APEC Climate Network (APCN) Working Group Meeting

Session II. Dynamic Ensemble Prediction Activities

Seasonal Prediction of Summer Rainfall Anomaly over China by IAP PSSCA

Lin Zhaohui Zhou Guangqing
Zhao Yan Zeng Qingcun
LASG, Institute of Atmospheric Physics,
Chinese Academy of sciences, Beijing 100029

Abstract

By using IAP Prediction System for Short-term Climate Anomaly (IAP PSSCA), the real-time seasonal predictions of summer monsoon rainfall anomaly over China since 1998 have been conducted. Comparison of the prediction with the observation shows that, the predicted pattern of rainfall anomaly over China for 1998 agrees quite well with the observation, although the strength of the predicted positive anomalies is rather weak. As for 1999, the large positive anomaly along Yangtze River and the large negative anomaly occupying large domain of North China are correctly predicted. During 2000, the observed positive rainfall anomalies locates between the Yellow and Yangtze River valley, and north part of China is dominated by negative rainfall anomaly, all these observed features have been captured by IAP PSSCA. The successful predictions during 1998-2000 demonstrate the skill of IAP PSSCA in the real time prediction of summer rainfall anomaly over China. However, there also exist some deficiencies, especially for the detailed distribution of predicted rainfall anomalies and their magnitudes, and these may suggest that the further improvement of climate model and the incorporation of initialization of land surface characteristics are urgently needed.
Key Words: Seasonal prediction, Ensemble technique, Rainfall anomaly

1. Introduction

Many studies show that large climate anomaly, such as severe flood and drought, can result in great losses for the local economy and even human lives, so climate predictions become more and more important in the planning of economical development and protection of the people from disasters, and many institutes and research centers have been developing seasonal to interannual climate prediction system during recent years (e.g., Cane et al., 1986; Zeng et al, 1990; Ward and Folland, 1991; Ji et al., 1994; Carson, 1998; Brankovic and Palmer, 1998).

China is a country where flood and drought occur frequently, so early in 1989, the experiment of seasonal prediction of summer monsoon precipitation had been carried out in the Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP/CAS), and the prediction result was encouraging (Zeng et al., 1990). After that, many efforts

have been continually taken for the establishment of IAP Prediction System for Short-term Climate Anomaly (PSSCA), and this prediction system have been applied for the real-time extraseasonal prediction of summer rainfall anomaly over China.

2. Brief description of IAP PSSCA

Briefly speaking, IAP PSSCA consists of atmospheric GCM and Oceanic GCM, generation of atmospheric initial conditions and surface boundary conditions, practical schemes of anomaly prediction, ensemble prediction technique and its standard deviation, correction of GCM prediction output, and the verification of prediction (See Fig.1), more detailed description of IAP PSSCA can be found in Li (1992) and Zeng et al. (1997).

After its establishment, IAP PSSCA has been applied to the semi-operational real time climate prediction (e.g., Zeng et al., 1990; Li et al., 1992; Zeng, 1994;Yuan et al., 1996; Zeng et al., 1997). Verifications show that IAP PSSCA can well predict the large positive and negative anomalies of summer rainfall resulting in disastrous climate events, such as the severe flooding in the Huaihe and Yangtze River regions in 1991, and the severe drought in the Huaihe and Yangtze River regions in 1994. Generally speaking, the prediction skill for IAP PSSCA is relative large over Eastern part of China and Southern China. After 1995, many efforts have continually been taken in order to increase the predictive skill of IAP PSSCA. These efforts include the improvement of Atmospheric and Oceanic general circulation model, Land surface model, the establishment of ENSO prediction system, etc., (e.g., Lin et al., 1998, 1999, 2000). Ensemble hindcasts experiments show that the predictive skill of the IAP PSSCA is generally increased after improvement, especially over North China, Northeast China and He-tao region.

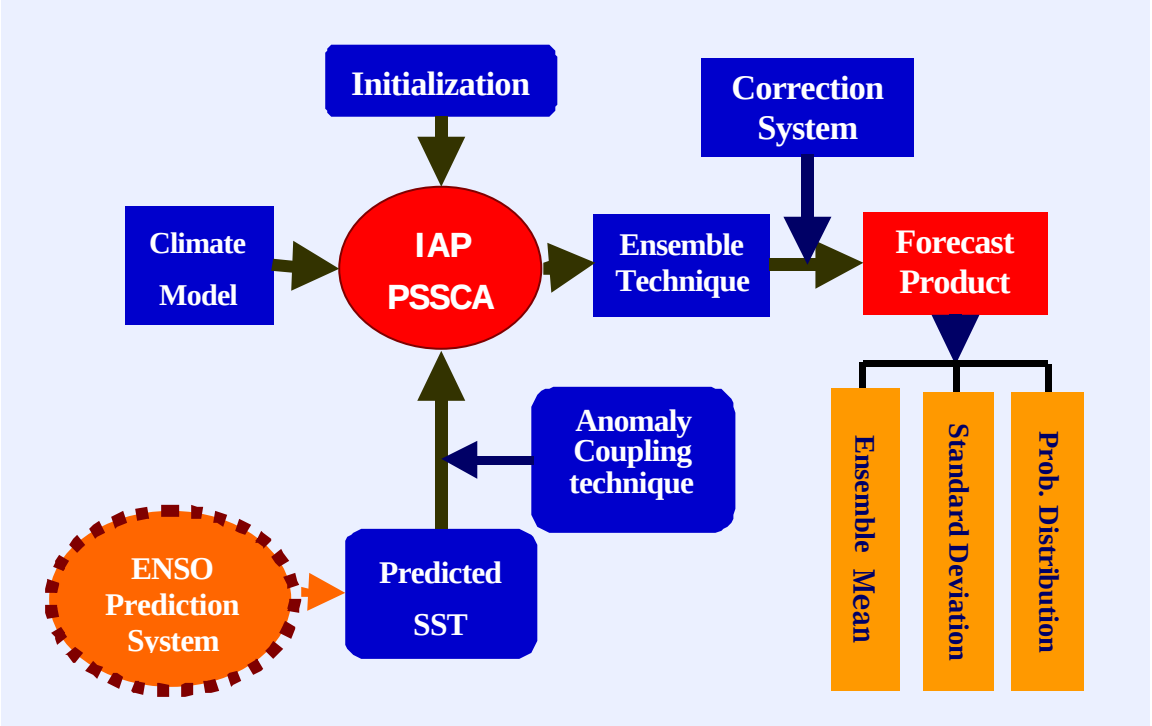

Fig.1 Schematic Map of IAP Prediction System for Short-term Climate Anomaly (IAP PSSCA)

3. Seasonal prediction experiments

In this section, the prediction results of summer rainfall anomaly over China by IAP PSSCA since 1998 will be presented. Actually, our prediction is conducted in two-tiered fashion (e.g., Bengtsson et al., 1993; Barnett et al., 1994; Hunt et al., 1994; Trenberth et al., 1998). In the first step, the tropical Pacific Sea Surface Temperature Anomaly (SSTA) is predicted by IAP ENSO prediction system; in the second step, an ensemble of AGCM runs (28 members) is preformed with the predicted SSTs to obtain the final prediction product of summer rainfall anomalies.

3.1 Prediction of 1998 severe flood over China

Fig.2 shows the predicted summer rainfall anomaly for year 1998 (Fig.2a), together with the observation (Fig.2b). Comparison result shows that, generally, the predicted pattern of rainfall anomaly agrees quite well with the observation. The positive rainfall anomalies over Yangtze River Valley, Northeast China and North part of Xinjiang have been well captured. However, the strength of the predicted positive anomalies are all too weak and the strong positive rainfall anomaly over Yangtze River valley doesn't extend westward enough. From Fig.5 we can also find that the negative rainfall anomaly between the Huaihe and Yellow river has also been well predicted by the IAP PSSCA.

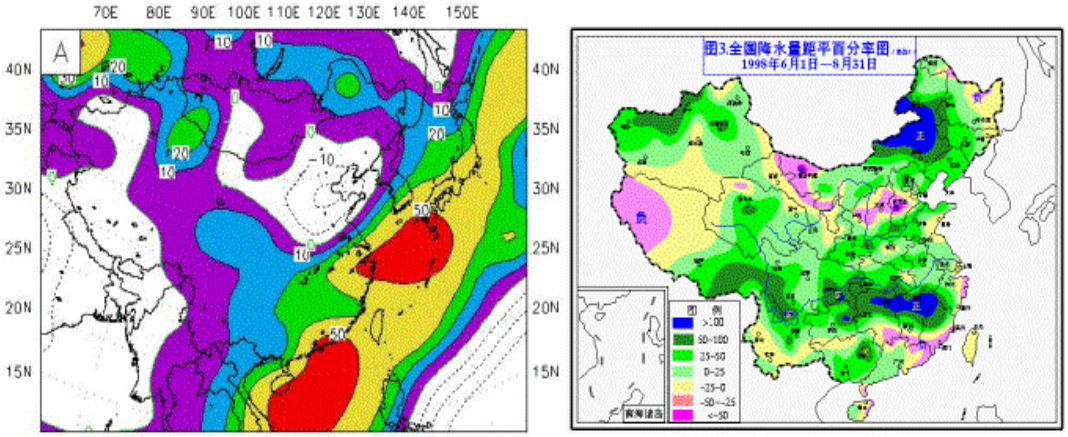

Fig.2 Percentage rainfall anomaly over China during summer of 1998

(a) predicted by IAP PSSCA and (b) Observation

3.2 Prediction of 1999 summer rainfall anomaly

From the observation map (Fig.3b) we can find that, in the summer of year 1999, generally speaking, the pattern of rainfall anomaly is positive in Southern part of China and negative over North part of China. There exist maximum centers for the positive rainfall anomaly over the lower reach of Yangtze River valley, and in the Northern Part of Xinjiang. However, over Northern China, there also exist several regions with positive rainfall anomalies, especially over the Southwest part of Hetao region where the positive rainfall anomaly is relative large.

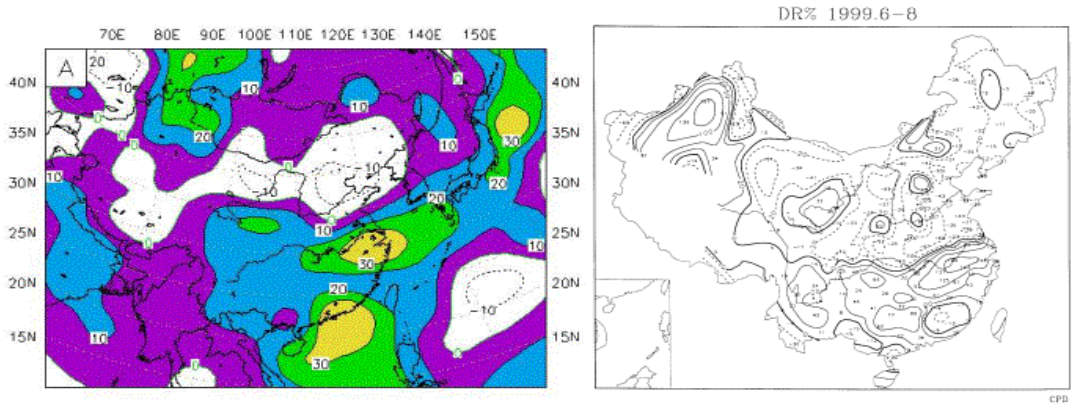

Fig.3 Percentage rainfall anomaly over China during summer of 1999

(a) predicted by IAP PSSCA and (b) Observation

Fig.3a shows the predicted percentage rainfall anomaly for the summer of 1999, and we can find that, generally, the positive rainfall anomalies over Yangtze River Valley, Southern China and Northern Part of Xinjiang have been well predicted by IAP PSSCA, and the drought over most part of North China have also been predicted, although the detailed rainfall anomaly distribution has some discrepancies compared with the observation, especially over North China.

3.3 Prediction of 2000 summer rainfall anomaly

For year 2000, drought condition dominates over most part of North China, and the positive rainfall anomalies locate in the region between Yellow and Huaihe river valley, southeastern and southwestern China and Xinjiang regions (Fig.4a). And a narrow band with negative rainfall anomaly appears in the middle and lower reaches of Yangtze river Valley.

From Fig.4b we can find that most of the observed features of rainfall anomaly have been predicted by IAP PSSCA, except that the band with negative rainfall anomaly over Yangtze River valley. On the other hand, the magnitude of the predicted positive rainfall anomaly between the Yellow and Huaihe river valley is rather weaker compared

with the observation

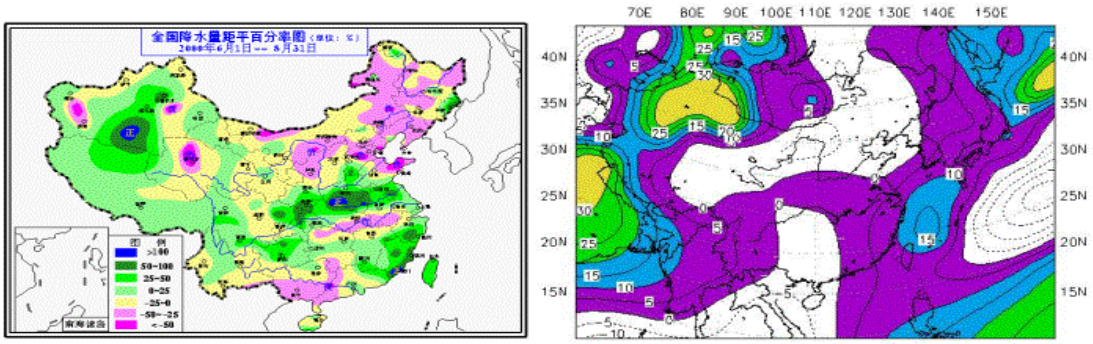

Fig.4 Percentage rainfall anomaly over China during summer of 2000
(a) Observation and (b) predicted by IAP PSSCA

3.4 Prediction of 2001 summer rainfall anomaly

Finally, we will give the prediction result for the summer rainfall anomaly of this year (Fig.5). We can see from Fig.5 that, drought will dominate over most part of China, including North China, Northeast China and most part of South China in the summer of 2001. However, over the lower reach of Yangtze River, the summer precipitation will be more than normal. For most part of South Korea, the summer rainfall will be less than normal, and the summer rainfall will be above normal over most part of Japan.

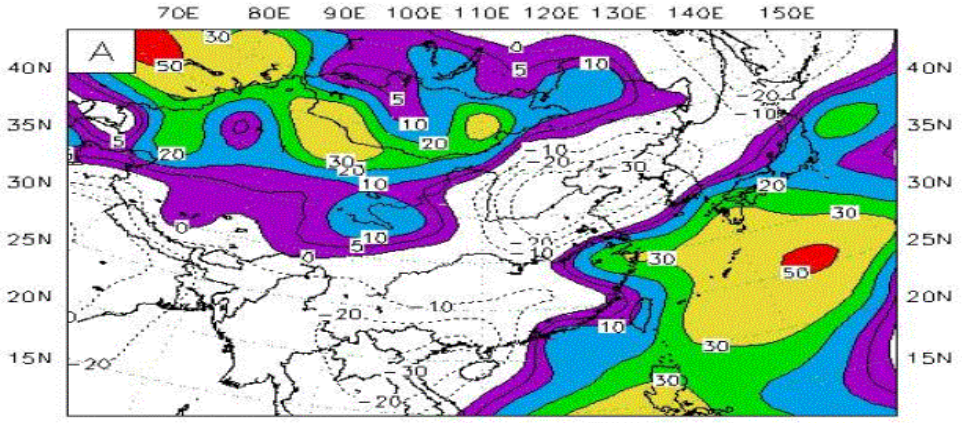

Fig.5 Predicted percentage rainfall anomaly over China during summer of 2001 by IAP PSSCA

4. Conclusion and discussions

By using IAP PSSCA, seasonal prediction of summer rainfall anomaly over China have been conducted. Verifications show that, the predicted patterns of summer rainfall anomaly for 1998,1999 and 2000 agree well with the observations, and these indicate that IAP PSSCA does show some skills in the prediction of summer rainfall anomaly over China.

However, there still exist some deficiencies for this IAP PSSCA. For example, the strength of the predicted positive anomalies over Yangtze river valley and Northeast China for 1998 are rather weak, as for 1999, the small regions with positive rainfall anomaly over North China has not been predicted. These deficiencies may be ascribed to the coarse resolution of the model, or the improper representation of certain physical processes within the climate model.

In order to further increase the predictive skill of IAP PSSCA, many improvements are still needed. One of the most important steps is the introducing of advanced high resolution AGCM. On the other hand, the initial conditions for the atmosphere and land surface are also quite important for the seasonal and extraseasonal climate prediction (e.g., Zeng et al., 1997; Fennessy and Shukla, 1999). So the initialization of the land surface characteristics for IAP PSSCA should be taken into account. Finally, the correction system has been proven to be quite important for the final prediction product (e.g., Zeng et al. 1994; Zeng et al., 1997; Zhao, 1999), so the more sophisticated correction system as suggested by Zeng et al. (1994) should be established in the near future for the further improvement of IAP PSSCA.