The Medium-range Forecast Verification of ECMWF in the summer of 1998

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Abstract

Take the ENMWF products at lead-time 120-h in the summer of 1998 for example, the forecast skills are tested from the point of view of operational forecast. The result shows that the ECMWF products have high predictive ability for the evolution and the adjustment tendency of the large circulation situation in Asia. The latitudinal and the meridional fluctuation tendency of the subtropical high forecasted by ECMWF are almost as same as observed. Especially in the last dekad of July 1998 ECMWF had successfully predicted the unusual phenomenon, which the subtropical high withdraw southward and eastward abnormally.

But there is systematic forecast deviation. In average, the intensity of the subtropical high forecasted by ECMWF was too strong. The latitude of the north-edge of the subtropical high forecasted was higher and the longitude of the west-edge of the subtropical high forecasted was smaller than that of the observed. By analyzing the forecast errors of 500hPa grid point height think that the major reason that causes the systematic forecast deviation of the subtropical high probably is due to the positive forecast errors in the mainland of China.

Introduction

Verifying and analyzing the Numerical Weather Prediction (NWP) products objectively and quantitatively and studying the predictive skills will help to improve the model and enhance predictive ability. As an operational forecaster, understanding the performance of NWP products timely and knowing it's systematic error are in favor of using the products. It is valuable to interpretation NWP products efficiently and raising forecast accuracy. It can be known which information from NWP products are correct and which one is not.

In the summer of 1998, there was sustained heavy rain in a large area of Yangtze River Valley, China. It had caused an unusual flood, which is rare in its histories. How is the forecast performance of ECMWF products in this period? In this paper, take the ENMWF products at lead-time 120-h in the summer of 1998 for example, the forecast skills are tested from the point of view of operational forecast. The main purpose is to obtain some useful conclusion in order to guide interpretation of ECMWF products in summer.

1. forecast ability of the circulation pattern at middle-high latitude in Asia

The changes of the westerly circulation index express the evolution and the adjustment

tendency of the large circulation situation, and it is one of major parameters used in the operational medium-range weather forecast. Figure 1 illustrates the daily westerly indexes (WI) in Asia on 500hPa level in 1998 from June to August, which are observed and forecasted by ECMWF at lead-time 120h. The variation period was about one month in June of 1998. The circulation pattern was low index circulation pattern before the 21 June, high index from 22 June to 15 July and low index after 16 July of 1998. In the period of low index, the exchanges between North and South are violently and it is in favour of rain. The curves show that variation tendency of the forecasted WI by ECMWF at lead-time 120h is basically as same as the observed. Especially, in July and August the two curves are so close as one. This indicates that the ECMWF products have high predictive ability for the evolution and the adjustment tendency of the large circulation situation in Asia, which is a reliably foundation for making medium-range weather forecast. But in June, the predictive skill of WI is slightly poor; the fluctuation and forecast errors of WI are quite bigger.

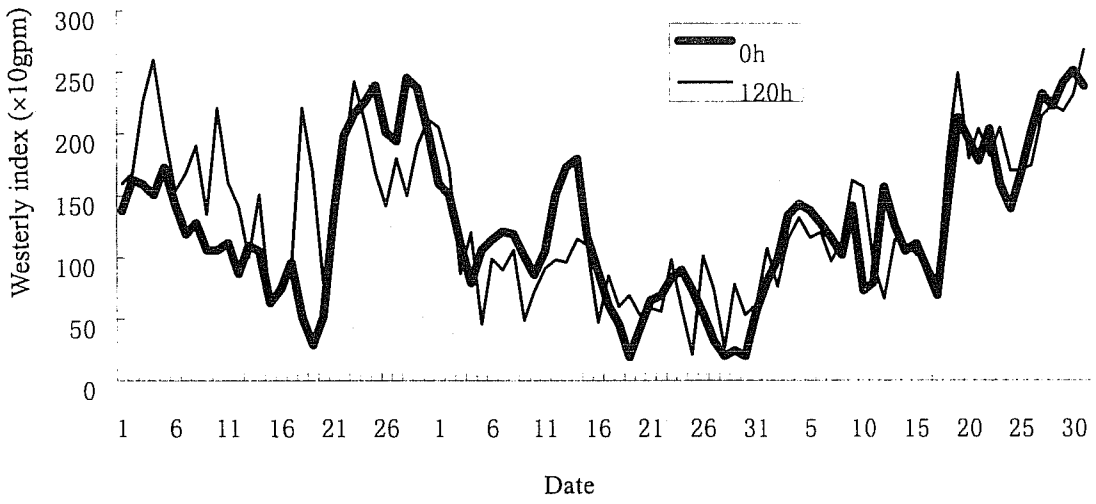

Figure 1.The daily westerly indexes in Asia on 500hPa level are observed and forecasted by ECMWF at lead-time 120h in June~August of 1998

The result of power spectrum analysis (Huang Jiayou, 1990) for the observed and forecasted WI in summer of 1998 is listed in table 1. The preferred wave numbers of the observed WI are 1-7 and 10. Waves of number 1-4, which corresponding wave periods are 92, 46, 30.7 and 23 days respectively, have passed through the significance test at the level that α is 0.05. The wave period of number 10 is about 9 days, but it had not passed through the significance test. The wave power of WI forecasted declined rapidly with the growing of weave number. The preferred wave numbers of forecast are 1-5, 14, and 21. Waves of number 1 and 3, the corresponding wave period are 92 and 30.7 days individually, have passed through the significance test only. The wave period of number 14 and 21 are 6.5 and 4.4 days.

The results of the power spectrum analysis indicate that the periodicity of the forecasted WI was worse than that of the observed in summer of 1998. In addition, there are a few short-wave fluctuations, which periods are about 6.5 days and 4.4days, on the forecasted curve, which reflects that the stability of model is not perfect.

Table 1 The power spectrum of WI observed and forecasted in the summer of 1998

Weave Number	Power 0h	120h	Weave Number	Power 0h	120h	Weave Number	Power 0h	120h
1	757.16	1764.41	16	14.69	17.08	31	20.91	27.17
2	818.34	173.11	17	16.94	8.36	32	5.07	27.28
3	421.17	269.39	18	8.59	55.06	33	8.56	0.31
4	334.94	130.62	19	3.82	68.28	34	9.35	15.88
5	219.11	128.73	20	4.43	23.55	35	0.56	5.3
6	112.24	9.61	21	14.56	109.28	36	0.03	22.09
7	201.75	36.76	22	6.76	0.04	37	1.89	12.25
8	41.79	60.35	23	2.39	14.62	38	2.31	2.06
9	54.17	65.41	24	0.9	75.14	39	2.58	0.73
10	117.56	6.07	25	61.2	35.21	40	1.11	0.83
11	82.2	36.44	26	7.87	14.27	41	1.29	13.09
12	89.83	1.53	27	9.55	7.25	42	5.73	46.72
13	41.02	44.71	28	7.97	23.09	43	1.61	14.69
14	52.39	122.05	29	12.65	1.83	44	1.7	1.2
15	14.15	34.75	30	3.46	12.39	45	0.15	19.7

2 predictive ability of the subtropical high over the northwest pacific

The precipitation area and intensity in China in summer are closely related the activities of the subtropical high over the northwest pacific (Zhang Jijia, 1994). So the predictive ability of NWP products for the subtropical high (SH) over the northwest pacific has a considerable effecting on the operational precipitation forecast.

2.1 forecast of the latitudinal fluctuation tendency of SH

There is a close relationship between the rain belt in China and the north-edge of SH in summer. The rain belt in China always locates in the north of the north-edge of SH. The latitude of north edge of 5880gpm and 5840gpm contour, which are the expressions of the north-edge of SH, are the measurements of the latitudianl fluctuation of SH.

Figure 2 shows the daily latitude of north edge of 5880gpm and 5840gpm contour at 120°E June-August of 1998, which are observed (a) and forecasted by ECMWF at lead-time 120h (b). The SH moved northward in June and had reached its most north position 38°N at 12 July. In 13-25 July SH moved southward more than 20° in latitude. The SH moved northward again in 26 July-2 August and was staying in a relatively high latitude position continuously in 2-24 August. The SH moved southward again from 25 August. Compared between Fig.2 (a) and (b), ECMWF

products had basically predicted the latitudinal fluctuation process of SH. Especially, in the last dekad of July SH usually cover the middle and lower reaches of Yangtze River of China at the mean climatic state. But in 1998 SH moved southward abnormal and covered the south China. This unusual phenomenon of SH was predicted correctly by ECMWF, which provide a reliable foundation for forecast rain belt in the middle and lower reaches of Yangtze River.

On the contrary, in 22-24 June, SH moved back eastward and the 5880gpm contour disappeared at the west of 120°E while it lay to the North of 25°N at the 120°E line forecasted by ECMWF. According to the forecast, it would be clear in South China because SH covers this area. But in actuality, there was sustained storm rainfall in this period in South China. This process was missing forecasted by ECMWF and this failure had an adverse influence on operational weather forecast.

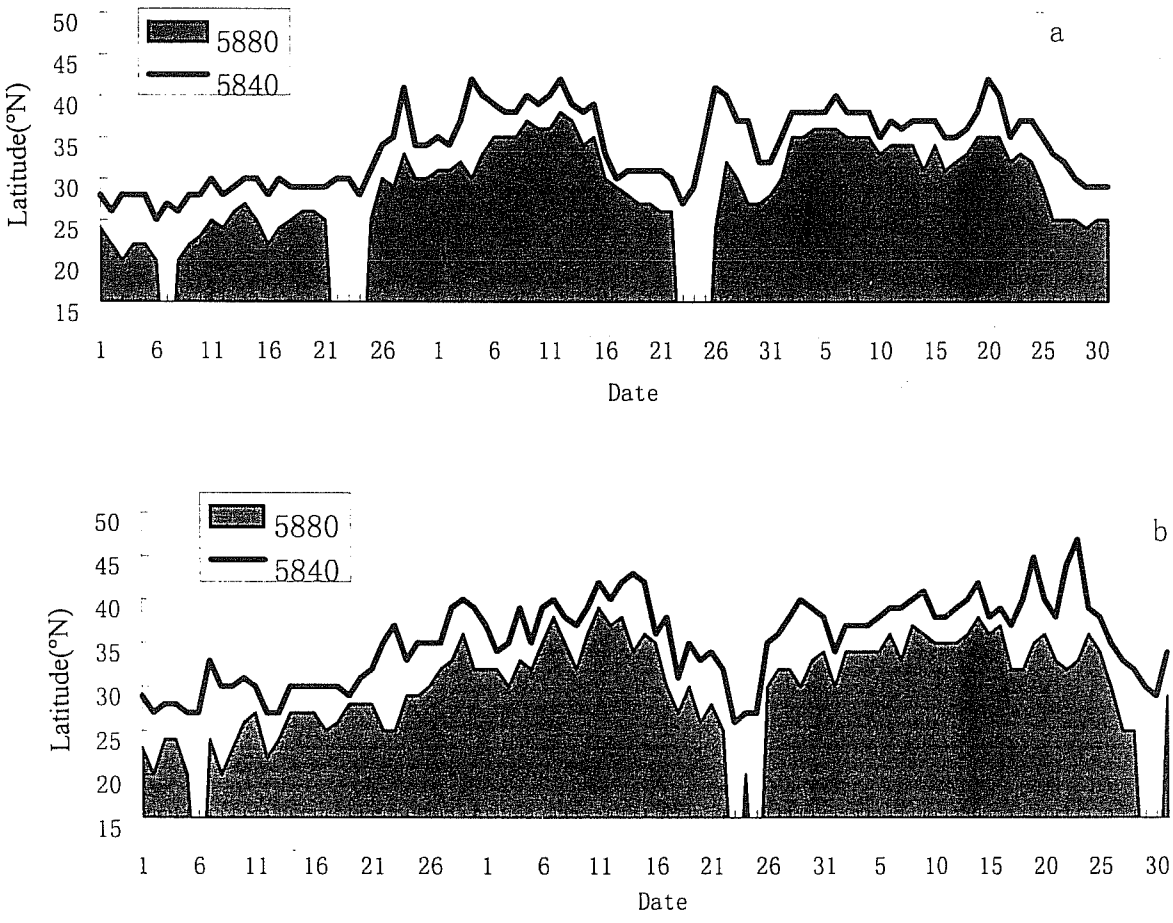

Figure 2. The daily latitude of north edge of 5880gpm and 5840gpm contour at 120°E June-August of 1998 are observed (a) and forecasted by ECMWF at lead-time 120h (b).

Now, compare the daily latitude of north edge of 5880gpm contour at 120°E forecasted by ECMWF with the observed in the summer of 1998 in order to analysis the forecast error of the

north-edge of SH. Figure 3 shows that the evolution tendencies of the two curves are very much alike. It indicates that the change tendency of the north-edge of SH forecasted by ECMWF is basically correct. But there are systematic errors, which the latitude of the north-edge of SH forecasted is higher than that of observed on the average. In the period of June to August the mean error is 1.2° in latitude and the frequency when the forecast higher than observation is 54%. The monthly mean error in June, July and August is 1.9°, 1.1° and 0.7° in latitude respectively, and the corresponding frequency is 67%, 55% and 42% individually.

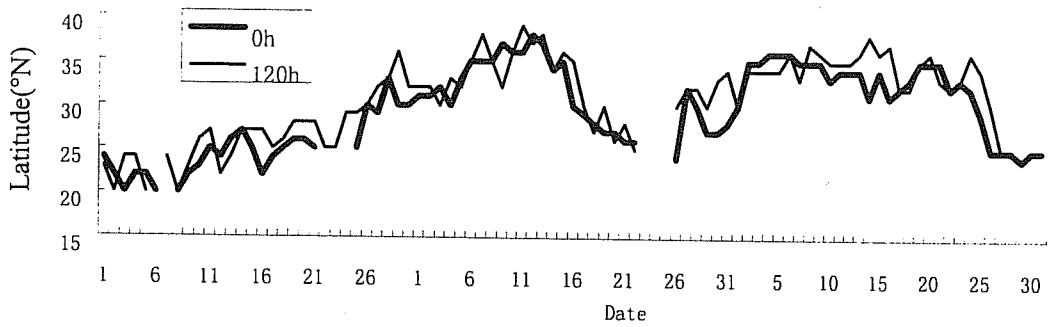

Figure 3. The daily latitude of the north edge of 5880gpm contour at 120°E are forecasted by ECMWF and observed in the summer of 1998.

2.2 forecast of the meridional fluctuation tendency of SH

The meridional fluctuation of SH is the expression of the intensity variation of SH and the evolution of low-latitude circulation situation. It has a considerable influence on the precipitation distribution in China. The position of the west-edge of SH is one of the important parameters, which express the meridional fluctuation of SH.

The daily positions of the west-edge of SH in June-August of 1998, which are observed and forecasted by ECMWF at lead-time 120h, are showed on figure 4. In the most times of the summer in 1998, the west-edge of SH was in the west of 120°E, except the periods of 7-8 June, 22-24 June and 20-25 July which exactly corresponding to the periods when the north-edge of SH disappearing in figure 3. The two curves illustrate that the forecast skill of ECMWF for the west-edge of SH was quit well. ECMWF has simulated the most processes of the meridional fluctuation of SH correctly in the summer of 1998. Especially from the last dekad of July to the first dekad of August, ECMWF has successfully predicted a meridional fluctuation process, in which SH move back and forth greatly. But the predictive skill for the west-edge of SH in June was much lower than that in July and August. Sometimes the movement tendency of SH between the forecast and observation was in the opposite direction, for instance, in the periods of 6-13 and 17-28 June.

Figure 4 clearly show that the positions of the west-edge of SH forecasted by ECMWF are

obviously in the west side of the observed. The frequency when the west-edge of SH forecasted located in the west of the observed was as high as 78% in the summer, 1998 and which in June, July and August was 83%, 77% and 74% respectively. Particularly in June 1998, the frequency was the highest and the difference between forecast and observation was the biggest.

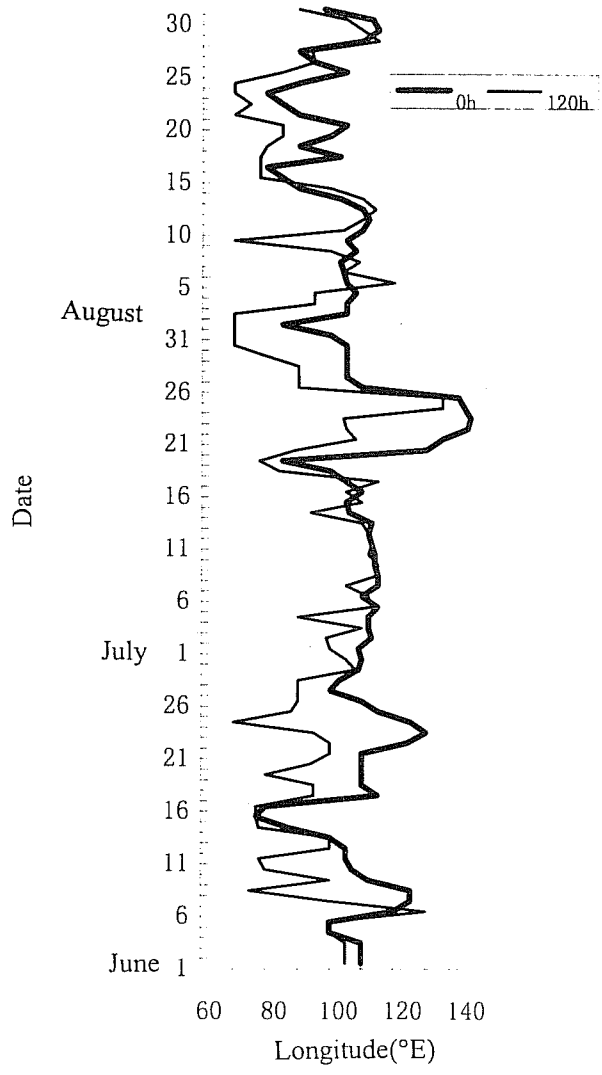

Figure 4. The daily positions of the west-edge of the subtropical high in June-August of 1998 are observed and forecasted by ECMWF.

3 forecast errors of 500hPa grid point height

The forecast errors of 500hPa grid point height for the grid length 5°×5° are calculated in the summer of 1998. Figure 5 shows the distribution of mean forecast errors (a) and mean absolute forecast errors (b). The mean forecast errors were positive in the mainland of China in the summer

of 1998. Both the mean forecast errors and the mean absolute forecast errors are bigger than 10gpm in the mainland of China. The mean absolute forecast errors are raising gradually from low to high latitude. In other words, the intensity of high forecasted by ECMWF was too strong and that of low was too weak in average over the mainland of China.

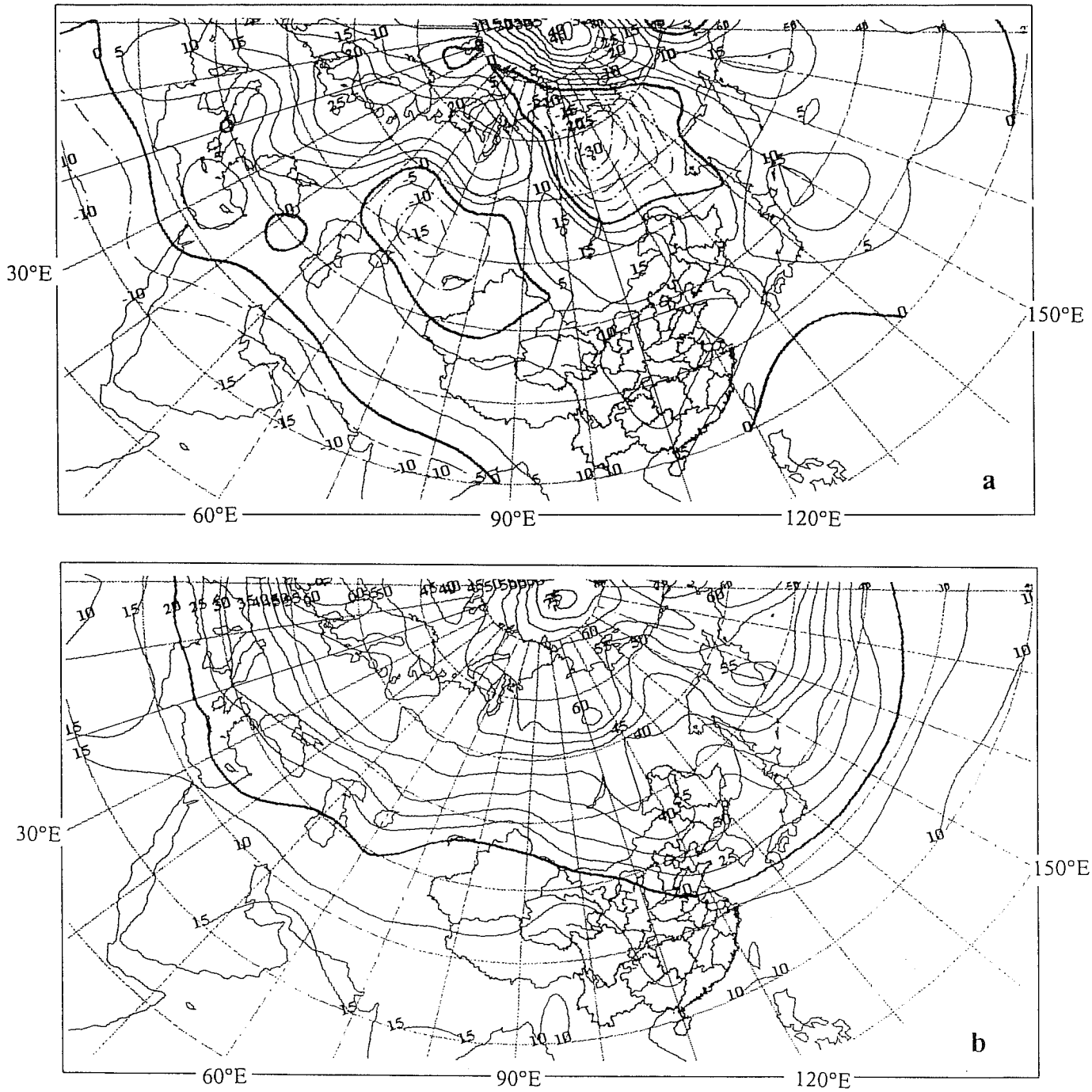

Figure 5. The distribution of mean forecast errors (a) and mean absolute forecast errors (b)

Figure 6 is the probability distribution of the forecast errors at 5 grid points on the 500hPa-height field. At the grid point of 20°N, 120°E, the probability distribution of forecast errors is symmetrical, forecast errors range from –20 to 30gpm, and the mean error equals to zero. The probability distribution of forecast errors deflect to right side of zero from the point of 120°E to west on the line of 20°N, i.e. the frequency of positive forecast errors is higher than that of negative forecast errors. Similarly, absolute errors and the frequency of positive forecast errors are raising from the point of 20°N to north on the line of 120°E . Forecast errors range from –30 to 60gpm and –100 to 100gpm at the point of 30°N and 40°N individually.

From the distribution of forecast errors we may conclude that the reason, which causes that the latitude of NP-SH forecasted are higher and the longitude of WP-SH forecasted are smaller than that of the observed, is the positive mean forecast errors in the mainland of China. That is to say, forecast errors in the mainland of China cause the forecast of the intensity of SH too strong and lead to the latitude of NP-SH forecasted are higher and the longitude of WP-SH forecasted are smaller than that of the observed.

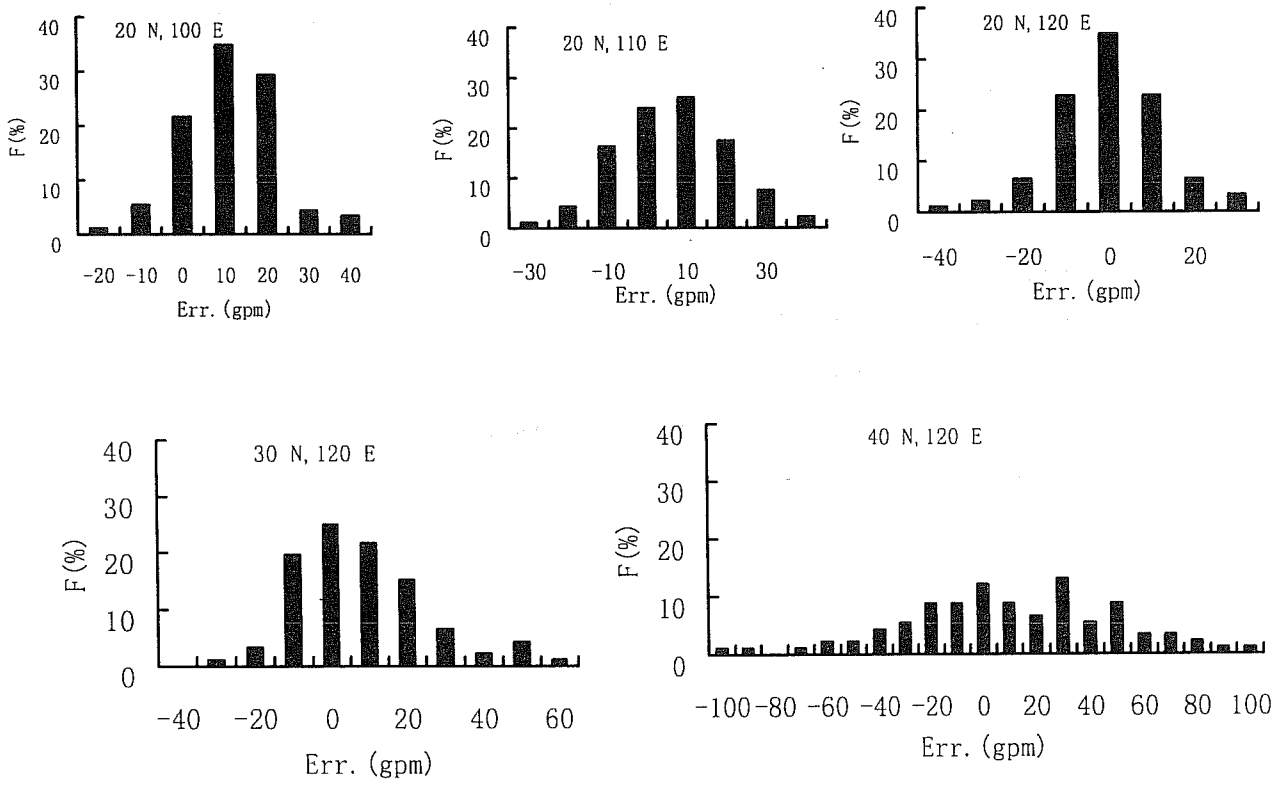

Figure 6. The probability distribution of the forecast errors at 5 grid points on the 500hPa-height field.

4 Conclusion

(1) The ECMWF products have high predictive ability for the evolution and the adjustment tendency of the large circulation situation in Asia in the summer of 1998.

(2) The latitudinal and the meridional fluctuation tendency of SH forecasted by ECMWF were almost as same as observed. Especially in the last dekad of July 1998 ECMWF had successfully predicted the unusual phenomenon, which SH withdraw southward and eastward abnormally.

(3) In average, the intensity of SH forecasted by ECMWF was too strong and the latitude of the north-edge of SH forecasted was higher and the longitude of the west-edge of SH forecasted was smaller than that of the observed. This systematic forecast deviation was remarkable in June. It had missing forecasted a process in which SH withdraw southward and eastward in 22-24 June.

(4) The mean forecast errors and the mean absolute forecast errors of 500hPa grid point height were bigger than 10gpm in the mainland of China. The absolute error and the frequency of positive errors were raising from the point of 20°N, 120°E to north and west. The major reason that causes the systematic forecast deviation of SH probably was due to the positive forecast errors in the mainland of China.

(5) Not only the forecast ability of the westerly index and subtropical high over the northwest pacific but also forecast errors of 500hPa grid point height, show that the forecast skills are slight poor in June.

Reference:

1 Huang Jiayou, Meteorological Statistical Analysis and Forecast Method. Beijing: Meteorological Press. 1990,4: 300-333

2 Zhang Jijia, The Basis of Long- and Medium-range Weather Forecast. Beijing: Meteorological Press. 1994,4: 450-464