Projection of the Climate Change for South Asia region with the High-resolution AGCM based on the RCP Scenarios

Oct 17~20, 2012

Jai-Ho Oh and Sumin Woo

Dept. Env. & Atmos. Sci., Pukyong National Univ., Busan, S. Korea

(sumin@climate.pknu.ac.kr)

Introduction of GME

◦ GME model : Atmospheric GCM used the Operation NWP of German weather Service

◦ It has been named GME because it replaced-operational global model (GM) and the regional model for central Europe (EM).

◦ Grid Structure: Icosahedral-Hexagonal grid

◦ Resolution : 40 km mesh size

➔ 368,642 gridpoints/layer

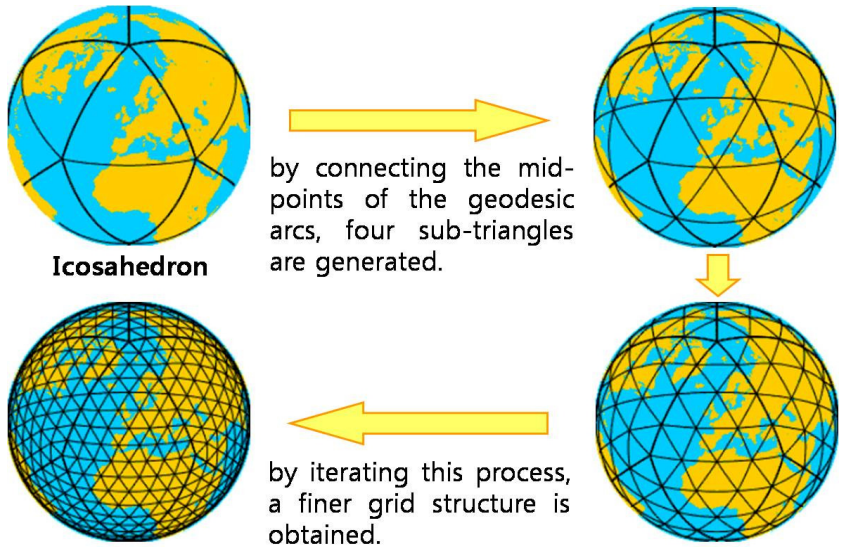
◦ Layer : hybrid (sigma/pressure) layer

◦ Prognostic variables : ps, u, v, t, qv, qc, qi, o3

◦ Time integration: semi-Lagrangian scheme

◦ Convection Scheme : Tiedtke, 1989

<Grid generation>

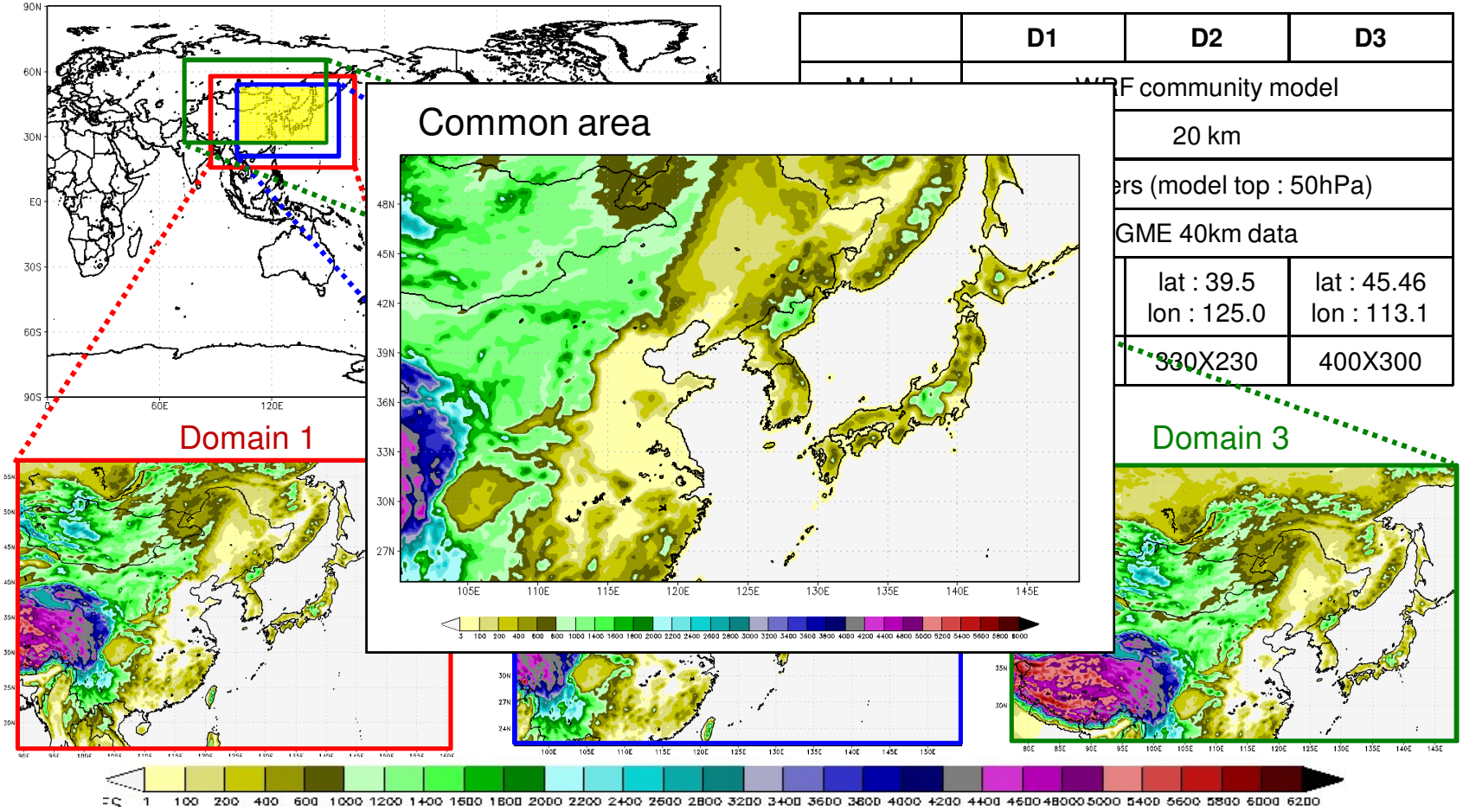


• Advantages of GME

- Avoid pole problem, so CFL for advection is not an issue.
- All cells are nearly the same size (within about 5% in terms of area).
- Avoids the large amount of global communication
- Data structure well suited to high efficiency on distributed memory parallel computers

Limits of Regional Downscaling Methods

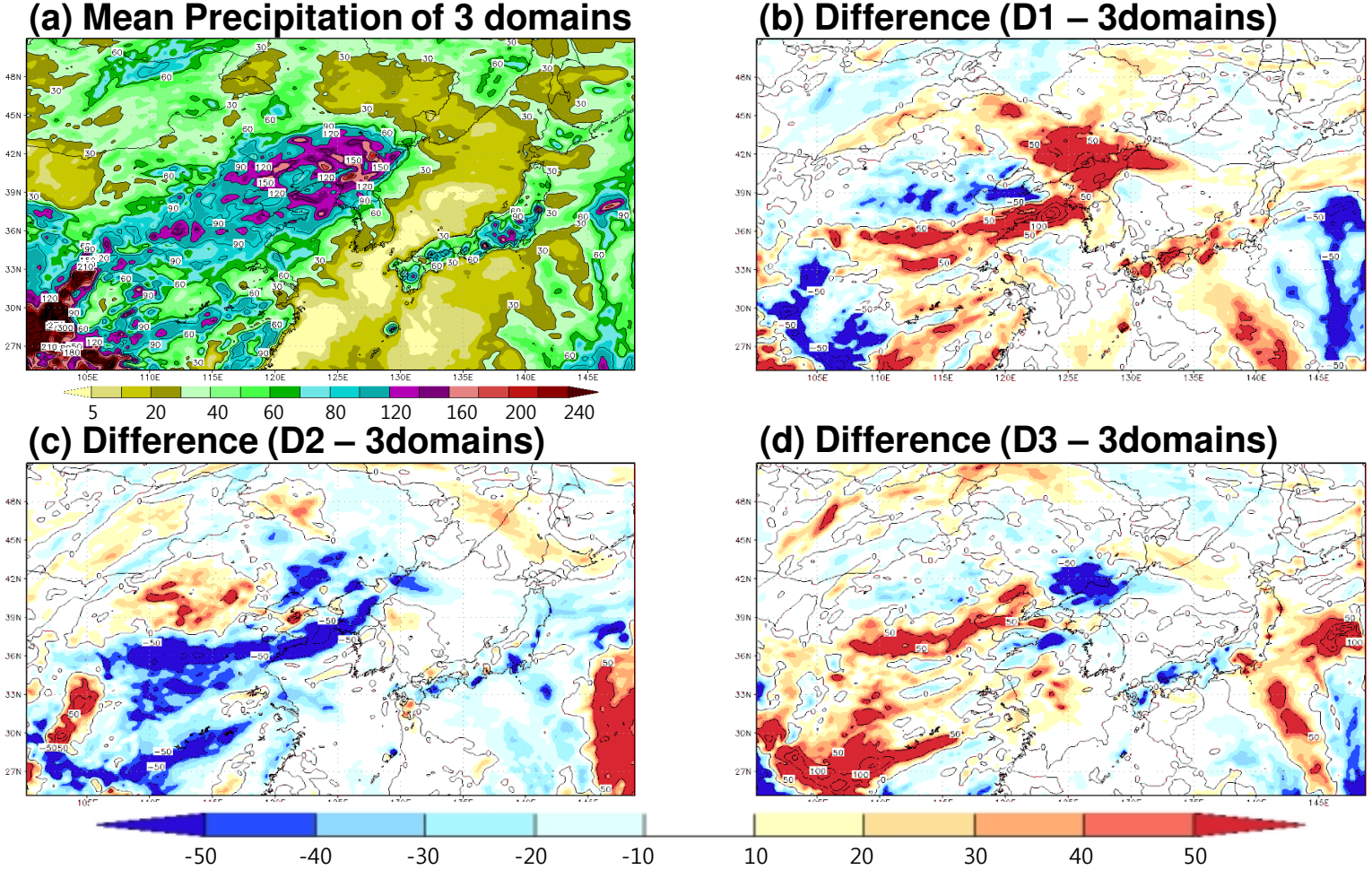
- Experiment on dependence of domain size and location of RCMs
  1. Set of 3 different domains including the East Asia and Korean peninsula
  2. Seasonal prediction for 1981-1982 using WRF regional model



	D1	D2	D3
	F community model		
	20 km		
	rs (model top : 50hPa)		
	GME 40km data		
	lat : 39.5 lon : 125.0	lat : 45.46 lon : 113.1	
	330X230	400X300	

Limits of Regional Downscaling Methods

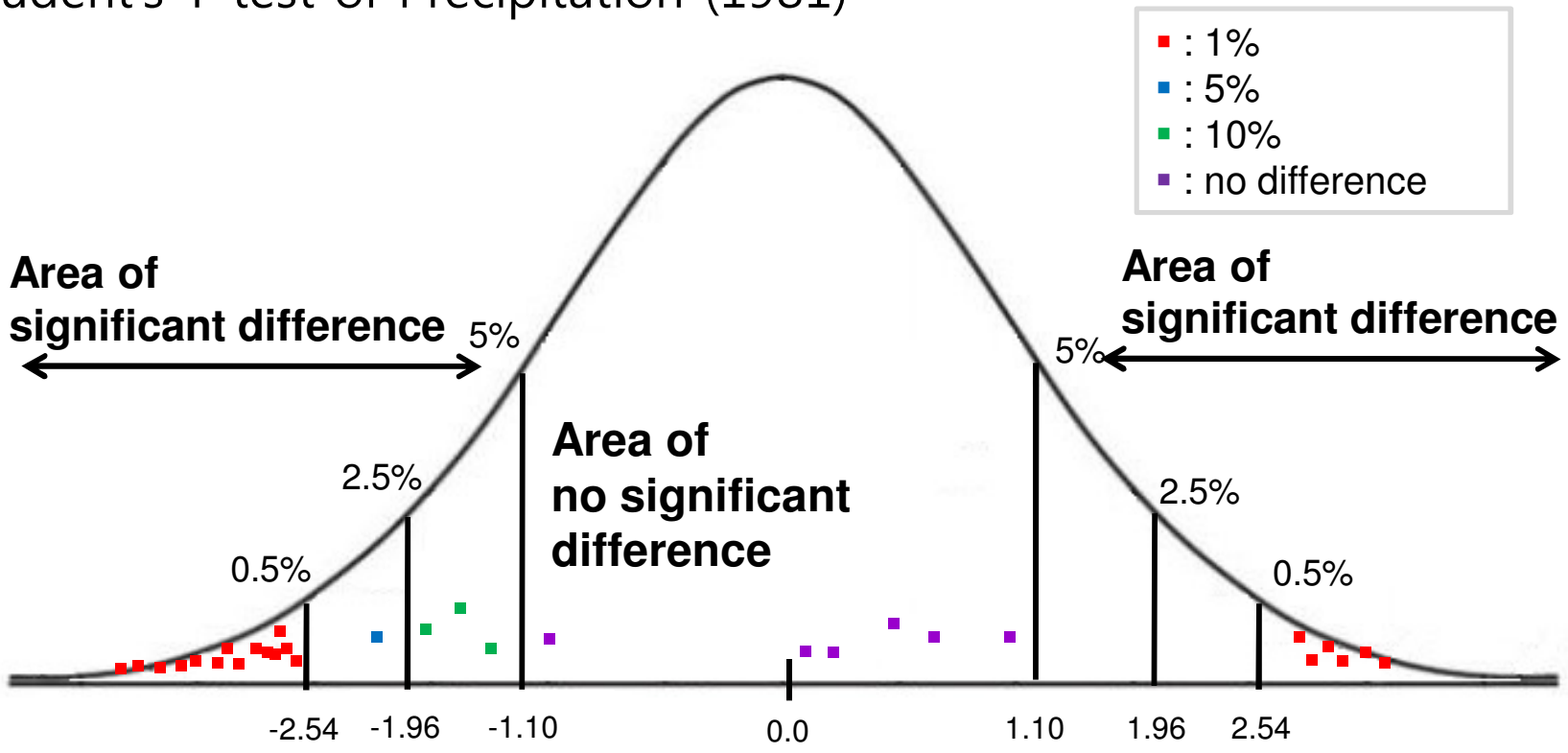
- Mean and Difference of Precipitation (July, 1982)



- When the domain size and location are changed, it shows the difference in spatial temperature (not shown) and especially precipitation pattern.

Limitation of Downscaling Method

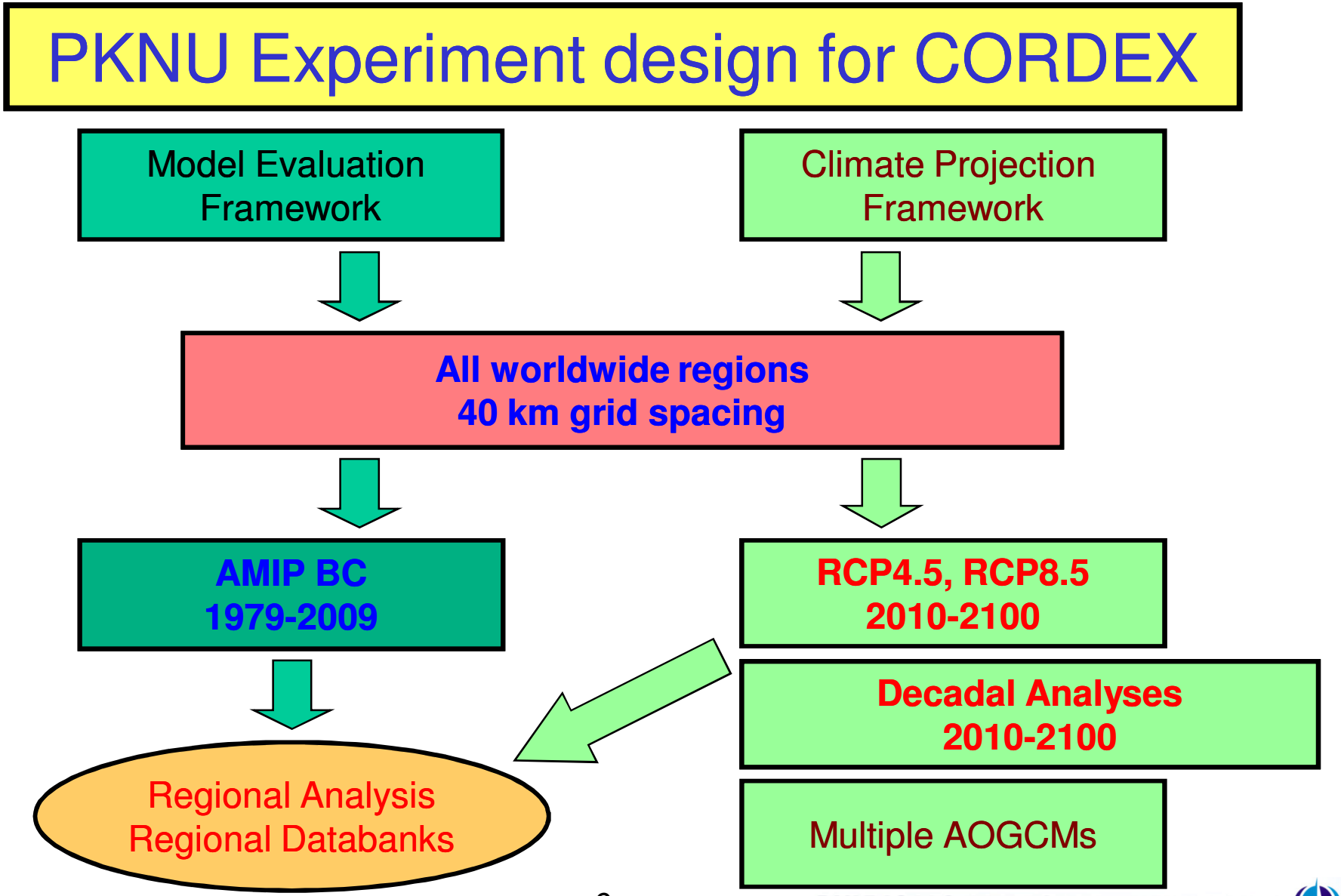
• Student's T-test of Precipitation (1981)



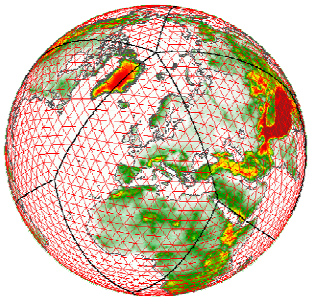
• Compared with the regional downscaling, global downscaling method can avoid the lateral boundary problems.

• So In this study, we suggest the climate simulation using **atmospheric global climate model** with horizontally high-resolution grid.

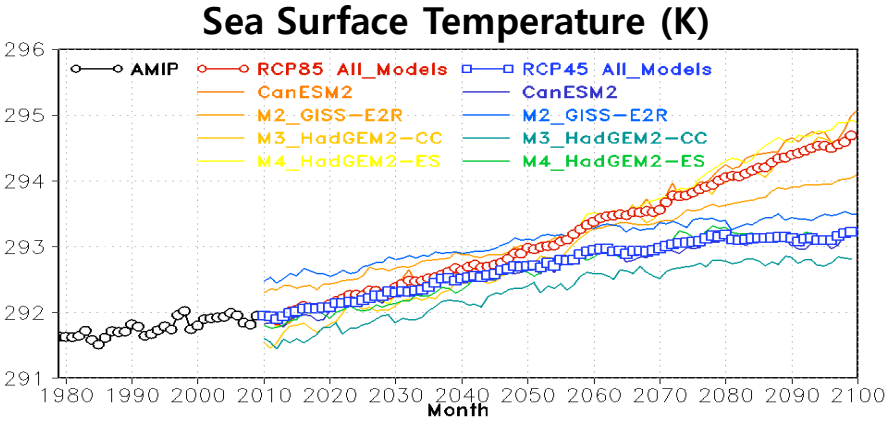
Experiment design

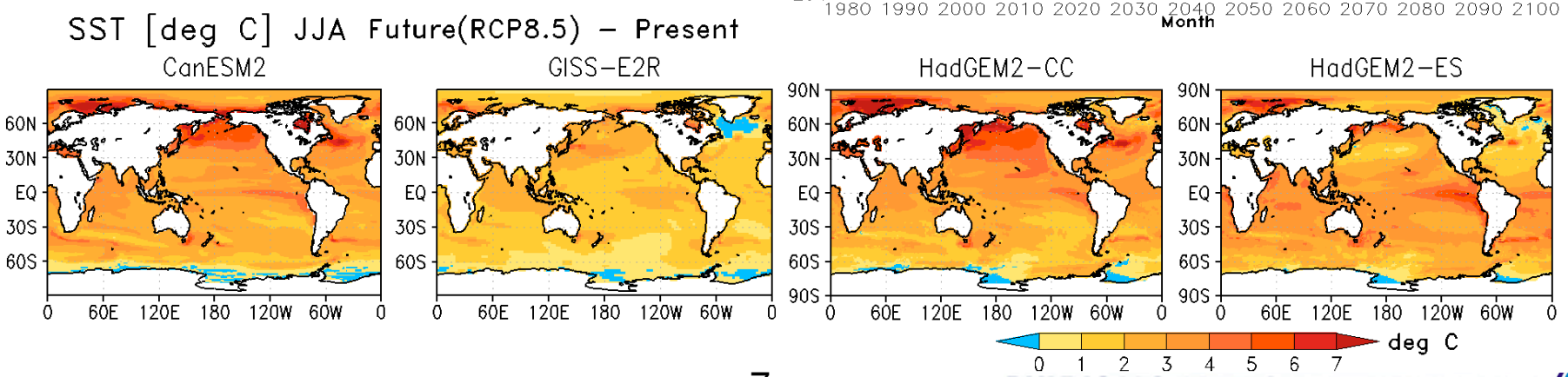


Configuration of the Experiment



- Model : Atmospheric GCM model GME with Icosahedral-Hexagonal grid
- Resolution : 40 km grid with 40 Layers
- Boundary condition : SST & Sea Ice Concentration
  - Historical run (1979-2009) : AMIP observation data
  - Future (2010-2100) : RCP 8.5, RCP 4.5 CMIP5 multi-models based on IPCC AR5
- Interval of BC : Daily interval
- CMIP5 multi-models
  - CanESM2 (Canada) : 128×64 grid
  - GISS-E2R (USA) : 144×90 grid
  - HadGEM2-CC (UK) : 192×145 grid
  - HadGEM2-ES (UK) : 192×145 grid

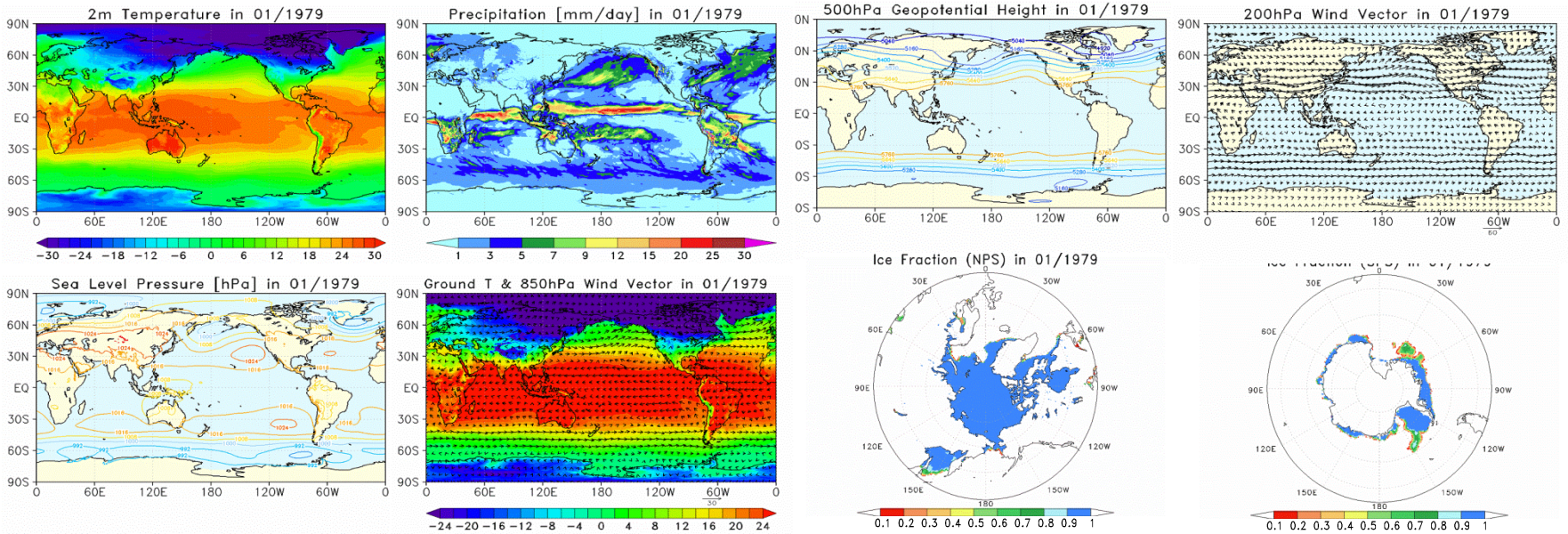




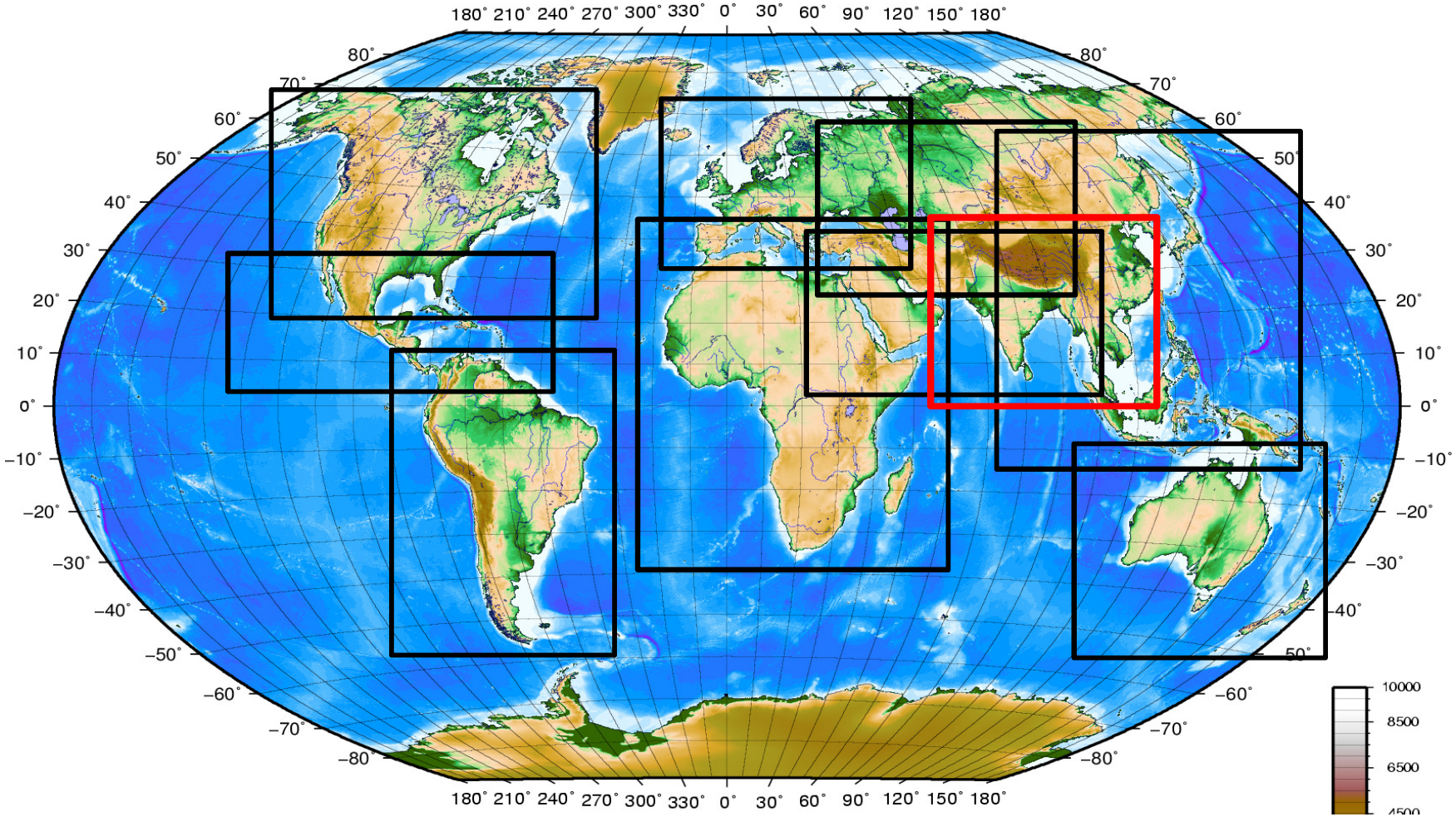
PUKYONG NATIONAL UNIVERSITY

Results of the Experiment

- Resolution : 900×451 (40km)/ 21 Layers
- Interval of Model output : 3 hourly
- Variable : Surface - 2m Air T, Precipitation, 10m U·V, MSLP, etc. (totally 80 variables)
  Vertical (21 layers) - Z, T, U, V, PS, QV, QC, QI, O3
- Model Output Size (Raw data) : 2.2 TB / 1 year (Grib format)
- Data Size for analysis (1 variable) : 1.6 MB / 1 time (converted to NetCDF format)
  ➔ 4.7 GB for 1 year
- Visualization Examples



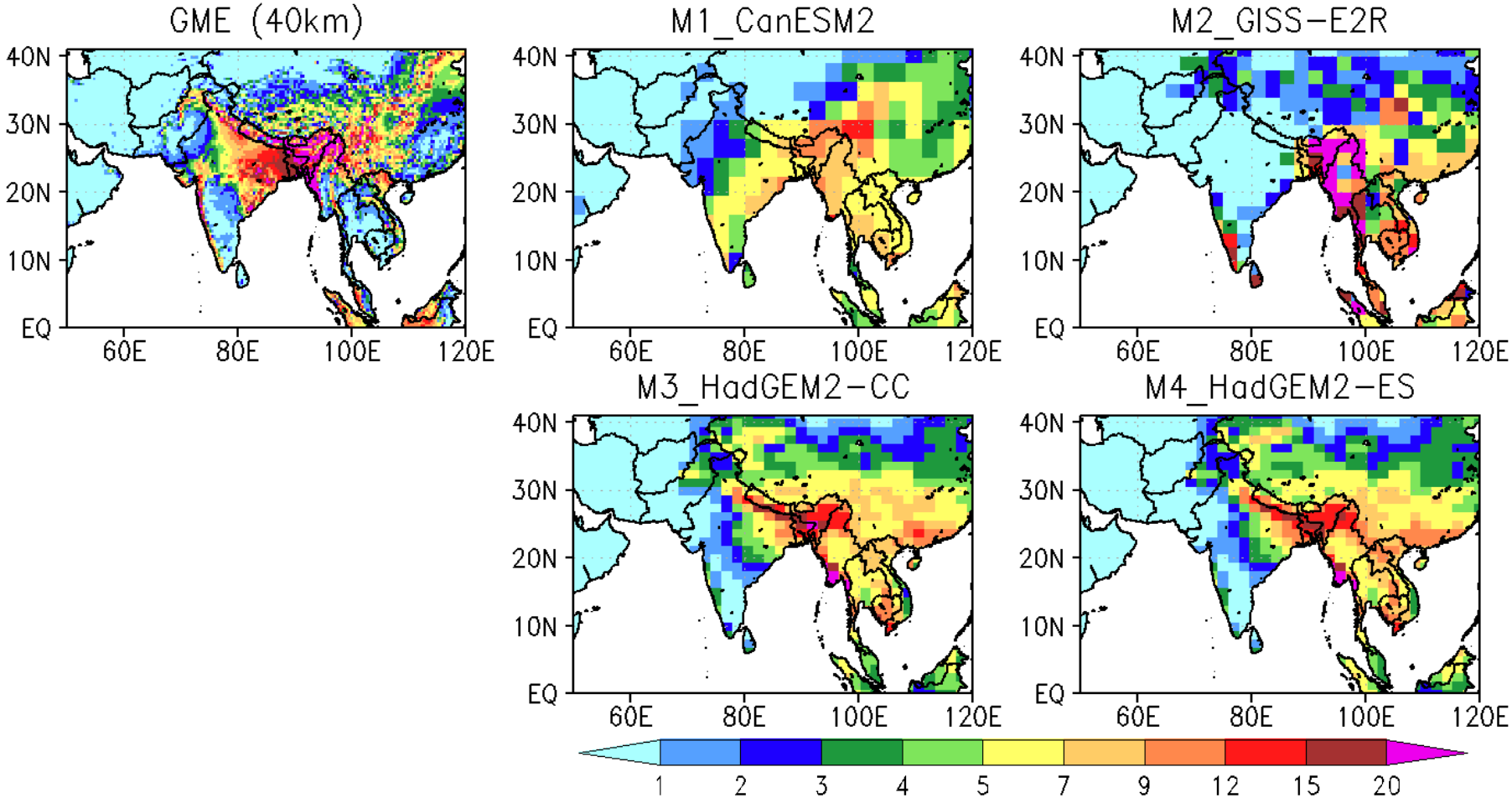
Analysis Domains



- Including the South Asia, we can analyze the atmospheric variables over the all worldwide regions.

Simulation Performance of AGCM

• GME(40km) and 4 models/CMIP5 in Precipitation for JJAS 1979-2009



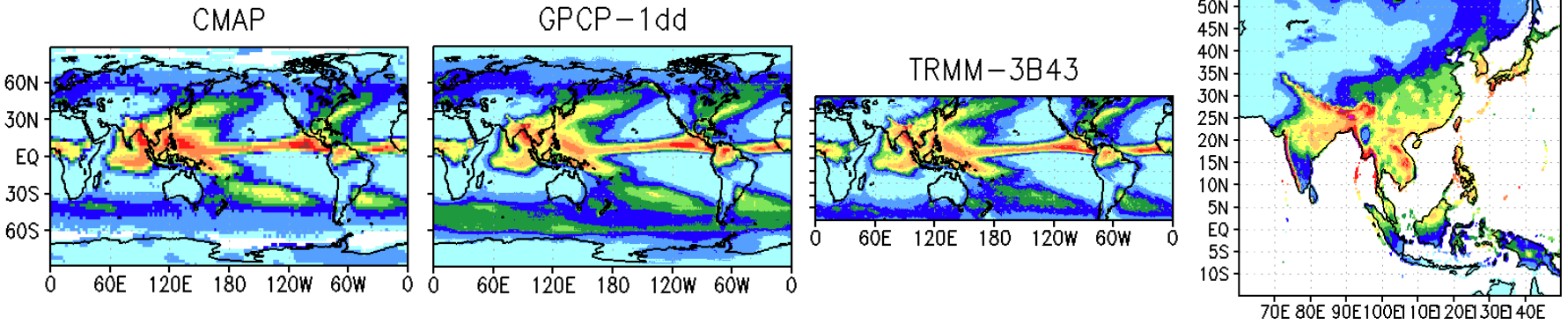
• In the comparison with 4 models of CMIP5, the GME shows the detailed features and reflects the precipitation patterns over Asia Monsoon region.

Simulation Results with Observations

over South Asia region

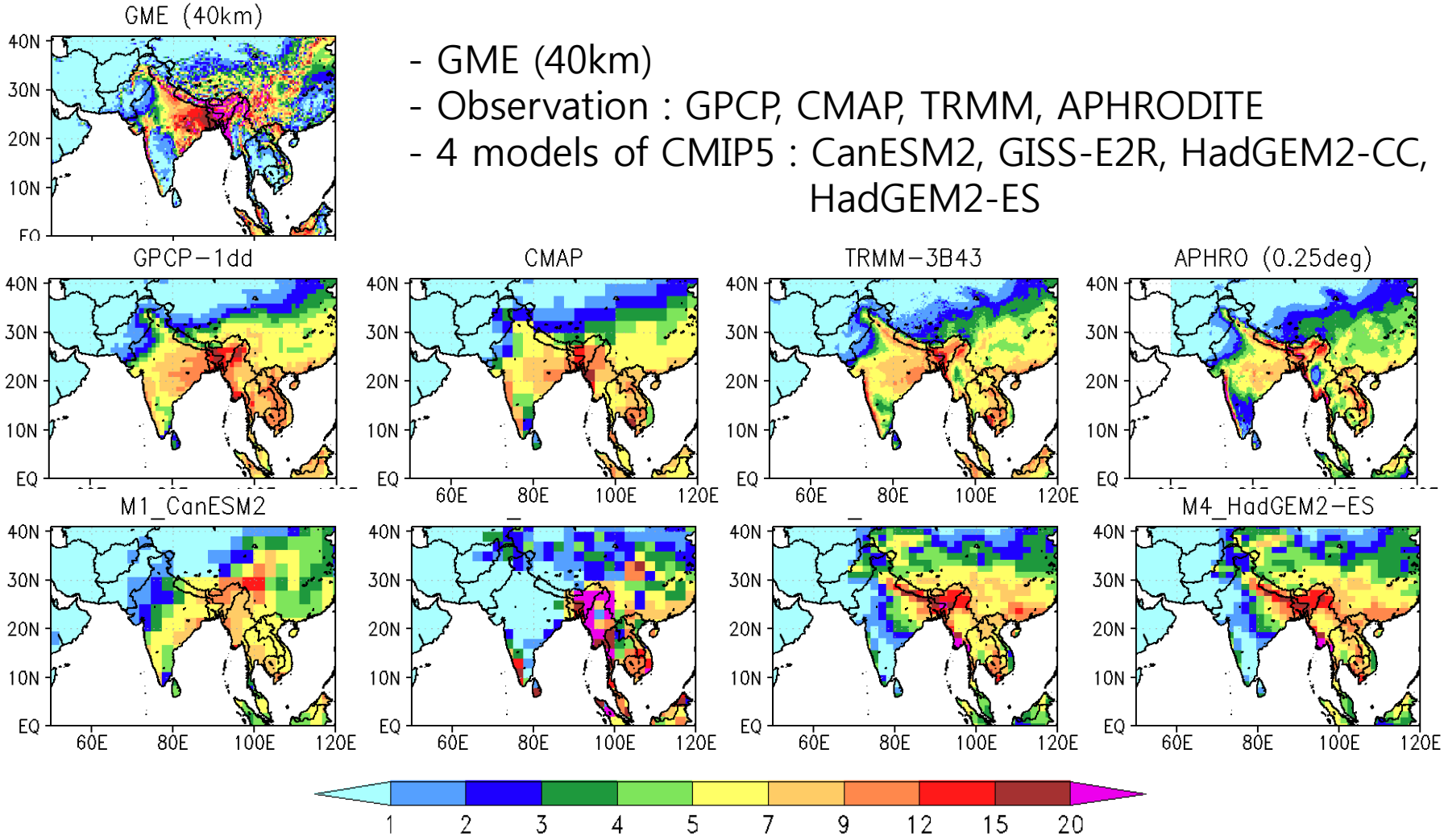
- GME 40km grid driven by AMIP Observation during 1979-2009 (31 yrs)
  - Seasonal mean (JJAS)
  - Annual cycle
  - PDF of Daily precipitation

- Observation in gridded Precipitation :
  - CMAP (monthly, 2.5°, 1979-2008)
  - TRMM-3B42 (daily, 0.25°, 1998-2008)
  - GPCP11 (daily, 1°, 1998-2008)
  - APRODITE (monthly, 0.25°, 1951-2007)



Seasonal Mean (JJAS) over South Asia

• Precipitation during JJAS 1998-2008 (unit: mm/day)

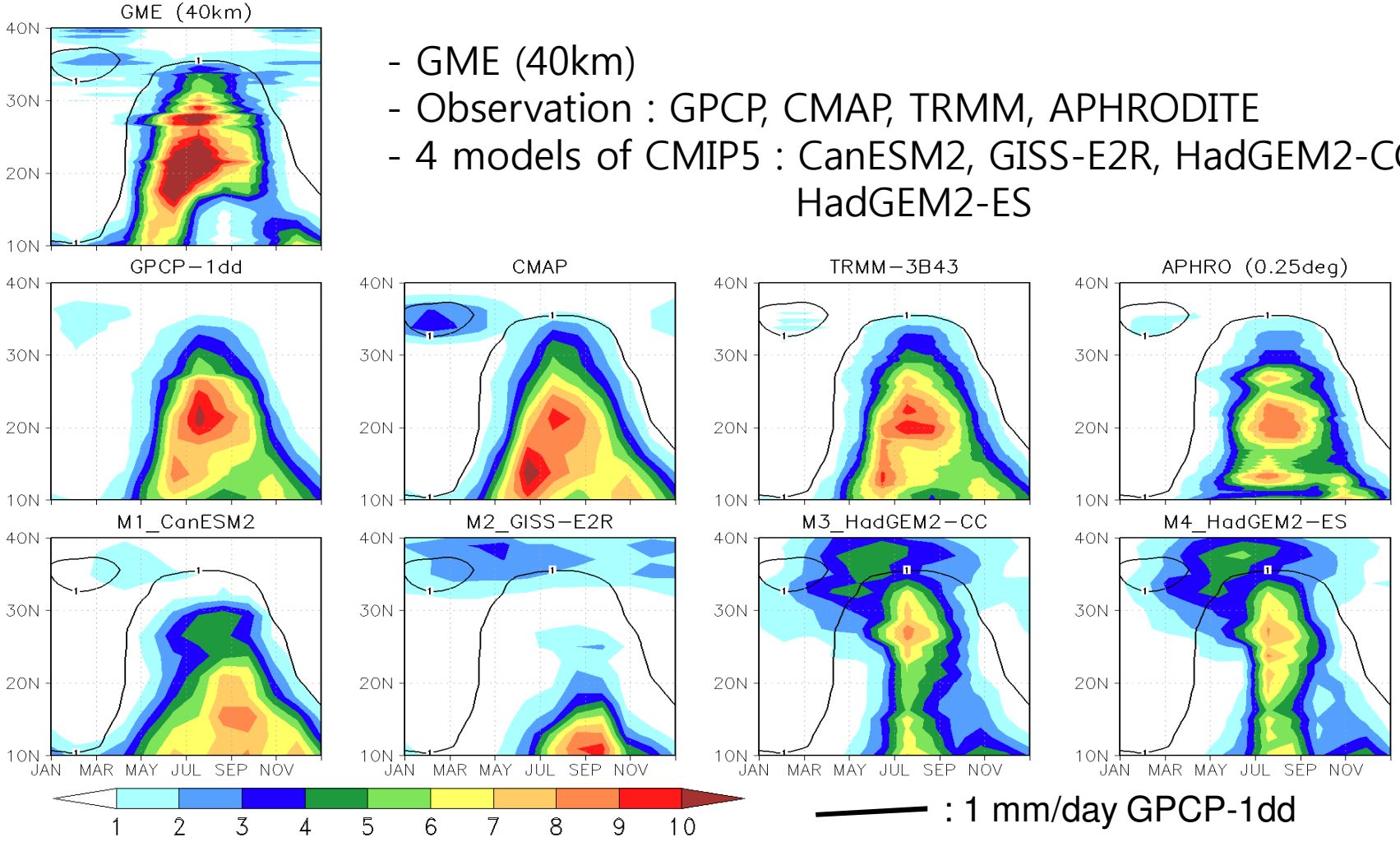


- GME (40km)
- Observation : GPCP, CMAP, TRMM, APHRODITE
- 4 models of CMIP5 : CanESM2, GISS-E2R, HadGEM2-CC, HadGEM2-ES

• We can see that the reproduced GME model with high-resolution grid is improved in simulation of precipitation than 4 models/CMIP5.

Annual cycle over Indian region

• Precipitation over Indian region (65-90W) during 1998-2008 (unit: mm/day)

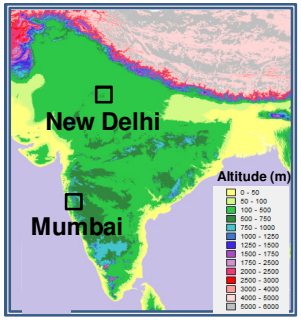


- GME (40km)
- Observation : GPCP, CMAP, TRMM, APHRODITE
- 4 models of CMIP5 : CanESM2, GISS-E2R, HadGEM2-CC, HadGEM2-ES

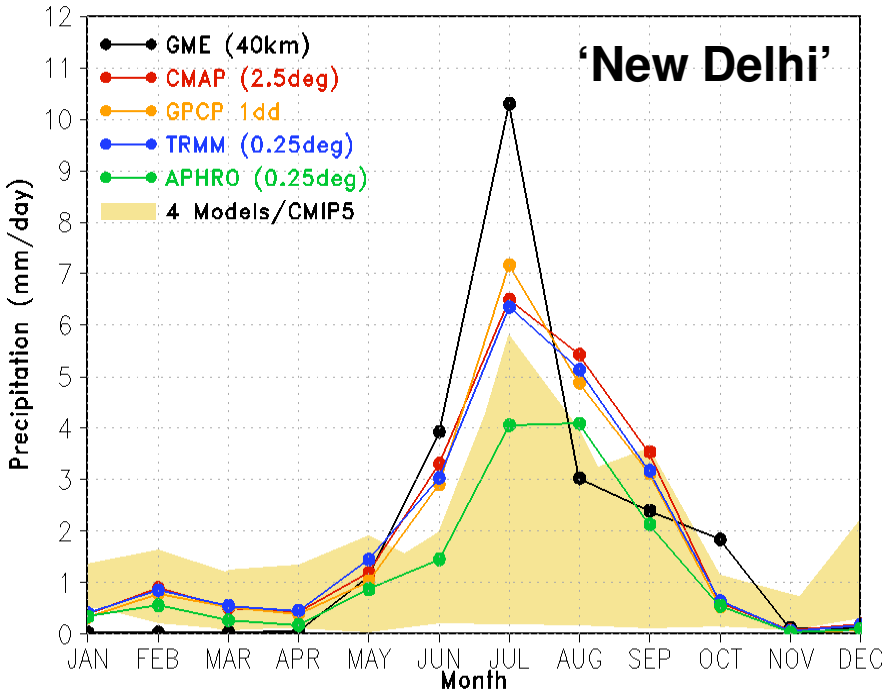
• Comparing the observations, GME shows the precipitation pattern well from May to Oct during Asia Monsoon Season.

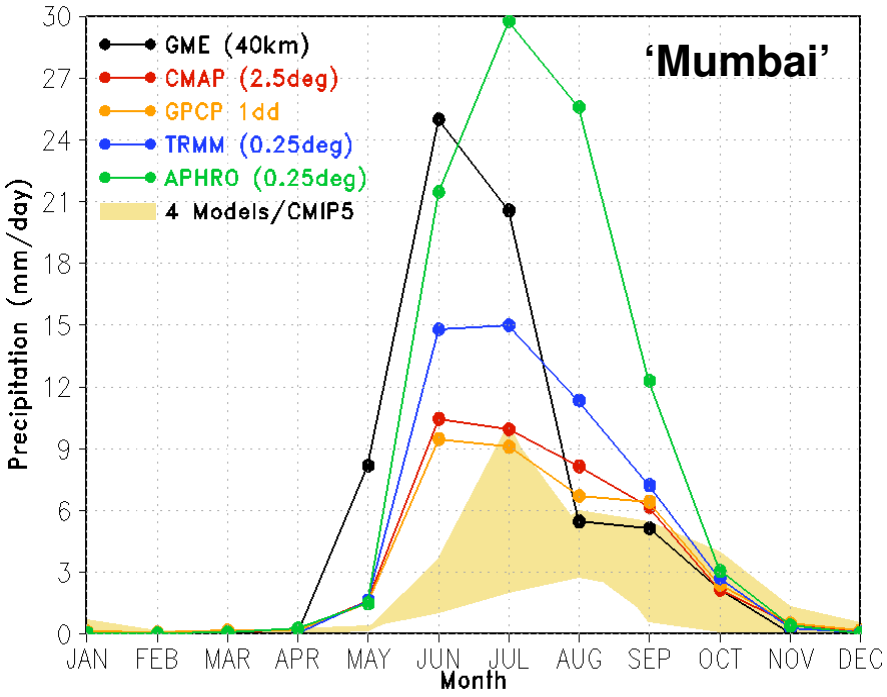
Annual cycle over Indian region

- Precipitation in Main city of India during 1998-2008 (unit: mm/day)



- GME (40km)
- Observation : GPCP, CMAP, TRMM
- 4 models of CMIP5 : CanESM2, GISS-E2R, HadGEM2-CC, HadGEM2-ES

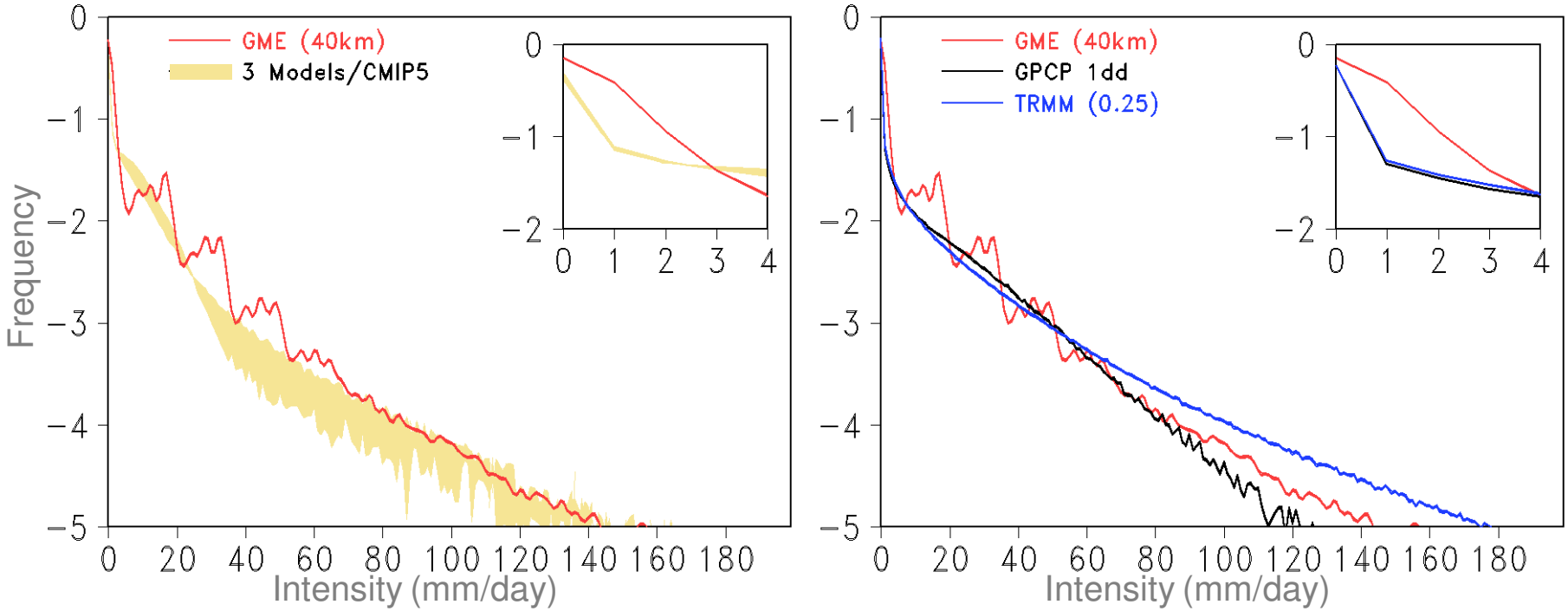




PDF of daily precipitation over Indian region

• Indian region (65~95°W 5~36 °N) during JJAS 1998-2008 (unit: mm/day)

- GME (40km)
- Observation : GPCP, TRMM
- 3 models of CMIP5 : CanESM2, HadGEM2-CC, HadGEM2-ES

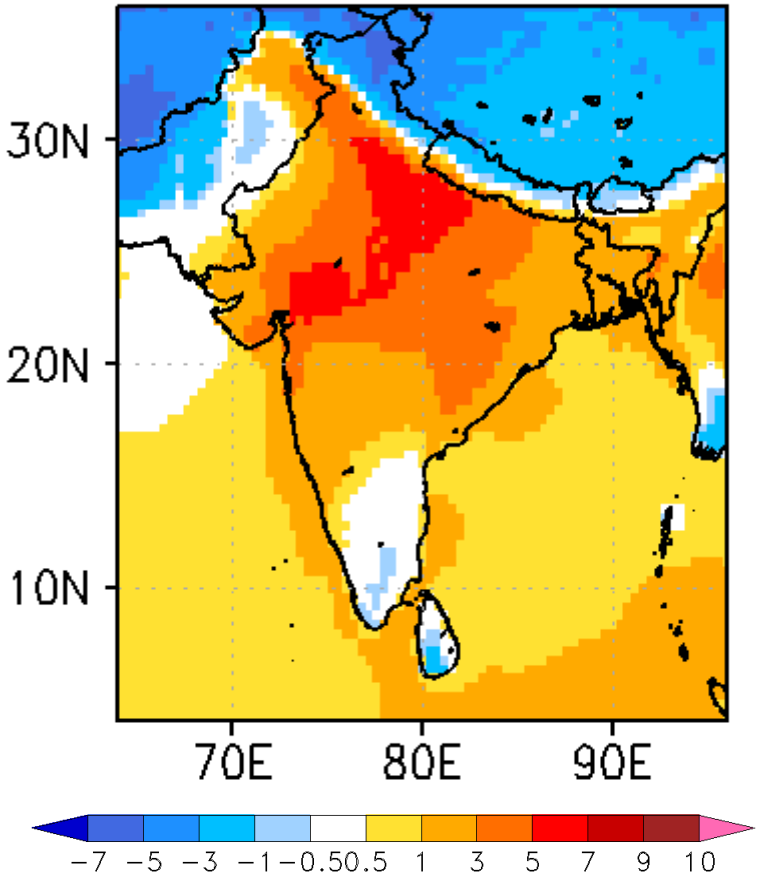


• In the comparison with 3 models of CMIP5, the GME shows more rainfall. And it reflect the heavy rainfall pattern comparing two observation data (GPCP and TRMM).

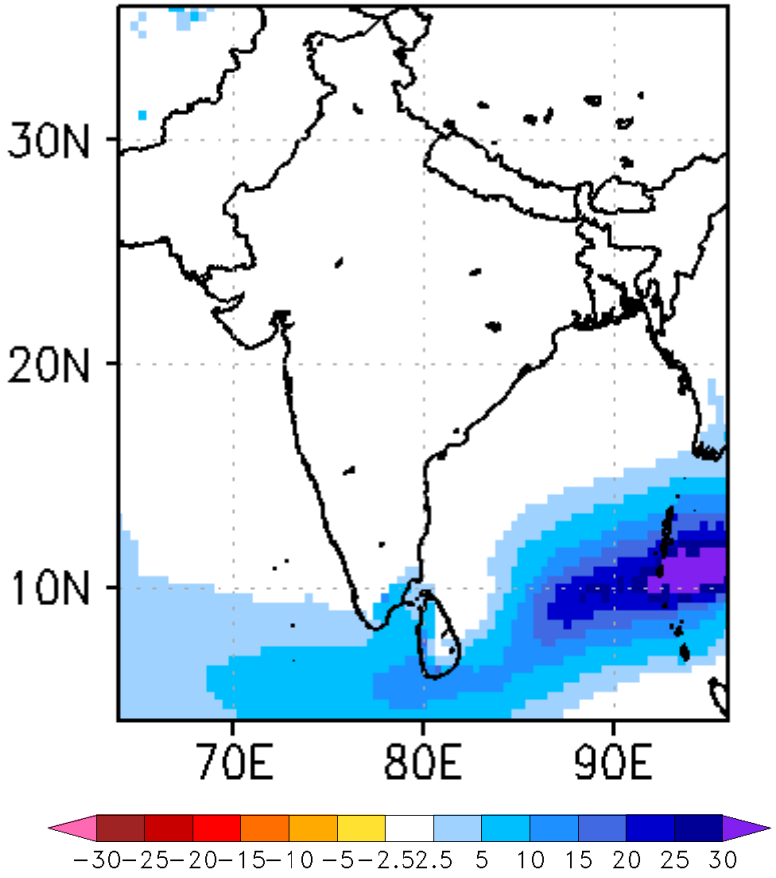
Future change over Indian region

• Future climate change during JJAS 2010-2040 relative to historical run (1979-2009) based on RCP 8.5

Air 2m temperature in JJAS
RCP 8.5 2010-2040



Mean Precipitation in JJAS
RCP 8.5 2010-2040



Summary

• The high-resolution atmospheric general circulation model (GCM) have been used for regional detail climate response for the future climate simulation due to the RCP scenario.

• For this long-term climate simulation, we have perform the present-day climate simulation during 1979~2009 using AMIP observation. And subsequently we have performed the future climate simulation during 2010~2100 due to the RCP 8.5 and RCP 4.5 respectively.

• It shows the detailed features in precipitation over the South Asia region and it shows the better performance than 4 models of CMIP5.

• In the comparison with observation, It can capture the precipitation patterns in the Main city of Indian region and reflect the frequency of heavy precipitation than CMIP5 models.

• In future climate change during next 20 years, it shows the increase of temperature and precipitation over the Indian regions.

Future Plan

Experiment	Scenario	Forcing	Period	Status
Present-day	-	AMIP	1979-2009	Finished
Future	RCP 8.5	4 GCMs/CMIP5	2010-2045	Finished
			2046-2100	In progress
	RCP 4.5	4 GCMs/CMIP5	2010-2100	Not yet

• We have already finished the AMIP-type run with high-resolution AGCM and model integration by RCP 8.5 is in progress.

❖ **Future plan**

- Model integration by RCP 8.5 and RCP 4.5
- Evaluate the model performance with observation
- Climate projection over worldwide regions
- Comparison with various CORDEX data

Thank you for attention