Regional Downscaling Experiments for CORDEX-East Asia

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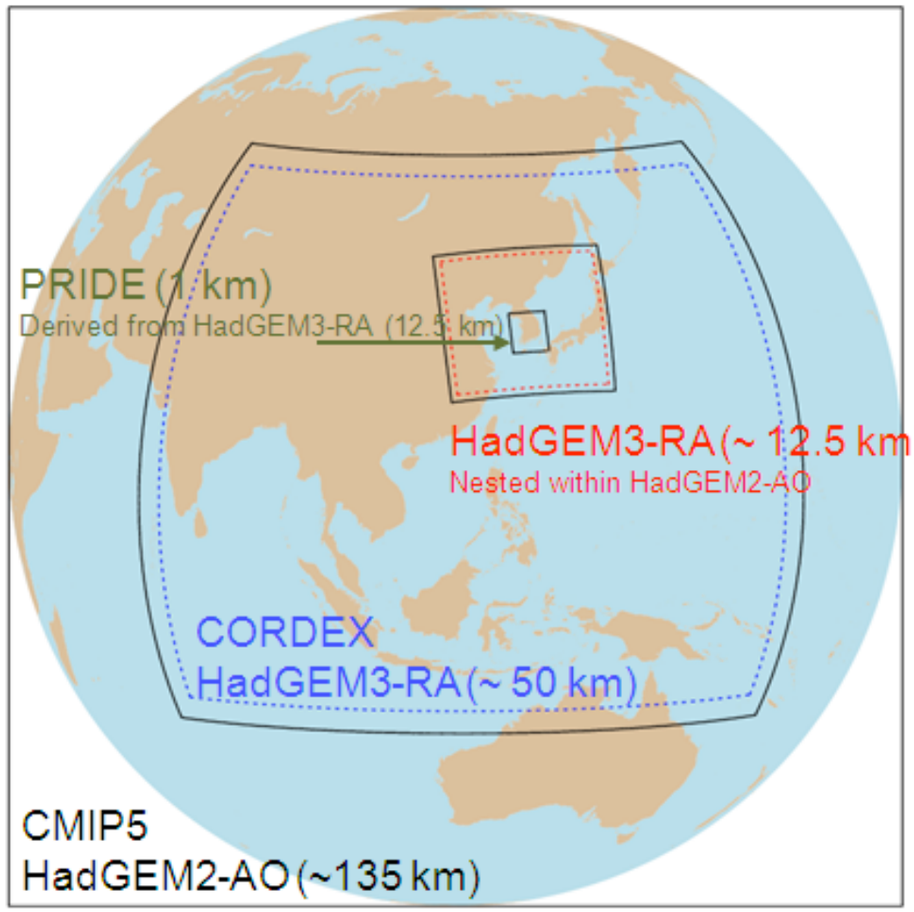
acknowledged to:

all colleagues at KNU, SNU, YU, UNIST, and POSTECH

The 7th ICTP workshop on Theory and Use of Regional Climate Models, 12-23 May 2014, Trieste, Italy

A Regional Downscaling Project coordinated by KMA

Domains for climate projections at KMA



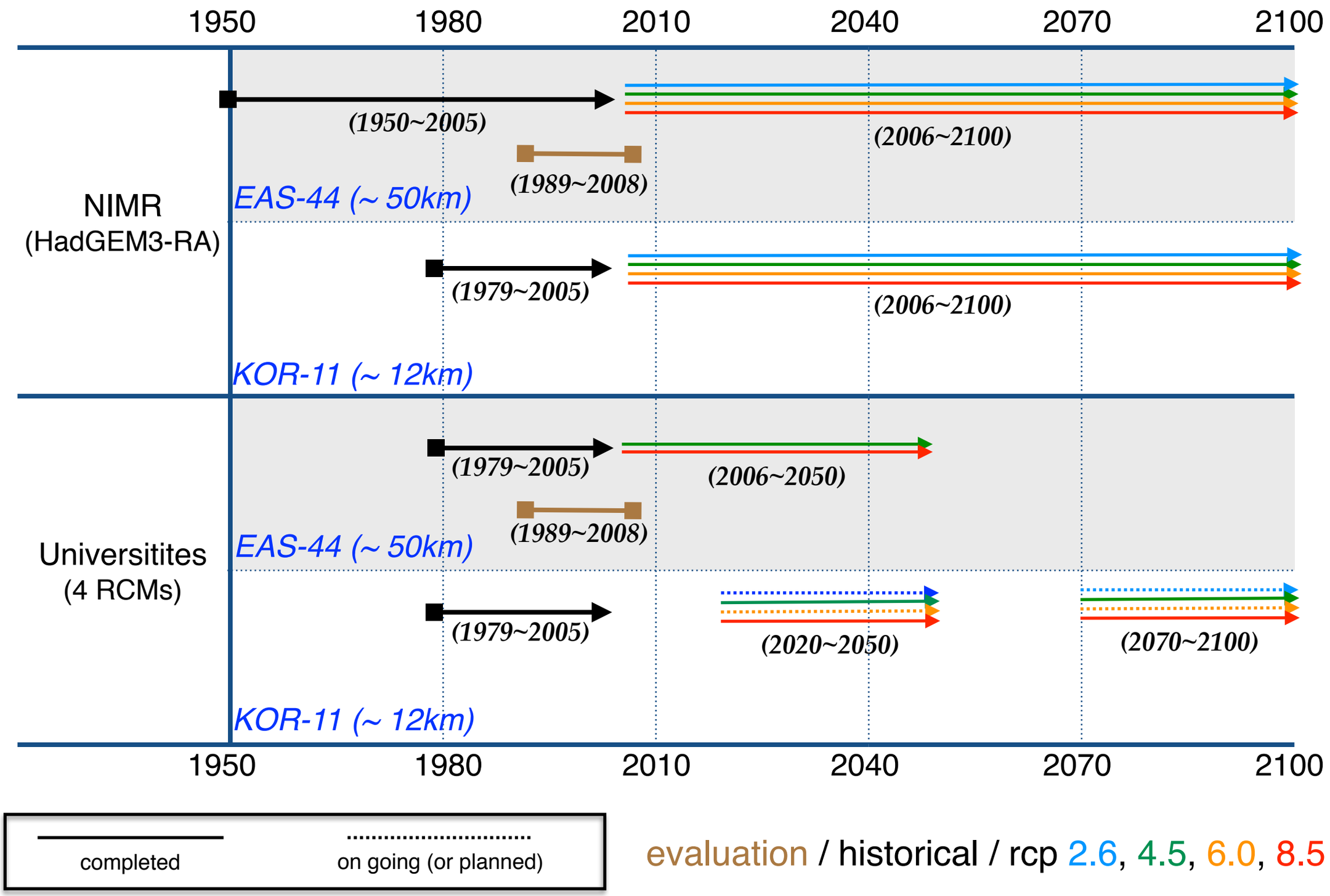
KMA/NIMR

CMIP5 experiment with HadGEM2-AO and provide GCM forcing
Regional downscaling for 2 domains with HadGEM3-RA
Maintaining CORDEX-EA databank

Dynamical Downscaling Group	Statistical Downscaling Group	(Extreme) Analysis Group	Application Group
• Multi-RCMs forced by HadGEM2-AO • Ensemble method • Uncertainty Assessment	• Methods' Development • High-resolution projection data up to 1 km • Focusing on national scenario	• Evaluation of CORDEX outputs for extreme events • Evaluation of Tropical Cyclones	• Essential factors for administrative districts in *agriculture*, *health*, and *disaster prevention* sectors.

- 5 regional climate models for CORDEX-EA domain (50 km) and smaller sub-region (12.5 km).
- 1 statistical downscaling model for Korean peninsula up to 1 km's resolution.
- 1 group from Japan (U.Tokyo) has participated recently.

Downscaling Experiments



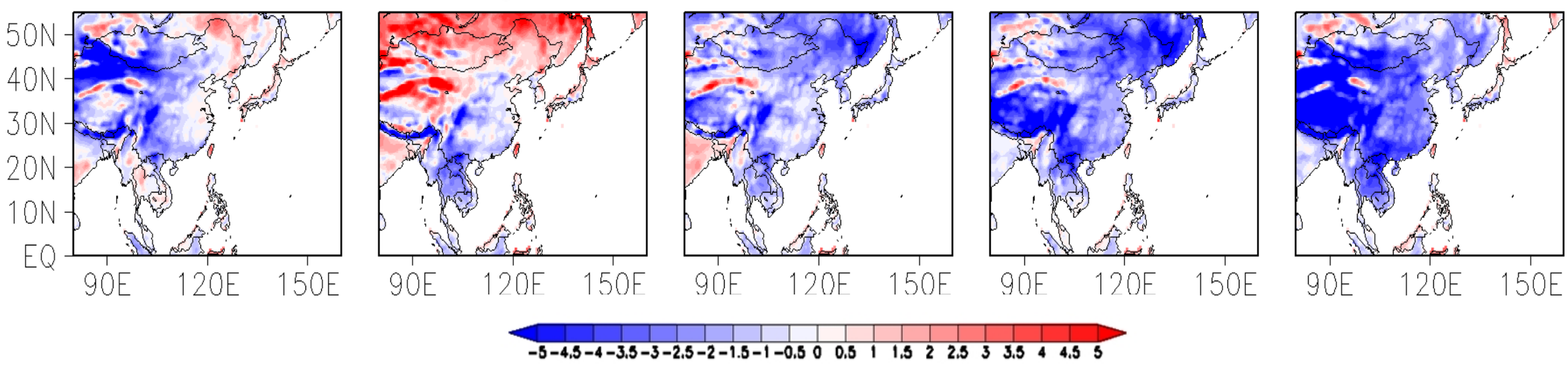
Model Configurations

Model		HadGEM3-RA	RegCM4	SNURCM (MM5)	WRF	GRIMS (YSU RSM)
Institute		KMA/NIMR	Kongju Nat. U.	Seoul Nat. U	Seoul Nat. U.	Yonsei U.
Grid Numbers (Lat. x Lon.)		183 x 220	197 x 243	197 x 233	197 x 233	198 x 241
Physics	Radiation	General 2-stream	CCM3	CCM2	RRTM	Chou
	Cloud	Mixed phase	SUBEX	Resiner II	WSM3	diagnostic microphysics
	Convection	Revised mass-flux	MIT-Emanuel	KF2	KF2	SAS
	Non-local PBL	Lock et al.	Holtslag	YSU	YSU	YSU
	Land	MOSE II	CLM3	CLM3	NOAH	NOAH
	Nudging	No	Yes	Yes	Yes	Yes

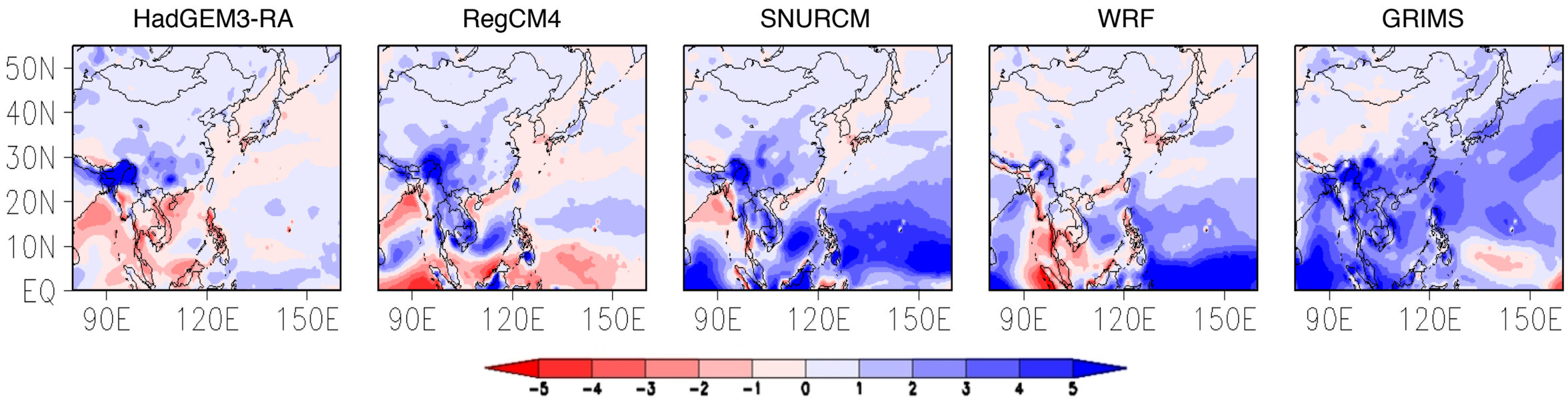
Annual Mean Bias (model - obs.)

20-year (1989-2008) mean

[Surface Air Temperature (°C)]



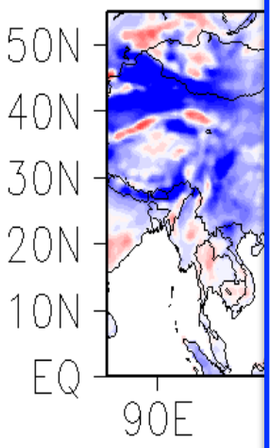
[Precipitation (mm/day)]



An[illegible] Bias (model – obs.)

[Surfac[illegible]

Had[illegible]



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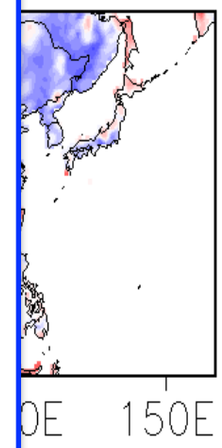
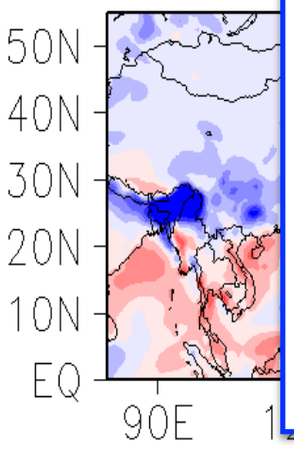


[Preci[illegible]

Had[illegible]



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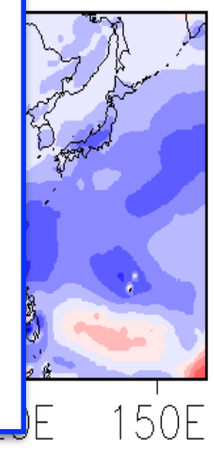
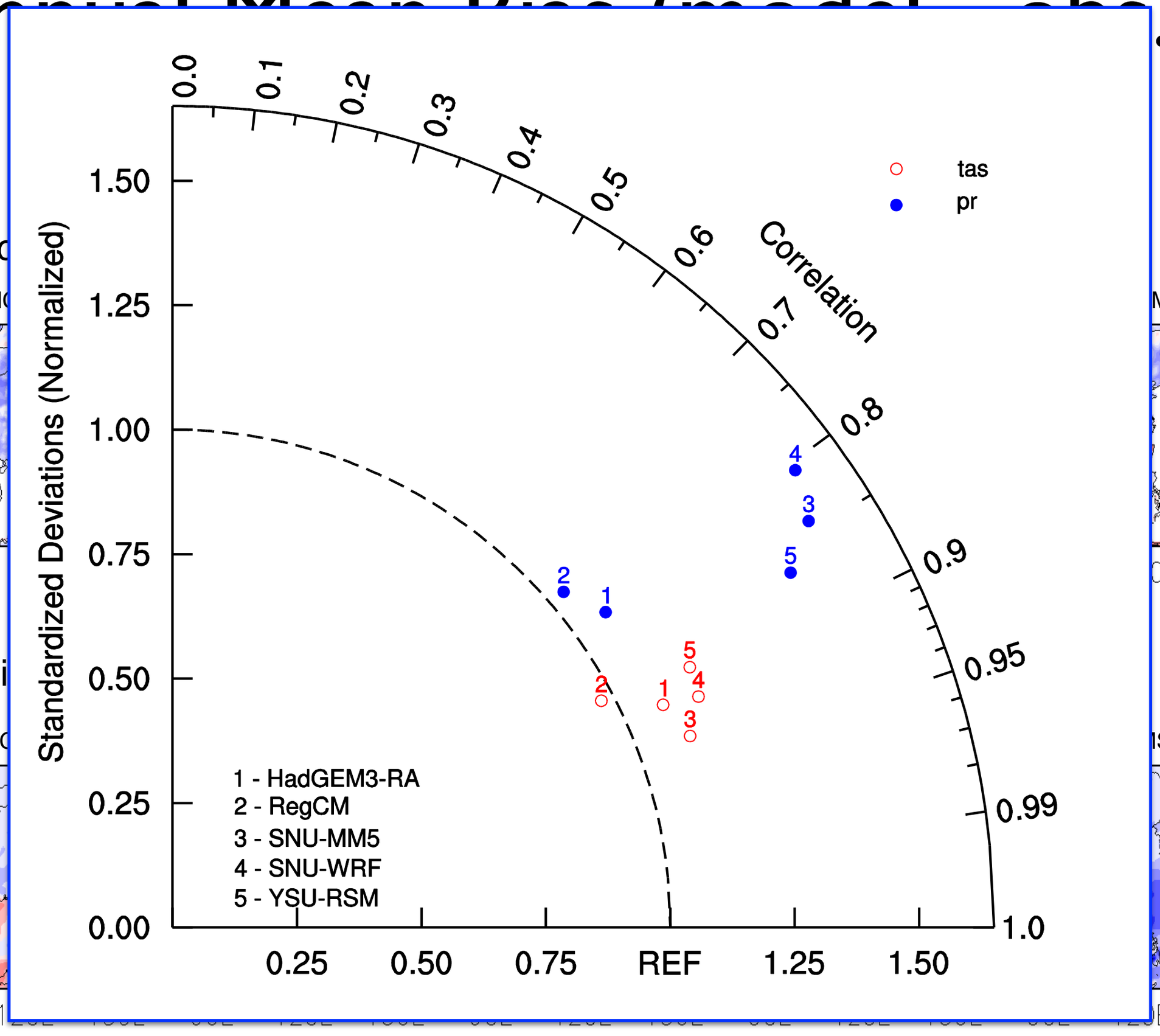
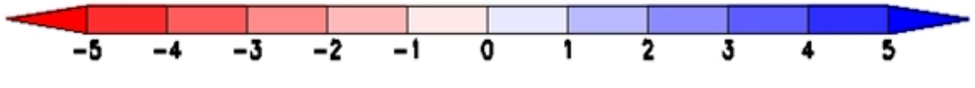






Performance-based Ensemble Average Method

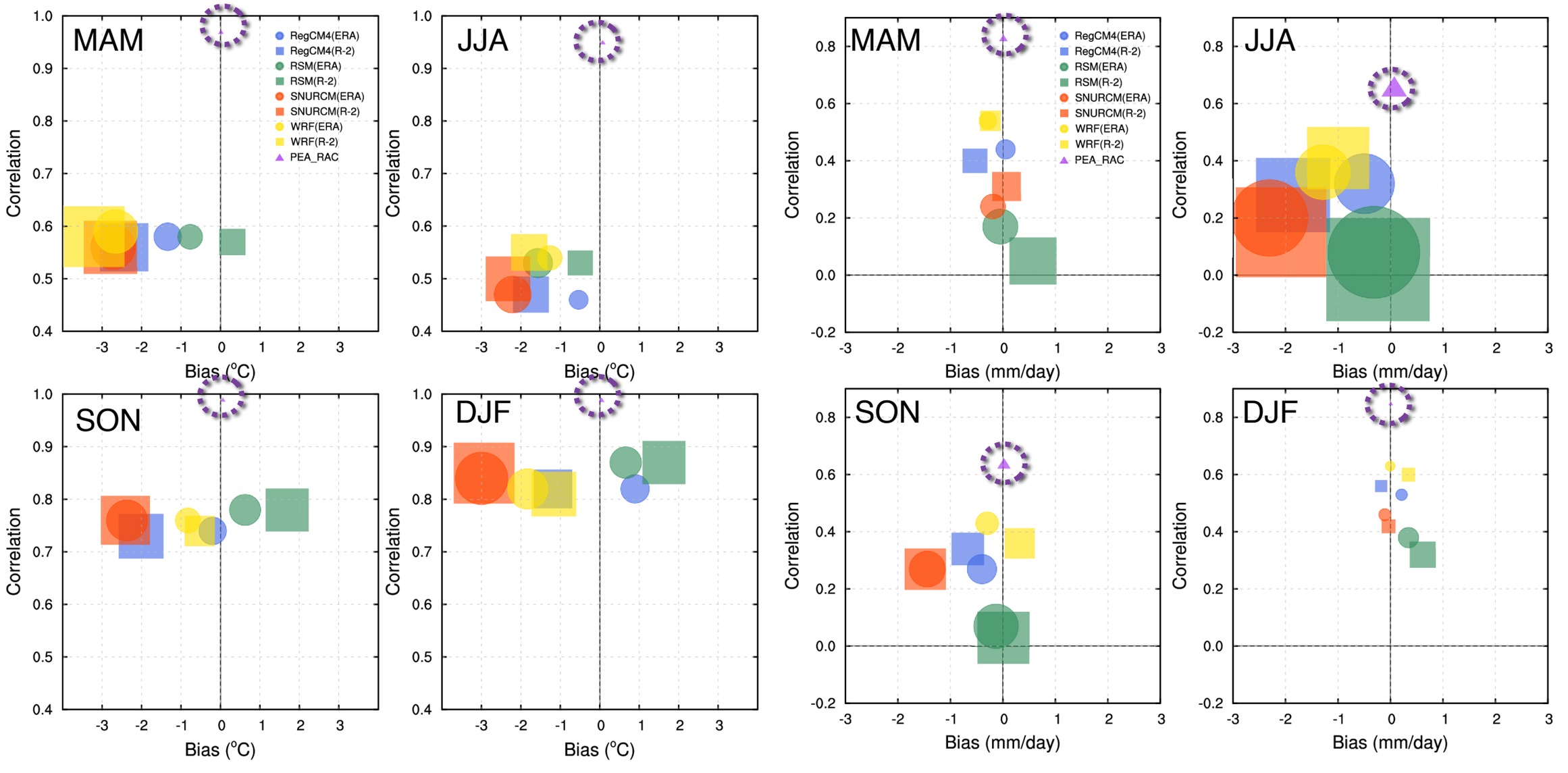
(Courtesy of Suh et al., 2012)

$$\tilde{T} = \sum_{i=1}^{N_m} Pw_i^n T_i - \sum_{i=1}^{N_m} Pw_i^n \Delta T_i \quad \text{, where} \quad Pw_i^n = \frac{Pw_i}{\sum_{i=1}^{N_m} Pw_i} \quad \text{and} \quad Pw_i = \frac{1}{(RMSE_i + 1)} |Cor_i|$$

RegCM4(ERA)
RegCM4(R-2)
RSM(ERA)
RSM(R-2)
SNURCM(ERA)
SNURCM(R-2)
WRF(ERA)
WRF(R-2)
PEA_RAC

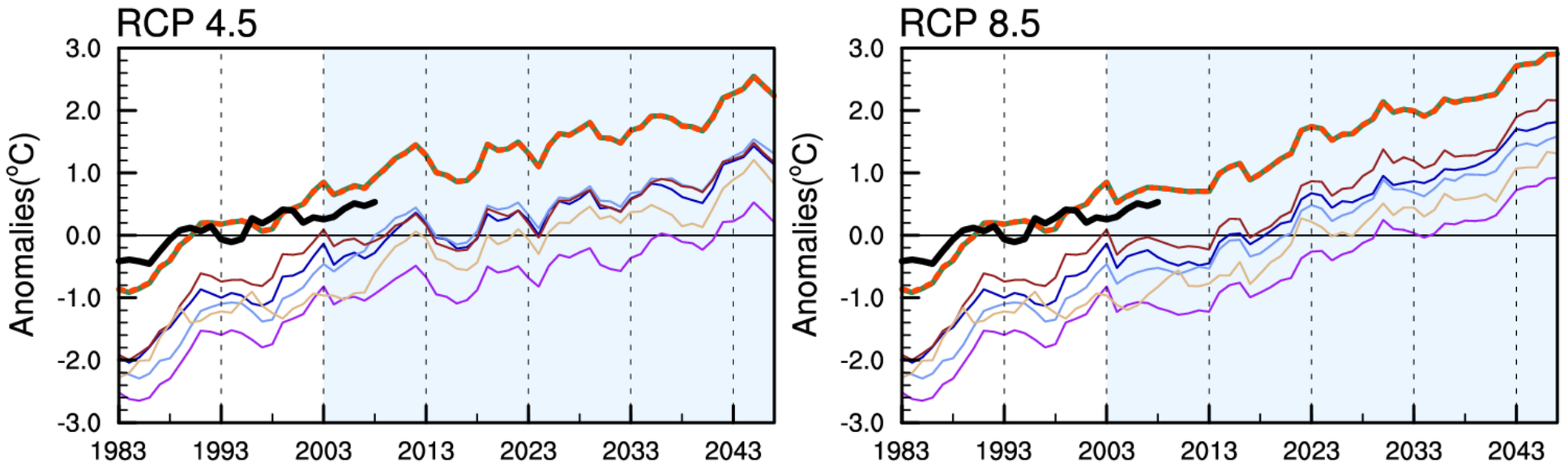
<Temperature>

<Precipitation>



Annual mean time series
(9-year moving average)

<Temperature>



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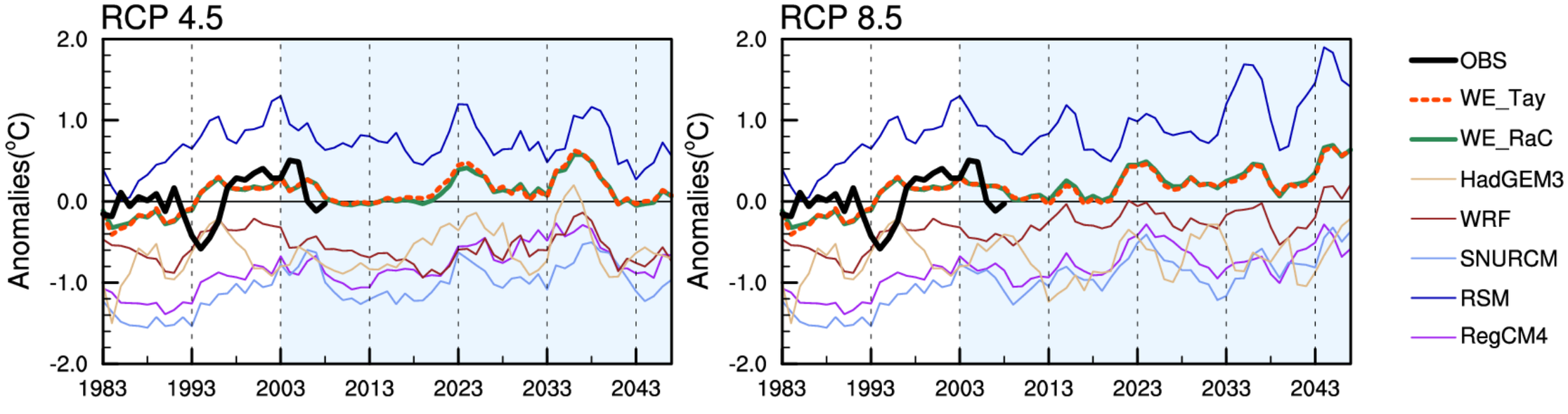
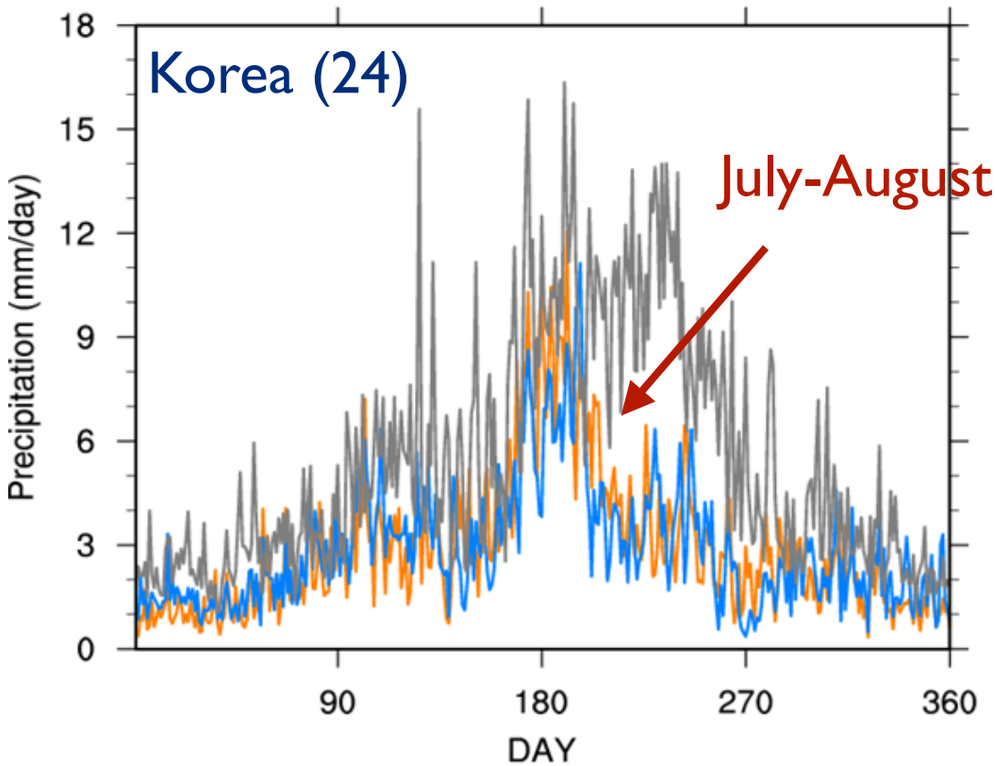
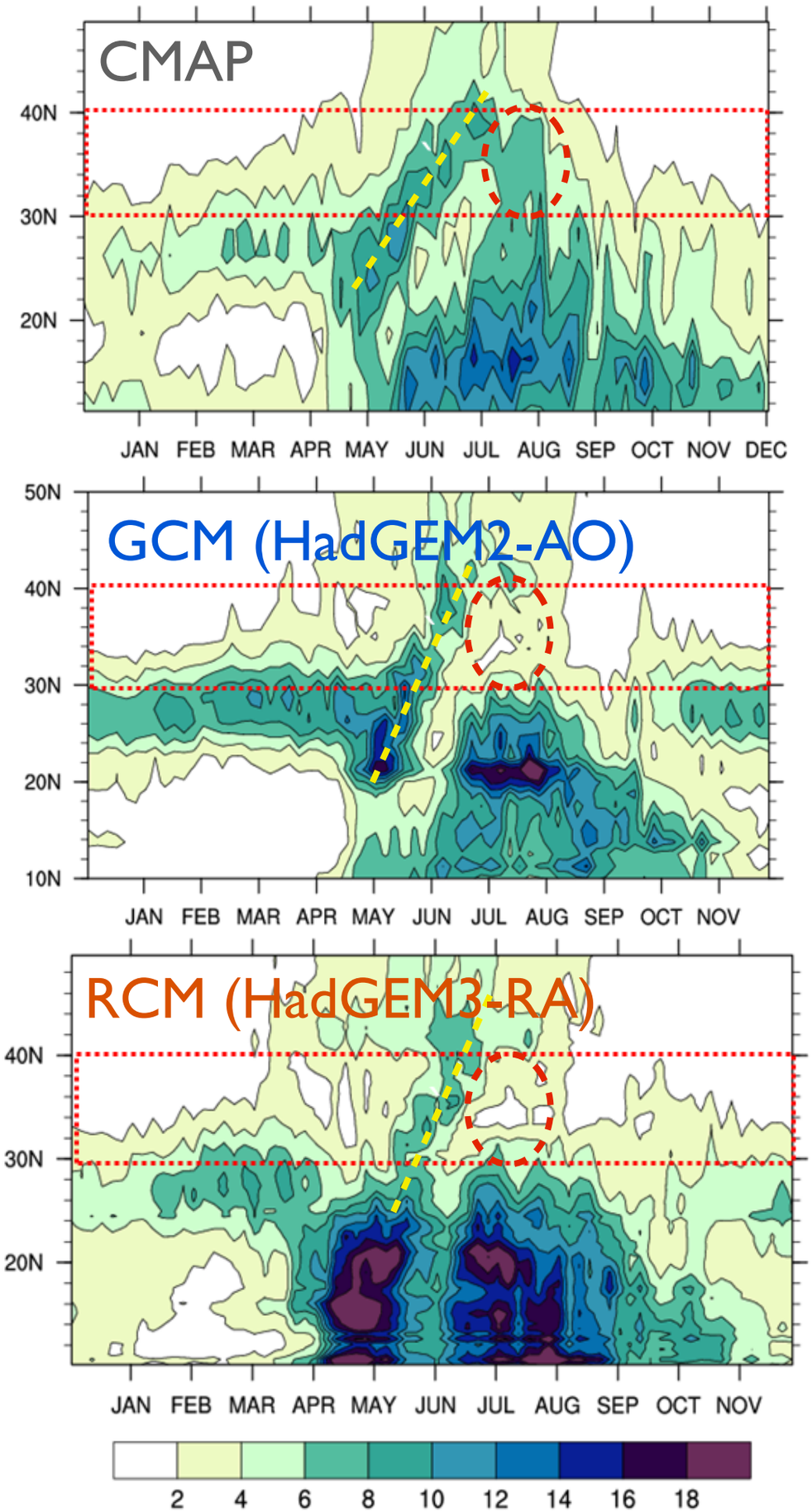


Monsoon Evolution (Korea)

Averaged over 120 -130 °E
(1979-2005)





CMAP

RCM (HadGEM3-RA)

RegCM4 (lon:120~130, lat:10~50)

RCM (RegCM4)

MM5 (lon:120~130, lat:10~50)

RCM (MM5)

WRF (lon:120~130, lat:10~50)

RCM (WRF)

RSM (lon:120~130, lat:10~50)

RCM (RSM)

40N
30N
20N

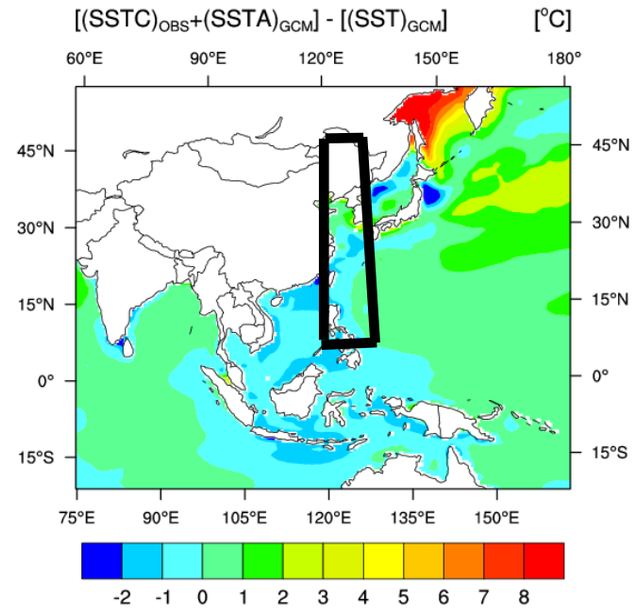
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

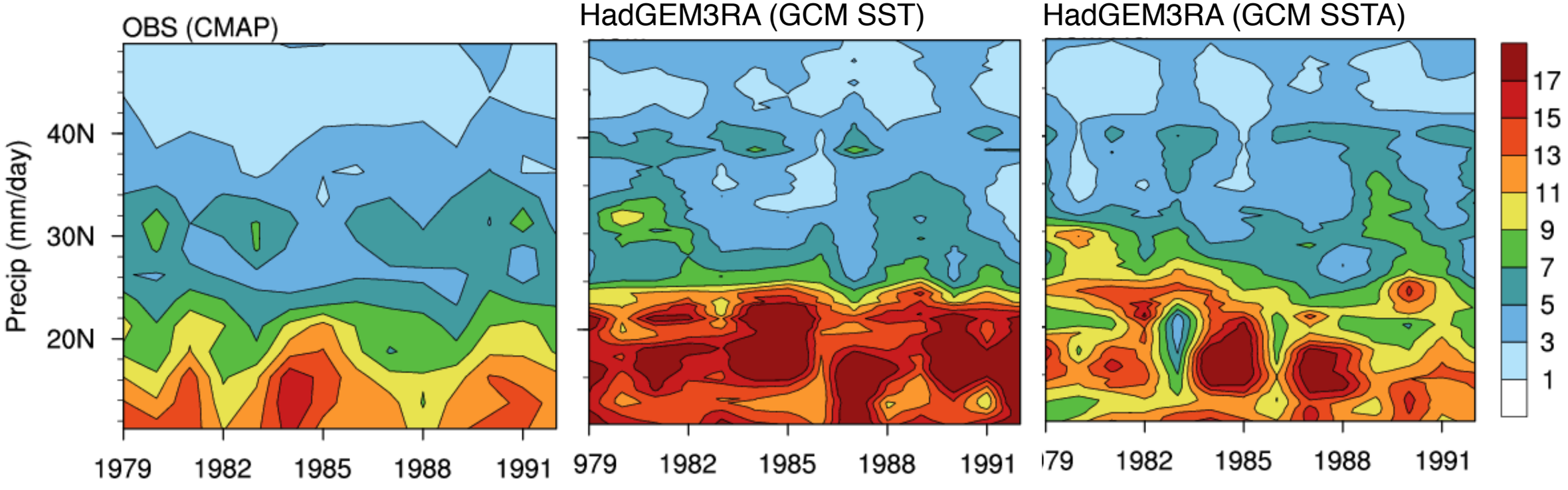
2 4 6 8 10 12 14 16 18

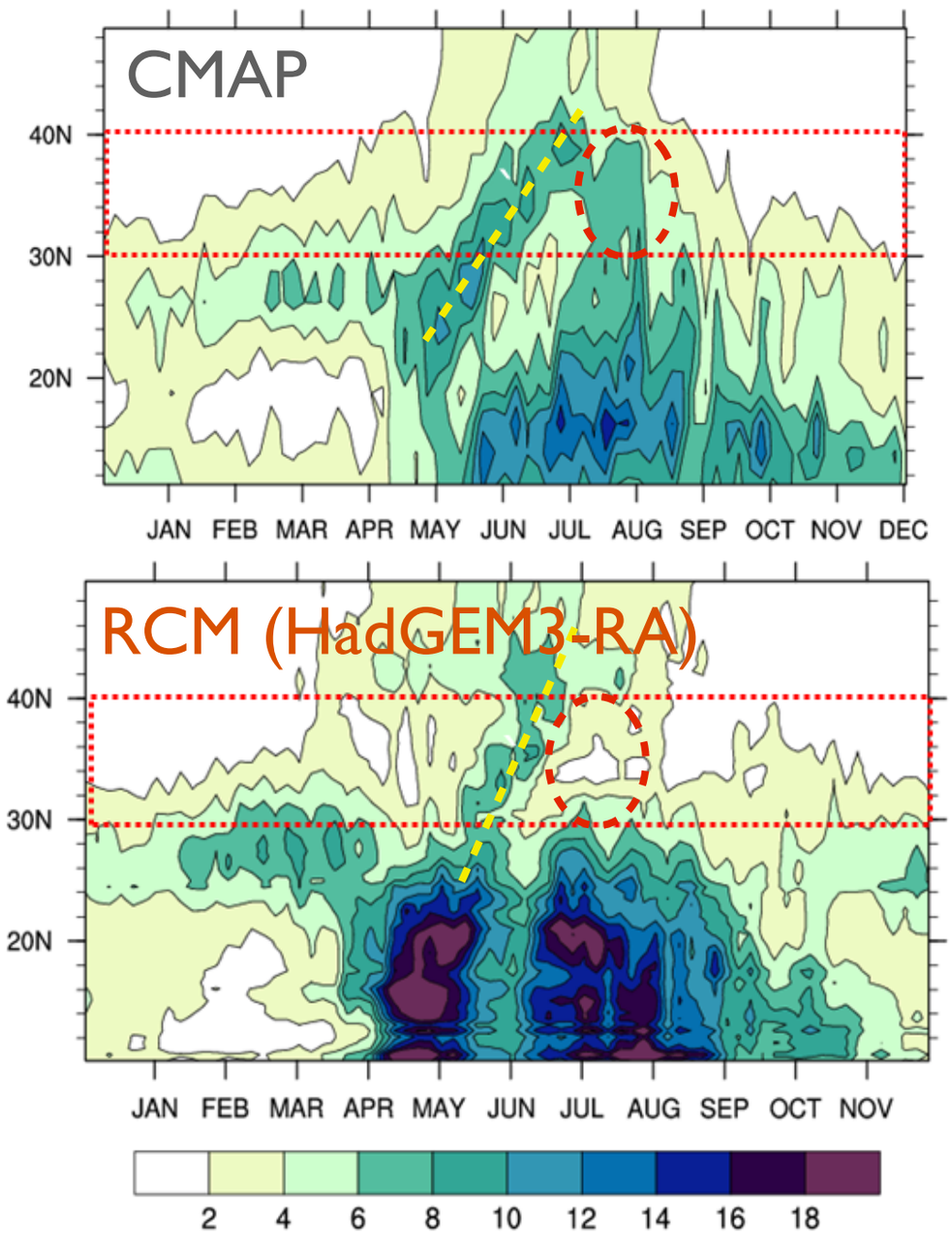
Additional Experiments with HadGEM3-RA

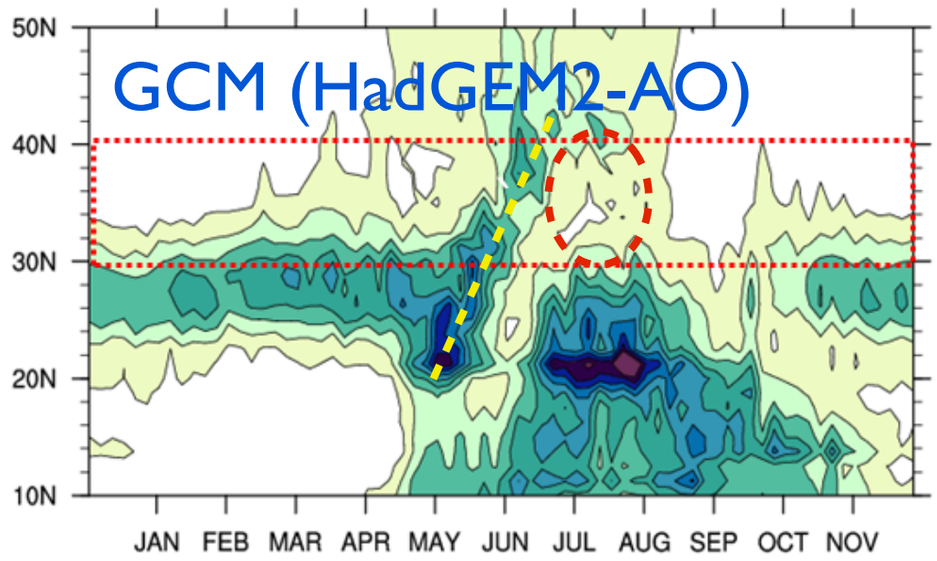
Boundary forcing impacts with

- SST and sea-ice: Observational Climatology + GCM anomalies
- Lateral BC: more stabilized (over 400 years) GCM forcing

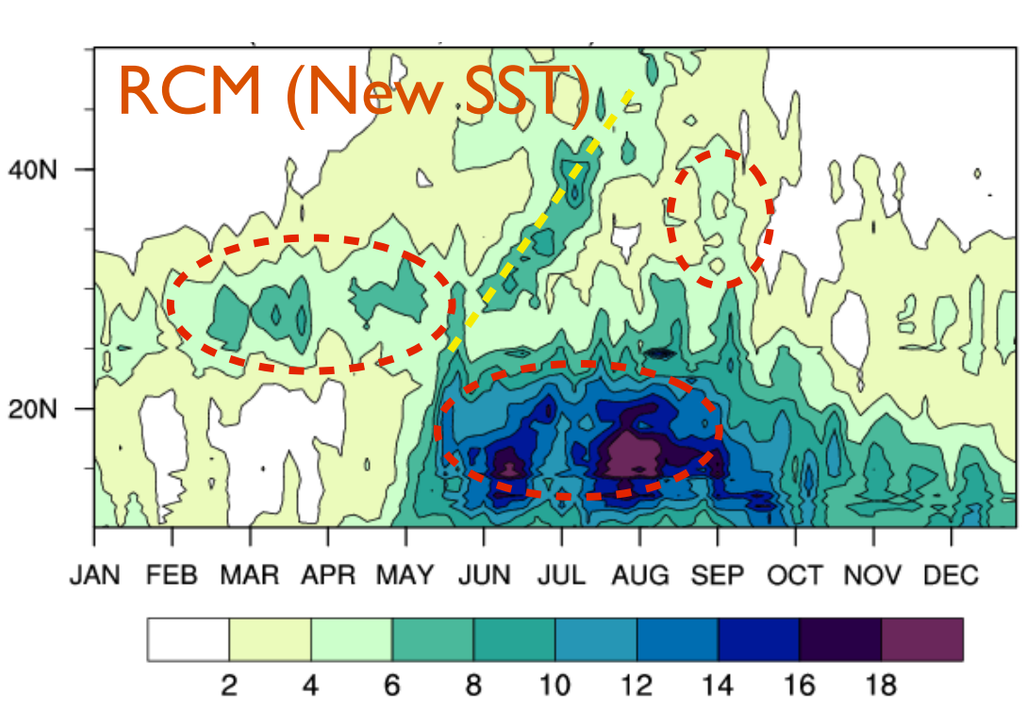





CMAP
40N
30N
20N
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

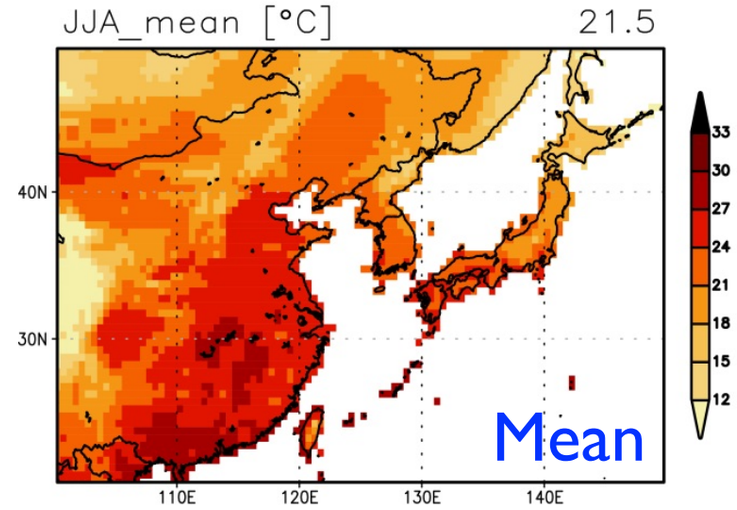

GCM (HadGEM2-AO)
50N
40N
30N
20N
10N
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV

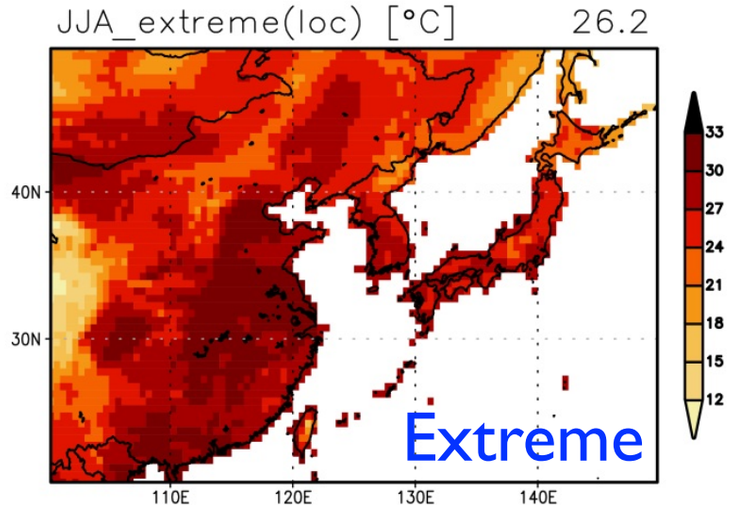
RCM (HadGEM3-RA)
40N
30N
20N
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV
2 4 6 8 10 12 14 16 18


RCM (New SST)
40N
20N
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
2 4 6 8 10 12 14 16 18

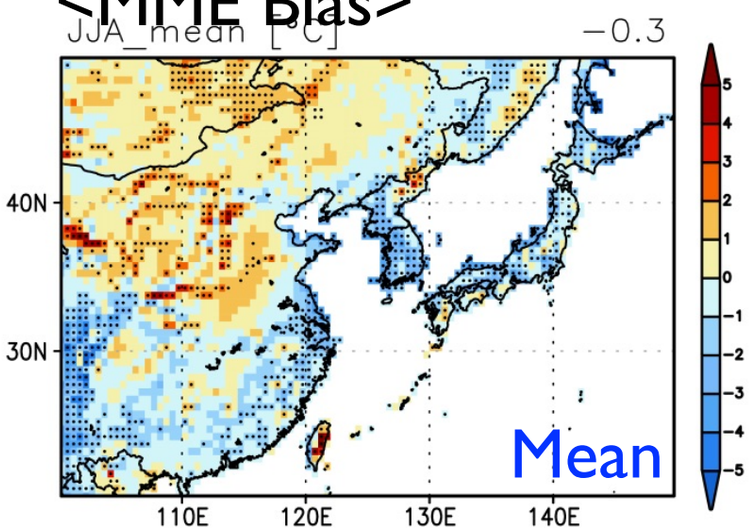
Surface Air Temperature Extremes (1979-2005 JJA)

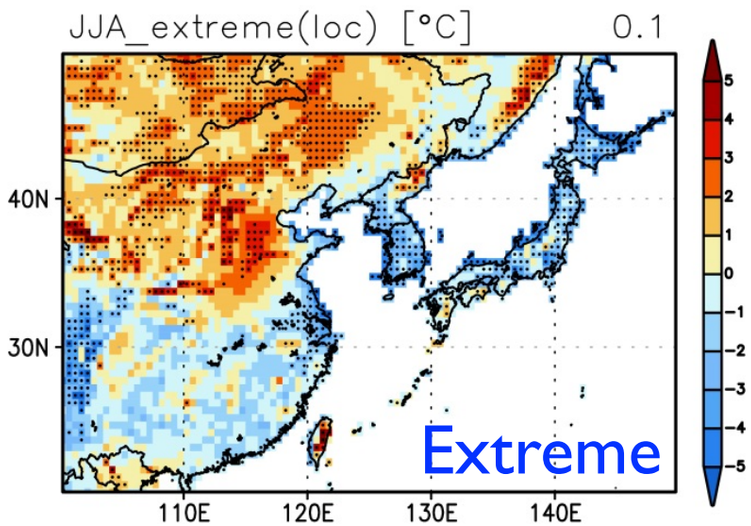
<Observation>





<MME Bias>





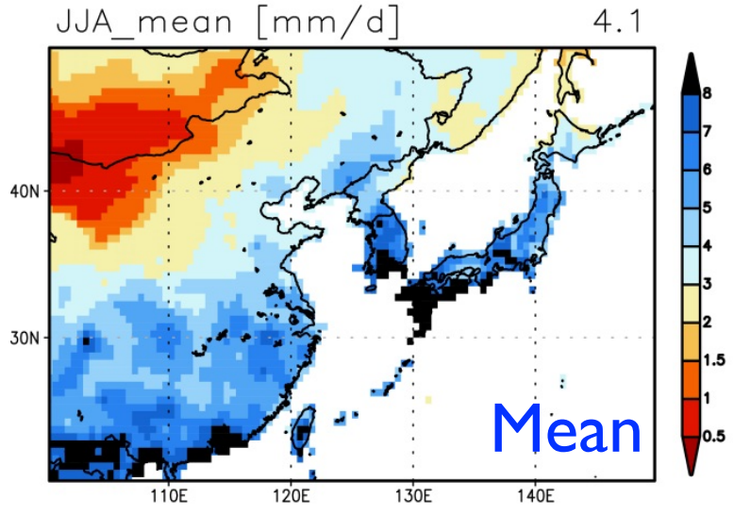
Stippling indicates region where all 5 RCMs show the same sign of bias.

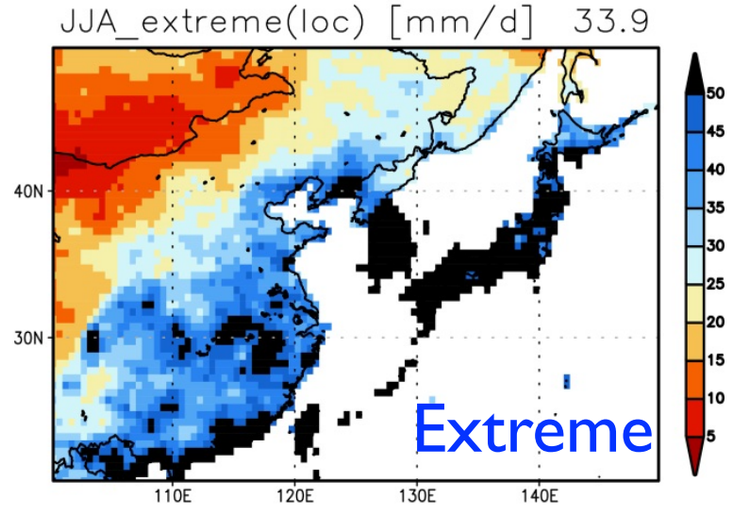
- Mean and extreme climatology
  - similar spatial pattern, i.e., warmer in eastern and southern China

- MME bias
  - Similar spatial patterns between mean and extreme
  - Cold bias in Korea, southern China, and Japan
  - Warm bias in central and northern China and Mongolia
  - Mean biases are smaller than extreme.

Precipitation Extremes (1979-2005 JJA)

<Observation>





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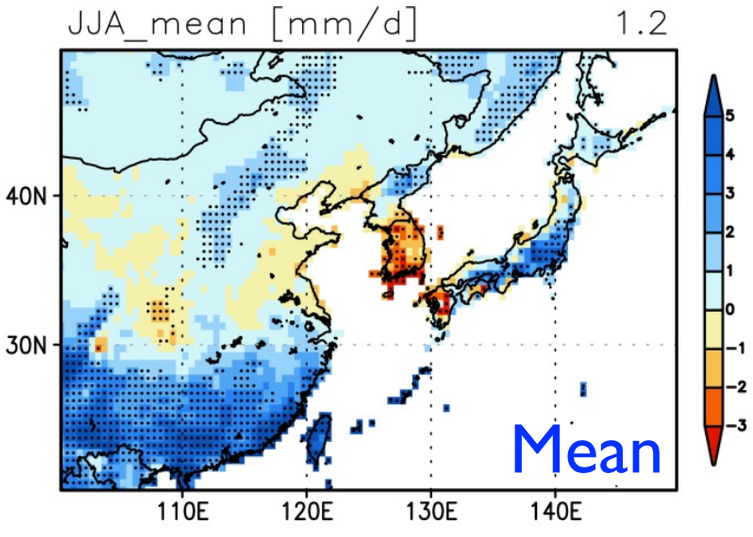
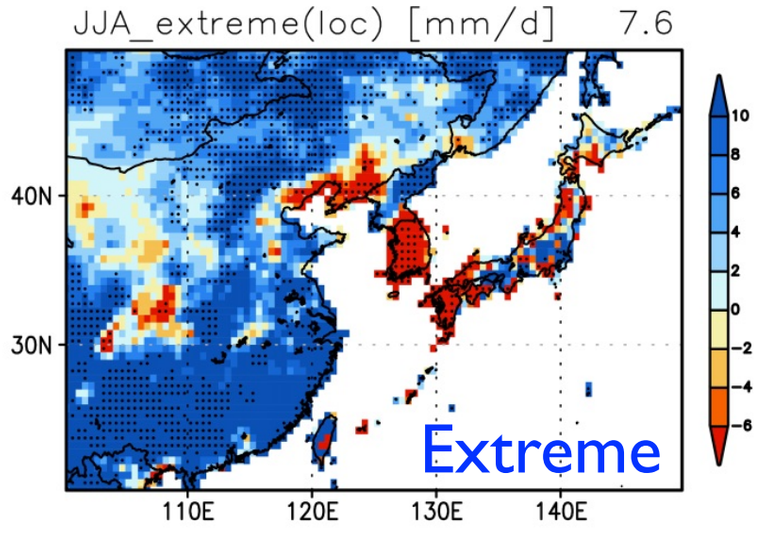


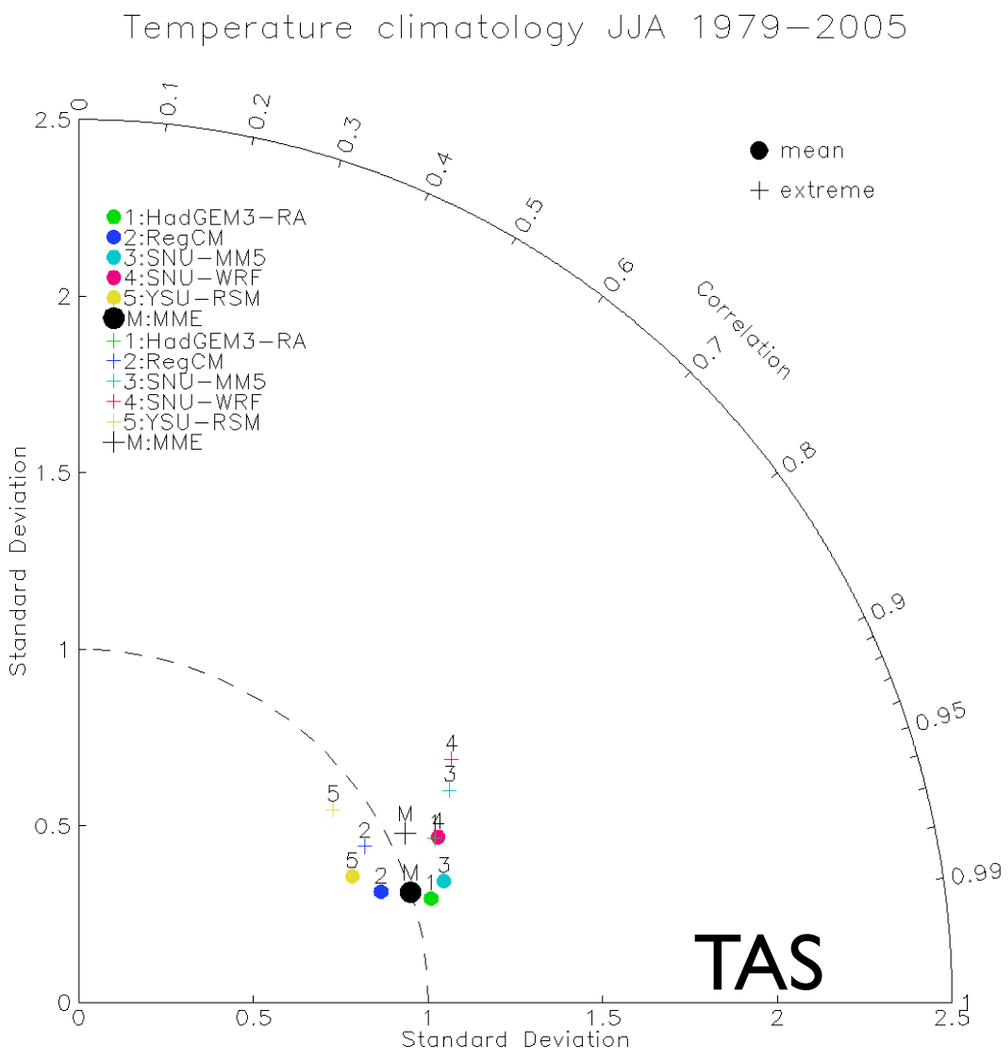


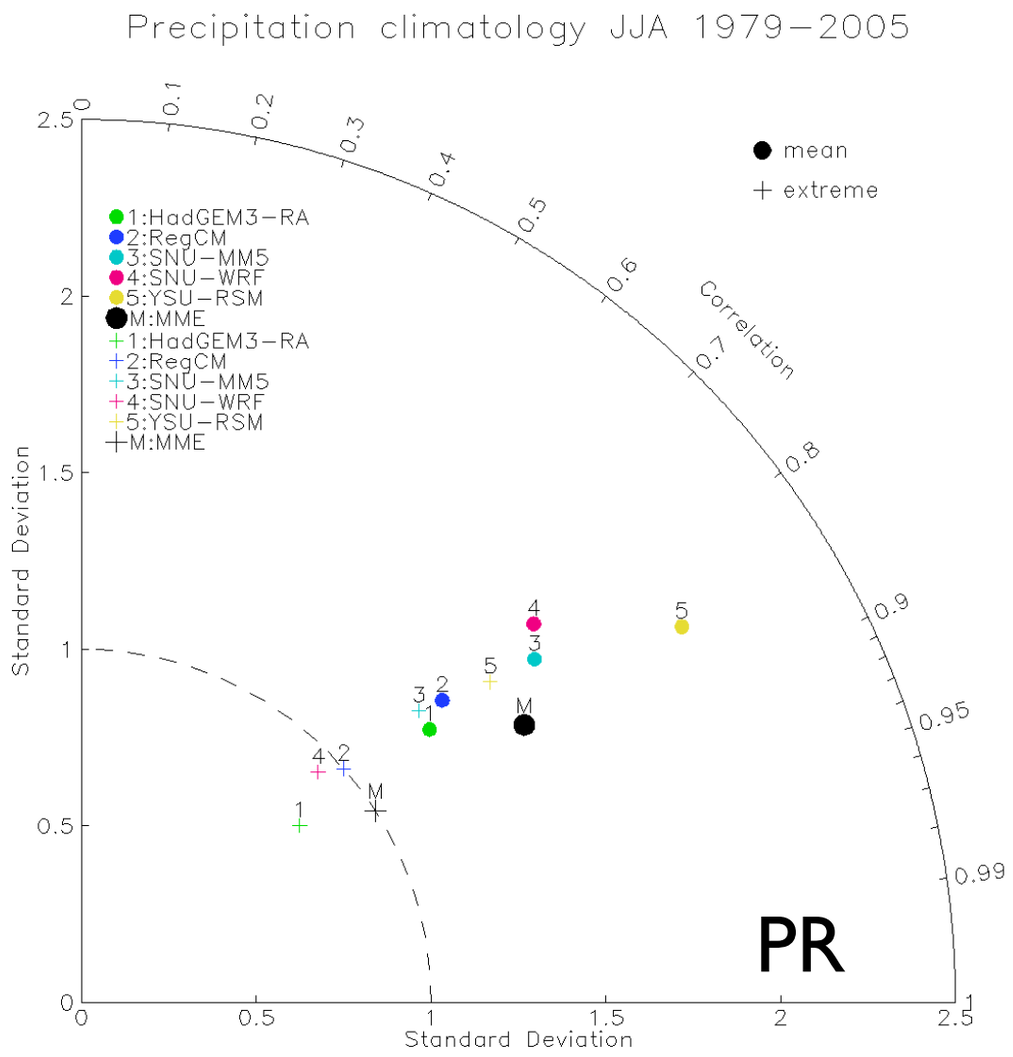
Stippling indicates region where all 5 RCMs show the same sign of bias.

- Mean and extreme climatology
  - similar spatial pattern (Monsoon rain bands and heavy rains in southern China, South Korea, and Japan)

- MME bias
  - Overall wet biases (29 % wetter in mean, 22% wetter in extreme)
  - Dry bias in South Korea and Kyushu, which means 'Changma' front is not captured by most RCMs.

Characteristics of Mean and Extremes





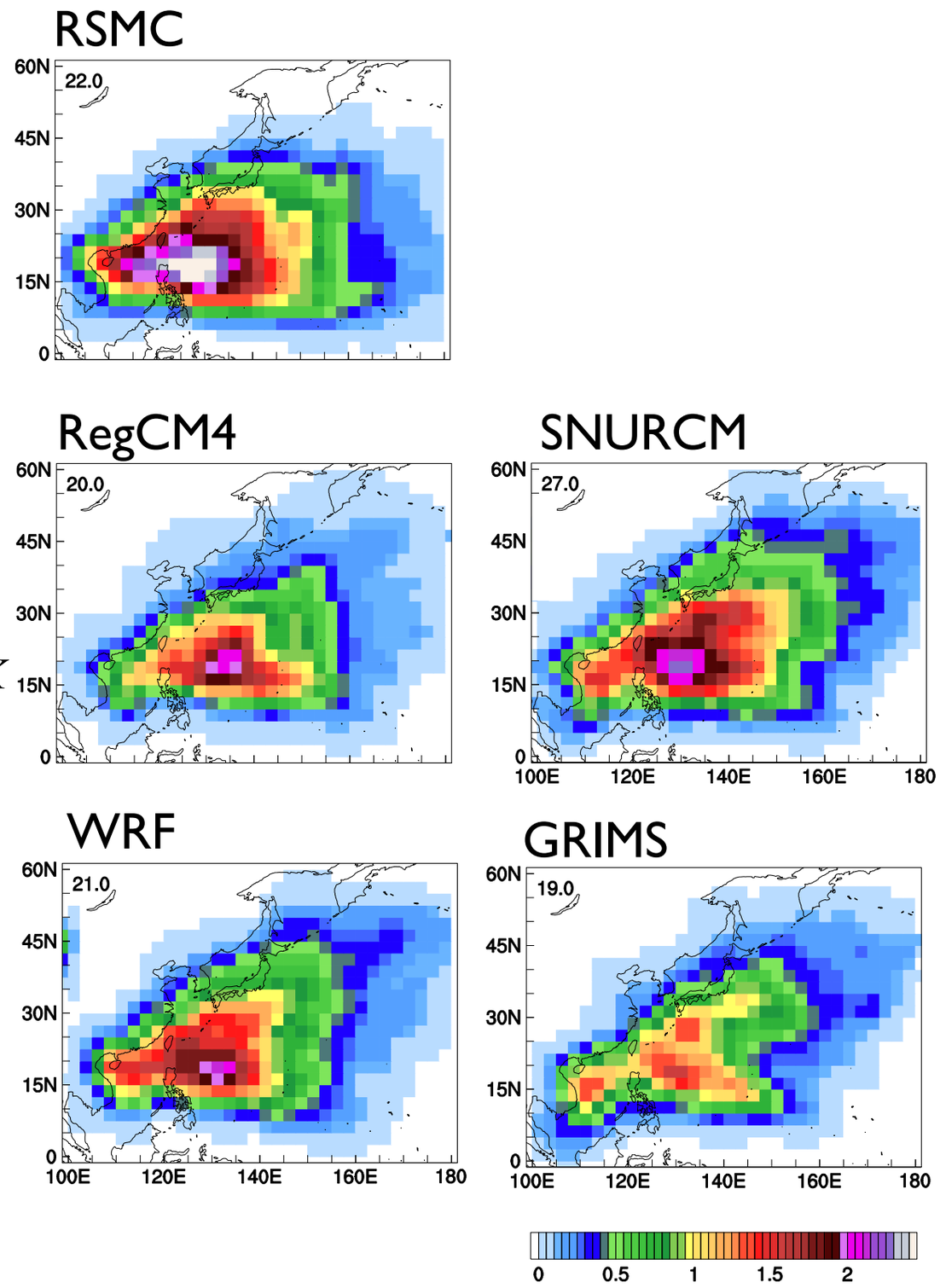
- TAS: means show better performance than extremes (higher spatial correlation)
- PR: extremes have higher skill than means (better spatial variability)
- HadGEM3RA and RegCM show better performance than others

Tropical Cyclone Track Density

Tracking Method

(Oouchi et at., 2006; Camargo et al., 2007)

1) Find the local minimum sea level pressure
2) Maximum RV at 850 hPa > 4.9 x 10^{-5} s^{-1}
3) Maximum wind speed at surface > 17 ms^{-1}
4) Warm core criterion: $\Delta T = \Delta T_{300} + \Delta T_{500} + \Delta T_{700} > 2.0K$
5) Maximum wind speed at 850 hPa > that at 300 hPa
6) Duration of all above condition > 2 days



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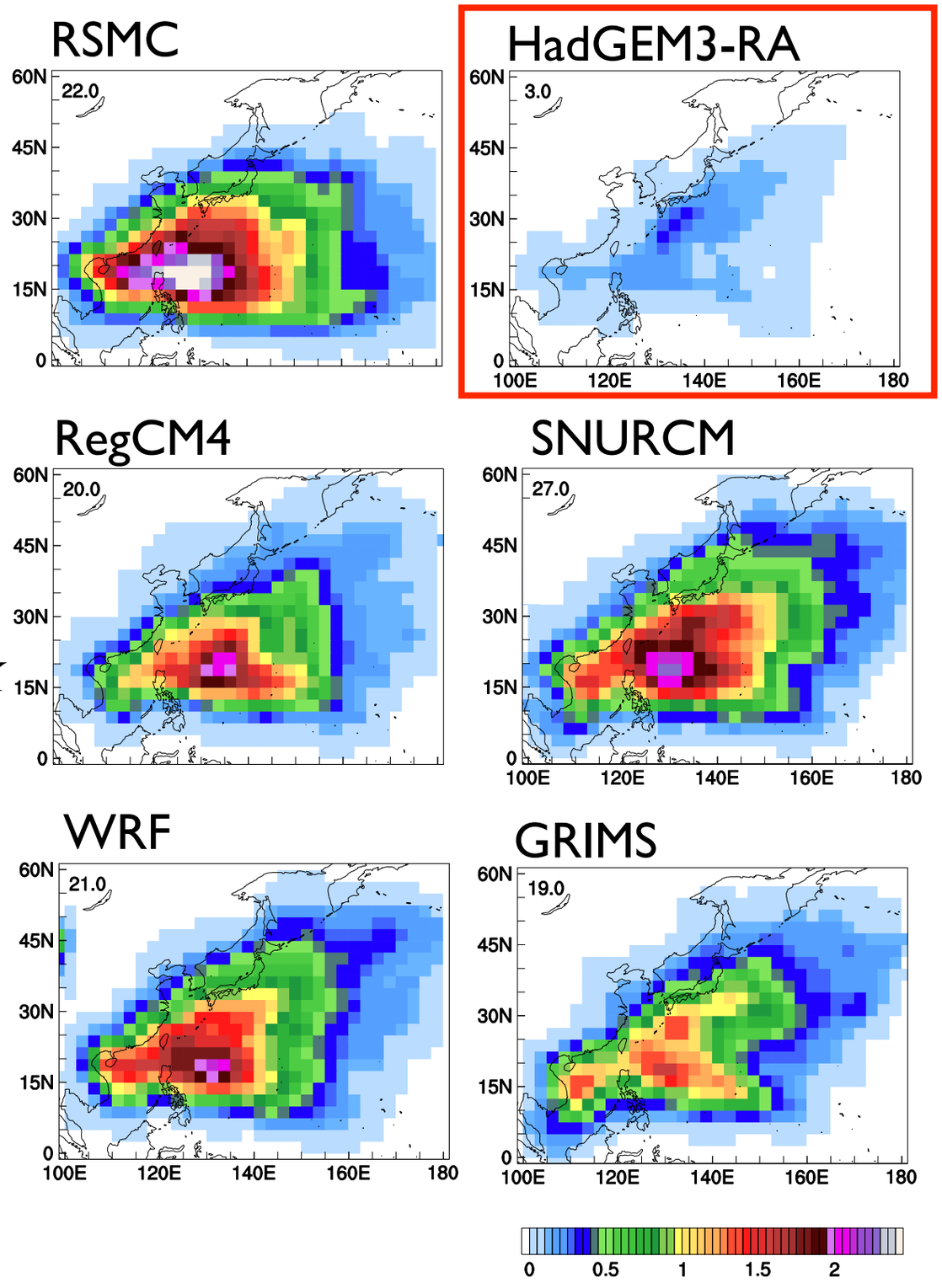
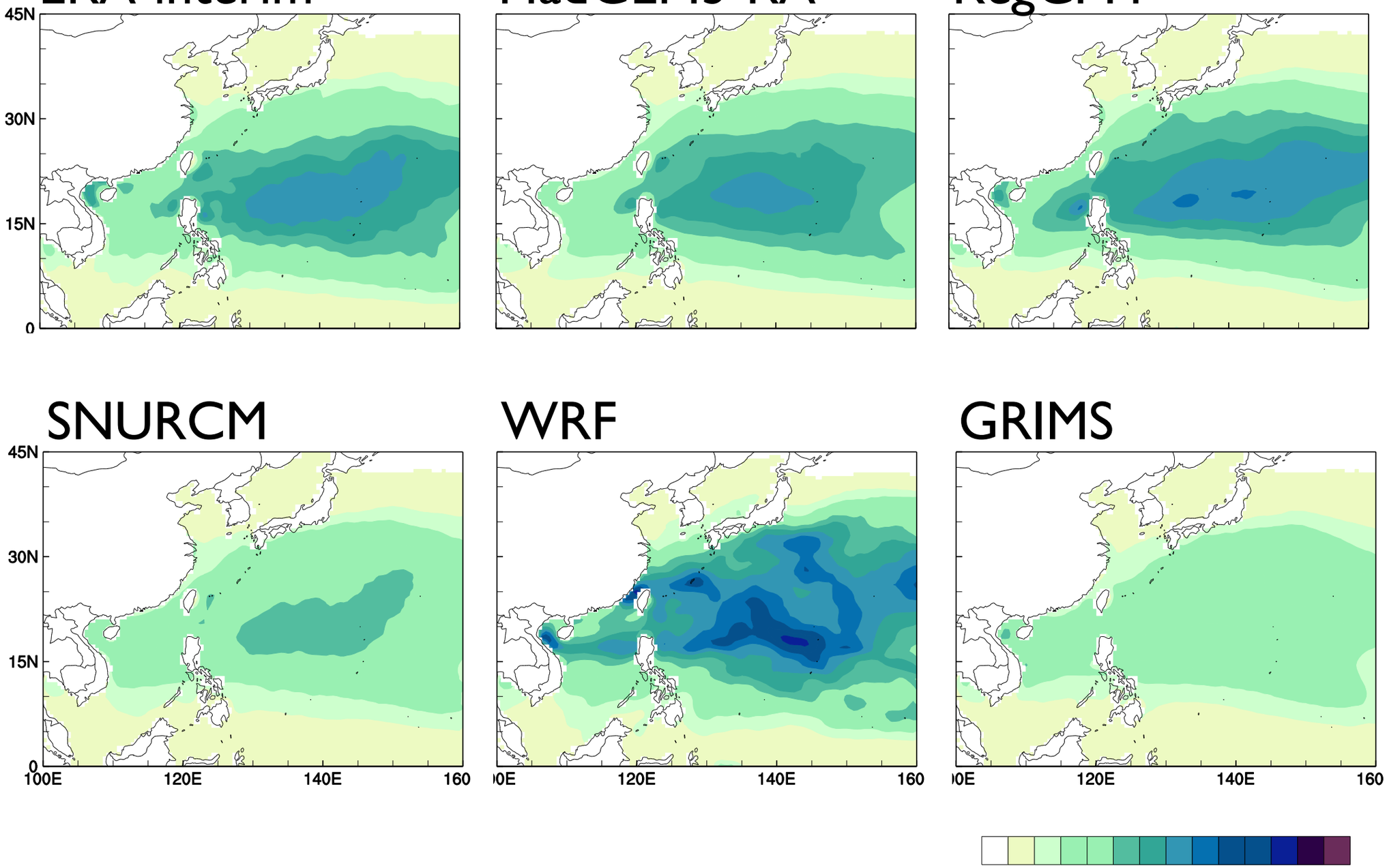


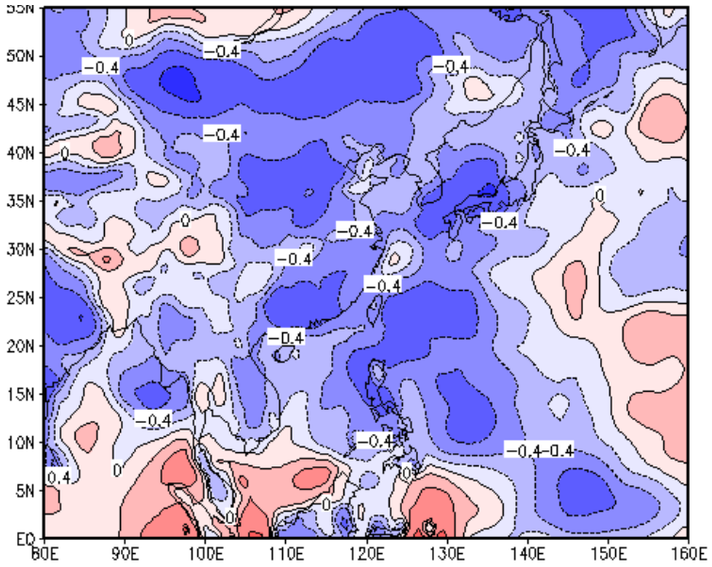
Genesis Potential Index (GPI)

$$GPI = \left|10^5 \eta\right|^{3/2} \left(RH/50\right)^3 \left(PI/70\right)^3 \left(1+0.1V_{shear}\right)^{-2}$$

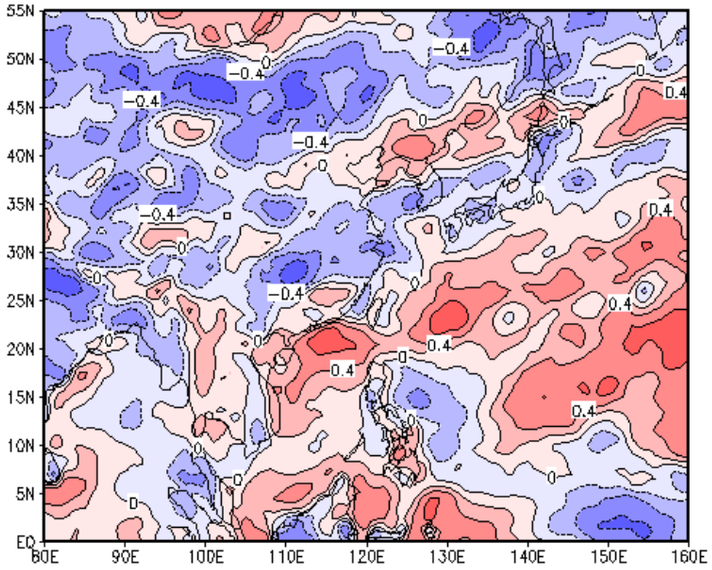


SFC. Temperature vs. Precipitation

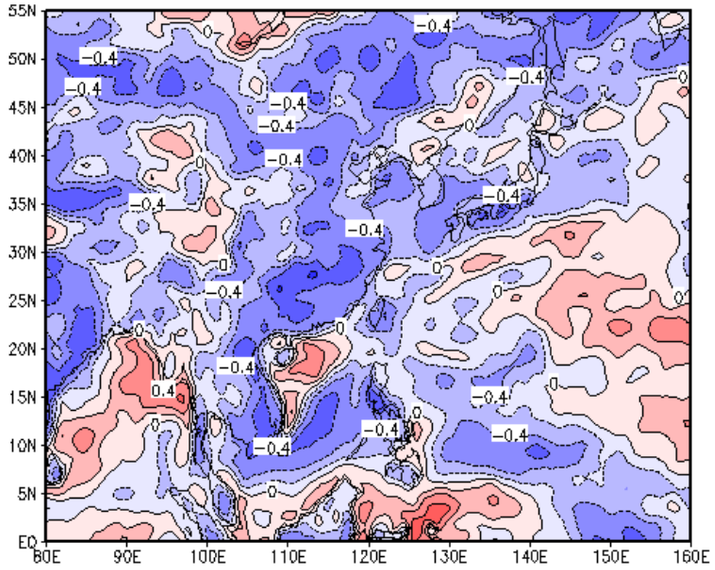
OBS (GPCP, ERA-interim)



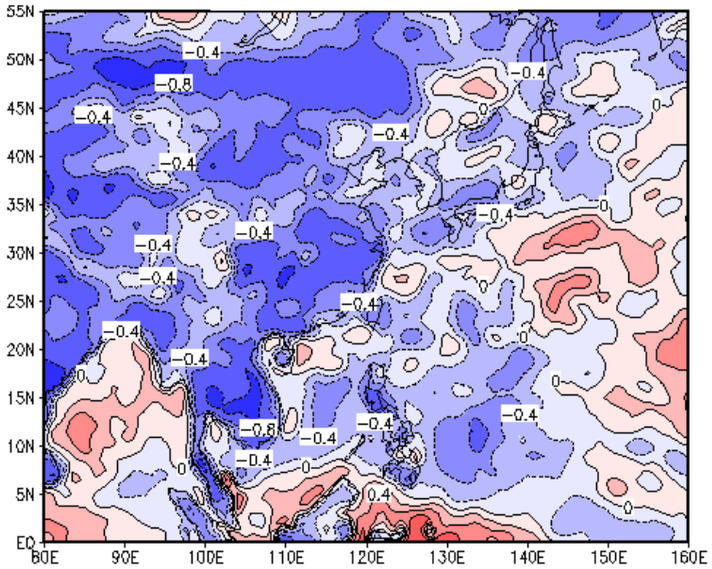
HadGEM3-RA



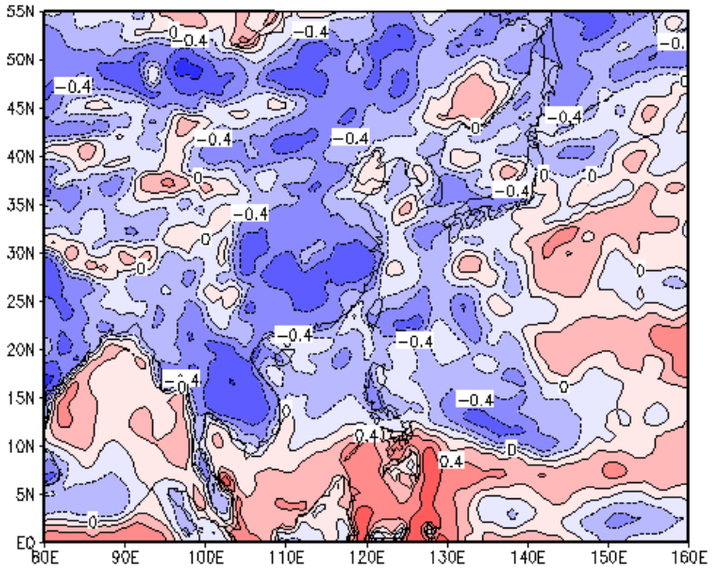
RegCM4



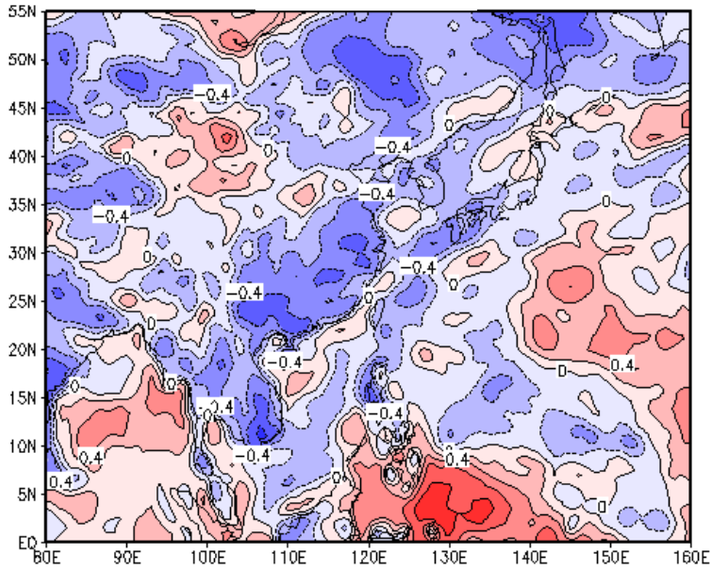
SNURCM

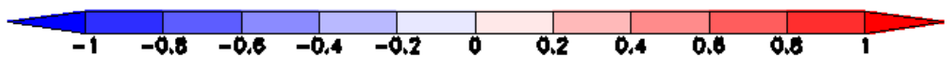


WRF

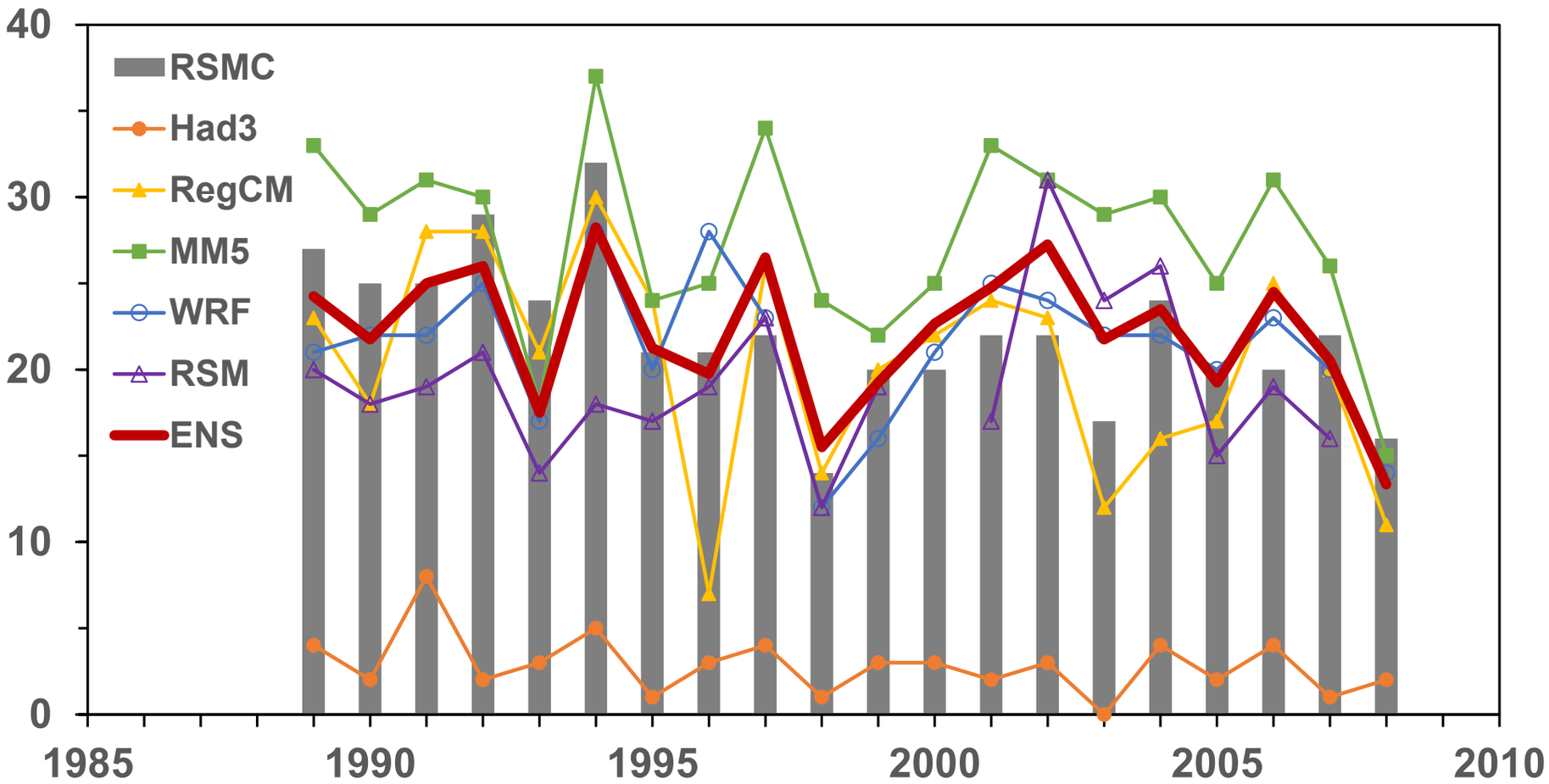


GRIMS





Interannual Variability of TC Genesis Frequency



	RSMC	HadGEM3RA	RegCM4	SNURCM	WRF	GRIMS	MME
AVE	22.2	2.9	20.5	27.6	21.3	19.3	22.1
STD	4.2	1.8	6.2	5.5	4.1	4.5	3.9
CORR		0.50	0.65	0.58	0.63	0.15	0.68

MME does not include the results from the HadGEM3-RA

Statistical Downscaling

PRIDE (PRISM based Downscaling Estimation Model)

Observation

PRISM based Seasonal Cycle using GIS information (DEM, topographic facet, costal proximity, and distance) and AWS observations

RCMs

Use the RCM-based anomalies by removing systematic bias and model seasonal cycle

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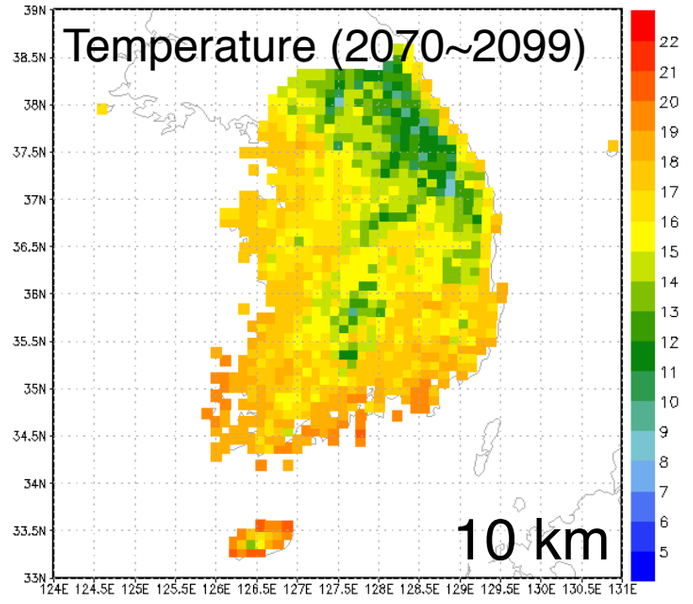
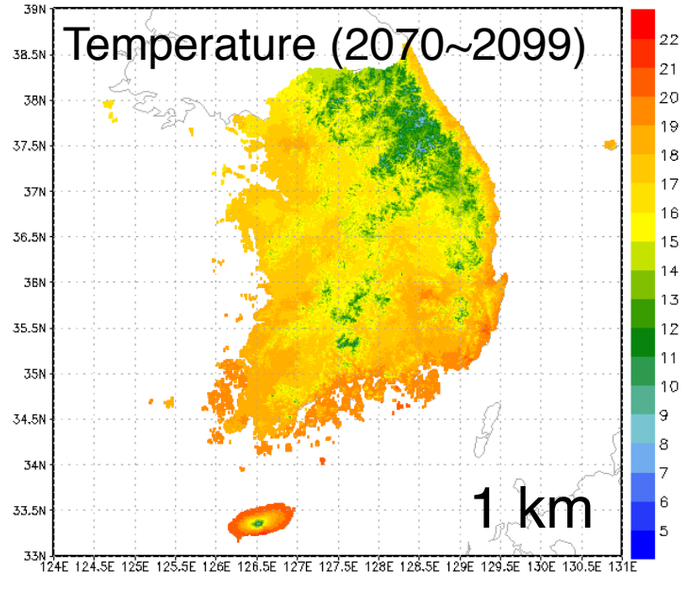


weighting factors for **Modified-PRISM**



Applications

- Based on the results from 4 RCPs x 2 RCMs
- Spatial distribution and time series for 230 administrative districts
- Essential factors for agriculture, health, and disaster prevention sectors.

<Agriculture>

growth duration, effective accumulated temperature, winkler scale, vegetable period, crop period, frostless period, chill units, climatic productivity index, thermo-hydro index, evapotranspiration, heating period, cooling period, etc…

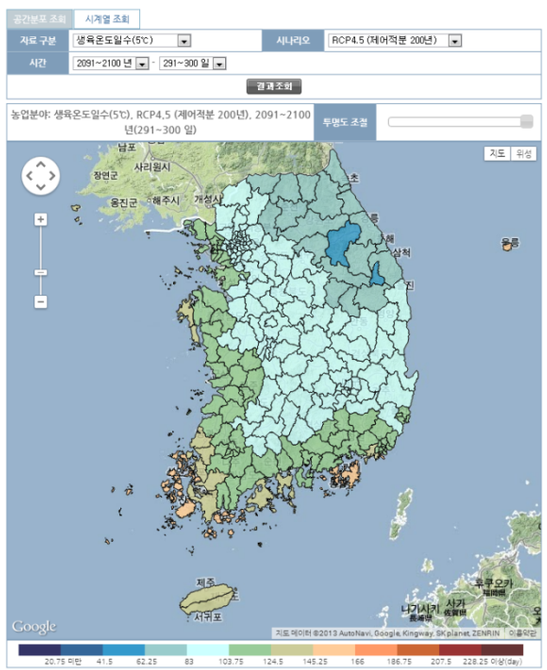
<Health>

Heat Index (HI), Discomfort Index (DI), Apparent Temperature (AT), Net Effective Temperature (NET), Humidex, Windchill

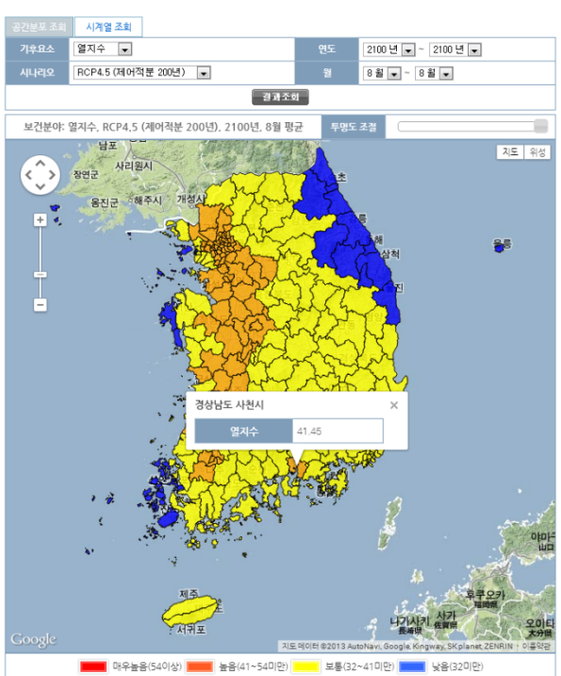
<Disaster Prevention>

Standard Precipitation Index (SPI)

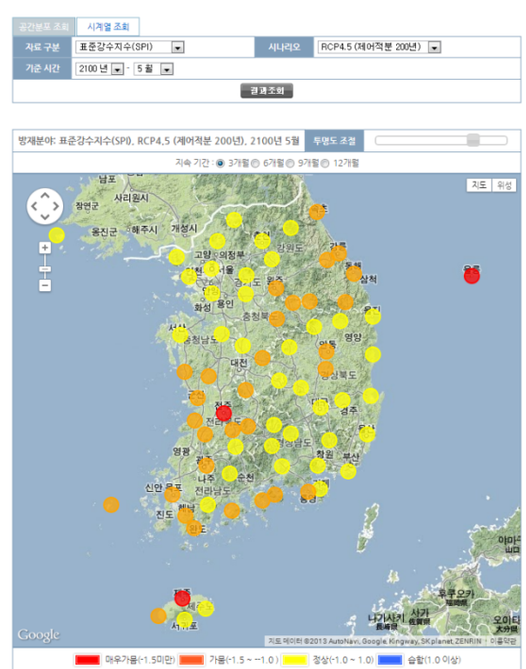
생육온도일수 공간분포 조회 화면



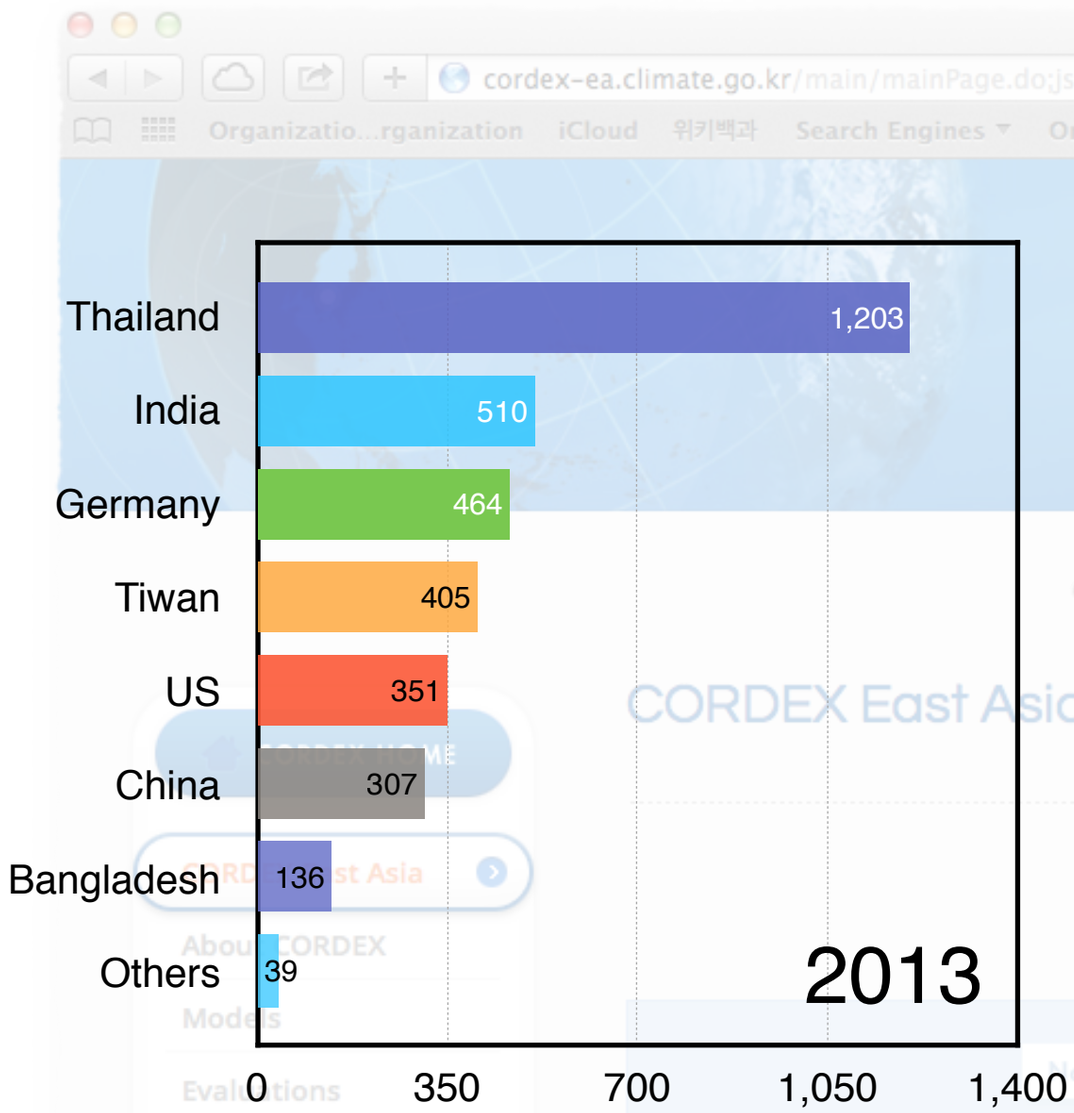
열지수 공간분포 조회 화면



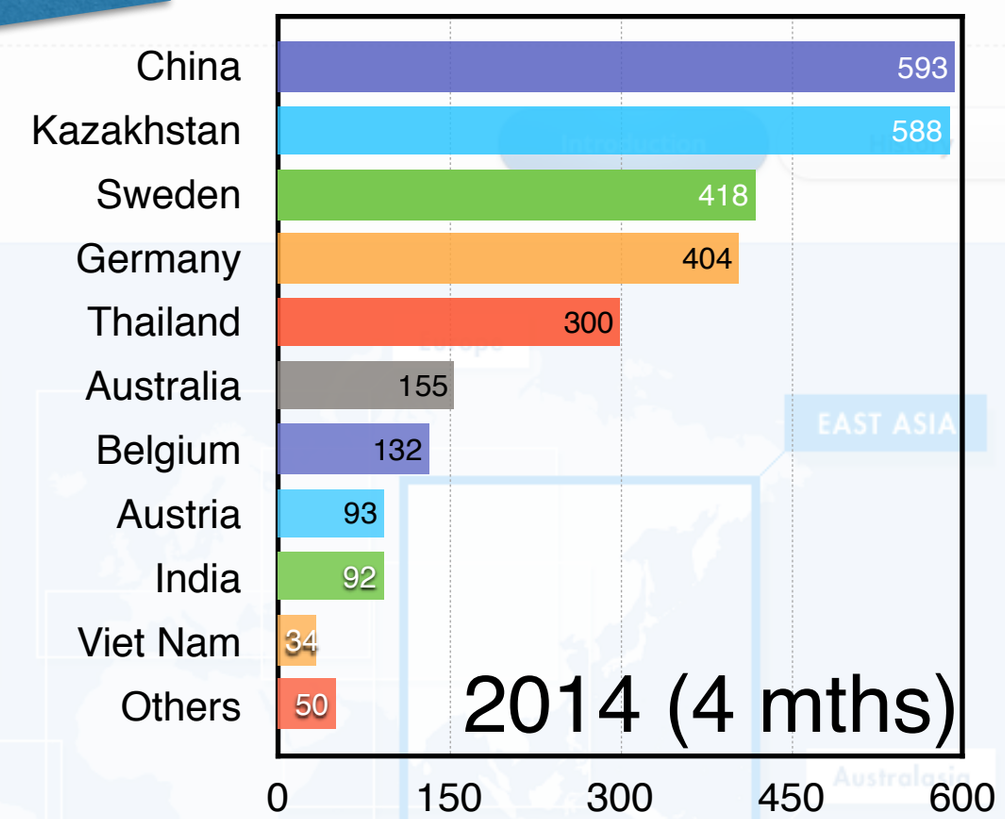
SPI 공간분포 조회 화면(RCP4.5, 2100년)



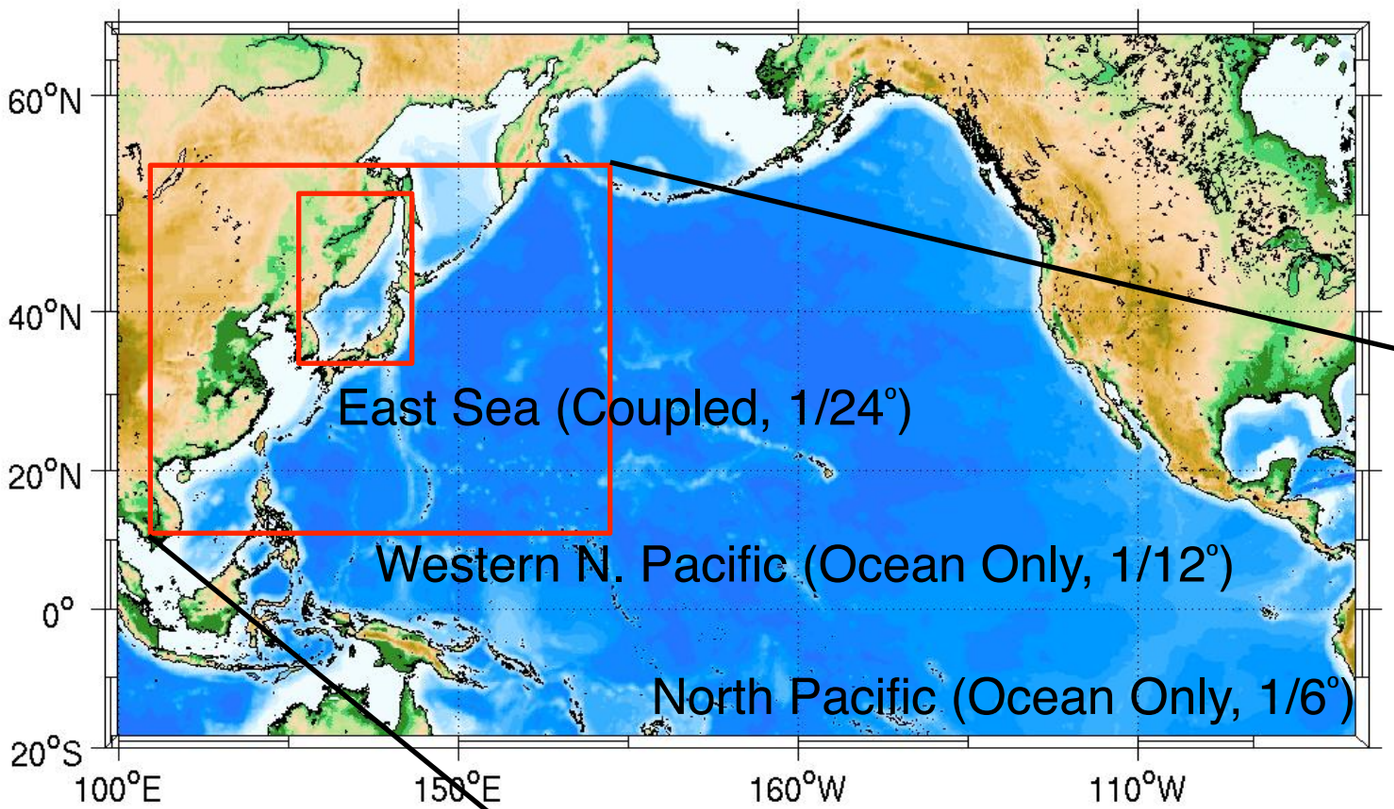
http://cordex-ea.climate.go.kr



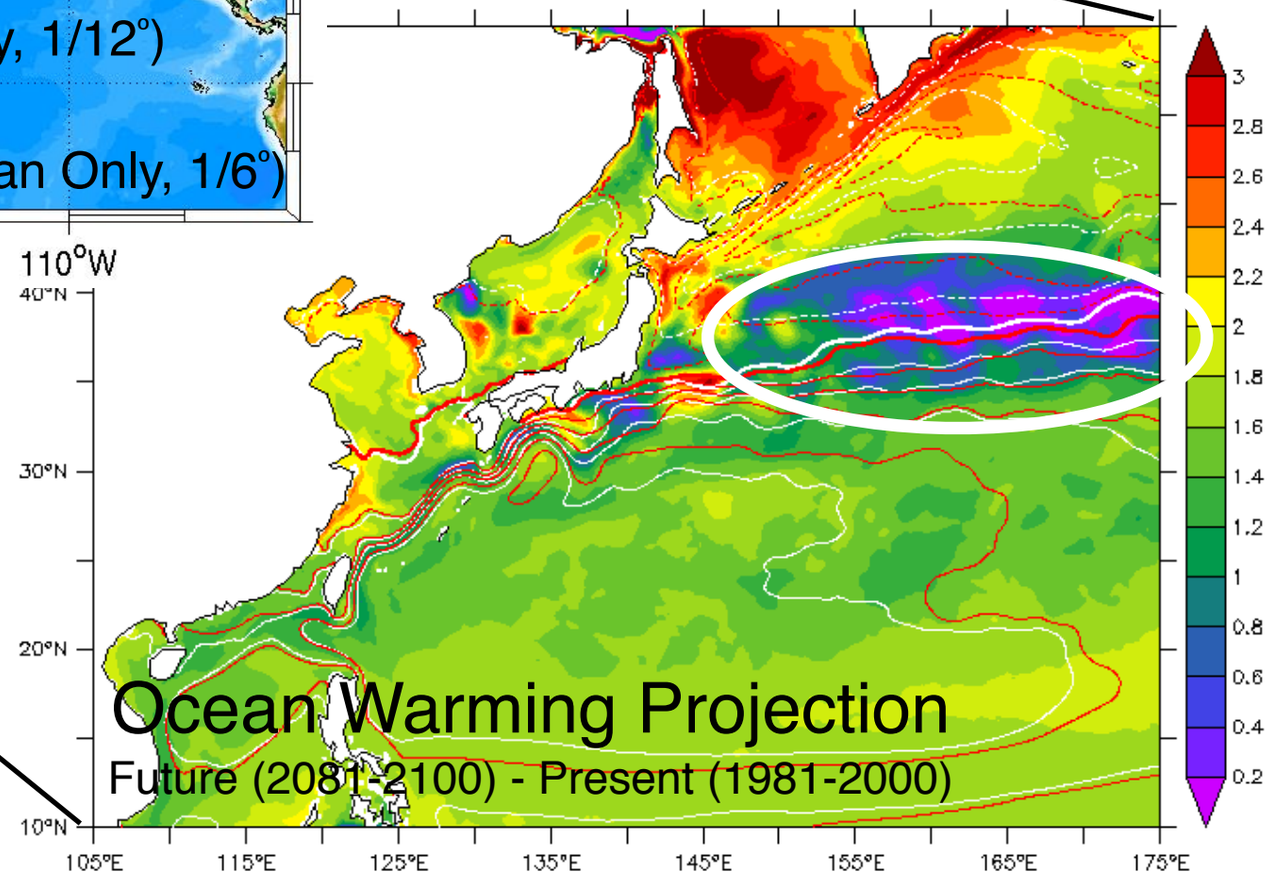
- Total number of download in 2013 is 16,034 including Korea (80%)
- Number of download in 2014 is 4,049 including Korea (only 25%)



Regional Ocean Downscaling



- Using ROMS with CanESM2 forcing (RCP4.5) by Pseudo Global Warming approach
- Least warming SST in east of Japan implies southward shift of Kuroshio current



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Summary

- CORDEX-Phase I experiments for East Asia region have been completed successfully, and their outputs are welcomed to be used by analysis groups as well as IAV sectors via http://cordex-ea.climate.go.kr
- Evaluation of the outputs are currently focusing on multi-model ensemble, monsoon evolution, and climate extremes including tropical cyclones.
- Multi-GCM/RCMs metrics are essential, and RCM should be further developed toward RCESM to capture more realistic activities of monsoon front and tropical cyclones.
- Statistical downscaling and its application for interdisciplinary sectors are still limited only on nation-wide scale.
- Phase-II experiments with smaller domain but with higher-resolution are prepared by EA groups.

Thanks for your attention.