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Regional Climate Downscaling over Vietnam: Time of Emergence in Temperature and Precipitation Changes

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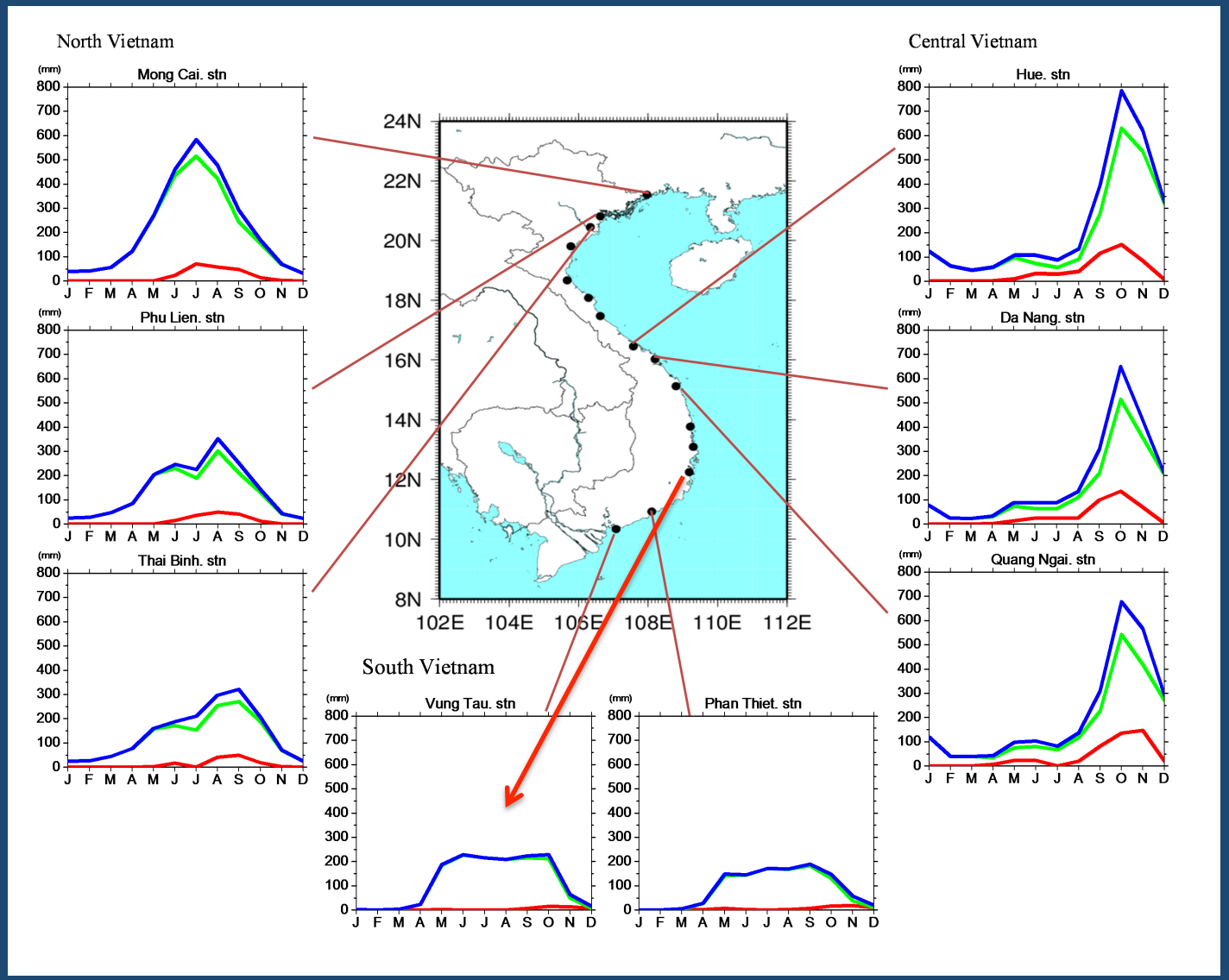
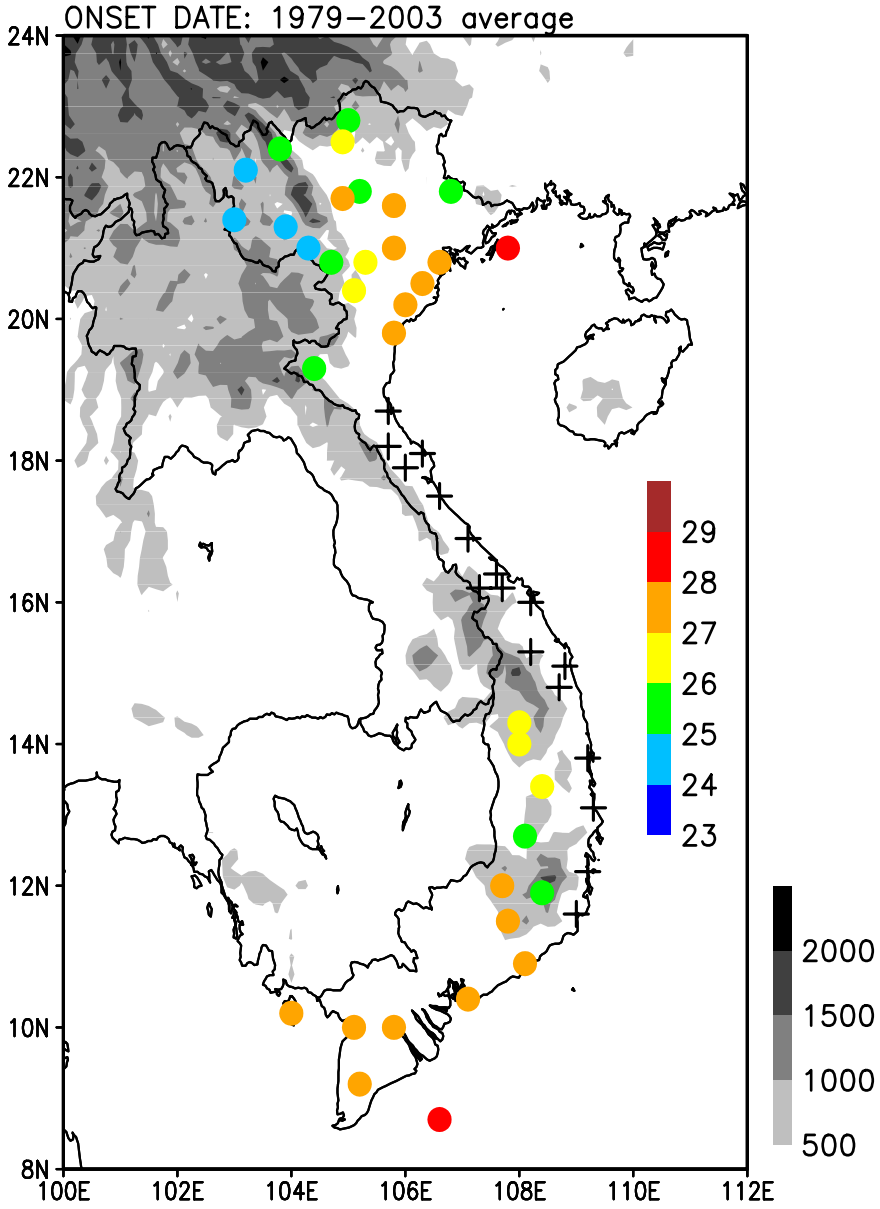
Monthly climatological distribution of rainfall in Vn



→ Regional/local characteristics of rainfall can not be caught with GCM

(Nguyen-Thi et al., SOLA, 2012)

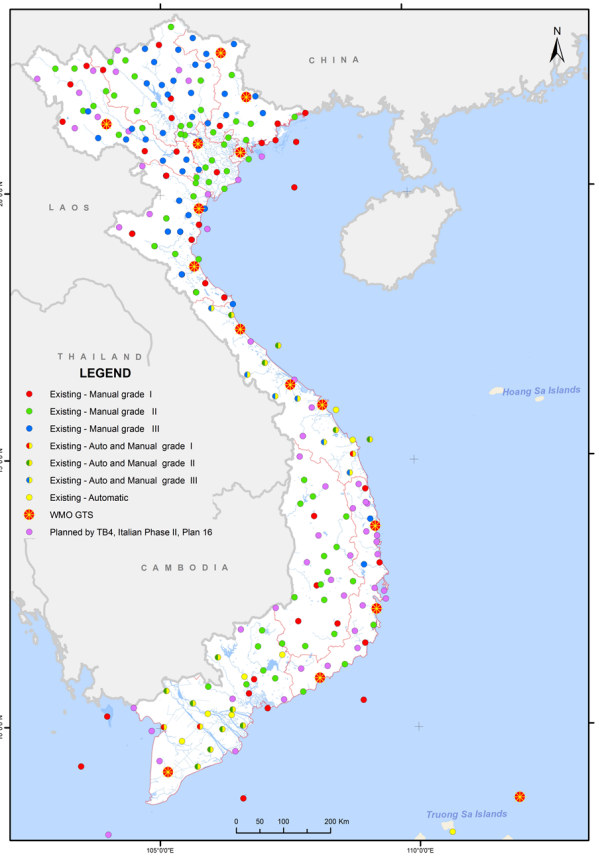
Nguyen-Le, Matsumoto, & Ngo-Duc (IJOC,2013)



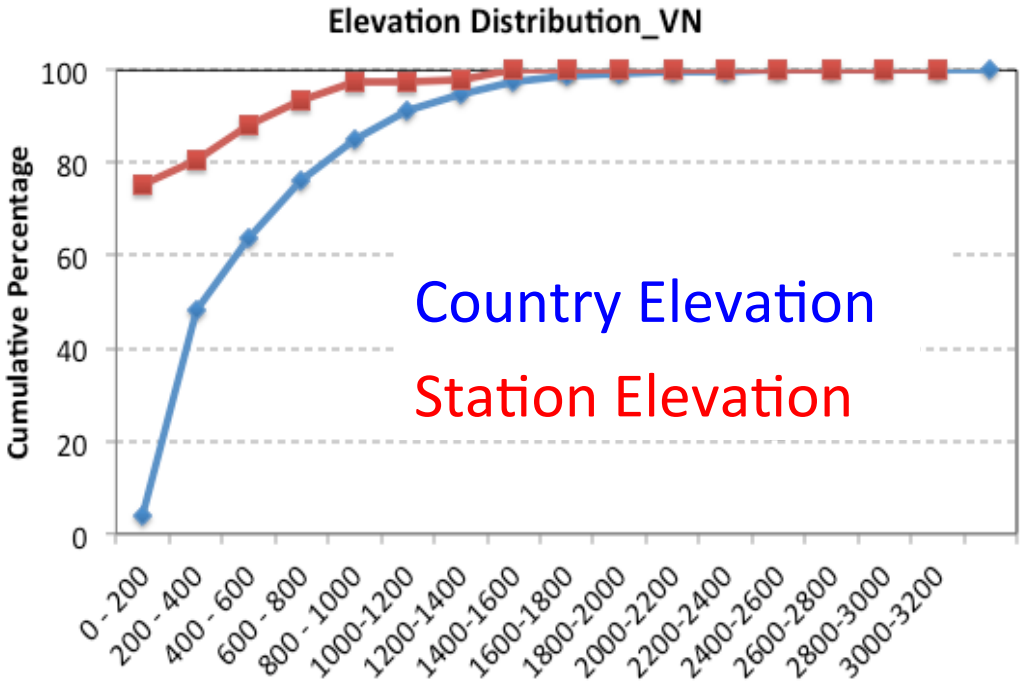
- climatological (1979-2003) summer monsoon onset date, criteria by Matsumoto (1997), based on rainfall only
- crosses denote stations have non-typical monsoon rainfall pattern

→ Regional/local characteristics of rainfall can not be caught with GCM

Spatial distribution of the surface meteorological stations



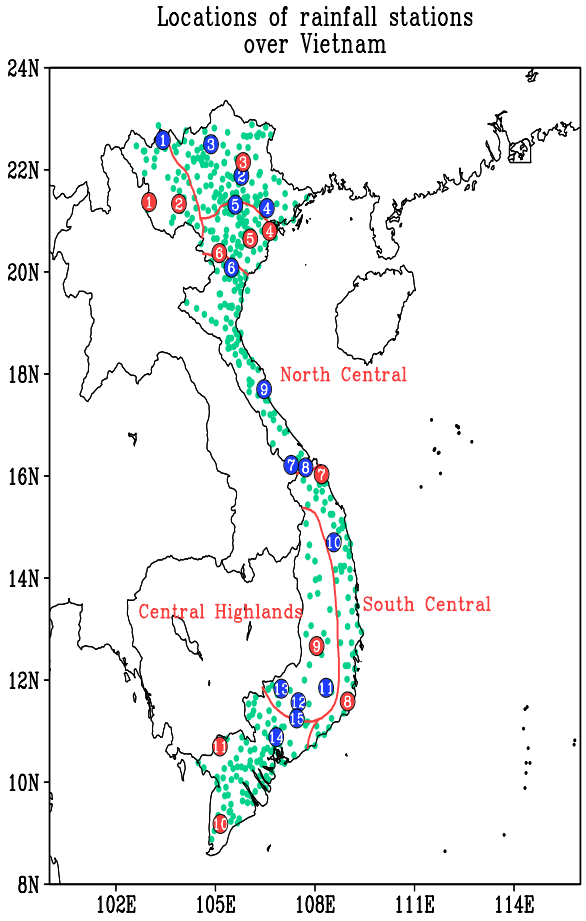
Vietnam surface meteorological stations (189)



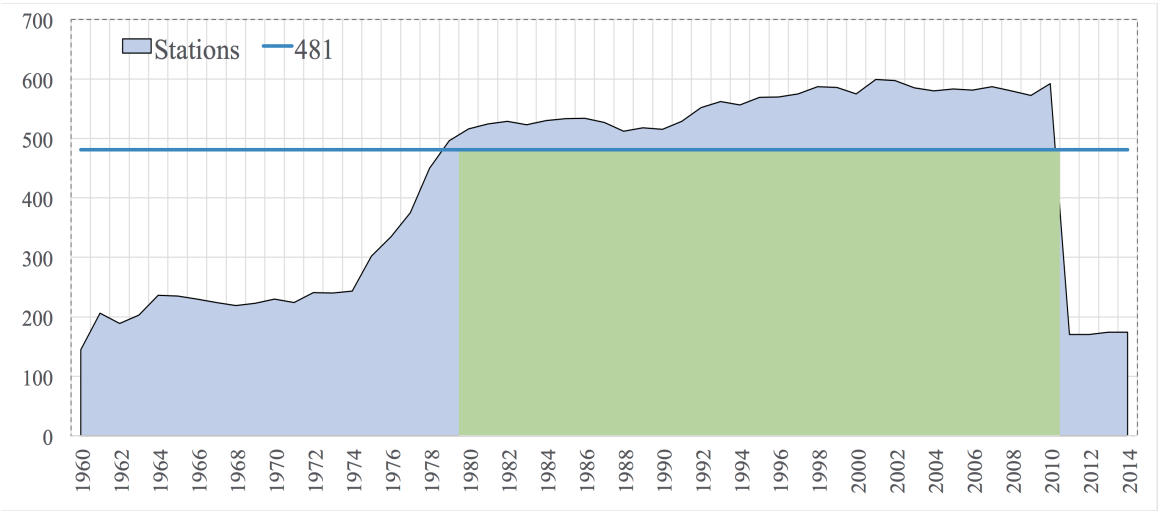
0-400m: 50% of the country area
80% of stations

→ **Lack of surface observations in mountainous area !**

Vietnam Gridded Precipitation (VnGP) Dataset



- 481 stations
- Daily observations
- Resolution: 0.25º, 0.1º
- Period: 1980-2010

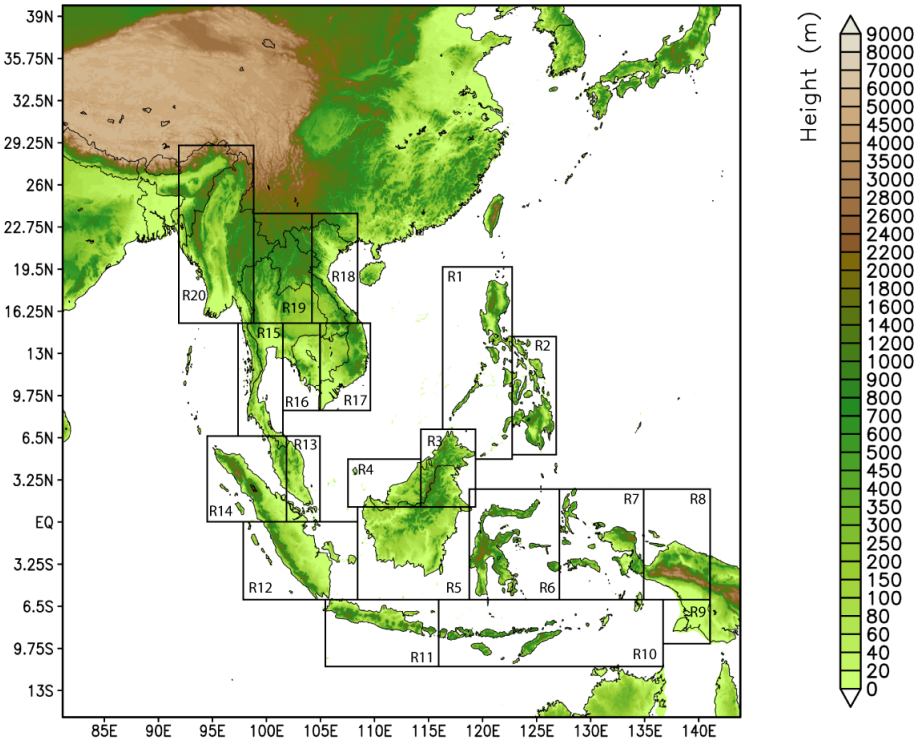


✓ The VnGP dataset has been registered to the Data Integrated and Analysis System (DIAS), Tokyo Univ. and can be accessible from http://dias-dmg.tkl.iis.u-tokyo.ac.jp/dmm/doc/VnGP_025-DIAS-en.html

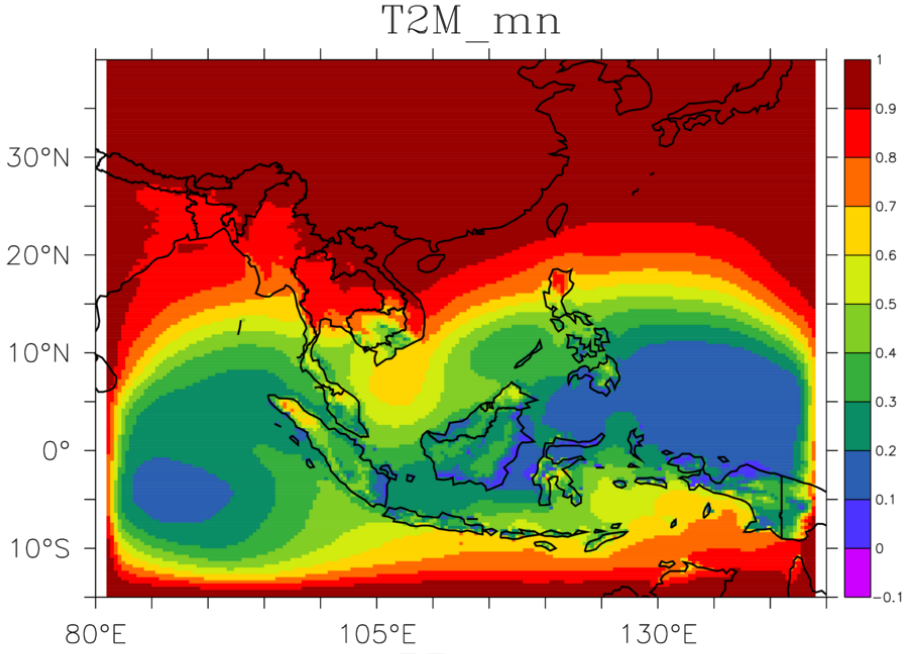
Nguyen et al., SOLA, 2016

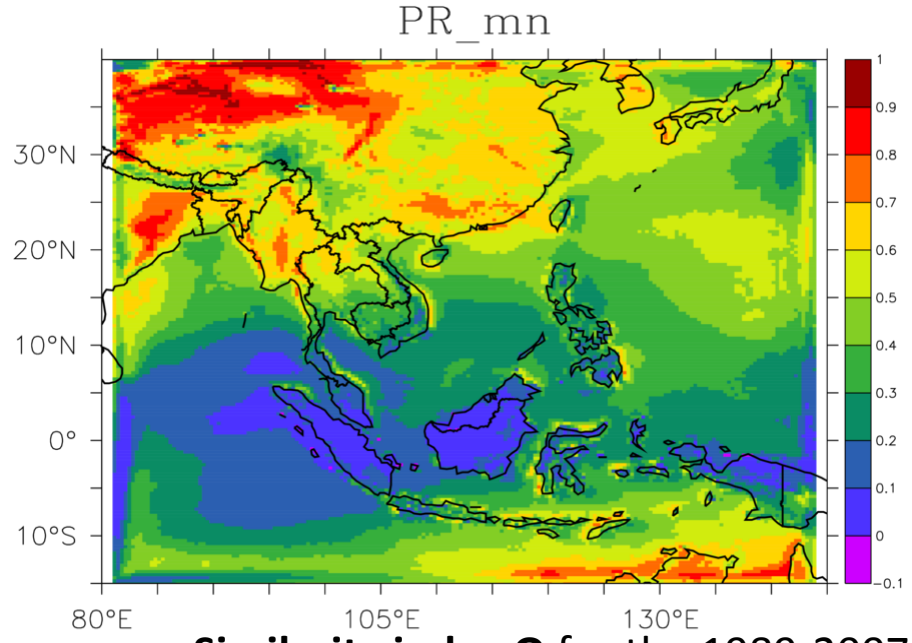
Dynamical downscaling over the CORDEX-SEA region using RegCM4

- Sensitivity experiments
  - ICBC: ERA-Interim (1989-2008)
  - 18 sensitivity experiments (CPS, ocean flux)



Juneng et al., 2016
Ngo-Duc et al., 2017
Cruz et al., 2017





Similarity index Ω

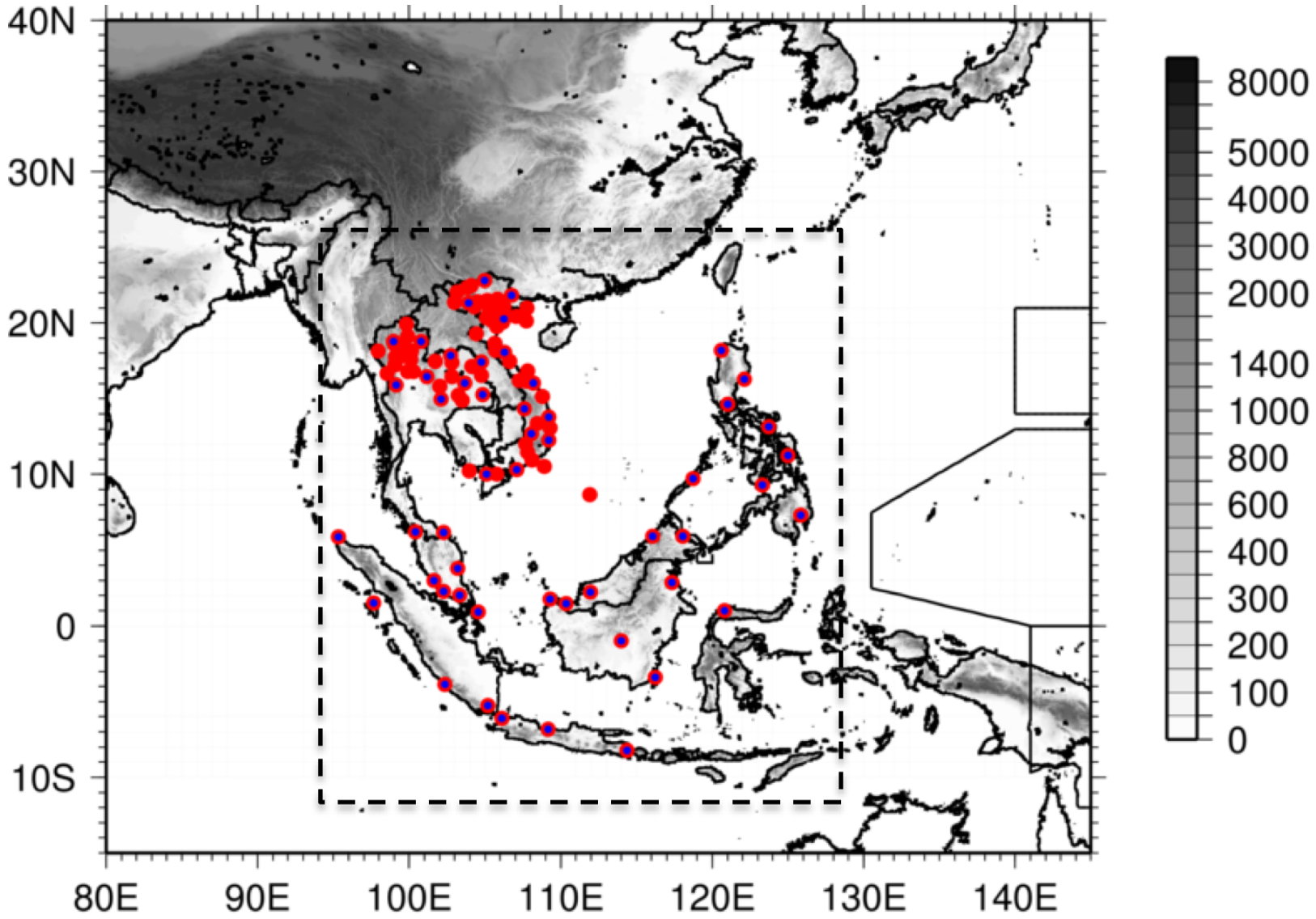
(Ngo-Duc et al., IJOC, 2017)

- Better similarity for Temperature than for Precipitation
- T2m and Pre over The Maritime Continent are more sensible to physical parameterizations

→ Downscaling performances depend essentially on the choice of physical parameterization scheme

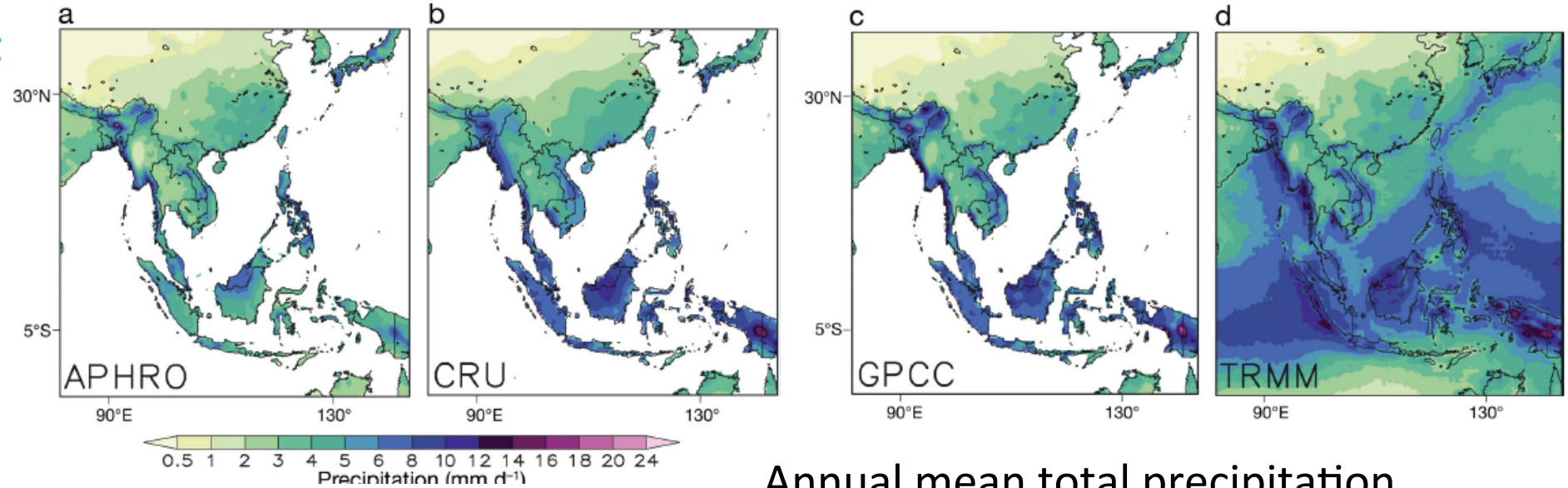
Similarity index Ω for the 1989-2007 **monthly values** of the 18 experiments – **Temperature & Rainfall**

Selection of the BEST schemes

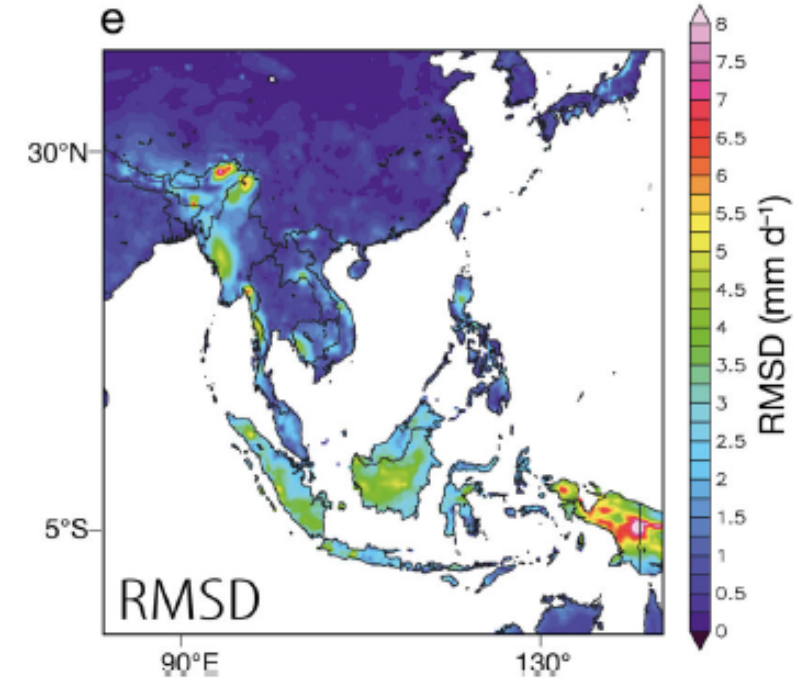


data from 123 stations, only 52 stations were selected for the analysis of extremes: daily rainfall, T2m, Tmax, Tmin

Attention: Different DATA sources can give different results



Annual mean total precipitation climatology over Southeast Asia

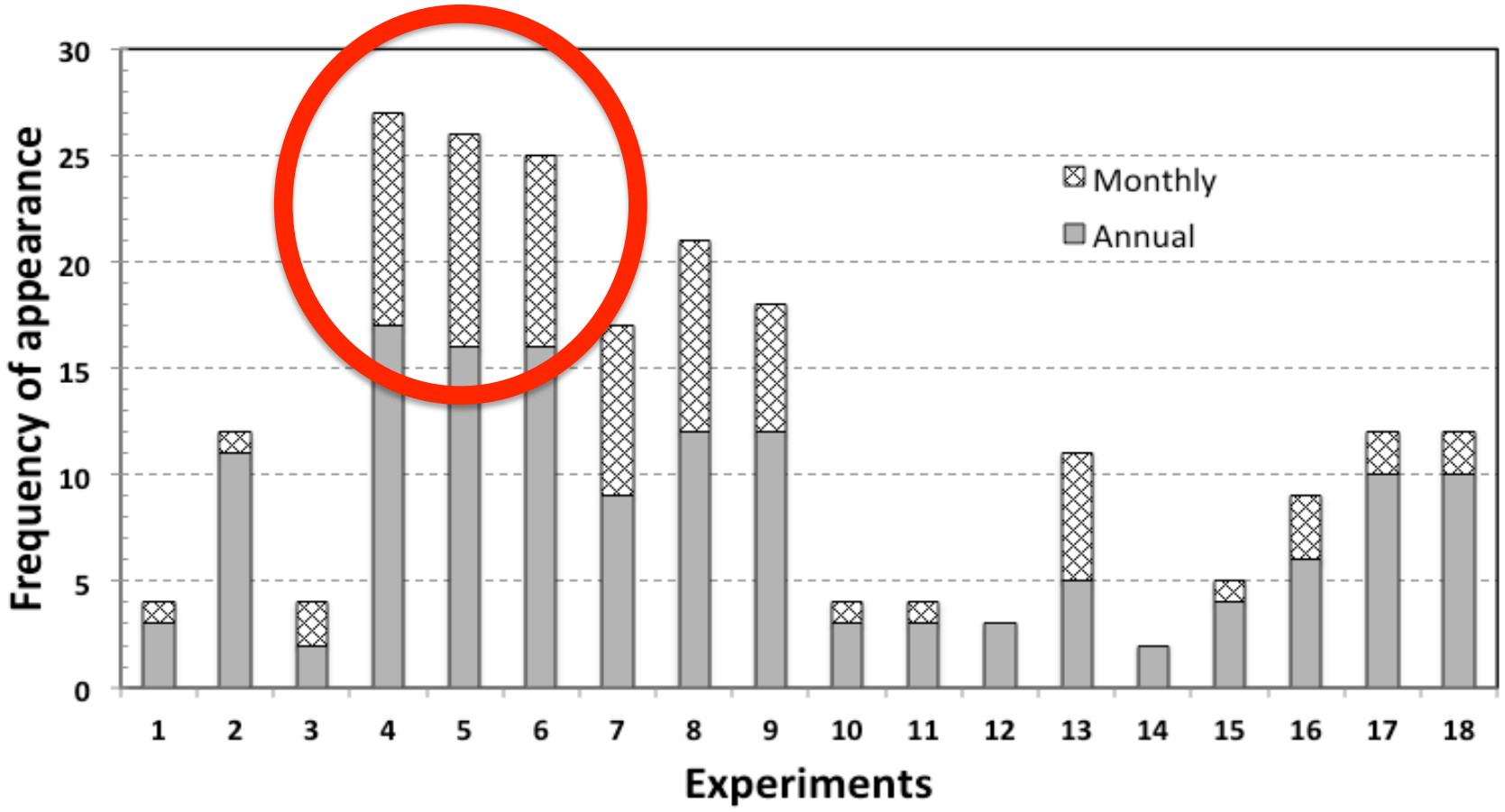


Root mean square difference between the 4 products

(Juneng et al., Clim.Res. 2016)

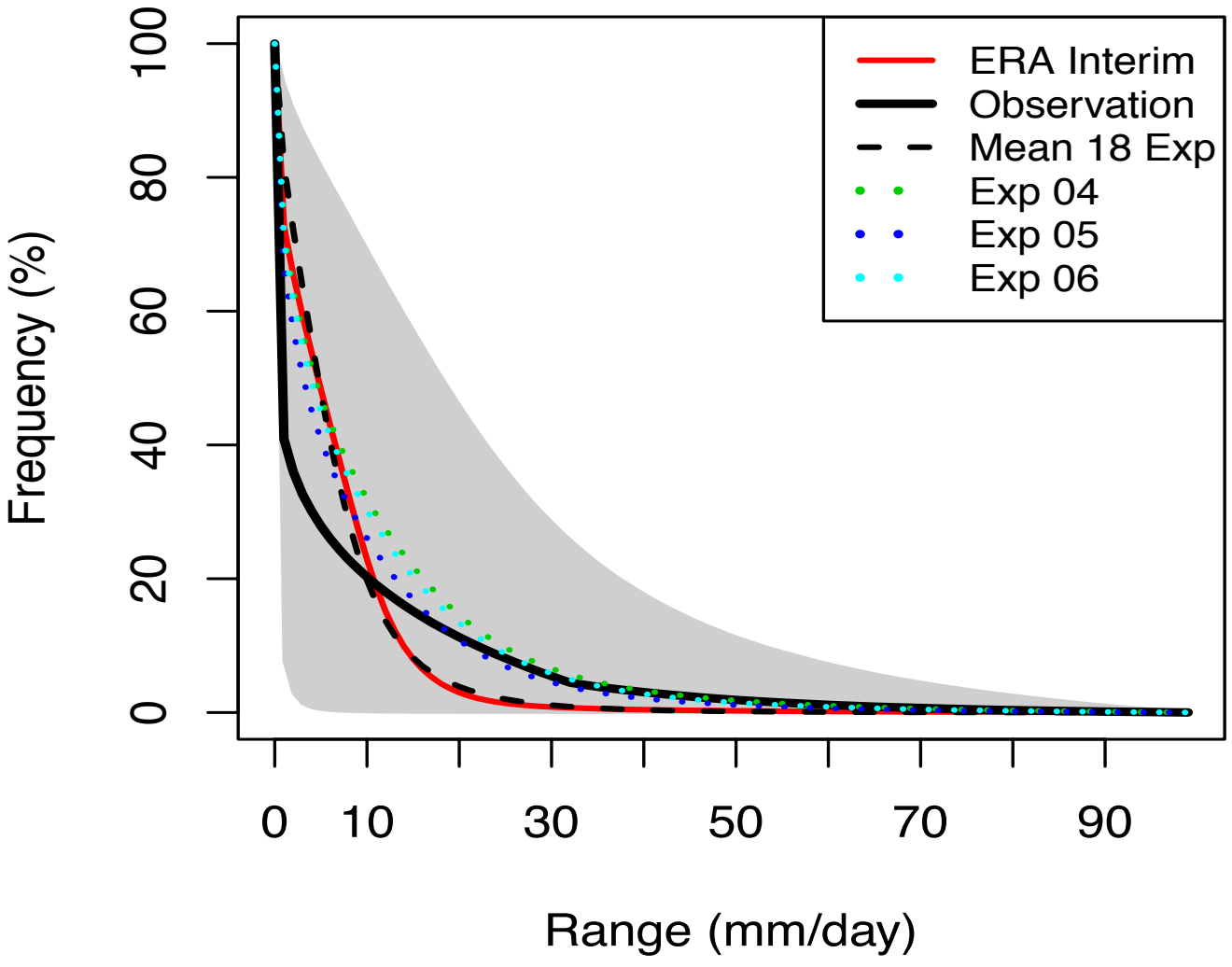
Ranking methods: for the 14 extreme indices

1) minimum absolute bias
2) minimum rmse
3) maximum correlation
4) the ratio of the model standard deviation to observed one is the closest to 1



The ranking scores of the 18 experiments

Precipitation Frequency



Probability density function of the frequency distribution of the precipitation over the 52 stations in the SEA region

→ The MIT-Emanuel convective scheme has been chosen for downscaling CMIP5 GCMs

Downscaling CMIP5 GCMs

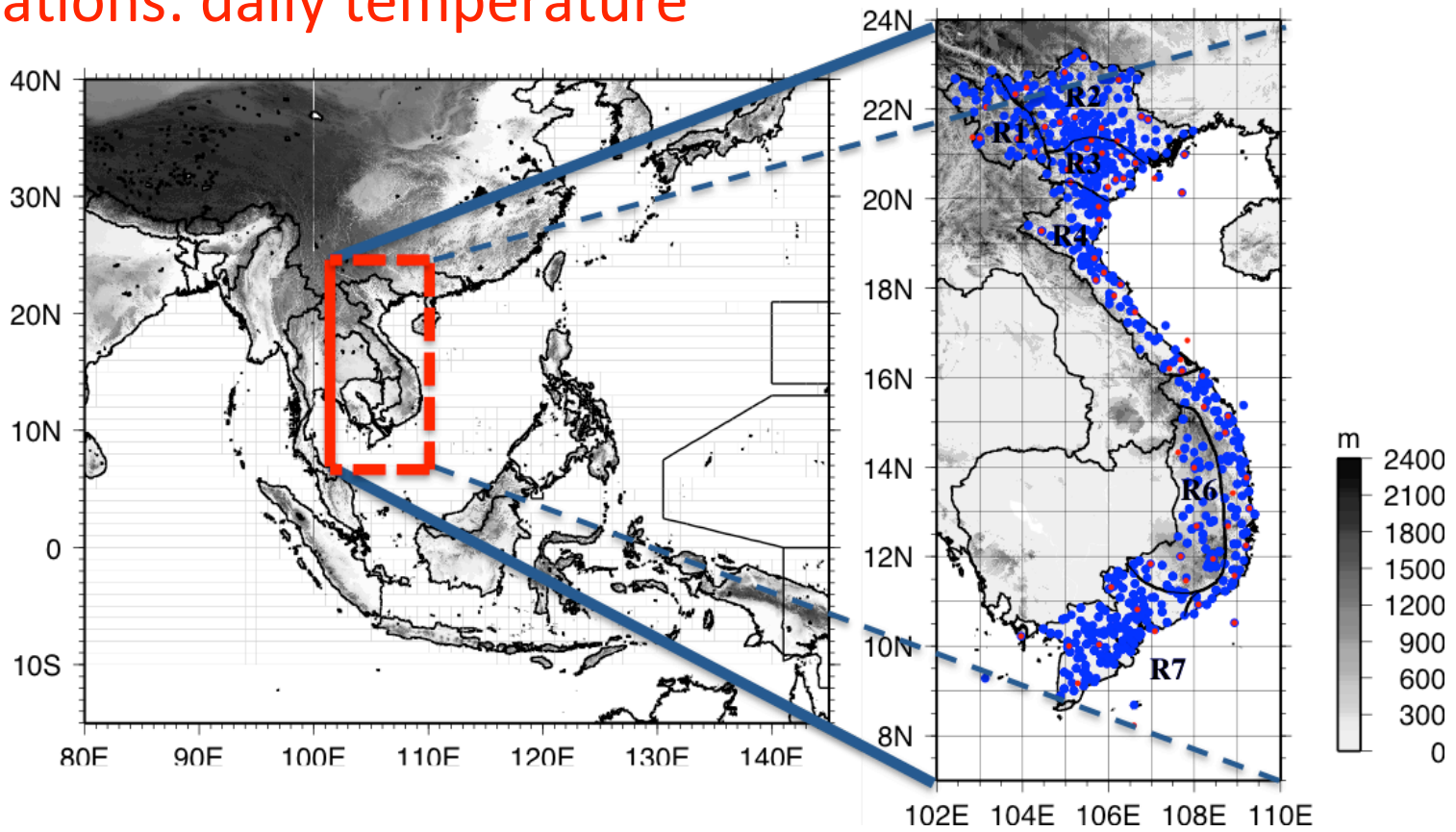
RegCM4.3

- MIT-Emanuel convective scheme
- BATS1e ocean scheme
- 25 km
- RCP4.5 & RCP8.5

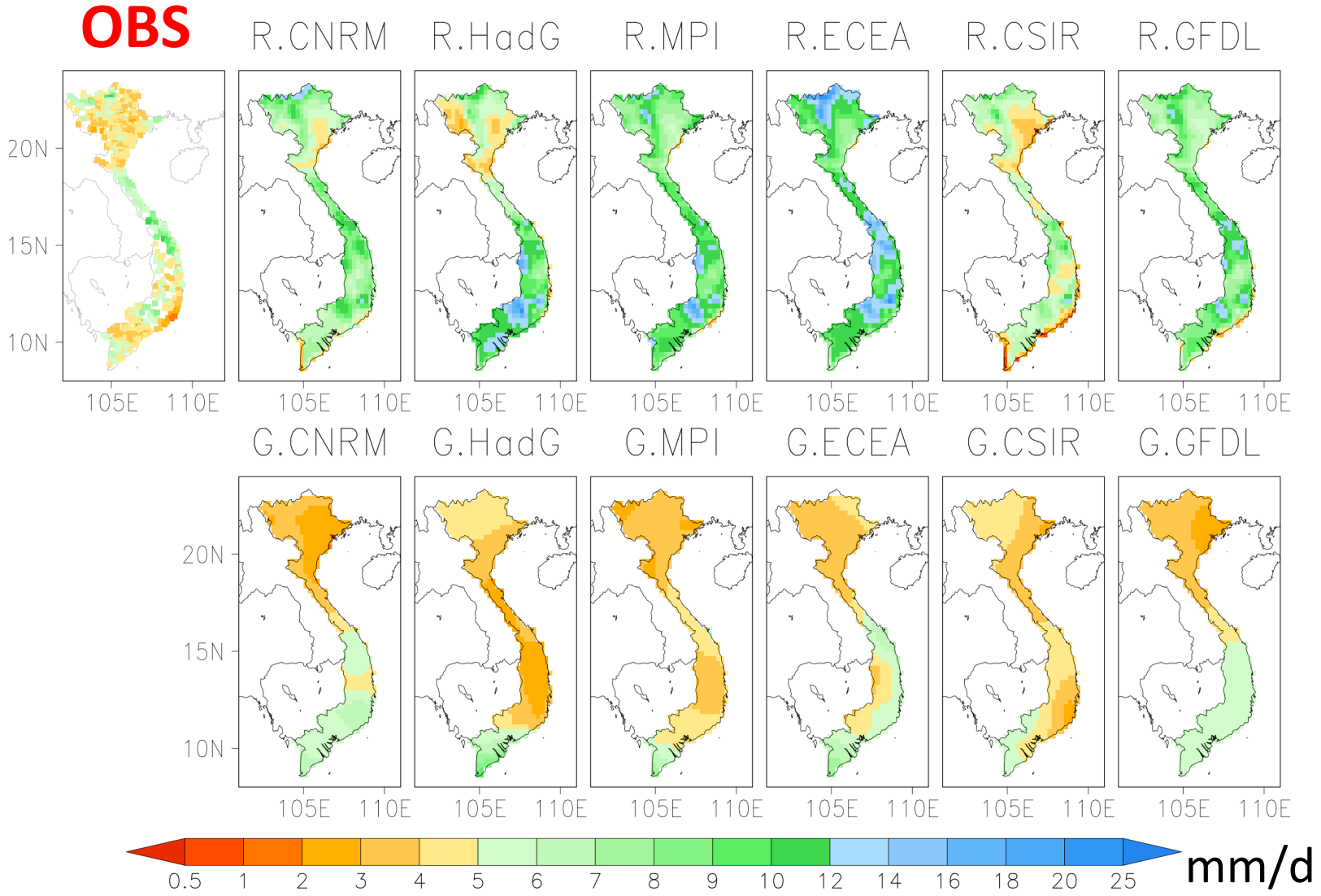
Exp Name	ICBC
1	CNRM-CM5
2	MPI-ESM-MR
3	EC-Earth
4	CSIRO-MK3.6.0
5	GFDL-ESM2M
6	HadGEM2

1986-2005 observed data for validation

- 608 stations: daily rainfall
- 70 stations: daily temperature



1986-2005 Rainfall

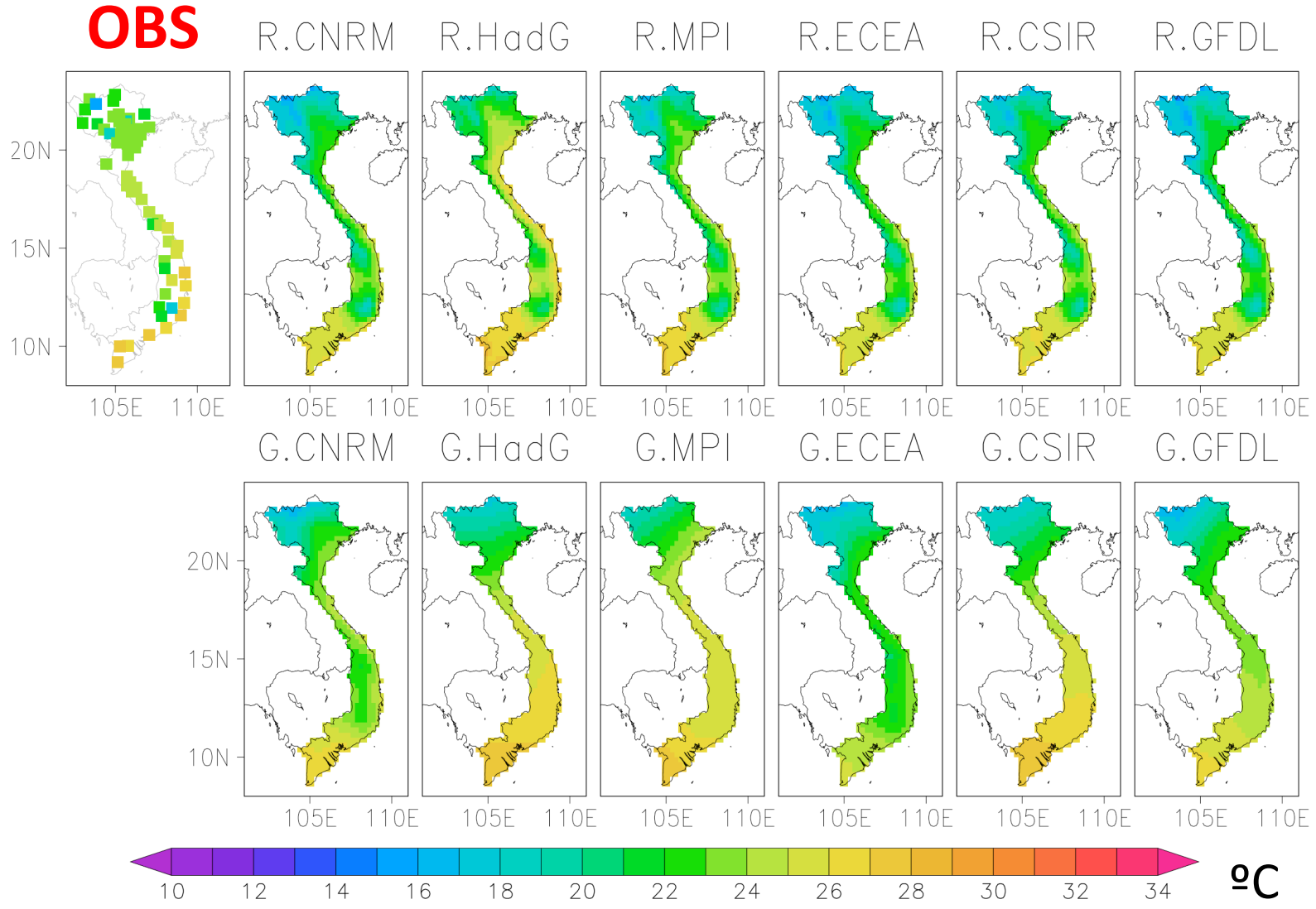


RCM

GCM

Wet bias of RCM

1986-2005 Temperature



RCM

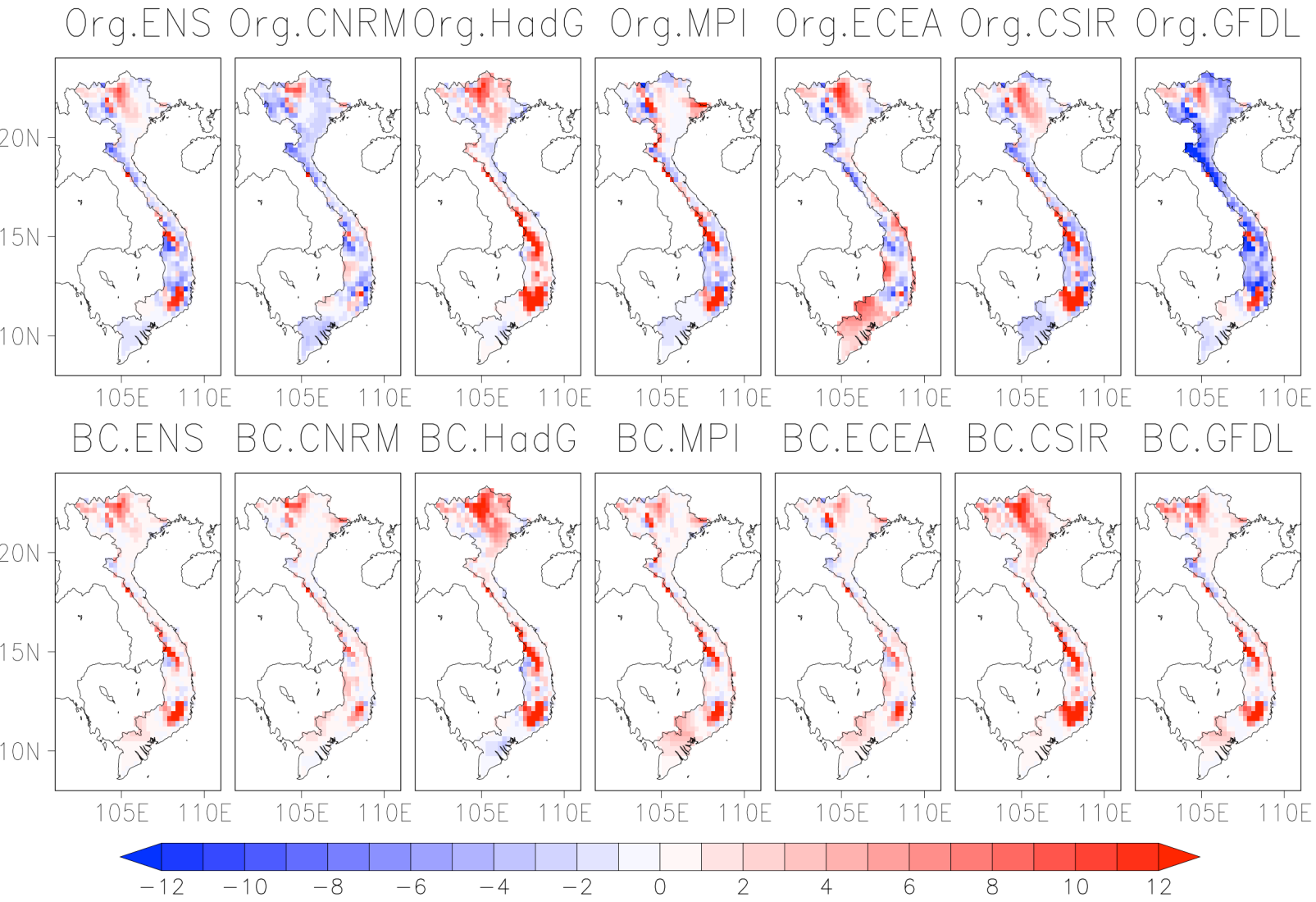
GCM

Cold bias of RCM (e.g. R.MPI)

Added values of downscaling: TEMPERATURE

$$AV = (X_{GCM} - X_{OBS})^2 - (X_{RCM} - X_{OBS})^2$$

(Di Luca et al., 2013)



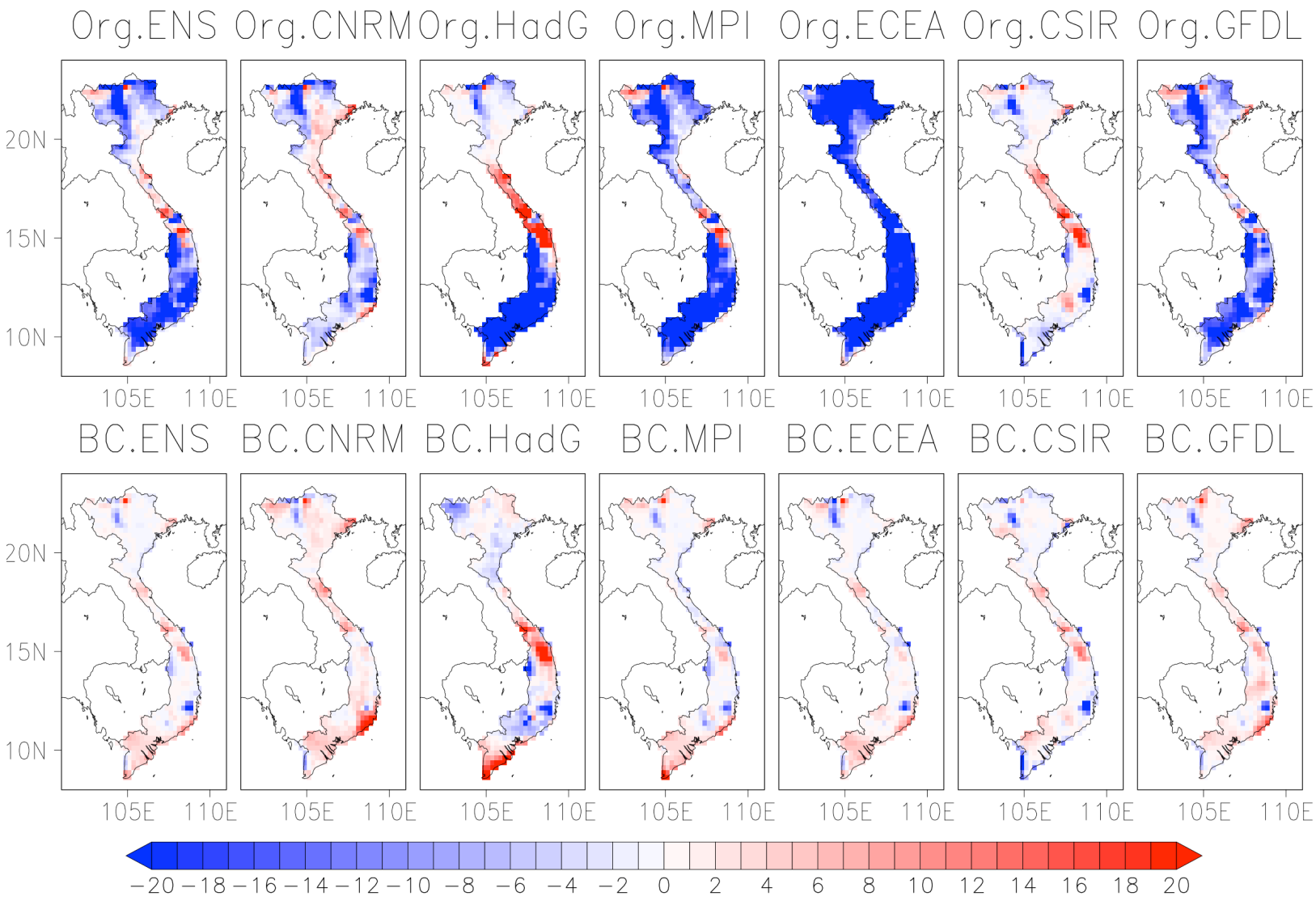
Without bias correction

With bias correction

Added values of downscaling: RAINFALL

$$AV = (X_{GCM} - X_{OBS})^2 - (X_{RCM} - X_{OBS})^2$$

(Di Luca et al., 2013)

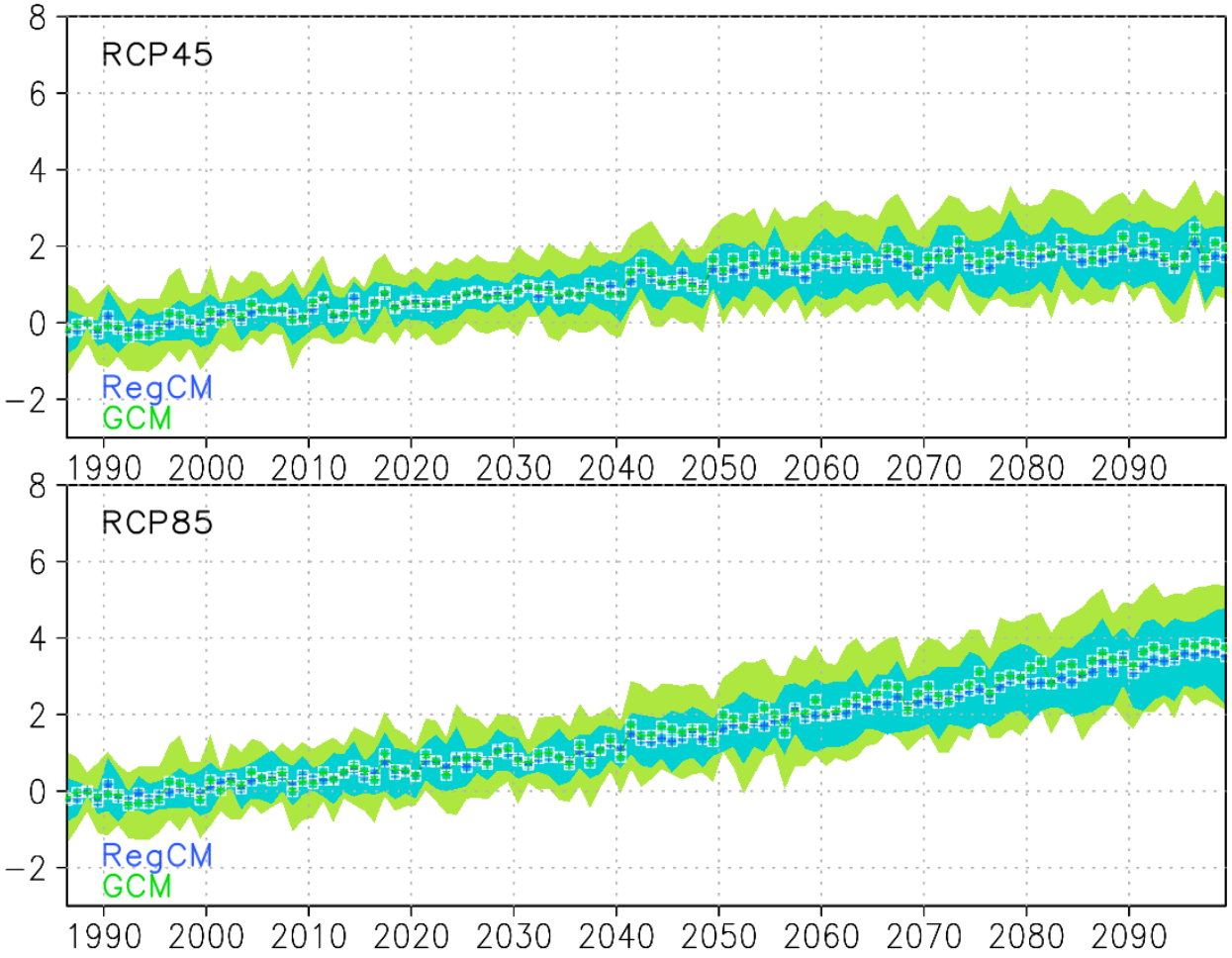


Without bias correction

With bias correction

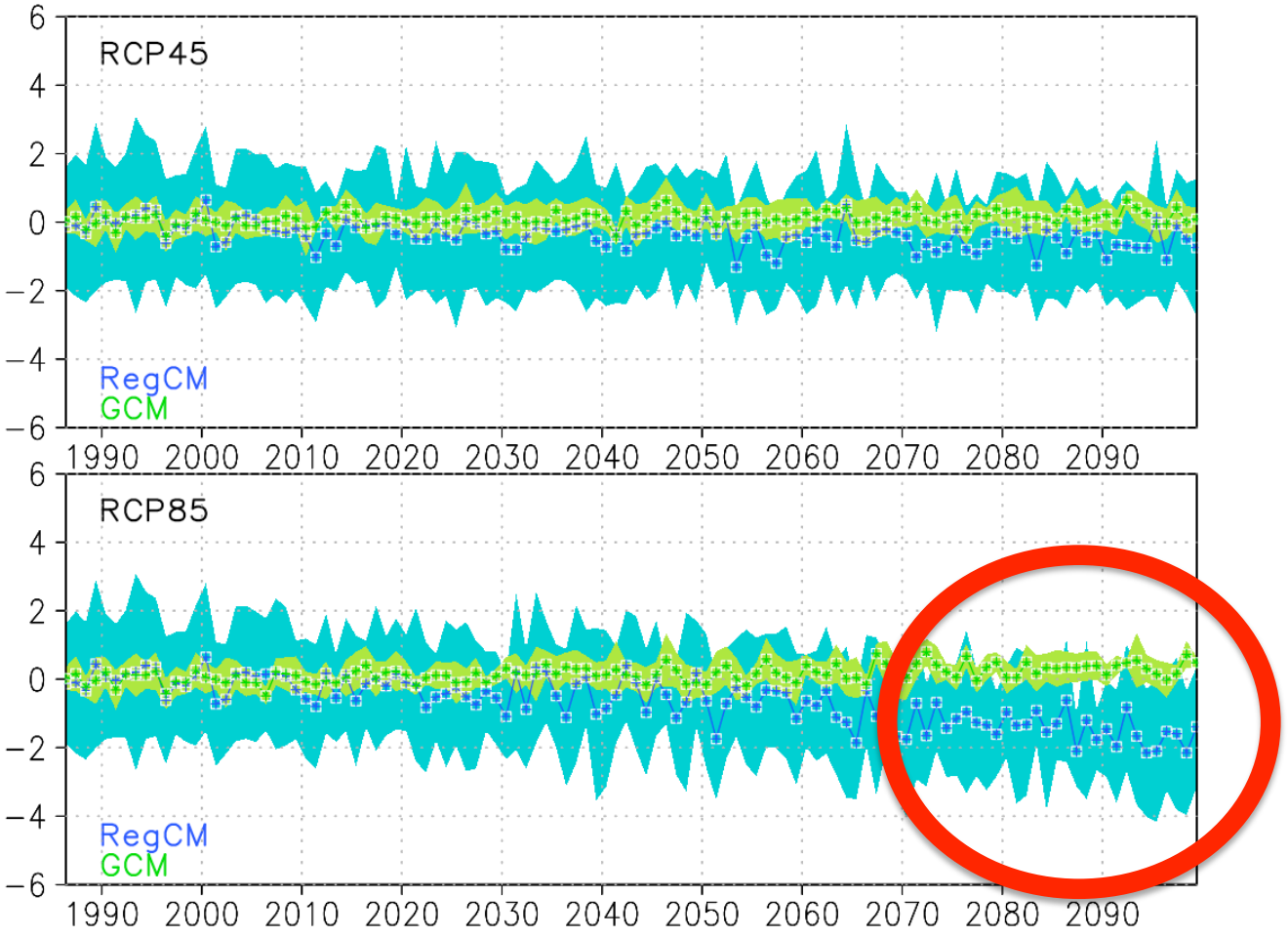
Annual average of temperature

- Ensemble mean of the **RCMs** & **GCMs**
- Shading shows the model +/- 1 standard deviation

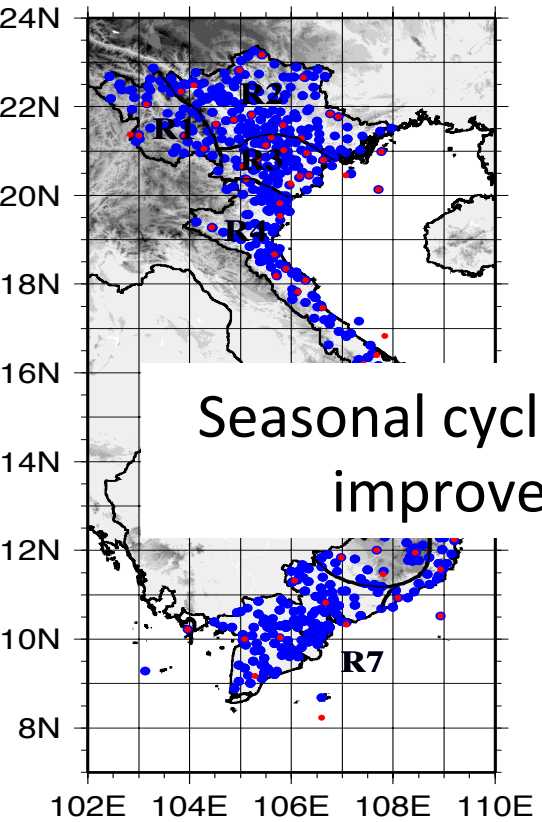


Annual average of Rainfall

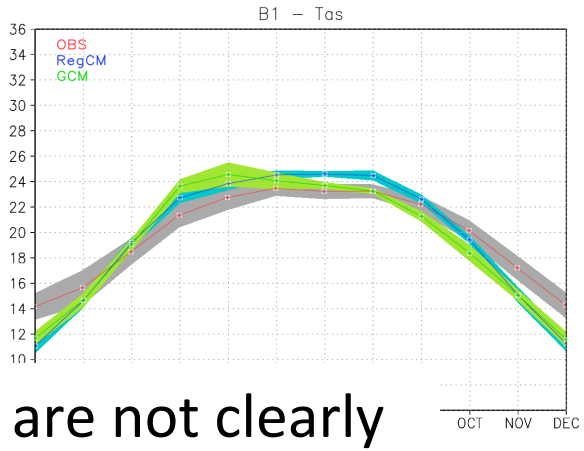
- Ensemble mean of the **RCMs** & **GCMs**
- Shading shows the model +/- 1 standard deviation

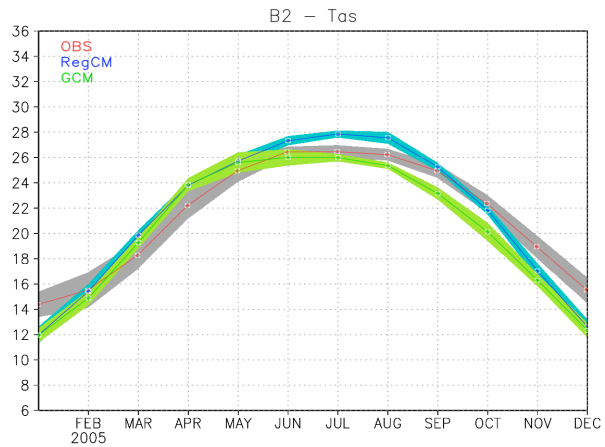


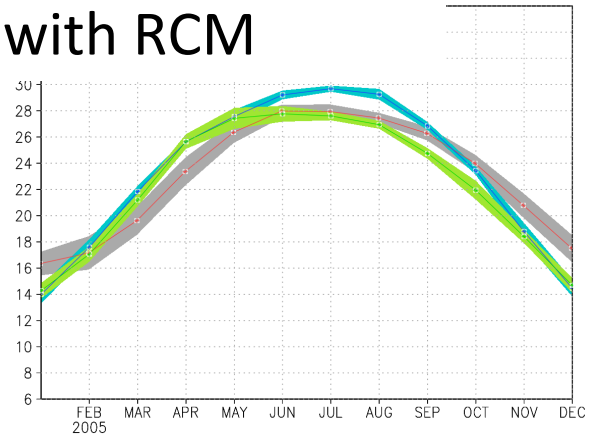
7 climatological sub-regions of Vietnam (Temperature)

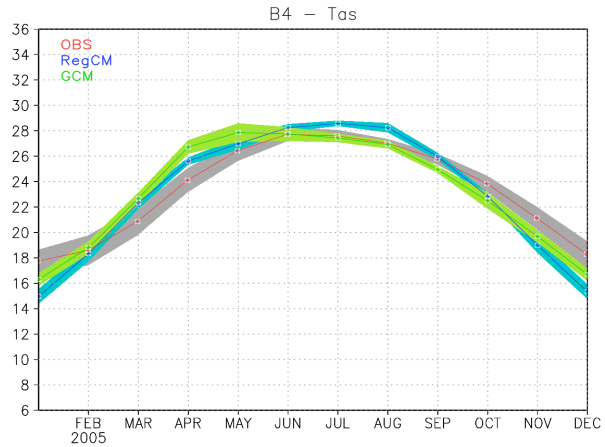


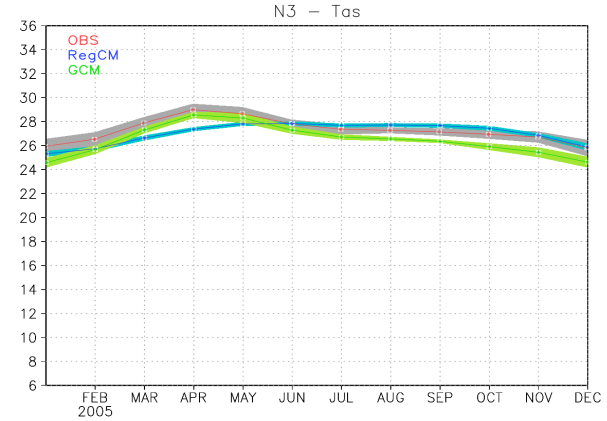
Seasonal cycles are not clearly improved with RCM

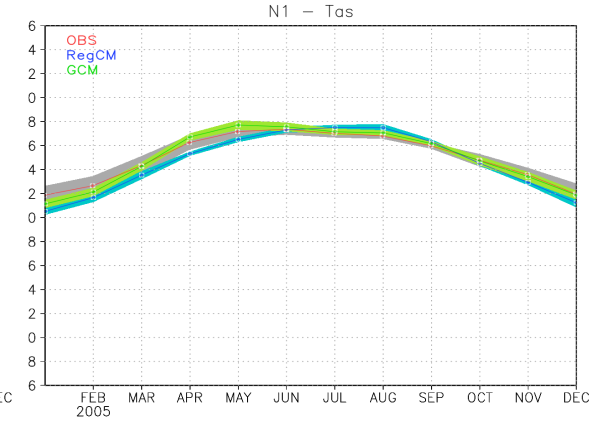


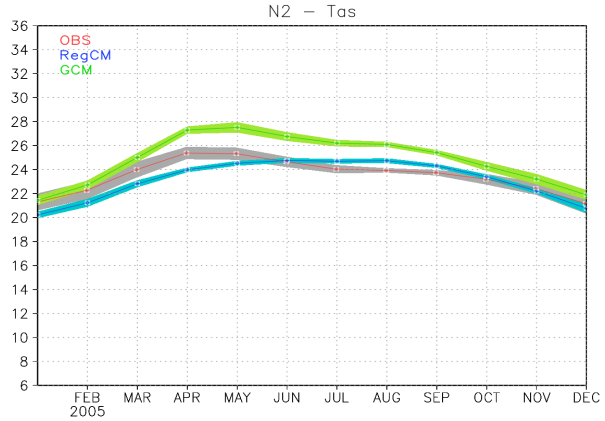












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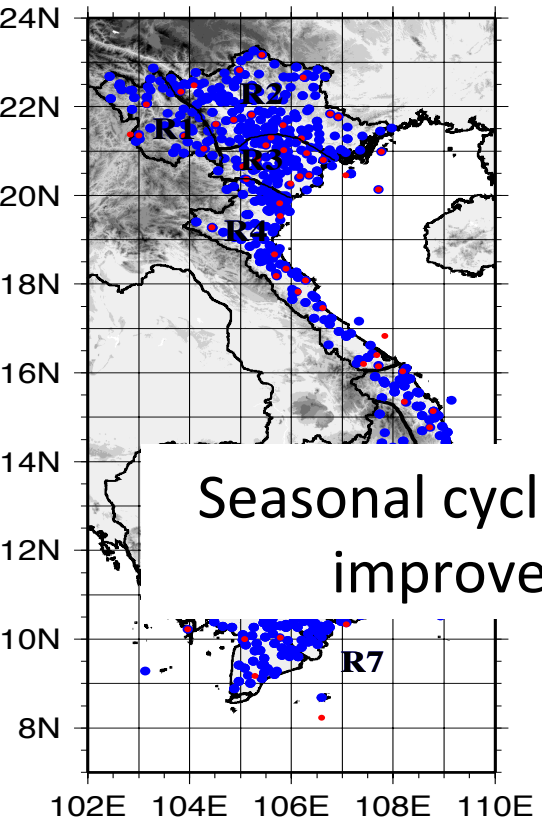
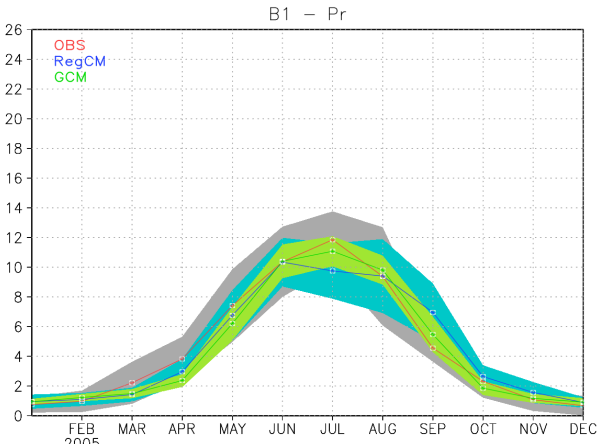
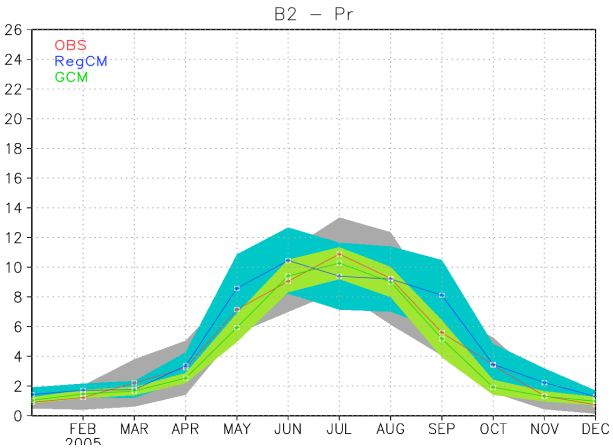
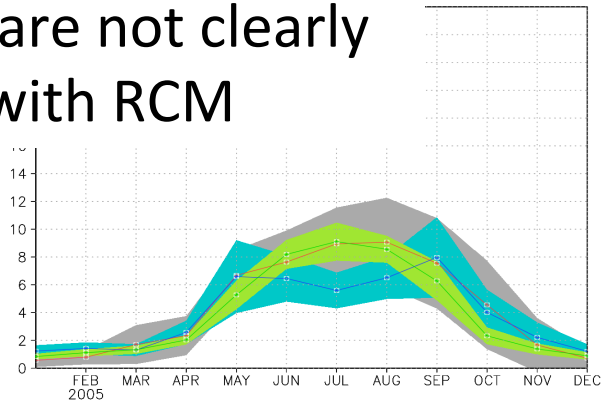
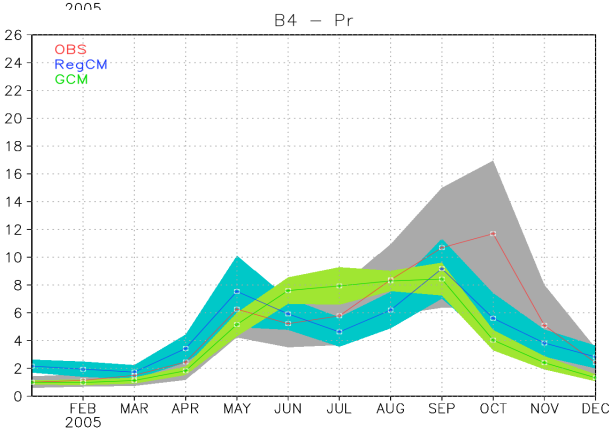


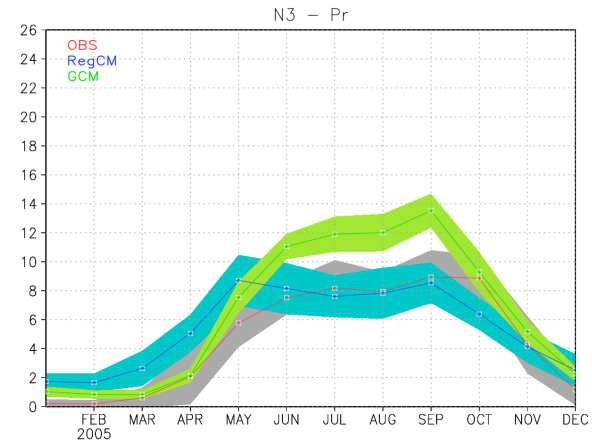
Seasonal cycles are not clearly improved with RCM

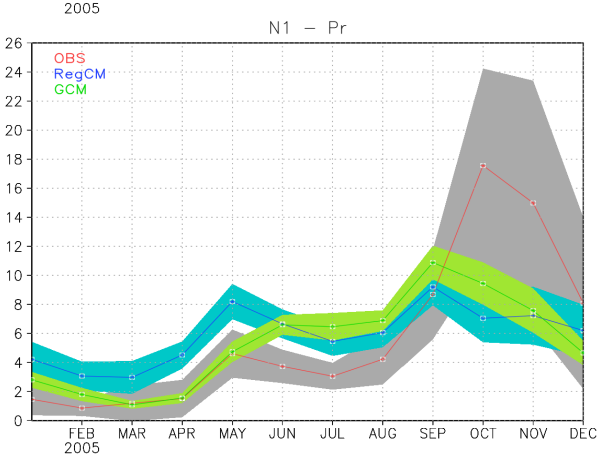


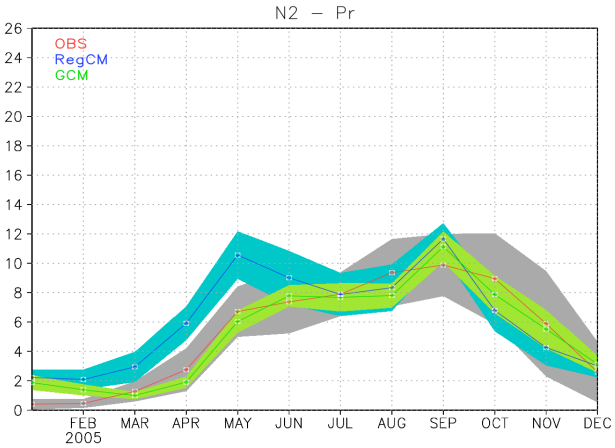












Time of Emergence

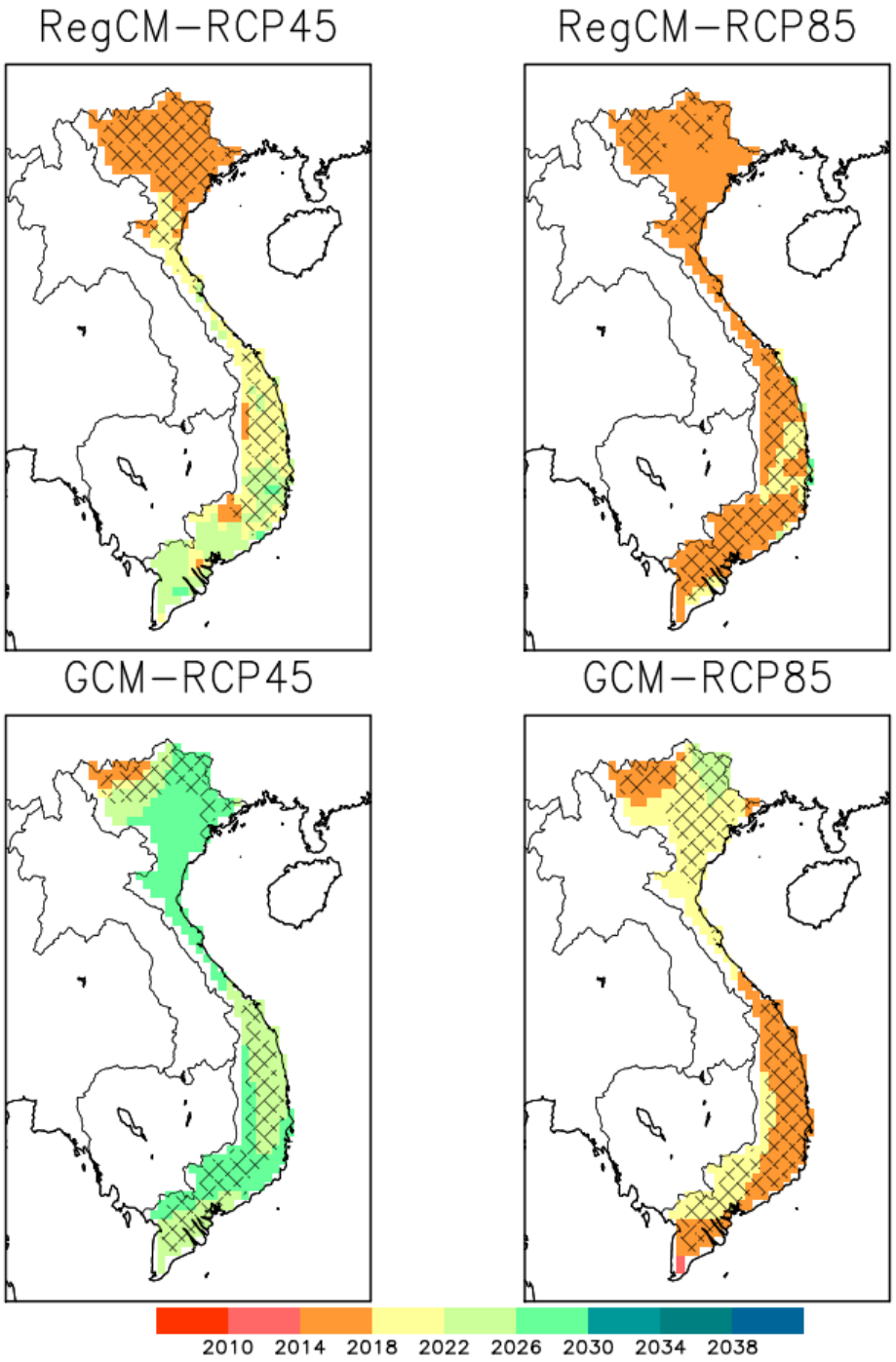
calculation method

- **Time of Emergence (ToE)** is defined when a climate change signal starts to exceed the noise range of projection uncertainty

$$\mathrm{SNR}=\frac{\bar{Y}-\bar{X}}{\sqrt{\left(\frac{1}{M_X}+\frac{1}{M_Y}\right)S_w^2}}$$

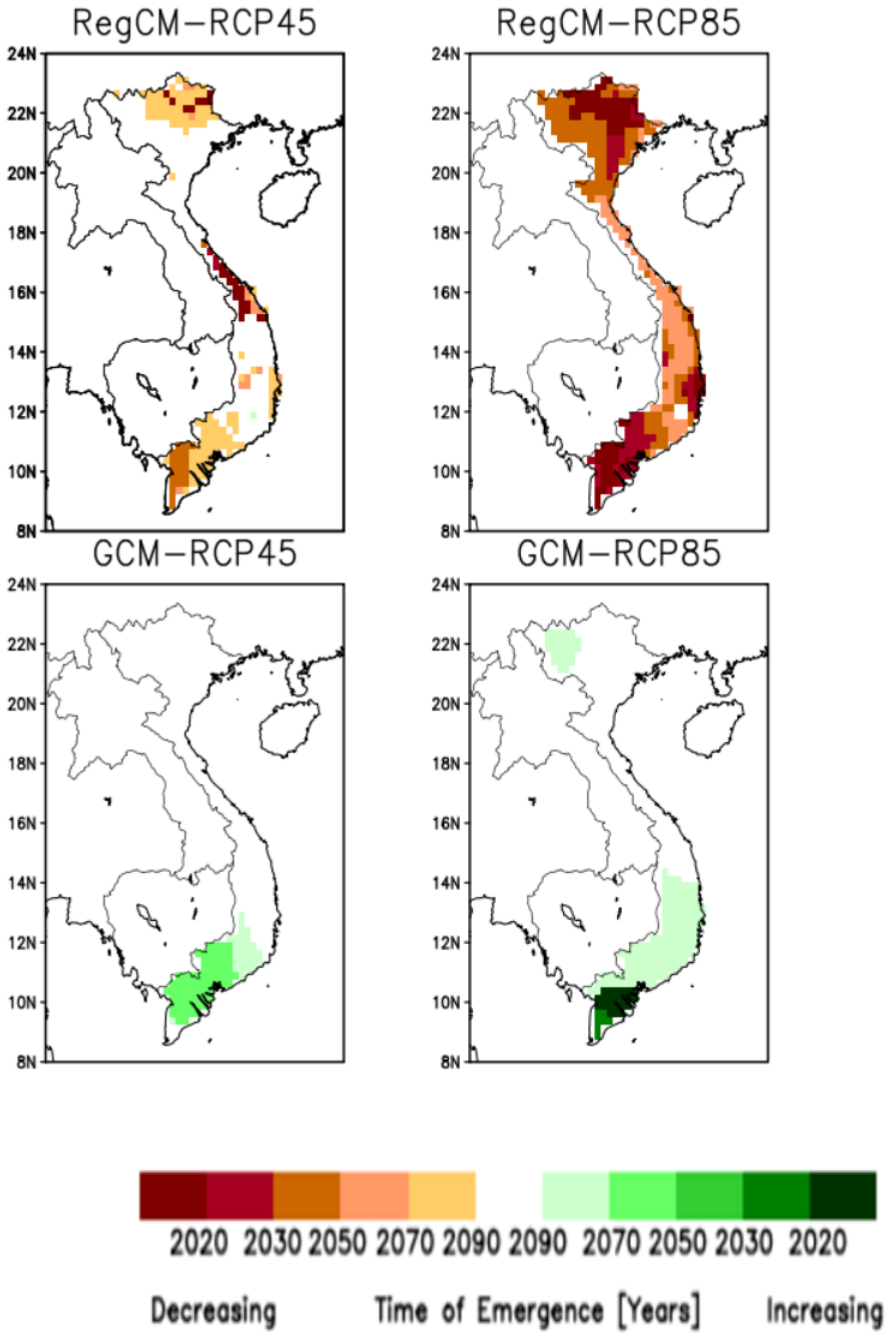
where *X* is the average of the M_X year baseline period (1986-2005), *Y* is the average of a given M_Y years in future. *Y-X* represents for climate change signal (S)

$$S_w^2=\frac{\sum_1^{M_Y}(Y_m-\bar{Y})^2-\sum_1^{M_X}(X_m-\bar{X})^2}{M_X+M_Y}$$



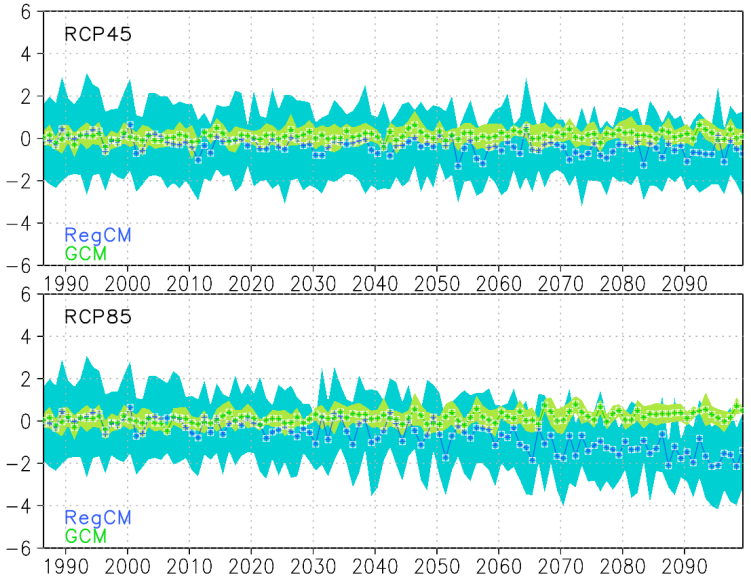
TOE of annual temperature

- Stippling region indicates more than 50% model with ToEs within ToE (Ensemble) ±5 years
- Earlier emergence of RCM compared to GCM



TOE of annual rainfall

- Stippling region indicates more than 50% model with ToEs within ToE (Ensemble) ±5 years
- Deacreasing Rainfall in RCM compared to increasing rainfall in GCM



Conclusions

- Downscaling results produce added values for annual average after a simple bias correction
- Seasonal cycles are not clearly improved with RCMs
- Strong drift in RCP85 precipitation needs to be explored
- Earlier of temperature TOE in RCMs compared to that in GCMs
- Opposite change direction in future precipitation for RCMs & GCMs

Thank you!

ありがとうございます

Xin cảm ơn!