Modelling the Interannual Variation of Regional Precipitation over China

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ABSTRACT

The interannual change of regional precipitation over China during 1979–1988, simulated by the IAP 2-L AGCM (the atmospheric general circulation model) developed in the Institute of Atmospheric Physics and by using the observational monthly sea surface temperature (SST) and sea ice occupations, was analysed and compared with that of observation. Results show that the abilities of the model to simulate the interannual variabilities of precipitation are different from one region to another in China. Studies indicate that the regional precipitation interannual variation which is correlated to the strong sign of sea surface temperature anomalies (SSTA) could be simulated well by the model, strong SSTA is important for the seasonal and extra-seasonal climate predictions through climate models. The results also suggest that the horizontal resolution of the model should be more refined in order to give better representations of regional details.

Key words: Interannual variability, Correlation, Numerical climate prediction

I. INTRODUCTION

The ultimate goal of climatic model developments and simulations is to make more and more accurate simulations and predictions (which themselves have objective limits) in various temporal and spatial scales. Because of the complexities in the real climate systems and in GCMs a variety of studies have to be done to understand both the climate and the GCMs better and to improve GCMs. The AMIP(Atmospheric Model Intercomparison Project) (Gates, 1993) is an approach to this. About 30 models in the world have been required to simulate the climate during 1979–1988 by using the observed SST and sea ice. To study the model's abilities in simulating the interannual variabilities of the climate which are closely related to the oceanic interannual variabilities is a fundamental goal of the AMIP.

In this paper the 336-station observational data of 10-day precipitation over China (1961–1988) are used to analyze the regional precipitation variation and to verify the abilities of IAP AGCM in simulating the interannual variations of regional scale precipitation. We divide the whole country into six parts: the Northwest (18°–30°N, 90°–105°E), the Northeast (38°–54°N, 120°–135°E), the Central North (38°–40°N, 105°–120°E), The Central South (18°–30°N, 105°–115°E), the Southwest (30°–50°N, 90°–105°E) and the Jianghuai region (26°–38°N, 105°–120°E). Since most regions are in the middle latitudes we just use the arithmetic mean method to get the mean precipitation value in each region. We also compare the variabilities of precipitation in the east and the west parts of the country.

II. THE SIMULATION OF THE 10-YEAR MEAN PRECIPITATION

The simulated 10-year averaged annual mean distribution of precipitation is reasonable

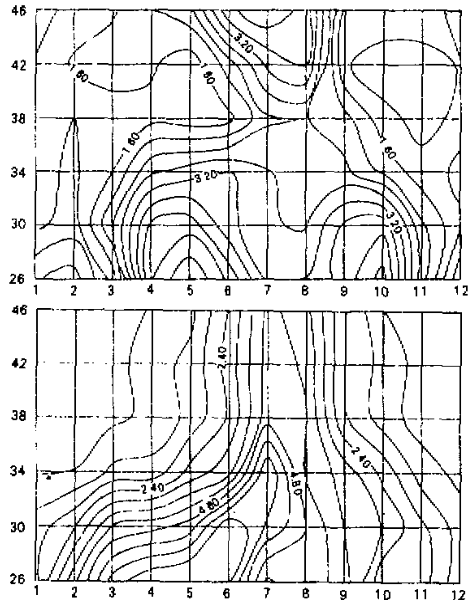


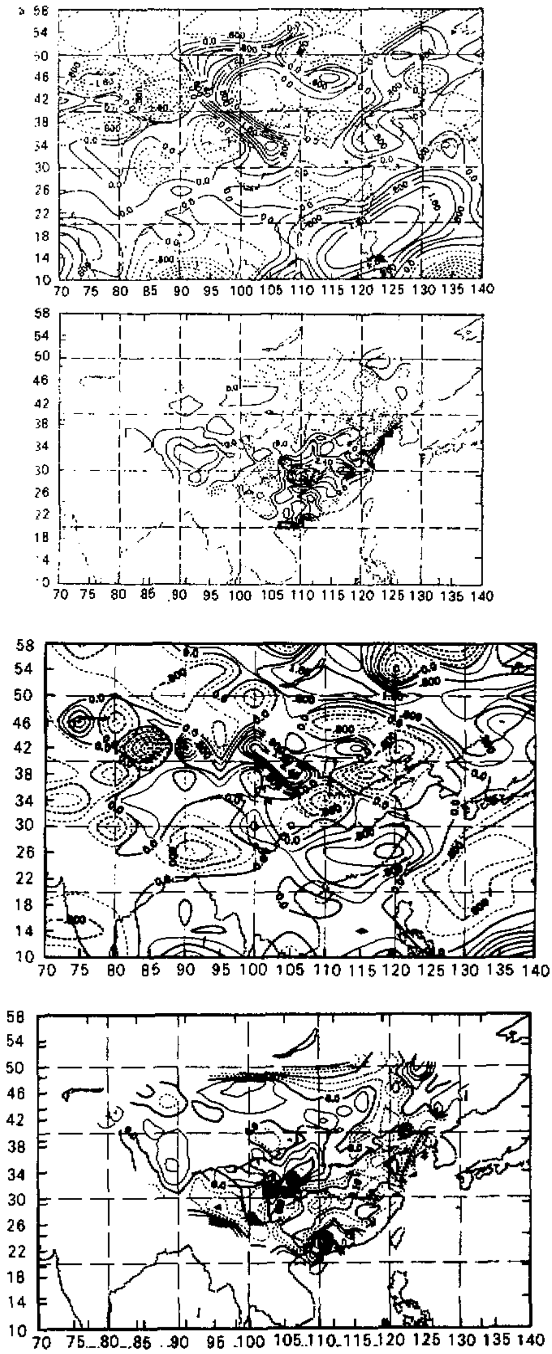
Fig. 1. Temporal and latitudinal distributions of simulated (a) and observed (b) zonal mean precipitation (mm / day) between 110°E and 130°E.

compared to the observed distribution despite some flaws. First, the simulated precipitation is systematically less than the observed one. Along the Yangtze River valley the simulated annual precipitation rate is about 1.2 mm / day less than the observed. Second, the precipitation over the region south to the Great Bend of the Yellow River is overestimated by the model and the simulated precipitation over the Central North China is a little less. The precipitation over Xinjiang is also exaggerated by the model.

In Fig. 1, we present the seasonal variation of zonal mean monthly precipitation between 110°–130°E. It is well known that there is a seasonal north–south transition of the maximum rain belt. In spring the maximum rain belt is at the lower latitude of the country. In June the belt moves to the north part of the country and then in late August or early September moves back to South China. For the simulation, the precipitation is generally less than that of the observation. Anyhow, the precipitation in winter in higher latitudes of the country is exaggerated by the model. Therefore, in higher latitudes the seasonal difference of simulated precipitation is smaller than that of the observation. So, generally speaking, the simulation of the seasonal variation is reasonable despite some errors in detail.

III. SIMULATION OF THE REGIONAL DISTRIBUTION OF PRECIPITATION ANOMALIES

As for anomaly we mean the difference between the precipitation in a certain year and the 10 year mean precipitation. In Fig. 2, we present the simulated and observed seasonal mean precipitation anomalies in June, July and August (JJA) for the years of 1980, 1981 and 1982, respectively. In 1980, the rainfall in the central North China is less than the average (negative anomalies) for both the observation and the simulation. The model also reasonably



58 54 50 46 42 38 34 30 26 22 18 14 10
70 75 80 85 90 95 100 105 110 115 120 125 130 135 140

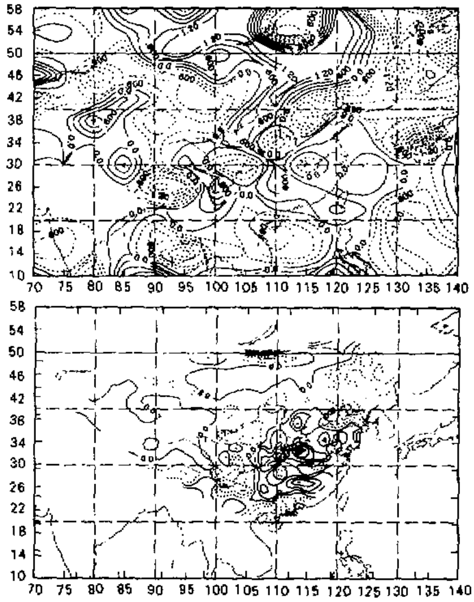


Fig. 2. Simulated (upper) and observed (lower) precipitation anomaly distributions for 1980 (a), 1981 (b) and 1982 (c).

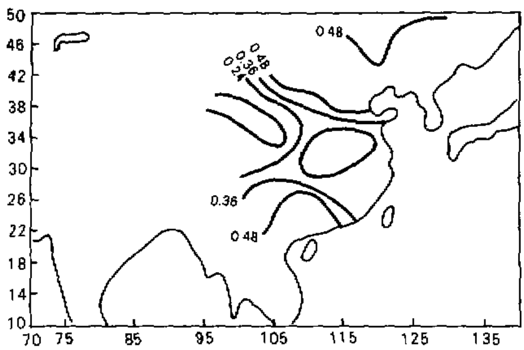


Fig. 3. Distribution of correlation coefficient of monthly precipitation between the observation and the simulation during 1980–1988.

simulated the positive summer rainfall anomalies in Jianghuai region and the negative anomalies in South China. In 1981, the simulated rainfall anomalies are opposite to the observation in the south part of the country, but in the central North China and the Northeast the simulations are quite reasonable. In 1982, the negative anomalies of precipitation in the Northeast is satisfactorily reproduced by the model and in the large areas south to the Yangtze River valley the positive anomalies are also simulated by the model. In the Southwest

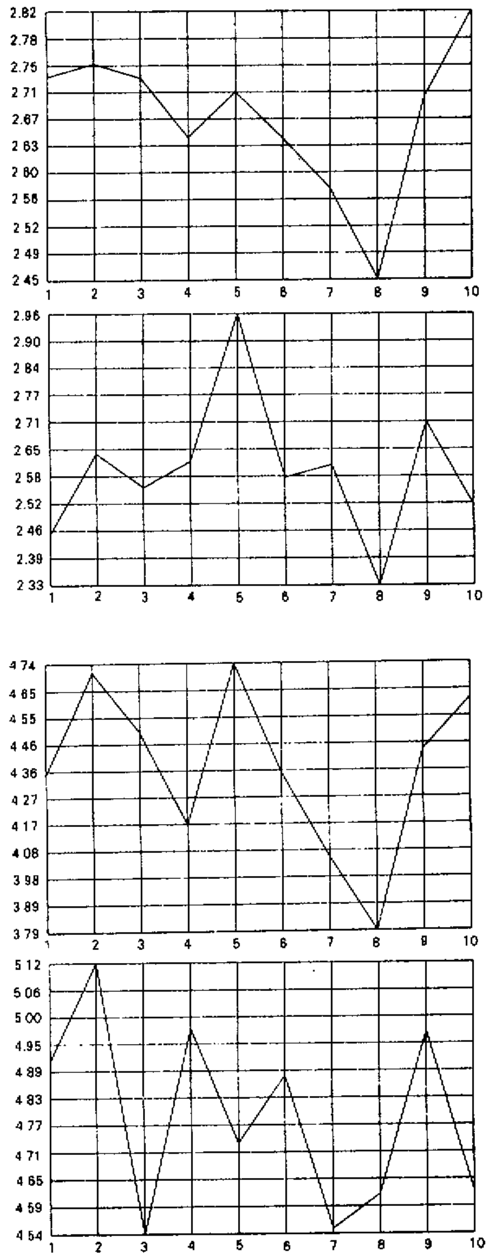
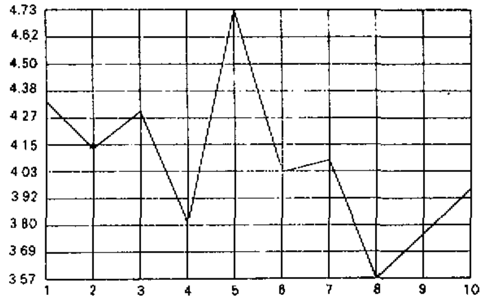
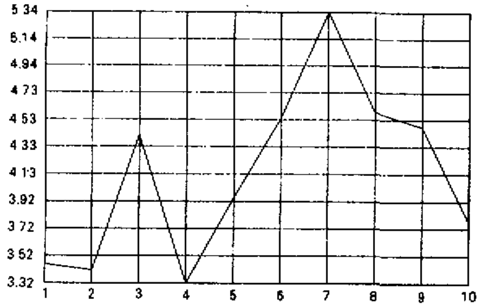


Fig. 4. The temporal change of the simulated (upper) and observed (lower) precipitation in East China during 1979–1988 for the annual mean (a) and the June–July–August mean (b).


4.73
4.62
4.50
4.38
4.27
4.15
4.03
3.92
3.80
3.69
3.57
1 2 3 4 5 6 7 8 9 10


5.34
5.14
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4.53
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4.13
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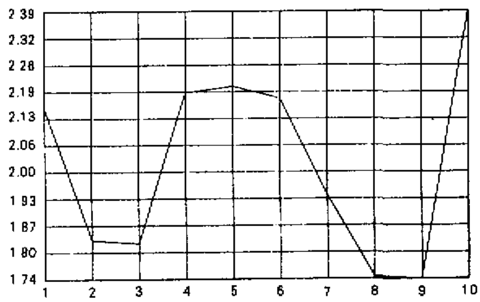
3.72
3.52
3.32
1 2 3 4 5 6 7 8 9 10


2.39
2.32
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2.13
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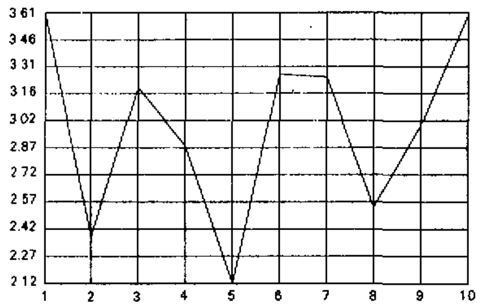
1.93
1.87
1.80
1.74
1 2 3 4 5 6 7 8 9 10


3.61
3.46
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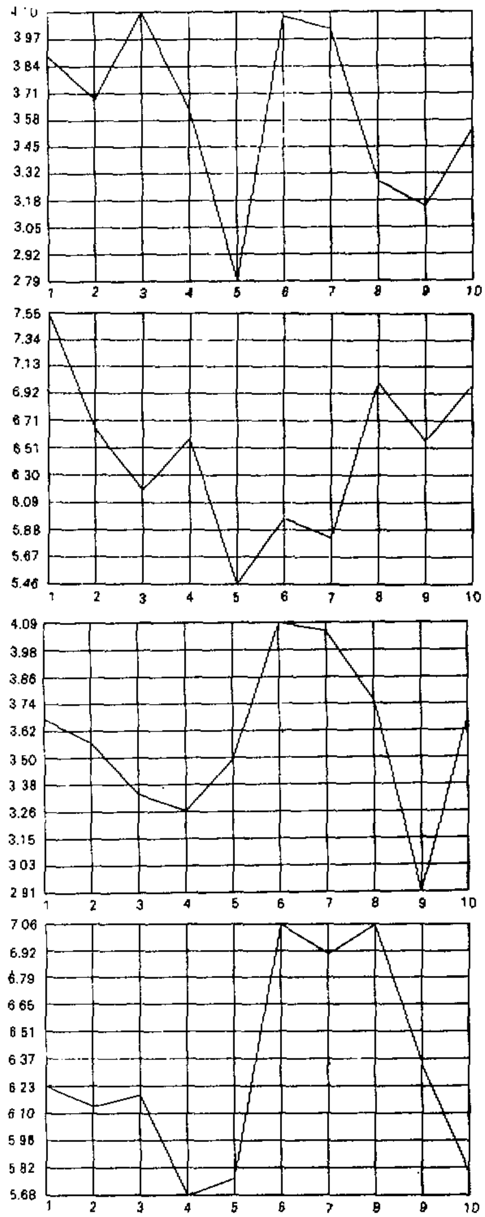

Fig. 5. The temporal change of the simulated (upper) and observed (lower) precipitation (mm / day) in NE (a), NC (b), SC (c) and SW (d) during 1979–1988 for the JJA mean.

the simulation partly agrees with the observation . However, the simulation in some regions is totally wrong. We can also take a look at the simulation of 1985 in that year large areas suffered from drought. The simulation in the Southeast and part of central North is good, but the model does not simulate the drought in the western Yangtze River valley qualitatively. To get general insight into the simulation of interannual variation we give the distribution of correlation coefficient between the simulated and observed precipitation over China (Fig. 3). One can find that in East China the correlation coefficient is positive, and that simulations in NE and SW are better while the simulation in NW is the worst.

IV. SIMULATION OF THE INTERANNUAL CHANGE OF REGIONAL PRECIPITATION

The temporal variations of precipitation over East China for the annual mean and the JJA mean with regard to the simulation and the observation are illustrated in Fig. 4, respectively. One can find that the interannual variation of the annual mean precipitation over China is simulated qualitatively. It is interesting to note that for the simulation, the 1982 and 1986 El Nino events caused negative precipitation anomalies and the observation seems to support the simulated phenomenon. Through the analyses of SST and rainfall data over China during 1961 and 1988, we find the correlation coefficient of the annual mean precipitation over East China to the eastern tropical Pacific SST is −0.42 and that to the western Pacific SST is 0.67. But the correlation coefficient of the precipitation over the whole country to the eastern or the western Pacific SST is small. This indicates that the ENSO cycle influences the monsoon and hence the monsoon rainfall over China, but the precipitation over western China is not influenced by the ENSO cycle strikingly. For the JJA seasons the simulation is also reasonable except for 1982 and 1983. Fig. 5, depicts the interannual changes of JJA precipitation over the central North , the Southwest, the Northeast and the central South China for the simulation and the observation, respectively. We note that the simulations for SW are quite reasonable, but the simulations for NC, NE and SC are not so good as that for SW.

The interannual variation for the simulation of NC precipitation is wrong in 1981, 1982 and 1983, while the simulation for SW precipitation is quite good. It looks like that there are negative correlation between the eastern Pacific SST and the summer precipitation over SW and NC. To test this idea we compute the correlation coefficients. For SW precipitation, the correlation coefficient to the eastern Pacific SST in summer is −0.27 and that to the western Pacific SST is 0.42 during 1961−1988, and −0.51 and 0.23 for NC respectively.

Therefore, the above results indicate that the interannual variation of regional precipitation which is closely related to SST variabilities could be reasonably simulated to some extent and hence the prospect of model prediction of short−range climate is optimistic in case that the coupled atmospheric−oceanic general circulation models could predict the ENSO cycle. There is no doubt that the model resolution should be enhanced in order to give better description of regional climatic characteristics.

V. CONCLUSIONS

From these experiments in this paper we can say that the interannual variations of precipitation in some regions over China can be qualitatively simulated by the IAP AGCM. Anyhow, longer time simulation and more detailed studies are necessary in order to get the problem settled down. This is a good foundation for seasonal and extra−seasonal climate predictions. In fact, Zeng et al. (1990) have done some prediction experiments and the results are encouraging. They have given a lot of reasonable predictions of the general circulation over East Asia and the precipitation in some regions over China.

It must be pointed out that precipitation variations over some regions which does not have clear correlation to the SST variations cannot be simulated well. For example, in the central South and the central East parts of the country the simulations of the interannual variations of precipitation are not satisfactory.

Possible factors which lead to the uncertainties of precipitation simulation are snow–cover age variations on the Tibetan Plateau, activities in middle and high latitudes such as blocking actions. The cloud parameterization and the horizontal and vertical resolution in GCMs are also accounted for the uncertainties in some cases.

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