Prediction of summer precipitation anomalies over China by CAM-RegCM nested model

Deng Weitao
Nanjing University of Information Science & Technology
NUIST
Nanjing, Jiangsu Province, China
nimmjy@nuist.edu.cn

Sun Zhaobo
Nanjing University of Information Science & Technology
NUIST
Nanjing, Jiangsu Province, China
sunzb@nuist.edu.cn

Deng xueliang
Anhui Institute of Meteorology
AIM
Hefei, Anhui Province, China
dengxueliang9989@yahoo.com.cn

Wu Lingling
Nanjing University of Information Science & Technology
NUIST
Nanjing, Jiangsu Province, China
ruodangkuai@yahoo.com

***Abstract*—The newly global atmosphere general circulation model CAM is nested with the regional climate model RegCM in order to predict the summer precipitation anomaly over China. The ensemble hindcast experiments from 1984 to 2000 are performed, and their results indicate that CAM-RegCM has some forecasting skills on the summer precipitation anomaly, that is the prediction score is above 80, the anomaly correlation coefficient can reach 0.29, and the forecasting effect is better in the north of East China than in the south. The real time forecast experiments from 2003 to 2007 show that it is correlated better in 2003, 2004, 2006 and 2007. Furthermore, correction is one important step in the short-term climate prediction.**

Keywords-component; nested model, short-term climate prediction, CAM, RegCM

I. INTRODUCTION

China lies in the monsoon area in East Asia, and so the drought and flood often occur in every flood period. The seasonal and annual prediction on the summer climate anomaly is of important significance to the economic construction, disaster prevention and reduction. The operational predicting methods contain the experiential statistic method, the numerical and physical statistic method, the physical conception model based on physical factors and foreboding intense signals, and the dynamic method, therein the predictions from the recent climatic dynamic method are inferred and used more and more, and its function and status are enhanced. With the further development of the dynamic model, the short-term climatic prediction will be guided by the objective forecast from it. The extra-season climate predicting system from the IAP (Institute of Atmospheric Physics) has better cross quarter predicting ability on the drought and flood situation in summer over China[1-4]. The predicting operational system using the dynamic climate model is established by the national climate center has some skills on forecasting the primary seasonal rain band[5-6].

Compared with the global circulation model, the resolution of the regional climate model has improved greatly, which can simulate the rational regional forcing effect and the physical process of which is more comprehensive. Because the regional climate model can provide more detailed results in time and space, the RegCM is nested in CAM to predict the summer rainfall anomaly over China in this article.

II. MODEL INTRODUCTION

The global generation circulation model is the latest 5th atmospheric cell model from NCAR, which is a global spectral model, using triangular spectral truncation, with horizontal resolution of T42, 128 grids in altitude evenly and 65 gauss grids in longitude, using η coordinate system, 26-layer and the top layer on 2.917hPa. The model includes physical processes such as radiation, clouds, convection, land surface, boundary layer and so on, which also contains an atmospheric model, a complete land surface model and an alternative ocean model, using semi-implicit time integrated scheme with step of 20minutes.

The regional climate model is RegCM3 exploited by ICTP, which was originally constructed on the base of a meso-scale model from NCAR-PSU, MM4 version, developed by Giorgi and improved continually. The model has horizontal resolution of 60km, centered in 110°E, 36°N, with grids 120*70 in level, 18 levels in vertical direction, top layer on 5hPa, and integrated time step of 200seconds. Among which, the exponential boundary layer scheme is adopted, with 12 buffer areas, the planet boundary layer scheme is Holtslag's non-local, the cumulus convection parameterization scheme is from Grell, the ocean flux parameterization is from Zeng, the land surface parameterization is from BATS, and the radiation parameterization is from NCAR CCM3.

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Figure 1 is the computation steps how CAM is nested in RegCM. First, the atmospheric initial field and the boundary field on underlying surface, mainly SST, are provided for CAM, which integrates from February 15th to September 1st. Secondly, the CAM results from February 15th to September 1st are used as background of RegCM, then the topographic data are put into RegCM, and last the model integrate. Finally, the RegCM results are corrected properly to obtain the forecasting results of summer precipitation anomaly percent.

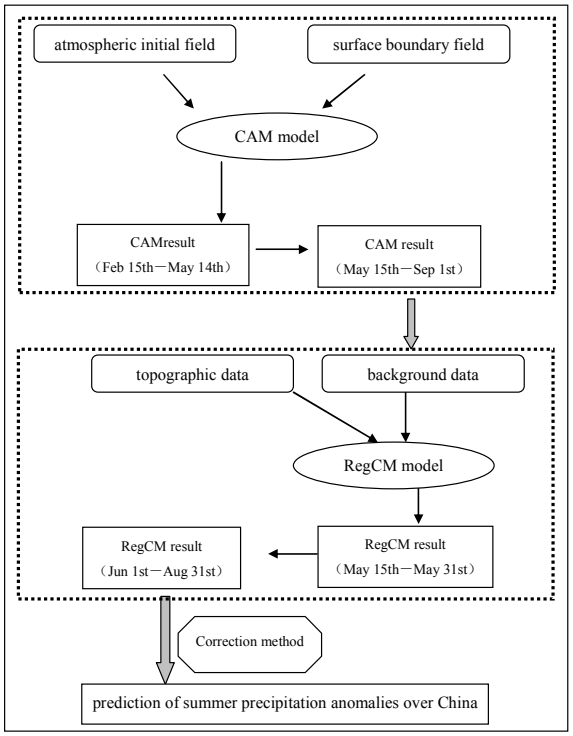

Figure 1. CAM-RegCM nested model's computation step.

III. RESULT

A. The ensemble hindcast experiments

In order to verify the predicting effect of CAM-RegCM systematically, the ensemble hindcast experiments from 1984 to 2000 are performed and their results are tested. The atmospheric initial field is derived from NCEP/NCAR reanalysis data from 1984 to 2000. The SST data are global monthly SST analyzed by Reynolds. The 9 samples, that is, the integrated results using the reanalysis data from February 11st to 19th at 00 as initial field, are applied to the ensemble forecast, by means of arithmetical averaging. Additionally, the precipitation anomaly percentage category based on ENSO is used in correction scheme[10].

The model precipitation is interpolated into 160 stations to compare with the observation of 160 stations in China from 1951 to 2006. In examination, five indices are used to evaluate repay result quantitatively, which are the operational prediction score (P), the skill score related to the climatic forecast (SS), the anomaly sign correct ratio (R), the anomaly correlation coefficient (ACC) and the anomaly test score (TS)[11].

With a vast territory, the characteristics and mechanics of summer rainfall in different area in China are varied. As a result, when analyzing the ensemble hindcast experiments' results, the area is divided into East China and West China. The assessments on CAM-RegCM nested model predictions of summer precipitation anomaly percentage in different sub-region of China during 1984 to 2000 are presented in table 1. After correction, P is 80.84, R 57.83, SS 0.23, and TS 0.20 around China, which also indicates that the CAM-RegCM nested model is good to predict the trend and intensity of the summer rainfall anomaly. Therein to, the hindcasted results vary in different regions, too. Considering the east of China, the forecasting effect is better in the north, than in the south.

TABLE I. ASSESSMENT ON CAM-REGCM NESTED MODEL PREDICTIONS OF SUMMER PRECIPITATION ANOMALY PERCENTAGE IN DIFFERENT SUB-REGION OF CHINA DURING 1984~2000 (BEFORE/AFTER: BEFORE/AFTER CORRECTION)

Region		China	East China	West China
P	before	72.19	71.91	70.80
	After	80.84	80.66	80.55
ACC	before	0.03	0.02	0.07
	After	0.29	0.28	0.31
R	before	51.00	52.44	49.94
	After	57.83	57.45	58.97
SS	before	0.09	0.10	0.05
	After	0.23	0.23	0.25
TS	before	0.12	0.13	0.12
	After	0.20	0.20	0.22

It can also known from table 2 that the indices are all better after than before correction in every region, which demonstrates that correction is one important step in short-term climate prediction, as it can improve forecasting effect.

A serious flood occurred in Changjiang and Sungari River valley in Northeast in 1998, as in Fig.2a. The CAM-RegCM nested hindcasted results in Fig.2b show that the more rainfall trend is in accordance with the observed in Changjiang River valley, Northeast and in the east of Mongol, among which, the central position of the precipitation anomaly percentage extreme is consistent with the observed, while the simulated intensity is weaker and the more rain trend in Changjiang and Huaihe River valley is not predicted well.

Figure 3 is the correlation coefficient (CC) between the ensemble hindcasted and the observed precipitation anomaly percentage. It is shown that CC is positive in the Northeast, the great part of North China, the north of Northwest, the west of South China and great part of Southwest, and CC is above 0.31 through the 0.10 level of significance test in only several individual regions before correction. After correction, CC is positive in most area of China, and negative in several individual regions in the west, furthermore, CC is above 0.31 through the 0.10 level of significance test in the Northeast, the great part of North China, the south of South China, the east of yunnan guizhou plateau and the east of Xinjiang. Above all, the CAM-RegCM nested model has some forecasting skills on the summer rainfall anomaly in China. Through the contrast on the

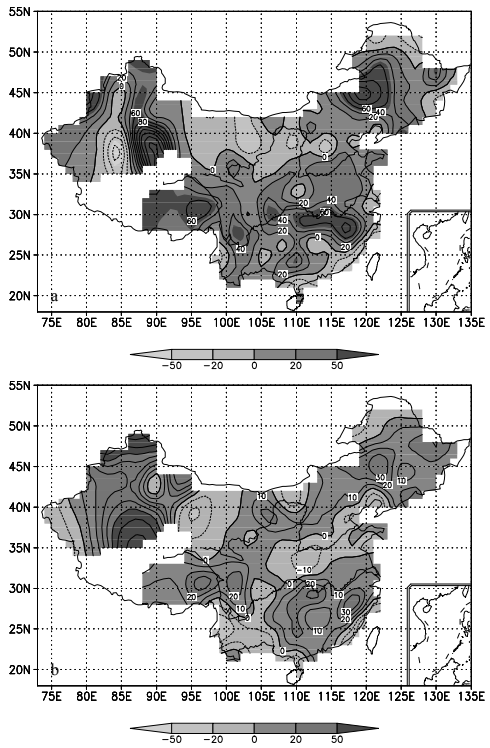

Figure 2. Observed(a) and predicted (b) summer rainfall anomaly percentage in 1998 by CAM-RegCM nested model (unit: %)

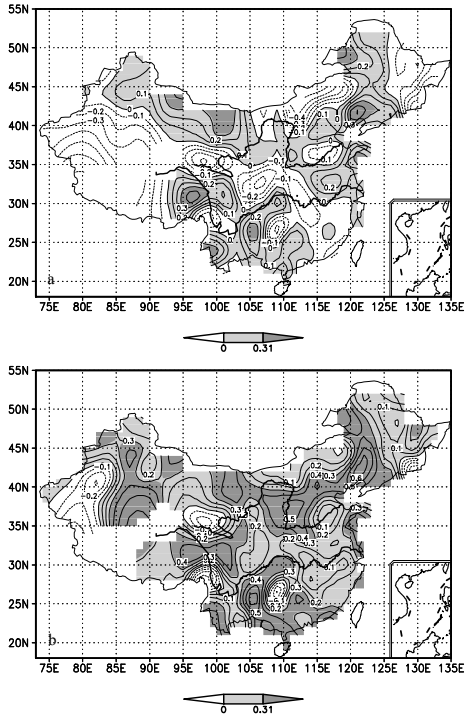

Figure 3. Precipitation anomaly's correlation coefficient between observed and hindcasted precipitation anomaly percent by CAM-RegCM nested model (a. before the correction, b. after the correction)

results before and after correction, the predicting effect improves after correction.

B. The real time forecast test

The CAM-RegCM nested model is used to do real time forecasting experiments from 2003 to 2006. The atmospheric initial field is NCEP/NCAR reanalysis data from 2003 to 2006. SST is the climatic sea temperature with seasonal variation, plus a continual anomaly, which is persistent during integration and is the observed monthly sea temperature anomaly when forecast begins, that is February. The 28 samples, that is, the integrated results using the reanalysis data from February 1st to 28th at 00 as initial field, are applied to the ensemble forecast, by means of arithmetical averaging.

Table 2 is the evaluating results of the real time forecast, among these, ACC is above 0.05 in 2003, 2004 and 2006, while in 2005 it is -0.11, and P is above 70 in 2003, 2004 and 2006, while in 2005 it is below 70. The real time forecasts assessments suggest that the forecasting effect is better in 2003, 2004 and 2006, not in 2005.

TABLE II. ASSESSMENT ON REAL-TIME PREDICTIONS OF SUMMER PRECIPITATION ANOMALY PERCENTAGE OVER CHINA BY CAM-REGCM NESTED MODEL DURING 2003~2006

	2003	2004	2005	2006	2007
ACC	0.15	0.05	-0.11	0.08	0.13
P	71.78	75.47	68.42	79.05	81.00

Figure 4 is the observed summer precipitation anomaly percentage in 2003 and that derived from the CAM-RegCM nested model, which suggests that CAM-RegCM succeeds in predicting the "－＋－" mode in the east of China in summer of 2003, that is, the primary rain band between Changjiang and Yellow River and the negative precipitation anomaly area in North China and South China. However, the prediction and the observation vary greatly, for example, the predicted rain band which mainly lies in the east of Changjiang and Huaihe River valley, is smaller, and that in Northeast is further south.

The CAM-RegCM nested model is good to predict the rain band from Yellow River and Huaihe River area to the east yunnan guizhou plateau in 2004. In 2006, it is good to predict the rain band in South China, Huaihe River valley and Northeast, and the drought in Chongqing, Sichuan and so on. In 2007, it can predict the rain band between Changjiang River and Yellow River, the rain band in the Northeast and the dry area in the South of Changjiang River. In 2005, it fails to predict the rain band between Changjiang River and Yellow River and the rain band in South China, but the predicted precipitation situation is similar to the observed.

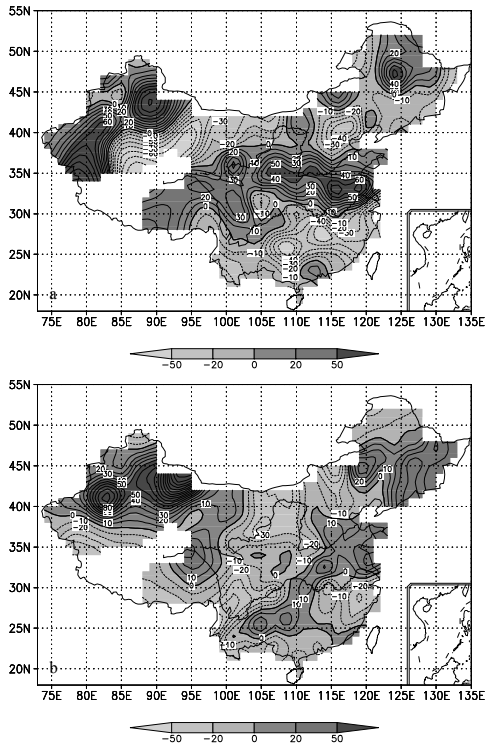

Figure 4. Precipitation anomaly percentage of summer 2003 (unit: m/s) (a. observation, b. prediction by CAM-RegCM nested model)

IV. CONCLUSION

The RegCM is nested in CAM in order to predict the summer precipitation anomaly in China. Results show that the CAM-RegCM model has some forecasting skills on summer precipitation anomaly, through the ensemble hindcast experiments from 1984 to 2000. The P score is above 80 and the anomaly correlation coefficient can reach 0.29, and other predicting assessment indices can reach higher level, too. Therein, the forecast effect is better in the north of East China than in South China. Correction is one important step in short period climate forecast, for the hindcasted experiments indicate that the indices are all better after than before correction in every region. The real time forecast experiments on the summer rainfall anomaly over China from 2003 to 2007 are performed through the CAM-RegCM model, which show that the predict effect is better in 2003, 2004, 2006 and 2007, not in 2005.

ACKNOWLEDGMENT

This study was supported by the the Project Innovation of Graduate Students of Jiangsu Province of China under Grant No.CX07B-044z.

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