SYSTEMATIC ERRORS AND FORECAST QUALITY OF ECMWF FORECASTS IN DIFFERENT LARGE-SCALE FLOW PATTERNS

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1. INTRODUCTION

Verification results of ECMWF products for the European area, as for instance given in the Forecast Reports, show high scores for the day 1, day 2 and day 3 forecasts. The high quality is confirmed by the forecasters in their subjective evaluations.

Coming to the medium range, the Centre's forecasts still have a relatively high quality compared to products from other operational systems (L. Bengtsson and A. Lange, 1982). However, after day 3 or day 4 in the forecast all verification results show a more rapid decrease in forecast quality (see Fig. 1.1). According to theory on predictability, a decrease must be expected, but some apparent systematic errors in the model affect the quality of the forecasts relatively quickly. It is shown by E. Lorenz (1981) that the quality of the Centre's products, under the assumption of unchanged day 1 quality, would increase substantially if such systematic errors were removed.

In a way, the forecaster, as the user of the medium range products, is in a similar position as forecasters in the early days of NWP for short range forecasts. There is some useful information in the numerical guidance, but there is also a considerable level of errors of which some are systematic. There are major differences, however. The predictability potential is lower and alternative methods like persistence and climatology are often poor. How then should the forecaster extract the useful information from the numerical medium range products?

He has to use all relevant knowledge, including that found at the Centre from the diagnostic studies and verification results combined with the synoptic experience within the community. One valuable tool for the forecaster is the statistical verification and interpretation system implemented at the Centre by the Product Development Group. The work could be extended towards field interpretation to correct for systematic errors. This can be tried using the method of canonical correlations on EOFs as suggested by A. Lange (1980).

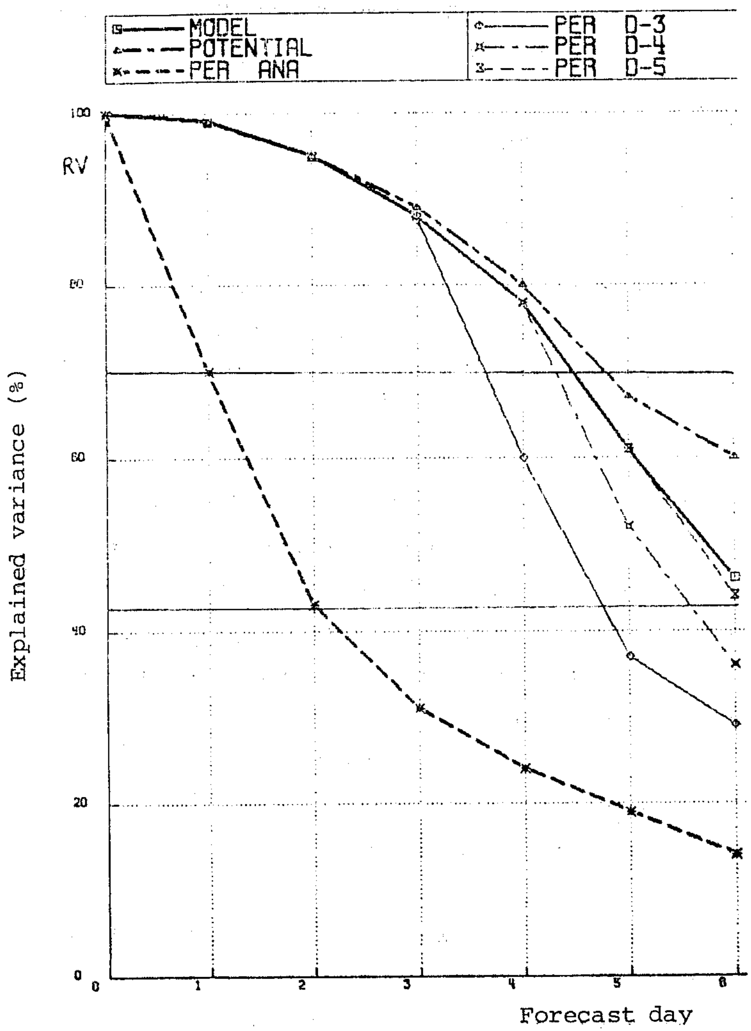


Fig. 1.1 Explained variance (Ev) full line, of 500 mb ECMWF height forecasts, northern European area, January 1981. Ev is defined as r^2 where r is the anomaly correlation.

The lower four curves give Ev of persistence forecasts using the analysis, the day 3 and day 4 and the day 5 forecasts as persistence. The upper curve, which may be regarded as a potentially achievable Ev, gives the results obtained using linear regression on this dependent sample with forecasts of the current and previous days as predictors.

The horizontal lines indicate the level of Ev for persistence forecasts for forecast days 1 and 2.

Very important for the forecaster is the synoptic experience gained during more than two years of operation. The value of this, although subjective in nature, should not be under-estimated. Because of this experience, a skilled forecaster is able to get more out of the forecasts than indicated by the average verification scores. To some extent, the synoptic experience is systematised and written down in reports that have been presented at ECMWF's forecaster meetings. A lot of smaller contributions have also been presented at weekly weather discussions held at the Centre.

Further synoptic experience is needed and studies in the field should be promoted. My contribution has been to set up a modest laboratory well suited for simpler investigations. Most of the material used are readily found among the ECMWF's archives, and consist of daily weather maps, daily verification results, a magnetic tape with two years of 500mb and 1000mb height analyses/prognoses together with some retrieval facilities. Here the results from one synoptic investigation are presented. Altogether 59 periods, ranging from 3 to 26 days, with relative high and relative low forecast quality are investigated. Systematic errors in terms of mean errors and errors in the cyclone tracks are presented for some of the longer periods and, further, some characteristics for situations with high and low forecast score are given.

2. DATA BASE FOR SYNOPTIC VERIFICATION STUDIES

The data base contains daily verification results from the European area and a single magnetic tape with two years of 1000 and 500mb analyses/forecasts for the northern hemisphere.

The verification results are taken from the operational regional verification system built up and described by Nieminen (1982). The methods used are conventional and include statistics like anomaly correlation coefficient and standard deviation of the errors. Out of this large amount, I have just picked daily verification results for 500mb height, European Area.

In this study, the anomaly correlation* is frequently used alone as a measure of forecast quality. It is shown by Nieminen, Fig. 2.1, that there is a correlation between this coefficient and the standard deviation of the height errors. The figure shows a contingency table over a three month period for day 7 forecasts. In spite of this relation, the anomaly correlation is no ideal measure of quality. First of all, it is very scale dependent and smaller scale features are bound to get low scores because of phase errors. There is also often little correspondence between this parameter and scores evaluated subjectively. However, it is hard to find any better single parameter to describe forecast quality and it is valuable when used with caution.

The magnetic tape is made as a subset from the operational verification data base. The 1000 and 500mb data are stored for the northern hemisphere with a resolution of 3^{o} longitude and latitude. From each day, there are analyses and forecasts up to seven days, altogether 16 fields for the two levels. The period starts from 1 January 1980 and covers two years. Retrieval software is prepared which makes it simple to select situations and subperiods and, further, plotting programs are available.

3. SPELLS WITH VERIFICATION RESULTS ABOVE AND BELOW AVERAGE

Fig. 3.1 shows how the forecast quality in terms of anomaly correlation and standard deviation of the errors for the European area varies throughout a period of three autumn months. The different curves are for the day 1, day 3, day 5 and day 7 forecast, all issued at the date found on the horizontal axis.

$$\text{*Anomaly correlation} = \frac{\sum\{(F-C) - (\overline{F-C})\}\{A_V - C - (\overline{A_V - C})\}}{\sqrt{\{\sum\{(F-C) - (\overline{F-C})\}^2 \sum\{(A_V - C) - (\overline{A_V - C})\}^2\}}}$$

where F = forecast, C = climatology, A_V = verifying analysis

Such curves are available for three years of operation and could be made a subject for further studies.

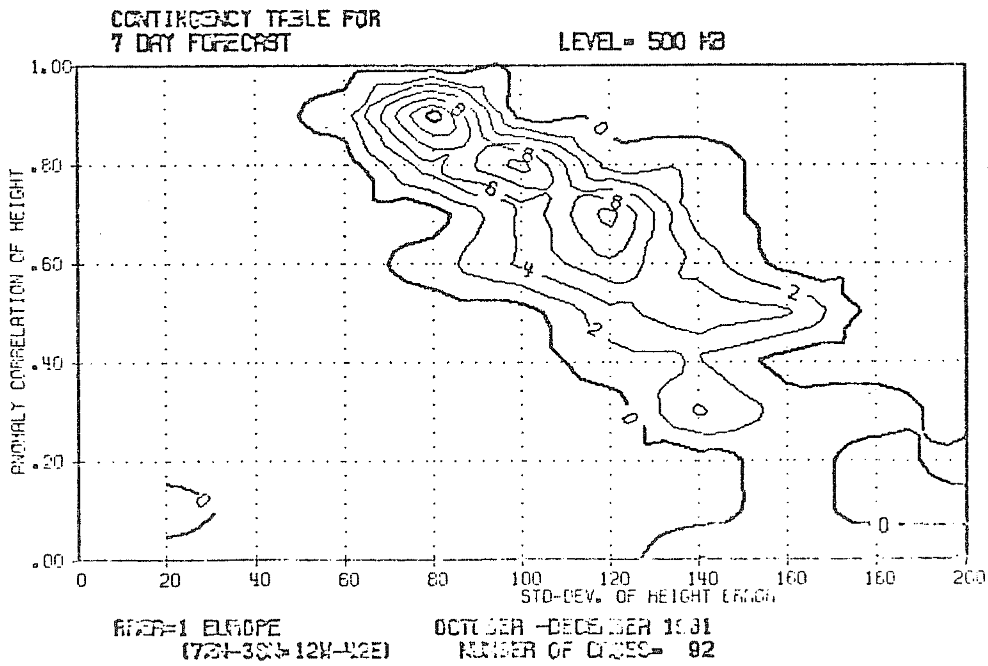


Fig. 2.1 Contingency table (with percentage frequencies) between the 500mb height anomaly correlation and standard deviation of error for 7-day forecast over the period of October - December 1981 in Europe.

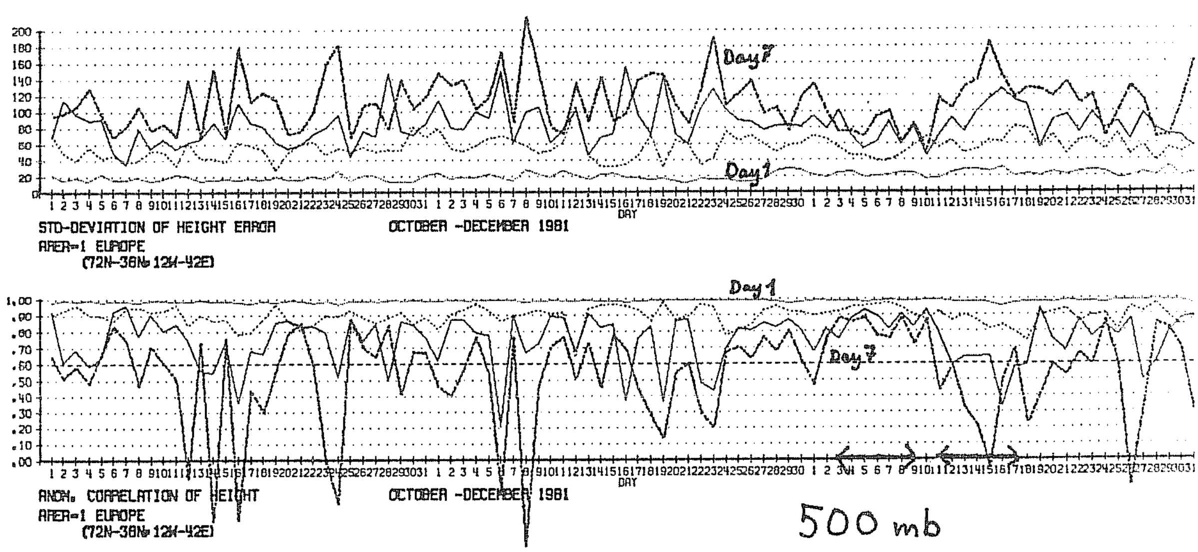


Fig. 3.1 Verification for day 1, day 3, day 5 and day 7 forecasts, European area.

The day 1 forecast has a stable quality with standard deviation of the height errors close to 20m and a high anomaly correlation. The quality decreases with the forecast length and for the day 7 forecast the standard deviation differs between 40 and 200m and the correlation from .9 down to large negative values.

Following the day 5 or day 7 correlation curve, large day to day variations are found. At some dates, there are abrupt changes from one day to the other, but such episodes seem to be overrepresented in this sample. Otherwise there is a positive cross-correlation present between consecutive days so that, if today's forecast has a high quality, it is likely that the same will be true for tomorrow's.

Some periods of several days are clearly above average score for day 5 and day 7, while other periods have relatively low scores. In this study, such periods with relative high and relative low scores are picked out and investigated in order to find systematic errors and other characteristics of the situations.

As an example of a period with high forecast quality at day 5 and day 7, we have the first days in December (Fig. 3.1). The daily maps are inspected and it is found that the situation from 3-9 December is dominated by a strong Atlantic blocking which prevents cyclone activity across the ocean. A mean 1000mb height analysis is shown on Fig. 3.2. Mean day 3, day 5 and day 7 forecasts are also computed for both 500 and 1000mb, and the mean 1000mb day 7 forecast is shown together with the mean verification analysis on Fig. 3.3. The difference between the two maps, forecast minus analysis, is given on the forecast map; this mean error is here referred to as the systematic error. Mean day 3, day 5 and day 7 500mb anomaly correlation is given in the figure text.

In this case, the mean error over Europe is relatively small with negative amplitudes. The scale of the errors are large compared to some error patterns in the Pacific. The maximum in the European region is connected to the SE European trough and the westerly flow crossing the Iberian Peninsula. At 500mb, we find the same kind of errors with a high amplitude indicating an equivalent barotropic structure. This is well in acordance with other verification results.

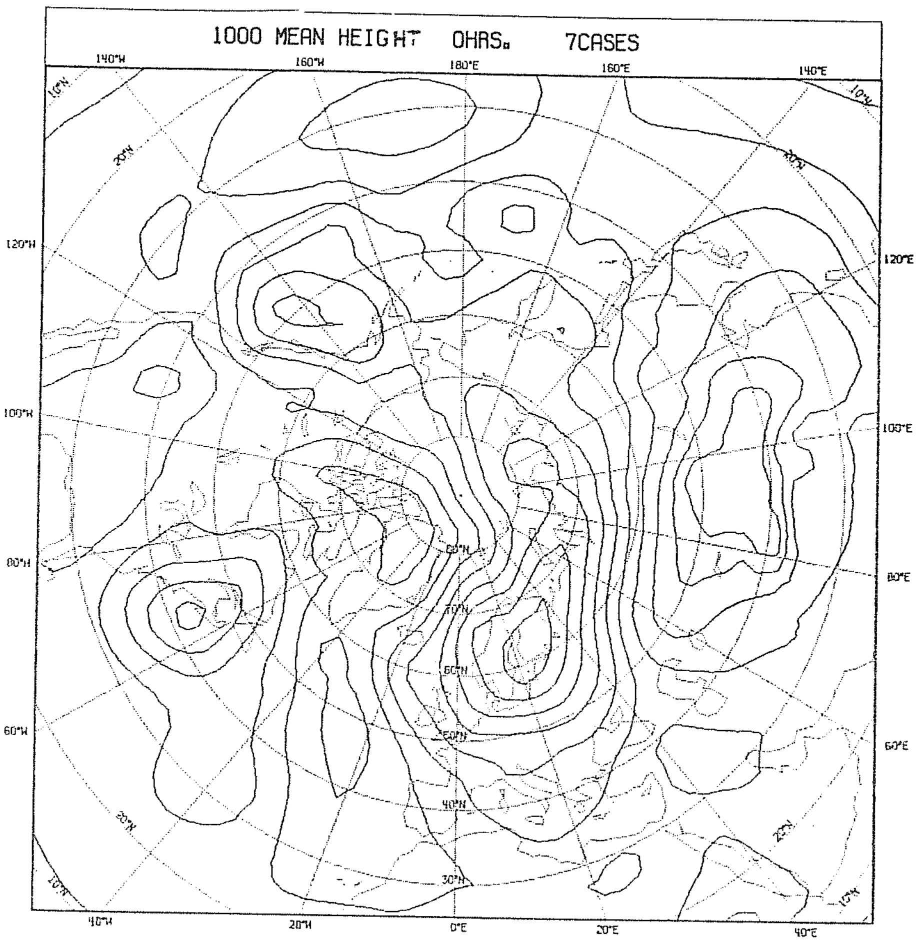


Fig. 3.2 Mean analysis, 3 - 9 December 1981

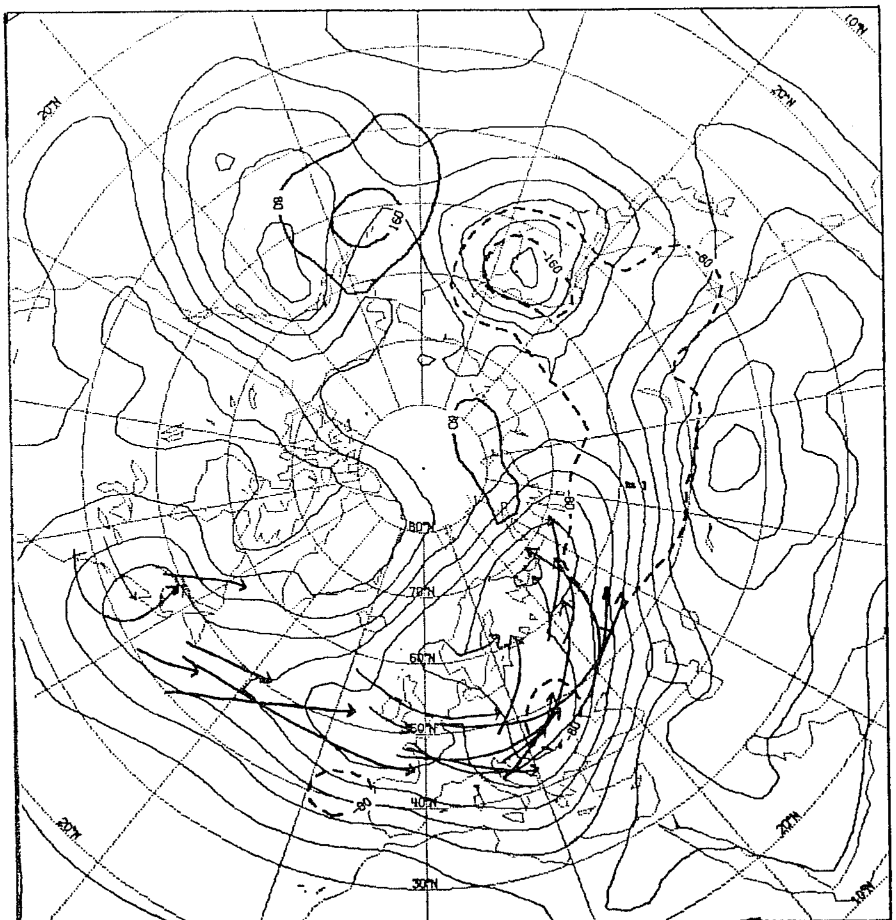


Fig. 3.3a
Mean day 7
1000mb height
forecast from
the period
3-9 December 1981.

Dashed lines
mean errors

Forecasted low
tracks from
day 5 to day 7
in the European/
Atlantic area

Mean 500mb anom.
correlation,
European area:

day 3 .93
day 5 .86
day 7 .82

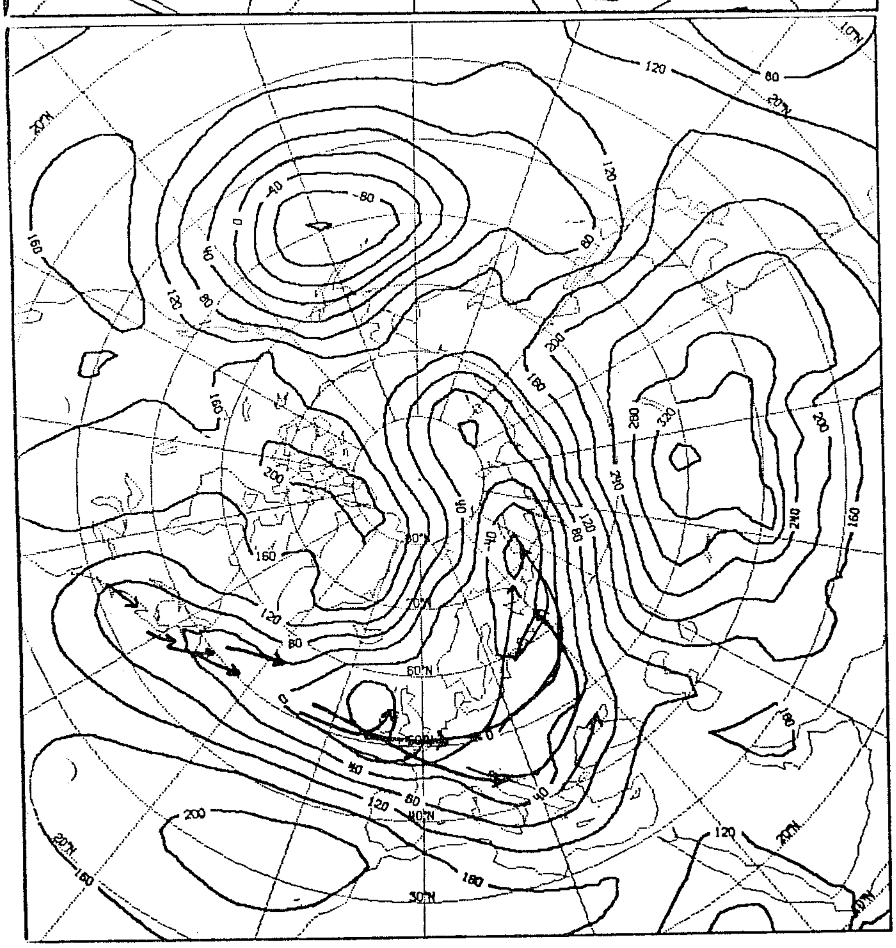


Fig. 3.3b
Mean verification
1000mb height
analysis

Low tracks
for the
European/
Atlantic area

The mean errors might not necessarily be an indication of the real forecast errors in this situation, and therefore, the low tracks are also plotted on the figure. On the forecast map, the forecasted tracks from day 5 to day 7 are given and on the verification map, the observed tracks are found. The low activity is predicted in a fairly accurate position. There are, however, several discrepancies. The two tracks over Balkan are missing and the eastern low tracks penetrate somewhat too far into the Eastern ridge. The mean errors and the tracks seem to support each other on these two details.

As an example of a relative poor forecast period, the days after 11 December are picked (see Fig. 3.1). The maps show that these days are characterised by a westerly jet across the Atlantic situated in a southerly position. In Fig. 3.4, the mean 1000mb surface map for the days 11-17 December is shown, and the day 7 mean forecast is shown in Fig. 3.5 together with its verification. In this case, the mean error amplitude is high over Russia. Otherwise the amplitudes are small, but the scale of the errors is smaller than in the former case. In addition to the break-down of the Siberian ridge, we find substantial errors in the shape of the middle European low. The errors in the low tracks are fairly well in correspondence with the mean errors. Spurious low tracks are breaking down the Siberian ridge and there are also clear errors in the south east European region. Altogether both the mean field and the low tracks are less well predicted in this situation than in the former case as it is also indicated by the mean anomaly correlations.

In a similar way altogether 59 cases are investigated during the two years 1980 and 1981. First, periods are picked from the verification figures like Fig. 3.1. Then the maps are inspected to find a stable synoptic situation within the period. This is done very subjectively. The length of the periods differs from 3 up to 26 days. The longest periods are studied separately and give an estimate of the systematic errors in that large-scale synoptic situation.

4. SYSTEMATIC ERRORS IN SOME LARGE SCALE SYNOPTIC SITUATIONS

In Table 4.1, twenty cases with spells of seven days or longer are listed. In the table, mean anomaly correlation for day 3, day 5 and day 7 are given and the cases are ranked according to the mean of day 5 and day 7 correlation. A few words are given to characterise the mean flow. As a reference, the average score for 1981 is found in Table 4.2. The yearly mean scores are .87, .59, .44 for day 3, 5 and 7 respectively and are slightly higher than the 1980 figures.

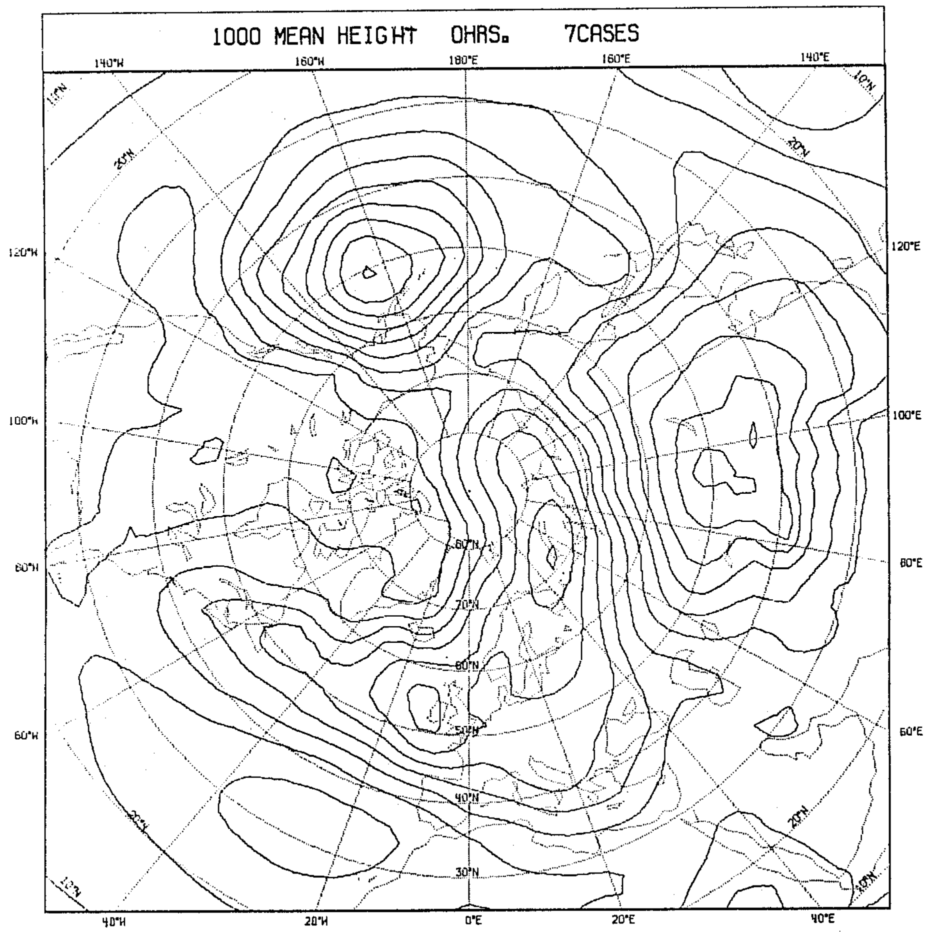


Fig. 3.4
Mean analysis
for the period
11-17 Dec. 1981

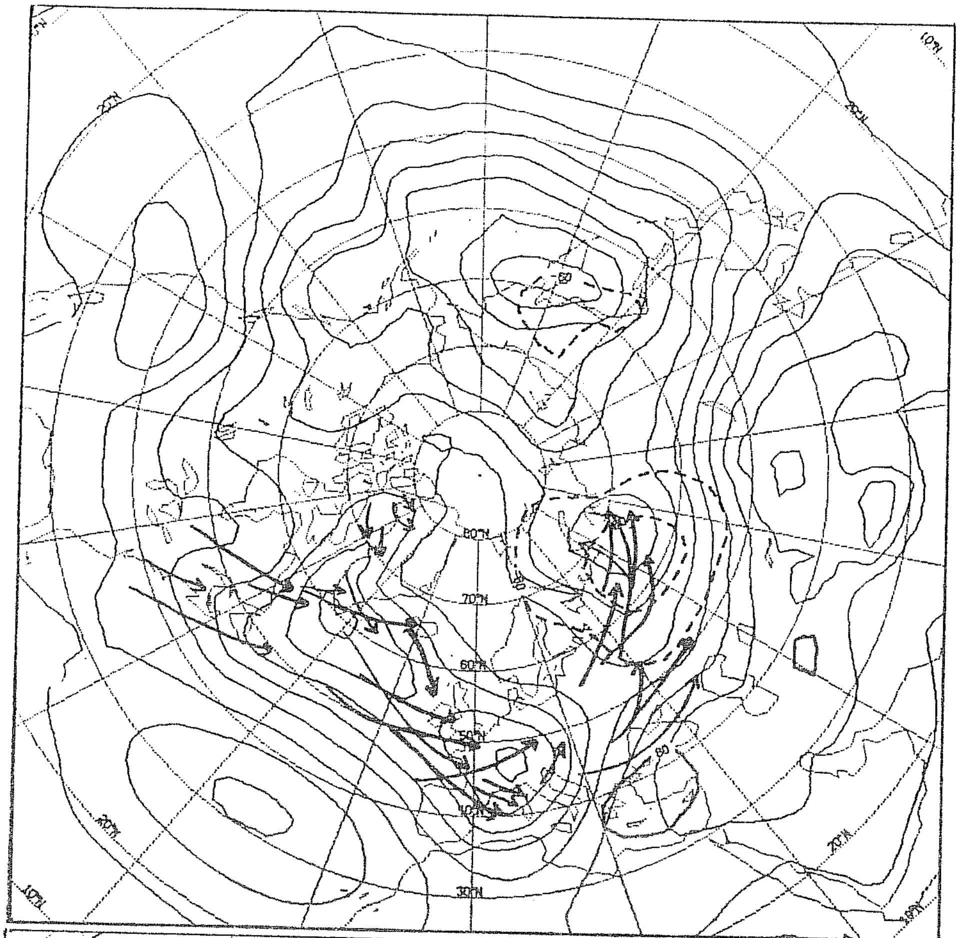


Fig. 3.5a
Mean day 7
1000mb height
forecast from
the period
11-17 Dec. 1981

Dashed lines
mean errors

Forecasted low
tracks from
day 5 to day 7
in the European/
Atlantic area

Mean 500mb anom.
correlation,
European area:

day 3	.85
day 5	.56
day 7	.35

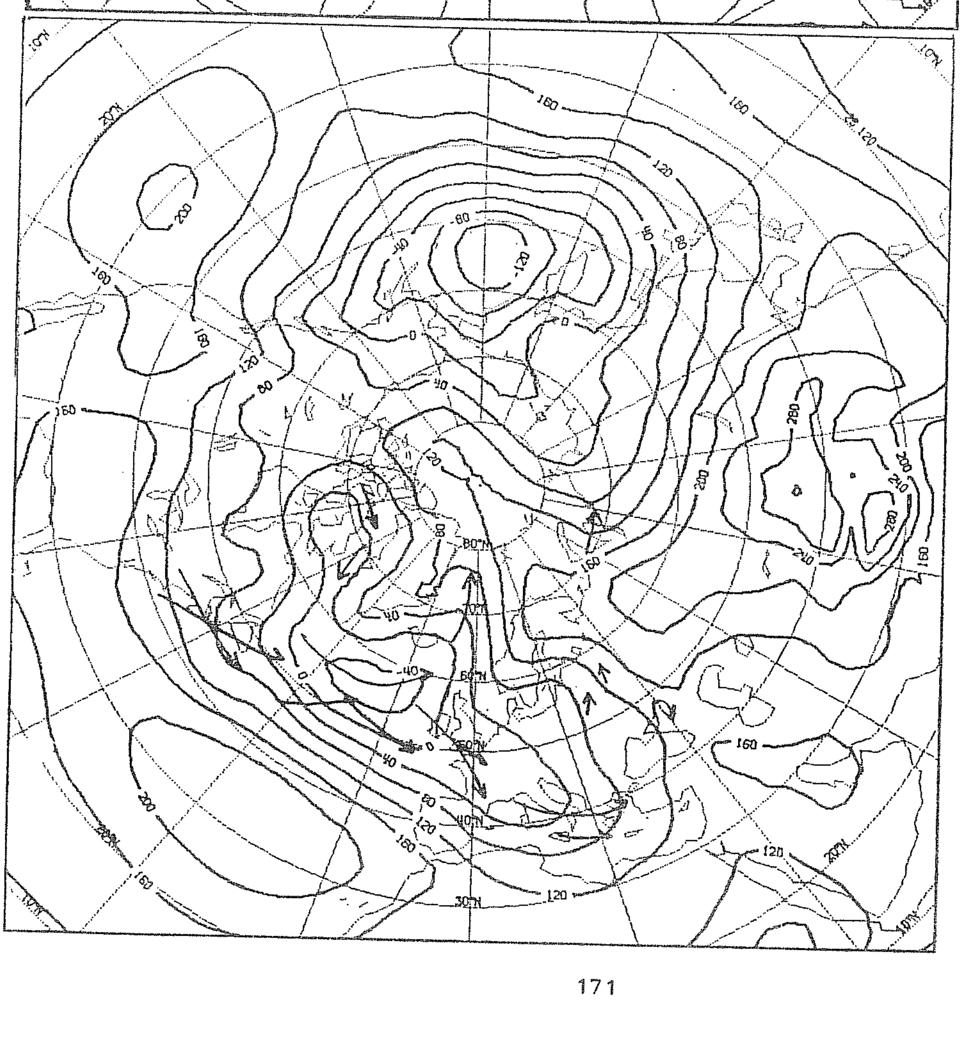


Fig. 3.5b
Mean verification
1000mb height
analysis

Low tracks
for the
European/
Atlantic area

RANK	STARTING DATE	NO. OF DAYS	MEAN 500 MB ANOM. CORR. Day 3	Day 5	Day 7	FLOW TYPE
1	811203	7	.94	.87	.81	Northern Atl. block
2	810508	18	.93	.82	.68	European block
3	801127	7	.88	.75	.68	Atlantic block
4	801101	20	.90	.75	.60	Northern Atl. block
5	810127	7	.87	.71	.64	SW Eur. block, zonal North Eur.
6	811017	14	.89	.74	.58	Zonal Atl. flow, split Europe
7	810210	18	.89	.75	.55	Siberian high towards Scandinavia
8	801210	22	.88	.72	.58	Zonal Atl. flow,split Europe
9	811111	19	.91	.70	.56	SW Eur. block,zonal North Eur.
10	810616	15	.89	.71	.52	Atlantic block
11	810912	7	.90	.70	.52	Northern European block
12	800916	7	.84	.70	.46	Weak European block
13	810416	15	.87	.60	.41	Atlantic block
14	811211	7	.85	.55	.40	Zonal Atl. flow
15	811012	7	.85	.59	.30	Zonal Atl./Eur. flow
16	800922	9	.85	.56	.30	Zonal Atl. flow, ridge Eur.
17	810101	26	.85	.55	.25	Zonal Atl. flow, split Eur.
18	810713	17	.78	.45	.20	Zonal Atl. flow,trough Eur.
19	800908	8	.82	.47	.10	Zonal Atl./Eur. flow
20	810829	7	.86	.50	. 5	Zonal Atl. flow,ridge Eur.

Table 4.1 Selected periods, ≥ 7 days, with 500mb anomaly correlation for the European area. The samples are ranked according to the mean of day 5 and day 7 correlation.

1981	day3	day5	day7
jan	.87	.56	.35
feb	.87	.68	.46
mar	.82	.58	.45
apr	.87	.64	.37
may	.92	.83	.69
jun	.89	.71	.53
jul	.78	.47	.26
aug	.86	.55	.34
sep	.88	.61	.26
oct	.89	.74	.50
nov	.90	.74	.50
dec	.89	.75	.57
mean	.87	.59	.44

Table 4.2 Monthly mean anomaly correlation coefficient for the European area, 1981.

The first 12 cases are considered to be above average and the rest mainly below average.

As expected, the best situations are characterised by some kind of a blocking. In the poorest cases, no blocking is involved and a more zonal Atlantic/ European flow is prevailing. A mean score value for the typical blocking situations representing 122 days are:

day 3: .89, day 5: .71, day 7: .55

and for the zonal flow situations representing 120 days:

day 3: .86, day 5: .56, day 7: .36

In those cases, the day 7 score in blocking nearly equals the day 5 score in zonal flow. The variations from this picture are, however, not small with significant differences within both blocking and more zonal flow situations.

The results in terms of systematic errors, cyclone track errors and forecast quality will now be given for some of the situations. The tracks are now simplified subjectively to make the discussion easier. The maps are still hemispheric, but only the Atlantic/European area will be considered.

<u>17-31 December 1980. Zonal flow, split over Europe</u>

We start with a winter zonal flow shown on Figure 4.1 in terms of mean analysis for 1000 and 500mb. The situation covers 22 days, and is characterised by a strong Azores high in a northerly position west of the Iberian peninsula, and travelling cyclones from Newfoundland to Scandinavia. The 500mb flow shows a split over Europe and there is some cyclonic activity in the Mediterranean. Although not being a blocking situation, the forecast quality is well above average, the rank is 8 out of 20.

The systematic errors are typical and show in the day 5 forecast at 500mb - Fig. 4.2 - a maximum over Europe connected with the split and also low values westwards along the core of the zonal flow. In other words, the forecasts fail to maintain the ridge west of Portugal and the westerly flow is predicted to be south westerly. At day 7 - Fig. 4.3 - the amplitudes of the errors have increased and the break-down of the ridge is more pronounced. The day 7 errors at 1000mb, Fig. 4.4, show a similar structure with smaller amplitudes. The break-down of the Azores high is very clear and the trough between this high and the Siberian high is far too strong, and covers too large an area.

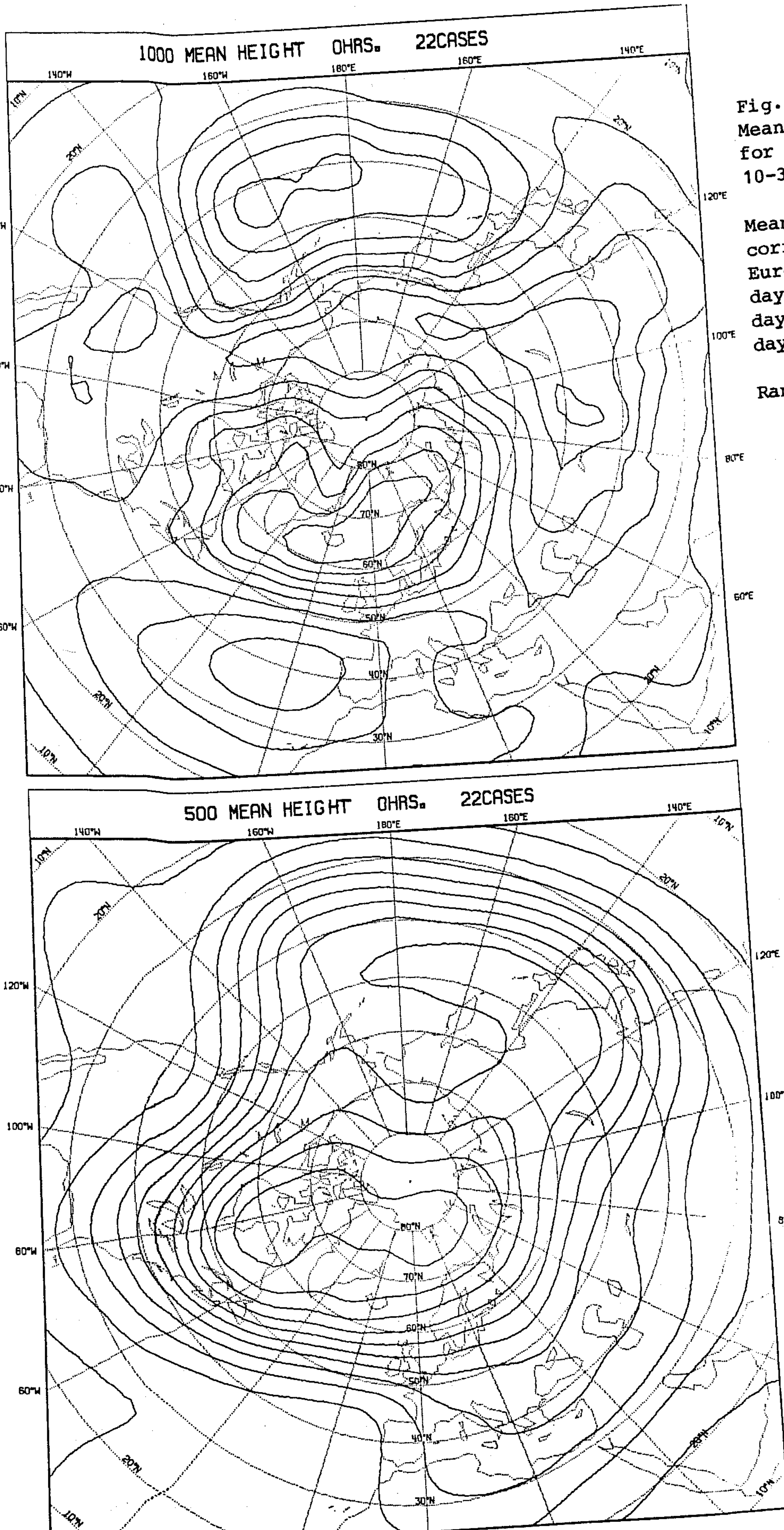


Fig. 4.1
Mean analysis
for the period
10-31 Dec. 1980.

Mean 500mb anom.
correlation,
European area:
day 3 .88
day 5 .72
day 7 .58

Rank 8 out of 20

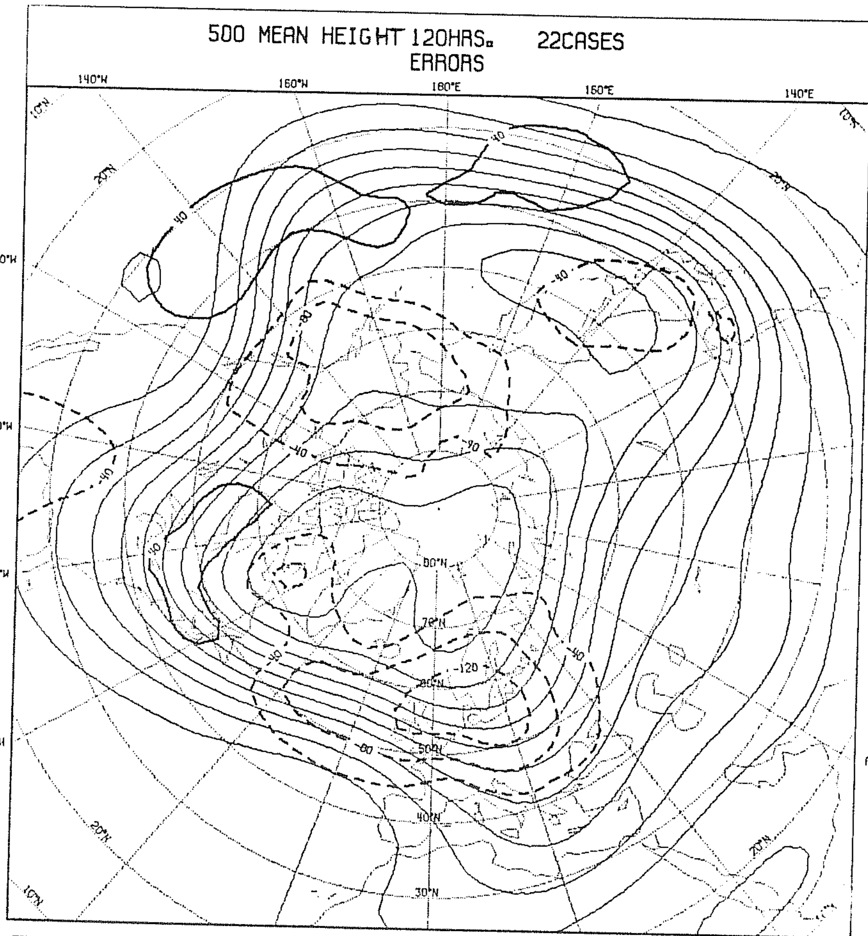


Fig. 4.2a
Mean day 5
forecast
from the period
10-31 Dec. 1980

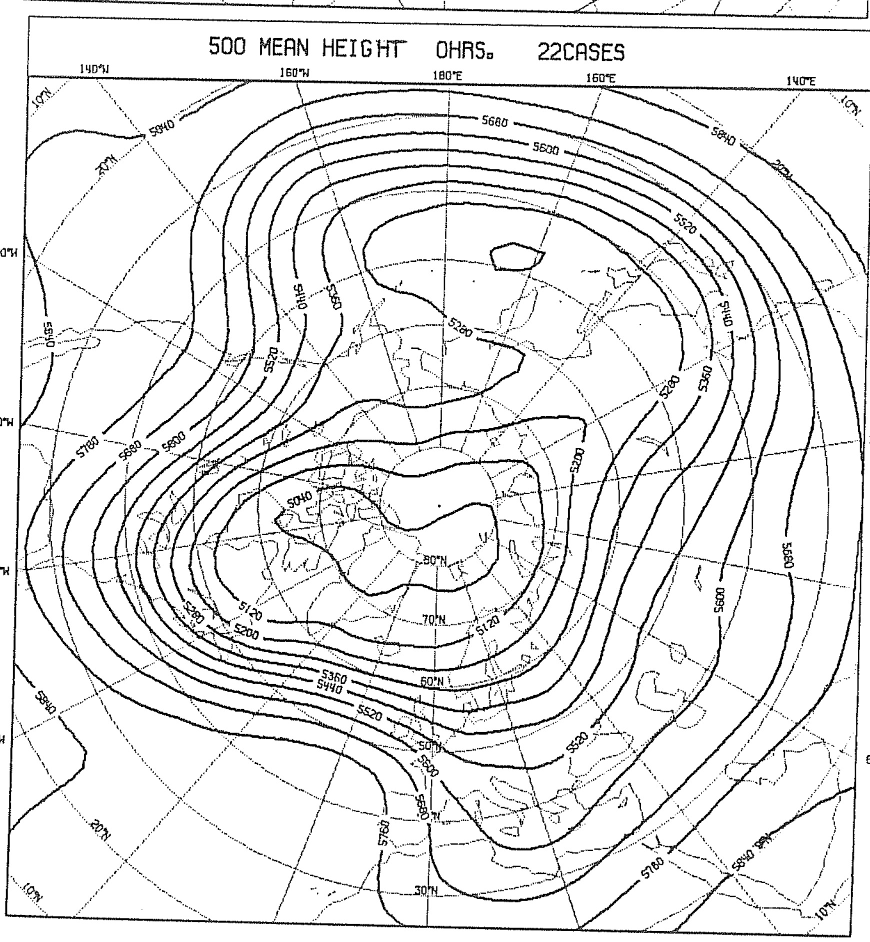


Fig. 4.2b
Mean
verification
analysis

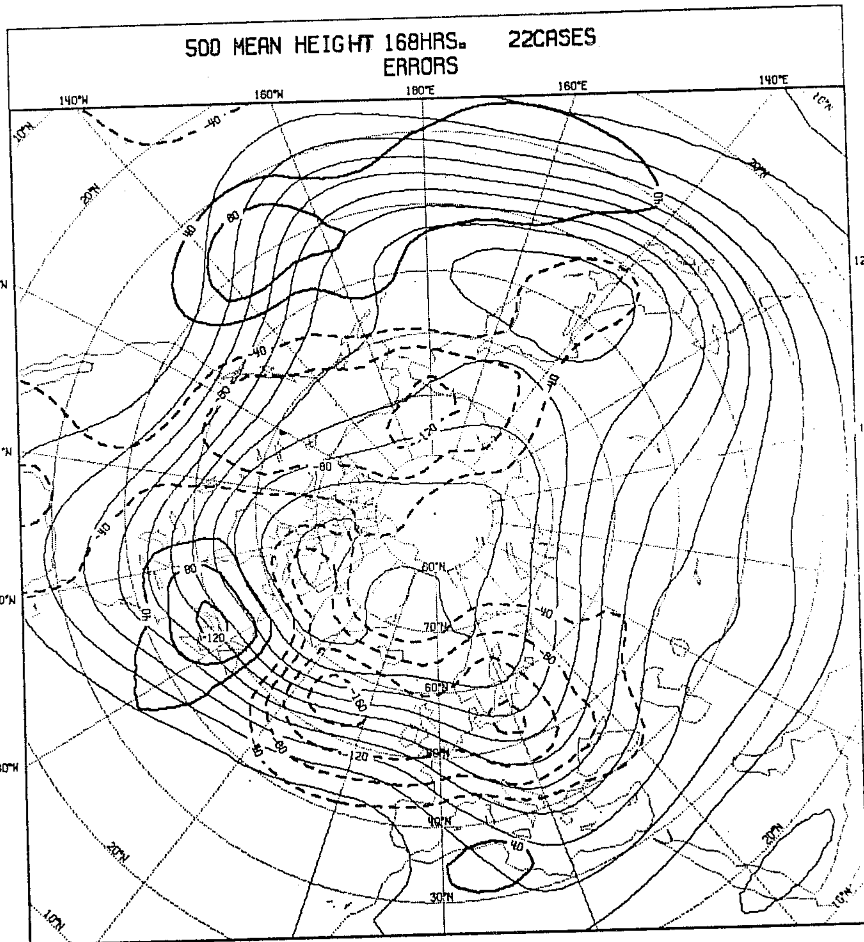


Fig. 4.3a
Mean day 7
forecast from
the period
10-31 Dec. 1980

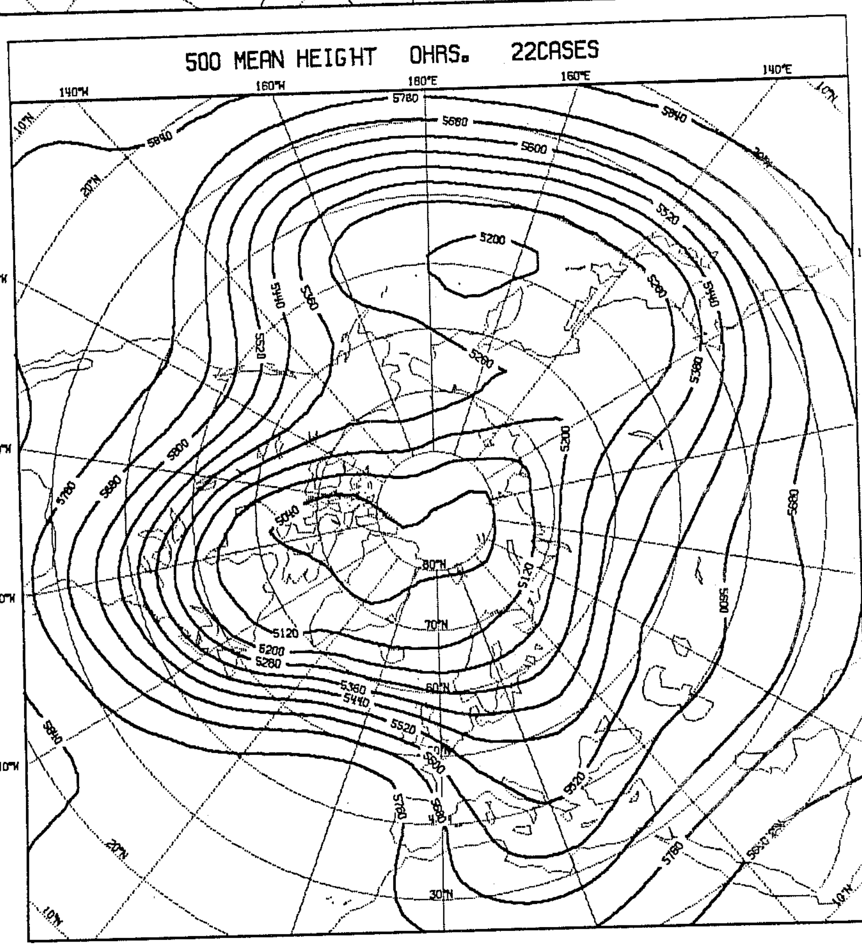


Fig. 4.3b
Mean
verification
analysis

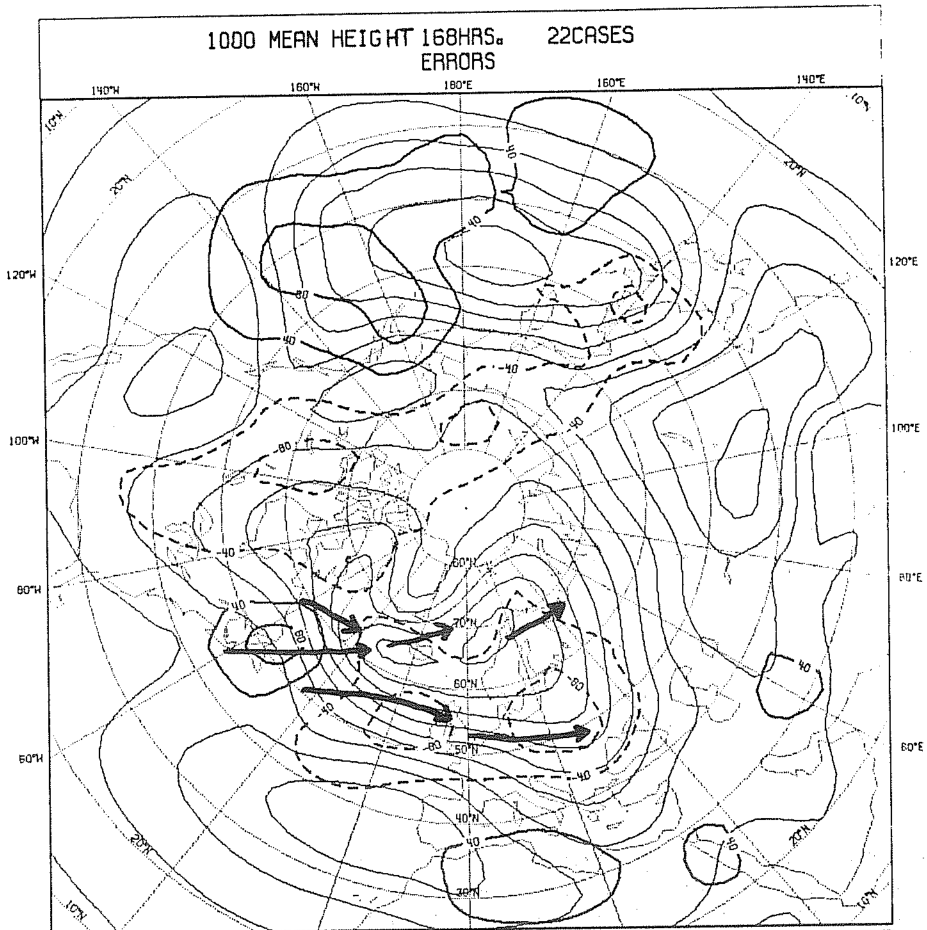


Fig. 4.4a
Mean day 7 forecast from the period 10-31 Dec. 1980

Indication of low tracks from day 5 to day 7, European/ Atlantic area

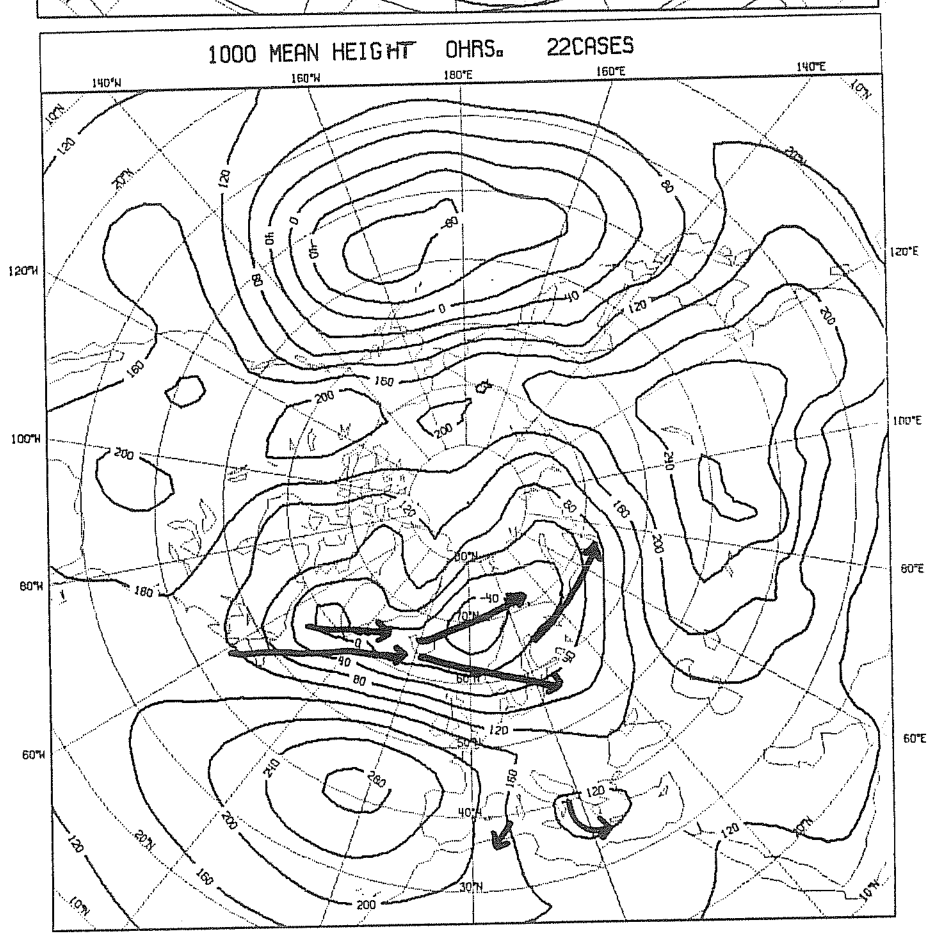


Fig. 4.4b
Mean verification analysis

Indication of low tracks, European/ Atlantic area

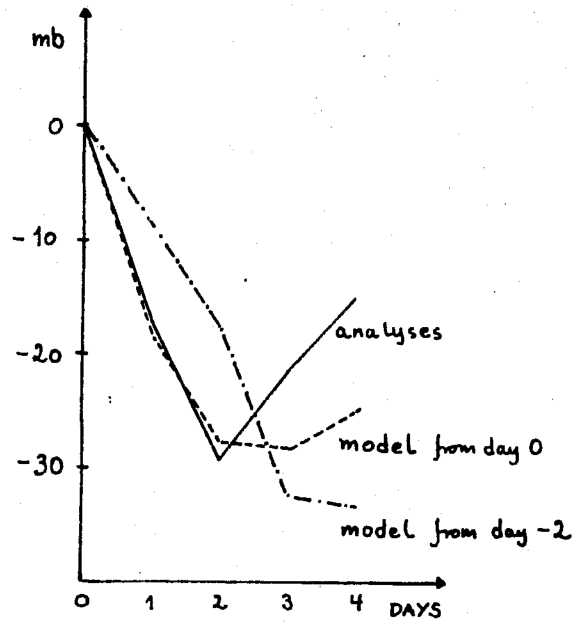


Fig. 4.5 Development of centre pressure in five major extratropical cyclones, Atlantic area winter 1980/81, all starting from small disturbances.

The indicated tracks of the lows from day 5 to day 7 show errors well in accordance with the systematic errors. We see that the secondary lows have their tracks in a position too far to the south, and on the other hand, the cyclone activity in the Mediterranean is missing.

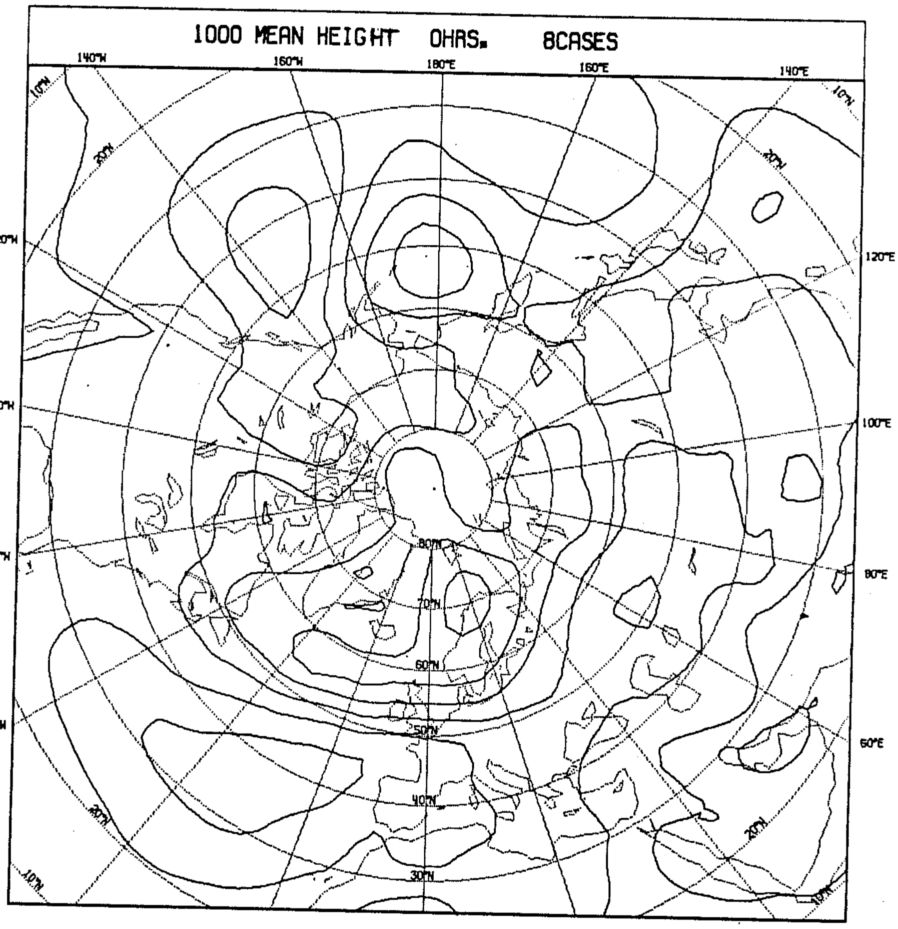
Similar errors as shown here are found in many of the monthly error maps. It is shown by J.M. Wallace, A. Simmons, S. Tibaldi (1982) that some of them are due to a too small mountain forcing in the model, especially from the Rockies and the southern European mountains. However, it is shown by K. Arpe (1982) that errors connected to the baroclinic instability also play an important part. This might be supported by Fig. 4.5 where the mean development of five major extratropical cyclones in the Atlantic from the winter 1980/81 is shown. It is clearly seen that the model fails to fill the lows in the mature stage. Similar filling errors are found to be present in nearly all situations investigated in this study.

8-16 September 1980. Zonal Atlantic/European flow

This situation, Fig. 4.6, shows a zonal flow with very poor forecast scores. In this case, the Azores high is in its normal position and not so strong and the European split is not as pronounced. The period covers only 8 days and in the day 7 1000mb verification map on the next figure, a ridge has developed over Europe and this is not forecasted. The mean forecast map shows a north European low still present, so also in this case the filling problem is there. On the other hand, the low quality of the European forecast seems also to be connected with phase errors. An indication of phase errors in the model is shown in Fig. 4.8. Here, explained variance for forecasts at a specific day is plotted using both the forecast at that day as well as forecasts from offset timesteps. At day 3, for example, it is clearly seen that the day 4 forecast gives a better estimate than the day 2 forecast and this indicates a phase error. At day 5, when the forecast quality is much lower, the phase error cannot be estimated from this figure. If the phase error here is estimated to be 10 hours at day 3, it will probably be 20 hours at day 6.

1-26 January 1981. Zonal flow, split over Europe

A similar situation as the first one is described in Figs. 4.9, 4.10 and 4.11. The forecast quality for these 26 days is, however, much lower, the rank being 17 out of 20. The main difference in the synoptic situation in the Atlantic/European area is that the ridge West of Europe is more pronounced. The systematic errors at 500mb are very similar, but the amplitudes are somewhat larger. At 1000mb, it is very clear that the high is moved southward and there is again no sign of a ridge between the Atlantic and the Siberian high. There is, however, more spurious cyclone activity present in the European area and the low scores are connected to these errors.



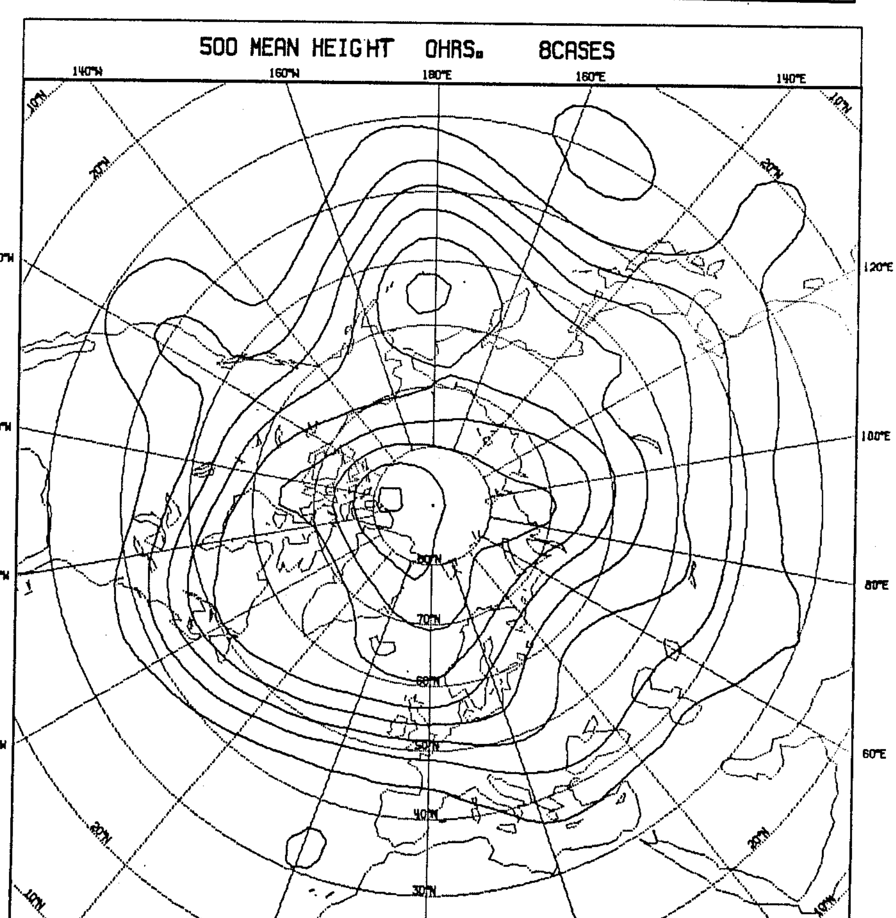


Fig. 4.6
Mean analysis
for the period
8-15 Sept. 1980

Mean 500mb anom.
correlation,
European area:
day 3 .82
day 5 .47
day 7 .10

Rank 19 out of 20

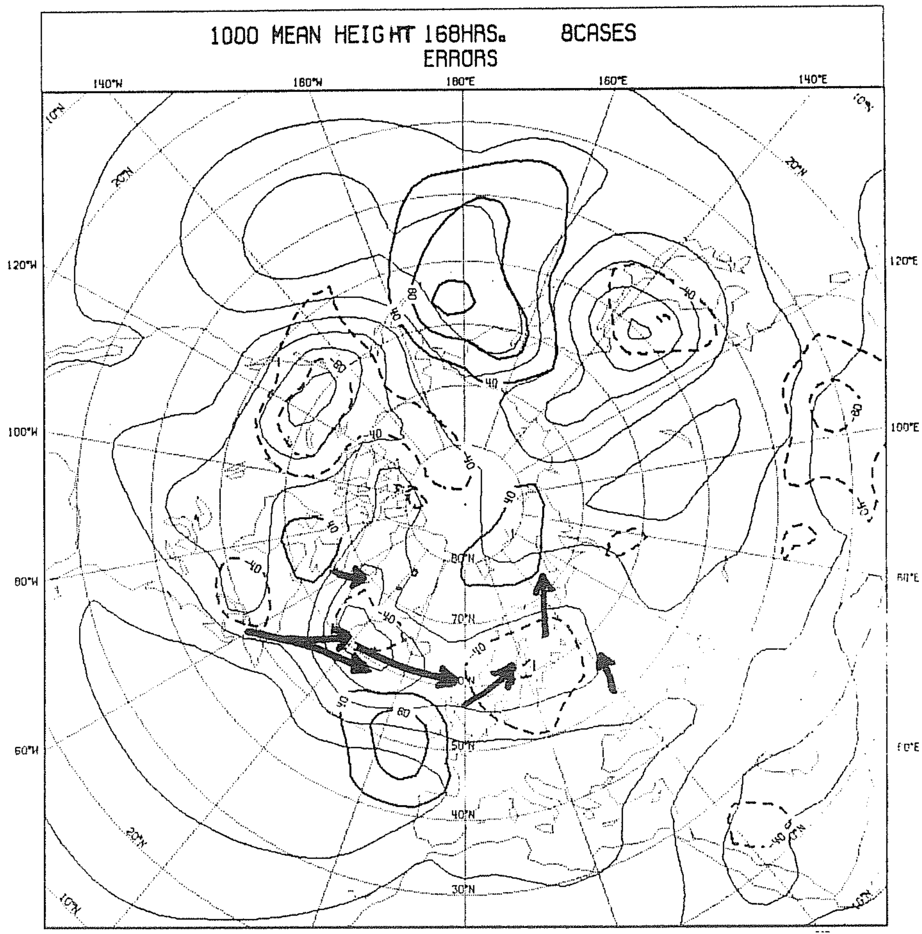


Fig. 4.7a
Mean day 7
forecast from
the period
8-15 Sept. 1980

Indication of
low tracks
from day 5 to
day 7,
European/
Atlantic area

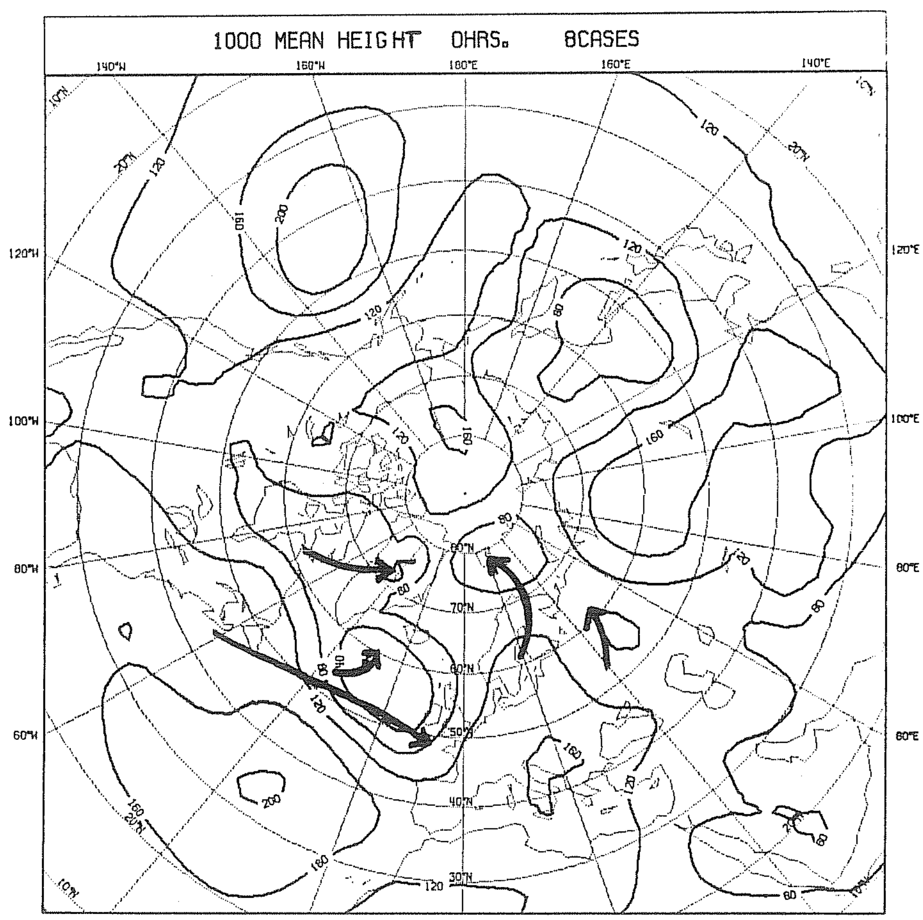


Fig. 4.7b
Mean
verification
analysis

Indication of
low tracks,
European/
Atlantic area

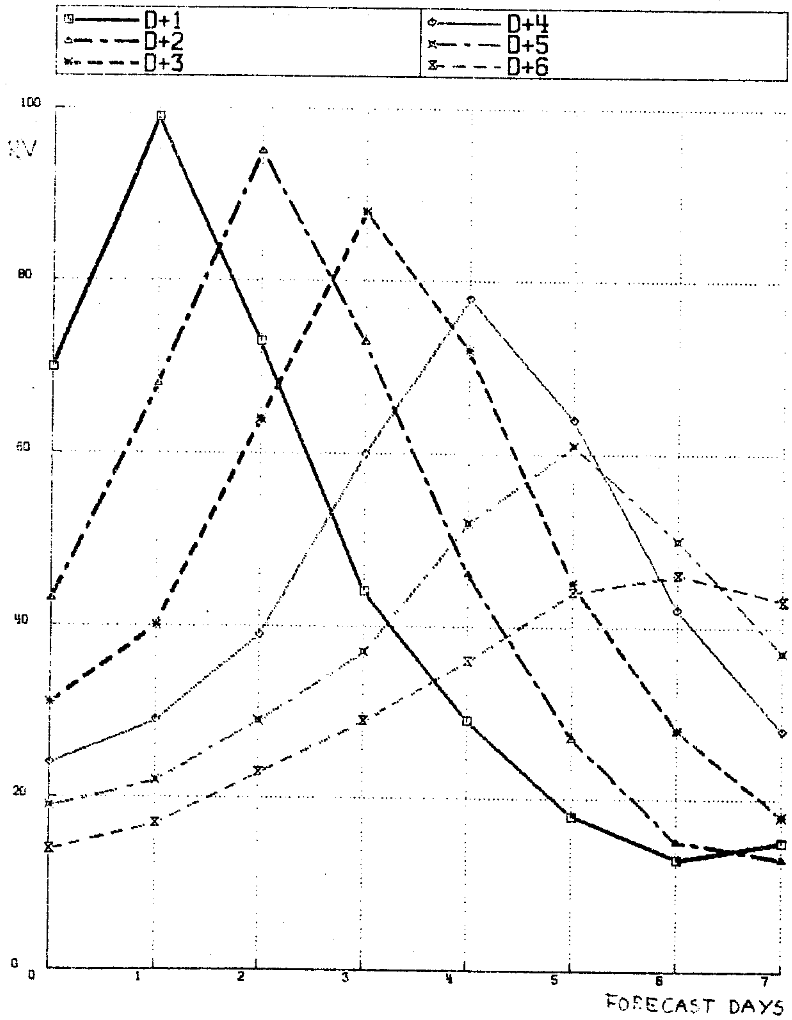
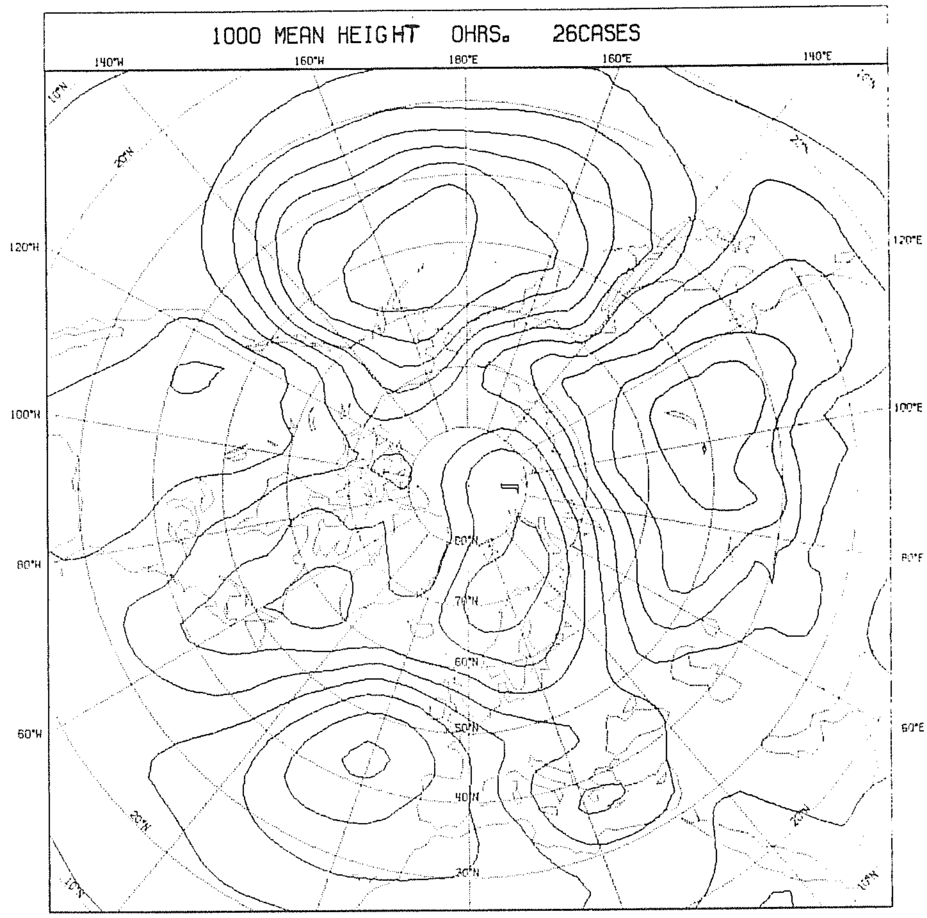


Fig. 4.8 Reduced variance (RV) of 500mb ECMWF forecasts, northern European area, January 1981. For all the forecast step the RV using all the steps up to day 7 is shown.



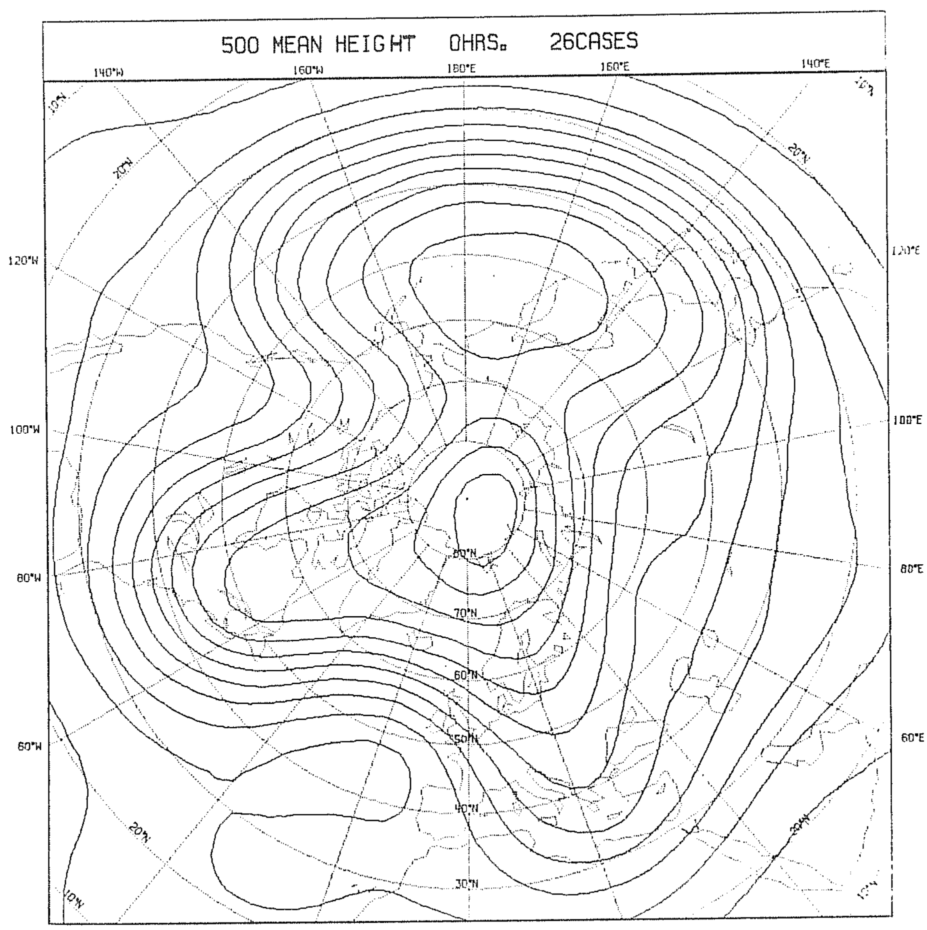


Fig. 4.9
Mean analysis
for the period
1-26 Jan. 1981

Mean 500mb anom.
correlation,
European area:
day 3 .85
day 5 .55
day 7 .25

Rank 17 out of 20

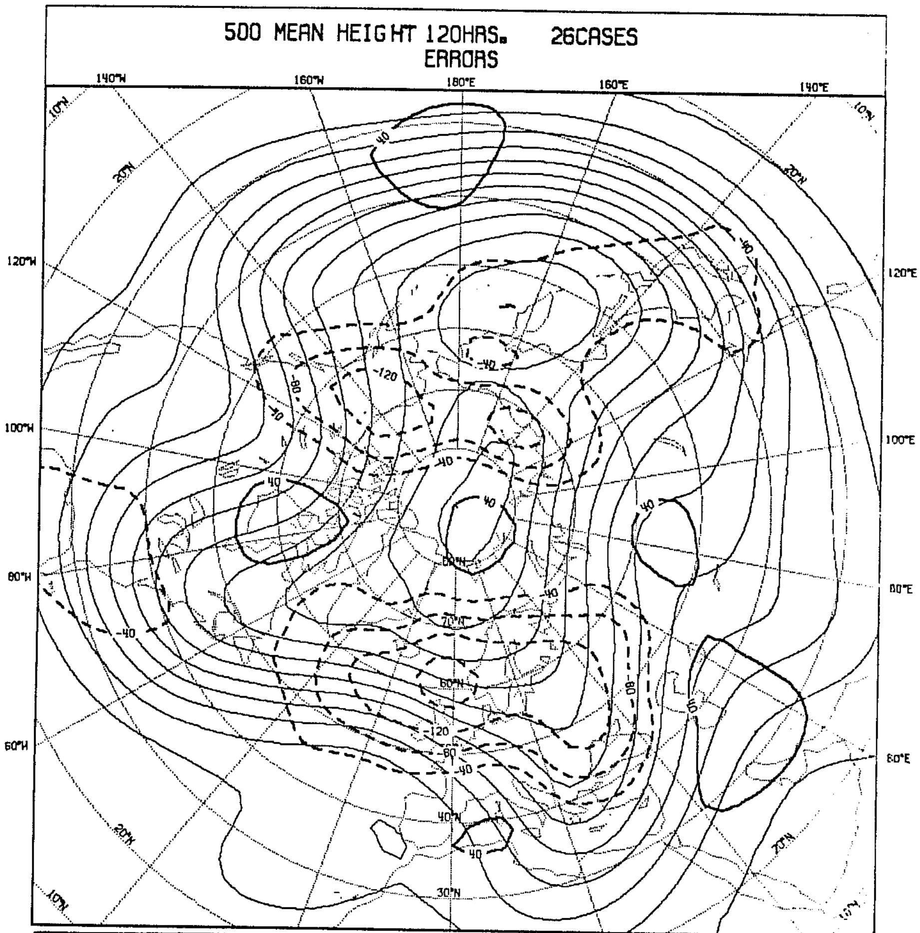


Fig. 4.10a
Mean day 5
forecast from
the period
1-26 Jan. 1981

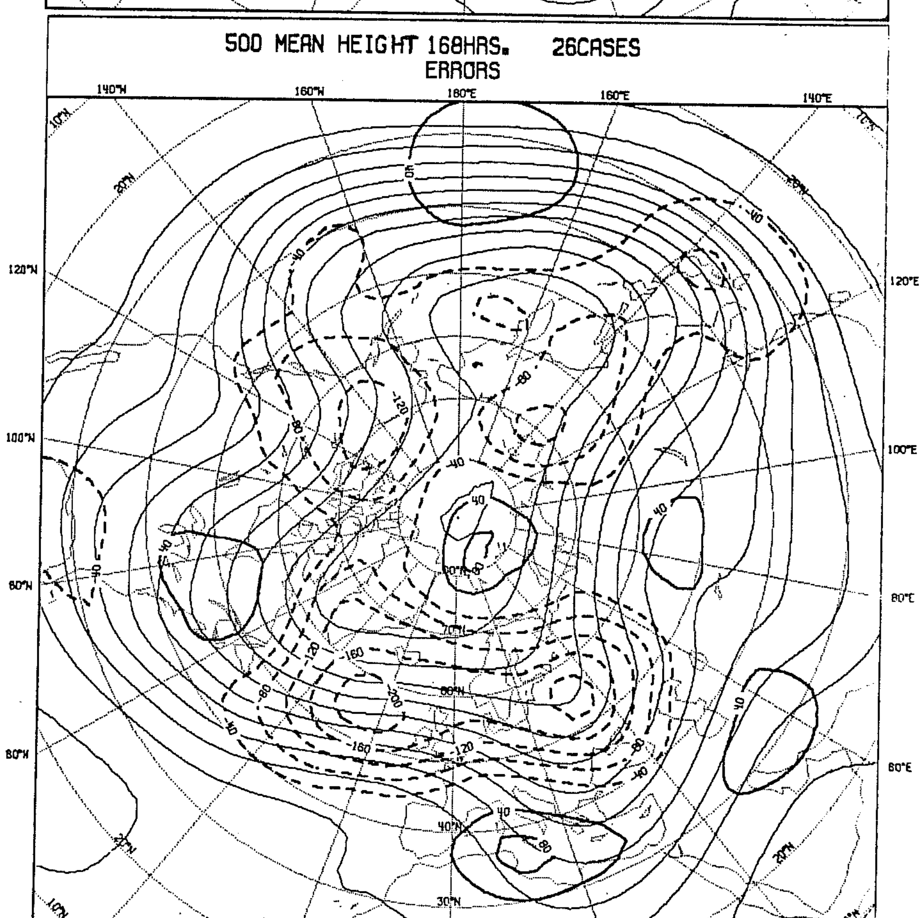


Fig. 4.10b
Mean day 7
forecast from
the period
1-26 Jan. 1981

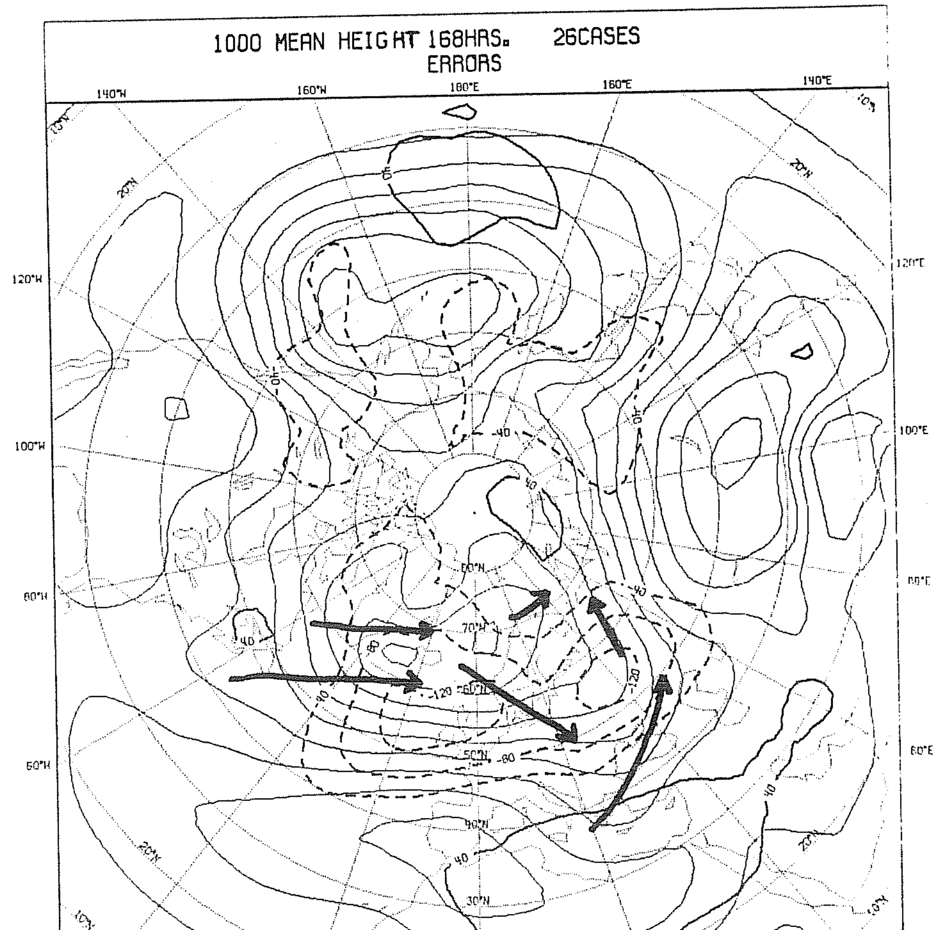


Fig. 4.11a
Mean day 7
forecast from
the period
1-26 Jan. 1981

Indication of
low tracks
from day 5 to
day 7,
European/
Atlantic area

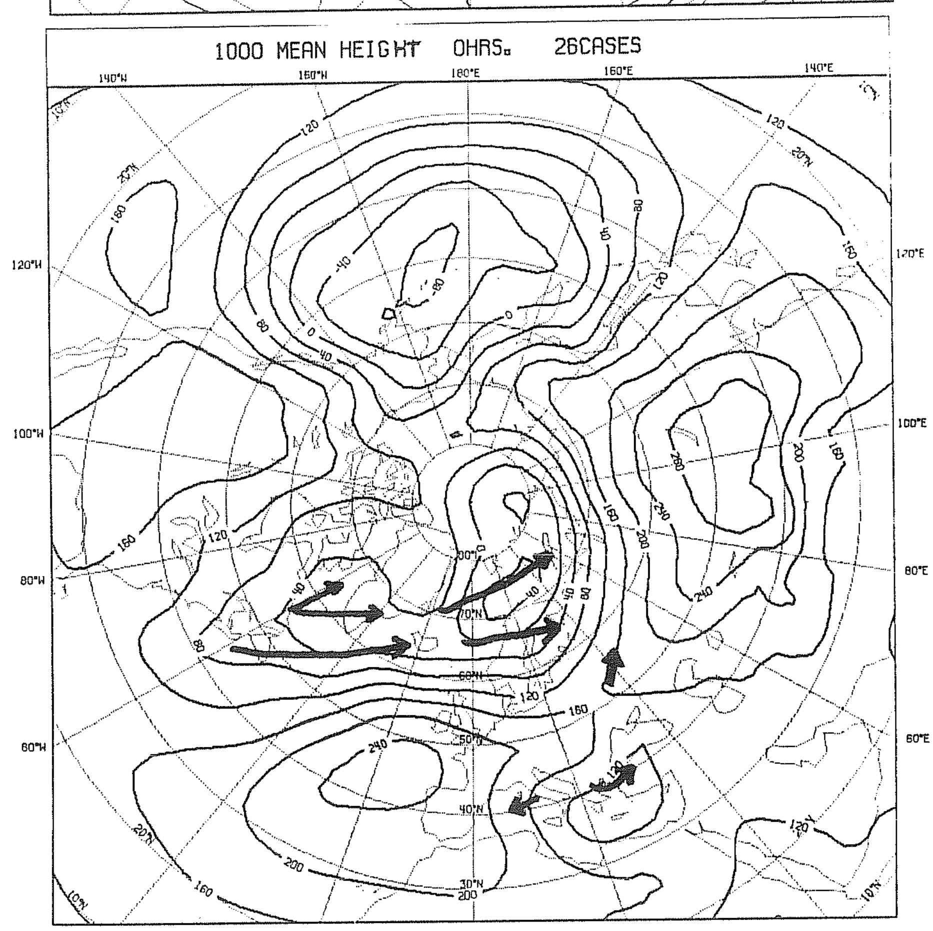
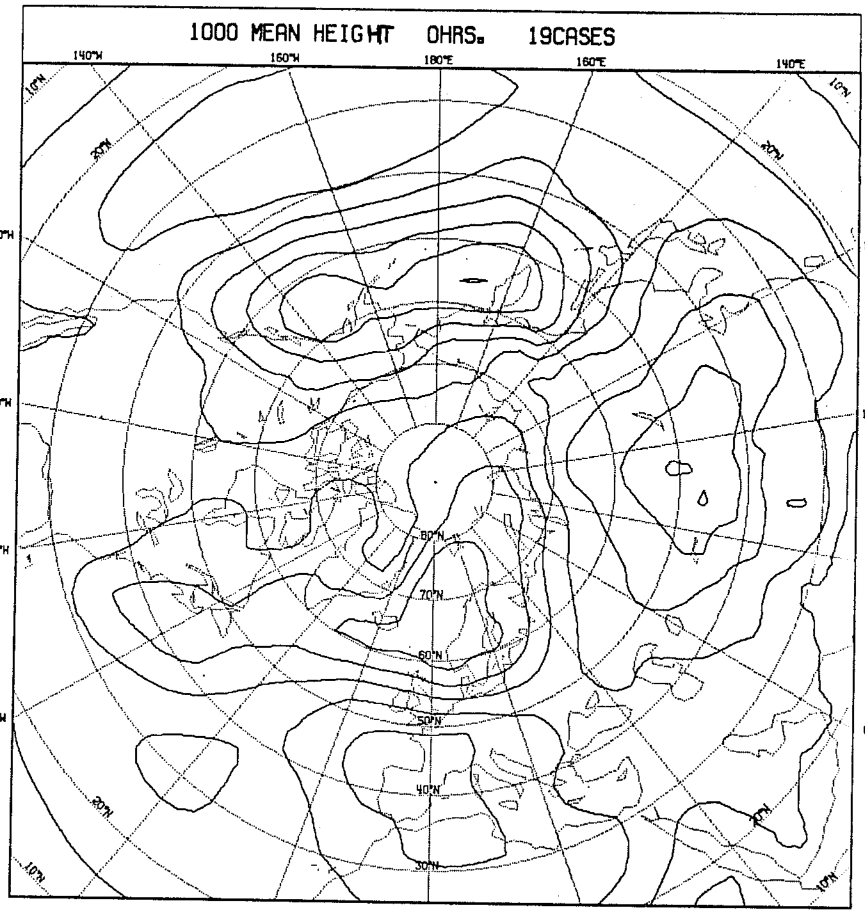


Fig. 4.11b
Mean
verification
analysis

Indication of
low tracks,
European/
Atlantic area



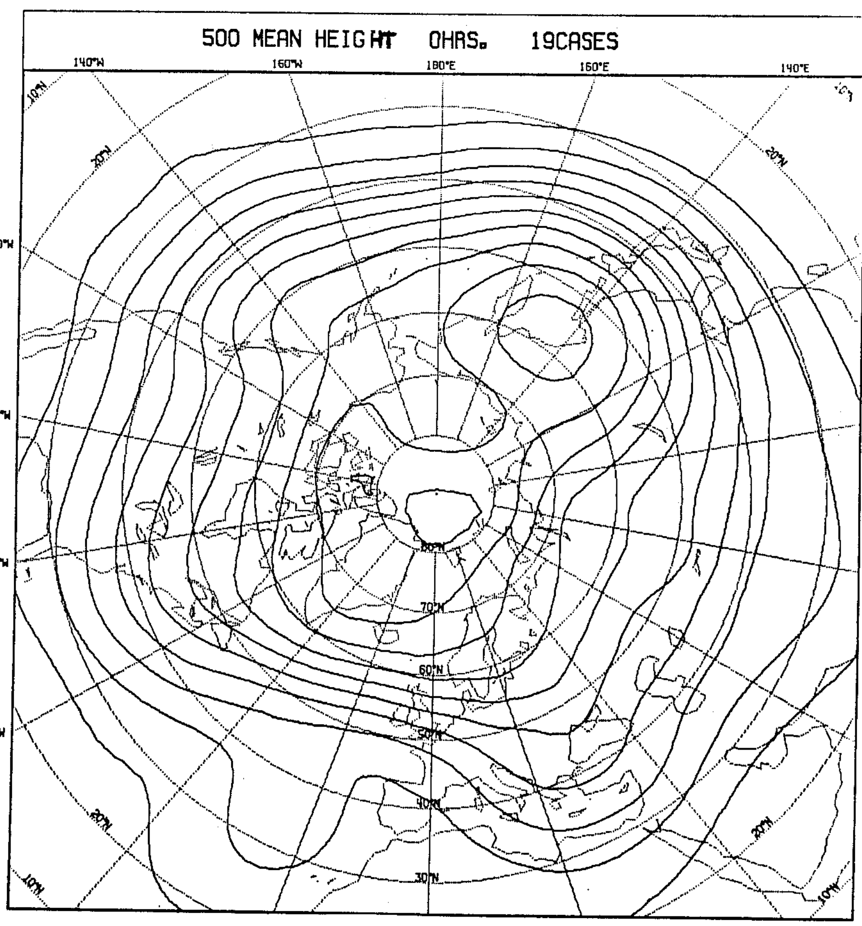


Fig. 4.12
Mean analysis
for the period
11-29 Nov. 1981

Mean 500mb anom.
correlation,
European area:
day 3 .91
day 5 .70
day 7 .56

Rank 9 out of 20

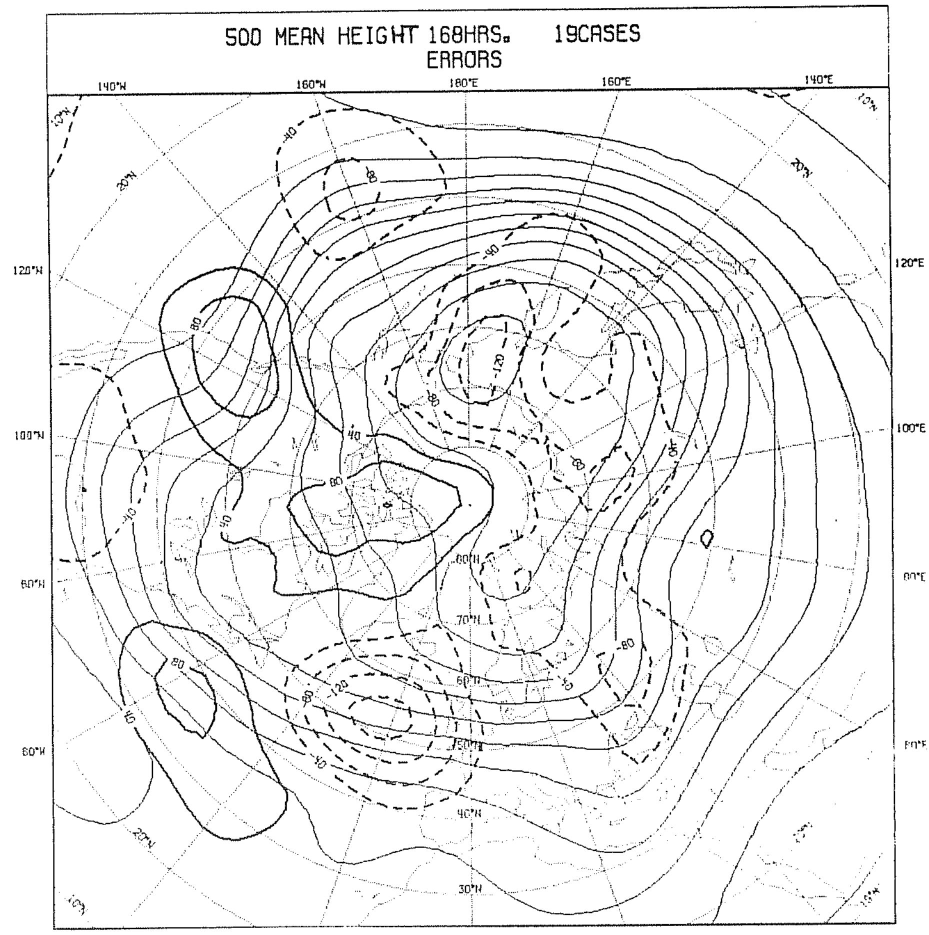


Fig. 4.13a
Mean day 7
forecast from
the period
11-29 Nov. 1981

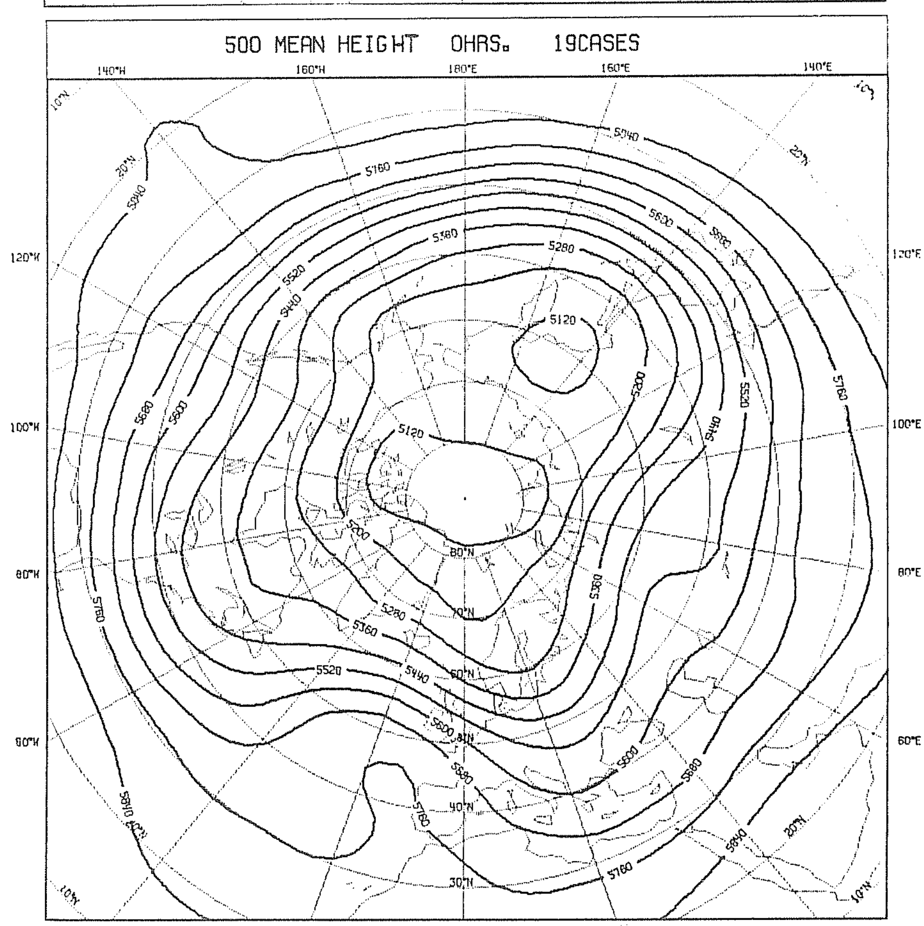


Fig. 4.13b
Mean
verification
analysis

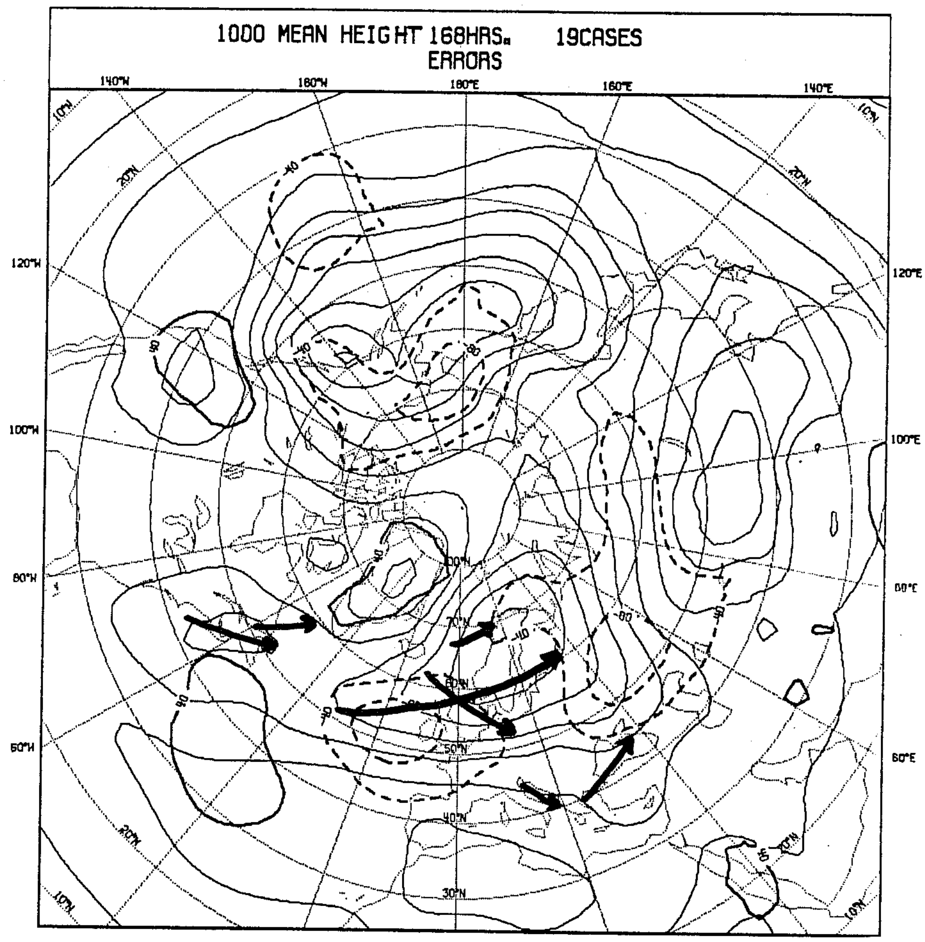


Fig. 4.14a
Mean day 7 forecast from the period 11-29 Nov. 1981

Indication of low tracks from day 5 to day 7, European/ Atlantic area

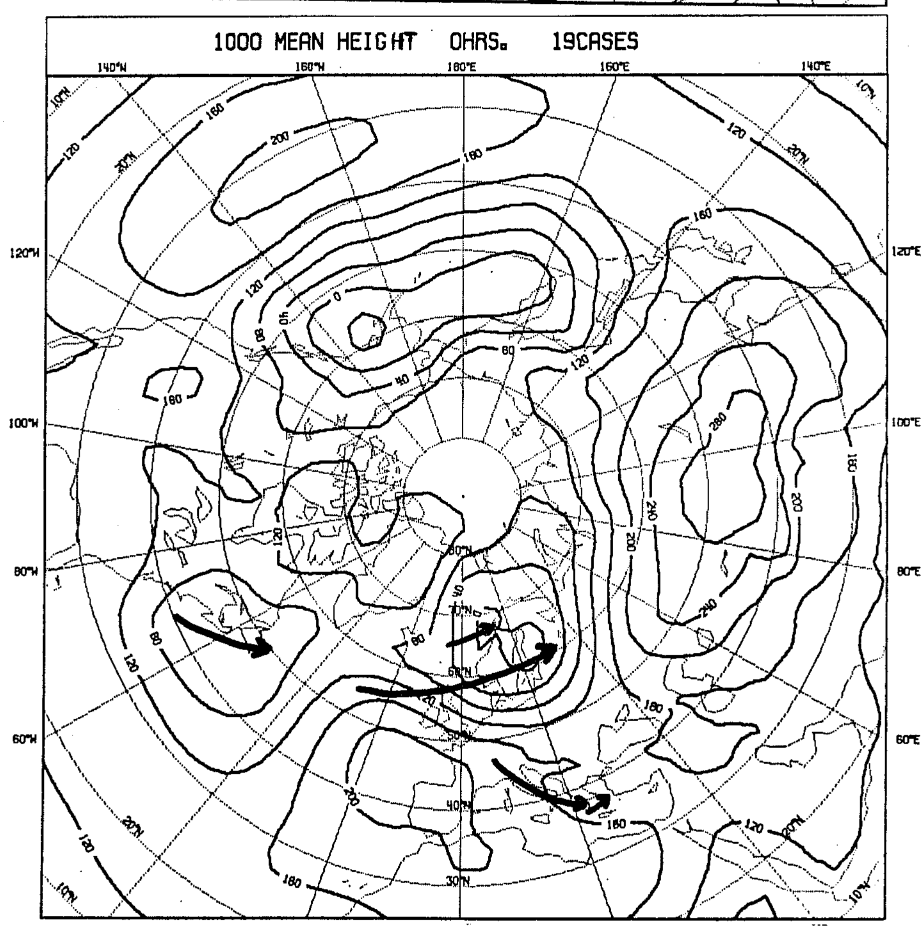
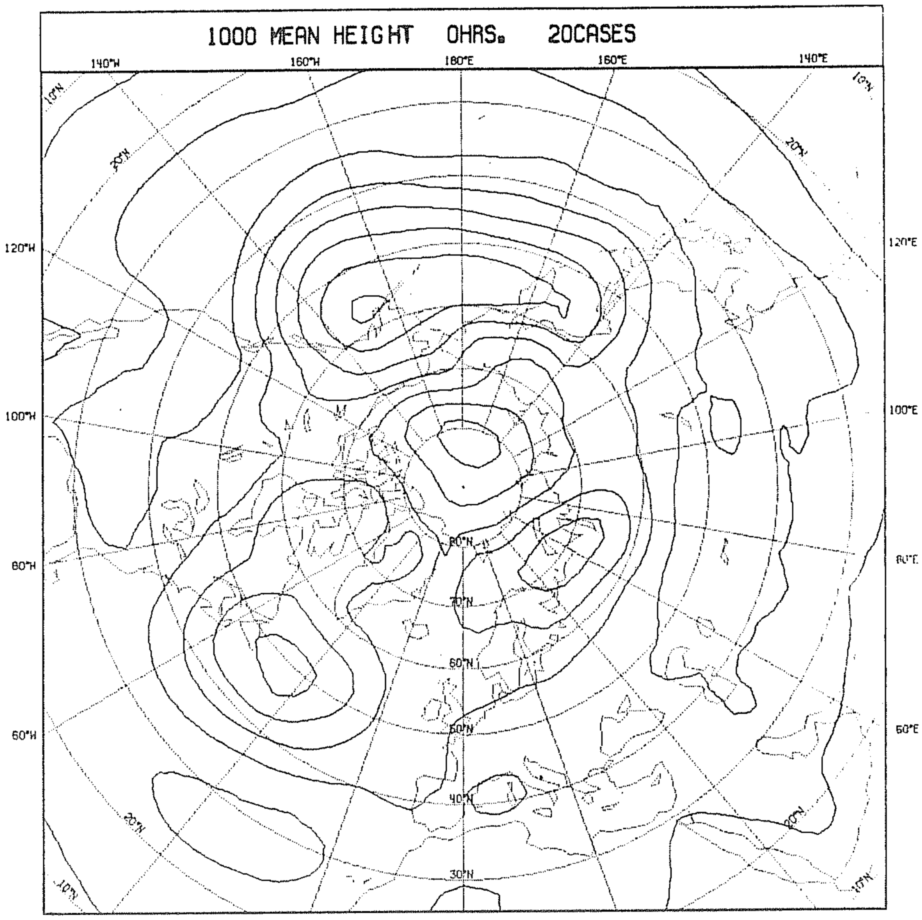


Fig. 4.14b
Mean verification analysis



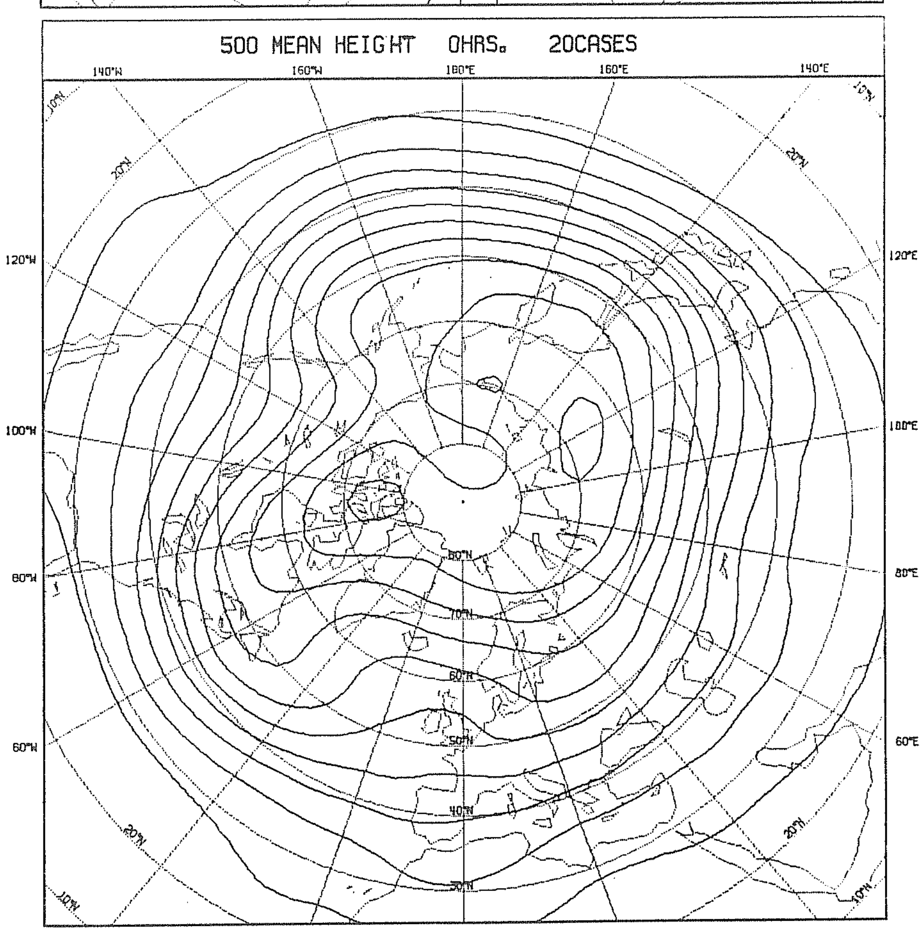


Fig. 4.15
Mean analysis
for the period
1-20 Nov. 1980

Mean 500mb anom. correlation, European area:
day 3 .90
day 5 .75
day 7 .60

Rank 4 out of 20

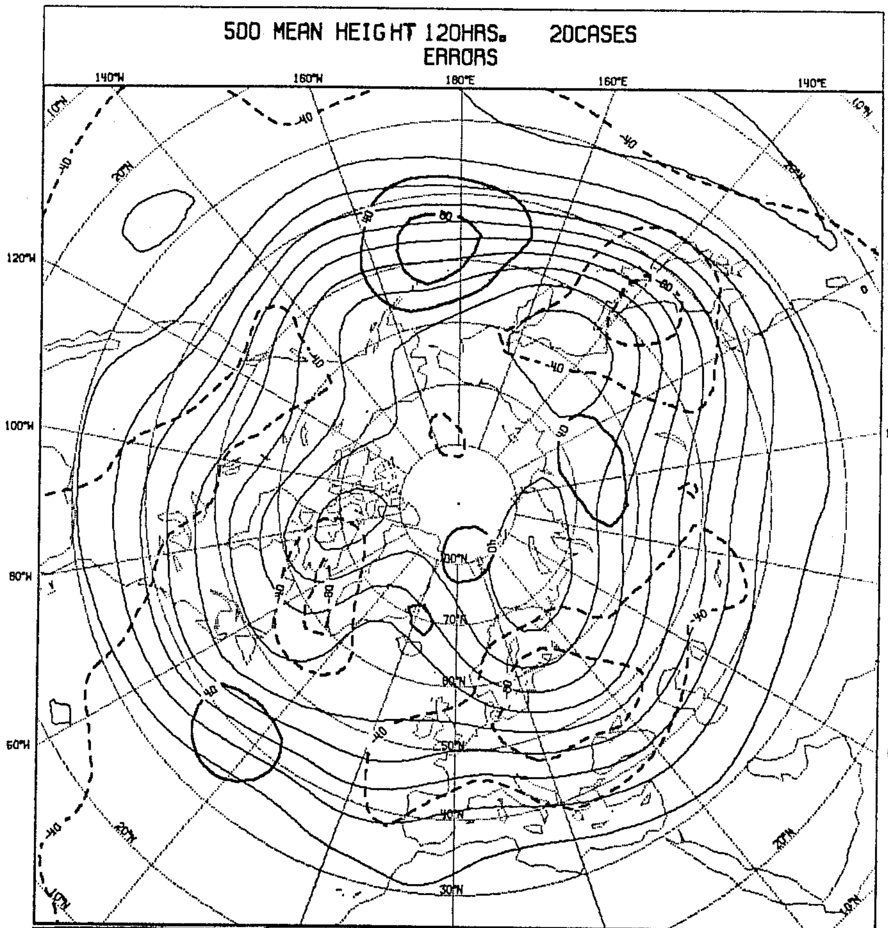


Fig. 4.16a
Mean day 5
forecast from
the period
1-20 Nov. 1980

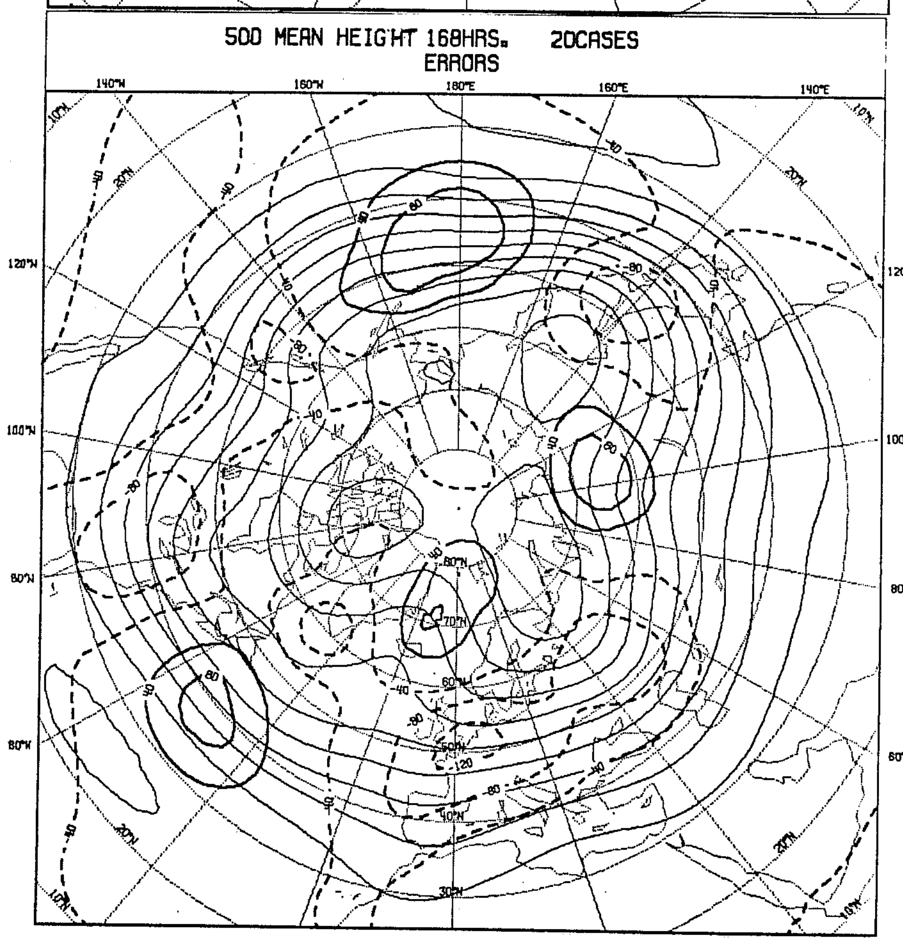


Fig. 4.16b
Mean day 7
forecast from
the period
1-20 Nov. 1980

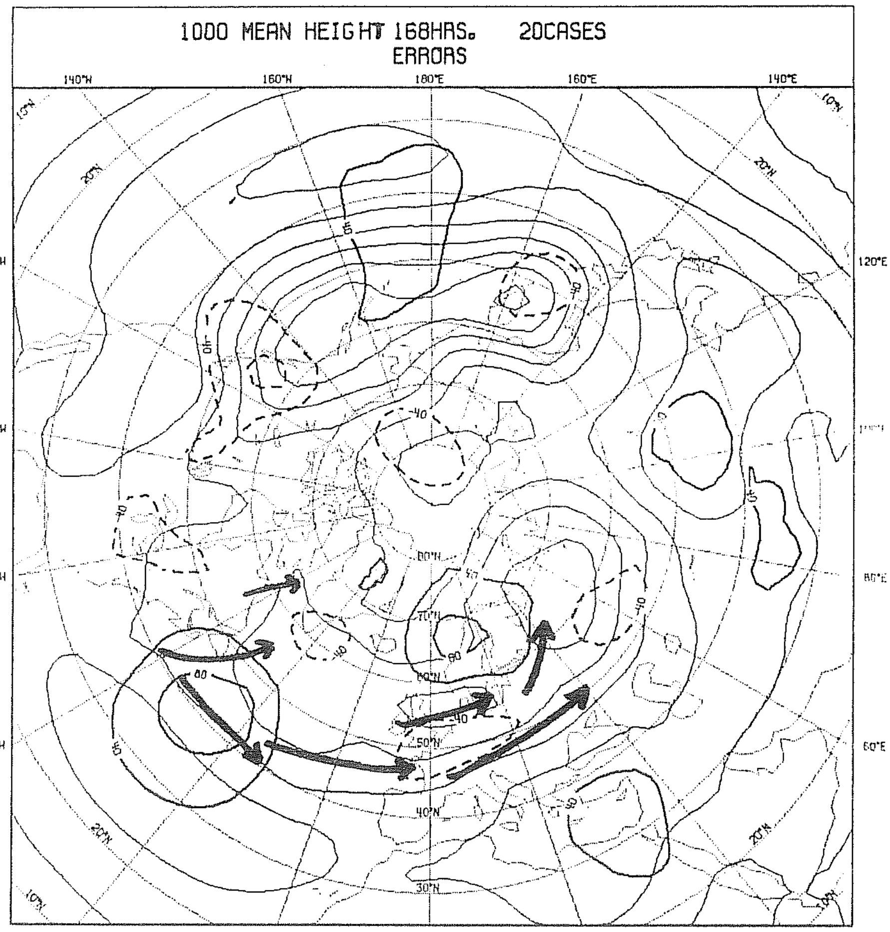


Fig. 4.17a
Mean day 7
forecast from
the period
1-20 Nov. 1980

Indication of
low tracks
from day 5 to
day 7,
European/
Atlantic area

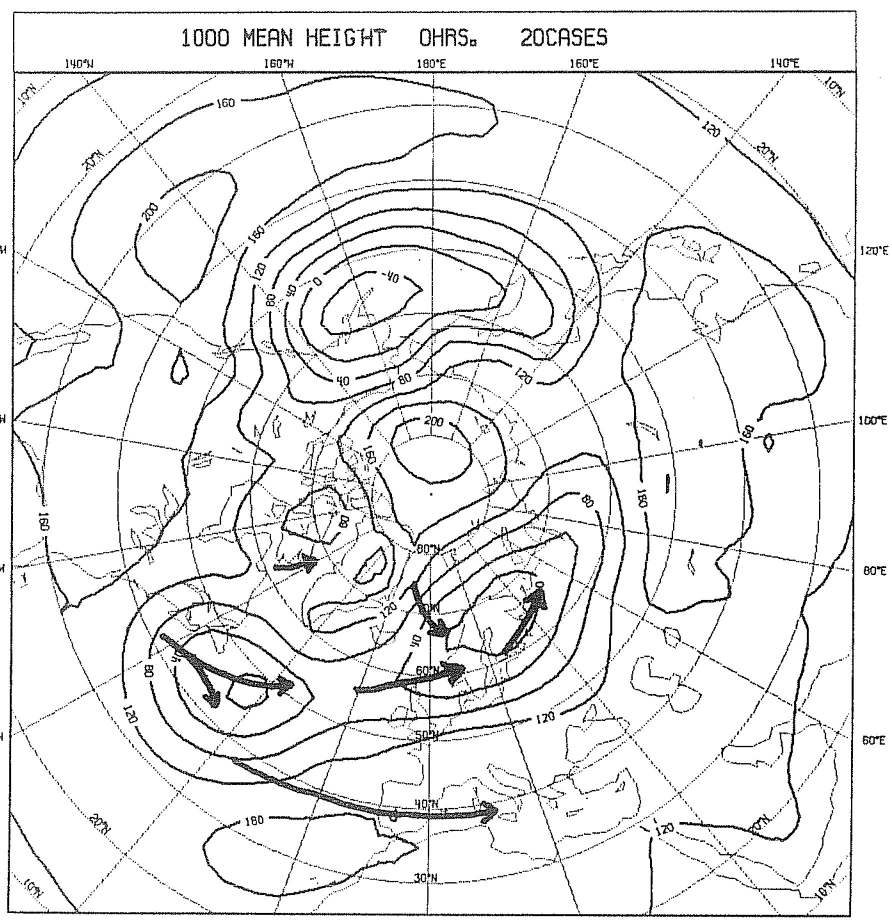
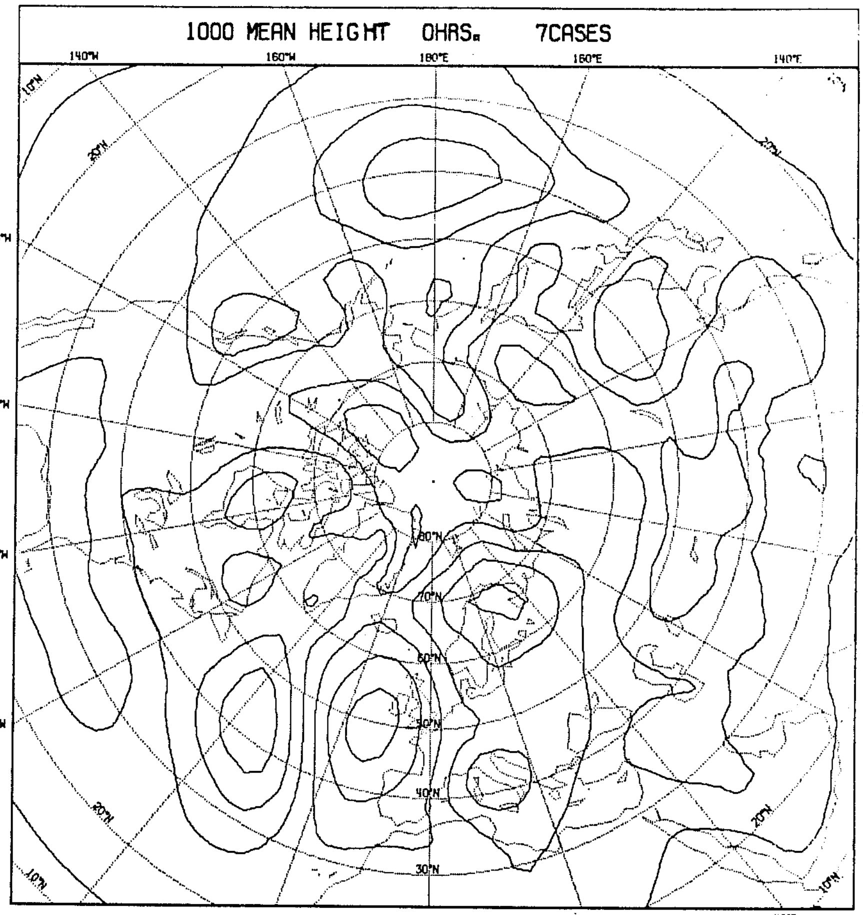


Fig. 4.17b
Mean
verification
analysis

Indications of
low tracks,
European/
Atlantic area



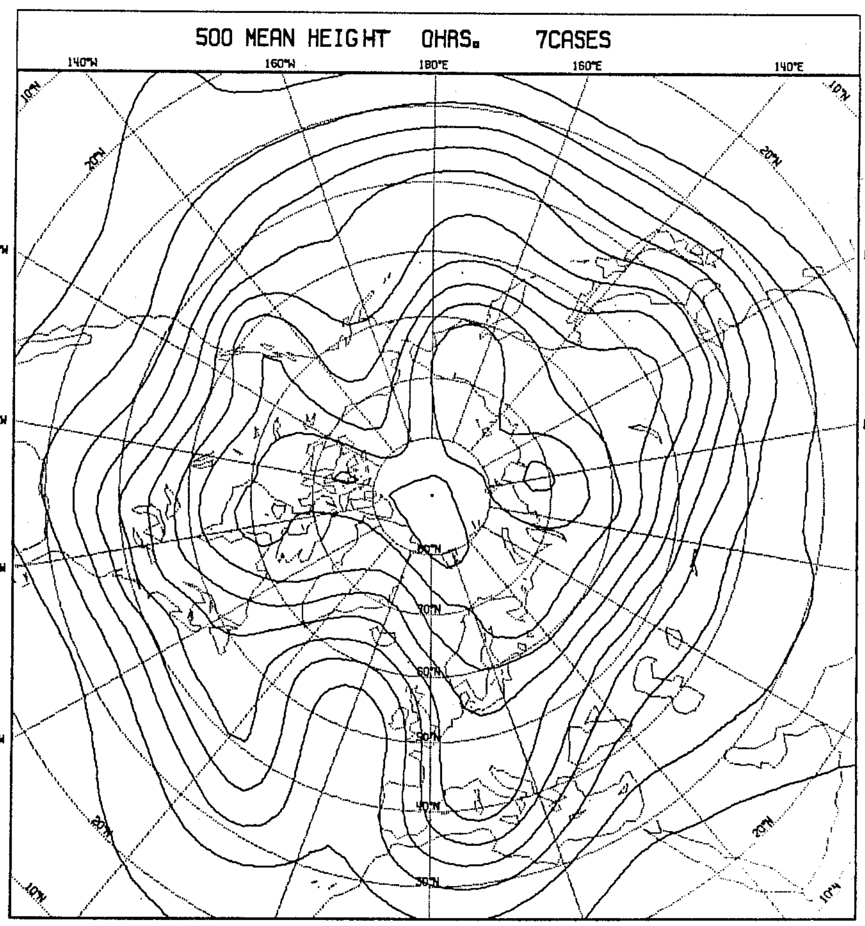


Fig. 4.18
Mean analysis
for the period
27 Nov.-3 Dec. 1980

Mean 500mb anom.
correlation,
European area:
day 3 .88
day 5 .75
day 7 .68

Rank 3 out of 20

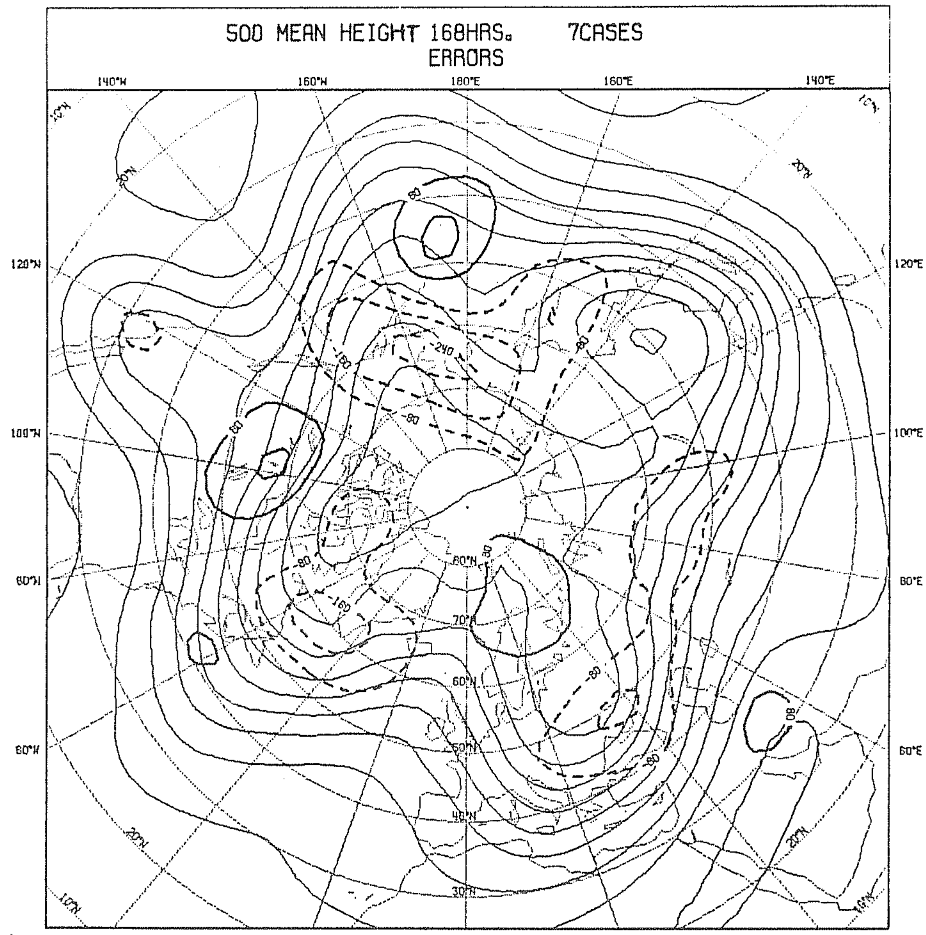


Fig. 4.19a
Mean day 7
forecast from
the period
27 Nov.-3 Dec. 1980

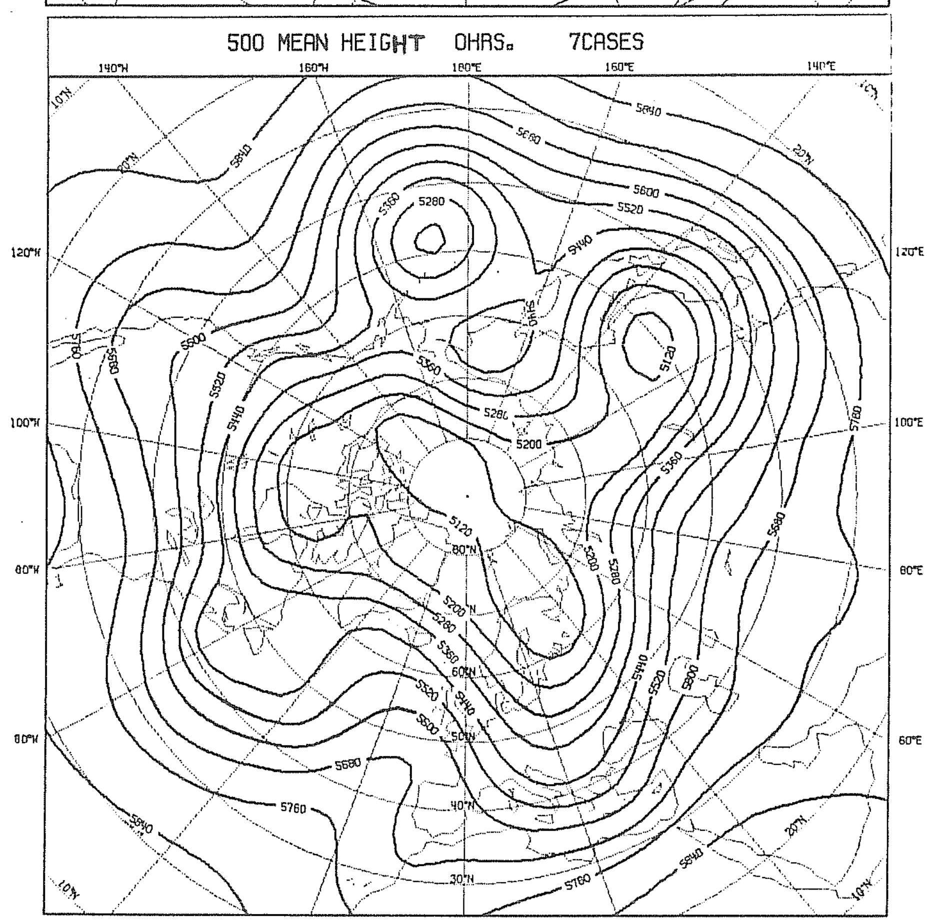


Fig. 4.19b
Mean
verification
analysis

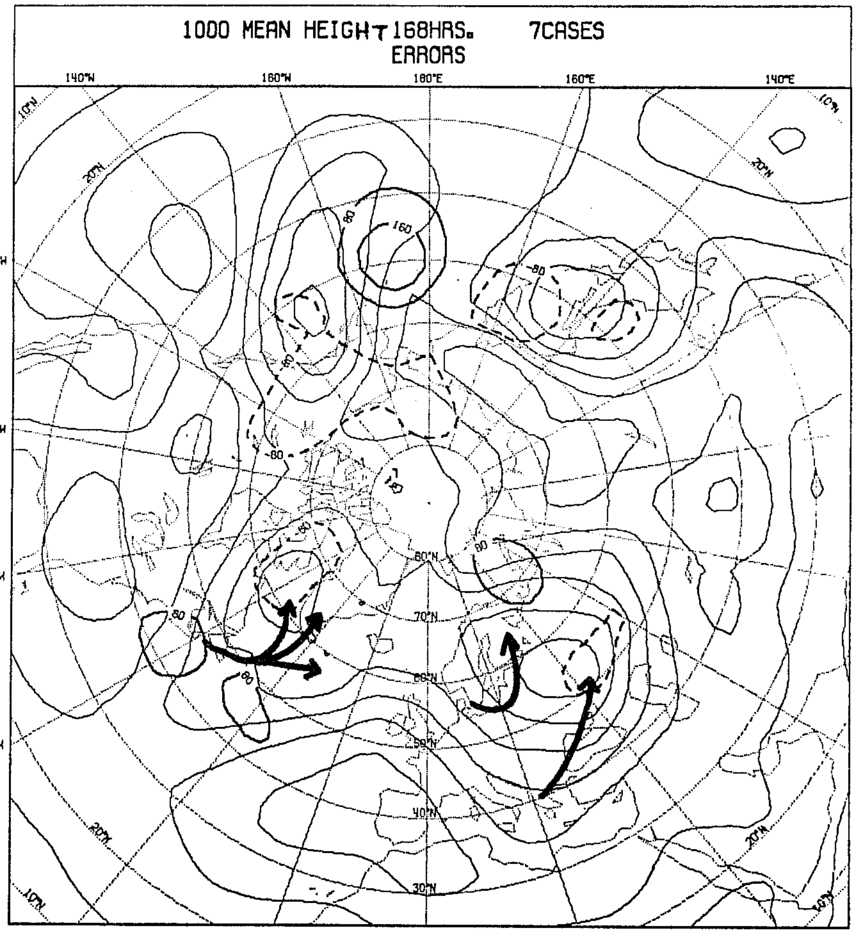


Fig. 4.20a
Mean day 7
forecast from
the period
27 Nov.-3 Dec. 1980

Indication of
low tracks
from day 5 to
day 7,
European/
Atlantic area

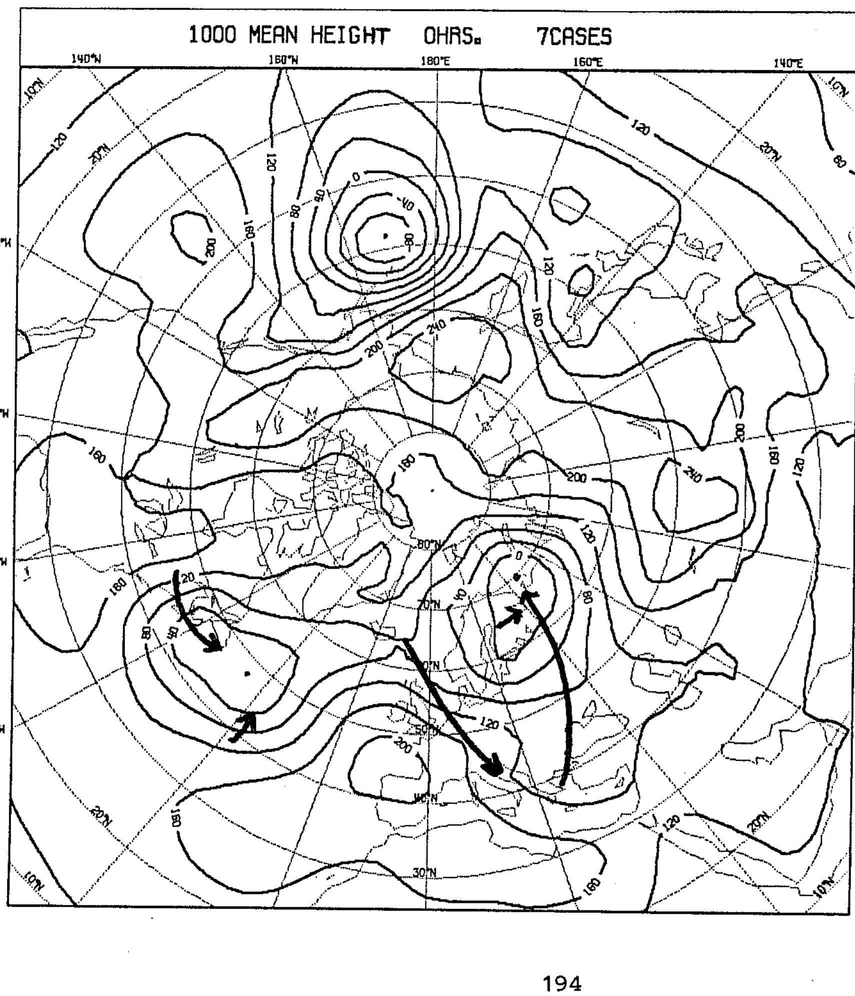


Fig. 4.20b
Mean
verification
analysis

Indication of
low tracks,
European/
Atlantic area

11-29 November 1981. SW-European blocking, Zonal north European flow

Also this situation, Figs. 4.12, 4.13 and 4.14, shows a westerly zonal Atlantic flow with a split in the 500mb flow over Europe.

The surface high is now situated over southwestern Europe and blocking in this area is involved. The situation covers 19 days and the quality of the forecasts is relatively high; the rank is 10 out of 20. The errors are well in accordance with the former situations, the Atlantic ridge at 500mb is broken down at day 7. The errors connected to the split are, however, much smaller. At 1000mb the typical filling errors connected to the trough are also smaller, but clearly present, especially on the eastern side of the trough. The errors in the low tracks are relatively small, but of the same type as earlier. The high scores are probably connected to the presence of the persisting southwestern European blocking.

1-20 November 1980. North Atlantic blocking

The rest of the situations are dominated by even more typical blocking. The first example, of a North Atlantic blocking (Figs. 4.15, 4.16, 4.17) covers 20 days and the rank is 4 out of 20. The systematic errors, with negative amplitudes, are first of all connected to the European trough with branches along the zonal flow. The forecasts manage to maintain the blocking structure, though the shape of it is distorted. At 1000mb the negative amplitudes connected to the eastern European trough are small, but the filling problem is recognised. The surface low is placed too far east and so is the Greenland ridge. According to the track indications, the European low activity is too far to the south.

27 November - 3 December 1980. Atlantic blocking

Two cases with Atlantic blocking in a more southerly position will now be presented. The first, Figs. 4.18, 4.19, 4.20, is an early winter case which covers just 7 days and the rank is 3 out of 20. The day 7 500mb map shows that the mean forecast manages to maintain a clear Atlantic ridge. The mean negative errors are again connected to the troughs and the shape of the ridge is altered in much the same manner as in the former case. The 1000mb maps again show the European low in a wrong position, this time too much to the southeast. The western European ridge is fairly well predicted and contributes to the high score. There are large errors in the low tracks. In the western low area, the cyclones penetrate too far into the ridge and in the European area the low activity is too strong in the southeast and the tracks from northwest are missing.

16-30 April 1981. Atlantic blocking

The other situation covers 15 days. The blocking is now weaker and the scores are lower, the rank is 14 out of 20. The maps are found on Figs. 4.21 and 4.22. The systematic error at 500mb shows that the ridge is being broken down, in a similar way to that in the situations with zonal flow and a ridge southwest of Europe. At 1000mb, large errors connected to the European low are present. As in the former case, the low tracks are too far southeast, and the filling problem seems to be larger. The errors in the low tracks are similar to those in the former case, but larger. The lows at Newfoundland do succeed in breaking down the ridge and in Europe, the activity is too far to the south.

8-25 May 1981. European blocking

The last map series, Figs. 4.23, 4.24 and 4.25, in this chapter show a situation with a solid European blocking. The situation covers 18 days and is ranked as 2. The 500mb errors connected to the mean day 7 forecast show some similarities to the other blocking situations. The amplitudes connected with the troughs are negative with the largest values on the eastern side of the ridge. The shape of the ridge is somewhat distorted and positive errors are also here found at the northern flank. At 1000mb the eastern low has a wrong position and is too strong. The shape of the west European low is stretched in the North-South direction. The tracks show that cyclone activity attacks the ridge in the north without breaking it down.

5. CHARACTERISTICS OF SOME MEDIUM RANGE FORECASTS WITH HIGH AND LOW SCORES

Now the shorter periods (< 7 days) with relatively high and relatively low anomaly correlation coefficients will be considered. In Table 5.1, 22 situations with high scores at day 5 and day 7 are listed and, in Table 5.2, 17 cases with low scores are listed in a similar way. A few words are written in the two tables to characterise the largescale synoptic situation and, for the cases with low scores, a few words are written about failures in the forecast. As for the longer periods, mean maps for 500 and 1000mb are computed, but none of them will be presented here.

From the high score cases in Table 5.1, it is seen that high correlation coefficients at day 5 and day 7 are connected to situations with blocking or persistent cut off lows. Altogether 20 out of the 22 belong to this category; the blocking or cut off lows are present either in the analysis or predicted within 3 days. Of these situations, 16 could be characterised as ordinary

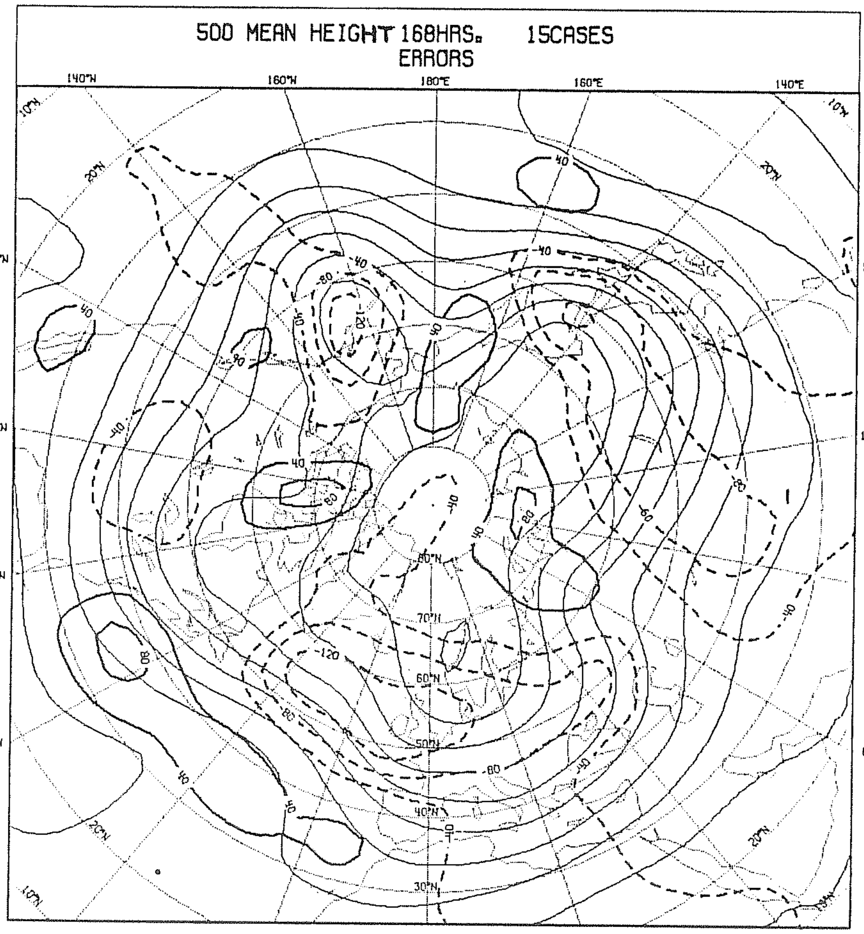


Fig. 4.21a
Mean day 7
forecast from
the period
16-30 Apr. 1981

Mean 500mb anom.
correlation,
European area:
day 3 .87
day 5 .60
day 7 .41

Rank 14 out of 20

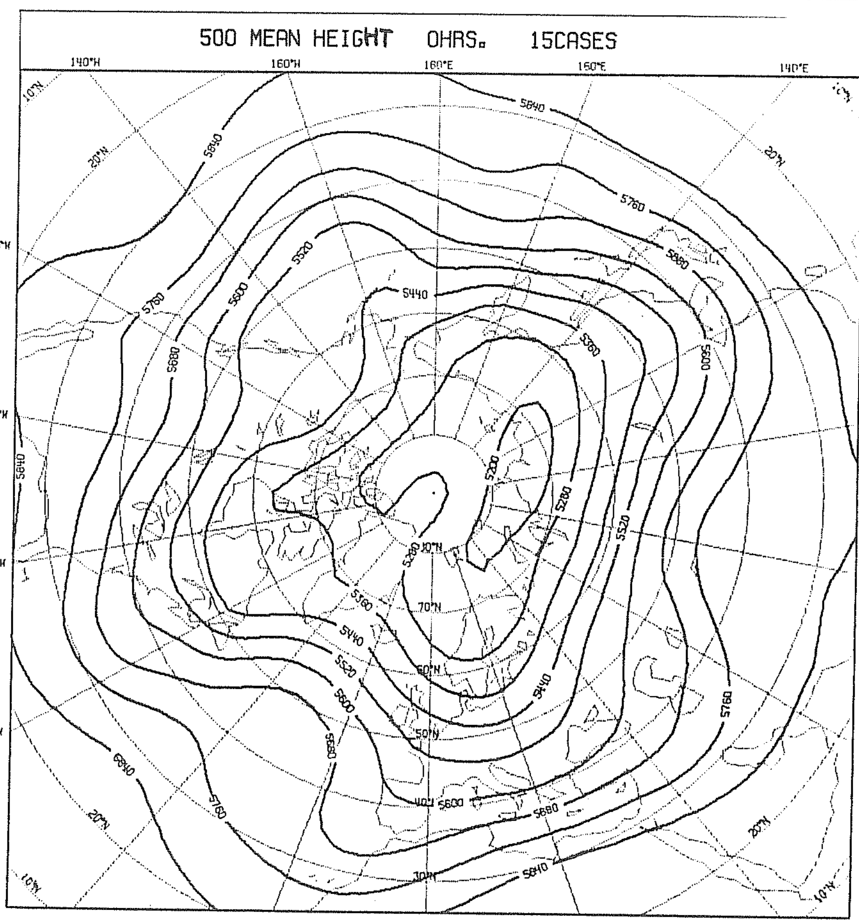


Fig. 4.21b
Mean
verification
analysis

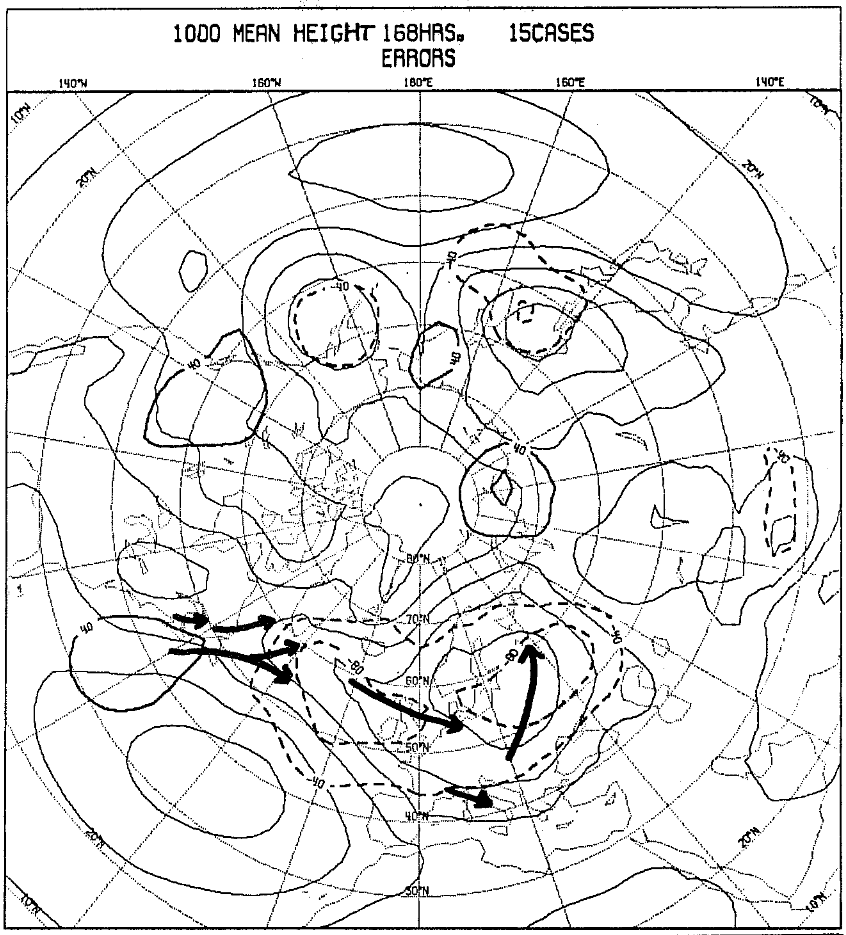


Fig. 4.22a
Mean day 7 forecast from the period 16-30 Apr. 1981

Indication of low tracks from day 5 to day 7, European/ Atlantic area

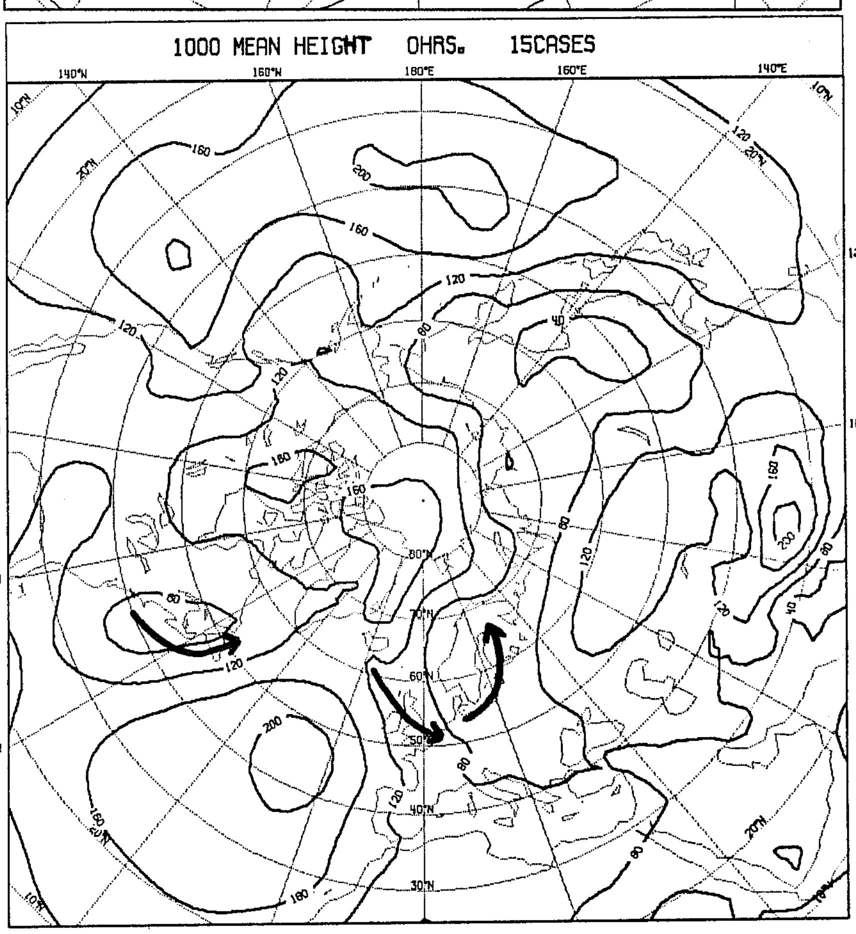


Fig. 4.22b
Mean verification analysis

Indication of low tracks, European/ Atlantic area

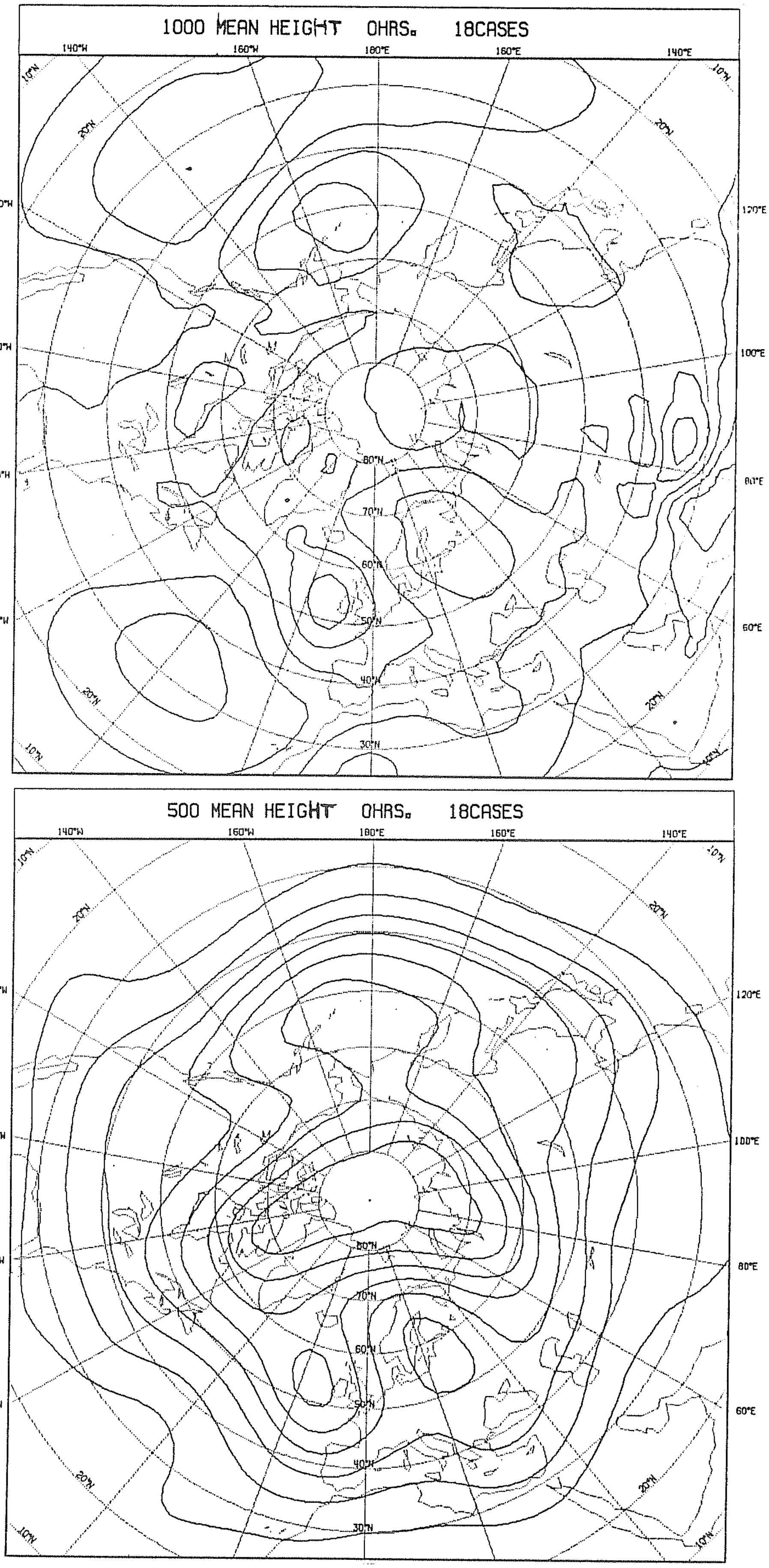


Fig. 4.23
Mean analysis
for the period
8-25 May 1981

Mean 500mb anom.
correlation,
European area:
day 3 .93
day 5 .82
day 7 .68

Rank 2 out of 20

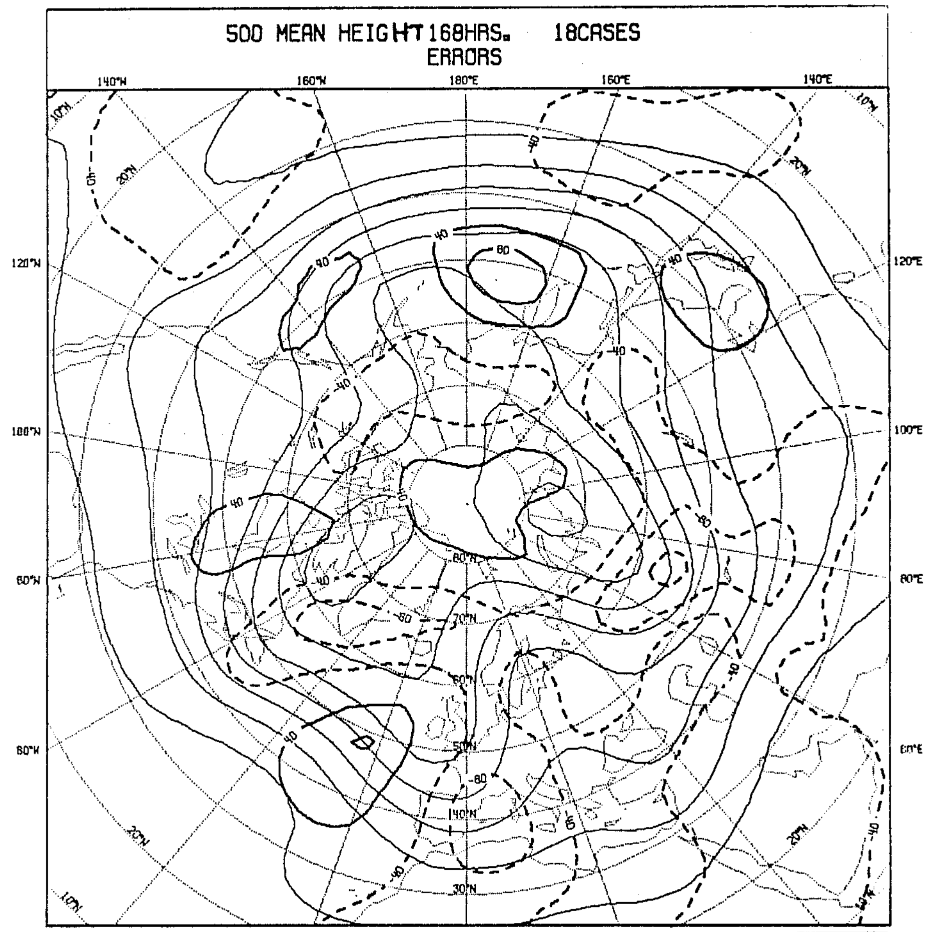


Fig. 4.24a Mean day 7 forecast from the period 8-25 May 1981

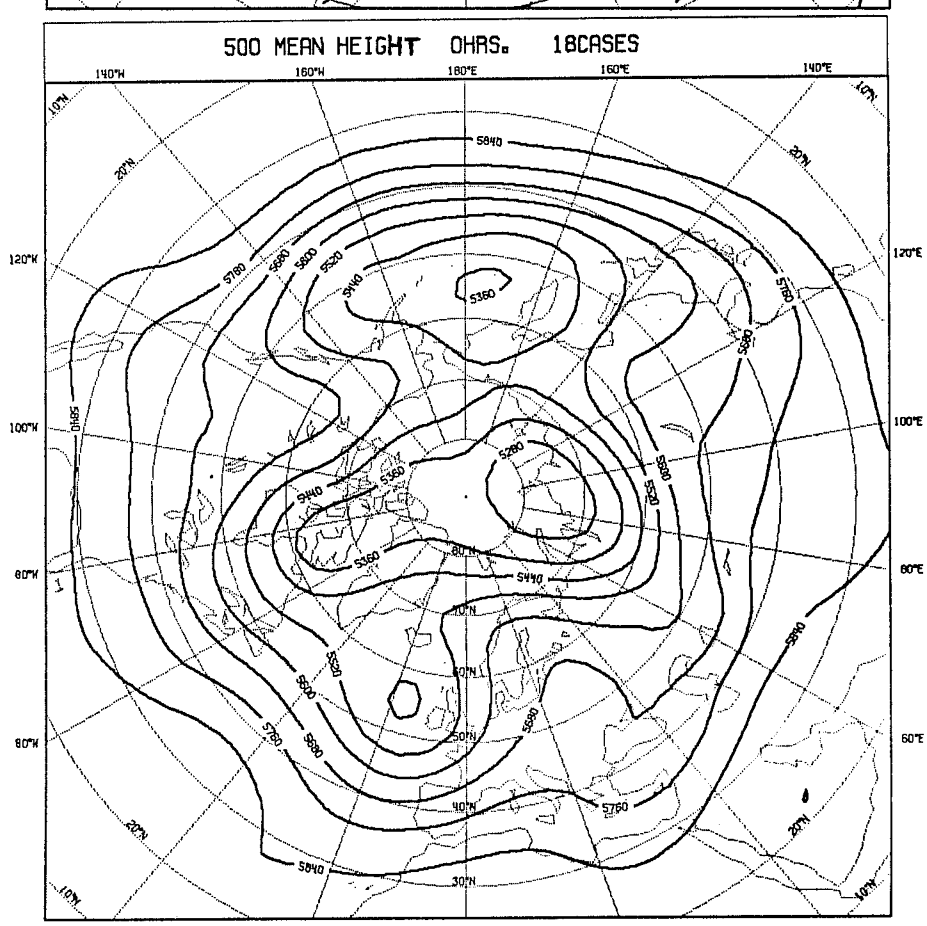


Fig. 4.24b Mean verification analysis

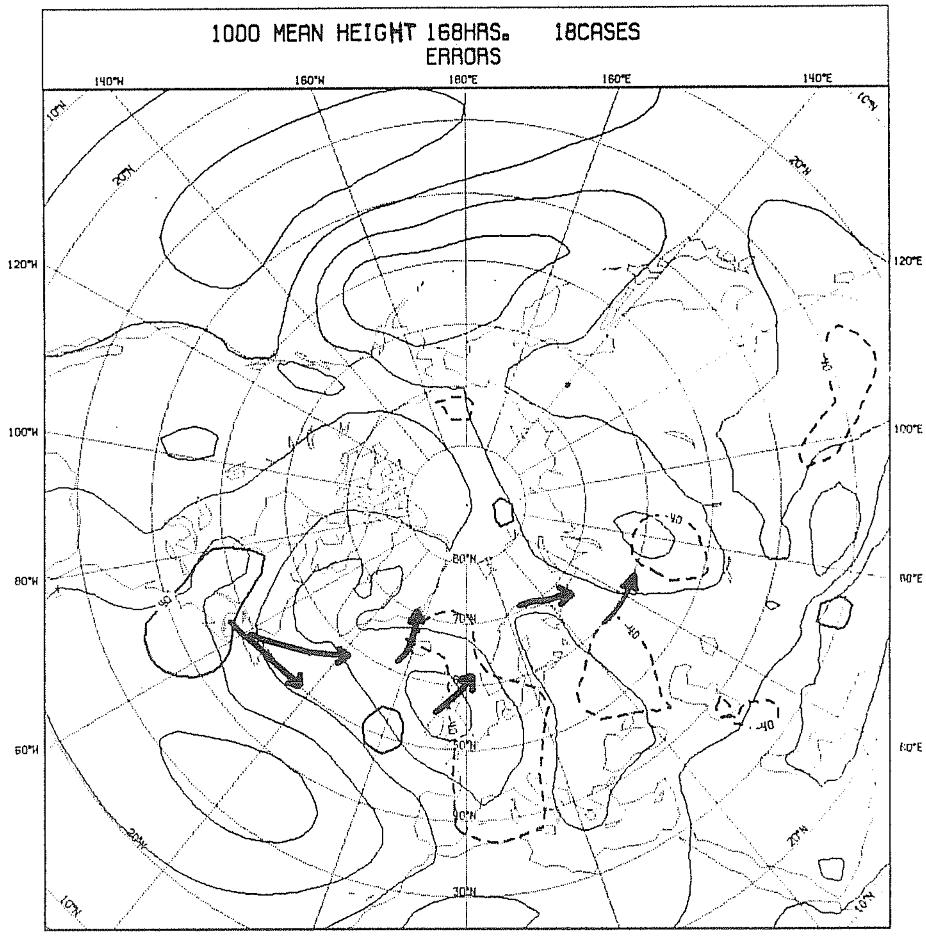


Fig. 4.25a
Mean day 7
forecast from
the period
8-25 May 1981

Indication of
low tracks from
day 5 to day 7
European/
Atlantic area

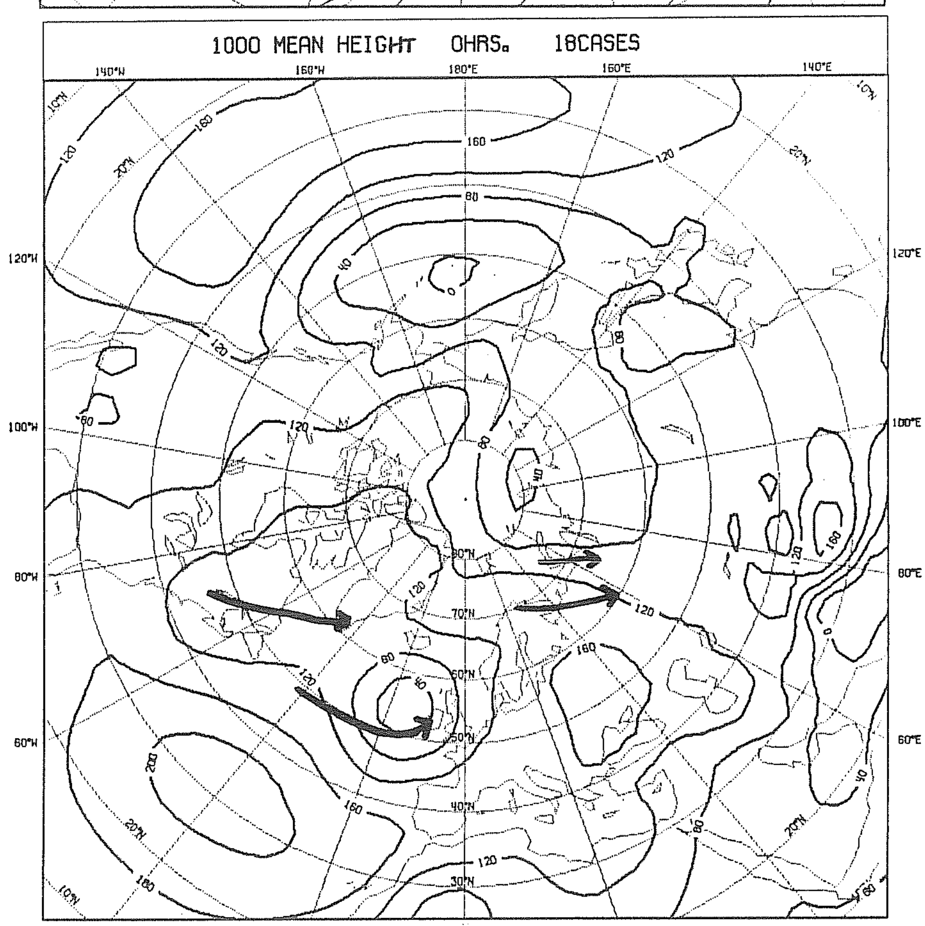


Fig. 4.25b
Mean
verification
analysis

Indication of
low tracks,
European/
Atlantic area

RANK	STARTING DATE	NO OF DAYS	MEAN 500 MB ANOM.CORR. Day 3	Day 5	Day 7	FLOW TYPE
1	810503	4	.93	.91	.89	Atl. block.,later Eur. block.
2	801227	4	.93	.89	.85	SW Eur. block.
3	800609	3	.92	.80	.74	Atl. block, later Eur. block.
4	810301	4	.92	.80	.72	Atl. block.
5	800615	4	.88	.80	.78	Eur. block.
6	801008	6	.88	.80	.73	Atl. block building up,cut off SE Eu.
7	811124	5	.87	.82	.71	Weak SW Eur. block,later Eur. blo.
8	800511	5	.91	.82	.66	Eur. block
9	800113	3	.85	.76	.72	Atl., Eur. block.
10	800127	3	.87	.72	.72	Atl. block
11	810210	6	.80	.77	.72	Cut off SW-Eur., later cut off SE Eu
12	810305	4	.92	.77	.68	Canada block, S. Atl/Eur zon. flow
13	801107	6	.89	.78	.68	Atl. block,broken down
14	810816	3	.80	.75	.70	Zonal Atl.,SW Eur. block predicte
15	800323	3	.87	.72	.68	Canada block, S. Atl/Eur zon. flow
16	800721	4	.85	.75	.60	Cut off SE Eur.
17	800708	3	.79	.68	.65	Weak N. Atl. block
18	810912	3	.89	.65	.65	Eur block,Strengthening
19	800622	6	.90	.70	.60	N Eur. blocking
20	800904	4	.83	.65	.60	Zonal Atl./Eur. flow (50-60°N)
21	800818	3	.90	.72	.30	Zonal Atl. flow(55°N),SW Eur high building up
22	800701	3	.88	.72	.30	Zonal Atl. flow(50°N) Weak N Eur. block

Table 5.1 Selected periods, < 7 days, with relative high anomaly correlation for the European area.

RANK	STARTING DATE	NO OF DAYS	MEAN 500 MB ANOM. CORR. Day 3	Day 5	Day 7	FLOW TYPE
1	800106	4	.80	.10	−.25	Atl. split,Atl. block.from day 5 not predicted
2	800120	3	.85	.20	−.20	Zonal flow(40°N),ridges Greenland and Scandin. N Eur. block from day 5 not predicted
3	810726	4	.68	.35	−.20	Zonal flow(50°). Failed to fill low N Eur.
4	810405	3	.78	.45	−.20	Atl. split,Eur. block from day 5 not predicted
5	800829	5	.65	.20	−.15	ZonalAtl. flow(50°N),split Eur. N Eur. ridge not predicted
6	810310	4	.65	.35	−.10	Zonal flow(35°N Atl,45°N Eur.) phase and filling problems
7	800203	5	.84	.48	−.10	Zonal flow(40°N Atl,45°N Eur.) Eur. ridge from day 5 not predicted
8	800813	5	.70	.30	.10	Zonal Atl. flow(45°N),split Eur. Large changes in Eur. not predicted
9	810120	5	.87	.50	.10	SW Eur.block.,broken down. Atl. ridge from day 5 not predicted
10	800326	2	.82	.30	.15	Zonal flow(35°N Atl.,40°N Eur.) phase and filling problems
11	800714	3	.78	.50	.10	Zonal flow(45°N),Cut off from day 5 not predicted
12	810204	6	.85	.50	.10	Zonal flow(45°N),split Eur. Cut off after day 3 not predicted
13	800217	3	.87	.55	.10	Zonal(45°N),split Eur. Eur. block after day 3 not properly predicted
14	810708	6	.80	.40	.30	Zonal flow(50°N),split Eur. Typical errors,not so bad predicted
15	811106	4	.90	.60	.10	Zonal flow,N Eur. ridge. Problems with SW Eur. cut off after day 3
16	801015	3	.87	.50	.15	Atl. ridge, large changes
17	810612	4	.89	.55	.30	Zonal flow(45°N) Eur. block after day 3 not predicted

Table 5.2 **Selected periods, < 7 days, with relative high anomaly correlation for the European area.**

blocking in the European/Atlantic area. In two of the cases, there is blocking with the high situated at the eastern part of Canada and zonal flow in Europe, and in two situations, cutoff in southern Europe is involved. Just two situations are fully characterised as zonal flow and these are ranked close to the bottom of the table.

The situations with blocking are also those with the highest anomalies and it could be argued that the high coefficients are just due to these high values. On the other hand, when the forecast maps are inspected, relatively high subjective scores must be given to these cases. Such quasi-stationary largescale features will dominate the general situation and will not easily be broken down in the model and the scores therefore will remain high. Their presence seems to steer the zonal flows involved and to some degree prevents the negative effects of the systematic errors.

The cases with low scores, Table 5.2, only contain one situation with blocking and are characterised by a zonal mean flow in the Atlantic/European area. In ten of the cases altogether, the model fails to build up blocking or cut off lows in the forecast at day 5 and day 7. In five of these cases, an eastern Atlantic or European split is present in the mean analyses. In three of the cases, the forecasts fail to build up European ridges and, since this is also the case in the blocking situations, this seems to be a frequent error well in agreement with the earlier results. Two cases are characterised by a zonal Atlantic flow in a fairly southerly position.

6. CONCLUSIONS

Altogether 59 periods, ranging from 3 to 26 days, with relatively high and low quality within relatively stable large-scale synoptic situations are investigated. Systematic errors in terms of mean errors at day 5 and day 7 and errors in the low tracks from day 5 to day 7, are presented for some of the longer periods and, further, some characteristics for situations with high and low forecast scores are given.

There is a correspondence between errors in the low tracks and the scale and amplitude of the systematic errors. As quality score the anomaly correlation coefficient at 500mb for the European area is used. There is a reasonable correspondence between this correlation coefficient and the mentioned forecast errors in the same region.

The maps and tables presented are considered to be the main result of this investigation. The information found is in agreement with other verification results and general synoptic experience, and could be considered as a supplement to the monthly verification results. To some extent, the results might be of value to the forecaster when the actual medium range forecast is evaluated. Some general conclusions concerning the systematic errors and forecast quality are listed below.

1. The systematic errors are equivalent barotropic in structure and normally negative anomalies are built up in the European area. These errors are connected to the troughs and cyclonic areas so that the cyclonic activity is too strong and covers too large an area. The errors are also connected to the zonal flow so that this is moved southwards and so that the connected surface high is broken down.

These systematic errors have serious consequences for the European medium range forecast. Some details about this are found in the figures presented.

2. In blocking situations, the character of the systematic errors is similar, but with comparatively small amplitudes. Again negative anomalies will be connected to the troughs and the surface low will be too strong, especially east of the high. When the blocking is situated west of Europe, the connected European surface low will also be positioned too far towards southeast or east. The connected cyclone tracks will consequently be further south than observed. It is also typical that cyclonic activity on the western side of the ridge will try to break down the high/ridge. Positive anomalies are likely at the northern flank of the ridge.

3. When the persistent quasi-stationary large-scale synoptic features like blocking and cut-off lows are present in the Atlantic/European area in the analyses or predicted within the first three days of the forecast, the medium range forecasts have above average scores for Europe. This seems to be especially the case when a blocking high is situated over Europe, but also in cases with Atlantic blocking the European flow is comparatively well predicted.

4. In more zonal flow situations, the European forecast quality will usually be lower because of larger influence of the systematic errors as mentioned in 1., but also because of larger phase errors. As a consequence of the systematic errors (negative amplitudes) the model often fails to predict European blocking or the building up of large-scale European highs after day 3 - day 5 in the forecast.

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