# Multi-year simulations of the East Asian monsoon by using the regional climate model(RegCM-NCC)

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**Abstract**

By using the regional climate model(RegCM-NCC), the East Asian mean circulations during 1998 to 2002 are simulated, and results show that the model can well reproduce the patterns and the intensity as well as seasonal march of the East Asian monsoon. The seasonal variation of regional rainfall and temperature are reproduced in the model, with three northward shift time and intensity of the rain belts over the sub-regions well corresponding to the observation, but rainfall in North China overestimated. Error evaluation shows that there is a systematic bias in the simulated air temperature in the lower troposphere in summer, which may be a main responsible factor for the stronger simulated summer monsoon, thus resulting in the overestimated rainfall in North China.

*Keyword: regional climate model, East Asian monsoon, numerical simulation*

## Model Introduction

The regional climate model (RegCM_NCC) used in the study is developed based on the second generation of the regional climate model of NCAR/RegCM2 (Giorgi et al., 1993a, b). By modifying and assembling the various physical process parameterization schemes in the RegCM2, the new regional climate model has been established during 1996-2000 and has been used in climate simulation and seasonal prediction (Ding et al., 1998). Table 1 listed the details of the physical schemes options for this study, the lateral boundary data are provided every 12 hours, the sea surface temperature data is updating per 7 days. Figure1 shows the simulated domain and the terrain height. .

Tible1 Physical process schemes

| **Model Configuration** | **RegCM_NCC** |
|---|---|
| Horizontal grids | 60km |
| Vertical layers (top) | 16 sigma layers (50 hPa) |
| Cumulus convection | Betts-Miller(Betts A K,1986) |
| Moisture scheme | implicit |
| PBL | Holtslag(Holtslag et al.,1990) |
| Radiation | CCM3(Kiehl et al.,1996) |
| Land surface | LPM Ⅱ ( Shi et al.,2000) |
| Boundary condition | Exponential relaxation |
| Initial, boundary data (SST) | NCEP/NCAR Reanalysis II (NOAA:OI.V2) |
| Simulation period | 1997.12~2002.12 |

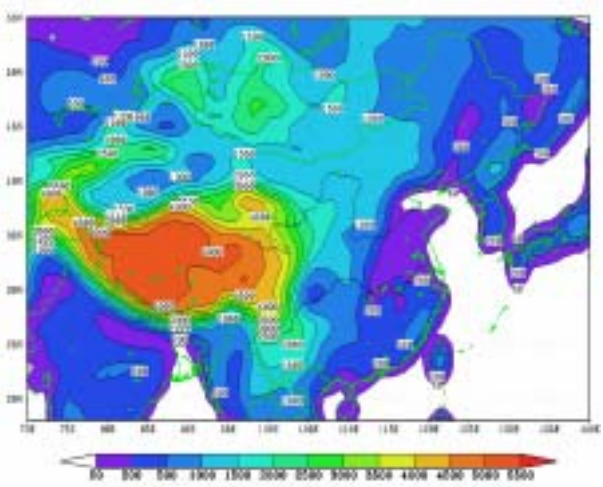

Fig.1 Model domain and terrain height

## Simulation analysis

The improved RegCM-NCC has been used in some case of extremely weather or climate events study (Shi, et al., 2001), relatively little work was performed over East Asia for long-term climate simulation. In this study, a 5-year simulation over East Asia is conducted to examine the model's capability in reproducing seasonal variation of East Asian monsoon and precipitation in China. The simulation period is selected from 1997 to 2002, compared to the 30yrs climatological field, winter mean temperature in the 5yrs is warmer in most regions of China, especially in 1998 and 2002, and summer mean precipitation is wet in south of China and droughty in north of China, so simulate result can help us to examine the model's capability to reproduce the abnormal climate characteristics.

Evaluation has been conducted through comparing the simulation with NCEP reanalysis data. Results show that the model well reproduces seasonal variation of East Asian circulation, such as the simulated location and intensity of South Asia high and the onset or retreat time of West Pacific subtropical high are consistent with the observation. The simulated seasonal transition and intensity of winter monsoon is closer to the fact. The

characters of Siberia cold high and outbreak frequency and main regions of “cold surge” over East Asia are also simulated with realistic manner. However, the simulated summer monsoon is stronger compared with NCEP reanalysis field. Figure 2 presents the height field at 500hPa, winter mean circulation is simulated very well, and the model also reproduces two major large-scale circulation patterns in summer: one is the subtropical high over the northwestern Pacific Ocean and the other is a mid-latitude westerly trough. However, the subtropical high is more intense and the mid-latitude trough is weakened compared to the reanalysis field. The location and intensity of the subtropical high not only control the progress of the East Asian monsoon but also influence the distribution of precipitation over china. Further investigation shows that the simulated skip time is similar to the observation, but the location of subtropical high is more intensive and being farther to north by 2-3 degrees than normal.

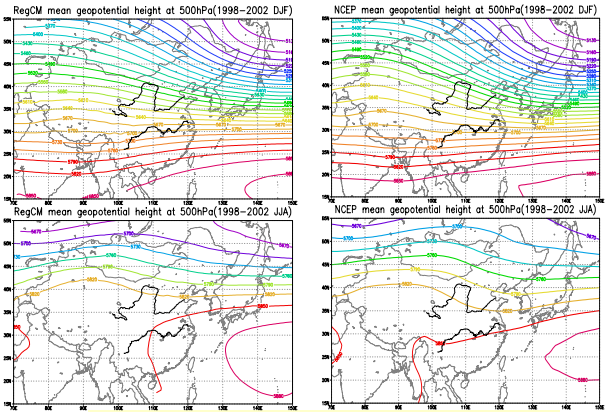

Fig.2 500hPa height field (unit: gpm)

The model also well reproduced seasonal character of the lower troposphere wind, in winter, there is strong northwest wind from Siberian and northeast china to Japan, in summer, a strong southwest monsoonal wind flow northward along the subtropical high, but the flow is more intense compared with the observation(sees in figure3). The model well indicates the location and intensity of upper-level jet in winter and south Asia high. The seasonal character of air temperature and the spatial distribution and transport of moisture in each layer are also well simulated.

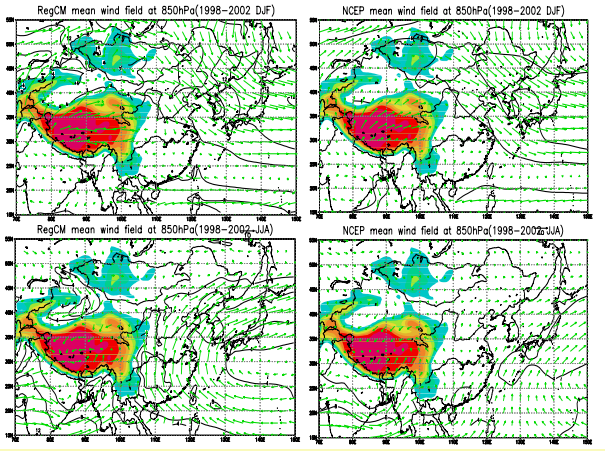

Fig.3 850hPa wind (unit: m/s) (shaded area is Tibetan)

Bias analysis found that summer mean bias of geopotential height on lower troposphere(below 500hPa) is positive over the ocean and negative over the land, on the contrary, temperature bias being negative over ocean and positive over land, and the systematic bias is not remarkable in other season. The systematic bias exaggerates the summer temperature difference between the land and ocean, which may be one of the main responsible factors for the stronger summer monsoon in the modeling.

The model well presents the seasonal spatial characteristics of surface air temperature and precipitation(sees in figure 4), the simulation in winter is better than that in summer. The simulated summer precipitation in south China, north-west China are exactly consistent with the observation, but in north china, the precipitation is overestimated, which is consistent with the simulation bias for subtropical high and summer monsoon. On the other hand, there are illusive rain belts in some areas with high topography.

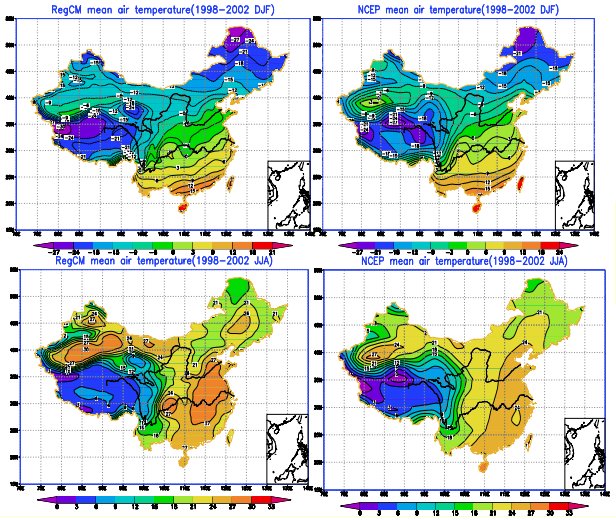

Fig.4 mean surface air temperature (unit:$^{o}$C)

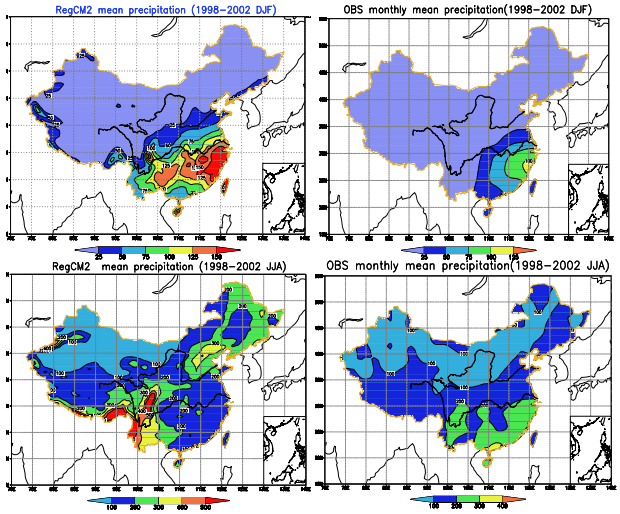


Fig.5 mean precipitation (unit: mm)

## Conclusions and discussion

1. The model can well reproduce seasonal variation of mean circulation in East Asia, the patterns and seasonal march of the East Asian monsoon are well identified in the modeling, the simulated transition and intensity of winter monsoon is closer to the observation, but the simulated summer monsoon is stronger compared with NCEP reanalysis field, with the location of subtropical high being farther to north by 2-3 degrees than normal.

2. The spatial distribution of rainfall and air temperature are well reproduced in the model, especially, rainfall in mid-lower Yangtze River basins and south China well corresponding to the observation, but rainfall in north China is overestimated.

3. Error evaluation shows that there is a discernible systematic bias in the simulated mean air temperature in the lower troposphere in summer. The systematic bias exaggerates the summer temperature difference between the land and ocean, which may be a main responsible factor for the stronger summer monsoon in the modeling, thus resulting in the overestimated rainfall in North China.

The simulation bias may be also related to the complex topography and cloud-radiation parameterization scheme, which would be the keystone for us to improve the model. In addition, due to the limited calculation condition, the simulation domain is too small to study the whole East Asia monsoon.

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