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The treatment of old Lows in the Southern Hemisphere by the Coarse Mesh model

by

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1. INTRODUCTION

A common problem with the operational coarse mesh global model is that many mature depressions stay deep for too long. This fact has been noticed by forecasters using the model on an operational basis and by others for research purposes. In the northern hemisphere depressions usually form over the oceans but by the end of their life cycle they are often over land. Because of this it was thought that the fault may have been due to deficiencies in some of the parameterizations of boundary layer processes over land. Several experiments have been performed in Met O 11 changing boundary layer parameters, for instance, increasing roughness length, removing surface moisture, but with limited success. This indicates that the reluctance of the model to fill old lows may not be entirely due to the representation of surface processes over the land, and that there may be a more fundamental, possibly dynamical, reason for this behaviour. To test this hypothesis it was necessary to first determine whether the model displayed the same symptoms in the treatment of depressions whose life cycles were completely over the sea and not influenced at any stage by land or ice. This was very difficult to do over the northern hemisphere because of the geography. The logical thing to do was to look at the model's treatment of lows in the southern hemisphere where there is more water than land. This note describes these investigations.

2. INVESTIGATIONS

2.1 Case selection

Four-fifths of the southern hemisphere is covered by water. It is not surprising, therefore, that the geographical coverage of conventional meteorological data is very limited. However, during the FGGE in

1979, a greatly increased number of observations were made, particularly over the oceans where data are normally sparse. For this reason, the cases were chosen from 1979 to reduce as far as possible any errors that could arise from lack of data. The cases were selected from the winter period when the normal track of depressions is further north than in summer. This meant that the complete life cycles of the lows were over the sea and the circulations were not affected by Antartica or the ice which surrounds the continent.

2.2 The FGGE analyses

The FGGE data were analysed at ECMWF using their data assimilation scheme. Data are analysed on standard pressure levels and the basic fields comprise: geopotential height, mean sea level pressure, and horizontal wind components. These fields are not initialised. Derived fields, for instance temperature, are calculated from initialised analyses, interpolated to σ -coordinates. The fields are then interpolated or extrapolated hydrostatically onto the standard pressure levels. These analyses were used as verification fields for the case investigations. A more detailed description of how the FGGE analyses were made can be found in (1).

2.3 Running the forecasts from FGGE data

The FGGE analyses are available in gridpoint form on the ECMWF N48 sigma coordinate grid. To run our global model from a FGGE analysis it was first necessary to interpolate the data from the ECMWF grid onto our grid. This was achieved in two stages. Firstly, the data were interpolated from the ECMWF model sigma levels to our model sigma levels on the N48 grid. The data were then interpolated from the N48 grid to the N60 grid of the coarse mesh model. Also, the data were adjusted to be consistent with the topography in the coarse mesh model. Each forecast was then run to 7 days using the latest available version of the model.

2.4 Case (1) DT 00Z 12/8/79

The FGGE IIIb mean sea level pressure analysis for 0000 GMT on 12/8/79 is shown in Figure (1). The main features of interest are; depression A between Tasmania and New Zealand, low B about 500 miles east of New Zealand and low C which was developing to the northeast of low B. Twenty-four hours later at 0000 GMT on 13/8/79 low B had lost its identity and had been absorbed into the circulation of low C which had deepened to 982 MB. Meanwhile, low A had moved east to be close to the southern edge of New Zealand. By midnight on 14/8/79 figure (2) shows that low C had become the dominant feature with a broad circulation around a central pressure of 981 MB at about 40° S 140° W. Low C maintained this intensity and depth for a further 24 hours, but by 0000 GMT on 16/8/79 it had filled by 10 MB and was beginning to lose its vigour, see figure (3). By 17/8/79 it had degenerated into a trough and figure (4) shows that it had lost its identity completely by 18/8/79. The height of the 500 MB constant pressure surface at 0000 GMT on 12/8/79 is shown in figure (5). The main feature which concerns us here is the trough at 45° S 163° W and labelled A. During the 24 hours to 0000 GMT 13/8/79 the trough had extended northeastwards and by 14/8/79 it had become a vortex at 37° S 140° W with a depth of 534 DM, see figure (6). This vortex persisted near this depth until 16/8/79 and moved only slowly eastwards. However, by 0000 GMT on 16/8/79 the vortex was beginning to become cut off from the main flow near 65° S. Figure (7) shows that at 0000 GMT on 17/8/79 the vortex became cut off near 118° W, it then moved steadily east during the two days to 19/8/79.

The coarse mesh model forecast charts are displayed in figures (8) to (12). Figures (8) and (1) show that the only differences between the initial mean sea level pressure field for the forecast and the corresponding FGGE analysis were over Antartica. These were due to different algorithms being used to calculate mean sea level pressure over high ground. By day 1 the model had deepened low C by 7 MB to 993 MB, this was not deep enough since the central pressure of the low was 982 MB. Lows A and B were handled correctly. Figure (9) shows that by 0000 GMT on 14/8/79 the forecast of low C had recovered and it was only 2 MB too shallow. However, during 14/8/79 the model continued to deepen the low and steered it too far south. By midnight 15/8/79 the central pressure of the low in the model was 10 MB too deep. It can be seen in figures (10) and (3) that by 0000 GMT 16/8/79 the model's low was 19 MB too deep, in reality the low had started to fill by this time but the model maintained it. By 17/8/79 the low had filled up, but the model retained it for the next three days as quite a deep feature with a central pressure around 978 MB, see figure (11). This evolution, whereby the model does not deepen a low enough during the first 24 hours of a forecast, but subsequently deepens the low too much and then is reluctant to fill it, is a common fault with the model. The important point to note in this case is that the model displayed the above characteristics in the treatment of a depression whose complete life cycle was over the sea.

The flow at 500 MB was well predicted by the model during the first 24 hours of the forecast. However, by day 2 the forecast depth of vortex A was 6 DM too deep. This vortex was kept too deep by the model throughout the rest of the forecast. This is reflected in the pressure pattern at mean sea level by maintaining low C too deep. The reason why vortex A was kept too deep was due to the fact that in reality this vortex started to become a cut-off feature by day 4 of the forecast whereas the model did not produce this evolution. The model maintained a flow of air into the western part of the vortex throughout the forecast. An example of this is shown in figure (12) which shows that at 0000 GMT 17/8/79 the model predicted vortex A to be 30 degrees too far west, 22 DM too deep and not cut off from the main flow. After day 2 the 500 MB flow over the Pacific between 30° S and 45° S and west of about 105° W was too strong. This mishandling of the flow is a possible explanation for the reluctance of the model to fill low C.

2.5 Case (2) DT 00Z 27/8/79

The depression which interests us in this case is shown as low A in Figure (13). At 0000 GMT on 27/8/79 this low was centred at 30° S 127° W with a central pressure of 997 MB. By 0000 GMT 28/8/79, the low had moved slowly east and had deepened by 3 MB. During the next 24 hours the low began to fill as it continued to move east. By 0000 GMT 30/8/79 the low had degenerated into a trough at 40° S 100° W, see figure (14), and by 0000 GMT on 31/8/79 it had filled completely and lost its identity. Figure (15) shows that at 0000 GMT on 1/9/79 an anticyclone was present in the area near 40° S 85° W which persisted to the end of the forecast period. During the first 24 hours of the forecast the model deepened low A correctly by 3 MB. However, it incorrectly maintained the feature further west than it was in reality. By day 3 of the forecast valid at 0000 GMT 30/8/79, figure (16) shows that the model still maintained low A with a closed circulation and a central pressure of 1008 MB. This was not correct since figure (14) shows that low A had degenerated into a trough by this time. Low A was maintained by the model during the next 48 hours and at midnight on 1/9/79 it can be seen in figure (17) that the low still had a compact circulation around a central pressure of 1009 MB. The forecast mean sea level pressure field over the eastern Pacific north of 50° S was becoming seriously wrong at this time due to the reluctance of the model to fill low A. The model redeveloped the low during day 5 and transferred it quickly eastwards into South America during days 6 and 7. This evolution was totally incorrect and is symptomatic of the problem which this paper addresses. The 500 MB flow in the model between latitudes 30° S and 45° S and longitudes 90° W and 120° W over the eastern Pacific was too strong. This is particularly noticeable on day 4 of the forecast shown in figure (18). The verifying FGGE analysis is shown in figure (19) for comparison. Like the previous case, this strong flow almost certainly contributed to the maintenance of low A and to its fast eastward progression in the later stages of the forecast.

3. CONCLUSIONS AND IMPLICATIONS

These two cases have produced evidence that shows that the coarse mesh model maintains depressions too deep for too long over the sea. This evidence seems to support the hypothesis that the reluctance of the model to fill old lows may be due to dynamical reasons rather than surface representations. The fact that in both these cases the model develops too strong a flow at 500 MB north of 45° S is interesting, since it is at those latitudes where the Andes would have the greatest effect upon the 500 MB flow. There is an analogy here with the problem of the model producing excessive westerly winds in the northern hemisphere, particularly during the winter months. The effect of the Andes upon the general circulation may be an area where more work is required, particularly regarding the treatment of old lows in the southern hemisphere.

References

1. FGGE III-B Daily Global Analyses part 3. June 1979 to August 1979. ECMWF publication April 1981.

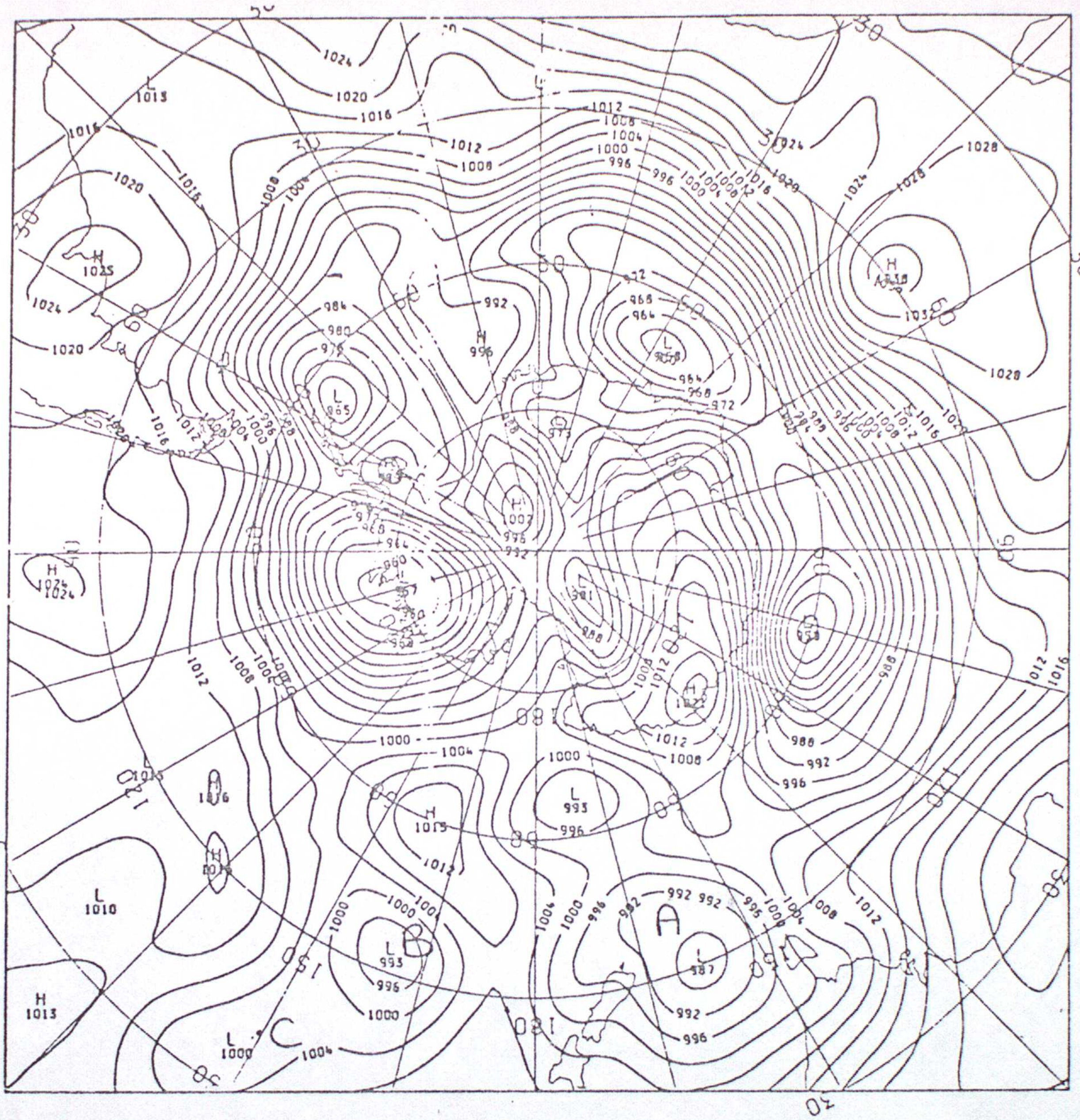

Figure 1)

FGGE IIIb mean sea level pressure analysis (MBS)
DT 0000 GMT 12/8/79

Figure 2)

FGGE IIIb mean sea level pressure analysis (MBS)
DT 0000 GMT 14/8/79

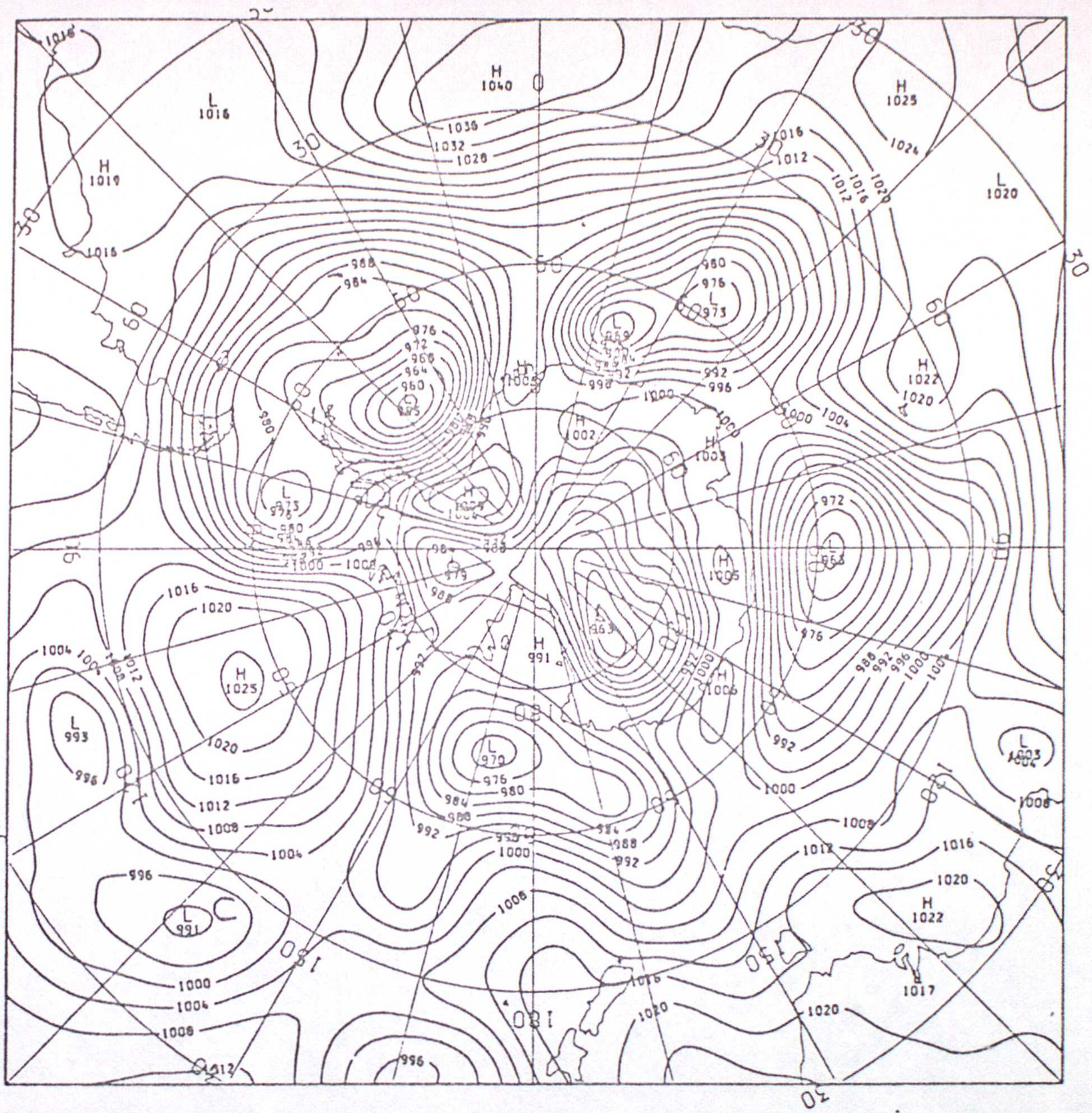

Figure 3)

FGGE IIIb mean sea level pressure analysis (MBS)
DT 0000 GMT 16/8/79

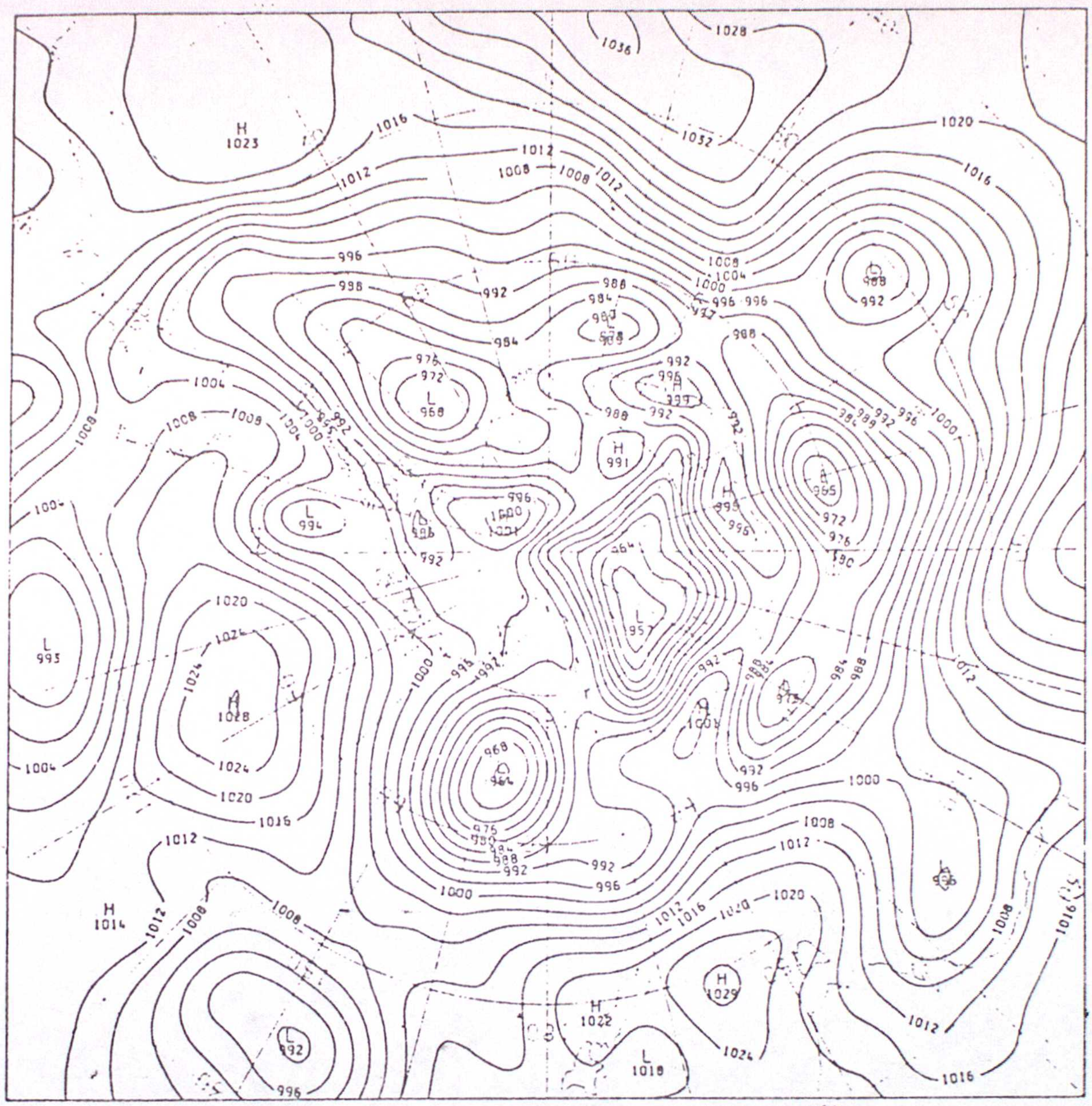

Figure 4)

FGGE IIIb mean sea level pressure analysis (MBS)
DT 0000 GMT 18/8/79

Figure 5)

FGGE IIIb 500 MB height analysis (gpm)
DT 0000 GMT 12/8/79

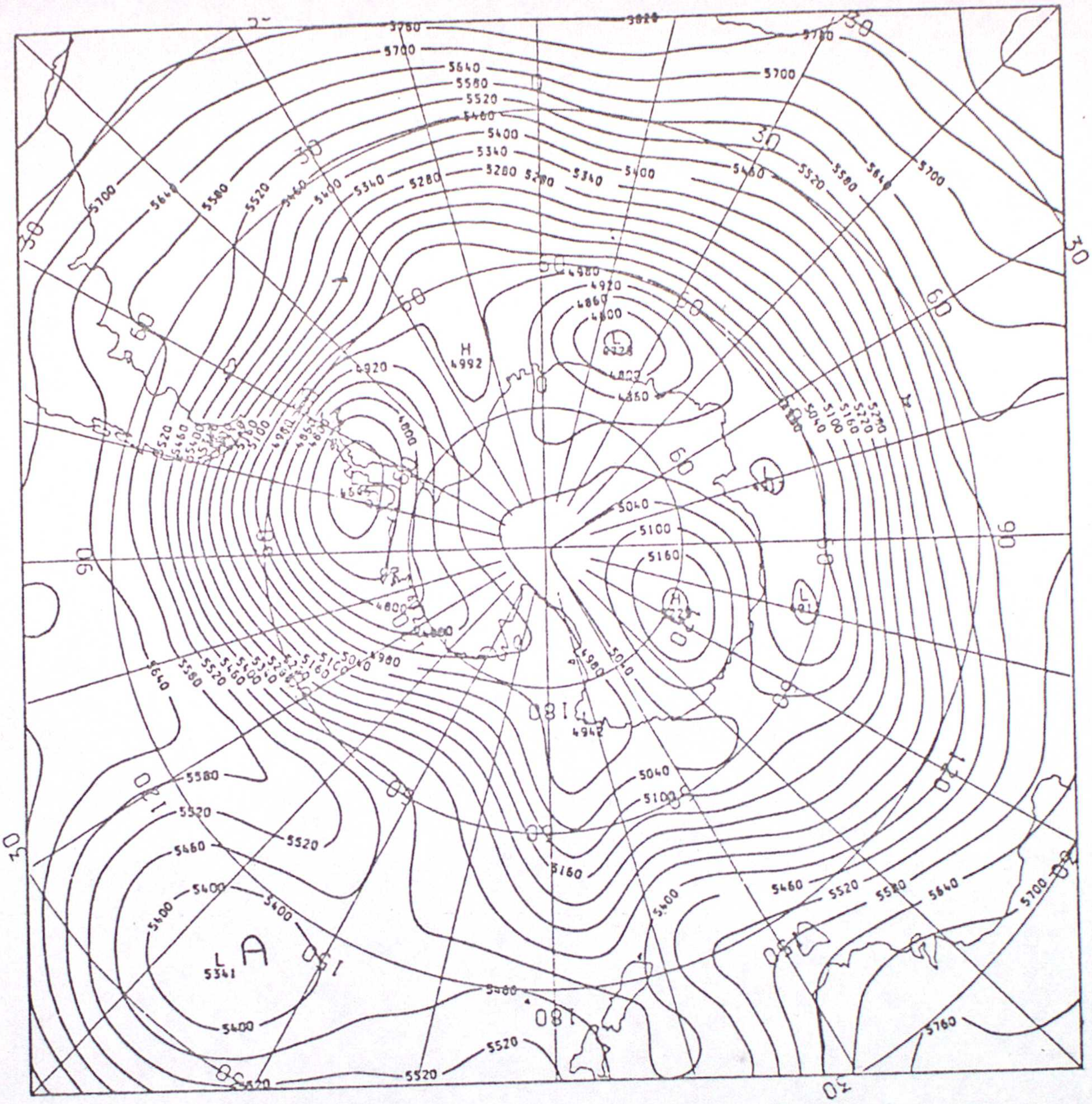

Figure 6)

FGGE IIIb 500 MB height analysis (gpm)
DT 0000 GMT 14/8/79

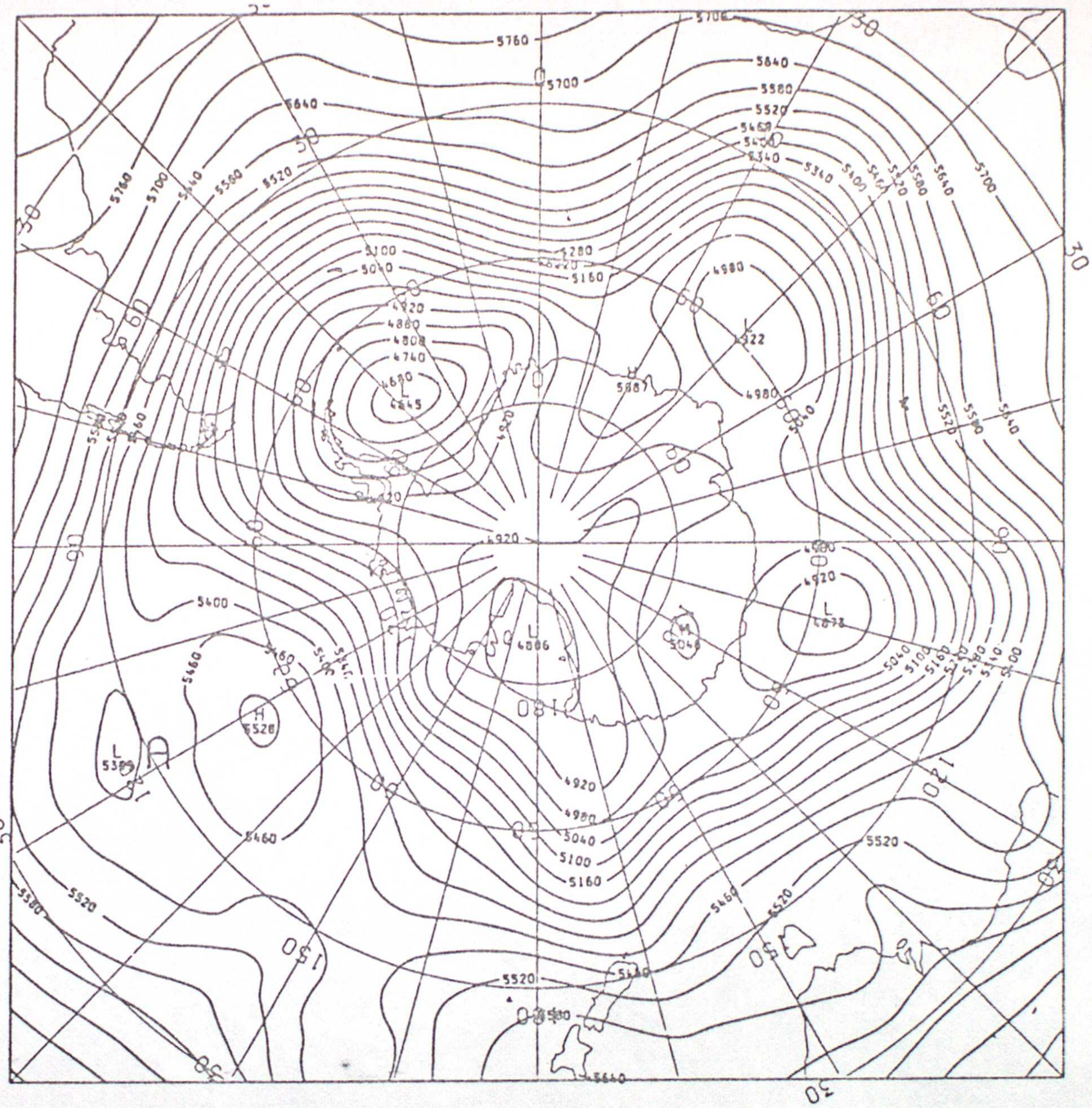

Figure 7)

FGGE IIIb 500 MB height analysis (gpm)
DT 0000 GMT 17/8/79

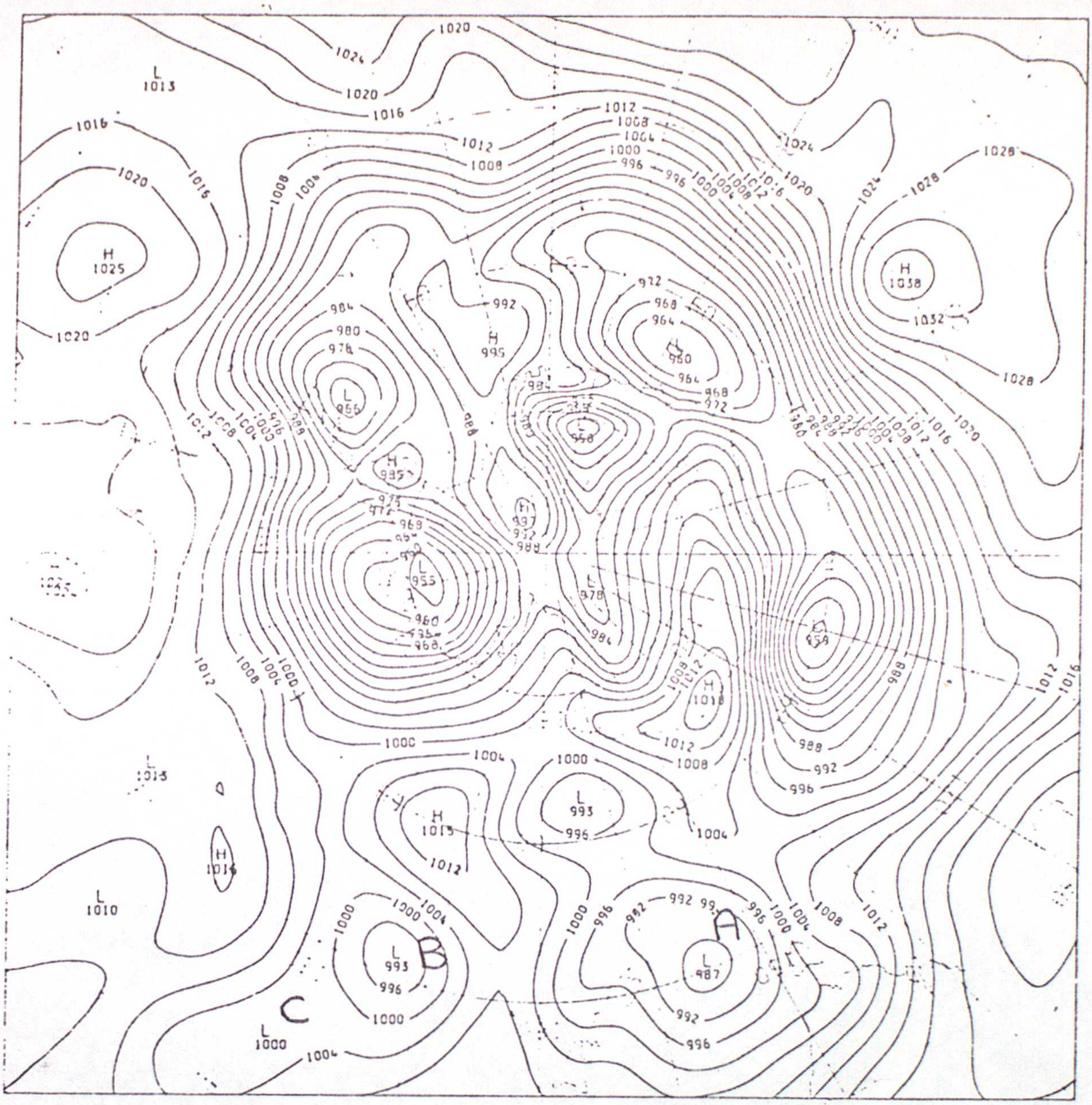

Figure 8)

Coarse mesh mean sea level pressure initial field (MBS)
DT 0000 GMT 12/8/79

Figure 9)

Coarse mesh forecast mean sea level pressure (MBS)
VT 0000 GMT 14/8/79   DT 0000 GMT 12/8/79

Figure 10)

Coarse mesh forecast mean sea level pressure (MBS)
VT 0000 GMT 16/8/79   DT 0000 GMT 12/8/79

Figure 11)

Coarse mesh forecast mean sea level pressure (MBS)
VT 0000 GMT 18/8/79   DT 0000 GMT 12/8/79

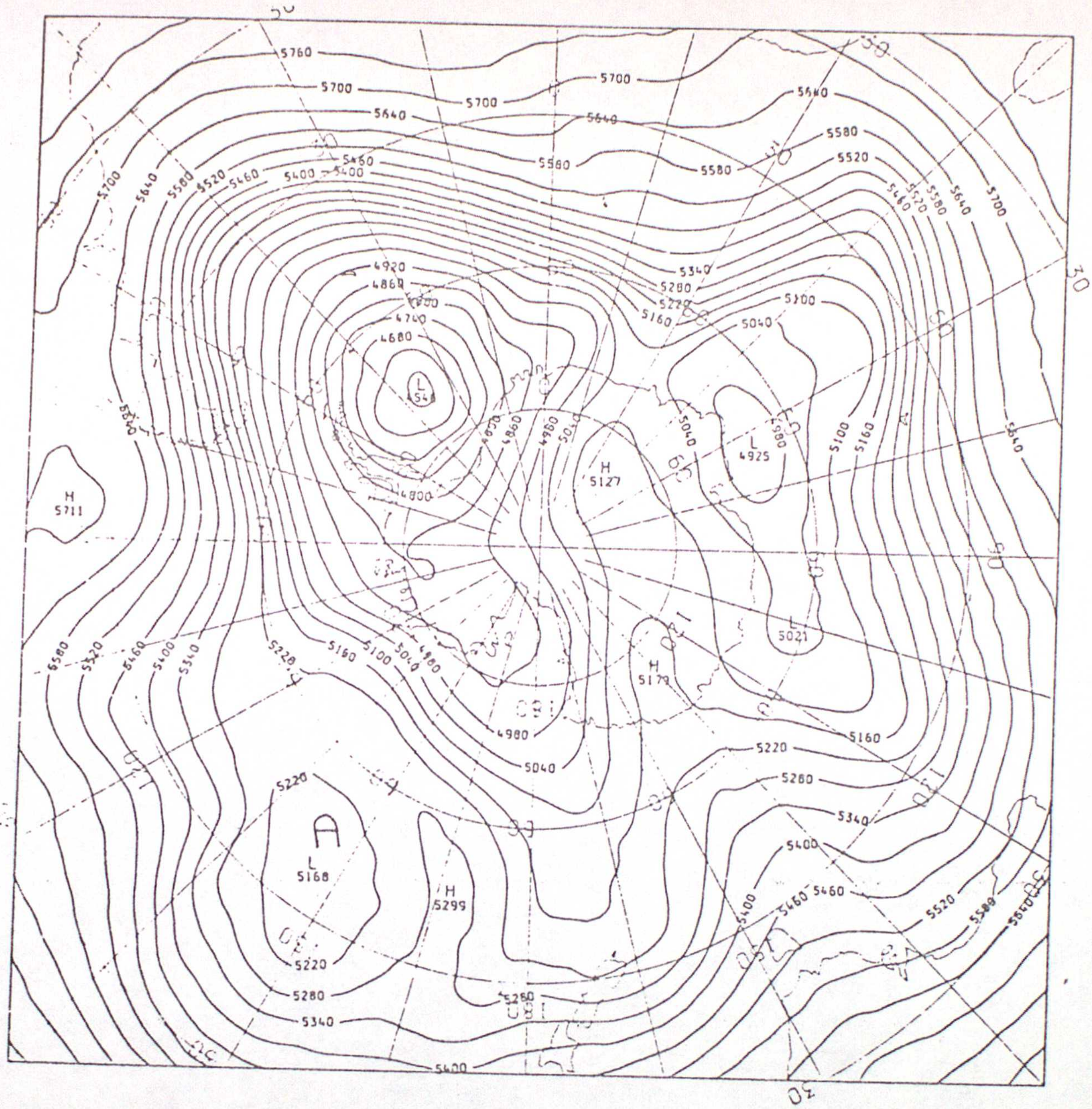

Figure 12)

Coarse mesh forecast 500 MB height (gpm)
VT 0000 GMT 17/8/79   DT 0000 GMT 12/8/79

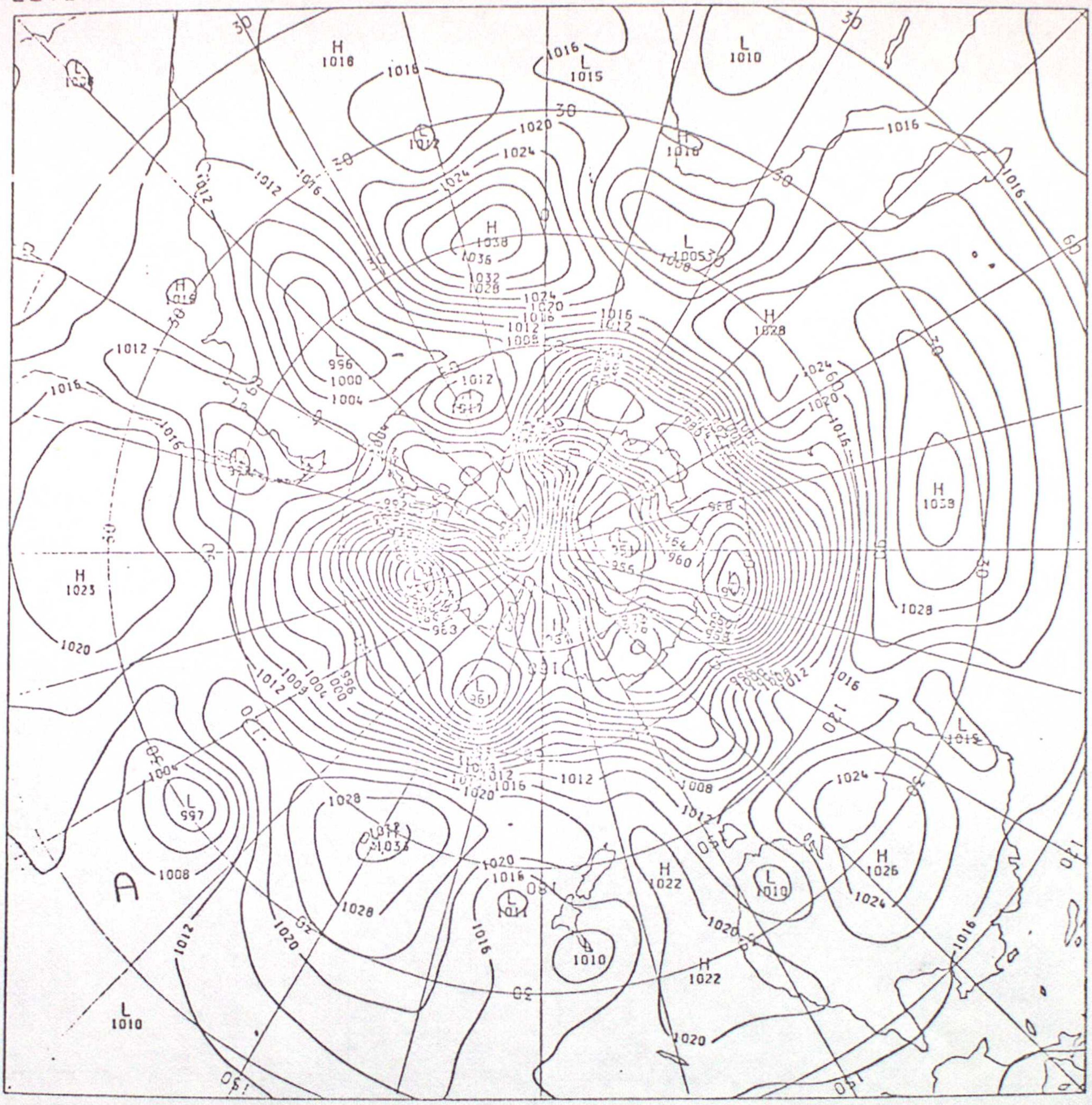

Figure 13)

FGGE IIIb mean sea level pressure analysis (MBS)
DT 0000 GMT 27/8/79

Figure 14)

FGGE IIIb mean sea level pressure analysis (MBS)
DT 0000 GMT 30/8/79

Figure 15)

FGGE IIIb mean sea level pressure analysis (MBS)
DT 0000 GMT 1/9/79

Figure 16)

Coarse mesh forecast mean sea level pressure (MBS)
VT 0000 GMT 30/8/79   DT 0000 GMT 27/8/79

Figure 17)

Coarse mesh forecast mean sea level pressure (MBS)
VT 0000 GMT 1/9/79   DT 0000 GMT 27/8/79

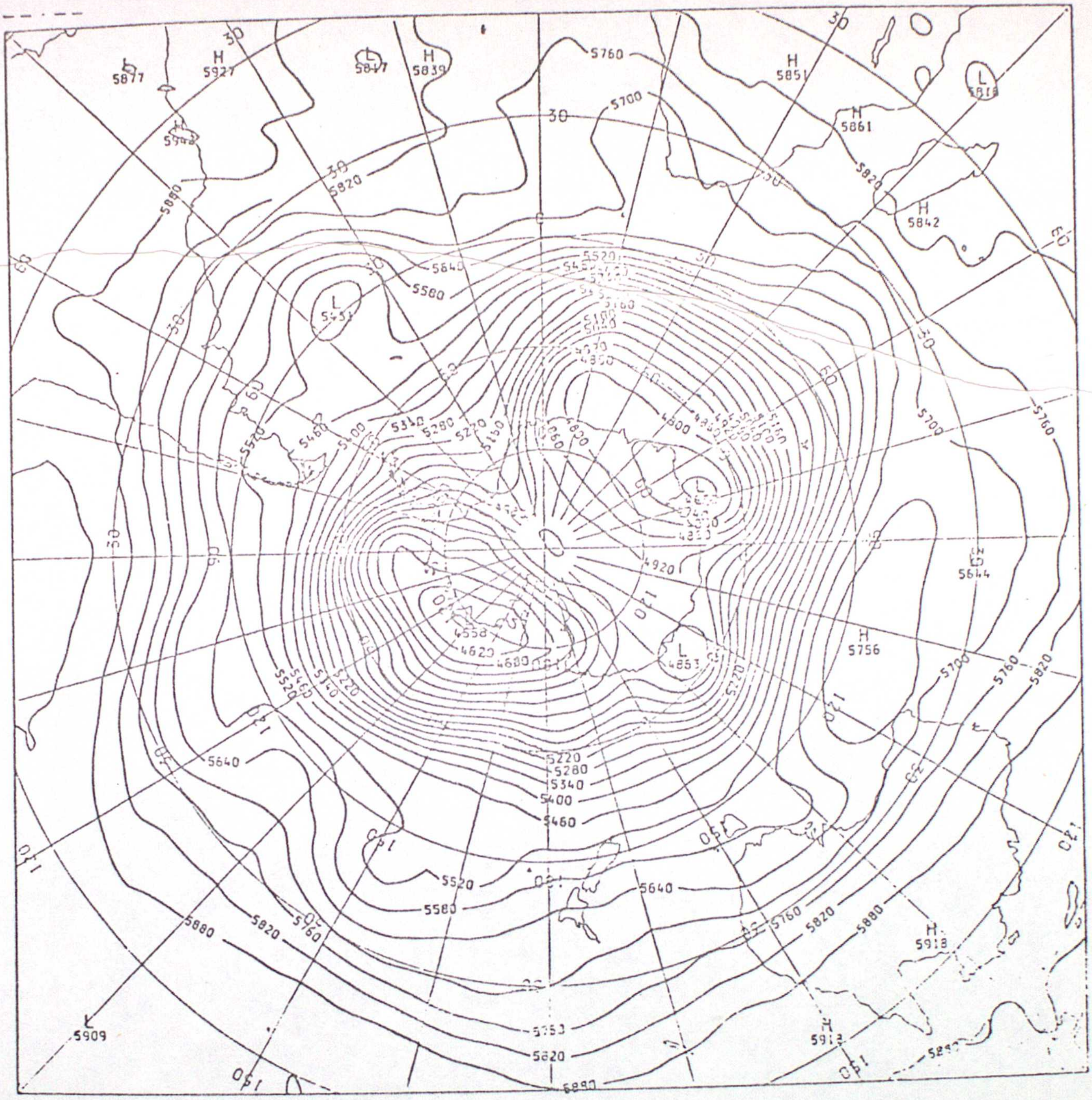

Figure 18)

Coarse mesh forecast 500 MB height (gpm)
VT 0000 GMT 31/8/79   DT 0000 GMT 27/8/79

Figure 19)

FGGE IIIb 500 MB height analysis (gpm)
DT 0000 GMT 31/8/79