Global and Regional Climate Projections based on the RCP Emission Scenarios at KMA

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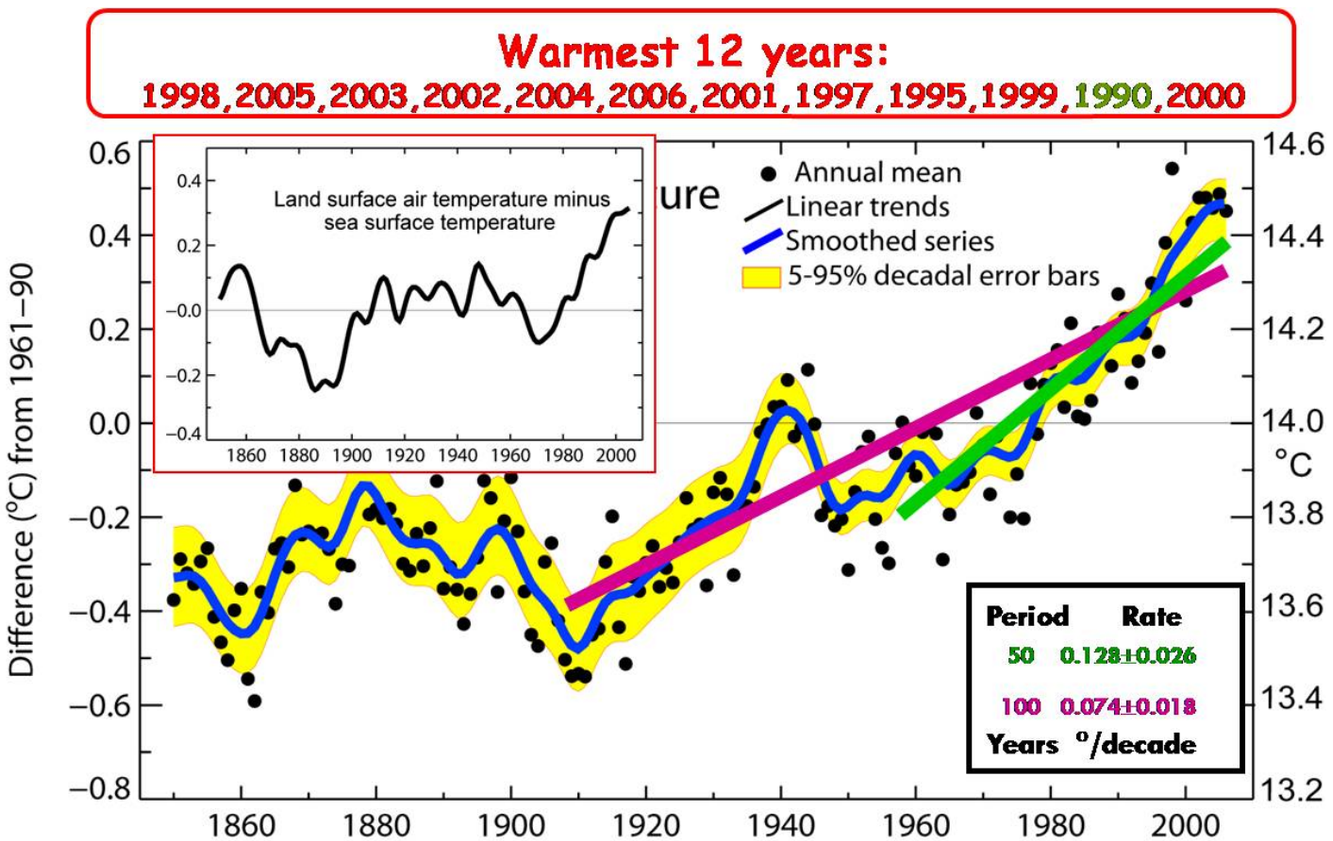
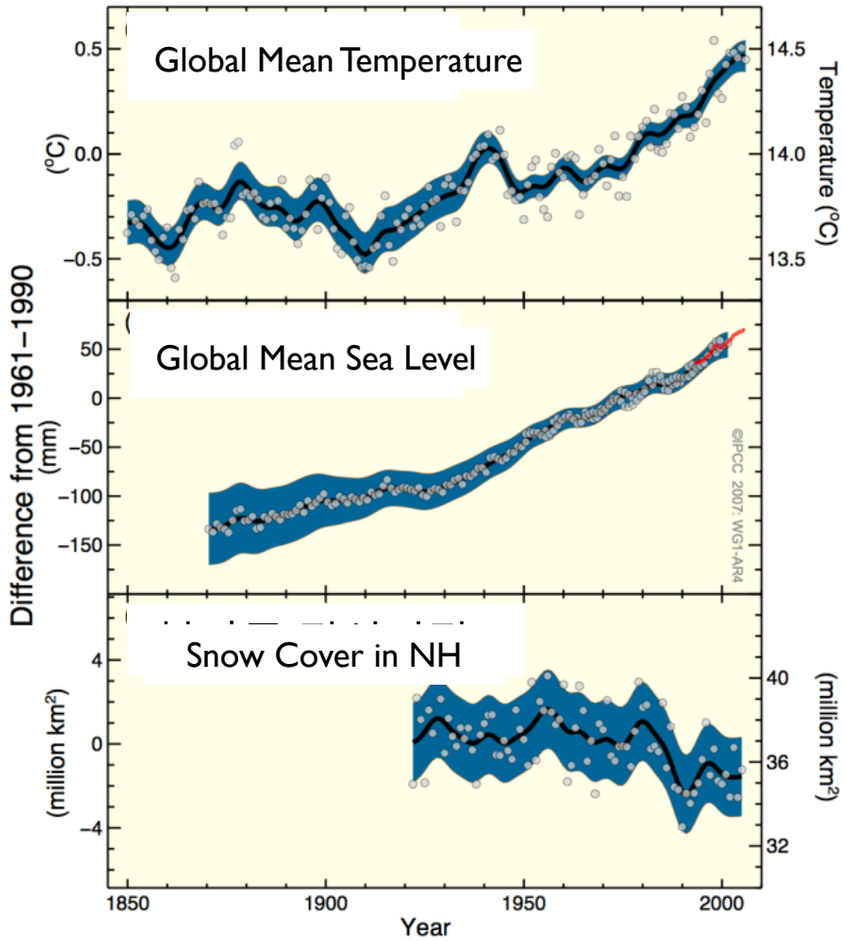
Global Change in IPCC AR4 (2007)

- Warming of the climate system is unequivocal.
  - Global mean temperature: +0.74°C (1906-2005)
  - Global mean sea-level rise: +1.3 mm/year since 1961
  - Snow cover in NH: - 2.7%/decade
  - Warming is accelerating in recent years.



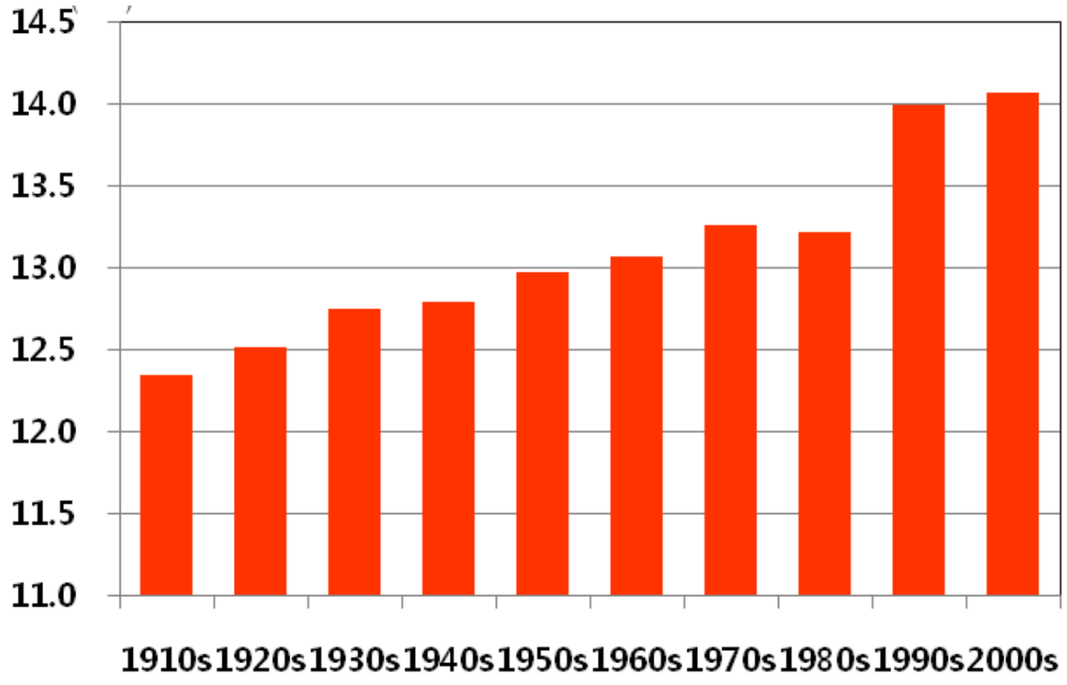
Changes in Temperature , Sea Level and Northern Hemisphere Snow Cover



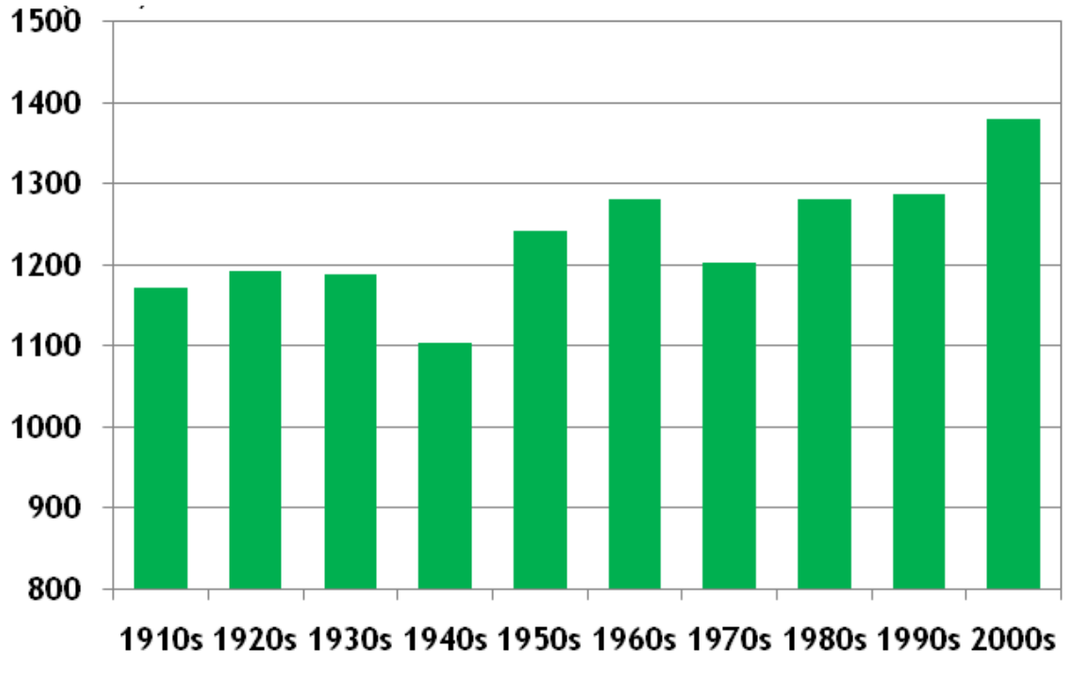
Climate Change in Korea

- Rapid change since the 1990s
  - Temperature: + 1.8°C/100years - more than double than that of global mean !!
  - Precipitation: + 217 mm/100 years
  - Sea level rise: + 8 cm during 1963-2006 (22 cm near Jeju island)
  - Property damages: ~ 1.6 Billion USD/year in 2000s - three times more than in 1990s

Temperature (°C)

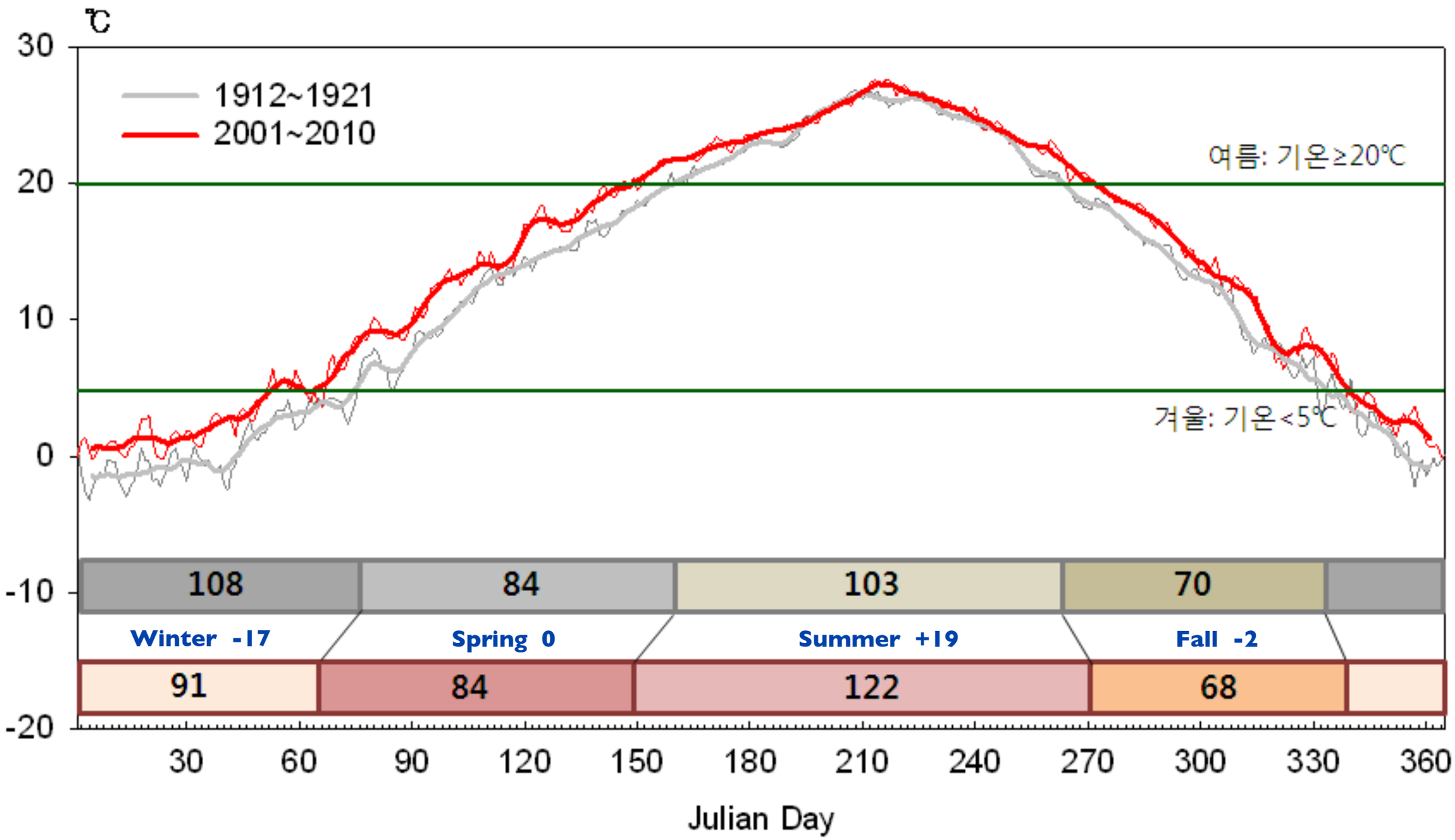


Precipitation (mm)



N.B. Six station measurements are used for 1912-2010

Seasonal Duration in Korea

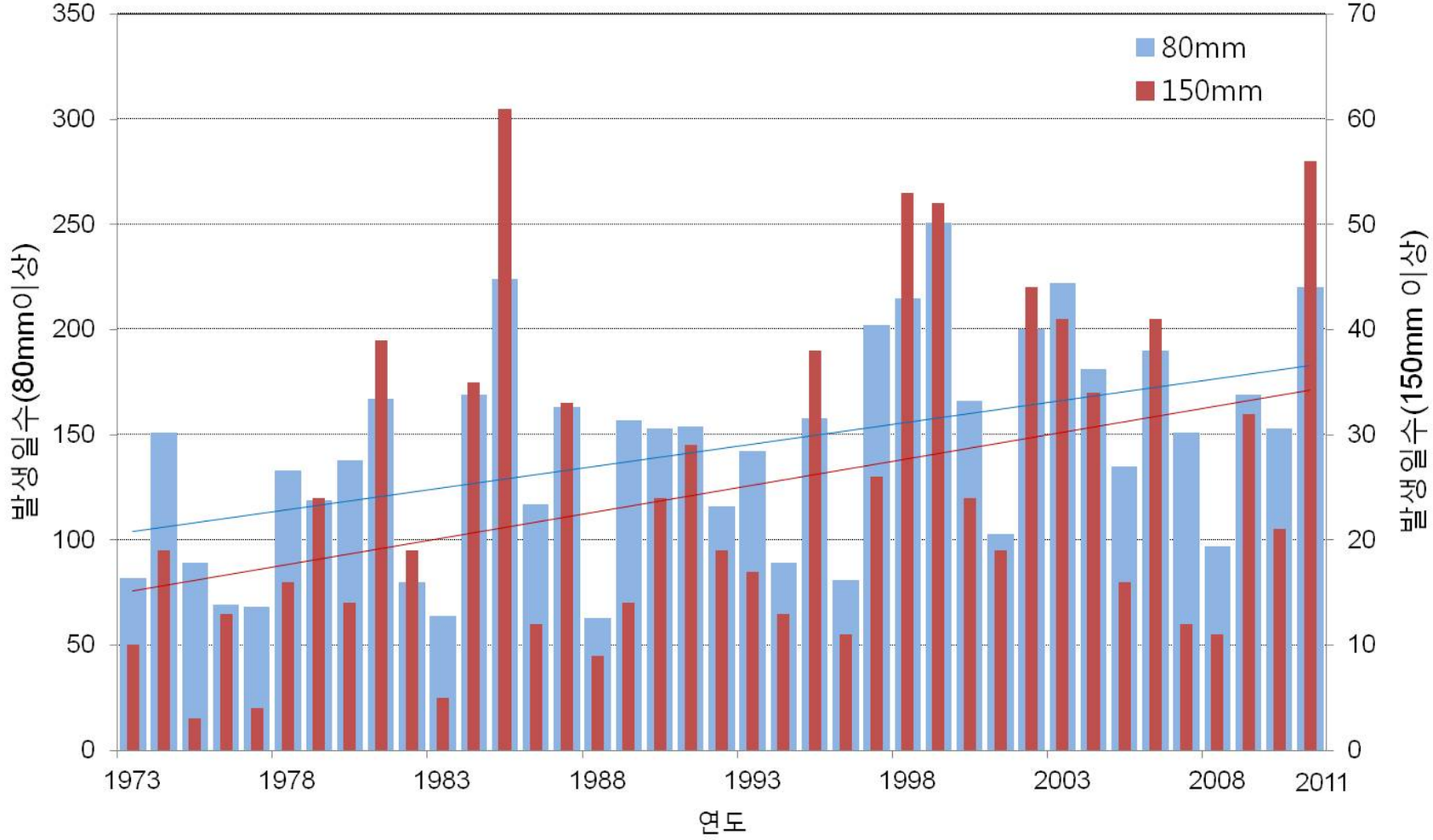


Heavy Precipitation in Korea

- 61 station measurements during 1973-2011.

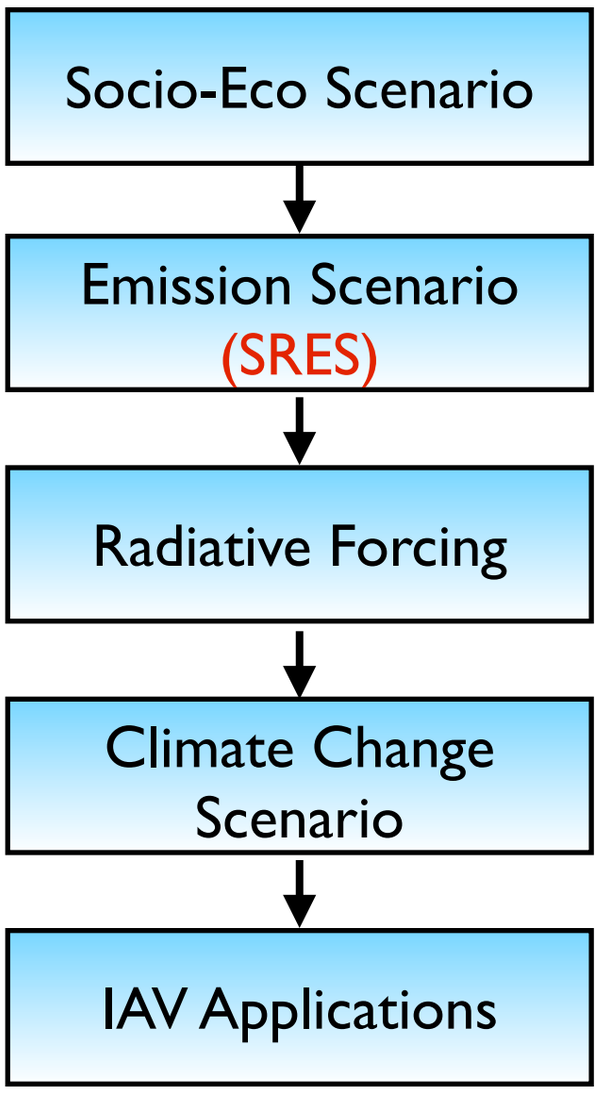
[Changes in number of days with heavy precipitation over Korea]

	1973-1982	2002-2011
80 mm/day	110	172
150 mm/day	16	31

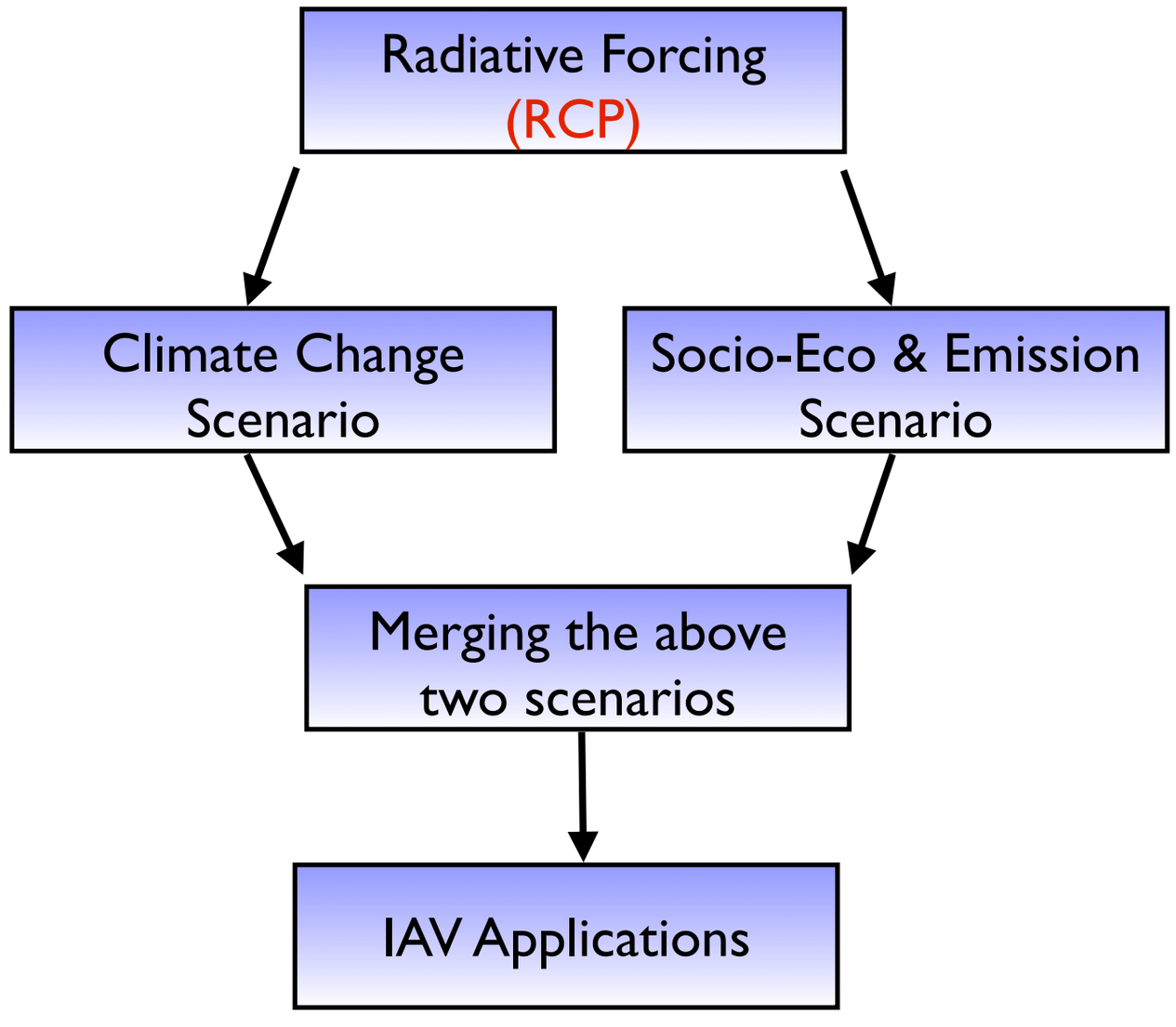


Different Approaches btw. AR4 and AR5

Sequential Approach (AR4)



Parallel Approach (AR5)



Representative Concentration Pathways

- Representative in that they are one of several different scenarios that have similar radiative forcing and emissions characteristics.

- Pathways in order to emphasize that their primary purpose is to provide time-dependent projections of atmospheric GHG concentrations.

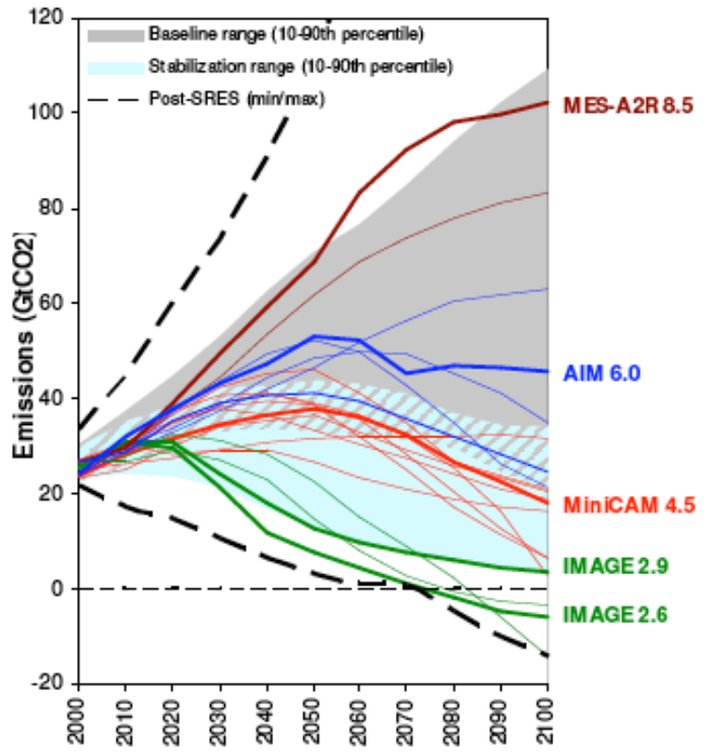
$$CO_2 = f(P, S, E, C, etc)$$

Energy replacement

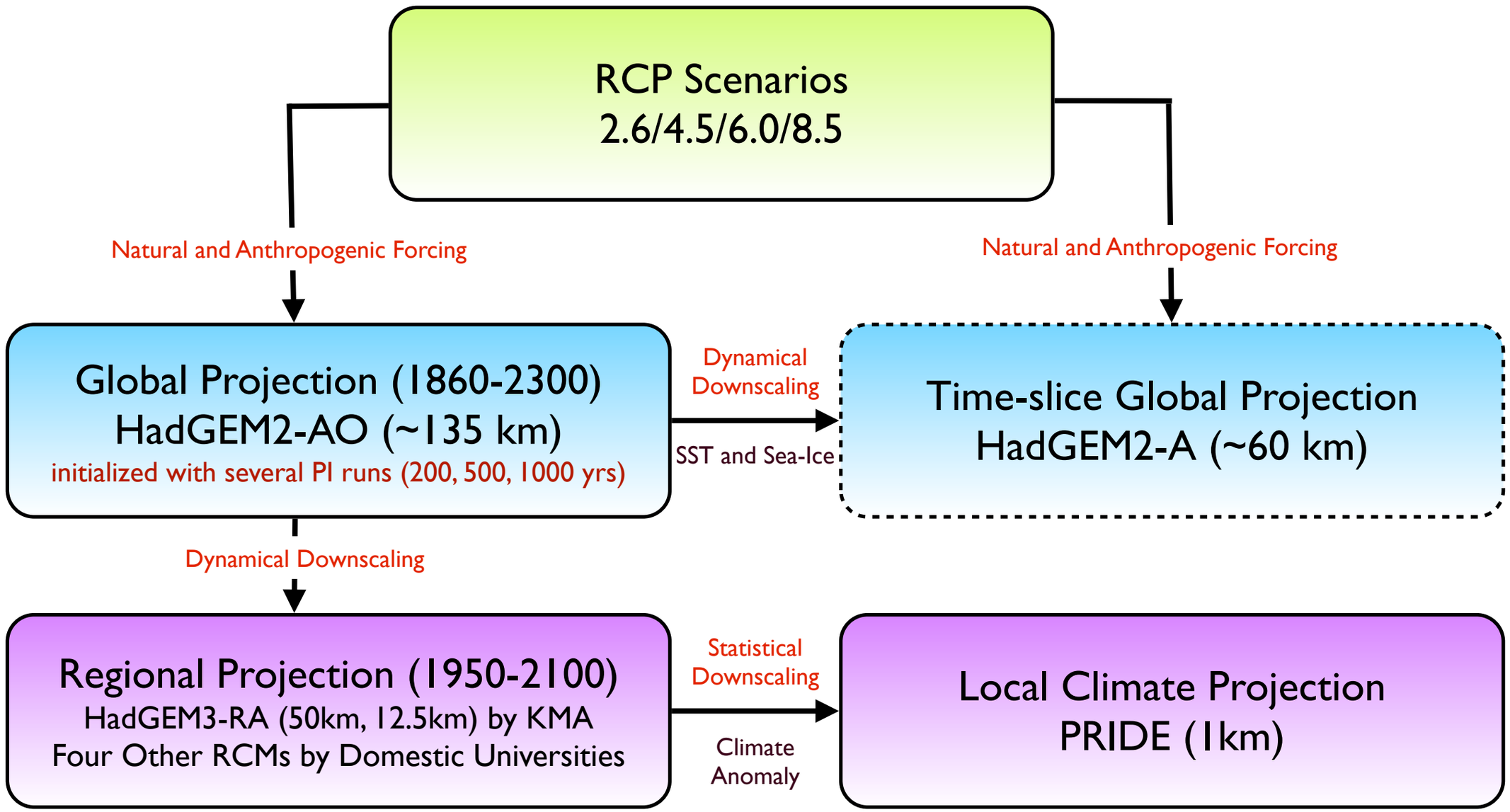
Energy efficiency

Economy growth

Population growth



Framework for Climate Projections at KMA/NIMR

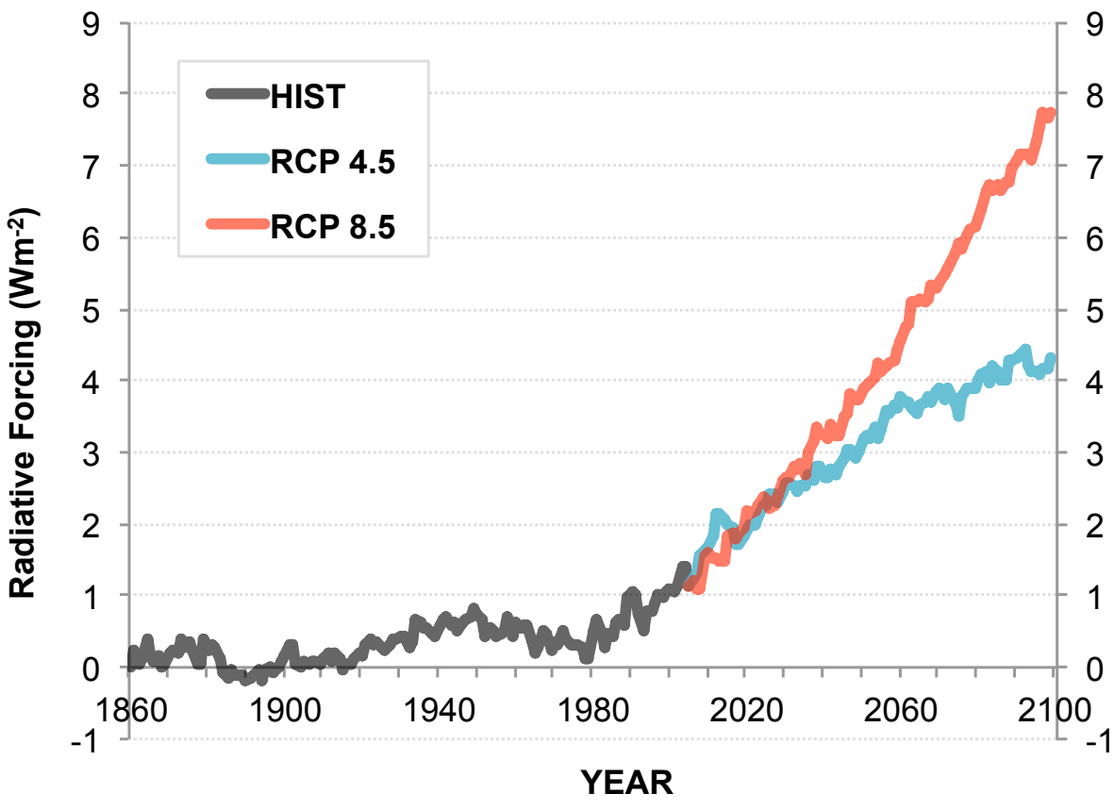


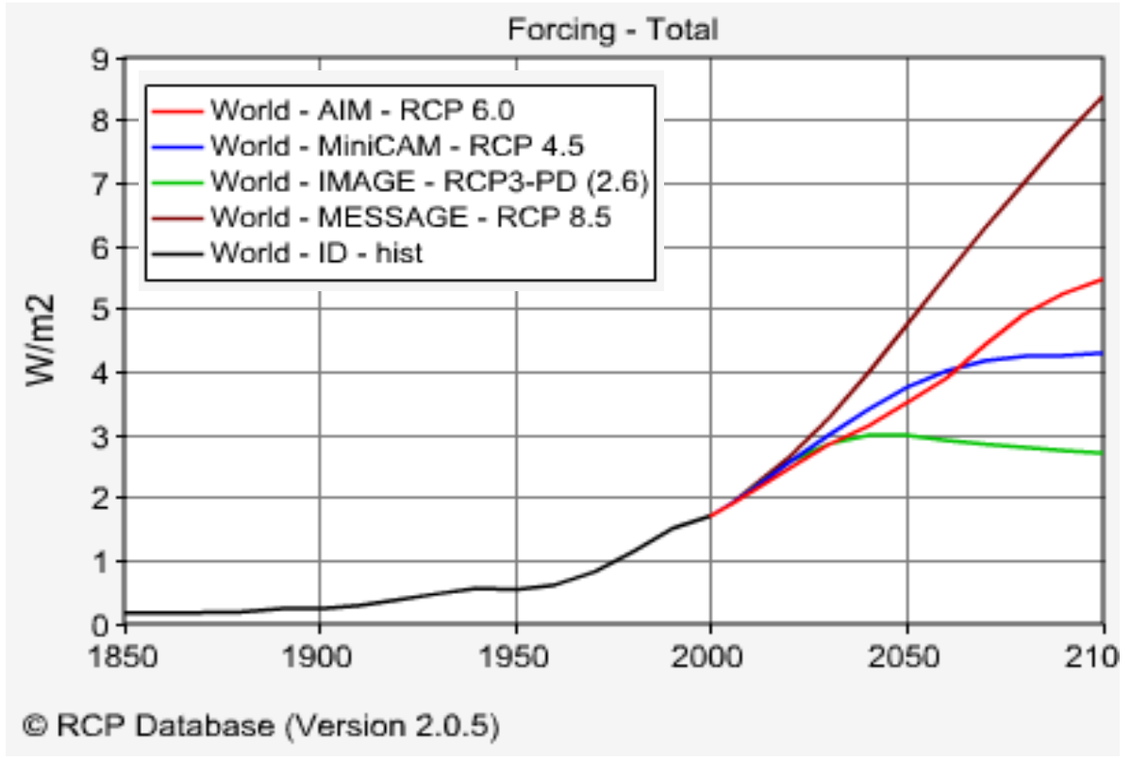
Radiative Forcing of RCP Scenario

- Radiative forcing can be used to estimate a subsequent change in equilibrium surface temperature (Δ Ts) arising from that radiative forcing via the equation:

$$\Delta T_s = \lambda \cdot \Delta F$$

where λ is the climate sensitivity, usually with units in K/(W/m2), and ΔF is the radiative forcing. A typical value of λ is 0.8 K/(W/m2), which gives a warming of 3K for doubling of CO2 (Ramaswamy et al., 2001).

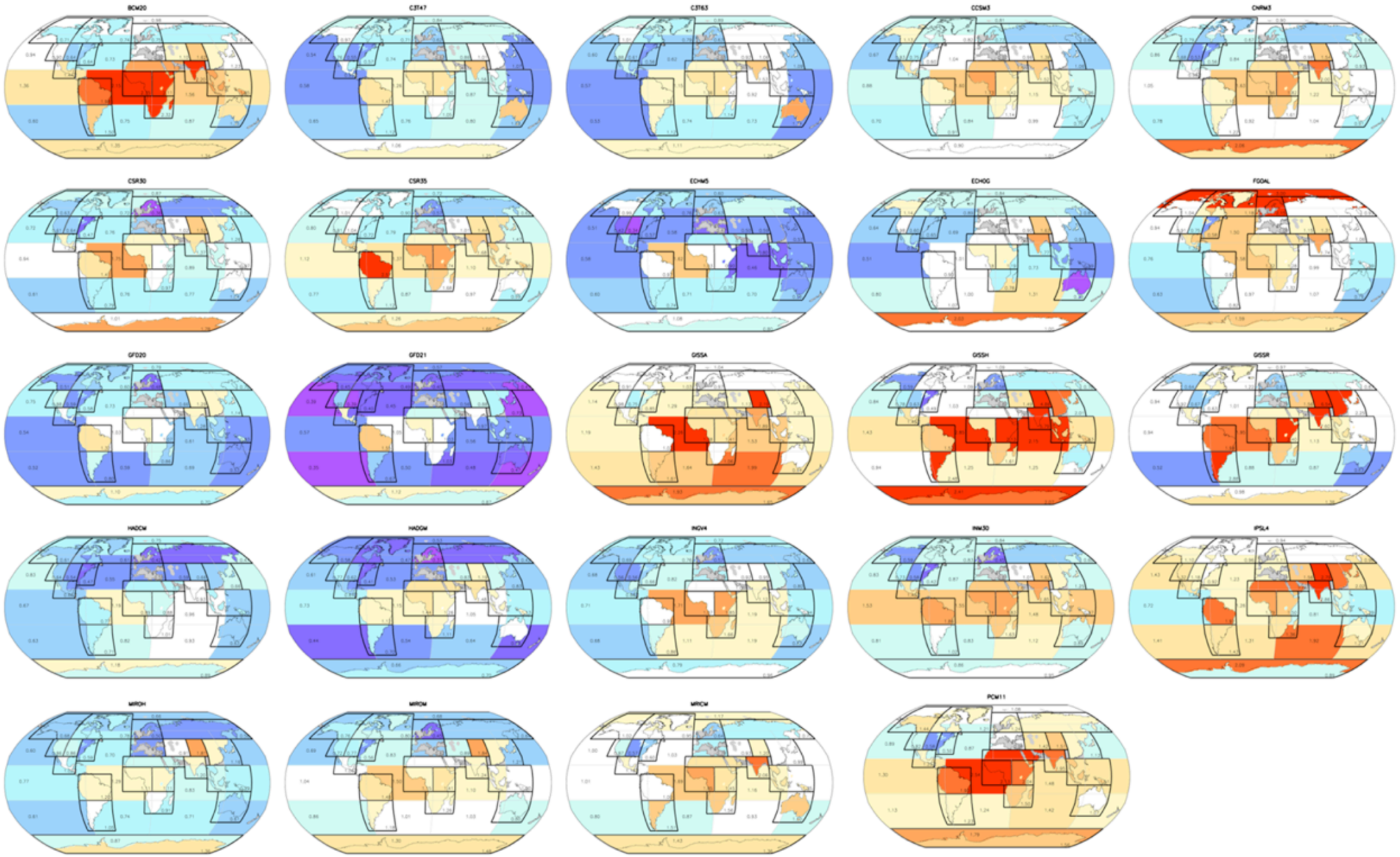




Evaluation of CMIP3 Models

(Reichler and Kim, BAMS, 2008)

- 31 variables (Dynamical 9, Physical 12, Ocean 9, Land 1) -



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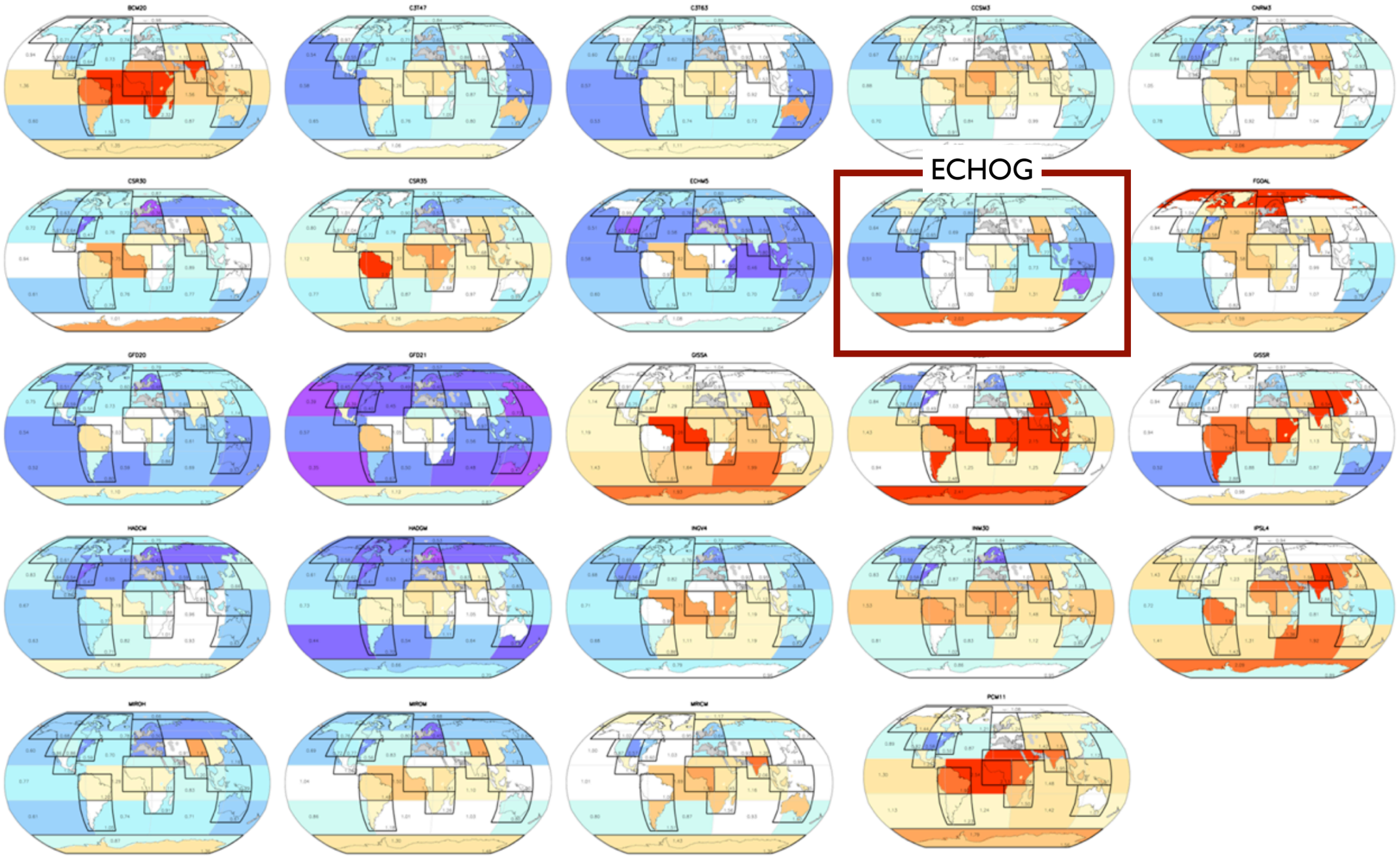

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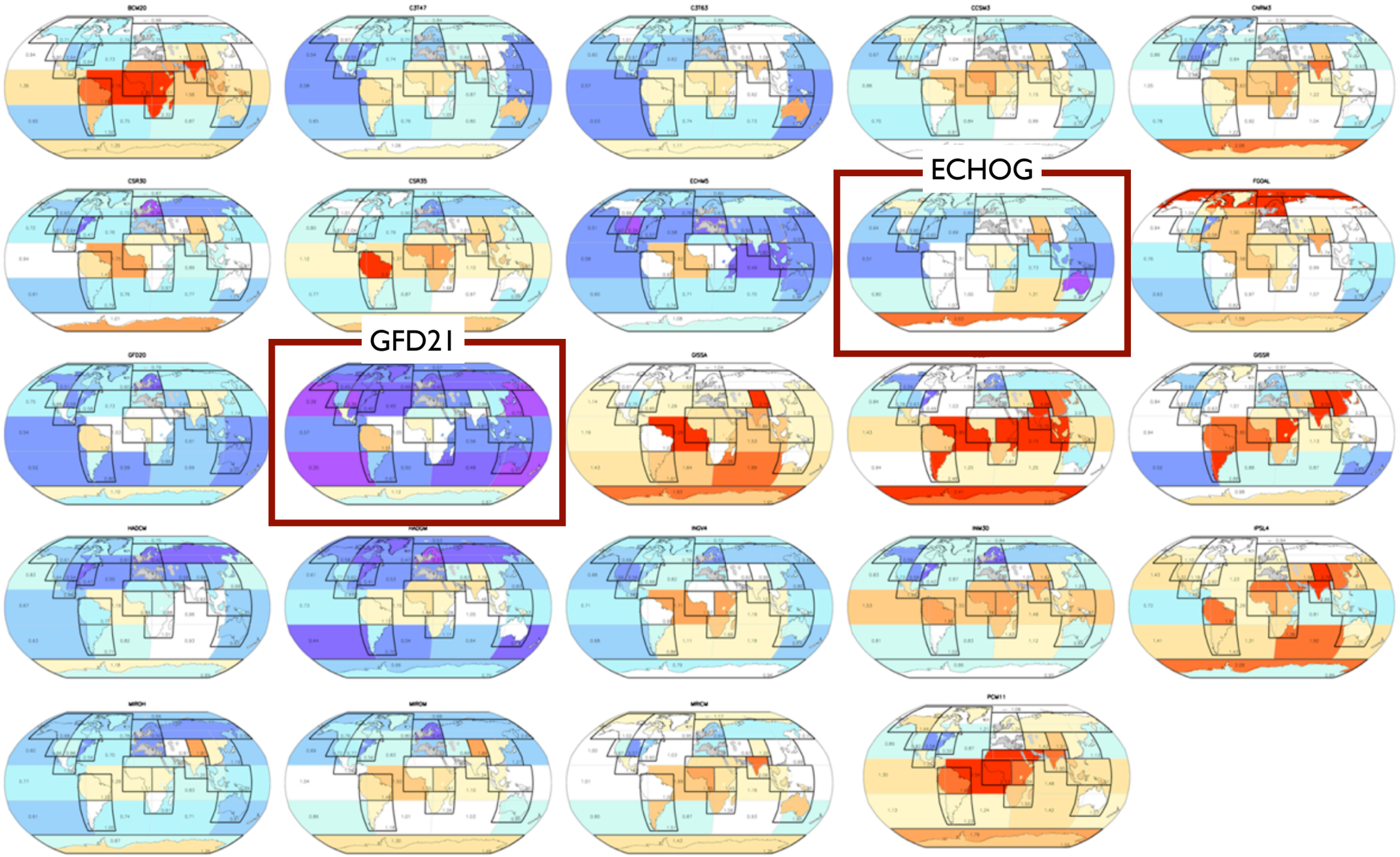

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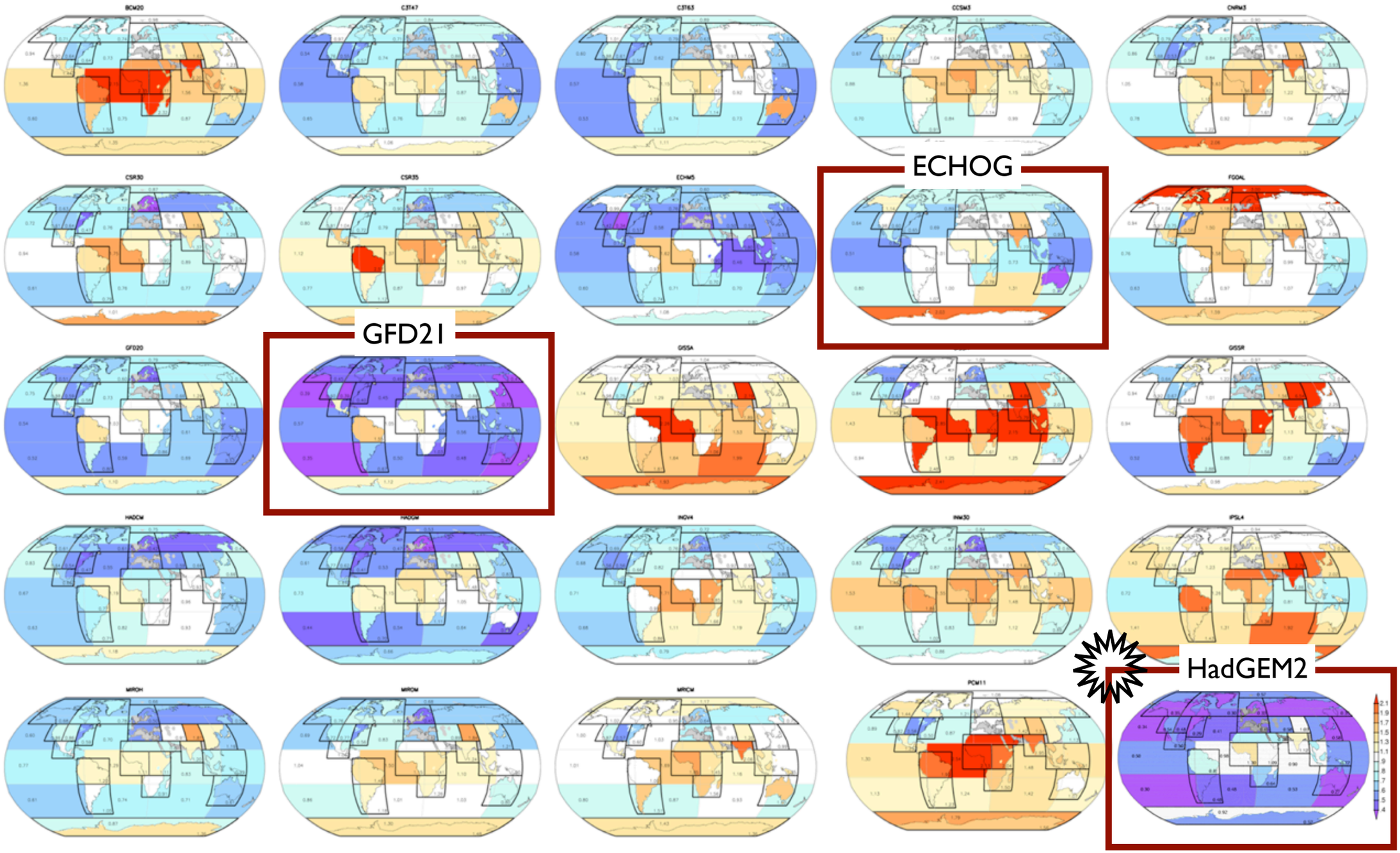
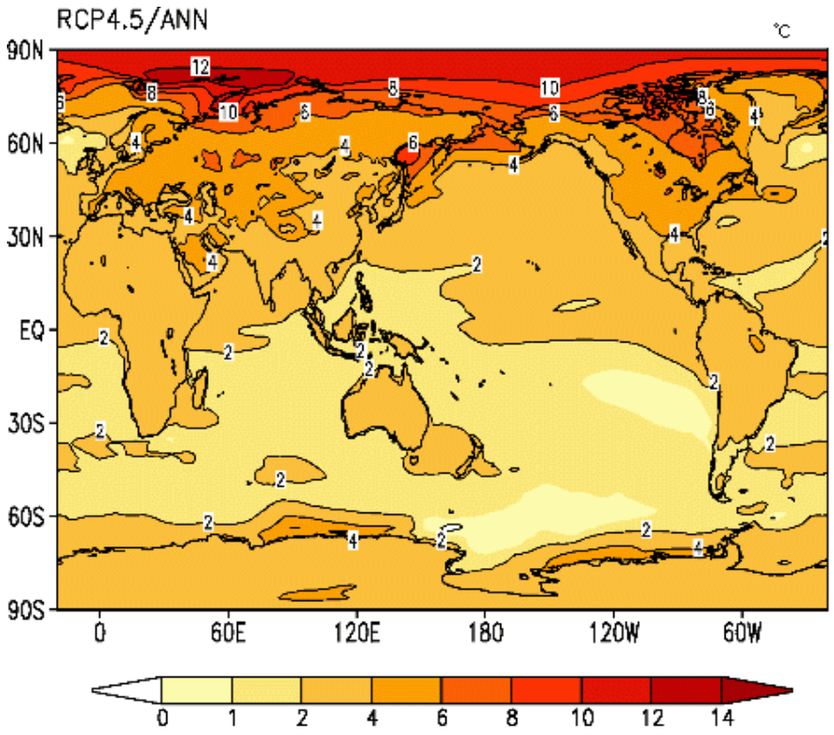
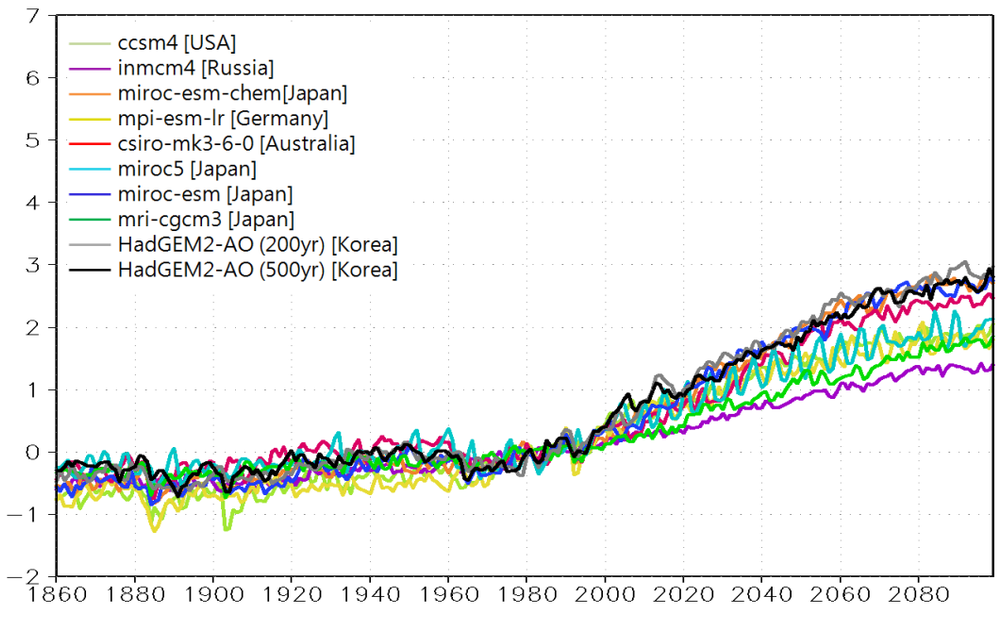


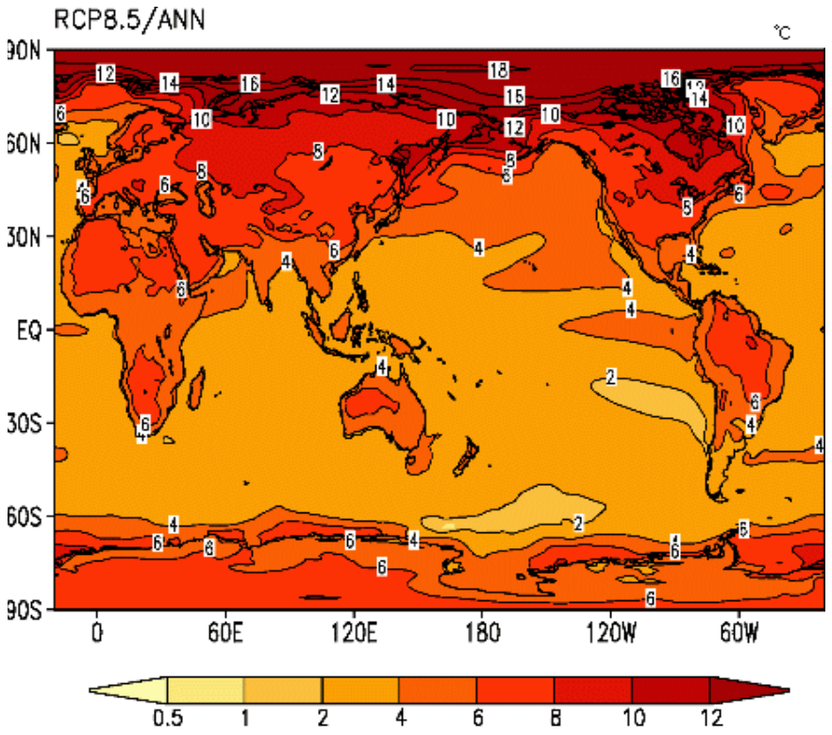
Global Mean Sfc. Air Temperature [deg]

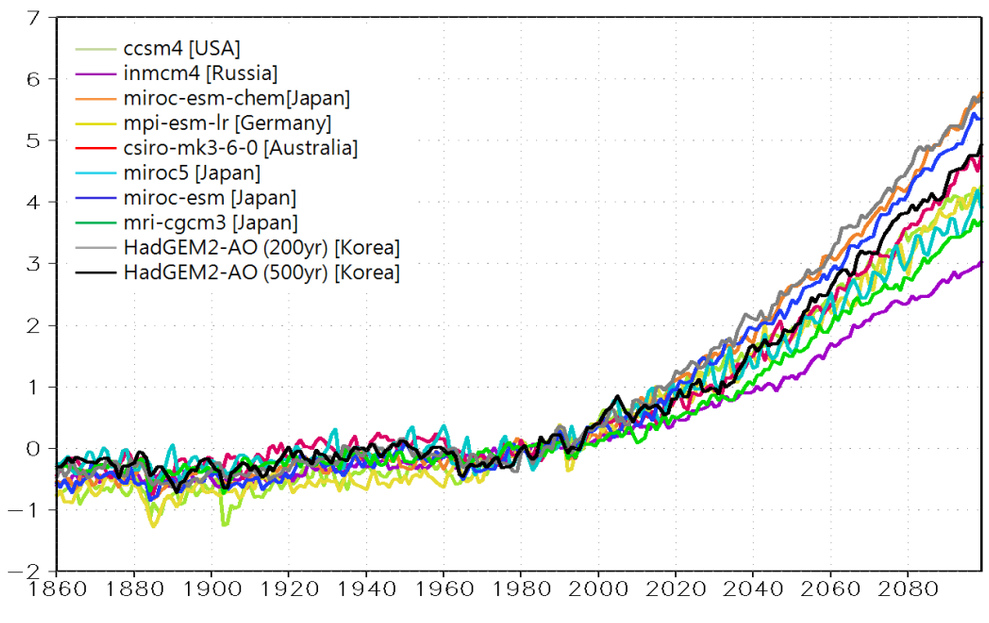
RCP 4.5





RCP 8.5

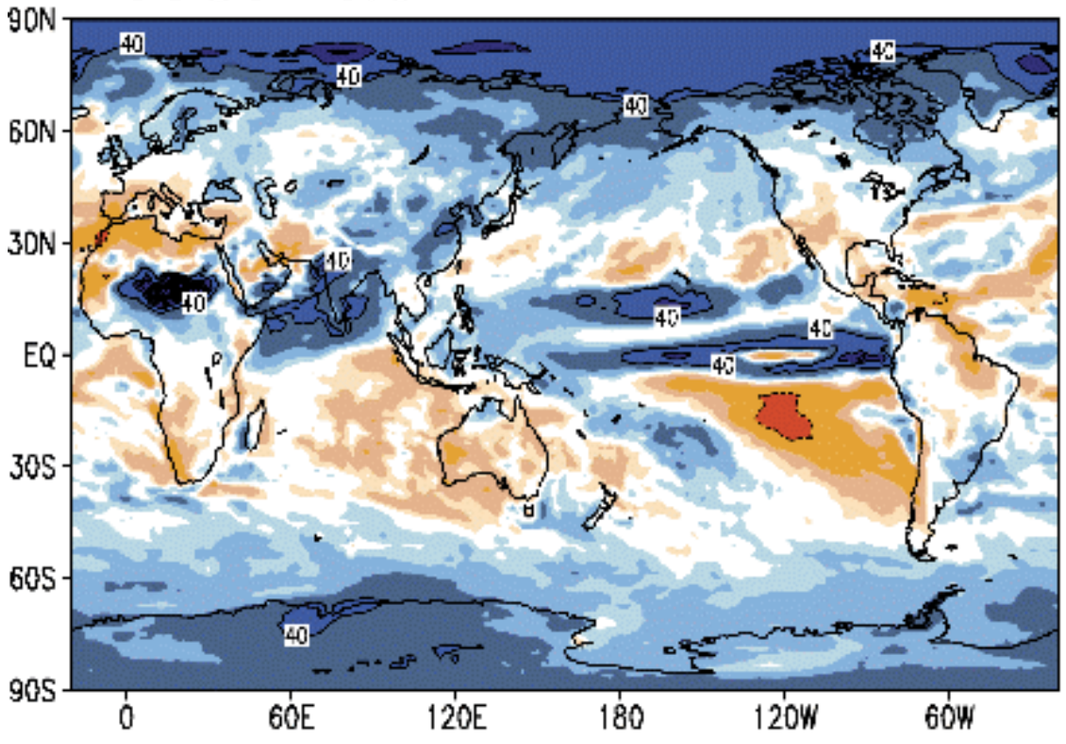




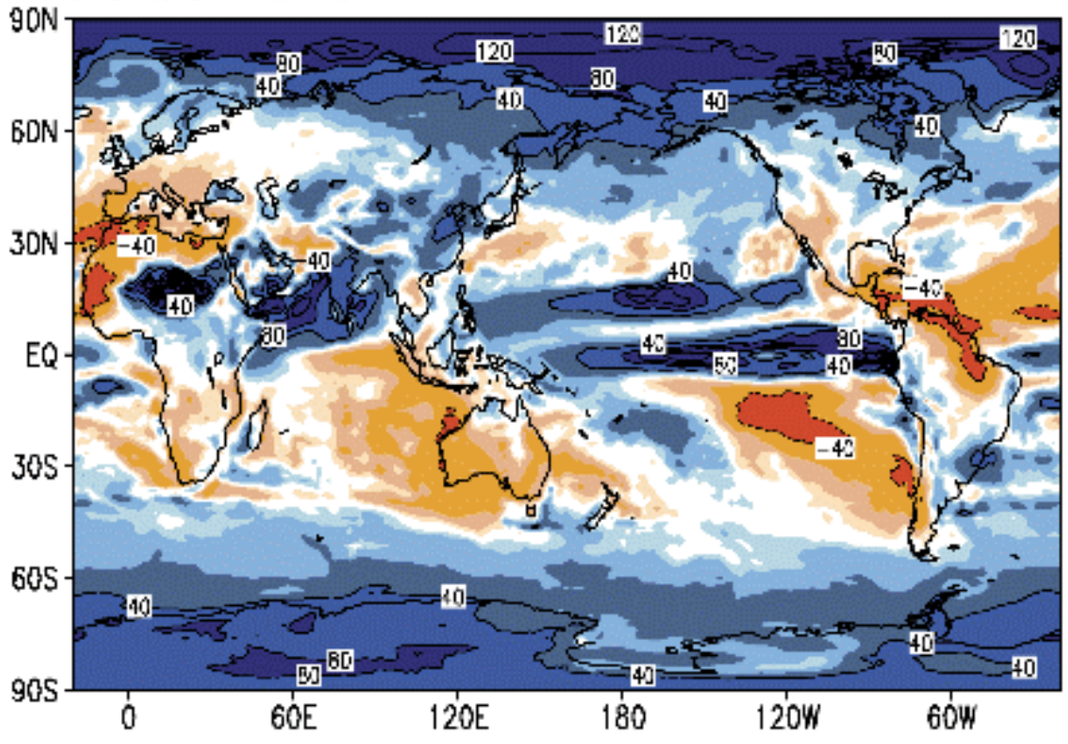
Changes in Global Precipitation (%)

[21st C minus 20th C]

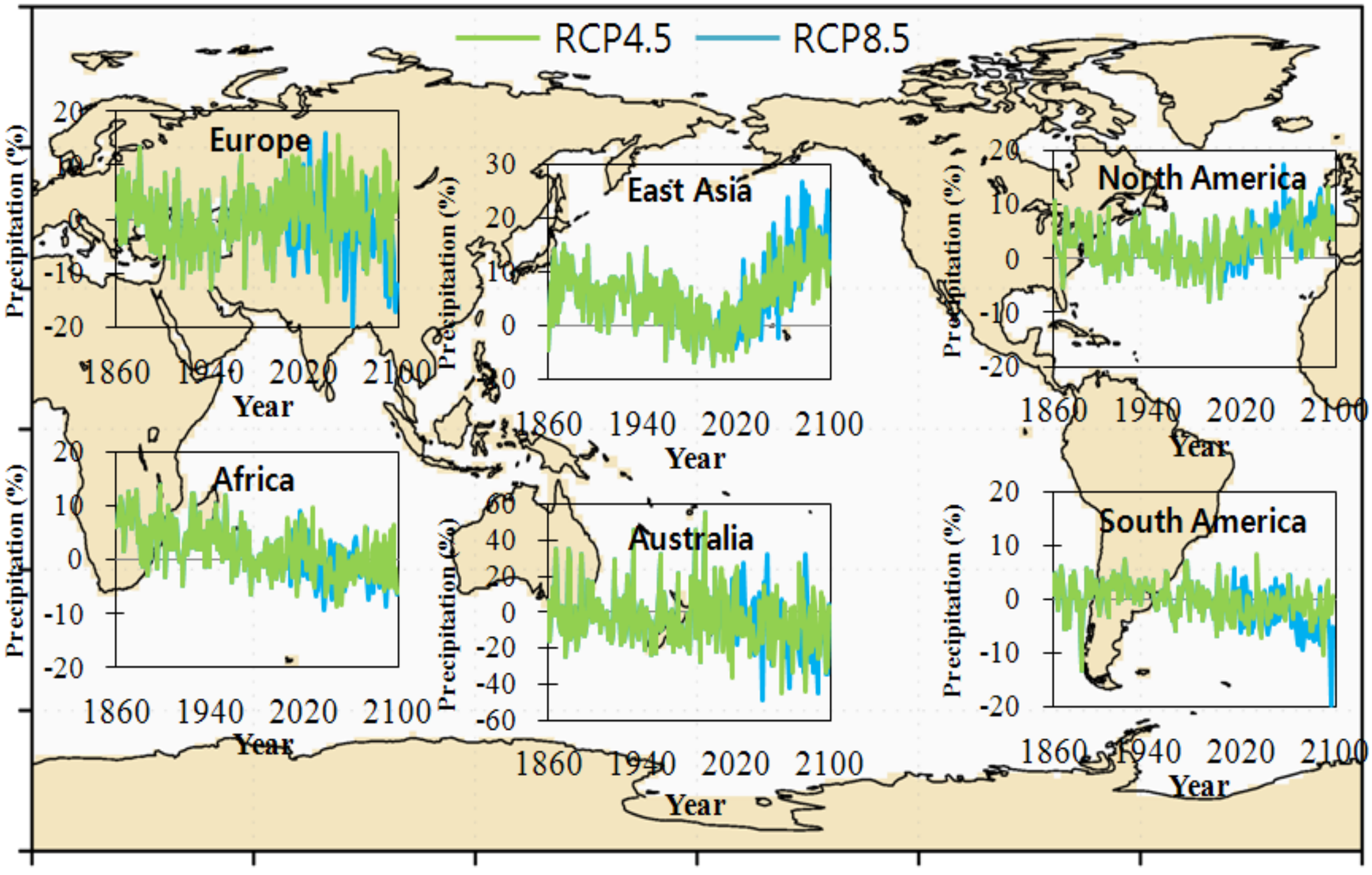
RCP 4.5



RCP 8.5

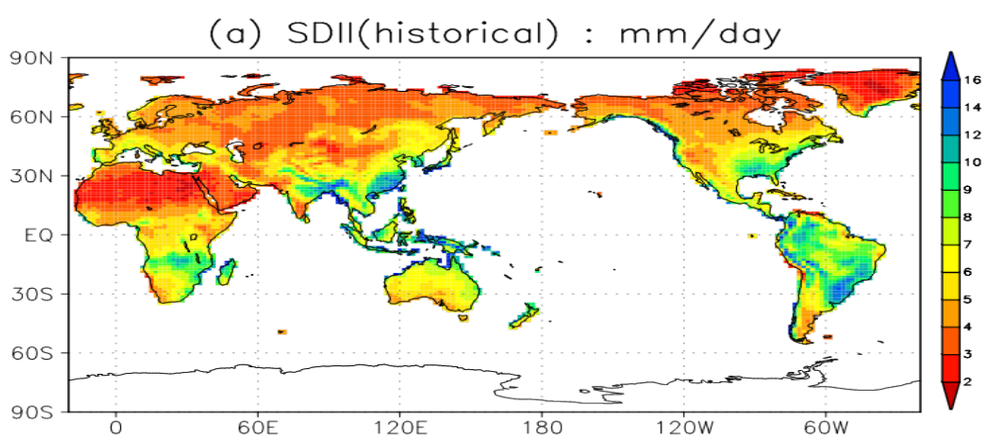


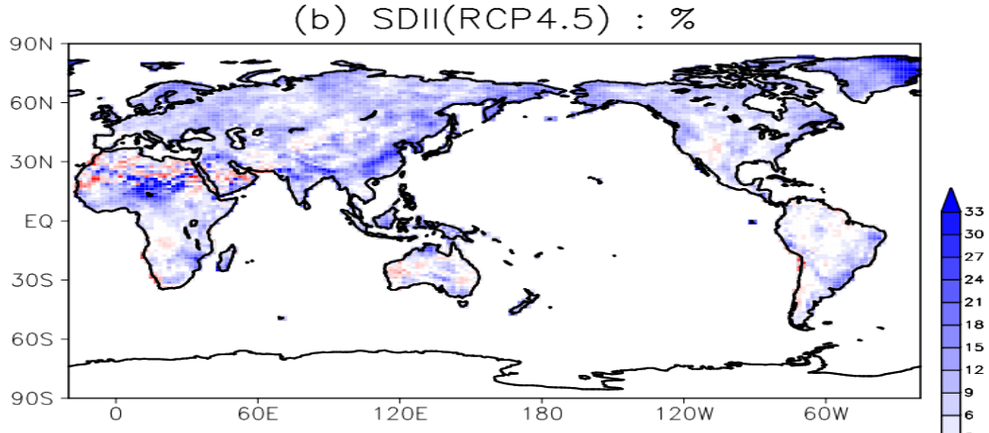
Regional (Continental) Precipitation [%]

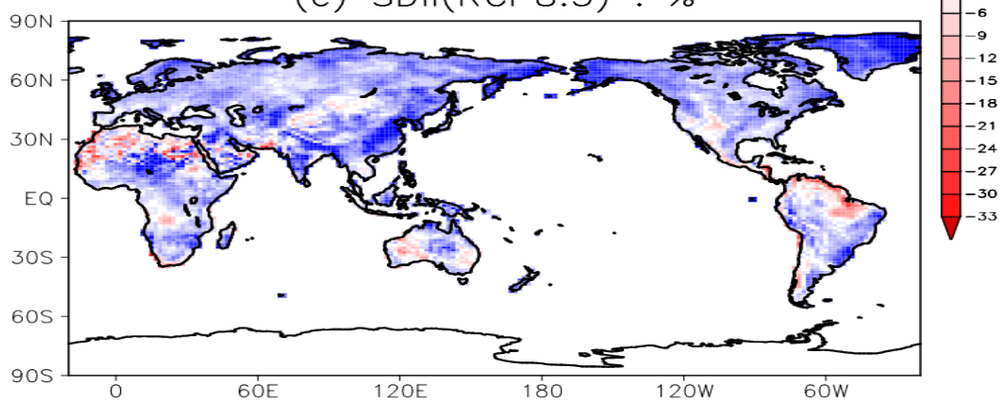


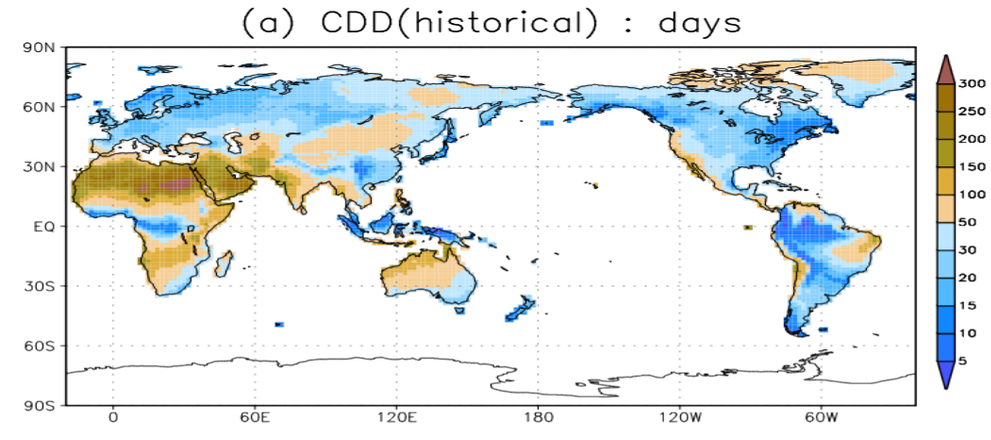
Refer to 1971-2000

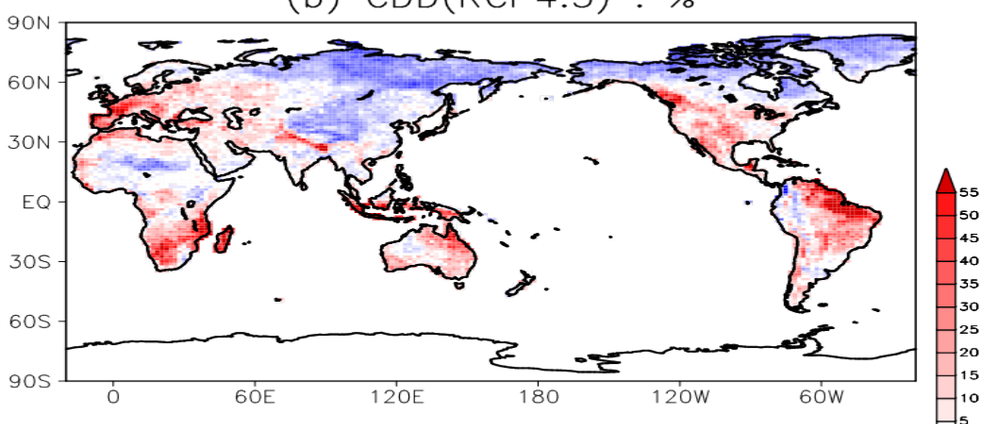
SDII and CDD from Precipitation

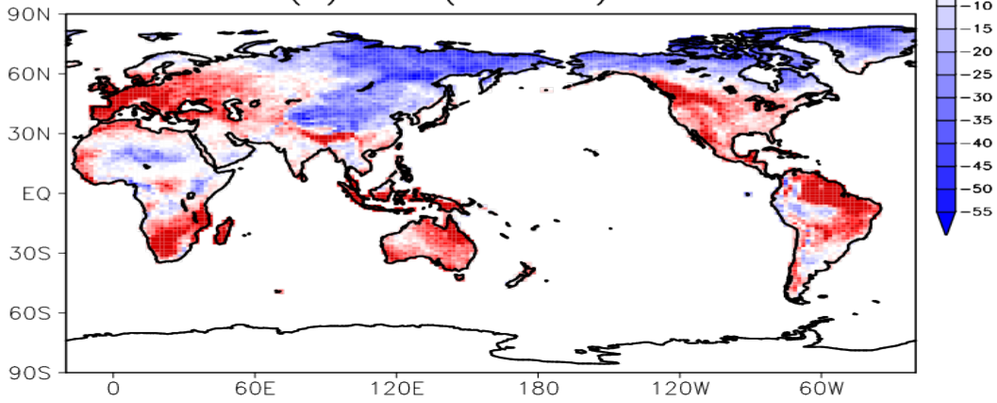






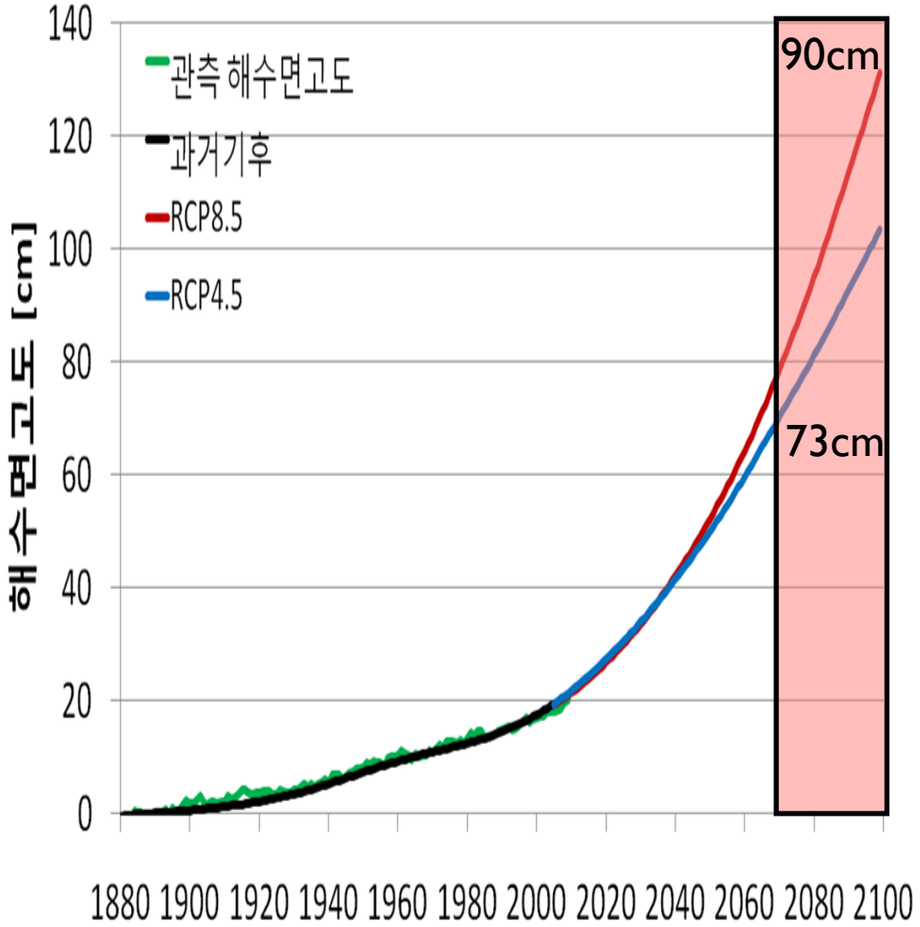




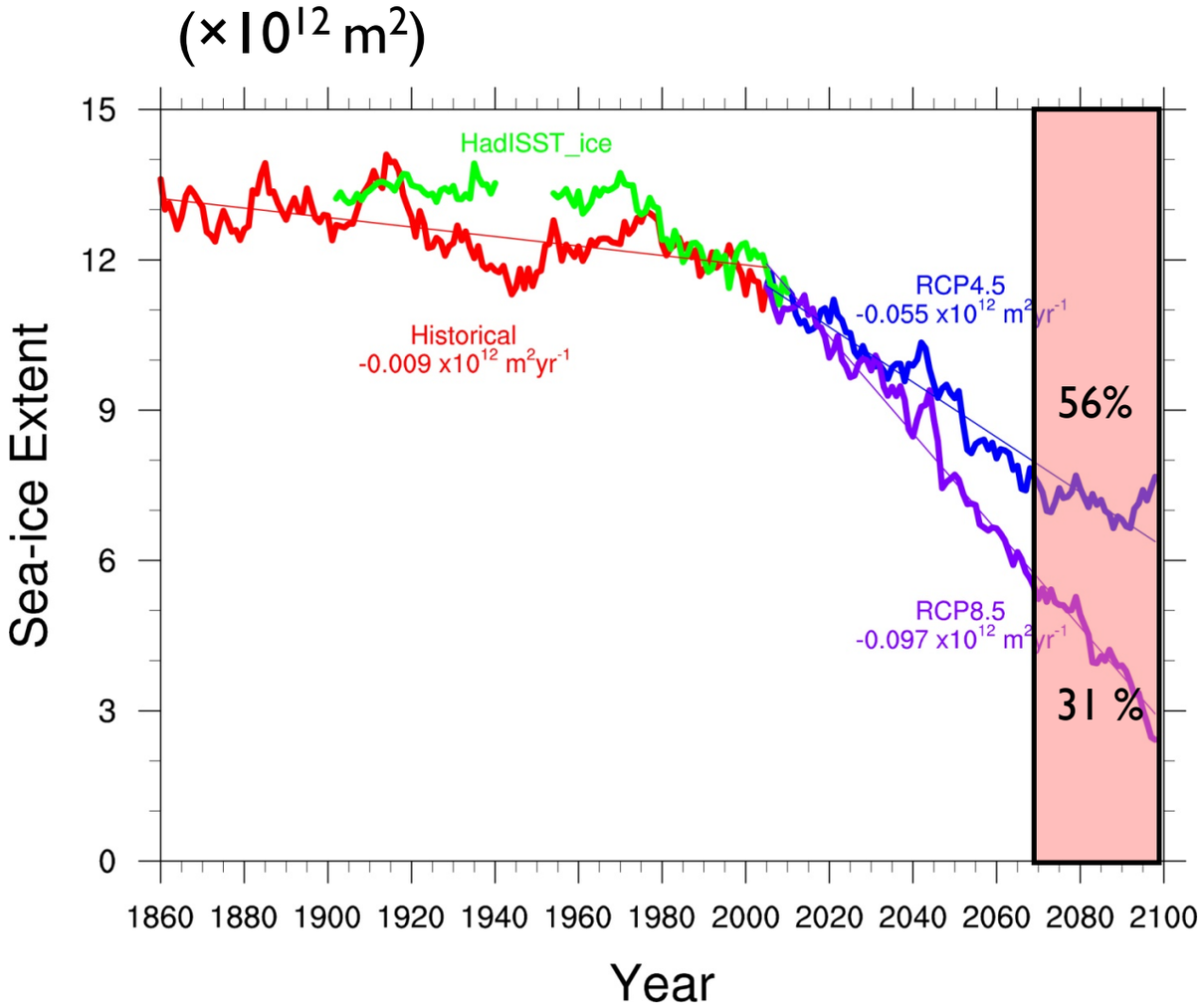


Global Mean Sea-level and Arctic Sea-ice

Sea-Level Rise
(Thermal expansion + Glacier melting)

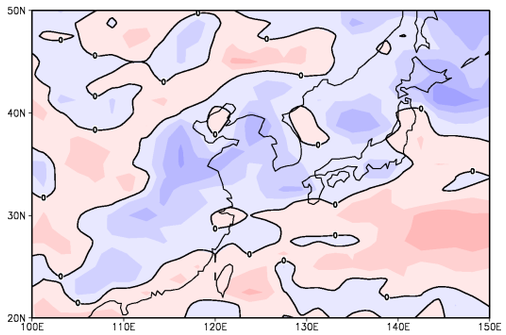
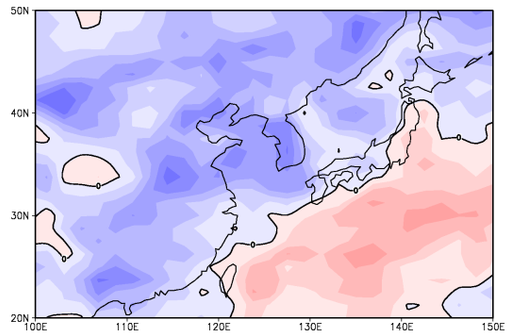
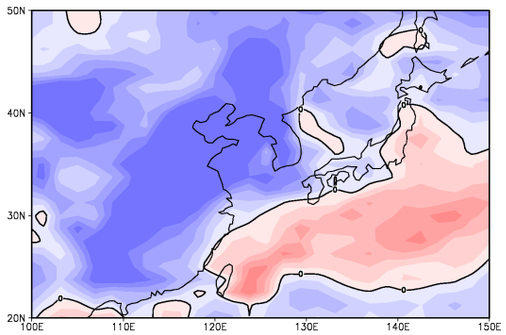
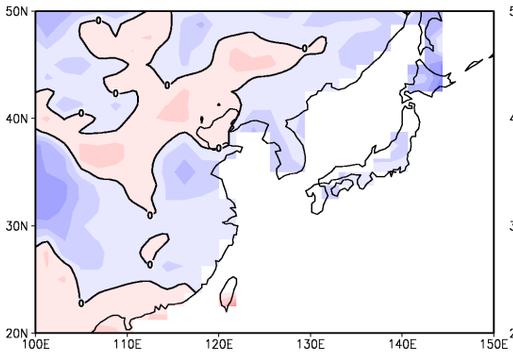
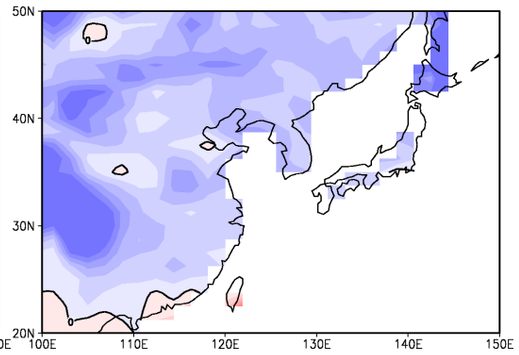
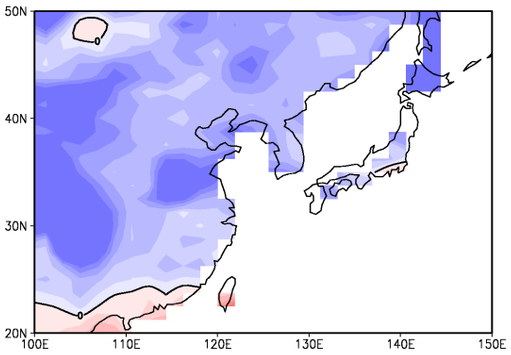
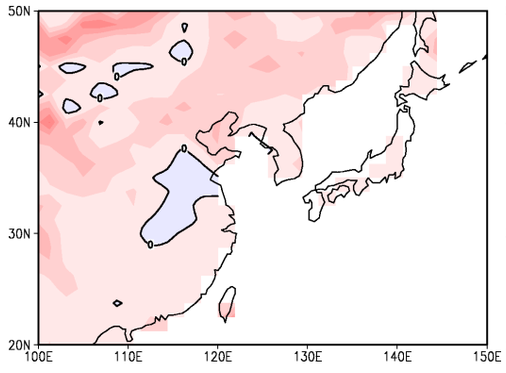
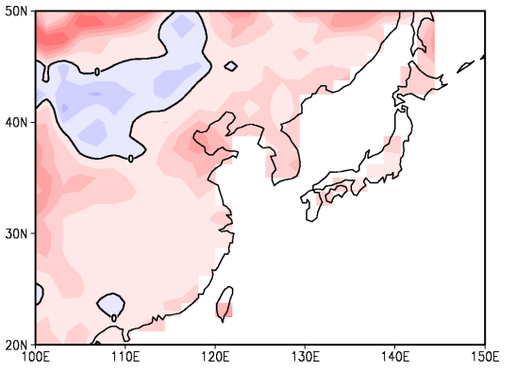
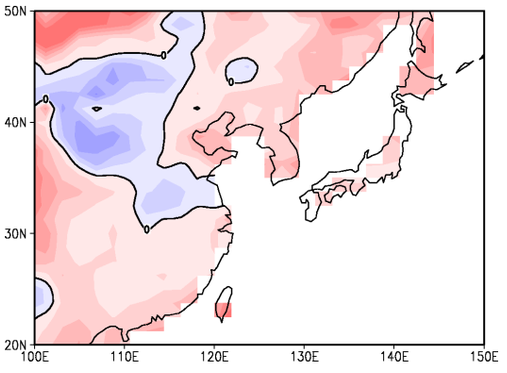


Sea-ice Extent



Changes in Water Cycle

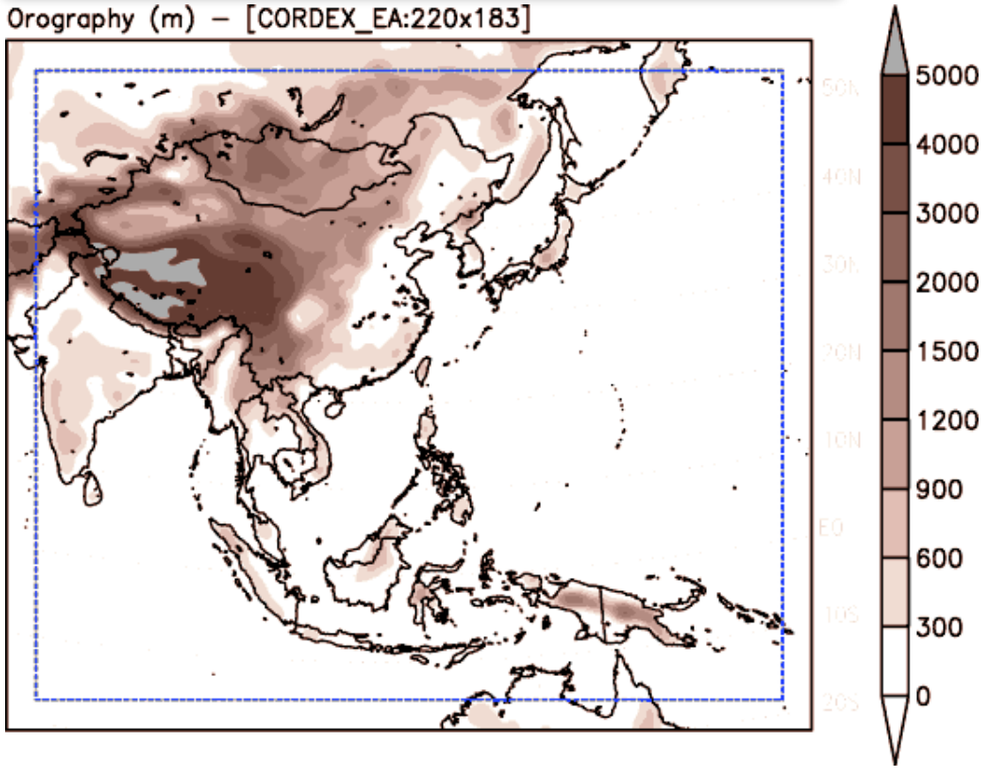
(RCP 8.5)

	2010-2039	2040-2069	2080-2099
Precipitation (%)			
Surface Evaporation (%)			
Soil Moisture [0-10cm] (%)			

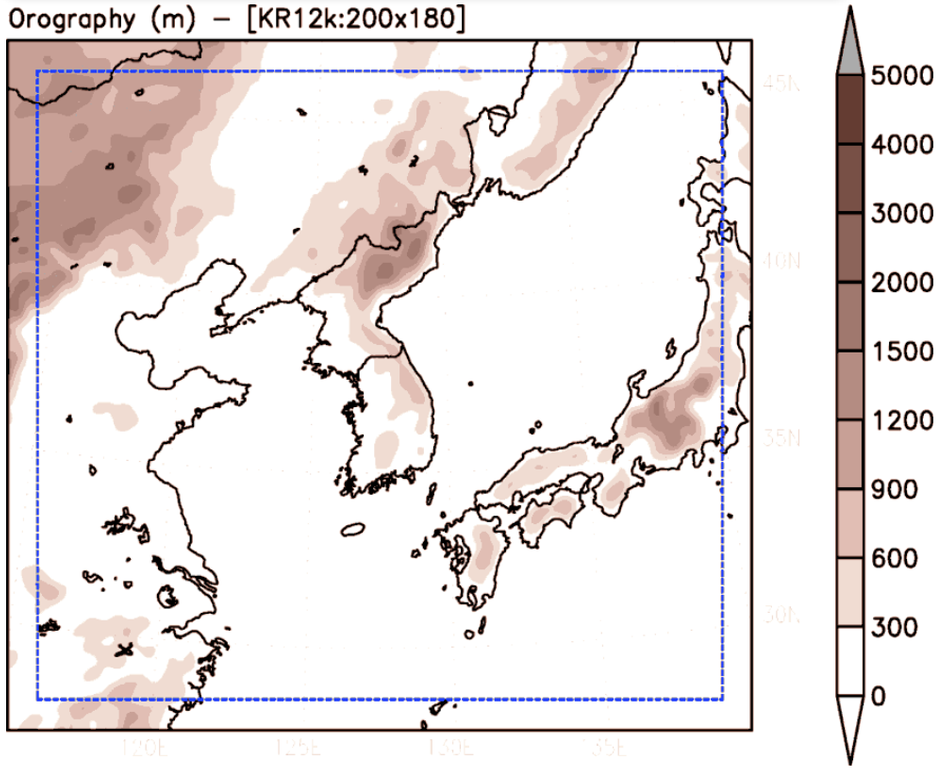
Regional Climate Projection

- 50km-res. for CORDEX-East Asia
- 12.5km-res. for Korea

CORDEX 50km domain



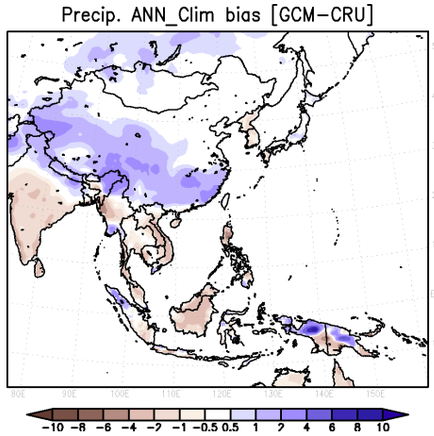
Korea 12.5km domain

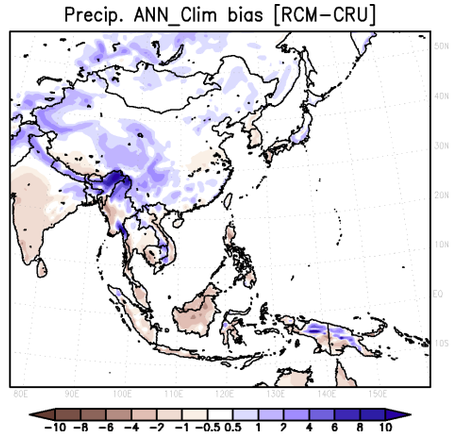


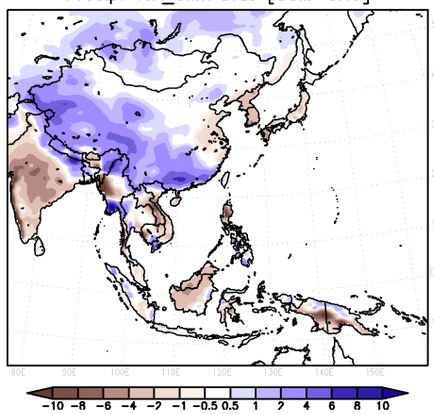
Bias of Precipitation and Temperature

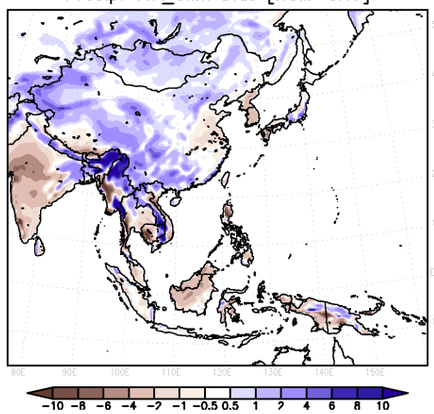
(GCM vs. RCM)

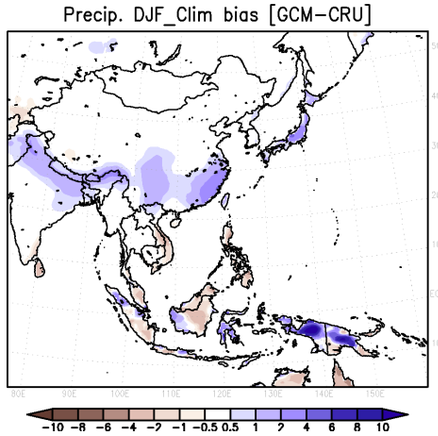
Precipitation

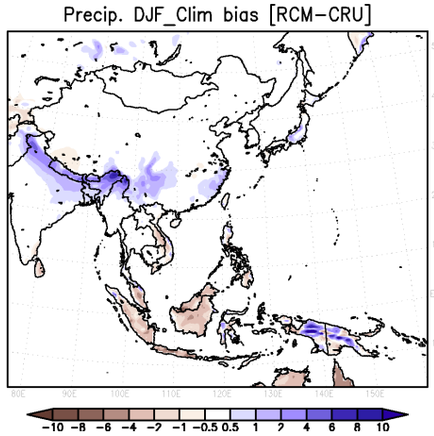




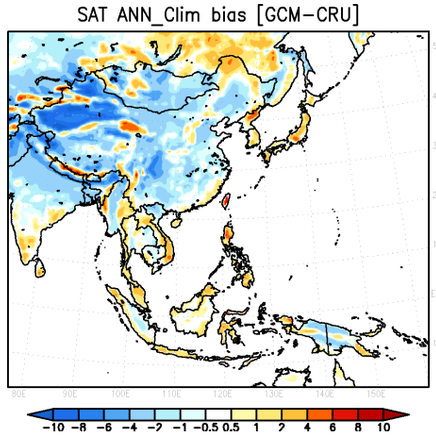


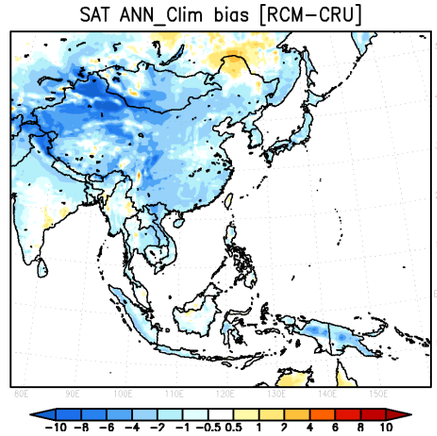


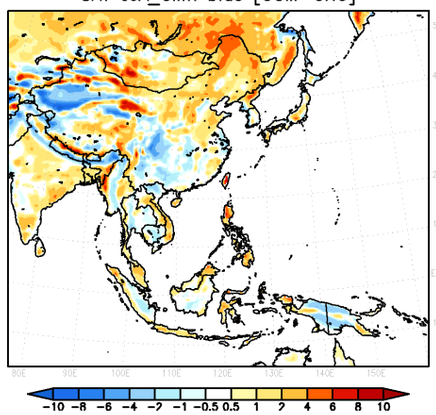


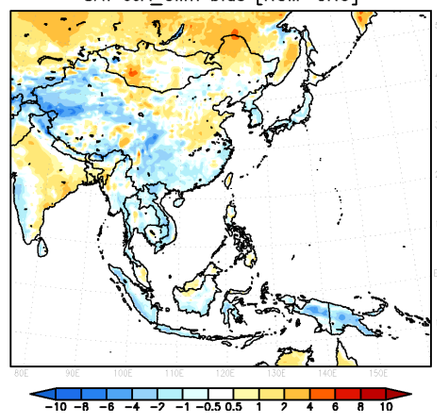


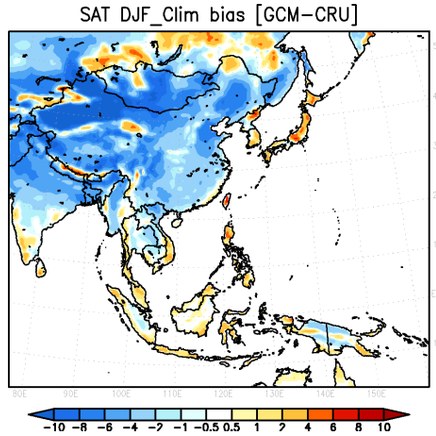
Temperature

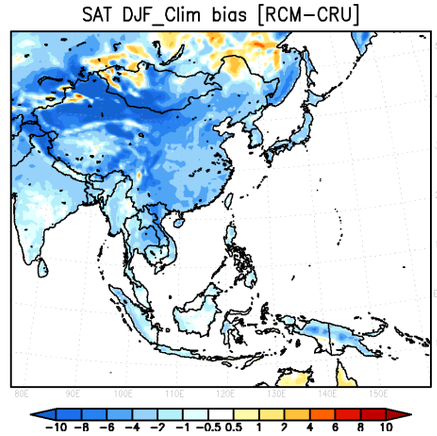








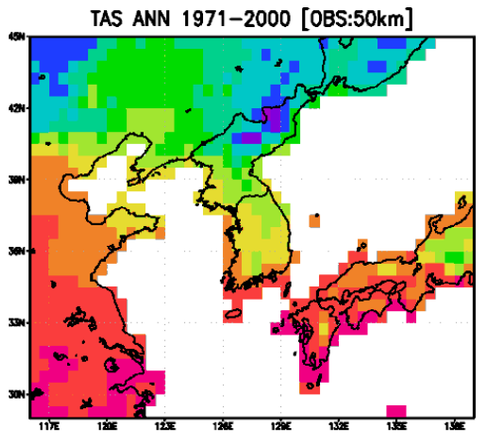


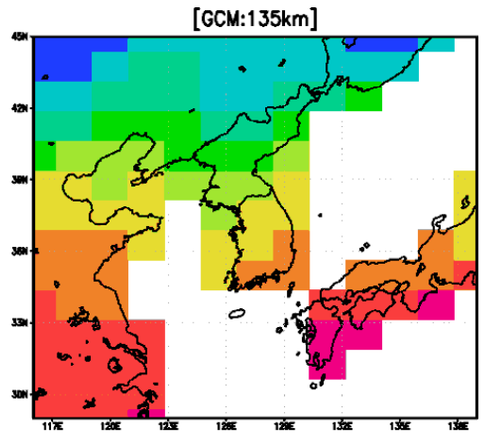


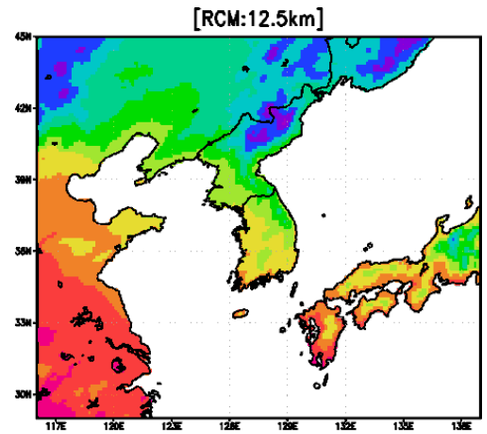
Added Values in Regional Projection (Surface Air Temperature)

Observation | GCM (135) | RCM (12.5)

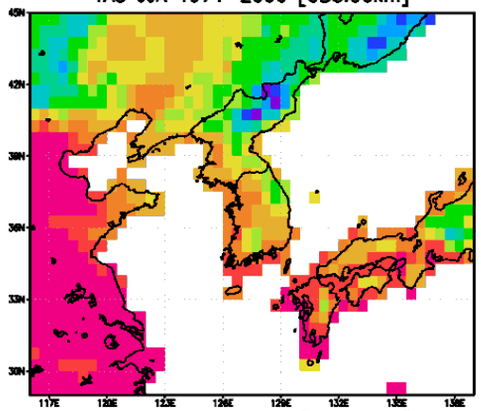
Annual

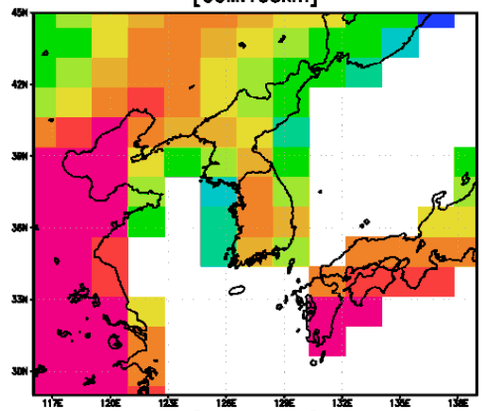


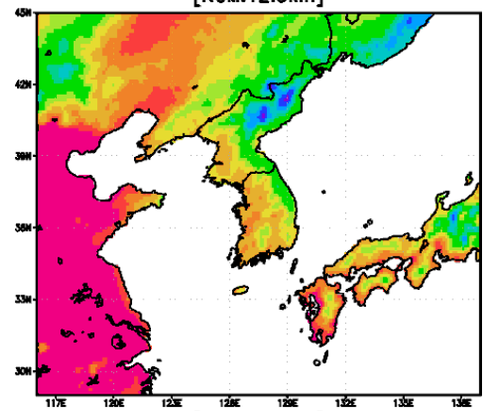




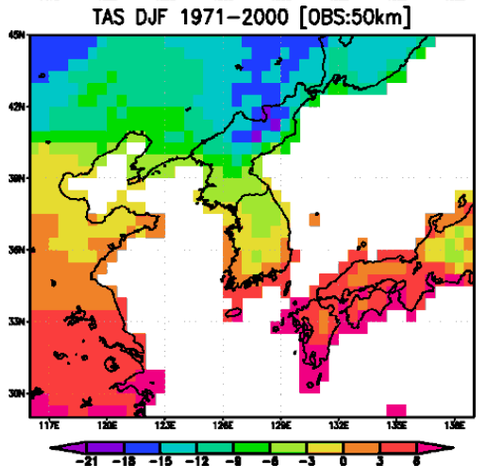
Summer

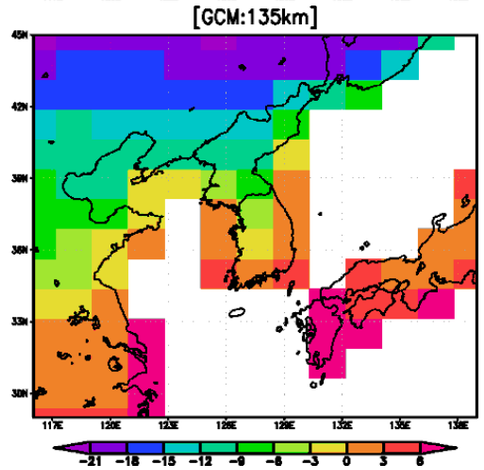


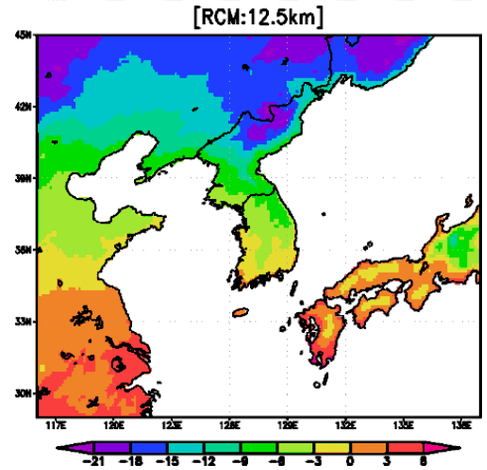




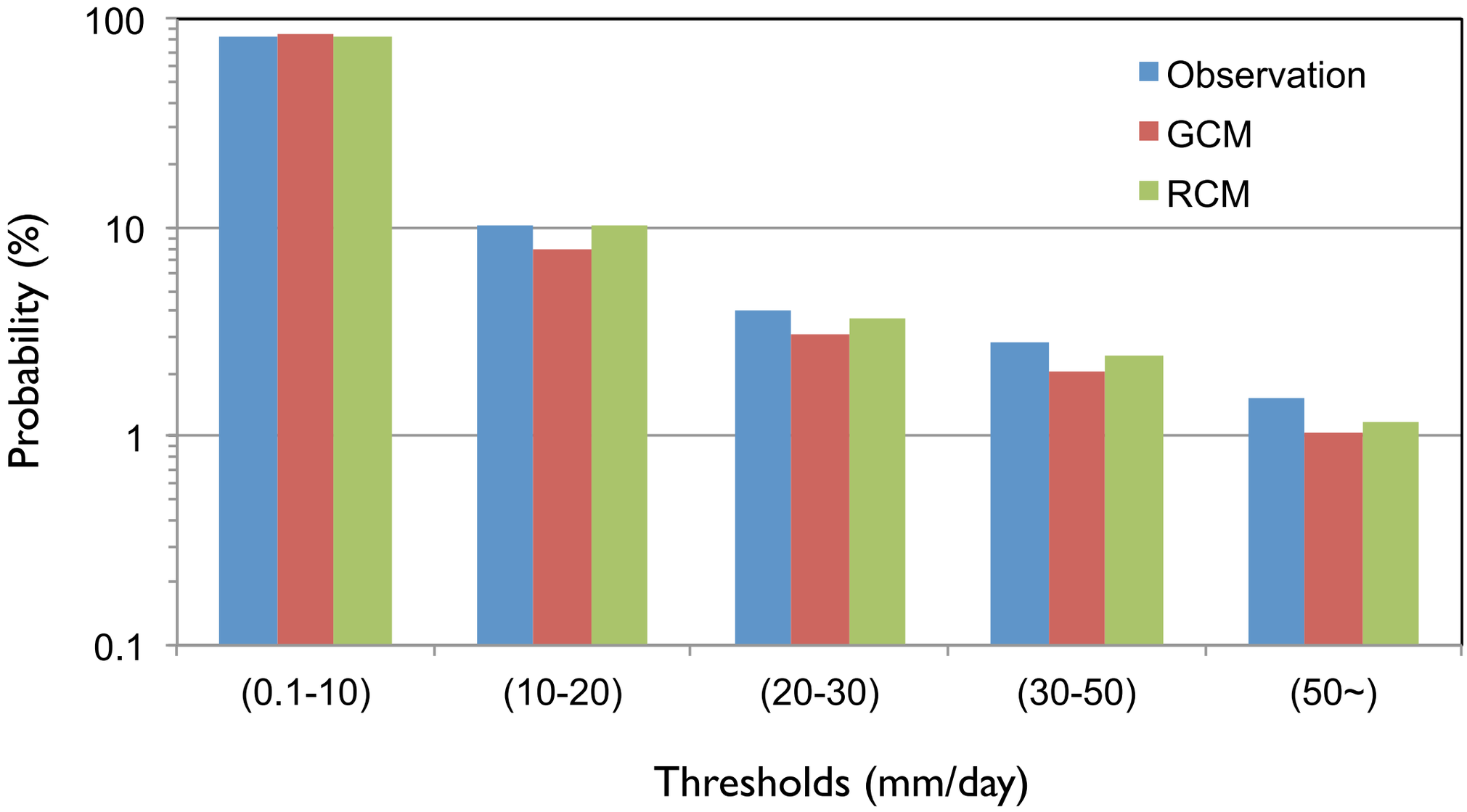
Winter



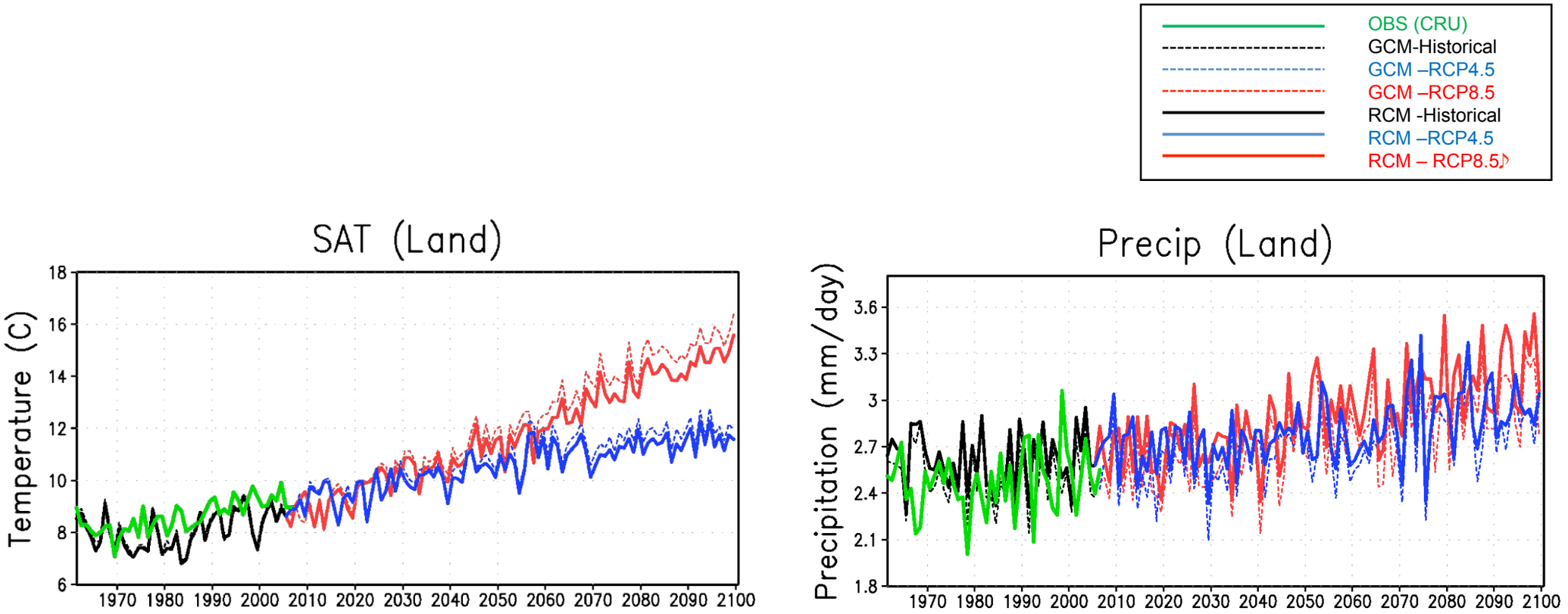




Probability of Daily Precipitation



Regional Projections

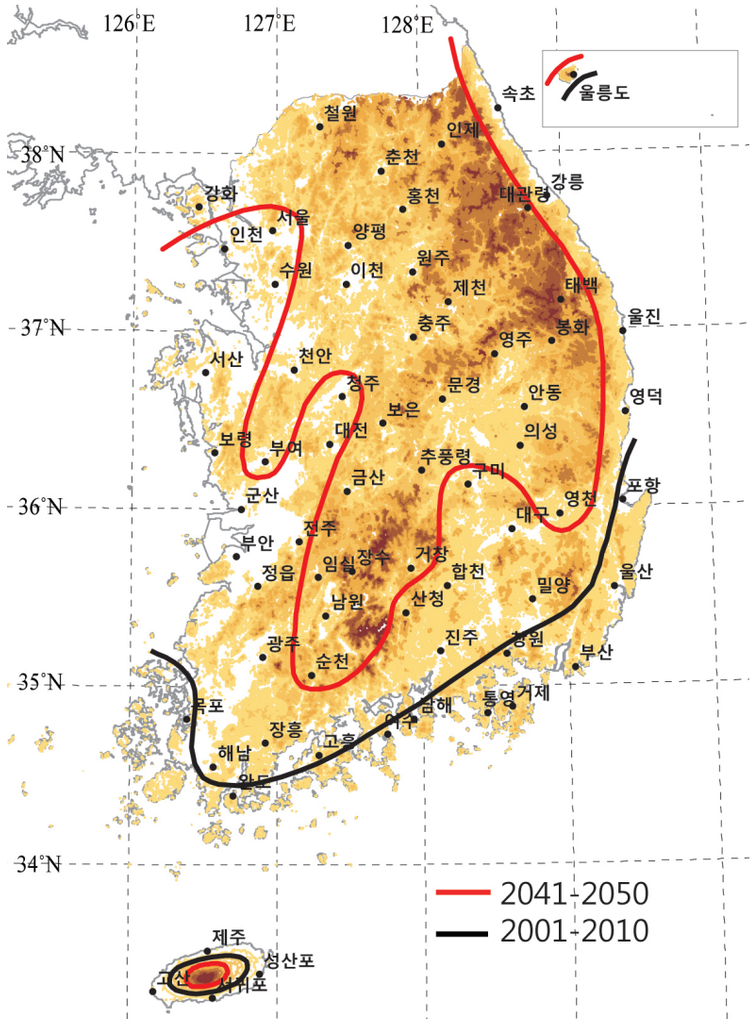


- Interannual variations of surface air temperature and precipitation in RCM are similar to the observation and GCM, which implies that RCM has little climate drift.

- RCM tends to underestimate warming trend, which seems to be associated with the lack of GHG forcing treatment in the model (It will be fixed).

Climate Regime and Seasonal Duration

2050s referred to 2010s in RCP8.5



Subtropical Climate Regime by Trewartha

Tmn of coldest month <= 18°C
8 <= (Number of month in which Tmn >= 10°C) <= 12

Seoul

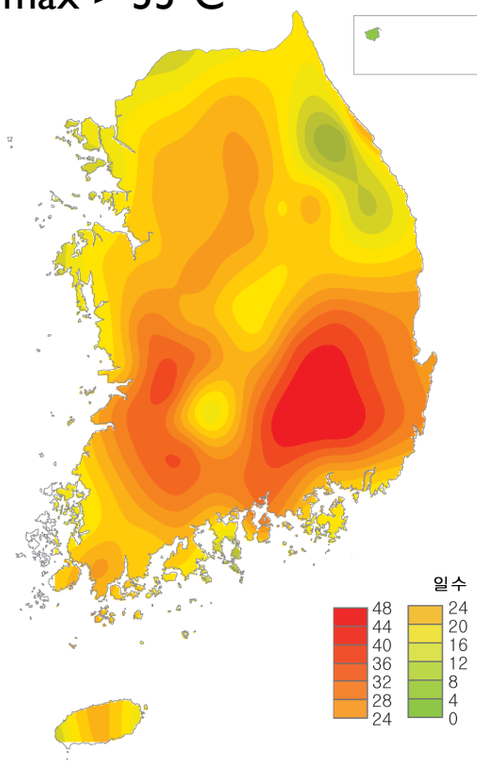
	1	2	3	4	5	6	7	8	9	10	11	12
'10	겨울		봄			여름				가을		
'50	겨울 (-27일)		봄 (+10일)			여름 (+19일)				가을 (-2일)		

Extreme Climate in Korea

2050s referred to 2010s in RCP8.5

Heat Waves

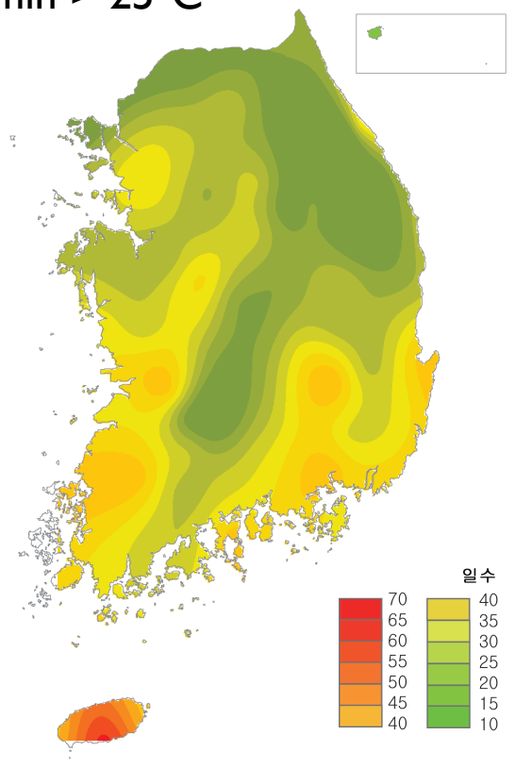
Tmax > 33°C



8.8 ➡ 25

Warm Nights

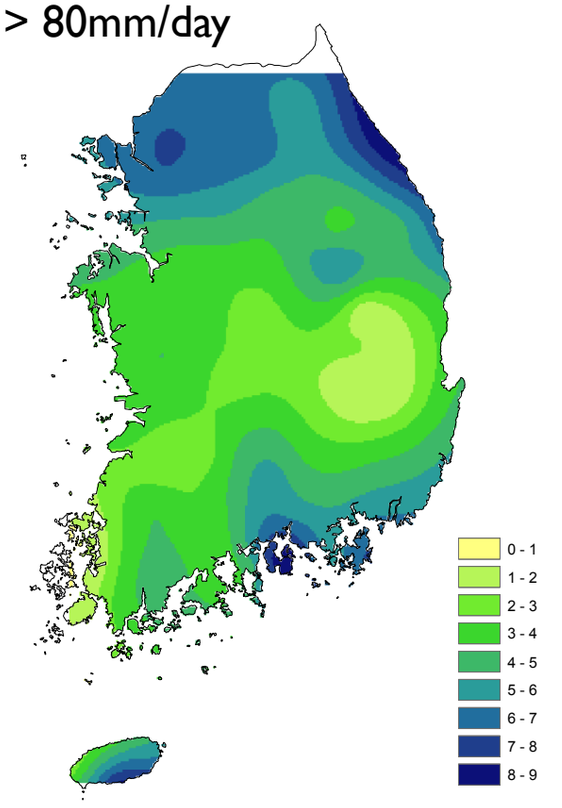
Tmin > 25°C



5 ➡ 30

Heavy Rain

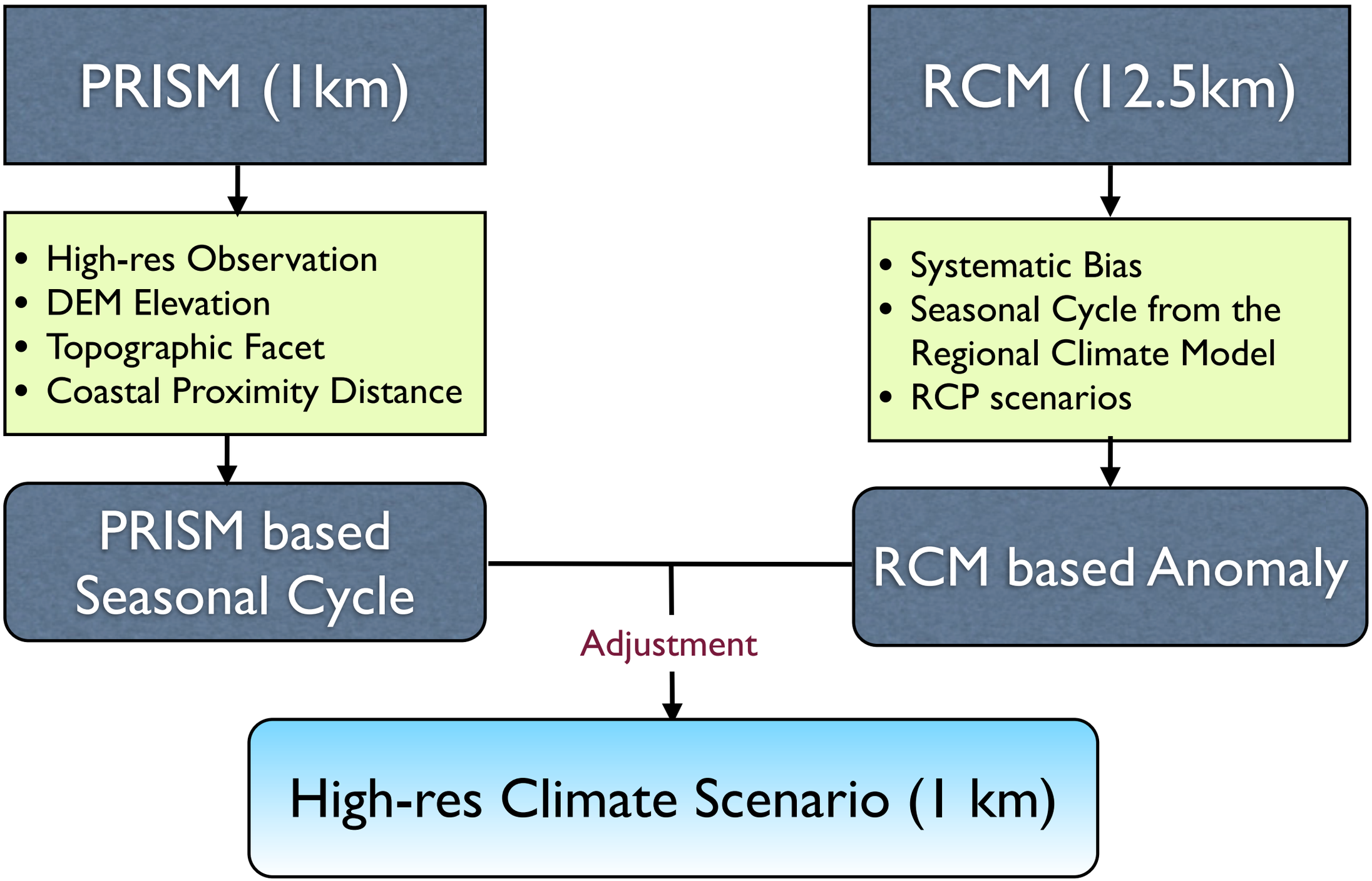
Pr > 80mm/day



2.7 ➡ 4.5

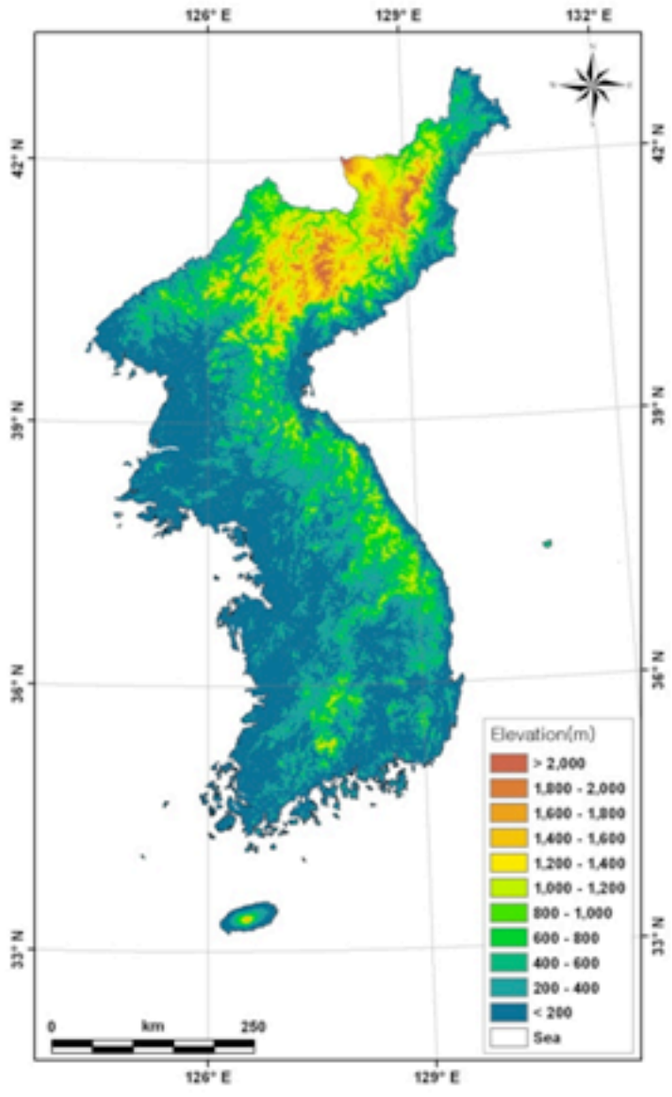
PRISM Based Downscaling Estimation (PRIDE)

(Kim et al., 2011)

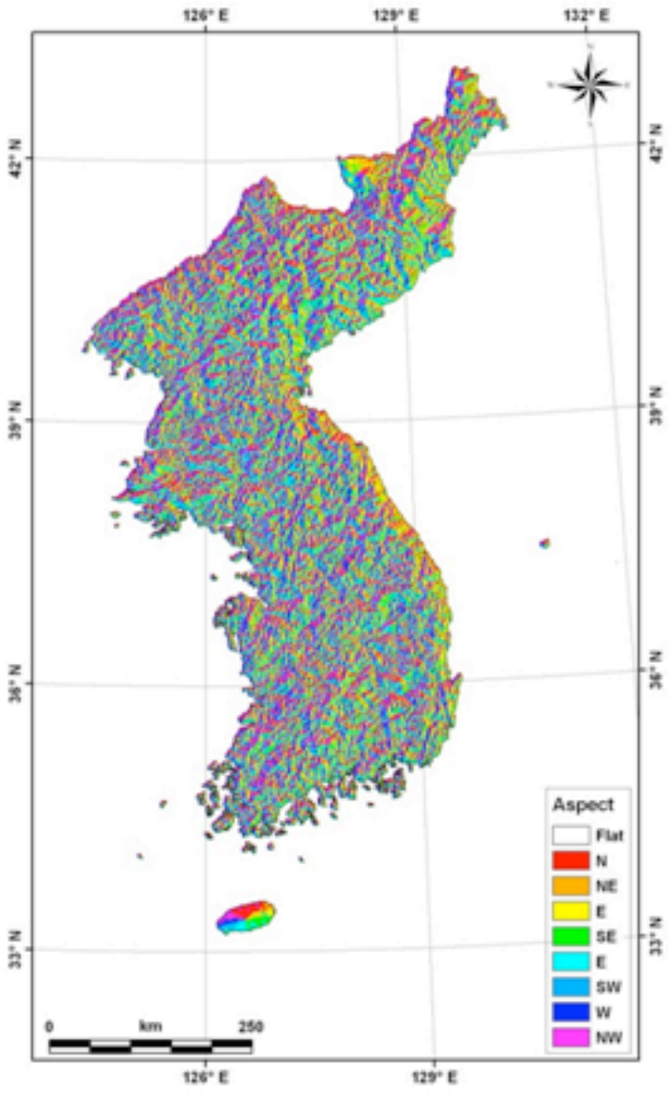


GIS Information

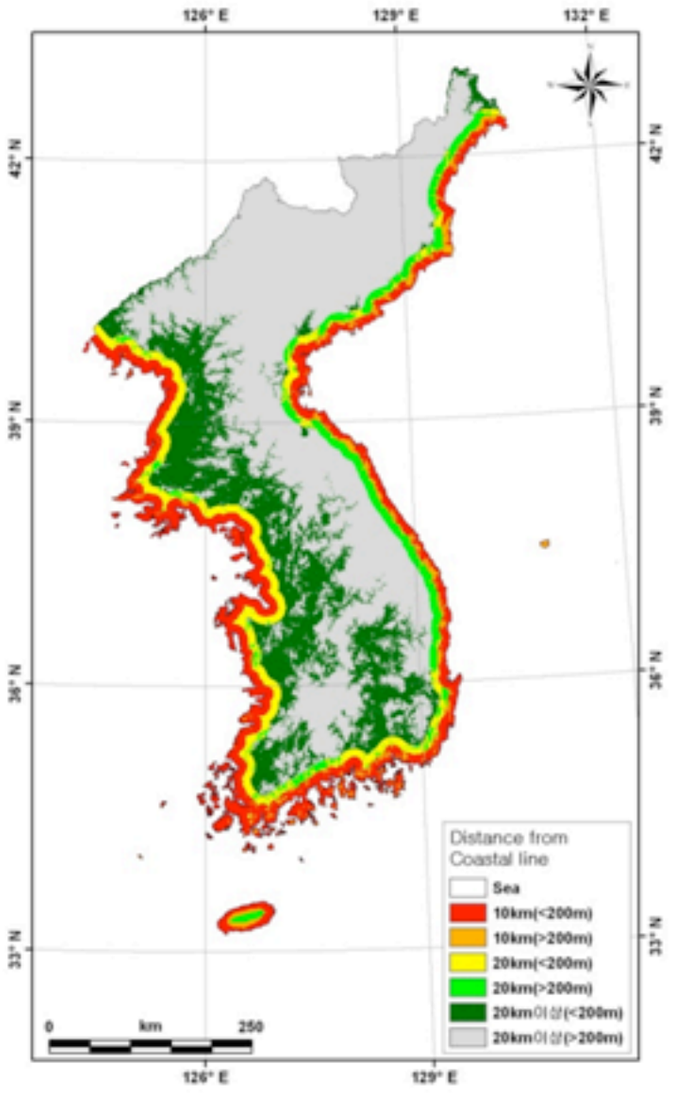
DEM



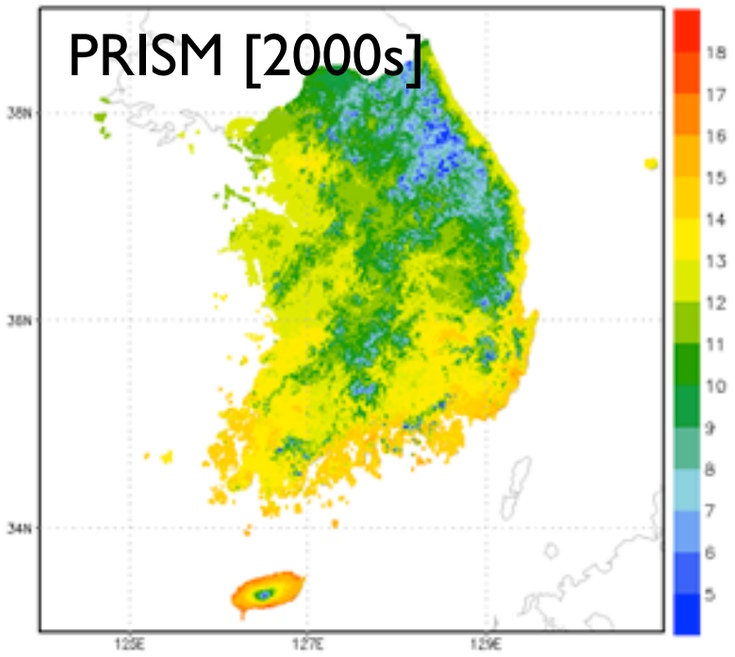
Topo. Facet

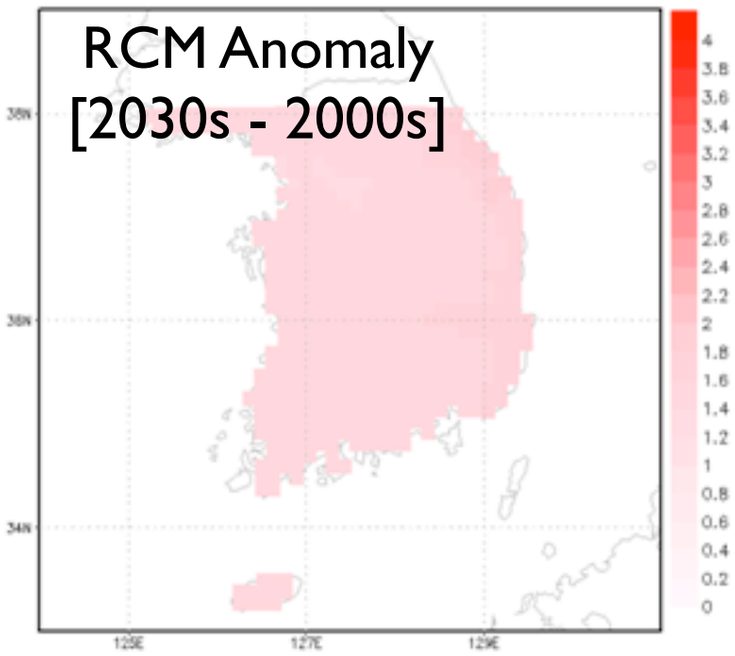


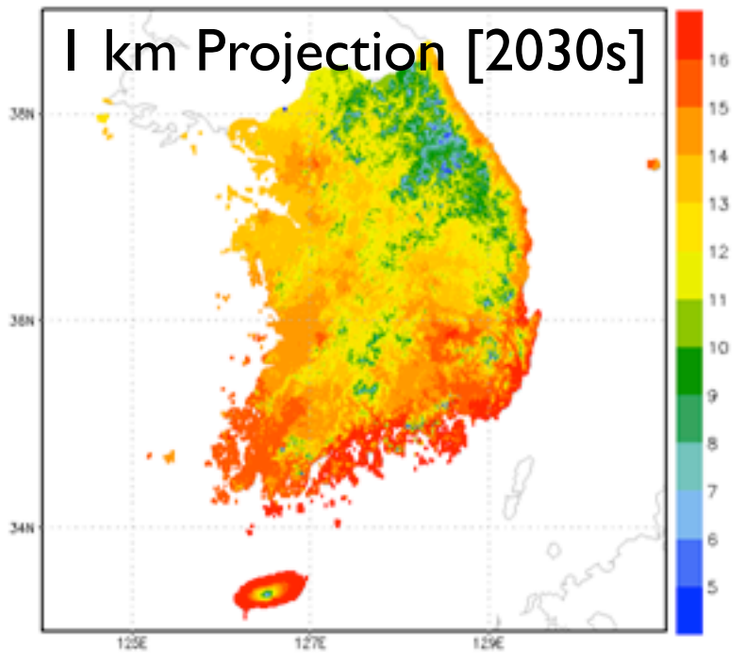
Coastal Proximity

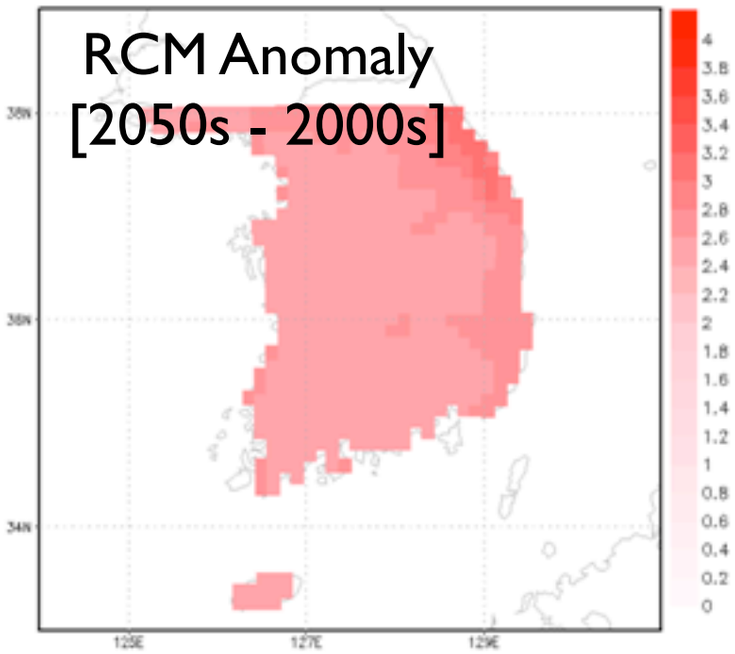


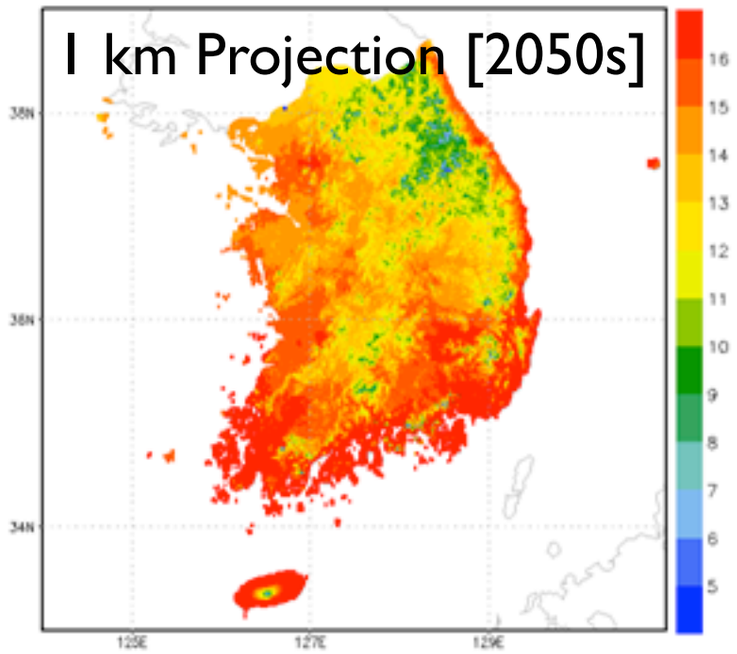
Example: Mean Temperature (RCP 8.5)











Summary and Further Plans

- KMA/NIMR has produced part of CMIP5 and CORDEX simulations using the HadGEM series models. In addition, dynamical and statistical downscaling have been applied for local climate projections over the Korean peninsula.

- Regional downscaling, both the dynamical and statistical methods, are efficient to get added values in local scales as well as climate extremes.

- CMIP5 and CORDEX simulations are still ongoing: More ensemble members initialized with 500 and 1000-yr PI runs for RCP 2.6/4.5/6.0/8.5 will be completed in 2012.

- Uncertainty should be further investigated.
  - Combinations with multi- GCM and RCM are not possible for a single group.
  - Regional Data Bank of CORDEX-EA is being prepared by KMA.

- Data Release for IAV application is available since Jan. 2012.
  - Global and Regional climate projections for international community
  - High-res. (1 km) for domestic usage

Thanks for your Attention!