Regionalization of the IPCC AR4 Climate Change Projections over Taiwan: From Climatic Mean to Extreme Indices

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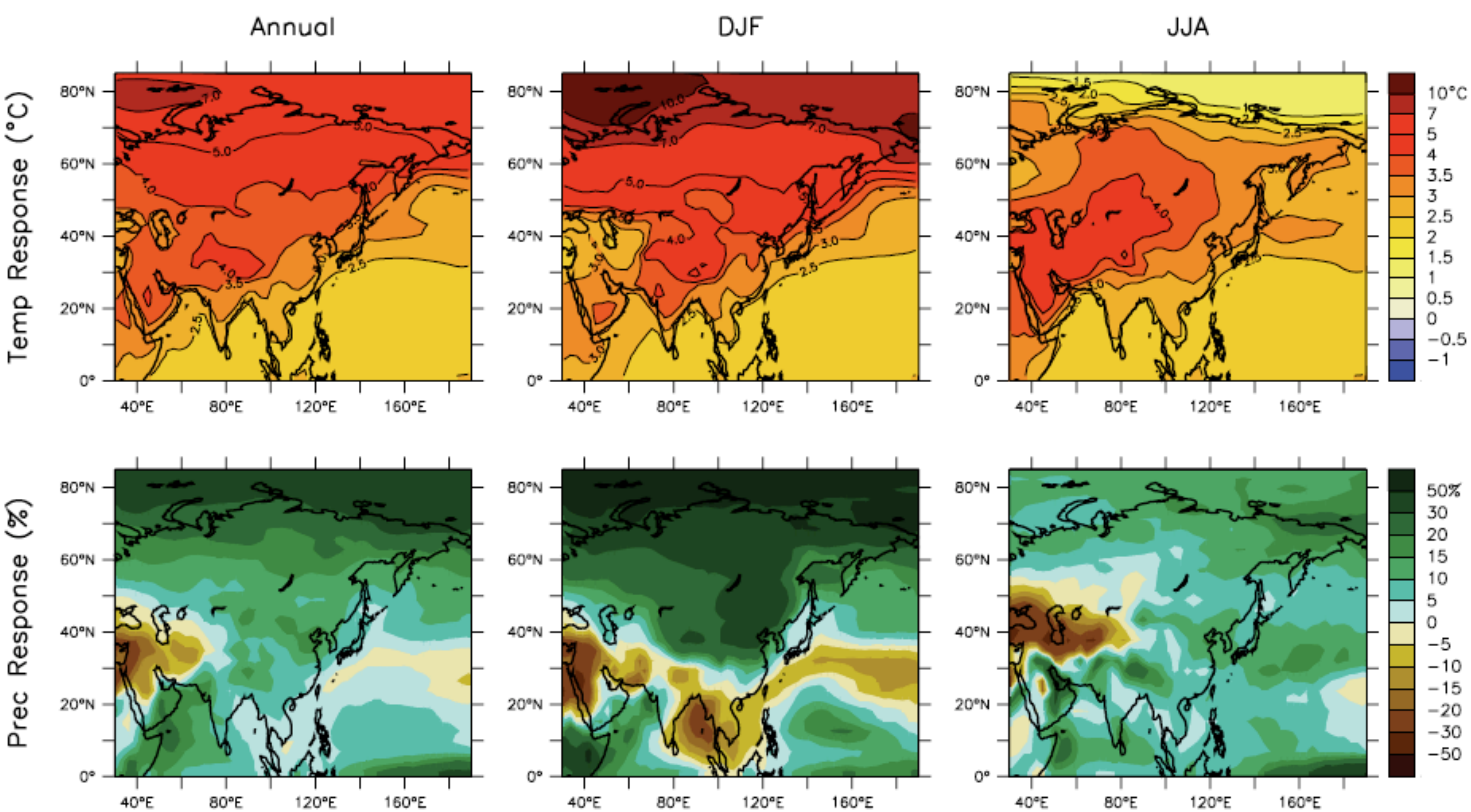
A1B scenario



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

Why downscaling?

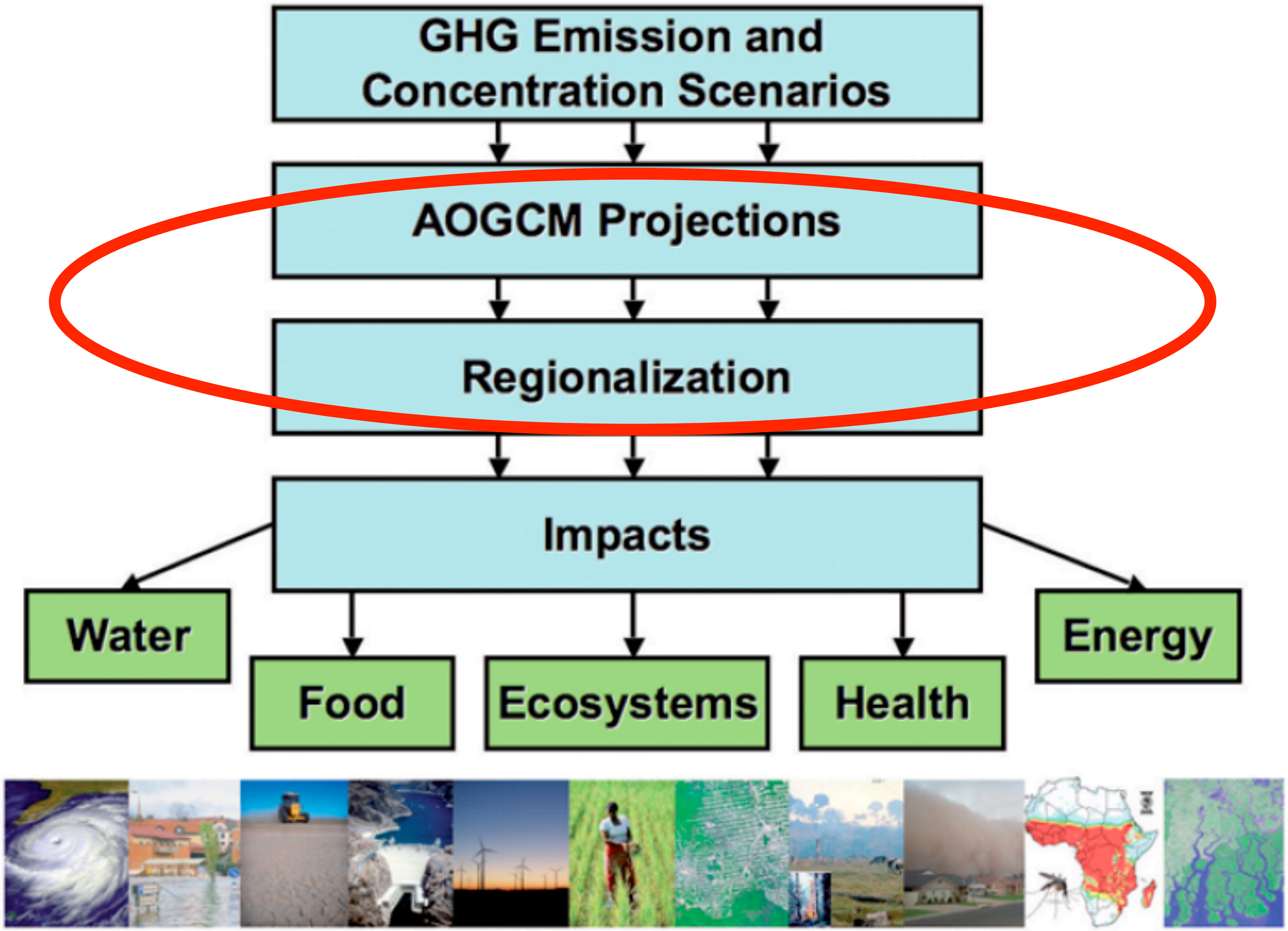
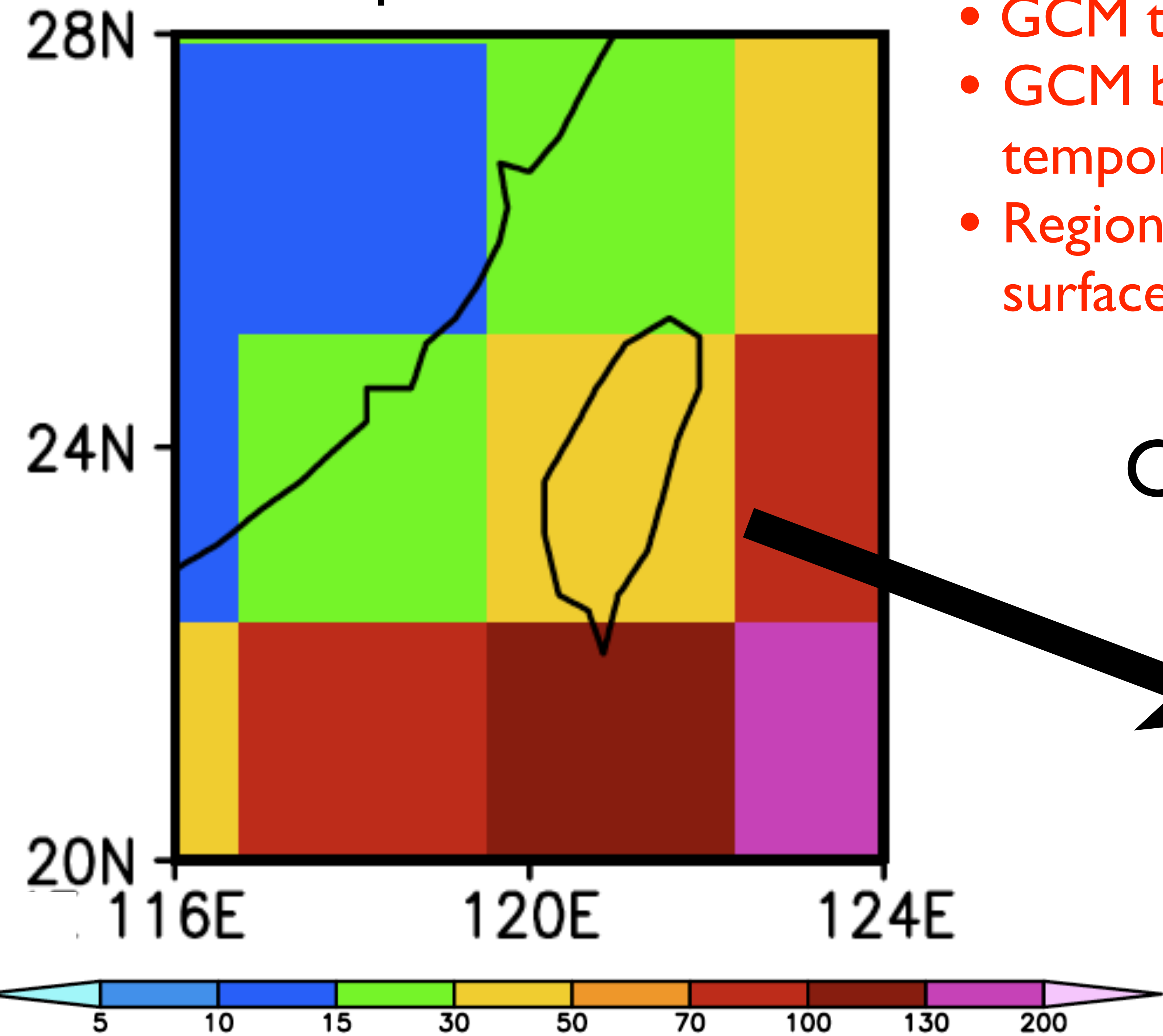


Figure 3 — Schematic depiction of the steps involved in the production of climate change information usable for impact assessment work via regionalization methods

Source: Giorgi (2008)

Why downscaling?

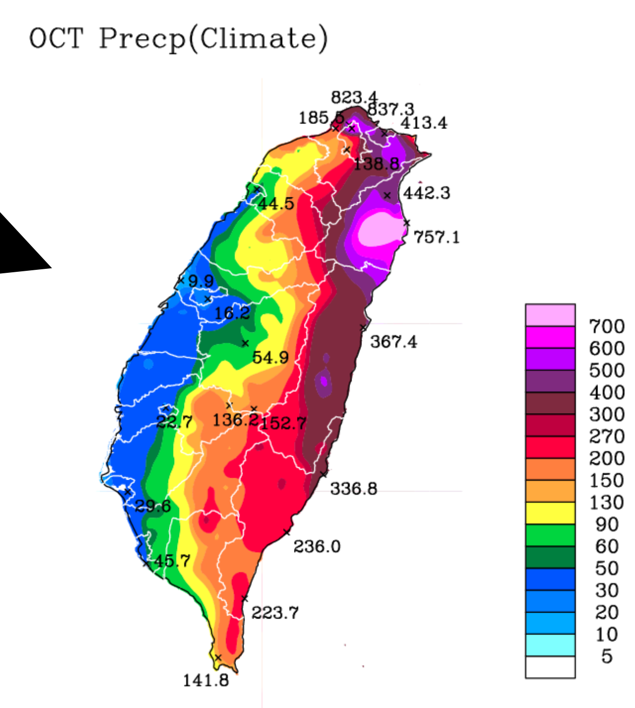
GCM (~300 km)
Precipitation October



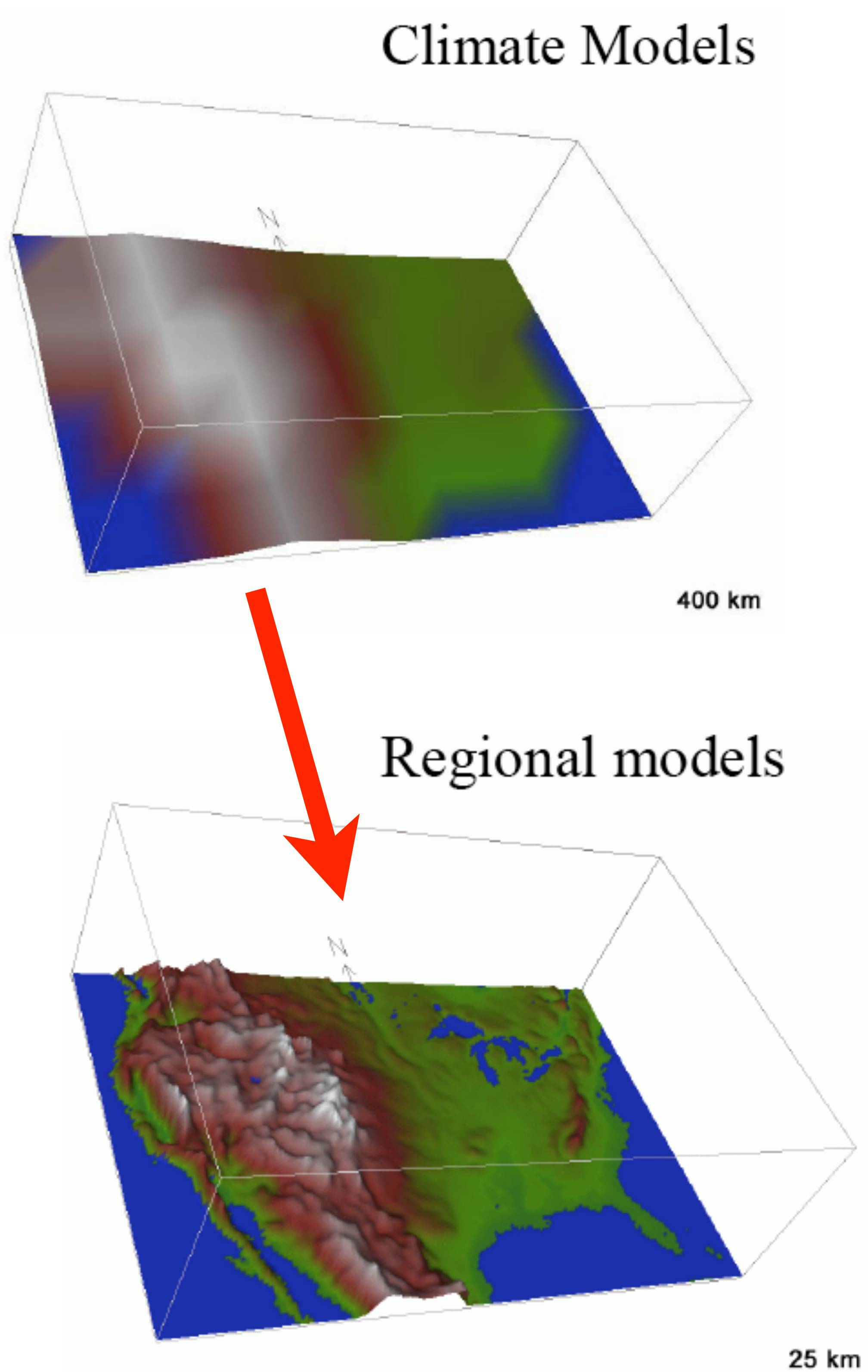
Problems:

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

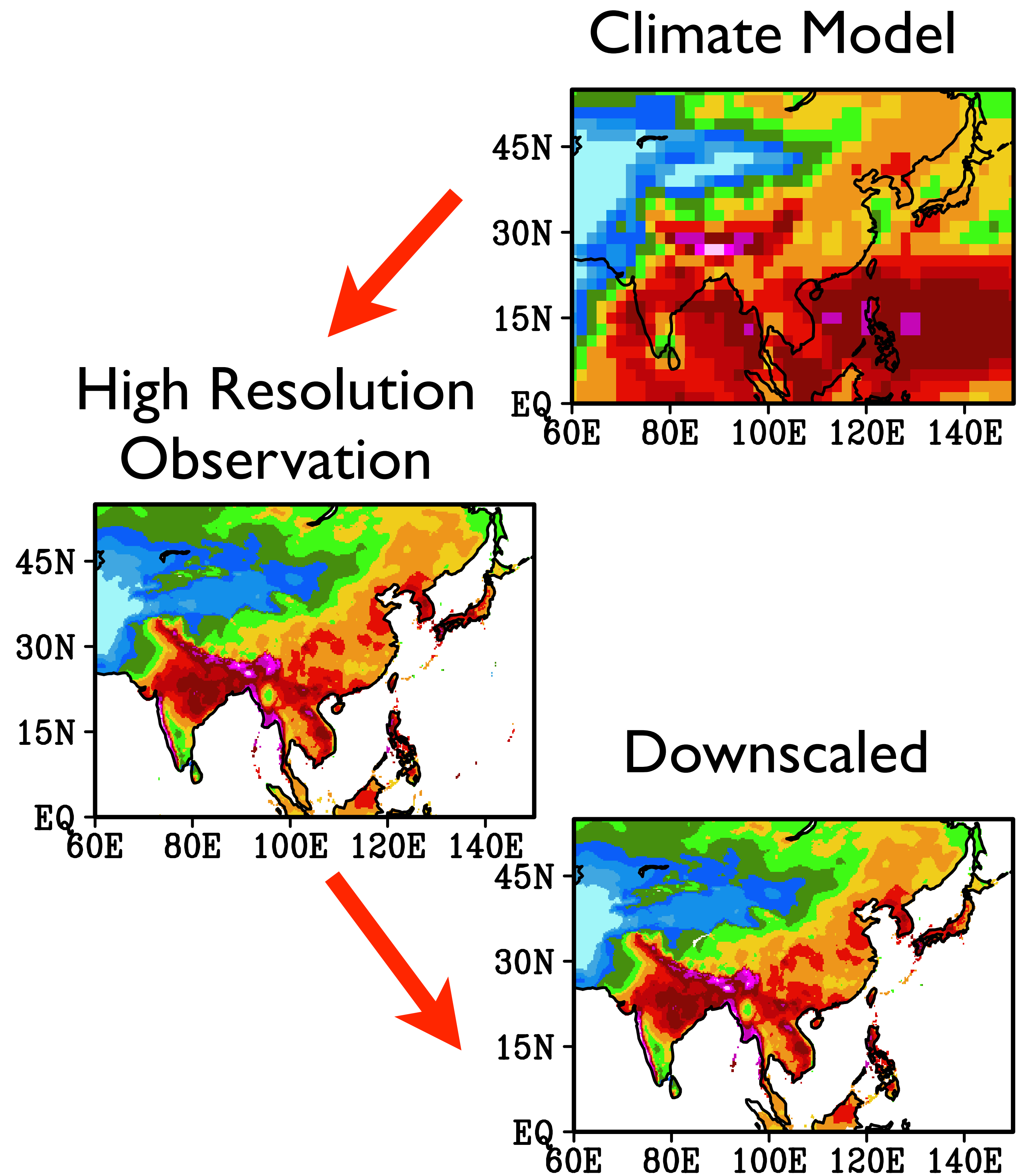
Observation (~5km)



Dynamical Downscaling



Statistical Downscaling



Why statistical downscaling?

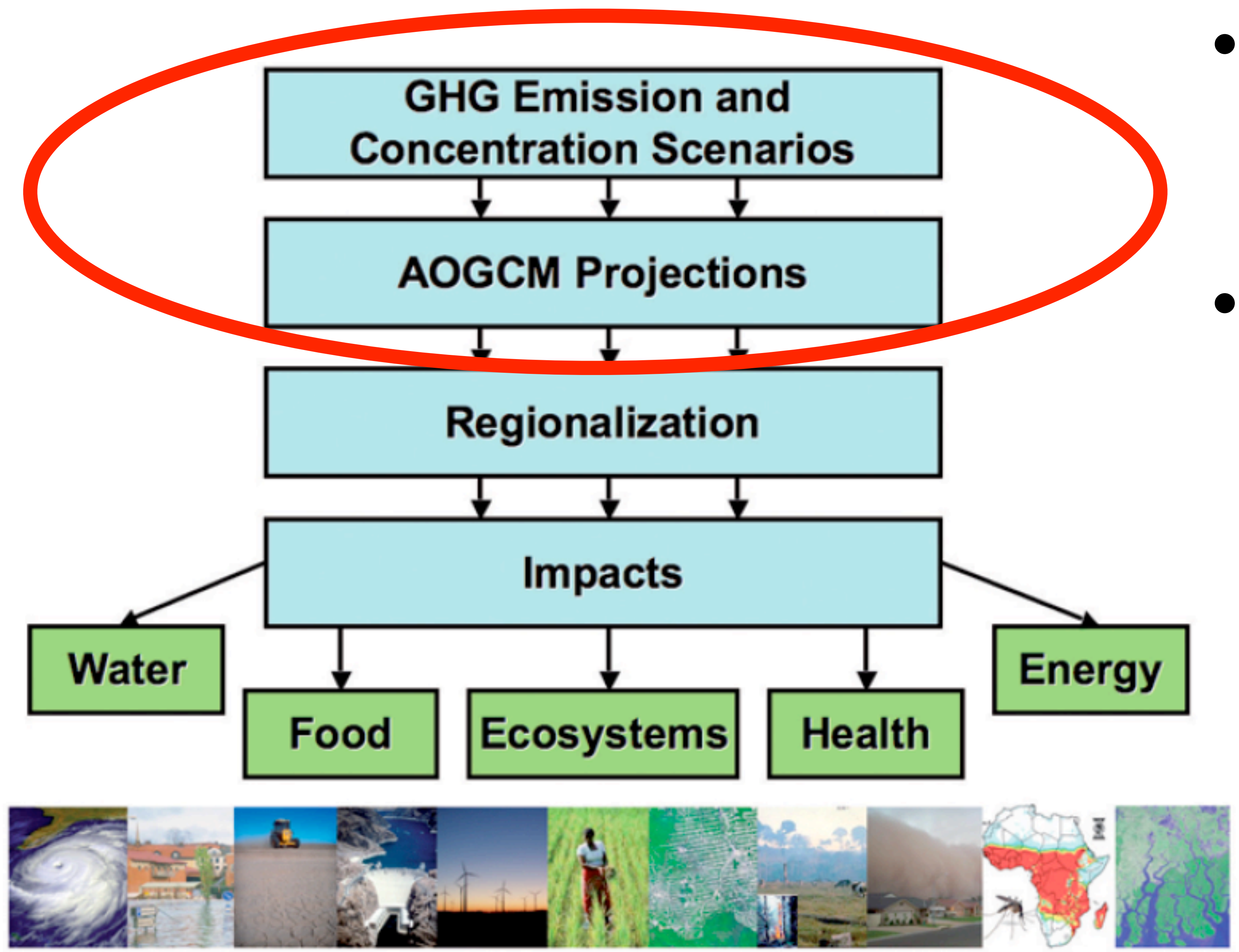


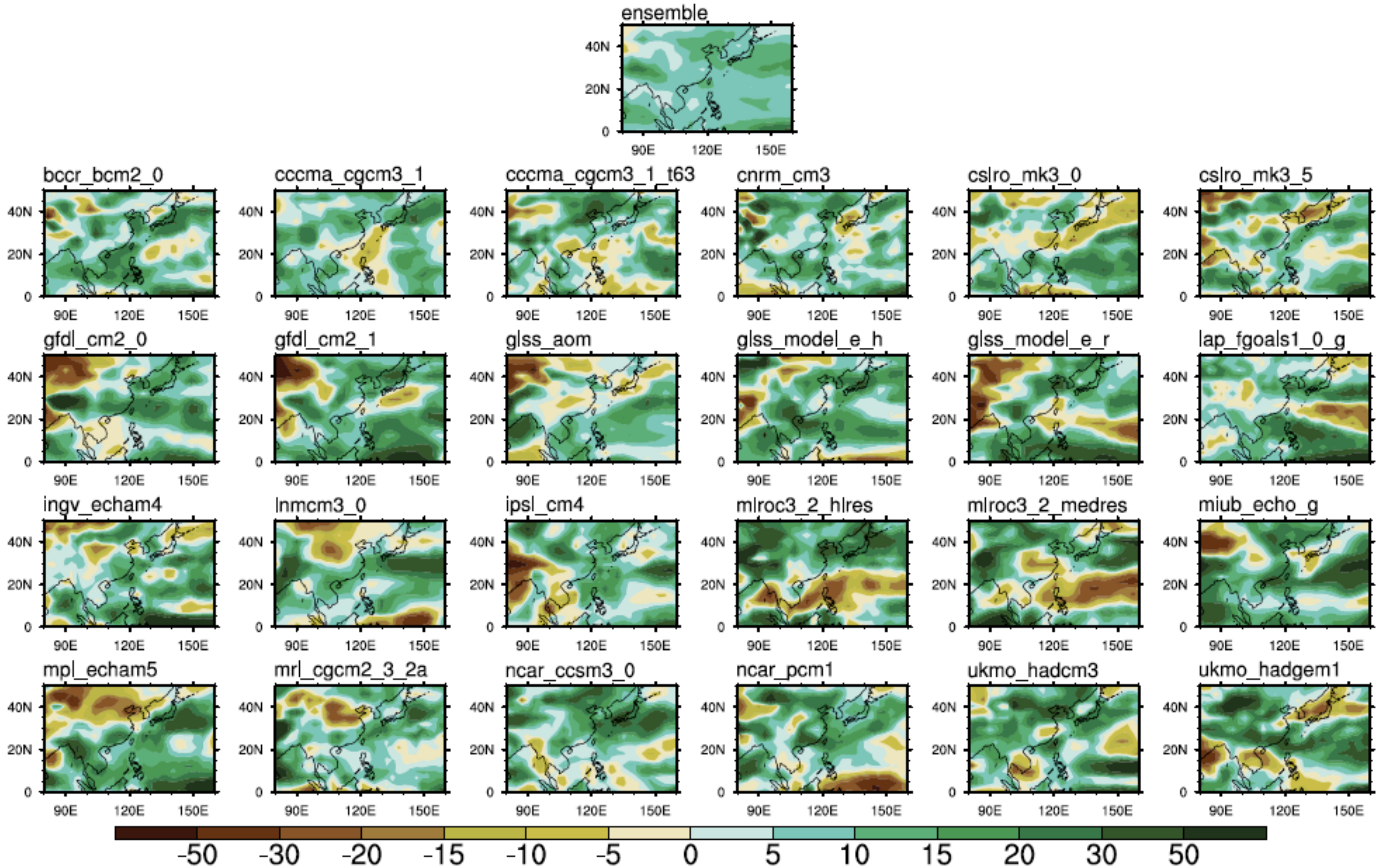
Figure 3 — Schematic depiction of the steps involved in the production of climate change information usable for impact assessment work via regionalization methods

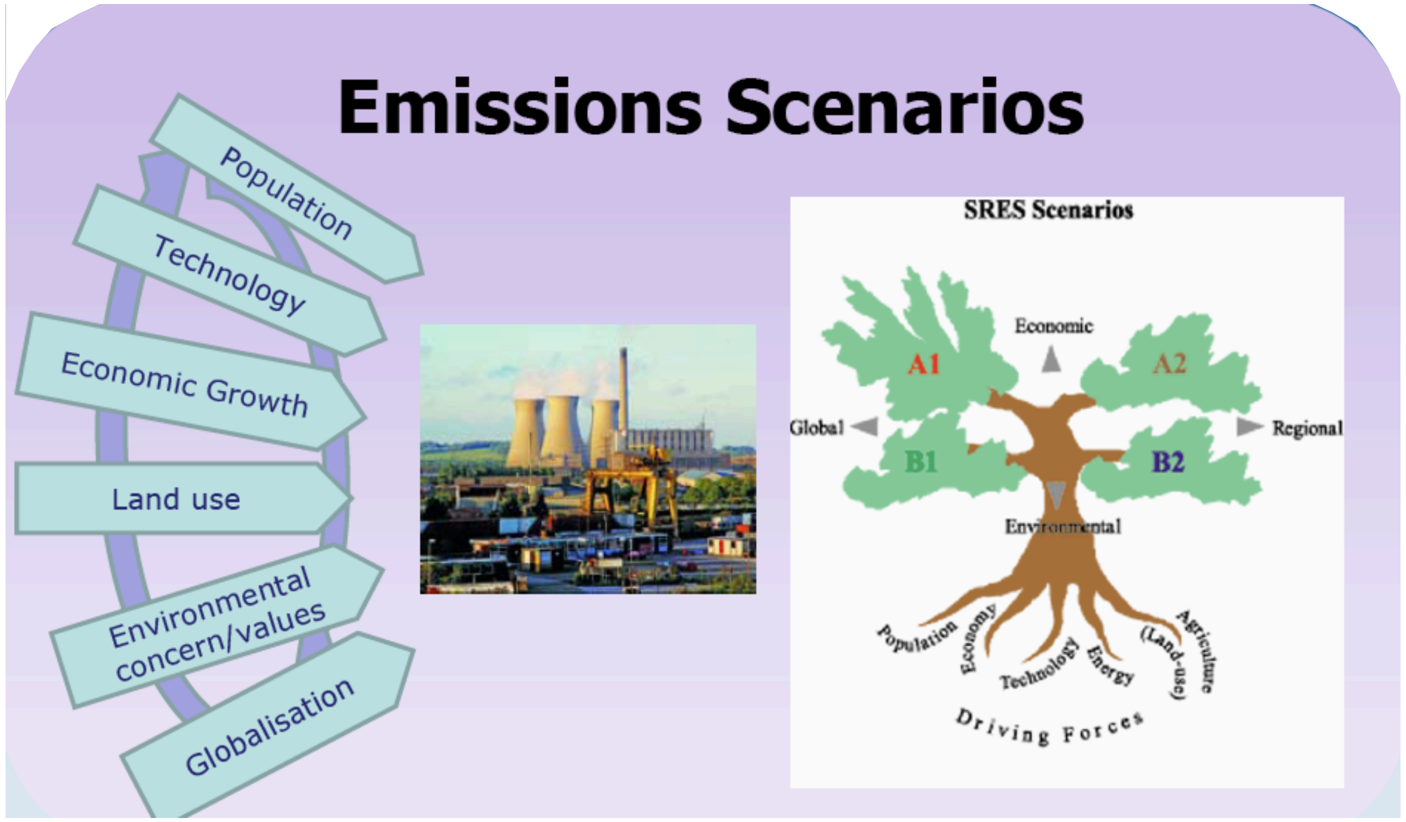
Source: Giorgi (2008)

- 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

Uncertainty from Global Climate Models

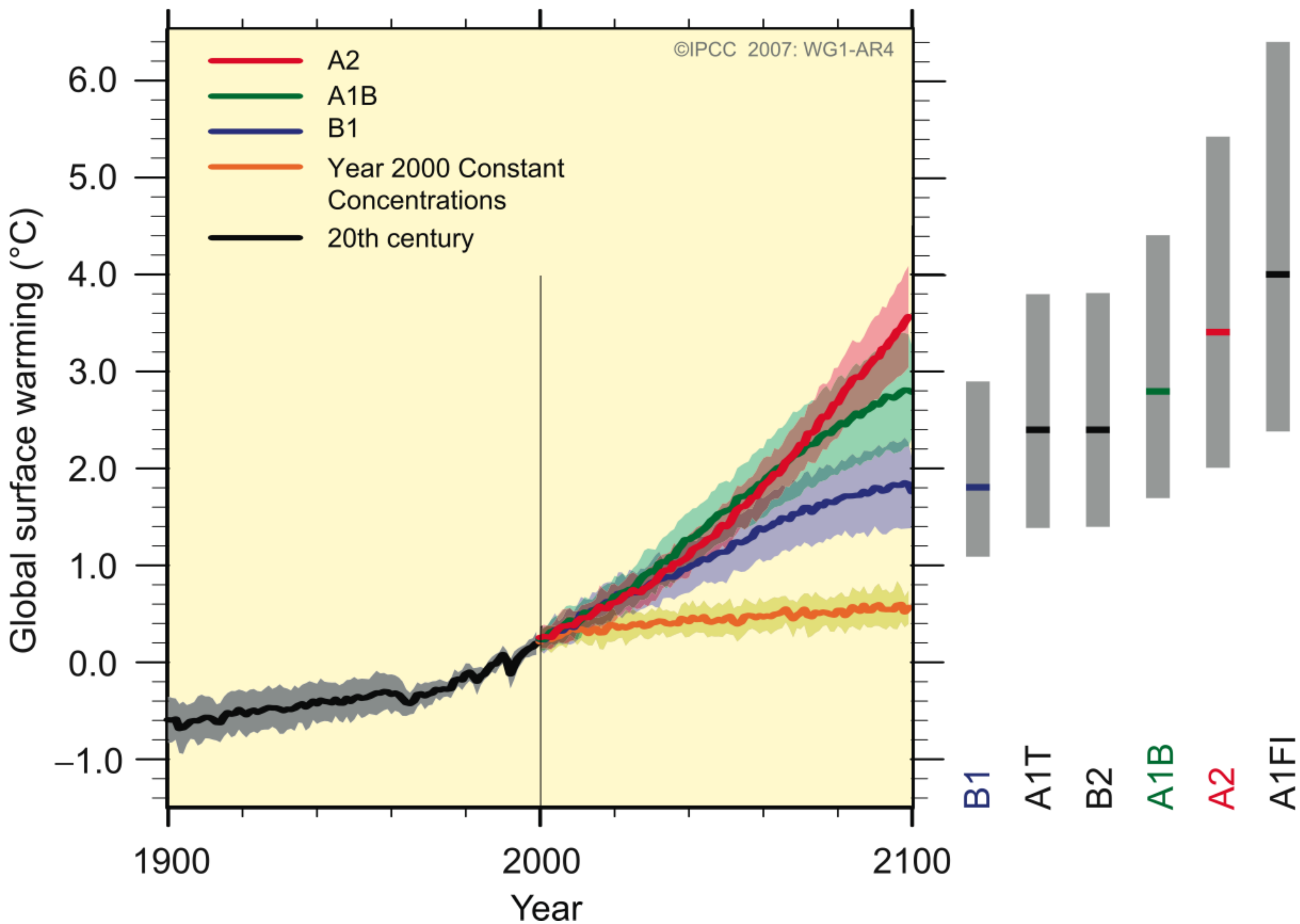
Summer precipitation change(%) with all IPCC AR4 models under A1B scenario





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

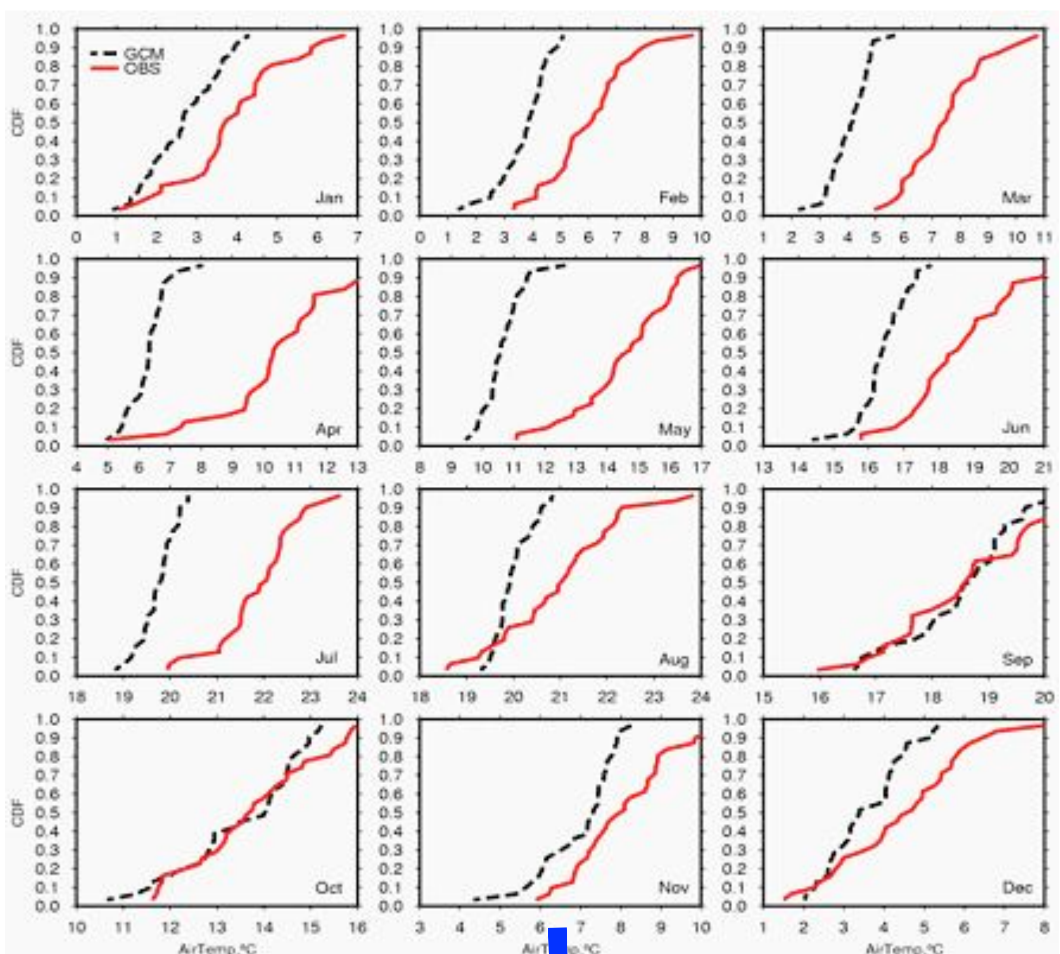


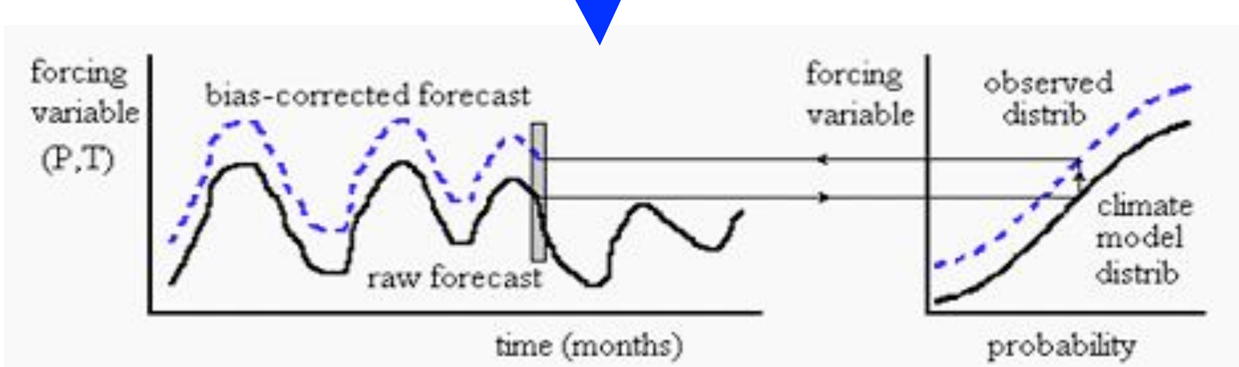
Probabilistic model future climate projection for individual scenarios

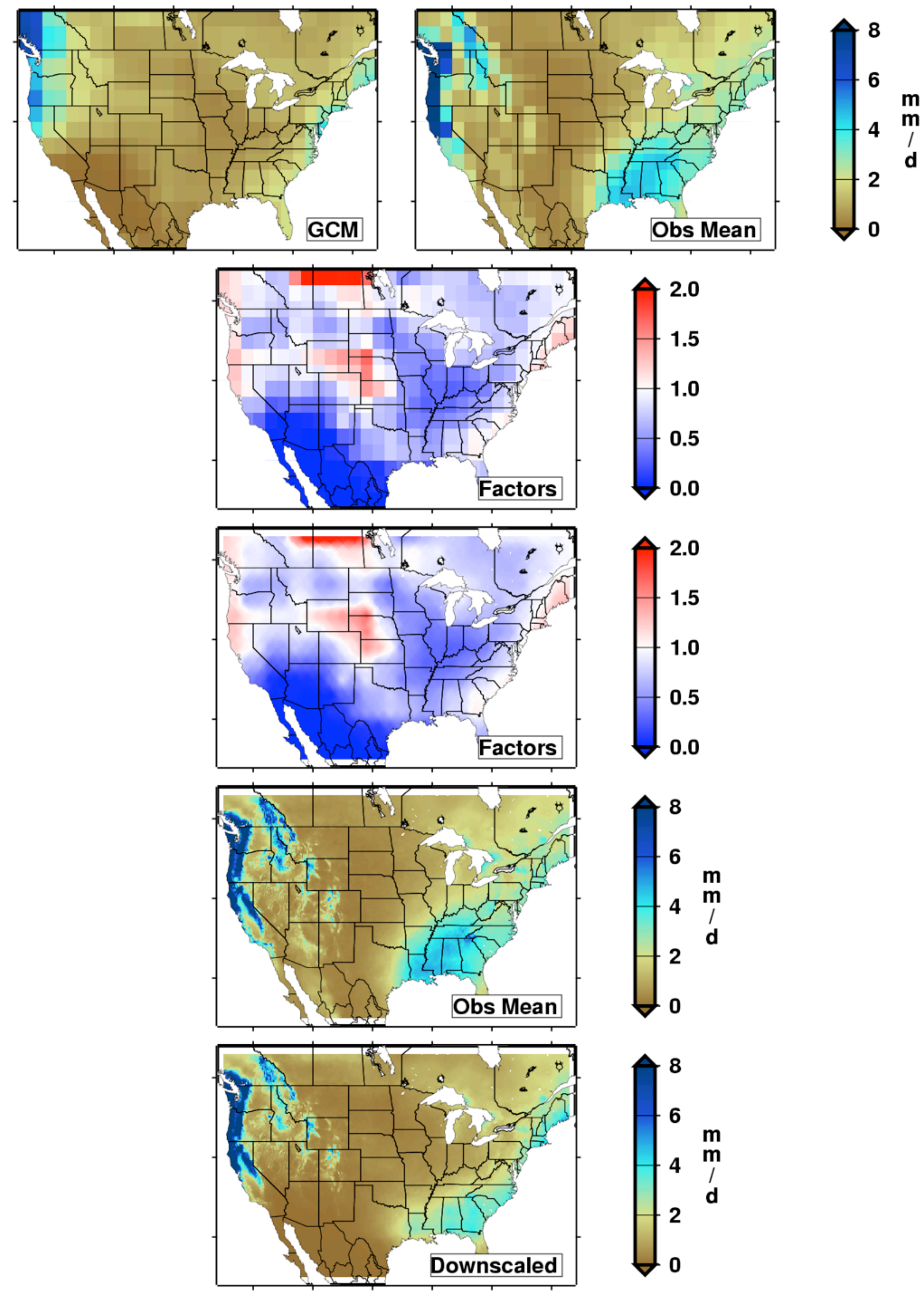
Statistical Downscaling

Wood et al. 2004, and Maurer 2007

Statistical downscaling and bias correction by cumulative distribution function and interpolation



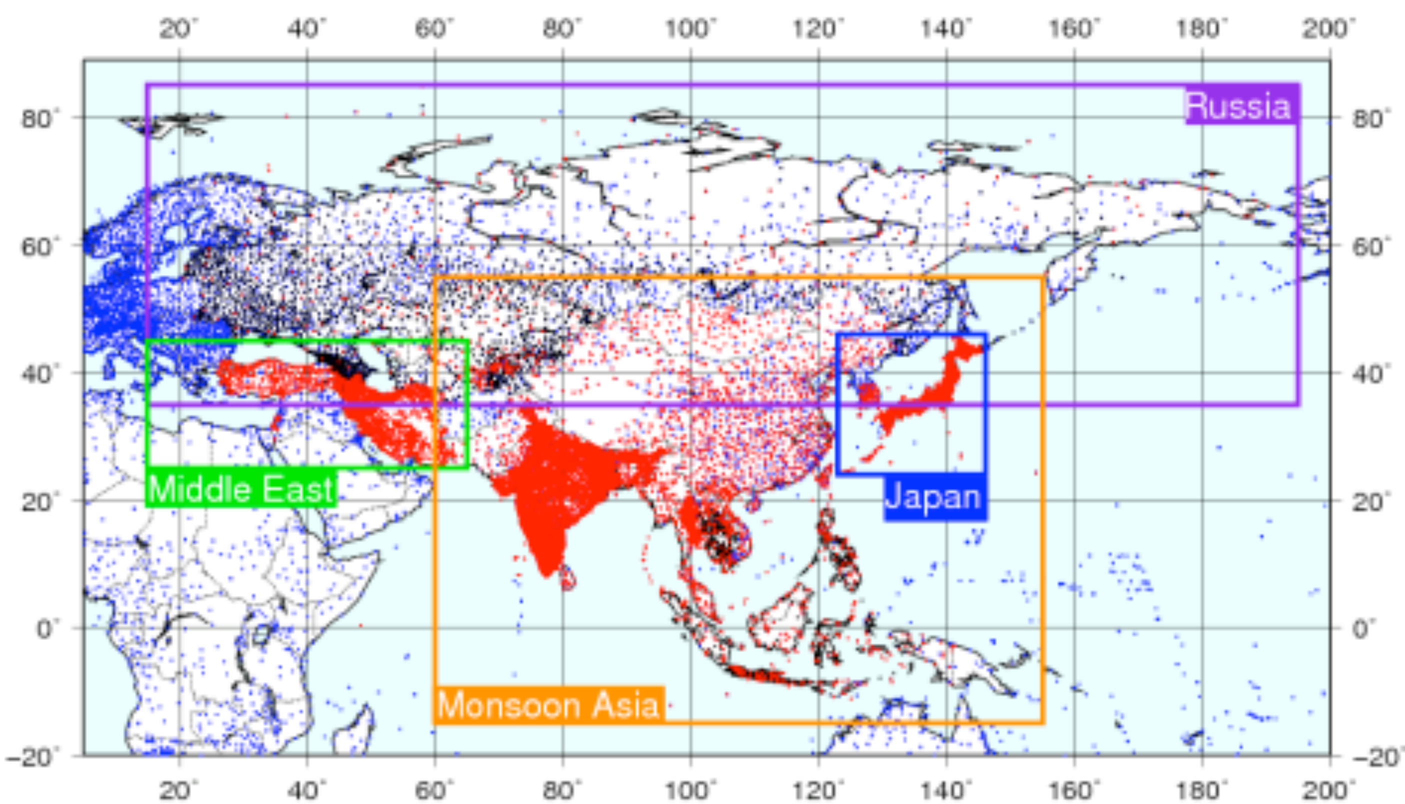




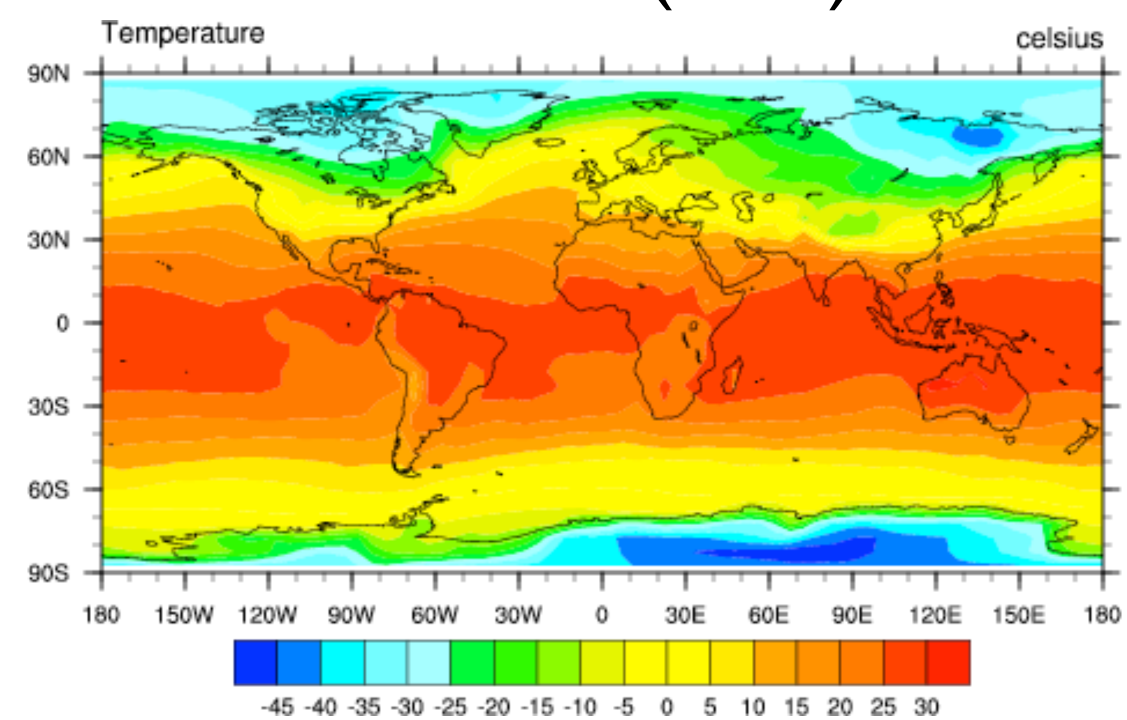
%

Require long-term high-resolution observations

APHRODITE (0.25°)



CRU (0.5°)



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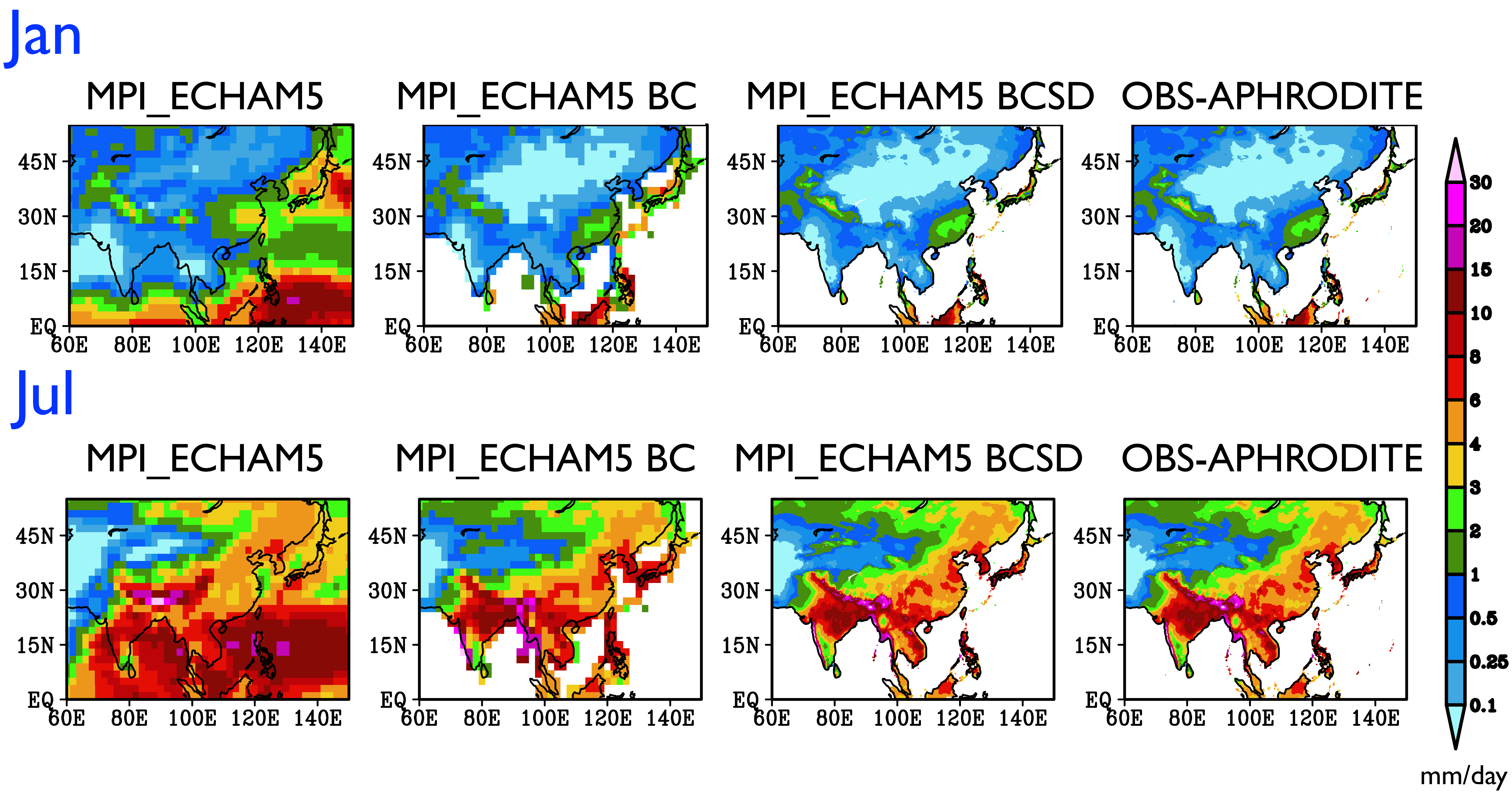
Name	Domain	Resolution	Period
Monsoon Asia (MA)	60°E-150°E, 15°S-55°N	0.5° and 0.25°, daily	1951-2007
Middle East (ME)	15°E-65°E, 25°N-45°N		
Russia (RU)	15°E-165°W, 34°N-84°N		

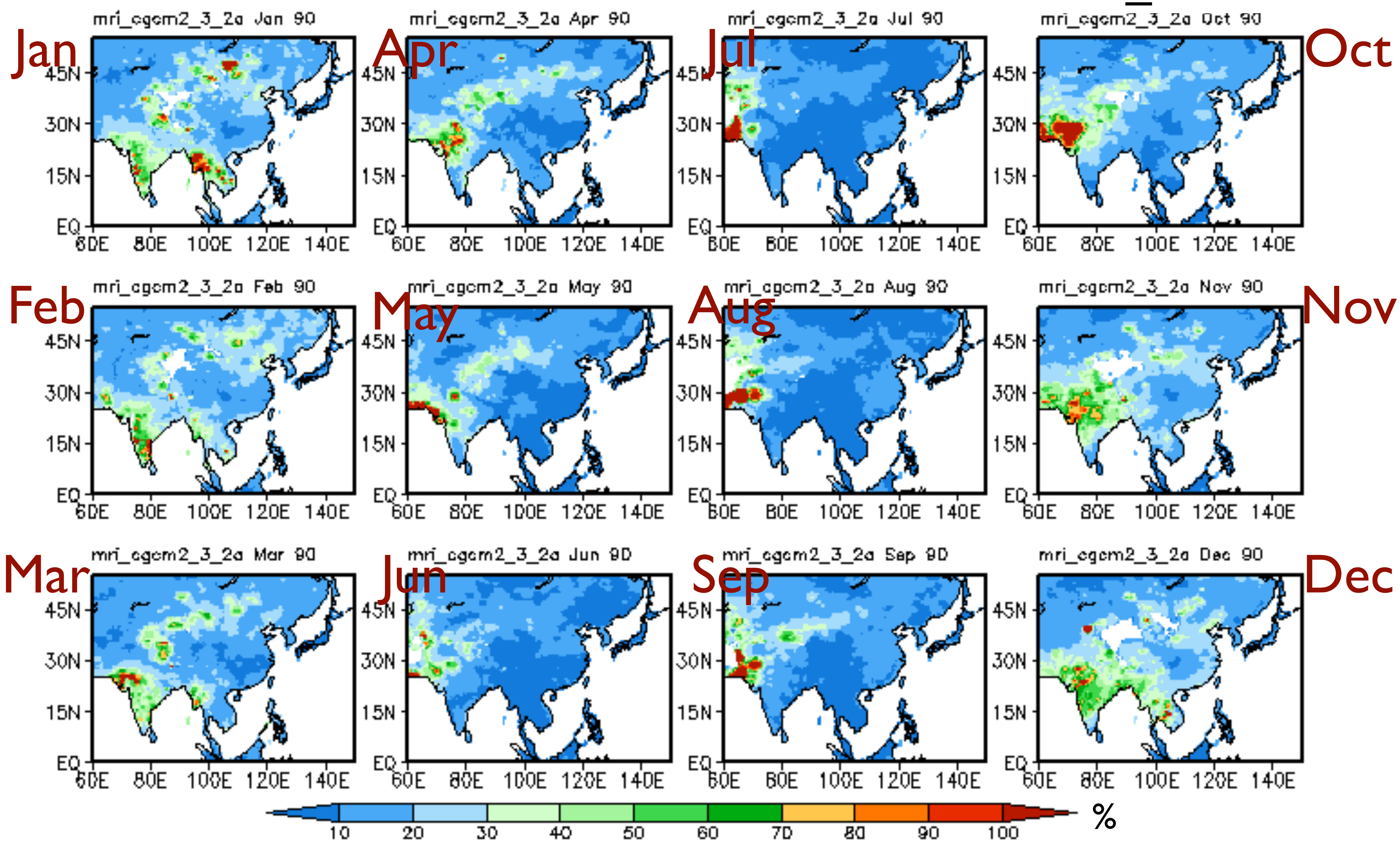
Validation

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

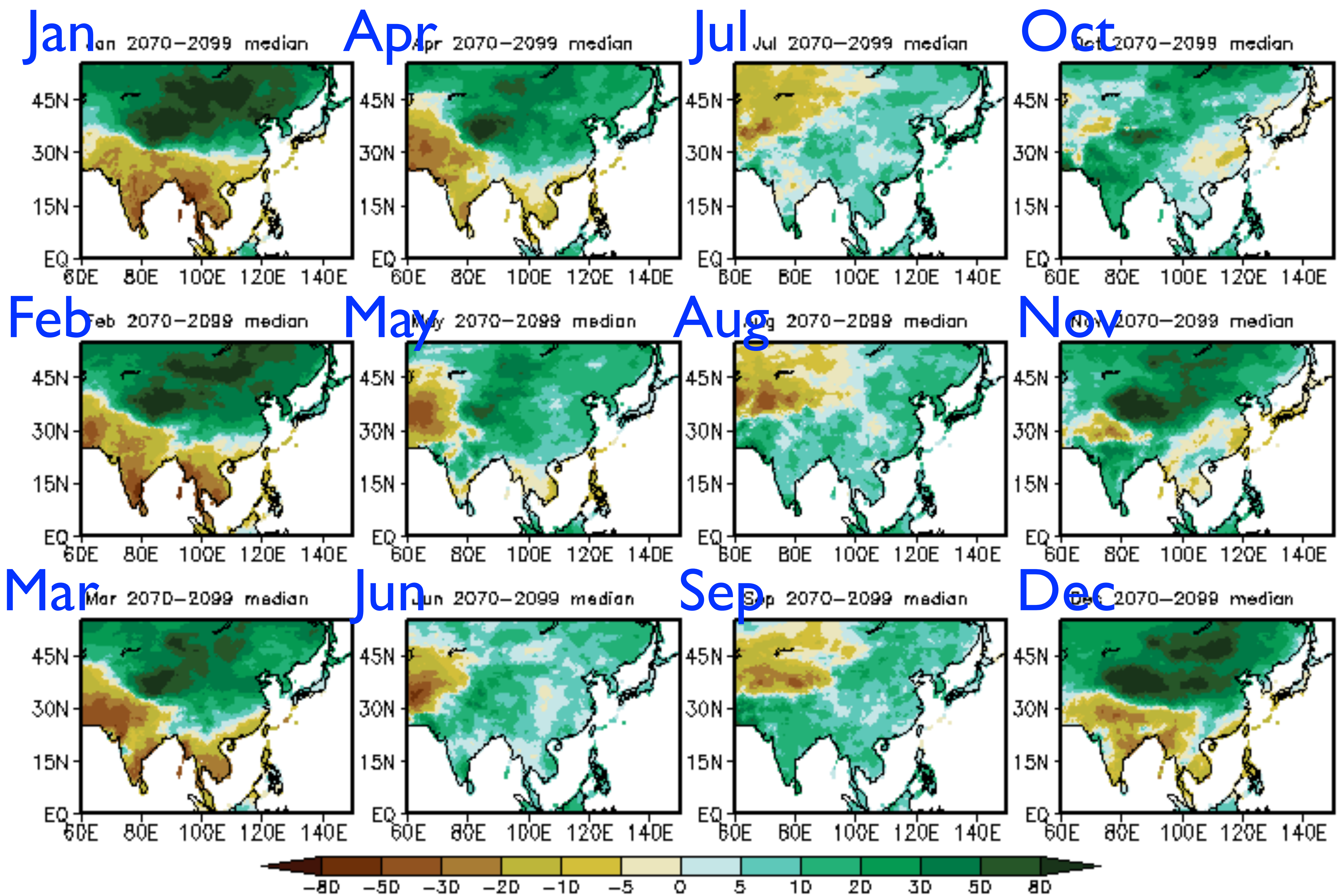


- 90th percentile of downscaled error estimate from bootstrapping 20 out of 40 years data from present climate
- Typically less than 10% error with regional monthly rainfall more than 2 mm/day

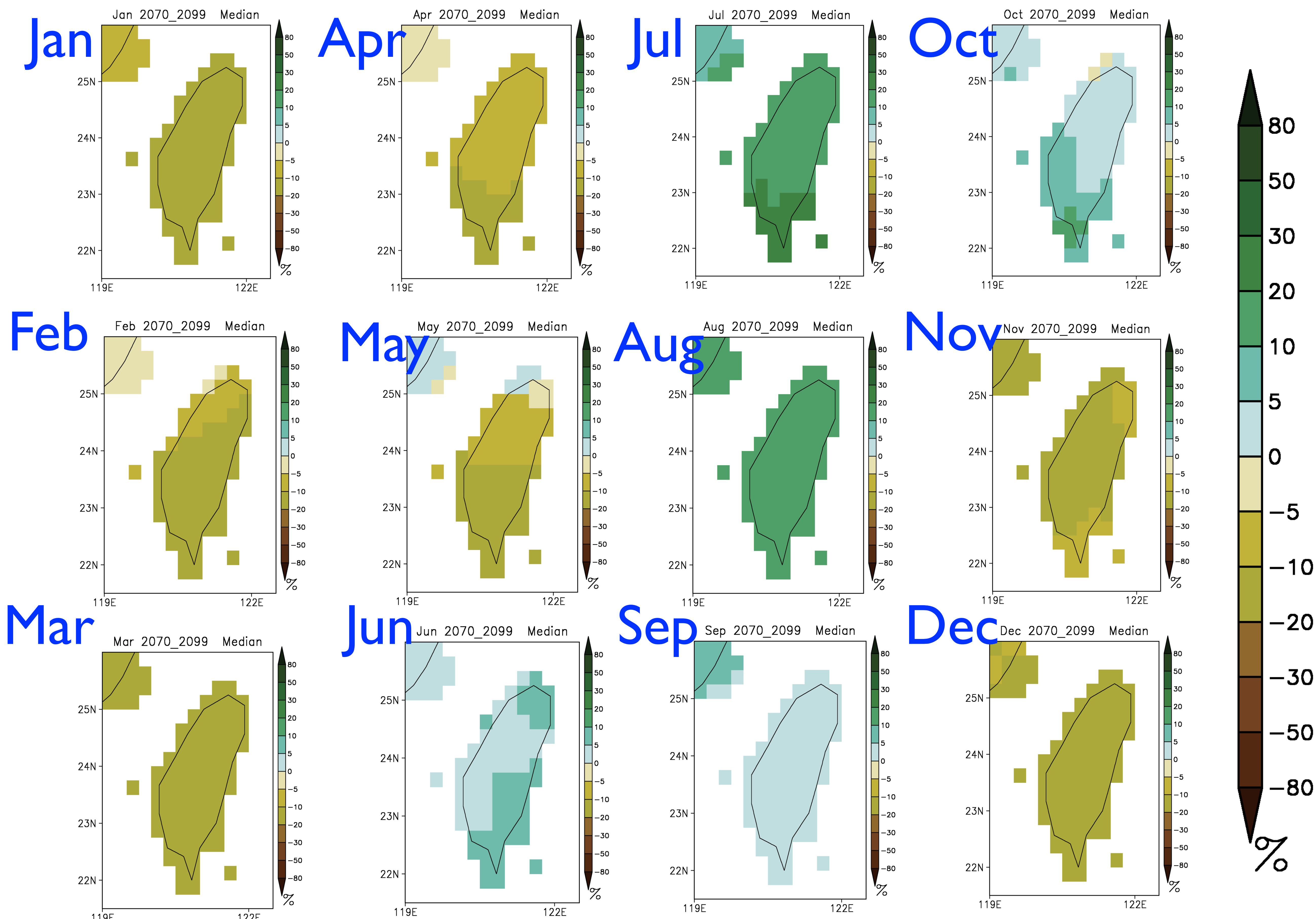
MRI_CGCM2.3.2



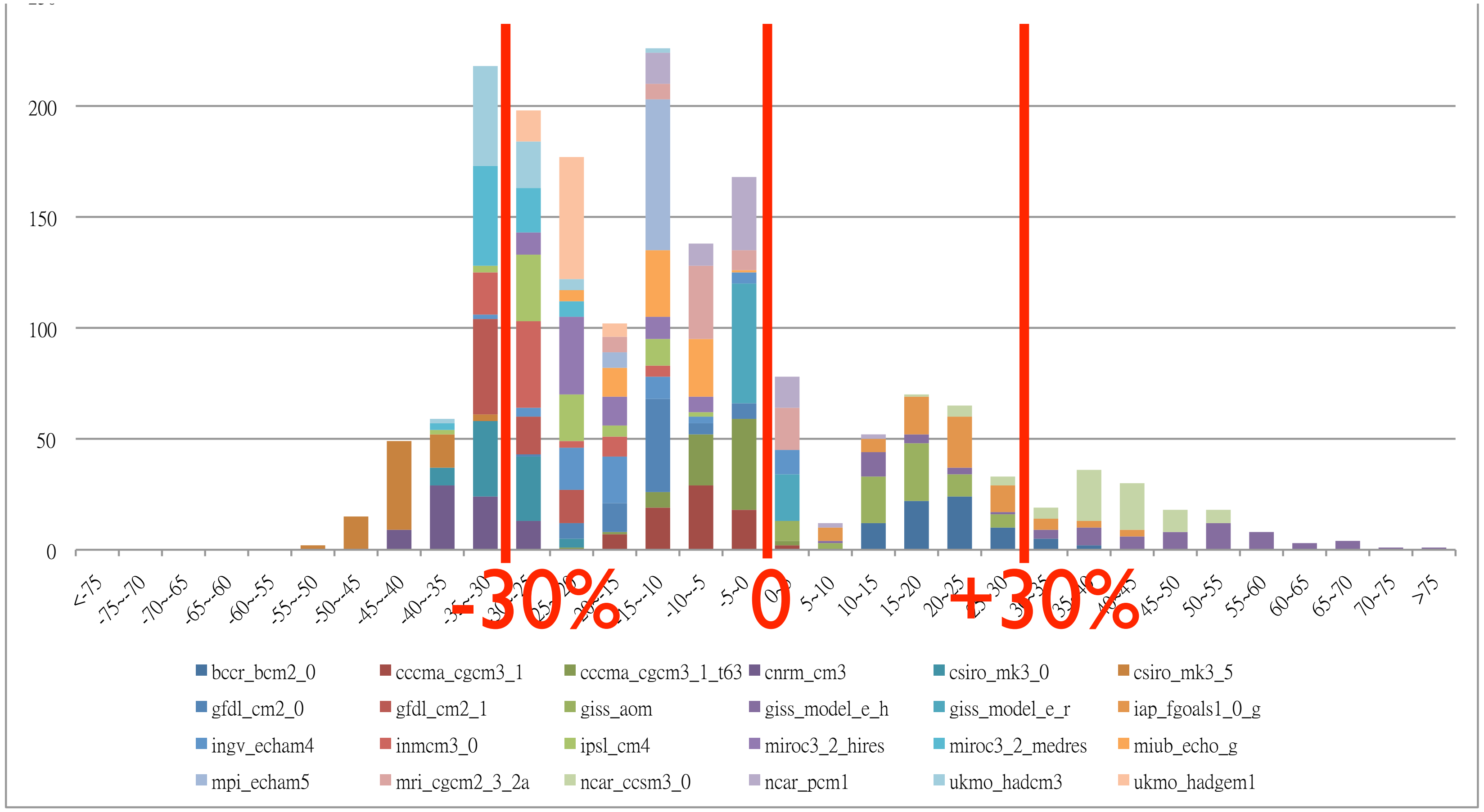
Model Median Future Change in Precipitation (%)



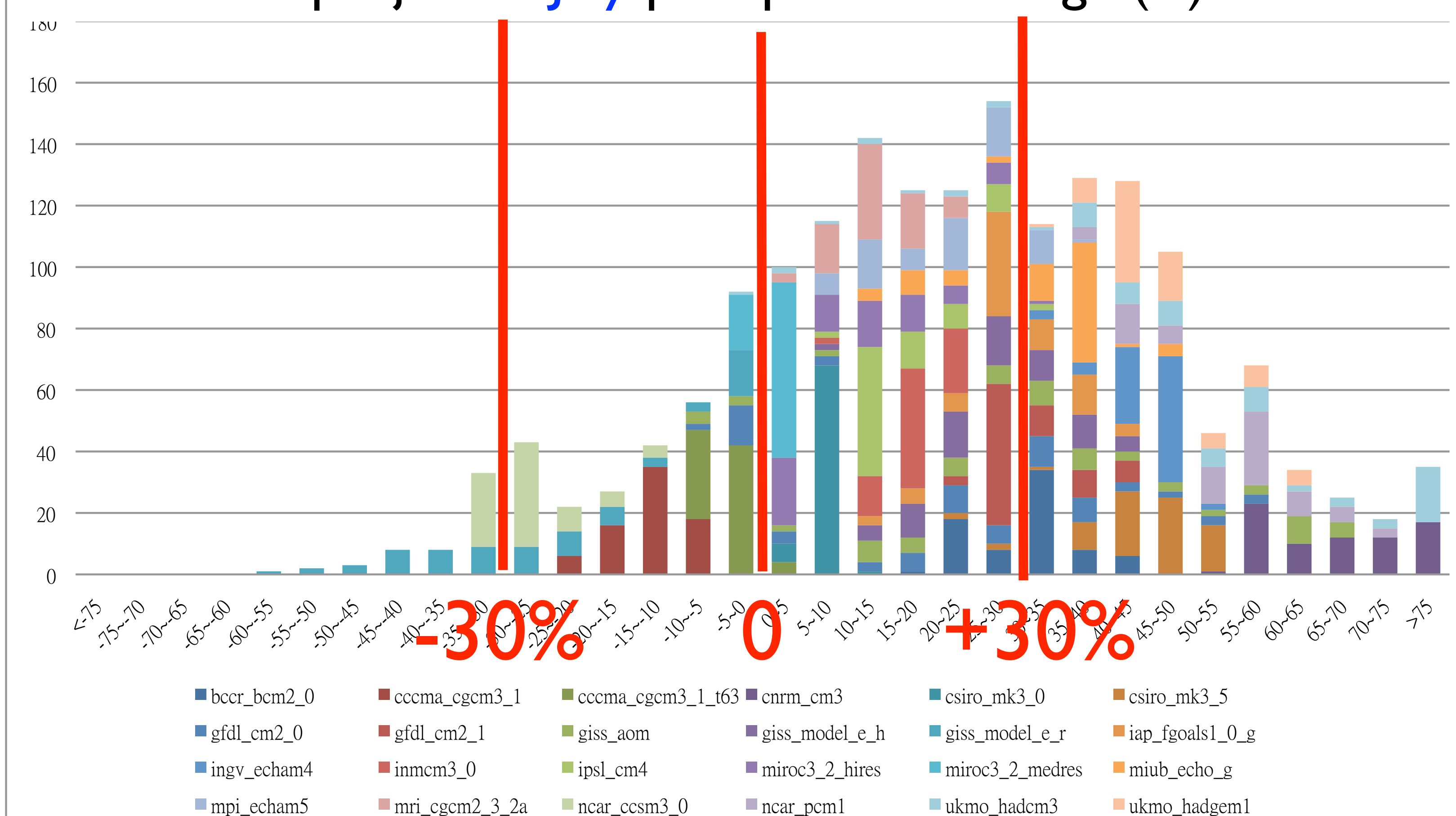
Model Median Future Change in Precipitation (%)



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

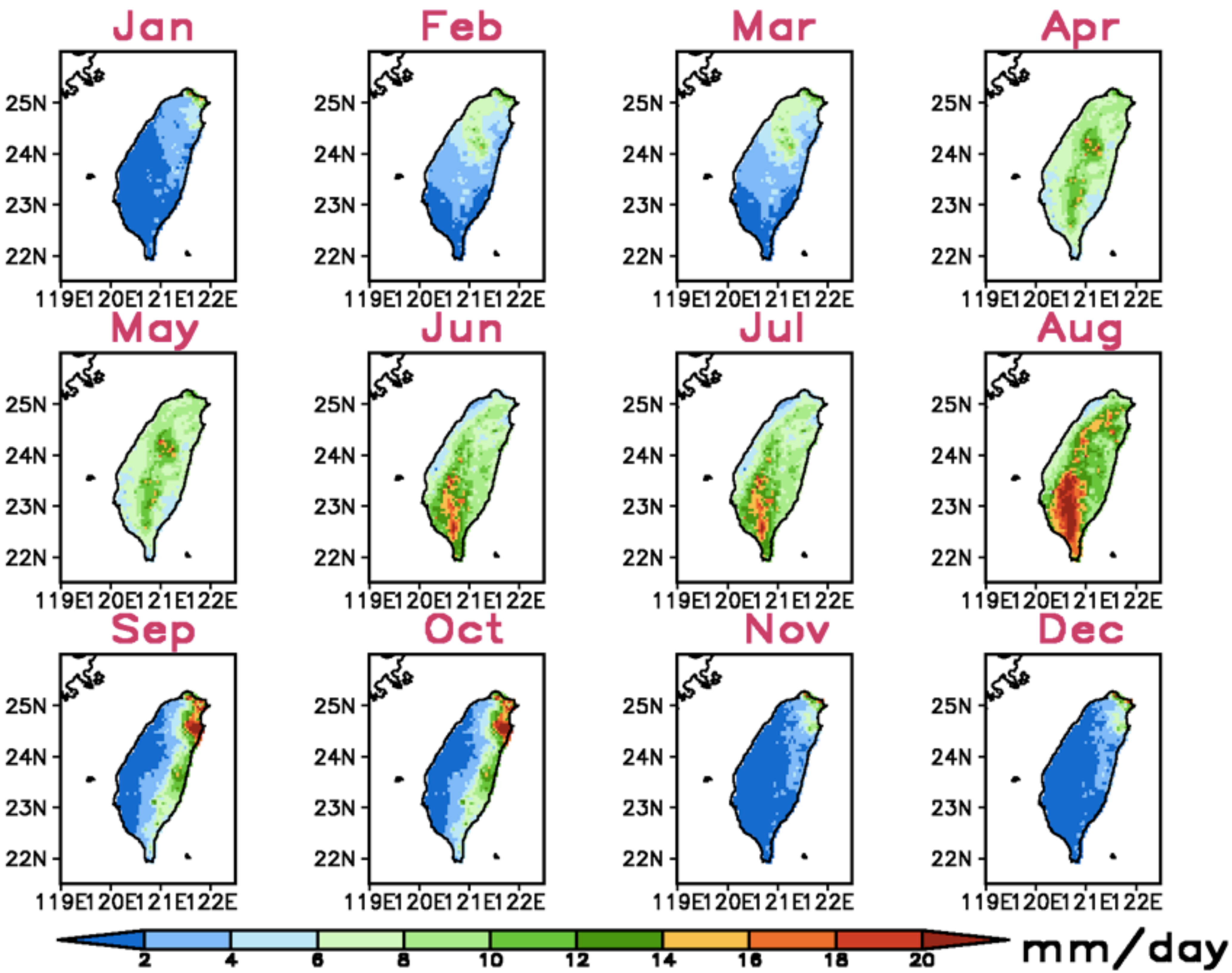


2070-2099 projected July precipitation change (%) in Taiwan

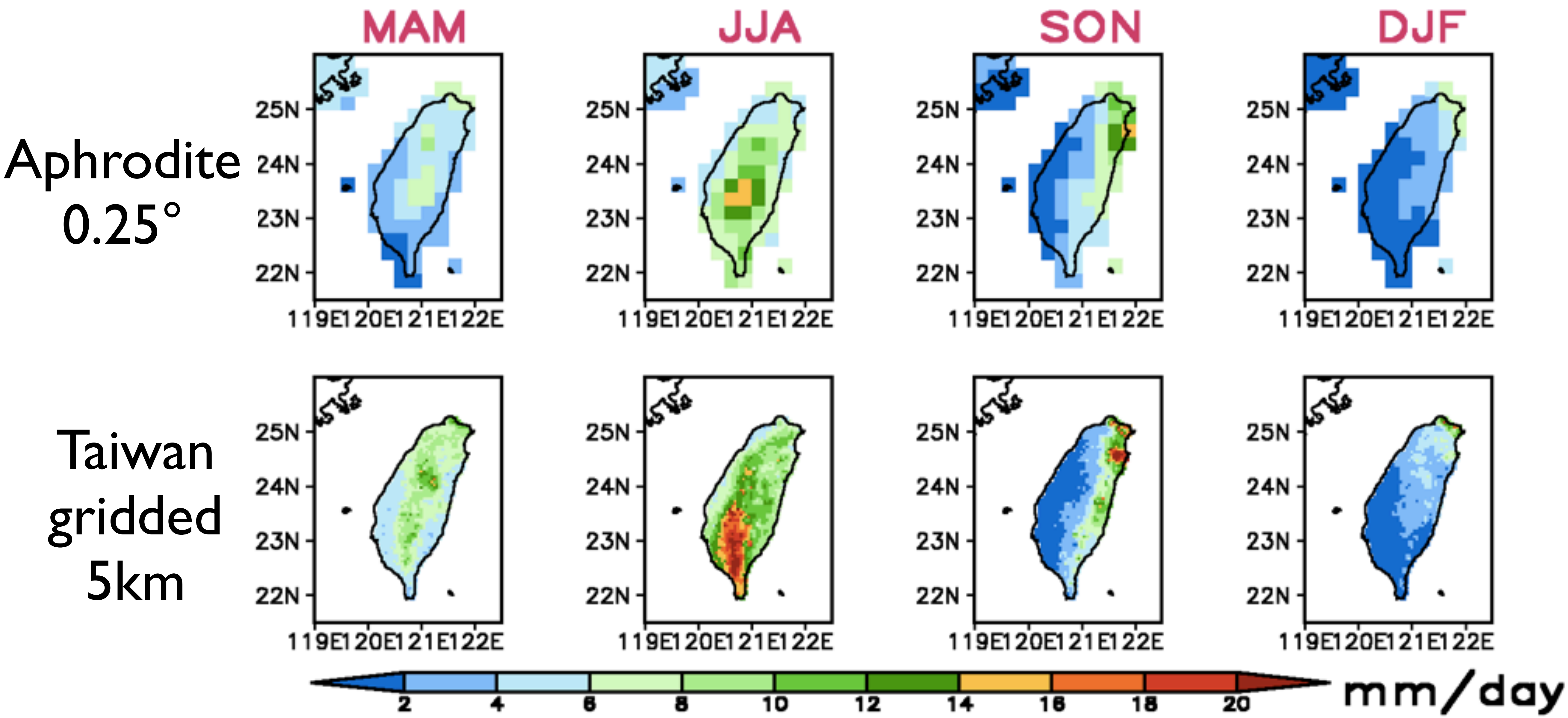


- One can also focus on area of interests and construct PDF for projected future precipitation from all models (Taiwan: 75 grids x 24 models)
- Ensemble of opportunity (probability)

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

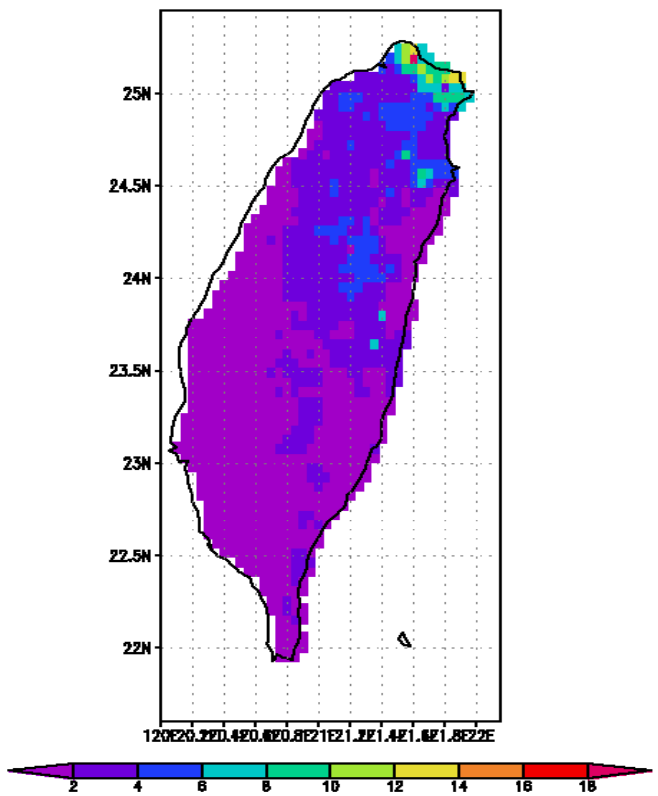


Taiwan 5km gridded rainfall better resolved local rainfall characteristics

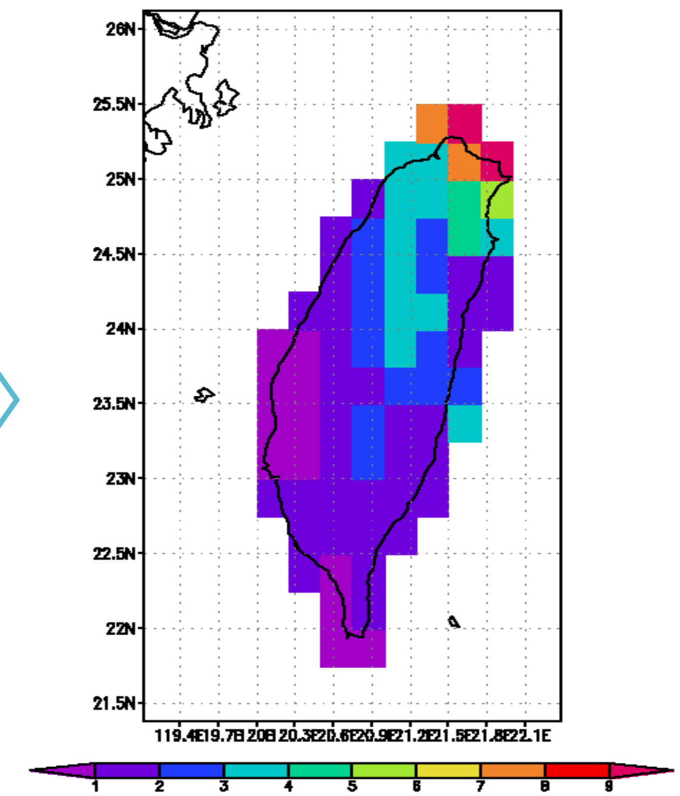


obs

5km
0.05x0.05
1960~2009



upscale

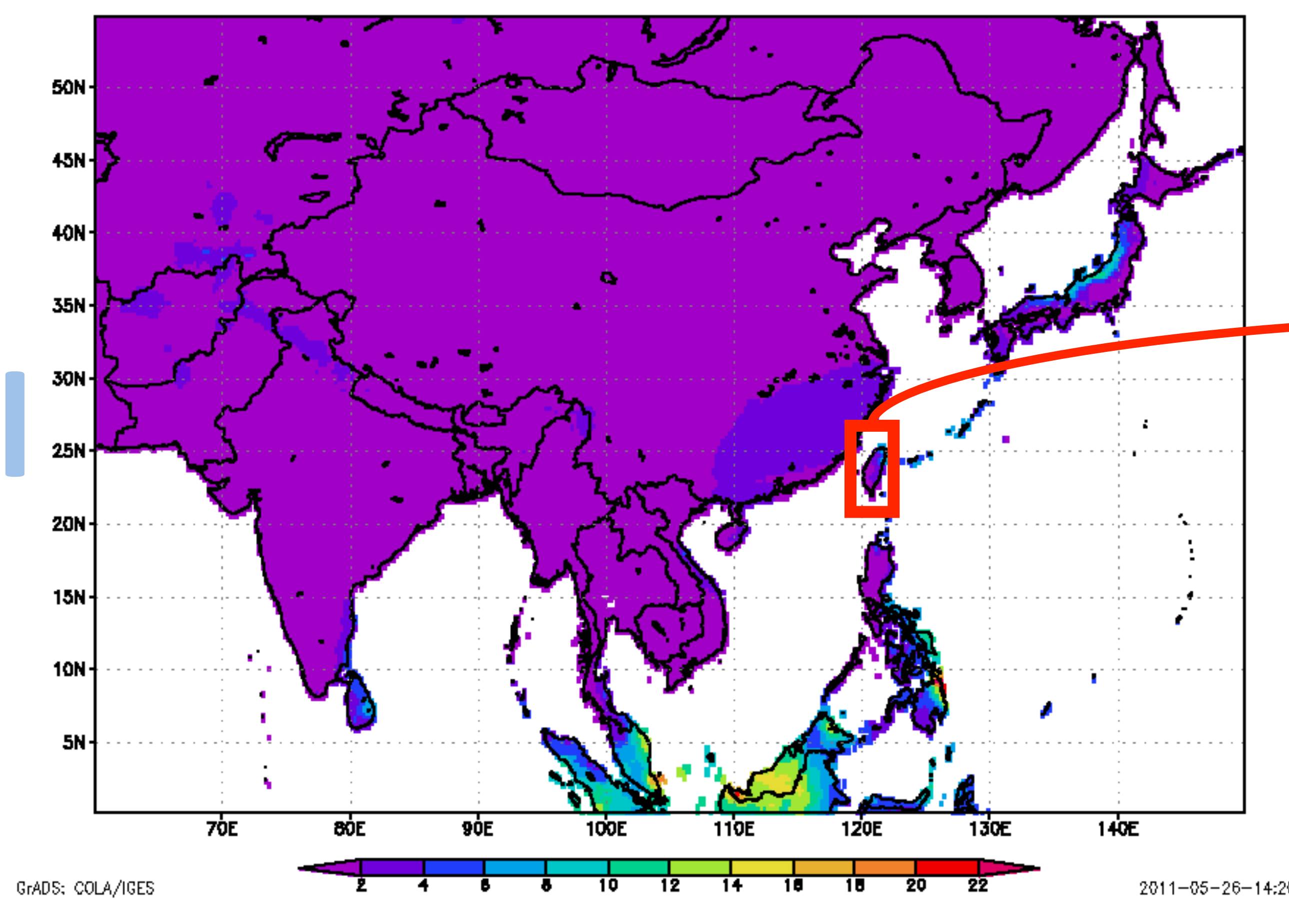


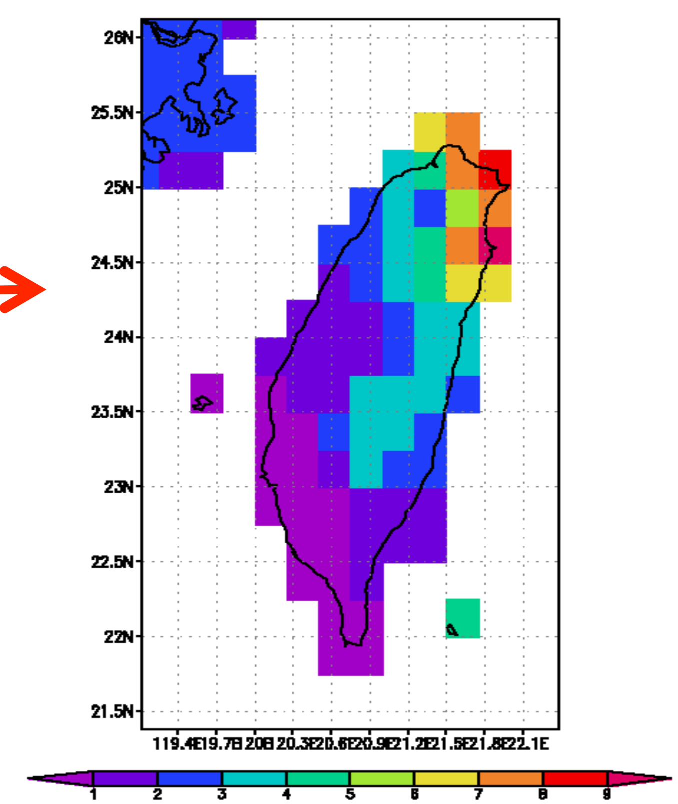
0.25x0.25

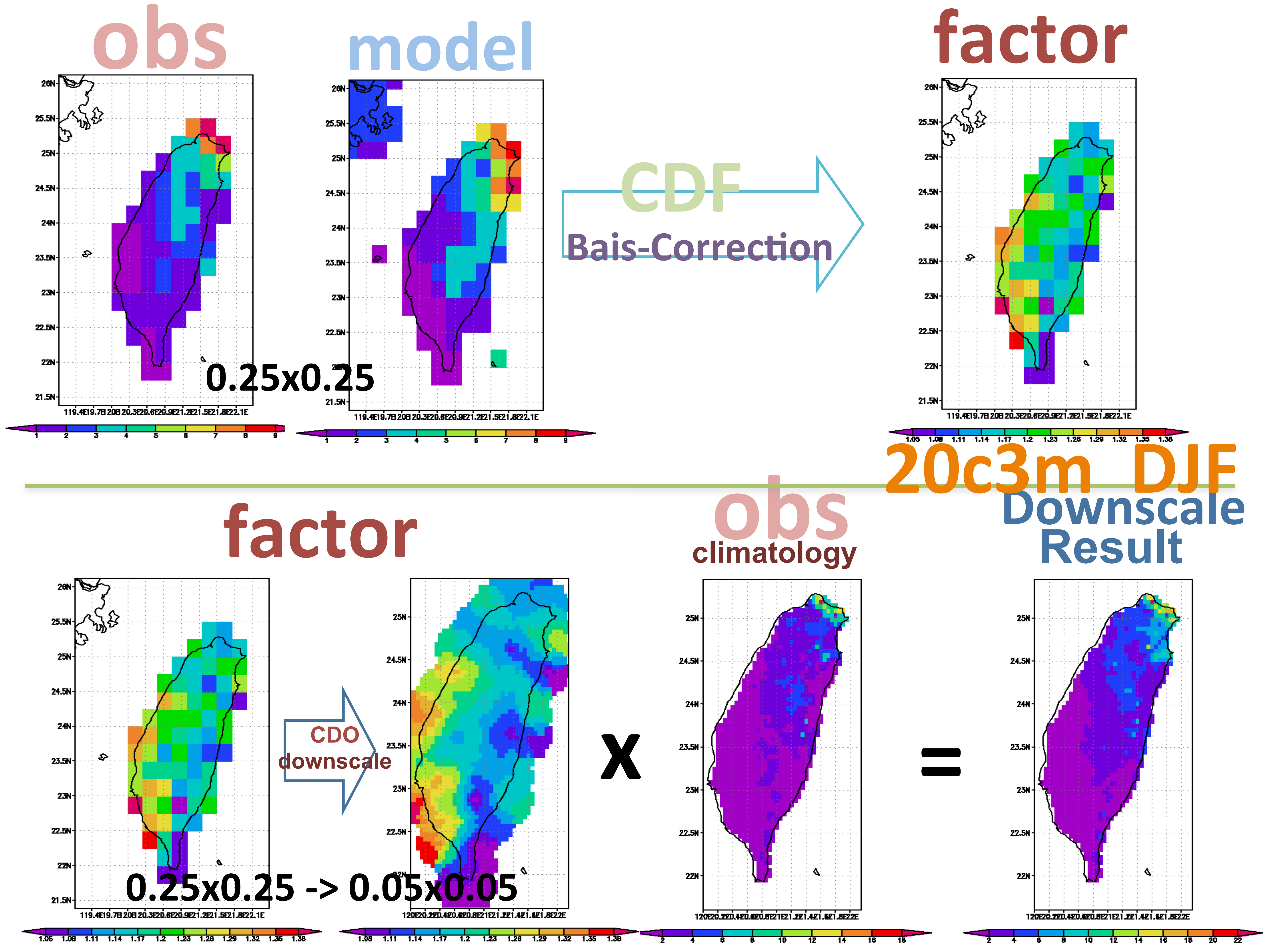
20c3m DJF

model

0.25x0.25
1961~2000



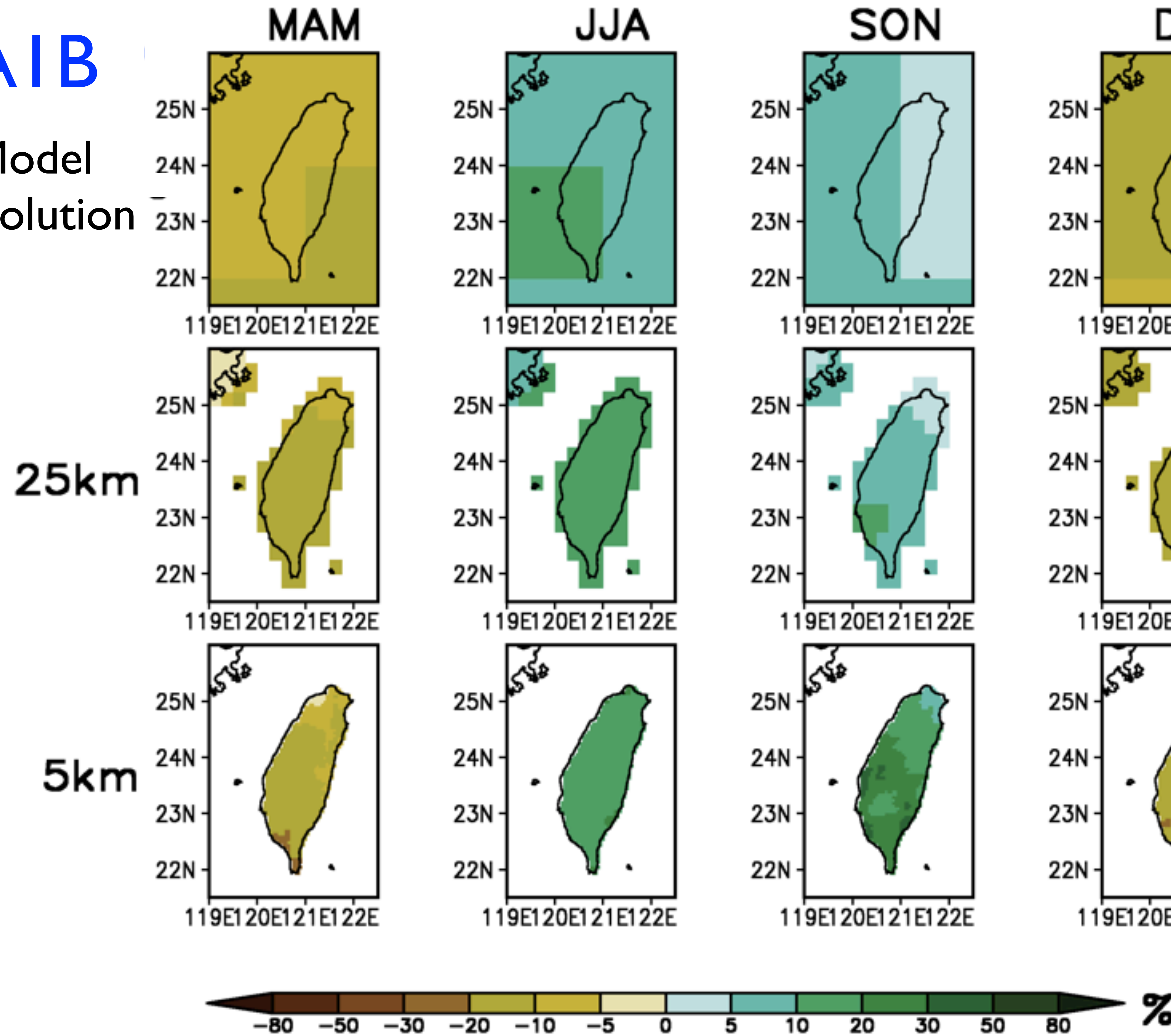



obs
model
factor
CDF
Bais-Correction
0.25x0.25
20c3m DJF
factor
CDO
downscale
0.25x0.25 -> 0.05x0.05
x
obs
climatology
=
Downscale
Result

Model Median Future Change in Precipitation (%)

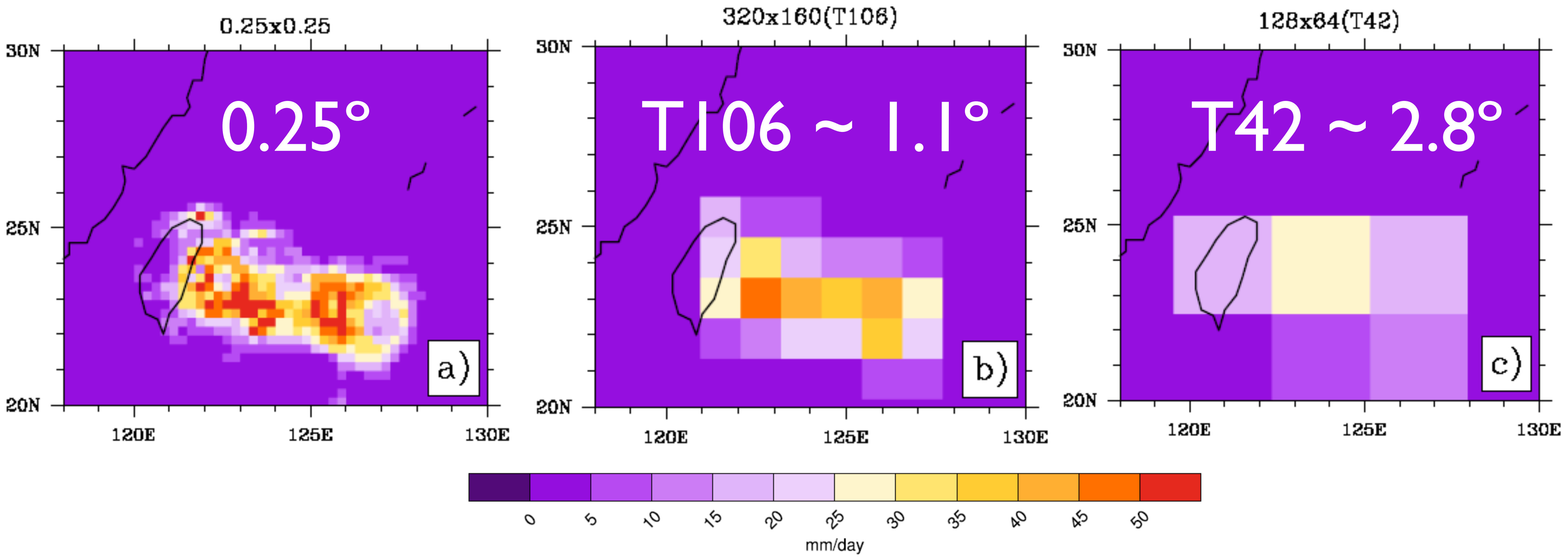
A1B

Model Resolution



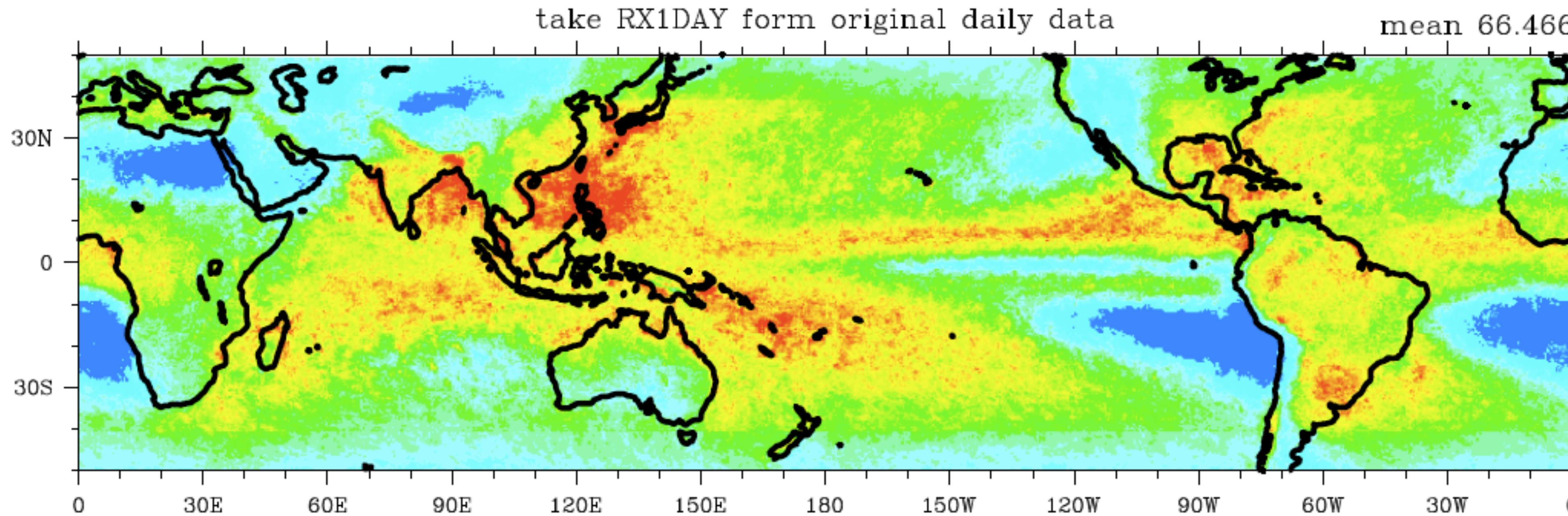
Statistical downscaling for the extremes?

High resolution observed daily rainfall analysis
regrid to typical model resolution

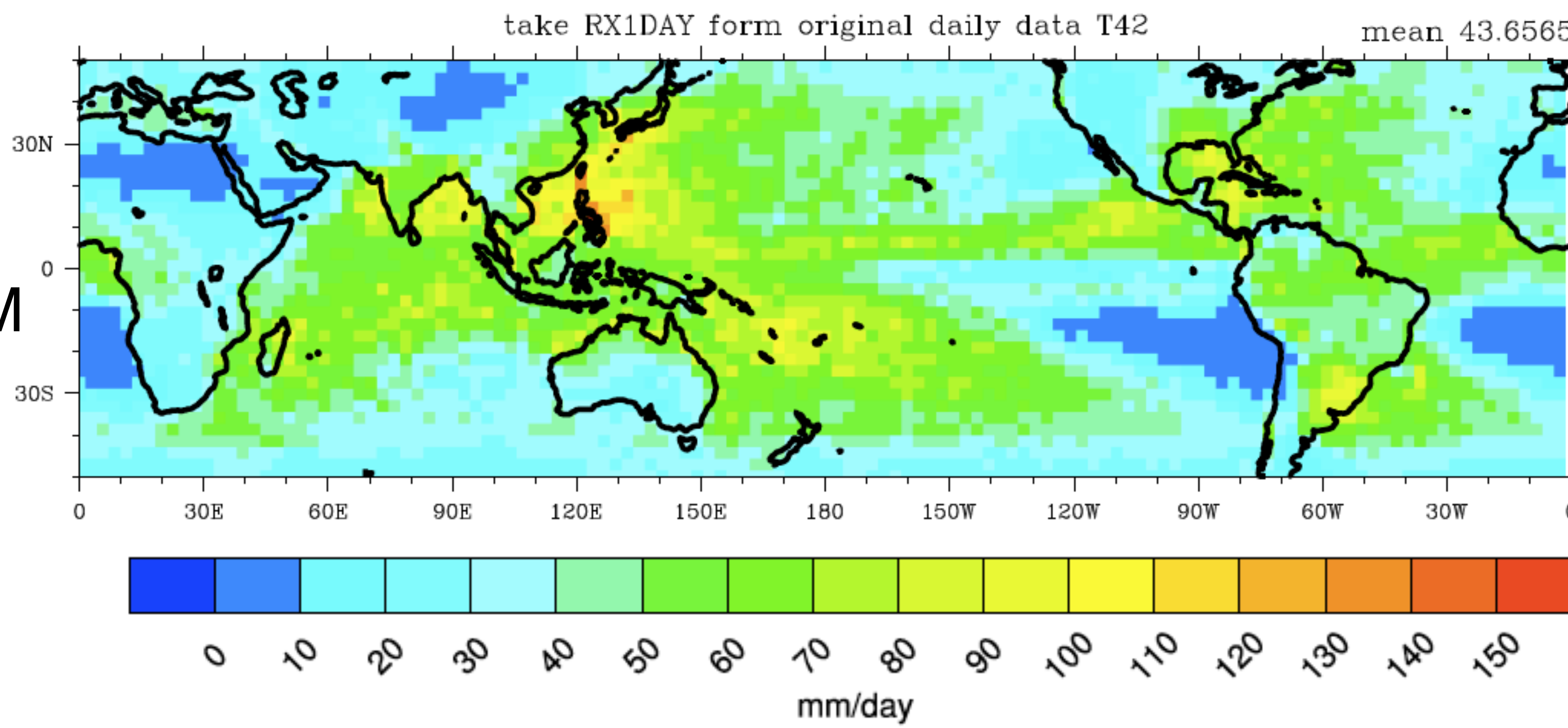


Deriving high-impact weather extremes at different spatial resolutions using observational estimates

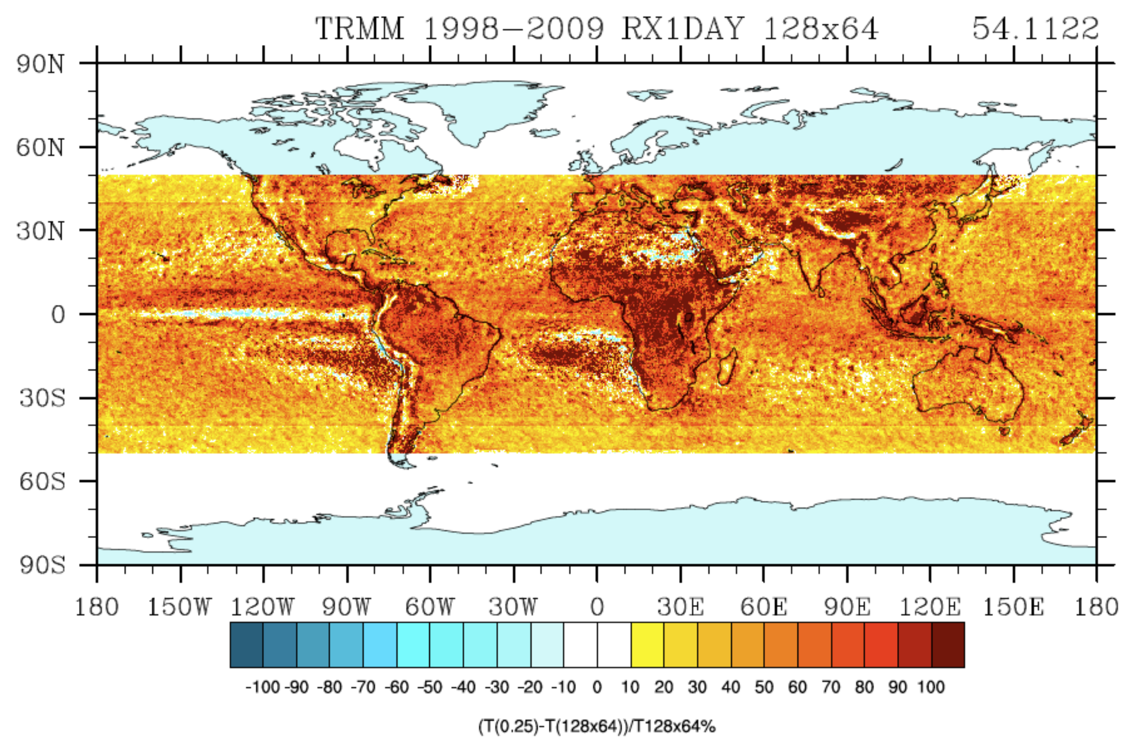
Annual maximum daily rainfall (Rx1day) at 0.25° resolution derived from TRMM (1998-2009)



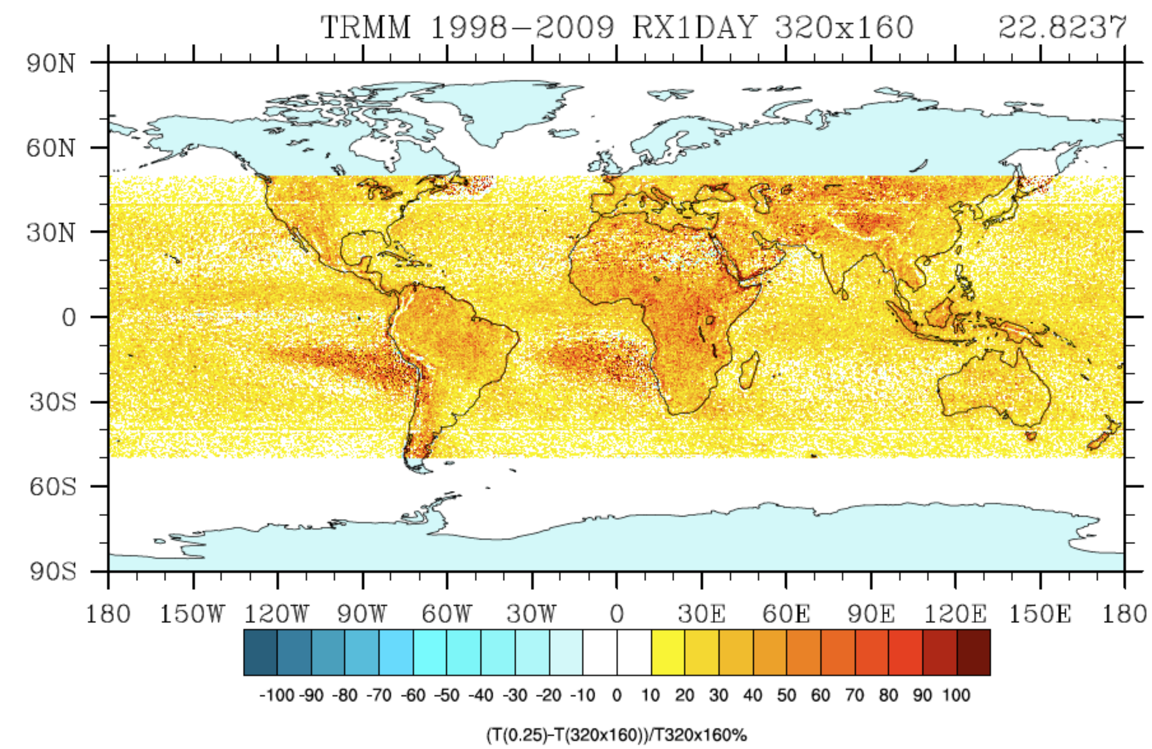
Annual maximum daily rainfall (Rx1day) at T42 derived from TRMM



Enhancing factor (%) from T42 to 0.25° resolution [P(0.25°)-P(T42)]/P(T42)

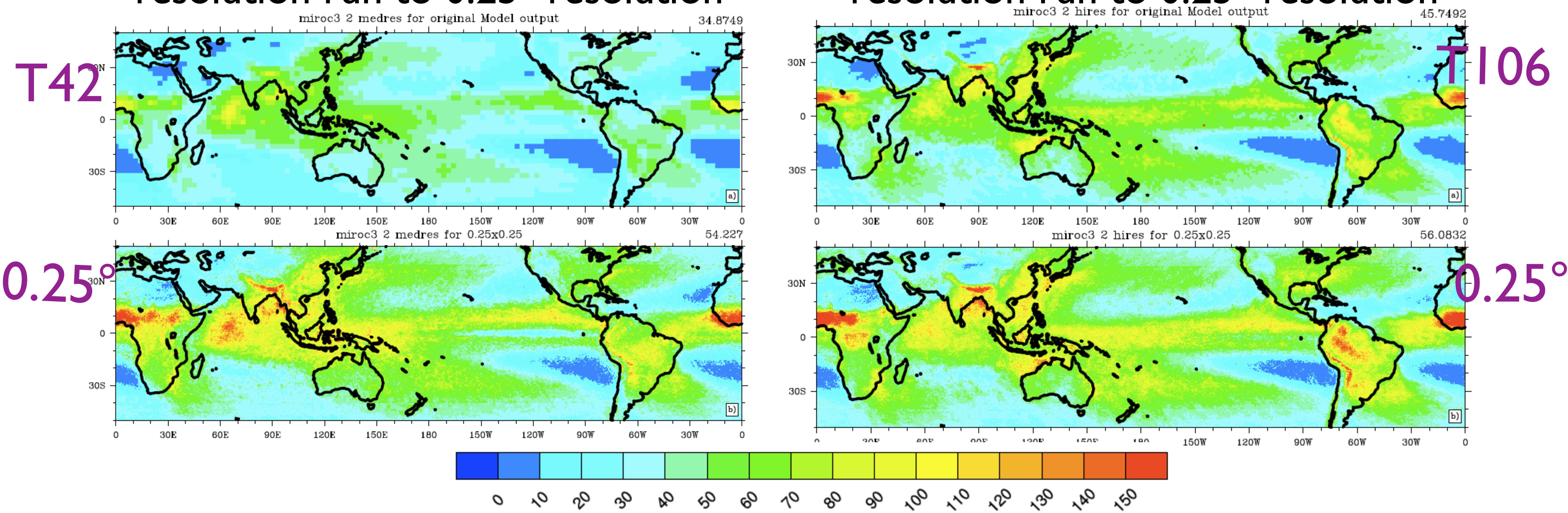


Enhancing factor (%) from T106 to 0.25° resolution [P(0.25°)-P(T106)]/P(T106)

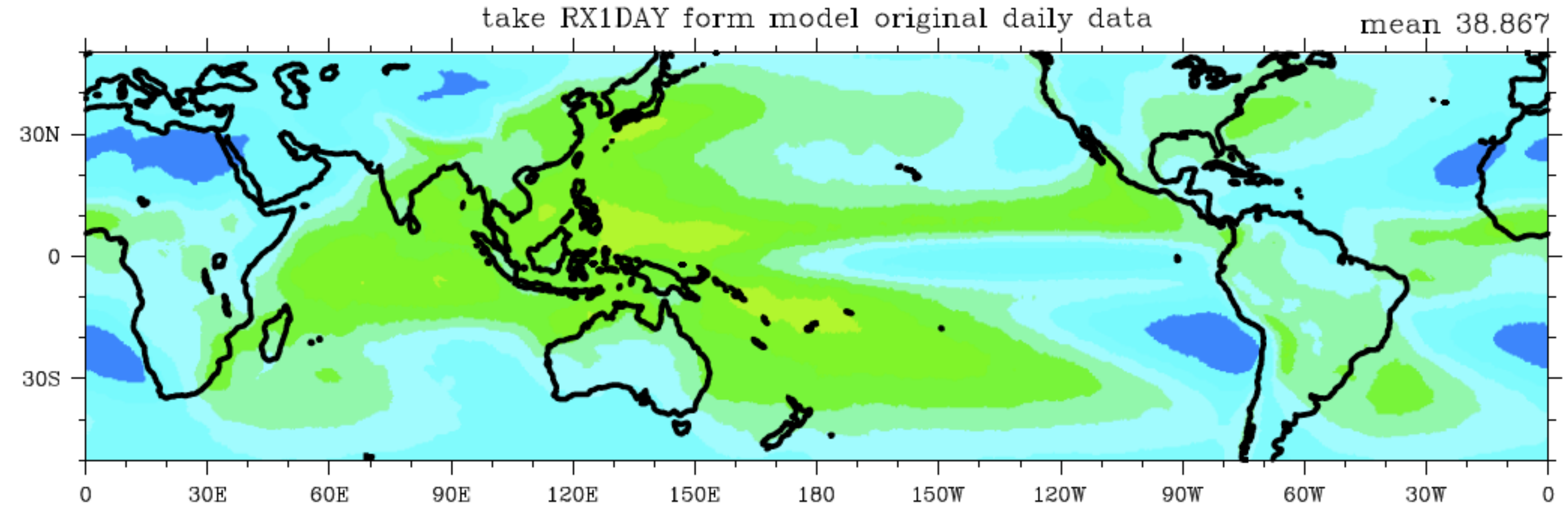


Projecting MIROC3.2 T42 medium resolution run to 0.25° resolution

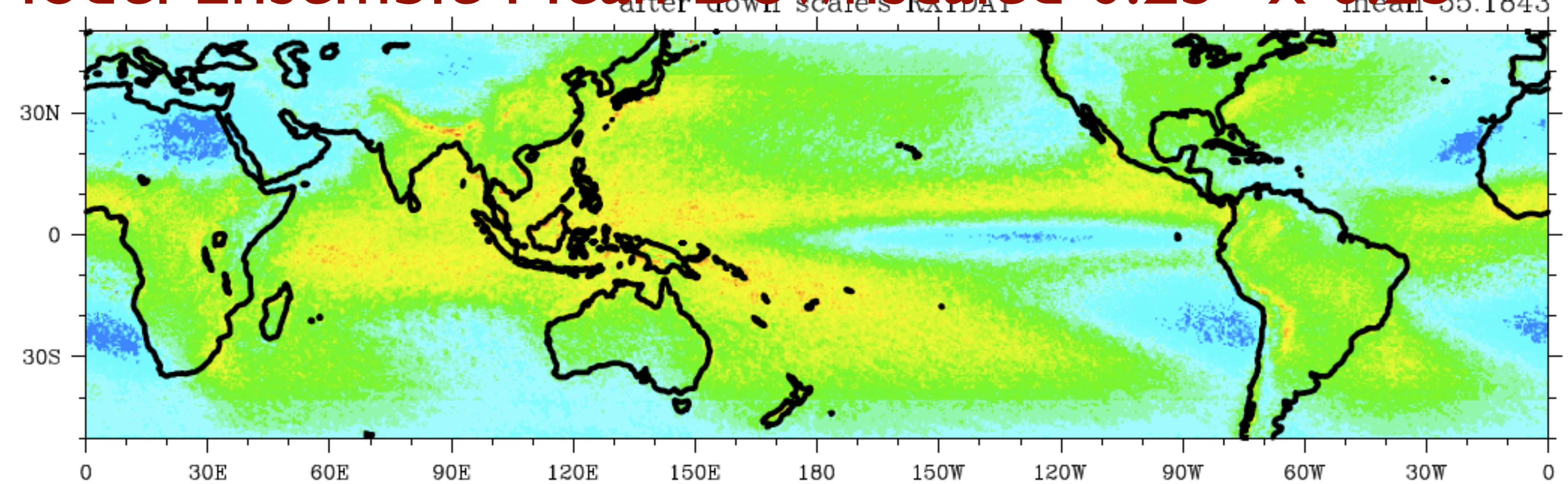
Projecting MIROC3.2 T106 high resolution run to 0.25° resolution



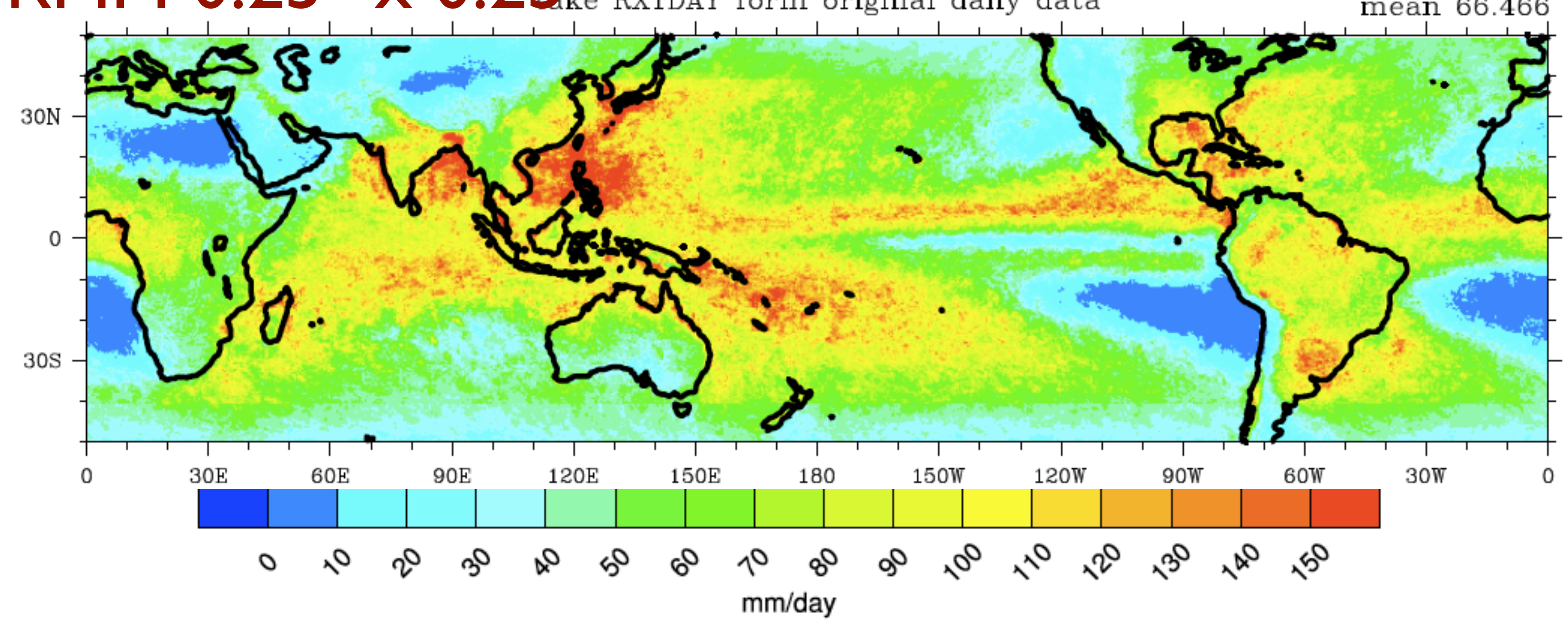
Model Ensemble Mean (at model original resolution)



Model Ensemble Mean Downscaled 0.25° x 0.25°



TRMM 0.25° x 0.25°



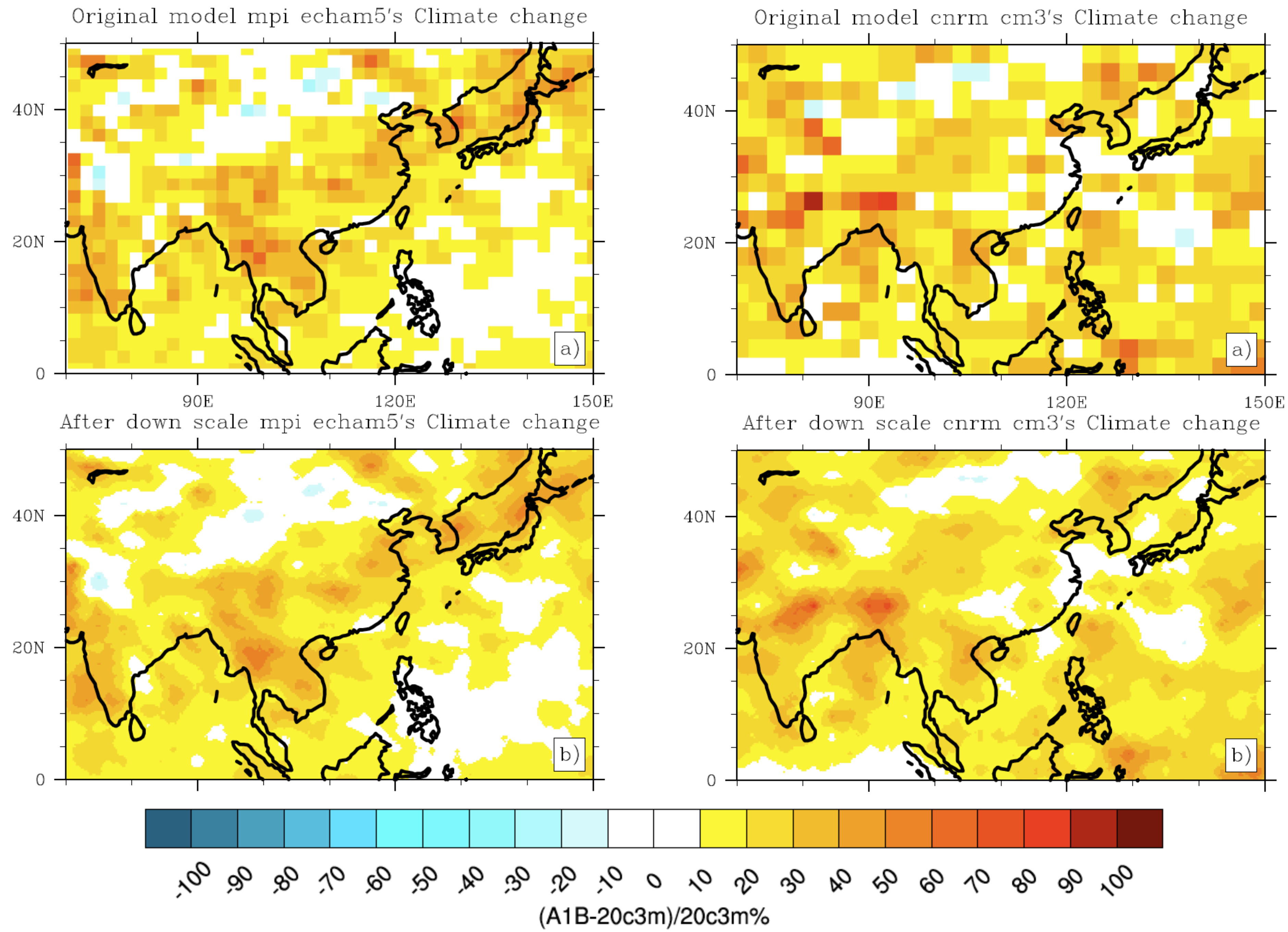
Regionalization significantly improve the model simulated extreme rainfall events at comparable spatial scale to the high resolution TRMM observation.

Regionalization of projected future changes in high impact weather and extreme climate indices can be derived while keeping the original spatial pattern.

ECHAM5/MPI-OM T63 | CNRM CM3 T42

Model projected future change (%) in Rx1day (original resolution)

Regionalized to 0.25° x 0.25° resolution



Summary and Concluding Remarks (mean)

- 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

  ....

Summary and Concluding Remarks (extreme)

- Spatial scale of daily precipitation data should be carefully considered in the extreme analysis, especially for model validation and comparison.
- While the model precipitation parameterization play important role in determining the simulated extreme daily rainfall amount, the spatial scale dependence of different climate models should be removed by up-scaling the high-resolution models or alternatively by downscaling the model simulation to higher resolution based on observational spatial statistics.
- The majority (not all) of CMIP/IPCC models still tends to underestimate extreme daily precipitation.
- Regionalization of CMIP model simulations and projections on the high-impact weather and climate extremes should be welcomed by climate impact studies which often required detailed local information.
- Limitations: Still need to correct model bias and whether the present observed statistics between different spatial scales stand.