MET O 11 TECHNICAL NOTE NO 128

SECOND YEAR INDUSTRIAL PERIOD PROJECT
PART 2

EXPERIMENTS WITH A GLOBAL DATA ASSIMILATION SCHEME USING FGGE DATA

N.A. Machin

W.H. Lyne

Met O 11 (Forecasting Research Branch)
Meteorological Office
London Road
BRACKNELL
Berkshire RG12 2SZ

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1. Introduction

A global data assimilation scheme based on the Met O 2Ø 11-level sigma co-ordinate primitive equation model was run in near real-time during the Special Observing Periods (SOPs) of FGGE, with the aim of assessing its potential as a basis for the next Meteorological Office operational model. It showed considerable promise, and experience gained suggested several modifications for the future. This note describes the results of a number of experiments to investigate the effect of some of these modifications on both global analyses and forecasts, using real data.

Since the FGGE assimilation scheme will be described in detail elsewhere only the briefest of descriptions is given here. The data to be used in the assimilation are vertically interpolated to the 11 model sigma levels, and consist of wind components, temperature, and humidity mixing ratio (on the lowest 7 levels only). They are then horizontally interpolated to the grid points using optimum interpolation, with the forecast fields as background.

The experiments were started from the 16 GMT FGGE global analysis run of 27th February 1979, and used data from Met O 2Ø tapes which contained intervention. Integration/assimilation was carried out for 2Ø hours, to 12 GMT on 28th February 1979, using each modification of the scheme. Since the new analyses were used to run forecasts to generate the background fields for the subsequent analyses, the experiments are independent of one another, except for the initial fields. The experimental analyses were compared subjectively with those of the FGGE scheme which had been run for a further 2Ø hours, with hand-drawn charts of observations, and objectively with the observations at 12 GMT on 28th February 1979.

72-hour global forecasts were run from the most interesting experimental final analyses. These were compared subjectively with the FGGE 72-hour forecast for the same period, the FGGE analysis for 12 GMT on 3rd March 1979, and objectively with the observations at that time.

Clearly, for a statistical interpretation of the results, each experiment should have been carried out several times, starting from different initial fields, but this was not possible in this project.

2. Modifications to the FGGE Assimilation Scheme

The experiments can be categorized into investigations of the following modifications to the FGGE assimilation scheme.

2.1 The Scaling Parameter Function

During the correction process the observed (interpolated) minus predicted fields are scaled by a parameter λ before being added to the model fields. In the FGGE scheme the value of λ increased linearly from zero $1\frac{1}{2}$ hours before the relevant synoptic hour, to Ø.5 at the synoptic hour, and thereafter decreased linearly to zero again $1\frac{1}{2}$ hours later, as in Fig I :

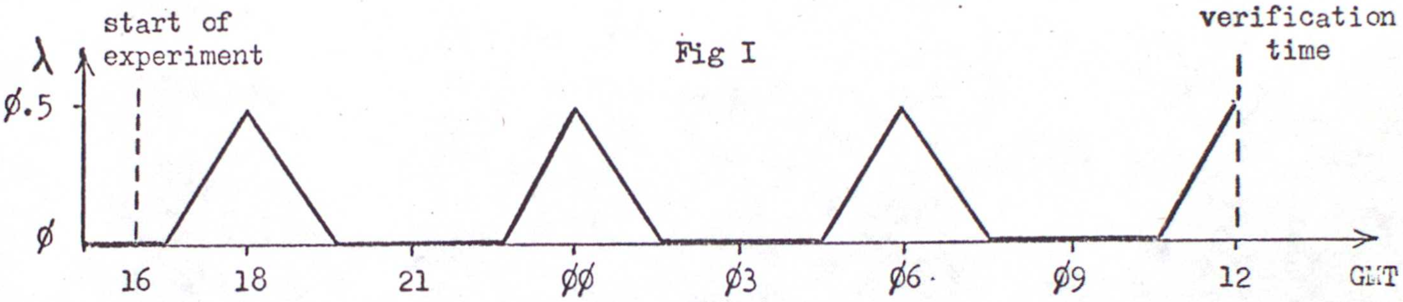


Fig I

Experiment A

The data was assimilated for 3 hours ahead of the relevant synoptic hour with the scaling parameter, λ , constant at Ø.5, as in Fig II :

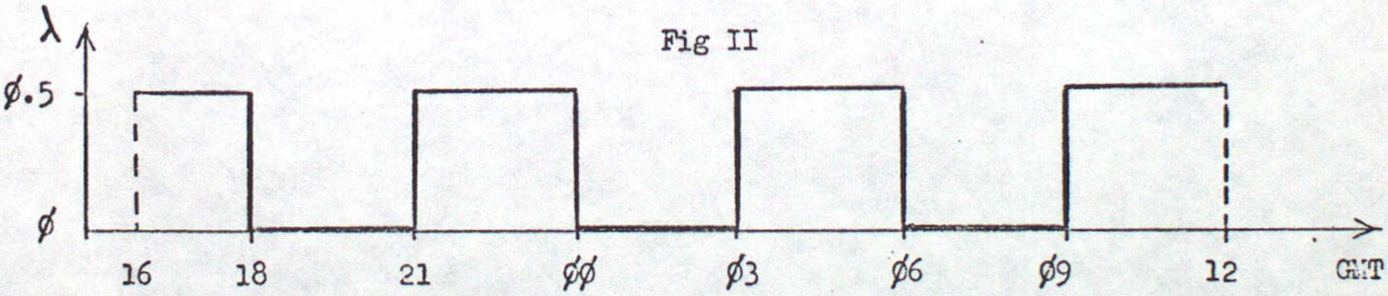


Fig II

Experiment B

The data was assimilated for 6 hours ahead of the relevant synoptic hour with λ increasing linearly from zero at the beginning of the cycle, to Ø.5 at the synoptic hour, as in Fig III :

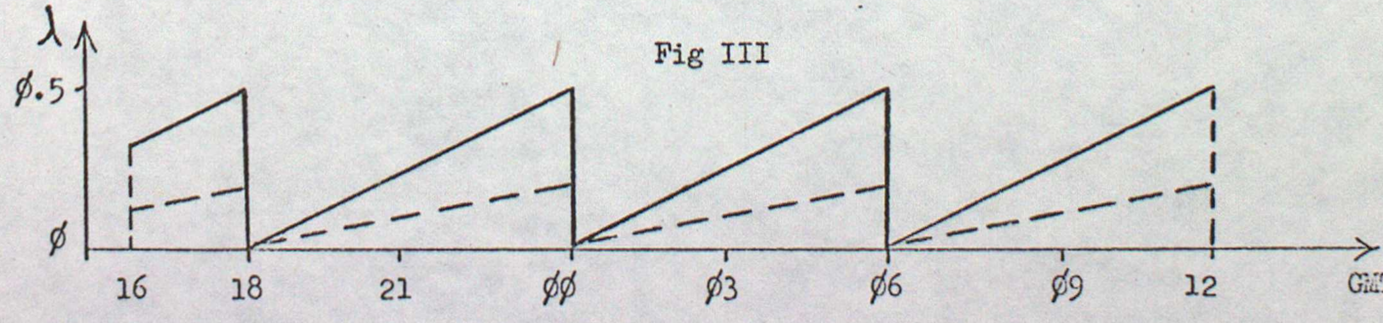


Fig III

Experiment C

As experiment B but with the scaling parameter increasing to only ∅.2 at the synoptic hour, as shown by the dashed line in Fig III.

2.2 The Radius of Influence

Observational weights are calculated for the statistical interpolation to model grid points using two-dimensional univariate optimum interpolation. However, the solutions are restricted to those observations within a specified radius of influence, the limiting factor being determined by the available core storage in the assimilation model. In the FGGE scheme this radius of influence was 3 grid spacings (66∅km) :

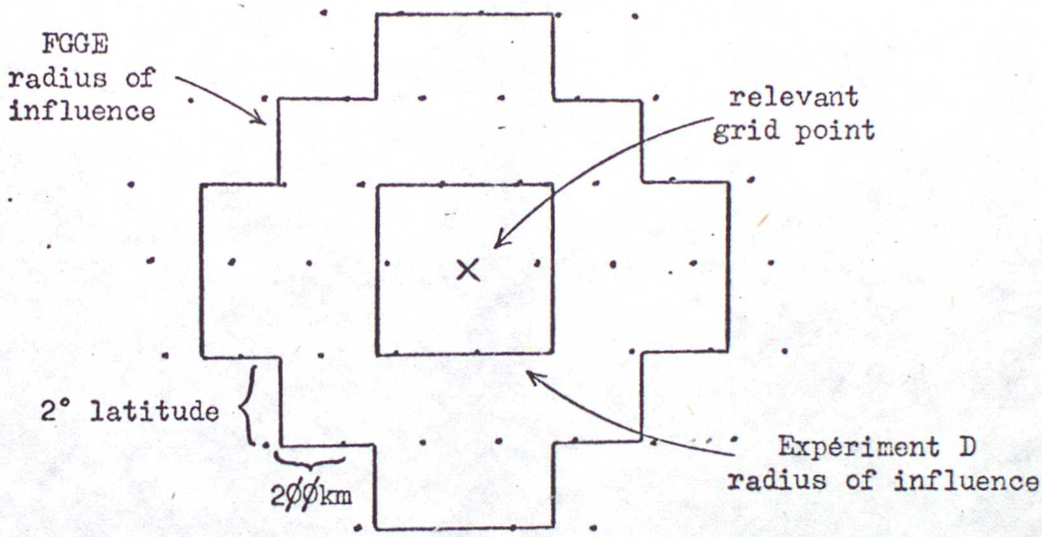


Fig IV (schematic only)

Experiment D

The radius of influence around a grid point was reduced to 1 grid length (22∅km), as shown in Fig IV.

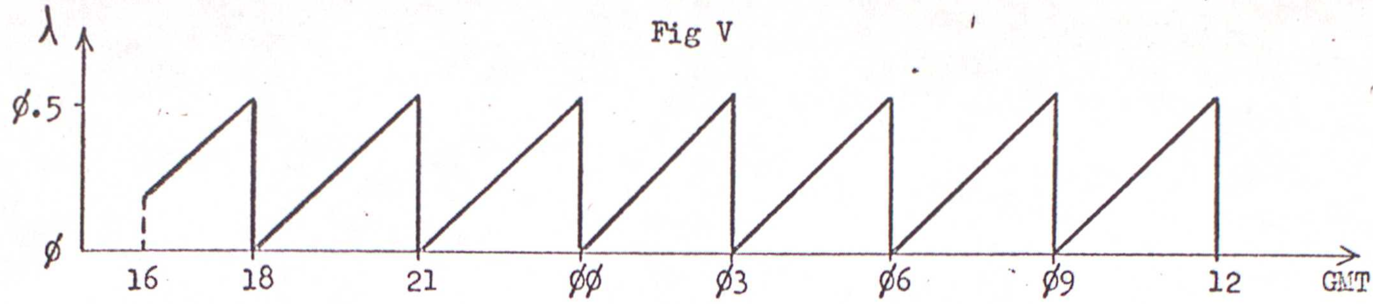
2.3 The Assimilation Cycle Period

During FGGE the data assimilation cycle had a 6 hour period, so that all observations were used and assimilated at one of the synoptic hours ∅∅, ∅6, 12, and 18GMT, with any asynoptic data being thrown to the nearest synoptic hour.

Experiment E

The period between assimilation cycles was reduced to 3 hours, so that any asynoptic data was thrown to the nearest synoptic or main hour. The data was assimilated for 3 hours ahead of the relevant synoptic or main hour, with the scaling parameter increasing linearly from zero at the beginning of the cycle, to Ø.5, as in Fig V :

Fig V



The observational data for these 3 hour periods was re-extracted from archived data banks without intervention, but so that the analyses and forecasts are comparable with those of the other experiments, exactly the same intervention was carried out. However there were a number of extra observations that had previously been excluded by the data cut-off time of the 6 hour dataset. These included a few drifting buoy observations north of 75N, though a large majority of the extra reports were of surface pressure in the tropics, where they made little difference to the analyses.

3. Comparison of Analyses for 12GMT 28/2/79

The global Mean Sea-Level Pressure (PMSL) and 25Ømb contour height analyses for experiments A to E are compared subjectively with those of the FGGE (denoted F) scheme, and with hand-drawn charts of observations, which are considered to be the closest approximation to the truth. Differences are in general small, but the following areas were noted, and the various analyses rated in descending order of 'nearness to the truth'.

3.1 Mean Sea-Level Pressure Analyses

(a) Trough, 39N ØØW

The hand-drawn analysis indicates a trough with a PMSL of 1Ø13mb at 39N ØØW. All the experimental analyses give a distinct cut-off low in this position, experiments C and F with a central PMSL of 1Ø1Ømb, and experiments A, B, and E as low as 1ØØ5mb.

The PMSL at this point had fallen by about 15mb during the previous 2Ø hours as the trough moved eastwards and amplified. A 'rogue' ship at 37N Ø1W reporting a PMSL of 1ØØ1mb was rejected by the hand-analyst, but accepted by the 12GMT quality control of the experimental assimilations. Consequently, those assimilation schemes which nudge the model towards the observations least give the best analysis in this case.

Rating : C, F, D, B, E, A

(b) High, 42N 114E

A distinct central PMSL of 1∅44mb is indicated by the hand-drawn analysis, whereas all the experimental analyses are more extensive, with this central pressure around 1∅4∅mb, and another equally high centre 75∅km to the west, where the hand-drawn analysis indicates a PMSL of only 1∅29mb.

The high had changed very little apart from drifting slowly southwards during the previous 2∅ hours. The forecast appears to want to build and move it WSWwards. Consequently the observations have failed to build the centre sufficiently at 42N 114E, and have failed to decline the centre to any marked degree 75∅km to the west.

Rating : F, E, B, A, C, D

(c) Low, 5∅N 17∅W

All experimental analyses were in good agreement with the shape and position of the hand-drawn analysis. This indicates a central PMSL of the order of 98∅mb, whereas the FGGE analysis gives 985mb. The best analysis is that of experiment A (981mb), and the worst, that of experiment D (987mb).

The low had deepened by about 7mb and moved quickly northeastwards during the the previous 2∅ hours, whereas the forecast appears to want to fill it slightly and move it more slowly. Therefore, in contrast to case (a), those assimilation schemes which nudge the model towards the observations to the greatest extent, give the best analysis in this case.

Rating : A, B, E, F, C, D

(d) Instability, North Pole

The output of mean global surface pressure tendency at each time-step during the integration/assimilation confirms that in experiments A, B, and C an instability developed directly over the North Pole while the ∅6GMT data was being assimilated, and in experiment E during the assimilation of the ∅3GMT data. It does not appear to affect the analysis below 88N and was markedly damped by the assimilation of the 12GMT data.

It is very difficult to ascertain what caused the instability to occur since the few observations above 75N at Ø3 and Ø6GMT seem good, and had not changed significantly since ØØGMT or by 12GMT. However, since this problem will be removed from the model by future modifications to the scheme, no rating will be given in this case.

Apart from the cases noted above, the northern hemisphere analyses of PMSL were in good agreement with each other, and with the hand-drawn analysis.

(e) High, 35S 1ØW

Although there is good agreement between the analyses as to the position of the high, there are differences in its extent. The hand-drawn analysis indicates a central PMSL of around 1Ø32mb. Experiment F gives the highest value of 1Ø34mb, and experiments A, B, C, and D are all low, with around 1Ø31mb.

The high had built by about 7mb and drifted slowly westwards during the previous 2Ø hours, and is in general well analysed. The reason for the relatively large difference between the analysis of experiment F and those of experiments A, B, C, and D which were assimilating the same data, is hard to determine, but may be due to the fact that the FGGE assimilation of 12GMT data is not complete by 12ØØ.

Rating : A, D, B, E, C, F

(f) Low, 62S ØØW

Although a data-sparse area, the hand-drawn analysis indicates a central pressure of the order of 965mb. Experiment F gives 968mb, whereas the best analyses, those of experiments B and C, agree with 965mb and the worst, that of experiment D, gives 971mb. All experiments are in good agreement as to the position of the centre.

The low had deepened by about 4mb and tracked eastwards during the previous 2Ø hours, but the forecast appears to want to fill it. We should therefore expect that those schemes which nudge the model closest to the observations would give the best analysis in this case, but this is not altogether borne out by the ratings.

Rating : B, C, E, A, F, D

(g) High, 8ØS 5ØE

At the start of the experiments this high was slightly further east with a central PMSL of 1Ø16mb. Experiment F declined it to 1Ø11mb 2Ø hours later, and the other experiments declined it further still, the lowest being experiment A with 1ØØ2mb.

Since there were no observations below 7ØS in this quadrant of the globe during the experiment, it is difficult to determine both the true value and also the reason for the difference in the analysed values, though it may be related to the high ant - arctic orography. It is hoped, as in all other cases, that an indication of the acc - uracy of the analysis will be reflected by the quality of the subsequent forecast, and no rating will be attempted.

Although the above cases are the only areas of large differences, in general the differences between the southern hemisphere analyses of PMSL are greater than those of the northern hemisphere. This is probably due to the fact that throughout the experiment there were by far fewer surface observations in the southern hemisphere (2335), than in the northern hemisphere (6446). The small differences between the analyses generated earlier in the experiment by the different assimilations of these observations are 'amplified' by the subsequent forecast steps, and there are comp - aritively few observations to then substantially modify the resulting fields.

In order to determine which assimilation schemes give the best global analyses of PMSL a simple comparative scoring system was introduced in which the analysis considered to be nearest the truth is given 6 points, the next best 5, down to the worst with 1 point. The schemes were scored as follows :

Table 1 Subjective Comparison of PMSL for 12GMT 28/2/79

Experiment	A	B	C	D	E	F
Overall Scores	19	22	17	12	18	17

An objective comparison of the PMSL analyses was also carried out by finding (observed - analysed) 'error' values for all surface observations at 12GMT.

Table 2 PMSL Analysis Error Statistics for 12GMT 28/2/79

Experiment	A	B	C	D	E	F
Mean (mb)	-Ø.18	-Ø.15	-Ø.1Ø	-Ø.29	-Ø.13	-Ø.20
RMS (mb)	2.99	2.89	3.18	2.96	3.16	2.99

The analysis error statistics would seem to suggest that there is no significant difference between the experimental analyses of PMSL. However it is clear that these errors are unduly weighted towards data-dense areas, where the subjective comparison confirms that there is indeed little difference. It is felt that the subjective comparison gives a fairer appraisal, and it can tentatively be concluded that, in this case, the global PMSL analysis of experiment B is better than that of the FGGE scheme, while that of experiment D is worse.

3.2 Upper Air Analyses

(a) 250mb heights, N.hemisphere

There were few differences between the charts of greater than 5dm, and even these occured in regions of steep gradients, for example 60N 30W, where the contour patterns were similar but shifted slightly. In general the hand-drawn and experimental analyses were in good agreement, and no significant differences were noted.

(b) 250mb heights, S.hemisphere

All the analyses were in close agreement with each other, the only large difference occuring at 62S 120W, where the FGGE analysis gives a height of 972dm. The highest analysed value was that of experiment A (976dm), and the lowest that of experiment D (968dm). It would appear that the (too low) forecast was modified to varying degrees by a nearby satellite derived 1000 - 250mb thickness of 991dm, though determination of the true value is not possible.

Clearly the sparsity of data at upper levels, particularly in the southern hemisphere makes the subjective comparison and verification of analyses very difficult. Therefore objective comparisons of height, temperature and wind speed analyses were carried out by finding error statistics as before, using all the observations for 12GMT. The results are shown in Tables 3,4 and 5, and the vertical structure of the RMS analysis errors are compared in Figs VI, VII and VIII.

These statistics and the graphs of their vertical structure indicate the following ratings over most of the atmosphere :

Height Analysis Rating : B, E, A/F, C, D

Temperature Analysis Rating : B, A, E, F, D, C

Wind Speed Analysis Rating : A, B, E, F, D, C

Table 3 Height Analysis Error Statistics for 12GMT 28/2/79

Level (mb)	Mean (dm) A	Mean (dm) B	Mean (dm) C	Mean (dm) D	Mean (dm) E	Mean (dm) F	RMS (dm) A	RMS (dm) B	RMS (dm) C	RMS (dm) D	RMS (dm) E	RMS (dm) F
100	12.25	12.44	15.40	22.95	13.34	15.25	49.04	48.31	53.32	51.83	47.82	48.32
150	16.63	16.66	19.84	25.75	17.45	19.10	44.59	43.34	49.45	50.28	44.28	45.42
200	9.61	9.58	12.12	16.86	10.13	11.38	38.24	37.23	42.09	42.48	38.25	38.65
250	13.97	14.08	16.31	20.24	14.55	15.49	37.21	36.57	40.66	42.07	37.50	38.27
300	22.84	22.94	25.00	28.78	23.44	24.30	39.93	39.46	42.89	45.29	40.31	41.29
400	27.45	27.44	28.97	32.49	27.77	28.47	38.83	38.27	40.30	44.09	38.82	39.55
500	19.44	19.35	20.42	23.66	19.52	20.09	31.68	30.71	31.46	35.72	31.24	31.61
700	14.50	14.40	14.88	17.57	14.30	14.85	27.56	26.43	26.00	29.77	26.79	26.50
850	6.82	6.77	6.60	8.73	6.65	6.75	23.77	22.50	21.07	23.88	22.72	21.92
1000	0.41	0.54	0.31	1.95	0.77	0.21	23.48	22.56	22.41	24.15	22.58	22.44

Table 4 Temperature Analysis Error Statistics for 12GMT 28/2/79

Level (mb)	Mean (°C) A	Mean (°C) B	Mean (°C) C	Mean (°C) D	Mean (°C) E	Mean (°C) F	RMS (°C) A	RMS (°C) B	RMS (°C) C	RMS (°C) D	RMS (°C) E	RMS (°C) F
100	-1.40	-1.38	-1.38	-1.27	-1.32	-1.34	3.06	3.07	3.21	3.17	2.96	3.11
150	-0.00	0.01	0.06	0.19	0.07	0.07	2.03	1.98	2.14	2.09	1.99	2.04
200	-0.40	-0.41	-0.36	-0.22	-0.37	-0.34	1.93	1.92	2.05	1.97	1.90	1.98
250	-1.81	-1.81	-1.77	-1.69	-1.82	-1.77	2.66	2.65	2.78	2.69	2.68	2.71
300	-1.29	-1.29	-1.23	-1.20	-1.27	-1.25	1.99	1.98	2.12	1.99	2.00	2.08
400	-0.57	-0.56	-0.49	-0.45	-0.52	-0.51	1.31	1.32	1.45	1.31	1.32	1.41
500	-0.00	0.01	0.07	0.11	0.01	0.02	1.15	1.16	1.27	1.18	1.14	1.20
700	0.30	0.33	0.43	0.58	0.33	0.36	1.22	1.21	1.34	1.37	1.23	1.24
850	-0.02	-0.02	0.04	0.18	-0.02	0.07	1.49	1.49	1.76	1.75	1.59	1.75
1000	-0.65	-0.72	-1.35	-1.37	-0.85	-1.10	1.70	1.69	2.60	2.74	2.01	2.45

Table 5 Wind Speed Analysis Error Statistics for 12GMT 28/2/79

Level (mb)	RMS (kt) A	RMS (kt) B	RMS (kt) C	RMS (kt) D	RMS (kt) E	RMS (kt) F
100	9.94	9.74	9.93	10.00	9.73	10.03
150	8.33	8.29	9.95	9.96	8.41	9.77
200	8.22	8.19	9.52	9.05	8.79	9.12
250	10.65	10.79	12.51	12.26	10.82	12.00
300	10.53	11.05	14.27	13.58	11.20	13.36
400	8.02	8.42	10.32	9.24	8.76	9.95
500	7.81	8.39	9.48	9.16	8.60	8.85
700	6.20	6.08	7.25	7.88	6.52	6.90
850	5.74	5.86	6.51	6.23	5.45	6.57
1000	5.40	5.09	6.38	5.69	5.48	6.01

Fig V   Vertical Structure of Height Analysis Errors for 12GMT 28/2/79

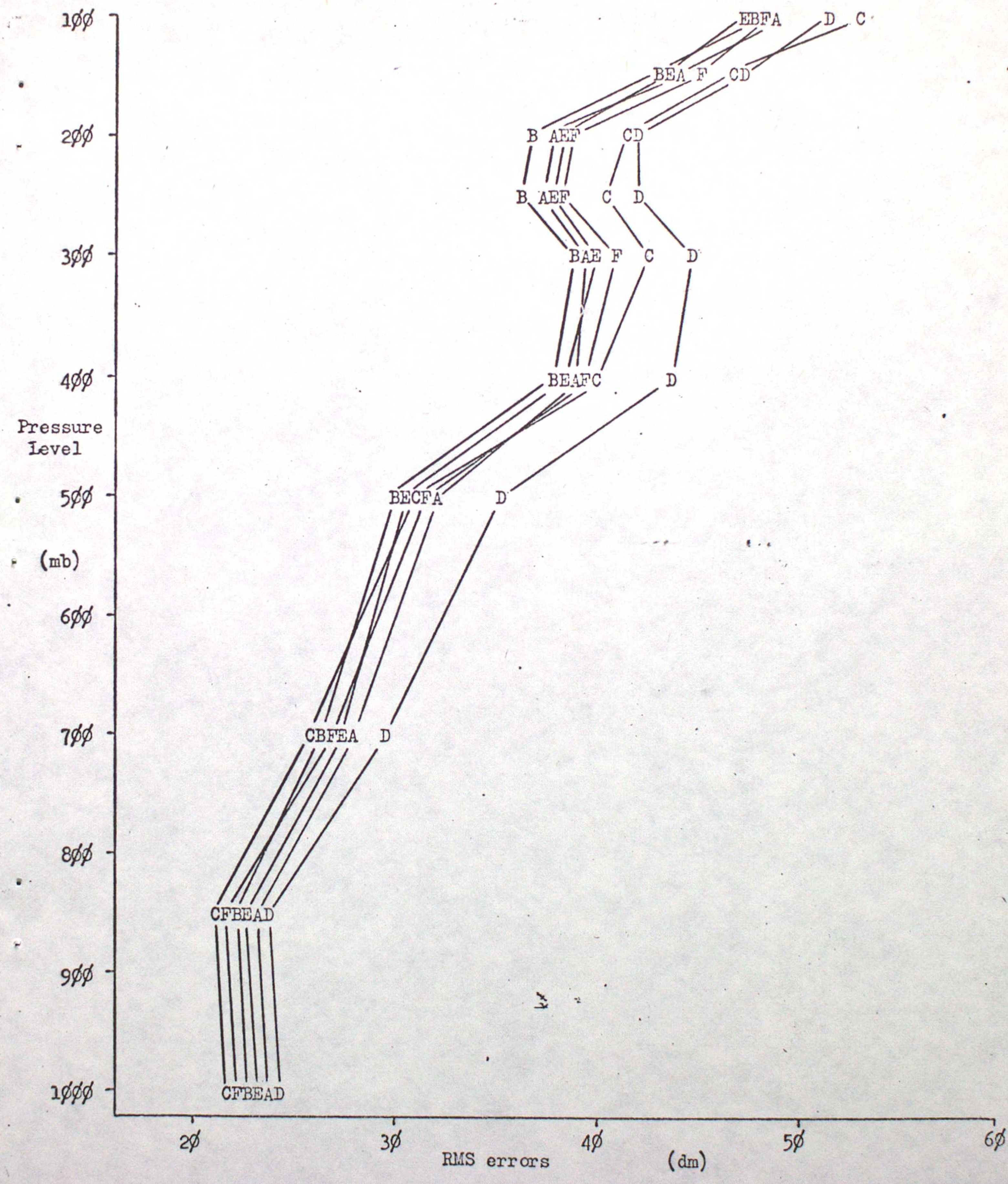


Fig VI Vertical Structure of Temperature Analysis Errors for 12GMT 28/2/79

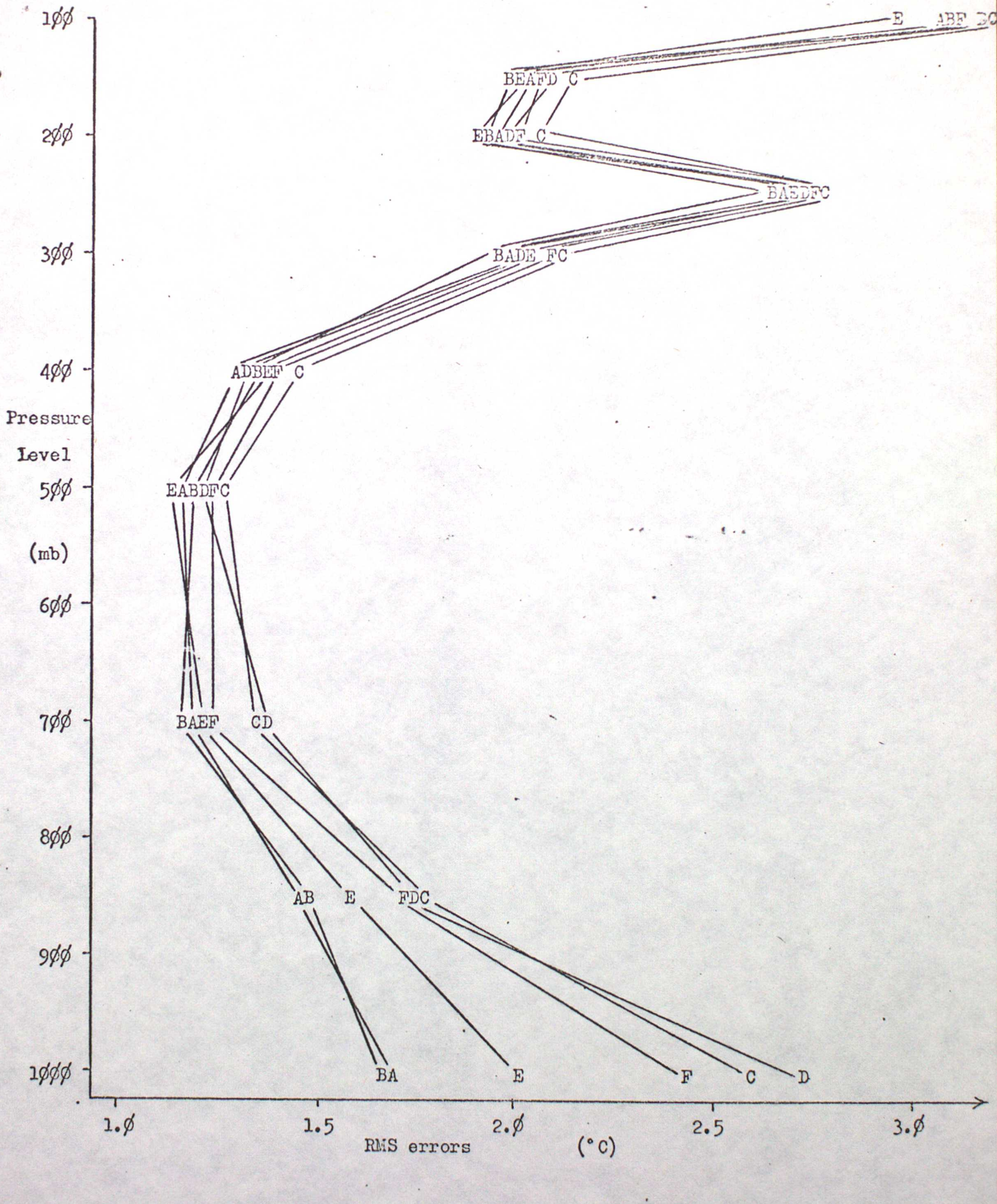
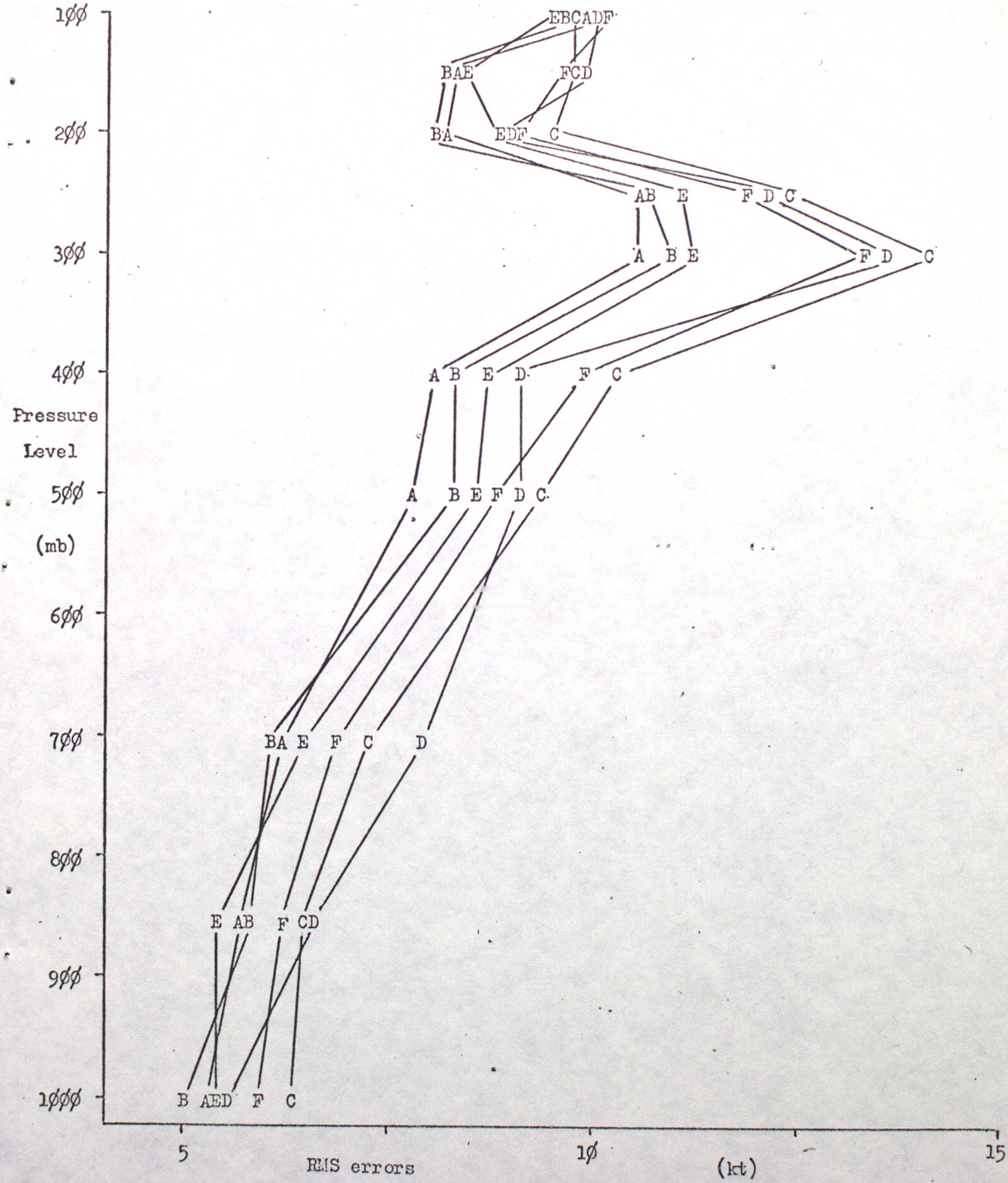


Fig VII Vertical Structure of Wind Speed Analysis Errors for 12GMT 28/2/79



Although the differences are small, the ratings are consistent with each other and with that of the subjective analysis of PMSL, and support the tentative conclusion that, in this case, the analyses of experiment B are better than those of the FGGE scheme, whereas those of experiment D are worse. Clearly the schemes which nudge the m odel towards the observations to the greatest extent have given the most accurate analyses, and it is interesting to note that, using the FGGE observing system, there appears to be no advantage in reducing the assimilation cycle from 6 to 3 hours, as in experiment E.

However it is difficult to verify analyses completely fairly, and ultimately the best assimilation scheme must be that which subsequently gives the most accurate forecasts.

4. Comparison of Forecasts for 12GMT 3/3/79

The global PMSL and 25Ømb contour height 72-hour forecasts, starting from the analyses of experiments A, B, D and E are compared with those of the FGGE forecast for the same period, and with the FGGE analysis for 12GMT 3/3/79. The main features were as follows, the latitude/longitude referring to the analysed position.

4.1 Mean Sea-Level Pressure Forecasts

(a) High, 3ØN 135W and 43N 11ØW

The general northeastward drift of the high is forecast by all the experiments. The analysis gives a weak northeastern centre with a PMSL of 1Ø23mb, and all forecasts are in good agreement with the position, correctly giving the southwesterly flow over the northwestern seaboard of the United States and the NNEly flow over New Mexico. The building of this centre, to 1Ø32mb by experiments D and F, and as high as 1Ø35mb in experiment E, did not occur so that the forecast gradients are too steep. The southwestern centre is more accurately forecast, though experiments A, D and F give its position around 14ØØkm east of that analysed. Experiment B gives the most accurate forecast, agreeing with the analysed PMSL of 1Ø25mb, about 9ØØkm to the southeast of the analysed position.

Rating : B, A, D/F, E

(b) High, 4ØN 1ØW

The southeastward development of the high is particularly well forecast, the central PMSL, the position of the centre, and even the details of the isobar pattern being in good agreement with the analysis. Experiments D, E and F give the most accurate isobar patterns, with experiments D and E agreeing with the analysed PMSL of between 1035 and 1036mb, and E and F more correctly forecasting the northeasterly flow over Algeria.

Rating : E, D, F, B, A

(c) High 49N 55E

Within the quasi-stationary Eurasian high, the analysis gives a high PMSL of 1043mb in this position. All the experiments forecast a more uniform area of high pressure, with only a weak centre around 900km to the north of the analysed centre, so that the WSWly flow between Scandinavia and western Russia is stronger than that forecast. Although experiment D gives the highest central PMSL of 1033mb, it also gives another centre of 1035mb about 1300km to the southwest, leading to an anomalous southeasterly flow over the eastern Mediterranean. Experiment B, although giving only 1031mb at the first centre, more correctly gives a weak area of around 1030mb near the second.

Rating : B, E, A/F, D

(d) High, 50N 60W

Although the position of the centre and the WSW-ENE orientation of the high axis is accurately forecast, the analysed central PMSL of 1040mb is higher in all the experiments. More importantly, the ridge forecast to extend up to Baffin Bay did not in fact develop so that instead of a strong southerly flow over eastern Canada, the analysis gives light westerlies. There are no significant differences between the forecast isobar patterns, but the most accurate central PMSL is that of experiment A with 1046mb, and the worst that of the FGGE forecast with 1049mb.

Rating : A, B, E, D, F

(e) Low, 59N 148W and 47N 169W

All experiments have correctly forecast the northeastward movement and deepening of the northeastern centre, and the slightly quicker eastward movement with little change in PMSL of the southwestern centre. The northeastern central PMSL, analysed as 975mb, is forecast about 500km further south in experiments A, B, E and F, with the FGGE scheme giving 971mb, and those of experiments A, B and E about 1mb higher.

Experiment D gives a central PMSL of 97∅mb, 6∅∅km to the east of the analysed position so that the southwesterly flow over the western seaboard of Canada has become anomal - ously strong. The analysis gives the southwestern centre as 979mb and again experiment A gives the most accurate forecast, agreeing with the central PMSL, 7∅∅km south of the analysed position. The forecast of experiment D is markedly worse, with a centre of 987mb over 1∅∅∅km further west, though all forecasts extend the low pressure approx - imately 1∅∅∅km too far west, so that the NNWly flow, forecast over Japan, is actually over the northwest Pacific.

Rating : A, B, E, F, D

(f) Low, 69N ∅2W

The development of the low is correctly forecast in almost every detail, and all forecasts, especially those of experiments A and B, would have given exceptional 72-hour guidance to the operational forecaster. The central PMSL of 958mb was most accurately forecast by experiment B with 963mb, 35∅km south of the analysed position, while experiment D was again worst, with a centre of 971mb, 6∅∅km to the south.

Rating : B, A, E, F, D

(g) High, 8∅N 18∅W

Although the northerly drift of the high is correctly forecast, its decline is overdone, so that the forecast of experiment D agrees with the position of the main centre, but with a PMSL as low as 1∅3∅mb, compared with the analysed values of between 1∅35 and 1∅37mb. Experiment A gives the most accurate forecast with a central PMSL of 1∅33mb in a similar position.

Rating : A, B, E, F, D

It should perhaps be noted that the N.hemisphere 72-hour forecast for the period chosen is markedly better than the remainder of those run during the SOPs of FGGE, making any significant improvements difficult.

(h) Southern Hemisphere

A similar subjective comparison was carried out for the southern hemisphere analysis and forecasts of PMSL for 12GMT 3/3/79. However it became apparent that such a comparison is misleading, since by the nature of the assimilation schemes, when there are few observations the analysis becomes virtually a forecast from the previous analyses. Consequently it should be expected that the FGGE S.hemisphere forecast and the FGGE analysis for the same time will be in closest agreement, and this is confirmed by the ratings and corresponding scores below.

Feature	Rating
High 39S 165W and 41S 135W	A/B, E, F, D
High 4ØS Ø8W and 42S 3ØW	F, E, A/B, D
High 4ØS 135E	A, F/B, E, D
Low 6ØS 12ØE and 63S 97E	E, F, D, B, A
Low 62S 8ØW	F, D, B, A, E
Low 65S ØØW	D, E, F, A, B
Low 66S 16ØW	A/F, E, B, D

Using the simple scoring system, the forecasts were rated as follows :

Table 6 Subjective Comparison of 72-hr PMSL forecasts for 12GMT 3/3/79

Experiment	A	B	D	E	F
N.hemisphere	26½	29	12½	22	15
S.hemisphere	21½	18½	16	22	27

The objective comparison of PMSL forecasts was also carried out by finding (observed - forecast) 'error' values for all surface observations at 12GMT.

Table 7 PMSL Forecast Error Statistics for 12GMT 3/3/79

Experiment	A	B	D	E	F
Mean (mb)	Ø.9Ø	Ø.9Ø	Ø.67	Ø.78	Ø.66
RMS (mb)	6.34	6.35	6.36	6.2Ø	6.42

The error statistics seem to suggest that there is no significant difference between the experimental forecasts of PMSL. However it is suspected that any small improvements at a number of observations are masked by the meaningless large differences that have occured between the forecasts of PMSL at the one or two observations over high topography.

When the southern hemisphere scores are disregarded, as they must be, the subjective comparison is in agreement with those of the analyses, and suggests that, in this case, the northern hemisphere 72-hour forecast of PMSL from the analysis of experiment B is better than that of the FGGE scheme, while that of experiment D is worse. The lack of an accurate analysis of PMSL makes a fair subjective assessment of the schemes impossible in the southern hemisphere.

4.2 Upper Air Forecasts

(a) 25Ømb heights, N.hemisphere

The small differences already noted between the experimental analyses was reflected by the small differences between the forecasts. The forecasts were in general accurate, but even in areas such as 7ØN 18ØW, where there is a marked difference between them and the analysis, there are negligible differences between the experimental forecasts on which to base the subjective rating. Obviously the differences between the assimilation schemes make least impact in the areas, or at the levels, where the data is most sparse.

(b) 25Ømb heights, S.hemisphere

As noted during the subjective comparison of southern hemisphere PMSL forecasts, such a comparison is probably meaningless because of the sparsity of data. Therefore no assessment will be made, apart from noting that there are negligible differences between the forecasts of experiments A, B, E and F. In all the forecasts the positions of the main features are in good agreement with the FGGE analysis, though in general the trough/ridge pattern is not as sharp in the forecasts, and that of experiment D is markedly smoother.

Objective comparisons of height, temperature and wind speed forecasts were carried out by finding error statistics as before, using all the observations for 12GMT. The results are shown in Tables 8, 9 and 1Ø, and the vertical structure of the RMS forecast errors are compared in Figs IX, X, and XI.

Table 8 Height 72-hr Forecast Error Statistics for 12GMT 3/3/79

Level (mb)	Mean (dm)					RMS (dm)				
	A	B	D	E	F	A	B	D	E	F
100	104.20	102.60	121.32	110.37	108.38	137.78	135.41	154.44	142.96	142.45
150	91.07	88.80	104.16	94.27	93.61	121.29	119.09	133.23	123.49	123.53
200	74.94	72.80	84.76	75.27	76.25	108.76	106.60	118.32	108.26	109.38
250	73.74	71.79	80.53	72.48	74.06	108.42	106.06	116.66	107.00	108.43
300	77.33	75.69	81.52	75.30	76.78	109.80	107.68	116.12	107.67	109.20
400	72.78	71.66	72.95	69.92	70.96	98.94	97.71	101.39	96.13	97.56
500	58.03	57.30	55.92	54.43	55.38	81.06	80.51	81.29	77.85	79.32
700	38.10	38.01	33.58	34.01	34.81	59.62	59.86	57.00	55.98	57.57
850	20.03	20.25	15.59	16.40	17.07	47.78	47.77	44.80	45.23	46.38
1000	11.06	11.49	7.29	7.61	8.39	52.07	51.89	50.45	51.14	51.43

Table 9 Temperature 72-hr Forecast Error Statistics for 12GMT 3/3/79

Level (mb)	Mean (°C)					RMS (°C)				
	A	B	D	E	F	A	B	D	E	F
100	-0.05	0.05	0.24	0.15	0.06	3.98	3.93	4.03	4.03	3.94
150	1.50	1.50	1.88	1.85	1.64	3.42	3.34	3.72	3.68	3.47
200	0.02	-0.01	0.43	0.29	0.17	4.42	4.39	4.62	4.47	4.44
250	-0.70	-0.73	-0.19	-0.49	-0.53	3.52	3.52	3.44	3.41	3.44
300	-0.19	-0.26	0.30	-0.08	-0.04	2.90	2.87	2.98	2.82	2.85
400	0.48	0.42	0.88	0.59	0.61	2.93	2.86	3.21	2.95	3.00
500	1.30	1.23	1.61	1.38	1.40	3.32	3.21	3.66	3.31	3.44
700	2.20	2.16	2.25	2.12	2.16	3.86	3.79	4.01	3.78	3.87
850	1.51	1.48	1.43	1.39	1.45	4.42	4.41	4.56	4.38	4.38
1000	-2.99	-3.01	-3.18	-3.10	-3.05	8.58	8.61	8.85	8.65	8.63

Table 10 Wind Speed 72-hr Forecast Error Statistics for 12GMT 3/3/79

Level (mb)	RMS (kt)				
	A	B	D	E	F
100	16.08	15.86	17.26	16.10	16.64
150	21.10	20.75	21.85	20.50	21.23
200	23.99	23.70	26.17	24.06	24.55
250	28.45	27.94	31.02	28.67	29.12
300	29.71	29.26	31.67	29.69	30.46
400	22.73	22.57	24.86	22.84	23.34
500	19.68	19.59	20.53	19.55	19.97
700	14.83	14.95	14.94	14.62	14.94
850	14.74	14.82	14.86	14.70	14.70
1000	10.71	10.86	10.62	10.73	10.59

Fig IX Vertical Structure of Height Forecast Errors for 12GMT 3/3/79

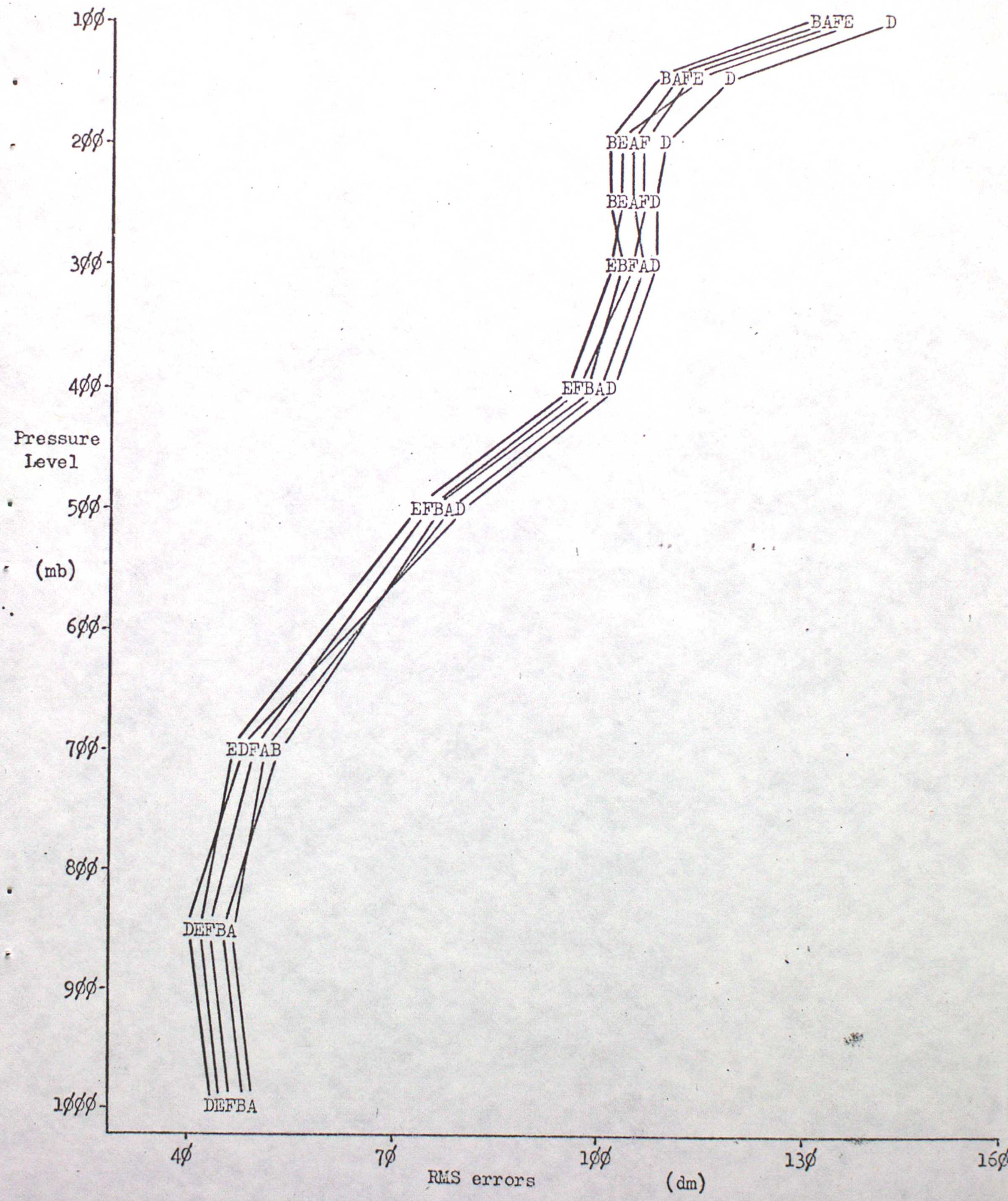


Fig X   Vertical Structure of Temperature Forecast Errors for 12GMT 3/3/79

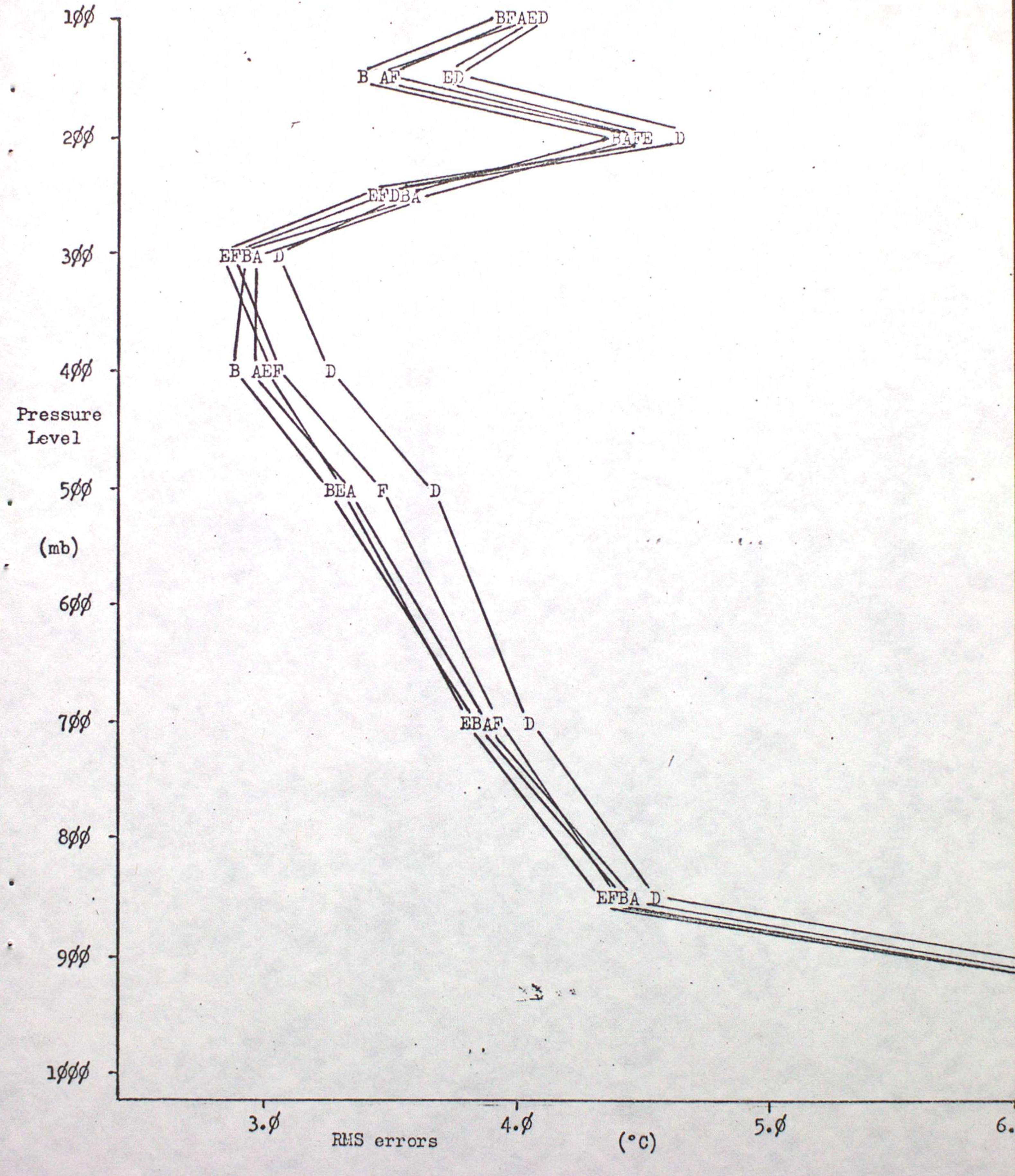
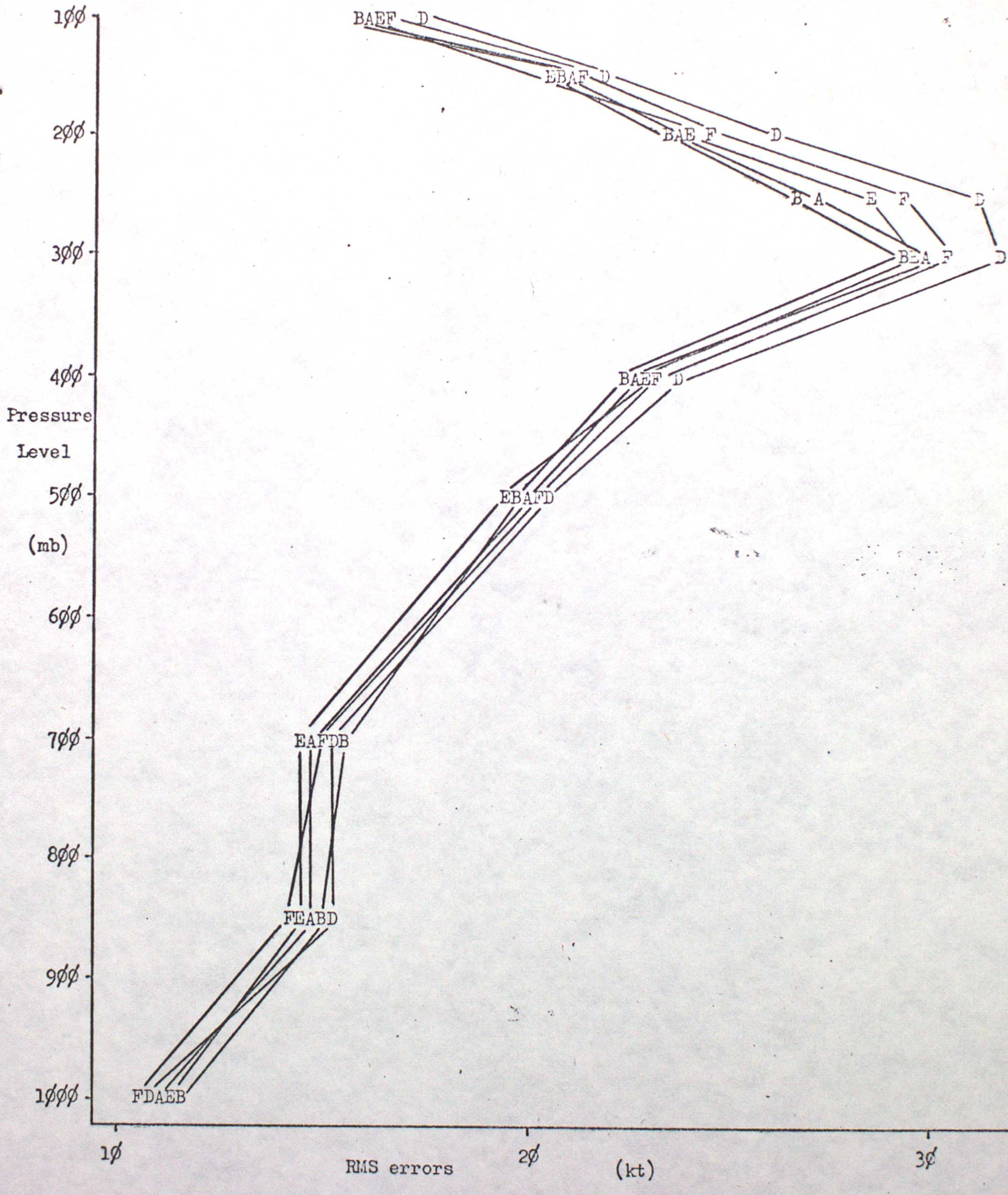


Fig XI Vertical Structure of Wind Speed Forecast Errors for 12GMT 3/3/79



These statistics and the graphs of their vertical structure indicate the following ratings over most of the atmosphere :

Height Forecast Rating : B, E, A/F, D

Temperature Forecast Rating : B, A, E/F, D

Wind Speed Forecast Rating : B, A/E, F, D

Again, although the differences are small, these ratings are consistent with each other, and with that of the subjective comparison of N.hemisphere PMSL forecasts. They are also in very good agreement with the analysis ratings. The evidence therefore supports the conclusion that, in this case, the 72-hour forecasts of experiment B are more accurate than those of the FGGE scheme, whereas those of experiment D are worse. It should be noted that the forecasts of experiment E are equally as good as those of the FGGE scheme despite using slightly earlier data, since its 12GMT assimilation did not use 1330-1500GMT data used by the other schemes.

5. Summary

A number of experiments were run to assess several modifications to the FGGE data assimilation scheme. Although differences are small, comparison of the analyses and 72-hour forecasts of the various schemes suggests that :

(i) There was an improvement in the accuracy of the analysis and forecast of the FGGE scheme when the data was assimilated for 6 hours ahead of the relevant synoptic hour with the scaling parameter increasing linearly from zero, to 0.5 at the synoptic hour.

(ii) The accuracy of the analysis and forecast was decreased when the radius of influence around grid points was reduced from 660 to 220km.

(iii) Using the FGGE observing system, there was no advantage in reducing the assimilation cycle from 6 to 3 hours, except that a forecast of comparable accuracy to that of the FGGE scheme was produced using slightly earlier data.

6. Charts

The following charts are numbered 'X.Y', where the appropriate legends are given by the keys below.

Table 11 Chart Legend Keys

X	Legend
1	Initial Analysis 16GMT 27/2/79
2	FGGE Analysis 12GMT 28/2/79
3	ExpB Analysis 12GMT 28/2/79
4	ExpD Analysis 12GMT 28/2/79
5	FGGE Analysis 12GMT 3/3/79
6	FGGE 72-hr Forecast 12GMT 3/3/79
7	ExpB 72-hr Forecast 12GMT 3/3/79
8	ExpD 72-hr Forecast 12GMT 3/3/79

Y	Legend
1	PMSL Northern Hemisphere
2	PMSL Southern Hemisphere
3	250mb heights Northern Hemisphere
4	250mb heights Southern Hemisphere

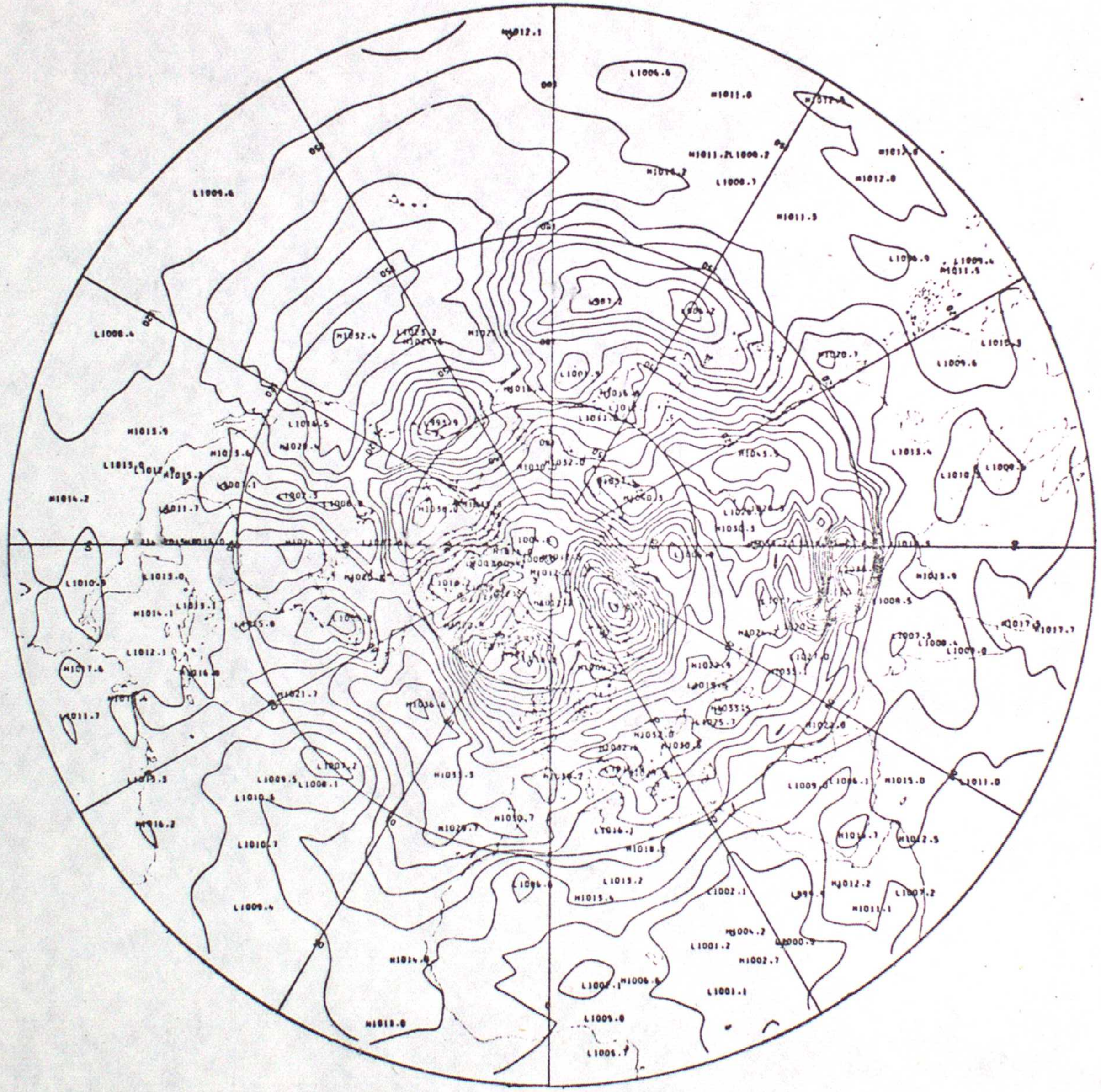


Chart 1.1
Initial PMSL N.hemisphere
Analysis 16GMT 27/2/79
Isobars at 4mb intervals

Chart 2.1
FGGE PMSL N.hemisphere
Analysis 12GMT 28/2/79
Isobars at 4mb intervals

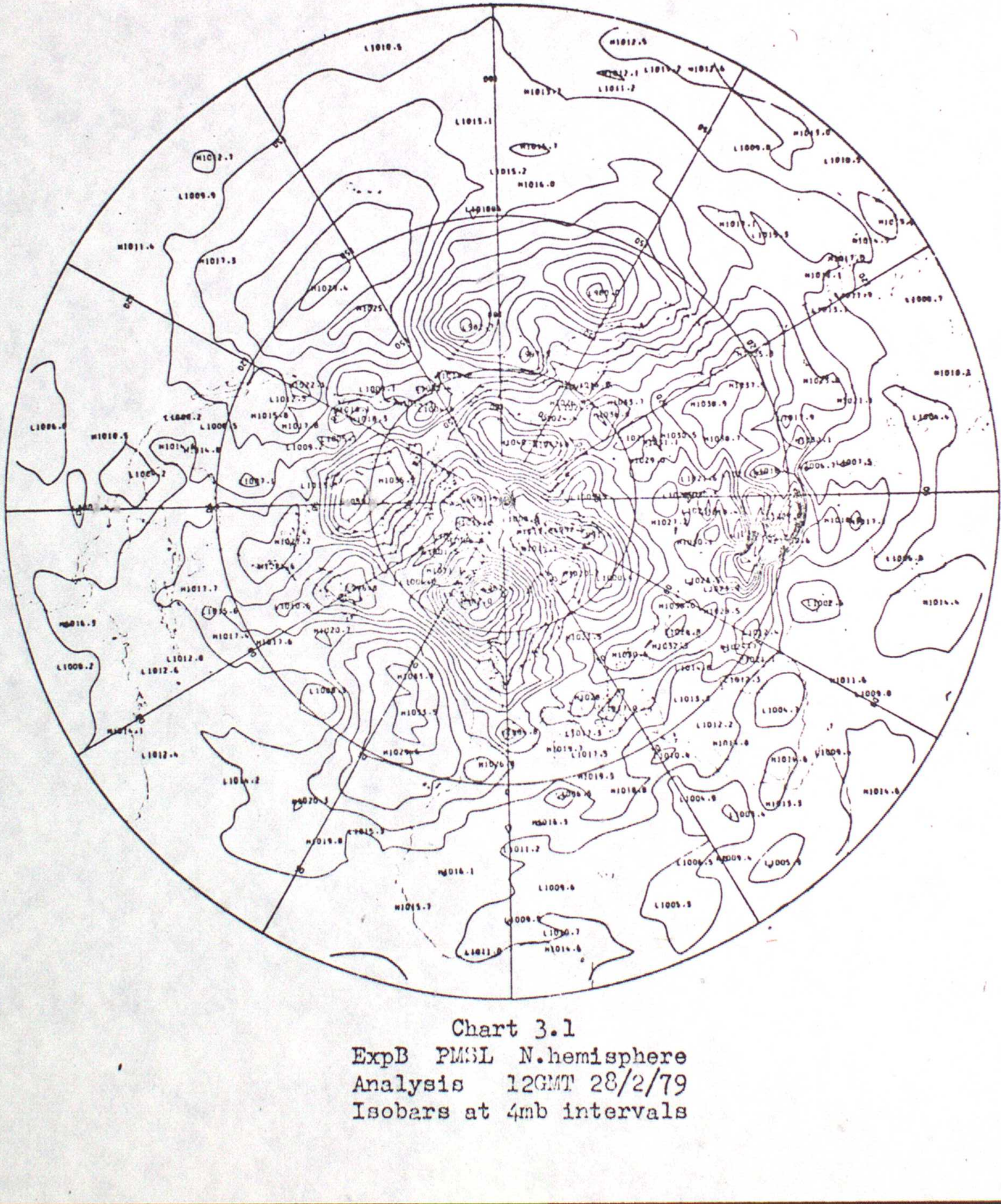


Chart 3.1
ExpB PMSL N.hemisphere
Analysis 12GMT 28/2/79
Isobars at 4mb intervals

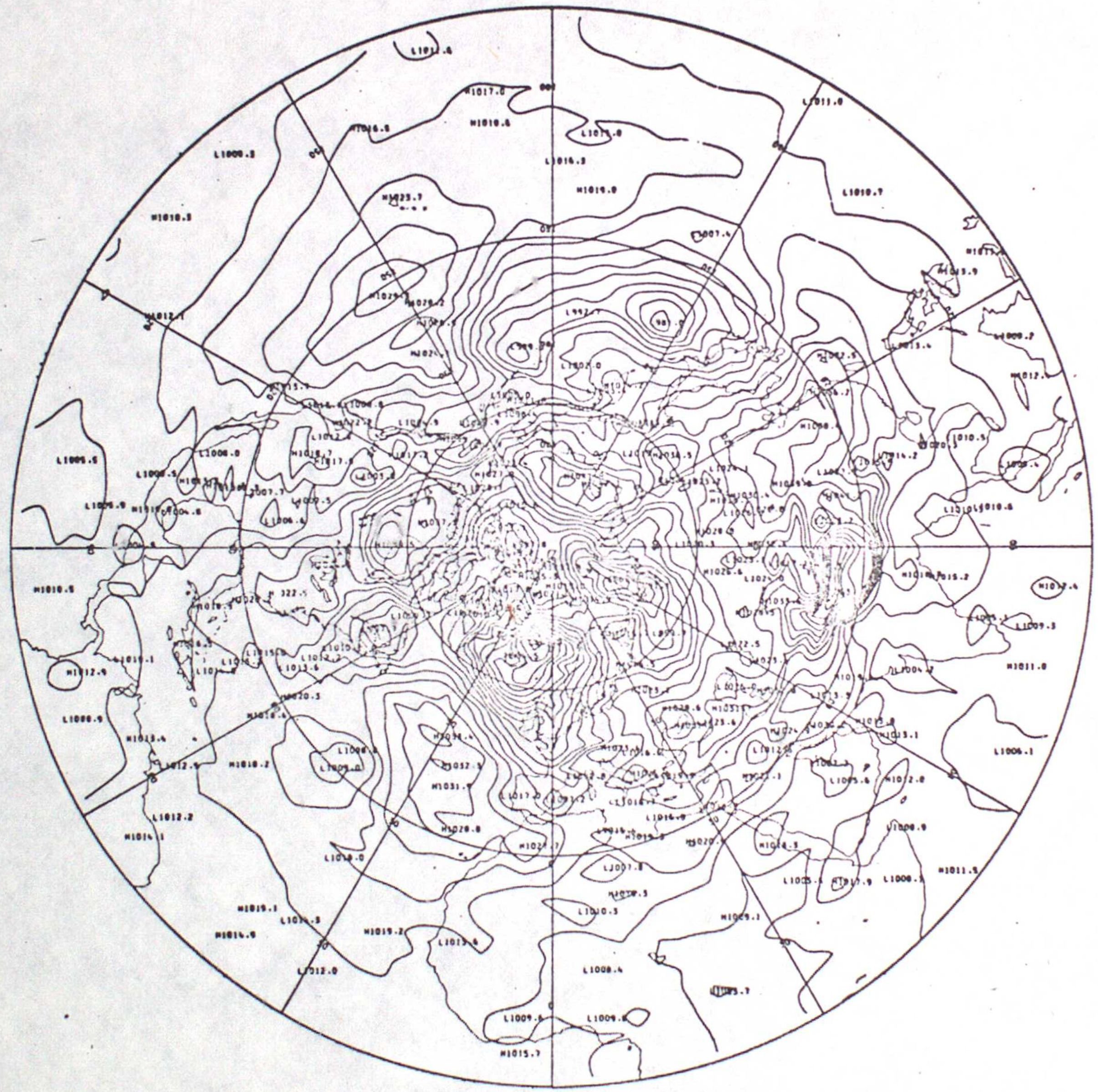


Chart 4.1
ExpD PMSL N.hemisphere
Analysis 12GMT 28/2/79
Isobars at 4mb intervals

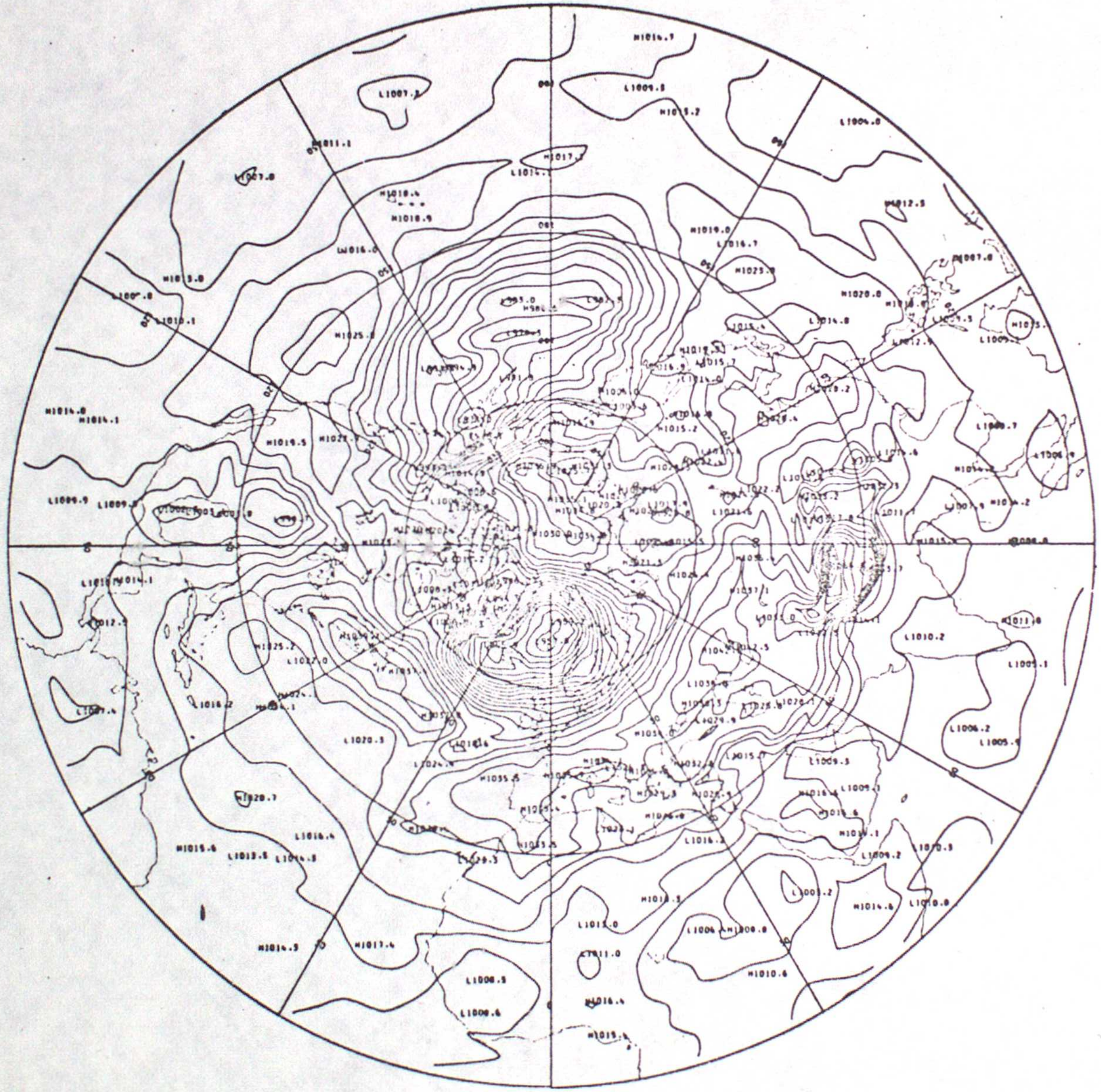


Chart 5.1
FGGE PMSL N.hemisphere
Analysis 12GMT 3/3/79
Isobars at 4mb intervals

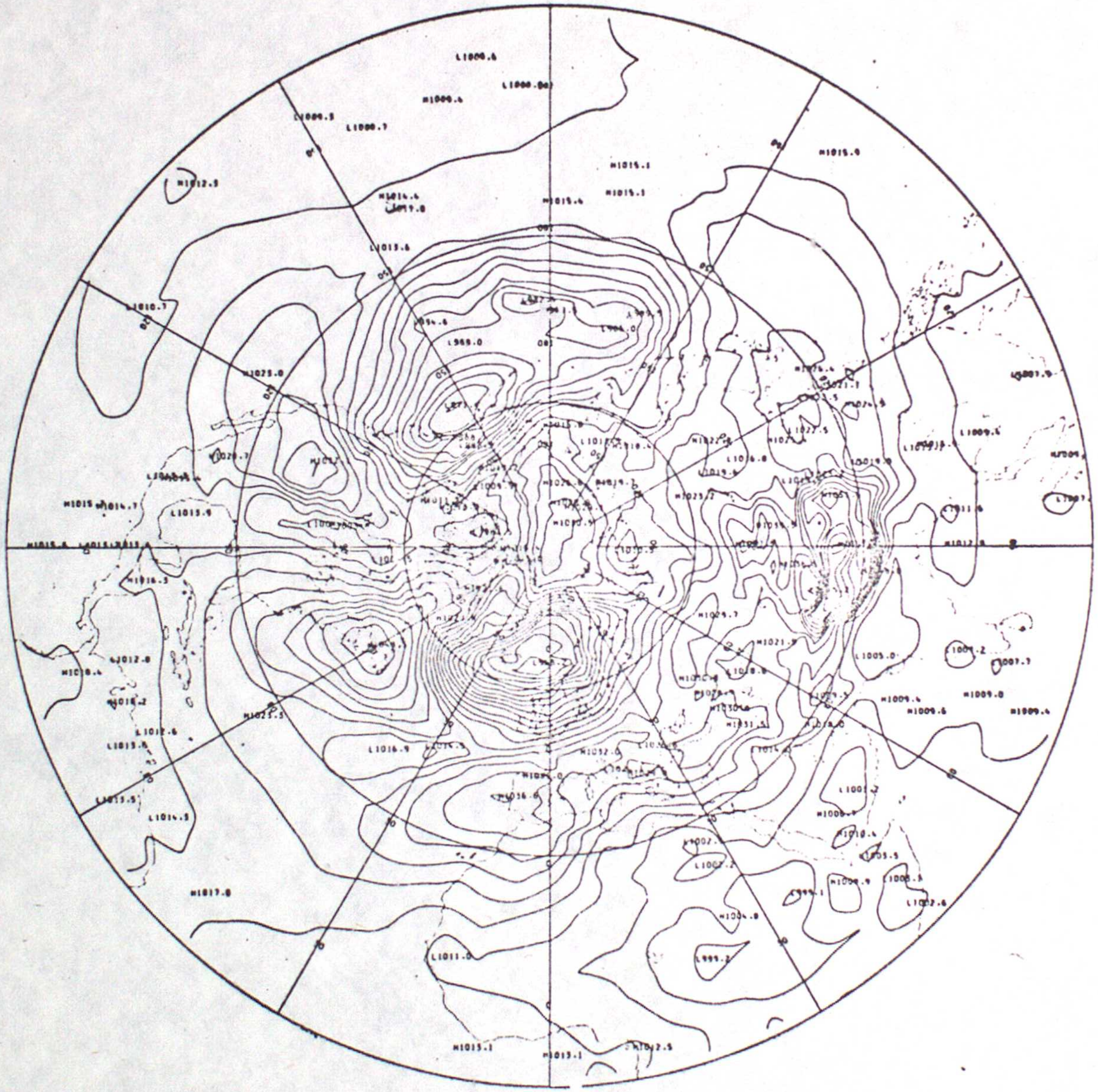


Chart 6.1
FGGE PMSL N.hemisphere
72hr forecast 12GMT 3/3/79
Isobars at 4mb intervals

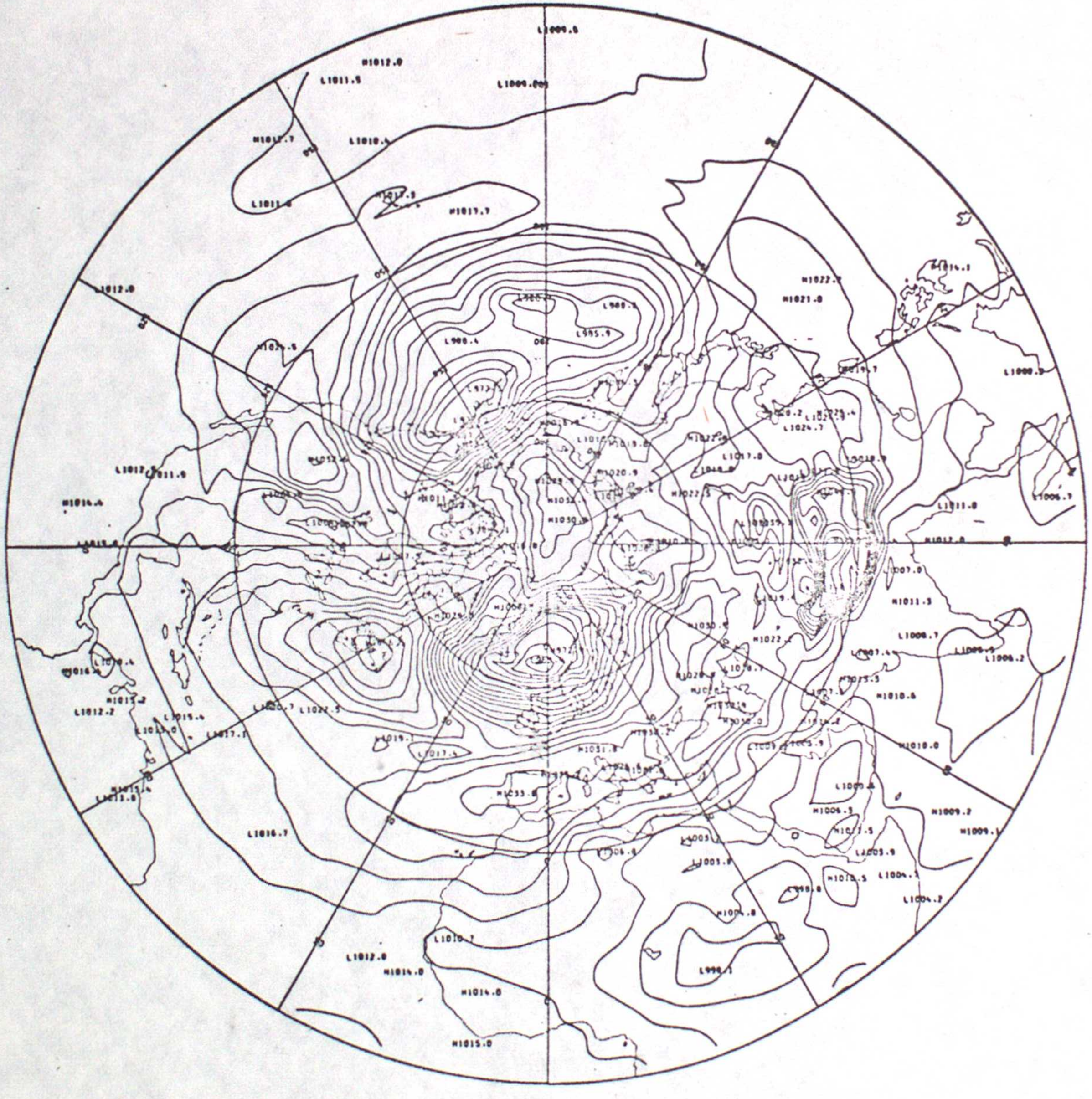


Chart 7.1
ExpB PMSL N.hemisphere
72hr forecast 12GMT 3/3/79
Isobars at 4mb intervals

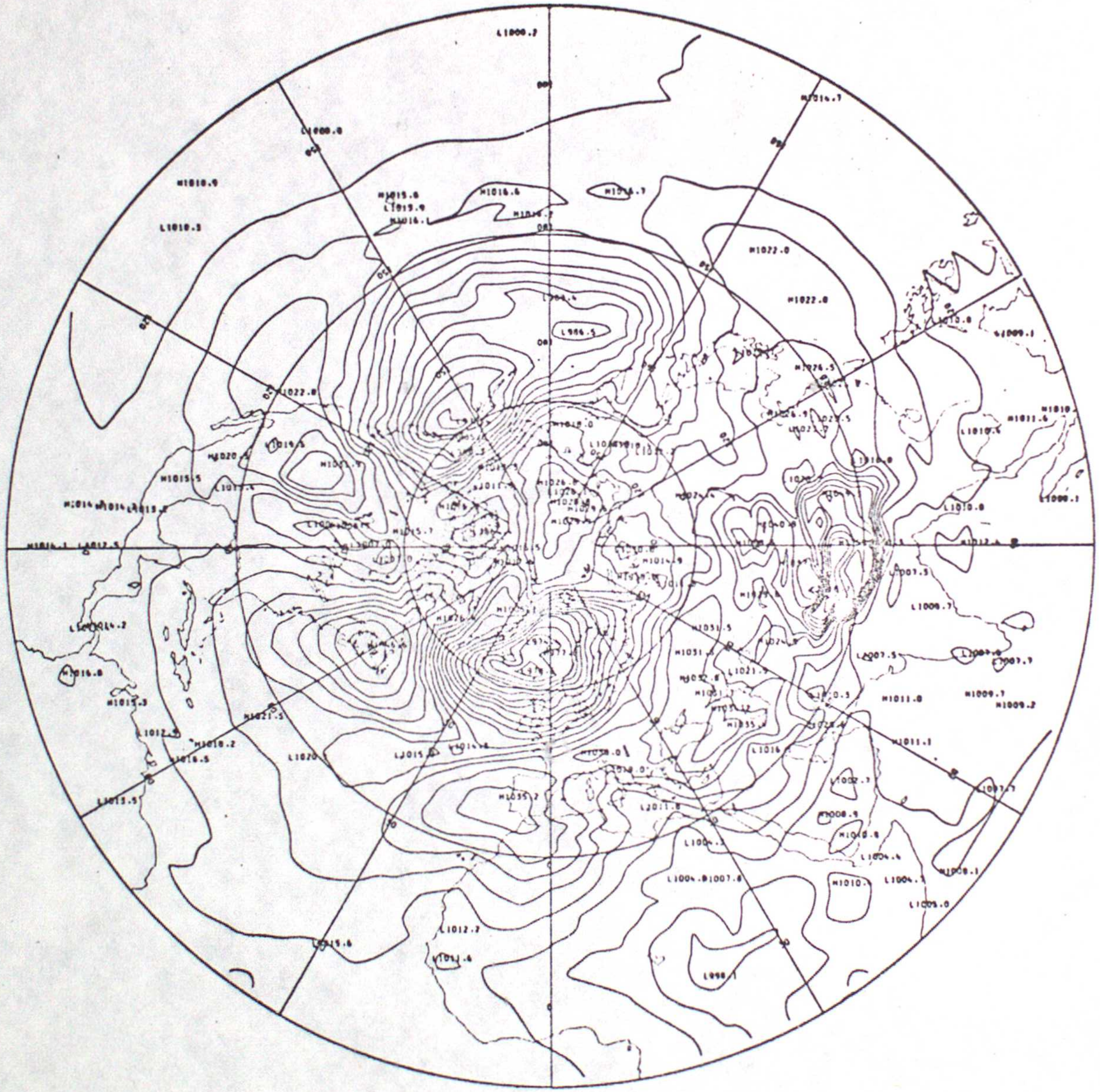


Chart 8.1
ExpD PMSL N.hemisphere
72hr forecast 12GMT 3/3/79
Isobars at 4mb intervals

Chart 1.2
Initial PMSL S.hemisphere
Analysis 16GMT 27/2/79
Isobars at 4mb intervals

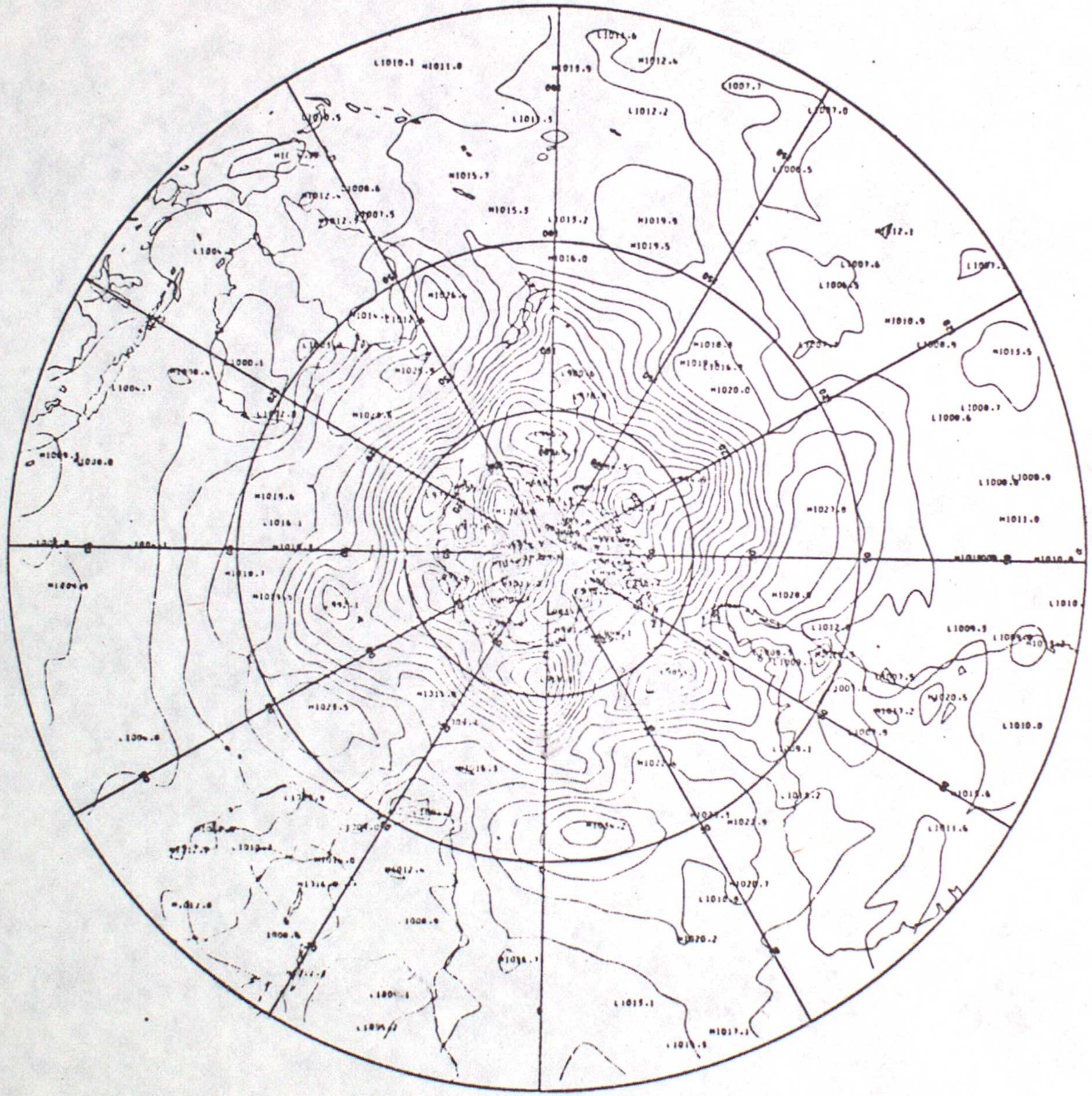


Chart 2.2
FGGE PMSL S.hemisphere
Analysis 12GMT 28/2/79
Isobars at 4mb intervals

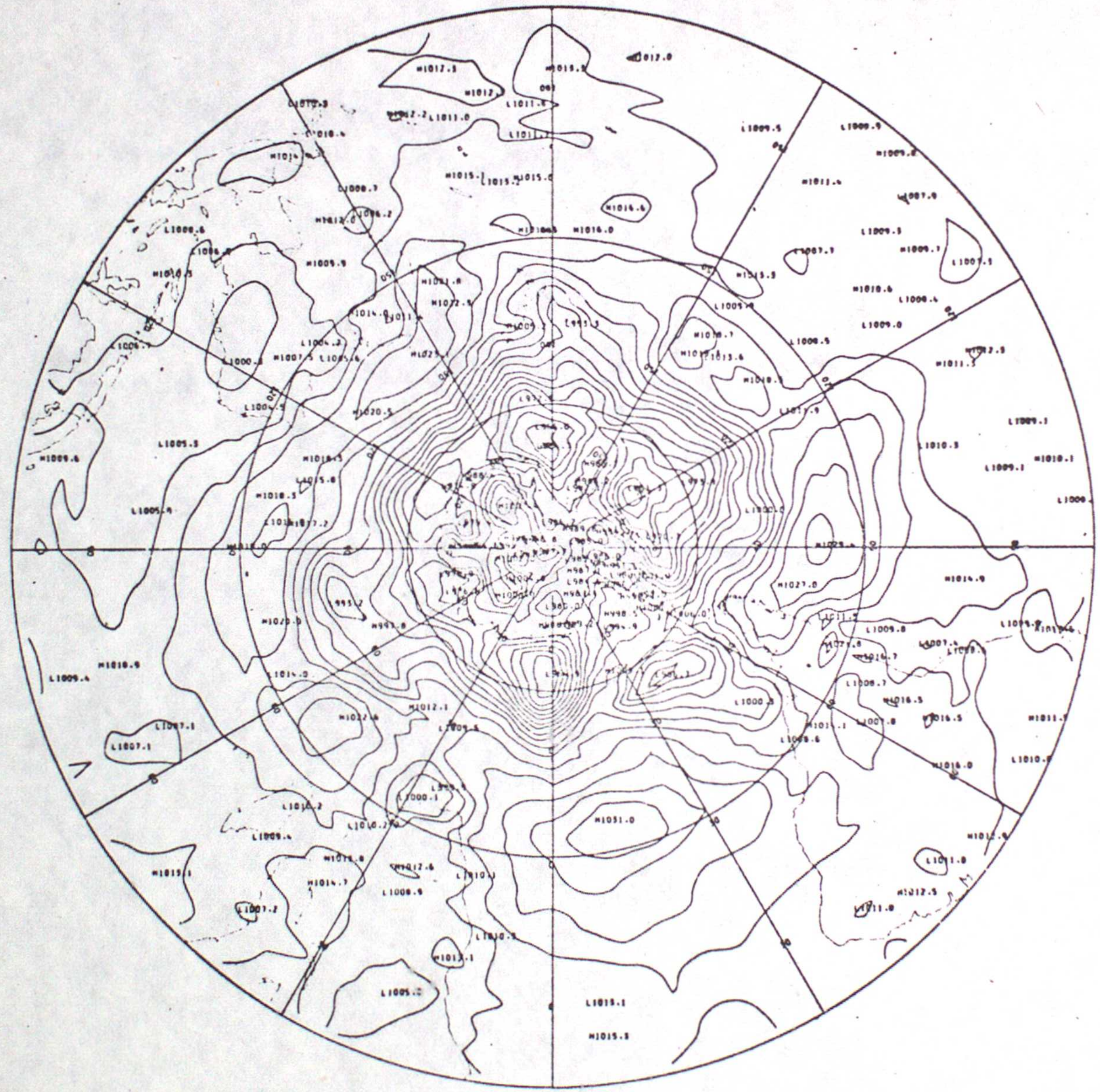


Chart 3.2
ExpB PMSL S.hemisphere
Analysis 12GMT 28/2/79
Isobars at 4mb intervals

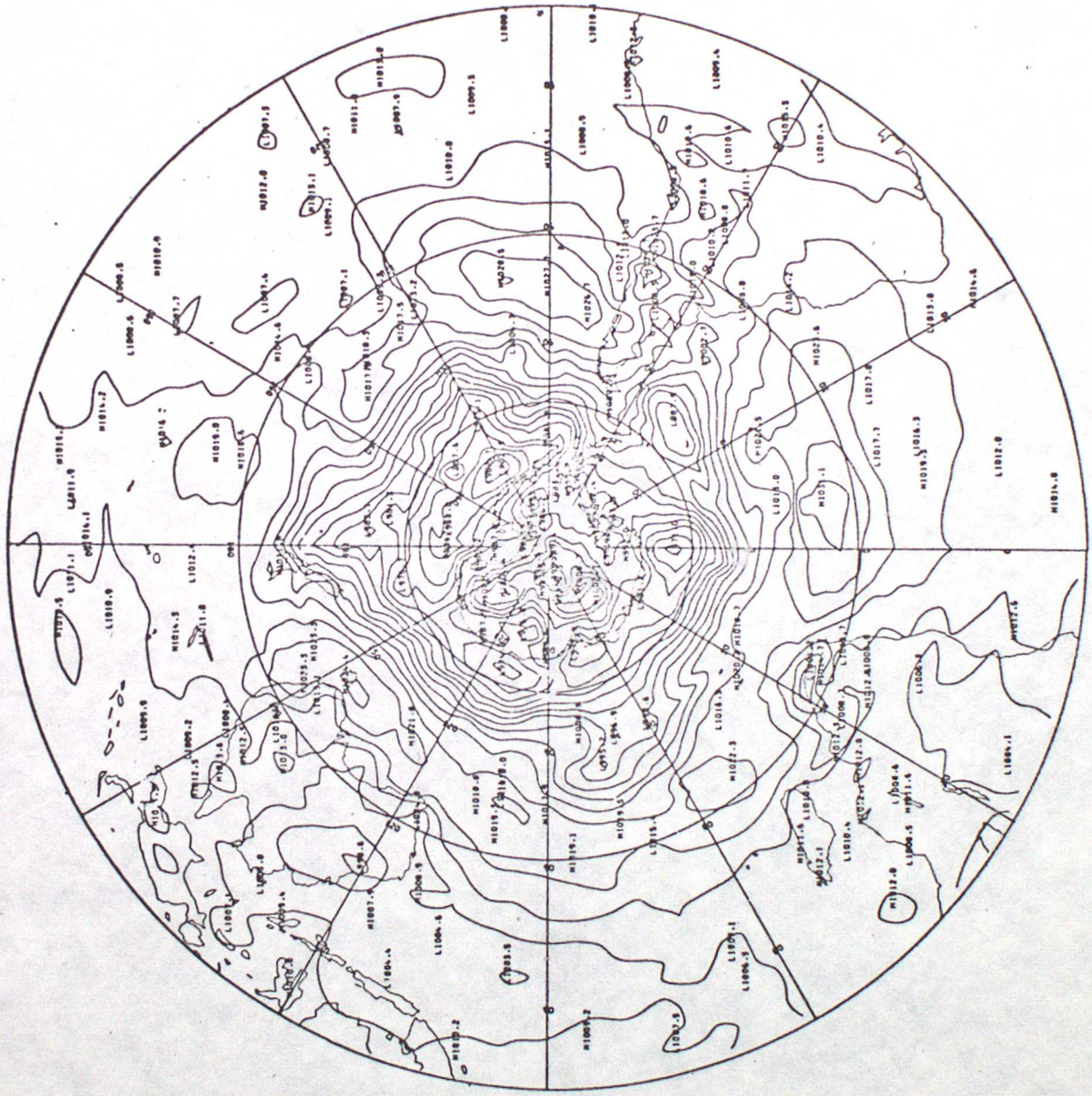


Chart 4.2
ExpD PMSL S.hemisphere
Analysis 12GMT 28/2/79
Isobars at 4mb intervals

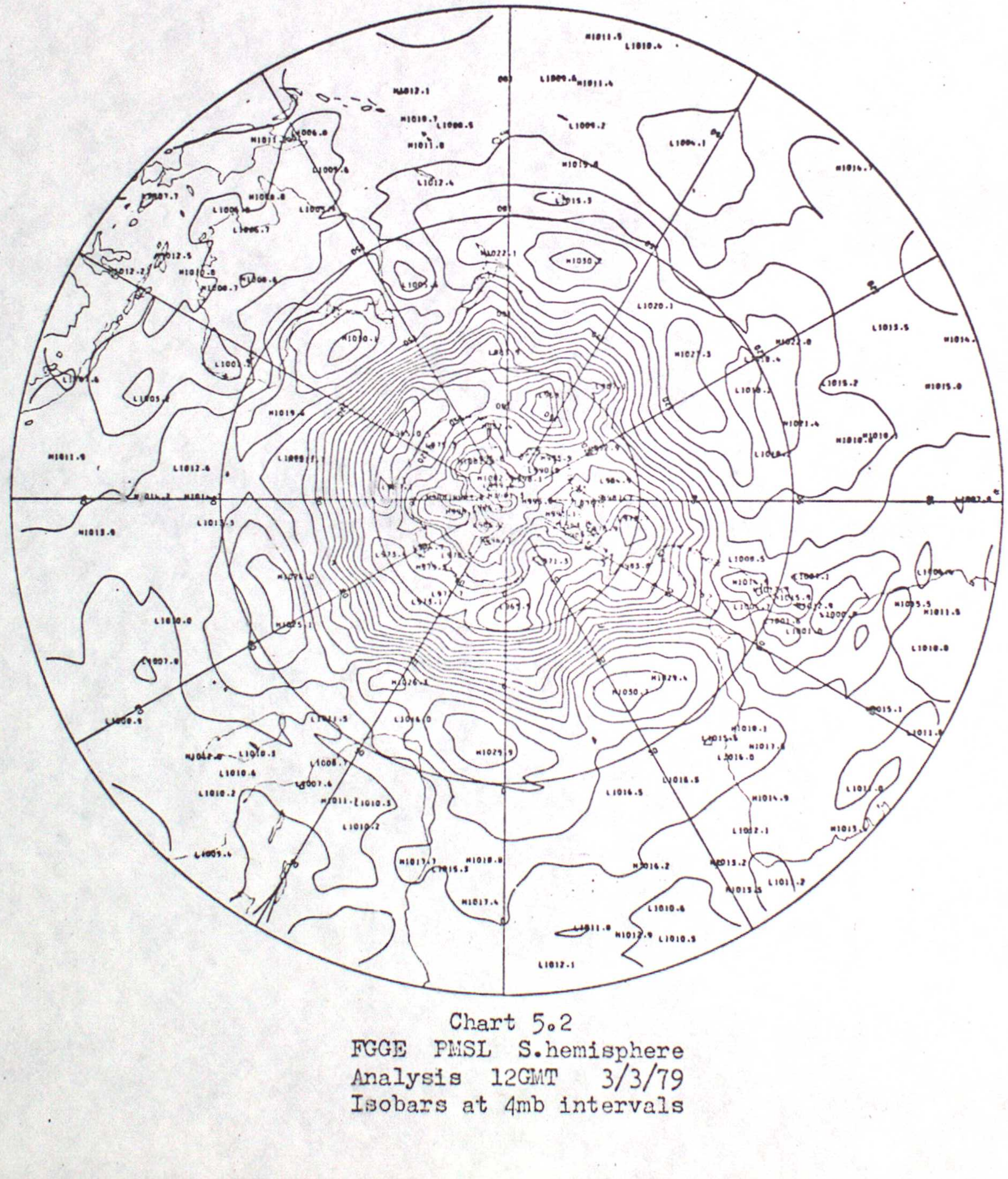


Chart 5.2
FGGE PMSL S.hemisphere
Analysis 12GMT 3/3/79
Isobars at 4mb intervals

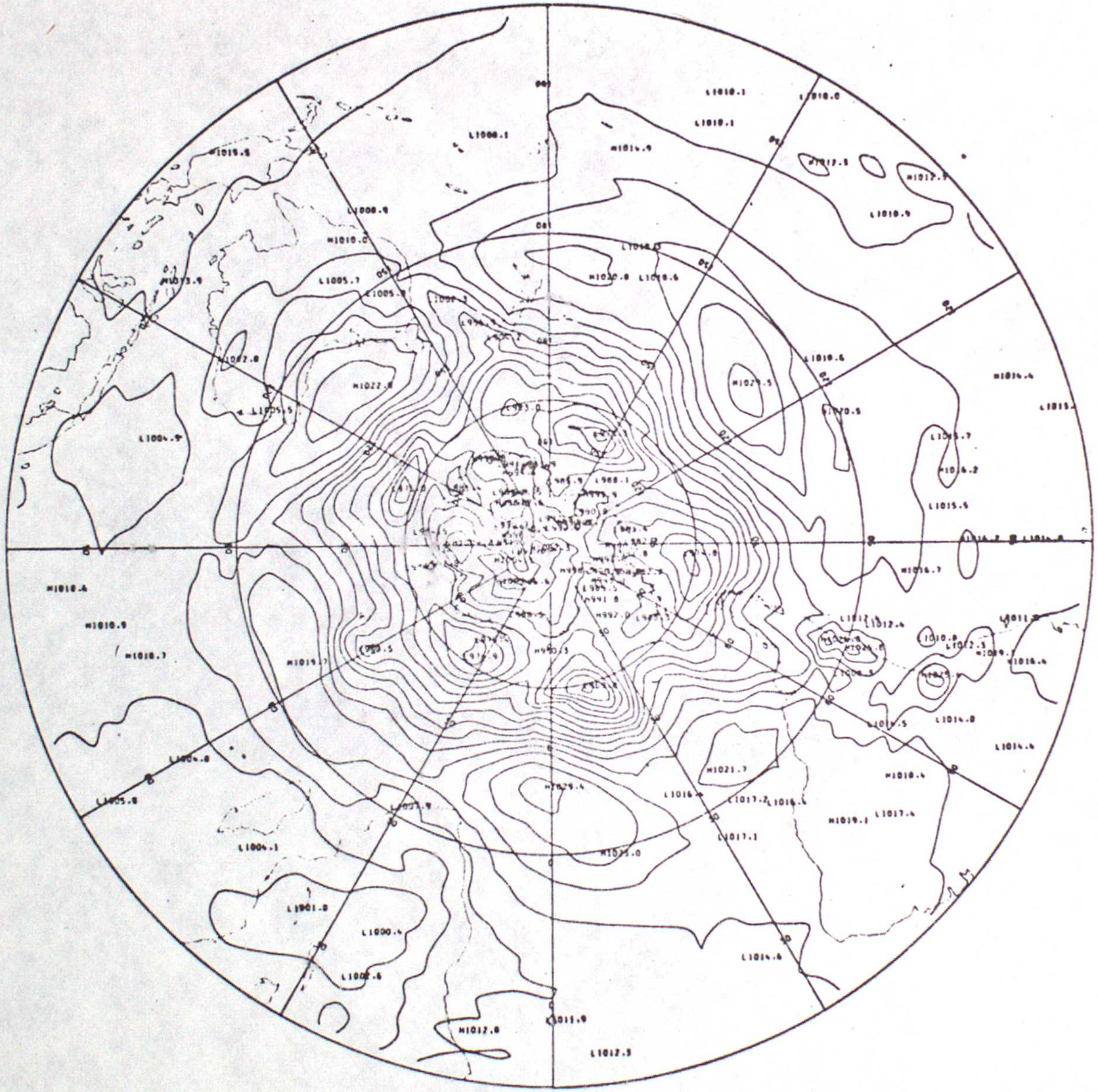


Chart 6.2
FGGE PMSL S.hemisphere
72hr forecast 12GMT 3/3/79
Isobars at 4mb intervals

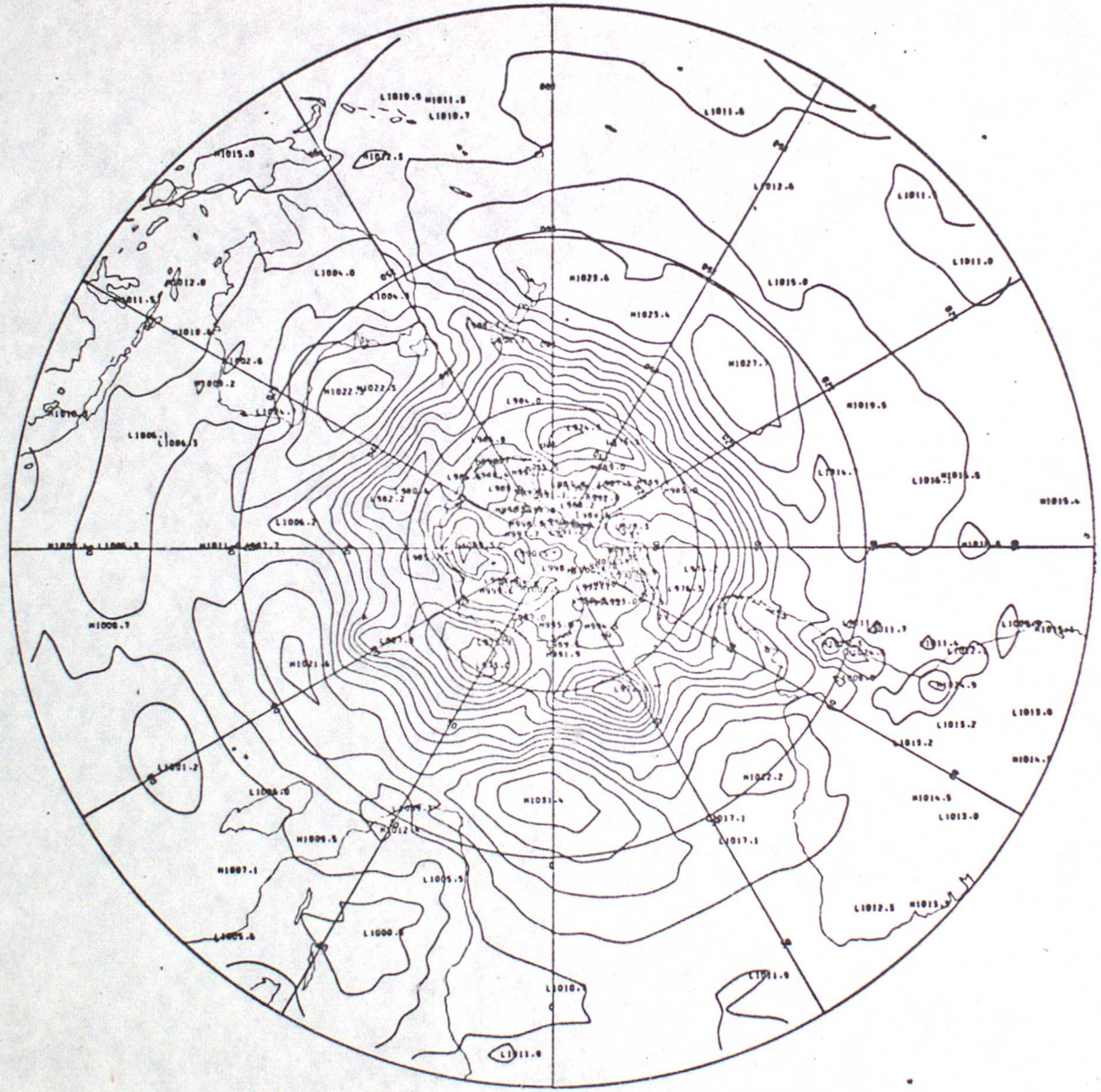


Chart 7.2
ExpB PMSL S.hemisphere
72hr forecast 12GMT 3/3/79
Isobars at 4mb intervals

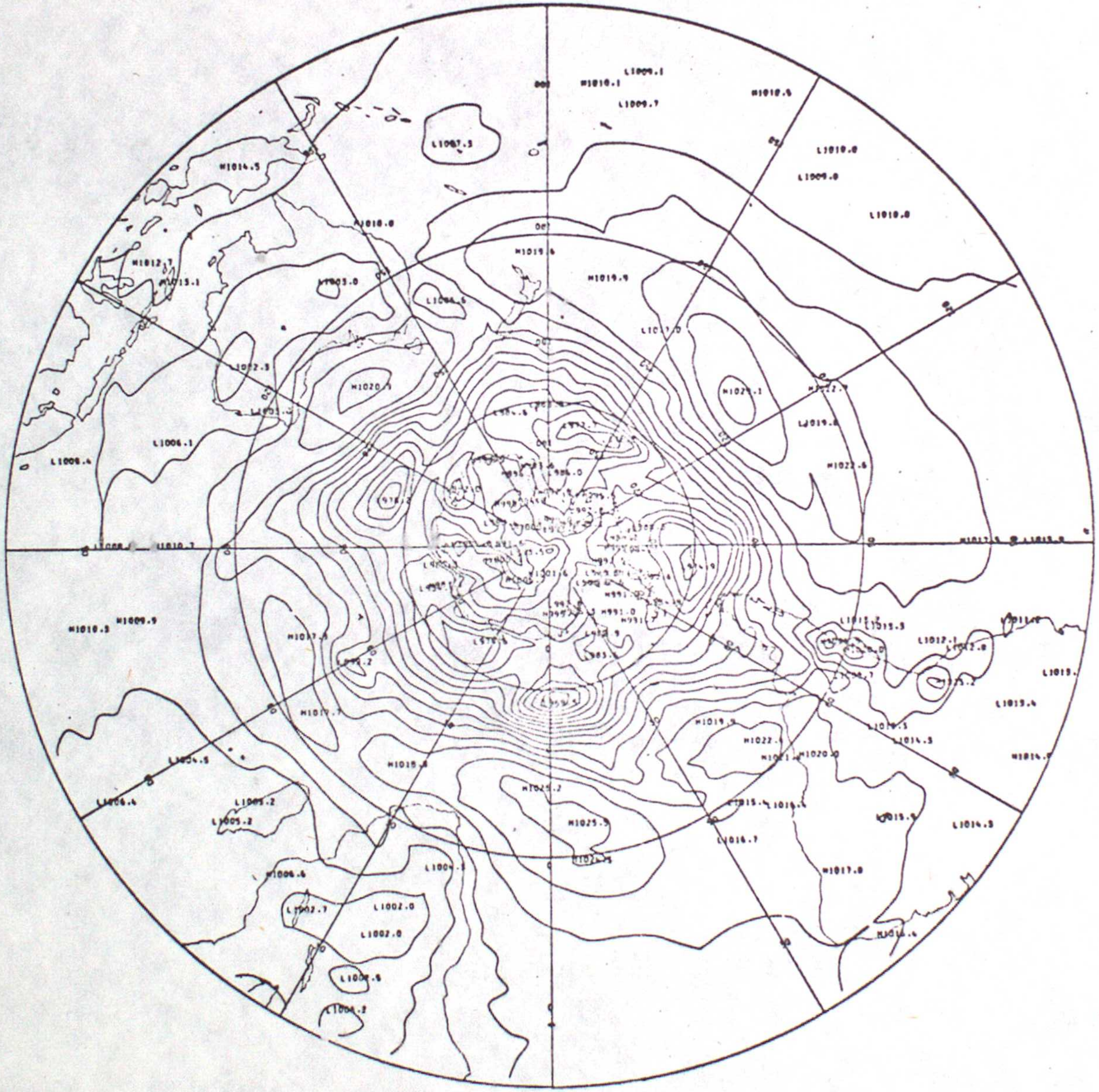


Chart 8.2
ExpD PMSL S.hemisphere
72hr forecast 12GMT 3/3/79
Isobars at 4mb intervals

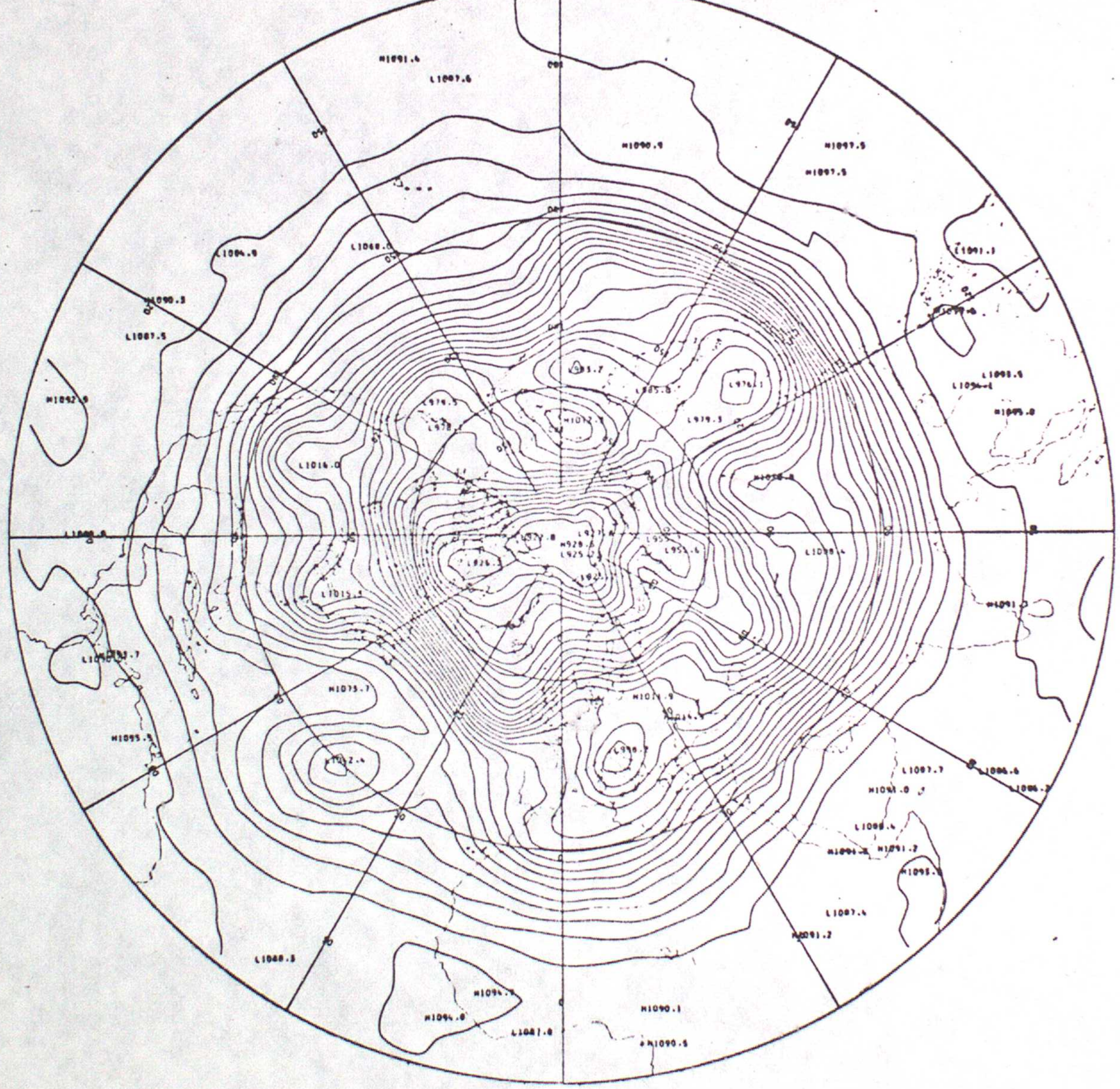


Chart 1.3
Initial 25Ømb heights N.hemisphere
Analysis 16GMT 27/2/79
Contours at 6dm intervals

Chart 2.3
FGGE 25Ømb heights N.hemisphere
Analysis 12GMT 28/2/79
Contours at 6ûm intervals

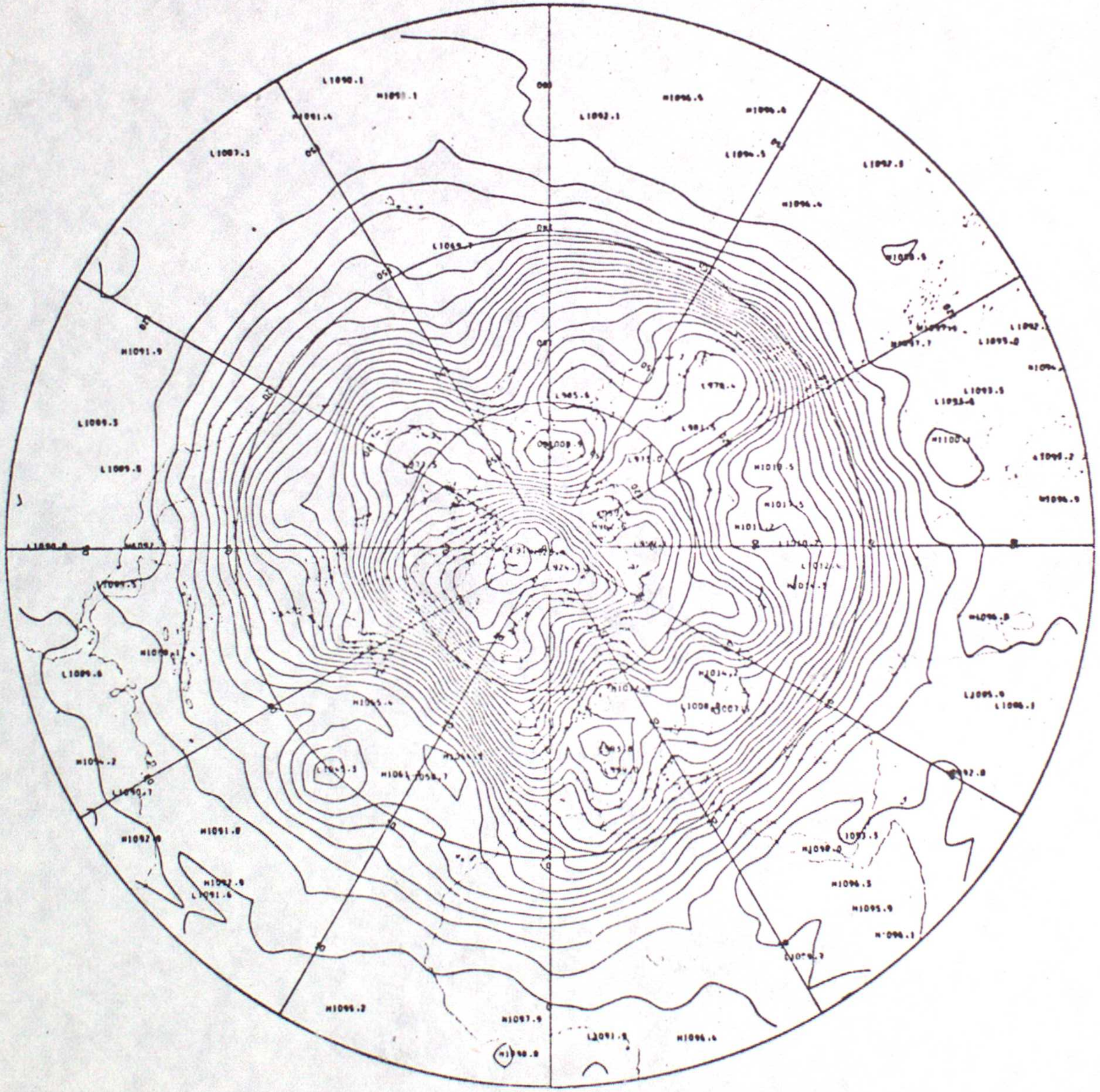


Chart 3.3
ExpB 25Ømb heights N.hemisphere
Analysis 12GMT 28/2/79
Contours at 6dm intervals

Chart 4.3
ExpD 25∅mb heights N.hemisphere
Analysis 12GMT 28/2/79
Contours at 6dm intervals

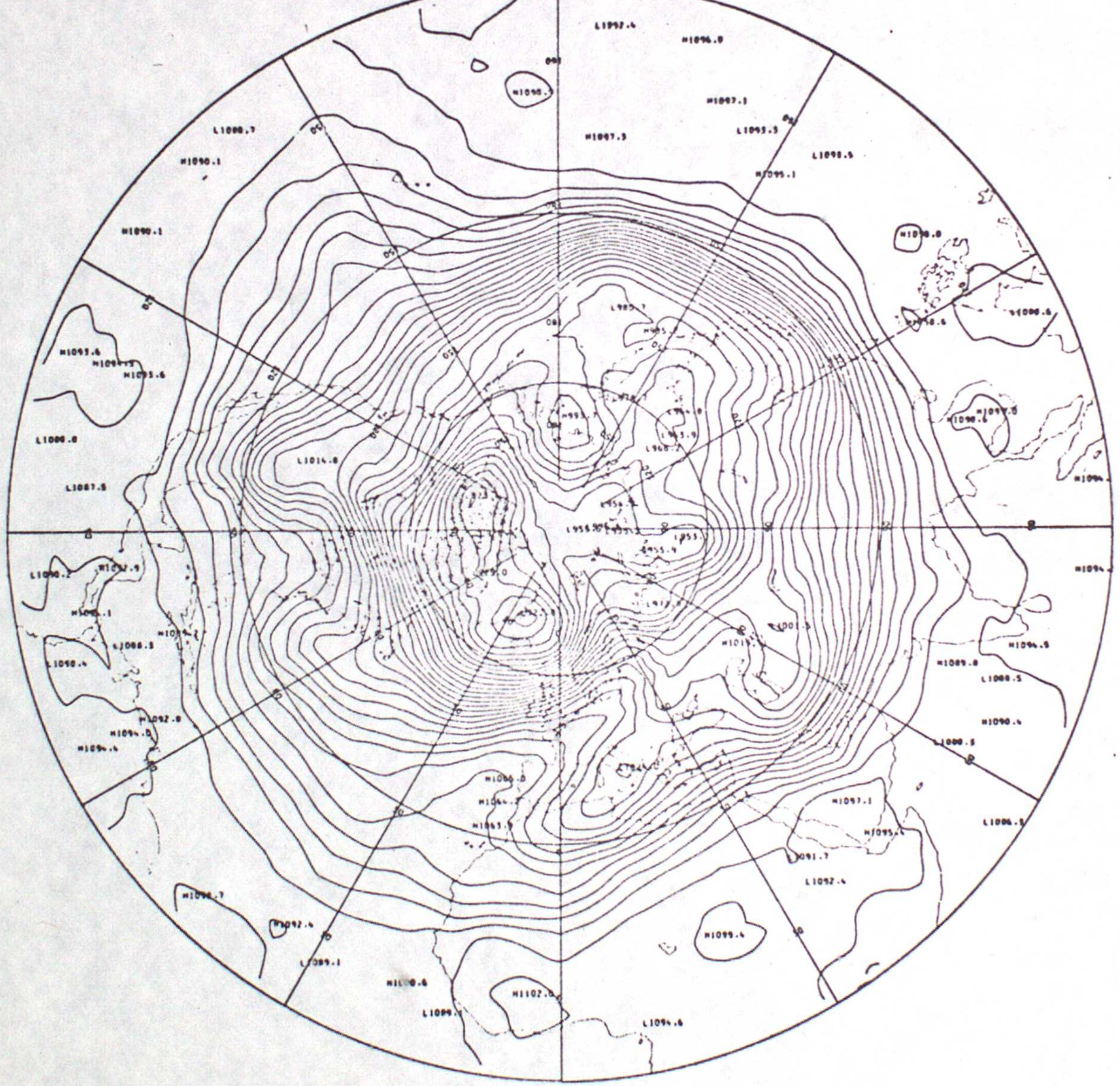


Chart 5.3
FGGE 250mb heights N.hemisphere
Analysis 12GMT 3/3/79
Contours at 6dm intervals

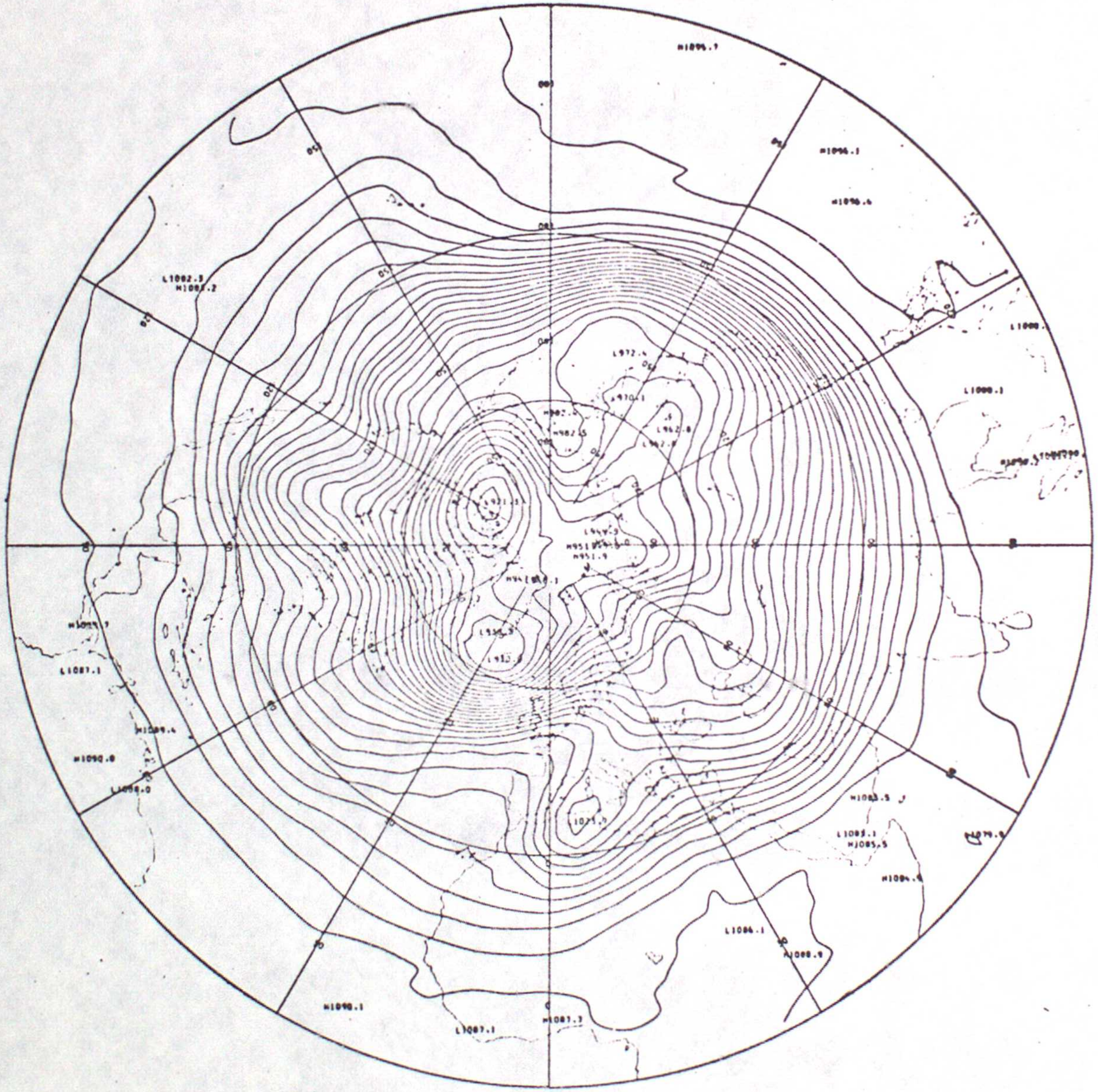


Chart 6.3
FGGE 25∅mb heights N.hemisphere
72hr forecast 12GMT 3/3/79
Contours at 6dm intervals

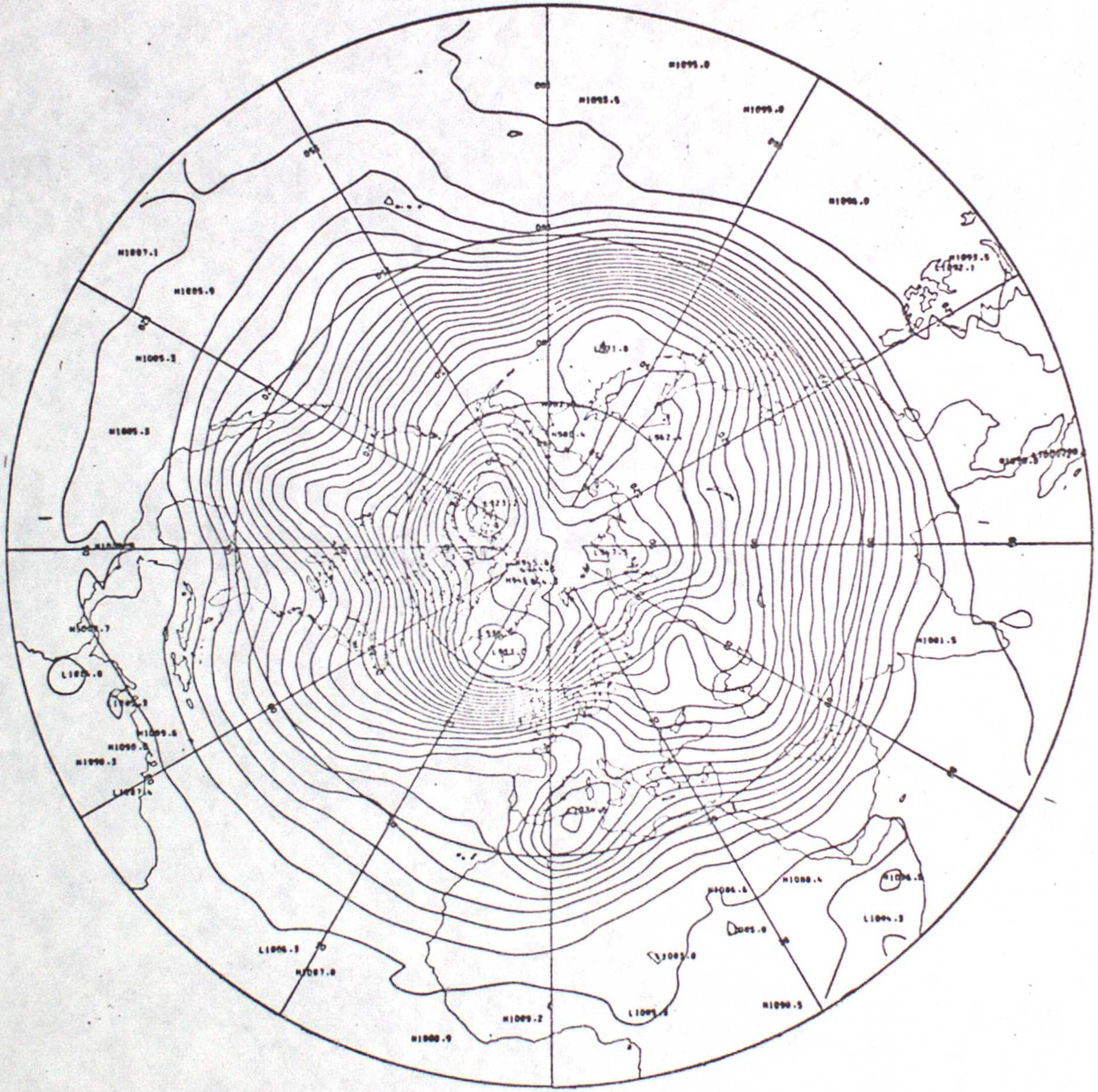


Chart 7.3
ExpB 25∅mb heights N.hemisphere
72hr forecast 12GMT 3/3/79
Contours at 6dm intervals

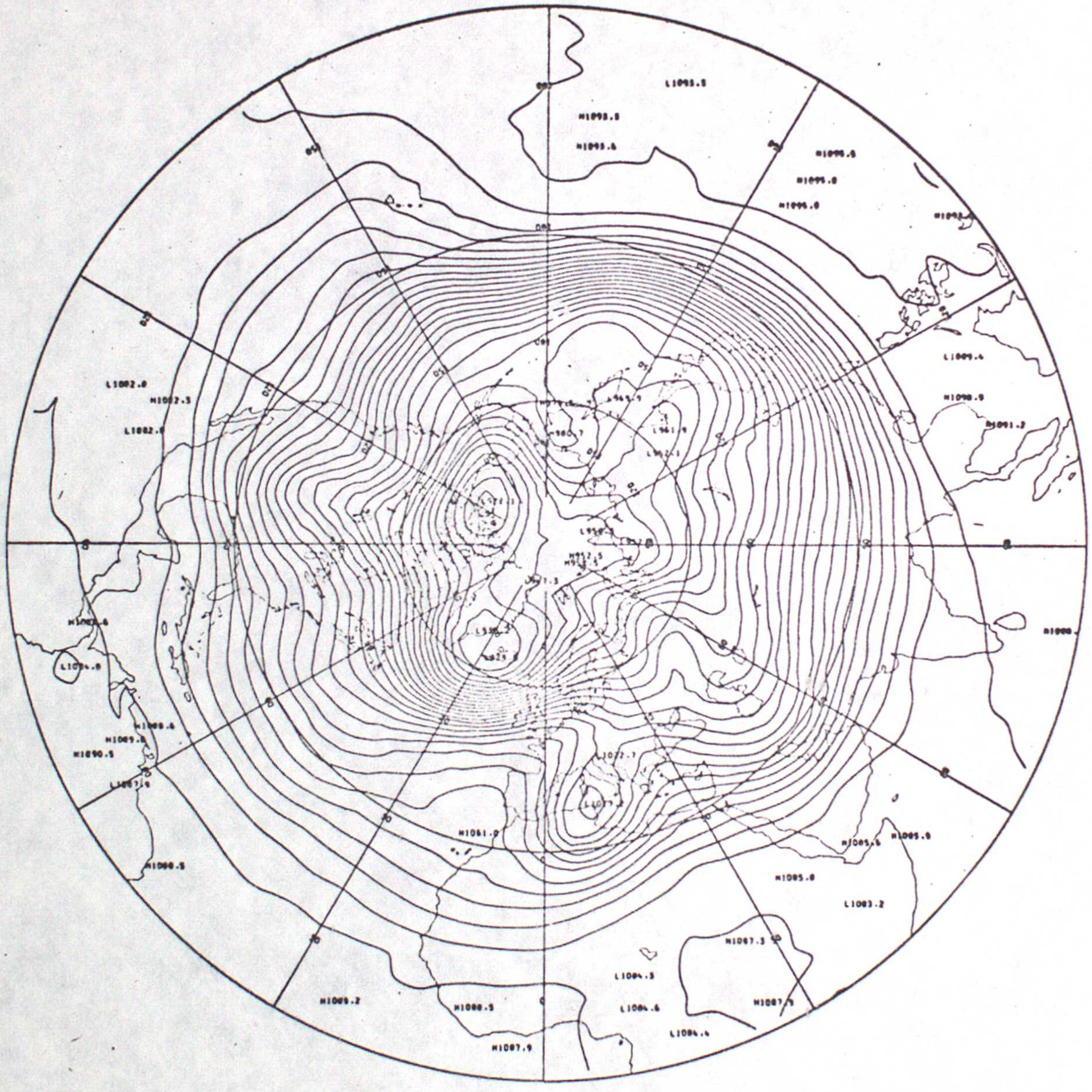


Chart 8.3
ExpD 25Ømb heights N.hemisphere
72hr forecast 12GMT 3/3/79
Contours at 6dm intervals

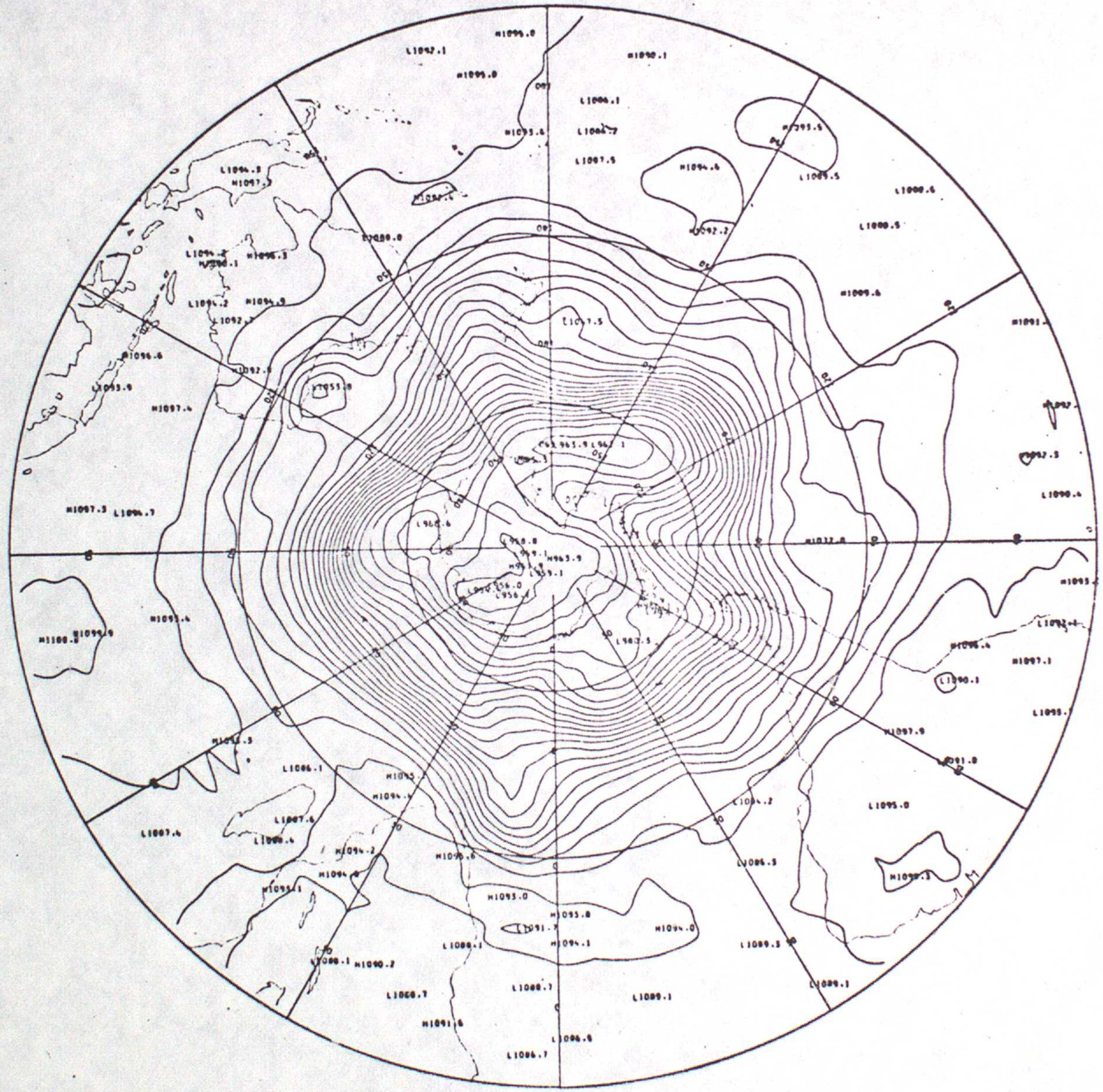


Chart 1.4
Initial 25∅mb heights S.hemisphere
Analysis 16GMT 27/2/79
Contours at 6dm intervals

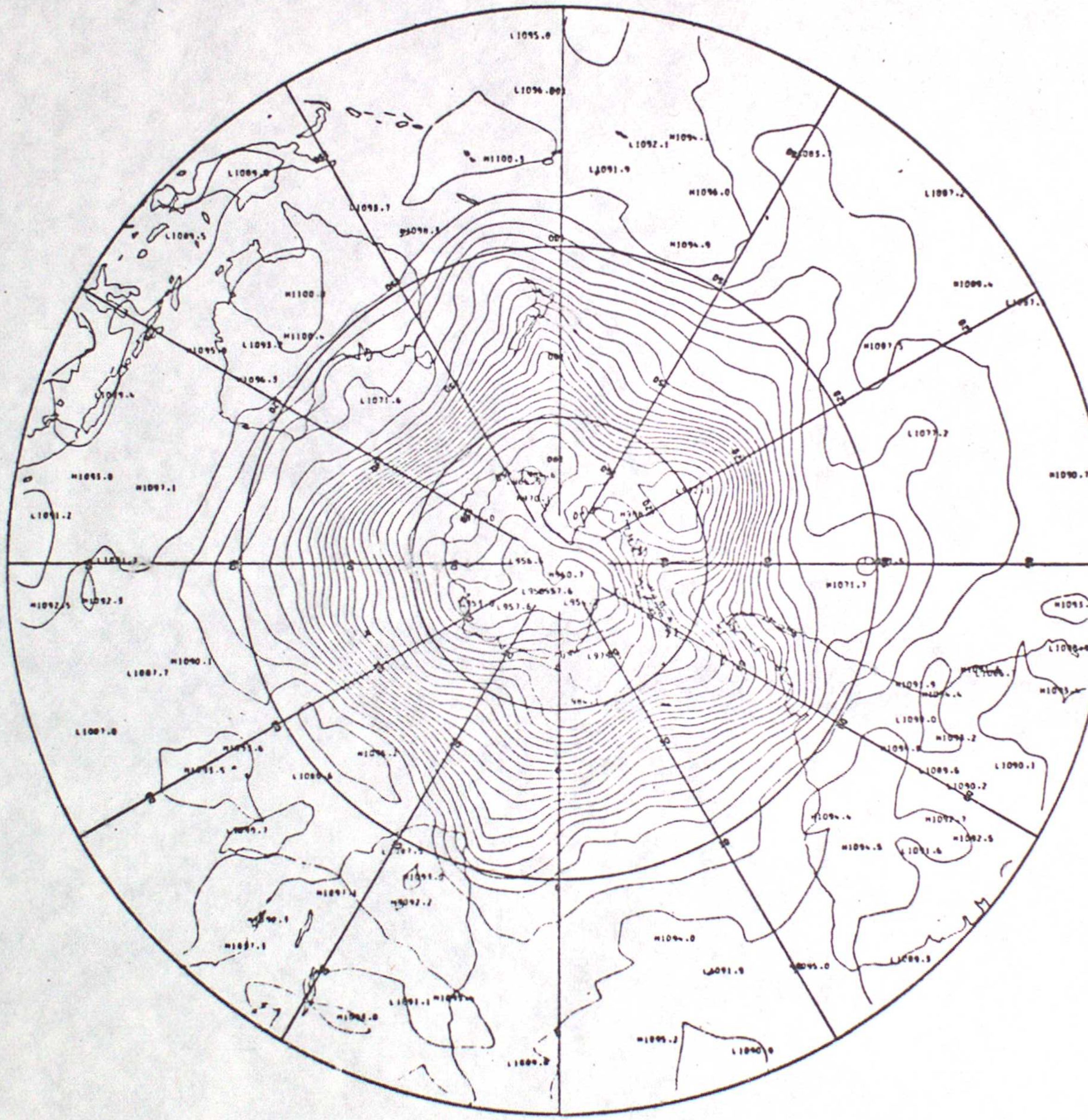


Chart 2.4
FGGE 25∅mb heights S.hemisphere
Analysis 12GMT 28/2/79
Contours at 6dm intervals

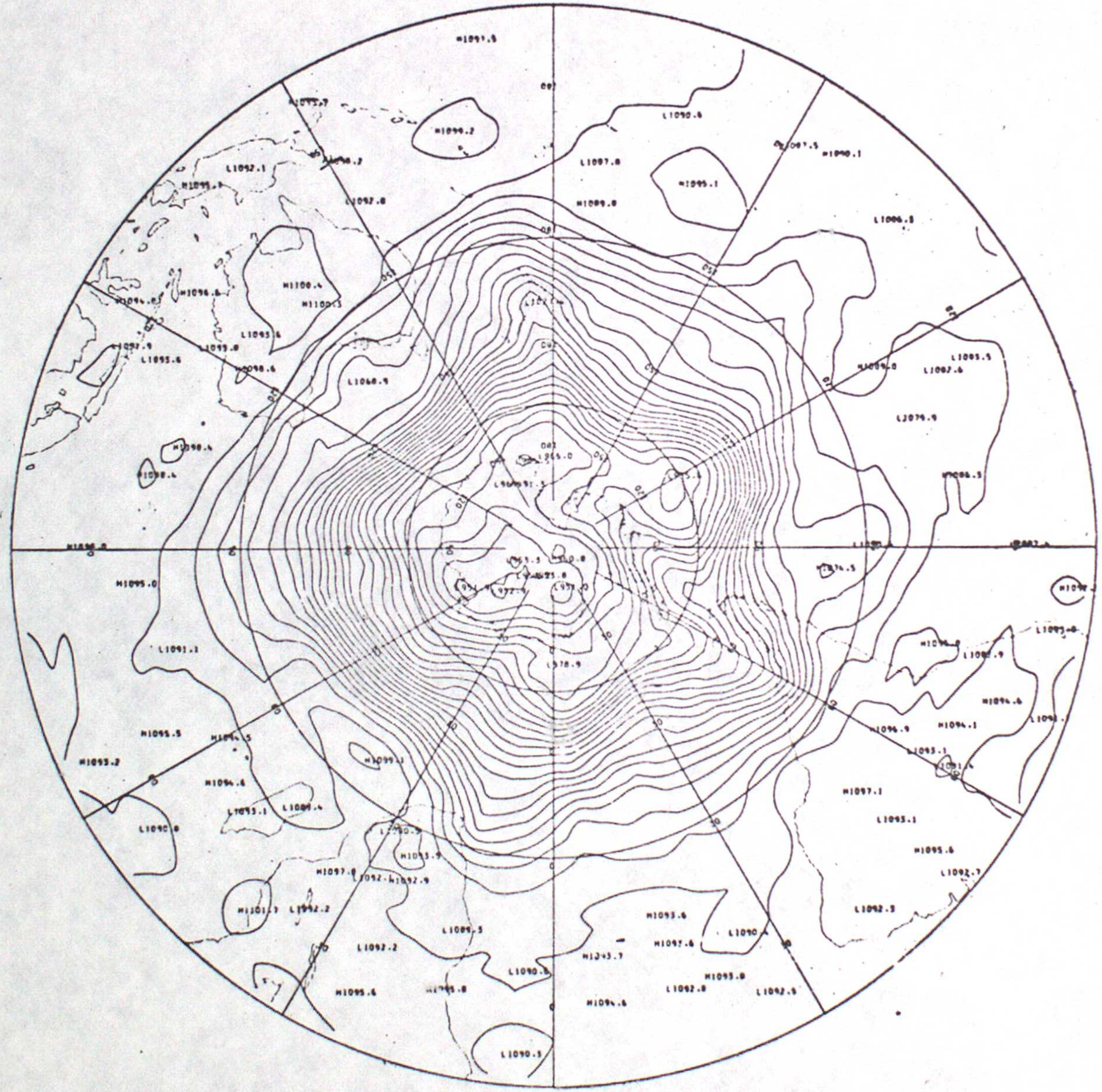


Chart 3.4
ExpB 25Ømb heights S.hemisphere
Analysis 12GMT 28/2/79
Contours at 6dm intervals

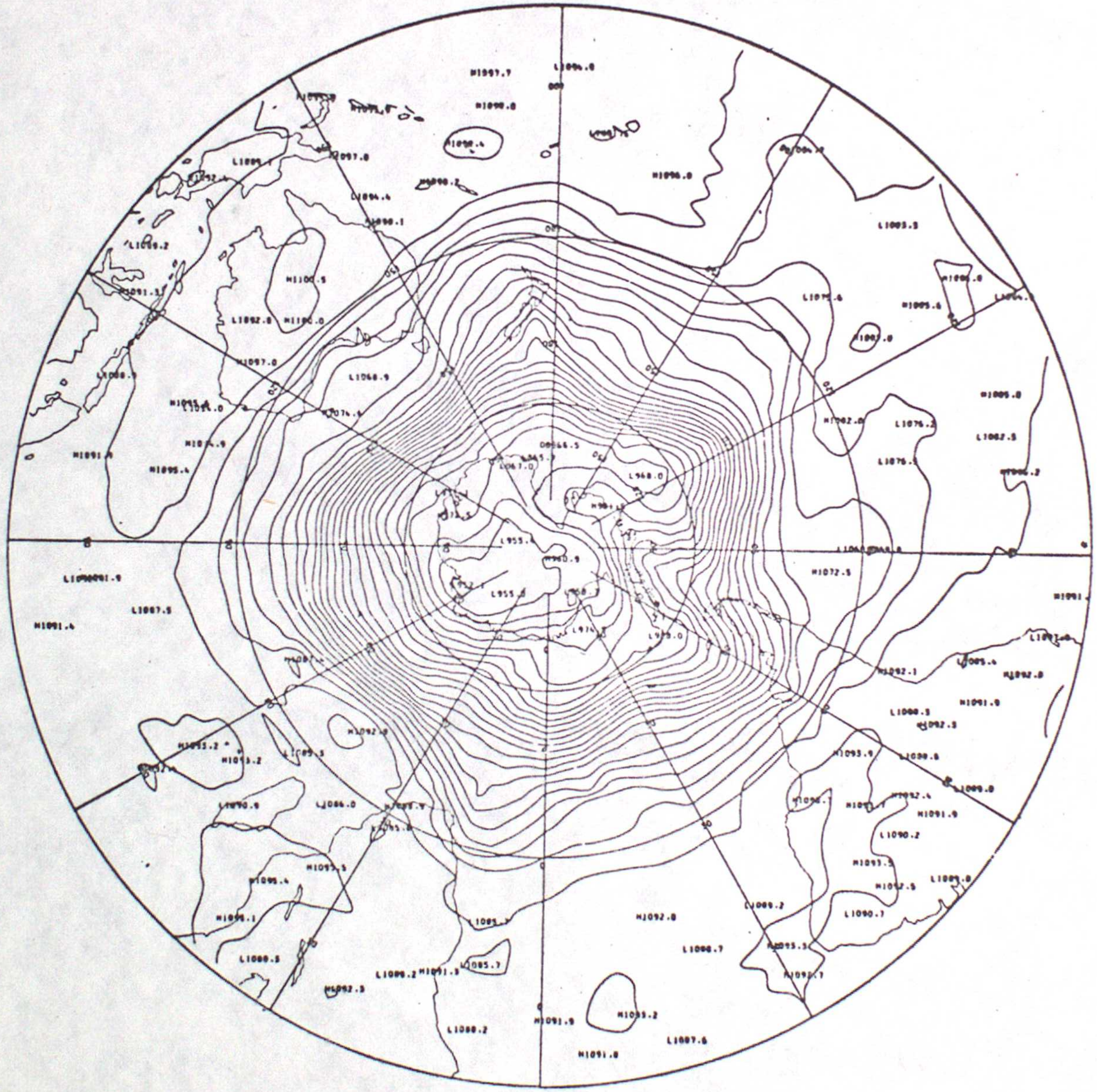


Chart 4.4
ExpD 25∅mb heights S.hemisphere
Analysis 12GMT 28/2/79
Contours at 6dm intervals

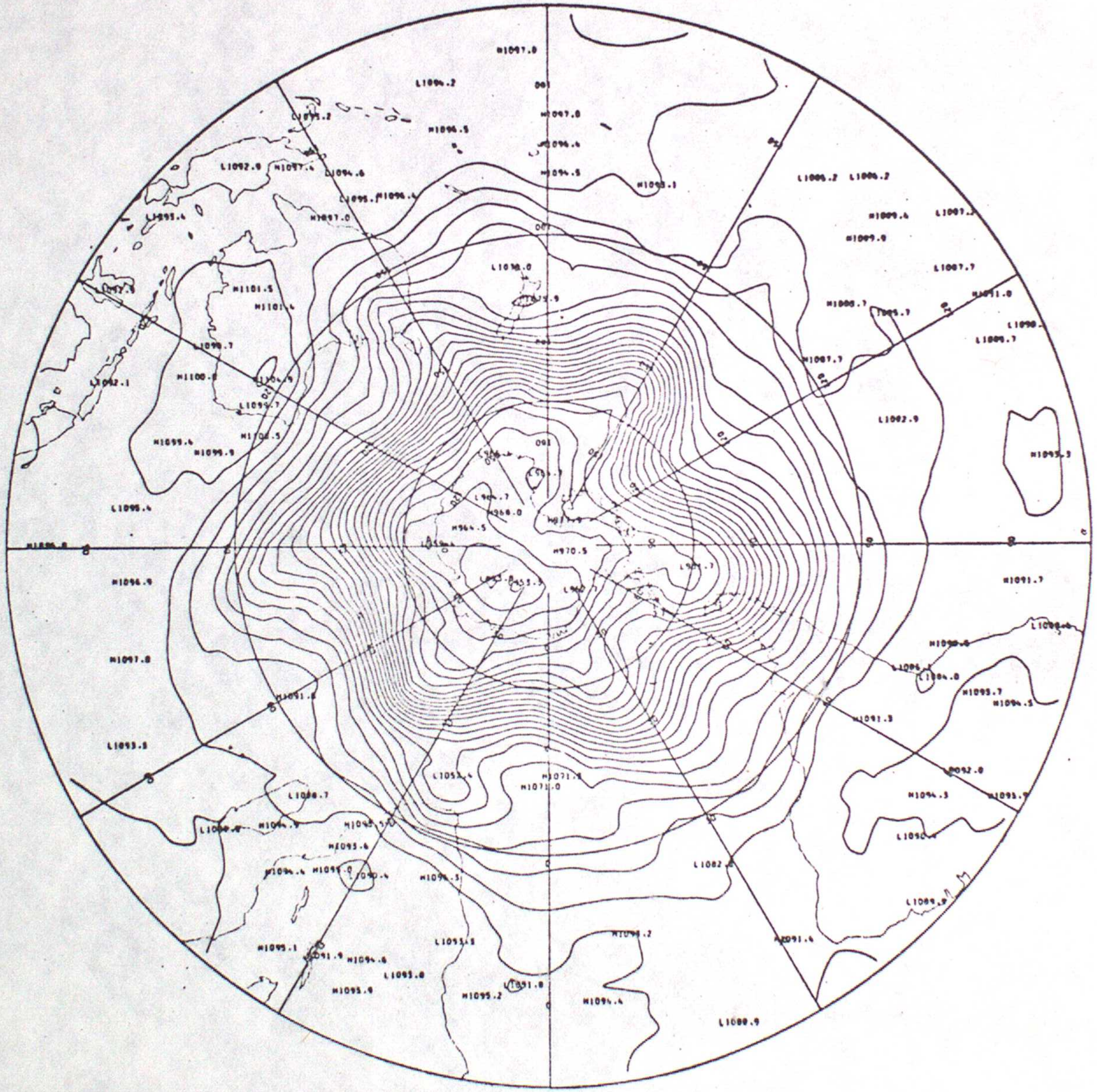


Chart 5.4
FGGE 25∅mb heights S.hemisphere
Analysis 12GMT 3/3/79
Contours at 6dm intervals

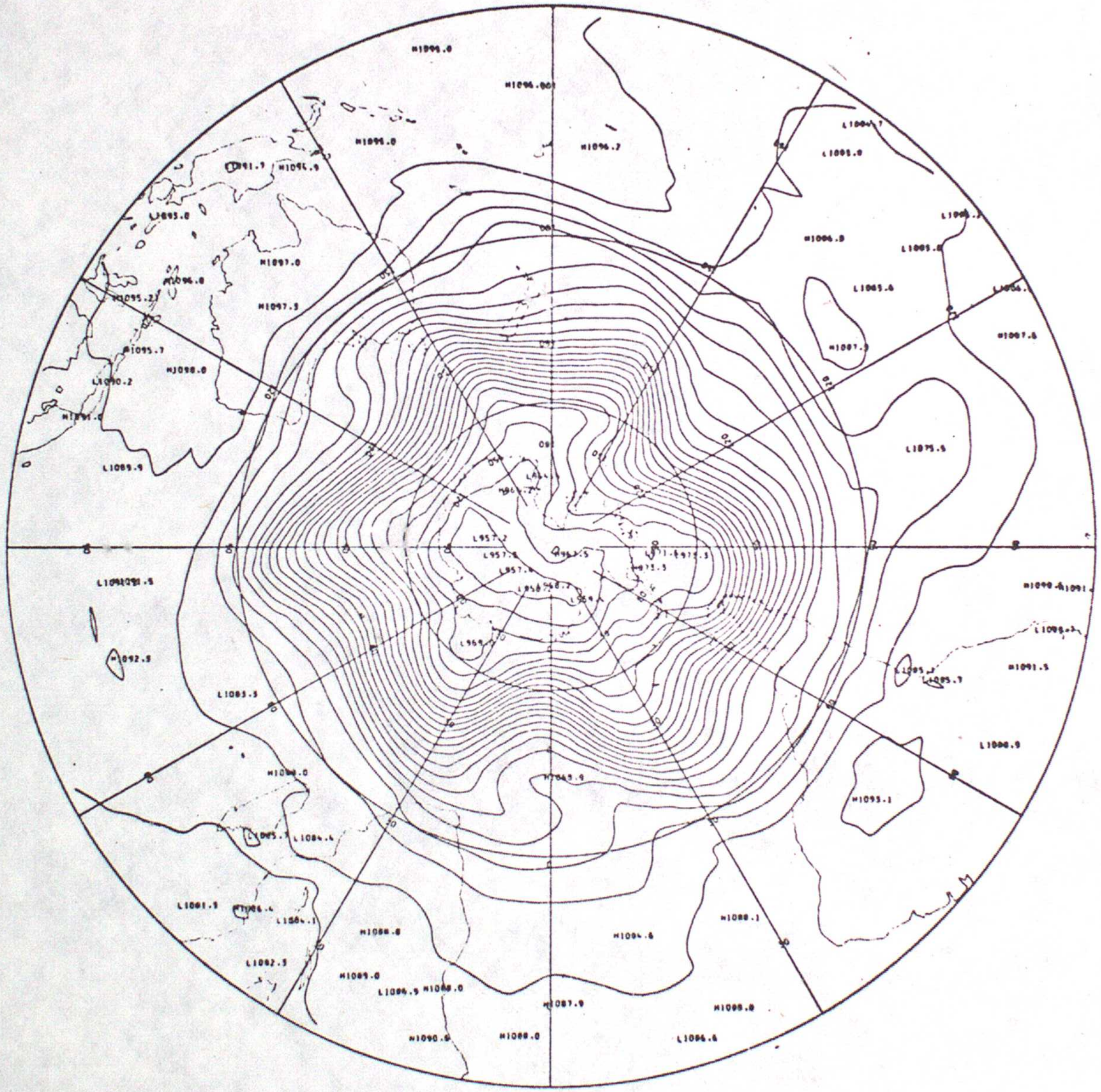


Chart 6.4
FGGE 25∅mb heights S.hemisphere
72hr forecast 12GMT 3/3/79
Contours at 6dm intervals

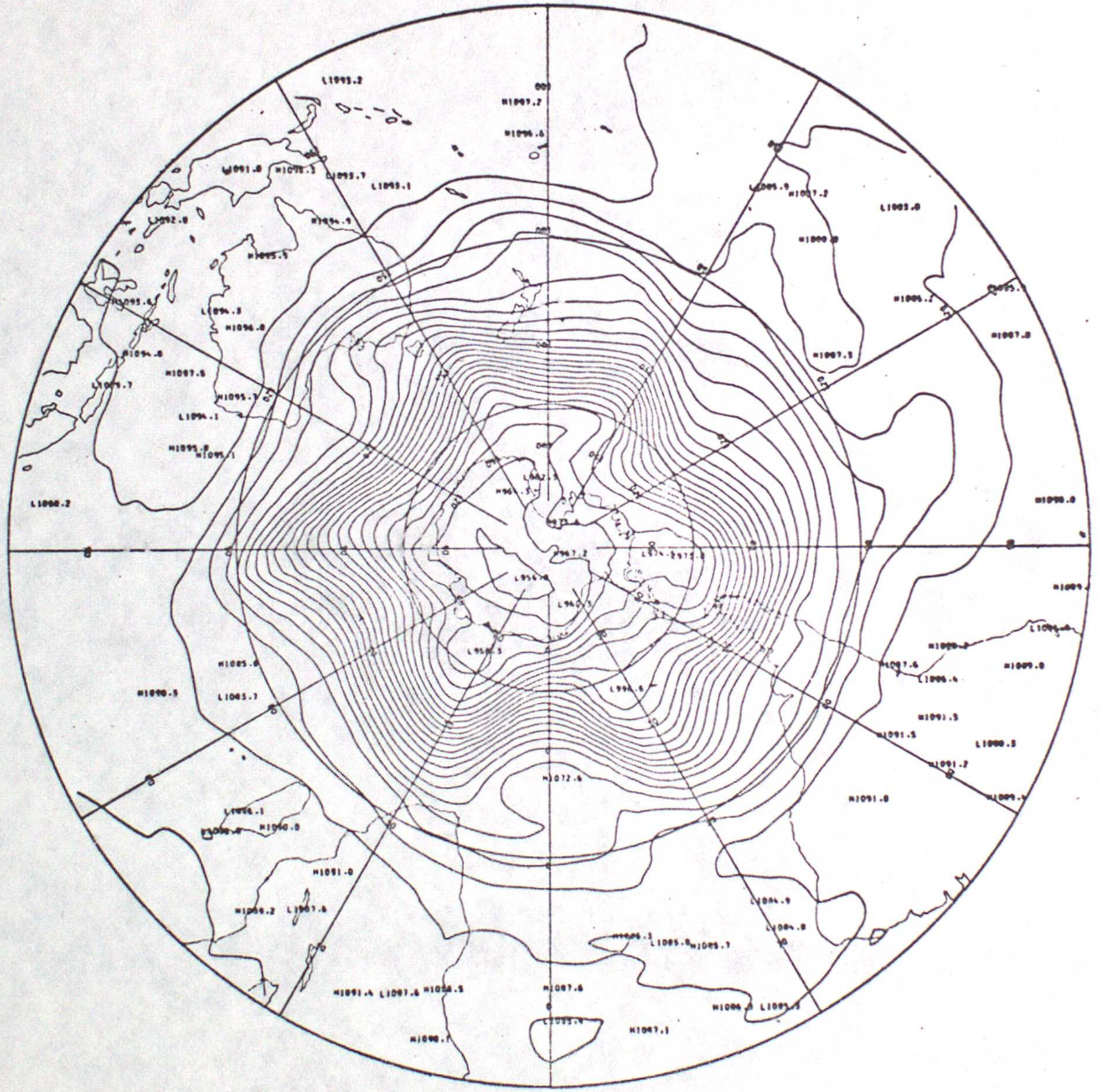


Chart 7.4
ExpB 250mb heights S.hemisphere
72hr forecast 12GMT 3/3/79
Contours at 6dm intervals

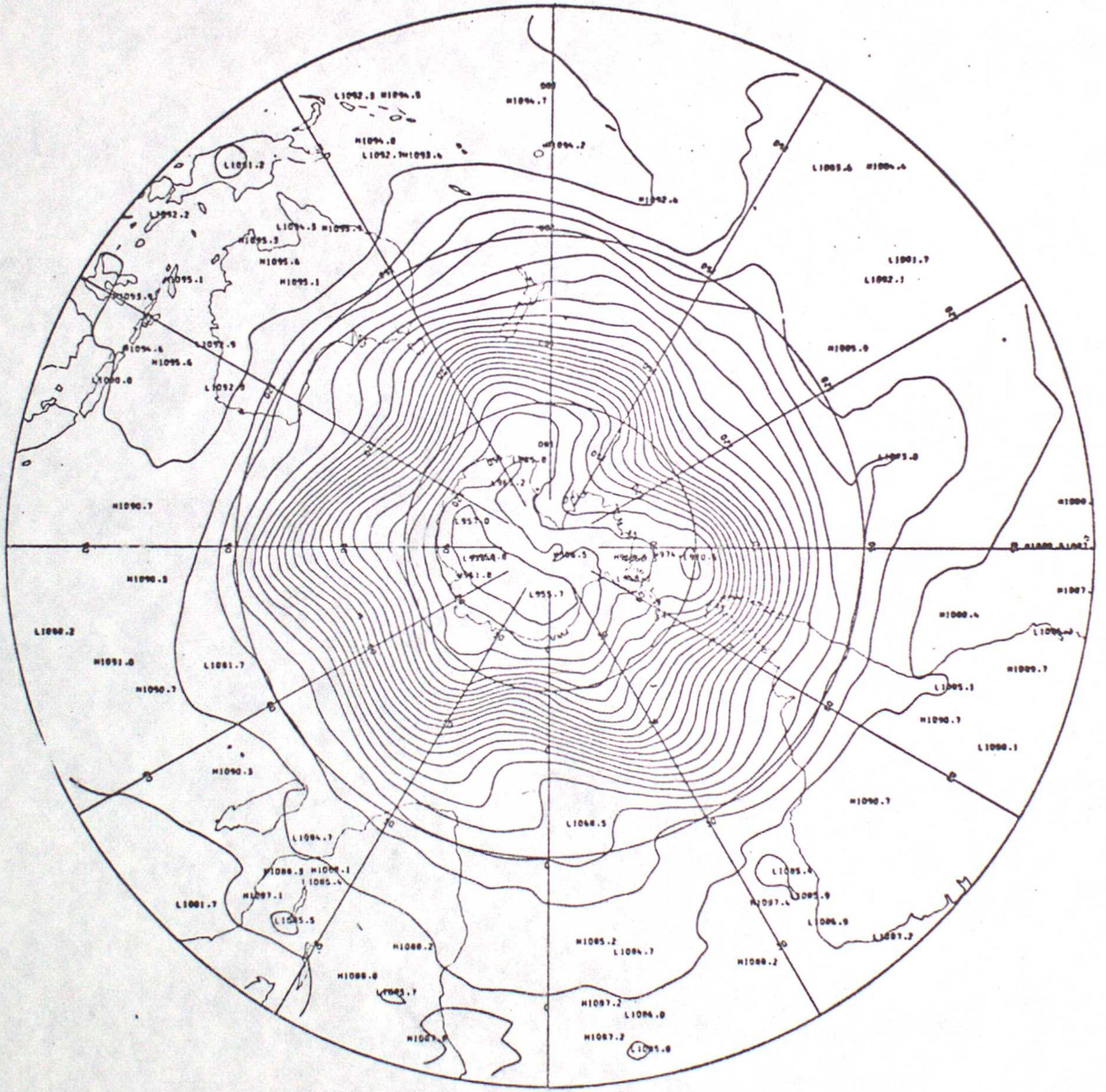


Chart 8.4
ExpD 250mb heights S.hemisphere
72hr forecast 12GMT 3/3/79
Contours at 6dm intervals