ROYAL OBSERVATORY, HONG KONG

Technical Note (Local) No. 58

RECORD LOW TEMPERATURE IN MID-SUMMER IN HONG KONG

by

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CONTENTS

		Page
	FIGURES	iii
1.	INTRODUCTION	1
2.	SURFACE OBSERVATION	2
3.	SYNOPTIC DEVELOPMENTS IN LATE JULY 1989	3
4.	COLD ADVECTION AT 850 hPa	4
5.	NUMERICAL MODELLING PERSPECTIVE	5
6.	FORECASTING ASPECTS	5
7.	SUMMARY	6

FIGURES

Page

Fig.1 Meteorological observations at the Royal Observatory Hong Kong during 28-30 July 1989. The wind observations were made at Waglan, an island station 19 km southeast of the Royal Observatory. Hong Kong Time is 8 hours ahead of UTC. 7

Fig. 2 Anemograph at Waglan for 28 and 29 July 1989. Hong Kong Time is 8 hours ahead of UTC. 8

Fig. 3 Surface isobaric analysis for 27-30 July 1989, 1800 UTC (2 a.m. Hong Kong time). Abbreviations: T, Typhoon; S.T.S., Severe Tropical Storm; T.D., Tropical Depression. 9

Fig. 4 Analysis of the 500-hPa height field (in gpm), 1200 UTC: a) 22 July; b) 26 July; and c) 28 July 1989. (d) Places referred to in the text. 10

Fig. 5 Visible picture taken by the Japanese Geostationary Meteorological Satellite (GMS-3) at 0300 UTC 30 July 1989. The demarcation in the middle indicates the receding edge of Sc and dense Ac to the east. Clouds appearing on the southwest were mostly dense Ci. Clouds to the north of 30°N and immediate west of 115°E were mostly dense As or Ns. 14

Fig. 6 24-hour temperature changes at 850 hPa, daily at 1200 UTC from 26 to 29 July 1989. 15

Fig. 7 Tephigrams for Hong Kong at 0000 UTC, 28 to 30 July 1989. 16

Fig. 8 a) ECMWF 96-hour prognostic 500-hPa height field (in gpm) for 1200 UTC 26 July; b) U.K. Meteorological Office 48-hour 500-hPa wind and temperature prognosis for 0000 UTC 26 July; and c) Royal Observatory Limited Area Model 48-hour 500-hPa wind, temperature and contour height (in deca-geopotential metre) prognosis for 1200 UTC 26 July 1989. 17

1. INTRODUCTION

July 1989 will be long remembered in Hong Kong for a record low temperature for the month. On 30 July (Sunday), the air temperature fell to 21.7°C, the lowest July temperature ever registered at the Royal Observatory Hong Kong since records began in 1884. This report describes the synoptic situation leading to the event and briefly discusses the weather prediction aspects.

The episode was associated with the arrival of an unseasonal surge of cool air from the north. The minimum for the previous day (29 July), 22.2°C, was the second lowest on record, and equalled those recorded on 17 July 1957 and on 23 July 1965. The latter two occasions were brought about by heavy rain associated with tropical cyclones.

This record low temperature is 4.6°C below the mean minimum of 26.3°C for July. Between 1947 and 1988, there were 27 days on which temperatures in July fell to 23.5°C or below. None of these, however, were associated with cool air intrusion from the north.

2. SURFACE OBSERVATIONS

Temperature, pressure and rainfall observations at the Royal Observatory during 28-30 July 1989 are shown in Fig. 1. Hong Kong Time is 8 hours ahead of Co-ordinated Universal Time (UTC).

The arrival of northerly winds in Hong Kong is well depicted on the anemograph trace at Waglan (Fig. 2), an island station about 19 km southeast of the Observatory. For most part of 27 July and the morning of 28 July, winds were from the west as a surface trough was located to the north of Hong Kong(Fig. 3a). As the trough approached (Figs. 3b and 3c), the wind direction was rather variable until the easterlies became established in the afternoon of 28 July and persisted for the remainder of the day (Fig. 3c). Fresh to strong northerlies behind the trough arrived in the early morning of 29 July, and winds remained northerly on 30 July as the trough moved southwards across the northern part of the South China Sea (Fig. 3d).

As shown in Fig. 1, the temperature started to drop significantly in the afternoon of 28 July and persisted into the following day. The Royal Observatory registered in the evening of 29 July a minimum temperature of 22.2°C, a drop of 7.5 degrees from the previous day's maximum. Overcast conditions and periods of rain lasted throughout the day in the territory. These conditions, as well as temperature drop, continued unto the morning of 30 July, and the record minimum temperature of 21.7°C occurred at 4:44 a.m. local time. A total rainfall of 70.2 mm was recorded during the episode.

3. SYNOPTIC DEVELOPMENTS IN LATE JULY 1989

Although the surge of cool air was rather unseasonal for July, the evolution of synoptic patterns leading to its outbreak in south China exhibits a high degree of similarity to monsoon surges commonly encountered in winter, when waves in the mid-tropospheric westerlies move eastward north of the Himalayas and initiated southward advances of cold air from Siberia.

The story could start on 22 July, when the 500-hPa flow showed a ridge spanning from the Caspian Sea to the west Siberian Plain and an accompanying trough exending from the central Siberian Plateau through Lake Baikal to Lake Balkhash (Fig. 4a). On 25 July, the ridge-trough system collapsed, resulting in the merging of the Caspian high with an anticyclone over central China, and in a cascade of strong northerlies around Lake Baikal. The most important effect of this development was that air from northern Siberia was pushed southward towards China.

By 26 July, another ridge-trough system became established, with the ridge centred around 40°N 80°E and a trough extending from northeast to central China (Fig. 4b). The northerlies behind the trough were further enhanced by a short wave north of Lake Baikal. This caused the southern branch of the 500-hPa trough to deepen.

In response to the southward migration of cold air from the mid-troposphere, a surface anticyclone intensified over north China and spread southwards. By the morning of 27 July, a surface trough, marking the front edge of the cold air, started to affect south China (see Fig. 3).

At the 500-hPa level, the eastward movement of the ridge-trough system was slow, and was further impeded as the Pacific ridge extended westwards. In the 24-hour period ending at 1200 UTC 28 July, increases in the 500-hPa geopotential height generally exceeded 50 gpm over Manchuria. Consequently on 28 July a geopotential low appeared at about 30°N 115°E (Fig. 4c). The northerlies behind this low provided a persistent push for the cool air on the surface to penetrate the coast of south China during 28 and 29 July.

On late 29 July, this low at 500-hPa over central China started to move northwestward and weaken. At the same time, the surface ridge of high pressure to the northwest of Hong Kong followed suit and weakened. However, by then a low complex over the western Pacific (which included Typhoon Judy recurving northward from Japan towards Korea) became linked up with the trough over the south China coastal areas at low levels (Figs. 3b and 3c). This weather system helped maintain northerlies along the coast of south China, thus ensuring a continual flow of cool air towards the coast till the morning of 30 July. Fig. 5 shows a picture in visible light taken by the Japanese Geostationary Meteorological Satellite that morning, showing cloud clearance to the west of Hong Kong's longitude. The local weather became brighter with sunny periods on the following day.

4. COLD ADVECTION AT 850 hPa

The movement of cool air may be visualised by temperature changes at 850 hPa. By 26 July, a pool of cool air accumulated over central China where the largest temperature drop at 850 hPa was about 8 degrees in 24 hours (Fig. 6a). Cold advection towards the south continued (Fig. 6b) and by 28 July the largest fall in temperature occurred over the south China coastal areas (Fig. 6c). Locally in Hong Kong, intrusion of cool air at the low levels was especially marked from 0000 UTC 29 July onwards (Fig. 7). By 1200 UTC 29 July, cold advection at 850 hPa generally abated over south China (Fig. 6d).

5. NUMERICAL MODELLING PERSPECTIVE

Forecasters in the Central Forecasting Office at the Observatory are routinely provided with products of the following numerical weather prediction models:

(1) the European Centre for Medium-Range Weather Forecast (ECMWF) model;
(2) the U.K. Meteorological Office global model; and
(3) the Royal Observatory limited area model (ROLAM) at one-degree resolution, adapted from a model developed by the Japan Meteorological Agency.

These products were generally satisfactory in identifying major changes in the weather pattern leading to the cool episode. As developments in the 500-hPa ridge-trough system usually give the first signal for a possible surge of cool air, forecasts made by the three models at this pressure level are used as examples to demonstrate their usefulness:

(a) In its 96-hour forecast for 1200 UTC 26 July, ECMWF (Fig. 8a) gave clear indication of the establishment of the blocking system, the cascade of strong northerlies south of Lake Baikal and deepening of the southern branch of the trough.

(b) The U.K. Meteorological Office 48-hour forecast for 0000 UTC 26 July, also suggested a similar evolution (Fig. 8b).

(c) The ROLAM 48-hour forecast for 1200 UTC 26 July correctly predicted deepening of the westerly trough to about 25°N and the existence of strong northerlies and low temperatures behind the trough (Fig. 8c).

6. FORECASTING ASPECTS

The consistency among these products led the forecaster to issue as early as 26 July a weather outlook to the public for a 'rainy and relatively cool' weekend (i.e. 29 and 30 July). 3-day forecasts issued during 26-28 July to special users however went for temperature ranges of the order of 26-29°C for 29 and 30 July and were less satisfactory quantitatively, although they already reflected a significant drop from the high temperatures of 28.7 to 32.0°C experienced on 27 July. As temperatures dropped sharply and the coolness began to be felt, the forecast issued at noon 29 July for a temperature range of 22 to 25°C the next day (30 July) compared favourably to the actual 21.7 to 25.7°C.

7. SUMMARY

This noteworthy cool episode in July 1989 may be viewed as the result of a concatenation of mechanisms belonging to different seasons of the year. The persistent ridge-trough system at 500 hPa, a feature occurring from time to time in winter, nonetheless appeared in late July 1989 and carried the cool air southward. The subsequent arrival of cool air in south China was assisted by the westward extension of the Pacific ridge and the presence of a low complex over the western Pacific, both phenomena more common in the warmer months. It was a combination of these features that gave us a memorable July in 1989. The useful guidance provided by the numerical prediction products helped make the forecasting experience a pleasant one.

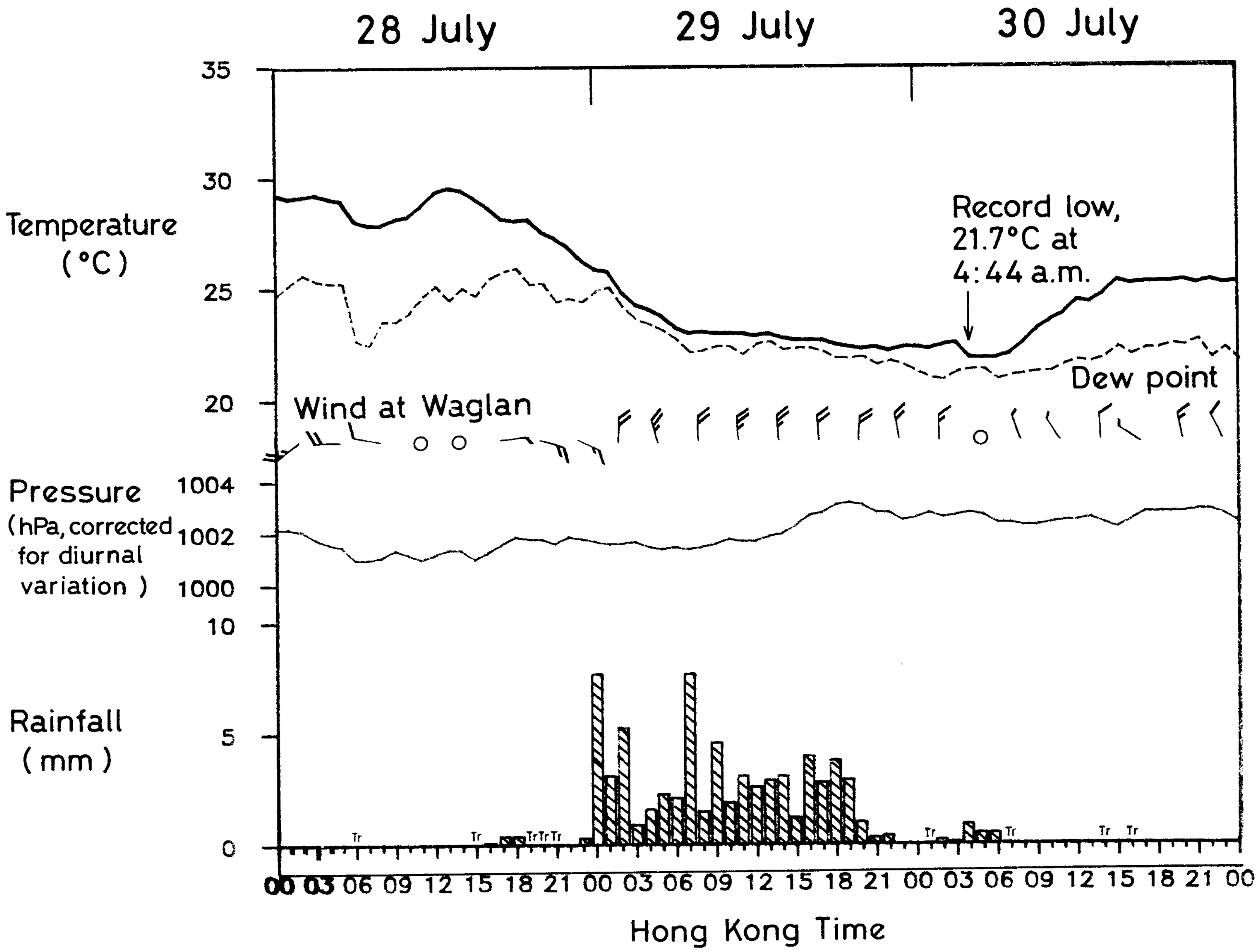


Fig.1 Meteorological observations at the Royal Observatory Hong Kong during 28-30 July 1989. The wind observations were made at Waglan, an island station 19 km southeast of the Royal Observatory. Hong Kong Time is 8 hours ahead of UTC.

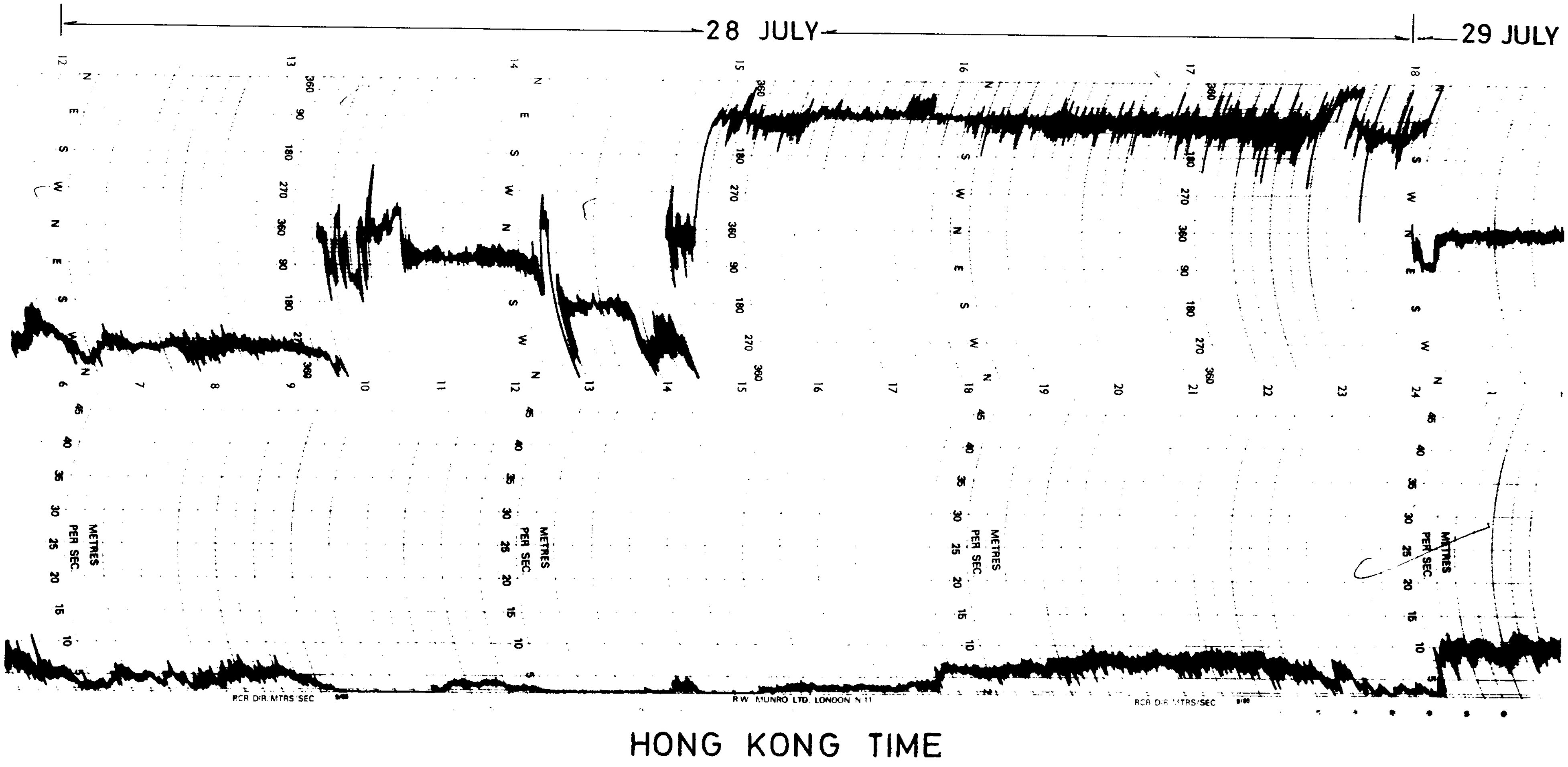


Fig.2 Anemograph at Waglan for 28 and 29 July 1989. Hong Kong Time is 8 hours ahead of UTC.

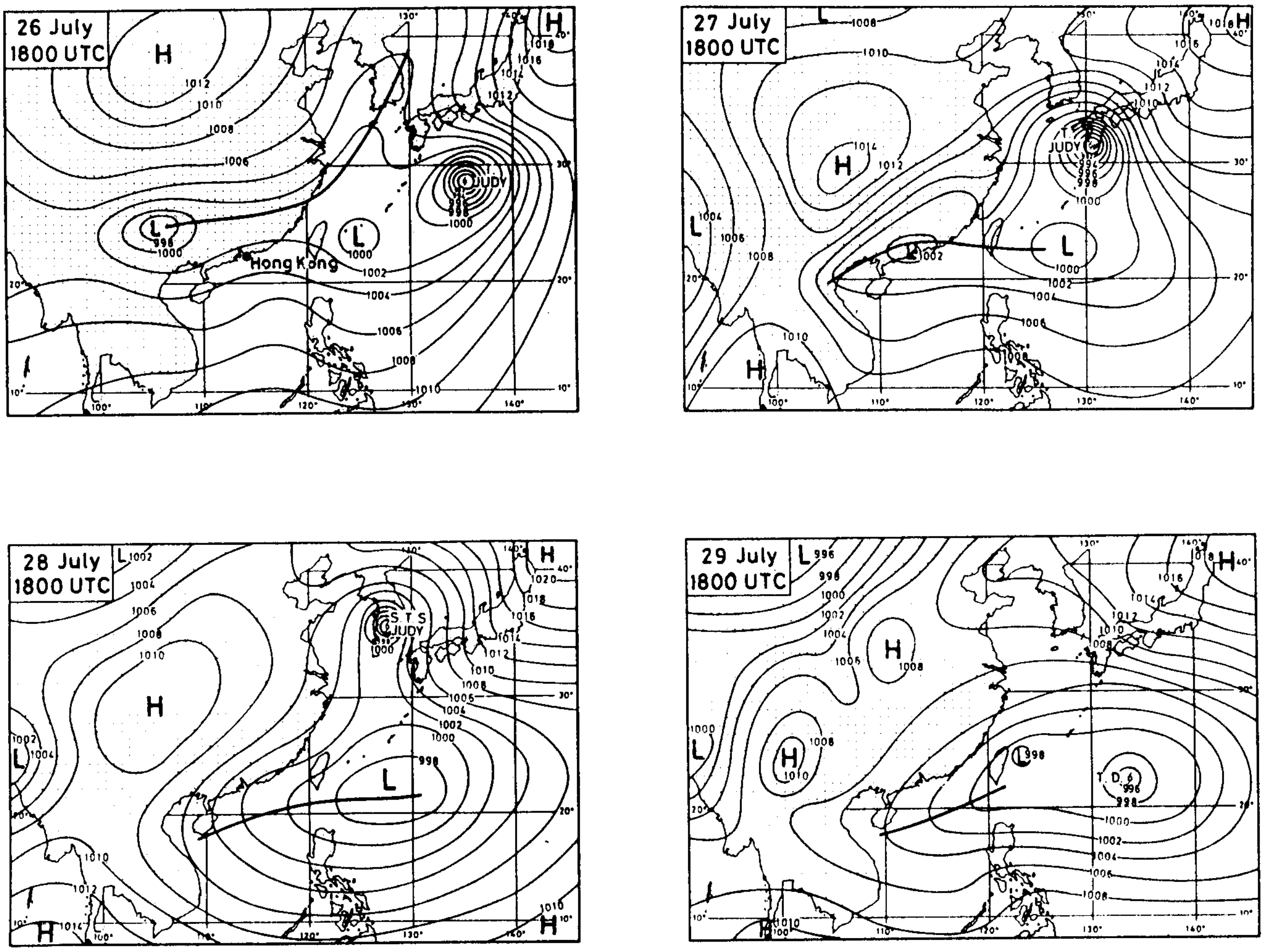


Fig.3 Surface isobaric analysis for 27-30 July 1989, 1800 UTC (2 a.m. Hong Kong time). Abbreviations: T, Typhoon; S.T.S., Severe Tropical Storm; T.D., Tropical Depression.

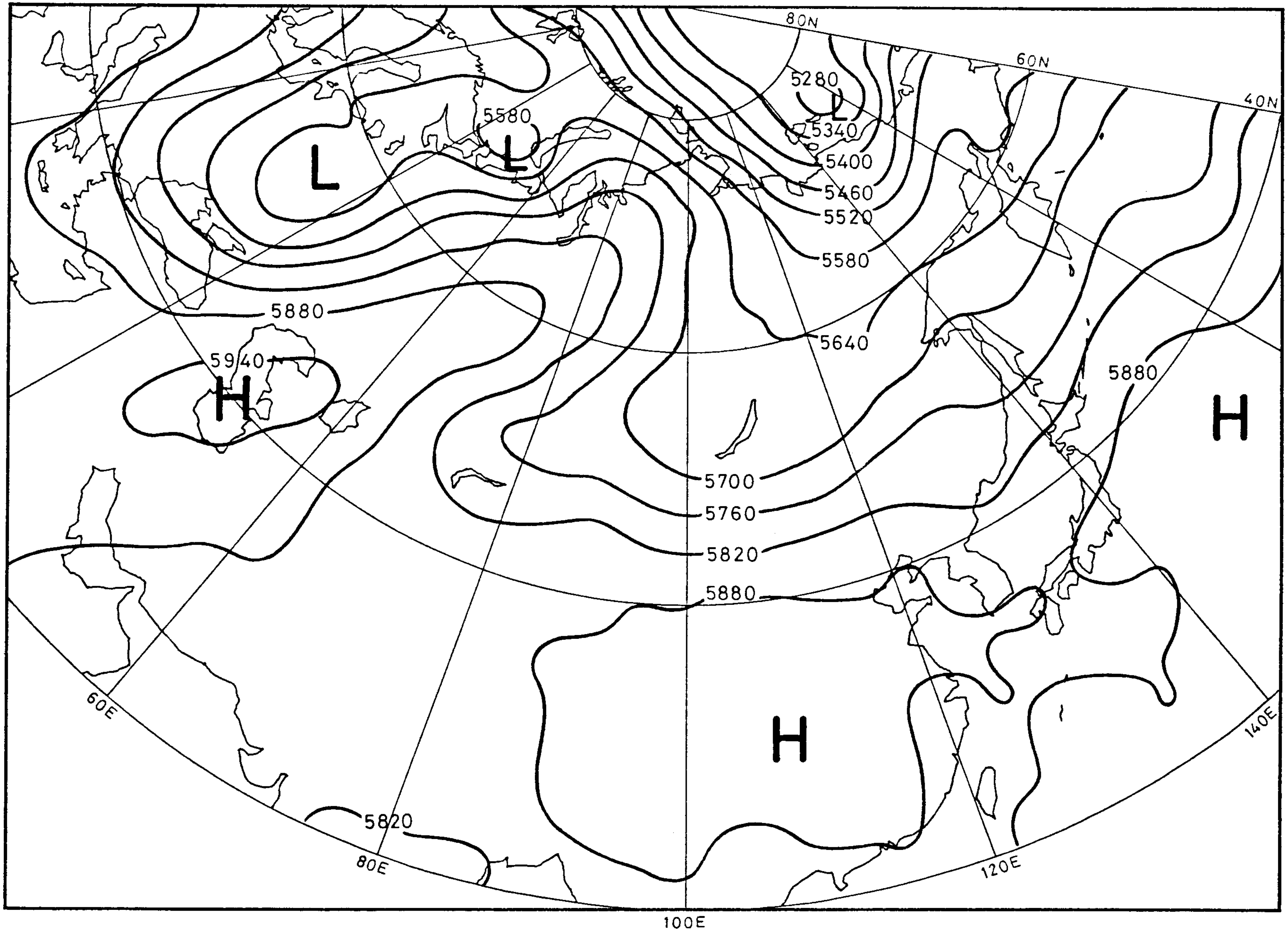


Fig.4a Analysis of the 500-hPa height field (in gpm), for 1200 UTC 22 July 1989.

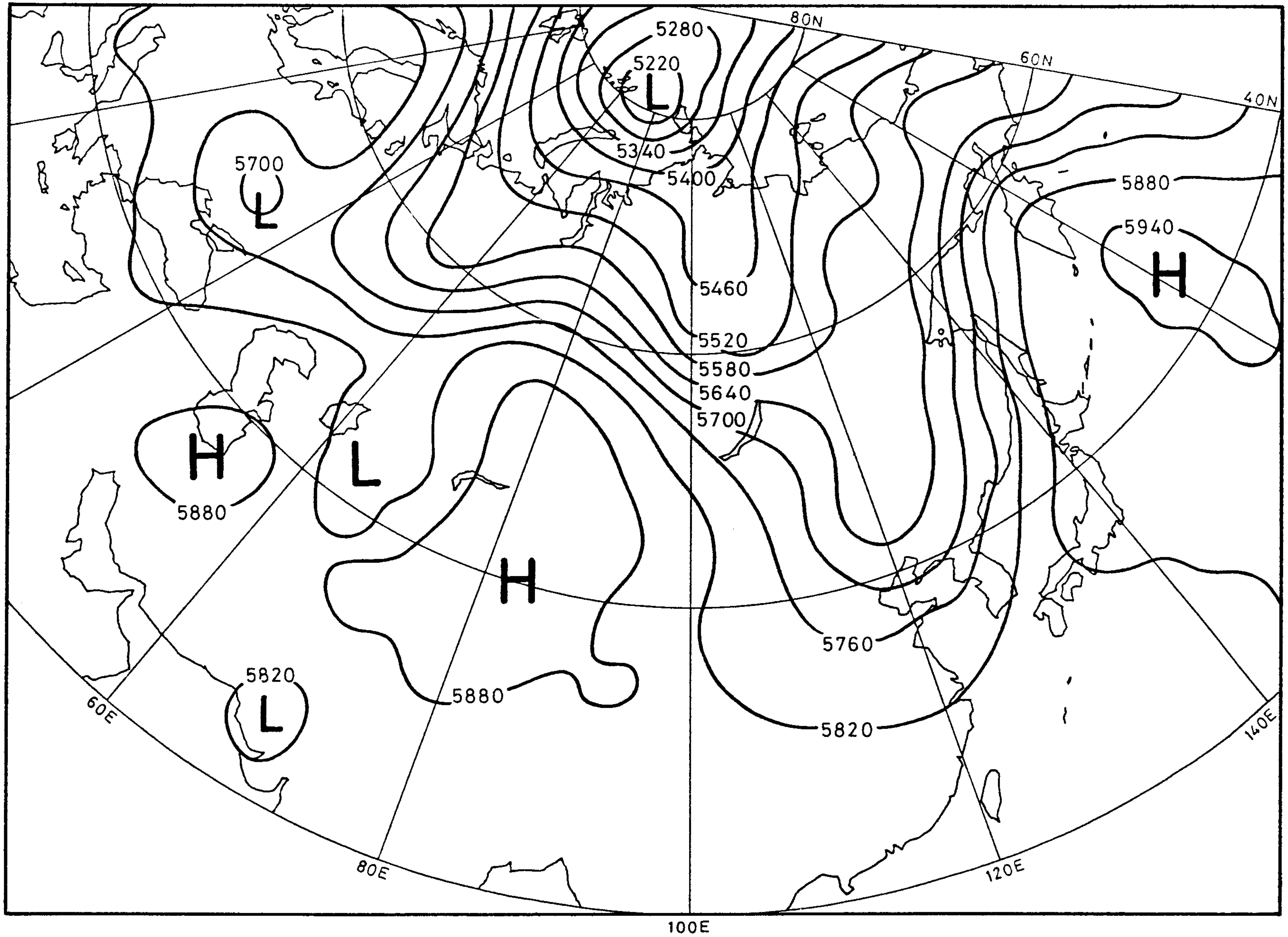


Fig.4b Analysis of the 500-hPa height field (in gpm) for 1200 UTC 26 July 1989.

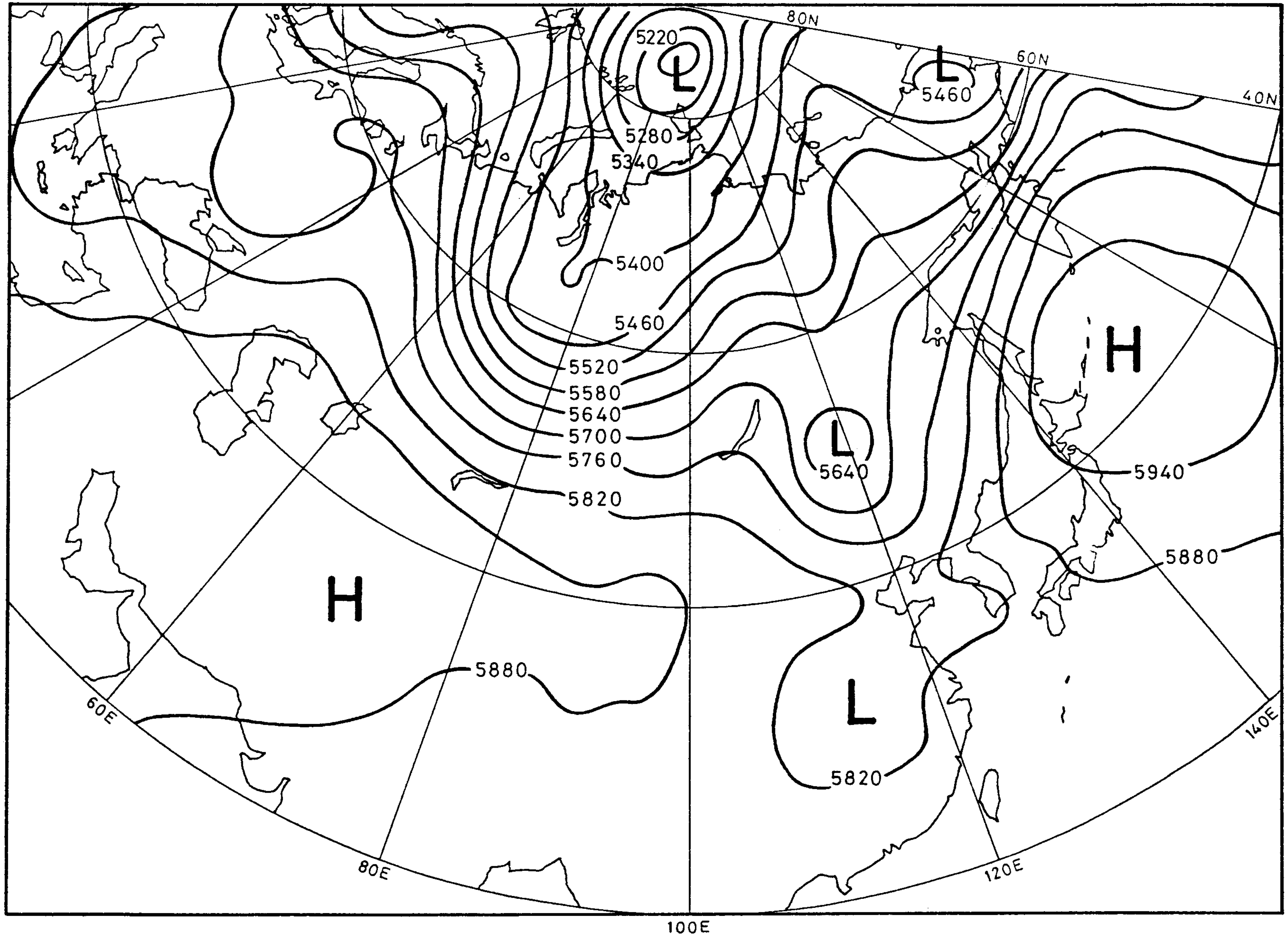


Fig.4c Analysis of the 500-hPa height field (in gpm) for 1200 UTC 28 July 1989.

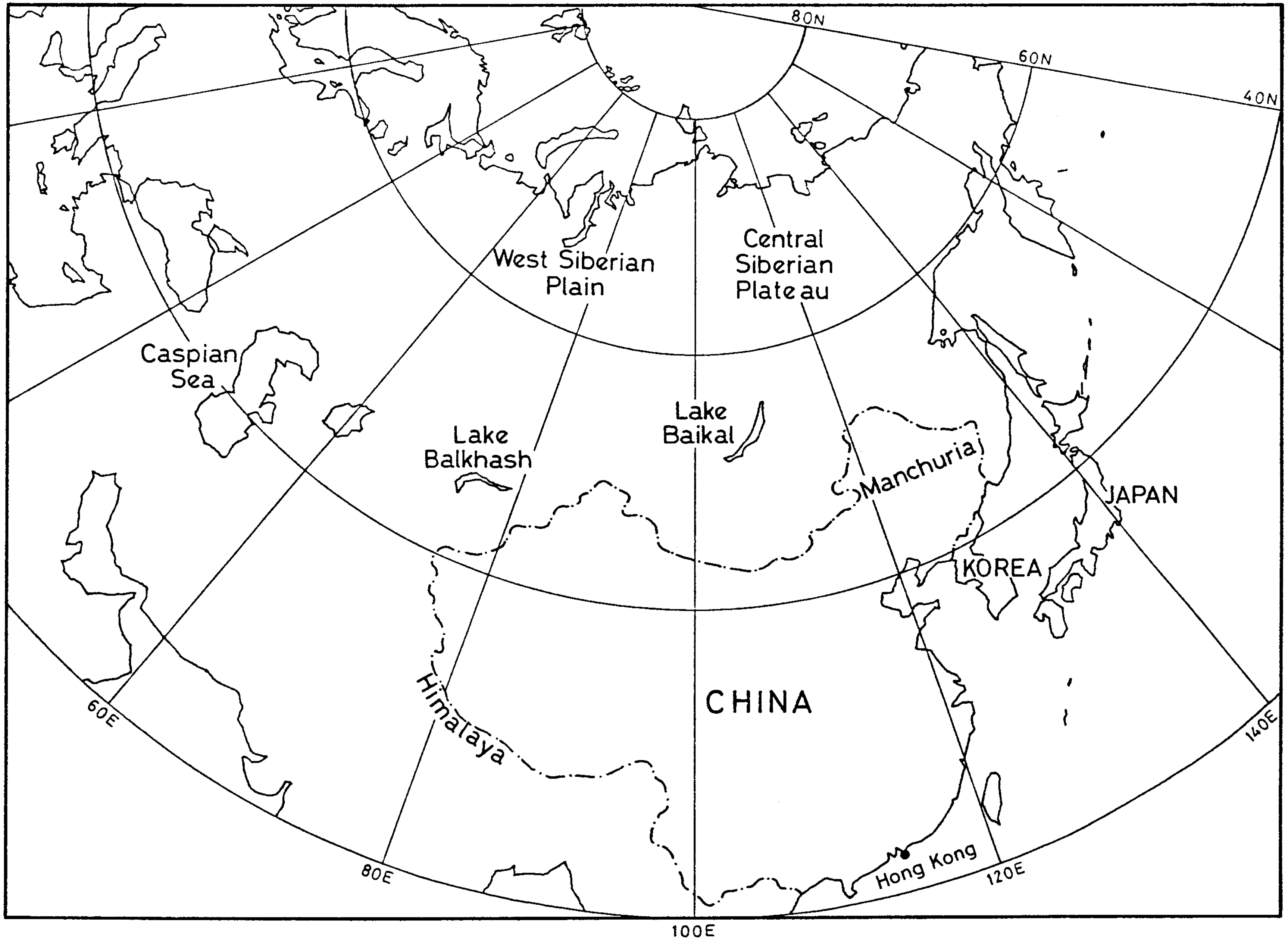


Fig.4d Places referred to in the text.

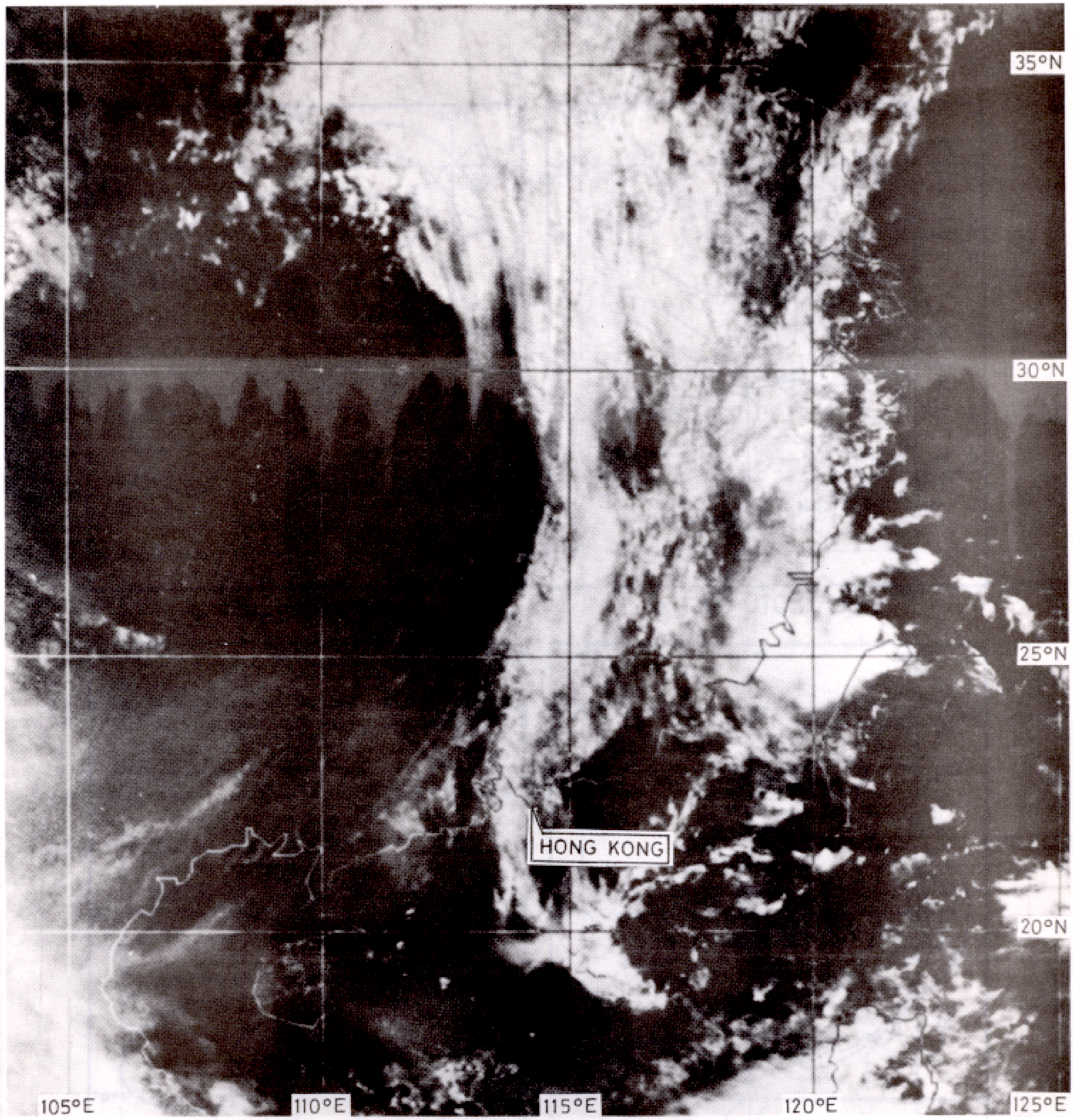
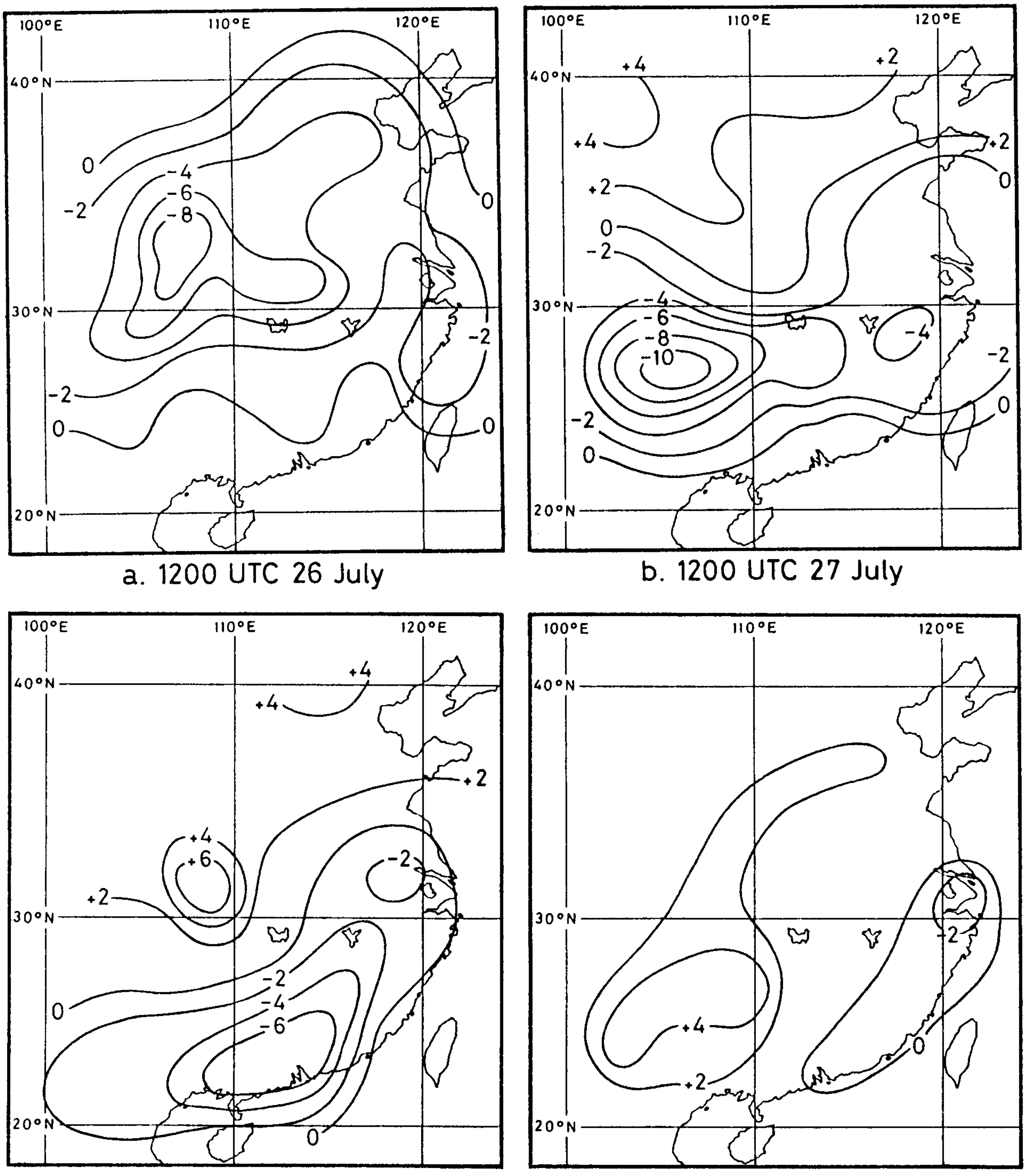


Fig. 5 Visible picture taken by the Japanese Geostationary Meteorological Satellite (GMS-3) at 0300 UTC 30 July 1989. The demarcation in the middle indicates the receding edge of Sc and dense Ac to the east. Clouds appearing on the southwest were mostly dense Ci. Clouds to the north of 30^{O}N and immediate west of 115^{O}E were mostly dense As or Ns.



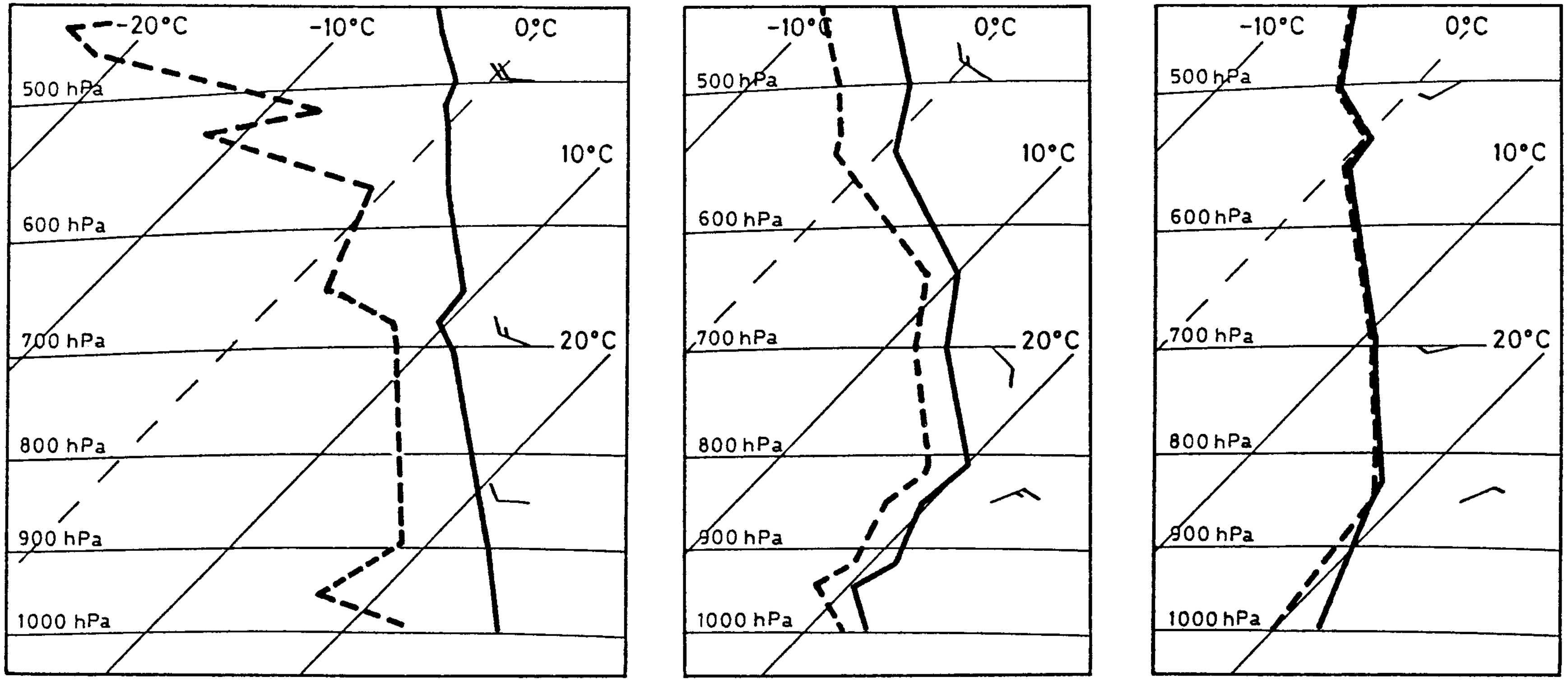
a. 1200 UTC 26 July

b. 1200 UTC 27 July

c. 1200 UTC 28 July

d. 1200 UTC 29 July

Fig. 6 24-hour temperature changes at 850 hPa, daily at 1200 UTC from 26 to 29 July 1989.



0000 UTC 28 July 1989

0000 UTC 29 July 1989

0000 UTC 30 July 1989

Fig. 7 Tephigrams for Hong Kong at 0000 UTC, 28 to 30 July 1989.

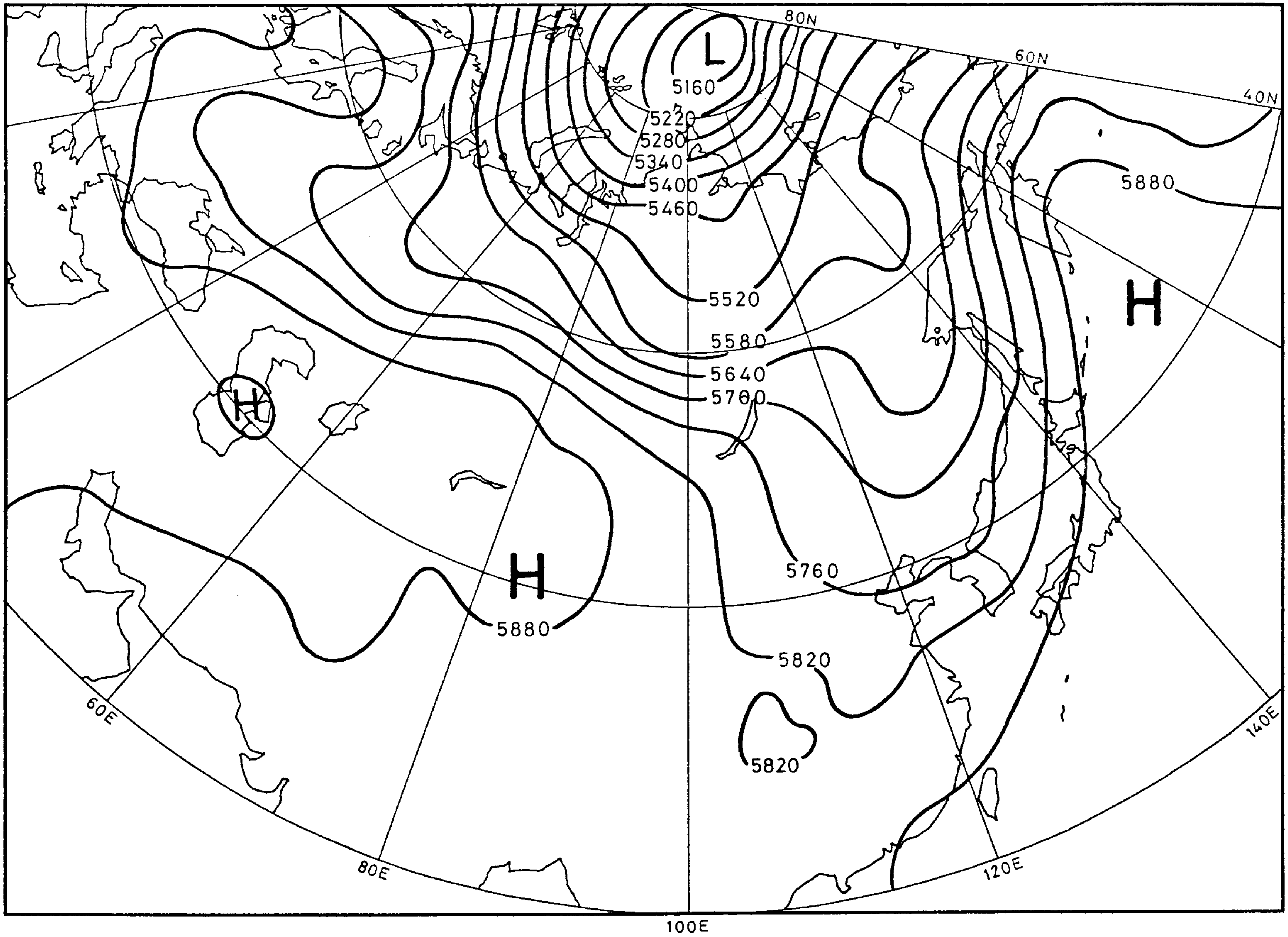


Fig. 8a ECMWF 96-hour prognostic 500-hPa height field (in gpm) for 1200 UTC 26 July 1989.

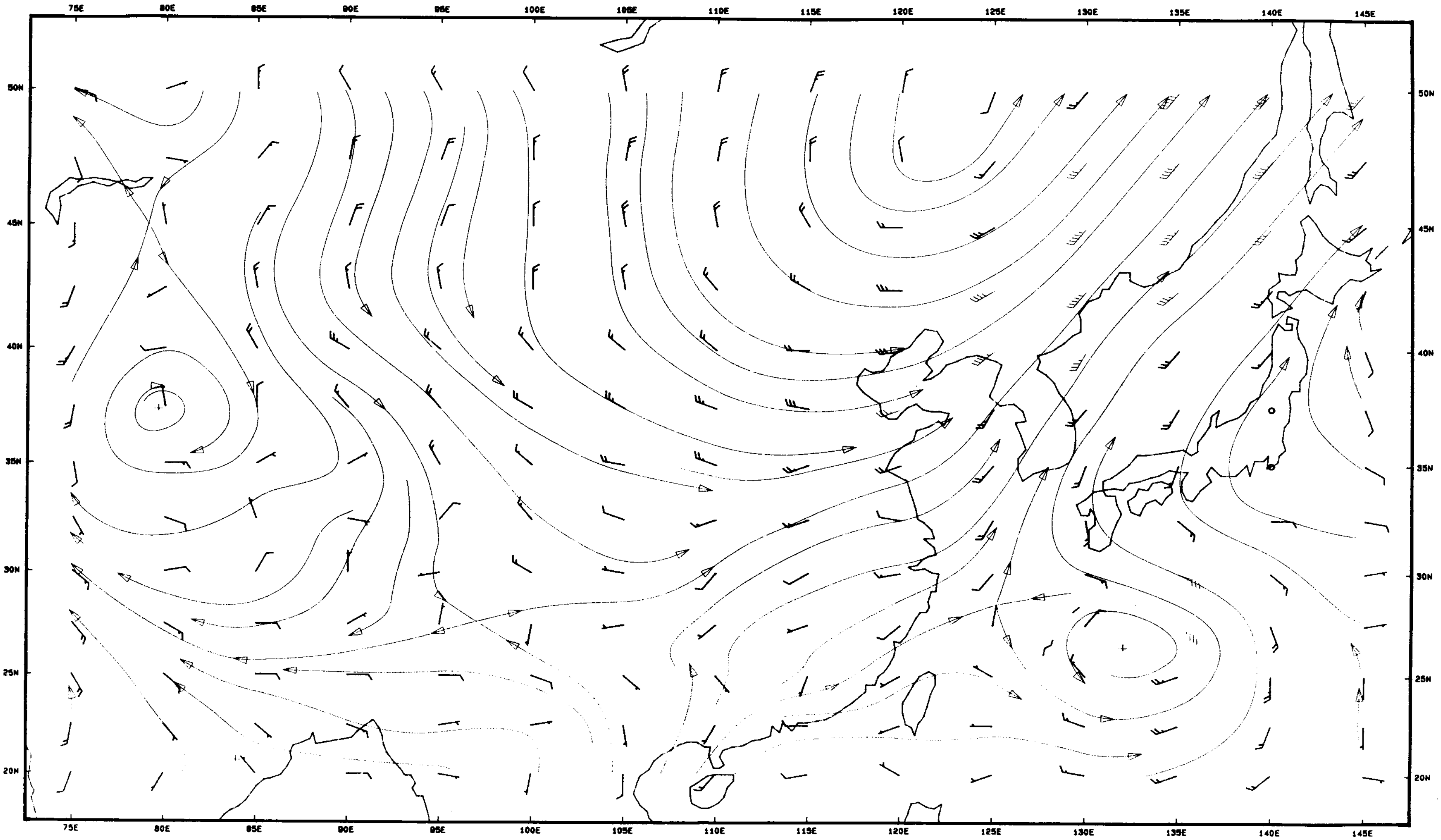


Fig. 8b U.K. Meteorological Office 48-hour 500-hPa wind and temperature prognosis for 0000 UTC 26 July 1989.

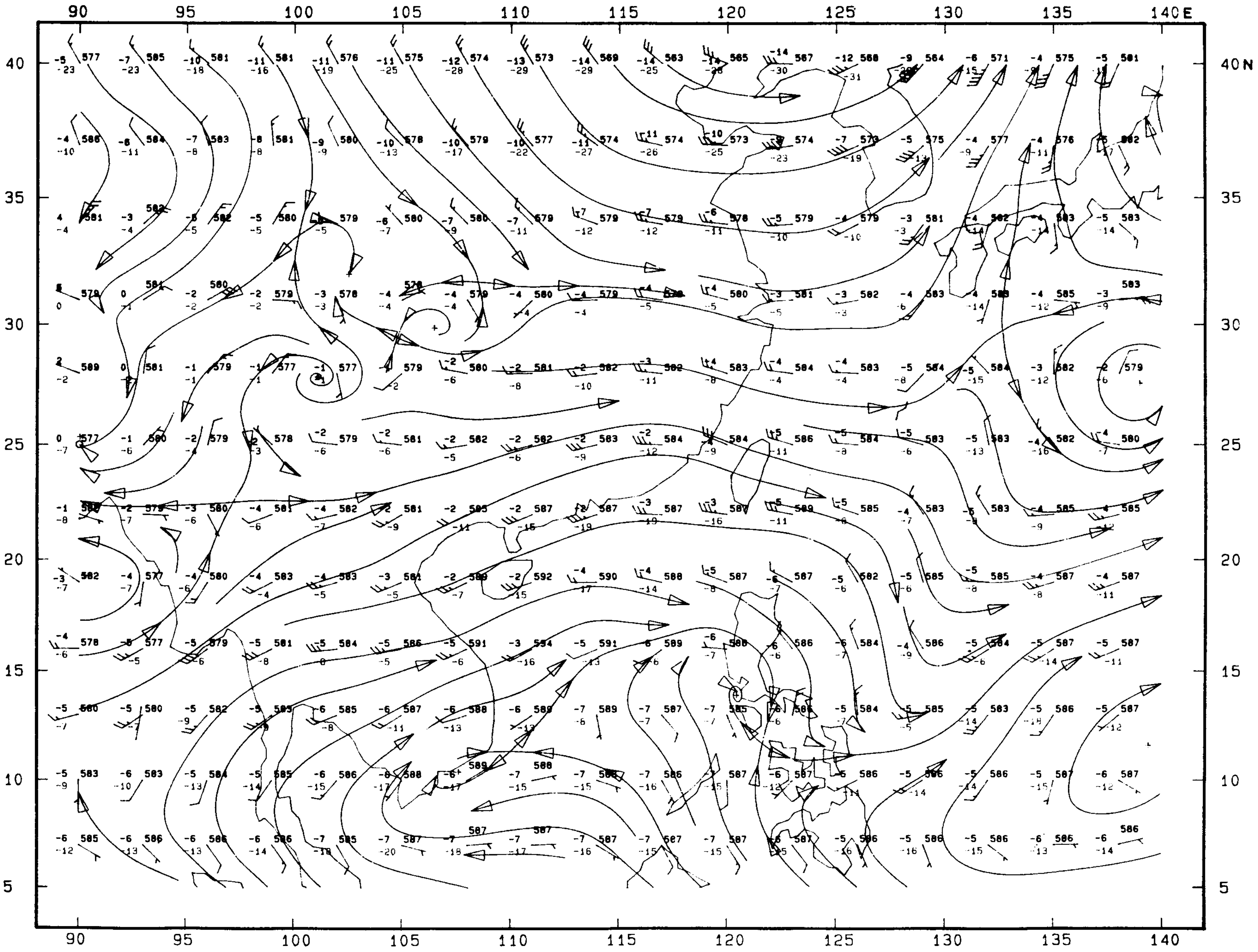


Fig. 8c Royal Observatory Limited Area Model 48-hour 500-hPa wind, temperature and contour height (in deca-geopotential metre) prognosis for 1200 UTC 26 July 1989.