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MET O 11 TECHNICAL NOTE NO 140

132986

A comparison of two different physics packages

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July 1980

Summary

Two physics packages, one with a climatological radiation scheme and the other an interactive radiation and cloud scheme were compared by producing three 5-day forecasts. The case studies chosen were 9th April 1978, 21st May 1978 and 1st August 1979. Charts were produced of mean sea level pressure (PMSL), 500 mb, temperature and wind vectors and the results were assessed, the main points being:-

1) The climatological scheme developed stronger highs at high latitudes and over the sea.

2) The climatological scheme gave lower pressure over land in middle latitudes.

3) The climatological scheme gave lower temperatures at 200 mb and contour heights at 500 mb.

4) The land-sea distribution was obvious in many of the difference charts.

5) There were no major synoptic differences between the two forecasts.

Contents

A comparison of two different physics packages

1. Introduction

An experiment was conducted using three case studies to compare two different physics packages in the Met O 20 11 level model, (Saker (1975)). Each of the case studies was run for five days, commencing at midday.

A description of the two schemes is given below.

(i) The Met O 20 climatological radiation scheme, HRCOOLER, was adapted to work at all times of year using global climatological values for January and April and using southern hemisphere coefficients in the northern hemisphere and vice-versa to obtain July and October values. These were then interpolated to the correct day of the year. The values were held constant for the sixty-day period around the winter and summer solstices. The boundary layer scheme, H43BNDRY, was used but with a simplified calculation of surface fluxes over land as in the Met O 20 experiment no 108. This scheme does not use a surface temperature and only a very simple partitioning of heat and moisture fluxes as shown in Figure 1.

This scheme will be given the identifying letter M.

(ii) The other version of the model uses the fully interactive radiation and cloud scheme in which the radiative fluxes and heating rates are calculated explicitly from the model's temperature and humidity fields, (Walker (1977)). In the radiation scheme, solar radiation is absorbed and scattered by atmospheric gases, clouds and by the earth's surface and infra-red (terrestrial) radiation is absorbed and emitted by atmospheric gases, clouds and the earth's surface. The cloud amounts used in the radiation calculations are predicted from the model's humidity and temperature structure. The scheme allows for three layer clouds (high, medium and low) and convective cloud. Layer cloud amounts are predicted using a quadratic relationship with relative humidity. In addition low cloud also occurs if a lower tropospheric temperature inversion exists, provided that there is an upward flux of sensible heat from the surface. In these experiments, no method for predicting convective cloud amounts has been included and thus convective cloud cover is taken as zero.

This scheme will be given the identifying leter J.

Both physics packages include the penetrative convection and dynamic rain routines.

The charts referring to the actual weather will be given the identifying letter A.

The three cases chosen were 9th April 1978, 21st May 1978 and 1st August 1979. The first two cases were run with the merged analysis, (Whiteway (1978)), and the third used F.G.G.E data. (A program was written to put the F.G.G.E data into a form suitable for the hemispheric forecast).

The diagnostics produced in each case were as follows:-

(i) PMSL and 500 mb charts for midday on each day.

(ii) 850 mb and 200 mb temperature charts for midnight on each day.

(iii) 850 mb and 200 mb wind vector charts for midnight on each day

(iv) PMSL and 500 mb difference field (M-J) for days 3 and 5.

(v) 850 mb and 200 mb temperature difference fields (M-J) for days 3 and 5.

100 mb charts for (ii), (iii) and (v) were produced for the August case only as in the other cases the ozone values for J were included in the model incorrectly.

One case is described in each of the following sections. The synoptic assessments are based on all the charts produced even though they may not all appear within this note. They concentrate on the differences between M and J, and are only then referred to observed values, which are regarded as the truth.

2. Synoptic assessment of 1st August 1979 case

The only charts included in this note are for day 5 unless otherwise stated. Differences in the charts for other days are summarised below.

Day 1 PMSL

Both forecasts predicted areas of low pressure in the same positions. The low over eastern Canada at 60°N 55°W in A was a little better in J. Neither M nor J correctly forecast the low over Scandinavia, but J was better. The high pressure area at 75°N 120°W in A was too large in both forecasts, M being rather worse. There were large differences over areas of high topography. This was also true on subsequent days.

500 mb

There were no major differences between the forecasts.

Day 2 PMSL

Both models failed to develop the low east of the Hudson Bay in A, nor did they predict the low over Scandinavia correctly. The areas of high pressure in both forecasts were much the same except that M, incorrectly, had higher pressures than J north of 60°N.

500 mb

The two upper lows at 65°N 80°W and 80°N 30°E were not deep enough in either model, but M did better. The ridges over Asia and Alaska were handled better by J. The difference map showed that this was mostly a mean difference with M producing lower contour heights over a large area north of 60°N. The intensities of the systems produced by the two models were similar.

Day 3 PMSL

The large high pressure areas were handled a little better by M. The difference field showed that this was partly a difference in the mean values, but at 40° - 60°N 60°W the gradient was greater in M.

500 mb

Both models failed to develop the two high latitude lows from day 2 correctly. The lower contour heights in M were nearer the truth.

Day 4 PMSL

The low at 60°N 170°E was better in J. Both models failed to develop the two lows in the North Atlantic. Otherwise, the forecasts were about the same.

500 mb

Differences between the charts were minor, except that J produced a slightly sharper trough at 60°N 30°W. M had a rather strong gradient in this area. Neither was correct.

Day 5 PMSL

The actual chart for day 5 is shown in Figure 2 with the forecast charts produced by M and J in Figures 3 and 4 and the difference between the two forecasts in Figure 5. By this time there were large errors. For instance, in the eastern Atlantic and UK sector, both forecasts underestimated low pressure moving in towards NW Scotland and missed the low pressure over north Germany. The difference field between the forecasts showed that M gave lower pressures over the band 30° - 60°N except over high topography. Detailed examination showed that M gave deeper depressions over land (60°N 90°E and 60°N 60°E) and J over the sea (50°N 40°W and 50°N 150°W). These differences were independent of the synoptic behaviour of the real atmosphere and neither was a better forecast. North of 60°N M gave higher pressure. In this case this was an improvement. South of 30°N M gave lower pressures over the land. Over Africa this was incorrect.

500 mb

The actual chart for day 5 is shown in Figure 6 with the forecast charts produced by M and J in Figures 7 and 8 and the difference between the two forecasts in Figure 9. The contour heights in M were generally lower by about 5 dm. The difference was largest in high latitudes, leading to slightly stronger gradients in M. The low values produced by M in higher latitudes and the higher values produced by J in lower latitudes were nearest the truth. Regarded as synoptic forecasts the two had similar validity and both contained substantial errors as compared with the actual.

Temperature Charts

It was difficult to assess the temperature fields separately for this and the following two cases as the charts were very similar, so the difference fields for days 3 and 5 were examined. The differences tended to amplify steadily through the forecast, so only the day 5 charts are shown. The discussion covers both days 3 and 5.

Day 3

At 850 mb the temperature differences tended to have the opposite sign to the surface pressure differences. The general trend of temperature in the two was similar. At high latitudes M was colder than J, and both were colder than the actual. In middle latitudes M was mostly warmer over land except over high mountains over the USA. The two models were similar over the sea. Over the USA J was better but over China M was better. South of 30°N M was warmer except over the Pacific. M was better at 25°N 15°W and J was better at 5°N 45°E. Thus, except at high latitudes, the forecasts were of similar standard.

At 200 mb M was cooler especially in low latitudes, where the differences reached 4°K. In middle latitudes J was generally nearer the truth, but in low latitudes the actual was in between the two forecasts. The models showed similar variability which was substantially less than the actual.

At 100 mb M was slightly warmer. This was usually an improvement but the difference was much smaller than the forecast errors.

Day 5

The 850 mb temperature difference field is shown in Figure 10. The differences again tended to have the opposite sign to the surface pressure differences. M was cooler at high latitudes and over high topography in middle latitudes and warmer at low latitudes than J. Over the sea the forecasts were similar apart from a few small areas where M was warmer. M was better at 30°N 35°E, 75°N 165°W, 20°N 55°E and 45°N 165°W. J was better over the Great Lakes. Otherwise the forecasts were similar.

At 200 mb (Figure 11) M was cooler in most regions, by an average of 3°-4°K and reaching as much as 6°K in a few places. In low latitudes M was predominantly colder than A and J warmer than A. In middle latitudes J was better at 50°N 75°W and 60°N 20°E, and M was better at 45°N 15°E and 50°N 135°E. Overall the forecasts were similar in standard.

At 100 mb (Figure 12) M was slightly warmer and on the whole was better than J in particular at 45°N 0°W.

Wind Vector Charts

In general the charts were very similar and compared favourably with A.

Slight differences occurred at 100 mb on day 4 between $0^\circ - 30^\circ N$ $140^\circ - 180^\circ E$ where J was a little better. At 850 mb on day 5 M was a little better to the west of South America and also over northern Africa. At 100 mb on day 5 the differences were minor.

3. Synoptic assessment of 9th April 1978 case

The PMSL and 500 mb charts included for this case are for day 4.

Day 1 PMSL

The only difference at this stage was in the low over Scandinavia. The lowest pressure was positioned better in J.

500 mb

There were no major differences.

Day 2 PMSL

By now M had deepened the Scandinavian low too much but had handled the large area of high pressure in the Atlantic a little better than J.

500 mb

The charts were very similar apart from the low at $65^\circ N$ $10^\circ E$ which was correctly less intense in J.

Day 3 PMSL

Again the charts were similar except that M gave better high pressure areas over the sea and J over land. The difference field showed that M gave higher pressure north of $60^\circ N$ and over the sea between 30° and $60^\circ N$ and J gave higher pressure over land between the same latitudes.

500 mb

The largest differences were over high topography. The low over Scandinavia was too deep in both forecasts but J was a little better. The contour heights over the USA were lower in J but neither model was obviously superior.

Day 4 PMSL

The actual chart for day 4 is shown in Figure 13. The forecasts given by M and J are shown in Figures 14 and 15 and the difference field in Figure 16. Most of the differences between the forecasts were accounted for by the generally higher pressure in M north of 60°N and over the sea north of 30°N, and the higher pressure in J over land between 30° and 60°N. The main exceptions to this pattern were over high topography. This difference led to weaker gradients in M near Greenland but a stronger gradient over the Norwegian Sea. These differences tended to occur irrespective of the real story. Thus, for instance, J gave a better forecast of the Scandinavian low and the high near the North Pole. The differences over the land reached 8 mb while over mid latitude oceans they were rarely more than 4 mb.

<u>500 mb</u>

The actual chart for day 4 is shown in Figure 17. The forecasts given by M and J are shown in Figures 18 and 19 and the difference field in Figure 20. There was a large difference between the models near the Great Lakes, but the actual was more different from either. M correctly gave lower contour heights over Scandinavia. It also did this in the two low centres at 75°N, here the values in J were more correct but the gradients were a little better in M. Both models gave too low contour heights further south. At low latitudes the differences were smaller.

<u>Day 5 PMSL</u>

The land-sea difference between the models persisted. The higher pressure given by M north of 60°N was correct. Over the sea the lower pressure in J was usually better, though the low at 45°N 60°W was too deep. Both made a large error over North China. In mid-latitudes the higher pressure in J was better over both the USA and Asia. Over the eastern seaboard of the USA the land-sea effect resulted in stronger gradients in J.

<u>500 mb</u>

M gave generally lower contour heights in high latitudes incorrectly. Otherwise the charts were very similar.

<u>Temperature charts</u>

<u>Day 3</u>

At 850 mb there was a similarity in the trend of temperatures in the two charts.

In high latitudes, M was mainly colder than J by as much as $8^{o}K$ in one place. Apart from over high topography., M was generally warmer over the land and coastal regions. This reflected the PMSL differences. Neither model appeared to be superior.

At 200 mb, M was cooler in all latitudes by as much as $4^{o}K$ apart from a few small areas, all over the sea, where M was up to $1^{o}K$ warmer than J. It was noted that nearly all the areas in which M was colder by $2^{o}K$ or more, occurred over the land. J was nearer the truth in low latitudes whereas M generally produced more realistic temperatures in mid-latitudes.

Day 5

At 850 mb (Figure 21) the temperature difference field had the opposite sign to the surface pressure differences in many areas. In high latitudes, M was colder than J, but was generally warmer in middle latitudes. These warmer areas occurred over the land. J was better over the North Atlantic and Europe apart from Italy where M was nearer the truth.

The 200 mb difference field is shown in Figure 22. Apart from a few isolated areas, mainly over the sea and in particular off the coast of California, M was colder than J in all latitudes by an average of $4^{o}K$. The temperatures over USA were more realistic in J's forecast but M was better in the Far East.

Wind Vector Charts

The first difference noted was at 200 mb on day 3 when M had stronger winds in the region 0^{o} - $10^{o}N$ 160^{o} - $180^{o}E$. On day 5 M had stronger winds at 850 mb between 0^{o} - $10^{o}N$ 40^{o} - $80^{o}E$ and at 200 mb between 100^{o} - $120^{o}E$ 30^{o} - $40^{o}N$.

4. Synoptic assessment of 21st May 1978 case

Day 1 PMSL

M accurately predicted the deep low over Newfoundland but J was 4 mb too deep. The low over Asia at $50^{o}N$ $60^{o}E$ was too deep in both cases but J was nearer the truth.

500 mb

J produced a ridge of the correct extent over Scandinavia, whereas M gave too weak a ridge.

Day 2 PMSL

Both models deepened the low at 55°N 60°E by the same amount, so J was still better, but M handled the high pressure areas better.

500 mb

By now the large area of low pressure, north of Canada had formed two cut-off lows which were more apparent in J. M was not as good as J at 60°N 140°E but was better at 75°N 105°E. The strong ridge over Scandinavia in M was not as good as that in J.

Day 3 PMSL

Both models filled the low over Europe, J completely and was closer to the truth. There was a large fairly deep low to the south of the Bering Straits in A, at which J made the better attempt. The high pressure areas in J were not as good as in M and the area around 75°N 60°E was completely wrong.

500 mb

The models failed to predict correctly the course of the two lows at 60°W, both handling the situation slightly differently, and it was difficult to say which was better. M produced a good attempt at the trough over Iceland but this forced the Atlantic ridge to the west instead of passing to the east and linking with the high over Scandinavia. In J the trough was not so pronounced, and, taking the short wave-length of the ridge into consideration, it was predicted that the ridge would move eastwards (which was correct) and thus J gave the superior forecast. The low at 75°N 100°E was too deep in both models, especially in M. J enlarged the low south of the Bering Straits, but failed to deepen it. M however enlarged it and deepened it a little, though not enough.

Day 4 PMSL

Neither model was correct in the region of 70°N 60°E but M was a little better. M produced excessive areas of high pressure in high latitudes, although in general the maximum pressure was better than in J. J gave better positions but too low central pressures.

500 mb

The low north of Canada was the correct depth in J, M being too deep whereas, although too great in extent, M had the better low at 75°N 75°E. M maintained the trough to the north-west of the British Isles forming a barrier between the ridge and the high, but in A it had moved north-east over Scandinavia. This trough was not in evidence in J. Although the ridge was not accurately forecast, the orientation and extent being incorrect, J was better than M. Both models made no attempt to move the low, to the south of the Bering Straits, eastwards, but they did deepen it. Thus M was still the better forecast in this area.

Day 5 PMSL

The actual chart for day 5 is shown in Figure 23 and the forecasts by M and J in Figures 24 and 25. The difference field is shown in Figure 26. M produced higher pressure, north of 60°N, by 8 mb, in many areas, which was incorrect. M also produced higher pressures over the oceans between 30° and 60°N by about 4 mb. In the Atlantic this was an improvement, but in the Pacific it was incorrect. M produced lower pressures over the land except over high mountains and over an area in NW Canada. In most areas this was incorrect. As a result of this, M produced stronger easterly gradients, incorrectly, over northern Siberia but correctly near the Aleutians.

500 mb

The actual chart for day 5 is shown in Figure 27 and the forecasts by M and J in Figures 28 and 29. The difference field is shown in Figure 30. M produced lower contour heights by about 8 dm, in high latitudes and 4 dm in low latitudes. The low values of M in high latitudes were correct, as were the higher values of J in low latitudes. The overall gradient was thus better in M. However, the maximum gradients were similar in both models. The mid-latitude cut-off lows at 55°N 50°W and 60°N 180°W were defined better in J because of the increased contour height to the north of them. The stronger south-east gradient produced by J near Greenland was not correct. There were substantial errors in both forecasts which were much greater than the difference between the models.

Temperature charts

Day 3

At 850 mb in high latitudes and over high topography the temperature differences once again tended to have the opposite sign to the surface pressure differences, indicating that J was warmer than M in these areas. M was only warmer than J over the land in middle and low latitudes. Neither model appeared to be superior.

At the 200 mb level, M tended to be colder than J in most areas at all latitudes, particularly over the land. The only places where M was either equal to or 1^{o}K warmer than J, occurred over the sea. M did better over USA and the Far East whereas J was nearer the truth over Europe and the Middle East.

Day 5

The 850 mb temperature difference field is shown in Figure 31. In most areas, and particularly in high latitudes the temperature differences had the opposite sign to the surface pressure differences. The majority of cases where M was warmer than J were over the land and the areas where M was colder than J were mainly concentrated in middle and high latitudes, the distribution between land and sea being about the same. M produced better temperatures over Europe and the Middle East.

The 200 mb temperature difference field is shown in Figure 32. M was colder than J in nearly all areas by an average of 4^{o}K, the two exceptions being in the Atlantic and the eastern Pacific, in particular off the coast of California. J was closer to A in high latitudes, Europe and the Middle East but M was better over the USA.

Wind Vector Charts

Again, differences in these charts were minor and only occurred in areas where the wind was very light except for day 5 at 200 mb where M had stronger winds than J in the area 30 - 40^{o}N 100 - 120^{o}E.

5. Conclusions

At the surface in all three case studies, M tended to have higher pressure than J in high latitudes and lower pressure over the land in middle and low latitudes. There were large differences over high topography. These effects led to large differences in gradients around 60°N and near coasts on several occasions. The distinction between land and sea was most obvious in the April case.

At the 500 mb level, M generally produced slightly deeper lows than J. From the 500 mb difference charts it can be seen that differences between the two were largest in high latitudes, decreasing towards the Equator, M having the greater overall gradient and generally lower contour values than J.

In each case, apart from day 3 of the April study which was less obvious, the temperature difference field at 850 mb usually had the opposite sign to the surface pressure differences. M was invariably colder than J in high latitudes for all cases. In the August study M was mainly the warmer of the two at middle and low latitudes except over high topography where J was warmer. In the April case, the areas where M was warmer occurred mainly in mid-latitudes and mostly over the land and coastal regions. In the May case, the areas where M was warmer than J were in middle and low latitudes, over or near land. It was noted that in the August and April studies, differences of 2°K or more were in general over land or coastal waters.

At 200 mb M was cooler than J in all three cases and at all latitudes by day 3 and to a greater extent by day 5. It was interesting to note that in each of the day 5 charts at this level there was a small area off the coast of California where M was 2° - 3°K warmer than J.

The 100 mb temperature difference charts were only analysed for the August case. At day 3 differences were small, apart from three areas - over the USA, Spain and southern France and Turkey. Differences were a little greater by day 5, M being the warmer of the two, and were distributed irrespective of the land-sea distribution.

There were no major differences in the wind vector fields and, for this reason, none of the charts have been included in this note.

Taken over all three case-studies, there was not a great difference in the major features of the forecasts produced by M and J, however J appeared to be nearer the truth on more occasions. Most of the differences were in the general levels of pressure or temperature over land or sea at particular latitudes. Therefore modifications to the coefficients in the climatological radiation scheme could remove the differences and improve the forecasts produced by M. Since the climatological scheme uses much less computer time than the interactive scheme, this is the course recommended.

Acknowledgements

I would like to thank Dr M J P Cullen and Mrs J Slingo for their help in this experiment and in the compilation of this note.

References

Saker, N J 1975 'An 11-layer general circulation model' Met O 20 Tech Note No II/30.

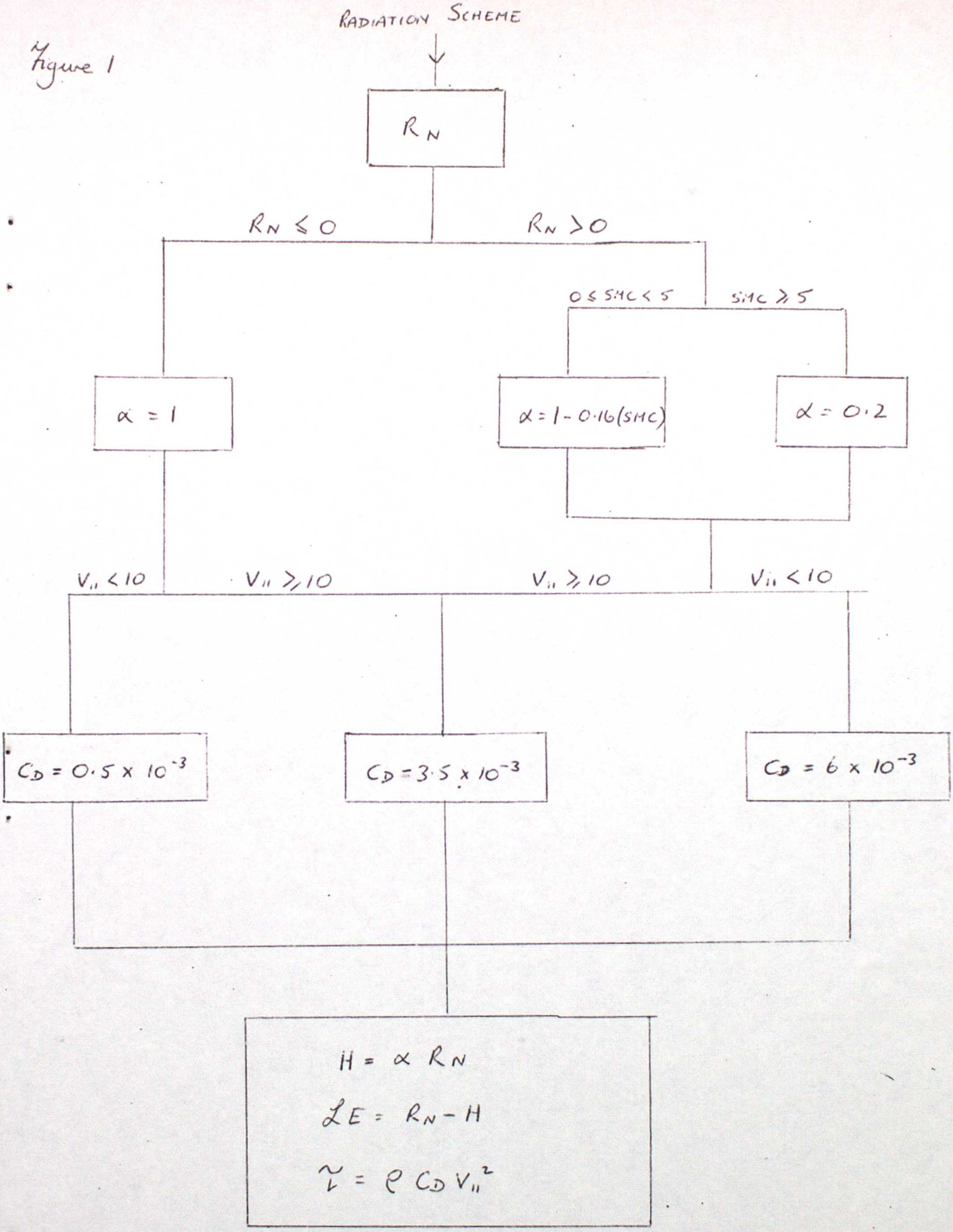
Walker, Julia 1977 'Interactive cloud and radiation in the 11-layer model Part I: Radiation scheme' Met O 20 Tech Note No II/91.

Whiteway, J 1978 'The merged analysis: a super-hemispheric critical data set for the high-resolution Model'. Met O 20 Tech Note No II/129.

List of Figures

Scheme for surface fluxes over land

Figure 1



EXPERIMENT 1 TIME = D005H12 PMSL
CONTOUR INTERVAL = 4.00 MB

Figure 2

1/8/79 A chart for day 5

EXPERIMENT 1 TIME = D005H12 PMSL
CONTOUR INTERVAL = 4.00 MB

Figure 3

1/8/79 M chart for day 5

EXPERIMENT 1 TIME = DOOSH12 PMSL
CONTOUR INTERVAL = 4.00 MB

Figure 4

1/8/79 J chart for day 5

Figure 5
1/8/78

PMSL difference M-J
for day 5

DIFFERENCE IN PMSL. FOR EXM 1 - EXM 1 0 SM12
CONTOUR INTERVAL = 3.00

EXPERIMENT 1 TIME = DOO5H12 500 MB HEIGHTS
CONTOUR INTERVAL = 6.00 DEKAMETRES

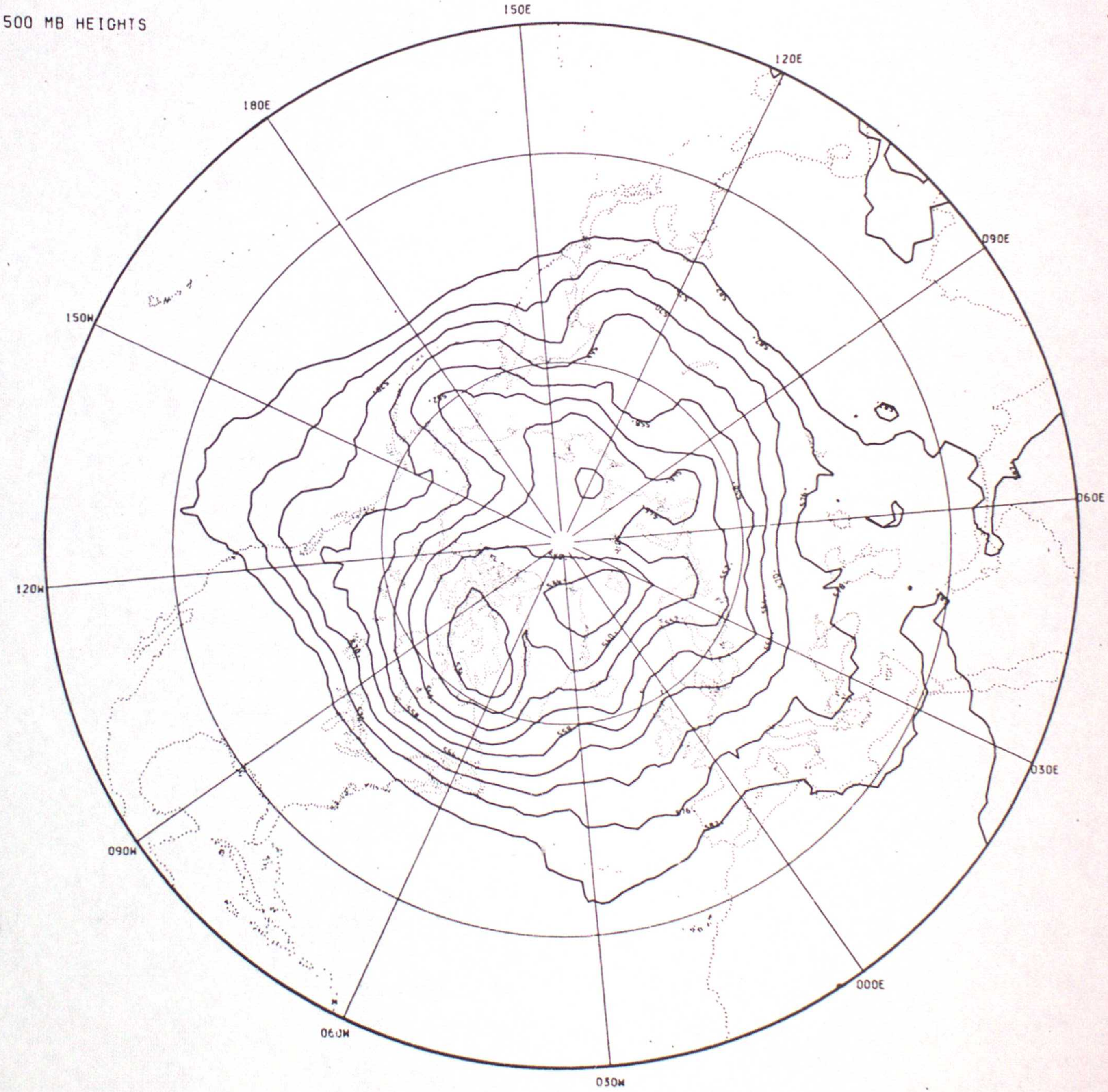
Figure 6

1/8/79 A chart for day 5

EXPERIMENT 1 TIME = DOO5H12 500 MB HEIGHTS
CONTOUR INTERVAL = 6.00 DEKAMETRES

Figure 7

1/8/79 M chart for day 5



EXPERIMENT 1 TIME = DOO5H12 500 MB HEIGHTS
CONTOUR INTERVAL = 6.00 DEKAMETRES

Figure 8

1/8/79 J chart for day 5

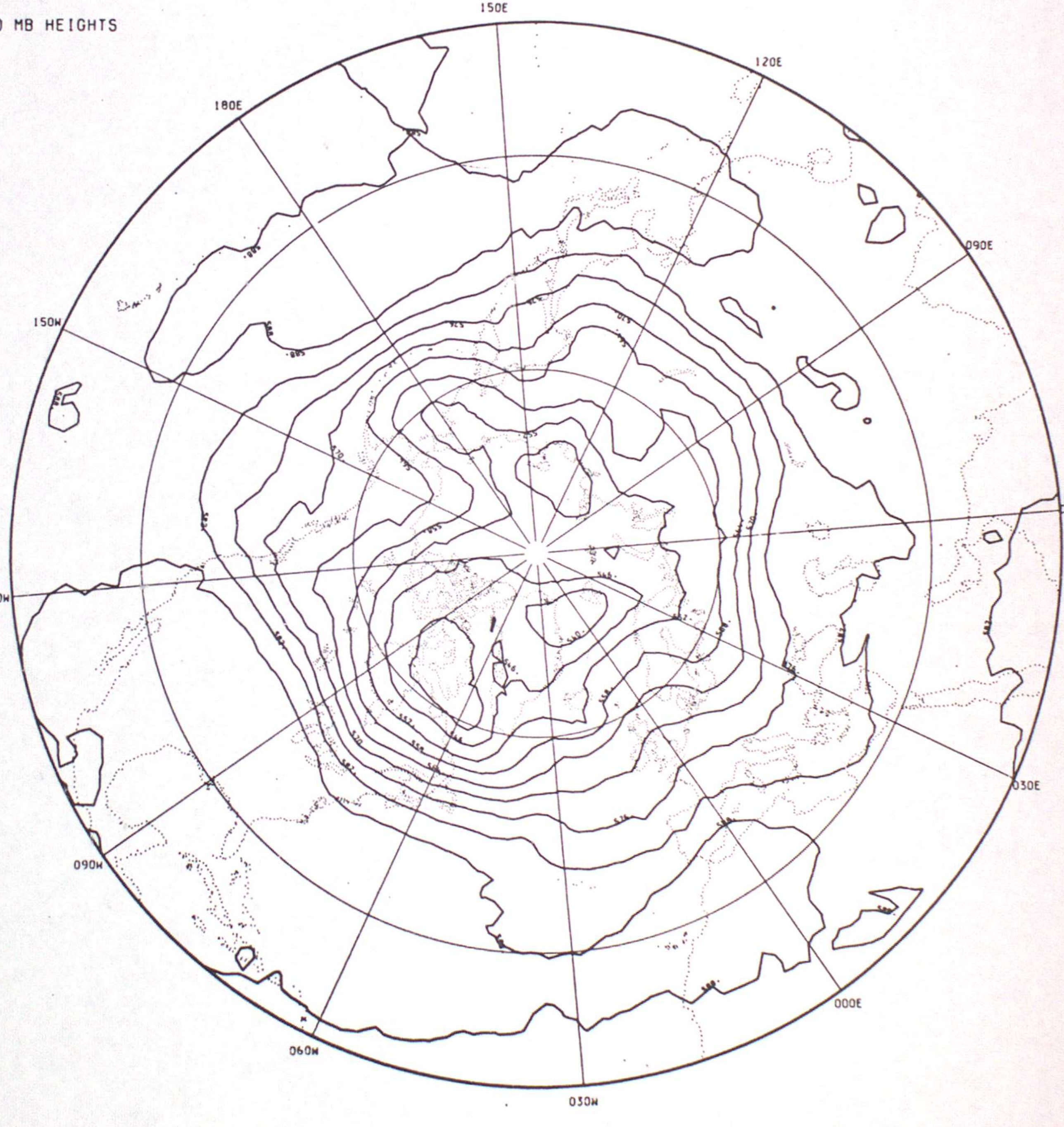
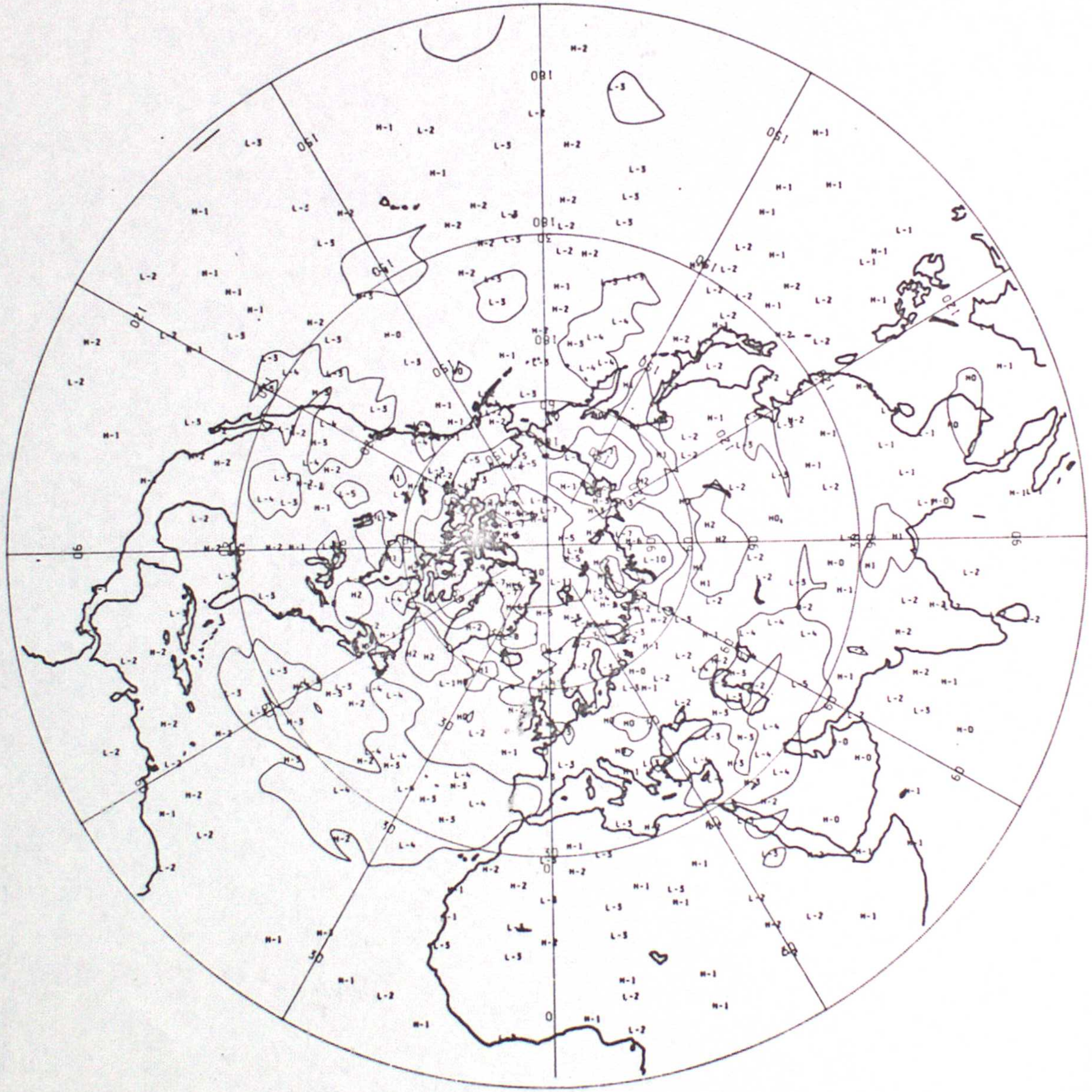


Figure 9
1/8/78
500 mb. difference M-J
for day 5



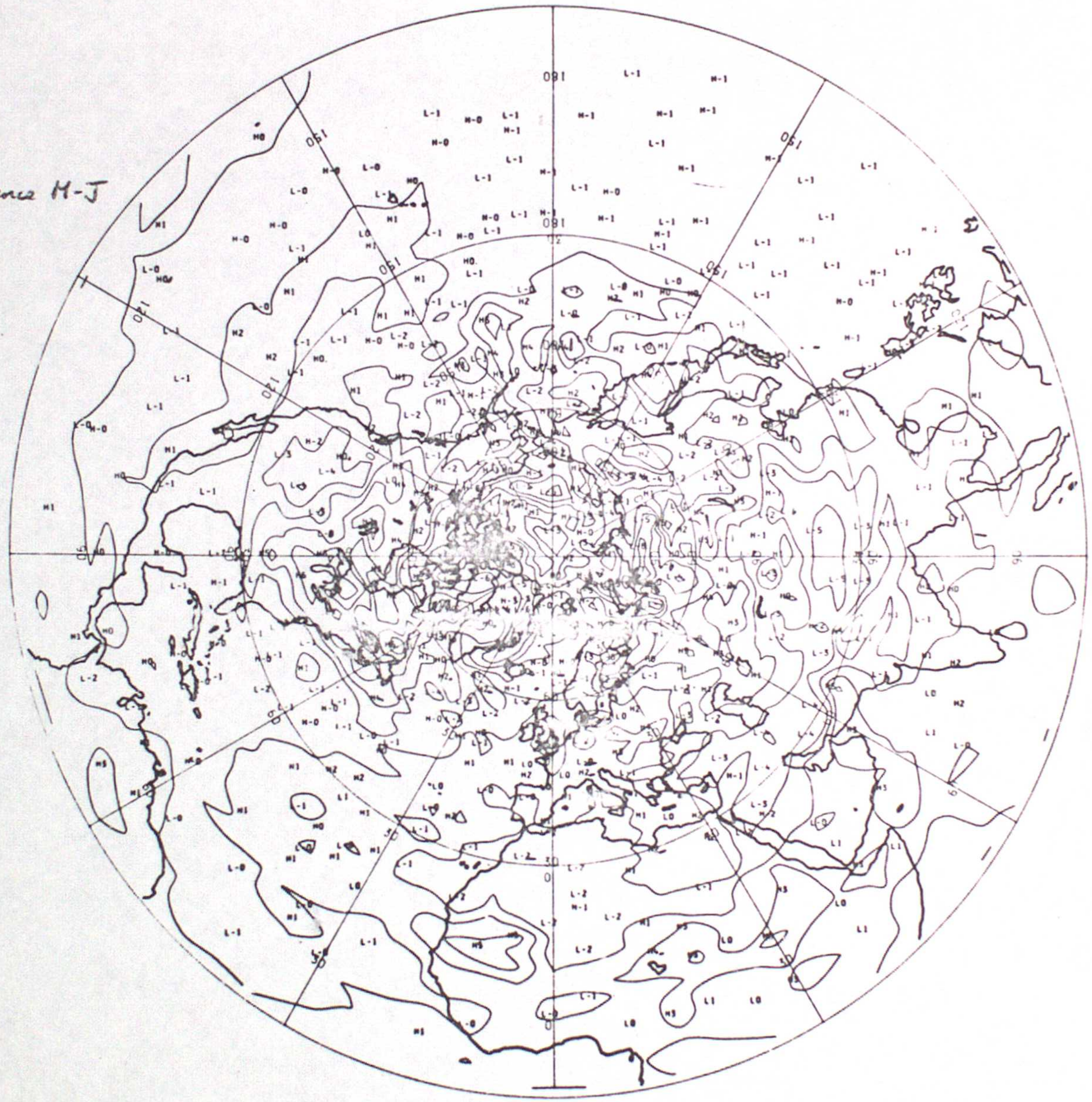
DIFFERENCE IN PRESSURE LEVEL =500.0 FOR EXH 1 - EXH 1 D 5H12
CONTOUR INTERVAL = 3.00

Figure 10

1/8/79

850 mb. Temperature difference M-J

for day 5



DIFFERENCE IN TEMPERATURE.SIGMA LEVEL=0.844 FOR EXH 1 - EXH 1 D 5H 0
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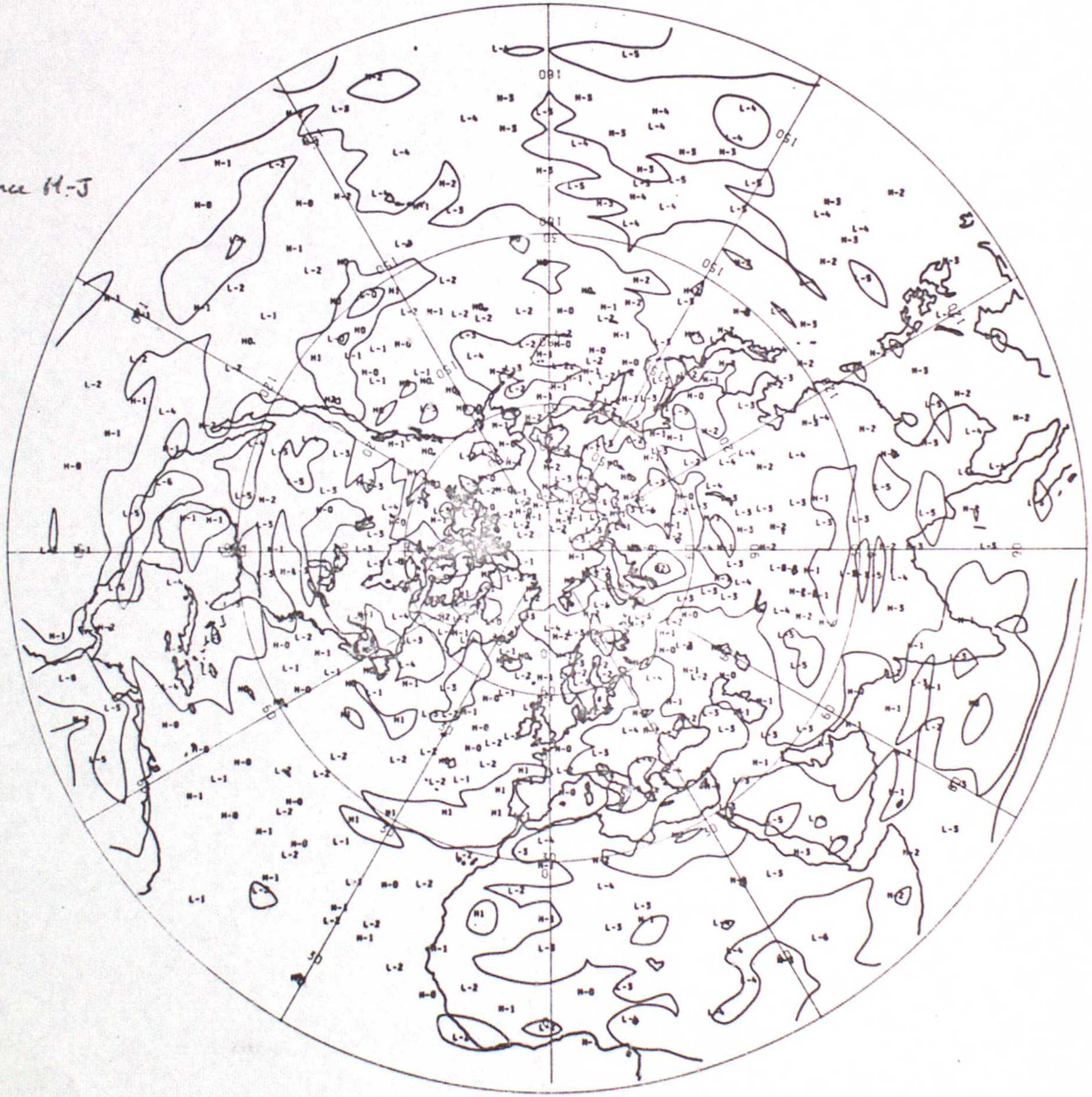
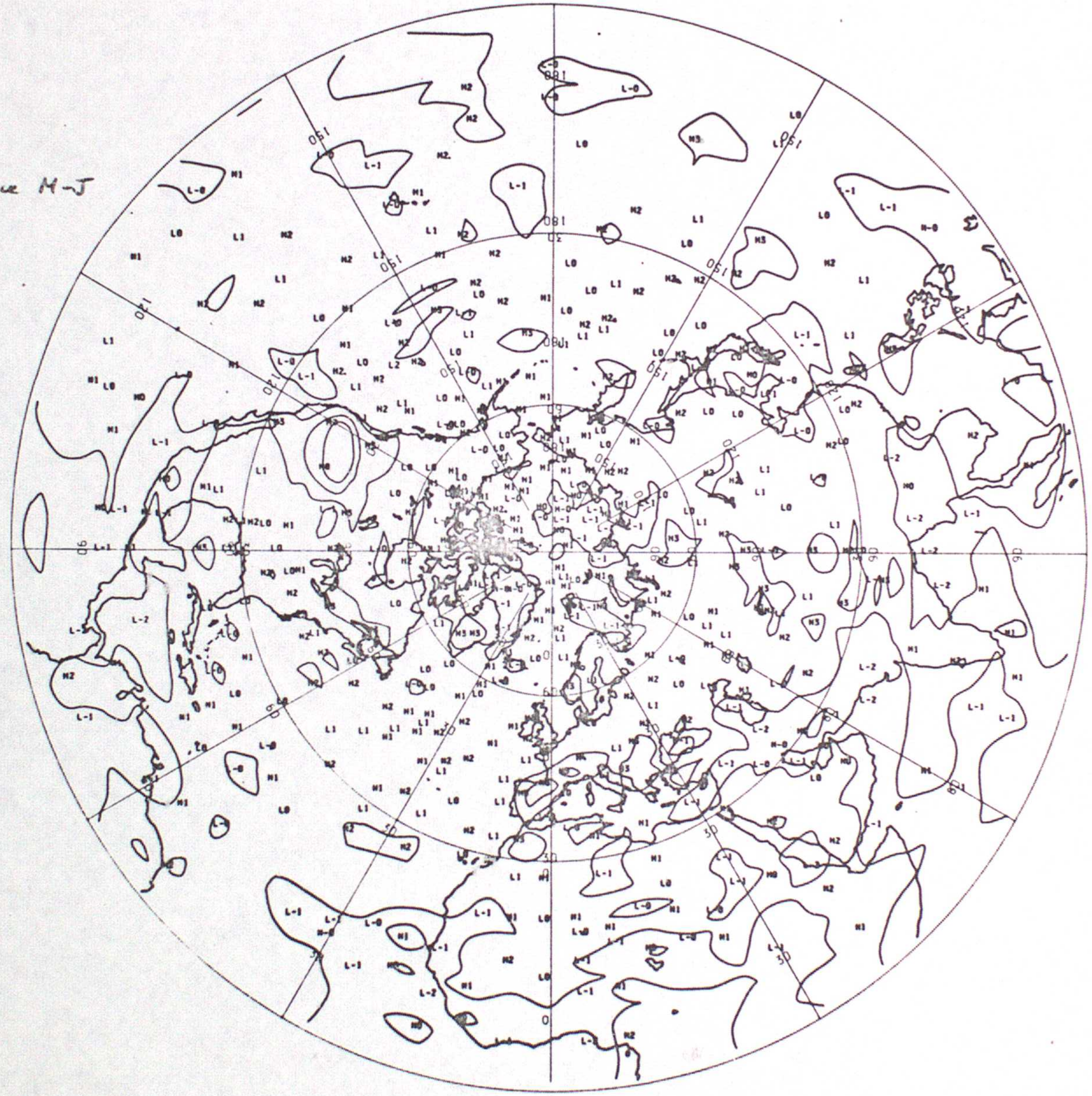
Figure 11
1/8/79
200 mb temperature difference H-J
for day 5



DIFFERENCE IN TEMPERATURE.SIGMA LEVEL=0.230 FOR EXH 1 - EXH 1 D 5H 0
CONTOUR INTERVAL = 2.00

Figure 12
1/8/79
100mb temperature difference M-J
for day 5



DIFFERENCE IN TEMPERATURE.SIGMA LEVEL=0.089 FOR EXH 1 - EXH 1 D 5H 0
CONTOUR INTERVAL = 2.00

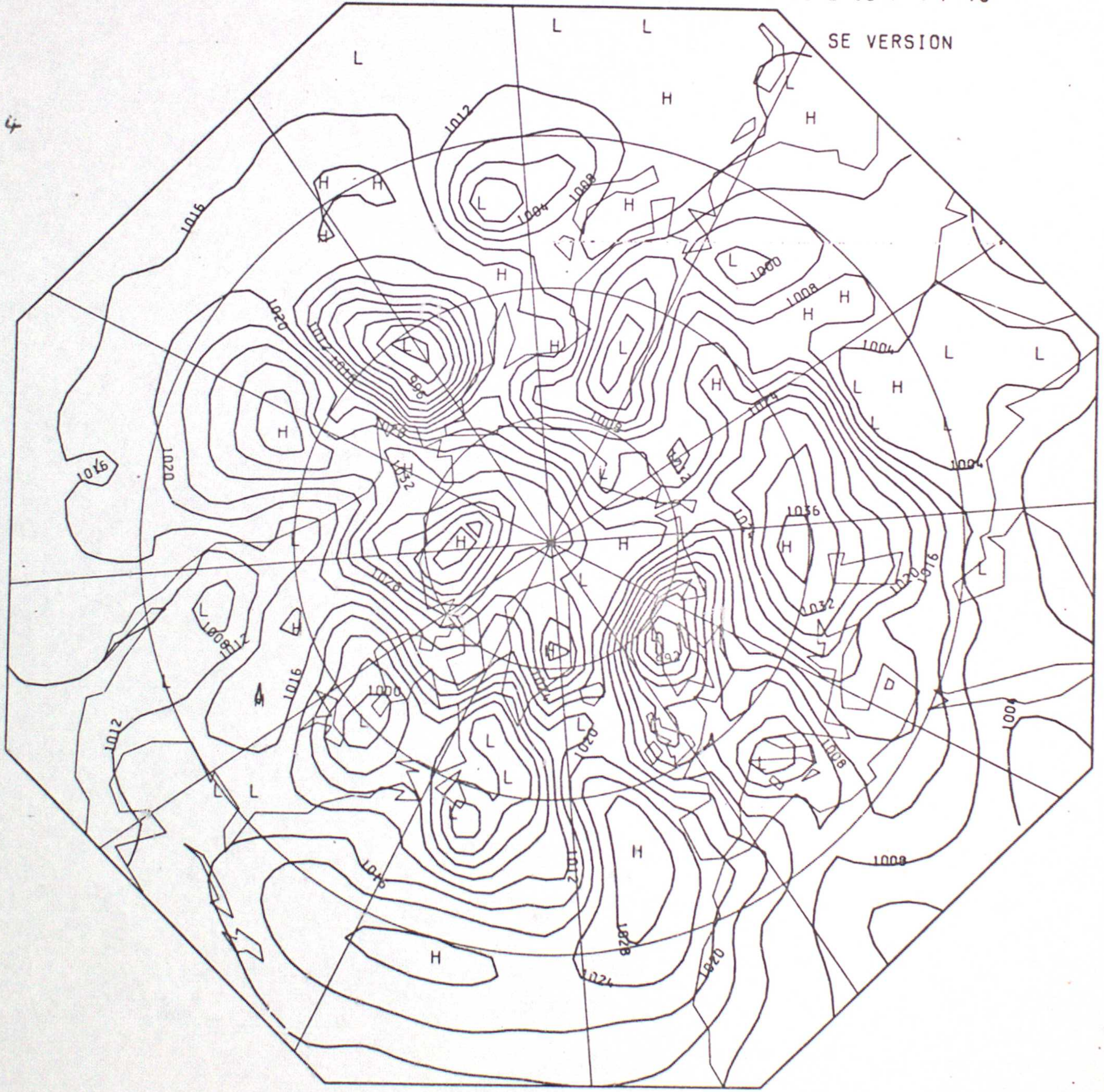
SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 13 / 4 / 78. VERIFICATION TIME 12 Z 13 / 4 / 78

SE VERSION

Figure 13

9/4/78 A chart for day 4



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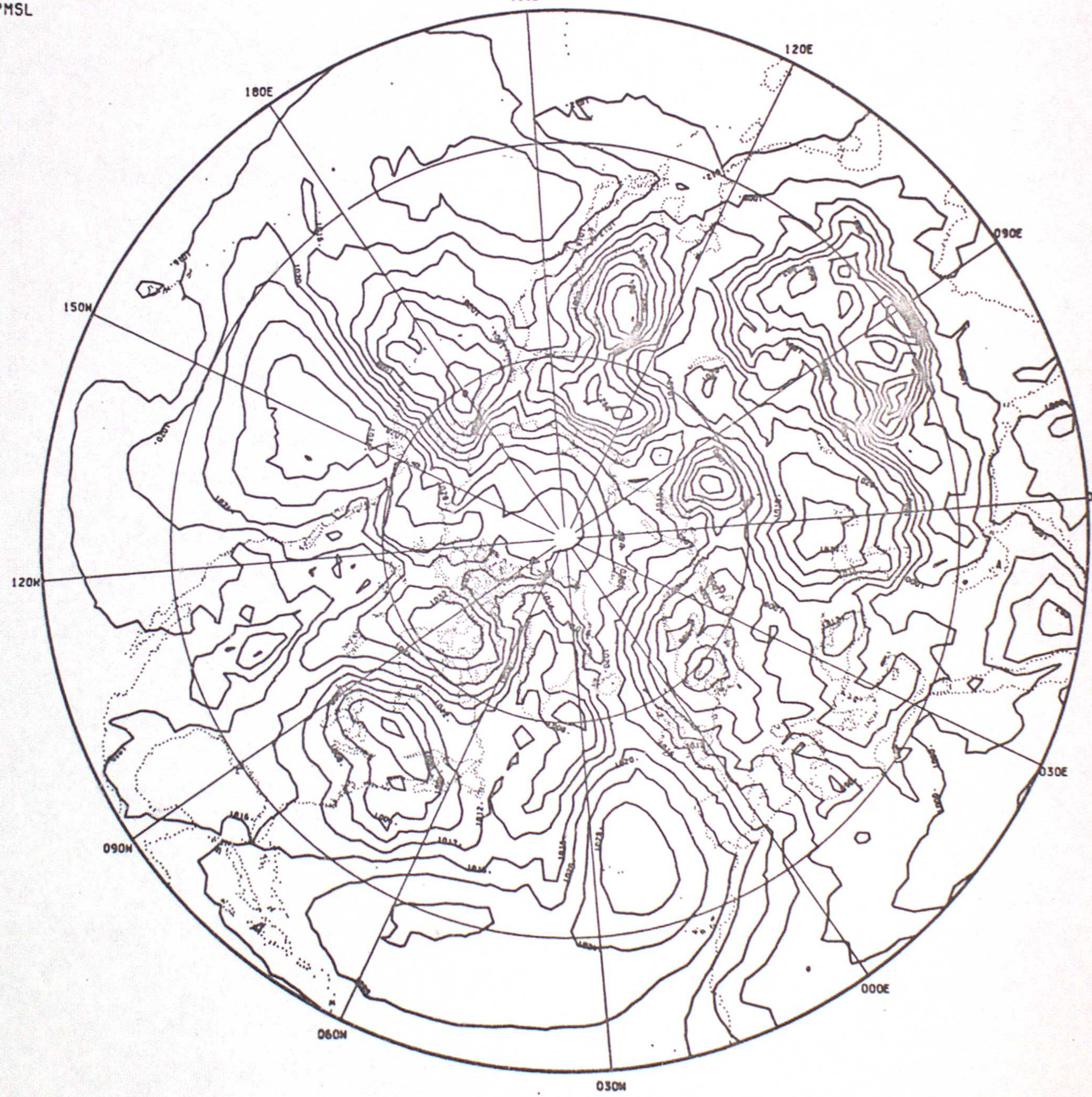
CONTOUR INTERVAL = 4.00 MB

Figure 14

9/4/78 M chart for day 4



EXPERIMENT TIME = D004H12 PMSL
CONTOUR INTERVAL = 4.00 MB

Figure 15

9/4/78 J chart for day 4

Figure 16
9/4/78
PMSL difference M-J
for day 4

DIFFERENCE IN PMSL. FOR EXH O - EXH O D 4H12
CONTOUR INTERVAL = 3.00

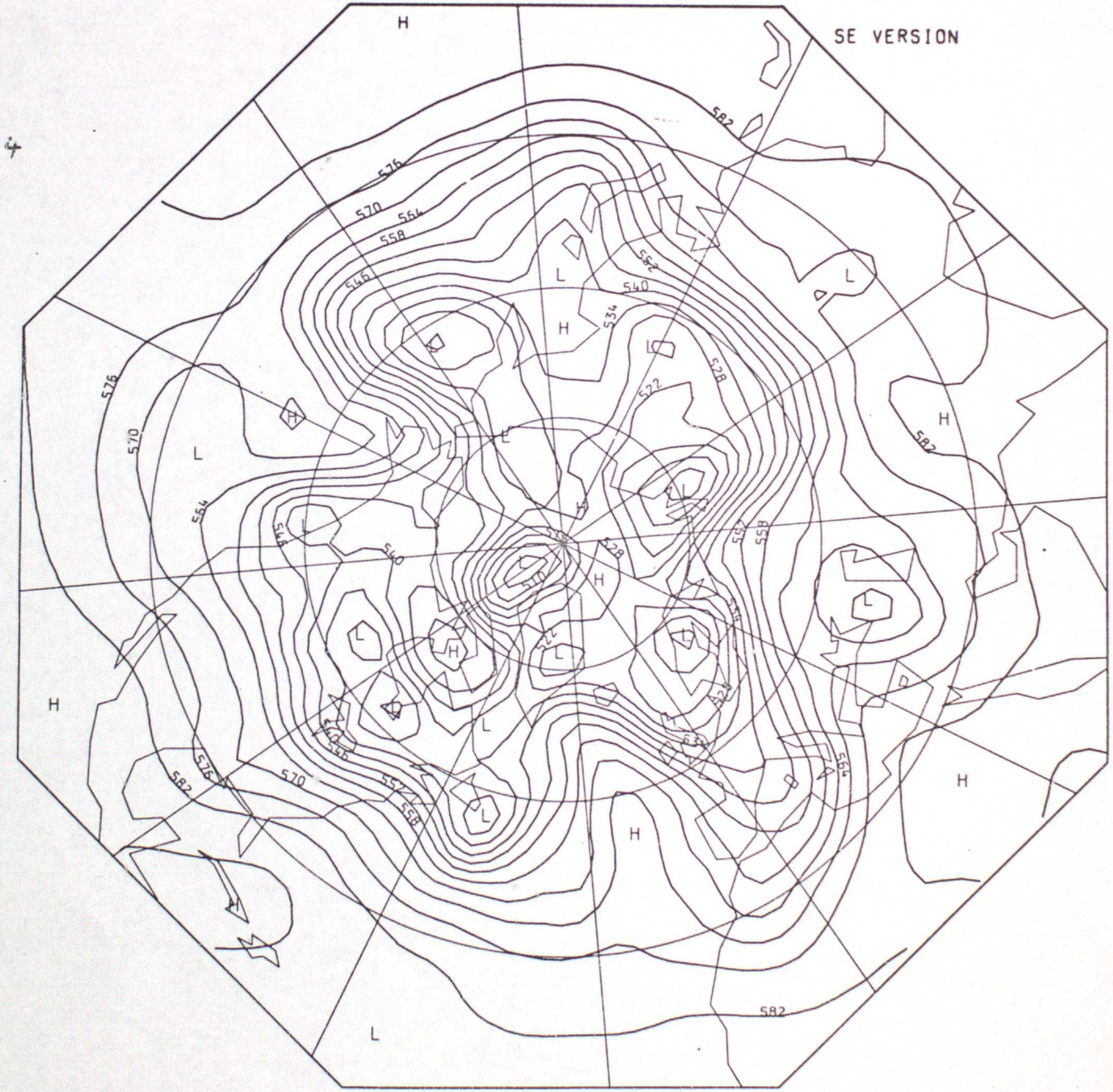
500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 13 / 4 / 78. VERIFICATION TIME 12 Z 13 / 4 / 78

SE VERSION

Figure 17

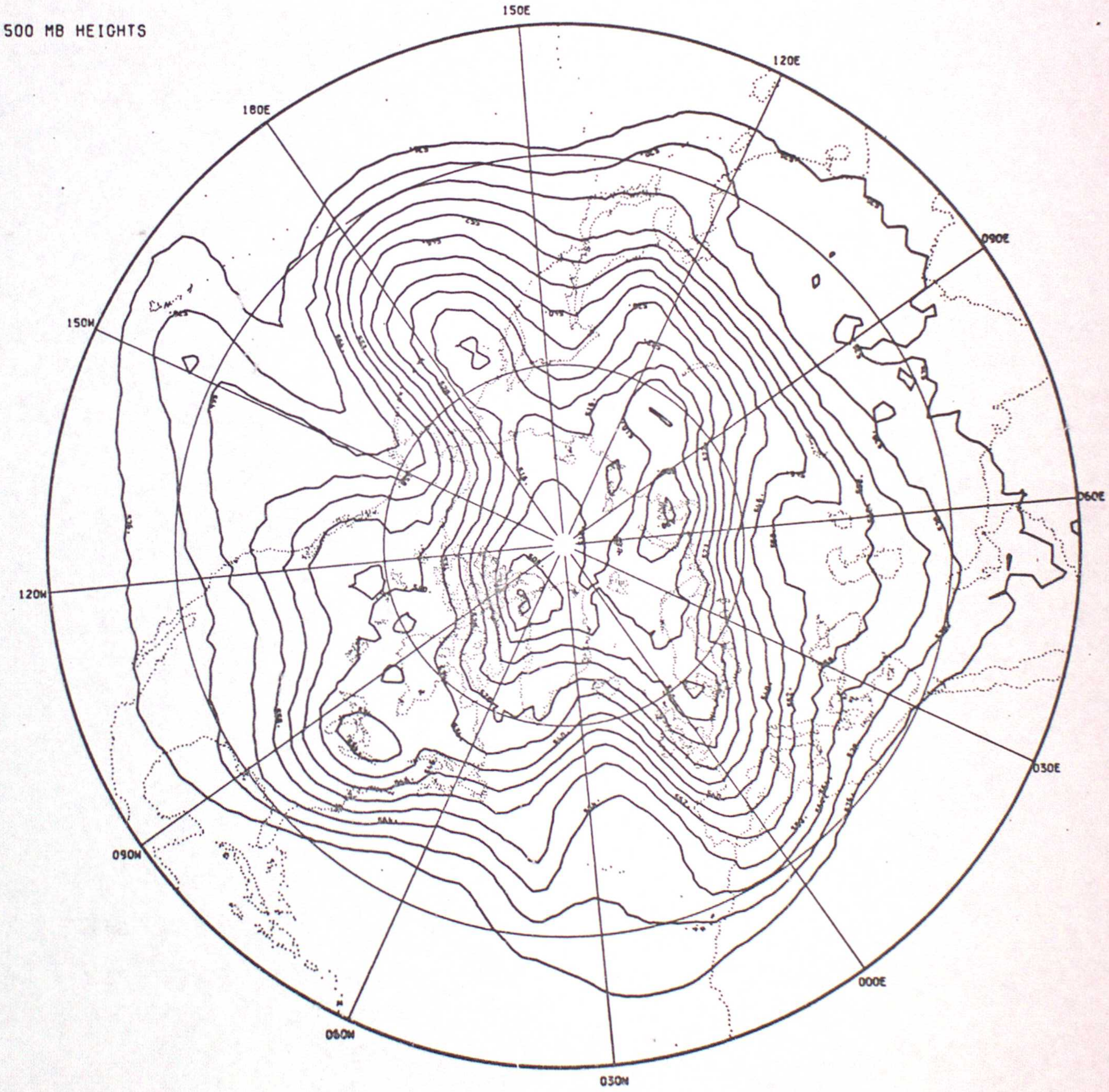
9/4/78 A chart for day 4



EXPERIMENT   TIME = D004H12   500 MB HEIGHTS
CONTOUR INTERVAL = 6.00 DEKAMETRES

Figure 18

9/4/78   M chart for day 4



EXPERIMENT TIME = D004H12 500 MB HEIGHTS
CONTOUR INTERVAL = 6.00 DEKAMETRES

Figure 19

9/4/78 J chart for day 4

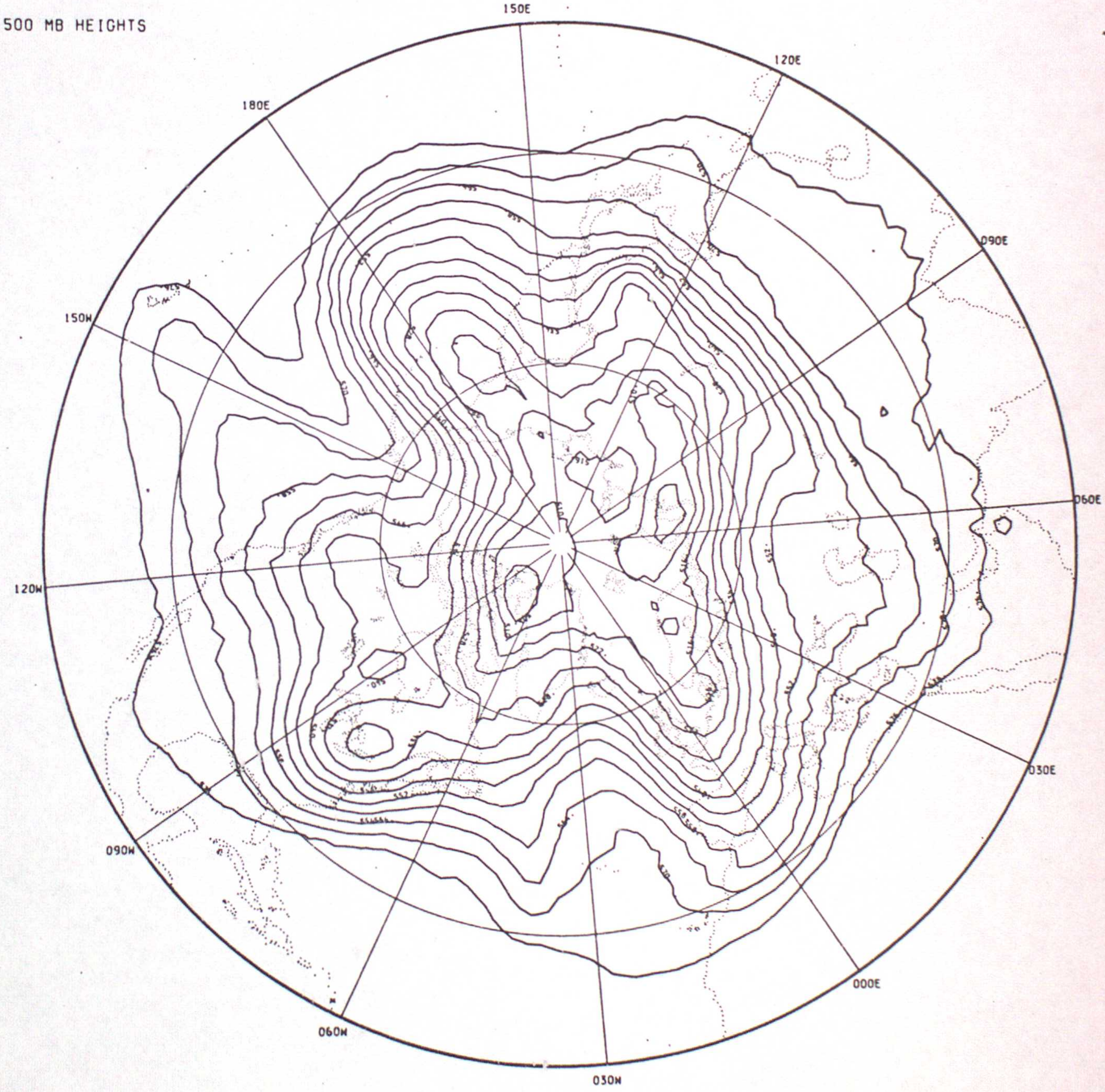
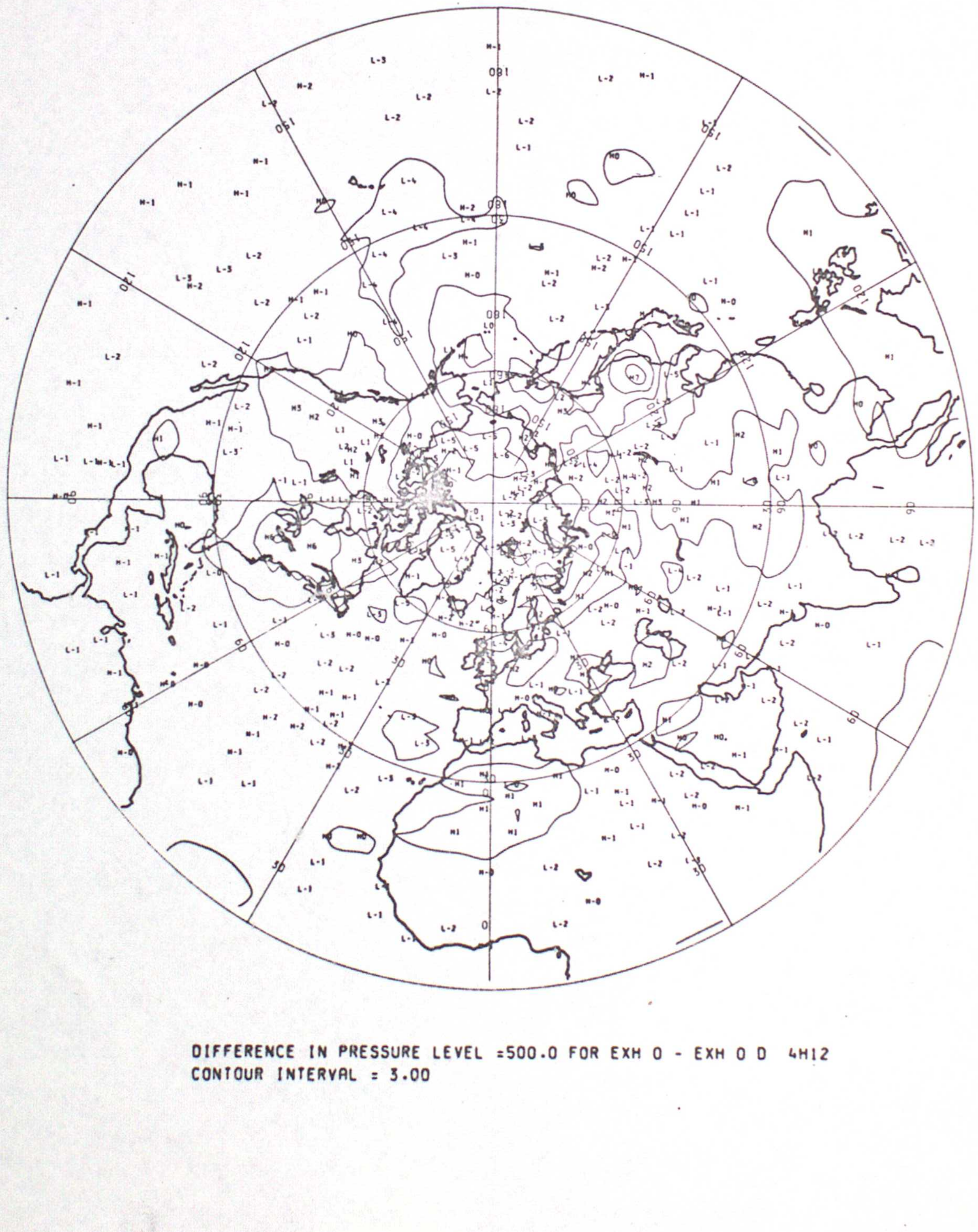


Figure 20
9/4/78
500 mb difference M-J
for day 4



DIFFERENCE IN PRESSURE LEVEL =500.0 FOR EXH 0 - EXH 0 D 4H12
CONTOUR INTERVAL = 3.00

Figure 21
9/4/78
850 mb temperature difference M-J
for day 5

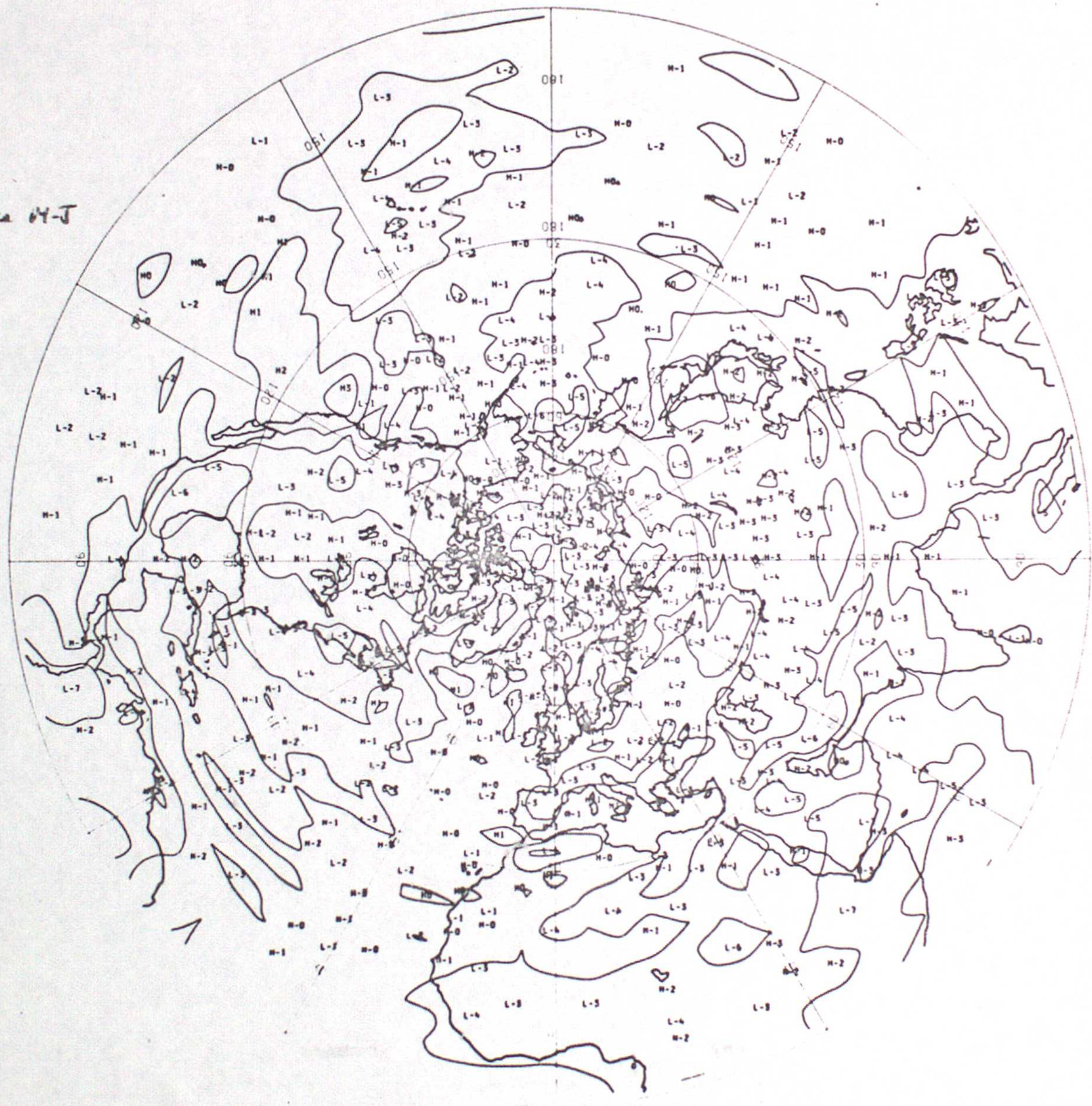
DIFFERENCE IN TEMPERATURE.SIGMA LEVEL:0.844 FOR EXH 0 - EXH 0 D 5H 0
CONTOUR INTERVAL : 2.00

Figure 22

9/4/78

200 mb temperature difference H-J

for day 5



DIFFERENCE IN TEMPERATURE.SIGMA LEVEL=0.230 FOR EXH 0 - EXH 0 D 5H 0

CONTOUR INTERVAL = 2.00

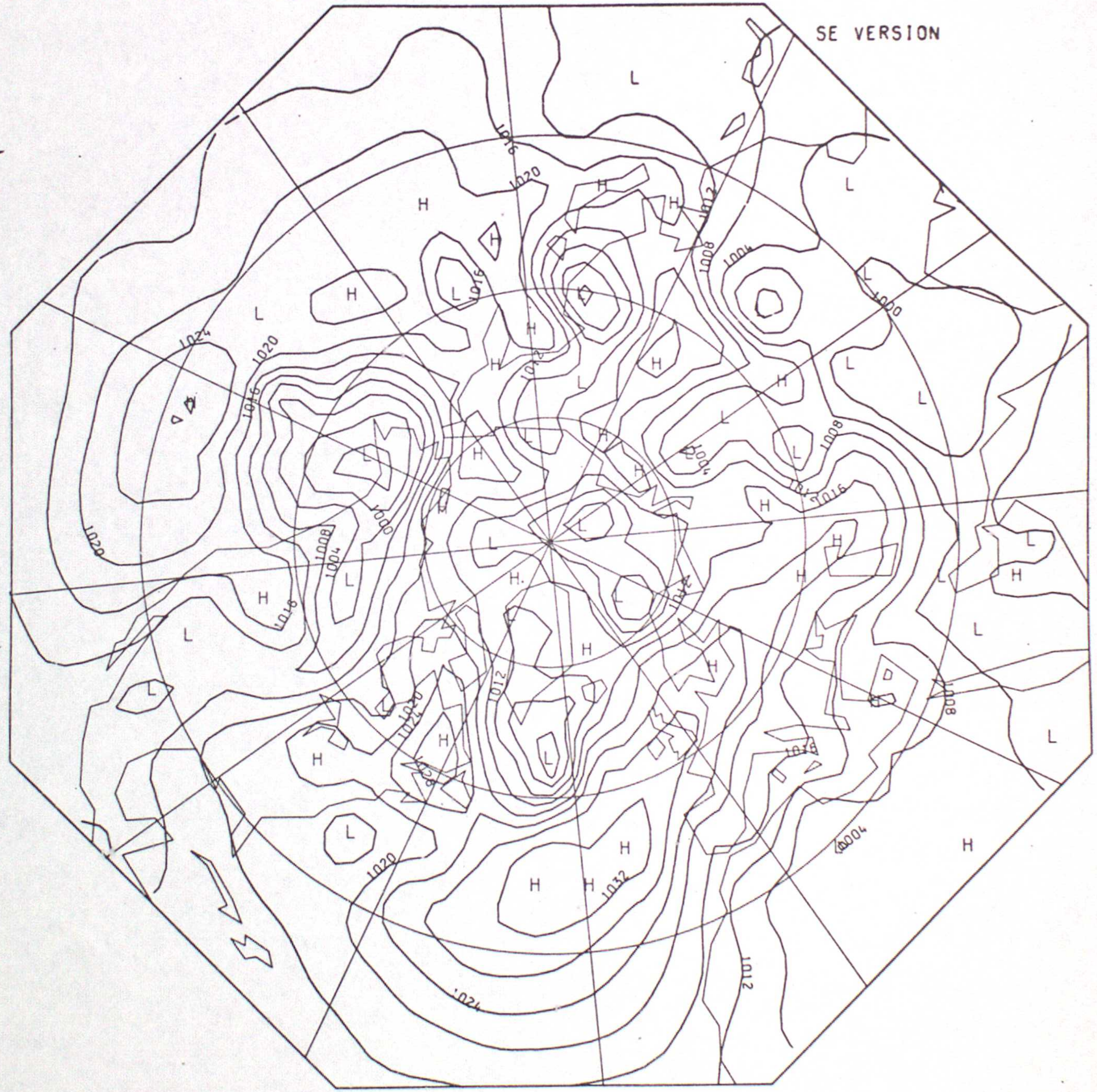
SURFACE PRESSURE • ISOBARS AT 4MB INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 26 / 5 / 78. VERIFICATION TIME 12 Z 26 / 5 / 78

SE VERSION

Figure 23

21/5/78 A chart for day 5



EXPERIMENT TIME = D005H12 PMSL
CONTOUR INTERVAL = 4.00 MB

Figure 24

21/5/73 M chart for day 5

EXPERIMENT TIME = D005H12 PMSL
CONTOUR INTERVAL = 4.00 MB

Figure 25

21/5/78 J chart for day 5

Figure 26
21/5/78
PMSL difference M-J
for day 5

DIFFERENCE IN PMSL. FOR EXH 0 - EXH 0 D SM12
CONTOUR INTERVAL : 3.00

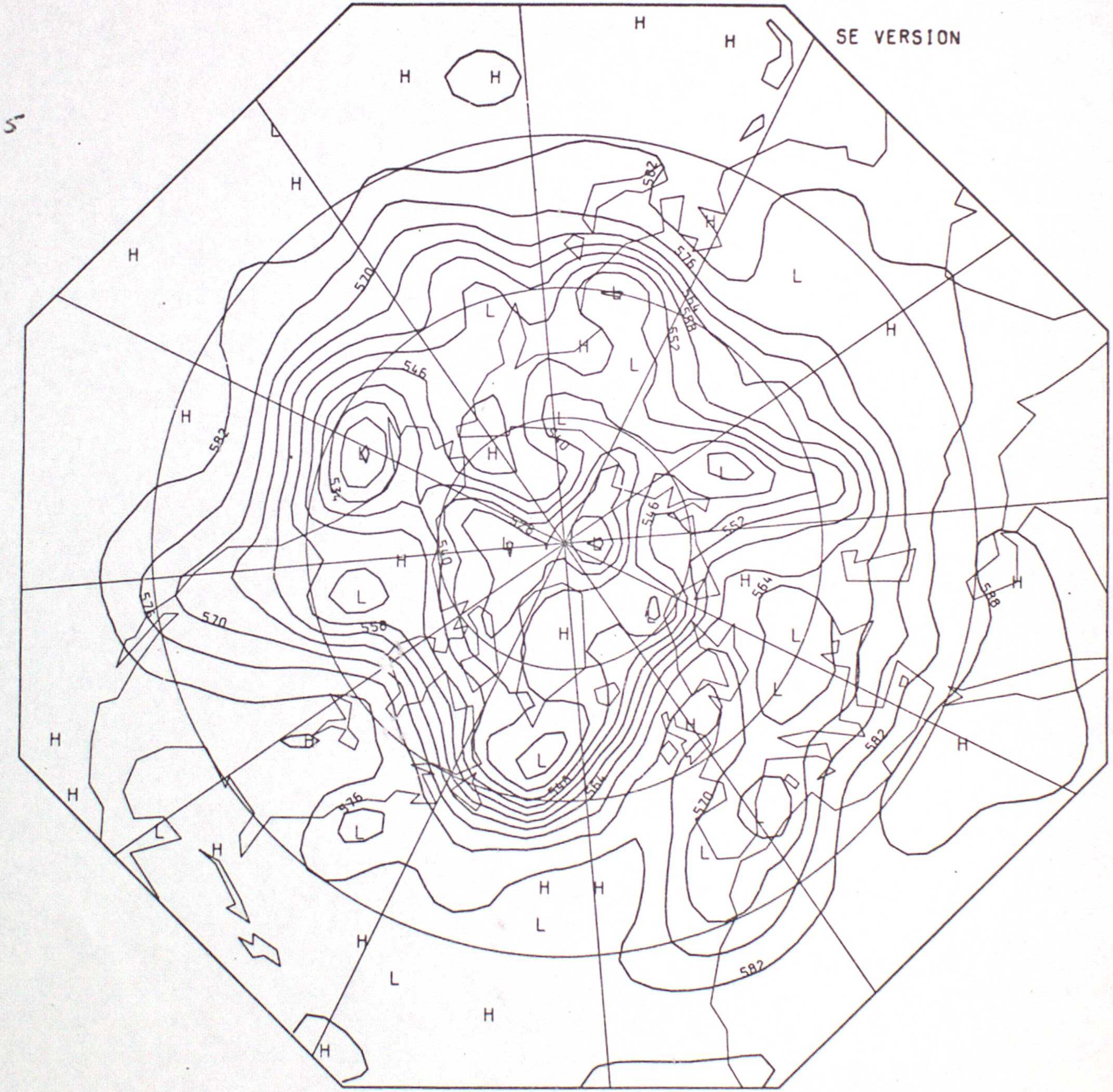
500 MB CONTOURS   CONTOUR LINES AT 6 DECAMETER INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 26 / 5 / 78. VERIFICATION TIME 12 Z 26 / 5 / 78

SE VERSION

Figure 27

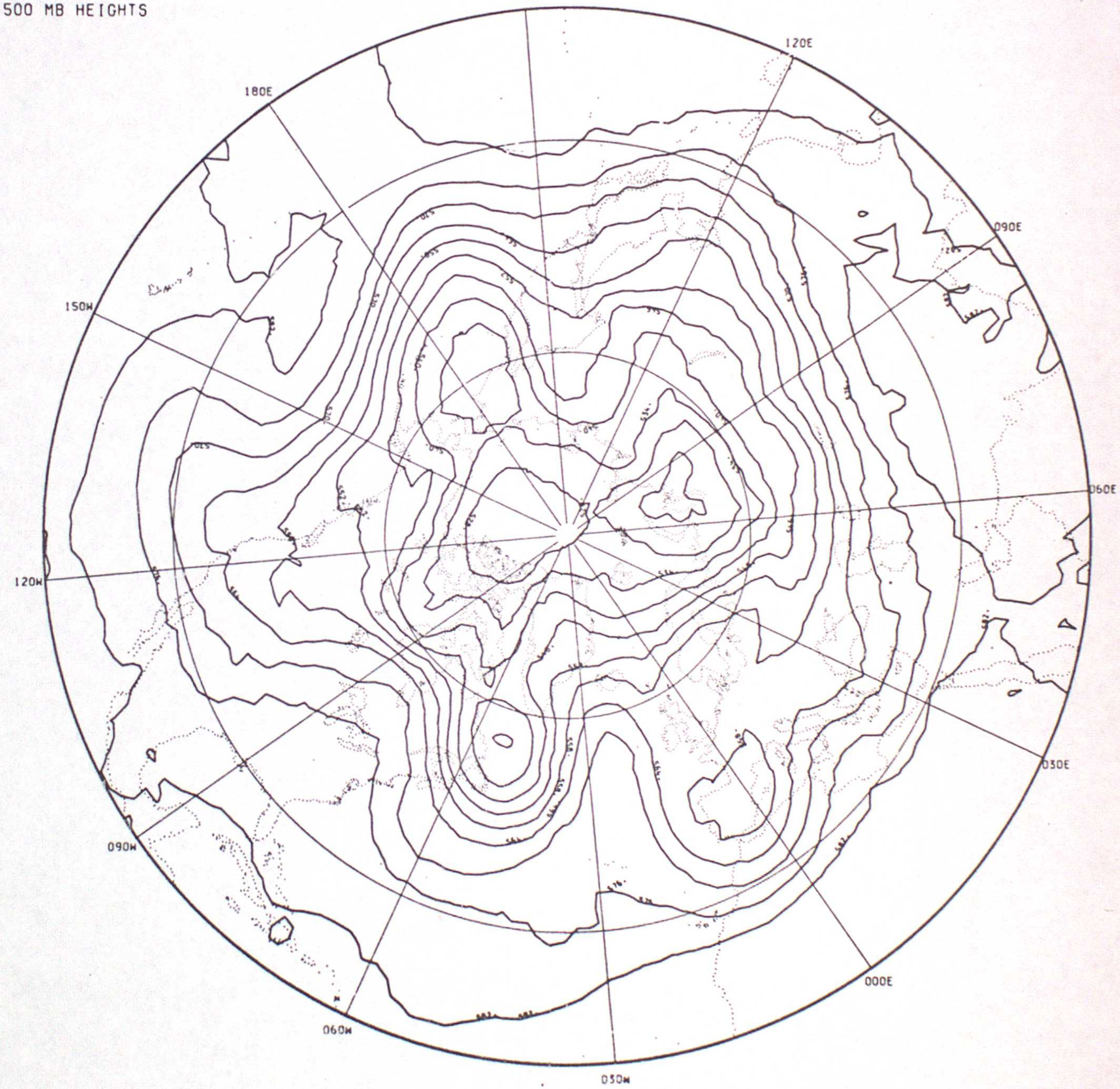
21/5/78 A chart for day 5



EXPERIMENT   TIME = D005H12   500 MB HEIGHTS
CONTOUR INTERVAL = 6.00 DEKAMETRES

Figure 28

21/5/73 M chart for day 5



EXPERIMENT TIME = D005H12 500 MB HEIGHTS
CONTOUR INTERVAL = 6.00 DEKAMETRES

Figure 29

21/5/78 J chart for day 5

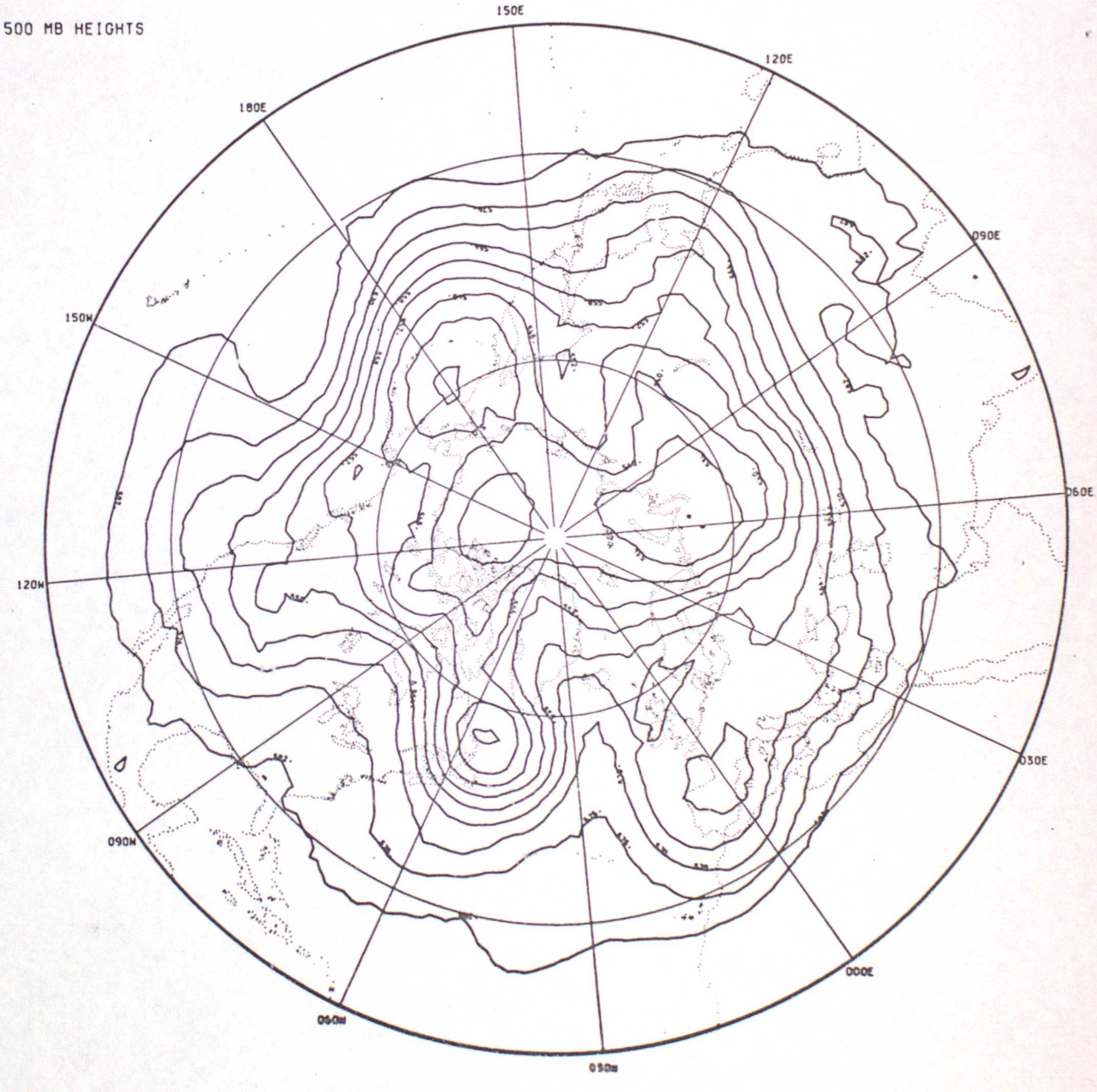
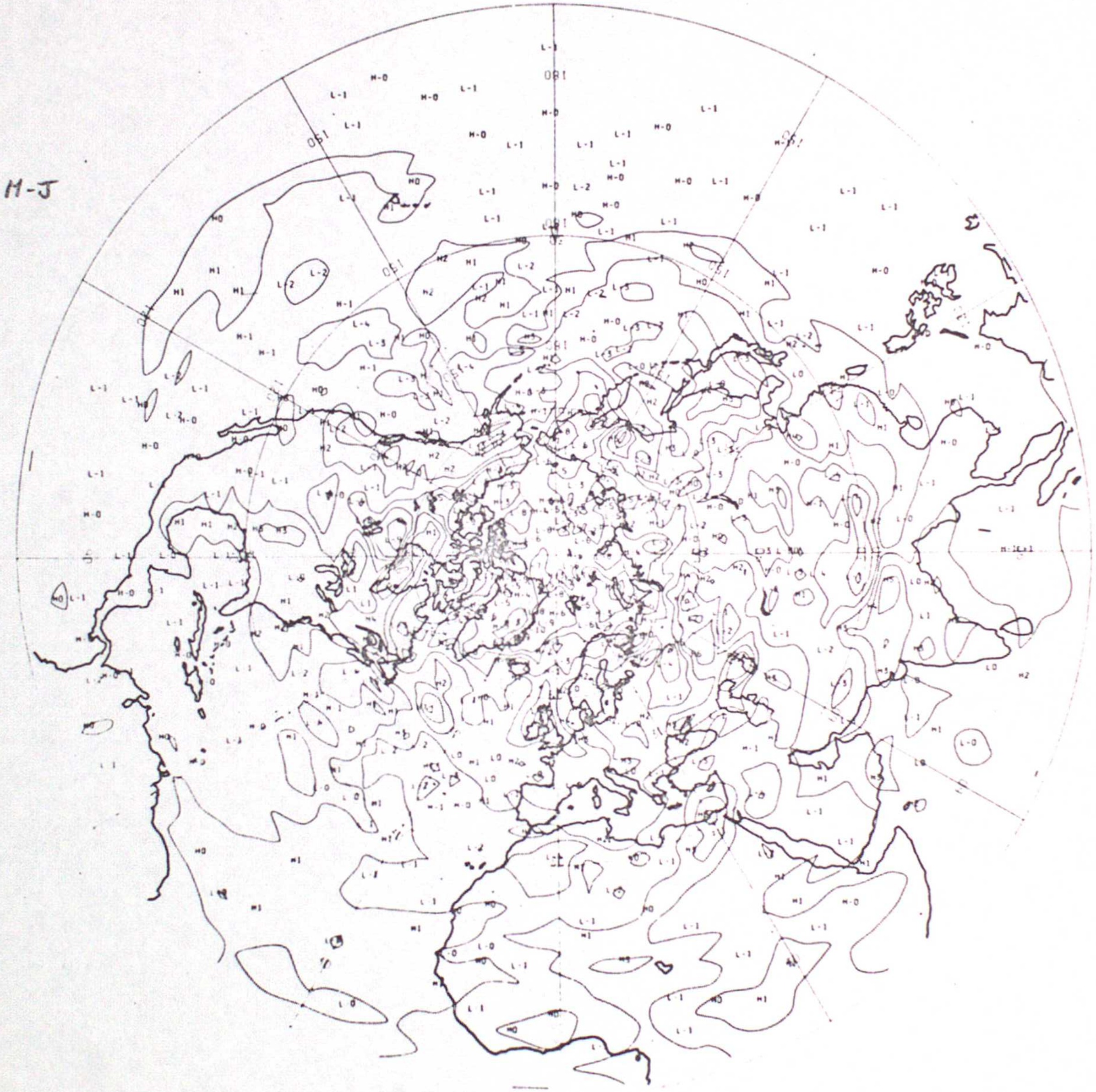


Figure 30
21/5/78
500mb. difference M-J
for day 5

DIFFERENCE IN PRESSURE LEVEL =500.0 FOR EXH 0 - EXH 0 D 5H12
CONTOUR INTERVAL = 3.00

Figure 31
21/5/78
850mb temperature difference M-J
for day 5



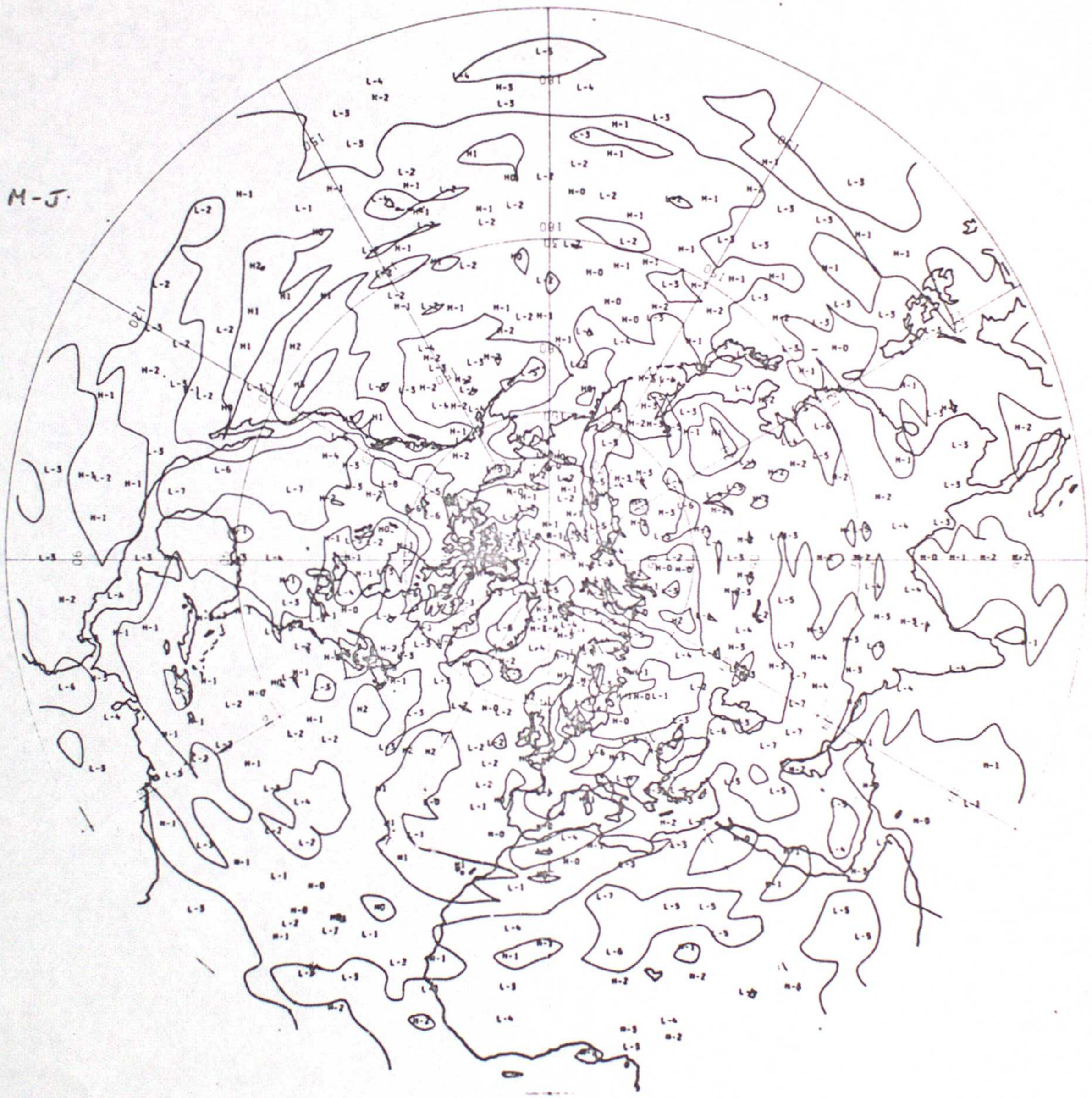
DIFFERENCE IN TEMPERATURE.SIGMA LEVEL:0.844 FOR EXH 0 - EXH 0 D 5H 0
CONTOUR INTERVAL : 2.00

Figure 32

21/5/78

200 mb. temperature difference M-J.

for day 5



DIFFERENCE IN TEMPERATURE.SIGMA LEVEL=0.230 FOR EXM O - EXM O D SM O

CONTOUR INTERVAL = 2.00