The simulation of precipitation based on RegCM3 in Haihe River basin

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Abstract—**For the impact of climate change and strong human activities, the amount and distribution of precipitation in Haihe river basin has changed greatly in recent years. The Regional Climate Model 3(RegCM3) is a useful model for simulating the atmosphere environment with physical and chemical mechanisms. In this article, the precipitation in Haihe river basin from 1991 to 2000 is simulated by the RegCM3. The results show that the tendency and amount of monthly precipitation can be simulated very well. But the simulations of peak values cannot reach a good accuracy. The applicability of this model for simulating the precipitation in different spatial scales and different terrains are compared. The simulation accuracy in the whole Haihe river basin is better than that in the third water resources zonings. It also indicates that the simulation in precipitation has a deep relationship with the terrain that the simulations in plain area behave much better than that in the mountain areas. As well as the simulation accuracy in different seasons is also analyzed.**

Keywords- RegCM3; Precipitation; Climate Change; Haihe River Basin.

I. INTRODUCTION

Changes in precipitation due to climate change have received much interest during the recent years, mainly because of the changing atmosphere environment. To explore the changing mechanisms of precipitation, many specialists have applied the Regional Climate Models for simulating the amount and distribution of precipitation at a local scale. Pal[1] has used the RegCM3 for modeling the rainfall of Europe from 1994 to 1995. And he indicates that the distribution of rainfall can be simulated very well, but the amount of the simulated rainfall is greater than the observed. The model is also used for the prediction of future climate. Jeremy[2] has applied this model for predicting the temperature and precipitation in Mediterranean Sea area from 2071-2106. Snylder[3] has combined this model with the Global Climate Model CSM1.2 for predicting the climate change in California. In China the RegCM3 is also widely used for researching the local atmosphere environment. Zhang Dongfeng[4] has simulated the precipitation from 1987-2001 in China. And the results show that the model can simulate the characters of rainfall among different seasons, but the simulation in the distribution of rainfall exist systematic errors. Liu Yiming[5] has modeled the summer rainfall of China from 1991-2000 by using RegCM3. The amount of simulating precipitation is bigger than the practical. The simulating accuracy in the west areas is better than the east regions. Although many specialists have used this model in many regions, the appropriate scale in spatial and temporal for simulating the water cycle has not mentioned. In this article, the simulation of precipitation in different spatial and temporal is presented. As well as in what scale the output of simulation can be used in hydrological model is presented.

II. RESEARCH AREA

The Haihe River is a crucial river in North China formed by the convergence of five rivers in Tianjin including the Southern Canal, Ziya River, Daqing River, Yongding River, and the Northern Canal. The southern and northern canals are parts of the Grand Canal. The Southern Canal is joined by Wei River at Linqing. The Northern Canal joins with the Chaobai River at Tongzhou. The Northern Canal is also the only waterway from the sea to Beijing. The catchment area is 317,800 square kilometers. The climate is belonged to temperate continental climate. The annually precipitation is 535 millimeters. For the impact of climate change and strong human activities, the precipitation in Haihe river basin has decreased sharply in recent 50 years. Comparing to the rainfall of 1956-1979 series, the rainfall of 1980-2000 series has decreased by 11 percentages. And the reduction in water resources reached 40 percentages.

The research area includes the Haihe river basin and its surrounding areas. The central area of the simulation is (39° N,116° E). The location of this simulation area and the rainfall stations can be seen in Figure 1.Forty three stations in Figure 1

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are selected for the calculation of the observed mean rainfall. The horizontal resolution of this simulation is 20 kilometers multiply 20 kilometers. The number of horizontal grid is 40 multiply 40. The vertical coordinate takes 18 non-uniform vertical stratifications.

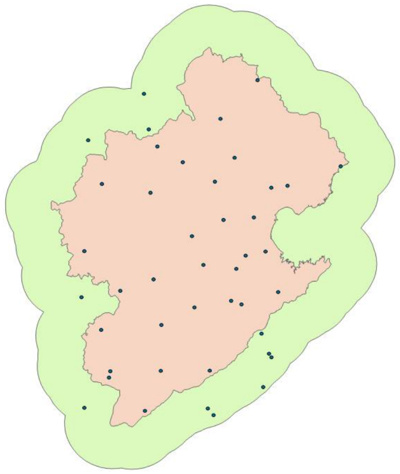

Figure 1. The location of the research area and the rainfall station

III. RESEARCH METHODOLOGY

First, we simulate the precipitation by RegCM3 and the research area can be seen in Figure 1. The parameter settings can be seen in Table1.The terrain data uses the GTOP30 data which made by the United States Geological Survey. The sea temperature data is from the OI_SST mean sea surface temperature data. 4-times daily, daily, and monthly averages of the NCEP/NCAR reanalysis data are used in this simulation for proving the input data of every step. By writing programmers we can get the output data at a frequency of every 6 hours in every region of the research area. And by static manners we can calculate the monthly and yearly rainfall of 15 third water resources zonings and the whole Haihe River Basin. At the same time the observing rainfall data is from the Meteorological Center of China. The observed rainfall is recorded by day. By comparing the simulating data and the observed ones, we can evaluate the accuracy of the RegCM3 and get to know the simulating characters of this model. The research methodology can be seen in Figure 2.

TABLE I. PARAMETERIZATION SCHEME

Parameterization Scheme	**Details**
Power Structure	MM5 Hydrosttatic
Cumulus	Grell
Large-scale precipitation scheme	SUBEX
PBL scheme	Holtslag
Land surface parameterization	BATS
Radiative transfer program	CCM3
Sea Surface flux program	Zeng scheme
The boundary fields	Relaxation index
Pressure gradient program	Recursive hydrostatic

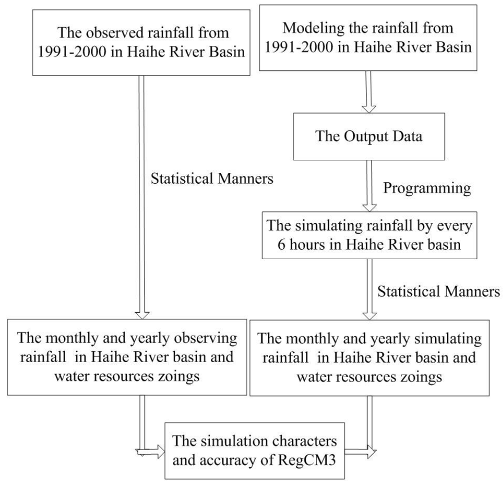

Figure 2. The research methodology

IV. THE ANALYSIS OF SIMULATING RESULTS

A. The simulation in water resources zonings

By reading the output of this simulation, we can get the 6-hours rainfall of every grid. The monthly precipitation of 15 third water resoources zonings is calculated by using the inverse distance squares interplotation method. By comparing the simulating and observing precipitation in third water resources zonings scale, it can be seen that the model can simulate the amount and distribution of monthly rainfall in most of the third water resources zonings.The correlation coefficient is between 0.67-0.83. The coefficient of 15 water resources zonings can be seen in Table 2.

TABLE II. THE CRRELATION COEFFICIENT OF 15 THIRD WATER RESOURCES ZONINGS IN HAIHE RIVER BASIN

Name	AREA(10^4km^2)	R^2
Moutain district of Luan river	4.63	0.70
Plain of Luan river and north of Hebei	1.14	0.73
mountain district of Beisan river	2.44	0.78
Up the Cetian reservoir of Yongding river	1.85	0.71
Cetian reservoir to Sanjiakou	2.91	0.71
Plain under Beisi river	1.62	0.83
Moutain of Daqing river	1.94	0.73
Dianxi plain of Daqing river	1.32	0.72
Diandong plain of Daqing river	1.41	0.74
Mountain district of Ziya River	3.17	0.78
Plain of Ziya river	1.55	0.77
Moutain district of Zhang and Wei river	2.63	0.68
Plain of Zhang and Wei river	0.92	0.67
Heilonggang and Yundong plain	2.30	0.78
Tuhaimajia river	3.23	0.82

From the figure above, we can figure out that the simulation accuracy is related with the terrain closely. The correlation coefficient in plain areas is bigger than that in mountain areas. It can be seen that the terrain is a sensitivity factor in simulating the rainfall. Illustrating the mountain district of Luan river and the plain under Beisi river as an example, the correlation coefficient of the plain under Beisi river is 0.83 and that is only 0.70 in the Mountain district of Luan river. The observed and simulated monthly rainfall in the mountain district of Luan River and the plain under Beisi river can be seen in Figure 3 and Figure 4.

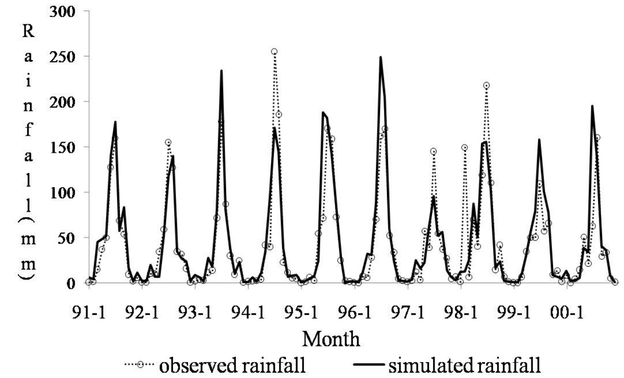

Figure3. The simulation of monthly rainfall in the Mountain of Luan river

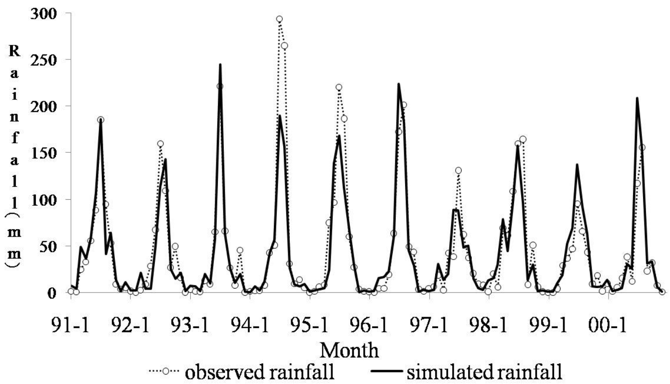

Figure4. The simulation of monthly rainfall in the plain under Beisi river

B. The Simulation in Haihe River Basin

By statistical manners, the mean monthly rainfall can be calculated by the output of the simulation. The correlation coefficient for the observer and simulated precipitation is 0.89. It is higher than that in the third water resources zoning scale. The results show that the model can reflect the amount and distribution of monthly rainfall in the whole Haihe river basin scale. It suggests that the simulation accuracy has a relationship with the square of the research area. The correlation coefficient becomes higher as the research area become bigger. The model can reflect the precipitation variation mechanism better in a larger spatial scale. The relationship between the observer and simulated rainfall can be seen in Figure 5. The simulating and observing tendency of monthly rainfall can be seen in Figure 6.

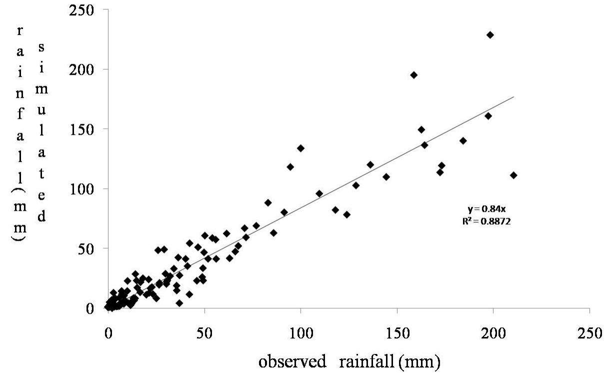

Figure5. The relationship between the observed and the simulated rainfall

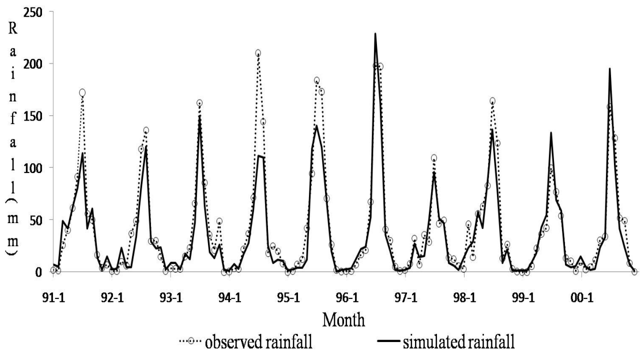

Figure6. The simulation of monthly rainfall in Haihe River Basin

C. The simulation in different seasons

By analyzing the precipitation characters in different seasons, we can evaluate the simulation accuracy in different seasons. The results show that the model can reflect the characters of the four seasons. For the time of simulating series is not long enough, the Nash coefficient is only between 0.4-0.5. But the correlation coefficient is over 0.95.The rainfall in summer and autumn account more than 90 percent of the rainfall in a year. And the statistics show that the simulation in these two seasons is better than that in spring and winter. And the simulation of summer and autumn rainfall in Haihe river basin can be seen in Figure 7 and Figure 8.

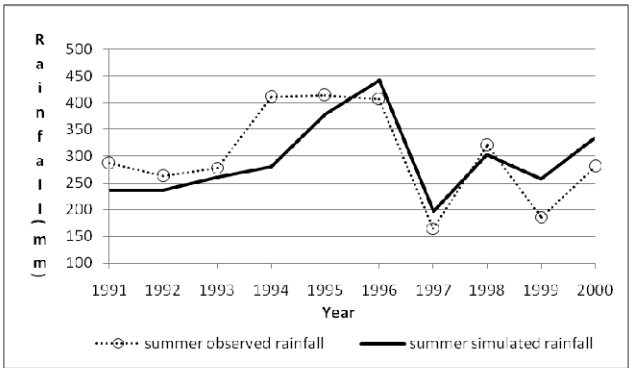

Figure7. The simulation of summer rainfall in Haihe River Basin

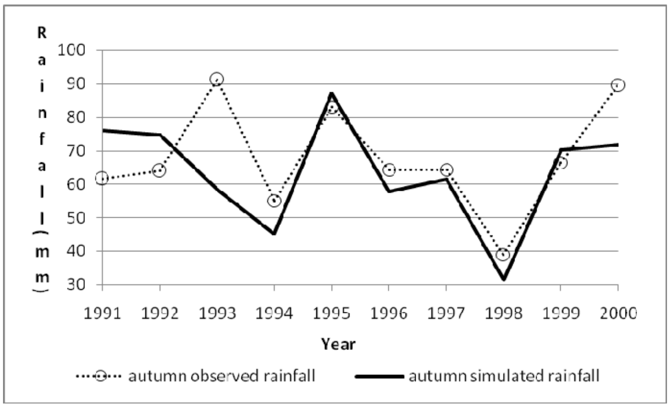

Figure8. The simulation of autumn rainfall in Haihe River Basin

V. CONCLUSION

In this study, the precipitation of Haihe river from 1991-2000 is simulated by the RegCM3. The applicability of this model for simulating precipitation in different spatial scales is analyzed. The results show that the simulation accuracy in the whole Haihe river basin is better than that in the third water resources zonings. It indicates that the simulation accuracy is related to the area of the researching district. Terrain is another sensitive factor for the simulating of precipitation. The simulation in plain area is greater than that in mountain area. To sum up, RegCM3 can reflect the precipitation characters in Haihe river basin. The simulation in mountain area and the peak value of precipitation are not very well. If the output of precipitation can be corrected, the model can be used for the modeling of regional water hydrological process and the analysis of water resources in certain areas.

ACKNOWLEDGMENT

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