Connecting global and regional models: A two-way nesting approach

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Climate differed from Weather

Climate Simulation

- radiation & convection processes
- hydrostatic equation (coarse resolution)
- long-time & global integrations

Weather Prediction

- dynamical & cloud processes
- non-hydrostatic equation (fine resolution)
- short-term & regional forecasts

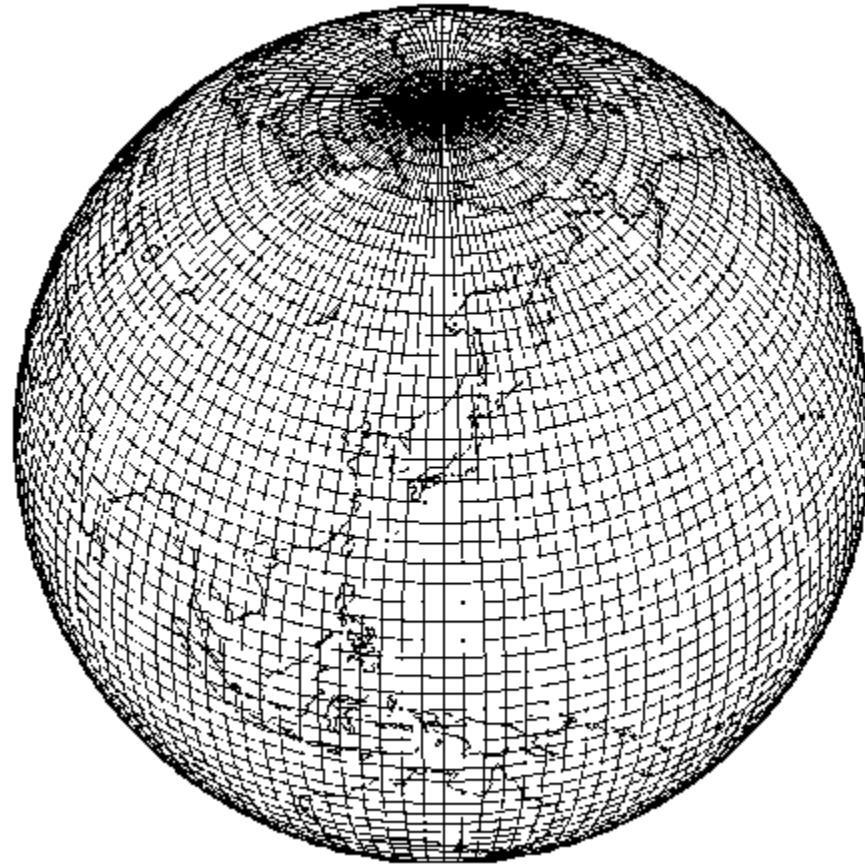# Climate gets closer to Weather

Two purposes:

1. high-resolution information.

2. precise physics.

→ A very high-resolution model, universally simulating from climate to weather.
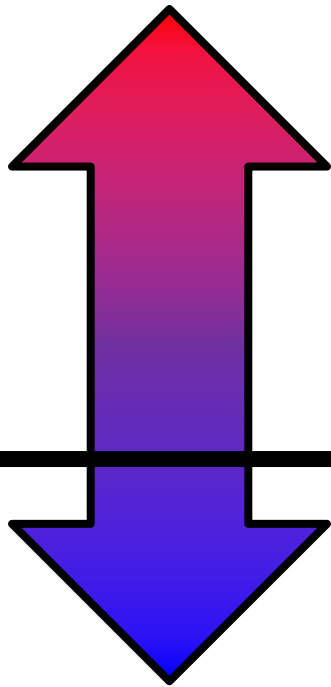
Entirely or partially?

Partially high-resolution strategy (PHS)

Two purposes and three methods

high-res. info.

- **Variable grid GCM**
  (Deque and Piedelievre 1995, and
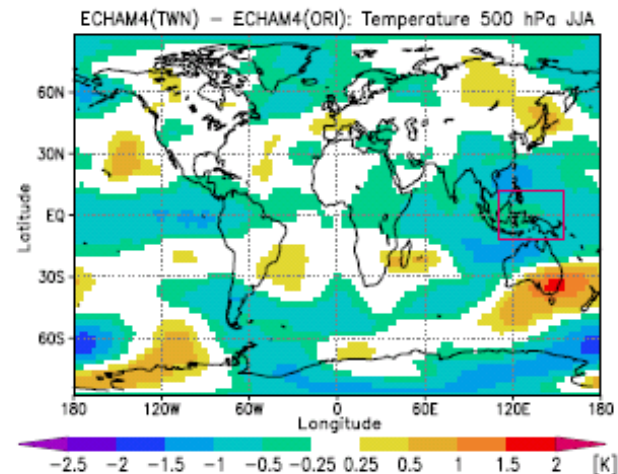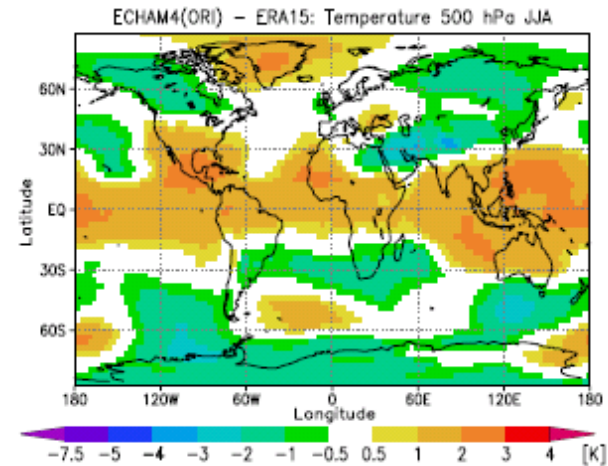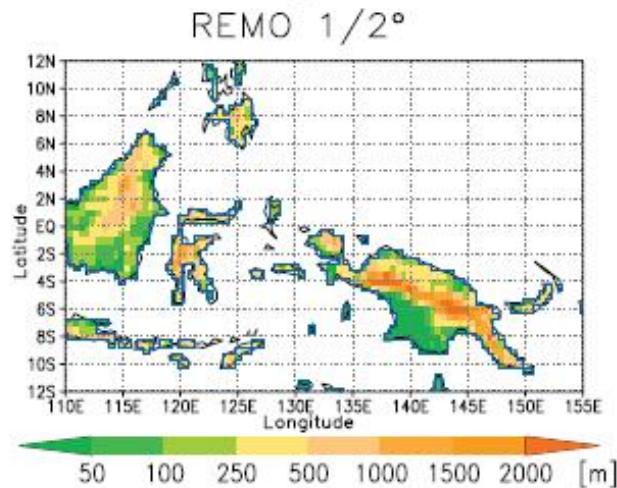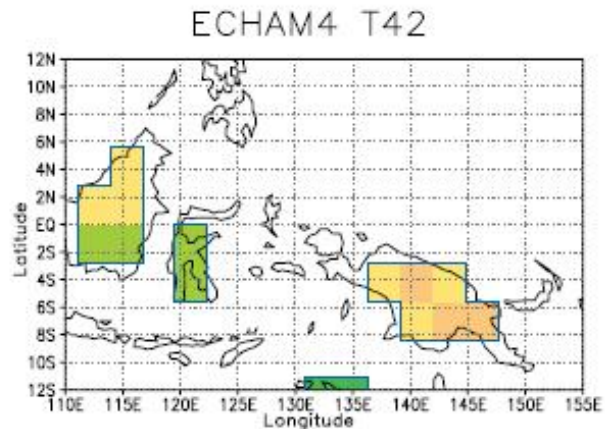 Fox-Rabinovitz et al. 2001, and more)

- **Two-way nesting GCM**
  (Lorenz and Jacob 2005, and
  Inatsu and Kimoto 2009)

- **Super-parameterization GCM**
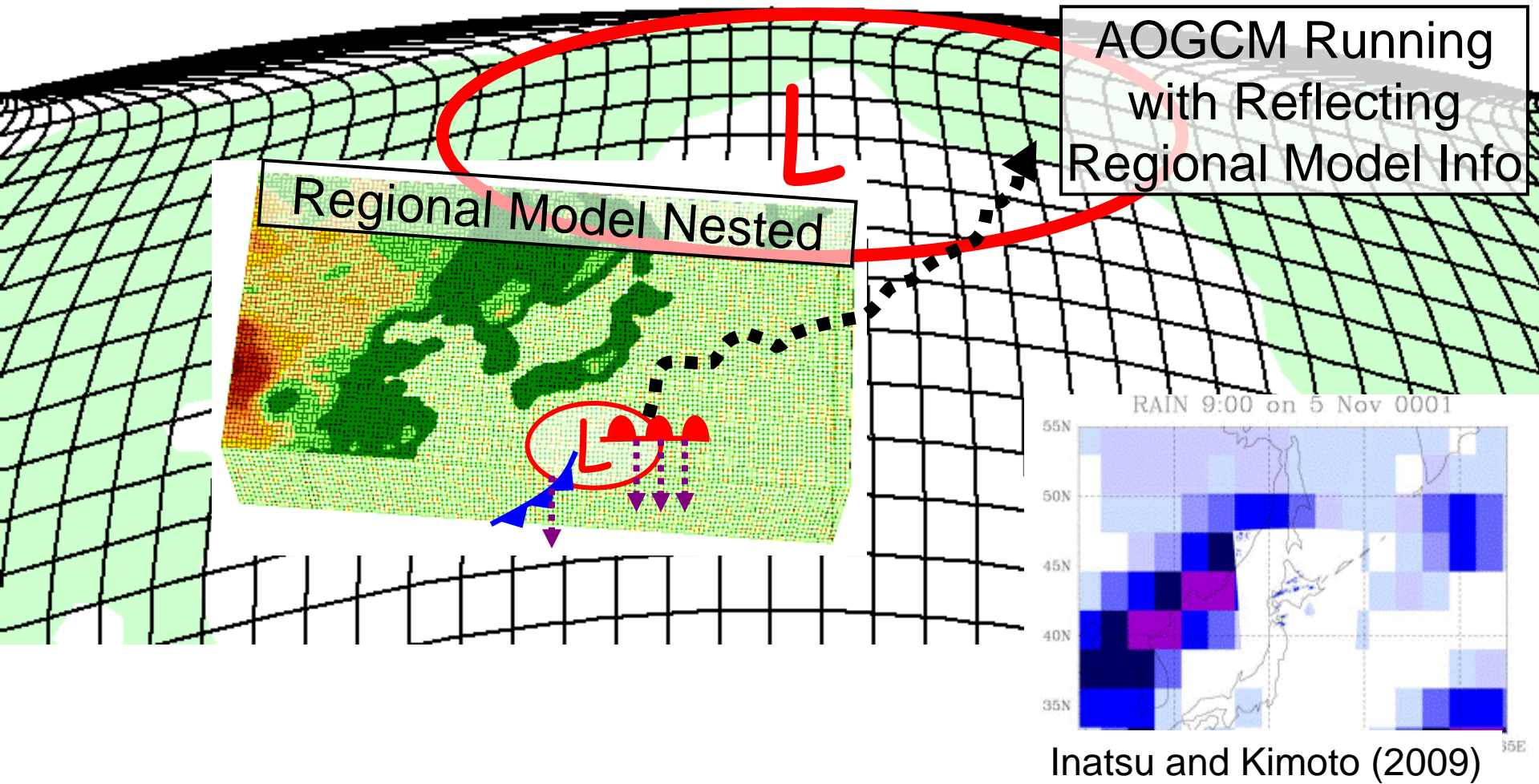 (Khairoutdinov and Randall 2001, and
  Khairoutdinov et al. 2005)

precise physics

The 1ˢᵗ paper in 2005 GRL.

Lorenz and Jacob (2005, GRL)

The 2nd paper in 2009 MWR.

INCL=Interactive Nesting CLimate Model

AOGCM Running with Reflecting Regional Model Info

Regional Model Nested

RAIN 9:00 on 5 Nov 0001

Inatsu and Kimoto (2009)

An example of two-way nesting climate model result

Reference: Inatsu, M., and M. Kimoto, 2009: A scale interaction study on East Asian cyclogenesis using a general circulation model with an interactively nested regional model. *Mon. Wea. Rev.*, **137**, 2851-2868.
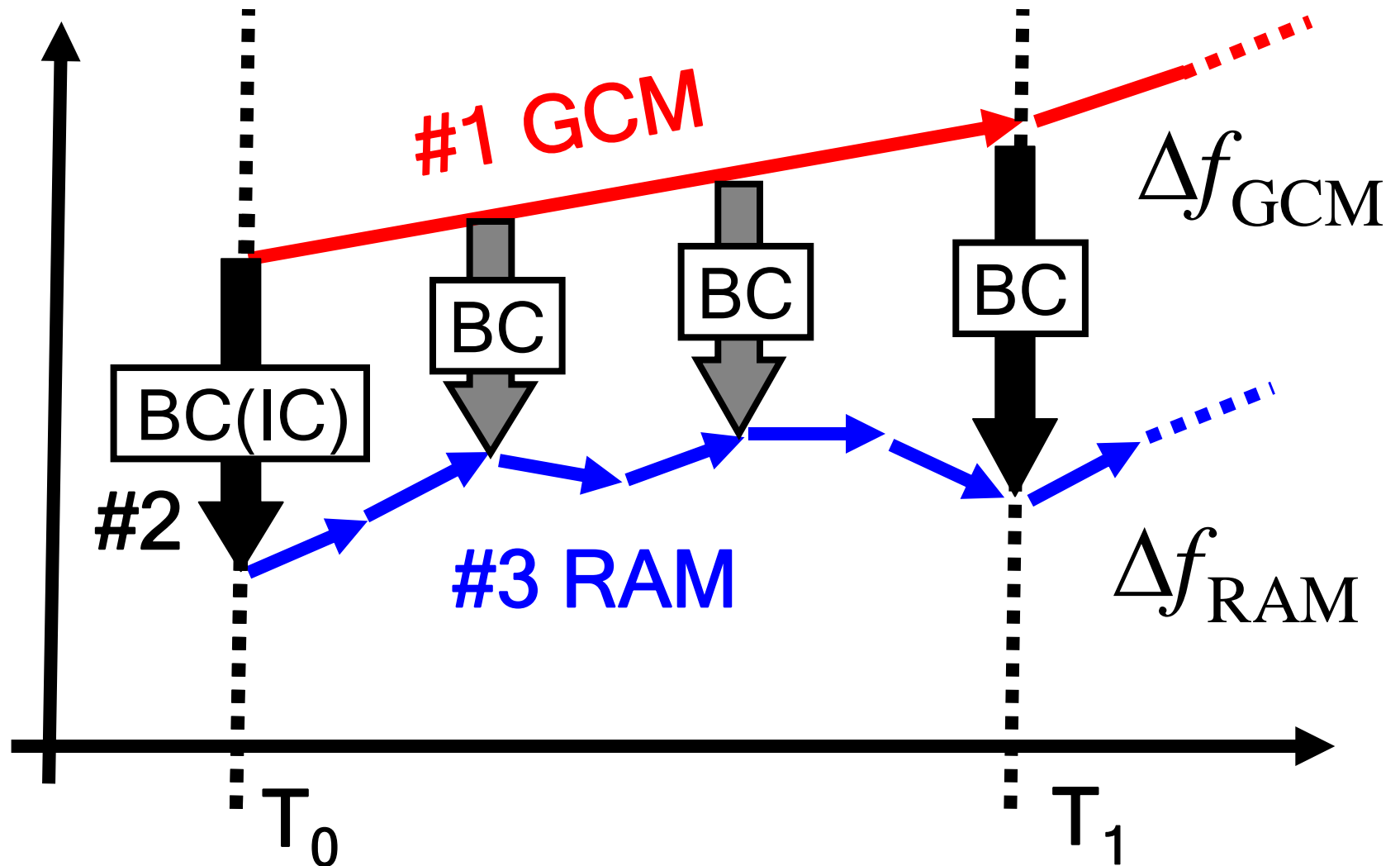
GCM: MIROC

- Global, 3-dim, hydrostatic
- T42L20 Atmos & 1x1L48 Ocean
- Cumulus cloud parameterization

RAM: JMA/MRI NHM

- Regional, 3-dim, non-hydrostatic
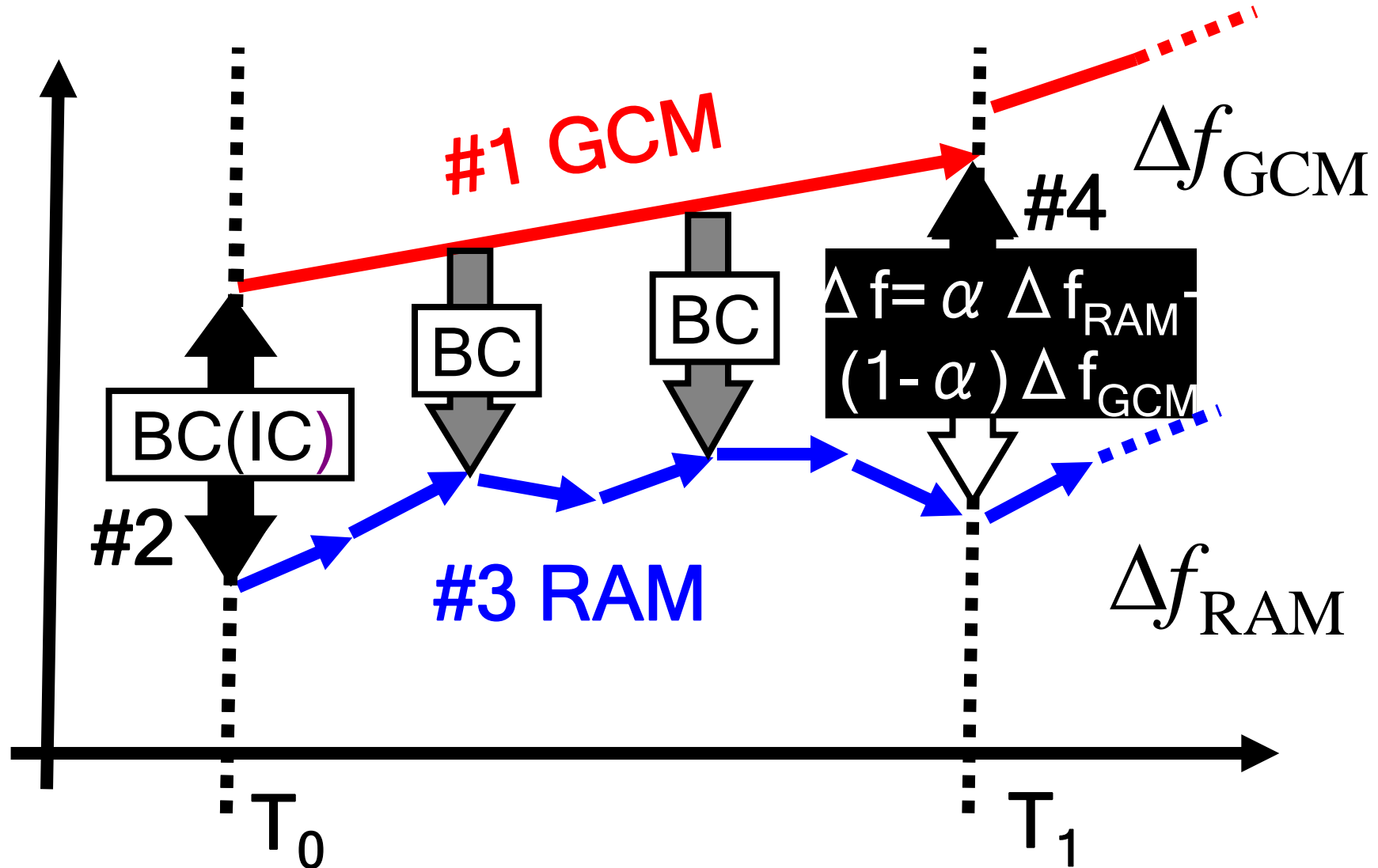- 40kmx40km L38 Atmos
- Cloud microphysics parameterization

1-way integration

#1 GCM
Δf_{GCM}
BC(IC)
BC
BC
BC
#2
#3 RAM
Δf_{RAM}
T_0
T_1

2-way integration

What can 2-way nesting GCM do?

- It could enable us to investigate the effects of subsynoptic-scale phenomena to phenomena with larger scales.
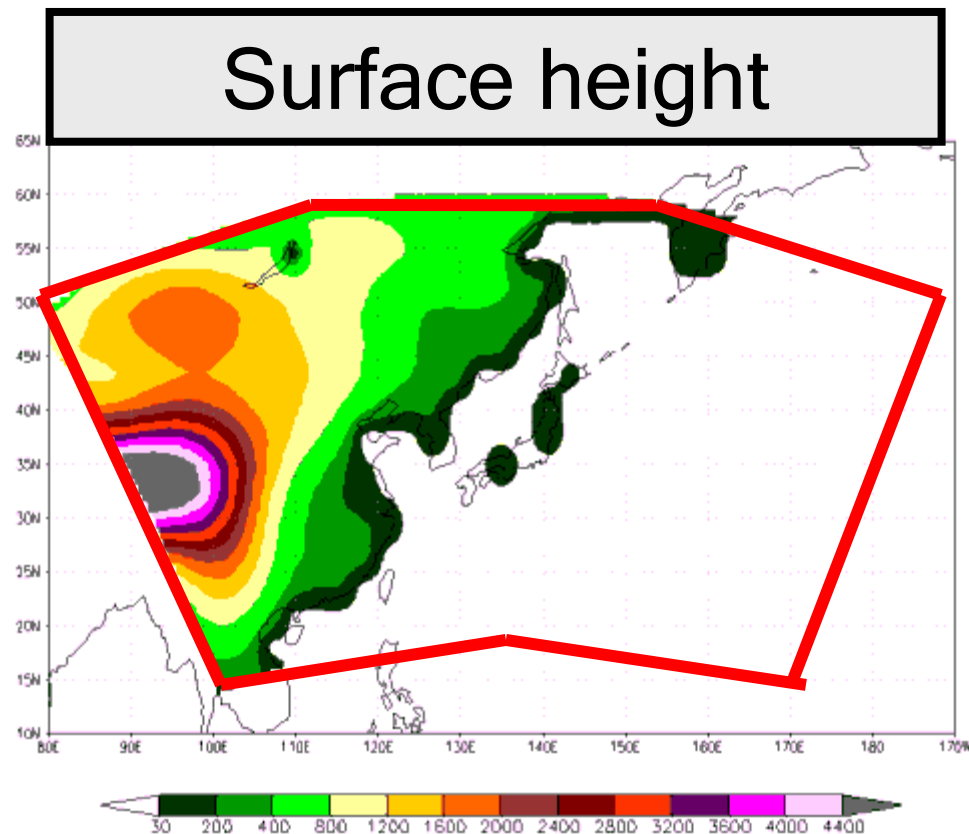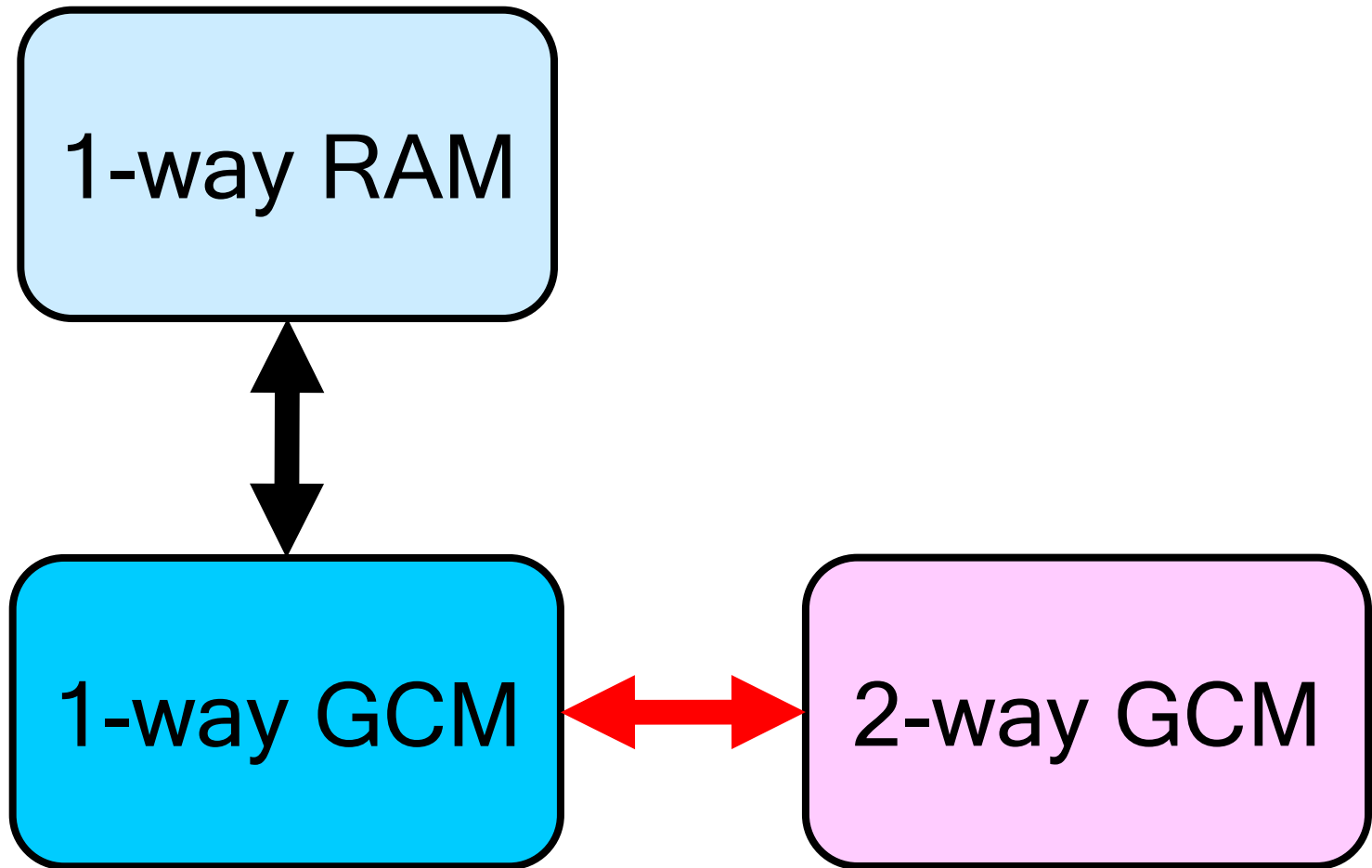
Section I
Subsynoptic-scale eddy effect

Experiments for Section I

- Ensemble experiments for 10 winters
- Same surface height for GCM & RAM

Surface height

Effects of subsynoptic eddies
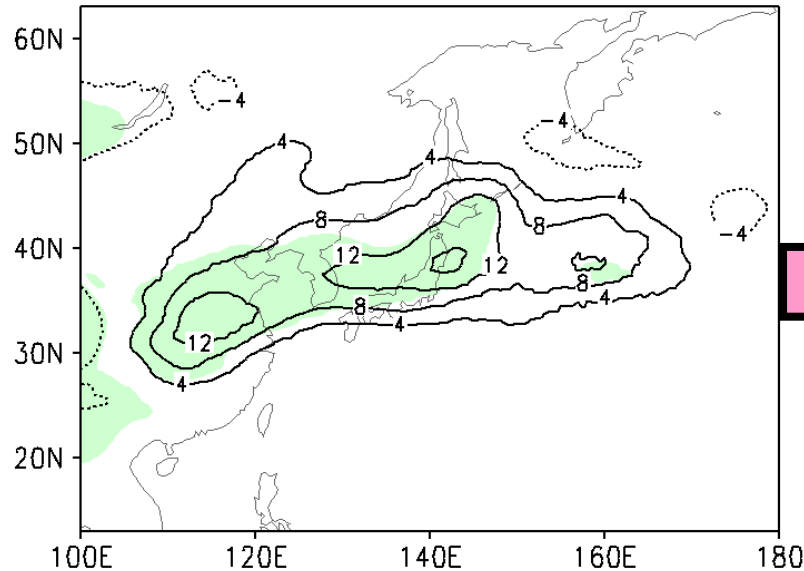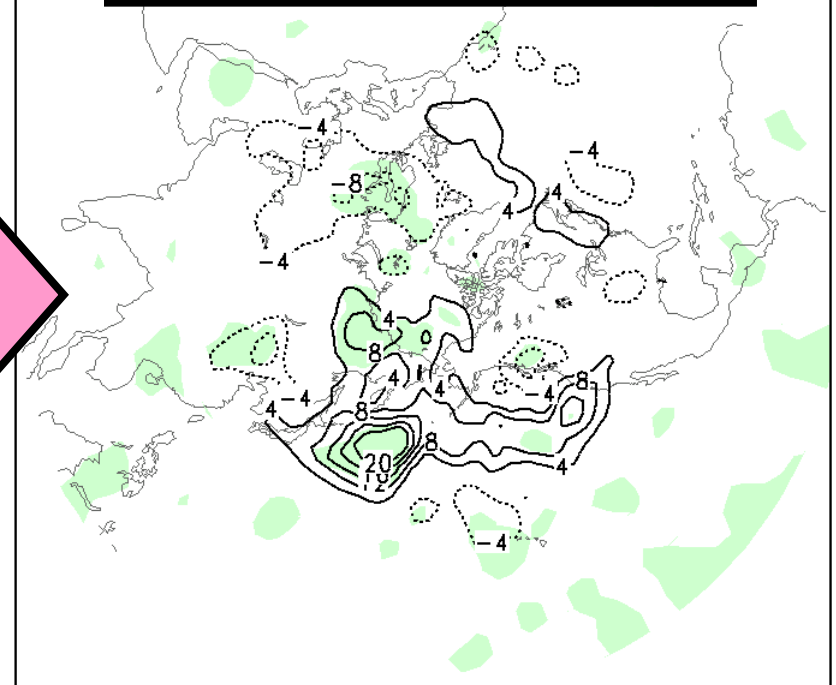
Effect of subsynoptic eddies (VhVh500)

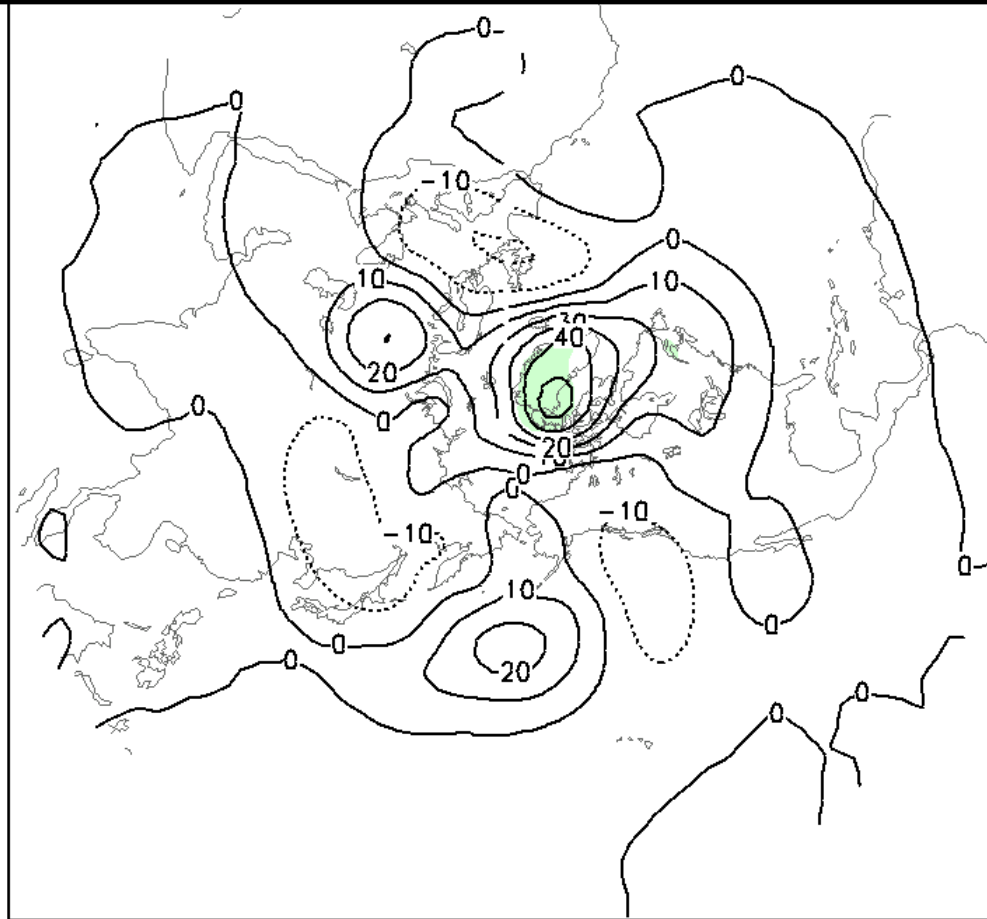1-way RAM diff
1-way GCM

2-way GCM diff
1-way GCM

Effect to Planetary waves (Z500)

2-way GCM diff 1-way GCM

Summary of Section I

- Section 1 revealed that the subsynoptic-scale eddies around Japan only modify synoptic-scale eddy activity in the Pacific.
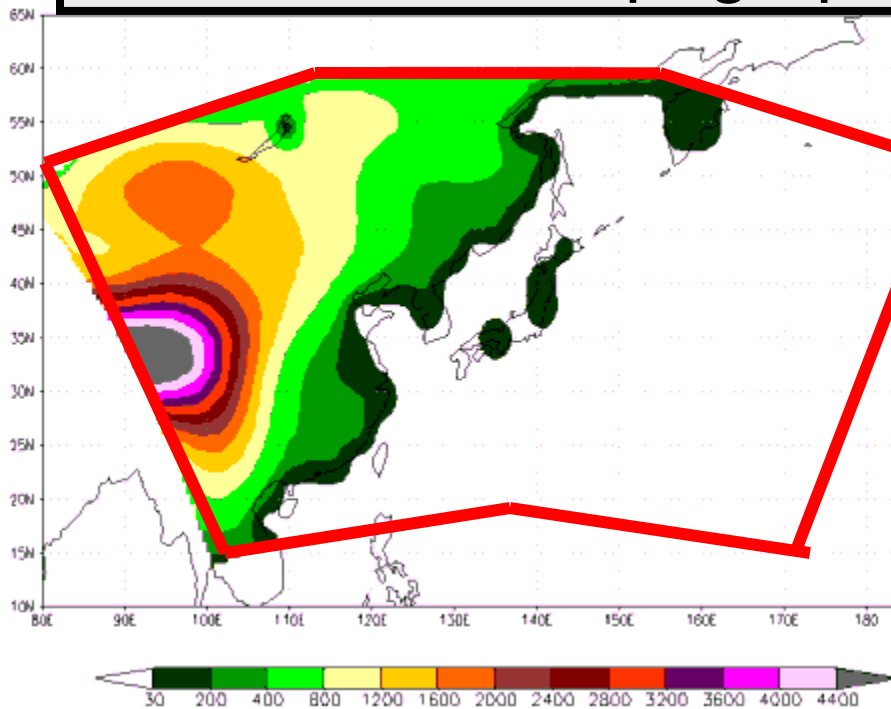
Section II
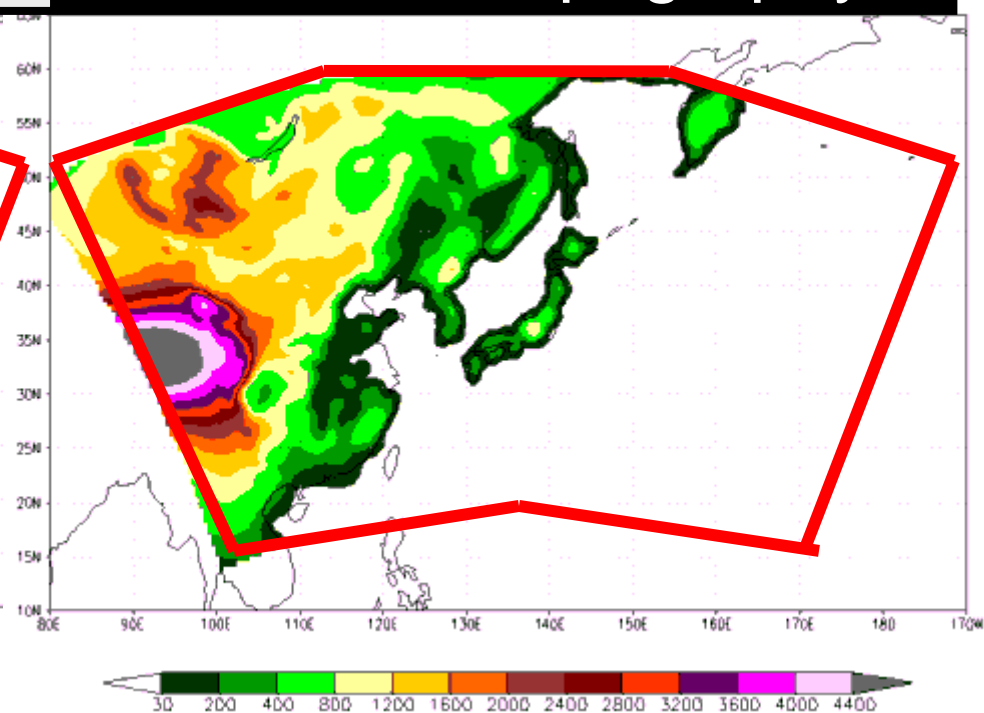# Subsynoptic-scale topography effect

Experiments for Section II
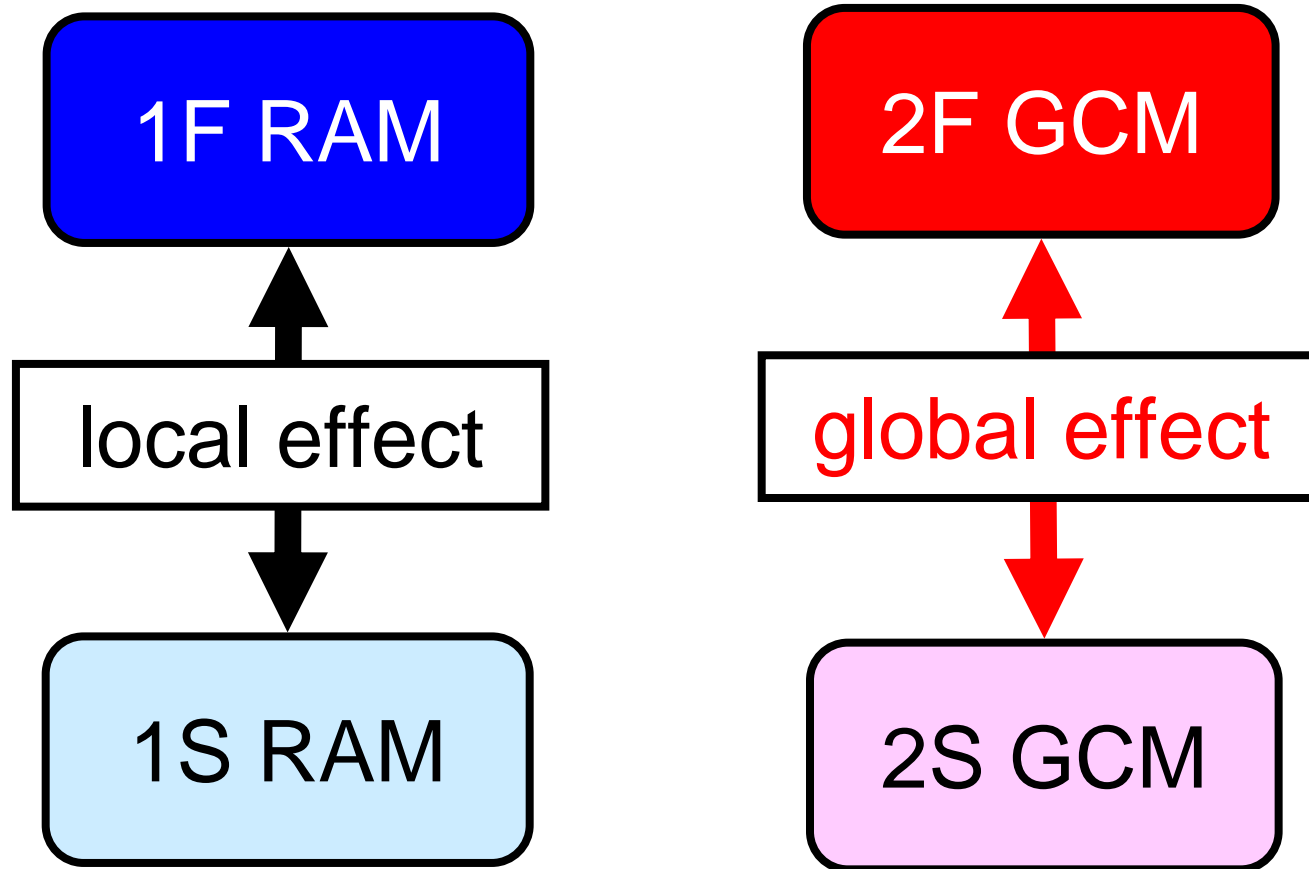

Smooth RAM topography

Fine RAM topography

Experiment Design

RAM topography	1-way	2-way
Fine	1F	2F
Smooth	1S	2S
Expts in Section 1 are 1S & 2S only.		

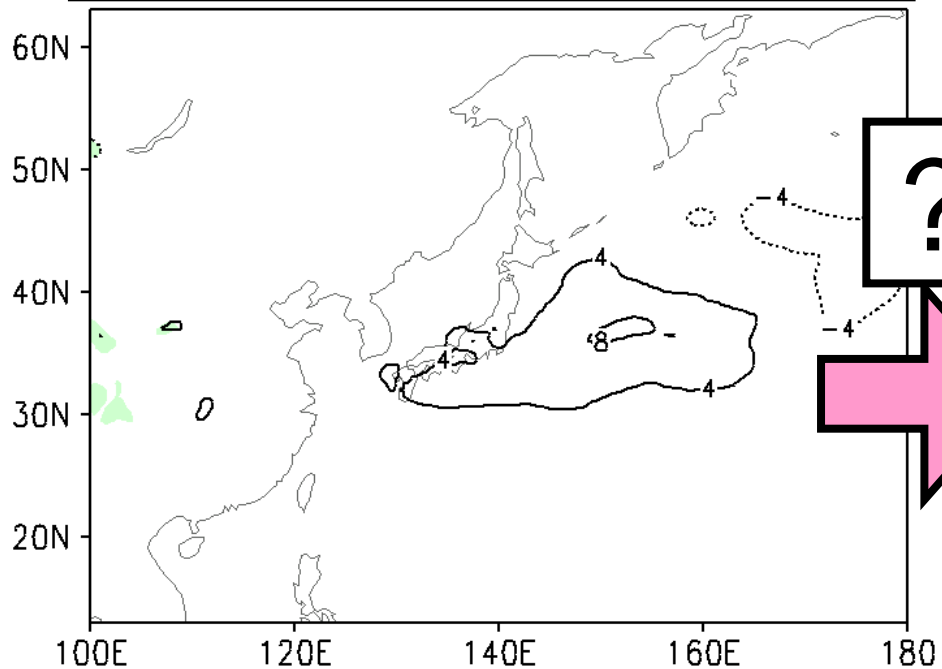Notice that 1F GCM equals to 1S GCM.

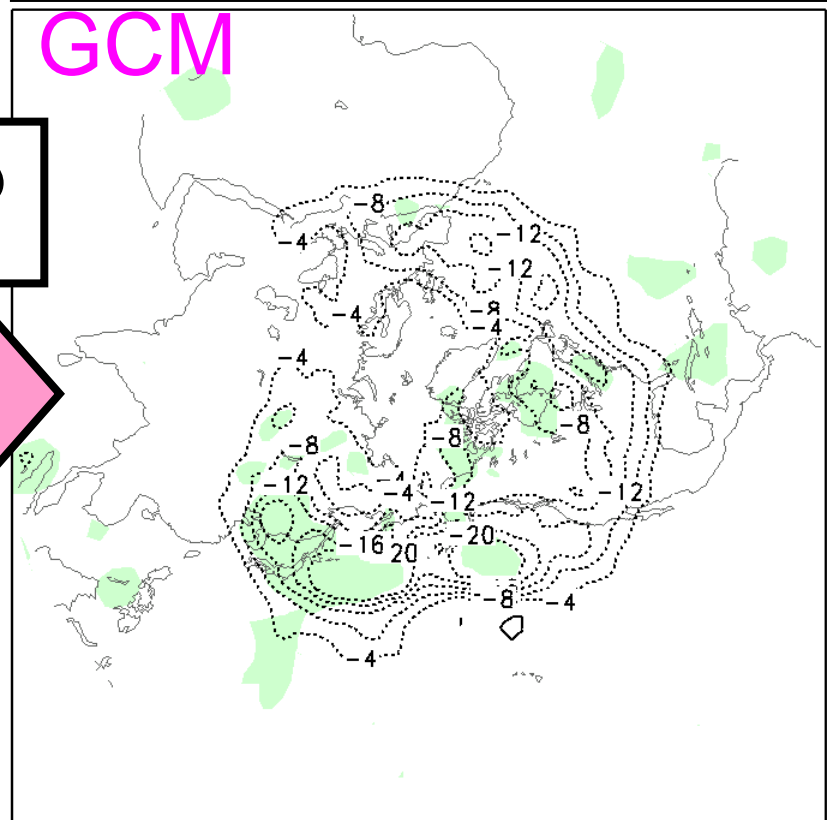# Effect of subsynoptic-scale topography

Effect to synoptic-scale eddy activity (VhVh500)
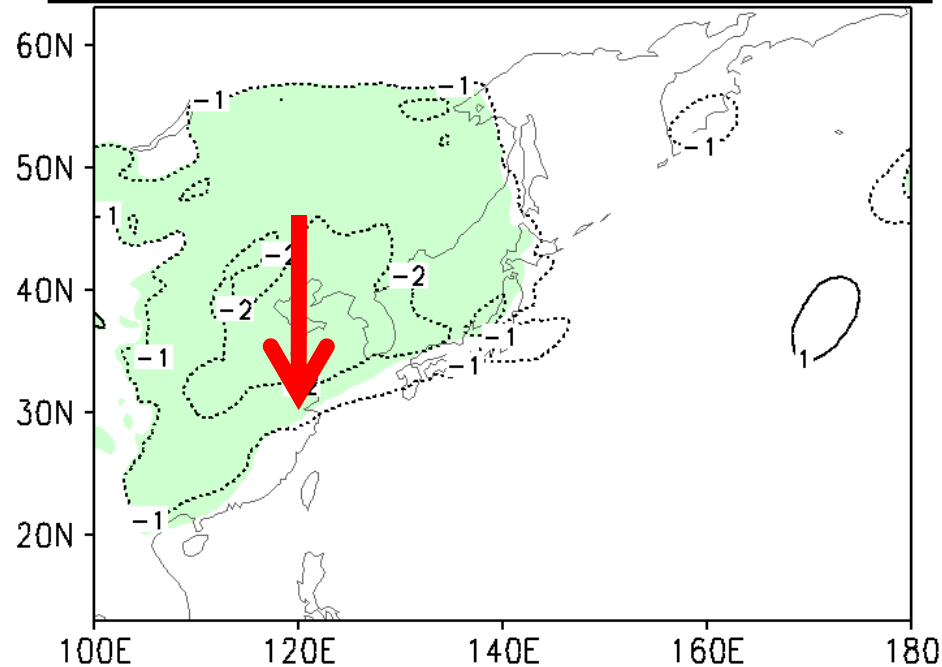
1F RAM diff 1S RAM

2F GCM diff 2S GCM

?

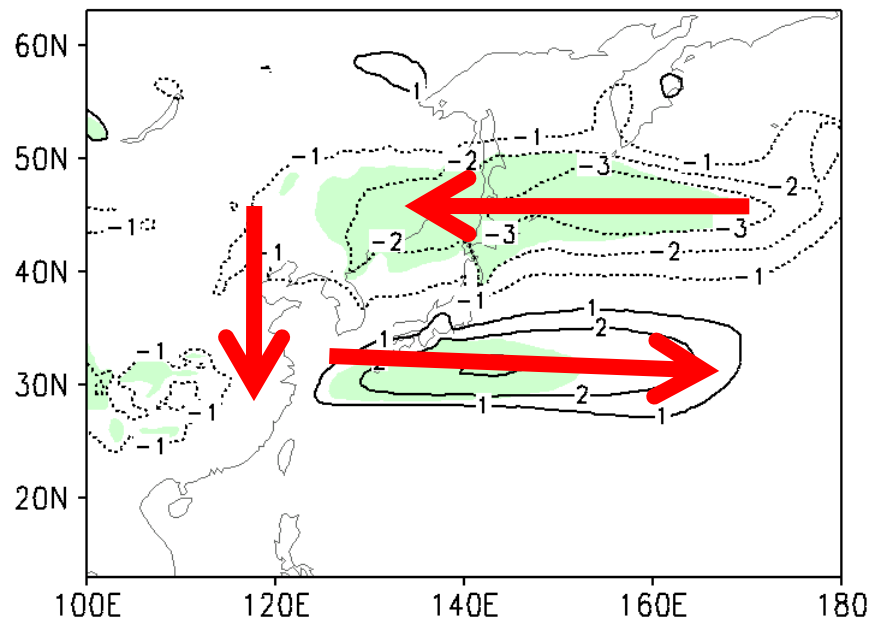# Effect to planetary-scale eddy activity (V500)

1F RAM diff **1S RAM**

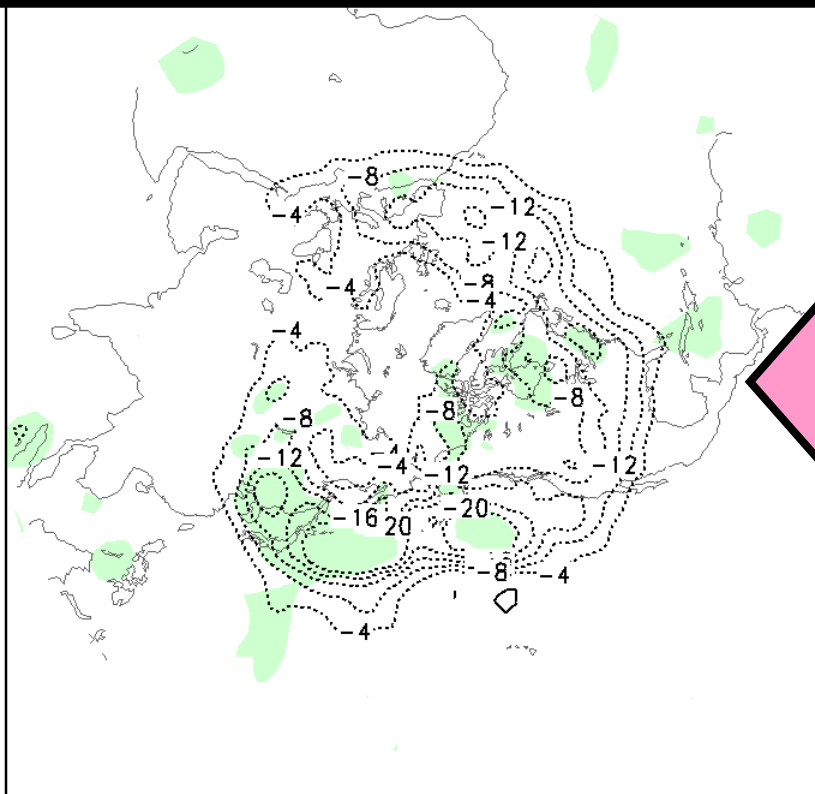# Effect to planetary-scale eddy activity (U500)

1F RAM diff 1S RAM

Subsynoptic-scale RAM topography forces cyclonic circulation in the W Pacific.

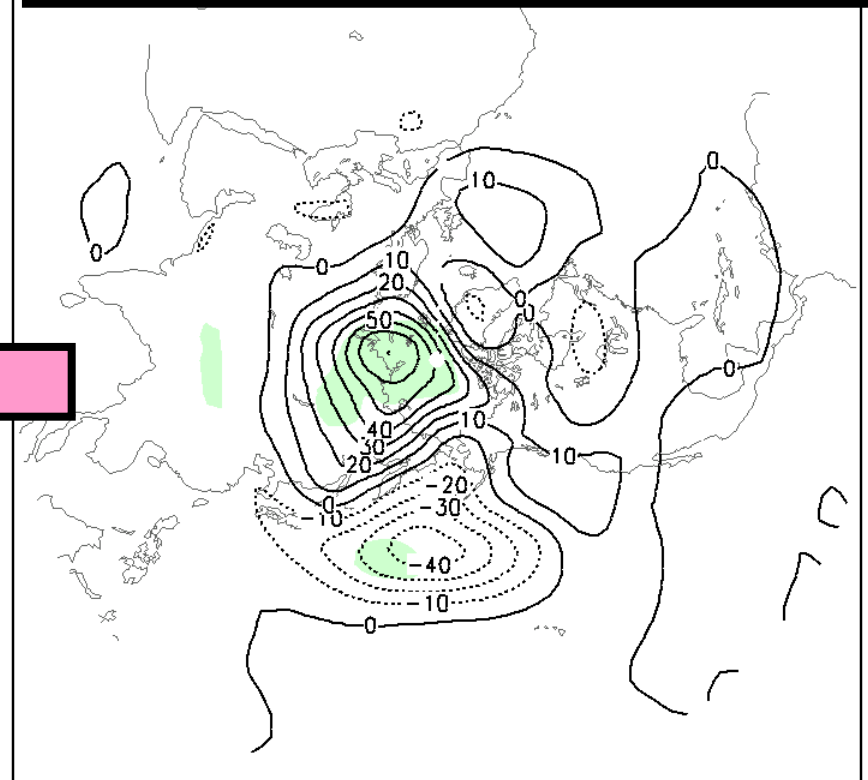# Effect to planetary-scale eddy activity

2F GCM diff 2S GCM
V_hV_h500

2F GCM diff 2S GCM
Z500

Summary for Section II

The subsynoptic-scale topography

- does not locally affect synoptic-scale eddy activity in the W Pacific; but

- does significantly affect planetary-scale eddy activity.

General summary

- The PHS is necessary to pursue both resolution effect and precise physics.

- Two-way nesting systems have been developed as one of the strategies and used for some scale-interaction problems.

- I showed one example of the use.