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MET O 11 TECHNICAL NOTE NO 116

Three case studies of 5-day forecasts using the 11-level, sigma, model with smoothed and unsmoothed topography

by

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Introduction

The Met O 20 high resolution 11-level model, as described by Saker 1975, has been under study in Met O 11 for a considerable period. Comparisons with the forecasts using the operational and sigma level octagons suggest that the PMSL fields produced by the 11-level model are distorted over areas of high ground. As both versions of the octagon use smoothed topography one possible cure in the 11-level model may be to do the same. Therefore it was decided to carry out tests using smoothed and unsmoothed topography in the 11-level model to see if this improves the PMSL forecast, especially with regards to synoptic features that are influenced by the mountains.

The initialisation times chosen for the forecasts were 12Z 8.5.77, 12Z 14.8.77 and 12Z 1.1.78. These forecasts have already been specially studied (Cullen 1978) and the data was readily available for these periods. These dates also give a good spread across the main climatic regimes of the year.

The 5-day forecasts with unsmoothed topography (in future in this Note referred to as the UTF) were already available and the initial data sets for the smoothed topography forecasts (in future in this Note referred to as the STF) were obtained by extracting the values of the topography from the UTF data set and smoothing the values using a 25 point smoothing technique (5 points in the N-S direction and 5 points in the E-W direction).

Firstly the topography at a grid point is smoothed in the E-W direction (along the rows of the model) by averaging the values of unsmoothed topography at 5 adjacent points in the row as follows:-

$$ST_{m,n} = \frac{\left[\frac{\left(\frac{T_{m,n-2}+T_{m,n-1}}{2} + \frac{T_{m,n-1}+T_{m,n}}{2}\right)}{2} + \frac{\left(\frac{T_{m,n}+T_{m,n+1}}{2} + \frac{T_{m,n+1}+T_{m,n+2}}{2}\right)}{2}\right]}{2}$$

m = row number T = Initial unsmoothed topography

n = point in row ST = Topography smoothed in the E-W direction only.

Now, because the 11-level model employs a staggered grid, there are no points directly north or south of the point being operated on. Therefore in order to use the principle mentioned above to smooth the topography in the N-S direction the X' values (See diagram 1) are calculated.

$$X' = ST_A\left(\frac{F}{D}\right) + ST_B\left(\frac{E}{D}\right)$$

Then the final smoothed topography (FST) is obtained.

$$FST_{m,n} = \frac{\left[\frac{\left(\frac{\left(X'_{m-2} + X'_{m-1}\right)}{2} + \frac{\left(X'_{m-1} + ST_{m,n}\right)}{2}\right)}{2} + \frac{\left(\frac{\left(ST_{m,n} + X'_{m+1}\right)}{2} + \frac{\left(X'_{m+1} + X'_{m+2}\right)}{2}\right)}{2}\right]}{2}$$

The surface pressure field is then recalculated as follows:-

$$\emptyset = \emptyset_{UNSMOOTHED} - \emptyset_{SMOOTHED}$$

$$P_{NEW\,SURF} = P_{OLD\,SURF}\left[\frac{TEMP + \frac{.0065}{G}\cdot\emptyset}{TEMP}\right]^{\frac{G}{.0065 \times R}}$$

$P_{NEW_{SURF}}$ = NEW SURFACE PRESSURE. $P_{OLD_{SURF}}$ = OLD SURFACE PRESSURE.

$\emptyset$ = HT. difference G = ACC. due to gravity

TEMP = Old Surface Temperature R = Gas Constant

The constant 0.0065 is introduced because of the assumption of a 6.5°C/KM Lapse Rate in the layer in question.

As the Surface Pressure is the only parameter recalculated the Time Smoothing Coefficient was increased to 0.05 from 0.005 to help smooth out any initial oscillations in the fields and the forecast fields were not compared until they reached 24 HR.

Examples of topography before and after smoothing can be seen in FIG 1.

All PMSL values for charts and error fields were calculated from the following formula

$$\phi_{11} = \phi_{SURF} + RT_{11} \ln\left[\frac{1.0}{.98744}\right]$$

$$P_{11} = .98744 \times P_{SURF}$$

$$PMSL = P_{11}\left[\frac{T_{11} + \frac{.0065}{G} \times \phi_{11}}{T_{11}}\right]^{\frac{G}{.0065 \times R}}$$

P_{11} = Pressure at sigma level 11 (sigma = .98744)

ϕ_{SURF} = Surface HT.

This is the method used in the sigma level octagon model.

The assessments of the forecasts were then done as follows:-

a) Subjectively using 500 MB and PMSL charts (charts included here for Day 3 only).

b) Using a diagnostic package of computer programs to produce the following:-

1. Error Fields of PMSL (at Day 3 only)

* (i) Actual minus UTF

(ii) Actual minus STF

* (iii) UTF minus STF

* 2. Correlation coefficients between Forecast minus Persistence and Actual minus Persistence at 500 MB and 1000 MB for Days 1-5

* 3. RMS differences (Forecast against Actual) at 500 MB and 1000 MB for Days 1-5

(In the tables at the end of this Note the values underlined are those where the STF is better than the UTF).

* CHARTS FOR THESE FIELDS ONLY INCLUDED IN NOTE.

CASE 1. 8TH MAY 1977

The Synoptic Situation

The basic 500 MB pattern is slow moving with almost stationary troughs over the western and eastern seaboards of N America and a ridge extending northwards over the continental USA and Canada. Another trough at 150°E progresses slowly to 180°E and weakens during the period while a trough at 90°E gradually deepens and progresses slowly to 120°E. A secondary centre is generated in the trough on the eastern seaboard of the USA and moves steadily east, followed by yet another centre on Day 5, throwing up a ridge ahead of it and finally combining with a stationary trough over western Europe which retrogresses somewhat to form a major slow moving feature over the UK.

At the surface an anticyclone is present throughout the period over central and eastern USA and Canada, although declining slowly, associated with the upper ridge. The Pacific High gradually declines but the Siberian High builds during the period, due to warm air thrown up by the W European trough, and combines with the Polar High.

The upper low centres moving eastwards over the N Atlantic produce steadily progressing surface depressions. The first starting over Newfoundland on the 8.5.77 and forming a major feature over the UK by Day 3, and ending up over Scandinavia on Day 5 with two other centres formed in the westerly flow behind it. One in mid N Atlantic the other over Newfoundland.

Subjective Assessment

On Days 1 and 2 both forecasts produce the same 500 MB patterns which are very similar to the actuals, but the secondary centre generated in the trough on the eastern seaboard of the USA does not deepen enough and move fast enough as it traverses the N Atlantic. This is true in both cases, the UTF being a little worse than the STF. Consequently the troughing action present over the NE Atlantic on Day 3 is not so pronounced on the forecasts and the resulting SW'ly jet in the SW approaches is weak producing bad timing and shape of surface depressions over the UK.

The surface depression formed on Day 3 over the N Atlantic by the UTF is not so deep as in the STF. However the UTF has produced a better shaped depression over the UK and the low centre over Scandinavia is more correctly positioned. The UTF also corrects its 500 MB flow somewhat on Day 4 compared to the STF.

The right exit profile of the jet is less pronounced over Spain on Day 3 and 4 on both forecasts rather than the actuals resulting in insufficient pressure rises over N African and the Mediterranean, the STF being worse than the UTF over Greece and Malta. Also on both forecasts the troughing action at 150°E and 90°E is weak and the troughs remain stationary compared to the actuals and pressure falls in the Pacific are not as pronounced as they should be.

By Day 4 the troughs in the USA seaboards are beginning to weaken in the forecasts whereas in actuality they persist as strong feature throughout the period. This results in the under development of surface features in those areas in both forecasts, however the STF does produce slightly better surface features on the eastern seaboard.

Considering the mountainous regions in more detail: The ridge over Greenland is better handled by the UTF. The area of low pressure values over Norway is better on the STF but the position of the centre is better placed on the UTF. The UTF produces too high a pressure over the Alps on Day 2 and the low pressure pattern over the Rockies on Day 3 is marginally better in the UTF otherwise both areas seem to be almost uncharged.

A smoother pressure pattern is produced over the Himalayas by the STF but synoptically there is little change.

Other Assessment

1. PMSL Error Fields (Day 3 only)

The Actual minus Forecast fields show reasonably close agreement with each other (See FIG 1a).

The small areas of disagreement are shown up on the UTF minus STF PMSL fields (See FIG 2a) as follows:-

(i) Area due north of Himalayas

Both forecasts produce considerable pressure gradients in this area, and agree quite closely with the actual. Being an area of steep pressure gradient minor changes in the shape of pressure fields cause large differences in pressure at a given point and this is the case here, although the STF is marginally better.

(ii) NE Atlantic area between Iceland and Scotland

This area has already been discussed in the synoptic assessment with the UTF being more correct.

(iii) Central and Southern Norway

In this area the UTF produces slightly lower pressures than actual and the STF is more correct in this but the shape of the PMSL fields is better in the UTF.

(iv) Mongolia/Manchuria area

Both forecasts are equally in error here, both producing large areas of low pressure to the NE and E of the Himalayas. The difference is due to different positions of the depression.

(v) Pacific coast of Russia (Sea of Okhotsk)

Both forecasts again incorrectly forecast the position of a depression in this area but with minor differences in position. The STF is marginally better.

(vi) N Morocco (Haut Atlas Mountains)

A ridge of high pressure extending SE across this area is over developed by the STF. The UTF gives a better result.

(vii) Southern Greece and Malta

Both forecasts incorrectly produced a depression over Libya. The STF is more in error, producing lower pressures over S Greece and Malta.

(viii) Rockies and Great Slave Lake area of Canada

The UTF is better here producing the higher and more correct pressures.

(ix) Newfoundland

The depression produced by the forecasts here is elongated too much in the E-W direction. The STF is worse in this and also incorrectly produces lower pressures.

(x) West and North West Russia

There is a rather slack gradient in this area with the UTF producing the slightly higher and more correct pressures.

(xi) Davis Straits

The STF develops a marginally slacker pressure gradient here in the northerly air flow and this is more correct.

2. Correlation Coefficients

(See Table 2a)

These indicate a slight improvement in the forecast when using unsmoothed topography which seems to remain fairly constant throughout the period of the forecast.

When examining this further by breaking down the correlation coefficients to values per latitude line the 500 MB figures seem to indicate two bands where the STF values is better than the UTF, one band from 79°N to 83°N and a second and larger band centred around 40°N which moves southwards as the forecast progresses, both these bands becoming less pronounced towards the end of the period.

At 1000 MB the STF is better in three bands, one near the N Pole, another around 58°N and the third at 20°N.

It is difficult to relate these bands to topography. However at 500 MB the northerly band lies across the northern mountains of Greenland and the southerly band lines up with the highest parts of the Rockies, high ground over Armenia and the northern edge of the Himalayas.

3. RMS Differences

(See Table 1a)

For this parameter the UTF appears to indicate a constant improvement over the STF throughout the period as the correlation coefficients above.

Further investigation into the break down of the RMS differences to values per latitude line, in fact, seems to confirm the impression given by the correlation coefficients in that it shows the STF better near the N Pole and generally in a band around Lat 15°N to 21°N and also on Days 3 and 4 around Lat 51°N to 55°N at 1000 MB.

These bands do not seem to tie in with any major areas of high ground. Although the band between Lat 15°N and 21°N does line up with the Sierra Madre mountains of Mexico.

Conclusion

In this case study the assessments suggest that smoothing the topography has small but mostly detrimental effects on the forecast.

It is difficult to tie the areas of major differences between the forecasts to regions of high ground apart from the areas over Morocco, Norway and the Rockies, and possibly the area North of the Himalayas. What one can say is that they mainly occur **north** of 30°N and when comparing them with the PMSL charts they seem, in by far the majority of cases, to coincide with areas where the pressure is below 1020 MB. Comparisons with the 500 MB flow suggest that in a considerable number of cases they also occur down wind of high ground such as the Rockies, Greenland and the Alps and in these leeward areas the UTF produces the higher and more correct pressures. The exceptions to this being the Mongolia/Manchuria and Sea of Okhotsk areas where, possibly due to some effect of the Himalayas , the opposite is true with the STF producing the higher and more correct pressures.

Although not so well defined there is also a tendency for these areas of maximum differences to occur in conjunction with the areas of strong wind at 500 MB.

There are some latitudes where the RMS differences and correlation coefficients are in favour of the STF and may indicate some smoothing of the airflow but it is almost impossible to connect them with mountainous areas and in any case these effects diminish as the forecast progresses. The overall picture is of a slightly poorer forecast when using smoothed topography.

CASE 2. 14.8.77

The Synoptic Situation

The 500 MB pattern has a stationary trough over the N Pacific throughout the period. A complex trough over E Canada and NE USA produces a satallite trough over the N Atlantic which ends up as a cut off low over the UK by Day 5. The progress of this feature eventually disrupts the Omega blocking pattern over the NE Atlantic, the remains of which end up as à cut of high NE of Iceland. Another upper trough over northern Russia retrogresses and moves to 50°E on Day 5.

At the surface low pressure persists over the N Pacific associated with the upper trough with a ridge of high pressure over the western seaboard of the USA and Canada. The anticyclone over the NE Atlantic collapses as the Omega block is disrupted and a depression forms over N France and the UK associated with the upper cut off low.

Synoptic Assessment

Both forecasts fail to retain the ridge/trough pattern over the N Pacific and western seaboard of the USA resulting in the collapse of the high pressure over the Rockies and W Canada and a building of pressure over the N Pacific. Also the upper trough at 90°E fails to retrogress resulting in too low a pressure field over N Russia.

The forecasts fail to produce a cut off low over the UK on Day 3. However the STF does produce a cut off circulation with a central height slightly lower than the UTF but too far to the southwest. The cut off ridge to the north of it is more pronounced but too far to the west. As a result both forecasts fail to produce the correct surface pressure pattern over the UK. At the surface the two forecasts are very similar up to Day 3 after which the UTF is better. The STF tends to over develop depressions such as those over the eastern seaboard of N America on Day 4 and incorrectly builds the anticyclone over N Italy on Days 4 and 5.

Regarding the mountainous regions there appears to be little difference in the forecasts over Greenland, Norway or the Rockies. Over the Alps the forecasts are also very similar but the UTF does produce slightly better values for the pressure. Both forecasts produce incorrect pressure fields over the Himalayas with the UTF giving the more correct pressures but the STF producing the smoother pressure pattern.

Other Assessment

1. PMSL Error Fields (Day 3 only)

FIG 1b and FIG 2b show that the difference in the two forecasts are relatively small compared to the differences between the forecasts and the actuals. The main areas of disagreement between the forecasts are as follows:-

(i) SE Spain/N Algeria

The UTF produces the more correct values of PMSL but both forecasts are slow in moving a surface depression across this area and in fact the pressure patterns are completely wrong with the centre of the depression being forecast to the west of the area when in actuality it is to the east.

(ii) Himalayas and Southern Russia

There are marked differences in the pattern of the error fields in the area produced by the two forecasts and both forecasts in their own way disagree with the actuals, but the UTF produces the more correct values of pressure.

(iii) Southern Quebec region of Canada

The depression produced by the STF was too low in pressure and the UTF produced rather a better result here.

(iv) Hudson Straits, Canada

Both forecasts produce depressions in the Davis Straits which are too deep but in addition the STF incorrectlyextends the depression more into the Hudson Straits.

(v) Saskatchewan, Canada

The forecasts produce lower pressures over Central Canada than actual. The STF is slightly worse in this respect.

(vi) NE Mexico and New Mexico

In this area the gradient is very slack and the models produce slightly different patterns with little to choose between them.

(vii) NE of Iceland

Both forecasts fail to produce the correct high pressure pattern in this area. The STF, however, is slightly better.

(viii) Finland

The pressure pattern is better reproduced by the UTF which gives marginally higher pressures.

2. Correlation Coefficients

(See Table 2b)

These figures show a slight improvement in the forecast when using unsmoothed topography. The coefficients analysed per latitude line however show some bands where the STF is better. At 500 MB the main band is south of 45°N, the second between 50°N and 60°N and the smallest near the N Pole. All these bands get more diffuse as the forecast progresses. At 1000 MB the band south of 45°N is much less pronounced and irregular but the other two bands show up here as well.

The band south of 45°N does contain some of the highest topography in the N Hemisphere such as the Himalayas and the Sierra Madre but the region between 50°W and 60°W is reasonable clear of high topography, as is the Polar region.

3. RMS Differences

Table 1b indicates an improvement in the RMS differences at 500 MB on Days 1 to 3 when using smoothed topography but this is not continued into the remainder of the forecast and at 1000 MB better results are obtained from the UTF. A breakdown of these figures at 500 MB shows only an area between 70°N and 80°N on Days 1 and 2 where the UTF is better than the STF but by Day 3 the better results in the STF shrink to two bands at 47°N to 60°N and south of 40°N. At 1000 MB the STF shows only two small bands of improvement over the UTF throughout the period, north of 80°N and south of 13°N.

An interesting point to note here is that the band between 70°N and 80°W corresponds to Greenland and this is the only band on Days 1 to 2 at 500 MB where the UTF is better than the STF. After Day 2 none of the areas where the STF is better than the UTF line up with high topography apart from the one at 500 MB south of 40°N.

Conclusion

The subjective assessment suggest only minor differences in the two forecasts at least up to Day 3, but it is noticeable that the STF produces deeper depressions such as over Russia and the east coast of N America.

The areas of major differences do not match up with high ground except for the Himalayas and possibly the area around New Mexico (southern end of Rockies) and the Atlas mountains of Morocco. However, once more the majority of differences between the forecasts occur north of 30°N and where the PMSL is less than 1020 MB. The connection with the 500 MB flow is more tenuous but a large percentage of the differences occur where the flow is strong. Also in most areas of difference between the forecasts the UTF is better and tends to produce higher pressures in the lee of mountains such as the Rockies and Norway.

The figures obtained from the RMS differences and the Correlation Coefficients reinforce the view that the UTF is better than the STF. The areas where the STF does produce better figures cannot be related to high ground and these apparent beneficial effects of smoothed topography become less noticeable as the forecast continues.

CASE 3. 1ST JAN 1978

Synoptic Situation

A stationary trough at 150°E maintains a zonal jet across the NE Pacific with a stationary ridge at 150°W.

An upper trough over the Great Lakes progresses eastwards throwing up a ridge ahead of it which ends up over the UK on Day 5.

On the surface a depression persists in the NE Pacific associated with the upper trough and a new depression deepens at 140°E in connection with the left exit of the jet. A further depression moves in over the western seaboard of the USA and declines on Day 5 as it reaches the left entrance of the westerly jet across the USA. The progress of the upper trough over the Great Lakes causes a depression over Newfoundland to deeper and more east with an anticyclone thrown up ahead of it. On Day 5 the depression is centred over Iceland and the high over France. The Siberian High persists throughout the period.

Synoptic Assessment

The upper ridge/trough pattern over the Pacific is fairly well reproduced on both forecasts although the ridge is not as high as it should be, with the UTF marginally worse than the STF. Also the Pacific jet is weaker with the UTF again producing the worse forecast. Consequently the depression which forms at the left exit of the jet in the Pacific is weaker than it should be and forms later.

The forecasts fail to produce a strong enough jet across the Atlantic, and to move the trough over the Great Lakes eastwards. Consequently the ridge/trough pattern over the Atlantic has insufficient amplitude. Therefore the depression over Newfoundland is much too shallow and does not move east as it should. The high that should form over France is produced over Spain and its central pressure is lower than in the actuals, the UTF is a little better in both these aspects.

Both forecasts maintain the low pressure over E Germany and Poland which in fact fills steadily.

The STF over develops the "Genoa low" on Day 3 otherwise there is very little difference in the forecasts in the region of the Alps. Over Norway the UTF produces slightly higher and more correct pressures throughout the period whereas over Greenland the STF is marginally better, forecasting lower pressures. In the region of the Rockies there is no difference in the forecasts while on the eastward side of the Sierra Madre the UTF produces slightly lower and better pressures.

The high pressure area over the Himalayas is forecast badly in both cases with little to choose between them.

Other Assessment

1. PMSL Error Fields (Day 3 only)

(See FIG 1c and 2c)

Compared with the large disagreements between the forecasts and the actuals the two forecasts show very good agreement although there are some areas which need further inspection as follows:-

(i) Southern Greenland

The forecasts fail to produce the correct shape, depth and position of a depression South of Greenland but the STF is a little better in the depth and position giving lower and more correct pressures over Southern Greenland.

(ii) Great Lake area of USA and Canada

There is rather a slack gradient in this area and the UTF produces higher and more realistic pressures here.

(iii) NW Pacific and Sea of Okhotsk

The depression in the NW Pacific was formed a little too far to the west and too shallow by both forecasts but the STF made a better attempt at it. The position of the depression over the Sea of Okhotsk and the Kamchatka peninsular was better produced by the UTF. Both forecasts failed to predict its depth.

(iv) Himalayas

Both forecasts produce complex areas of high pressure here, both seeming a little too high in some places and one forecast is no better than the other.

(v) NE Russia

The high pressure in this area is better reproduced by the UTF.

2. Correlation Coefficients

(See table 2c)

Apart from Day 1 at 500 MB the UTF shows marginally better correlation coefficients than the STF. The breakdown of the values per latitude line show that, in fact, the STF is better in some areas.

At 500 MB there are three bands, one north of 59°N, the second between 21°N and 37°N and the third south of 9°N. All these bands become more diffuse as the forecast progresses. At 1000 MB the bands are less well defined but are mainly north of 60°N and between 40°N and 25°N. These coincide very well with Greenland and the Himalayas.

3. RMS Differences

(See table 1c)

The overall RMS differences show the same pattern as the correlation coefficients with the 500 MB Day 1 value being better on the STF only. In the breakdown at 500 MB there are two bands where the STF is better than the UTF, from approx 55°N to 80°N (which is very irregular) and also south of 30°N. The 1000 MB values show the same bands although here they are more diffuse. These areas also coincide reasonably well with Greenland and the Himalayas.

Conclusion

Both of these forecasts are rather poor with regards to the actuals especially in the region of the UK, but as with the previous two case studies the STF is worse than the UTF with a tendency to over develop low pressure areas.

The assessments seem to point to a closer connection between areas of differences in the forecasts and regions of high ground, with the PMSL error fields showing areas of maximum differences over S Greenland and the Himalayas. Differences over the Great Lakes and, E and S Europe do seem to be due to the lee effect of the Rockies, and the Alps and Norway respectively. In both these areas the UTF is better with higher pressures. Over NE Russia and the NW Pacific the behaviour is similar to the 8.5.77 forecast with the STF producing the higher pressures and being marginally better than the UTF over the NW Pacific. The larger PMSL differences between the forecasts are consolidated into four or five areas which are bigger than in the previous case studies, although the majority still lie where the PMSL is less than 1020 MB.

The RMS differences and correlation coefficients seem to indicate better results over high ground when using smoothed topography even though the subjective assessment indicates the reverse. This implies that there is some smoothing of the air flow over the mountains which may have an adverse effect on the forecast.

Final Assessment and Recommendations

All three case studies show a small but significant degradation of the forecast when using smoothed topography. These detrimental effects are larger and more organised during the winter than in the summer. One possible explanation is that the mountains are required as barriers which modify the 500 MB flow. Lowering of these barriers smooths the wave patterns but causes pressures to fall on the leeward side of the high ground. The effects are more noticeable in the winter because the 500 MB flow is at its strongest and therefore the barrier effect is greatest. However the areas influenced by the Himalayas such as E Russia and the NW Pacific are peculiar in showing rises in pressure and in some cases better PMSL fields. It may be, as far as the 11-level model is concerned, that the topography in this region is too much of a barrier and needs some smoothing independently of the rest of the model. Therefore I conclude that although smoothing topography can produce smoother PMSL fields over high ground in the main it has an adverse effect on the forecast and other methods should be found to obtain better PMSL charts. There may be a case, however, for some smoothing of the topography in the region of the Himalayas in order to improve the forecast.

RMS DIFFERENCES (BETWEEN N POLE AND 25°N)

TABLE 1a 8.5.77 FORECAST

DAY	500 MB		1000 MB	
	UTF	STF	UTF	STF
1	3.866	3.957	3.721	4.075
2	5.573	5.812	4.563	4.953
3	6.598	6.775	4.965	5.454
4	7.311	7.610	5.503	6.098
5	8.570	8.440	6.114	7.000

TABLE 1b 14.8.77 FORECAST

DAY	500 MB		1000 MB	
	UTF	STF	UTF	STF
1	3.279	2.988	3.203	3.861
2	4.962	4.653	4.404	4.130
3	6.518	6.385	5.094	5.934
4	7.408	7.536	5.215	6.207
5	7.906	8.125	5.203	6.193

TABLE 1c 1.1.78 FORECAST

DAY	500 MB		1000 MB	
	UTF	STF	UTF	STF
1	4.191	4.199	3.869	3.989
2	6.925	7.096	5.391	5.583
3	8.614	8.882	6.987	7.338
4	8.910	9.266	8.150	8.459
5	9.633	10.162	8.073	8.381

CORRELATION COEFFICIENTS (BETWEEN N POLE AND 1^{o}N)

TABLE 2a 8.5.77 FORECAST

DAY	500 MB		1000 MB	
	UTF	STF	UTF	STF
1	.7416	.7297	.6465	.6085
2	.8035	.7908	.7041	.6753
3	.7944	.7851	.6915	.6647
4	.7740	.7560	.6876	.6653
5	.7772	.7462	.6490	.5947

TABLE 2b 14.8.77 FORECAST

DAY	500 MB		1000 MB	
	UTF	STF	UTF	STF
1	.6900	.6893	.4636	.4226
2	.7432	.7421	.4683	.4410
3	.6714	.6580	.4197	.3713
4	.6341	.6045	.4320	.3682
5	.6343	.6036	.4353	.3862

TABLE 2c 1.1.78 FORECAST

DAY	500 MB		1000 MB	
	UTF	STF	UTF	STF
1	.8355	.8367	.7836	.7730
2	.8156	.8143	.7844	.7788
3	.7772	.7765	.7307	.7180
4	.7524	.7504	.6962	.6905
5	.7077	.6638	.6695	.6504

References

Saker, N J	1975	An 11-Layer General Circulation Model Met O 20. Technical Note No II/30.
Cullen, M J P	1978	Six case studies from the forecast model intercomparison experiment (2/77 - 4/78) Technical Note No 113.

DIAGRAM 1

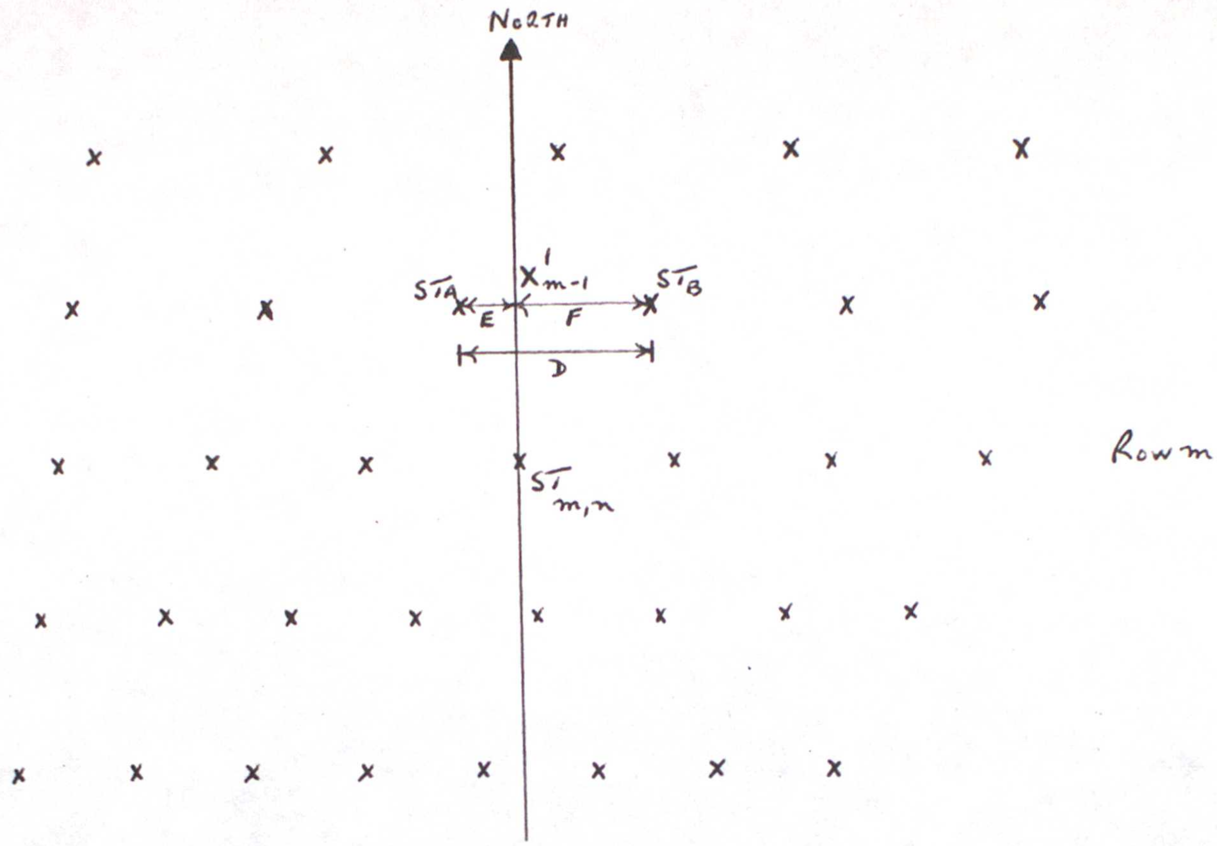


FIG 1

SECTIONS ALONG ROW 29

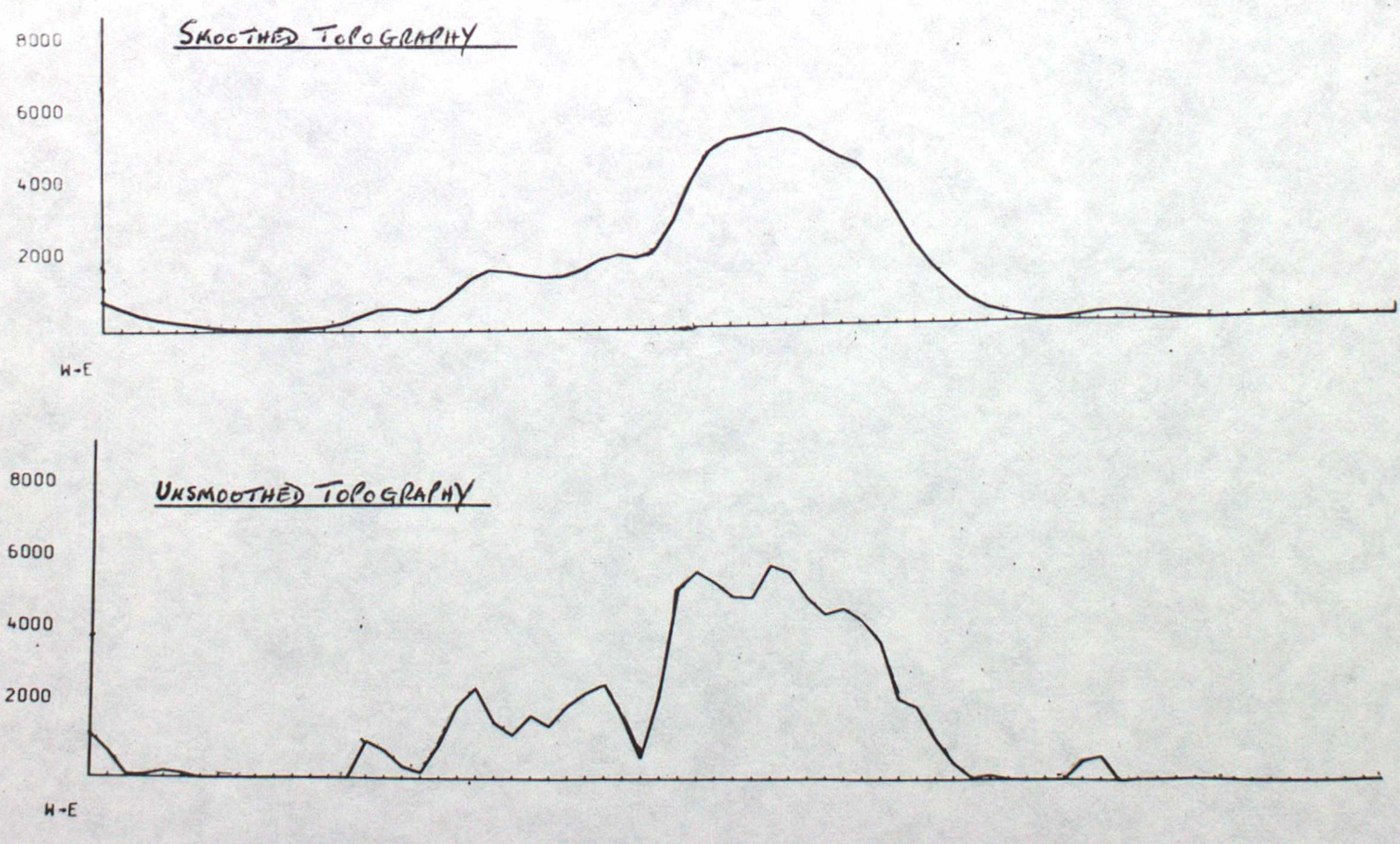


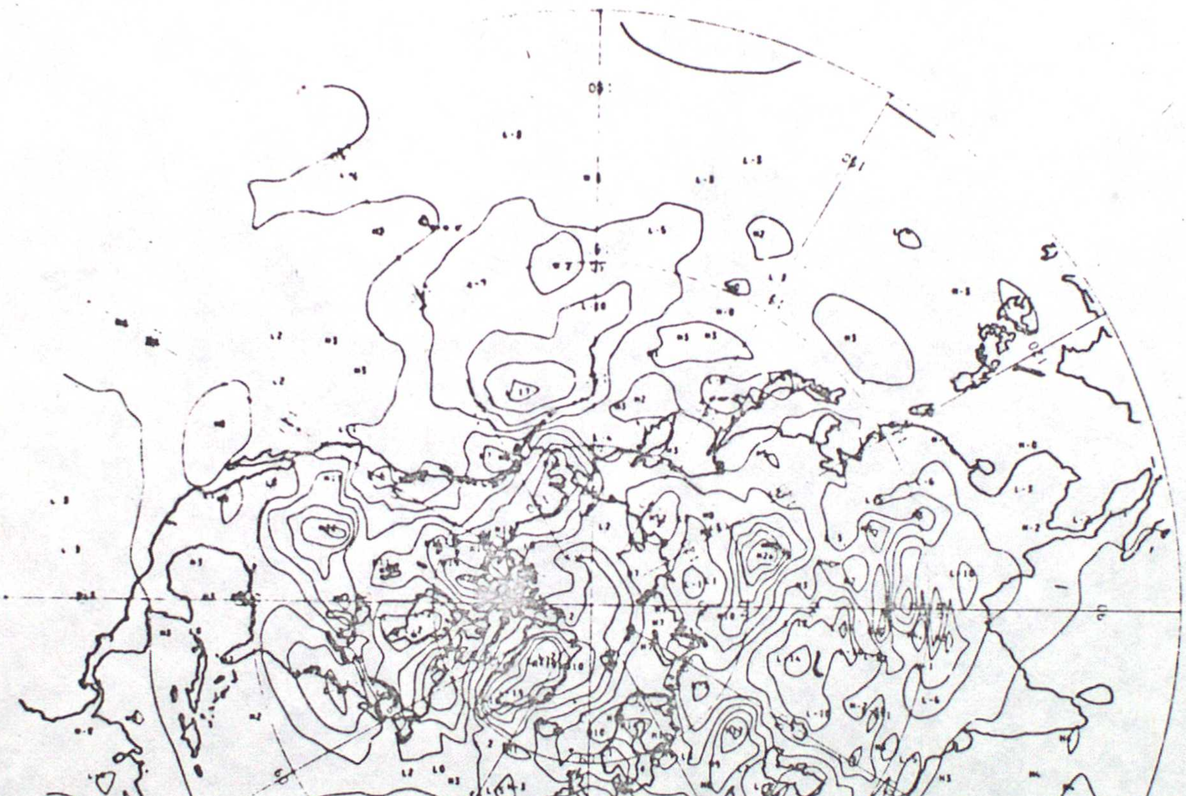
FIG 1a

DAY3 PMSL DIFFERENCE FIELDS (ACTUAL MINUS UTF) 12Z 8.5.77 F/C

DIFFERENCES IN PMSL SIMA=0.0 FOR EXH 0-EXH 0D 0H12D 3H 0
CONTOUR INTERVAL = 4.00

FIG 1b

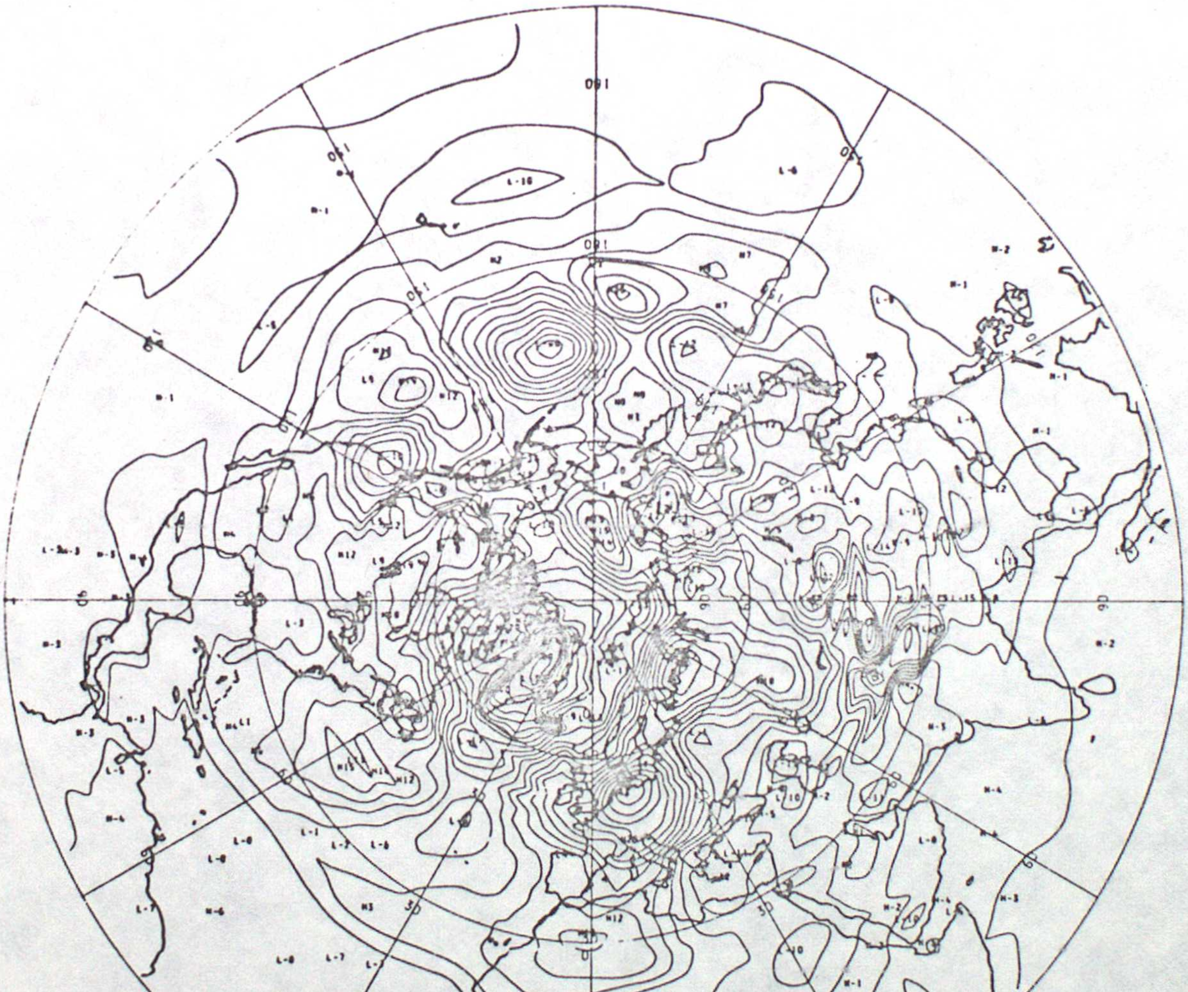
DAY3 PMSL DIFFERENCE FIELDS (ACTUAL MINUS UTF) 12Z 14·8·77 F/C



DIFFERENCES IN PMSL SIMA=0.0 FOR EXH 0-EXH 0D 0H12D 3H 0
CONTOUR INTERVAL = 4.00

FIG 1c

DAY 3 PMSL DIFFERENCE FIELDS (ACTUAL MINUS UTF) 12Z 1.1.78 F/C



DIFFERENCES IN PMSL SIMA=0.0 FOR EXH 0-EXH 0D 0H12D 3H 0
CONTOUR INTERVAL = 4.00

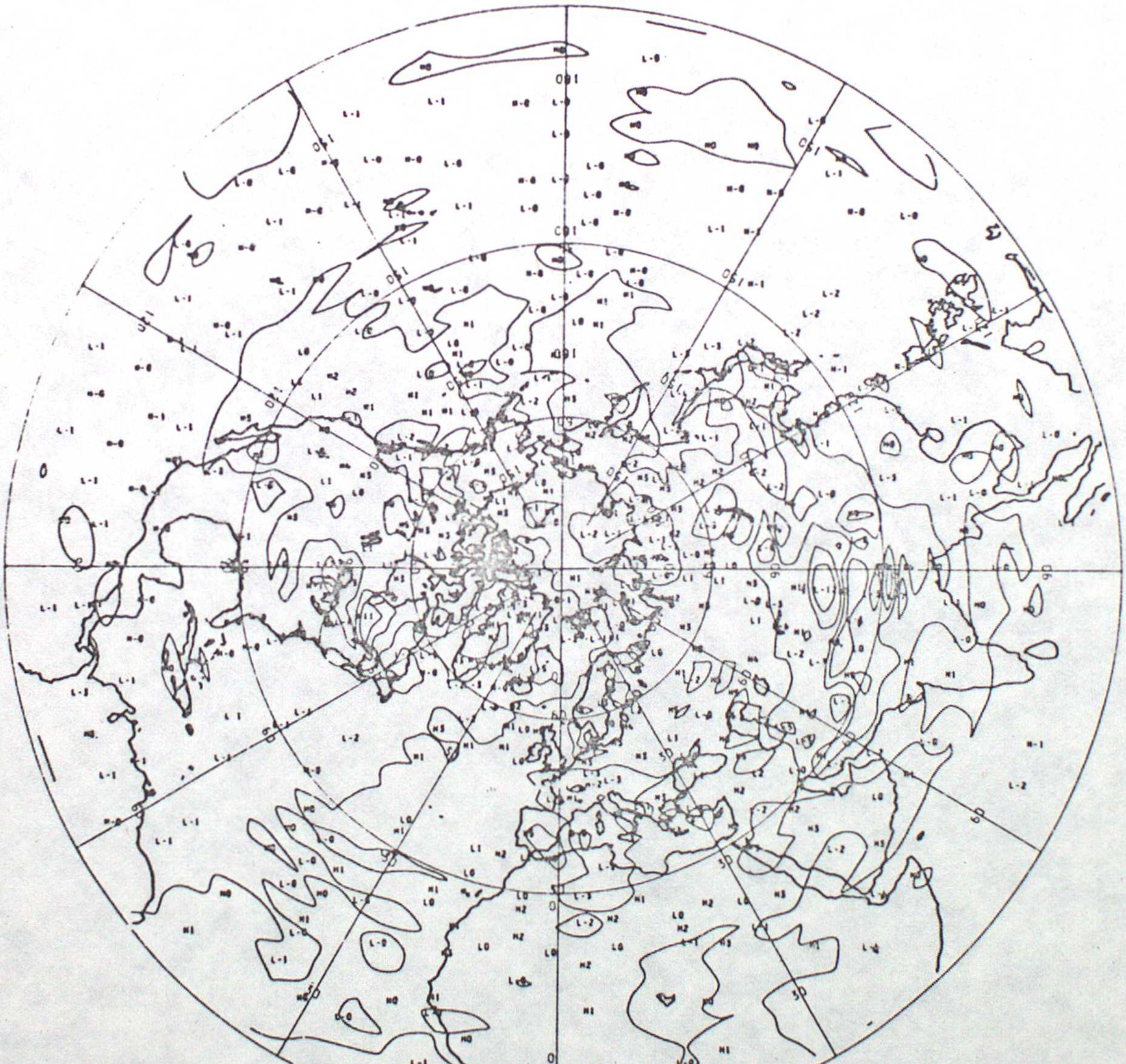
FIG 2a

DAY 3 PMSL DIFFERENCE FIELDS (UTF MINUS STF) 12Z 8.5.77 F/C

DIFFERENCES IN PMSL   SIMA=0.0 FOR EXH 0-EXH 0D 3H 0D 3H 0
CONTOUR INTERVAL = 4.00

FIG2b

DAY3 PMSL DIFFERENCE FIELDS (UTF MINUS STF) 12Z 14.8.77 F/C



DIFFERENCES IN PMSL SIMA=0.0 FOR EXH 0-EXH 0D 3H 0D 3H 0
CONTOUR INTERVAL = 4.00

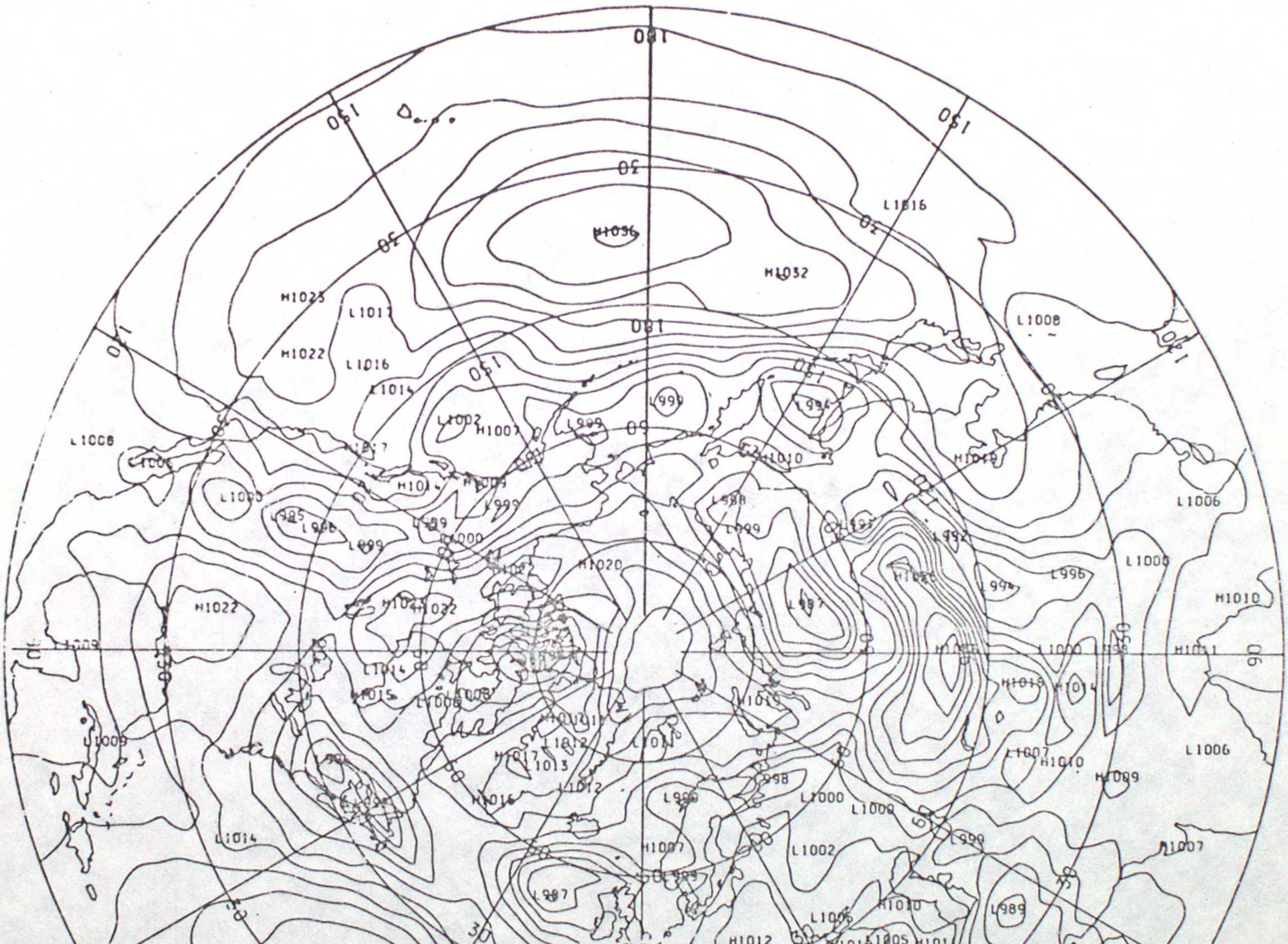
FIG 2c

DAY 3 PMSL DIFFERENCE FIELDS (UTF MINUS STF) 12Z 1.1.78 F/C

DIFFERENCES IN PMSL SIMA=0.0 FOR EXH 0-EXH 0D 3H 0D 3H 0
CONTOUR INTERVAL = 4.00

DAY 3 OF 12Z 8.5.77 F/C WITH SMOOTHED TOP.

PMSL.

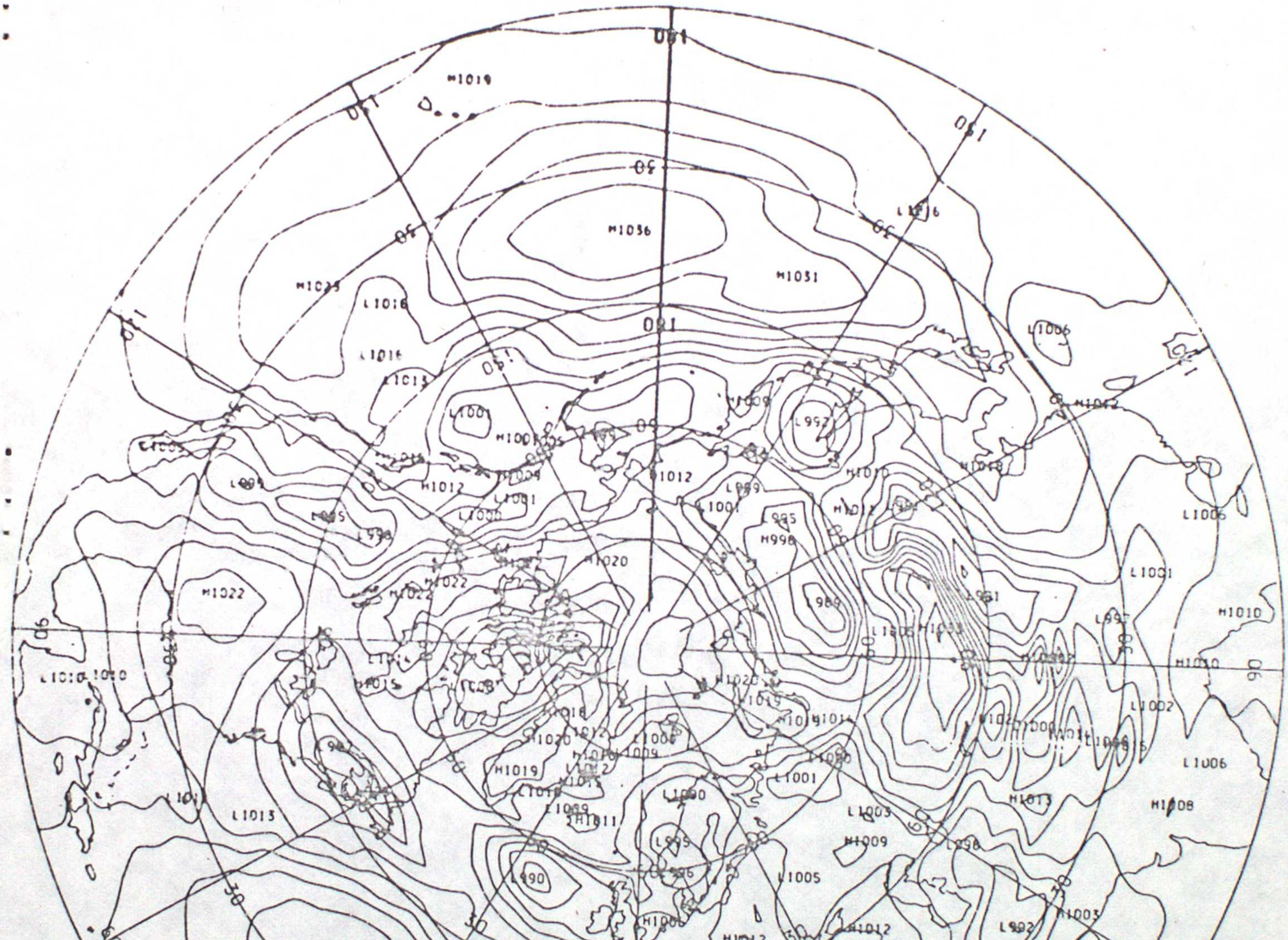


DAY3 OF 12Z 8.5.77 F/C WITH SMOOTHED TOP.

500MB

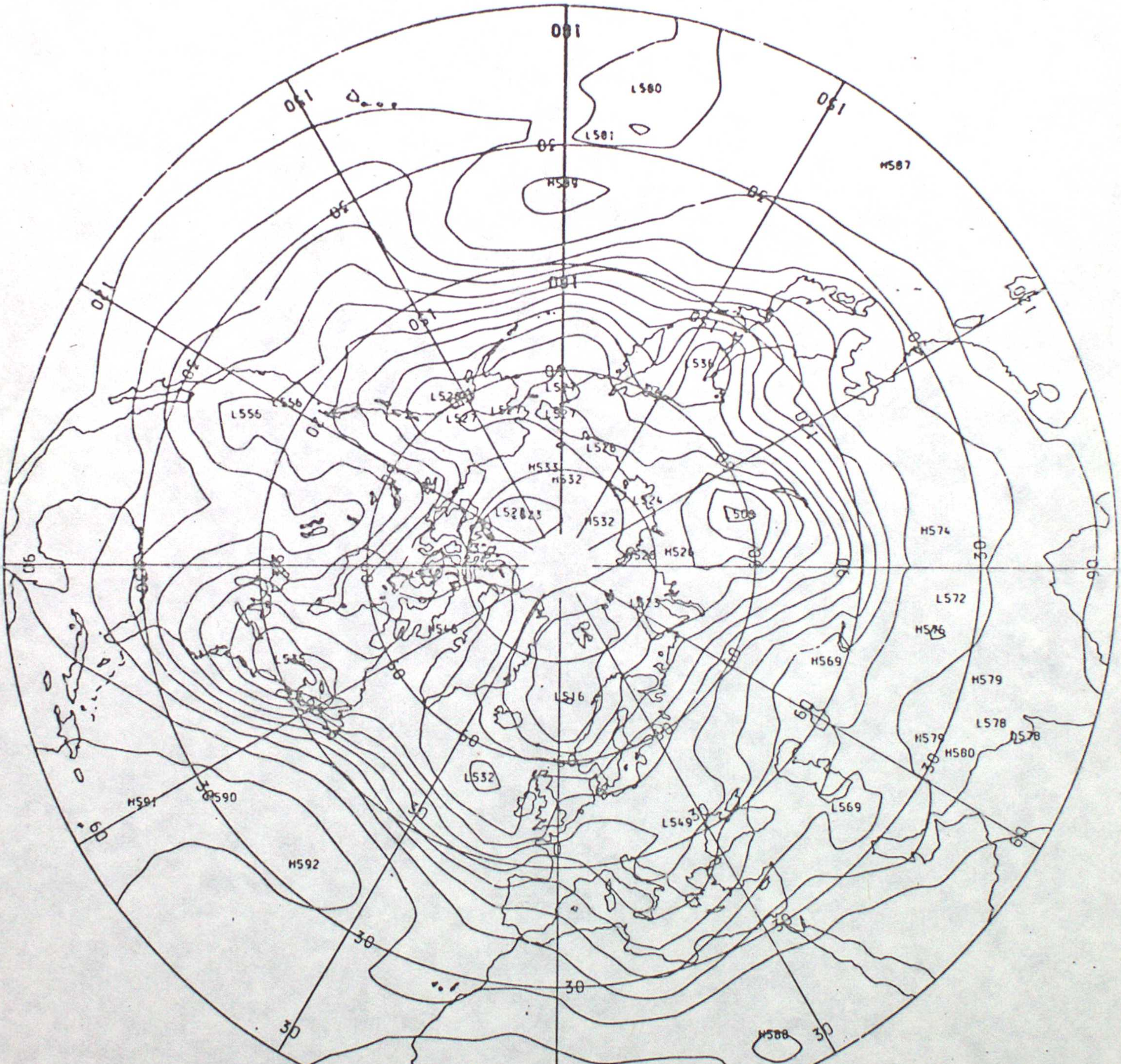
DAY3 OF 12Z 8.5.77 F/C WITH UNSMOOTHED TOP.

PMSL



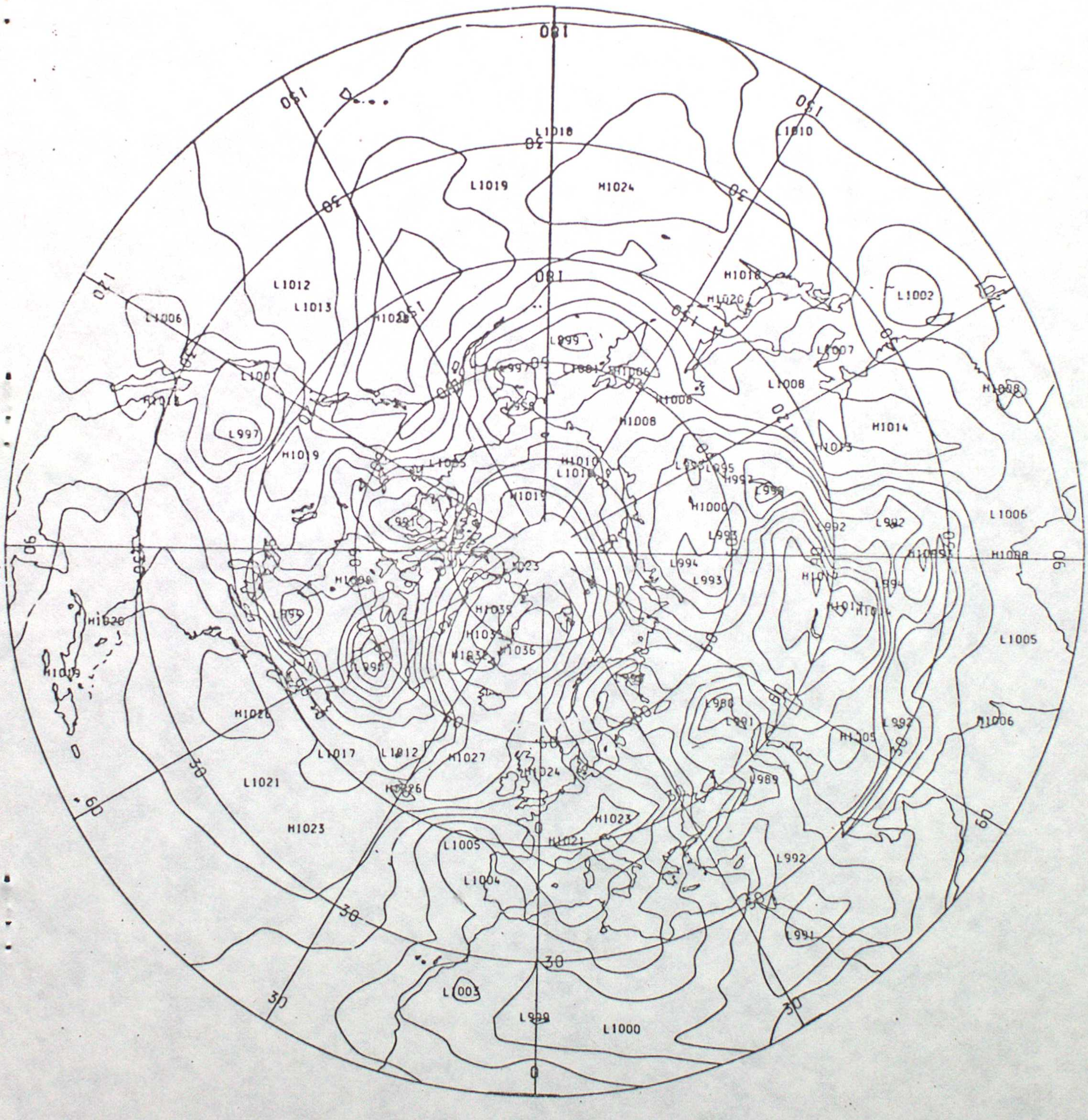
DAY 3 OF 12Z 8.5.77 F/C WITH UNSMOOTHED TOP.

500MB.



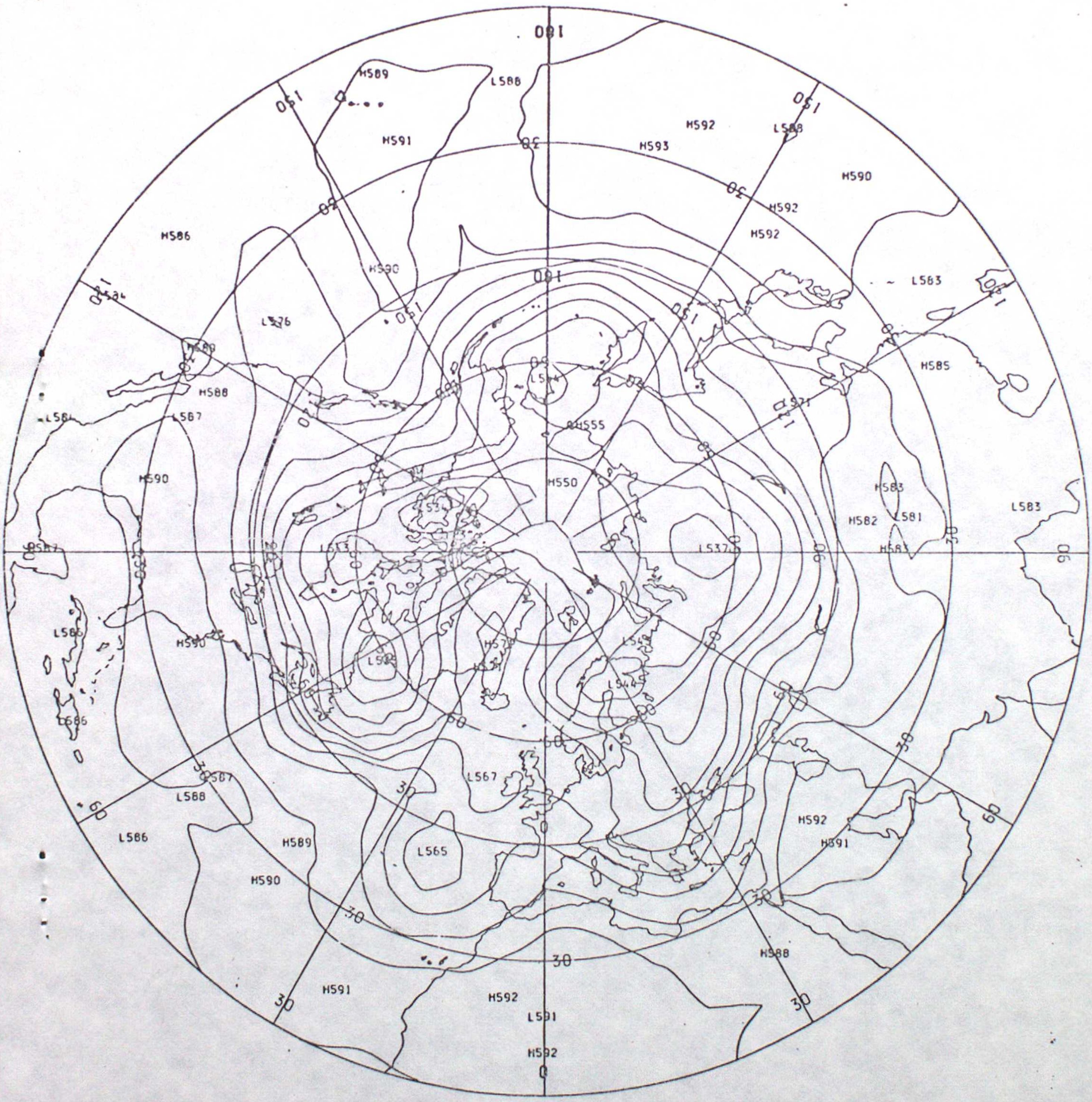
DAY 3 OF 12Z 14.8.77 F/C WITH SMOOTHED TOP.

PMSL.



DAY 3 OF 12Z 14.8.77 F/C WITH SMOOTHED TOP

500MB.

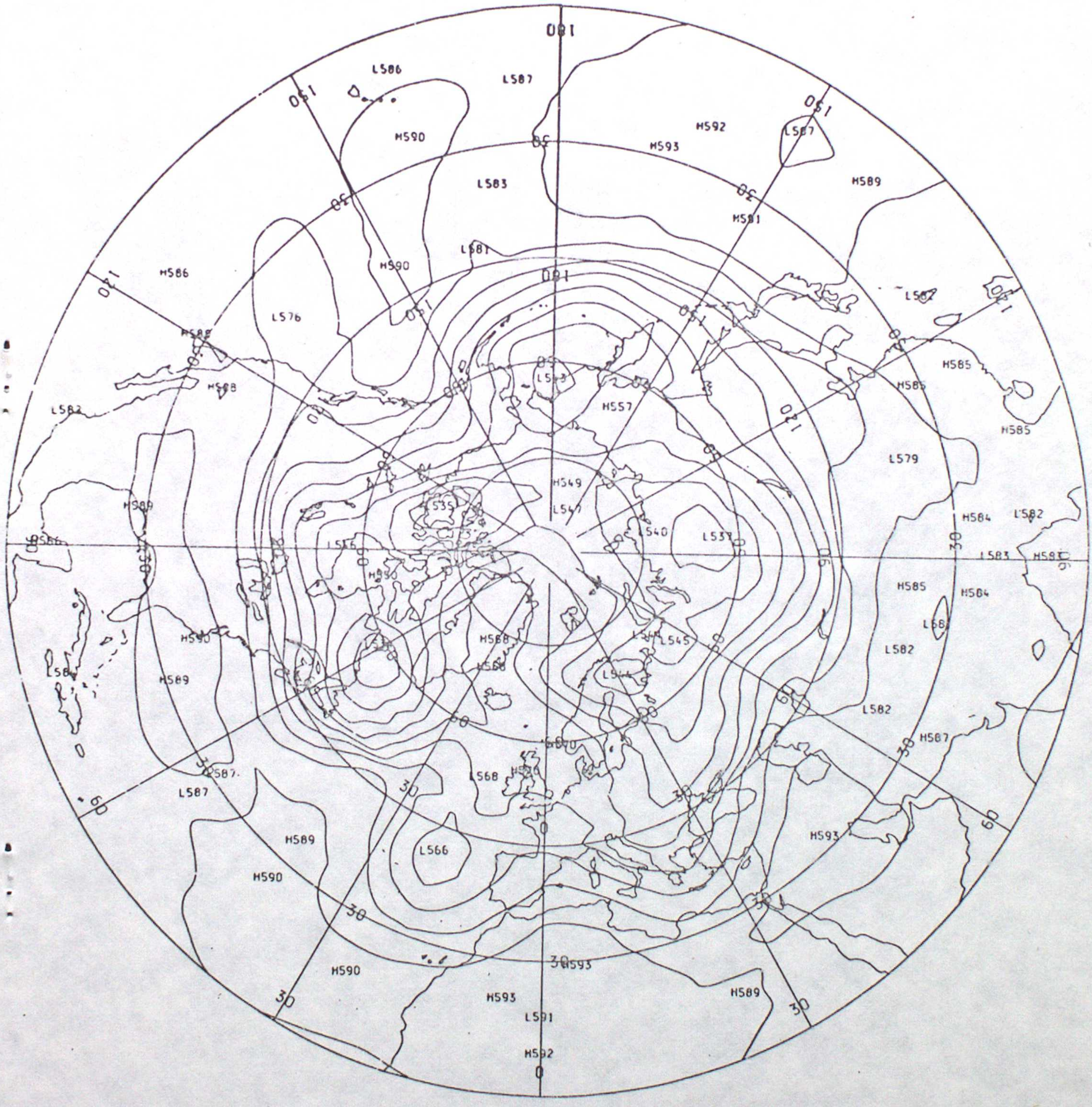


DAY 3 OF 12Z 14·8·77 F/C WITH UNSMOOTHED TOP.

PMSL.

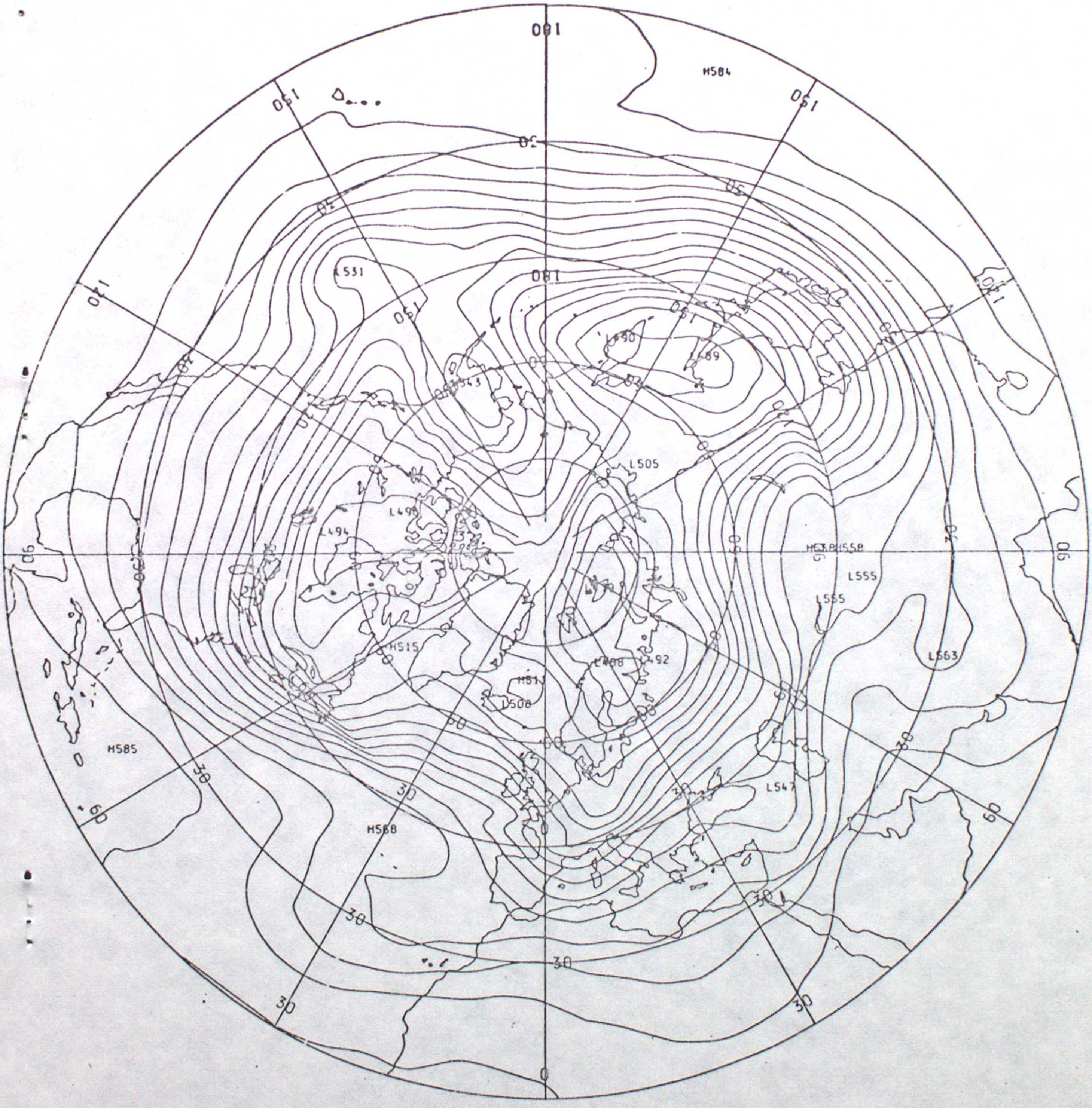
DAY 3 OF 12Z 14·8·77 F/C WITH UNSMOOTHED TOP.

500MB



DAY 3 12Z 1.1.78 F/C WITH SMOOTHED TOP.

500MB.



DAY 3 OF 12Z 1.1.78 F/C WITH UNSMOOTHED TOP.

500MB