TECHNICAL MEMORANDUM

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A preliminary verification from China to ECMWF 500 mb numerical products

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1. Introduction

The Xin-jiang Weather Bureau, China, has received the ECMWF 500mb numerical products from 2 August 1982. The forecast times available are 48, 72, 96 and 120 hours. The area is bounded from 20°N to 90°N and 0°E to 90°E, but 0°E to 180°E for the 120 hour forecast. First experiences of using the ECMWF products in the operational weather forecast during August to October 1982 were good, and so, since 5 October 1982, the Xin-jiang Weather Bureau has transmitted the ECMWF maps and some data to the county stations of the Region by facsimile and broadcast.

Following requests from the National Weather Bureau and the suggestion of Professor T.C. Yeh, this preliminary report has been written to report on the experiences of the ECMWF products in Xin-jiang Weather Bureau. It is hoped this paper will be found useful by meteorologists who will be using the European Centre's products in Asia.

2. Analysis of the correlation coefficient and monthly mean error

2.1 Correlation Coefficient

Figure 1 is the correlation coefficient of the 500mb geopotential height between ECMWF 72 hour forecasts and the locally-produced analyses during August to October 1982. It is evident that the correlation between the forecast and analyses is quite good. From Fig. 1, the following points are worth noting:

i. In the computed region, the ECMWF forecasts correlate highly with the analyses.

ii. The forecast results are better in the middle and high latitudes than in the low latitudes. Also, they are better in Asia than in Europe.

iii. For the forecasts of middle and high latitudes, the results in eastern Siberia are best. For the lower latitudes, i.e. in the regions of Xin-jiang, China and from the Mediterranean to the Black Sea, the forecast becomes a little worse.

2.2 Mean forecast errors in August 1982

The monthly mean 48 hour and 120 hour forecast 500mb geopotential heights and their deviations from the mean analyses in August 1982 were calculated, i.e.

$$\overline{\Delta Z_{48}} = \overline{(Z \text{ predicted value})_{48}} - \overline{(Z \text{ analysed})}$$

$$\overline{\Delta Z_{120}} = \overline{(Z \text{ predicted value})_{120}} - \overline{(Z \text{ analysed})}$$

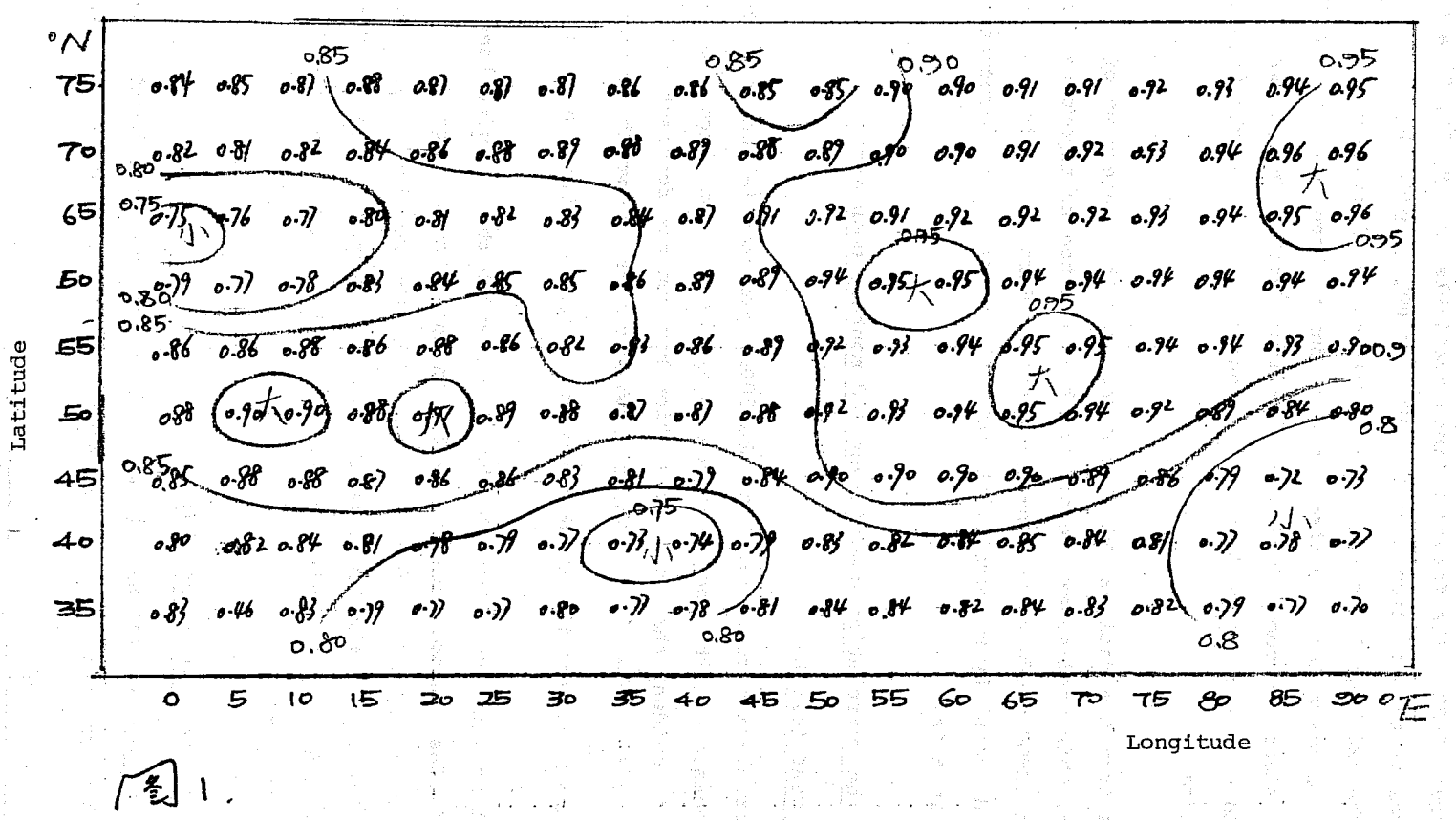

Fig. 1 The correlation coefficient between 72 hour forecast and analysed 500mb height

where "—" indicates monthly averages. This is shown in Fig. 2 and Fig. 3. From these figures, it can be seen that:

i. over the whole field, the monthly averaged numerically predicted heights are lower than those analysed, i.e. there is a large area of negative deviation. This indicates that a weaker field is predicted for high value weather systems and a stronger field (too deep) is predicted for low value weather systems. The absolute value of the negative deviation is larger for 120 hour forecasts than for 48 hour forecasts, but in the northern region from 75°N and in the northern part of India, there were positive deviations in both the 120 hour and 48 hour forecasts.

ii. the latitude variation of the deviation field indicates that it reaches a minimum at high and low latitude while it is large in middle latitudes. North of 70°N, it is less than 10 gpm. South of 35°N, it is less than 30 gpm. The largest deviation is concentrated in the 35°N - 55°N belt. In the area of western Europe, the eastern Black Sea and Balkhash lake, it is -60, -50 and -70 gpm respectively. The deviation of the 120 hour forecast is large in the 40°N -70°N belt, and in Europe, it exceeds -80 gpm.

iii. note that the forecast errors, both for 48 hour and 120 hour, indicate that in Europe, the Aral Sea and Balkhash lake area, the negative deviation is very pronounced. This large scale error may be considered as a systematic error of the ECMWF forecasts.

3. Westerly zonal indices predicted from ECMWF products

Two belts of zonal index from 0°E - 90°E, one in 30°N - 50°N (southerly) and the other in 50°N - 70°N (northerly), are calculated from ECMWF forecast products and compared with those calculated from the analyses. These are shown in Fig. 4 for 48 hour forecasts and Fig. 5 for 120 hour forecasts. The 48 hour forecasts of ECMWF correspond well to the analysed (Fig. 4) while the 120 hour forecasts (Fig. 5) give the tendency of the variation of the index. Table 1 gives the variance of the forecast deviation of the indices.

	50°N - 75°N	30°N - 50°N
48 hour forecast	1.13	0.89
120 hour forecast	1.94	1.41

Table 1 The variance of the forecast deviation of the zonal indices

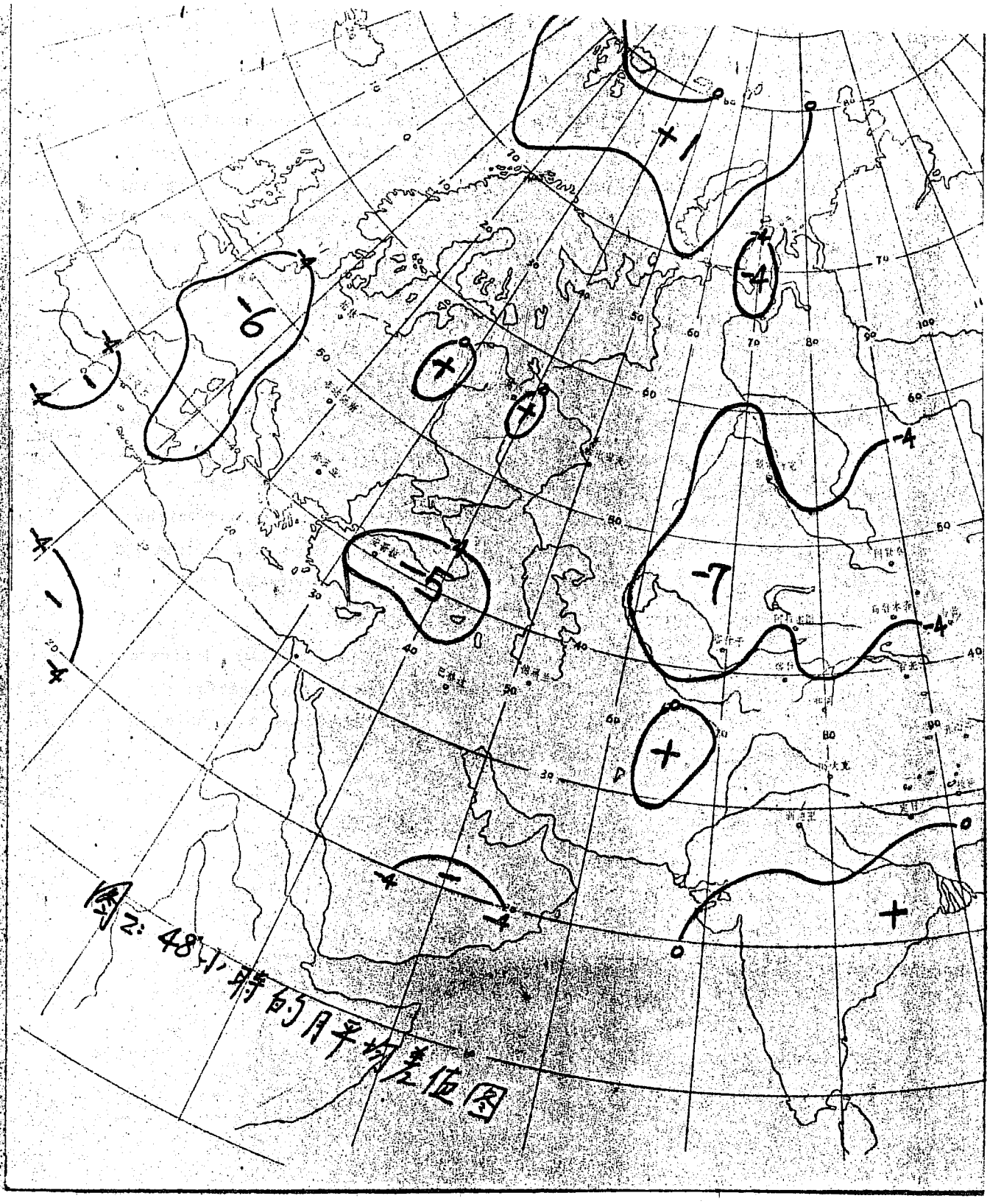

Fig. 2 Monthly average of deviation of 48 hour predicted 500mb height from the analysed

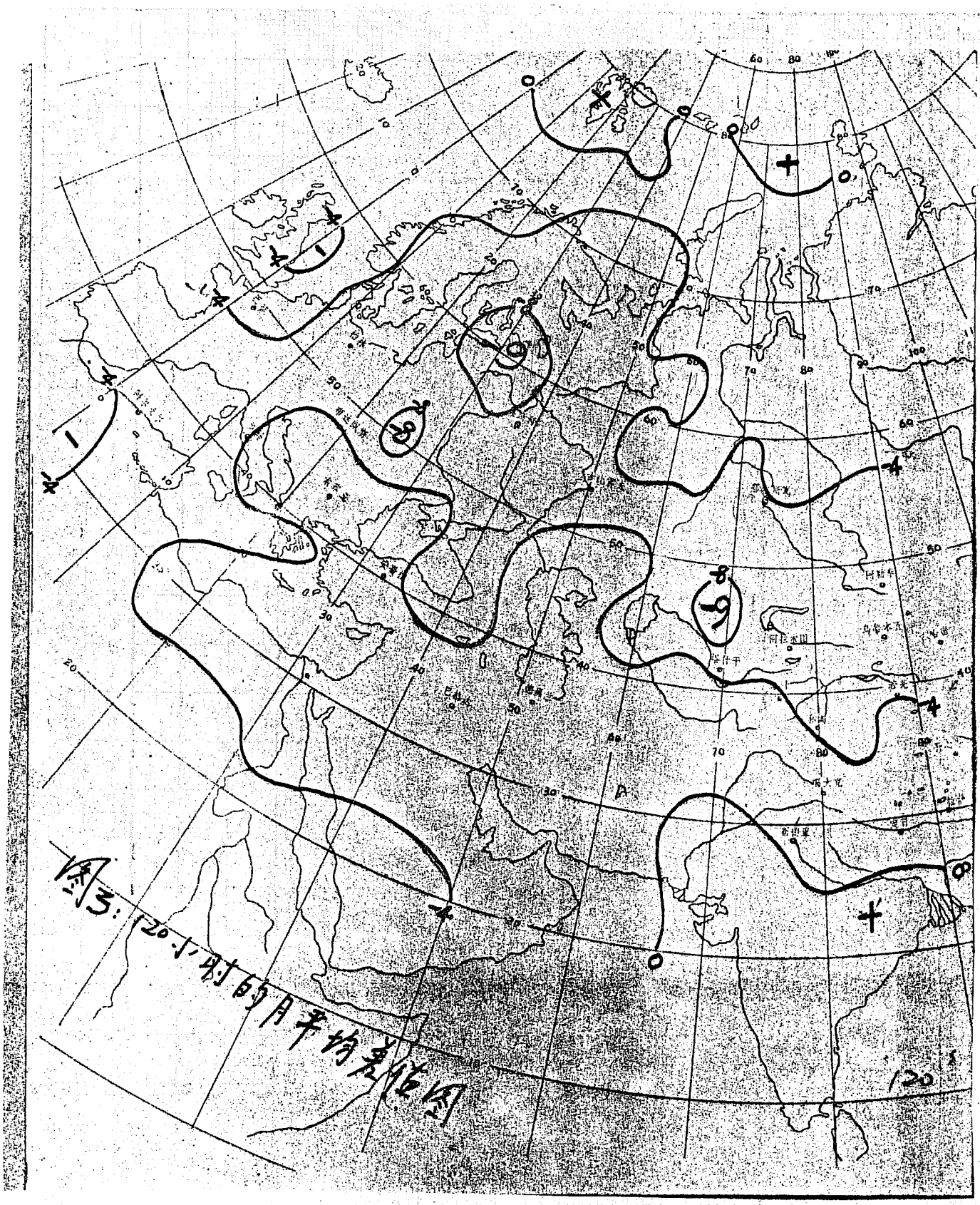

Fig. 3 Mean deviation of the 120 hour predicted 500mb height from the analysed

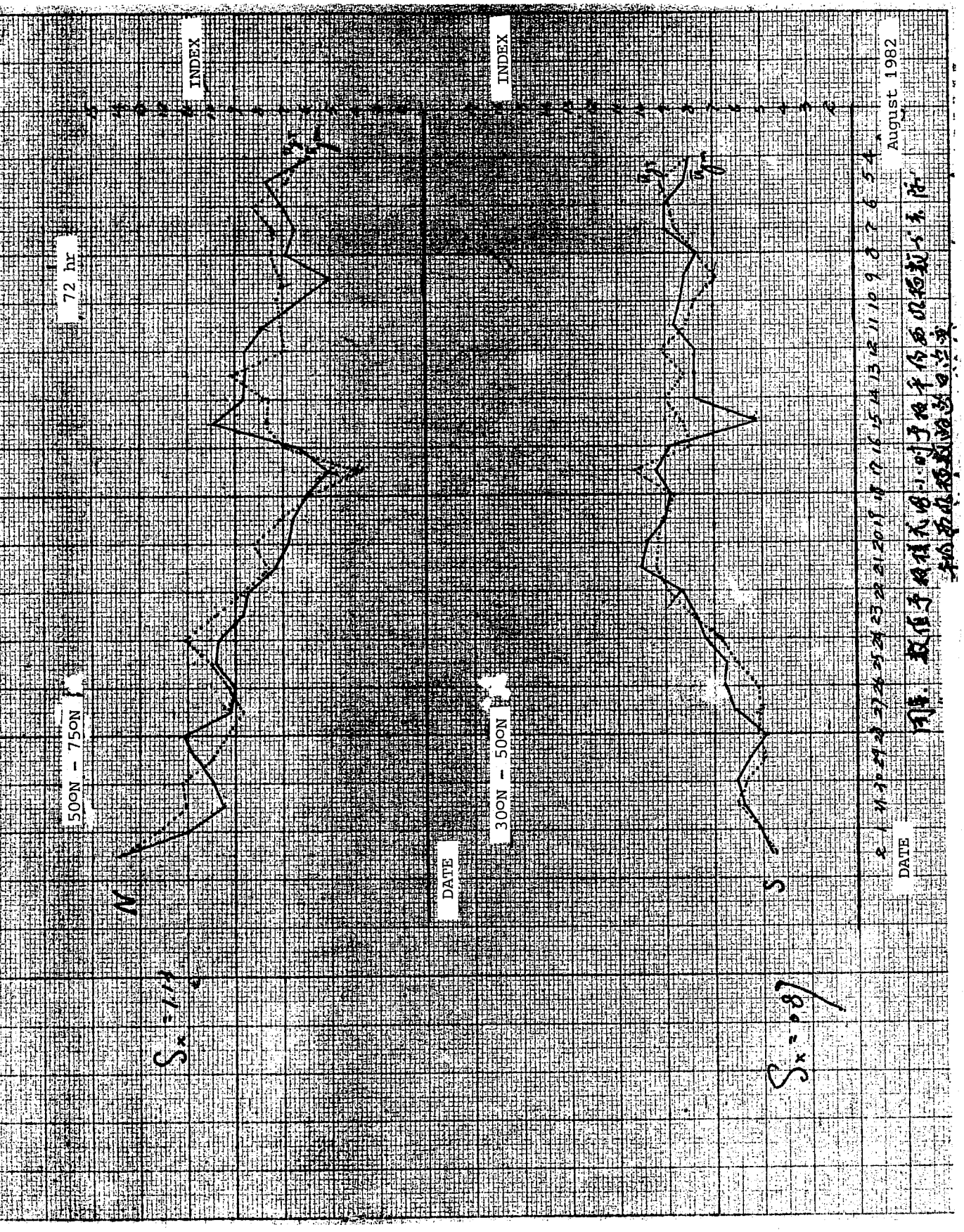

Fig. 4 Variation of the zonal index during 4 August to 2 September 1982 (from right to left). Solid line denotes analysed, dashed line denotes 72 hour forecast values

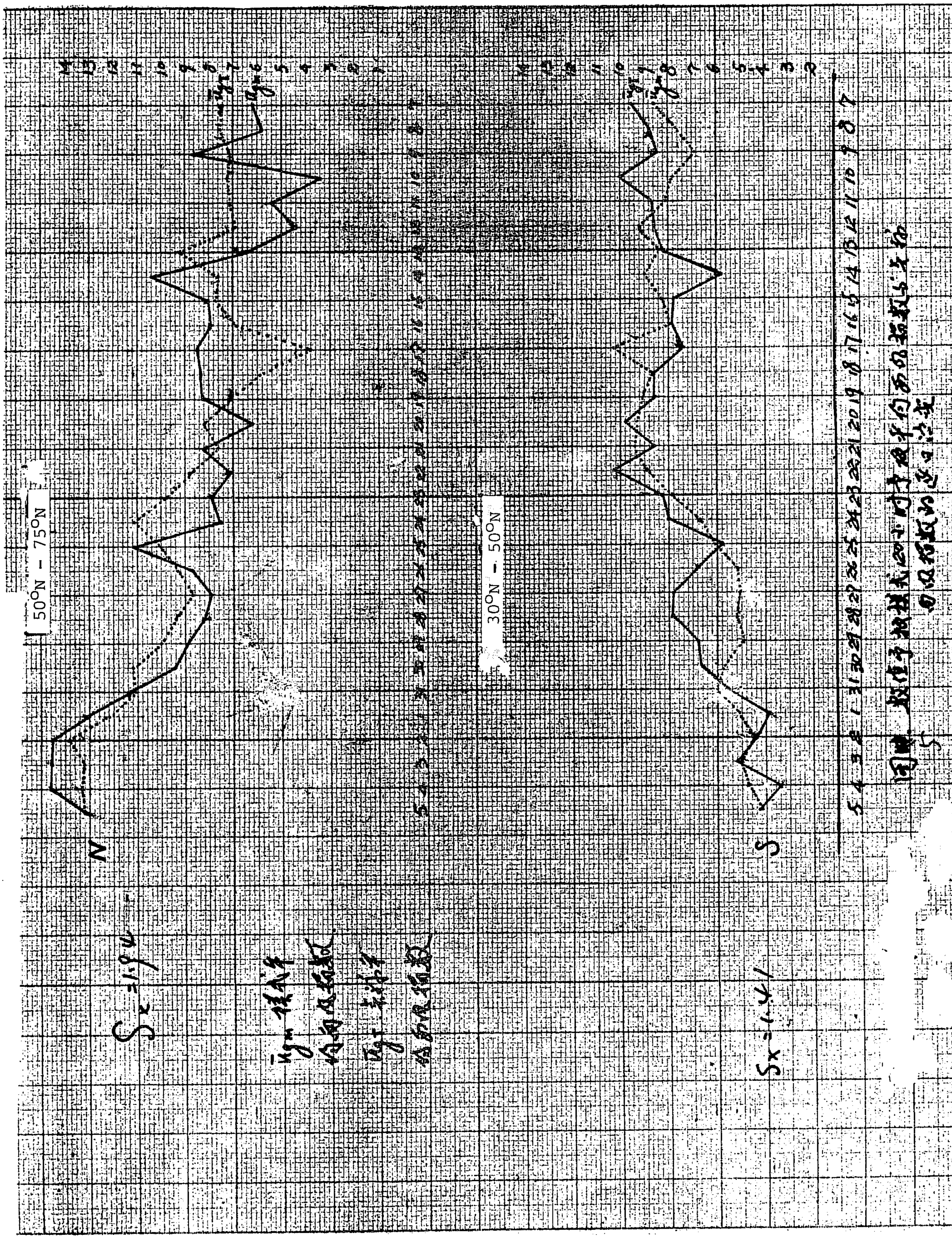

Fig. 5 As for Fig. 4 but for 120 hour forecast

4. Prediction of variations of the circulation pattern

Variations of the large scale circulation are most important in weather prediction. A "weather process" is composed of a combination of the large-scale circulation pattern, influencing synoptic systems and local weather phenomena. It is most important to verify the model's ability to predict the weather process.

There were five weather processes during August 1982 in Xin-jiang:

i. 4.8.82 12GMT - 7.8.82 12GMT. The west European ridge was maintained, and under the influence of a disturbance in southern jet, moderate rain was recorded.

ii. 7.8.82 00GMT - 12.8.82 00GMT. This process was accompanied by a change in the long waves. The southern European ridge developed, the low over Novaya Zemlya (Kara Sea) moved southward, and the trough over the Ural mountain moved eastward.

iii. 12.8.82 00GMT - 17.8.82 00GMT. The polar high moved westward to Kara Sea. The trough over Europe weakened and moved eastward to Xin-jiang.

iv. 17.8.82 00GMT - 24.8.82 12GMT. Accompanied by a change of long waves, the trough at the European Atlantic coast developed; the ridge over Europe moved eastward to the Urals and developed into a closed high. A trough oriented west to east on the south side influenced Xin-jiang.

v. 25.8.82 00GMT - 31.8.82 00GMT. This was the strongest weather process. A large area of precipitation over southern Xin-jiang occurred and, in the later stage, a pronounced temperature drop was recorded in northern Xin-jiang. On 25 August, the east-west trough over central Asia was cut off and a cold vortex was formed. The Indian low developed and interacted with this vortex. At the same time, the Pacific sub-tropical high developed and extended westward. Heavy rainfall occurred over the south western part of Xin-jiang. On 29 August, the cold vortex weakened and moved into Xin-jiang and caused a temperature drop in northern Xin-jiang.

ECMWF's forecasts for these five weather processes were essentially correct, especially for those of 11-12 August, i.e. the redevelopment of the European ridge; 23-24 August, the forming of the middle Asia level trough, and 25-31 August, the cut-off cold vortex. The meteorologists in Xin-jiang were deeply impressed by the forecasts.

To verify further the model's ability, the area was divided into four principal parts: 1) 20° - 50°E, 50° northward. 2) 50° - 80°E, 50° northward. 3) 10° - 35°E, 50°N southward. 4) 45° - 65°E, 50°N southward. These four areas are the key areas for the Xin-jiang weather forecast.

For these four areas, we calculated the error of the model forecast; the results are shown in Table 2.

HOURS	AREA NO.	DATE 4	6	11	16	23	25	27	29	Correct frequency	Wrong f/c
	I	-8	<-4>	<-4>	-4	-4	-4	-4	4	7/8	0
48 hr	II	<-4>	-4	0	-4	-8	-4	-4	-4	7/8	0
Forecast	III	-4	<-4>	-4	4	-4	4	-8	-4	7/8	0
	IV	-4	-4	<-4>	-4	4	-8	0	-4	7/8	0
	I			4	-16	-8	-12	-16	-12	1/6	4/6
120 hr	II	NO	NO	-12	12	-16	8	-8	-8	0	3/6
Forecast	III	DATA	DATA	-8	-4	-4	4	-8	-4	4/6	0
	IV			-4	-4	4	-4	-8	-4	5/6	0

Table 2 The forecast error (10 gpm) of the model in 4 key areas. <-4> means that the error is less than -4.

If we define an absolute error of 40 gpm or less to be correct, and an absolute error larger than 80 gpm to be wrong, Table 2 shows that the 48 hour forecasts are all correct and, for the 120 hour forecasts in key areas III and IV, they are also essentially correct. This indicates a high prognostic ability of the ECMWF model.

5. Example of an operational forecast

We conclude with an example of an operational forecast made from ECMWF products in October 1982.

Fig. 6 is the 500mb chart manual analysis. A blocking high occurred over Europe and a trough over Ural mountain. The weather in Xin-jiang, dominated by a flat ridge, was fine. The key point is: when will this blocking be destroyed and how? The 120 hour forecast from the analysis of 2 October, valid for 7 October (Fig. 7) and 72 hour forecast from the analysis of 4 October (Fig. 8) both give a correct forecast as we may compare Fig. 7 and Fig. 8 with the manual analysis 500mb chart on 7 October (Fig. 9). In the discussion of the weather forecast, according to ECMWF's forecast on 6 October afternoon, a weather prognosis of an intense cold air outbreak in Xin-jiang was issued.

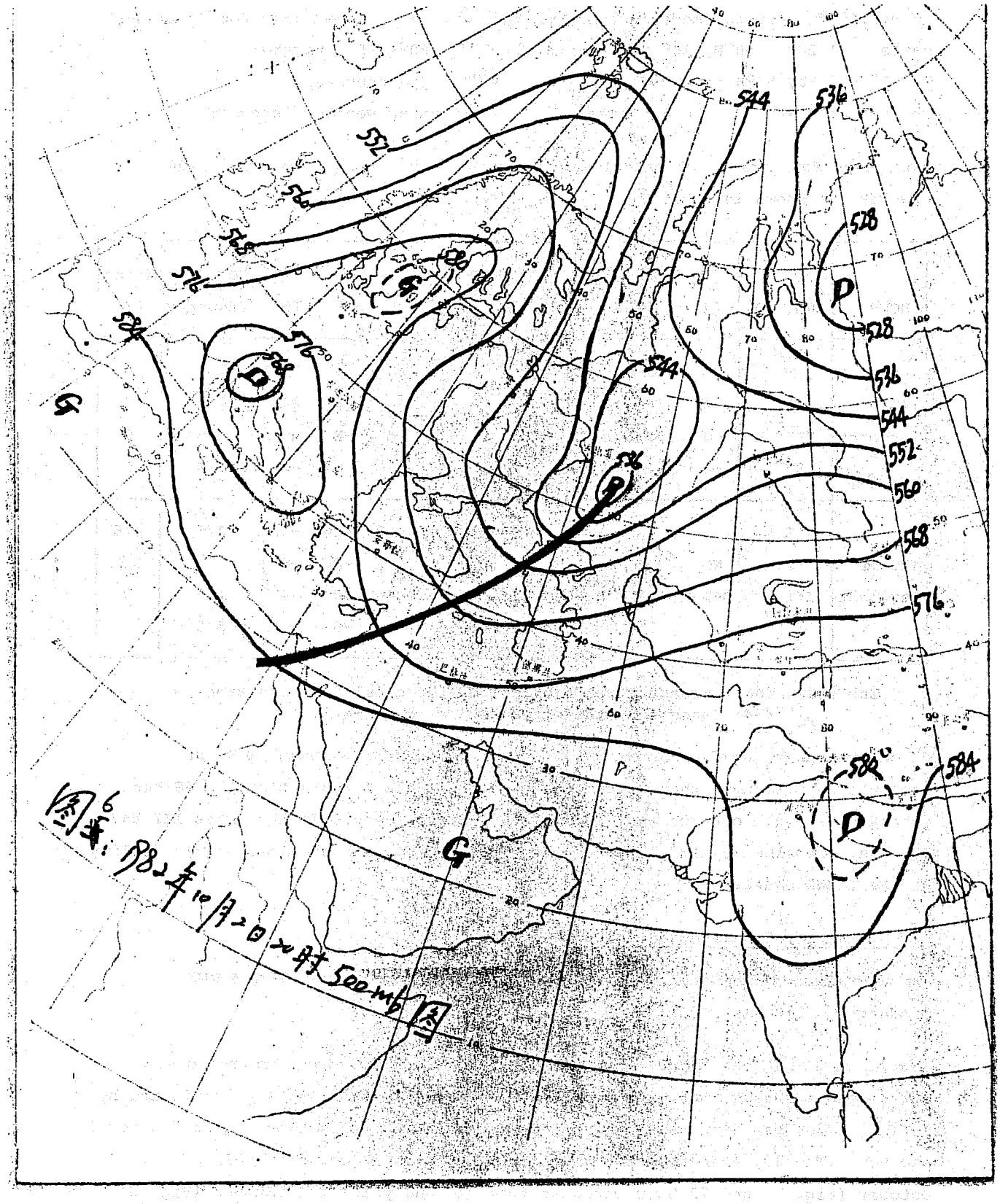

Fig. 6 500mb 2 October 1982 12GMT - Initial data

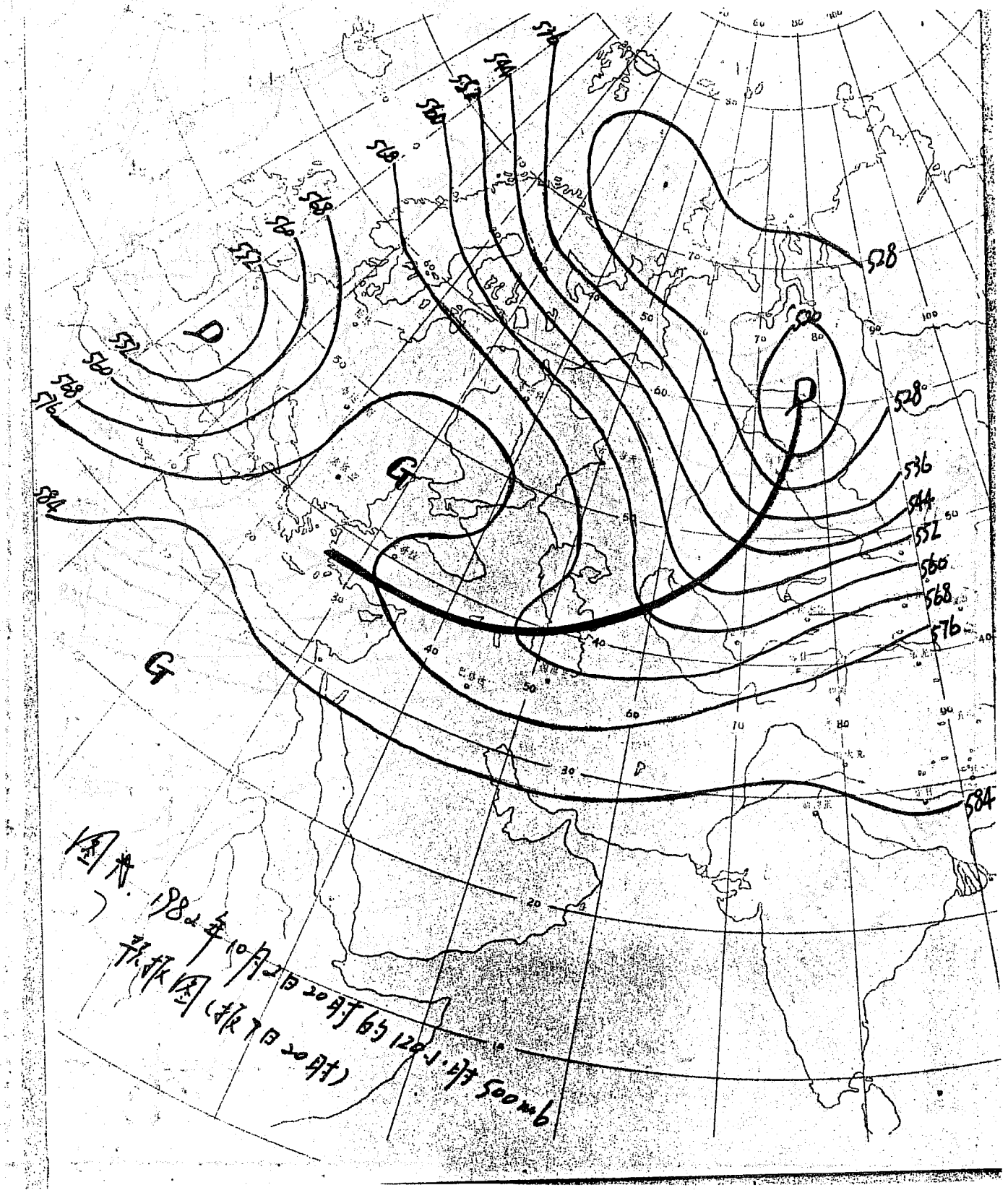

Fig. 7 120 hour forecast from 2 October 1982
V.T. 7 October 1982 12GMT

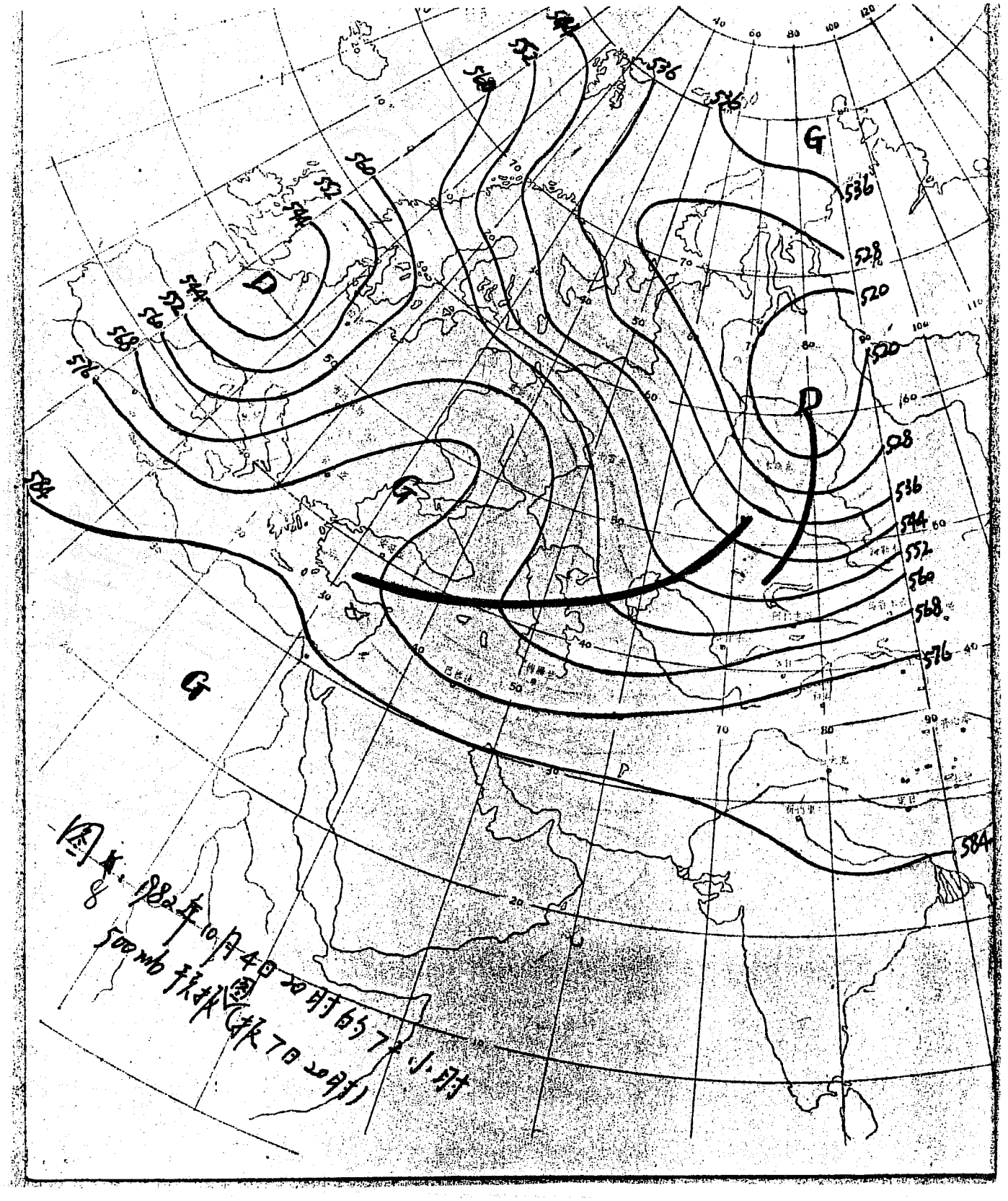

Fig. 8 72 hour forecast from 4 October 1982

V.T. 7 October 1982 12GMT

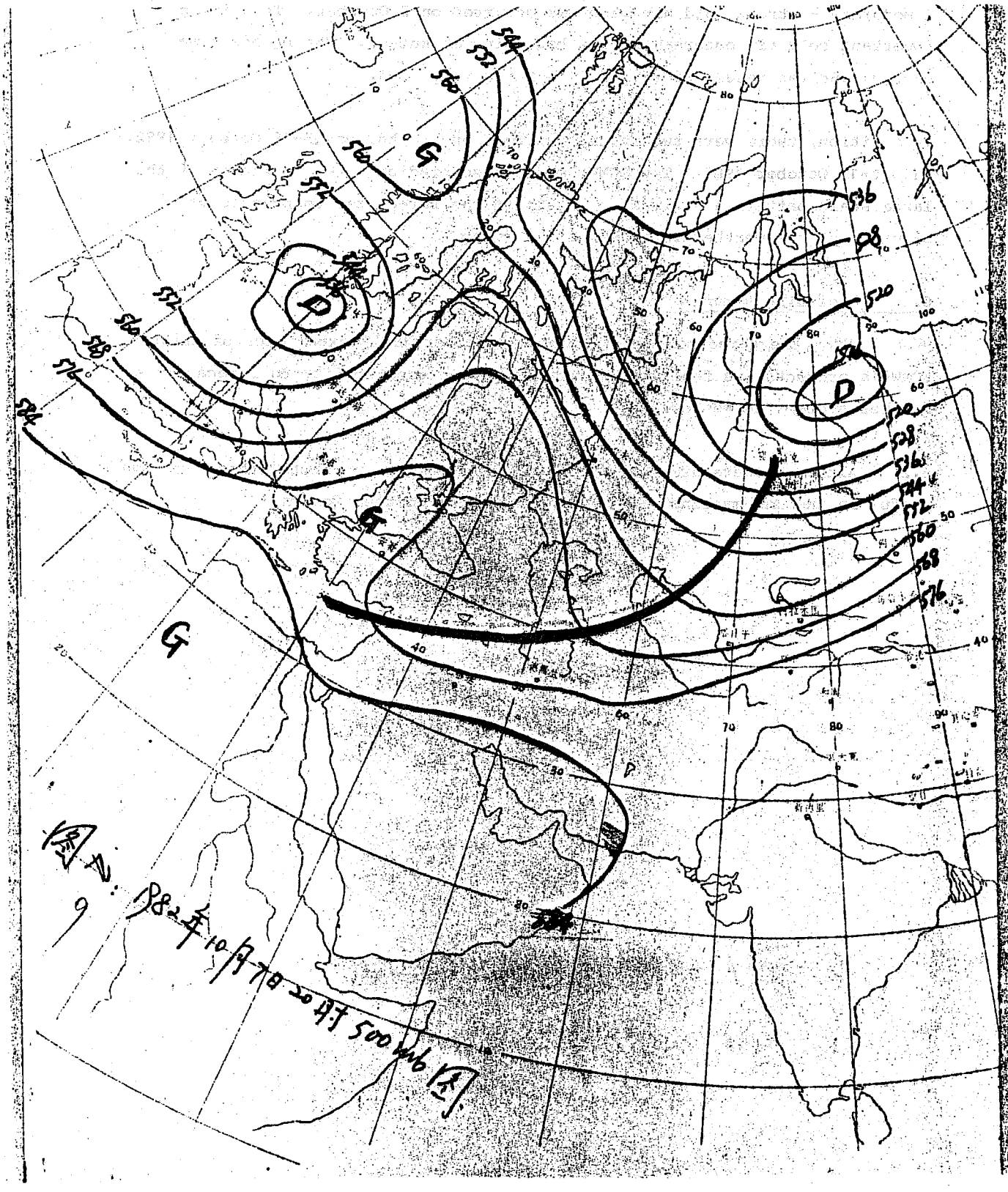

Fig. 9 Verifying analysis

V.T. 7 October 1982 12GMT

A moderate - strong cold air outbreak occurred on 8 October. This is an important cold air outbreak at the beginning of autumn. The forecast was correct and the result of this forecast was very good.

In addition, there were two strong cold air outbreaks, on 25-29 October 1982, and 10-13 October 1982. The ECMWF model also predicted the variation of the large scale pattern and gives good help to the forecaster to promote the accuracy of the weather forecast in Xin-jiang.

6. Concluding Remarks

6.1 From the three months' (August to October 1982) experience of using ECMWF's products, we feel these products have a good ability to forecast the weather systems in westerlies.

6.2 Although there are some weak points in ECMWF's products, these are found useful in the man-machine mix to provide a good weather forecast.