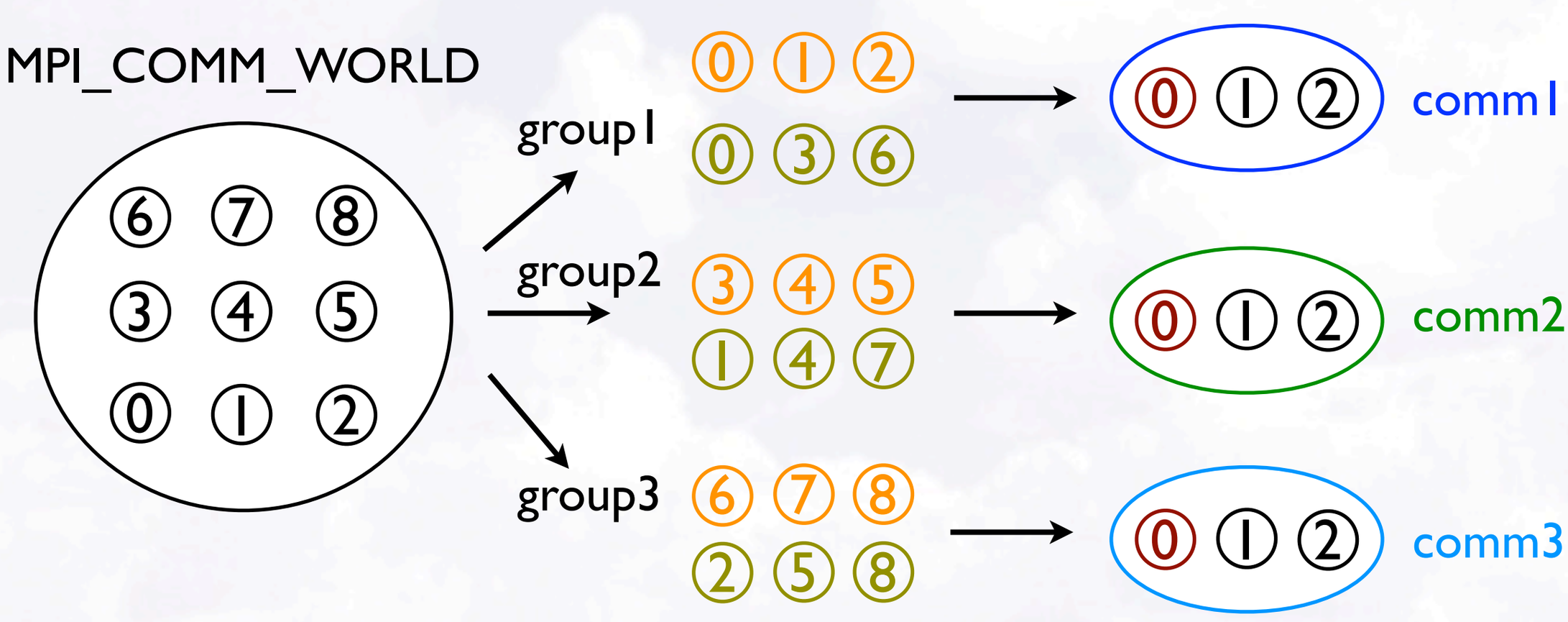
y-channel



No need of extra message passing

Parallelization Exceptions

- I/O - gathered to one process into global size array.
- **Elliptic Solver:** A relaxation procedure is used to solve the w-eq, which is based on an iteration method.
  - New groups are formed as subsets of global group.
  - One process of each group performs the relaxation procedure.



Completed Tasks

- Forming a primary structure of Q3D MMF: coded & tested
  (coupled structure of GCM and CRM, I/O, individual channel calculation, elliptic solver, handling channels located in different direction, and so on)
- Inclusion of Q3D algorithm: almost coded & tested
  (channel coupling, bg field calculation, ghost point calculation, and so on)

Near Future Tasks

- Completion of the parallelized code
- Test of the code through a complete simulation
  (serial *vs.* parallelized calculations, efficiency check, and so on)

Future Plans

- Test the Q3D MMF with a non-trivial GCM.
  (Still using an idealized setting with a domain size of a few thousands km.)
- Investigate the coupling strategy between GCM and CRM.
- Test the convergence of the Q3D MMF to the 3D CRM as the GCM grid size decreases.