KAKUSHIN Coupler, its features and futures

Takashi Arakawa
Research Organization for Information Science and Technology

Mar. 24 2010

Epochal Tsukuba, Tsukuba, Ibaraki, Japan

0 What can be said at all can be said clearly.

In my presentation

Project overview of KAKUSHIN coupler development

Features of KAKUSHIN coupler

Futures of KAKUSHIN coupler

will be said.

1 The world is all that is the case.

Back ground of the program

The world (climate) is complex system.

The equation is a projection of the world, so it is formulated as a complex system.

$$\frac{\partial \Phi}{\partial \sigma} = -\frac{RT_v}{\sigma}$$

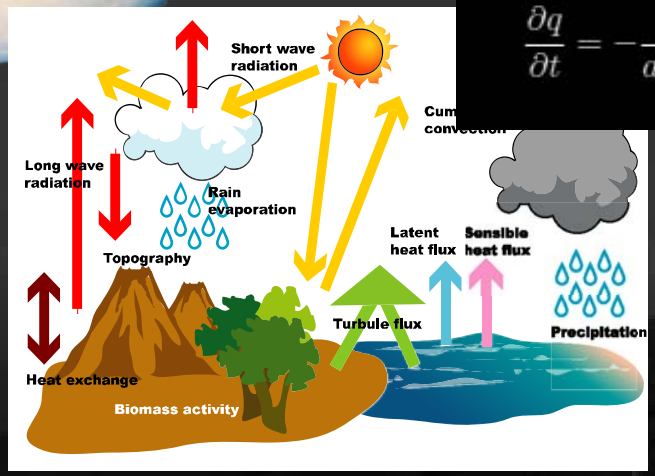
$$\frac{\partial \zeta}{\partial t} = \frac{1}{a\cos\varphi}\frac{\partial A_v}{\partial \lambda} - \frac{1}{a\cos\varphi}\frac{\partial}{\partial \varphi}(A_u \cos\varphi) - \mathcal{D}(\zeta)$$

$$\frac{\partial D}{\partial t} = \frac{1}{a\cos\varphi}\frac{\partial A_u}{\partial \lambda} + \frac{1}{a\cos\varphi}\frac{\partial}{\partial \varphi}(A_v \cos\varphi) - \nabla_\sigma^2(\Phi + R\overline{T}\pi + E) - \mathcal{D}(\zeta)$$

$$\frac{\partial T}{\partial t} = -\frac{1}{a\cos\varphi}\frac{\partial uT'}{\partial \lambda} - \frac{1}{a}\frac{\partial}{\partial \varphi}(vT'\cos\varphi) + T'D - \dot{\sigma}\frac{\partial T}{\partial \sigma}$$

$$+\kappa T\left(\frac{\partial \pi}{\partial t} + v_H \cdot \nabla_\sigma \pi + \frac{\dot{\sigma}}{\sigma}\right) + \frac{Q}{C_p} + \frac{Q\,diff}{C_p} - \mathcal{D}(T)$$

$$\frac{\partial q}{\partial t} = -\frac{1}{a\cos\varphi}\frac{\partial uq}{\partial \lambda} - \frac{1}{a}\frac{\partial}{\partial \varphi}(vq\cos\varphi) + qD - \dot{\sigma}\frac{\partial q}{\partial \sigma} + S_q - \mathcal{D}(q)$$



Three problems on complex system simulation

Non-linear
Multi-scale
Multi-physics

Scientific uncertainty

Software complexity

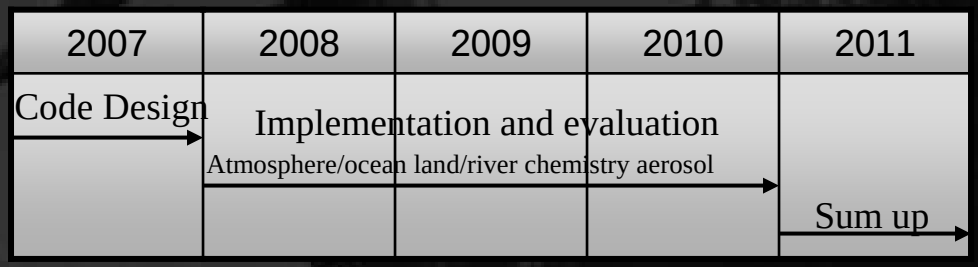
Computational performance

2 What is the case – a fact – is existence of state of affairs.

Project overview

Outline of the coupler development program

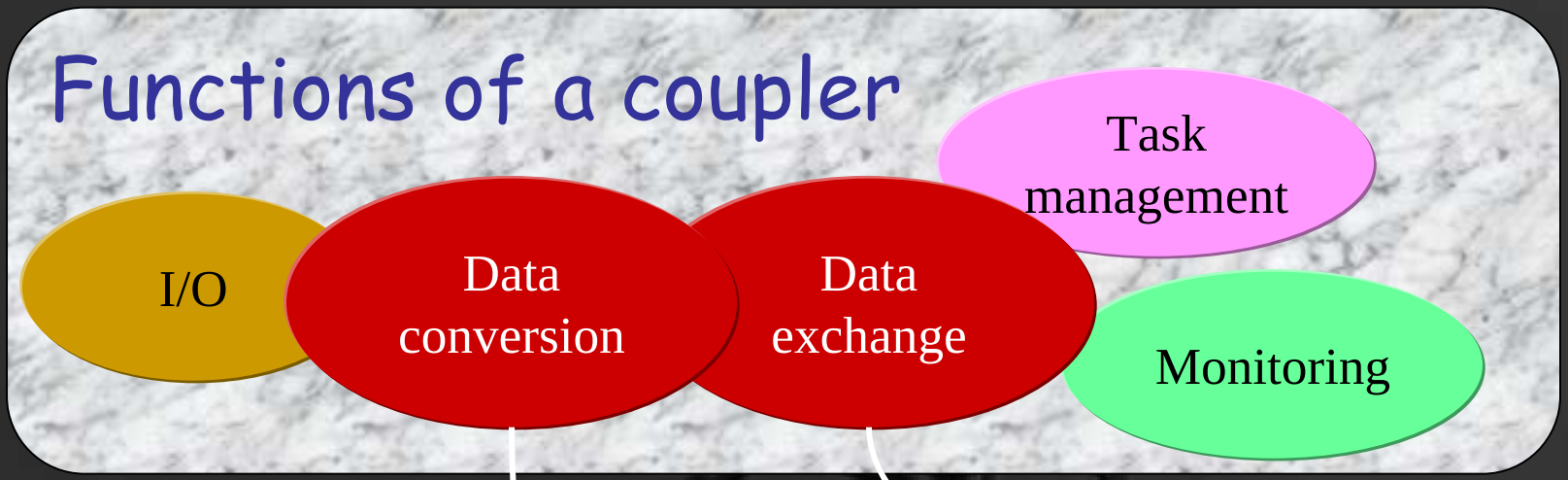
- Target
  - MIROC（based）ESM
  - MRI/JMA ESM
  - the Others (NICAM etc)
- Goal
  - design and make a (Japan standard) coupler
  - applies it to the Earth System Models and evaluate
- Team
  - FRCGC, CCSR, MRI, RIST
- Plan
  - 2007
    - coupler design
  - 2008
    - AGCM-OGCM coupling
  - 2009
    - AGCM-AEROSOL coupling



3 A logical picture of facts is a thought.

Design and implementation

Functions of a coupler



Divide the coupler code into the two parts

without the change of the value

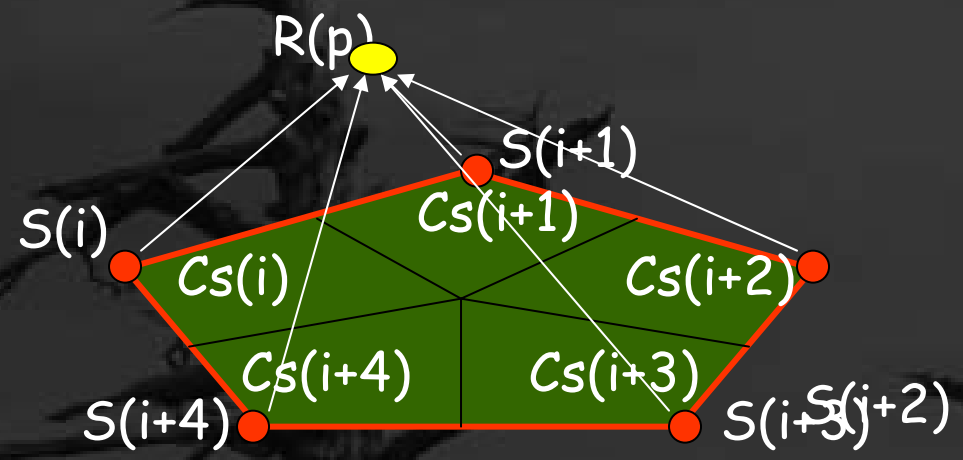
with the change of the value

The interpolation code which changes the value is put under the control of researchers

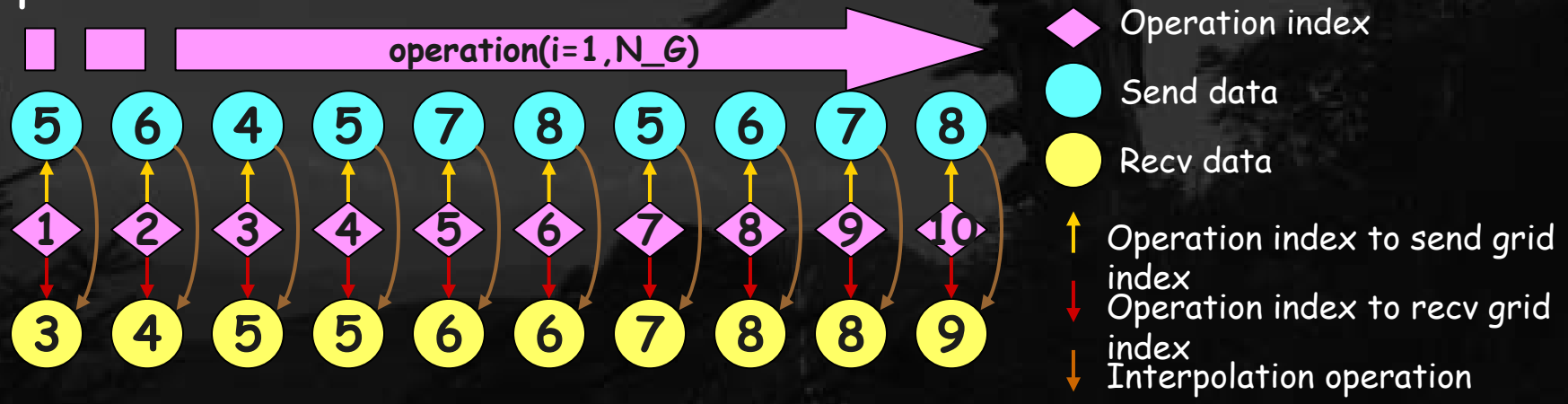
Portability

Flexibility

Interpolation = finite operation of a set of send data and coefficients



Interpolation can be represented as 1 dimensional operation



General form of Interpolation scheme

- The value R is computed from S(i) and coefficients
  - Related to R mesh, Related to S mesh
  - General coefficient

$$
\begin{aligned}
&Do\ I = 1, N \\
&\qquad R(Ir(I)) = R(Ir(I)) + \mathbf{F}\big(S(Is(I)), \\
&\qquad\qquad Cs_1(Is(I)), Cs_2(Is(I)), \cdots, \\
&\qquad\qquad Cr_1(Ir(I)), Cr_2(Ir(I)), \cdots, \\
&\qquad\qquad Co_1(I), Co_2(I), \cdots\big) \\
&End\ Do
\end{aligned}
$$

Ir : Conversion table from operation index I to R grid
Is : Conversion table from operation index I to S grid
Cr : Coefficients related to R mesh
Cs : Coefficients related to S mesh
Co : General Coefficients

4 A thought is a proposition with a sense.

Atmosphere-ocean coupling

Objective of the experiment

Target:MIROC

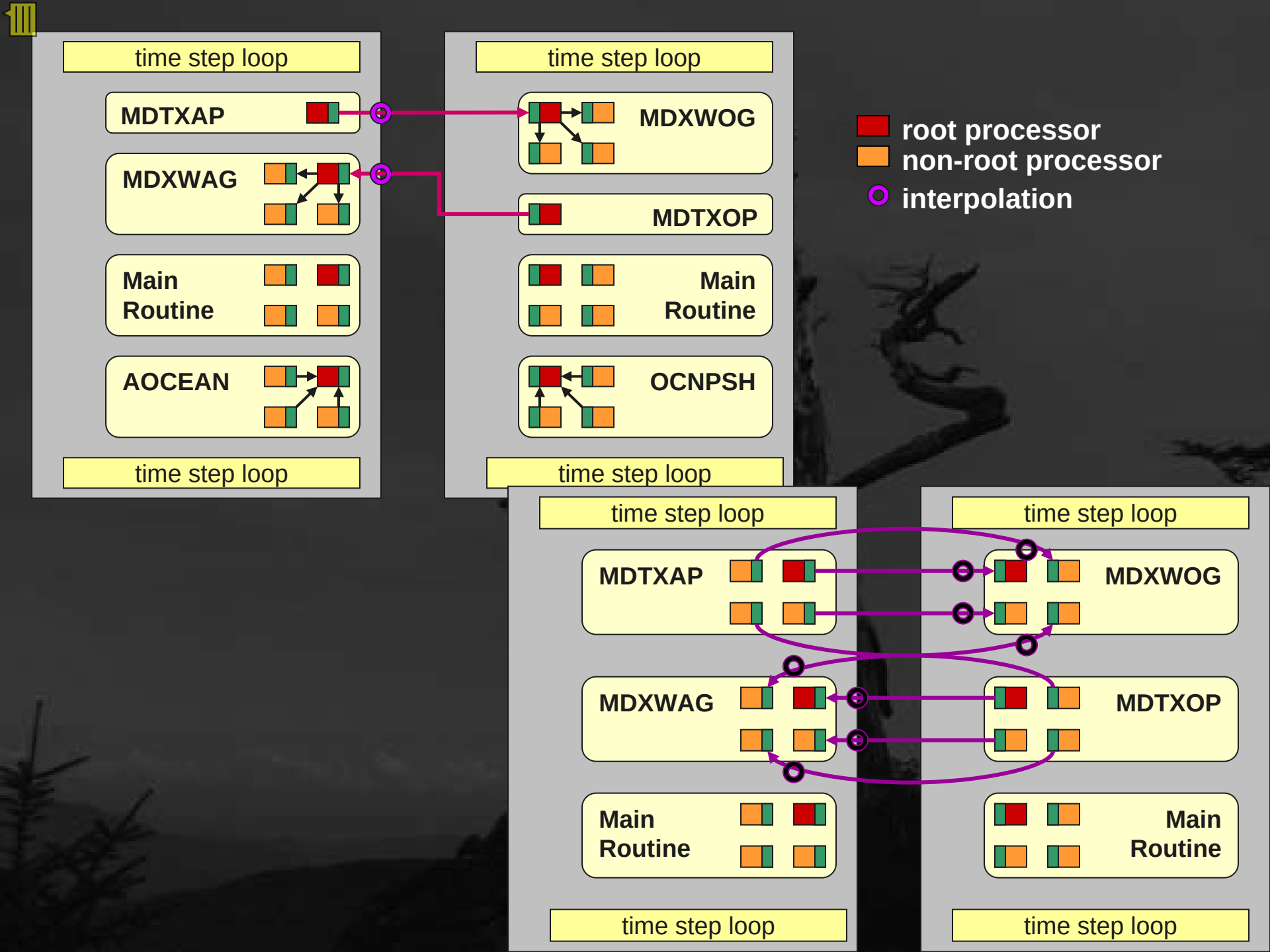
Coupling scheme of MIROC code

Non parallel

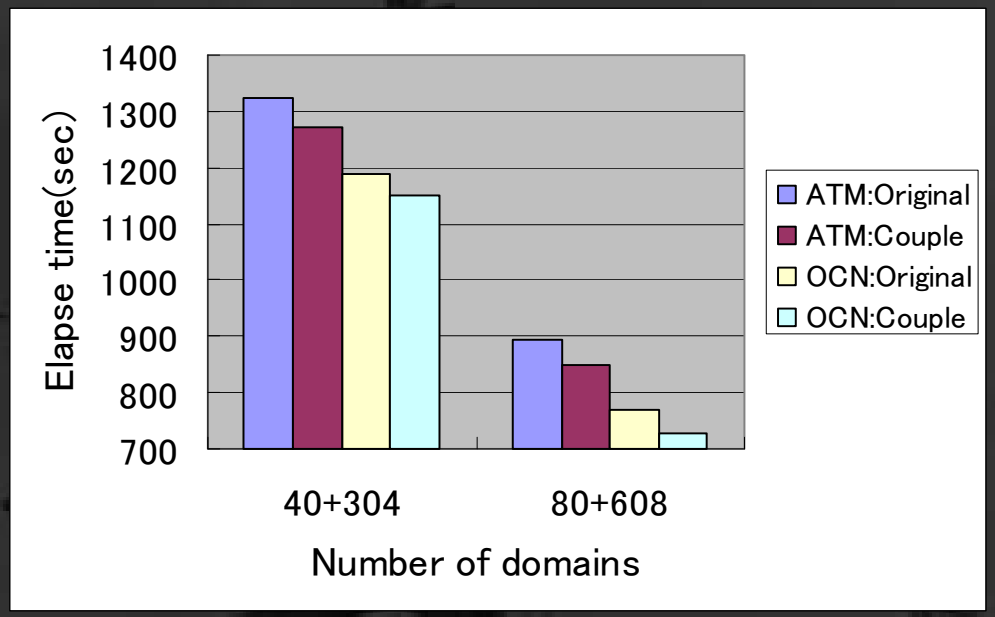
Coupling scheme of Jcup

Parallel

Performance improvement
Parallel efficiency


time step loop
MDTXAP
MDXWAG
Main Routine
AOCEAN
time step loop
time step loop
MDXWOG
MDTXOP
Main Routine
OCNPSH
time step loop
root processor
non-root processor
interpolation
time step loop
MDTXAP
MDXWAG
Main Routine
time step loop
time step loop
MDXWOG
MDTXOP
Main Routine
time step loop

Resolution : T106, 1280x916
Domain decomposition :40+304,80+608
Machine : ES1



Time for interpolation (sec)

	Original		Coupler	
# of PE	ATM to OCN	OCN to ATM	ATM to OCN	OCN to ATM
40+304	49.49	23.34	0.683	0.067
80+608	49.53	23.37	0.347	0.041

Interpolation time was decreased to negligible level
→Efficiency of Jcup is proved

5 A proposition is a truth-function of elementary propositions.

Atmosphere-Aerosol model coupling

Objective of the experiment

Divide a physical process and re-couple via Jcup

Aerosol process is a part of atmospheric processes

Coupling process requires 3D data exchange

What is the effective way in case of huge amount of data exchange is required ?

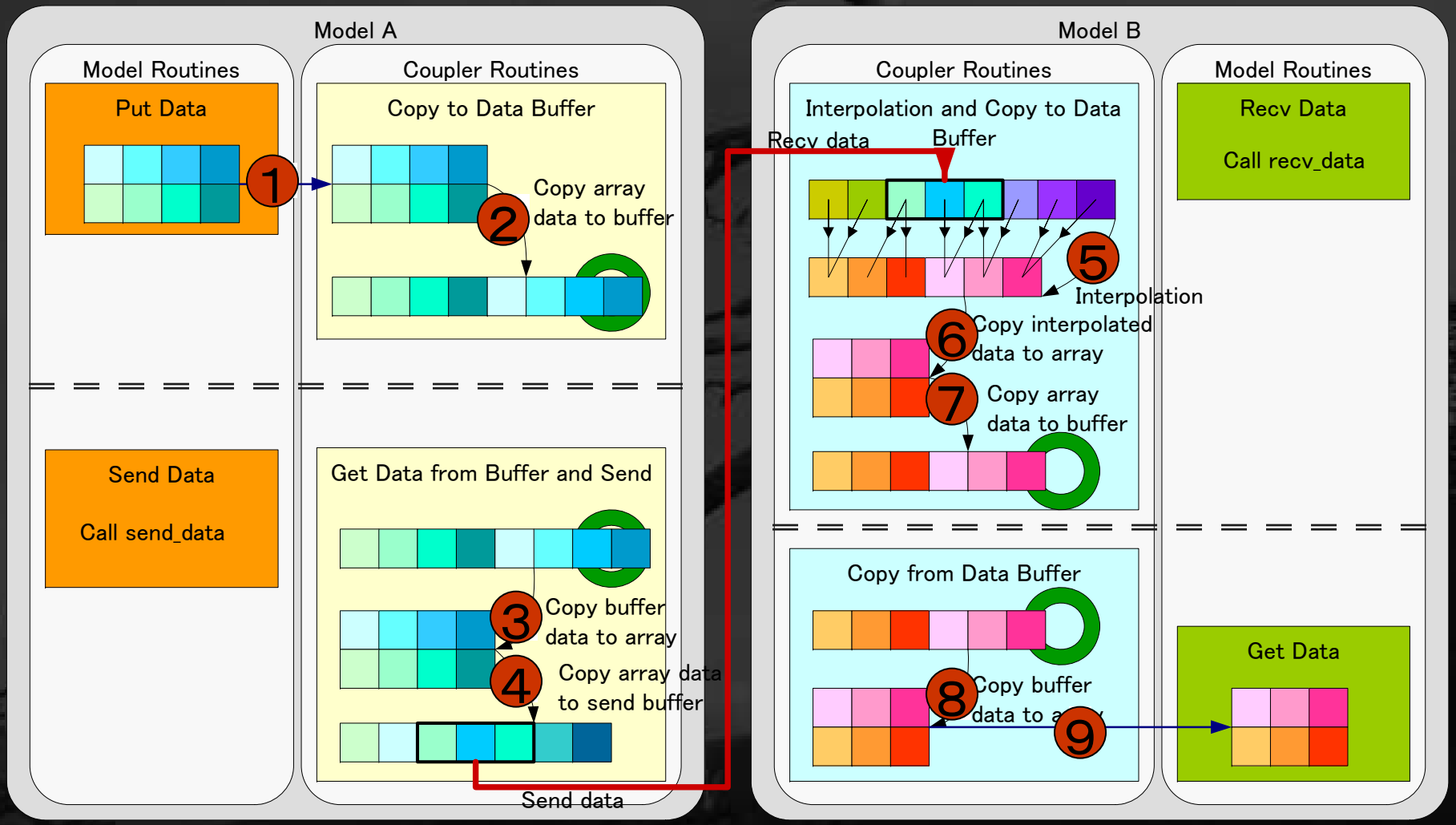
Detail of the experiment

- Aerosol process was divided from AGCM
  - Aerosol model：SPRINTARS（Takemura et al.）
- Re coupled via Jcup
  - 3D(and 4D) data exchange
    - Number of data
      - AGCM→SPRINTARS：22
      - SPRINTARS→AGCM：19
    - Data size：320x160x56

    - Exchange data amount:100 times of atmosphere-ocean coupling

Data flow

put, buffering, exchange, interpolation, get

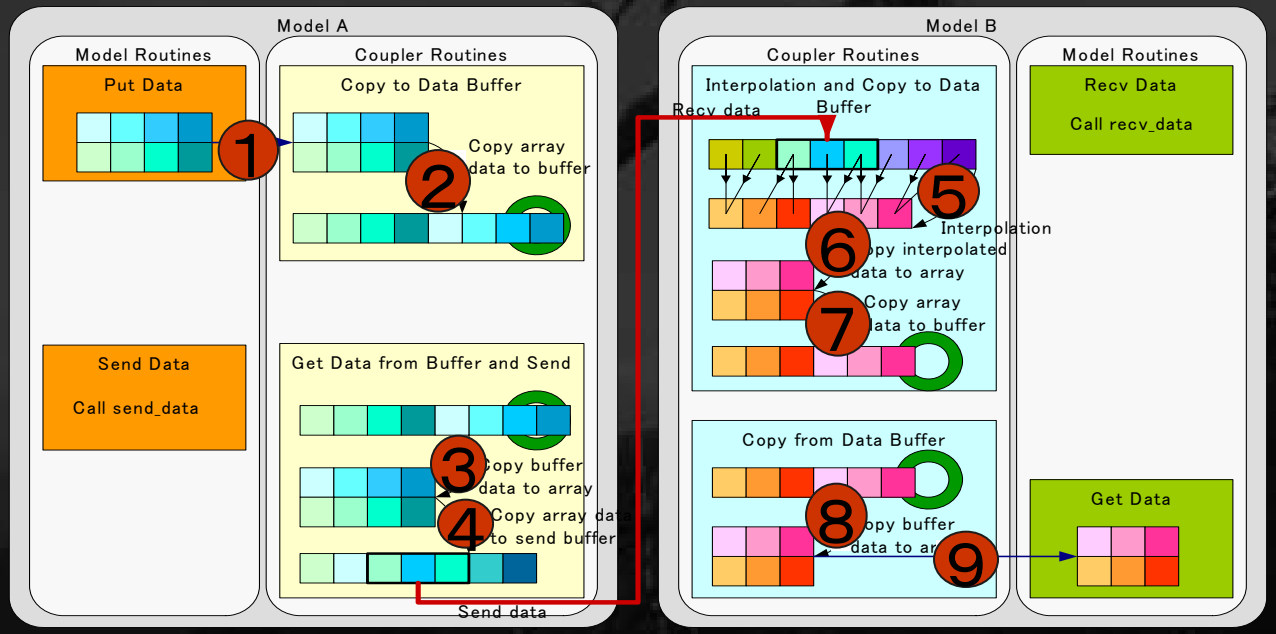


Send-recv data flow

Resolution : T106L56
Domain decomposition :40+40,40+80,40+160
Machine : ES2

4case

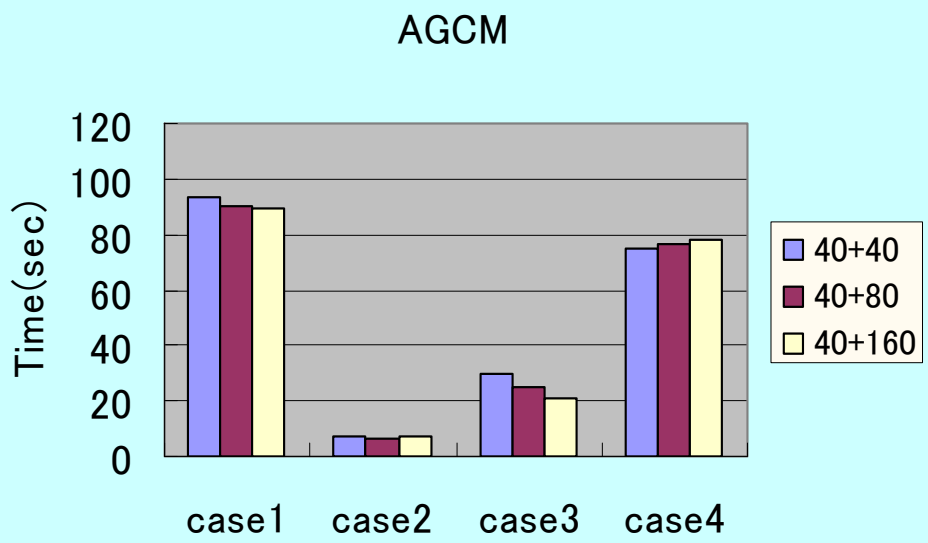
Case1	Default (with interpolation, buffering)
Case2	Direct (without interpolation, buffering) : ①→⑨
Case3	Without buffering : ①→④→⑤→⑧→⑨
Case4	Without interpolation : ①→②→③→⑦→⑧→⑨

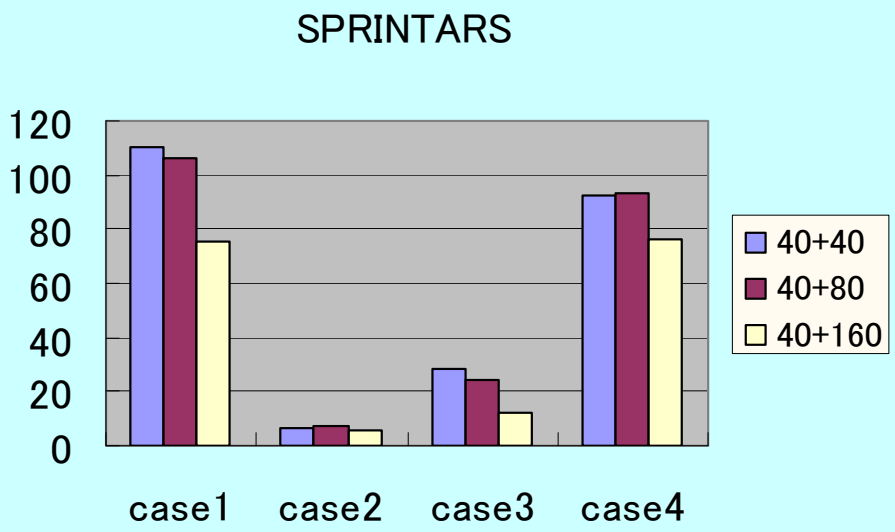


Efficiency of Data exchange

case2＞case3＞＞case4＞case5

Case3:good linearity for # of PEs





Elapse time for data exchange

Interpolation ?

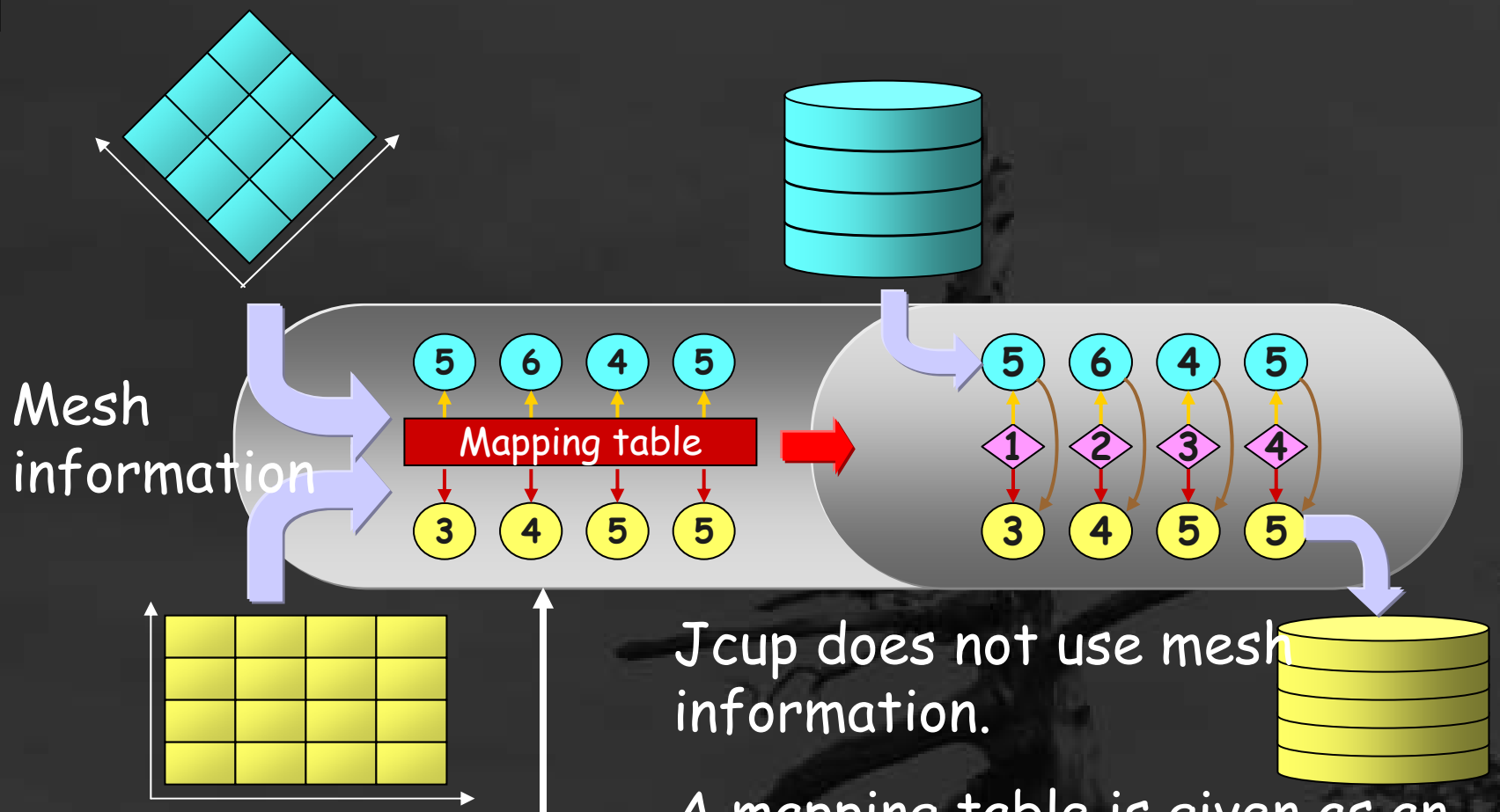
No → case2

Yes → case3

Non buffering option

6.1 The propositions of logic are tautologies.

Future plan



Jcup does not use mesh information.

A mapping table is given as an "a priori" information

Next Challenge

How to compute a mapping table effectively in case of very large scale, high resolution simulation.

7 What we cannot speak about we must pass over in silence.