Regional Climate Model Inter-comparison Project for Asia

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1, Introduction

To improve the simulation of regional climate change has been listed as one of the high priority areas in climatic change study, as it is the urgent requirement for usage in the impact assessment. Recent years there are an increasing number of research groups developing or using different versions of RCM to simulate the regional climate in Asia. Some studies have demonstrated that the RCM can reproduce the seasonal evolution of monsoon rain-belts over Asia that very often is not captured by the GCM. However it will be of great benefit for the further improvement of RCMs applications in Asia if more systematic analysis of the RCM performance and the intercomparison of various RCMs in simulating the regional climate in Asia and to describe RCM's distinctiveness in comparison with the GCMs are taken.

This paper introduces briefly a Regional Climate Model Inter–comparison Project (RMIP) for Asia under the join support of Asia-Pacific Network for Global Change Research (APN), Global Change System for Analysis, Research and Training (START) and Chinese Academy of Sciences (CAS) and several projects of participating nations. The project is a join effort of 10 research groups from Australia, China, Japan, S. Korea and United States, but also involve scientists from India, Italy, Mongolia, North Korea and Russia.

The designed tasks include three phases to be implemented in four years since 2000: phase one, 18 months run from April 1997 to September 1998 which includes a full annual cycle and two extreme cases to assess the model performance in reproducing the annual cycle of monsoon climate and capturing the extreme climate events; phase two, 10 years run from January 1989 to December 1998 to assess the statistical behavior of the models; and phase three, to project the climate scenarios of the 21^{st} century by nesting the RCM with the GCM.

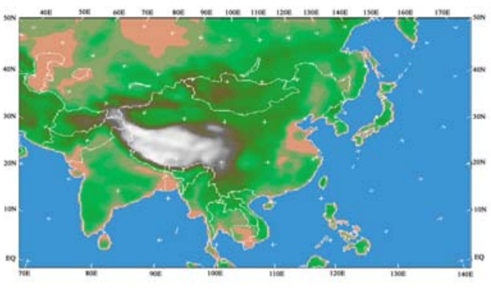


Fig.1. Simulation domain

Figure 1 presents the domain of model simulation, which includes most of Asia continent and part of western Pacific, Arabian Sea, Bay of Bengal and South China Sea, with the center at 35N/105E. It has the horizontal grid resolution of 60 km, with the grid numbers in longitude and latitude of 151x111. A relaxation lateral boundary treatment and, in some cases, a spectral nesting scheme are to nest with large scale forcing and 10 grids buffer zone is used. The domain for analysis is the inter part area with the buffer zones subtracted from each side of the integrated domain. It is divided into 12 sub-regions as shown in Figure 2. The models are driven by the large-scale fields either from observational data (e.g. NCEP analysis data) or GCM outputs at 6 hours interval. The land cover data set used in the simulation is the land cover classification derived from Global data sets for land-atmosphere models, International Satellite land cover surface climatology project (ISLSCP), initiative 1,1987-1988,vol.1-5, at 1^{o}x1^{o} resolution (Meeson, B.W. et al, 1995), which then is interpolated into each grid point. The topography data with the resolution of 0.5X0.5 degree from National Center for Atmospheric Research (NCAR) is used for this study.

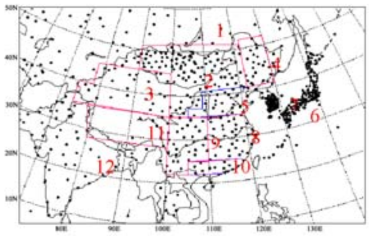


Fig.2. Distribution of stations and classification of sub-regions

The validation data for the model simulations against the observation are as following:

1) Station data There are totally 514 observation stations with daily records used for validation, including 193 from China, 155 from Japan, 72 from Korea, R.O., 6 from D.P.R.Korea, 73 from Mongolia and 15 from India. The data set is collected through regional collaboration. It is unique for being much more close to the reality as the observation than NCEP reanalysis data, although there are only few daily station data available over certain areas. The distribution of the stations is shown in Figure 2.

2) Grid data For the areas where there are only few station data to be used for validation, a number of grid data sets including global monthly precipitation data from Xie & Arkin for precipitation, NCEP reanalysis data for maximal/minimal temperature, Japan Meteorological Agency data for sea level pressure are utilized after interpolating into model resolution.

2, the results of phase one-the 18-month run

(1) Temperature

I. All the models can reproduce the spatial patterns and the annual variation of mean, maximal and minimal temperature

II. Nearly all models have the cold bias over most sub-regions, but the bias in the lower latitudes are smaller than those of higher latitudes;

III. All the models have the largest bias in the arid/semi-arid region of northern domain.

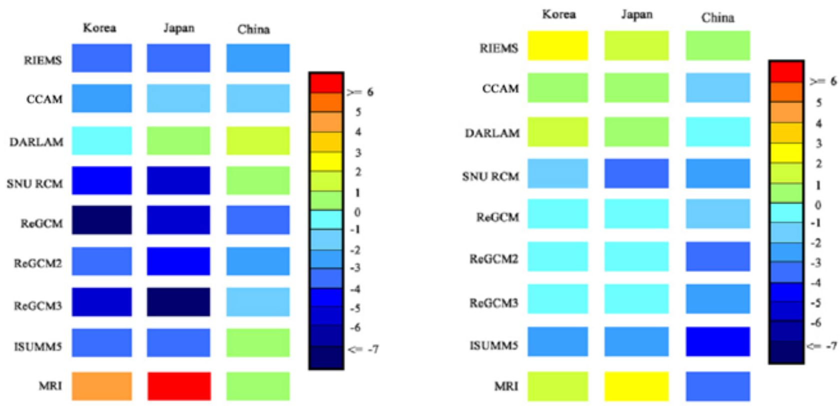


Fig.3. Seasonal averaged surface air temperature bias (a) left in winter 1997, (b) right in summer 1998

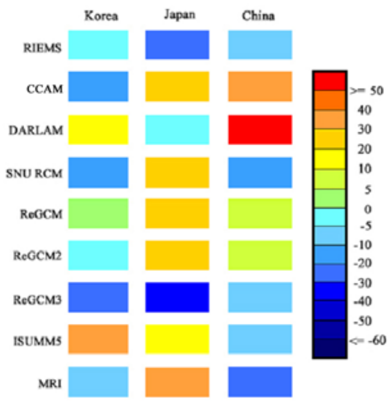
For more quantitative assessment, Figure 3 presents the bias of mean temperature simulation in China, Japan and Korea where more dense station data are available for validation. In winter (Figure 3a), there are overall cold bias in all models' simulation on-averaged of –4℃, except for MRI model of Japan which has warm bias over there regions with maximum of 5-6 ℃ over Korea and Japan. DARLAM model of Australia shows the best performance in winter temperature simulation with the bias of ±1℃. In summer (Figure 3b), most models also show cold bias over three regions in the range of –1 to –4℃, while RIEMS model of China shows warm bias in 1-3℃ (< 1℃ over China, < 2℃ over Japan and < 3℃ over Korea). DARLAM and MRI show also warm bias over Japan and Korea in 1-3℃.

(2) Precipitation

I. Nearly 50% of the models can reproduce the spatial pattern of seasonal total precipitation; the degree of agreement in winter is better than that of in summer;

II. Nearly all the models reproduce the seasonal cycle in most sub-regions, except in, e.g. west arid/semi arid region;

III. Models tend to overestimate the precipitation in higher latitude regions, e.g., in East arid/semi arid region, West arid/semi arid region, and North China;



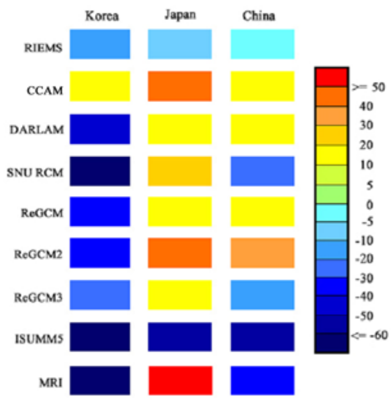


Fig.4. Seasonal total precipitation bias (%) (a) left in winter 1997 (b) right in summer 1998

Same as temperature, three areas of China, Japan and Korea are chosen for more quantitative assessment of the bias in precipitation simulations as shown in Figure 4. In winter, most models show bias in the range < +/- 30%, while in summer most models show dry bias in Korea, but wet bias over Japan. There are mixed +/- bias from different model over China: CCM shows wet bias, while RIEMS and ISU/MM5 show dry bias.

In order to understand the possible reasons of bias in surface climate simulation, the atmospheric circulation both in lower and higher altitudes are analyzed further.

(3) Sea level pressure

I. Most models reproduce the domain of Siberia High in winter, but the location and the intensity of the system center are in less agreement with the observation;

II. Sub-tropical High in summer is captured by most models, but it extends further northwestwards than the observation. This supports the northern shift of simulated rain-belts in summer.

(4) Atmosphere circulation

I. Nearly 70% of models can reproduce the location and intensity of both South Asia High and Westerlies over 200hpa properly;

II. Most models capture the locations of Sub-tropical High and Low-Level Jet over 850hpa, but nearly 50% of models tend to overestimate the magnitude of Low-Level Jet;

III. Nearly 70% models simulate successfully two S-N water vapor transport centers, but their intensities are not well simulated.

(5) Land-surface physics

I. Simulated patterns of both sensible heat and latent heat are reasonable, e.g, the major center of sensible flux matches the location of Kuroshio warm current in winter, while it is over the heated land in summer;

II. Most models' surface run-off patterns are in agreement with those of precipitation either in summer or in winter

(6) Extreme events

I. Nearly 50% of the models can reproduce the hot summer of 1997 over large part of Asia continent;

II. There is overall northward shift of rain belts in summer in most of models and nearly 70% of models underestimate the intensity of heavy rain in Yangtze valley in June 1998, but the heavy rainfall center in second dekad of June is well capture by nearly 50% models;

III. The models with better precipitation simulation show good performance to reproduce the upper/lower level jets. However, models with reasonable circulation simulation do not necessarily give the right simulation of precipitation.

Further analysis of the 18-months run is still going-on. In the meantime, the preparation for the 10-year simulation are taking place and phase 2 simulation and preliminary analysis on the statistical behaviors of all participating models will be accomplished in 2002-2003.