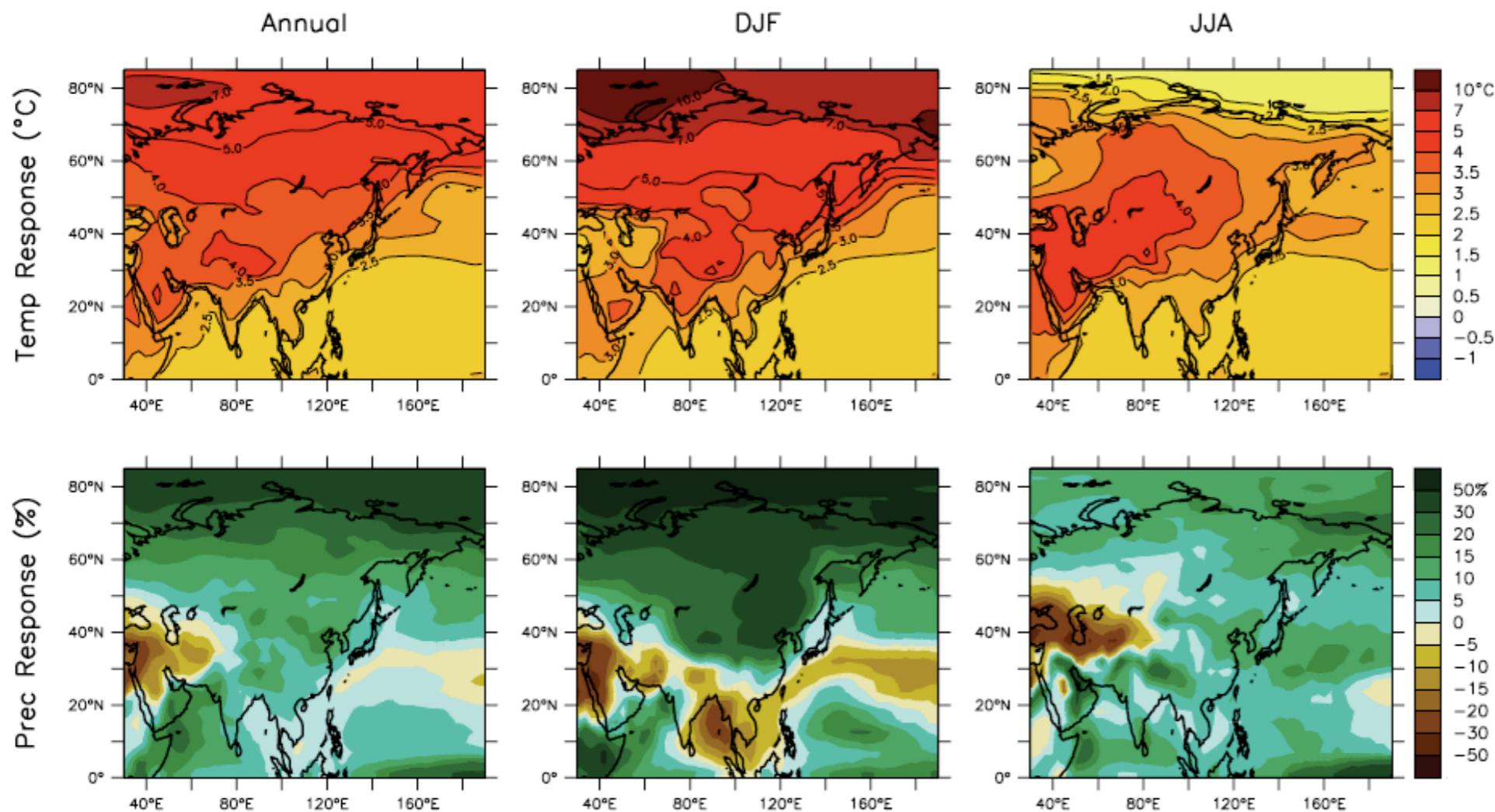


以統計方法提供 IPCC 氣候模式對台灣未來氣候變遷推估的區域細節與機率分佈

陳正達、張雅茹、林修立、童裕翔 國立台灣師範大學地球科學系暨海洋環境科技研究所
國家災害防救科技中心 台灣氣候變遷推估與資訊平台建置計畫 (TCCIP) 降尺度研究團隊

A1B scenario



- 為什麼需要降尺度？
- 降尺度方法
- 處理氣候推估的不確定性
- 主要結果與應用注意事項

Why downscaling?

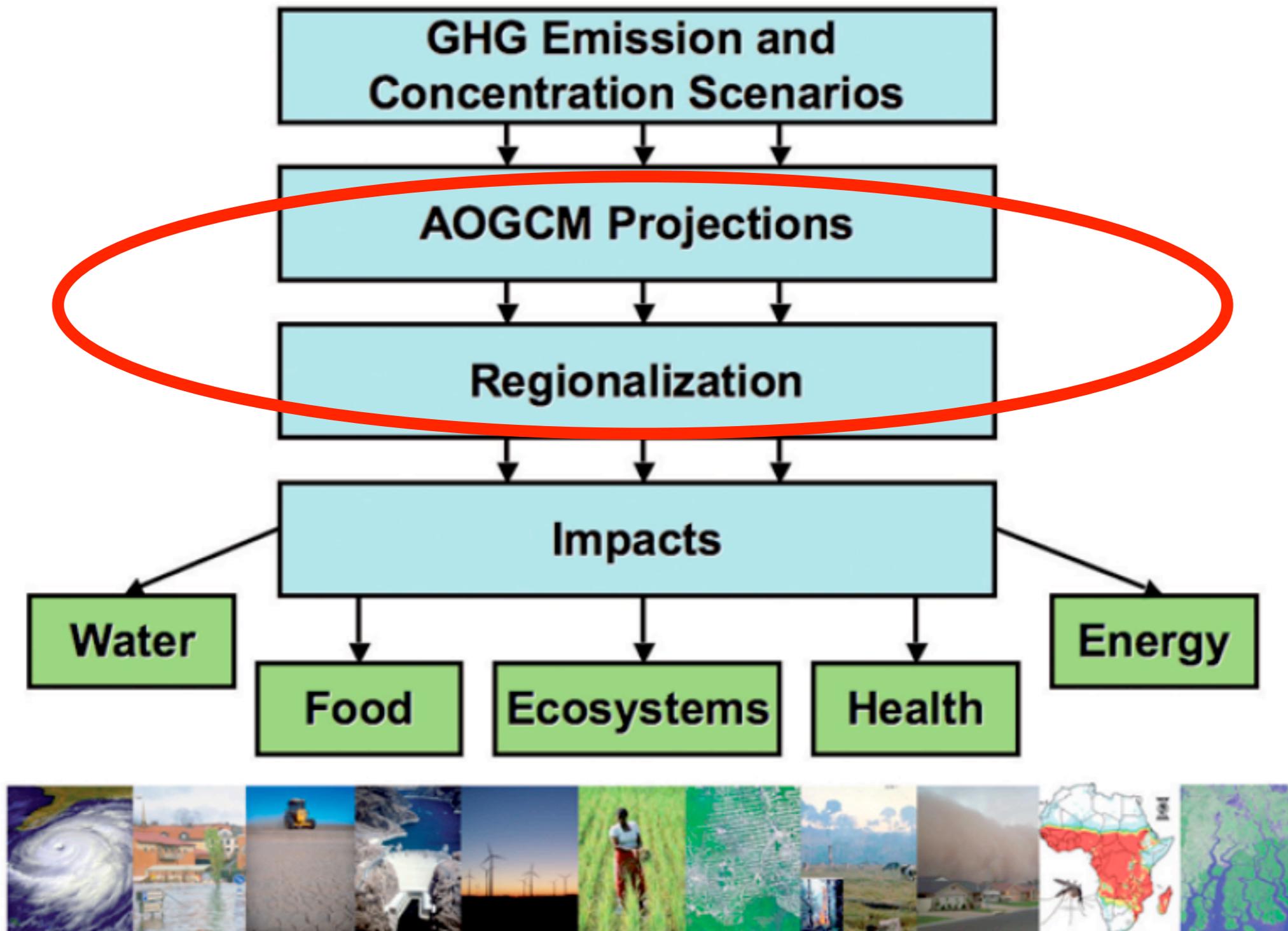
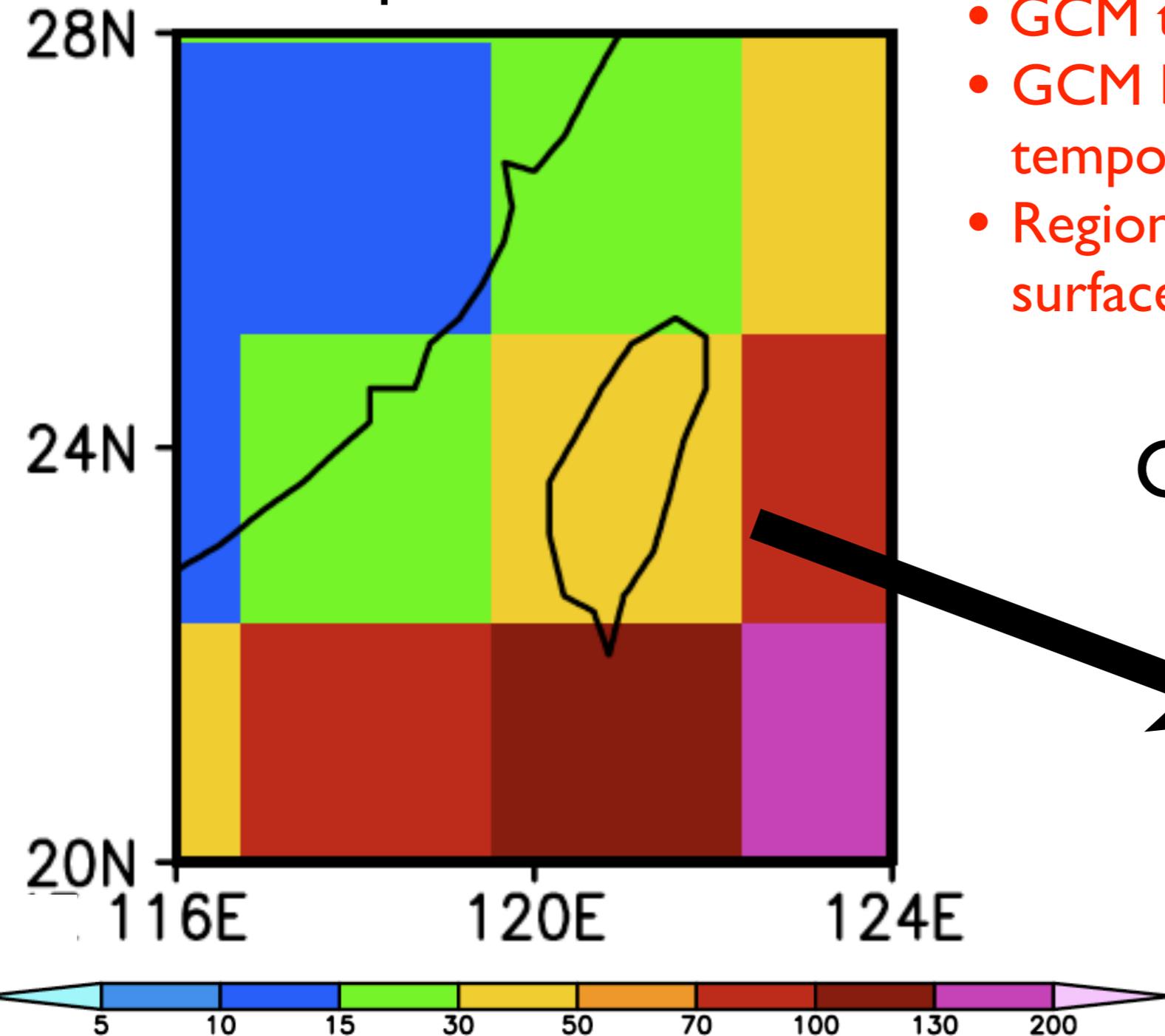


Figure 3 — Schematic depiction of the steps involved in the production of climate change information usable for impact assessment work via regionalization methods

Source:
Giorgi (2008)

Why downscaling?

GCM (~300 km)
Precipitation October

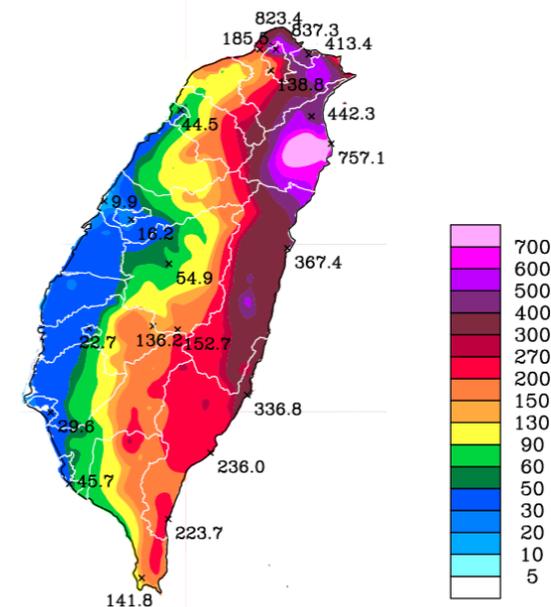


Problems:

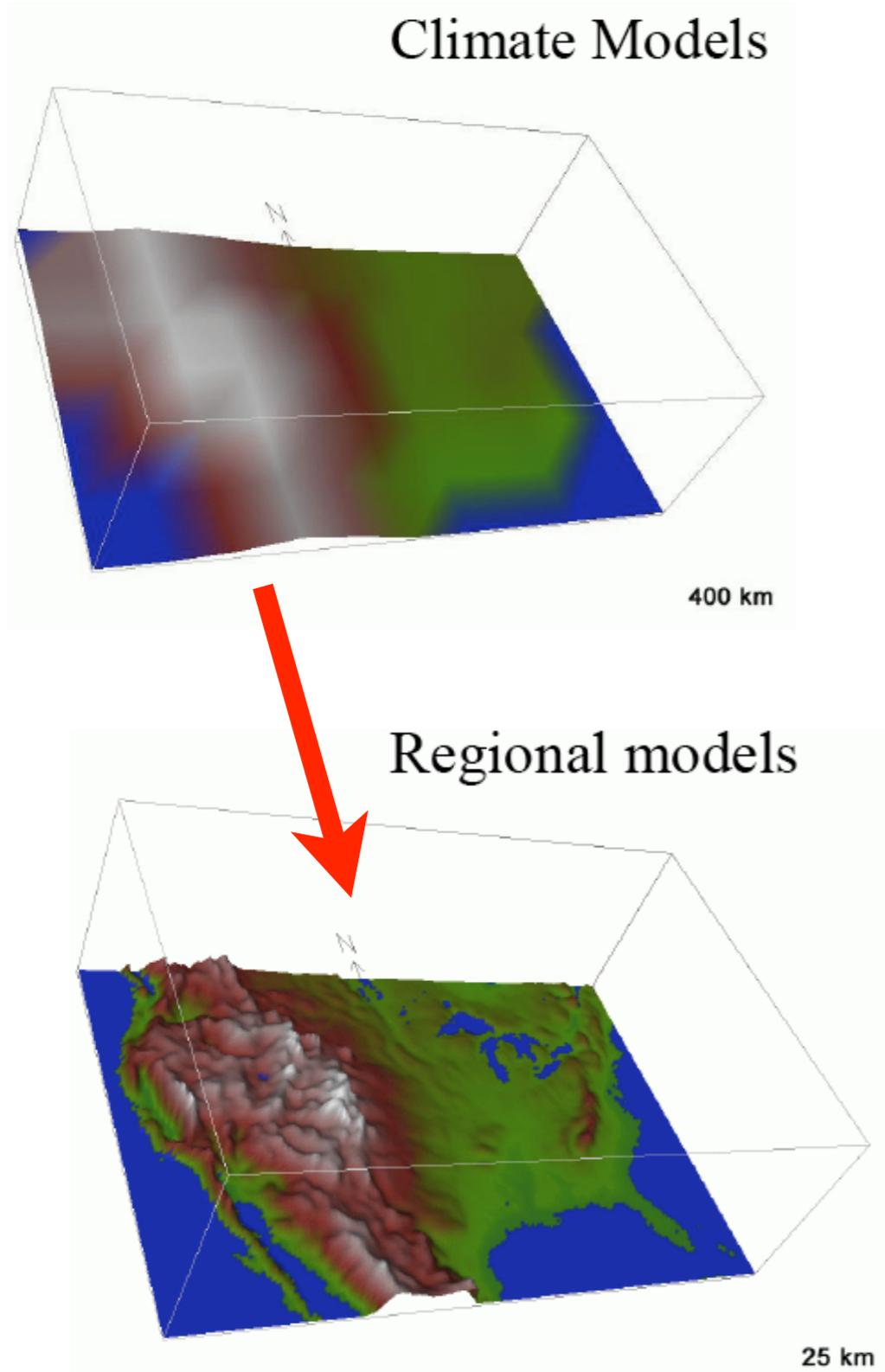
- GCM too coarse for local assessment
- GCM biases in climatology (spatially and temporally)
- Regional climate variability (topography, surface landscapes, coastlines)

Observation (~5km)

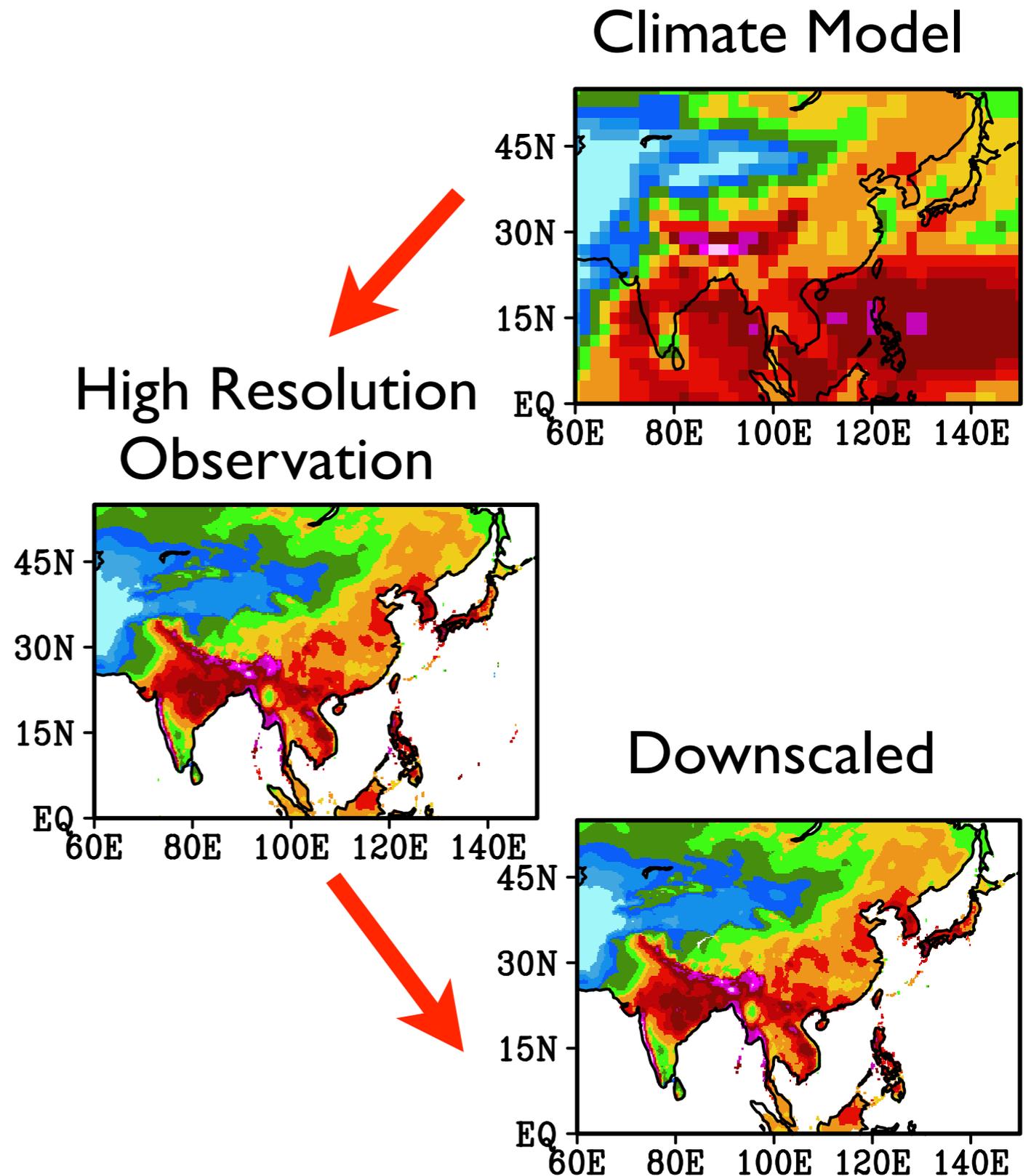
OCT Precp(Climat)



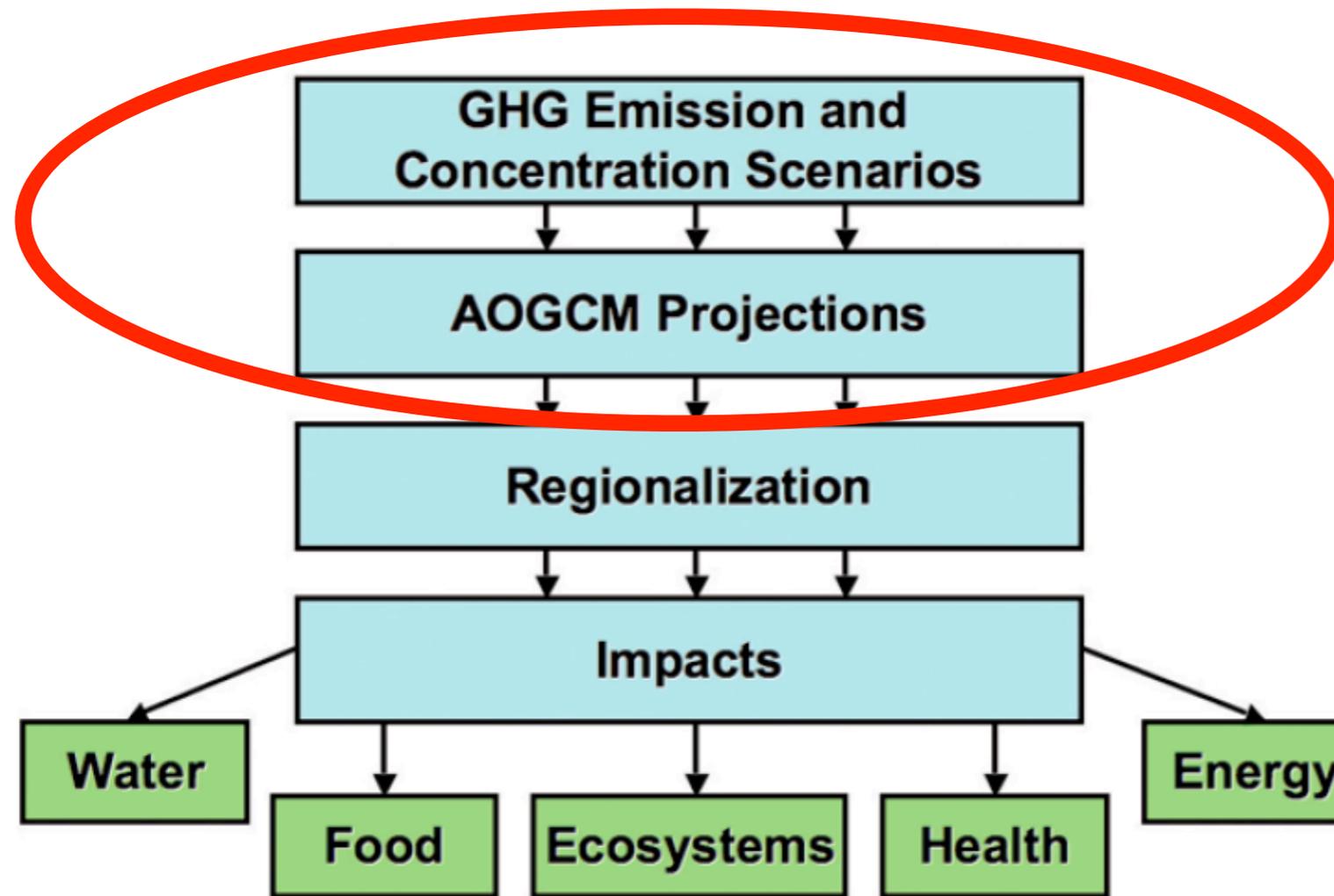
Dynamical Downscaling



Statistical Downscaling



Why statistical downscaling?



- Uncertainties in future greenhouse gas and aerosol emissions
- Uncertainties in global and regional climate sensitivity, due to differences in the way physical processes and feedbacks are simulated in different models

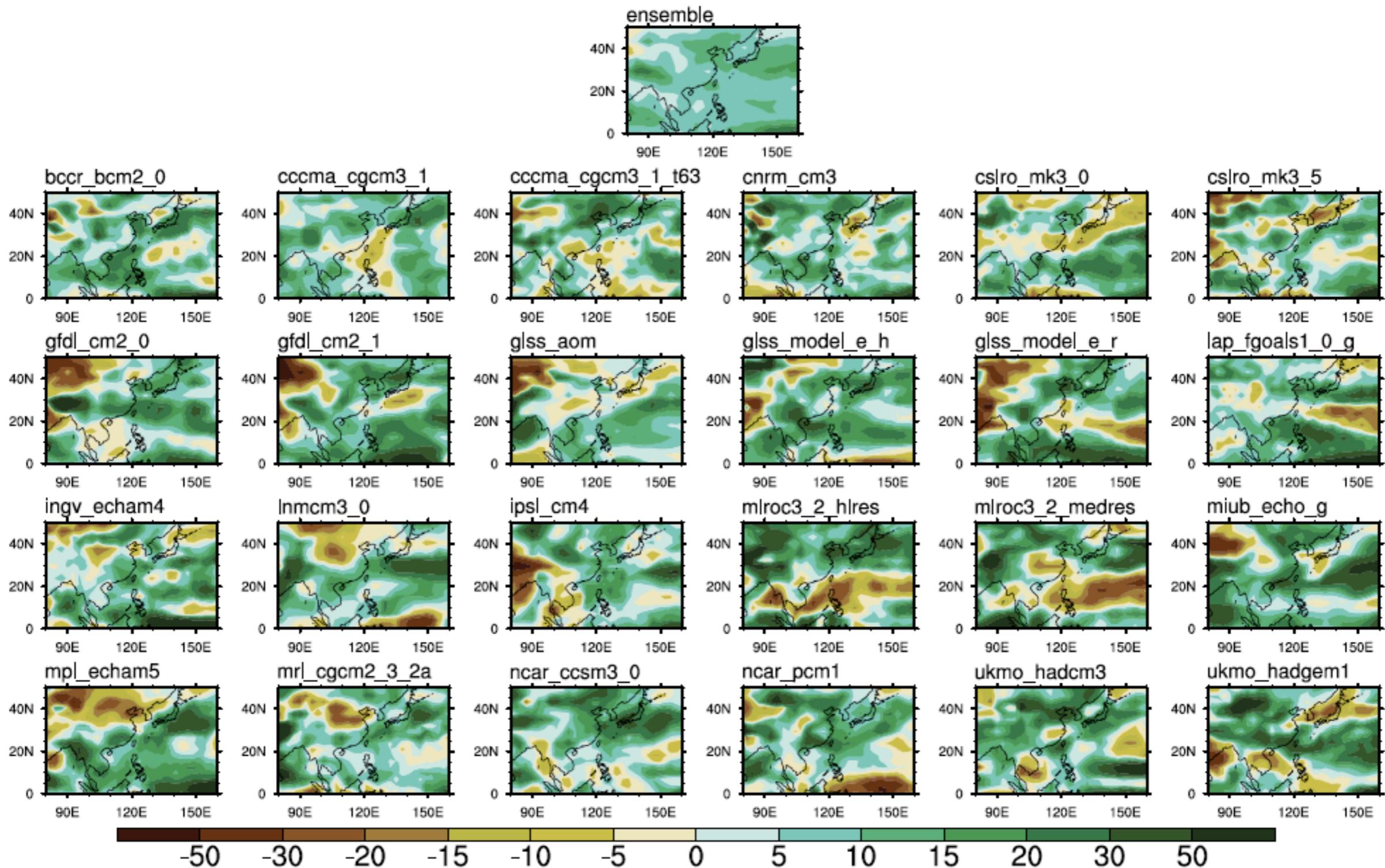


Figure 3 — Schematic depiction of the steps involved in the production of climate change information usable for impact assessment work via regionalization methods

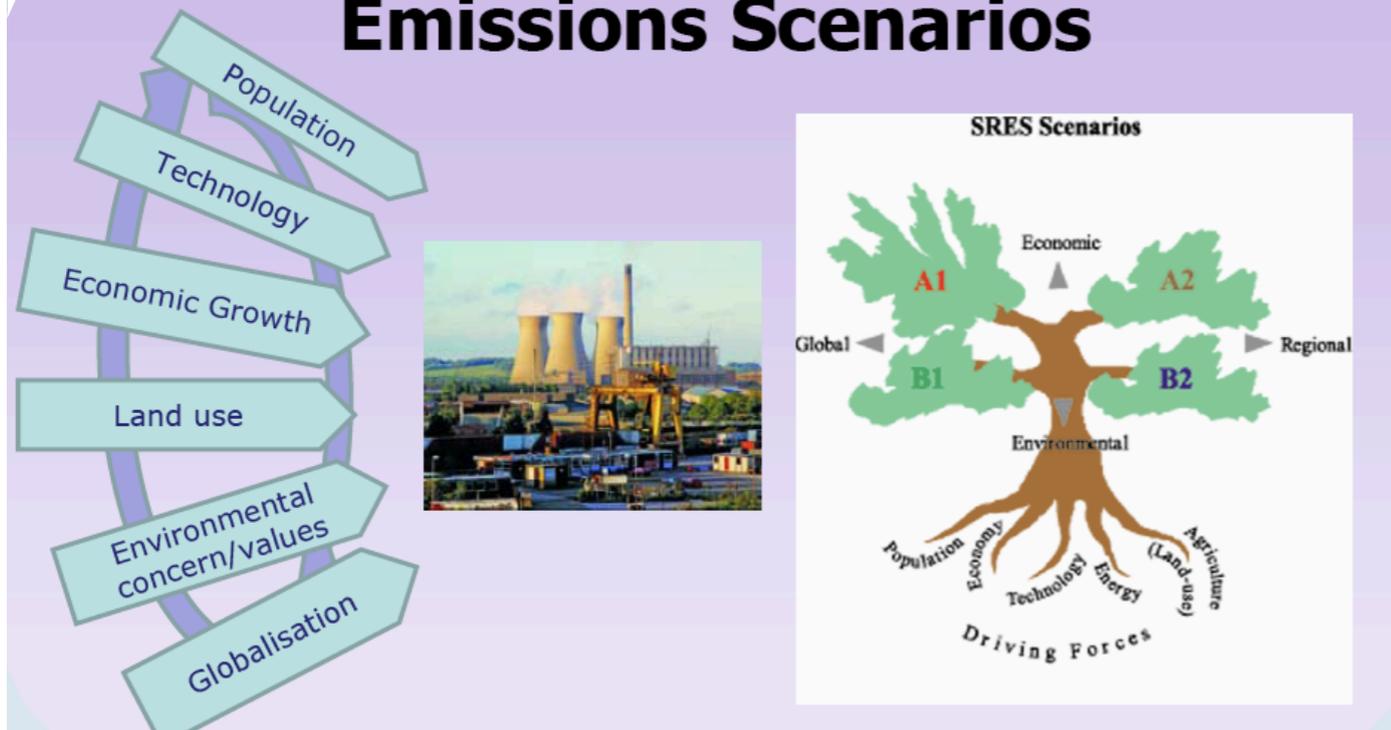
Source: Giorgi (2008)

Uncertainty from Global Climate Models

Summer precipitation change(%) with all IPCC AR4 models under A1B scenario

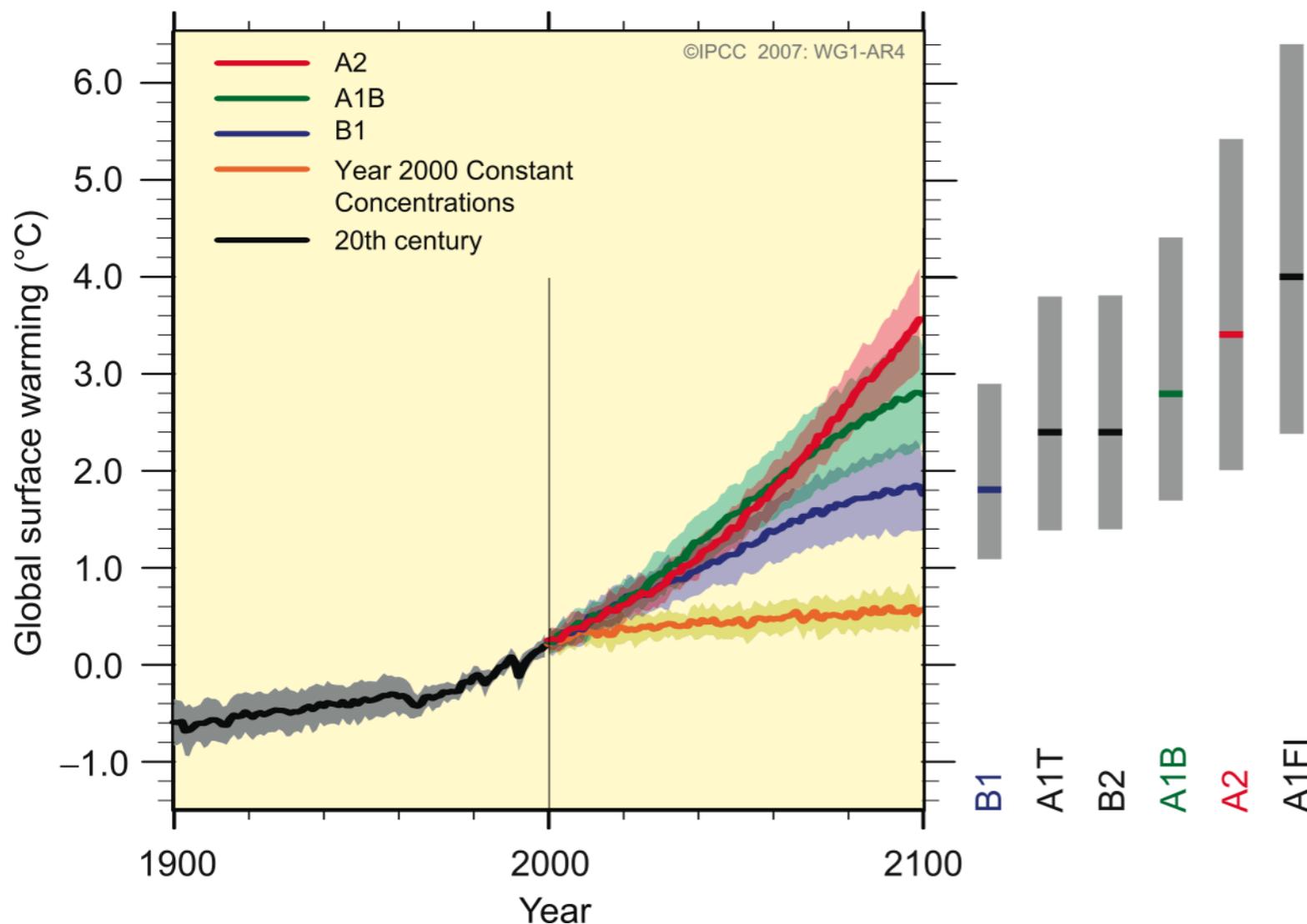


Emissions Scenarios



Keep the uncertainty

- Uncertainties in future greenhouse gas and aerosol emissions
- Uncertainties in global and regional climate sensitivity, due to differences in the way physical processes and feedbacks are simulated in different models

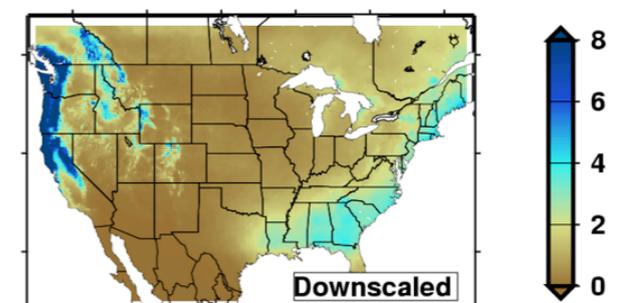
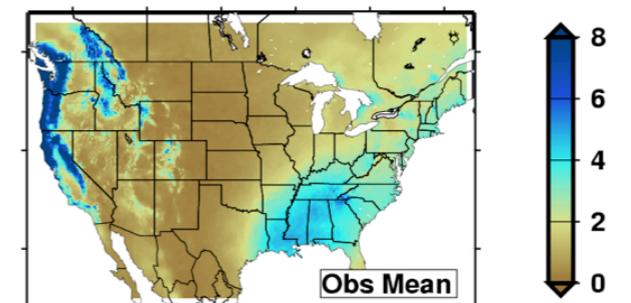
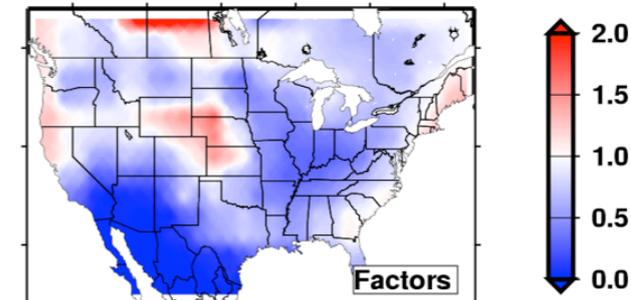
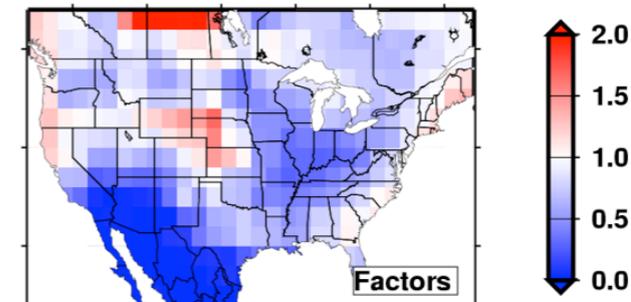
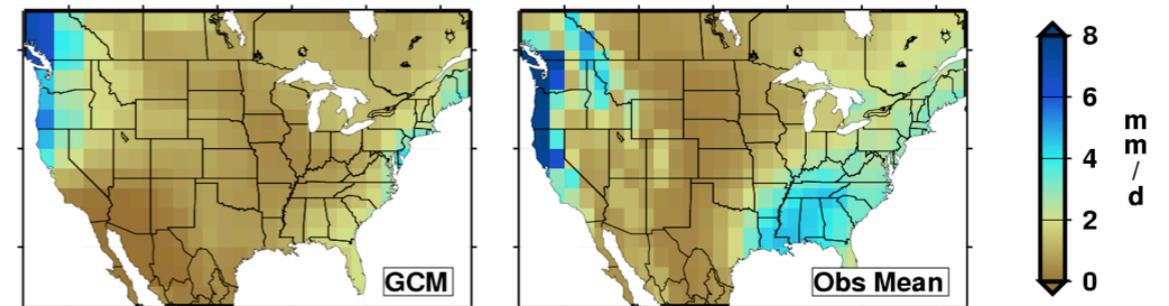
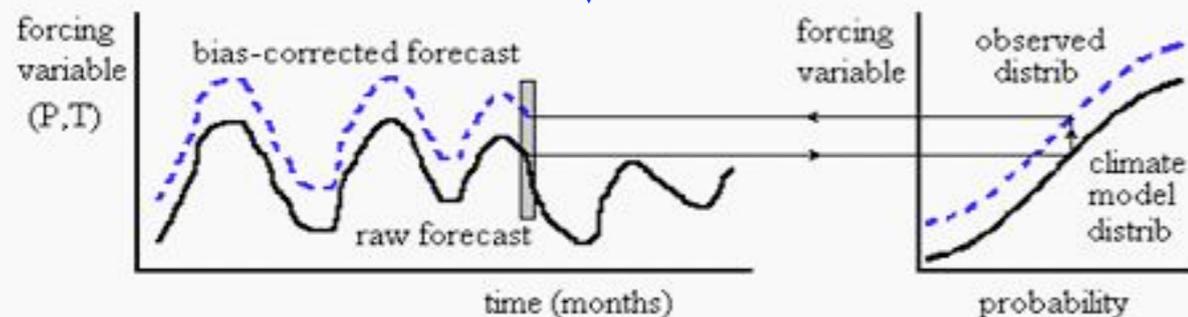
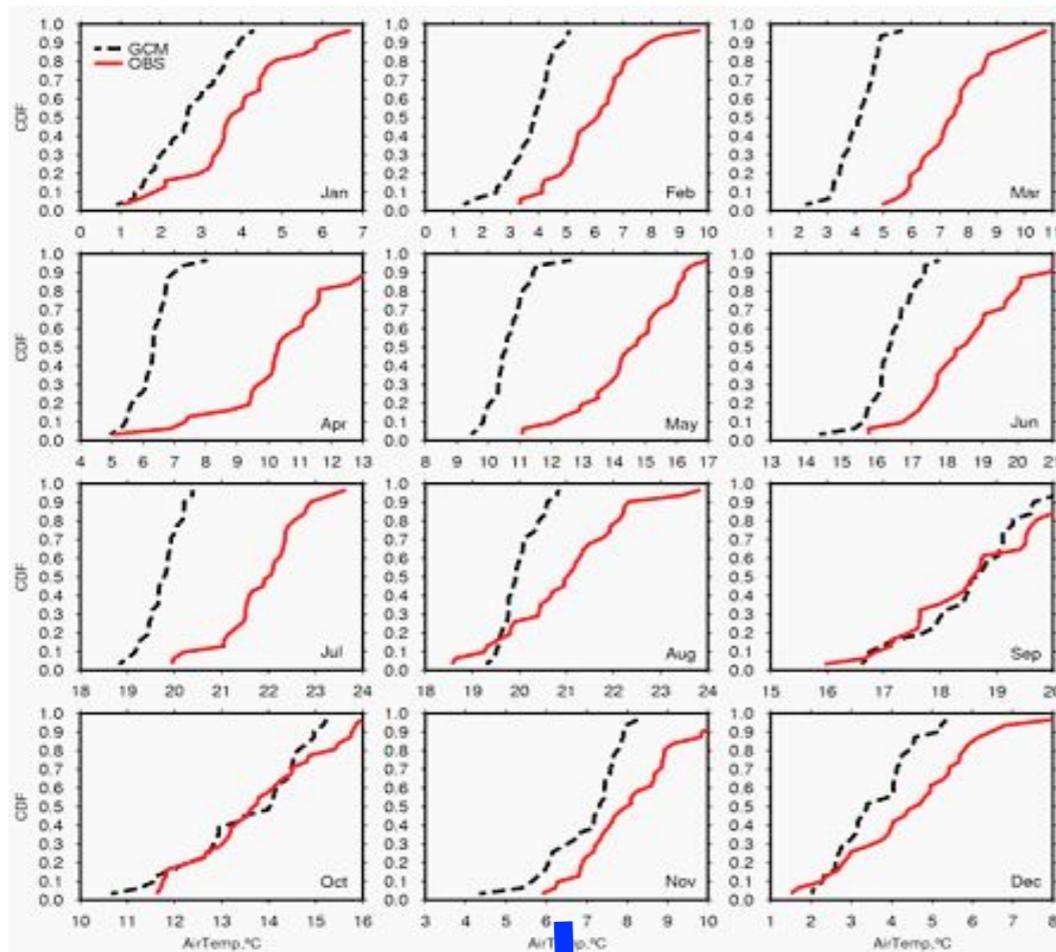


Probabilistic model future climate projection for individual scenarios

Statistical Downscaling

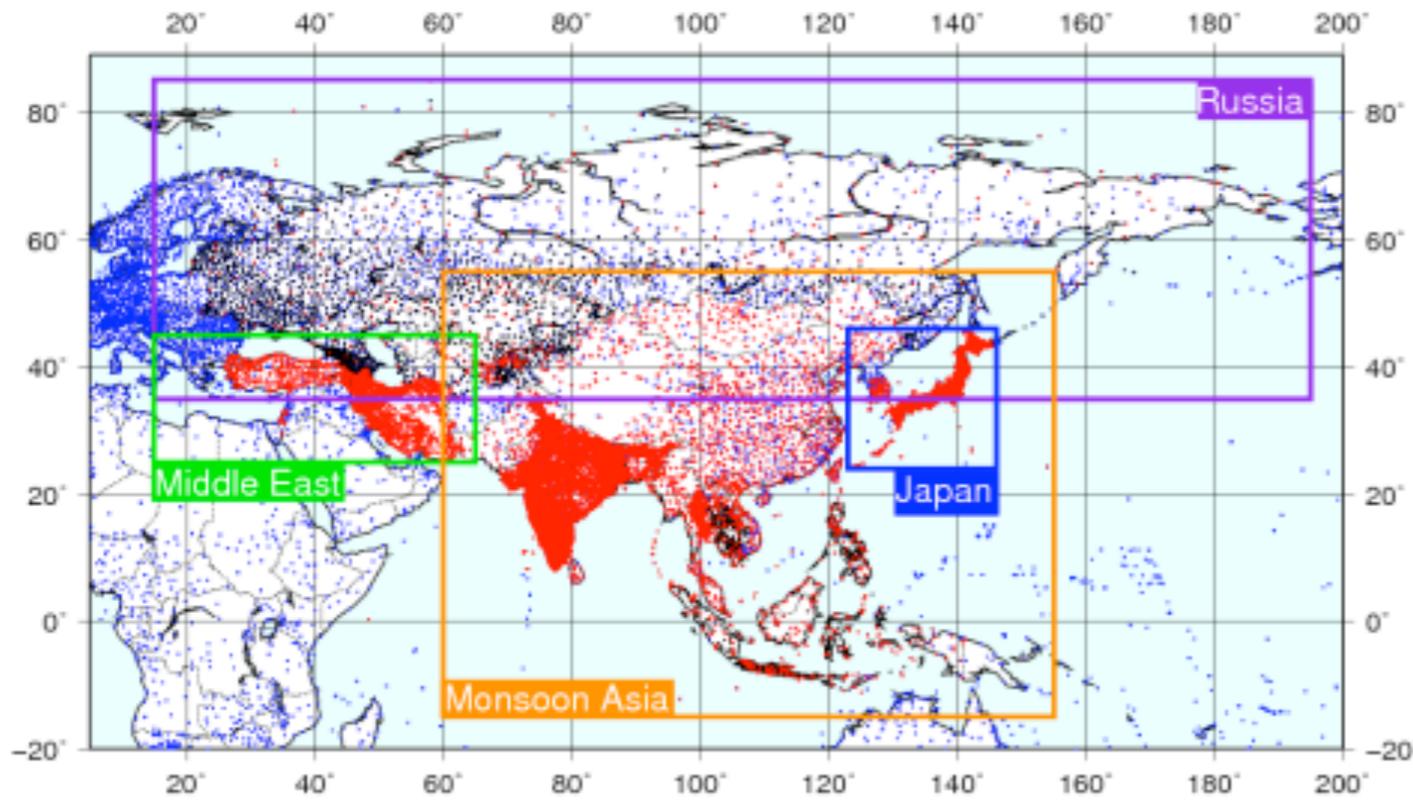
Wood et al. 2004, and Maurer 2007

Statistical downscaling and bias correction by cumulative distribution function and interpolation

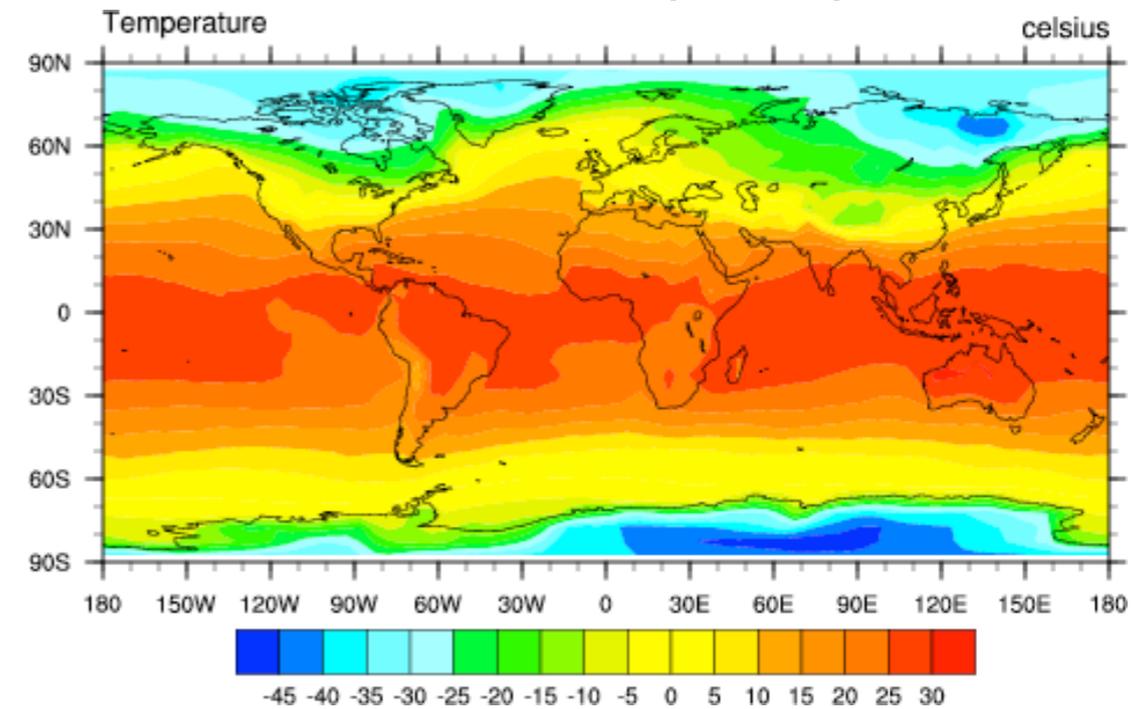


Require long-term high-resolution observations

APHRODITE (0.25°)



CRU (0.5°)



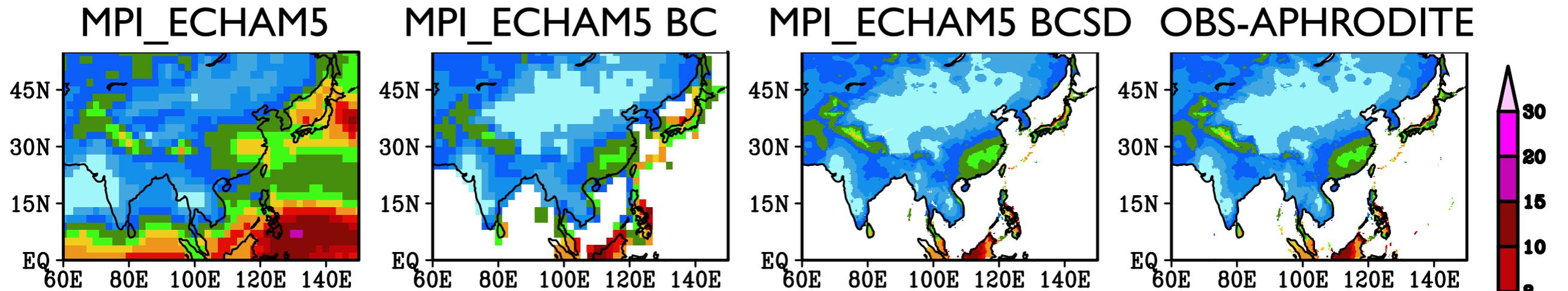
Current version: V1003R1 [Download](#) » [Readme](#) » [Errata](#)

Name	Domain	Resolution	Period
Monsoon Asia (MA)	60°E-150°E, 15°S-55°N	0.5° and 0.25°, daily	1951-2007
Middle East (ME)	15°E-65°E, 25°N-45°N		
Russia (RU)	15°E-165°W, 34°N-84°N		

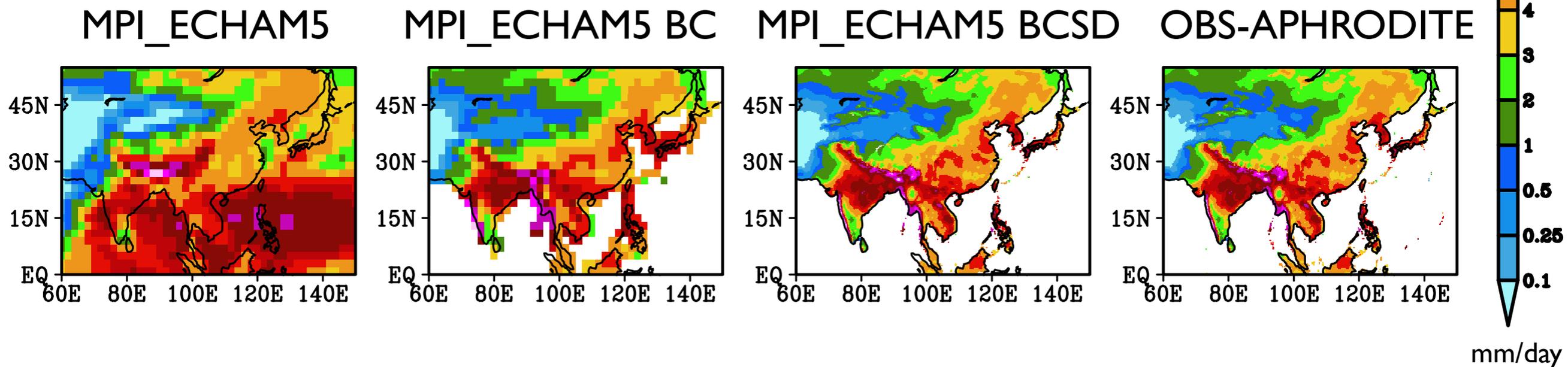
Validation

- Bias corrected and downscaled of current climate using APHRODITE rainfall analysis

Jan



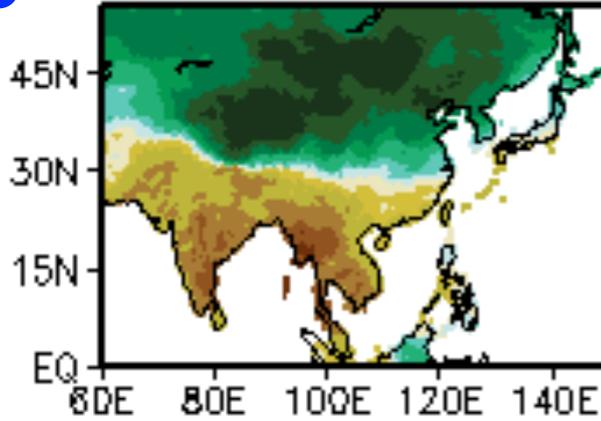
Jul



Model Median Future Change in Precipitation (%)

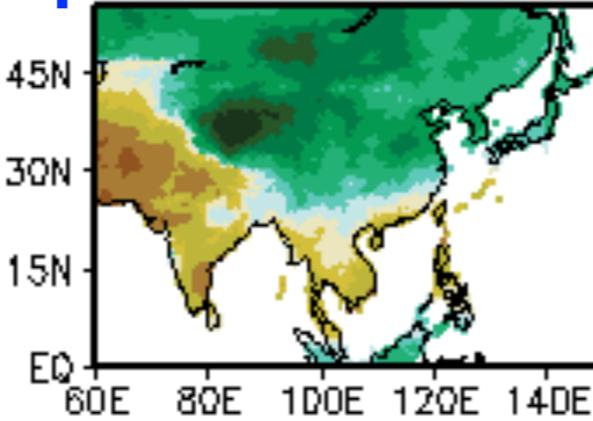
Jan

Jan 2070-2099 median



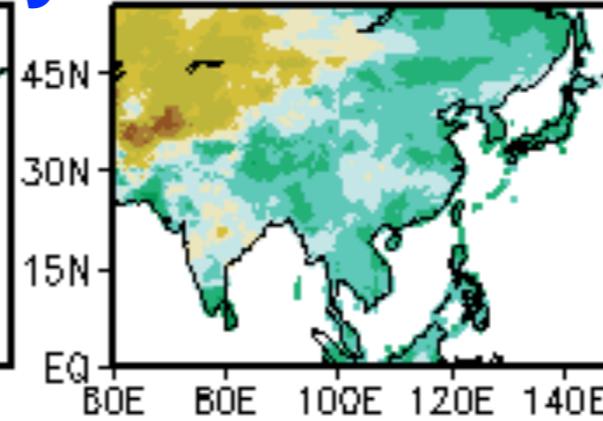
Apr

Apr 2070-2099 median



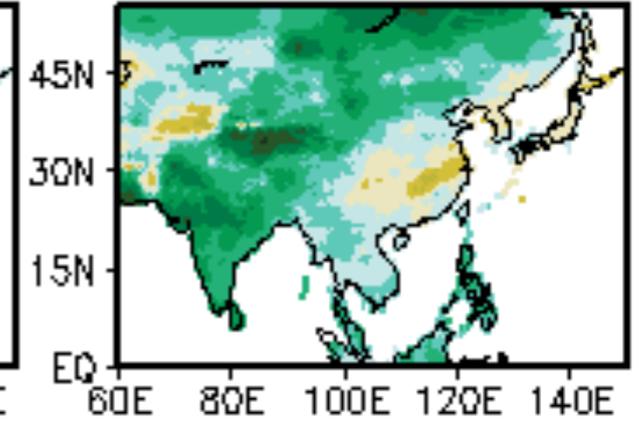
Jul

Jul 2070-2099 median



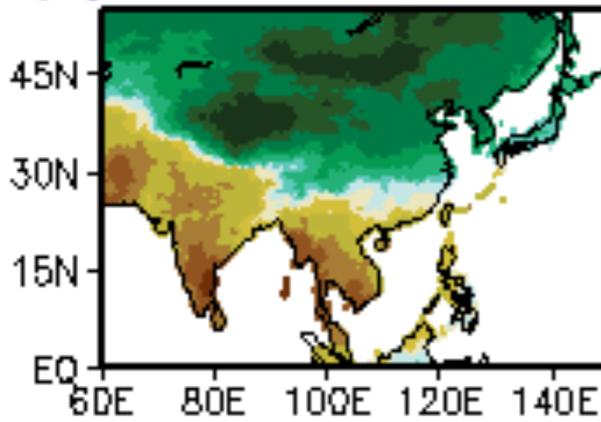
Oct

Oct 2070-2099 median



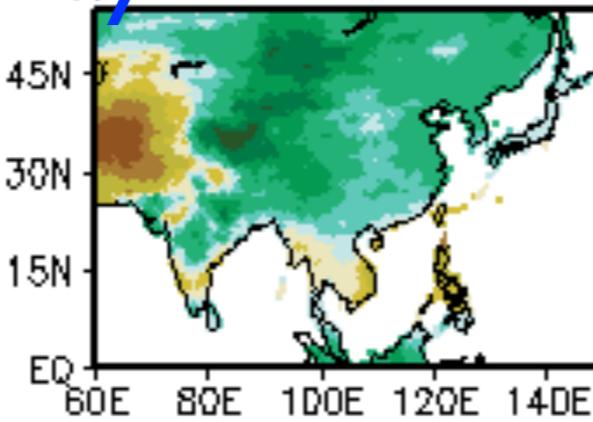
Feb

Feb 2070-2099 median



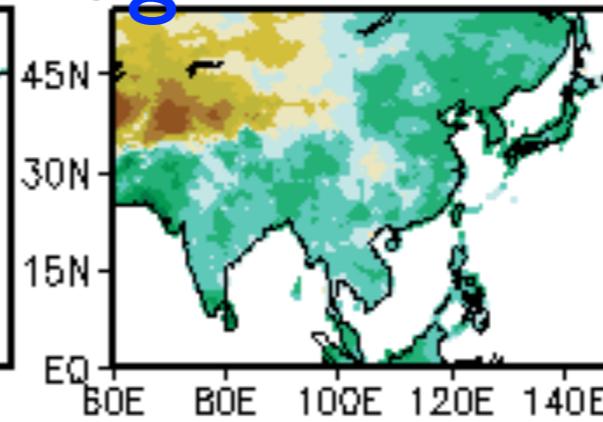
May

May 2070-2099 median



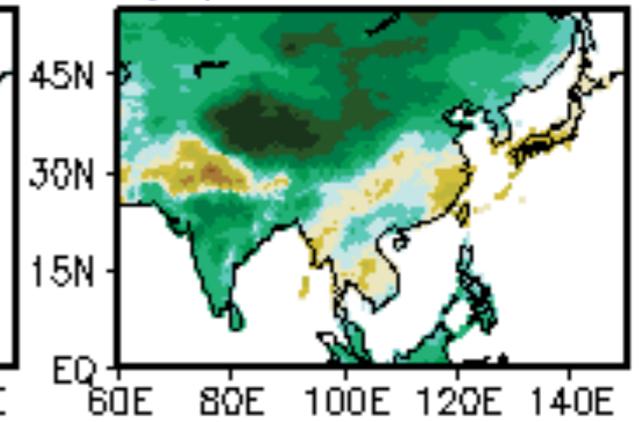
Aug

Aug 2070-2099 median



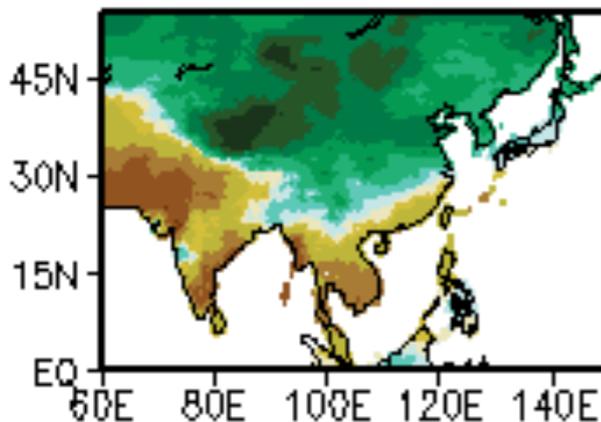
Nov

Nov 2070-2099 median



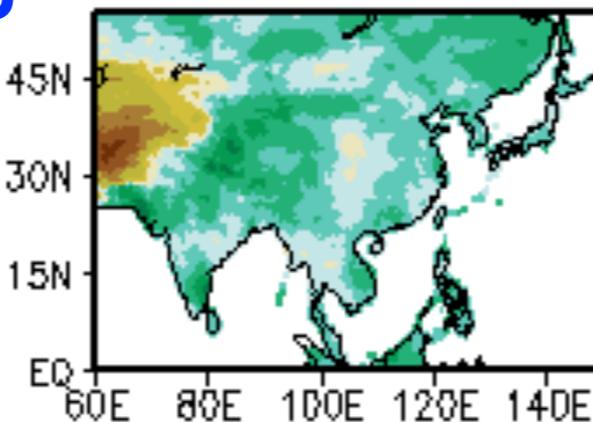
Mar

Mar 2070-2099 median



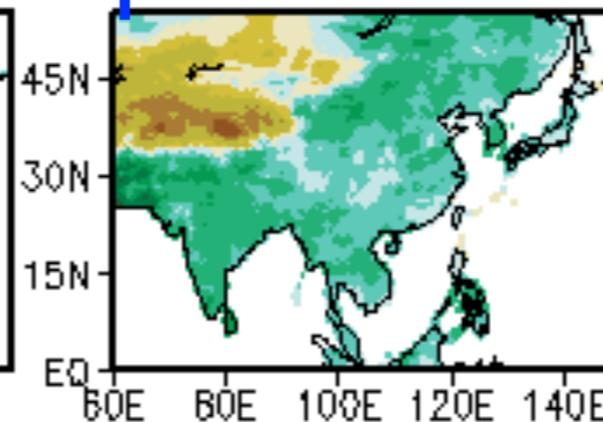
Jun

Jun 2070-2099 median



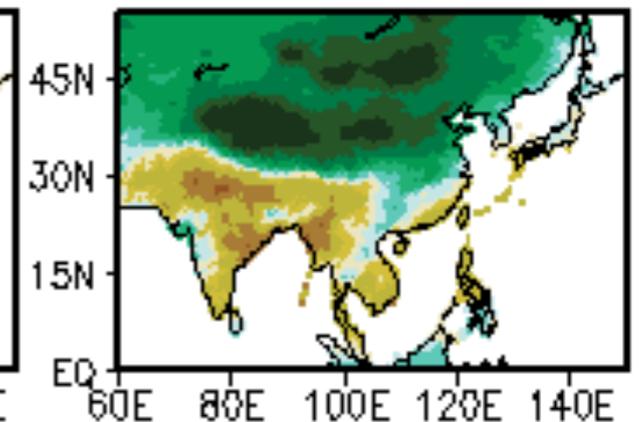
Sep

Sep 2070-2099 median

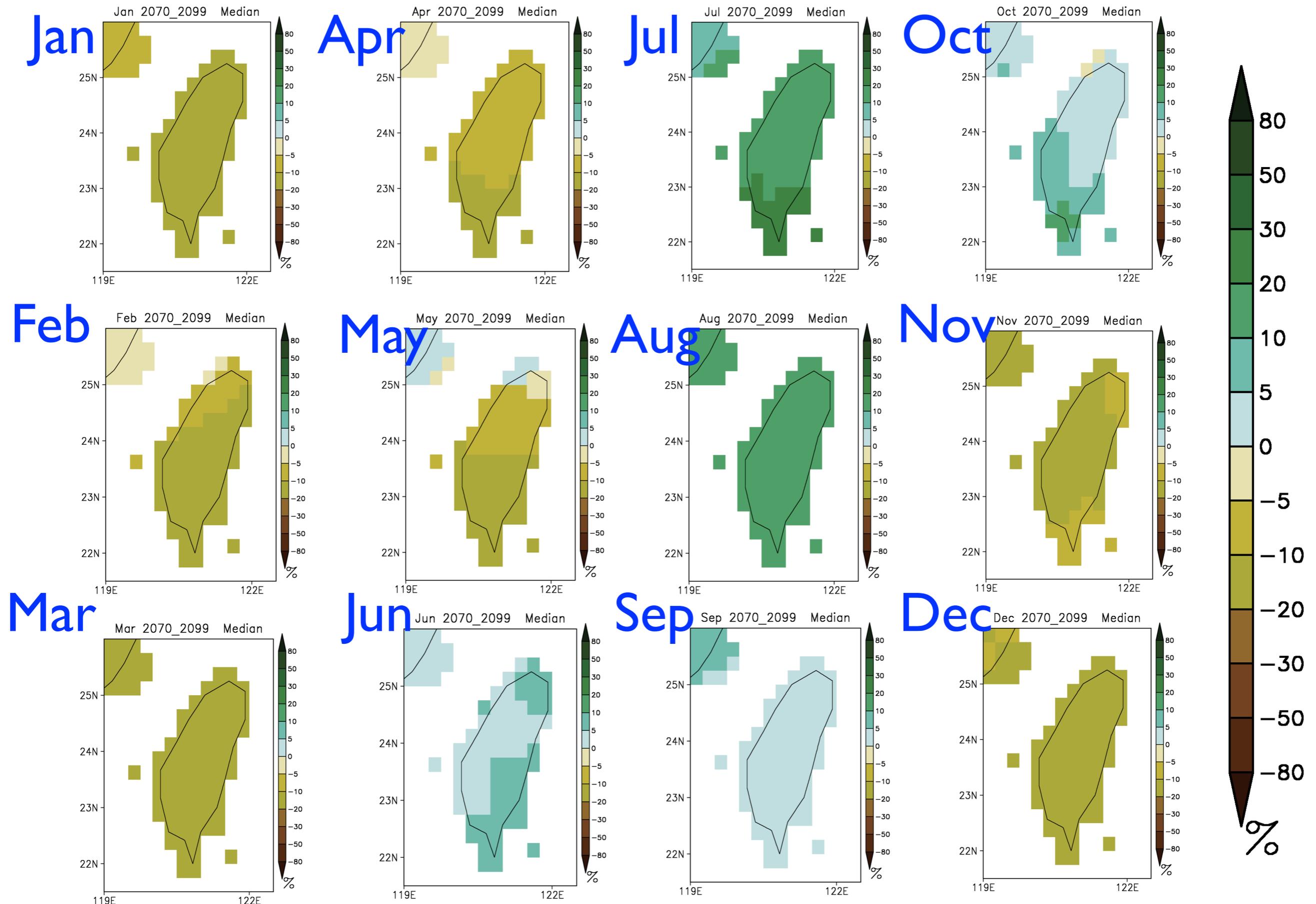


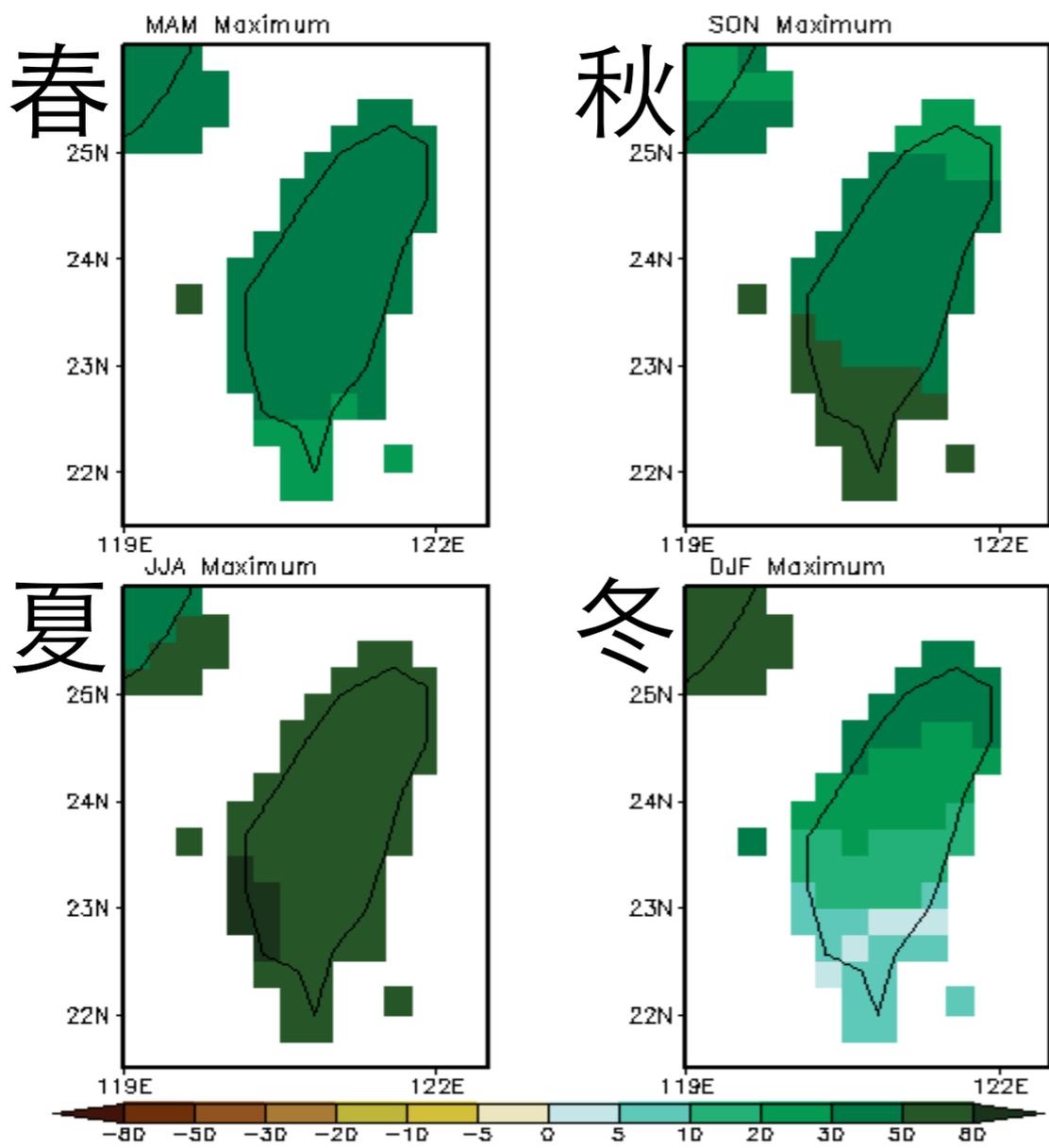
Dec

Dec 2070-2099 median

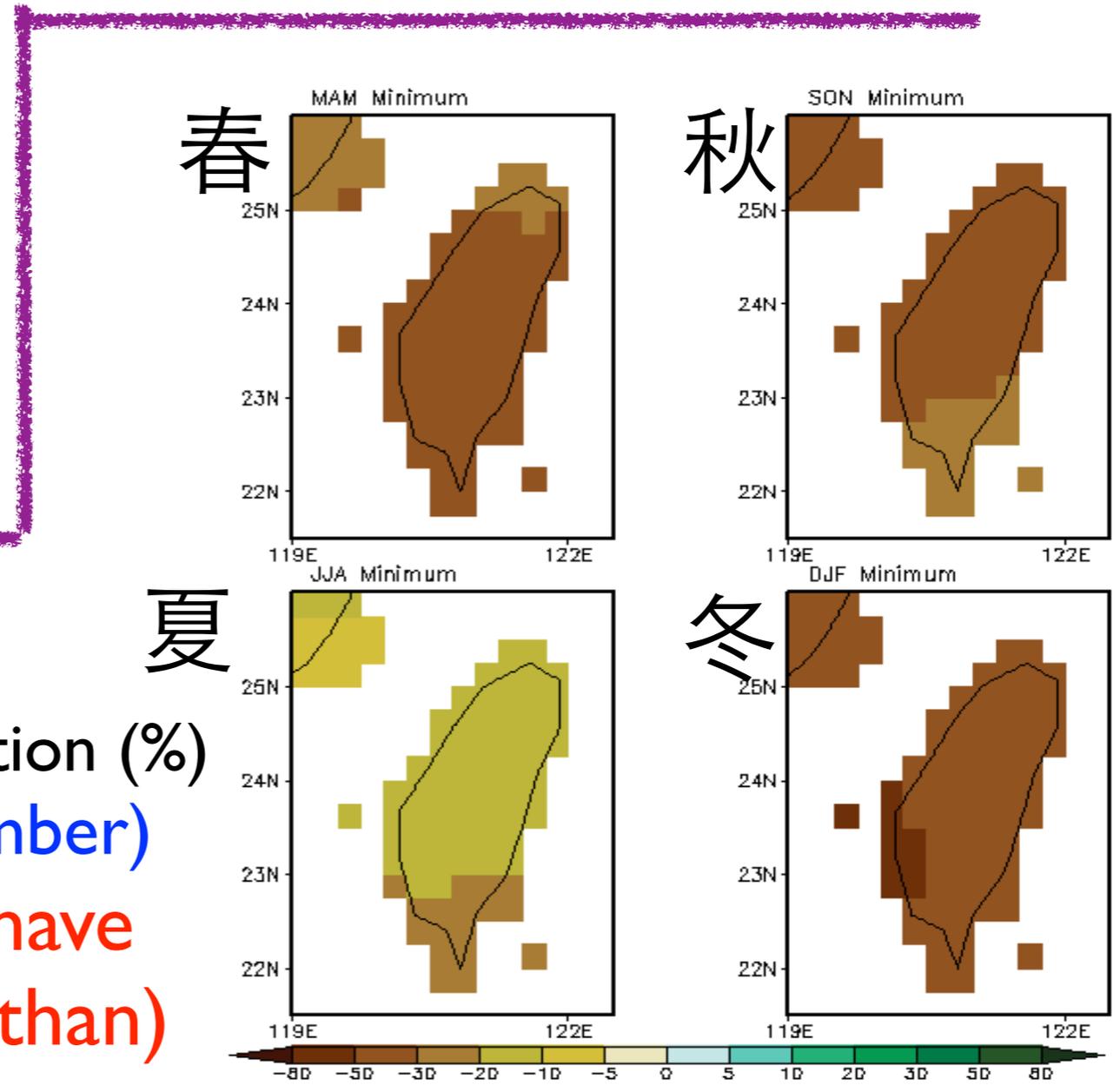


Model **Median** Future Change in Precipitation (%)



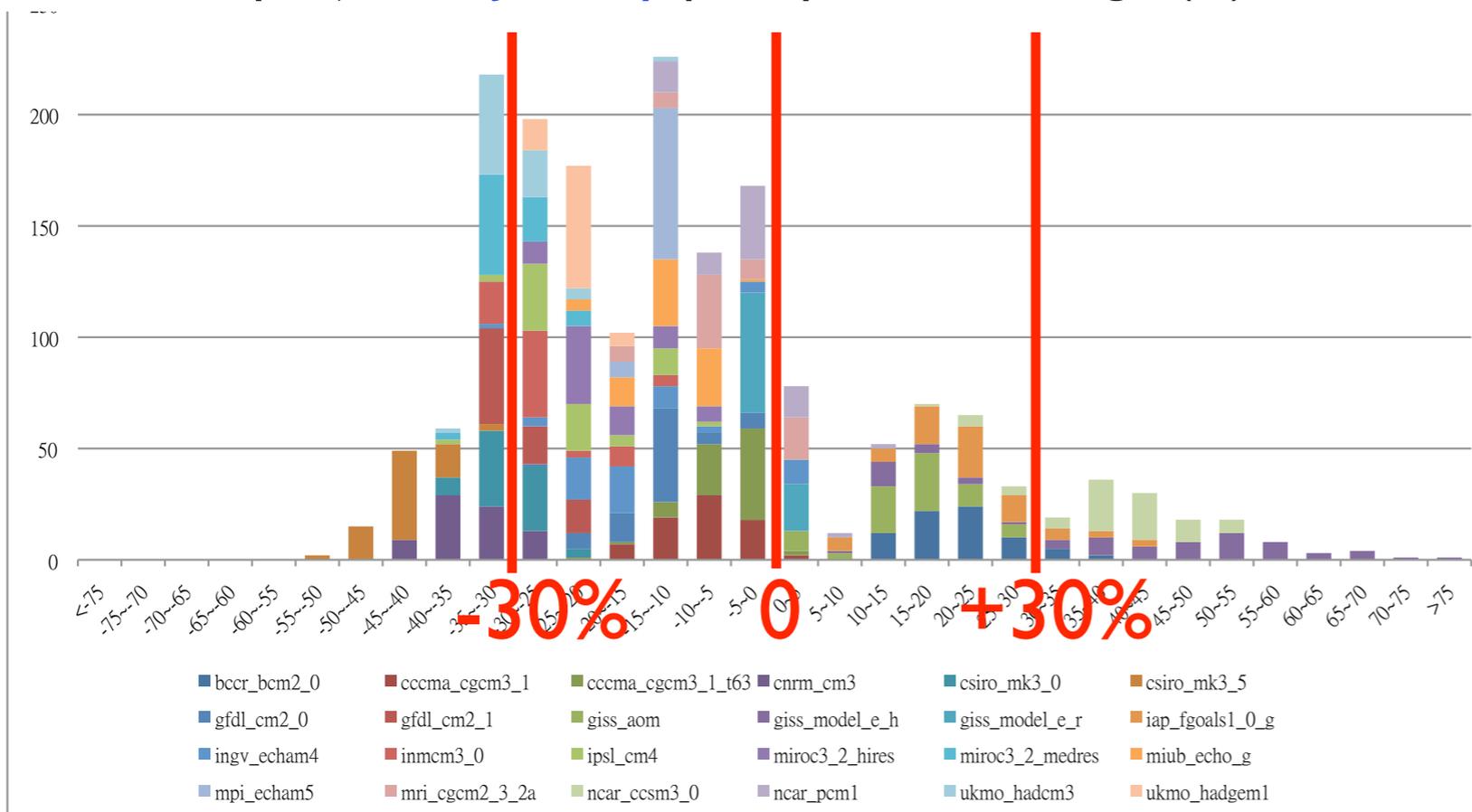


Model Maximum
 Future Change in Precipitation (%)
 (from January to December)
 (extreme unlikely to have
 future increase more than)



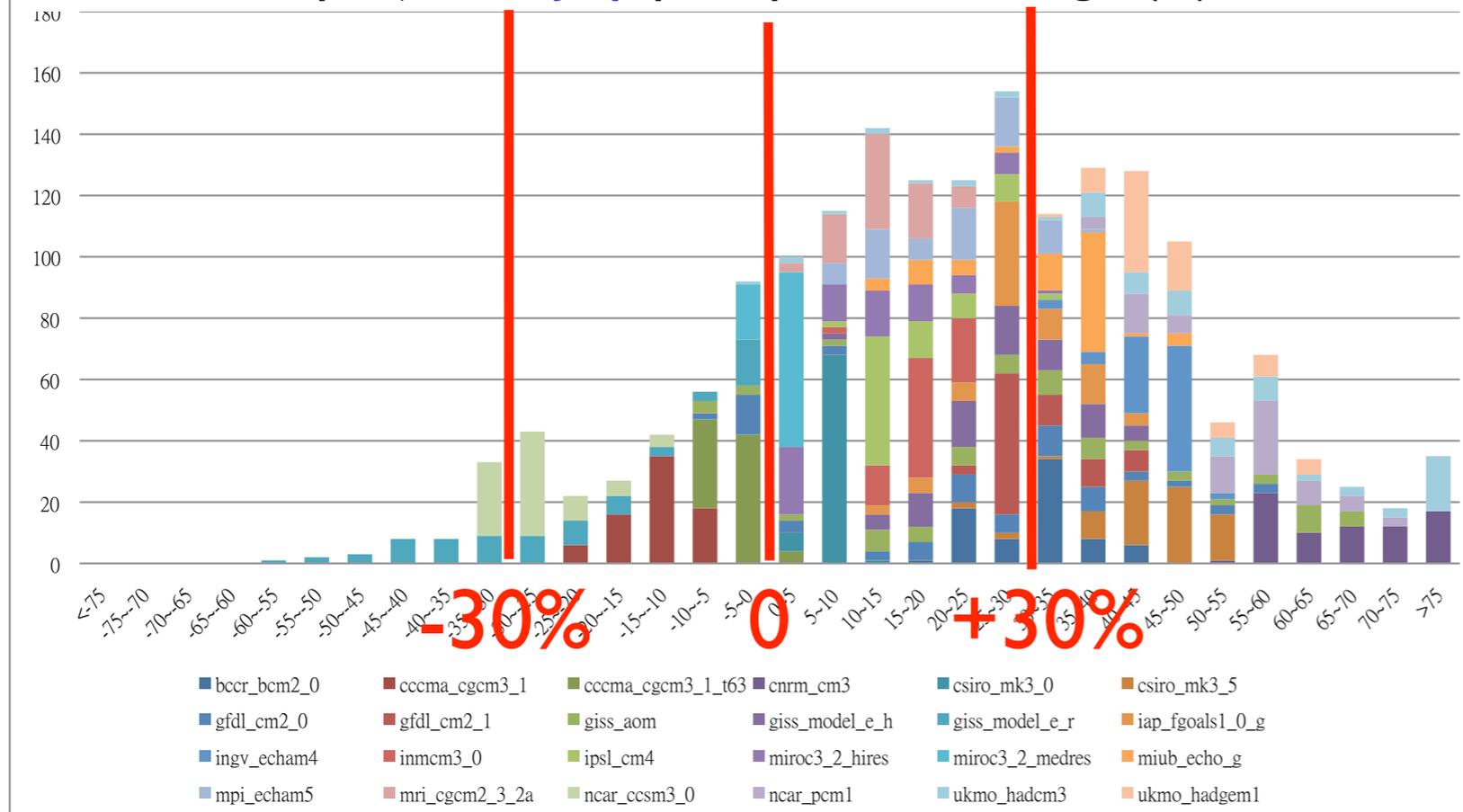
Model Minimum
 Future Change in Precipitation (%)
 (from January to December)
 (extreme unlikely to have
 future decrease more than)

2070-2099 projected **January** precipitation change (%) in Taiwan



- One can also focus on area of interests and construct PDF for projected future precipitation from all models (Taiwan: 75 grids x 24 models)

2070-2099 projected **July** precipitation change (%) in Taiwan

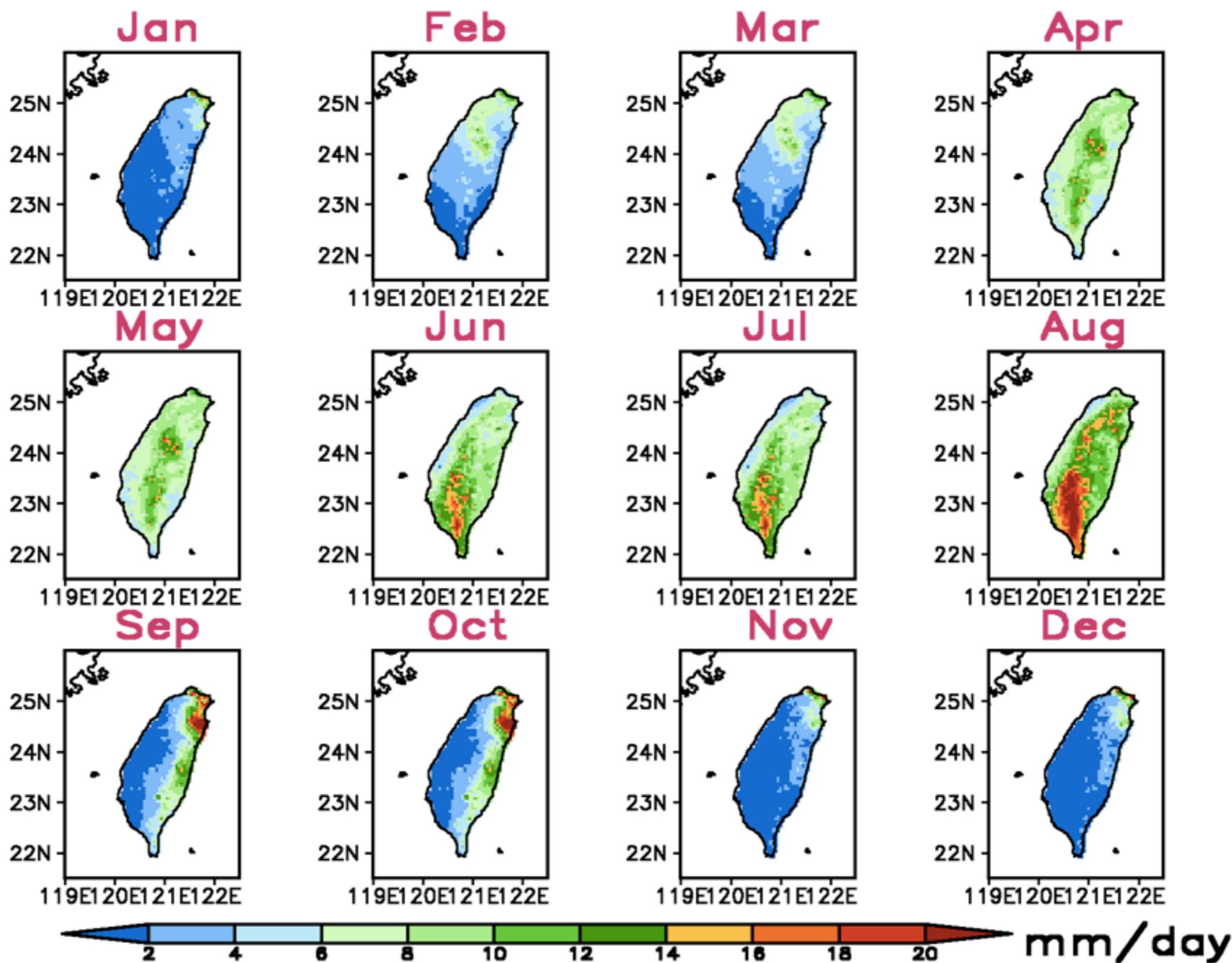


- Ensemble of opportunity (probability)

Regional averages of temperature and precipitation projections

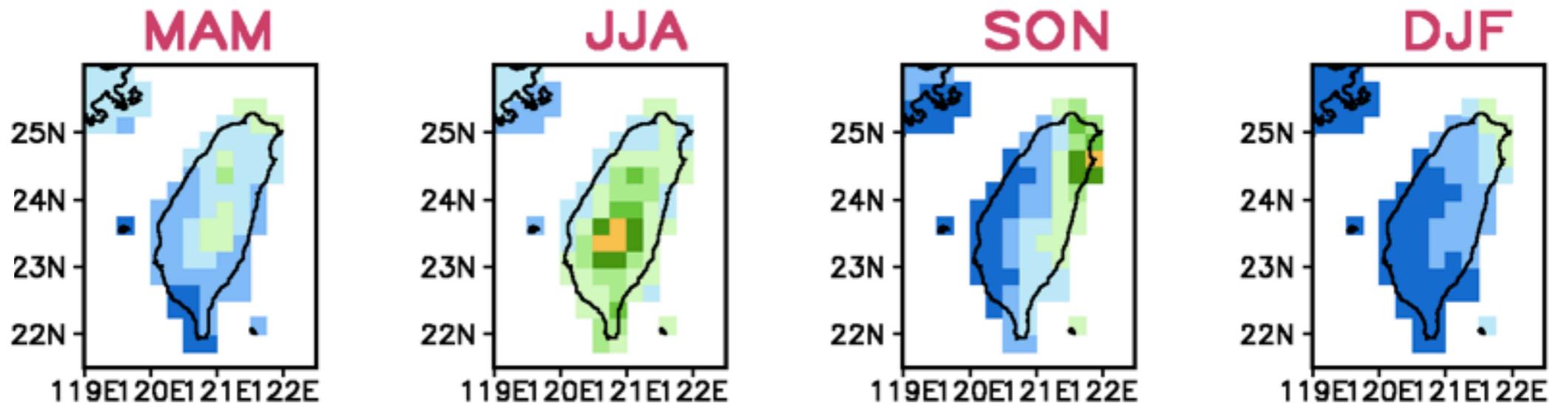
		Temperature Response (deg C)							Precipitation Response (%)						
Region	season	min	10	25	50	75	90	max	min	10	25	50	75	90	max
Northern Taiwan	DJF	1.9	1.9	2.1	2.7	3.1	3.4	3.8	-44	-29	-20	-13	-3	7	33
	MAM	1.7	1.8	2.2	2.6	2.9	3.4	3.9	-31	-24	-14	-8	6	17	36
	JJA	1.7	1.8	2.2	2.7	3.0	3.3	4.0	-15	-12	-1	14	29	46	64
	SON	1.6	1.8	2.2	2.6	3.1	3.3	3.8	-33	-25	-10	8	21	28	34
Central Taiwan	DJF	1.8	1.9	2.0	2.6	3.0	3.3	3.7	-49	-33	-22	-15	-4	6	22
	MAM	1.6	1.8	2.1	2.6	2.9	3.3	3.8	-36	-25	-16	-10	3	17	41
	JJA	1.8	1.8	2.2	2.7	3.0	3.2	4.0	-15	13	2	14	26	64	69
	SON	1.6	1.8	2.2	2.6	3.0	3.3	3.7	-34	-23	-7	11	25	31	45
Southern Taiwan	DJF	1.7	1.7	2.0	2.5	2.9	3.2	3.4	-47	-34	-22	-13	-5	5	8
	MAM	1.5	1.8	2.0	2.5	2.8	3.0	3.6	-41	-26	-21	-14	-5	22	34
	JJA	1.7	1.7	2.2	2.5	2.9	3.2	4	-20	-19	7	16	26	69	76
	SON	1.5	1.7	2.1	2.6	2.9	3.1	3.6	-28	21	-8	13	25	36	55
Eastern Taiwan	DJF	1.8	1.8	2.0	2.6	3.0	3.3	3.7	-44	-31	-20	-12	-3	5	17
	MAM	1.5	1.8	2.1	2.5	2.8	3.3	3.8	-37	-25	-18	-11	1	20	36
	JJA	1.7	1.7	2.2	2.6	2.9	3.2	4.0	-17	-15	3	15	26	57	64
	SON	1.6	1.8	2.1	2.6	3.0	3.2	3.7	-30	-23	-10	10	23	33	43

5km gridded rainfall from all available (hundreds) rain gauges in Taiwan

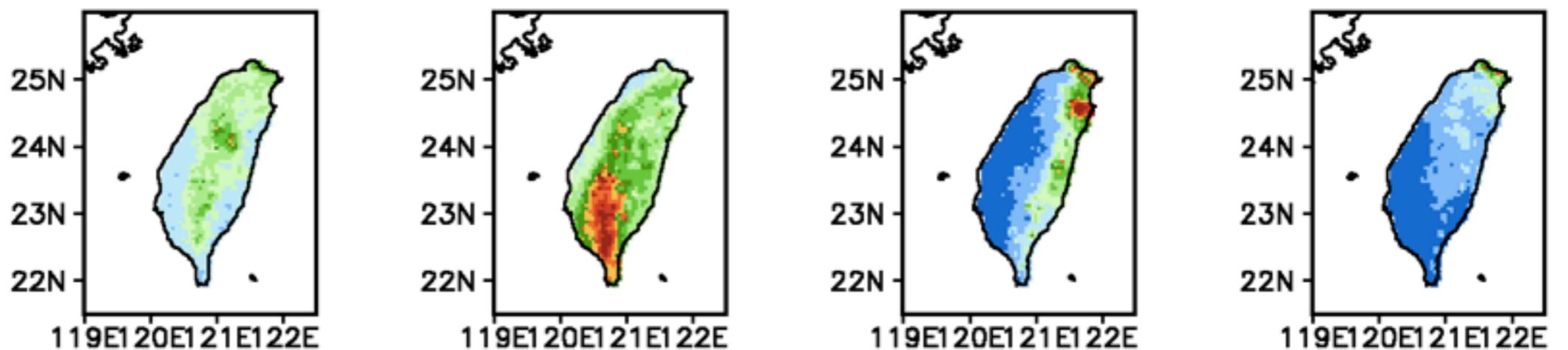


Taiwan 5km gridded rainfall better resolved local rainfall characteristics

Aphrodite
0.25°

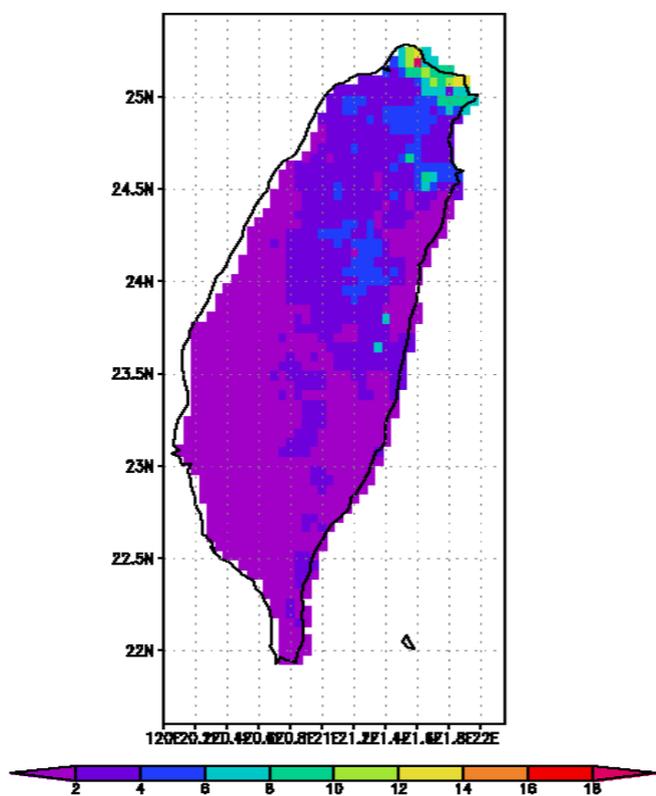


Taiwan
gridded
5km



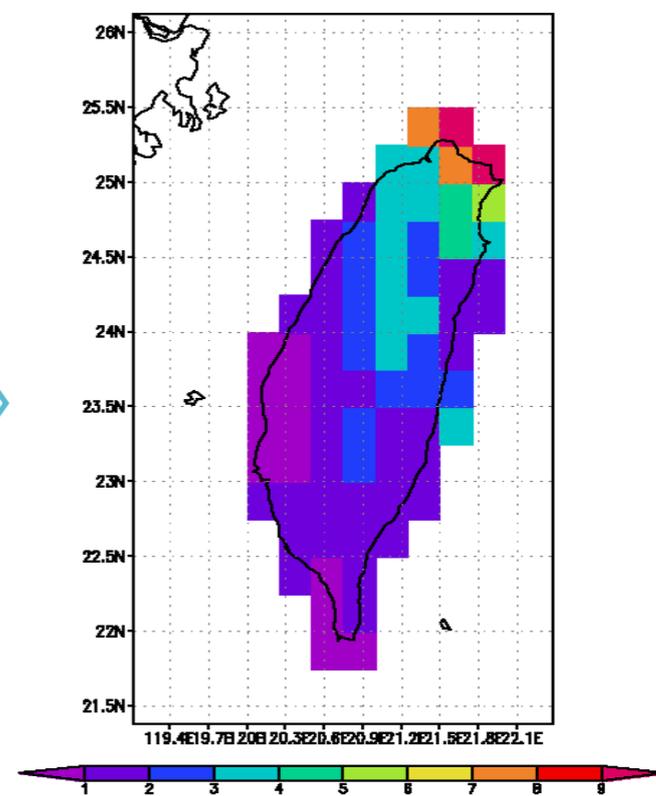
obs

5km
0.05x0.05
1960~2009



upscale

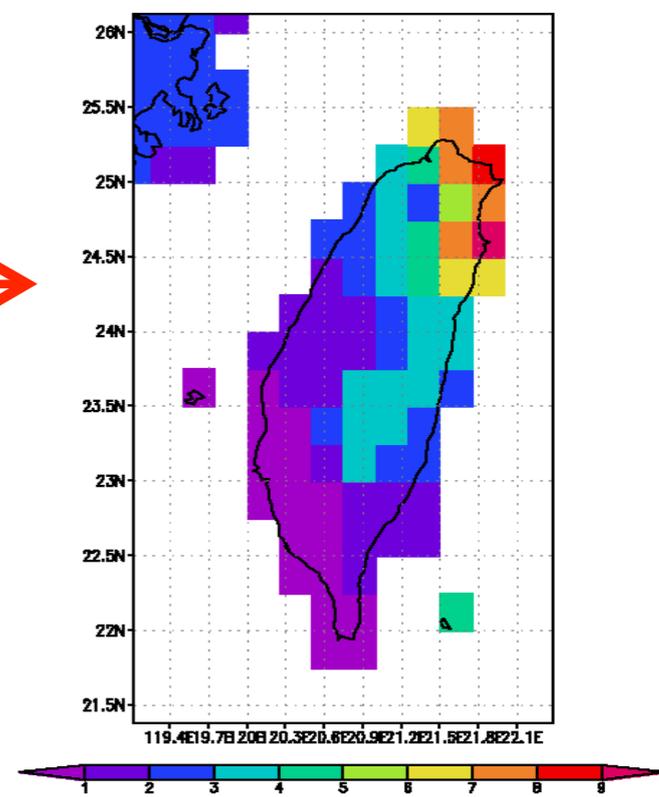
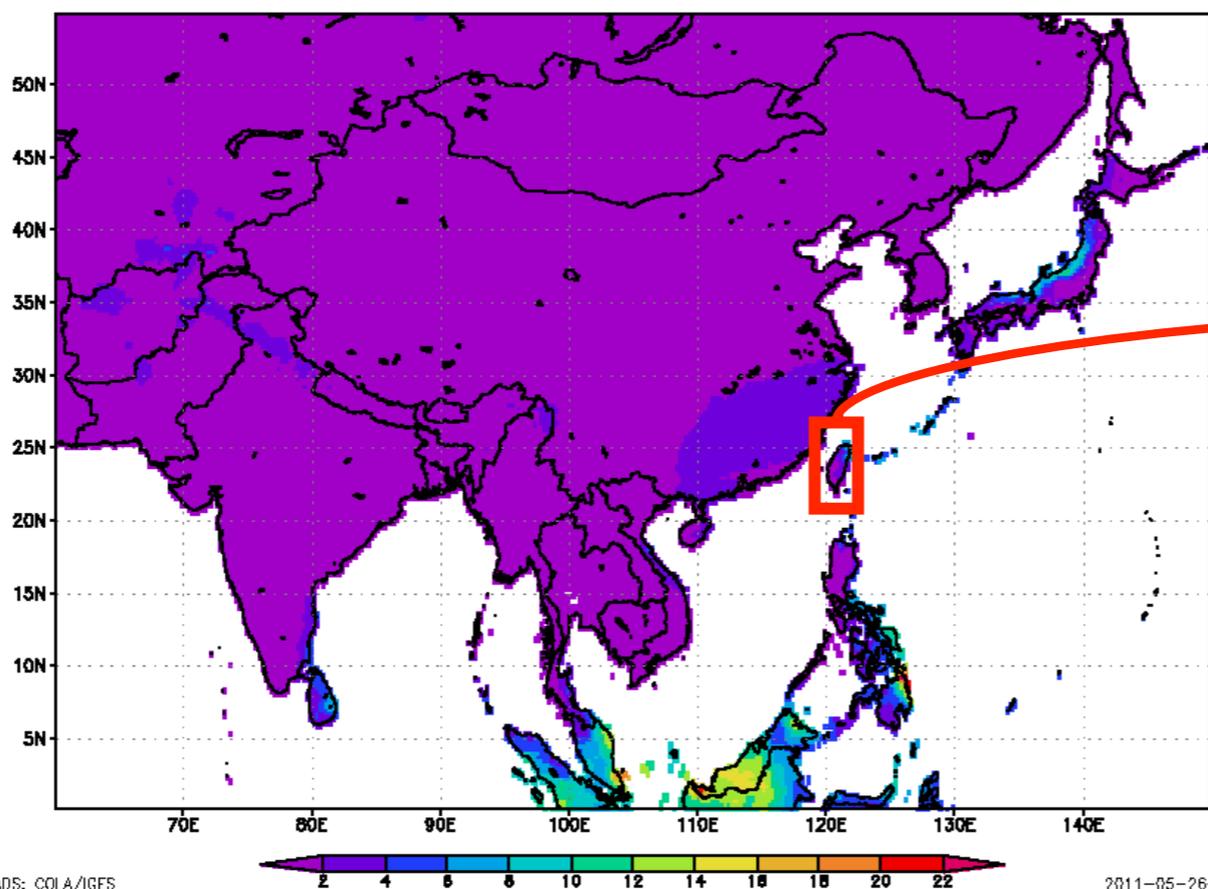
0.25x0.25



20c3m DJF

model

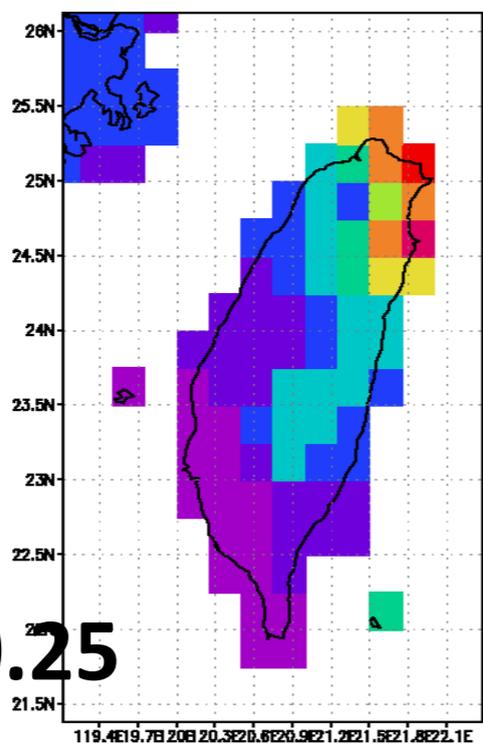
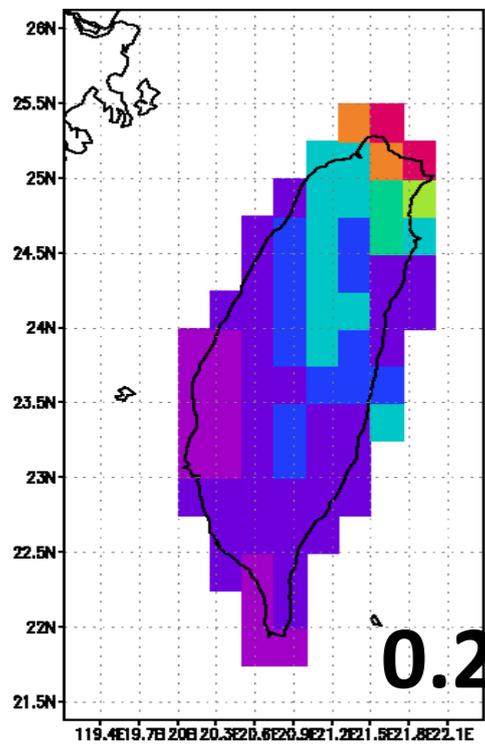
0.25x0.25
1961~2000



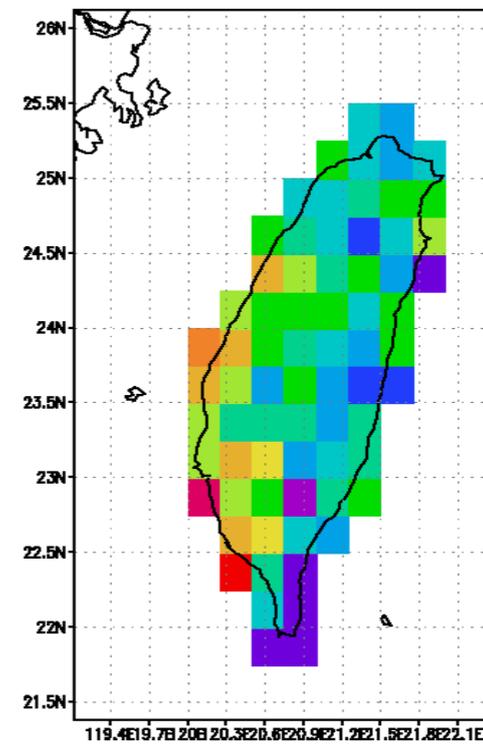
obs

model

factor



CDF
Bias-Correction



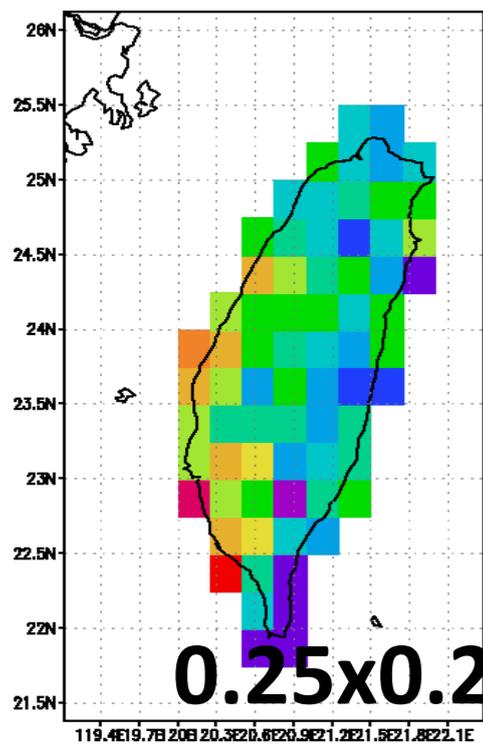
0.25x0.25

20c3m DJF

factor

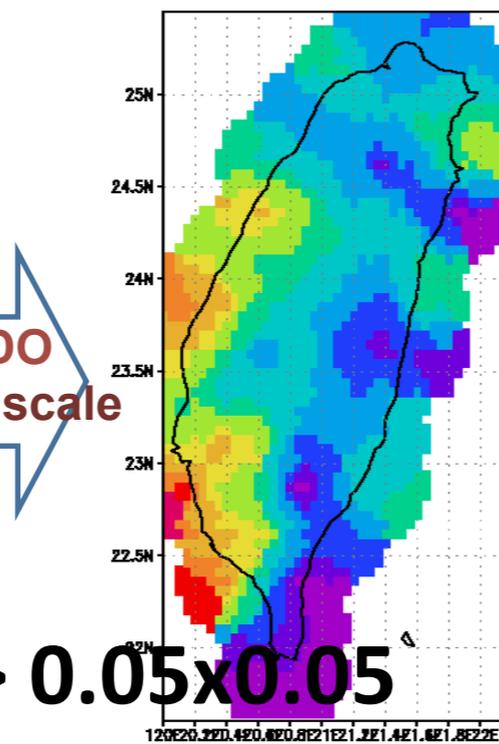
obs climatology

Downscale Result

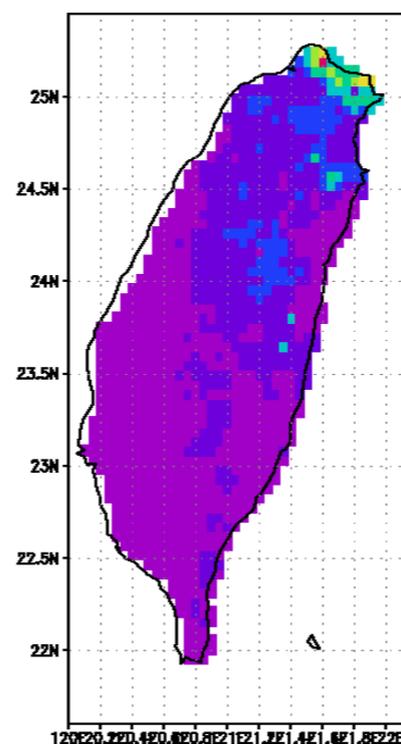


CDO
downscale

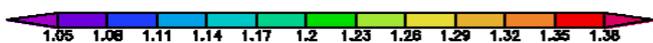
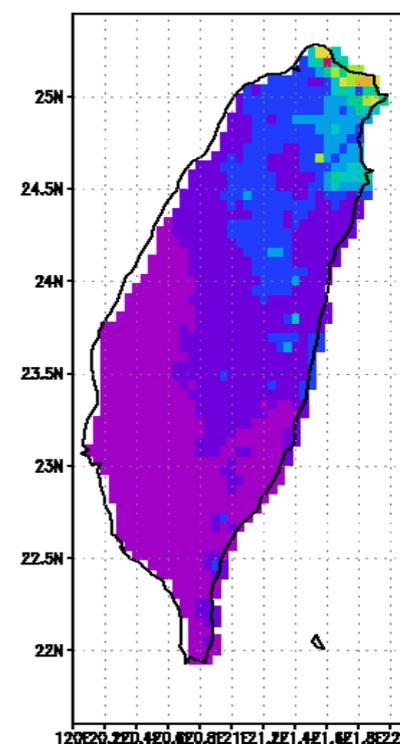
0.25x0.25 -> 0.05x0.05



X



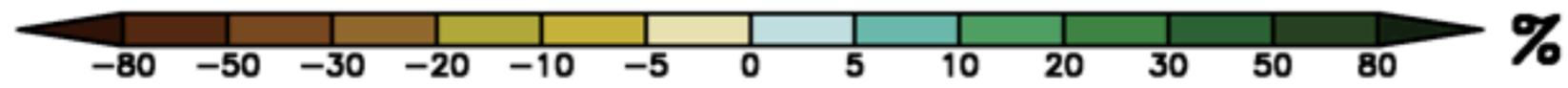
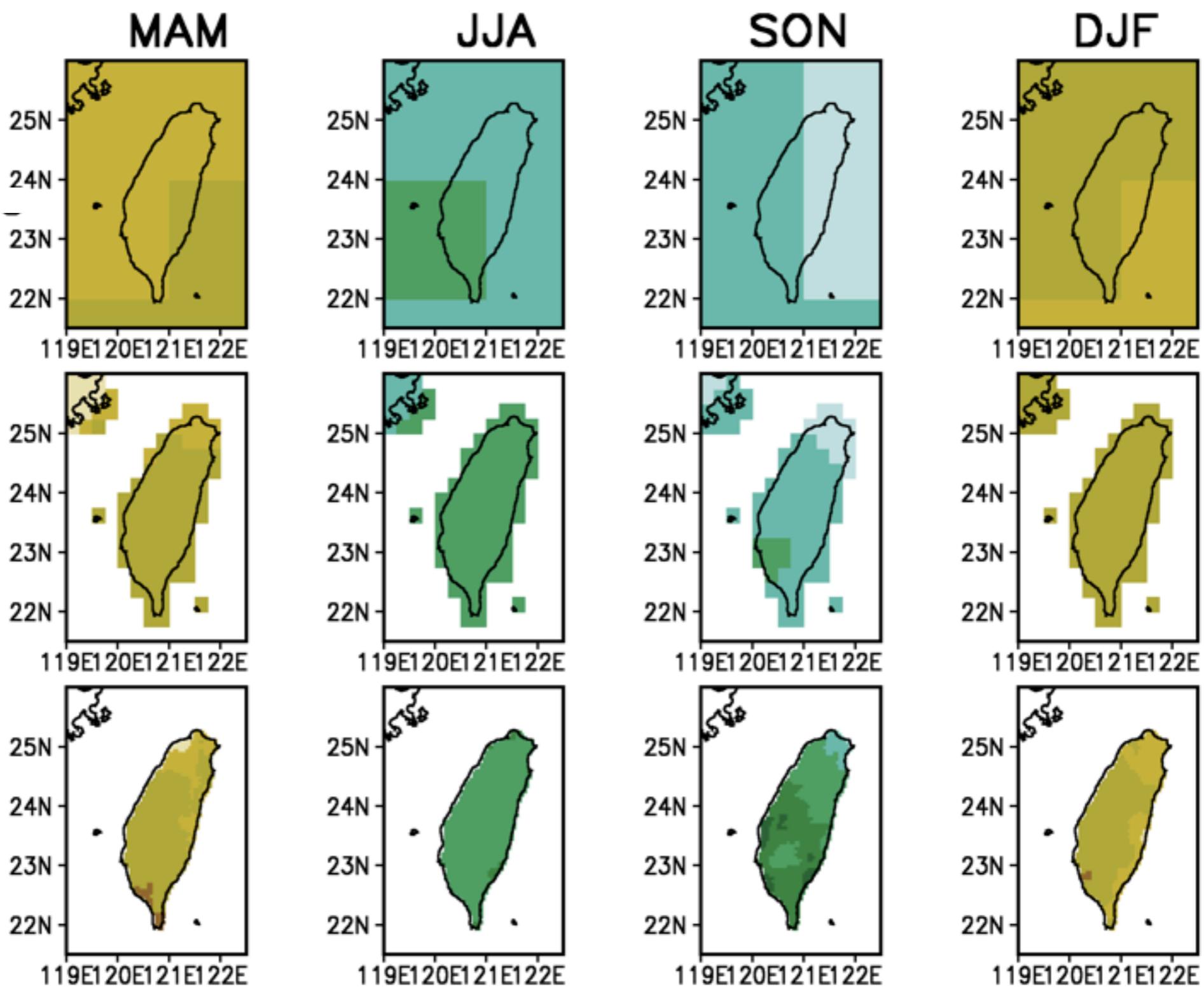
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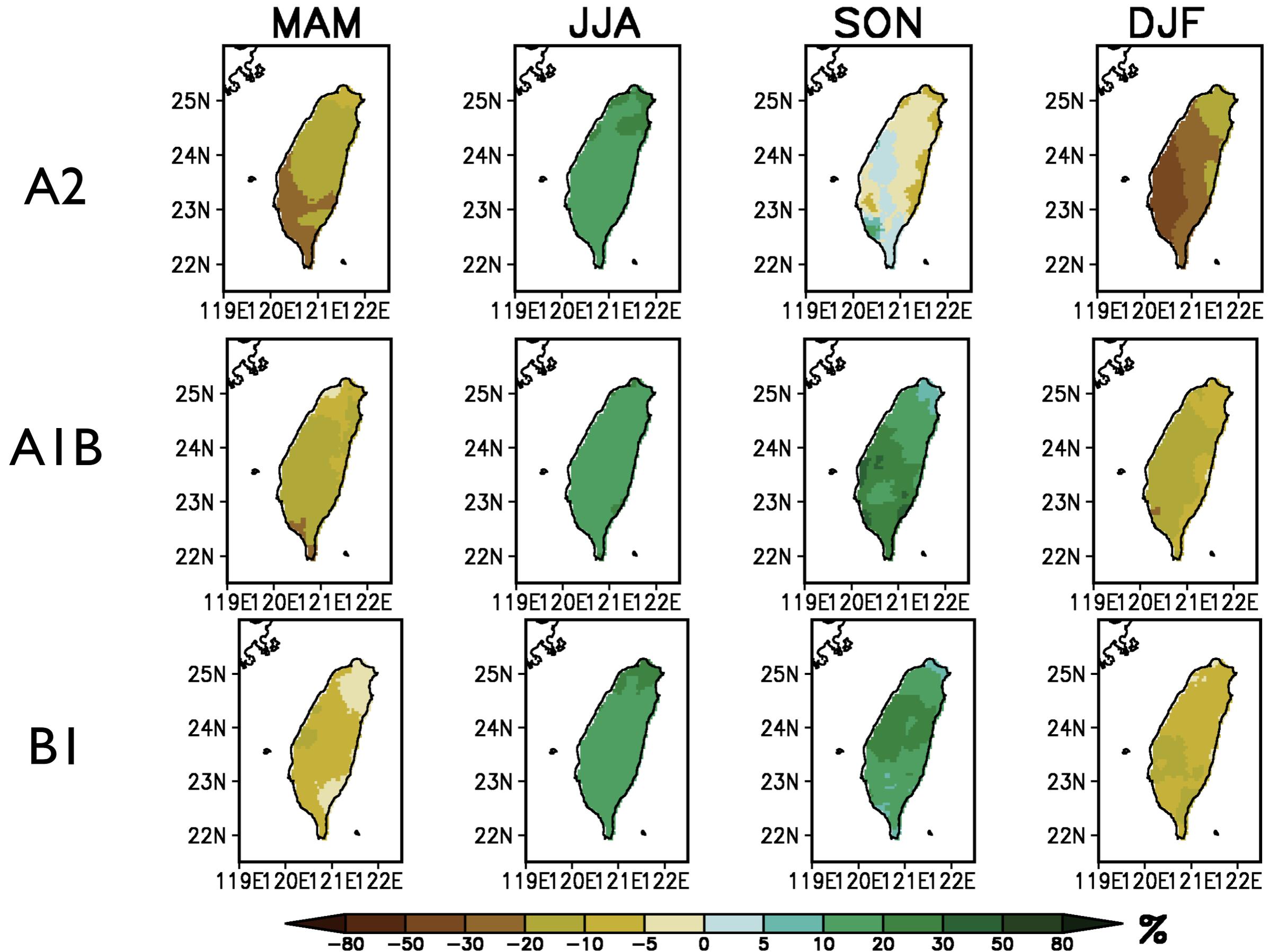
Model Median Future Change in Precipitation (%)

AIB

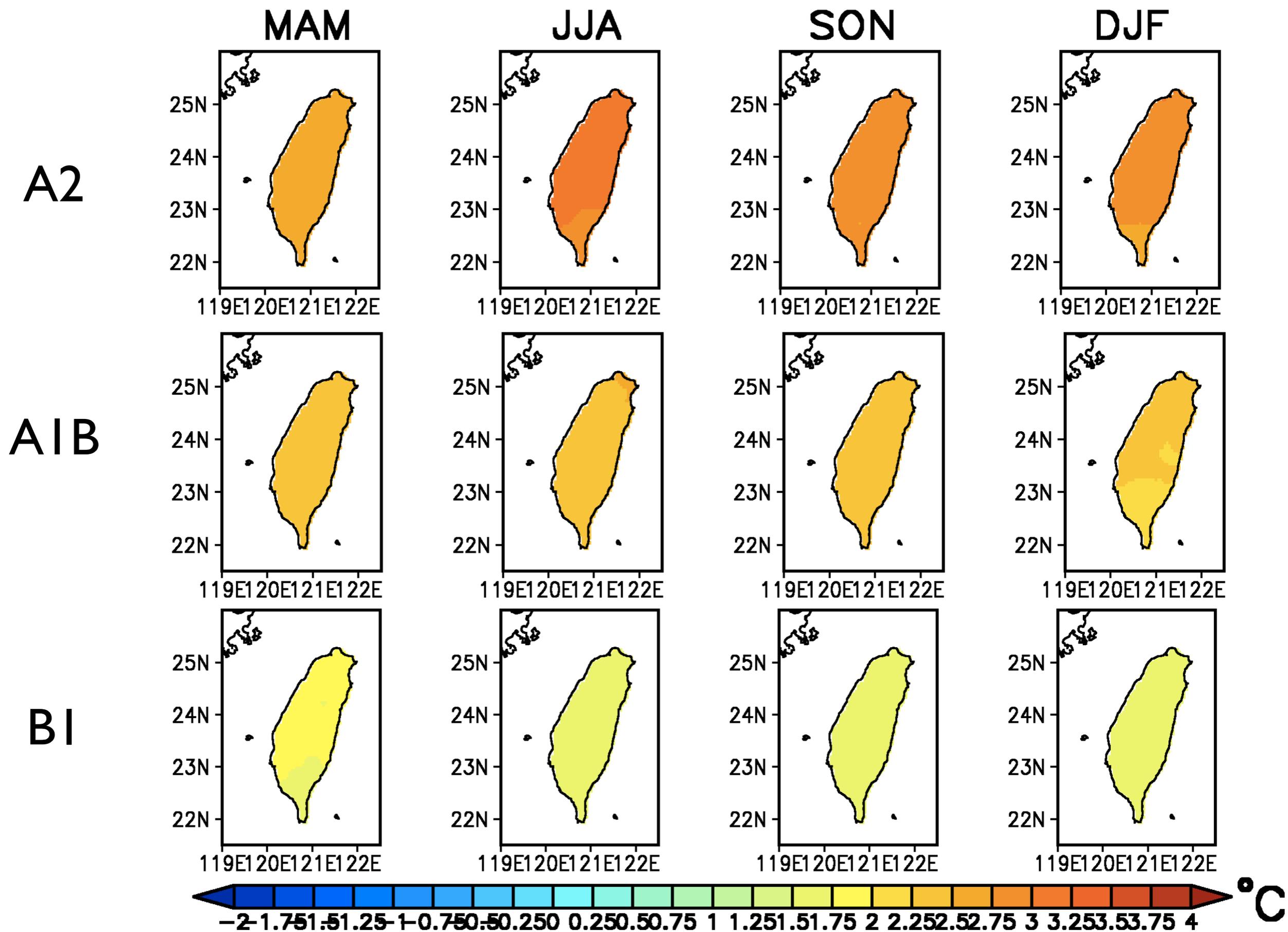
Model Resolution



Model **Median** Future (2080-2099) Change in Precipitation (%)



Model **Median** Future (2080-2099) Change in Temperature (°C)



Summary and Concluding Remarks

- Must consider the other major uncertainties (emission scenario, model, etc.) regarding future climate in addition to downscaling to local scale. **Probabilistic projection better represent the uncertainty.**
- Large resources are needed for dealing with all the uncertainties using dynamical downscaling approach. **Statistical approach is a relatively simple alternative.**
- Although the uncertainties can be more easily included with statistical downscaling approach, one **should aware about the assumption, limitation and caveats** of this type of climate information regionalization tool:
 - long-term high-resolution observation availability
 - statistical relationship between model data and observation remains valid for periods outside calibration period
 - only limited area with local change passed statistical significance test
 -