Regionalization of the IPCC AR4 Climate Projections over East Asia and Taiwan with Statistical Downscaling

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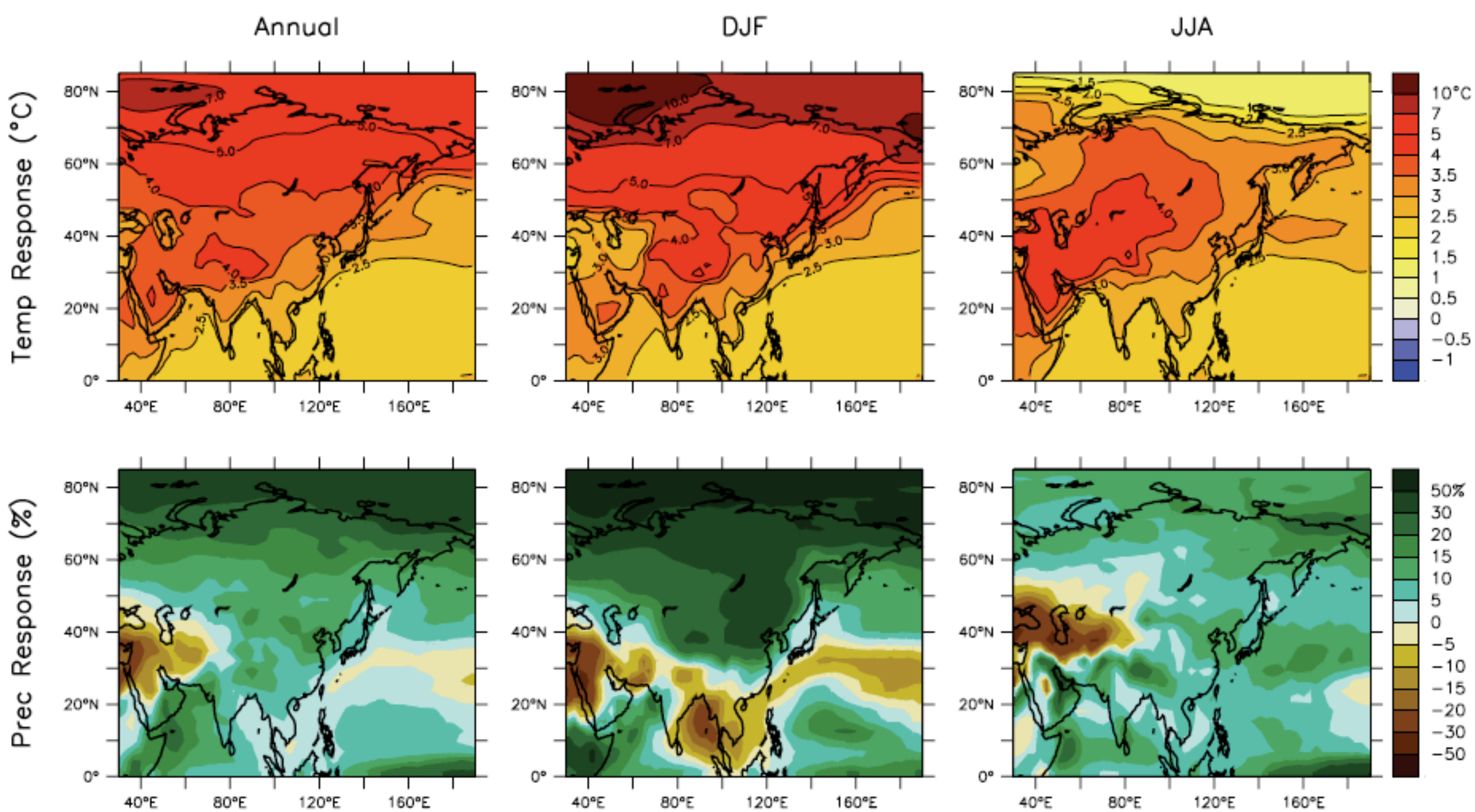
A1B scenario



- Why downscaling?
- How?
- Uncertainty
- Key findings and Limitations

Why downscaling?

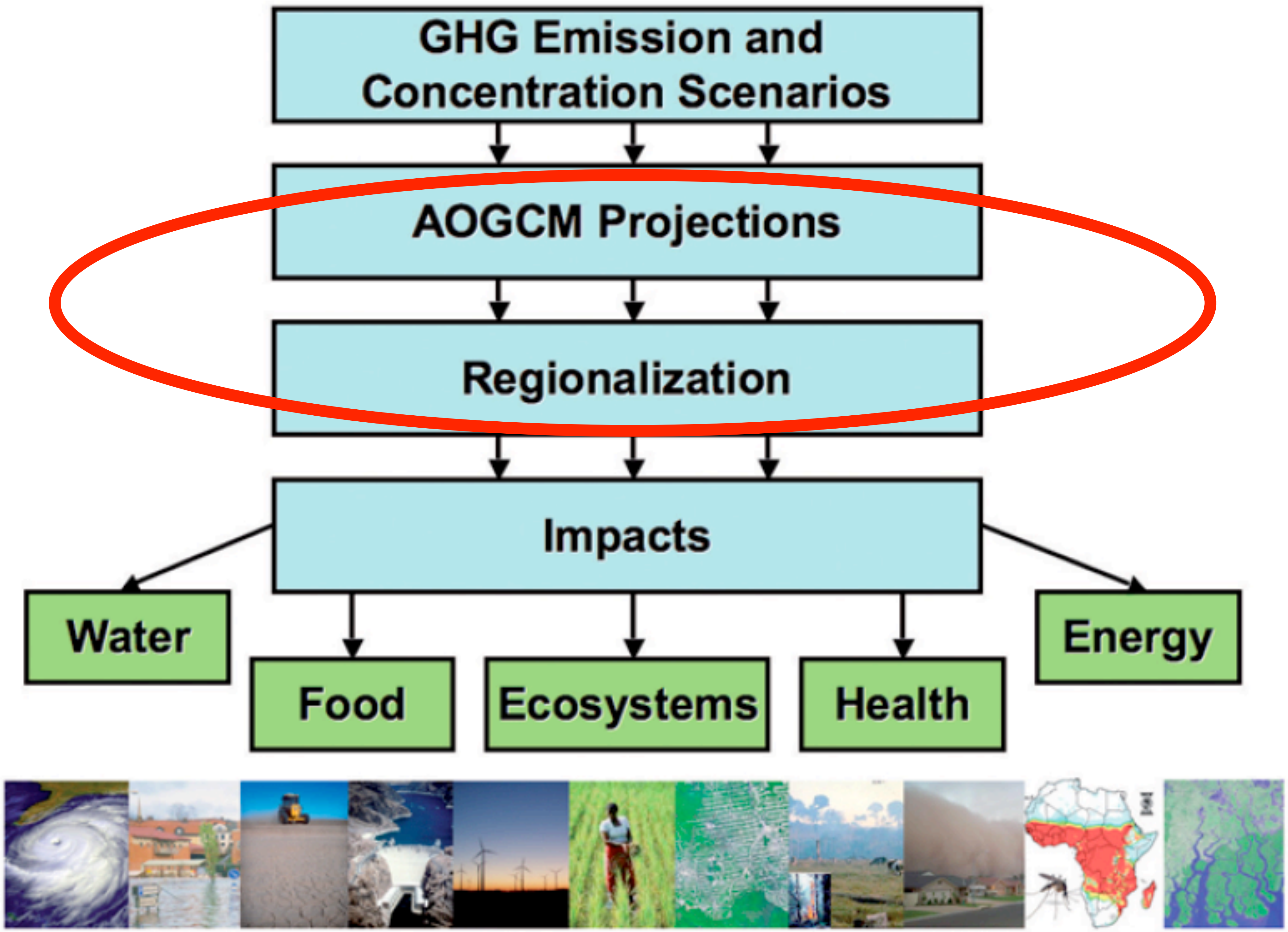
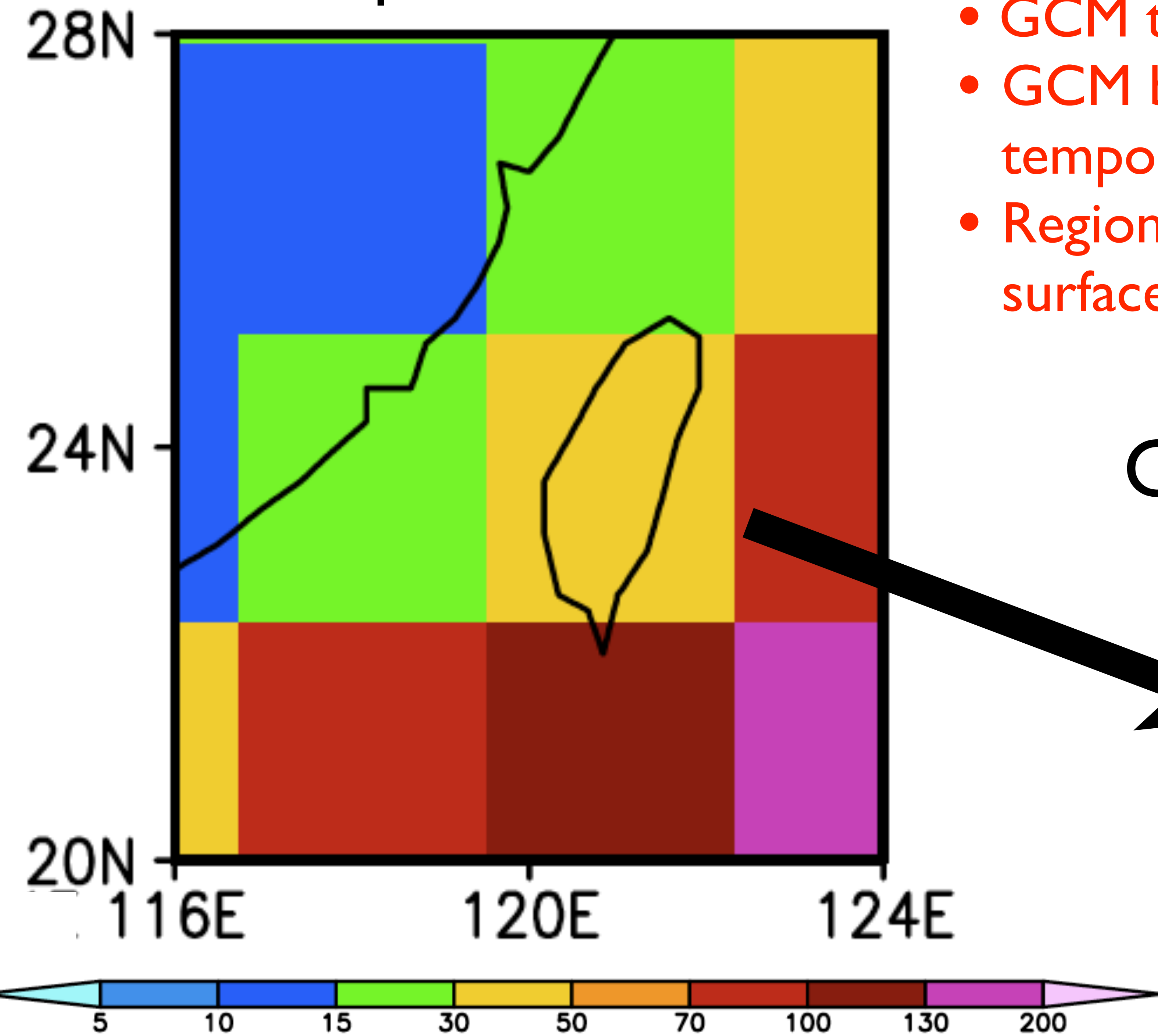


Figure 3 — Schematic depiction of the steps involved in the production of climate change information usable for impact assessment work via regionalization methods

Source: Giorgi (2008)

Why downscaling?

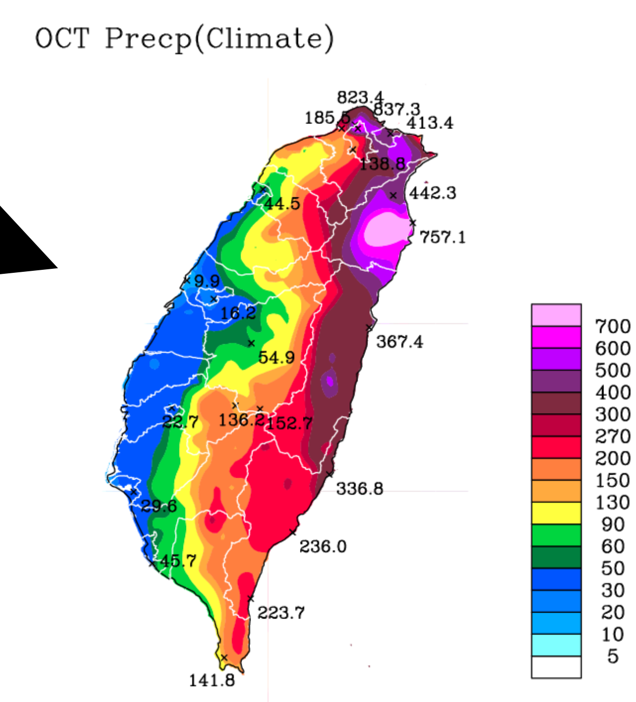
GCM (~300 km)
Precipitation October



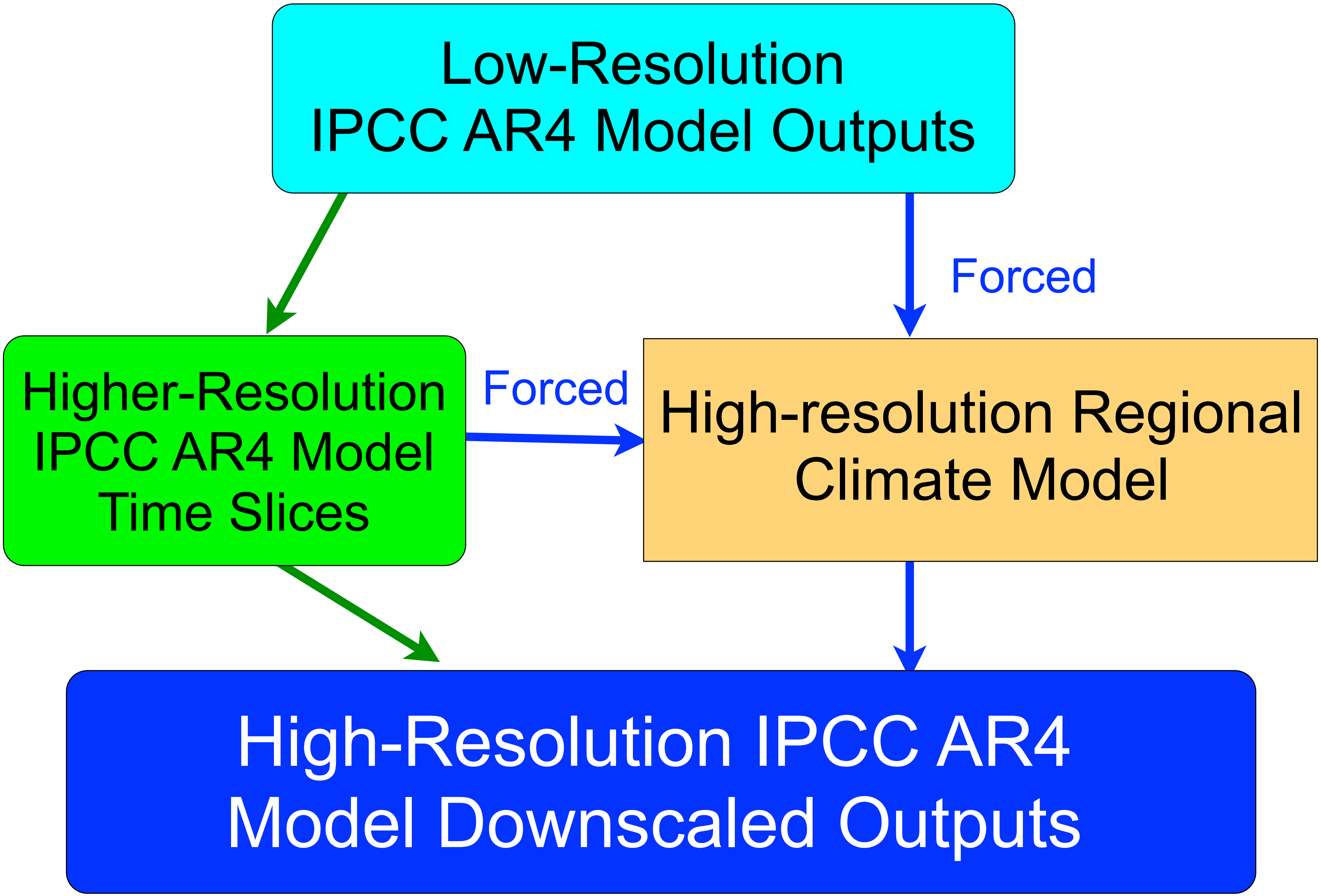
Problems:

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

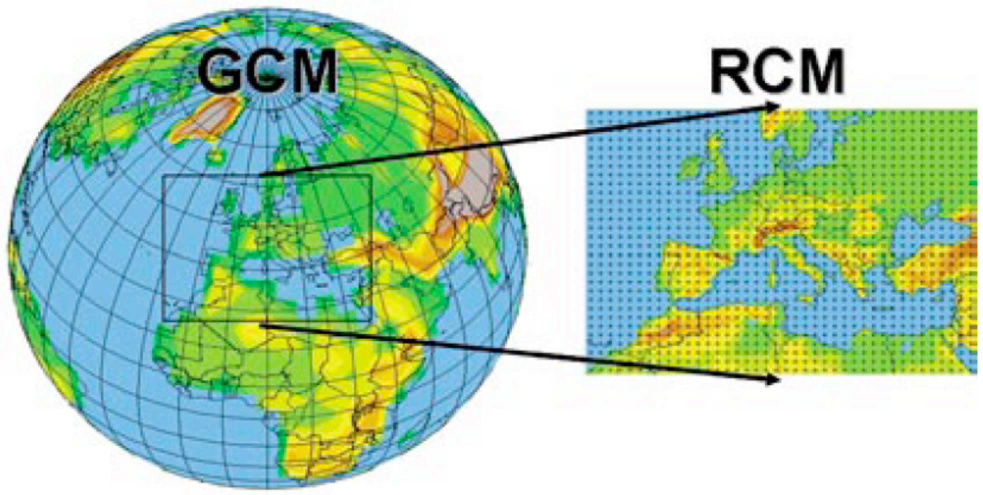
Observation (~5km)



Dynamical Downscaling



Dynamical downscaling (RCMs)



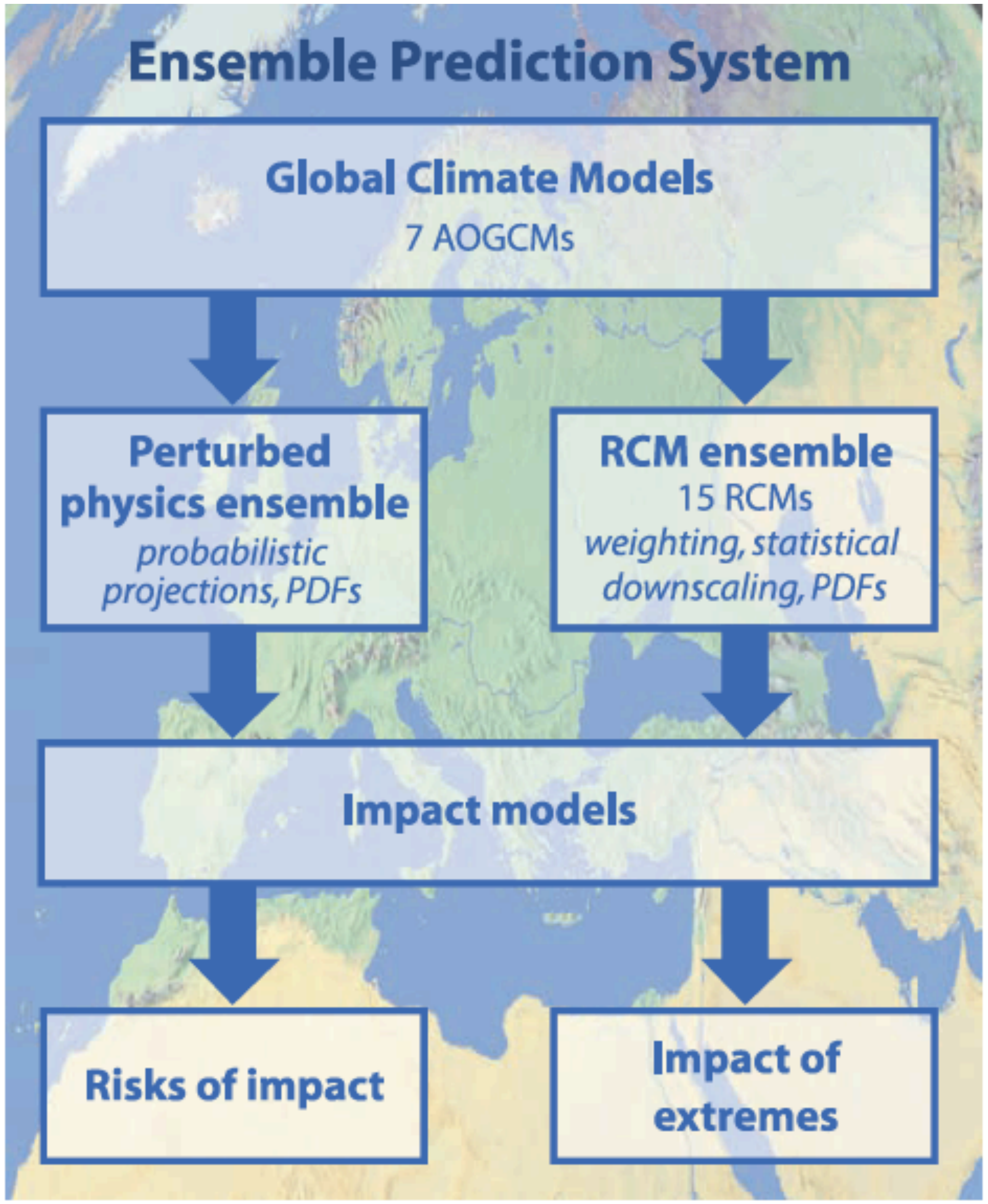
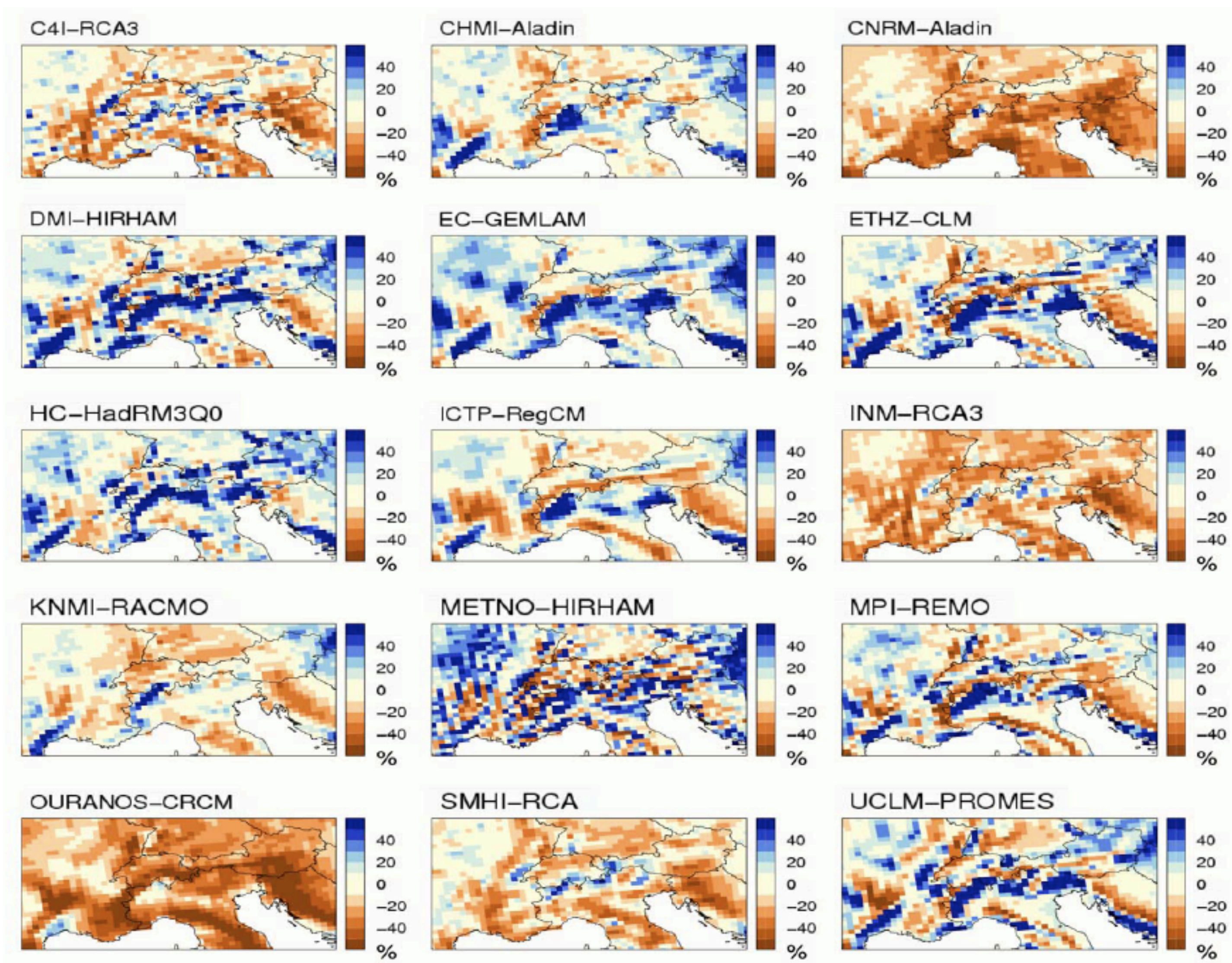
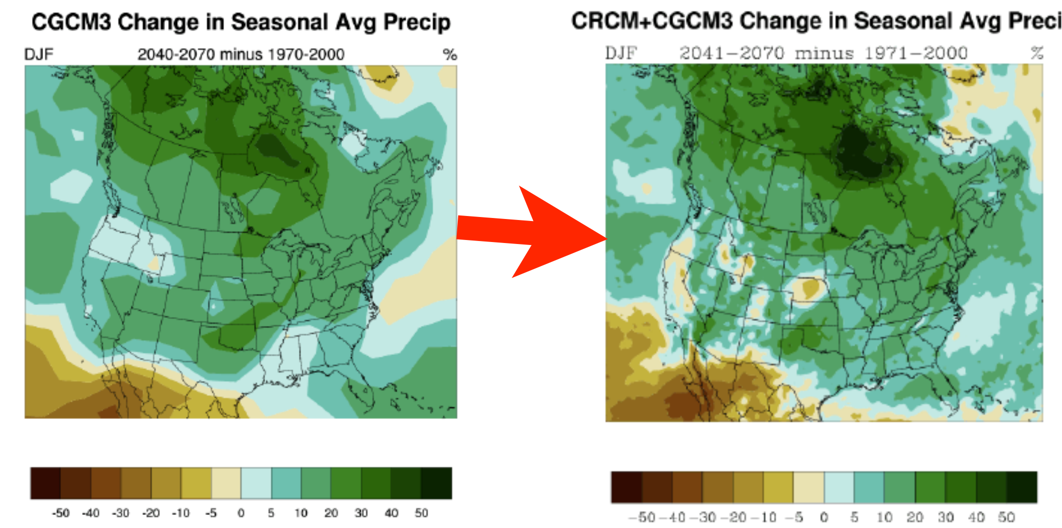


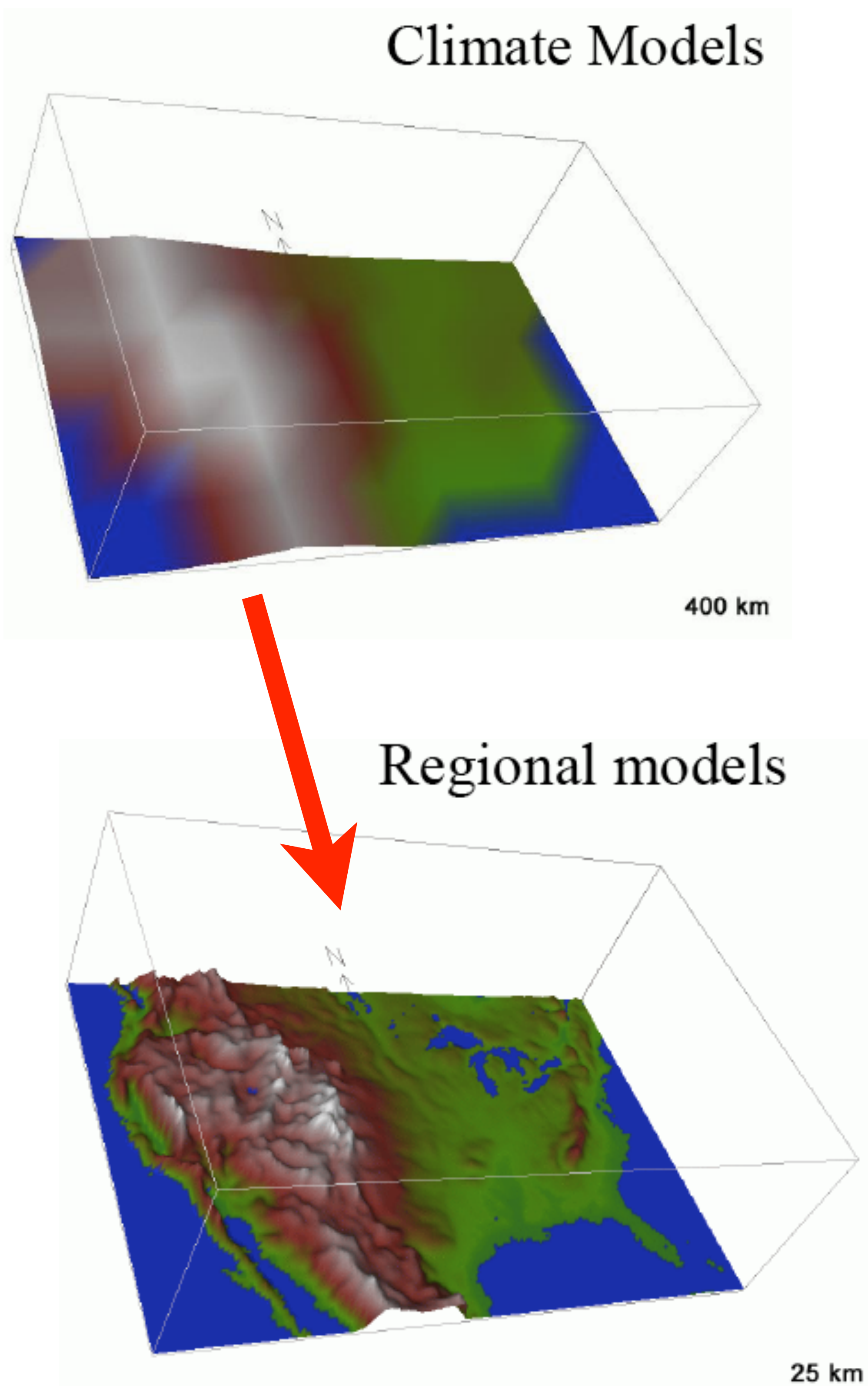
Figure 2.1: Linkages between the modelling components of the ensemble prediction system (EPS), as developed for use at multi-decadal to centennial timescales, and the methods of impact assessment using outputs from the system.

EU ENSEMBLE Project RT3

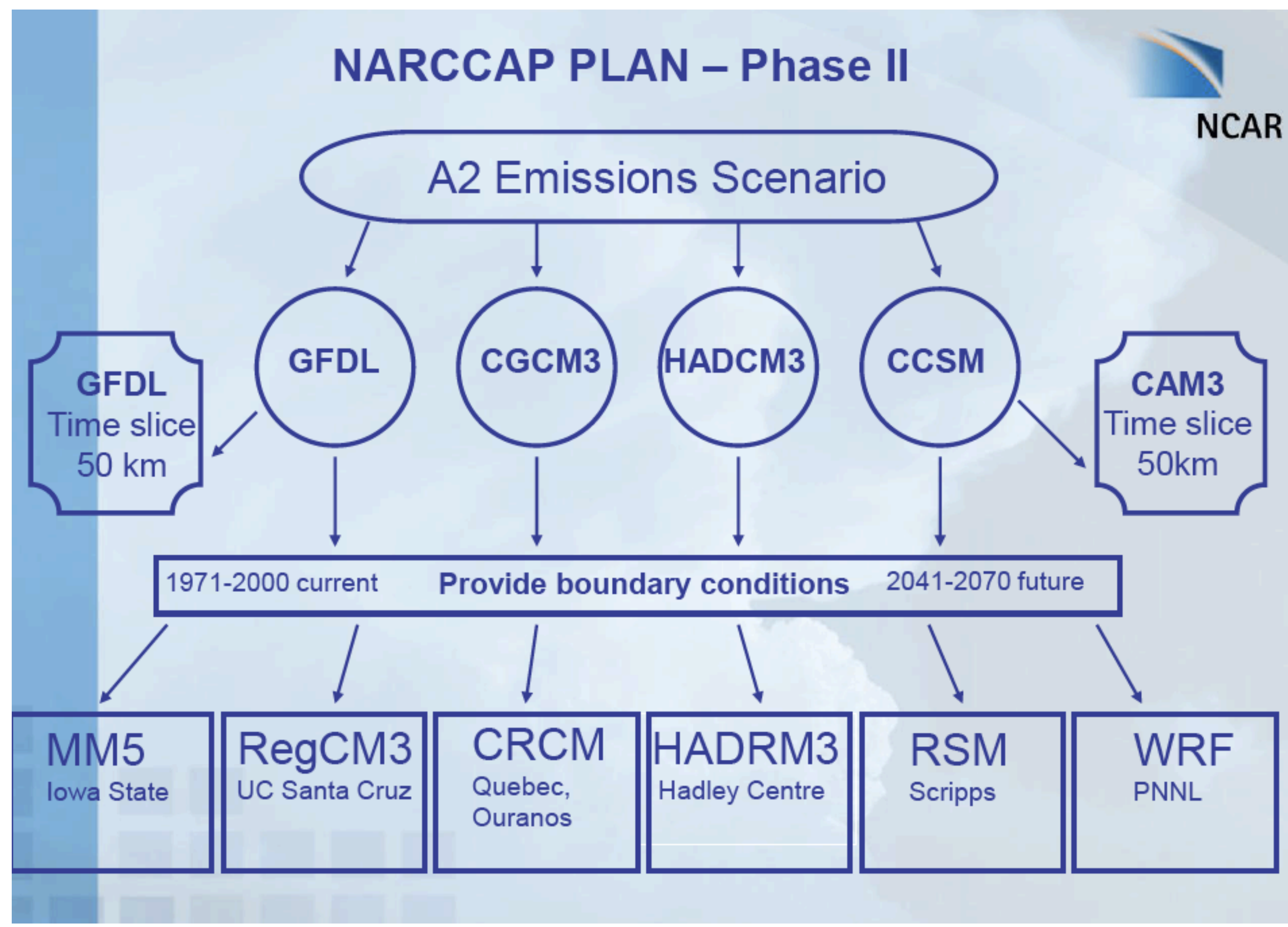


Dynamical downscaling (RCMs)





US NARCCAP Project



Mearns (2009)

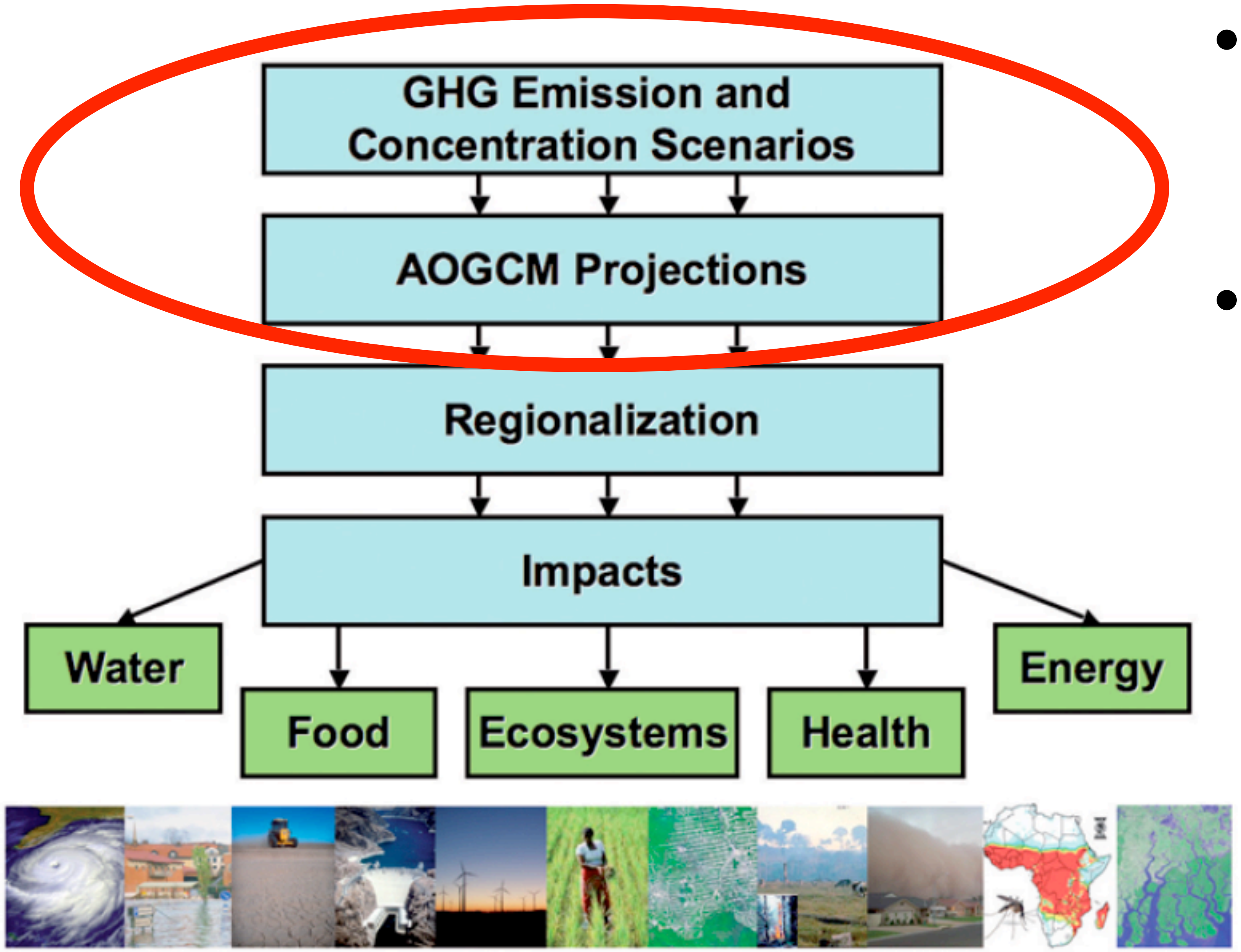
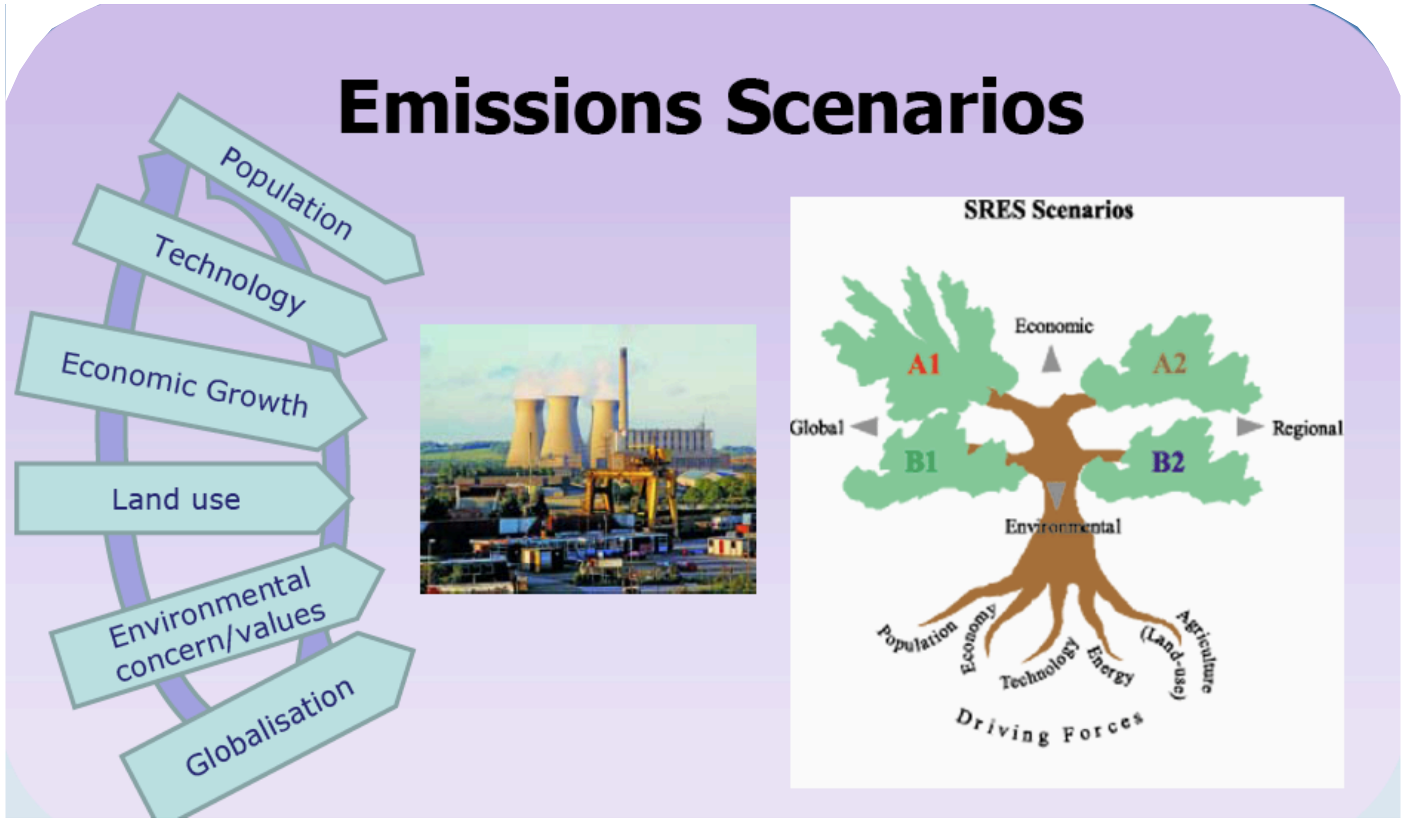
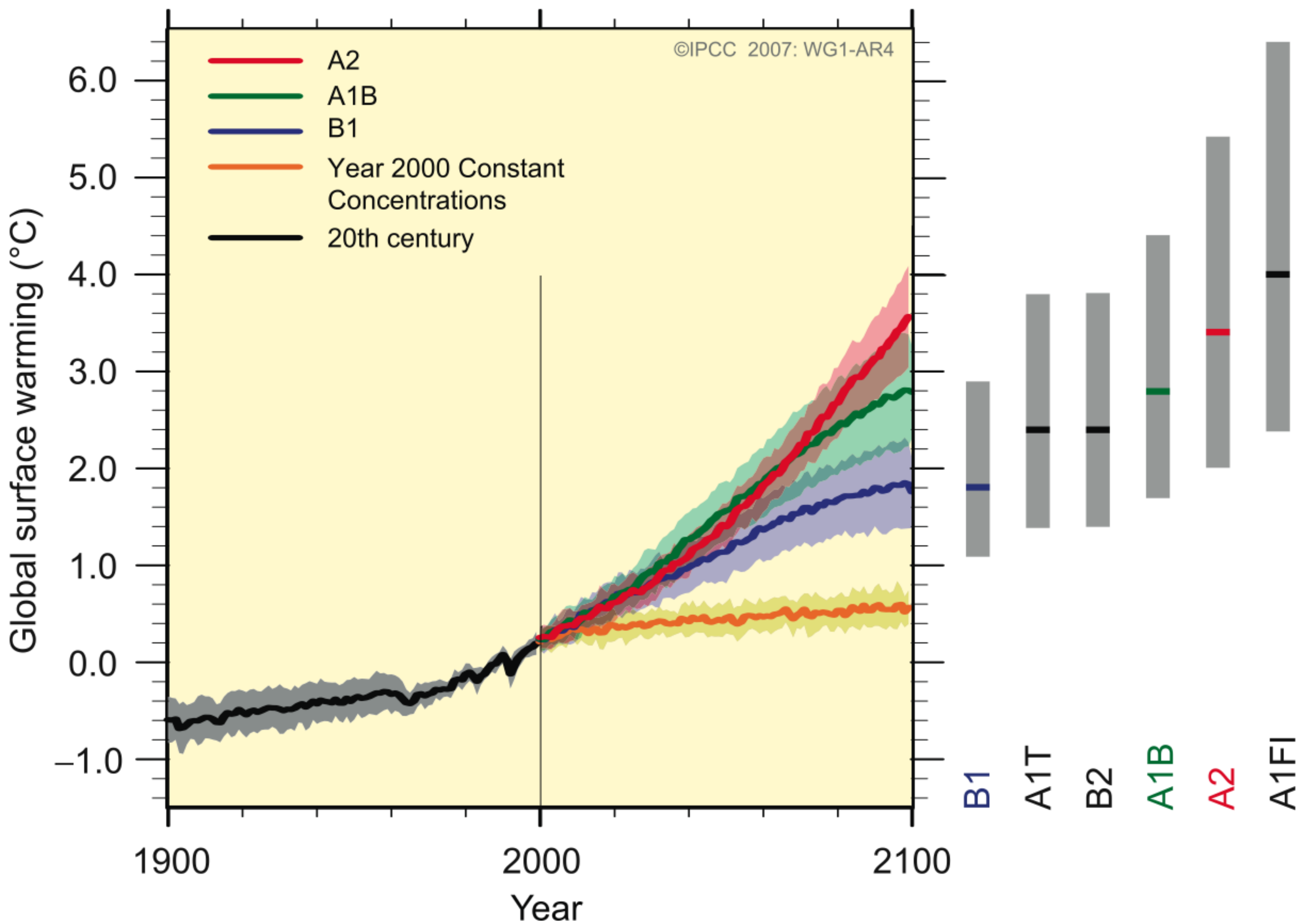


Figure 3 — Schematic depiction of the steps involved in the production of climate change information usable for impact assessment work via regionalization methods

Source: Giorgi (2008)

- 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





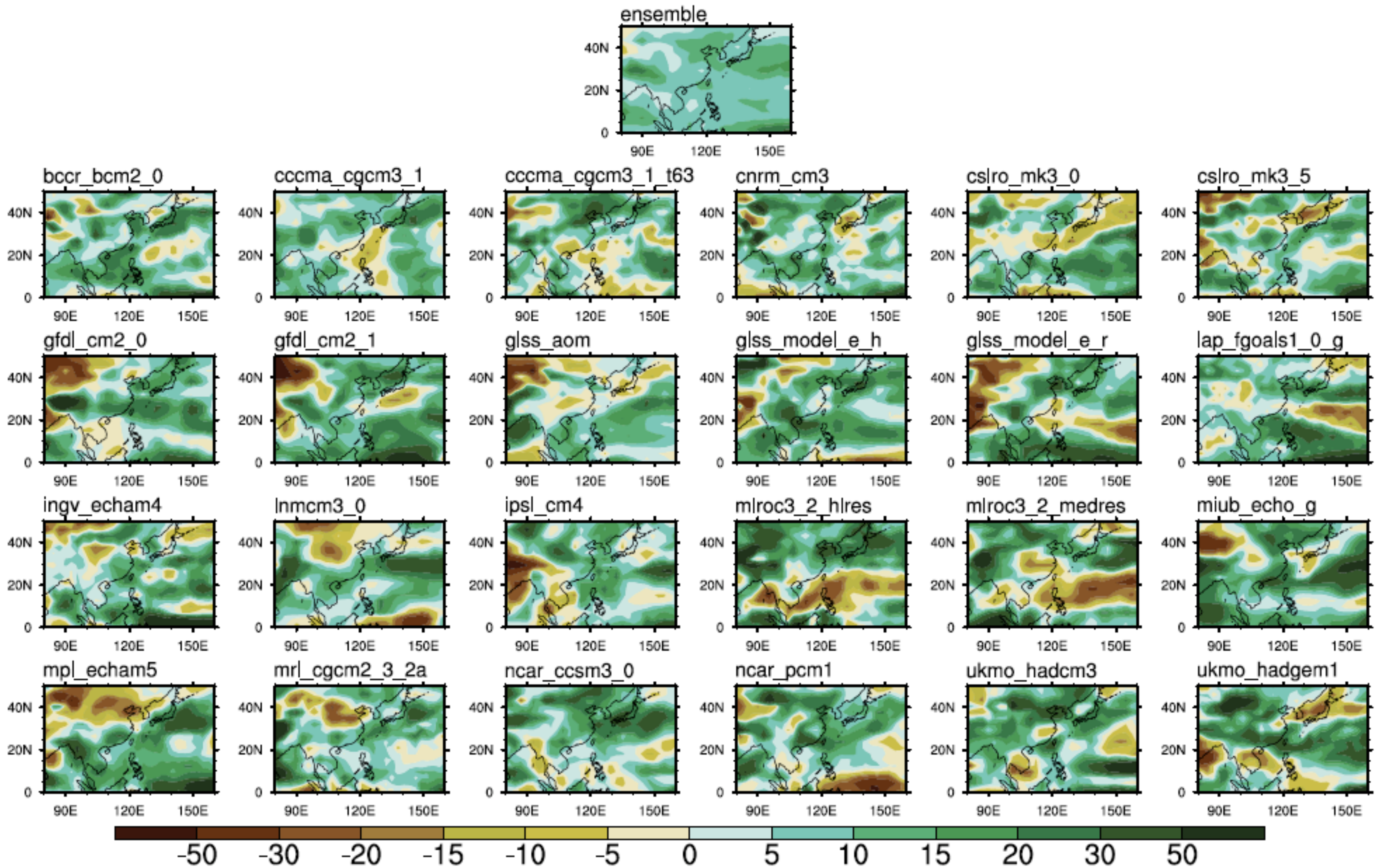
Keep the uncertainty

- 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

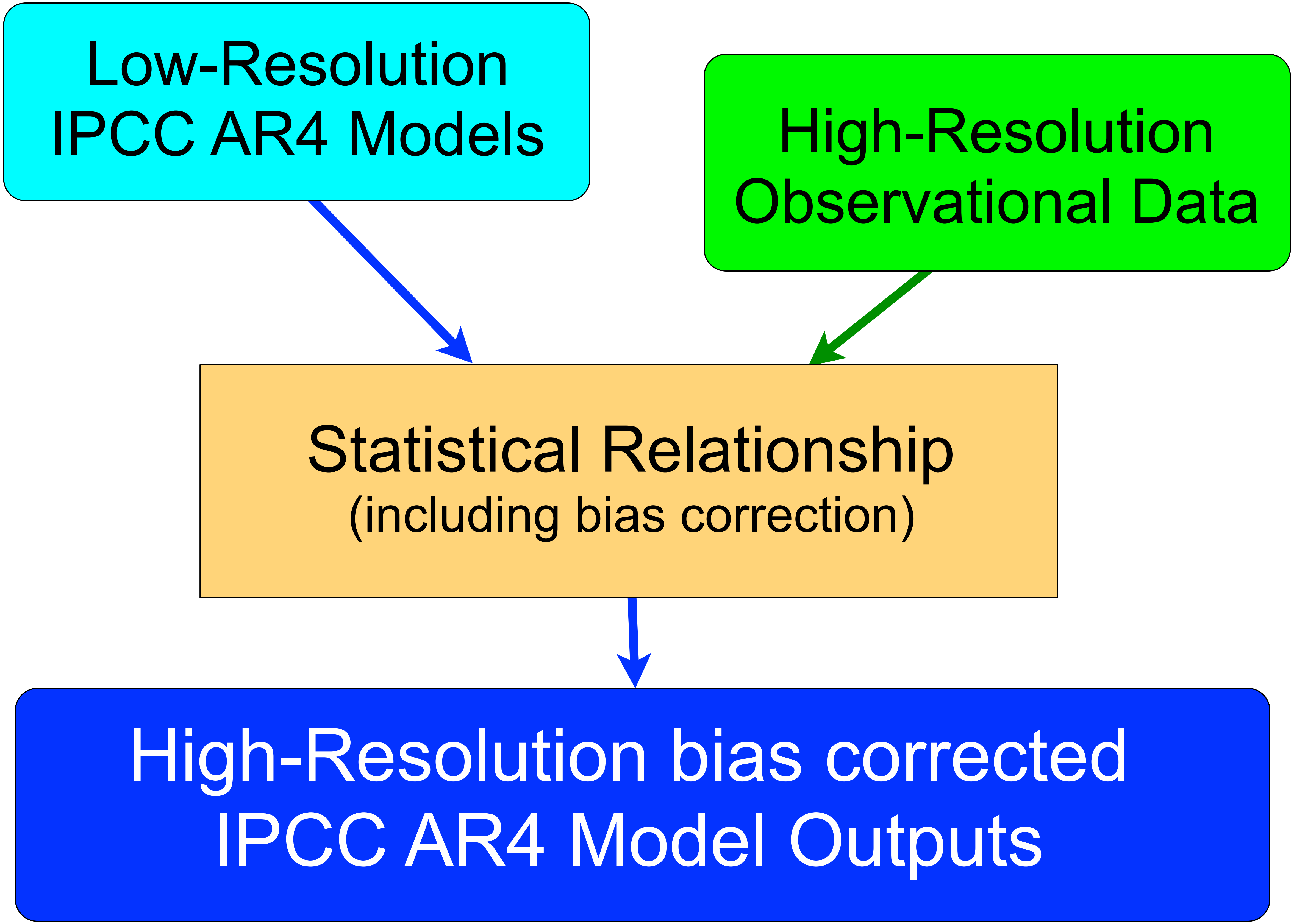
Including all scenarios and all models for future climate projection

Uncertainty from Global Climate Models

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



(Dynamical-) Statistical Downscaling



(Dynamical-) Statistical Downscaling

Simple Statistical Downscaling:
Bias Correction Spatial Downscaling (BCSD)

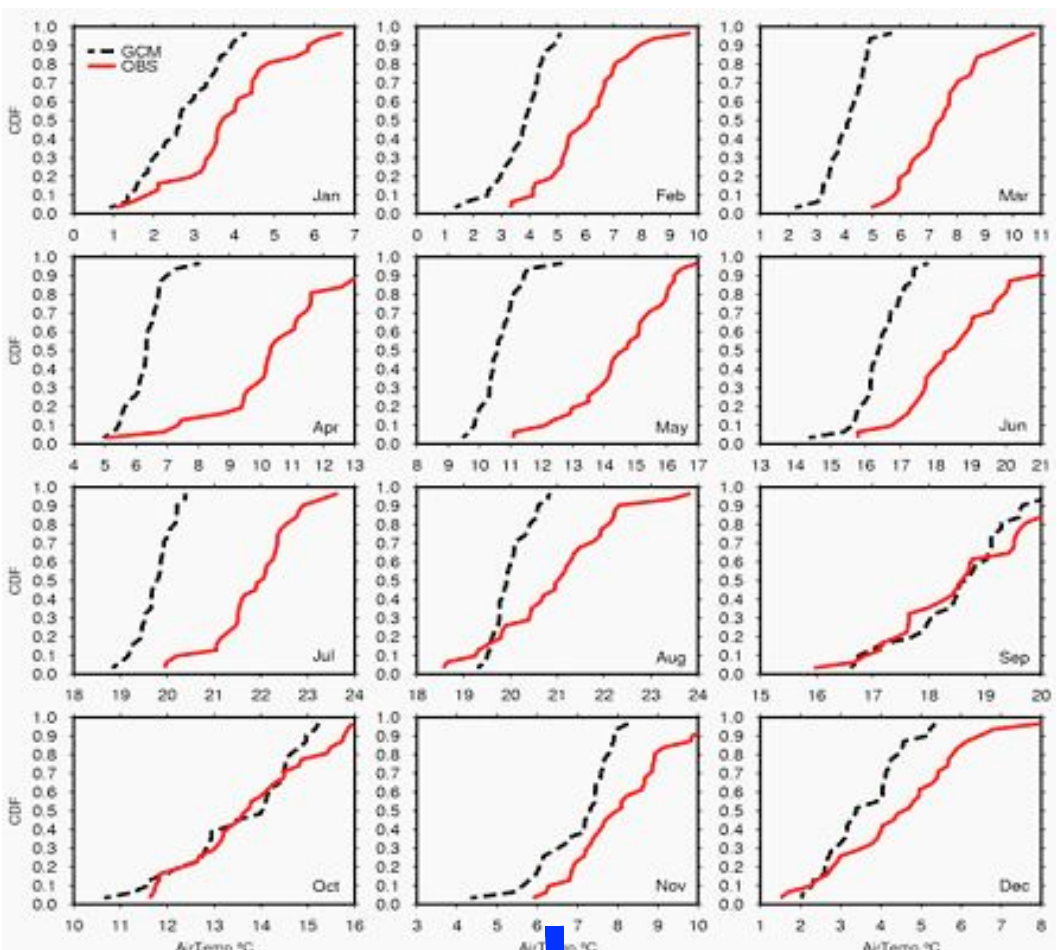
Wood et al. 2004, and Maurer 2007

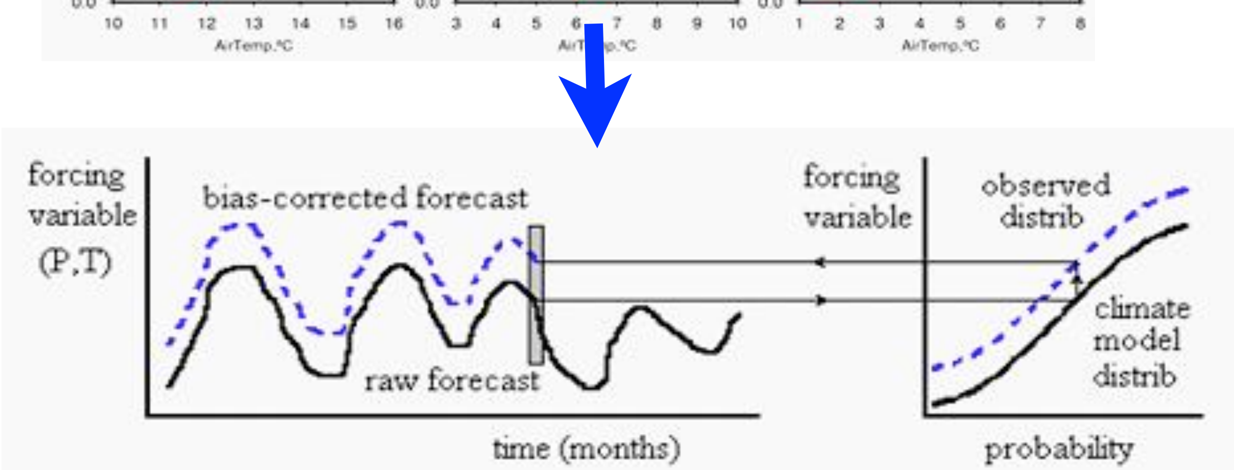
- Aggregate gridded OBS to GCM resolution
- Remove trend (if the trend is significant)
- Generate CDF of observed and GCM data
    - Q-Q mapping approach
    - limitation on extrapolation
- Add trend back in
- Resample/interpolate to finer resolution
- Apply spatial factor to account for subgrid topography

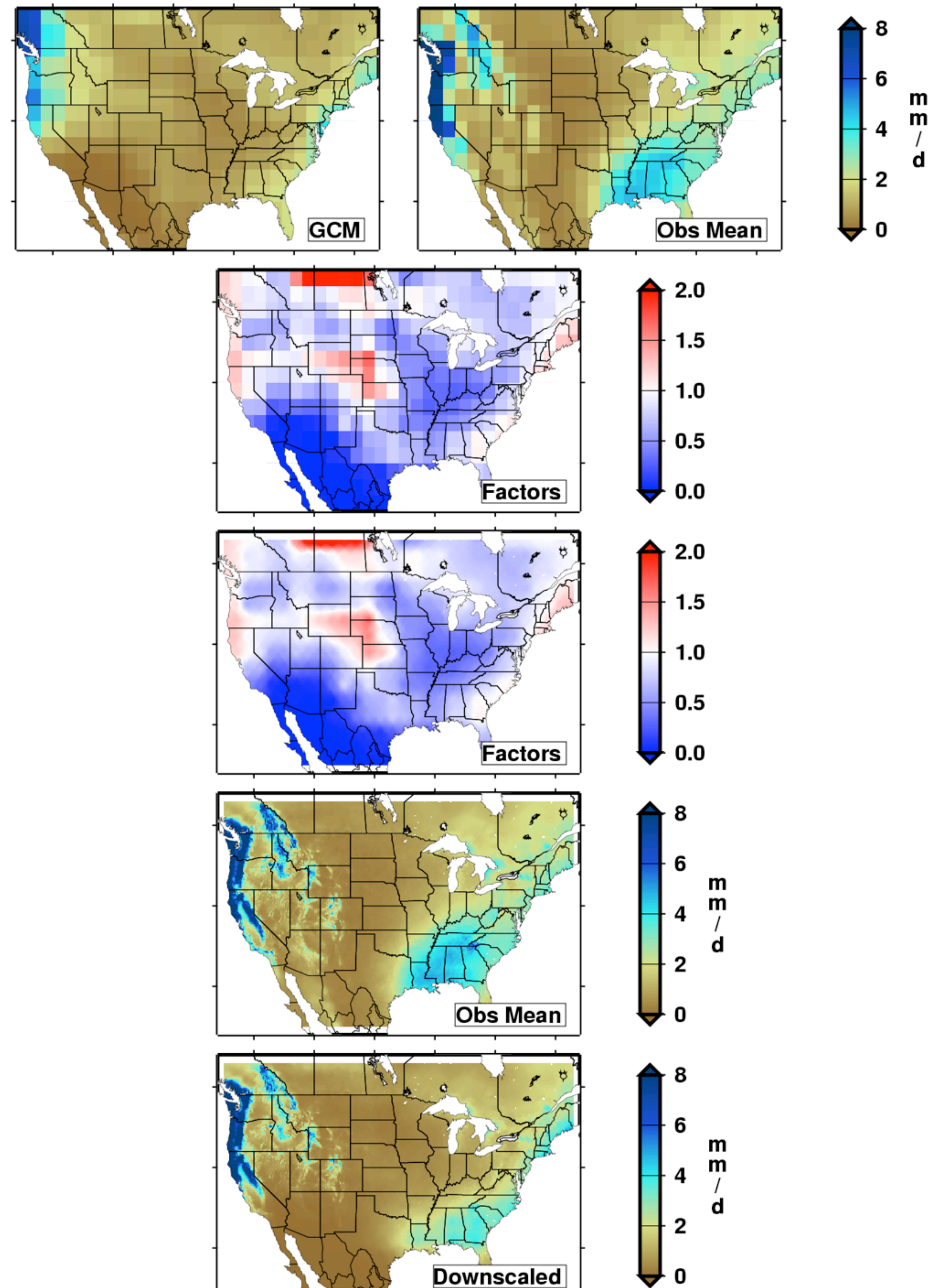
(Dynamical-) Statistical Downscaling

Statistical downscaling and bias correction by cumulative distribution function and interpolation

Wood et al. 2004, and Maurer 2007



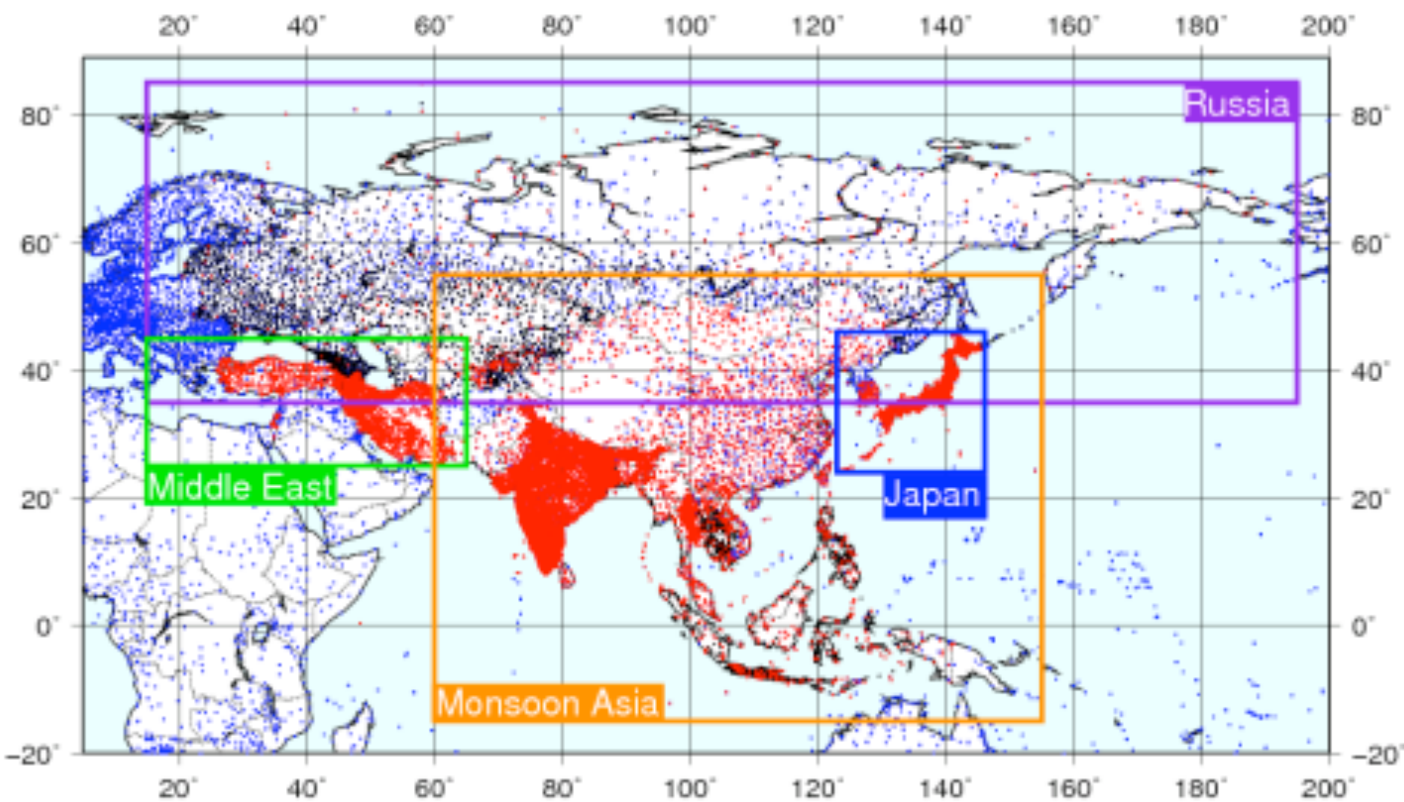




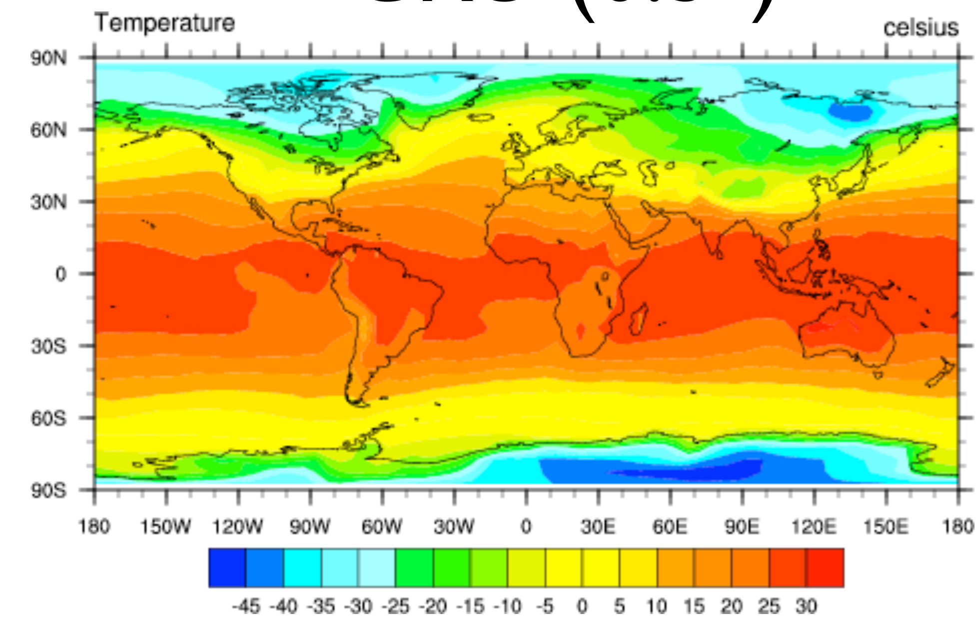
%

Require long-term high-resolution observations

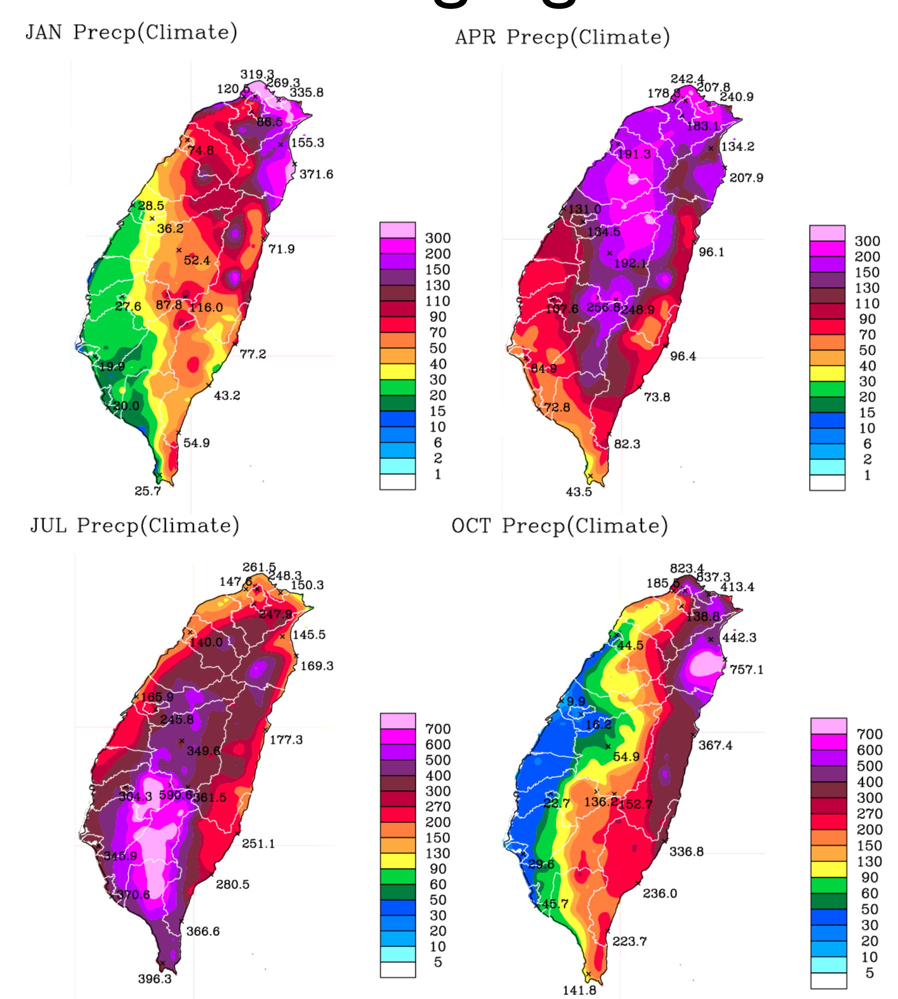
APHRODITE (0.25°)



CRU (0.5°)



Automatic rain gauges in Taiwan



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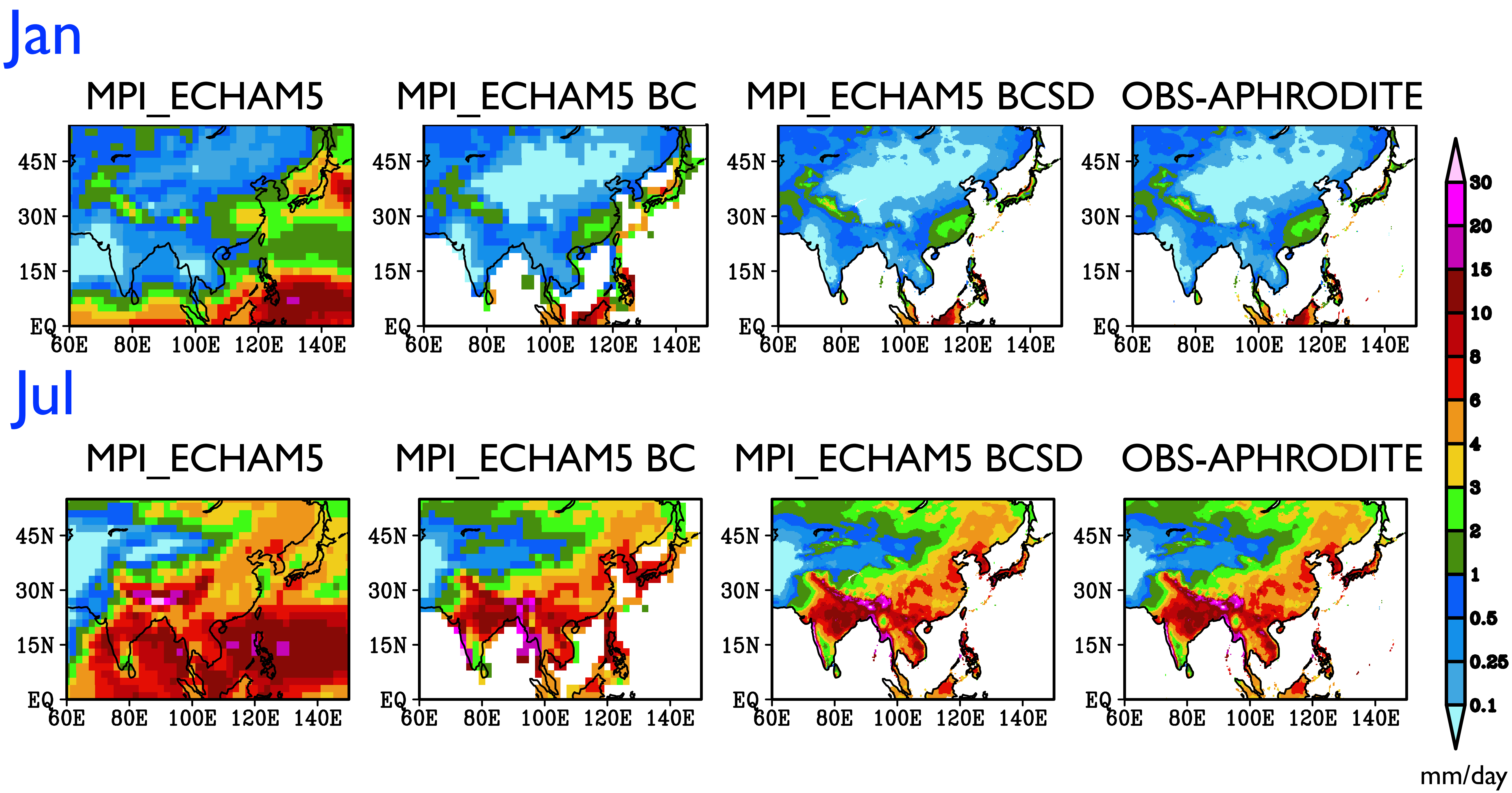
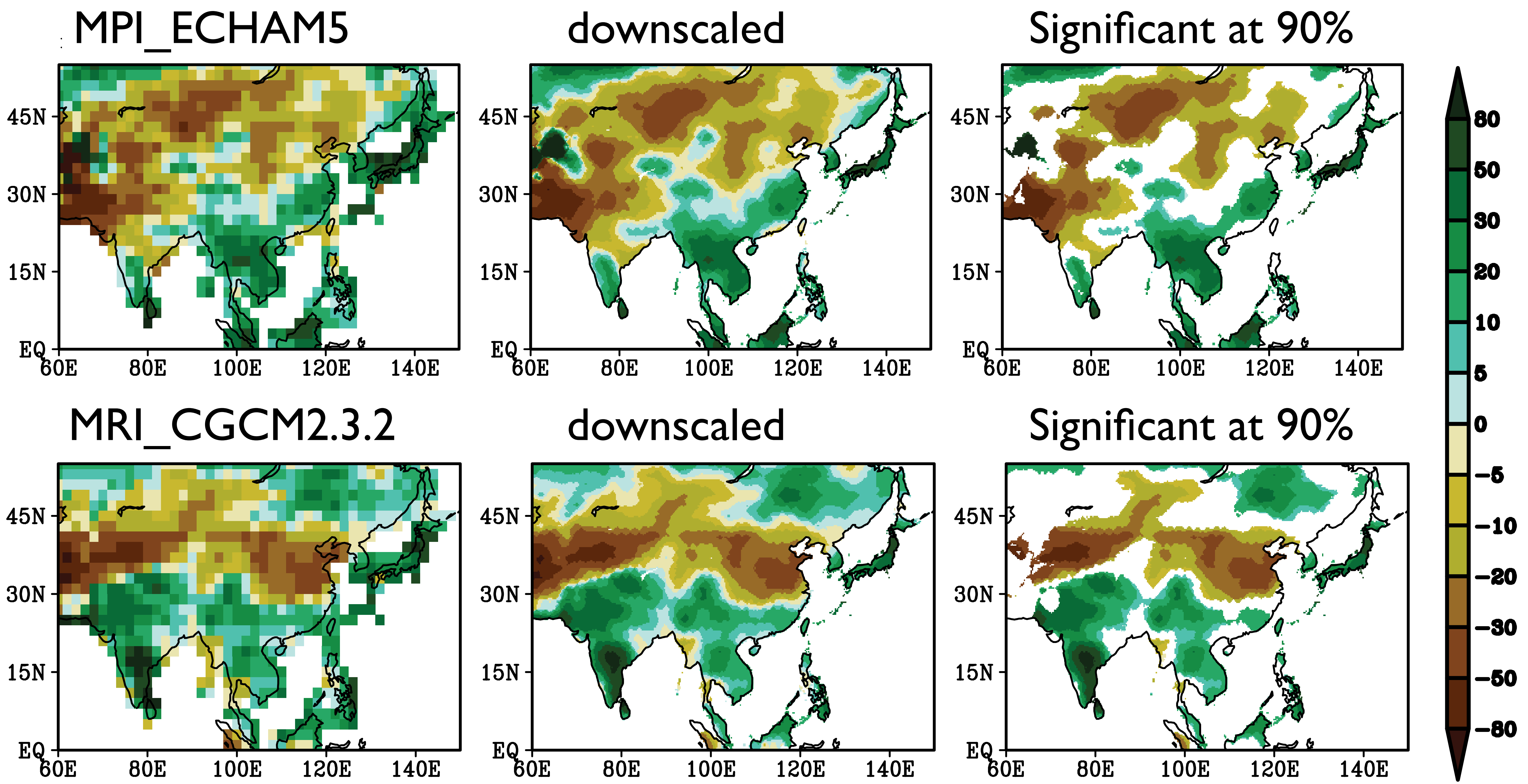
Name	Domain	Resolution	Period
Monsoon Asia (MA)	60°E-150°E, 15°S-55°N	0.5° and 0.25°, daily	1951-2007
Middle East (ME)	15°E-65°E, 25°N-45°N		
Russia (RU)	15°E-165°W, 34°N-84°N		

Validation

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

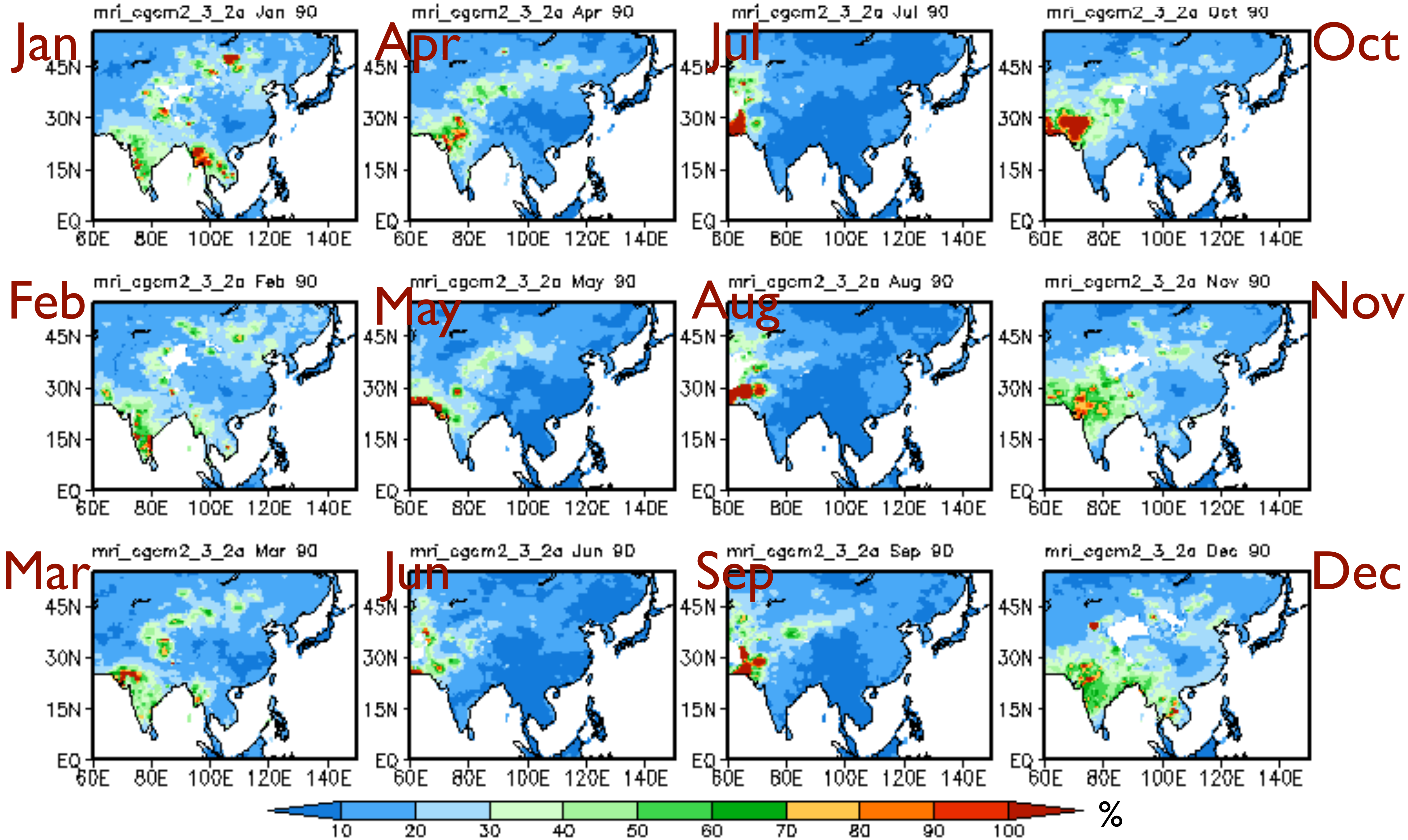


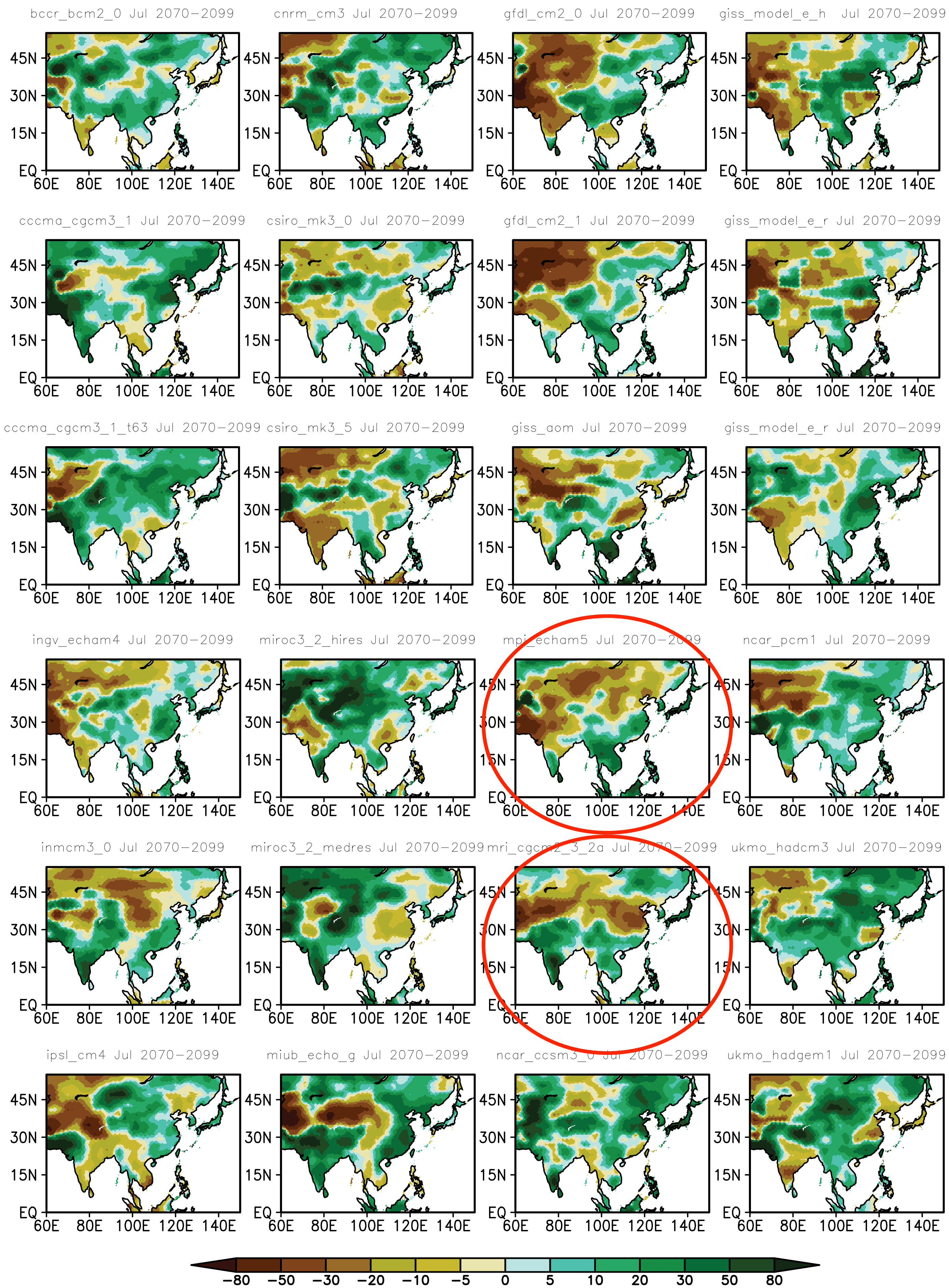
- Projected future(2070-2099) change(%) in July precipitation
- Downscaling projected change to 0.25° resolution
- Significant test on the downscaled change by bootstrapping 30 out of 40 years data from present climate



- 90th percentile of downscaled error estimate from bootstrapping 30 out of 40 years data from present climate
- Typically less than 10% error with regional monthly rainfall more than 2 mm/day

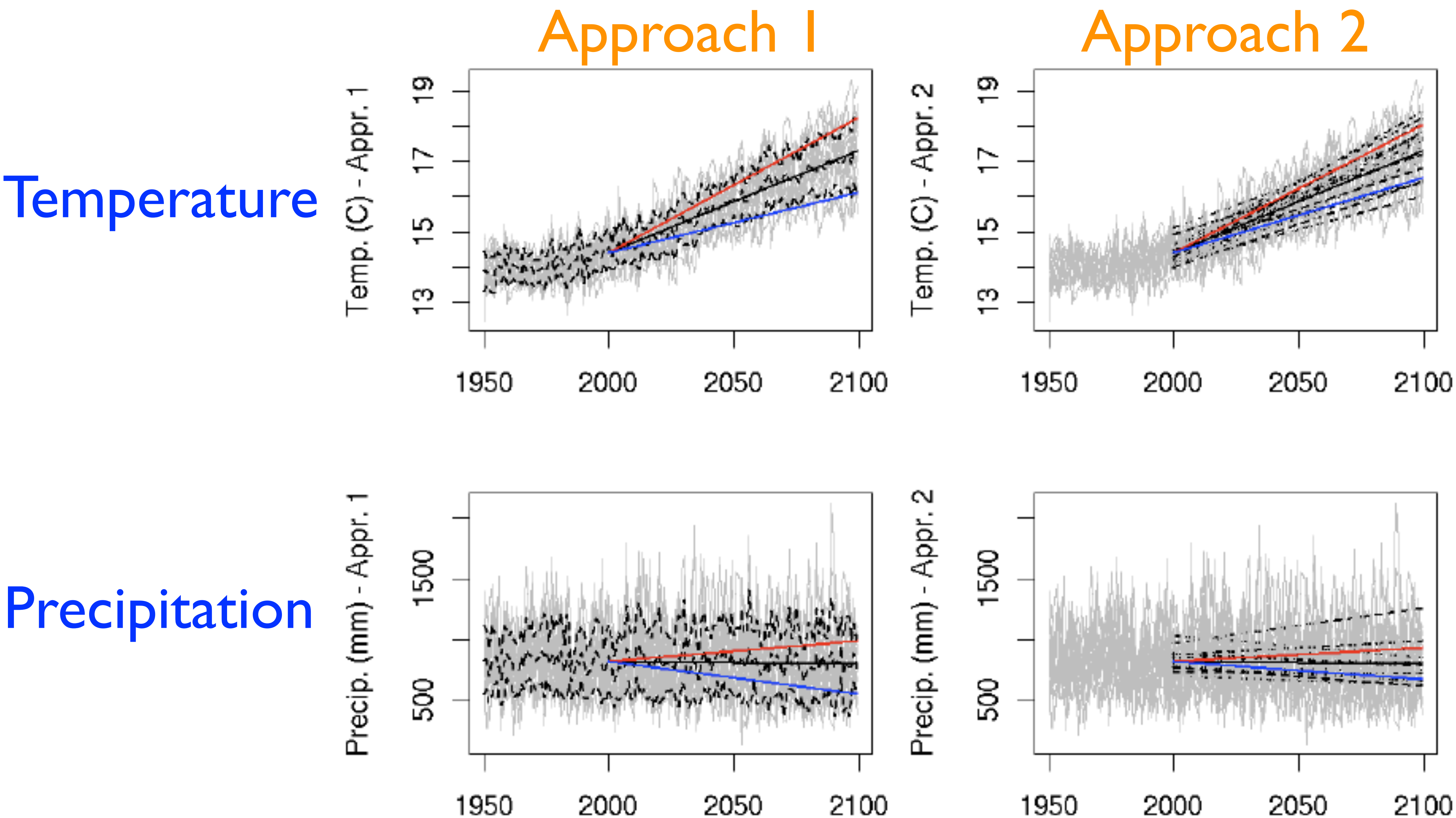
MRI_CGCM2.3.2





- Downscaled projected future(2080-2099) precipitation change(%) in July of 24 IPCC AR4 AOGCMs to 0.25° resolution under A1B scenario
- How to deal with model uncertainty?

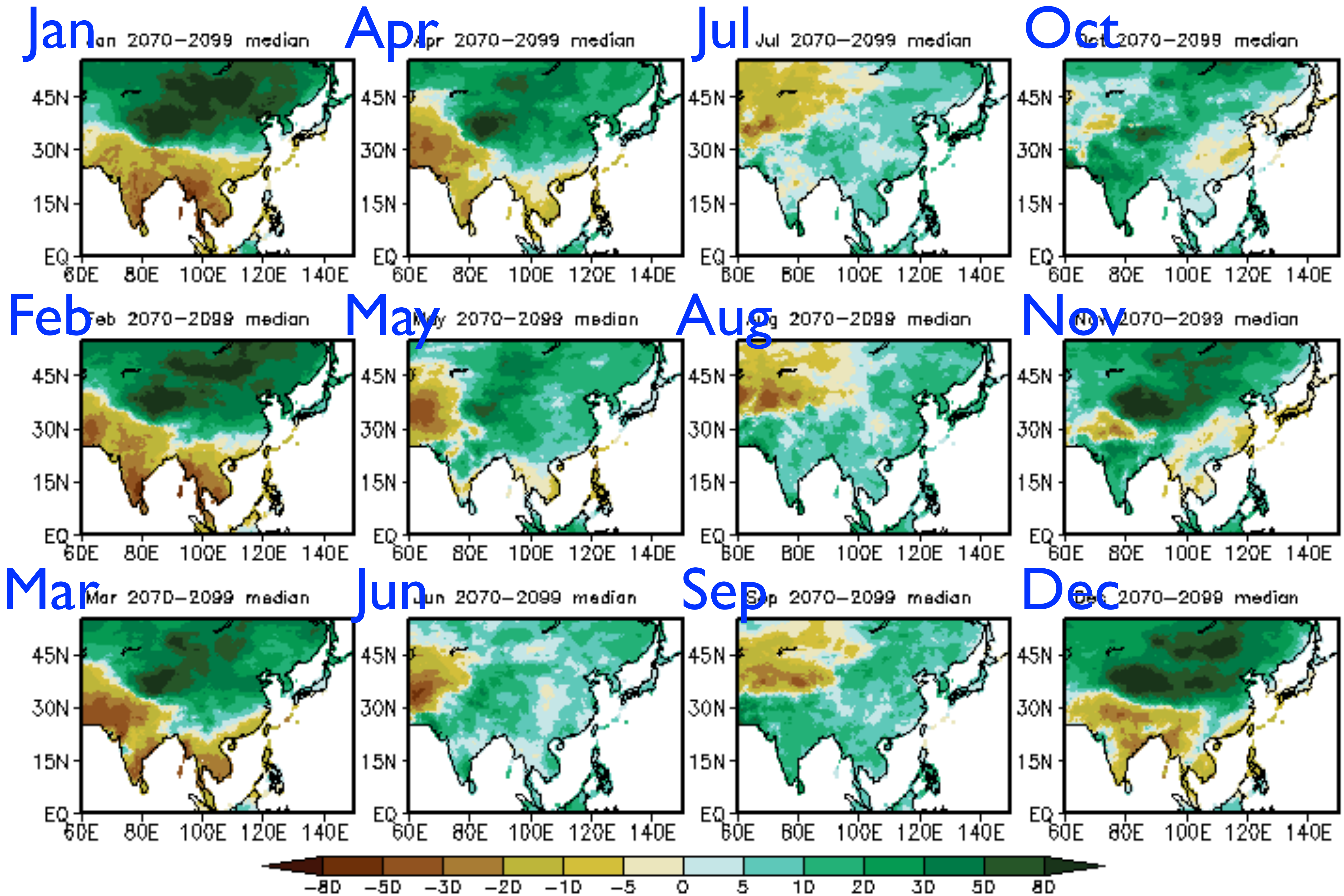
Approaches to describe the uncertainty from local model responses



Loarie et al. (2009)

Figure S6| Comparison of temporal gradients using two approaches for a single pixel in California.

Model Median Future Change in Precipitation (%)
(more likely than not)

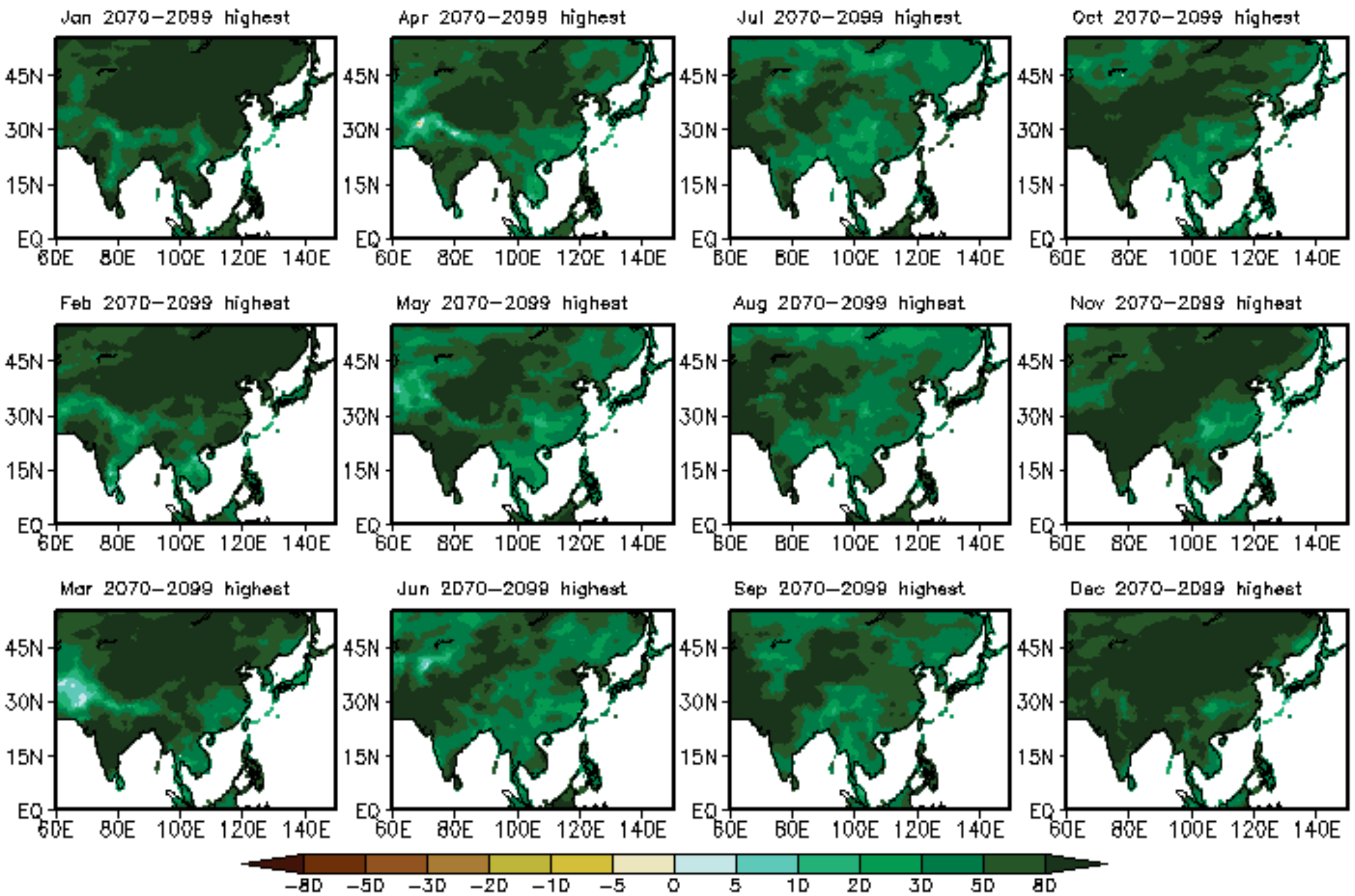


Model Maximum

Future Change in Precipitation (%)

(from January to December)

(extreme unlikely to have future increase more than)

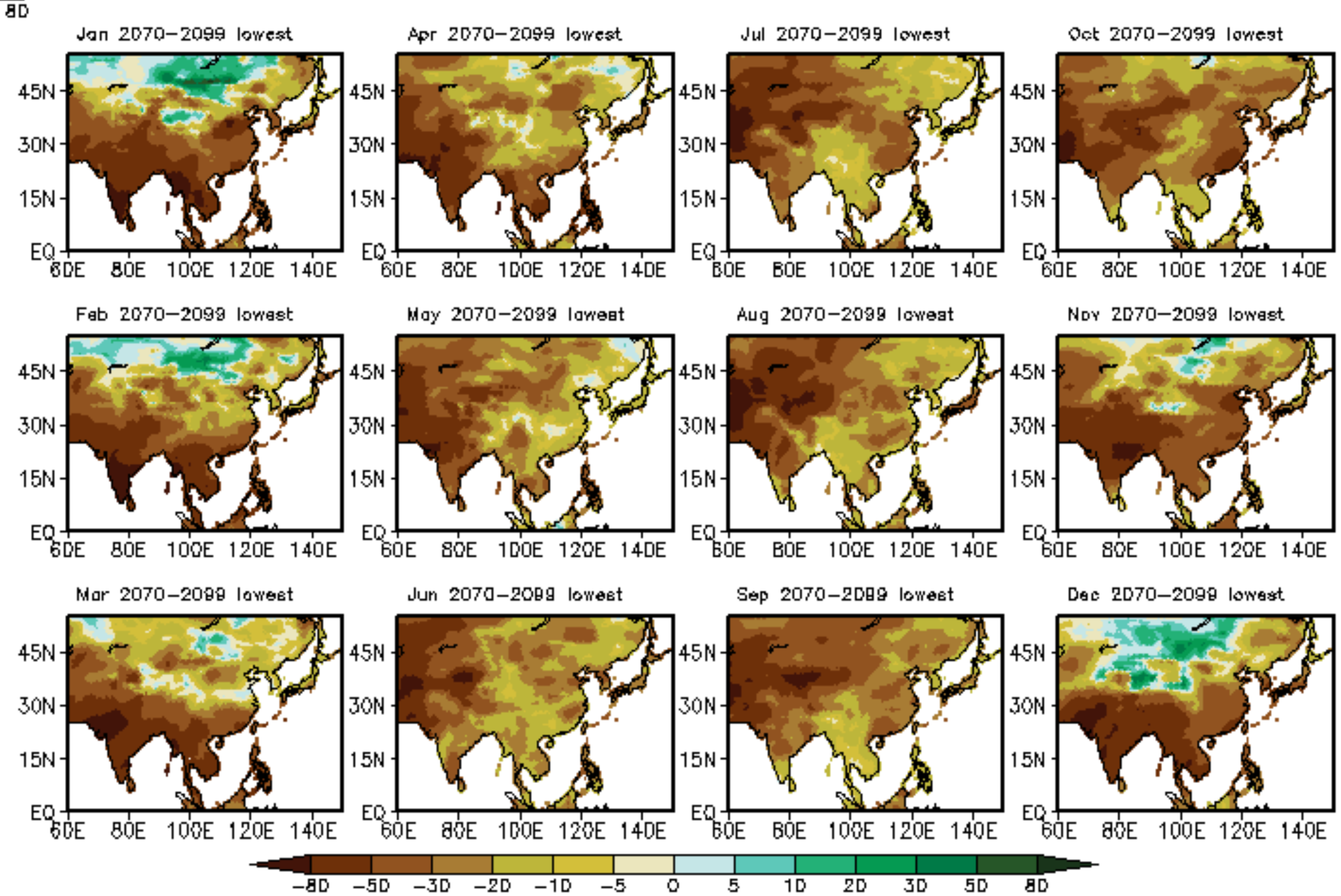


Model Minimum

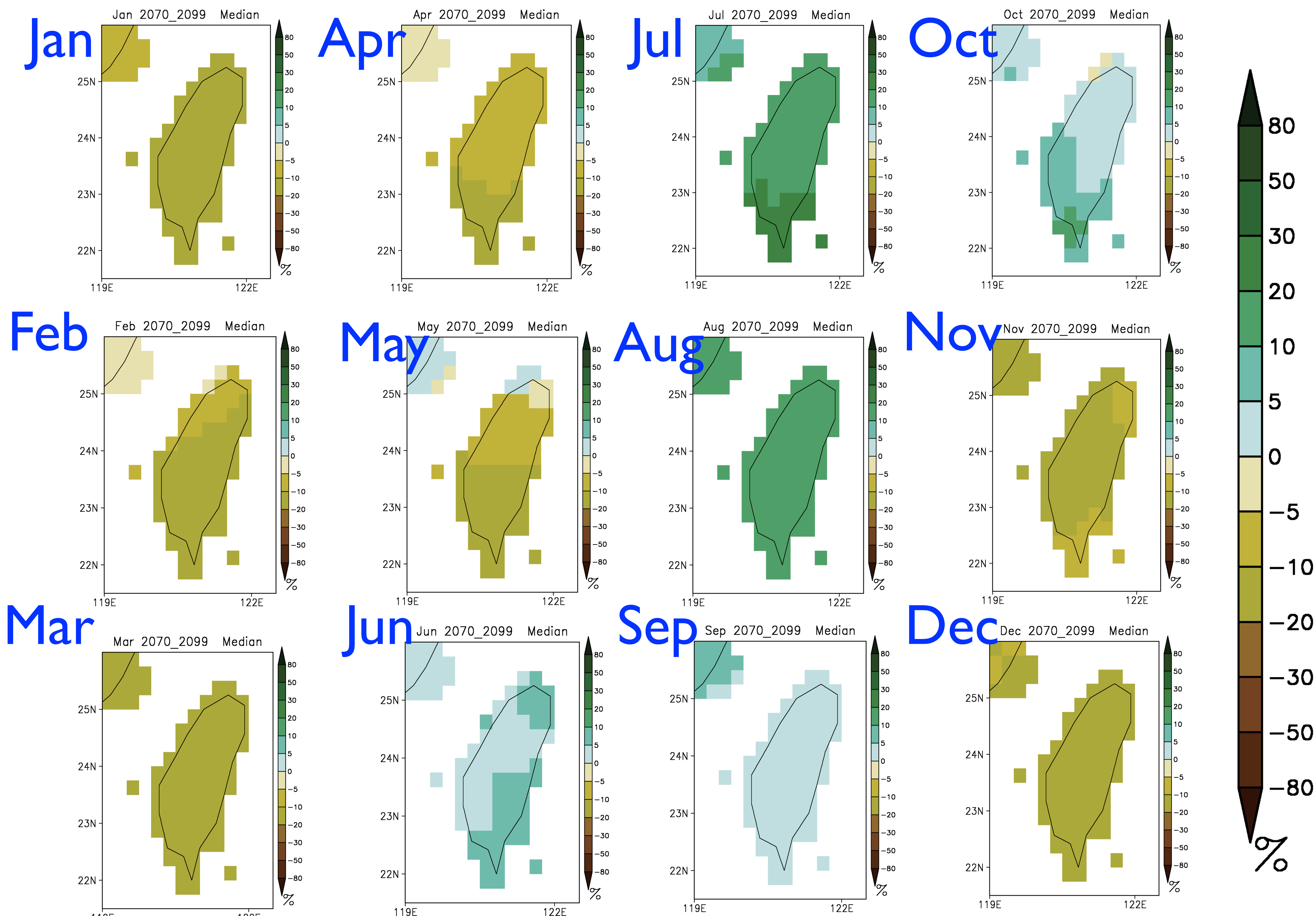
Future Change in Precipitation (%)

(from January to December)

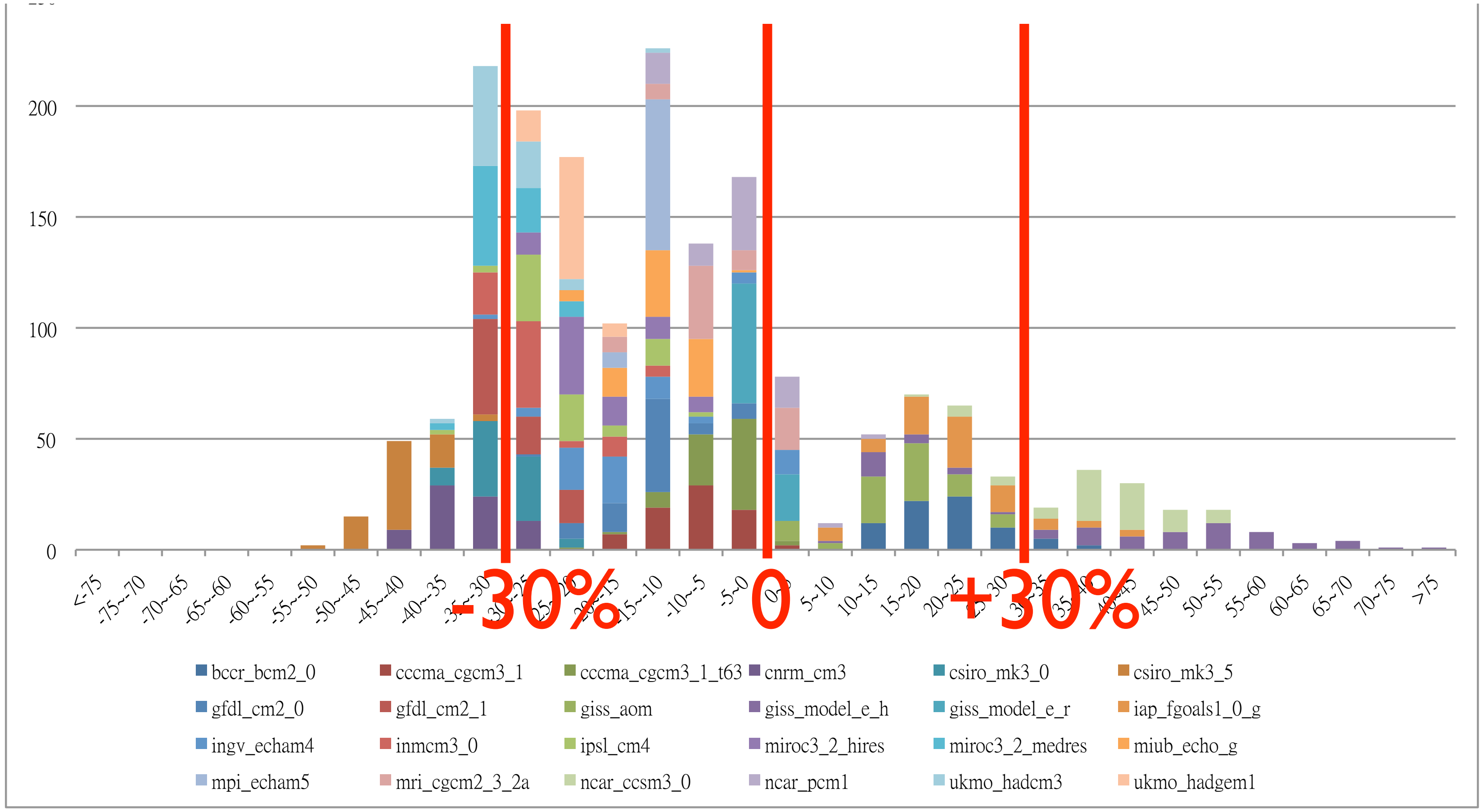
(extreme unlikely to have future decrease more than)



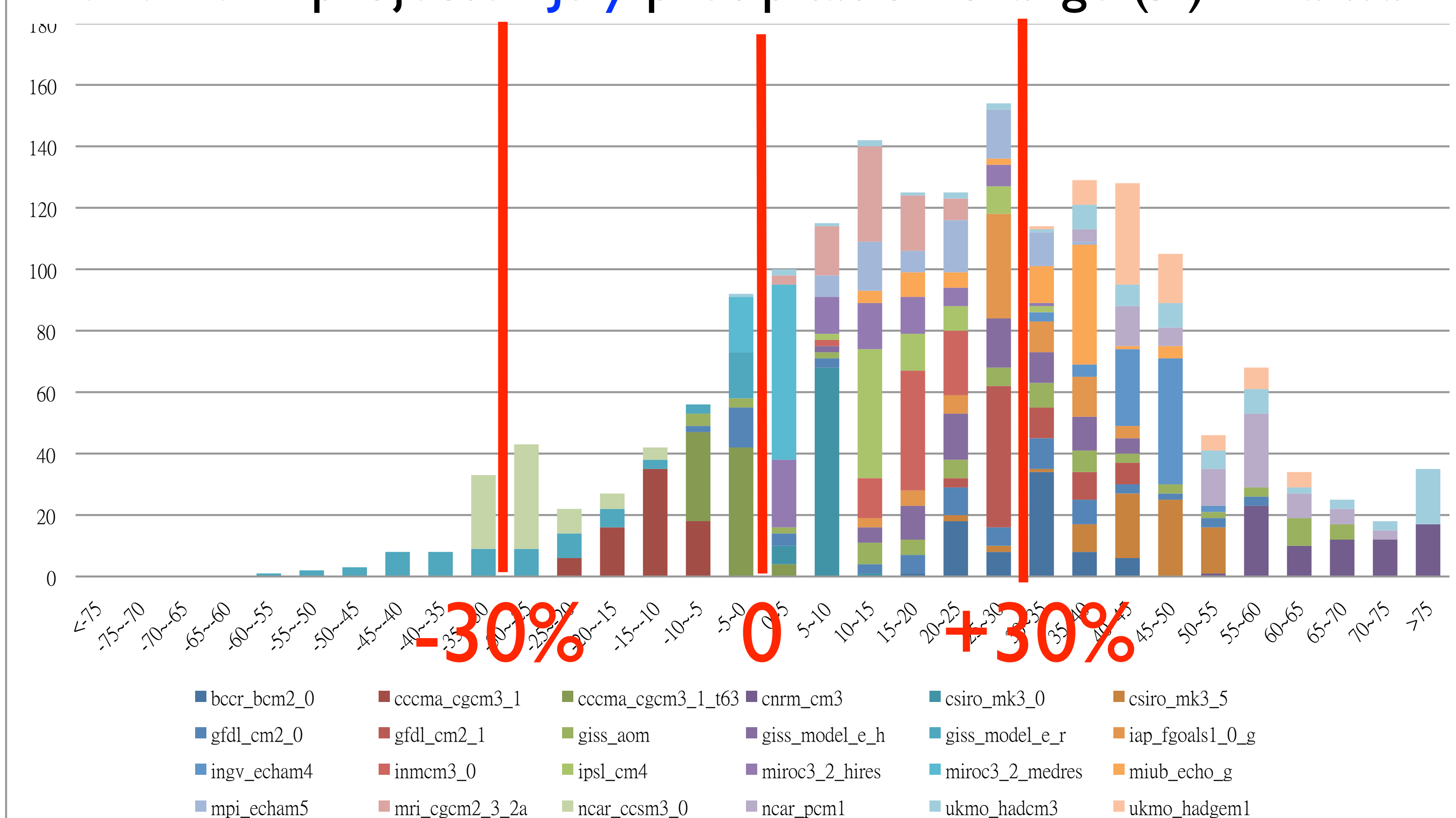
Model Median Future Change in Precipitation (%)



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

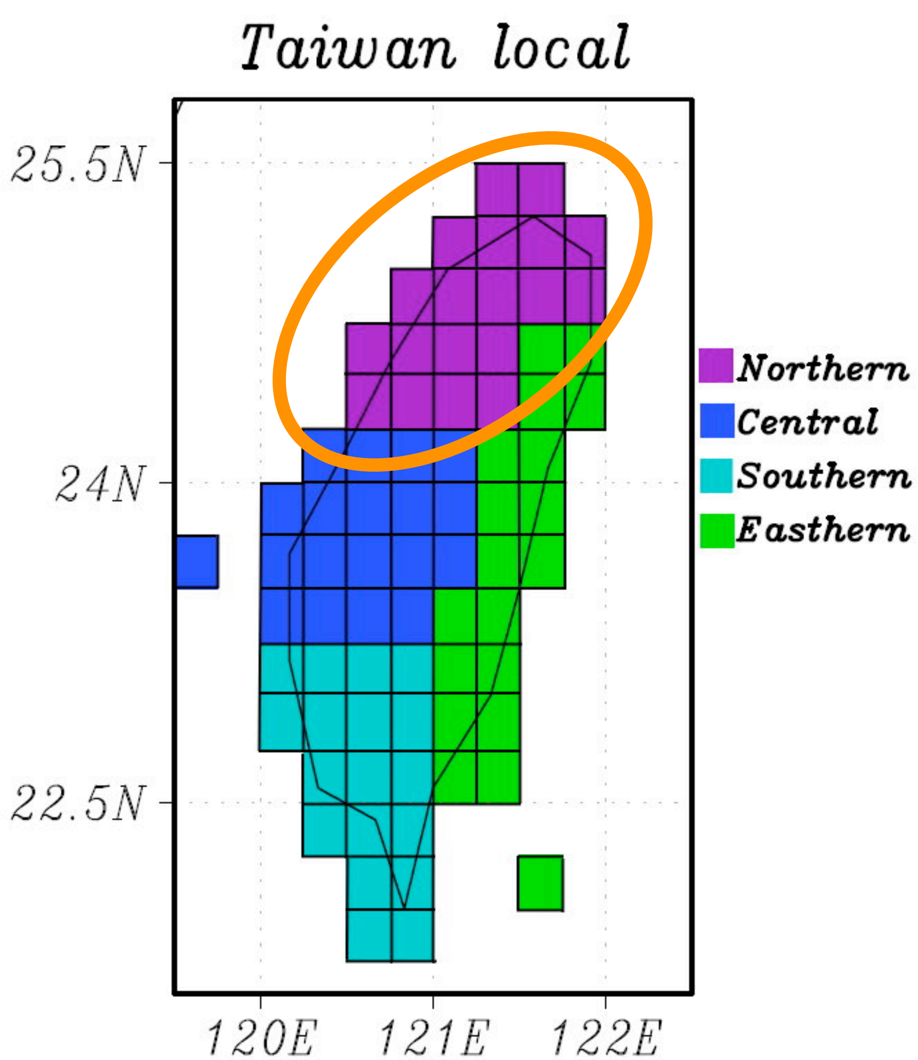


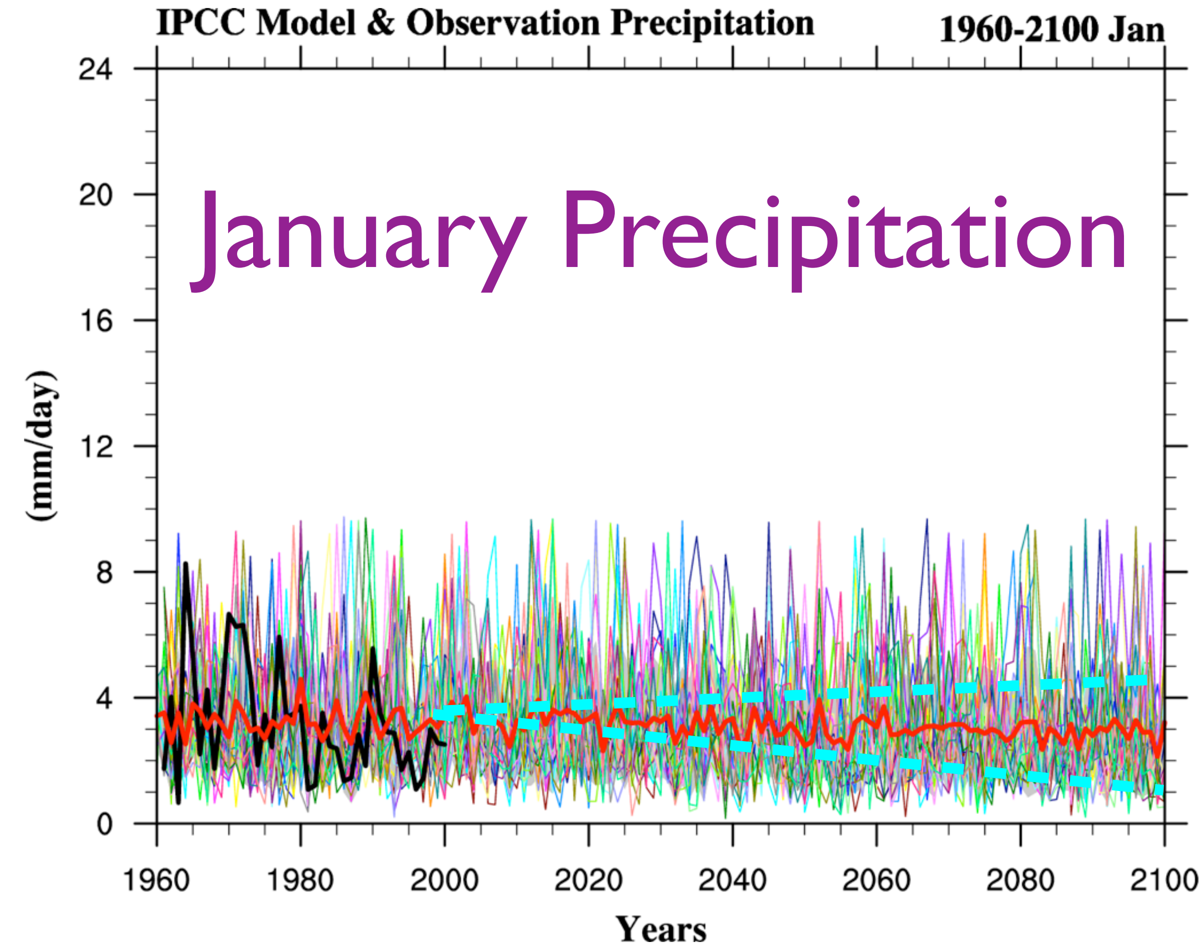
2070-2099 projected July precipitation change (%) in Taiwan

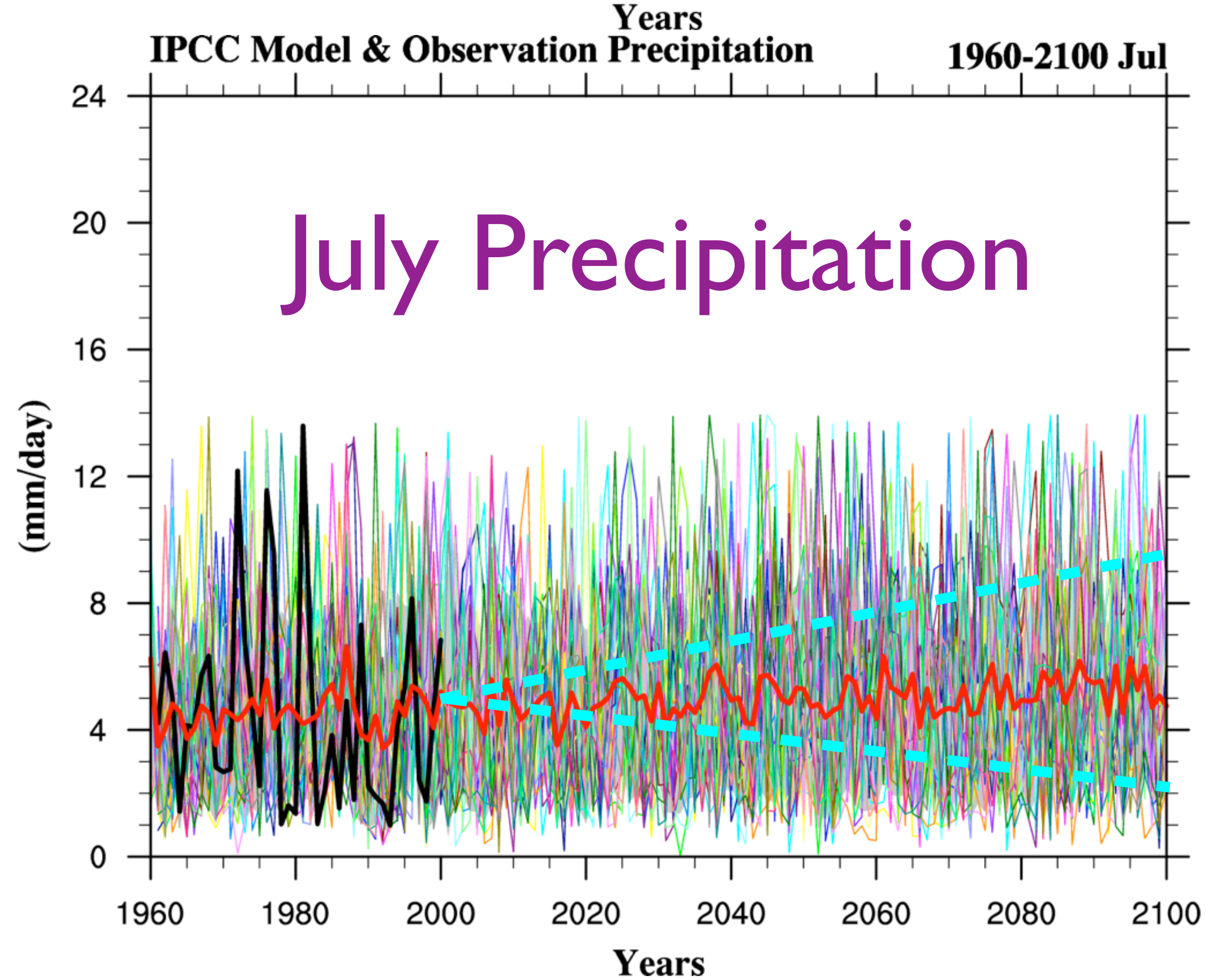


- One can also focus on area of interests and construct PDF for projected future precipitation from all models (Taiwan: 75 grids x 24 models)
- Ensemble of opportunity (probability)

Northern Taiwan Area Mean Time Series (1960-2100)







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

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 can 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

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