Seasonal Prediction Experiments of the Summer Droughts and Floods during the Early 1990's in East Asia with Numerical Models

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Received November 14, 1997; revised January 6, 1998

ABSTRACT

It has been shown by the observed data that during the early 1990's, the severe disastrous climate occurred in East Asia. In the summer of 1991, severe flood occurred in the Yangtze River and the Huaihe River basin of China and in South Korea, and it also appeared in South Korea in the summer of 1993. However, in the summer of 1994, a dry and hot summer was caused in the Huaihe River basin of China and in R. O. K..

In order to investigate the seasonal predictability of the summer droughts and floods during the early 1990's in East Asia, the seasonal prediction experiments of the summer droughts and floods in the summers of 1991–1994 in East Asia have been made by using the Institute of Atmopsheric Physics–Two–Level General Circulation Model (IAP–L2 AGCM), the IAP–Atmosphere / Ocean Coupled Model (IAP–CGCM) and the IAP–L2 AGCM including a filtering scheme, respectively. Compared with the observational facts, it is shown that the IAP–L2 AGCM or IAP–CGCM has some predictability for the summer droughts and floods during the early 1990's in East Asia, especially for the severe droughts and floods in China and R. O. K..

In this study, a filtering scheme is used to improve the seasonal prediction experiments of the summer droughts and floods during the early 1990's in East Asia. The predicted results show that the filtering scheme to remain the planetary–scale disturbances is an effective method for the improvement of the seasonal prediction of the summer droughts and floods in East Asia.

Key words: Seasonal prediction, Drought and flood, General circulation model (GCM)

I. INTRODUCTION

Droughts and floods associated with the monsoon rainfall variability cause frequently serious damages to the economy, agriculture and human life in East Asia, especially in the Yangtze River and the Huaihe River basin of China, R. O. K. and Japan. Therefore, the seasonal prediction of monsoon rainfall variability has been a matter of great concern for the countries of monsoon area. However, because the interannual and intraseasonal variabilities of Asian monsoon are complex, the seasonal prediction of Asian monsoon variability has been a significant scientific problem since the end of the 19th century, and it may be still an important research issue in next century.

The prediction methods with experiences and statistics have been widely applied to the seasonal prediction of monsoon rainfall in the countries of monsoon area, but the forecasting accuracies by these methods are unstable, especially the prediction of droughts and floods in East Asia. Thus, many scientists are making efforts to investigate the effective prediction method using dynamical and numerical models. The recent progresses in the GCM and numerical simulations of atmospehric general circulaiton may lead the monthly or seasonal prediction to success. Recently, some progresses have been made in the prediction of monthly mean circulation with the GCM or the atmosphere / ocean coupled model, such as Spar et al. (1976), Caverly et al. (1981), Miyakoda (1986), Cubasch et al. (1986), Mansfield (1986) have performed many experiments of monthly mean circulation, and their results were interesting.

However, the seasonal predictions of summer monsoon rainfall with the GCM and the coupled GCM are rare so far. Zeng et al. (1990) firstly made a try at the seasonal prediction of the summer monsoon rainfall, and their result was heartening. Moreover, Zeng et al. (1994, 1995) also made a series of seasonal forecasting experiments. Their results explained that the GCM or the coupled GCM may be an effective seasonal forecasting method for the summer monsoon rainfall. This is due to that not only the dynamical and thermal processes of anomalous climate caused drought and flood can be considered in a GCM or a coupled GCM, but also the seasonal rainfall anomalies can be predicted quantitatively.

During the early 1990's, anomalous summer monsoon appeared in East Asia, especially severe droughts and floods occurred in the Yangtze River and the Huaihe River basin of China, R. O. K. and Japan. Therefore, the IAP–AGCM including a filtering scheme and the IAP–CGCM were respectively used to make the seasonal prediction experiments of droughts and floods in China in the summers of 1991–1994 (Li and Yuan, 1995; Huang et al., 1996). Similarly, these numerical models were used to predict the droughts and floods in East Asia. Therefore, these experiments on the seasonal prediction of summer droughts and floods in East Asia including the eastern China, R. O. K. will be summarized in this paper, but the severe drought and flood summers in East Asia are emphasized.

II. THE SST ANOMALIES IN THE EQUATORIAL PACIFIC AND THE SUMMER RAINFALL ANOMALIES IN CHINA AND R. O. K. DURING THE EARLY 1990's

During the early 1990's, due to the SST anomalies in the equatorial central and eastern Pacific, anomalous summer monsoon frequently appeared in East Asia. As a consequence, serious droughts and floods occurred not only in the Yangtze River and Huaihe River basin of China, but also in R. O. K.. In the following, the SST anomalies in the equatorial central and eastern Pacific and the summer monsoon rainfall anomalies occurred in East Asia during the early 1990's will be simply described.

1. *The SST Anomalies in the Equatorial Pacific during the Early 1990's*

During the early 1990's, the SST anomalies frequently occurred in the equatorial Pacific. Fig. 1 is the longitude–time cross–section of the SST anomalies in the equatorial Pacific. Obviously, the SST anomalies in the equatorial central and eastern Pacific are positive, and the warming spreads from the equatorial central Pacific to the equatorial eastern Pacific. During the summer of 1991, the 1991 / 92 ENSO event was in a developing stage. Moreover, it can be also seen from Fig. 1 that in 1993, negative SST anomalies were also persisted in the equatorial western Pacific, but the SST anomalies at the equator were positive. The warming spreads also from the equatorial central Pacific to the eastern Pacific from March to July in 1993. A weak ENSO event occurred in the tropical Pacific. However, it may be found from Fig. 1. that the SST anomalies during 1994 were obviously different from those during 1993. In 1994, positive SST anomalies appeared in the tropical western Pacific from the early spring to September, while negative SST anomalies were maintained in the equatorial eastern Pacific from

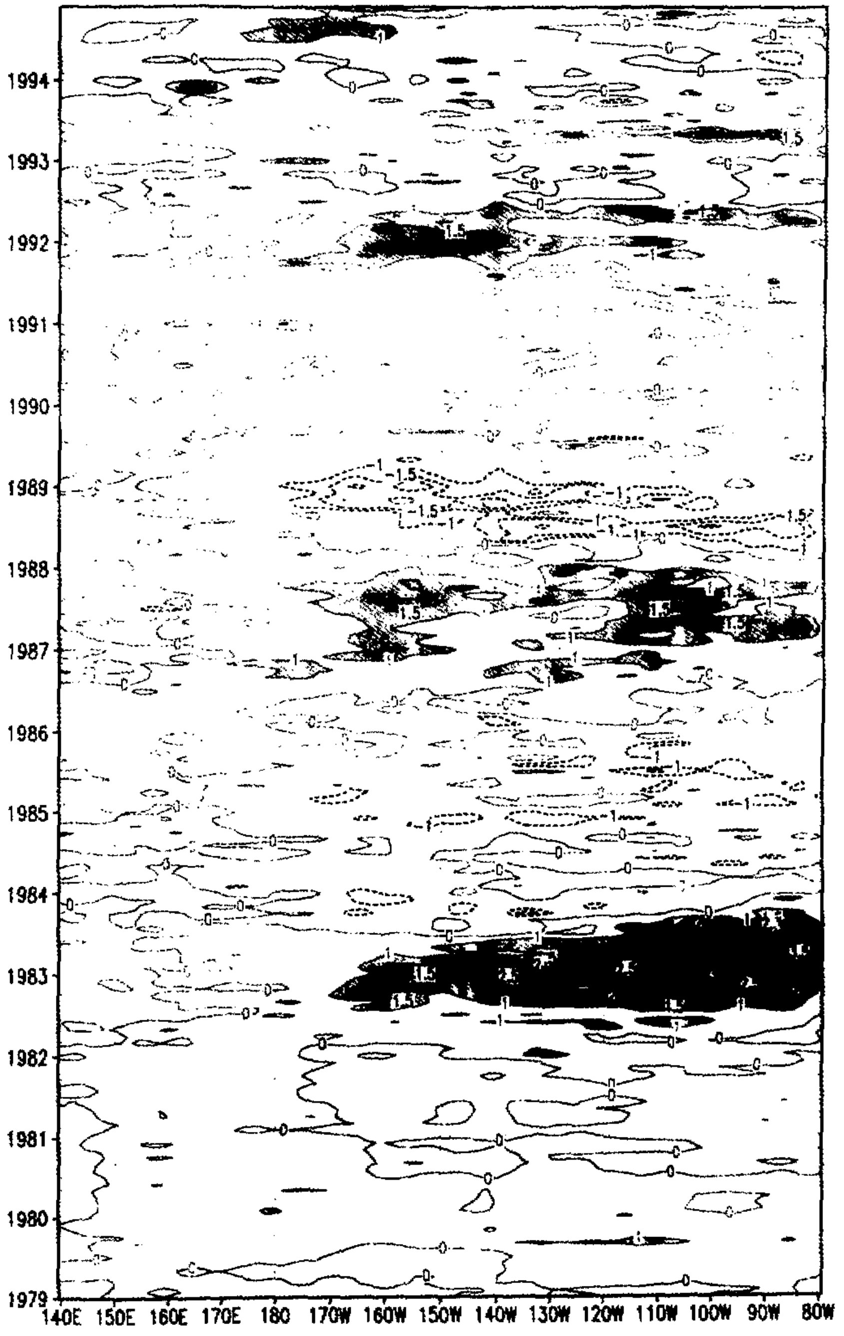
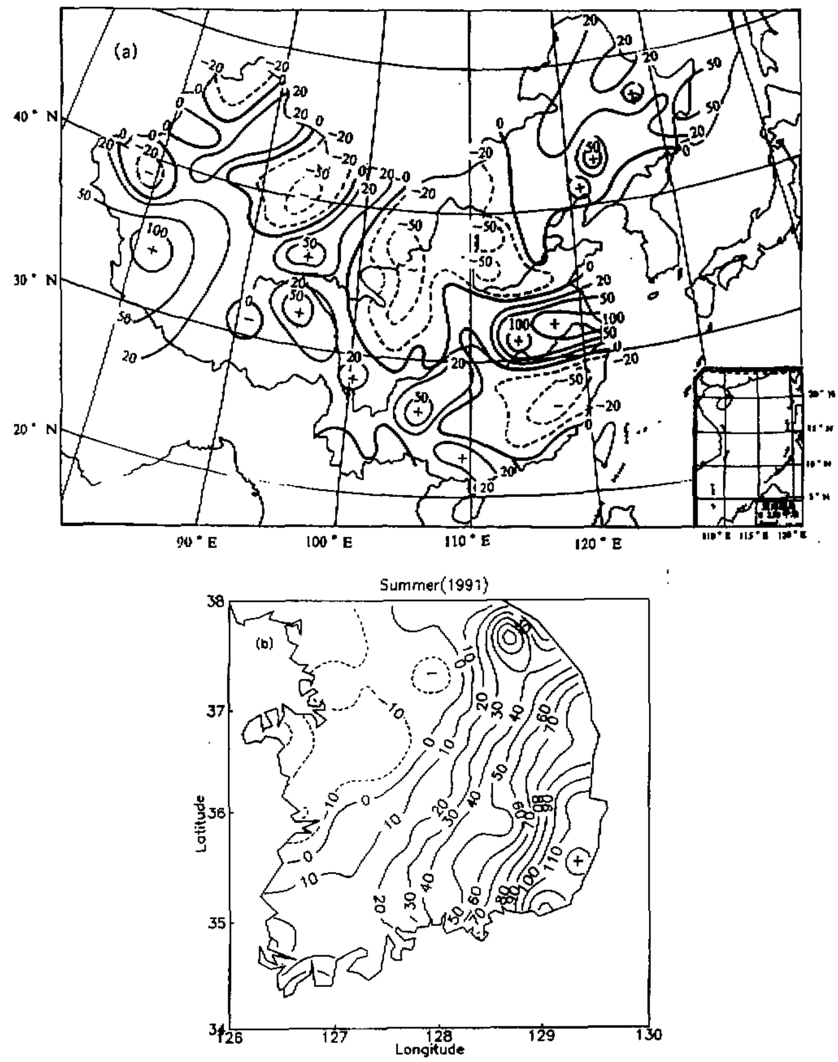


Fig. 1. Longitude–time cross–section of the SST anomalies in the equatorial Pacific averaged along 4.5°N–4.5°S. Zero contours are omitted, areas above +1.0℃ are shaded, and dashed lines indicate the SSTA below −1.0℃.

early January to September. Therefore, during the summer of 1994, a weak La Nina phenomenon occurred in the equatorial wastern Pacific. It may be said that the SST anomaly distribution in the tropical Pacific in 1994 was opposite to that during the summer of 1993. But the SST was rising in the equatorial central and eastern Pacific after the summer of 1994, a weak ENSO event occurred there.

ENSO cycle has a significant influence on the Asian summer monsoon (See Huang and Wu, 1989). Influenced by the ENSO cycles occurred during the early 1990's, the severe droughts and floods were caused in East Asia.



Rainfall anomaly(%)

Fig. 2. The summer rainfall anomaly percentage during June–August, 1991 in China (a) and R. O. K. (b).

2. *The Summer Rainfall Anomalies in China and R. O. K. during the Early 1990's*

(a) *In the summer of 1991*

During the summer of 1991, the rain belt was maintained in the area from the middle and lower reaches of the Yangtze River and the Huaihe River basin to R. O. K.. An unprecedented heavy flood disaster occurred there. As shown in Fig. 2(a), the summer precipitation was more than 100% above normal in the middle and lower reaches of the Yangtze River and in the Huaihe River basin during the period from June to August. The summer of 1991 was one of the particularly severe flood summers, following 1954 in the middle and lower reaches of the Yangtze River and the Huaihe River basin, and a severe disaster was caused there. However, in North China and to the south of the Yangtze River, the summer precipitation anomaly percentages were about 50% below normal, and severe droughts occurred in these regions.

Similarly, during the summer of 1991, as shown in Fig. 2(b), the summer precipitation anomaly percentage was also more than 50% above normal in R. O. K., and severe flood occurred in the southeastern R. O. K. during June–August. Particulerly, the summer precipitation anomaly reached more than 600 mm around Pusan.

(b) *In the summer of 1993*

During the summer of 1993, the monsoon rain belt was maintained to the south of the Yangtze River. As shown in Fig. 3(a), the summer precipitation anomaly percentage was about 50% above normal, and a flood occurred to the south of the Yangtze River. Moreover, in the Huaihe River and the Yellow River basin, the summer precipitation was about 20% below normal.

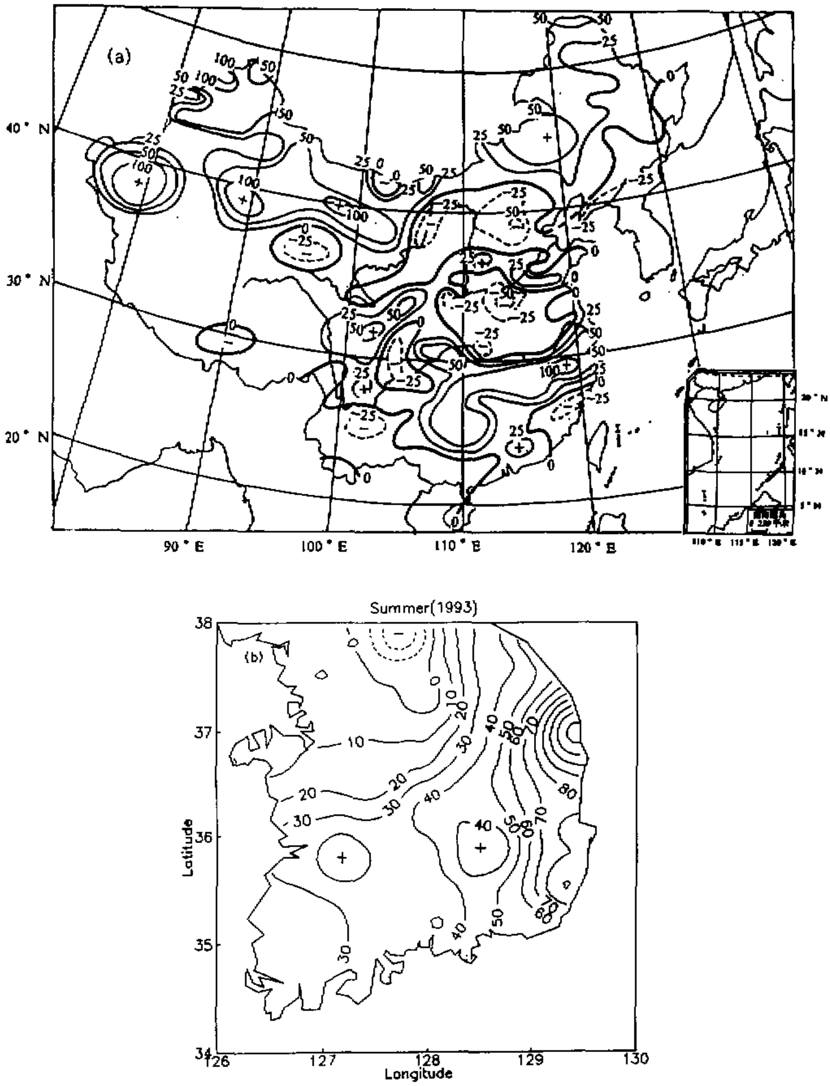
Similarly, as shown in Fig. 3(b), the summer precipitation anomaly percentage was more than 30% above normal in R. O. K. and even reached 70% above nomal in the eastern coast of R. O. K.. A cooling and flood summer appeared there.

It was opposite to that during the summer of 1991 that during the summer of 1994, the monsoon rain belt was maintained in South China during May–June and North China during July–August. As shown in Fig. 4(a), the summer precipitation anomaly percentage was about 50% above normal in South China, and it even reached 100% more than the normal in some areas. Therefore, serious flood occurred in South China, and it caused a severe disaster. Moreover, during July–August, the anomalous summer rainfall also appeared in the southern part of Northeast China and the northern part of North China, and a serious flood also occurred in the southern part of Northeast China. However, in the middle and upper reaches of the Yangtze River and the Huaihe River basin, the summer precipitation anomaly percentage was more than 30% below normal, and even it reached 50% below normal in some areas. Therefore, a severe drought and hot summer occurred there and caused serious disaster.

Similarly, as shown in Fig. 4(b), the summer precipitation was 30–40% below normal in R. O. K., and a drought and hot summer also appeared there.

(c) *In the summer of 1994*

From the above mentioned observations, it may be found that during the early 1990's, in the developing stage of the ENSO event, the summer monsoon rainfall is strong in the Yangtze–Huaihe River basin of China and R. O. K., but it is weak there in the decaying stage of the ENSO event. This is in agreement with the result investigated by Huang and Wu (1989). Moreover, it may be seen that there is a similar character between the interannual variability of Meiyu in the Yangtze River and the Huaihe River basin of China and



Rainfall anomaly(%)

Fig. 3. Same as in Fig. 2, but for the summer of 1993.

the interannual variability of Changma in R. O. K.. Generally, when the Meiyu is strong or weak in the Yangtze River and the Huaihe River basin of China, the Changma is also strong or weak in R. O. K. (Lu et al., 1995). However, there are some differences between the interannual variability of Meiyu in China and the interannual variability of Changma in R. O. K.. For example, during the summer of 1993, the Changma was strong in R. O. K., but in the Huaihe River basin, the Meiyu was not strong.

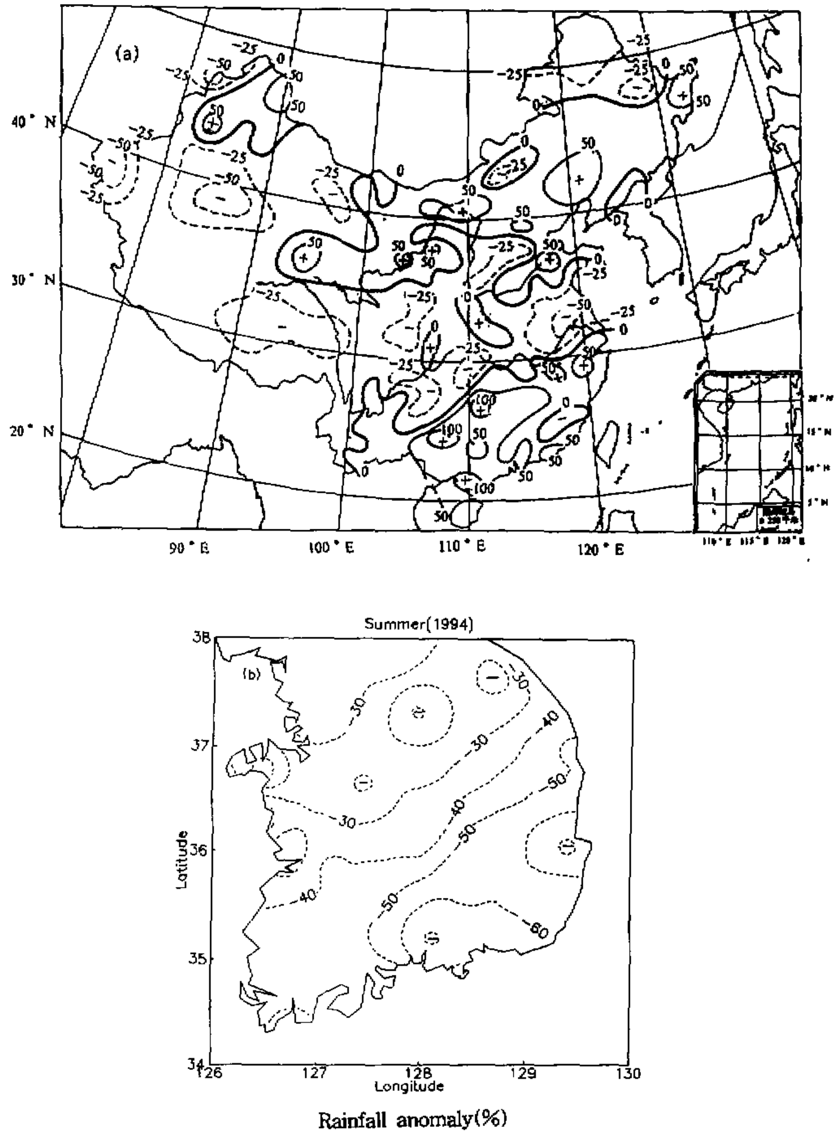


Fig. 4. Same as in Fig. 3, but for the summer of 1994.

III. NUMERICAL MODELS AND THE EXPERIMENT SCHEMES USED IN THE SEASONAL PREDICTION OF DROUGHTS AND FLOODS IN EAST ASIA

The IAP–L2 AGCM and the IAP–CGCM are used to make the tests of seasonal prediction of droughts and floods in East Asia. The IAP–L2 AGCM is a two–level, grid–point primitive equation model of atmospheric general circulation, and the IAP–CGCM is a coupled model of the IAP–L2 AGCM and a 4–level Pacific Ocean Basin General Circulation Model. These two models were described in the first version of the IAP–Numerical Prediction System of Short–Range Climate Anomalies in detail (See Zeng et al., 1990). A reference atmosphere is firstly introduced in the dynamical frame of the IAP–L2 AGCM, and the total energy conservation is satisfied in the model. Moreover, in order to improve the seasonal prediction of droughts and floods in East Asia, the IAP–L2 AGCM including a filtering scheme is used in this study.

In the integration of the models, the analyses of geopotential and wind fields on February 15 by National Meteorological Center (NMC) of China are taken as the initial conditions in the atmosphere. The initial field of SST is specified, i.e., the climatological distribution of SST with annual cycle plus SST anomalies in initial month (here Feburary) or predicted by the coupled model. Then, the following two numerical schemes of the seasonal prediction of droughts and floods in East Asia are carried out in the experiments:

1. *Scheme I*

In this scheme, the IAP–L2 AGCM is integrated from February 15 to August 31 with the analyses on February 15 by NMC of China and persistent SST anomalies. The daily precipitation can be obtained from the integration of the model, and the monthly mean is made from the daily precipitaitons. Moreover, the monthly climatological–mean precipitations, obtained by integrating the model for 25 model –years, are subtracted from the monthly mean precipitation obtained from integration of the model, and the monthly precipitation anomalies can be obtained. Thus, the monthly precipitation anomalies are used to predict the summer drought and flood in East Asia using the average of the monthly precipitation anomalies for the period from June to August.

2. *Scheme II*

This scheme is the same as the scheme I, but the model used in the integration is the IAP–CGCM, in which the SST in the Pacific is predicted by the coupled model. Moreover, the monthly anomaly coupling method (described in Zeng's paper) is used in this scheme.

IV. EXPERIMENTS ON THE SEASONAL PREDICTION OF THE DROUGHTS AND FLOODS DURING THE EARLY 1990'S IN EAST ASIA

As shown in the introduction, during the early 1990's, the anomalous summer monsoon succesively appeared in East Asia. It caused the serious floods and droughts in the Yangtze River and the Huaihe River basin of China and R. O. K.. Therefore, we have carried out a series of experiments on the seasonal prediction of droughts and floods in East Asia for the summers of 1991–1994 with the schemes I and II, respectively, and these experiments are compared with the observed facts, particularly, the predicted results of the severe droughts and floods in China and R. O. K. will be emphasized in the following.

1. *The Seasonal Prediction of Droughts and Floods in the Summer of 1991*

In late March 1991, an experiment on the seasonal prediction of summer drought and flood during June–August in East Asia was made by using the above–mentioned two schemes, respectively. Figs. 5(a) and 5(b) are the distributions of the predicted summer precipitation anomaly percentage averaged for June–August, 1991 in East Asia by using the IAP–L2 AGCM and the IAP–CGCM, respectively. According to Fig. 5, it was predicted that

" in the summer of 1991, positive rainfall anomalies, whose maximum is 50% above normal, may be located in the region from the middle and lower reaches of the Yangtze River and the Huaihe River basin to R. O. K. and the southern part of Japan, and negative rainfall anomalies may be located in North China". Compared with the observation shown in Fig. 2(a), in the middle and lower reaches of the Yangtze River and the Huaihe River basin this prediction was in good agreement with the observation. However, there is some difference between the predicted seasonal rainfall anomalies shown in Fig. 5(b) and that shown in Fig. 5(a) in R. O. K.. The seasonal rainfall anomalies predicted by using the IAP–CGCM are negative anomalies in R. O. K., as shown in Fig. 5(b). This is different from the observation shown in Fig. 2(b).

2. The Seasonal Prediction of Droughts and Floods in the Summer of 1993

In late March 1993, we also made an experiment on the seasonal prediction of summer drought and flood during June–August, 1993 in East Asia using the schemes I and II, respectively. As shown in Fig. 6(a), it was predicted in late March that " in the summer of 1993, positive rainfall anomalies may appear in the Huaihe River basin, R. O. K. and Japan". This prediction was in good agreement with the observed distribution of summer rainfall

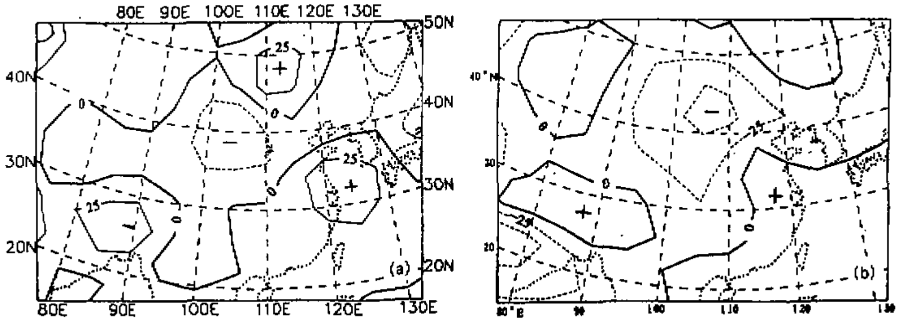


Fig. 5. Distribution of the predicted summer precipitation anomaly percentage in East Asia averaged for June–August, 1991, calculated with the IAP–L2 AGCM (a) and the IAP–CGCM(b), respectively.

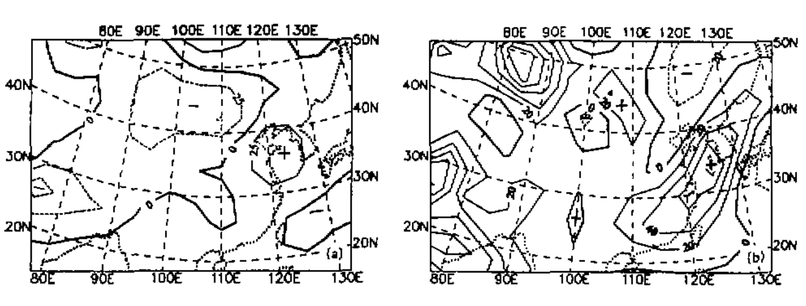


Fig. 6. Same as in Fig. 5, but for the summer of 1993.

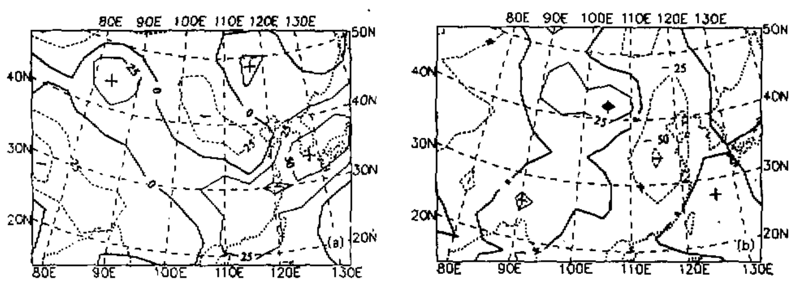


Fig. 7. Same as in Fig. 5, but for the summer of 1994.

anomalies in R. O. K. and Japan, although it was smaller than the observation shown in Fig. 3(b). However, the prediction was different from the observation shown in Fig. 3(a) in the Huaihe River basin. Moreover, a drought was well predicted in North China, as shown in Fig. 6(b).

3. *The Seasonal Prediction of Droughts and Floods in the Summer of 1994*

In late March 1994, an experiment on the seasonal prediction of summer drought and flood during June–August in East Asia was also made by using the schemes I and II, respectively. As shown in Fig. 7(a), it was predicted by using the scheme I that "in the summer of 1994, positive rainfall anomalies, whose maximum is 50% above normal, may be located in the region from the middle and lower reaches of the Yangtze River and the Huaihe River basin to R. O. K. and Japan, negative rainfall anomalies may appear in North China". This prediction was opposite to the observation shown in Figs. 4(a) and 4(b), except for South China. However, as shown in Fig. 7(b), the summer rainfall anomalies predicted by using the scheme II were better than those predicted by using the scheme I in the Huaihe River basin and R. O. K.. In these regions, negative anomalies of summer rainfall were well predicted by using the scheme II.

From the above–mentioned experiments of the seasonal prediction of summer monsoon rainfall anomalies in East Asia, it may be seen that the IAP–L2 AGCM and the IAP–CGCM are of some predictability for the large–scale summer droughts and floods in East Asia. Moreover, the predictability of summer droughts and floods in the Yangtze River basin, the Huaihe River basin and R. O. K. may be larger than that in the western China. This may be due to that only the anomalous thermal effect of the SST in the equatorial Pacific on the summer monsoon circulation and precipitation in East Asia is considered in the experiments.

The above–mentioned experimetns also show that the results predicted by using the IAP–CGCM appear to be better than those predicted by using the IAP–L2 AGCM. This may explain that the variability of SST in the tropical Pacific may play an important role in the summer monsoon rainfall.

V. AN IMPROVEMENT OF THE SEASONAL PREDICTION OF SUMMER DROUGHTS AND FLOODS IN EAST ASIA

How to increase the predictability of seasonal climate variability is a significant research issue, which needs to be investigated further. Many dynamical prediction experiments have shown that the seasonal predictability of climate variability in the extratropics is directly influenced by synoptic–scale disturbances, meso– and small–scale disturbances (See Shukla, 1986). Therefore, in order to increase the accuracy of seasonal predicition of droughts and floods in East Asia, a filtering scheme is used to improve the seasonal prediction experiments of droughts and floods in the summers of 1991 –1994 in East Asia. In this filtering scheme, the synoptic–scale disturbances are filtered from the initial fields including the monthly–mean field of SST and geopotential and wind fields, and the planetary–scale disturbances are remained in the initial fields. Moreover, in the integration of the IAP–L2 AGCM, the filtering scheme is used to remain the planetary–scale disturbances and to filter the synoptic–scale disturbances from the integrated fields at intervals of 5 model–days. Thus, a series of experiments on the seasonal prediction of droughts and floods in East Asia in the summers of 1991–1994 were carried out by using the IAP–L2 AGCM including the filtering scheme. Fig. 8 is the seasonal prediction experiment of the summer drought and flood in East Asia in the summer of 1993, made by using the IAP–L2 AGCM including the filtering scheme. The figures of the seasonal prediction of the summer droughts and floods in East Asia in the summers of 1991, 1992 and 1994 are omitted.

As shown in Fig. 8, the seasonal predictions of the summer droughts and floods have been well improved in eastern China by using the filtering scheme. The summer monsoon rain belt from the south of the Yangtze River to Japan through R. O. K. was well predicted by using the filtering scheme.

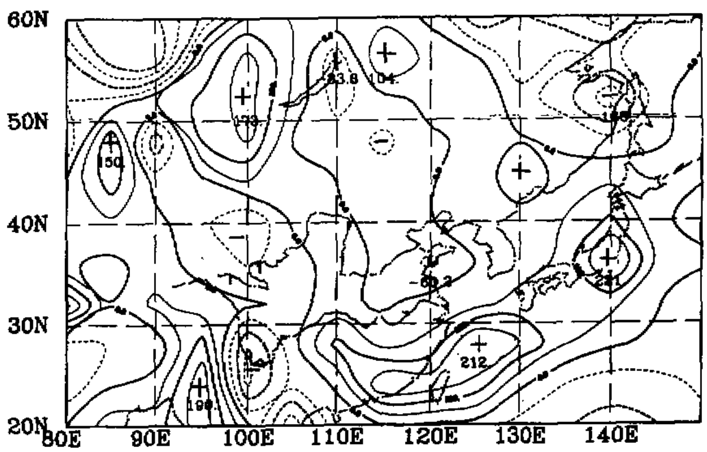


Fig. 8. Distribution of the predicted averaged for June–August, 1993 by using the IAP–L2 AGCM including a filtering scheme. Units in mm

In the following, we will analyze quantitatively the seasonal prediction experiments on droughts and floods in East Asia in the summers of 1991–1994. Thus, an accuracy is defined by using the similarity between the predicted anomaly and the observed anomaly of seasonal precipitation during June–August. According to the definition, if the predicted anomaly of precipitation during a summer is positive in a grid point, and the observed anomaly of the precipitation during the summer is also positive in the grid point, then, the prediction can be considered as accurate in the grid point. Otherwise, the prediction is wrong. These are summarized in Table I.

Table 1. Similarity Percentage between the Predicted Summer Precipitation Anomalies and the Observed Summer Precipitation Anomalies in China

Year	eastern China (east of 105°E)	western China (west of 105°E)
1991	60%	41%
1993	76%	52%
1994	68%	63%
average for the summers	68%	52%

From Table 1, it may be found that the filtering scheme may play a role in the improvement of the seasonal prediction of summer droughts and floods in East Asia, and the results of seasonal predictition of summer droughts and floods in the eastern China are better than those in western China. This result is the same as the results predicted by using the schemes I and II.

VI. SUMMARY

The observed facts show that owing to the influence of the ENSO cycle during the early 1990's, the severe climate anomalies occurred in East Asia. In the summer of 1991, severe flood occurred in the middle and lower reaches of the Yangtze River and the Huaihe River basin of China and in R. O. K., and it also appeared in R. O. K. in the summer of 1993. However, in the summer of 1994, a dry and hot summer was caused in the Huaihe River basin of China and in R. O. K..

In order to investigate the seasonal predictability of summer droughts and floods in East Asia, the seasonal prediction experiments on the summer droughts and floods in the summers of 1991–1994 in East Asia have been made by using the IAP–L2 AGCM, the IAP–CGCM, and the IAP–L2 AGCM including the filtering scheme, respectively.

From the comparison between the prediction experiments and the observed droughts and floods in the eastern China and R. O. K., it may be shown that the IAP–AGCM and the IAP–CGCM are of some predictability for the summer droughts and floods in East Asia, especially for the severe droughts and floods in China and R. O. K. to some extent. Moreover, the filtering scheme remaining the planetary–scale disturbances is an effective method for the improvement of the seasonal prediction of the summer droughts and floods in East Asia. The seasonal prediction experiments made in this study also explain that the accuracy of seasonal predictition of summer droughts and floods in the eastern China and R. O. K. is larger than that in the western China. This may be due to the strong thermal effect of the western Pacific warm pool on the East Asian summer monsoon through the EAP pattern teleconnection suggested by Nitta (1987) and Huang and Li (1987).

However, it should be pointed out that the seasonal prediction experiments made in this study are preliminary. The samples used in the seasonal prediction experiments are few. The seasonal variability of the East Asian summer monsoon circulation and precipitation is sensitive to not only the surface heat flux in the western Pacific warm pool region but also to the convective parameterization scheme, the land surface processes and the snow cover in the Eurasian continent. Therefore, it is necessary to apply the climate model with high resolution, in which not only the surface heat flux in the western Pacific warm pool but also land surface processes, snow cover and sea ice et al. are included, to making the seasonal prediction experiments of the summer monsoon circulation and rainfall.

REFERENCES

Caverly, R., K. Miyakoda and L. Umscheid (1981), Three cases of one month GCM forecast, Proc. The Sixth Annual Climate Diagnostic Workshop, Oct. 14–16, 1981, 292–299.

Cubasch, U., S. Tibaldi and F. Molteni (1986), Deterministic extended range forecast experiments using the global ECMWF spectral model, Proc. the First WMO Workshop of the Diagnosis and Prediction of Monthly and Seasonal Atmospheric Variations over the Globe, July 29–August 2, 1985.

Huan]g, R. H. and W. J. Li (1987), Influence of the heat source anomaly over the tropical western Pacific on the subtropical high over East Asia, Proc. International Conference on the General Circulation of East Asia, April 10–15, 1987, Chengdu, China, 40–51.

Huang, R. H. and Y. F. Wu (1989), The influence of ENSO on the summer climate change in China and its mechanism, *Adv. Atmos. Sci.*, **6**: 202–214.

Huang, R. H., J. Z. Chen, R. Y. Lu and A. D. Liu (1996), Role of a filtering scheme in the improvement of the numerical seasonal–prediction experiments on the summer drought and flood during 1991–1995, Collected Papers on the Disastrous Cliamte Prediction and Its Impact on Agriculture and Water Resources, Part. III, China Meteorological Press (in Chinese).

Li, X., C. G. Yuan and Q. C. Zeng (1996), A review on the real–time predictions of short–term climate anomalies during 1991–1995, to be published in Collected Papers on the Disastrous Climate Prediction and Its Impact on Agriculture and Water Resources, Part V (in Chinese).

Lu, R. Y., Y. S. Chung and Huang, R. H. (1995), Interannual variations of the precipitation in Korea and the comparison with those in China and Japan, *J. Korean Envir. Sci. Soc.*, **4**: 345–356.

Mansfield, A. A. (1986), The skill of dynamical long–range forecast, including the effect of sea surface temperature anomalies, *Quart. J. R. Meteor. Soc.*, **112**: 1145–1176.

Miyakoda, K. and J. Sirutics (1986), Extended range forecasting, *Adv. in Geophysics*, **28(B)**: 55–85.

Nitta, Ts. (1987), Convective activities in the tropical western Pacific and their impact on the Northern Hemisphere summer circulation, *J. Meteor. Soc. Japan*, **64**: 373–390.

Shukla, J. (1986), Physical basis for monthly and seasonal prediction, Proc. the First WMO Workshop on the Diagnosis and Prediction of Monthly and Seasonal Atmospheric Variations over the Globe, July 29–August 2, 1985.

Spar, J., R. Atlas and E. Kuo (1976), Monthly mean forecast experiments with the GISS model, *Mon. Wea. Rev.*, **107**: 181–192.

Zeng, Q. C., C. G. Yuan, H. J. Wang and R. H. Zhang (1990), Numerical prediction experiments of extra–seasonal climate anomalies, *Chinese J. Atmos. Sci.*, **14**: 10–25.

Zeng, Q. C., C. G. Yuan, and X. H. Zhang (1995), IAP Climate Models and their applications, *Progress in Natural Sciences*, **5(3)**: 257–269.

Zeng, Q. C., B. L. Zhang, C. G. Yuan, P. S. Lu, F. K. Yang, X. Li and H. J. Wang (1994), A note on some methods suitable for verifying and correcting the prediction of climate anomaly, *Adv. Atmos. Sci.*, **11**: 121–127.