Seasonal and inter-annual variations of surface climate elements over Vietnam

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Outline of talk

- Motivation
- Model and experiment design
- Results and discussion
- Summary
- Further works

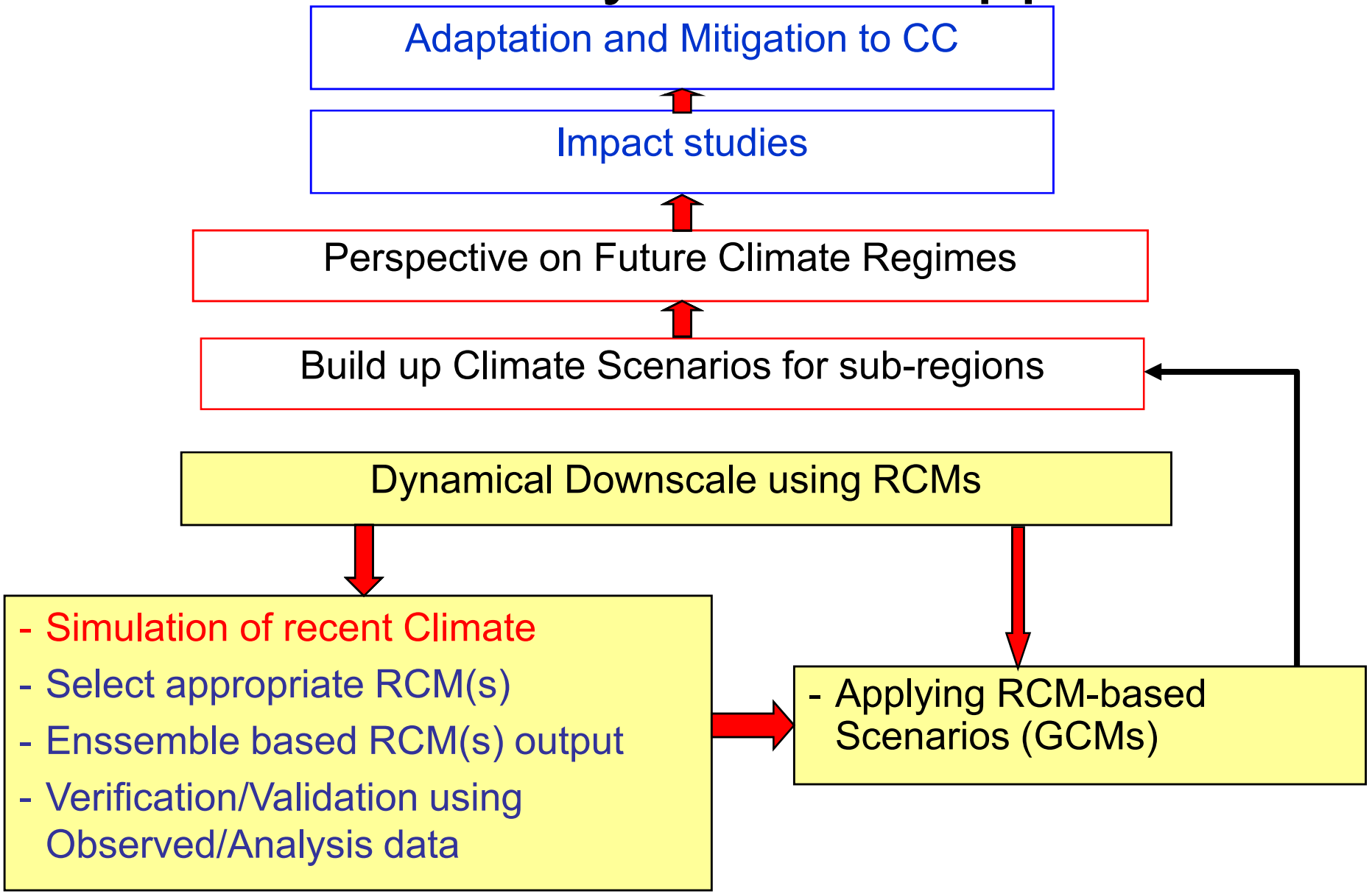
Motivation

- The UNDP warned that **Vietnam** is in the top five countries affected by climate change:
  - If the sea level rises by 1m, **Vietnam** will lose 5% of its land, 7% of agricultural output and 10% of GNP. Additionally, 11% of Vietnamese people will lose their homes.
- Recent years, there are many National and International conferences/workshops regarding to "adaptation", "Action plans of adaptation", or "stragetic planning of adaptation",… to Climate change in Vietnam
- But, there are NO or UNCERTAIN information say about "How climate of Vietnam changes in the future"

Motivation

- From my of view, for doing so-call “adaptation” to Climate Change (CC) in Vietnam, there are the following main steps in sequence:
  - To identify climate conditions in the future over sub-regions based on “climate scenarios”
  - To access the impacts of CC on sectors/sub-regions
  - To develop feasible action plan to effectively respond to CC in short-term and long-term periods for sectors/sub-regions
- This study towards first task

Motivation - Dynamical approach



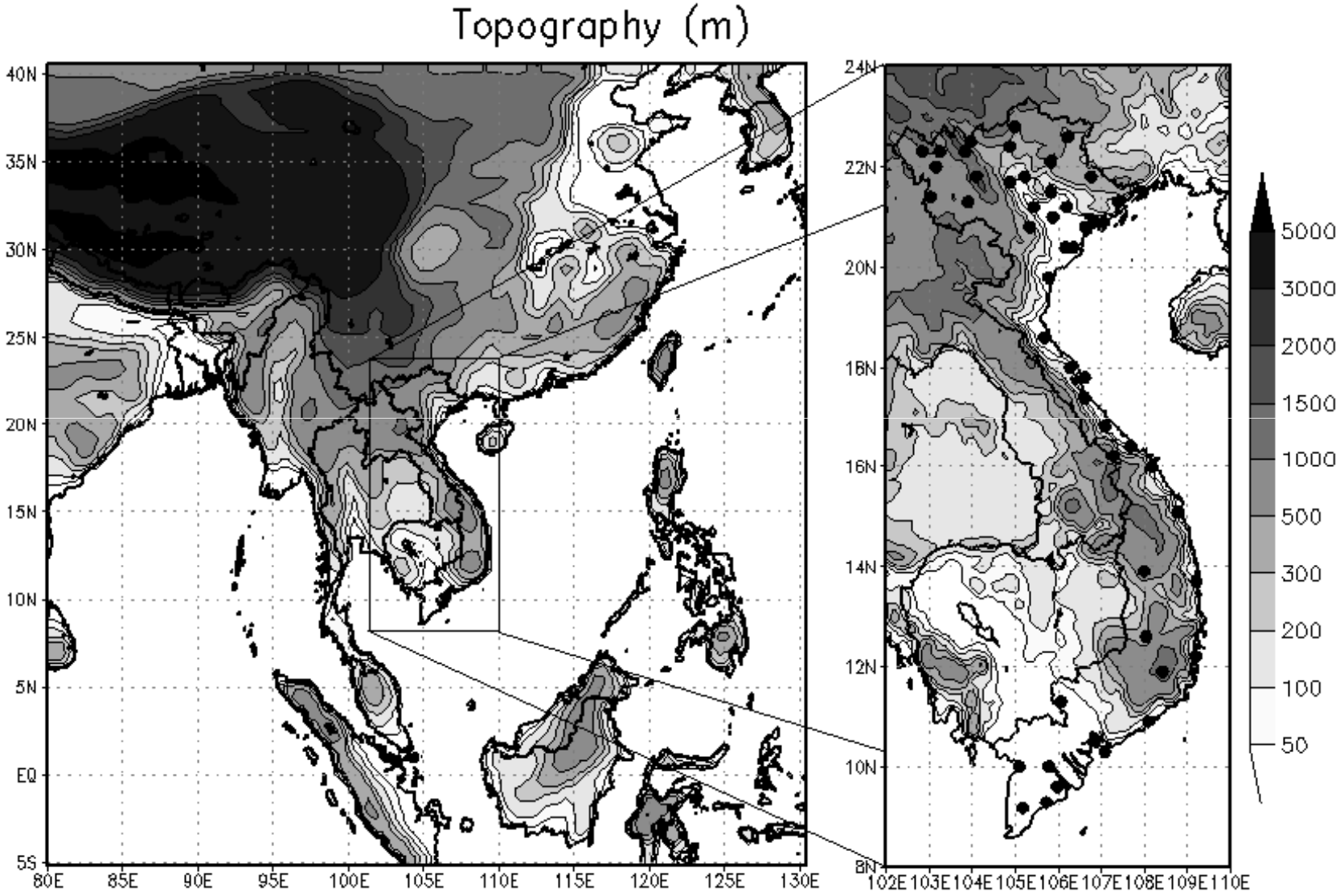
Model and experiment design

- Model: RegCM3 (Regional Climate Model Version 3.0) (http://users.ictp.it/~pubregcm)
- Sensitivity tests have been done (2006-2008)
  - Domain size, domain possition and resolution
  - Different reanalysis data (ERA40, NNRP1, NNRP2)
  - SST (weekly and monthly OISST)
  - Physical parameterization schemes
    - Ocean fluxes (BATS, Zeng)
    - Convection (BM, Kuo, MIT-Emanuel, Gell-AS, Grell-FC)
  - Continuous vs discontinuous integrate
  - Seasonal scale simulation (only for summer moonson periods)
  - Seasonal forecasting using output from CAM3.0 (RegCM+CAM)

Model and experiment design

- In this study, RegCM3 is used with configurations:
  - Domain size: 80E-130E and 5S-40N
  - Horizontal resolution: 54 km
  - Vertical resolution: 18 vertical σ-levels, top at 70mb
- Boundary data:
  - ERA40 (2.5 x 2.5 deg, 6 hourly
  - OISST (1.0 x 1.0 deg, weekly)
- verification data:
  - CRU
  - CMAP
  - Observed data at 50 meteorological stations over VN

Model and experiment design



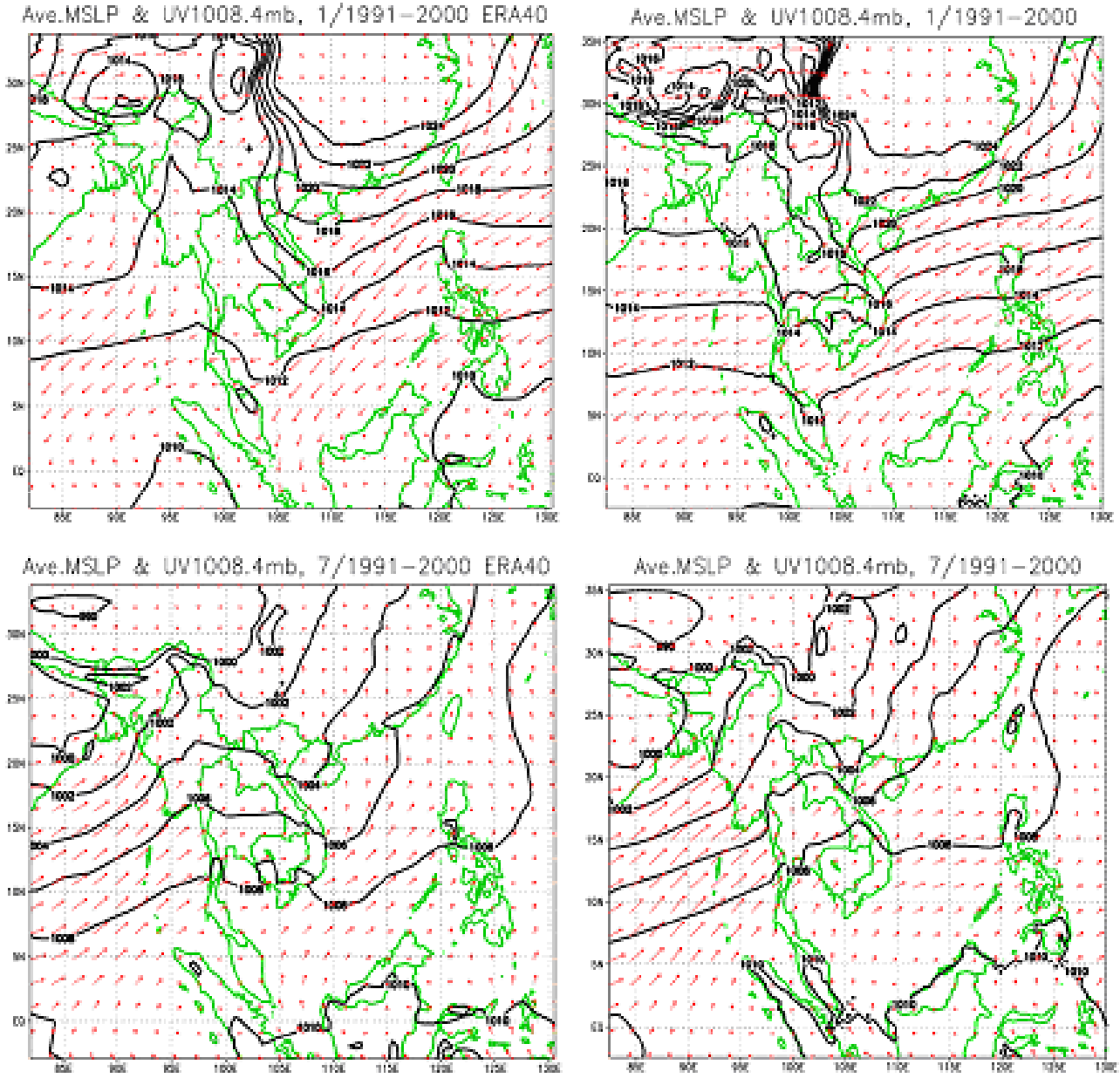
Model domain and meteorological station network over VN

Model and experiment design

- Physical parameterizations:
  - Radiation scheme: CCM3
  - Land-Atmosphere exchange: BATS
  - Ocean fluxes: BATS
  - Convective scheme: Grell scheme with Arakawa and Schubert closure assumption (Grell-AS)
- Period of simulation: 10 years (Dec 1990 – Dec 2000) with ONE month spin-up time (Dec 1990)

Results and discussion

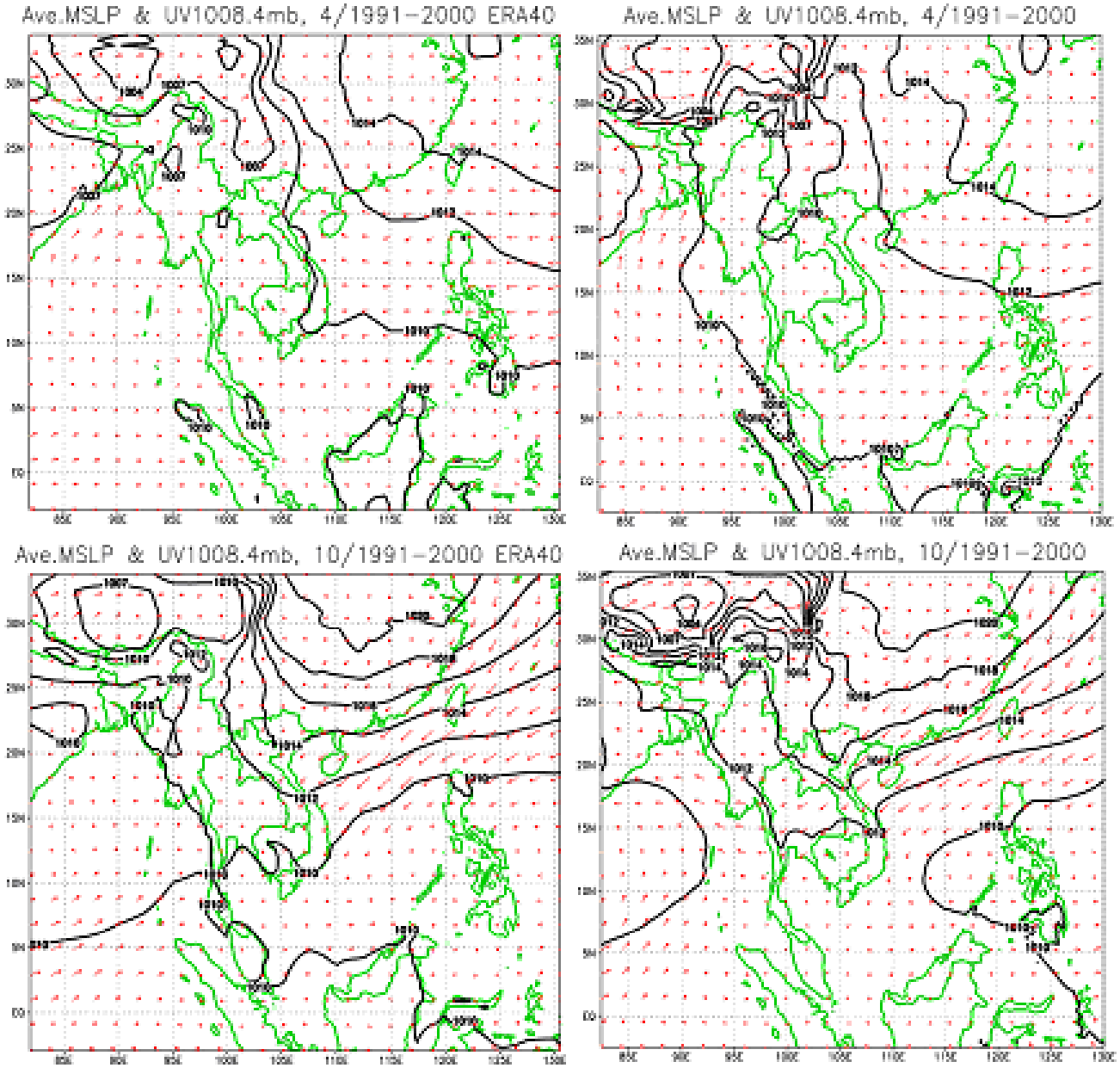
Regional circulation patterns



The 1991–2000 average of mean sea level pressure from ERA40 (left) and RegCM3 (right) in January (upper), July (lower)

Cold high pressure in winter and warm low pressure in summer are quite well captured by the model

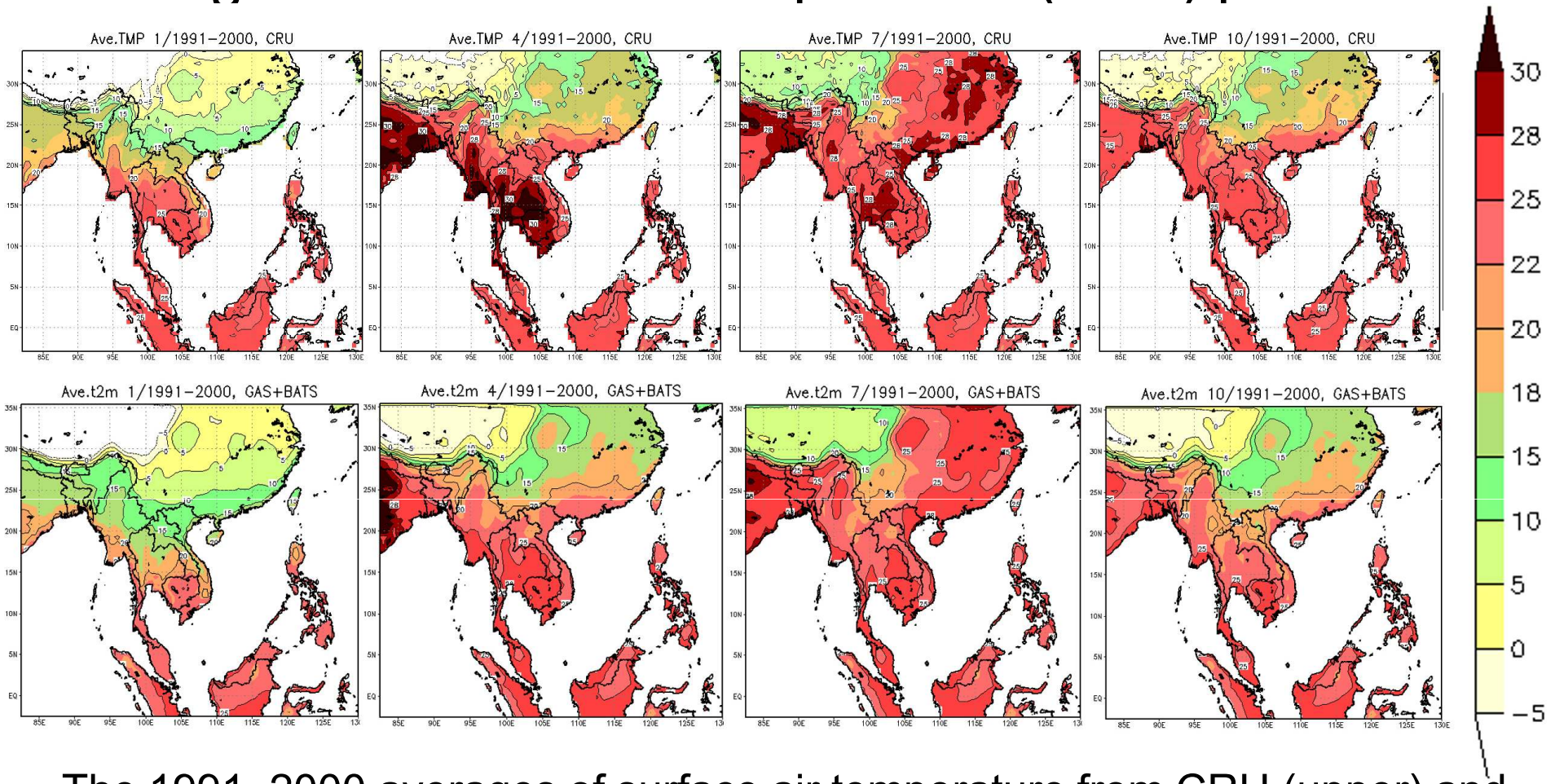
Regional circulation patterns



The 1991–2000 average of mean sea level pressure from ERA40 (left) and RegCM3 (right) in April (upper), October (lower)

Circulation patterns in the transitional periods are also well reproduced

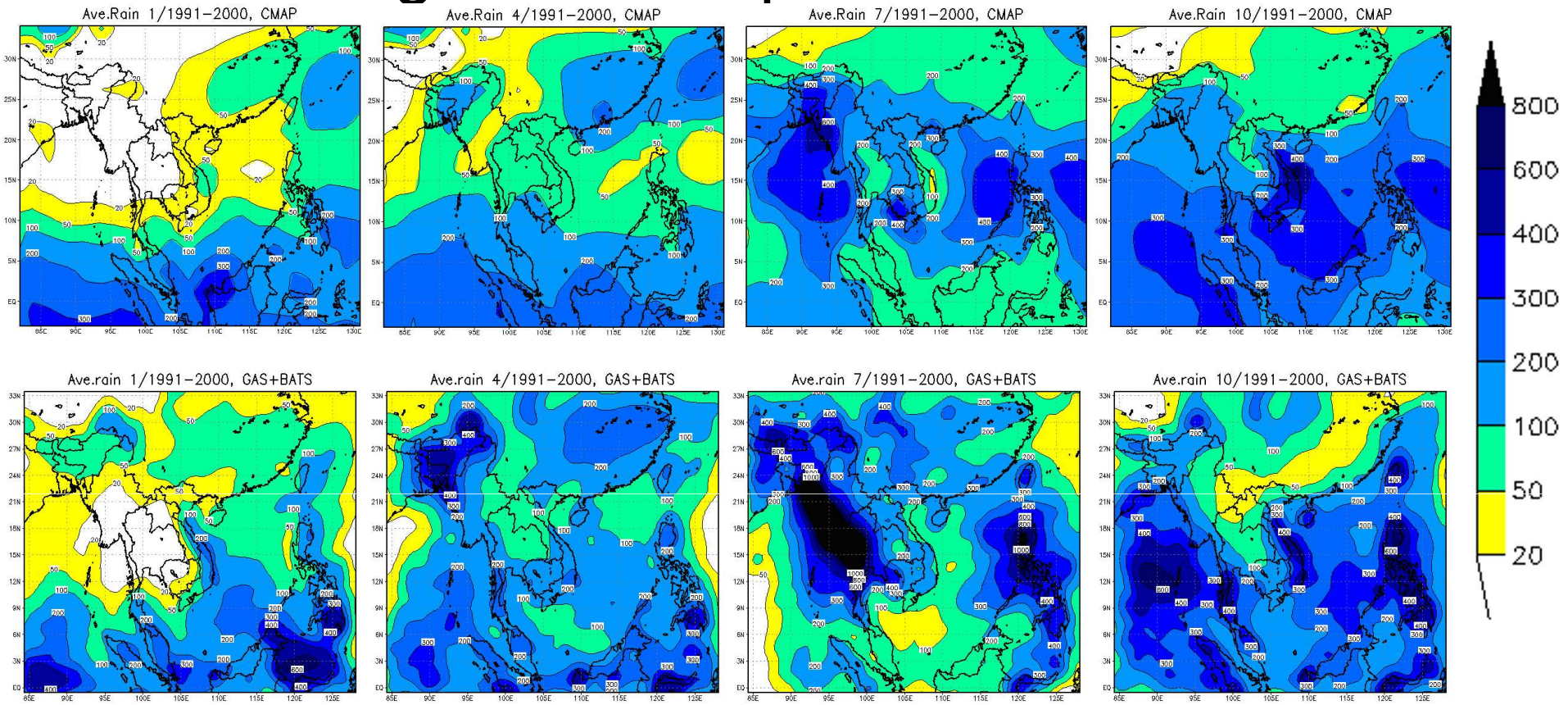
Regional surface air temperature (T2m) patterns



The 1991–2000 averages of surface air temperature from CRU (upper) and RegCM3 (lower) in January, April, July and October (left to right). Unit in ºC.

The main features of spatial distribution of T2m simulated by RegCM3 agree well with the CRU data. But the model simulation shows a tendency to underestimate temperature by 1–2ºC with CRU

Regional Precipitation Patterns

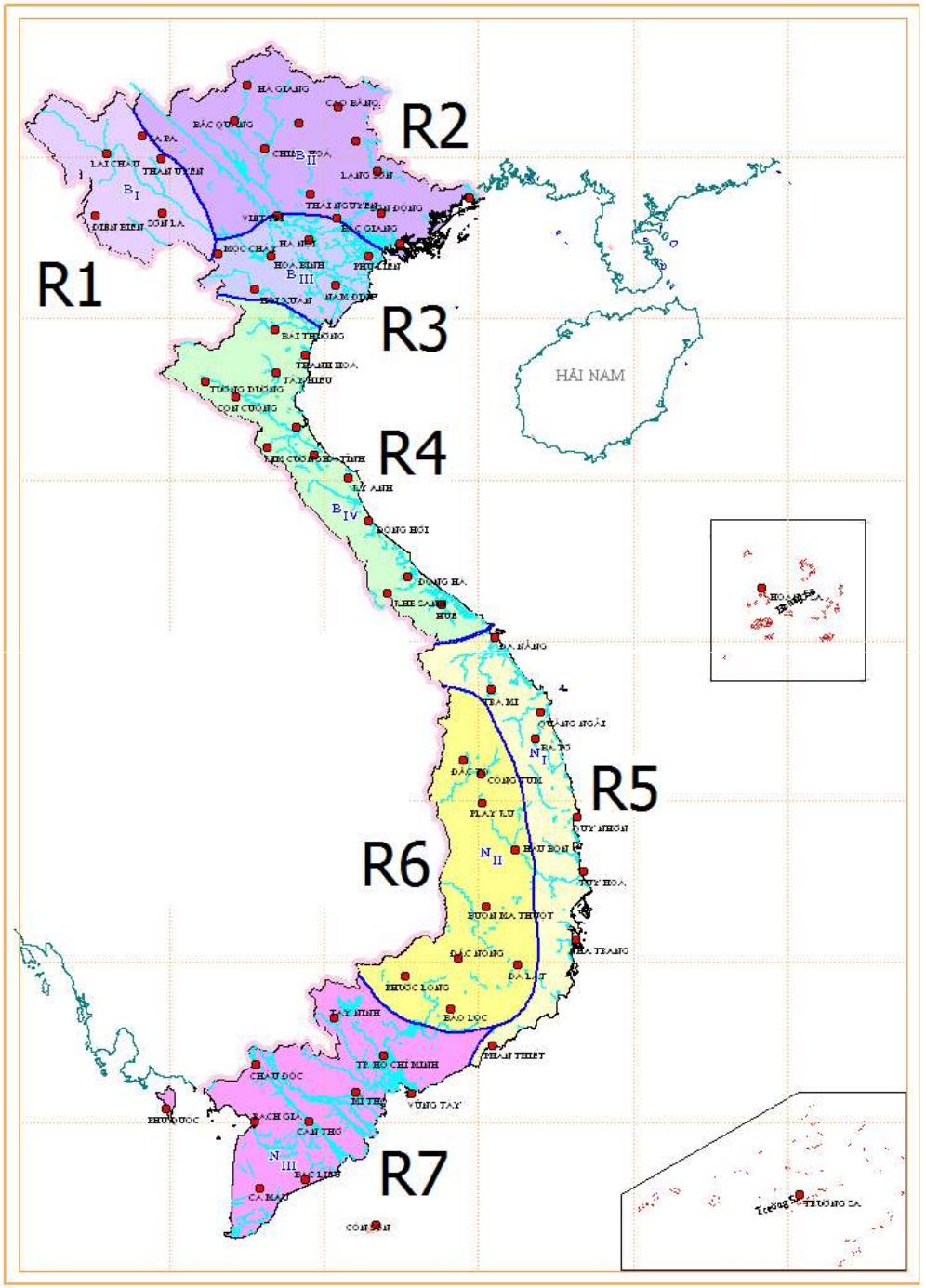


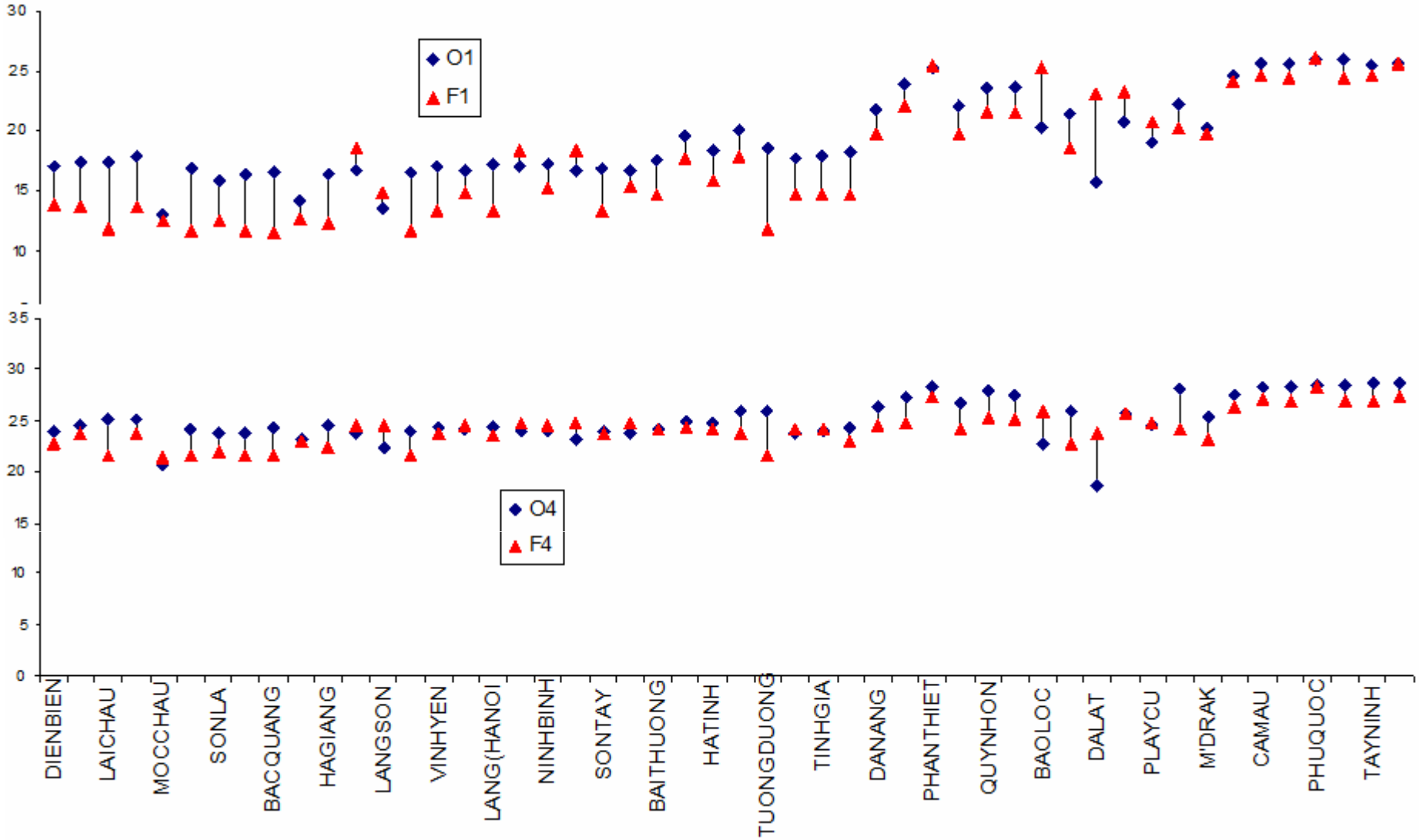
The 1991–2000 averages of precipitation from CMAP (upper figures) and RegCM3 (lower figures) in January, April, July and October (left to right). Unit in mm/month.

Model can capture general rainfall patterns although considerable differences exist. In some regions, the RegCM3 simulation compares more favorably with observations, while in other regions less favorably. It seems that model tends to overestimate precipitation

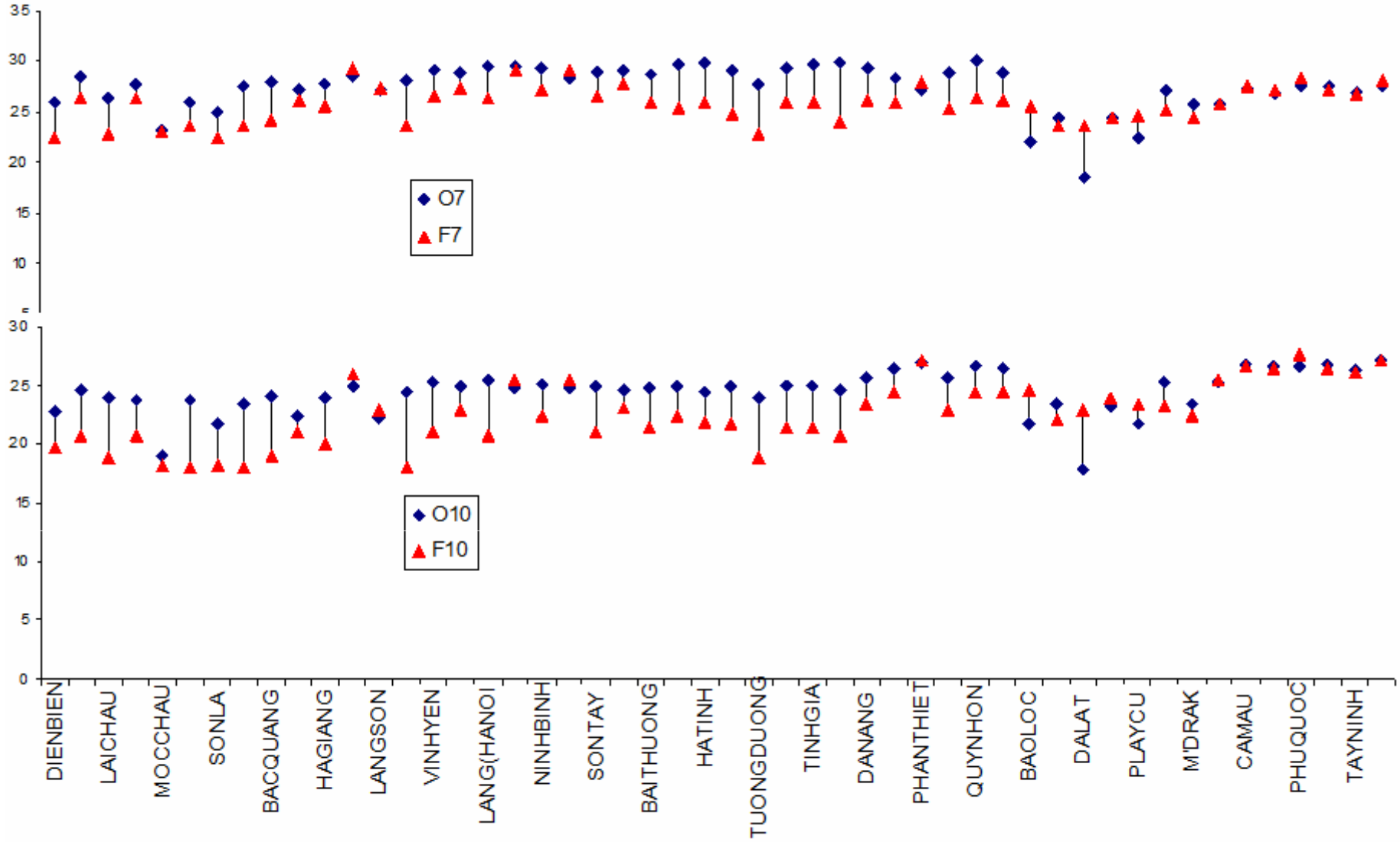
Validation for Vietnam

- Monthly mean T2m and accumulated precipitation from **50 stations** over **seven climatological sub-regions** are collected from January 1991 to December 2000
- The model results **are interpolated** to the stations

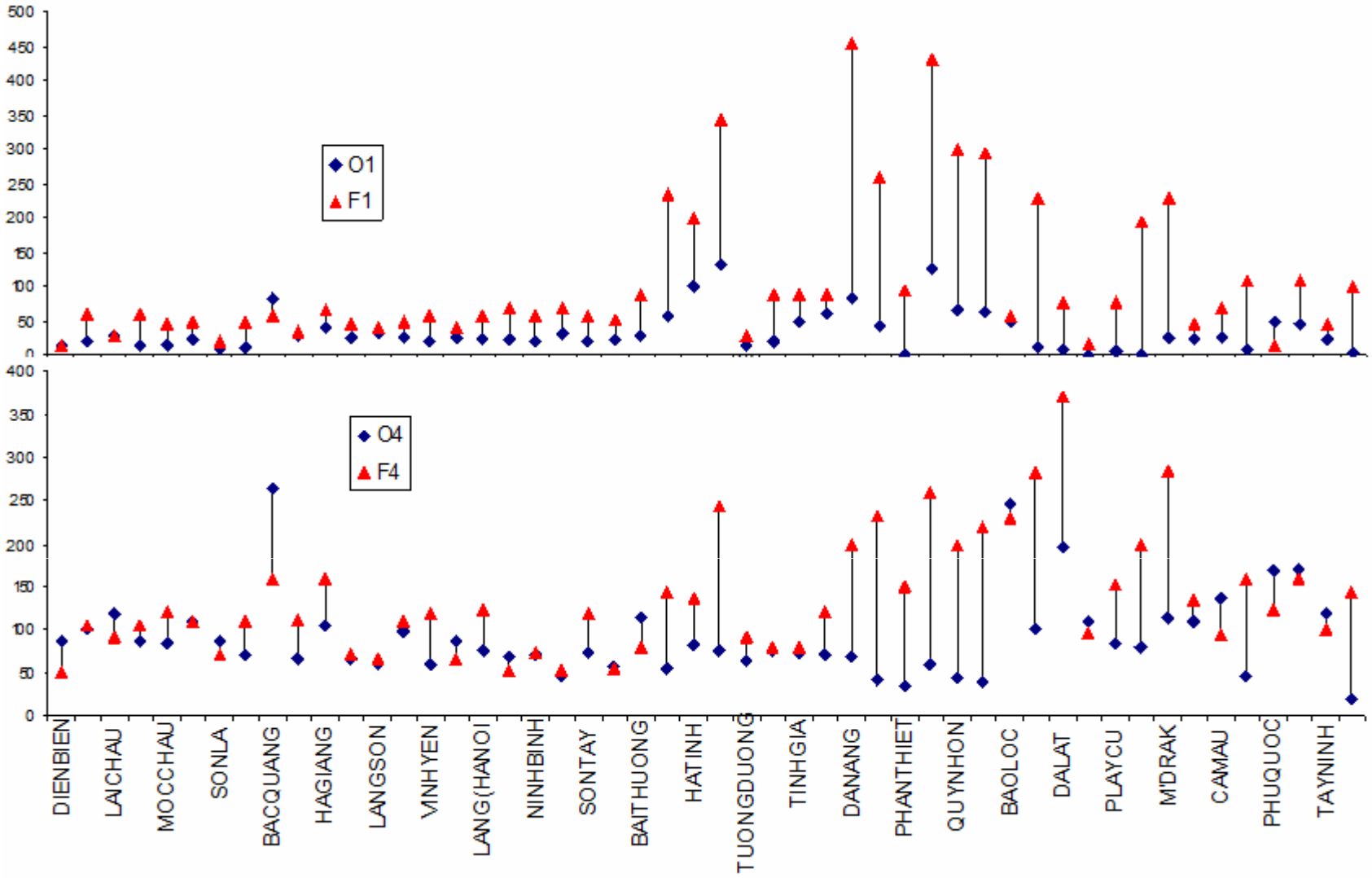




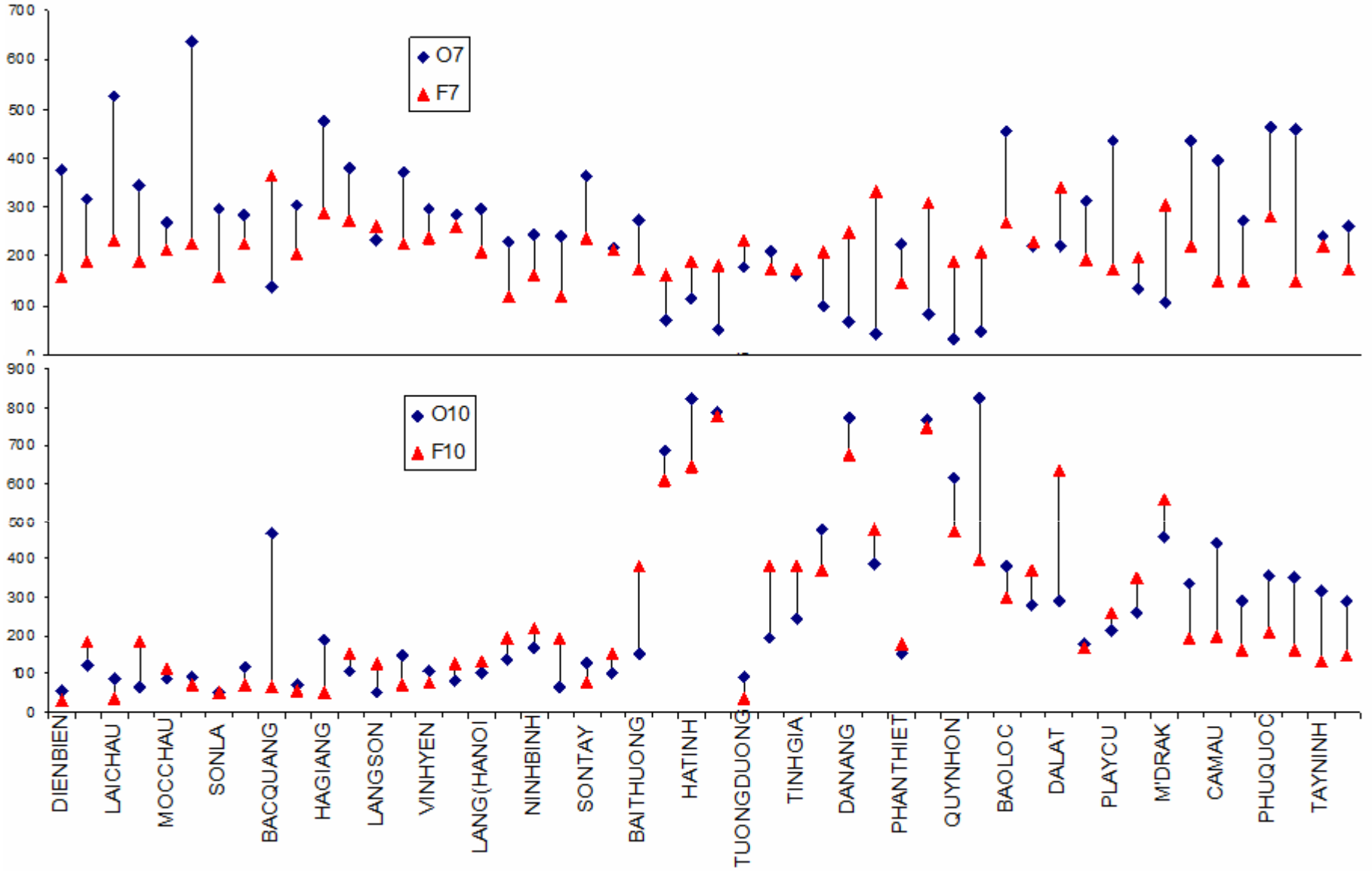
The 1991–2000 averages of Obs (blue) and model (red) T2m at stations in January (upper) and April (lower). Unit in ^{o}C. (O: Observed; F: Model)



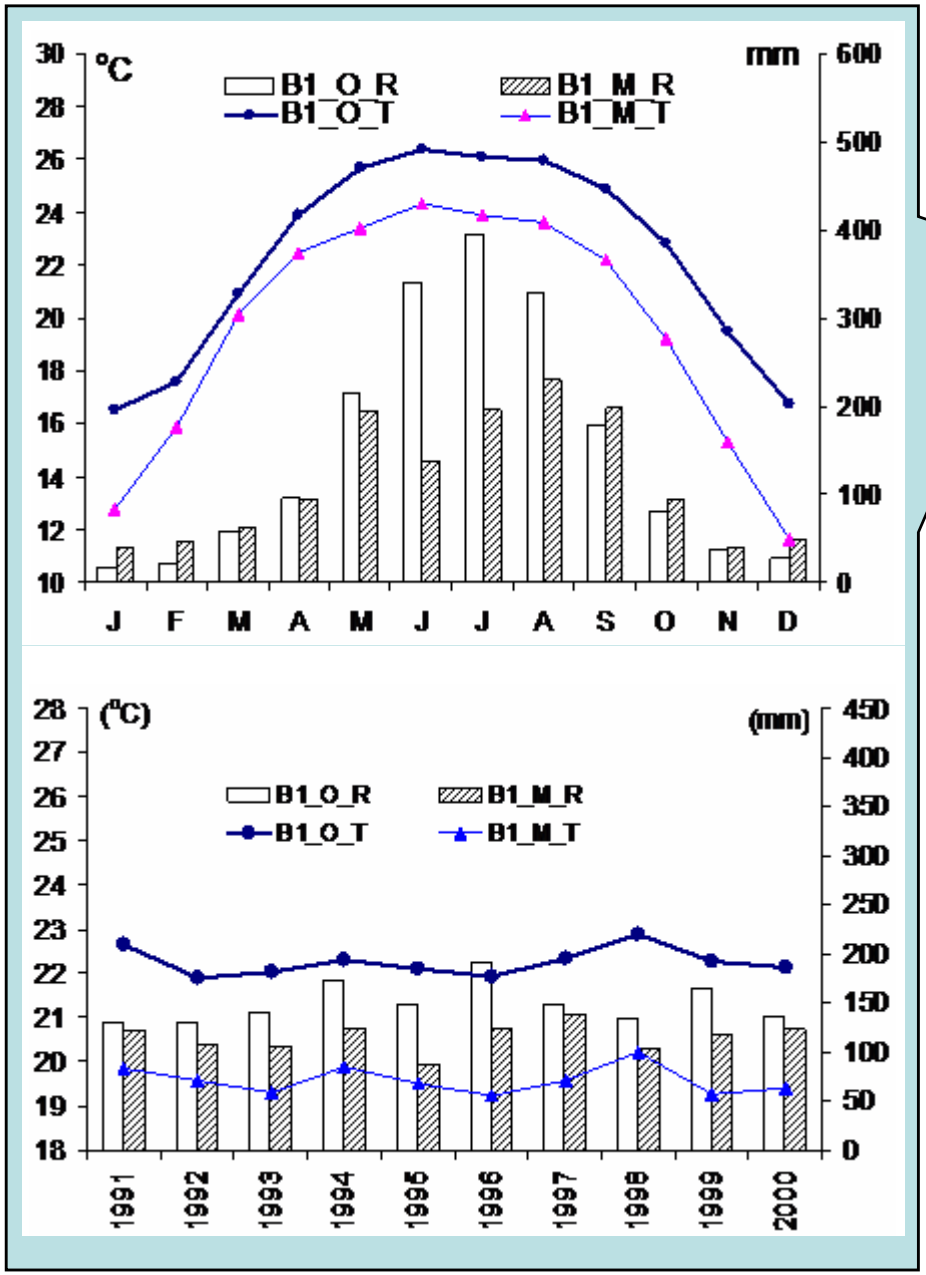
The 1991–2000 averages of Obs (blue) and model (red) T2m at stations in July (upper) and October (lower). Unit in ^{o}C. (O: Observed; F: Model)

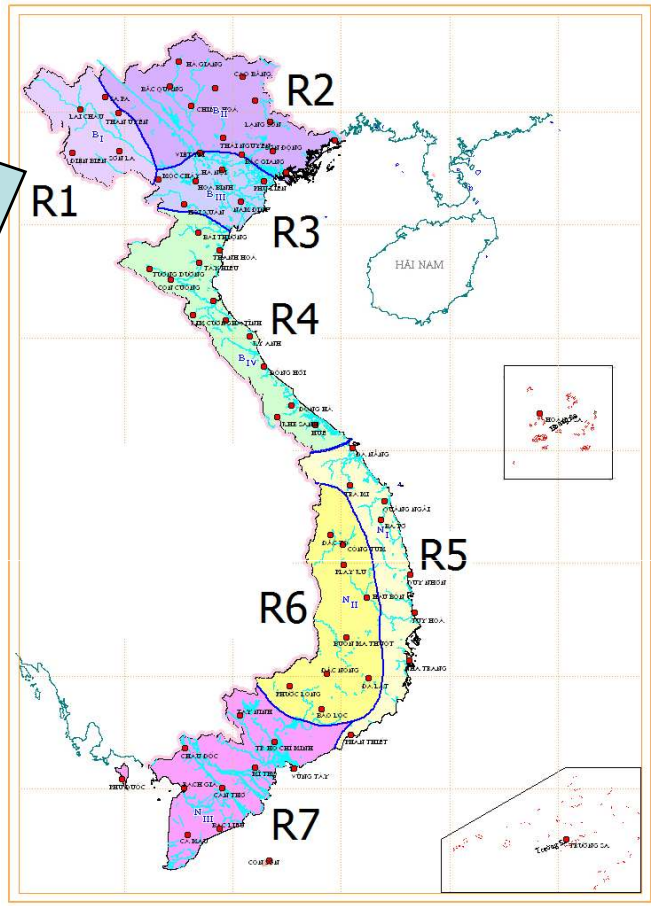


The 1991–2000 averages of Obs (blue) and model (red) rainfall at stations in Jan (upper) and Apr (lower). Unit in mm/month. (O: Observed; F: Model)



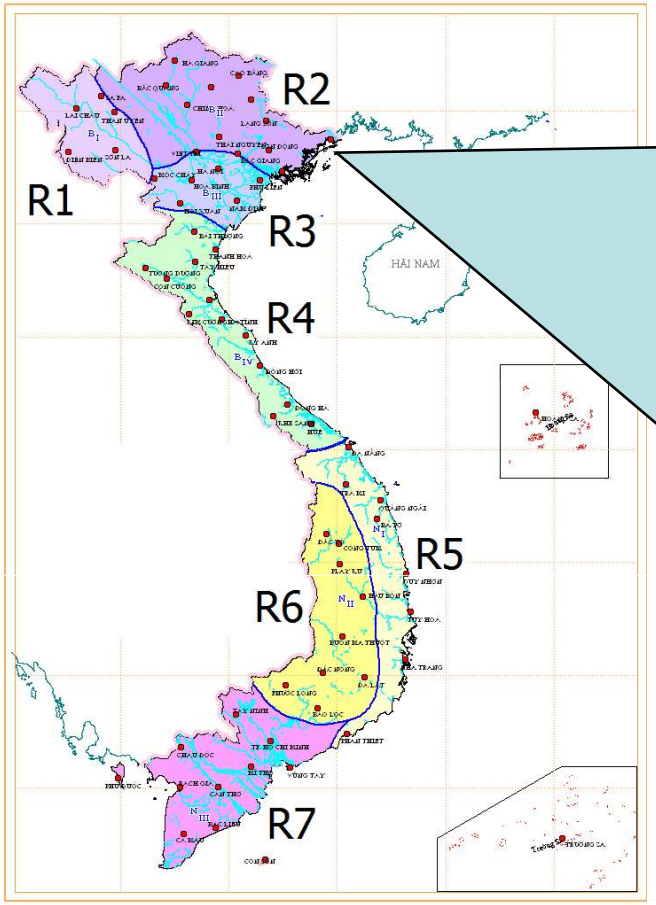
The 1991–2000 averages of Obs (blue) and model (red) rainfall at stations in Jul (upper) and Oct (lower). Unit in mm/month. (O: Observed; F: Model)

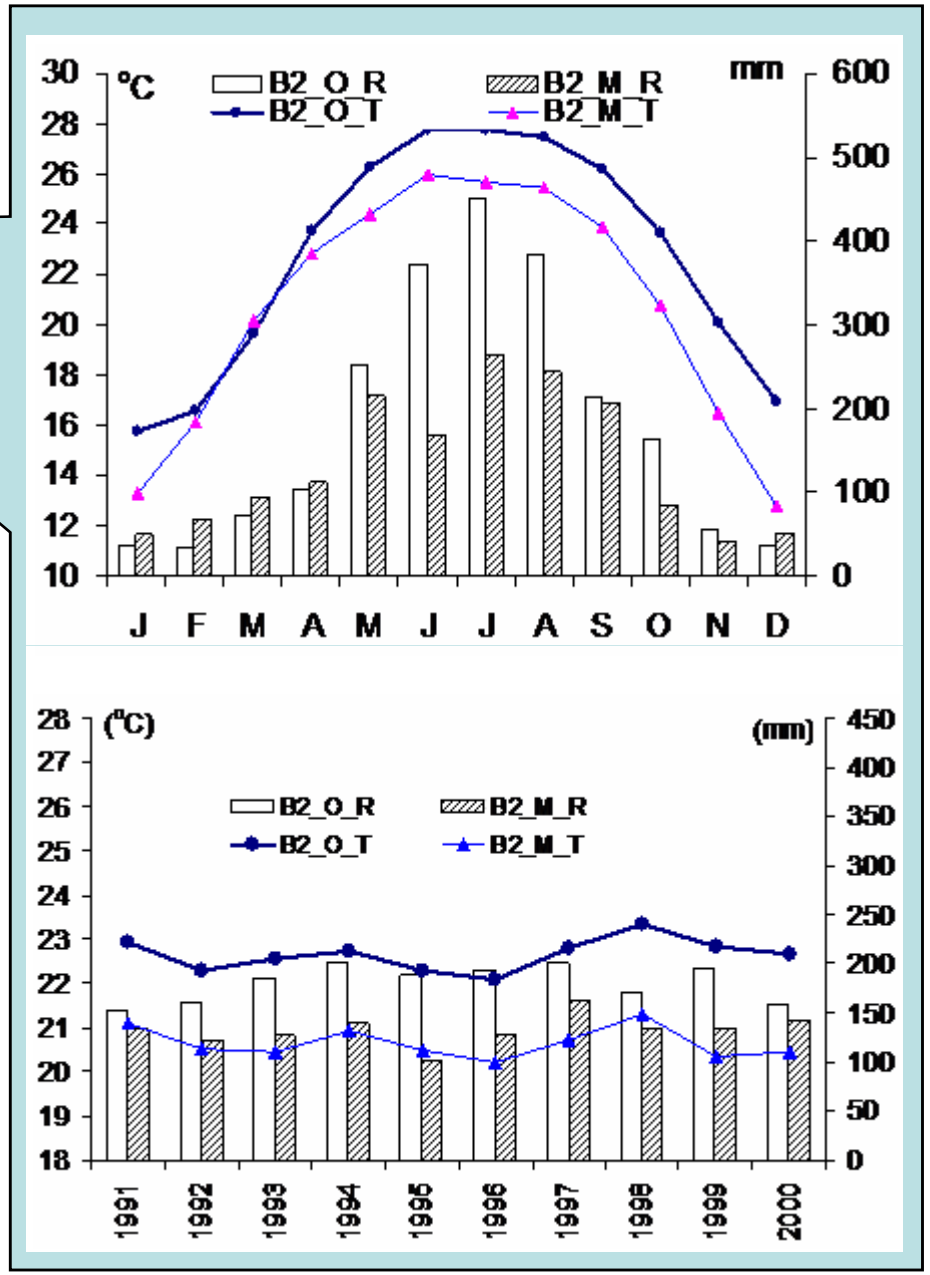




O: Observed; M: Model

T: T2m; R: Precipitation





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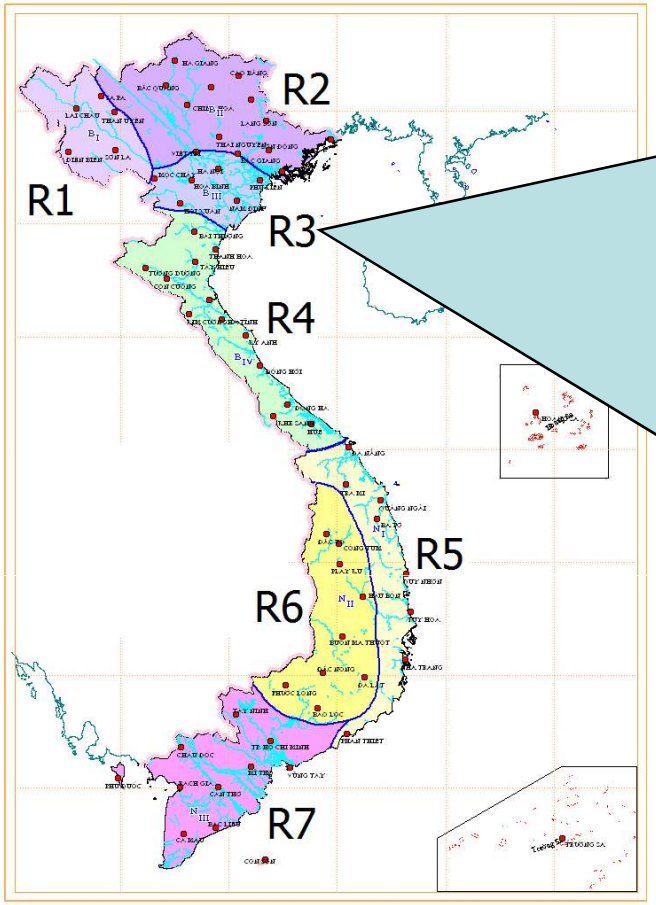

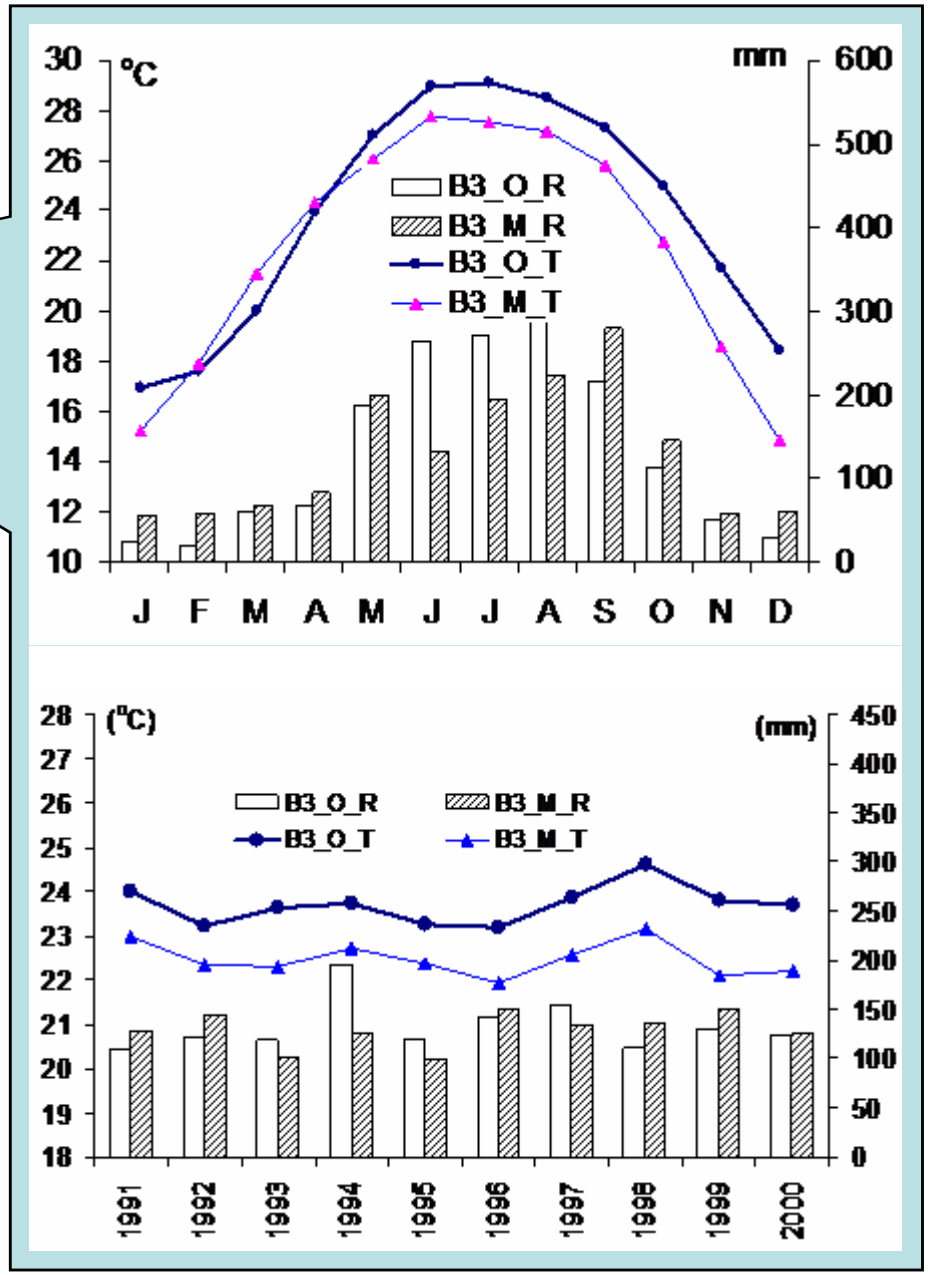

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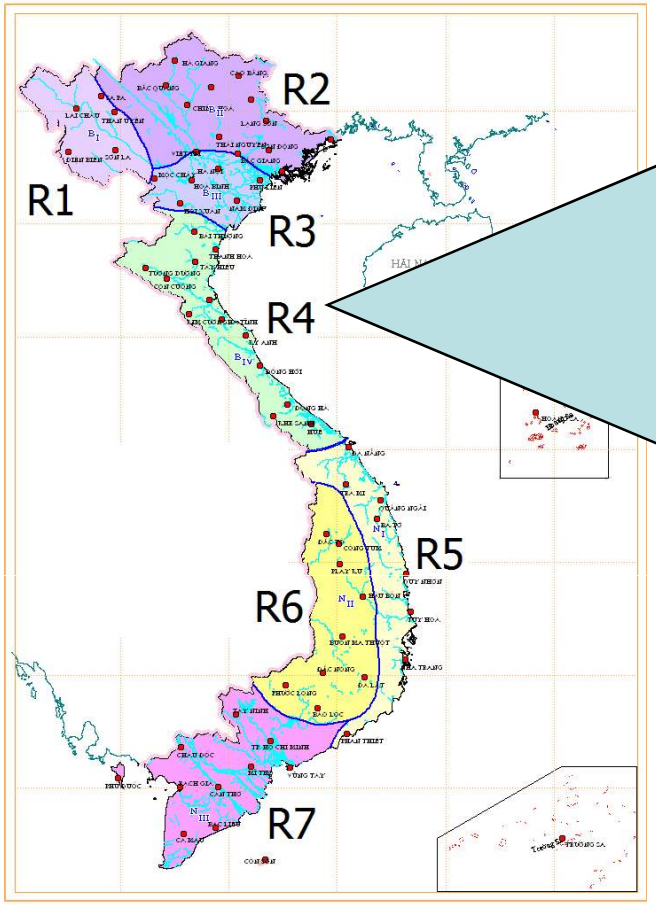

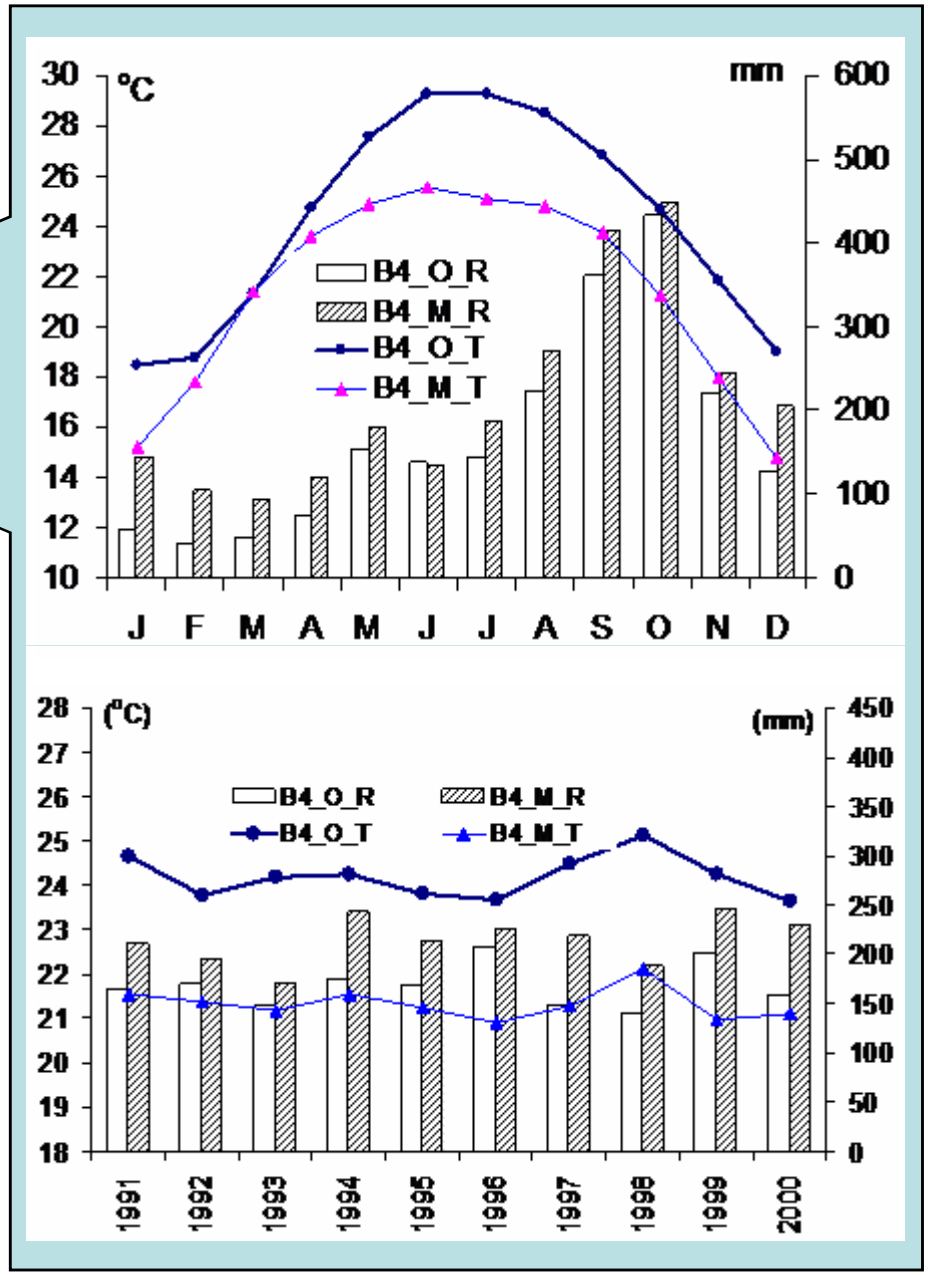

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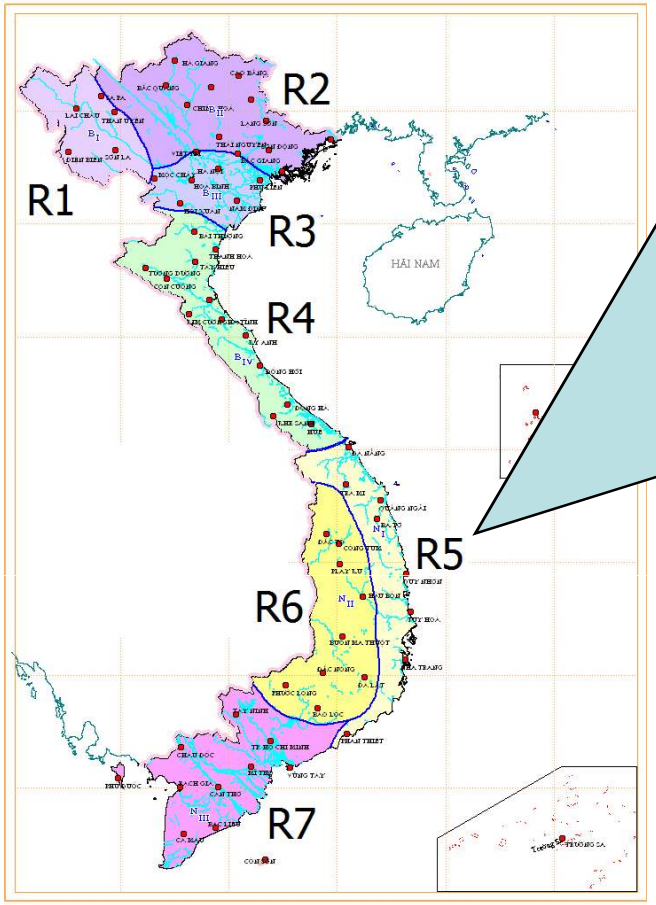

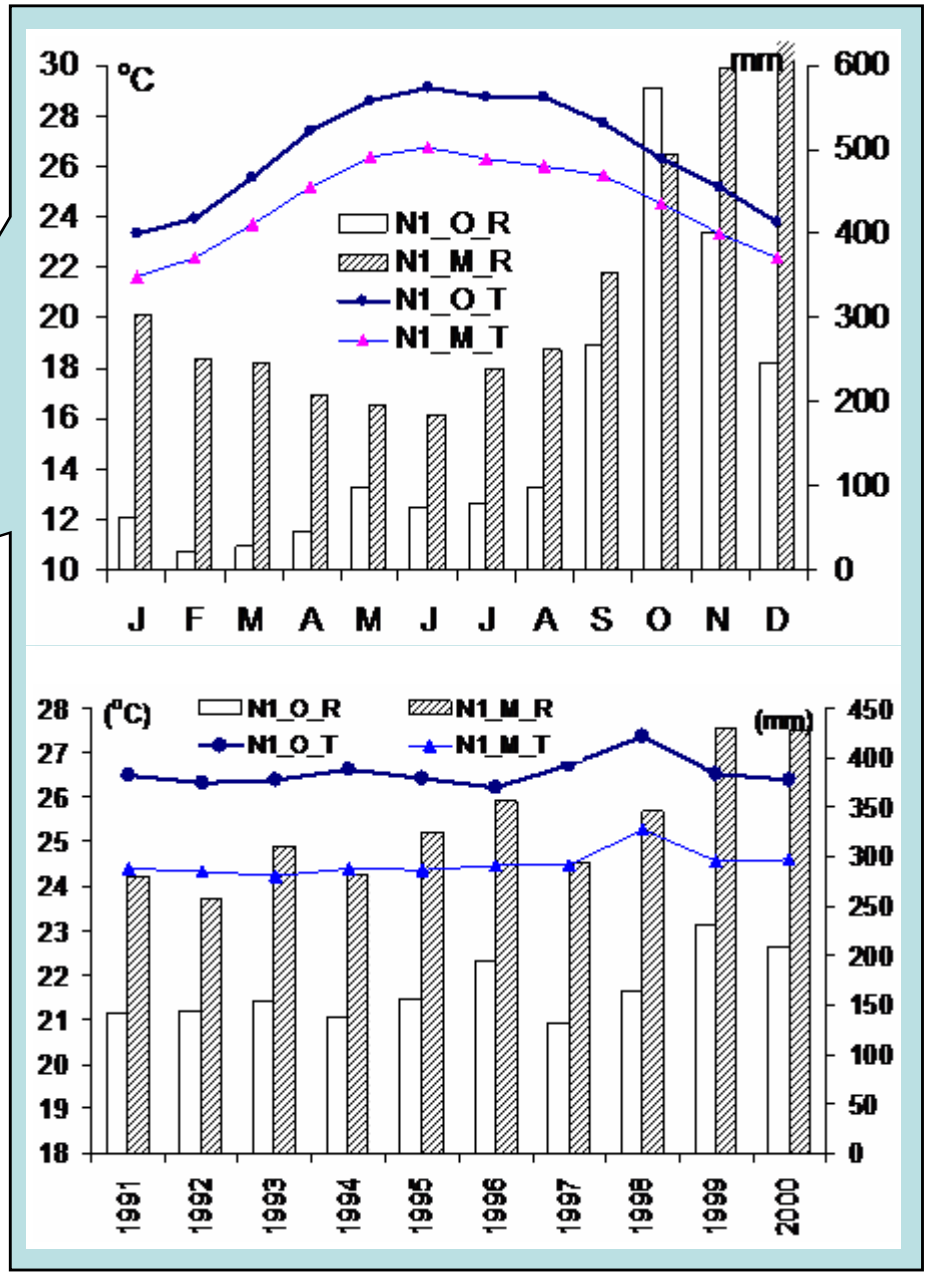

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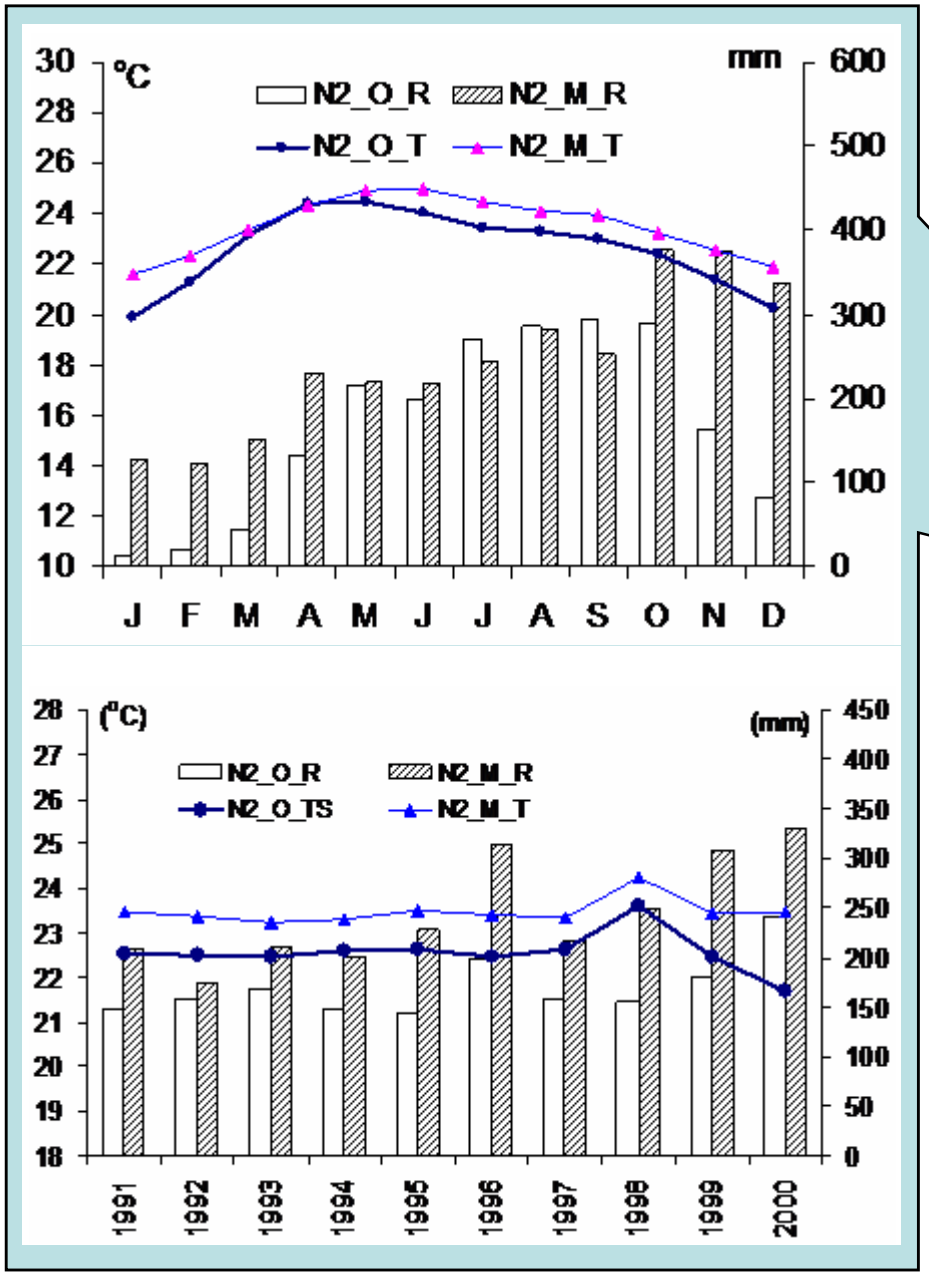

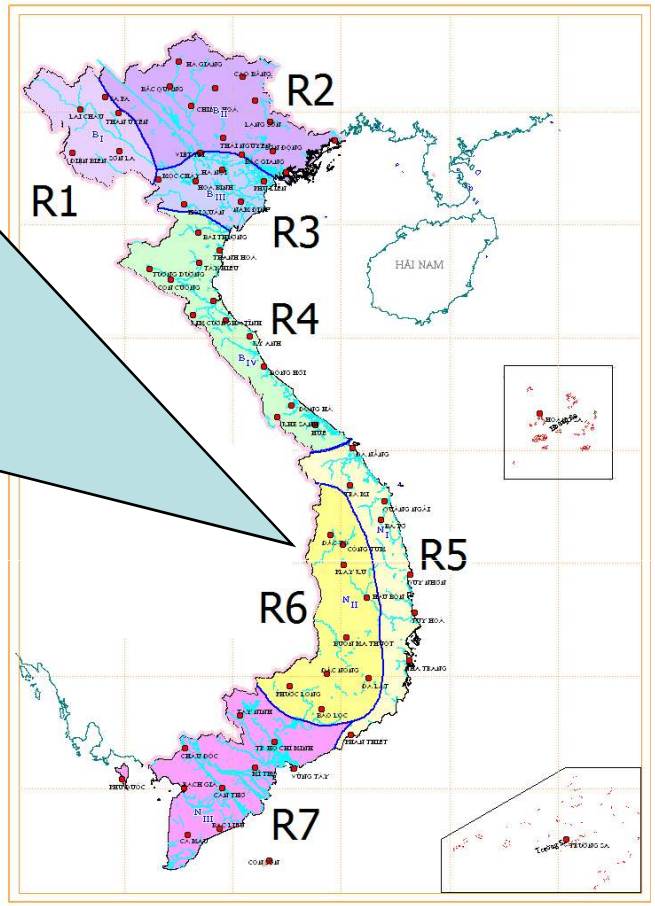

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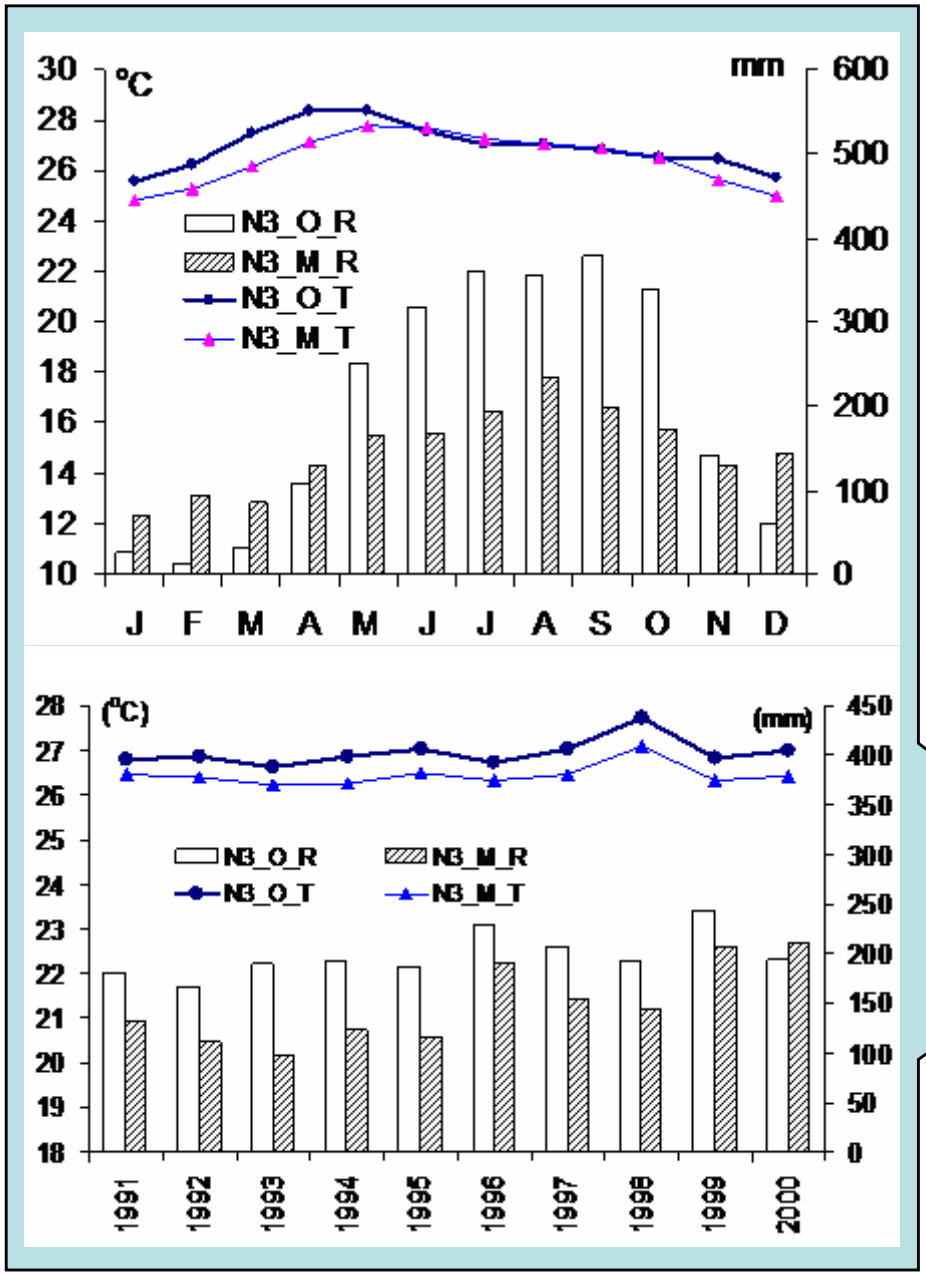

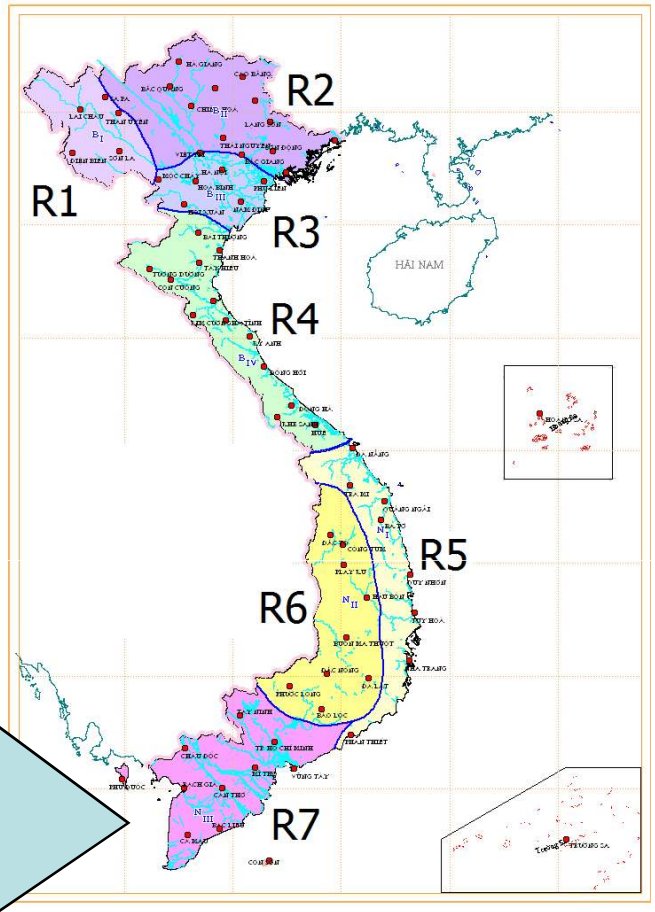

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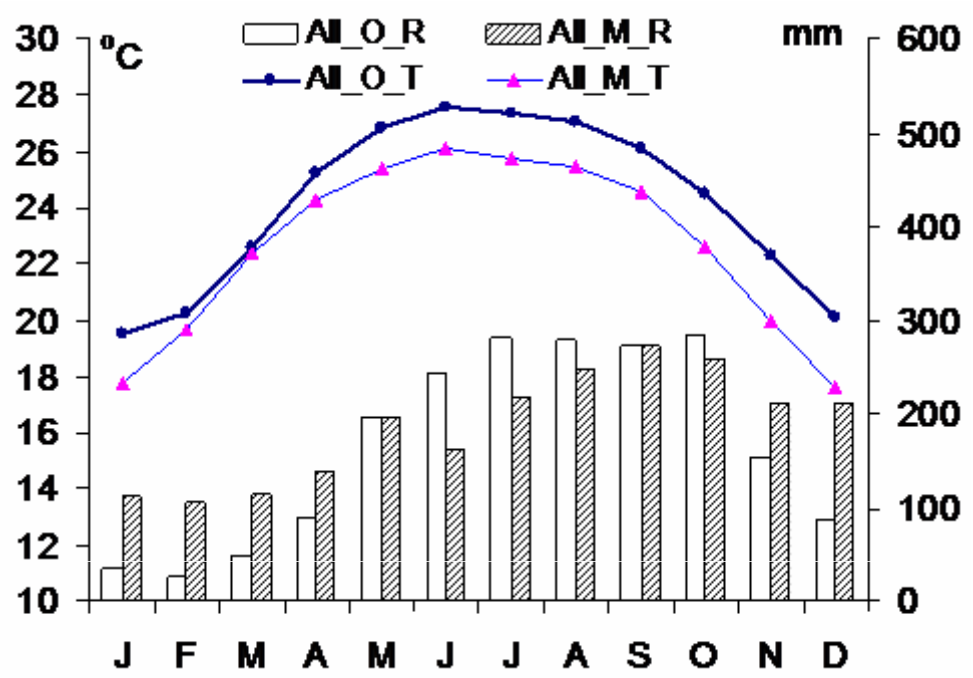
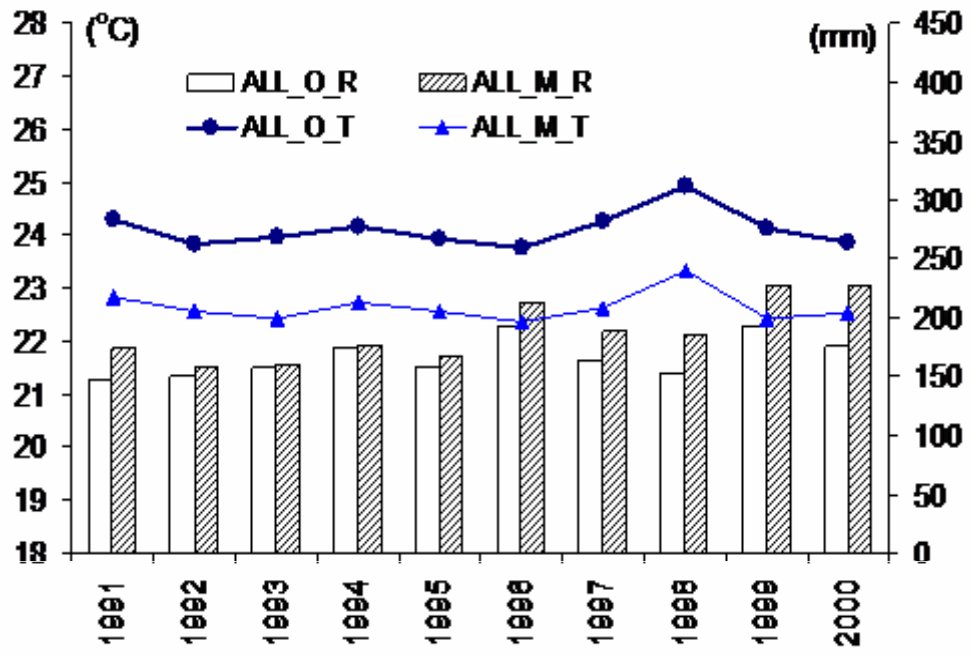


- In general, the model systematically underestimates T2m over almost sub-regions (except for R6) in all months; with largest difference is –5.1°C over the region R1 in Dec.
- The best simulated results are in the R6 and R7 areas, with biases range from -0.1 to 1.7°C and from –1.3 to 0.2°C, respectively
- Average biases over the whole country shows negative values and range from -0.2°C in March down to -2.5°C in December

- The model biases of precipitation are large and significantly different among sub-regions
- RegCM3 produces the most realistic results over the R4 and R6 areas in rainy season, while it produces too large dry biases over the R1, R2 areas in the summer months (JJA) and over the R7 area in the whole rainy season (from May to October)

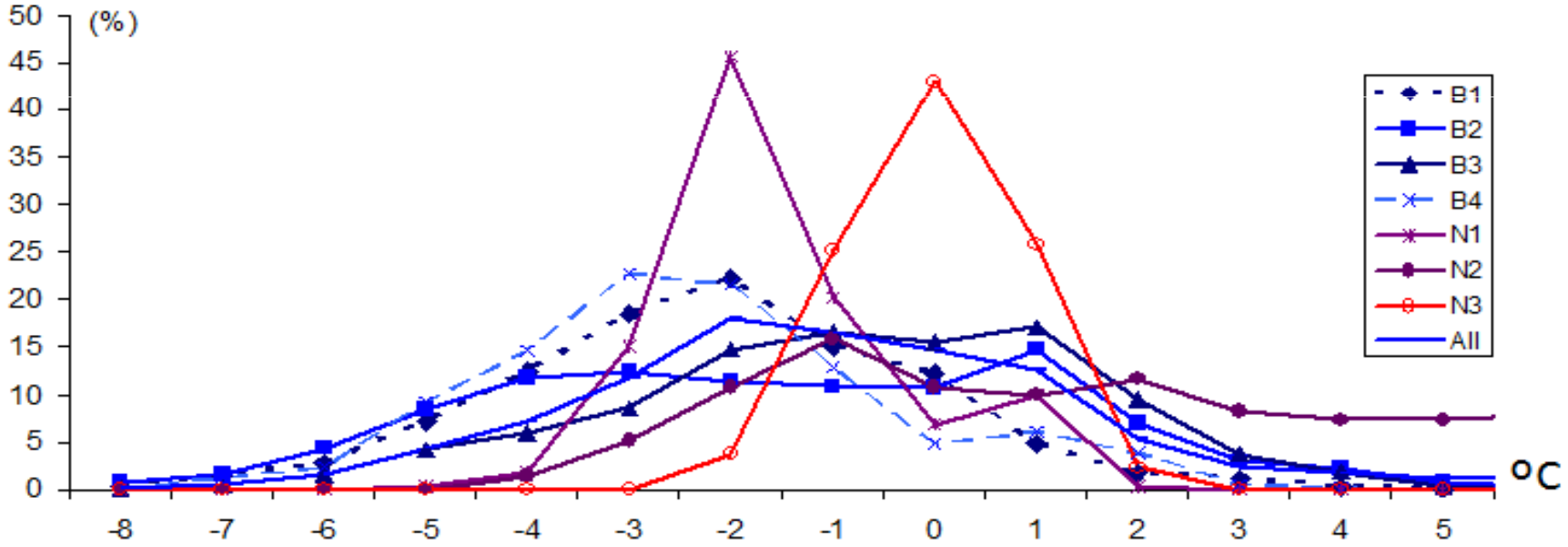


- Interannual variations of T2m over all sub-regions are well represented: The mean model errors within a given sub-region are stable from year to year
- Except for R6, annual values of simulated temperature for other sub-regions are systematically underestimated, from about 0.5°C for R7 to about 3.0°C for R1 and R4

- Interannual variations of simulated precipitation are generally in agreement with observations
- However, mean biases are different from year to year and from sub-region to sub-region
- Annual mean precipitation values simulated by RegCM3 have tendency to be overestimated for the R4, R5, R6 sub-regions and to be underestimated for the R1, R2 and R7 sub-regions

How to explain?

- It seems that, one of reasons caused the cold biases for R1-R5 and R7, and warm biases for R6 in T2m is the terrain height representation error of the model



Bias frequency distributions of monthly surface air temperature over the seven sub-regions and the entire Vietnam territory

How to explain?

The model elevation errors and mean errors of T2m for sub-regions

	Station Elevation (HS)	GridBox Elevation (HG)	Differences (HG-HS)	Mean Error (°C)
R1	**407.9**	**704.1**	**296.2**	**-2.7**
R2	**158.1**	**520.2**	**362.1**	**-2.0**
R3	**19.6**	**103.1**	**83.4**	**-1.2**
R4	**20.0**	**243.6**	**223.6**	**-2.9**
R5	**7.5**	**177.8**	**170.3**	**-2.0**
R6	**679.7**	**516.3**	**-163.4**	**0.9**
R7	**31.7**	**69.0**	**37.2**	**-0.5**

How to explain?

- Contribution to precipitation amount in the interested region is mainly convective

Convective rainfall vs Non-Convective rainfall (6/1996)

- Precipitation amounts vary greatly from year to year due to the winter and summer moonson activities, interaction between early winter moonson and tropical perturbations (ITCZ, typhoon,…) and terrain (especially in the centeral Vietnam – R4, R5)

Sub-region	R_1	R_2	R_3	R_4	R_5	R_6	R_7
Rainy Season	**4-9**	**5-10**	**5-10**	**8-12**	**8-12**	**5-10**	**5-10**

- ➔ Errors in the model precipitation might be mainly caused by convection parameterizations.

Summary

- Although significant differences between the RegCM3 simulation and the observations remain, RegCM3 can be used to reproduce the climate of the South-East Asia in general and of Vietnam in particular
- The results suggest that RegCM3 can be used for other studies in this region, such as seasonal forecasting, climate change, etc.
- Necessary parameterizations and calibrations could be also other future topics to deal in order to solve the cold biases in temperature and over/under-estimations of precipitation in dry/rainy seasons

Further works

- Use RCMs (RegCM, MM5, REMO) to simulate climate of Vietnam and Southeast Asia for recent decades (At least from 1960)
- Build up regional climate change scenerios for VN
- To access the impacts of CC on Extreme Weather and Climate Events, on moonson activities, and on other sectors/sub-regions (Agriculture, Water resource,…)
- Suggestions from you ?

Thank you