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A comparison of the OWSE Assimilation Scheme with the Operational Global Assimilation Scheme

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1. INTRODUCTION

The first aim of OWSE-NA, the Operational World Weather Watch Systems Evaluation, North Atlantic is:-

> 'To determine the Composite Observing System for the North Atlantic (COSNA) which most closely satisfies the requirements of meteorological services in terms of both operational performance and cost'
> (Paragraph 3.3 of the Final Report of the Organizing Meeting for OWSE-NA, 29 April - 3 May 1985.)

As part of the OWSE, a modified version of the global suite has been created and is run in parallel with the operational version for several periods of about a month each, see, for example, Bromley et al (1988). The operational suite is described by Bell and Dickinson (1987). Ideally, when both versions of the suite are using the same observations they should give identical results. However, a number of alterations have been introduced into the modified version to save computer time. Inevitably these changes produce some differences in the resultant analyses.

In the modified version a number of observations are 'deactivated' in the North Atlantic region to establish their effect on analyses and forecasts. Although 'deactivated' observations are passed to the analysis program, this is only in order to calculate the differences of the observations from the model fields: the 'deactivated' observations are not permitted to influence the determination of the eventual analysis fields. To achieve a full understanding of the effect of withholding observations from the OWSE runs, it is necessary to know what effects the other differences between the suites may have on the analyses.

This note describes the differences between analyses produced by the operational and modified versions of the suite by adopting two complementary approaches. First, a single, arbitrary case is chosen and the effects on the analysis of the various differences between the two versions explored in some detail. Secondly, results between the two versions, in the absence of deactivation, are compared for 36 consecutive analyses during a 9-day period.

2. THE MODIFIED SYSTEM

The procedure employed in the modified system is illustrated in Figure 1.1 and the areas involved are shown in Figure 1.2. In order to minimize the amount of computer time required by the modified version of the suite, a hemispheric assimilation is used. Starting from a hemispheric analysis, a set of observations is assimilated over a period of six hours of model time. All the observations from 40E through 180 to 140W and from the equator to 80N are omitted (Figure 2, area 'A'). From the resulting hemispheric analysis, an area of the model is removed and placed in the corresponding location in the global operational analysis, valid for the same time: the area that is 'patched' in this way is larger than the area being investigated over the North Atlantic, but excludes the region from 40E through 0 to 140W (Figure 2, area 'B'). Finally the Northern Hemisphere of this global analysis is taken to be the starting point for the next cycle of the procedure.

3 THE CASE STUDY

3.1 The experiment

For an arbitrarily chosen case, 00z on 9 February 1987, three different analyses have been created. All are formed from 6-hour assimilations using the operational analysis for 18z on 8 February as their initial conditions. The first analysis is formed from a hemispheric, rather than global, assimilation: this will be referred to as the hemispheric analysis. The second analysis is created by the process described in Section 2, but with no observations deactivated in the North Atlantic area: this will be referred to as the patched analysis. The third analysis is produced in the same way as the second except that, as in the OWSE experiments, some observations are deactivated in the North Atlantic area prior to assimilation: this will be referred to as the reduced analysis. Differences are formed between each of these analyses and the corresponding operational analysis. These differences are then compared to show separately the effects of patching and of using a hemispheric assimilation scheme.

3.2 Operational and reduced analyses

Figures 2.1 and 2.2 show the pmsl and the 500mb height from the operational global analysis for 00z on 9 February 1987. The two most intense features in the pmsl field over the North Atlantic are areas of low pressure off Newfoundland and to the south-west of Iceland. The low near Iceland is associated with a low in the 500mb height field and the low near Newfoundland is associated with a short wavelength trough in the 500mb height field. There are three other low pressure areas over the North Atlantic, over the American sea-board near 35N 75W, over the Davis Strait and to the south-west of Ireland; all are associated with troughs in the 500mb height field. The main features in the pmsl and 500mb height fields are treated similarly in all 3 analyses.

Figures 3.1 to 3.4 show the differences between a selection of fields from the operational and reduced analyses. The positions and identifiers of the observations deactivated in the reduced system are shown on the maps.

To the east and west of the patched area (east of 40E and west of 100W) the differences are extremely small. The regular pattern of contours shown in this region on Figure 3.1 are an artifact of the plotting package.

The difference maps for pmsl, 500mb height and 250mb height all show a similar pattern. On the large scale there is an area of positive differences (operational values are higher) to the west of Iberia and another to the east of Florida, otherwise the differences are mainly negative. Two areas of small positive differences extend north-south near to the edges of the patched area, one near to 30E and the other near to 100W. There are a number of smaller, more intense features, mainly near the positions of the deactivated observations. In the pmsl, 500mb height and 250mb height maps there are differences near 40W and between 40 and 50N which are not close to any deactivated observations.

The 850mb relative humidity map (Figure 3.4) shows a more confusing pattern, with many small differences on a relatively short spatial scale. There are larger differences near to the North Pole and near to ship 'FNOU' (20N 58W), but otherwise no clear pattern is apparent.

In the following two sub-sections a selection of difference fields between the operational analysis and both the hemispheric and patched analyses are discussed. These differences are compared with those between the operational and reduced analyses already described in this section.

3.3 Hemispheric analysis

Figures 4.1 to 4.4 show the differences between the operational analysis and the hemispheric analysis. The features in Figures 3.1 to 3.4 which are also seen in Figures 4.1 to 4.4 are therefore a result of using a hemispheric assimilation and not a result of deactivating observations.

Much of the large-scale pattern in Figure 4.1 is very similar to that in Figure 3.1, particularly south of 50N. Both figures show positive differences off Iberia and Florida and both figures show local, but more intense features, near 40W and between 40N and 50N. Similar results may be seen for the 500mb and 250mb height fields if Figures 4.2 and 4.3 are compared with Figures 3.2 and 3.3.

Comparing Figures 4.4 and 3.4 shows the differences in relative humidity at 850mb. In general the differences are noisier than those for mean sea level pressure and geopotential height, and are of a smaller magnitude for the hemispheric analysis than for the reduced analysis. Over parts of the Atlantic the pattern of positive and negative differences are similar in the two figures, most notably near 40N 55W where there are relatively large negative differences in both figures.

These comparisons show that many of the small magnitude differences between the operational and reduced analysis are due to using a hemispheric assimilation to produce the reduced analysis. Clearly, not all the differences seen between the reduced and operational analyses (Figures 3.1 to 3.4) are a result of observations being deactivated.

3.4 Patched analysis

Figures 5.1 to 5.4 show the differences between the operational analysis and the patched analysis. For all four fields (pmsl, 500mb and 250mb heights and relative humidity at 850mb) the differences over the Atlantic are virtually identical to those seen between the operational analysis and the hemispheric analysis (Figures 4.1 to 4.4). Near the meridional boundaries of the patched area (30E and 100W), but only north of 45N, there are areas of positive difference which are not seen for the hemispheric run. These differences are probably a direct result of the patching process.

3.5 Discussion of the case study

This case study has shown that some of the differences between the operational analysis and the reduced analysis are artifacts of the version of the suite used, rather than a result of deactivating observations. There are differences on large spatial scales, but of a small magnitude, especially south of 50N, which are entirely due to the version of the suite used. Most are a result of using a hemispheric assimilation, but some changes near 30E and 100W are a result of patching.

Another feature of the case study is the area near 40W and between 40N and 50N where there are some relatively large differences. They have similar spatial scales and magnitudes as those produced by deactivation, but are entirely a product of the version of the suite used. Figures 2.1 and 2.2 show that this region is ahead of an intense low pressure system and 500mb height trough.

All the largest impacts seen, namely those near ship 'C7L', drifting buoys '65562' and '65570', and near ship 'C7M' are the result of deactivating observations. A comparison of Figures 3, 4 and 5 show that the smaller changes near ship 'FNOU' and drifting buoy '62591' are generated by deactivating those observations. However, since these changes are of the same order as some of those which are artifacts of the system, it would be difficult to distinguish them without doing such a comparison.

4 THE PARALLEL RUN

4.1 Procedure

A 9-day parallel run of the modified version of the suite, but with no observations deactivated, was carried out from 00z on 19 October 1987 to 18z on 27 October 1987, part of the period of an OWSE-NA run. During this period a continuous sequence of 6-hourly assimilations was maintained and each day an additional analysis for 00z was created and used as initial conditions for a 24-hour forecast. The differences between the results of the parallel run and the results of the operational run are entirely due to the version of the suite used. A comparison of these differences with those between the OWSE-NA run and the operational run allows a comparison between the effects of using a modified version of the suite and the effects of deactivating observations.

The differences between the runs are taken over all available pairs of 6-hourly analyses. Results are shown in appropriate boxes over the North Atlantic and Europe. Each box has been assigned a number, shown in the top left-hand corner. The calculations have been made using the actual values of the model fields at all the grid points within each box, the number of points in each box shows some variation: the maximum is 42 and the minimum is 30.

4.2 Box area statistics

Figures 6.1 and 6.2 show rms differences between the parallel run and the operational run for pmsl and potential temperatures at σ=.870. Figures 6.3 and 6.4 also show rms differences, for the same fields and the same period, but between the OWSE-NA run and the operational run. For both fields, but especially for pmsl, the differences in the southernmost row are only slightly larger for the OWSE-NA run: this indicates that in this region the differences between the OWSE-NA run and the operational run are mainly a product of the version of the suite used rather than of the deactivation of observations. This is also true in parts of the Western Atlantic and to a lesser extent near to the African and European coasts. In the central and Northern Atlantic the differences are much larger for the OWSE-NA run than for the parallel run: this indicates that in these regions the differences between the OWSE-NA run and the operational run are mainly produced by the deactivation of observations.

4.3 Quality control decisions

There are relatively large rms differences in boxes 11, 12, 19 and 20 (all near to 50N 20W), for pmsl and potential temperature at σ=.870 and also in box 17 (near to 45N 45W), for potential temperature at σ=.870 (Figures 6.1 and 6.2). An examination of the individual analyses for the 9-day period shows that these mean differences result from individual analyses where the differences in the region of these boxes are much larger than usual.

Figures 7.1 and 7.2 show differences between the operational analysis and the reduced analysis for 00z on 20 October 1987. The pmsl shows a 'bulls eye' difference near to 50N 20W with the pmsl in the operational analysis being 4mb higher. The differences near to 50N 20W are shown to extend up to 250mb (Figure 7.2). Figure 7.3 shows a similar feature, in nearly the same position, at 00z on 23 October 1987. Figure 7.4 shows a somewhat weaker feature near to 45N 45W (in box 17).

The differences near 50N 20W and 45N 45W are found to result from differences in quality-control decisions. For example, at 00z on 20 October 1987 the surface pressure from ship 'SQNZ' (51.4N, 19.6W) was different from the background for the modified analysis by 7.8 mb and different from the operational background by 7.9mb. In the parallel run this observation was accepted, but in the operational run it was rejected. As a result of this quality control decision a background difference of 0.1mb becomes an analysis difference of 4mb (Figure 7.1). Nearly all the larger box area differences away from the southern boundary appear to be due to the effect of quality-control decisions.

5 SUMMARY AND CONCLUSIONS

In the case study, differences of small magnitude, but on relatively large spatial scales, near to 20E and 90W were found to result from the patching process, and differences south of 50N to result from using a hemispheric assimilation. More intense differences, again due to using a hemispheric assimilation, were found near to 45N 40W in an area of rapid development.

For the parallel run, some relatively large rms differences were found to result from differences in quality control decisions. In these cases small differences in the background resulted in much larger differences in the analysis.

The rms differences in the north-eastern and central Atlantic were found to be much smaller for the parallel run than for the OWSE-NA run. Therefore, in these regions, the differences between the OWSE-NA run and the operational run appear to be mainly a product of the deactivation of observations. For other regions, particularly for the southernmost row of assessment boxes, most of the differences between the OWSE-NA run and the operational run appear to result from the version of the suite used, rather than from the deactivation of observations.

Overall this work has shown that some of the differences observed between the parallel runs are due to differences in the numerical procedures employed. Due allowance should be made for such errors when assessing the results of the parallel runs for OWSE-NA.

REFERENCES

Bell R.S. and Dickinson, A. 1987 'The Meteorological Office operational numerical weather prediction system', Meteorological Office Scientific Paper No. 41. Meteorological Office, Bracknell, U.K.

Bromley, R.A., Ingleby, N.B. and Reed, D.N. 1988 'Report on the Parallel Run for OWSE-NA at the UK Meteorological Office, Summer 1987 Part III: Assessment of the Results.

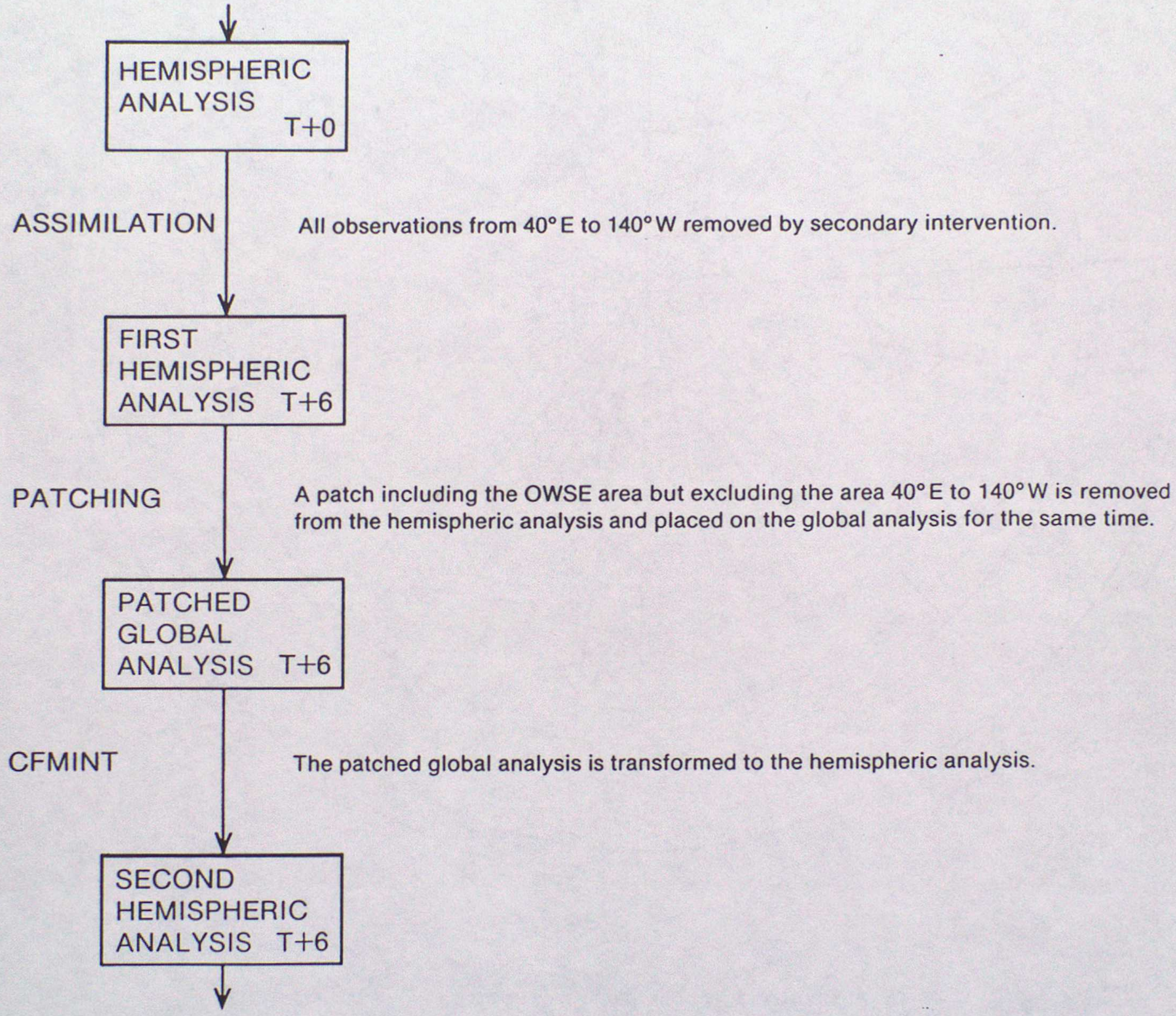


Figure 1.1 Schematic diagram of the Patching procedure

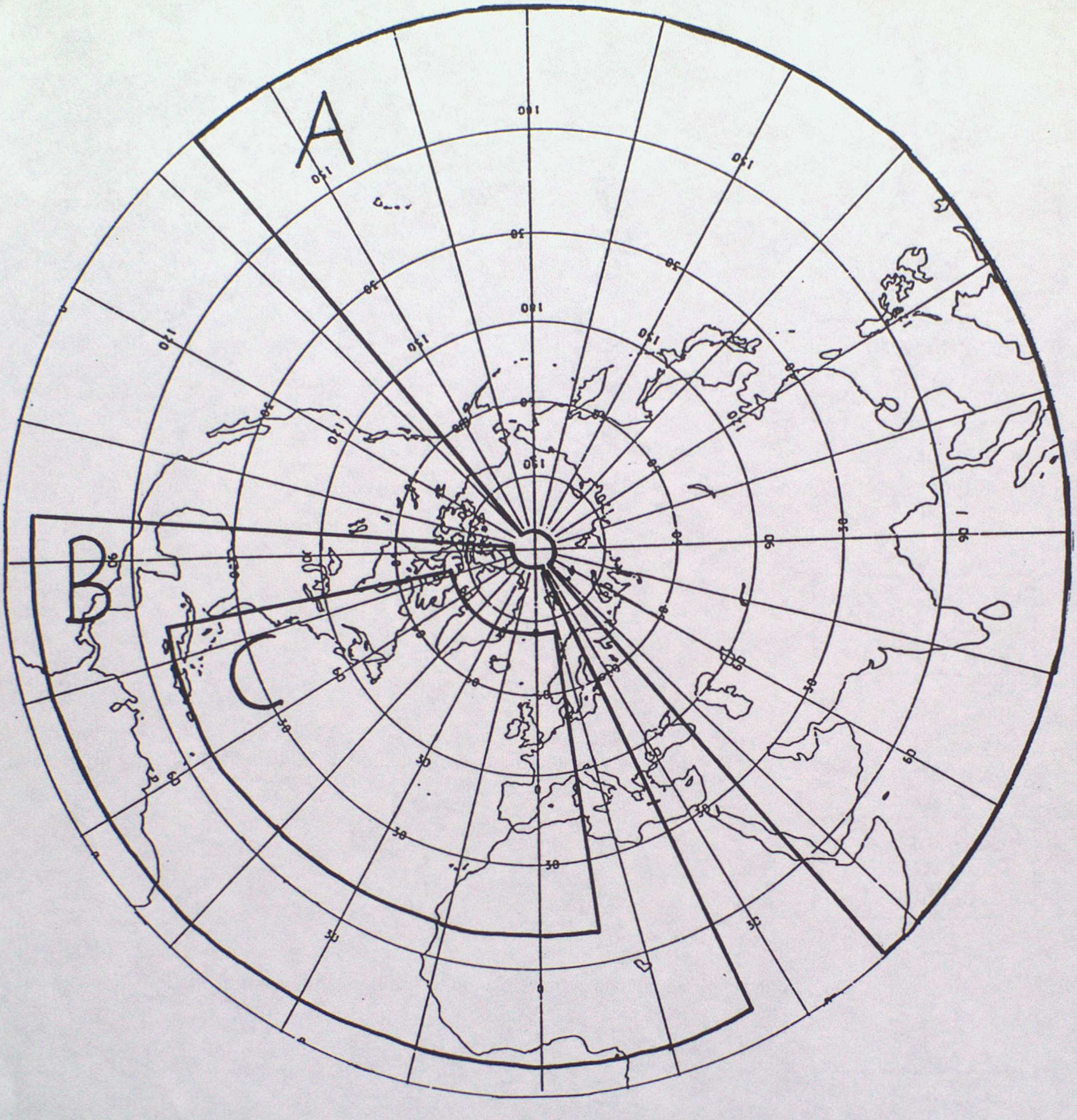
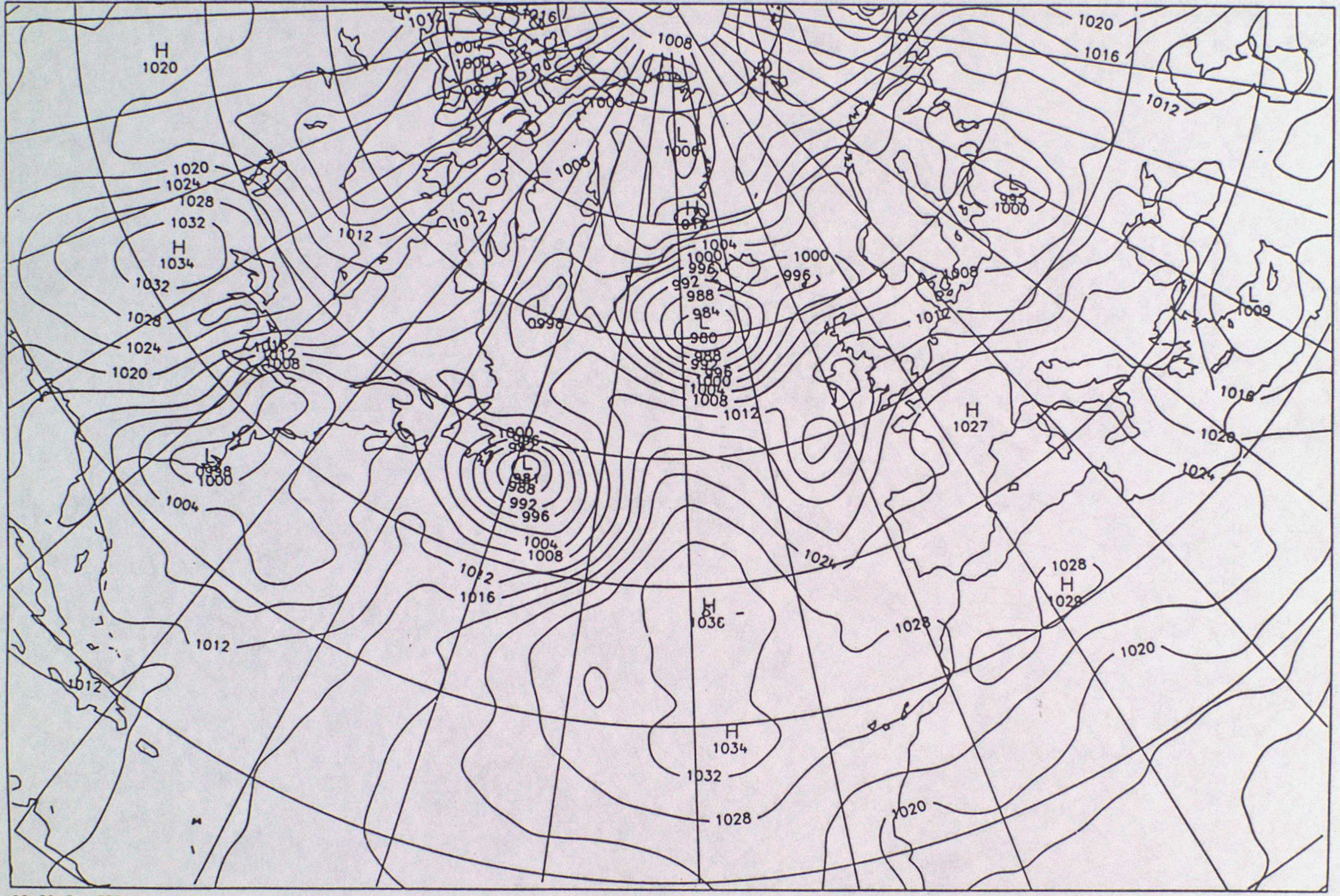


Figure 1.2 The areas involved in the reduced system.

A: Area where all observations are omitted during the assimilation.
B: Area which is patched into the operational analysis.
C: The OWSE area.

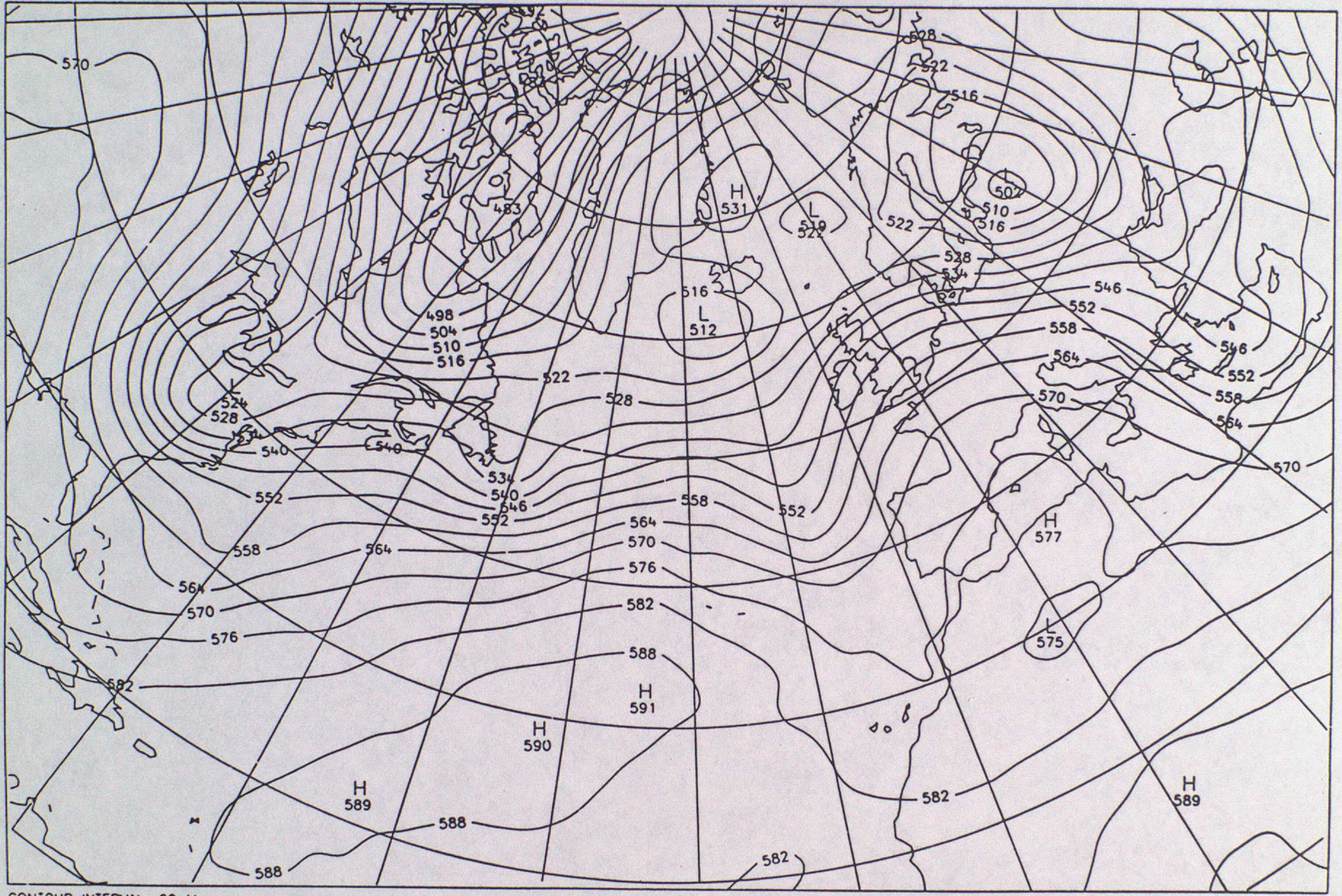
MEAN SEA LEVEL PRESSURE
VALID AT 0Z ON 9/2/1987 DAY 40   DATA TIME 0Z ON 9/2/1987 DAY 40
LEVEL: SEA LEVEL



CONTOUR INTERVAL: 4 MB

Figure 2.1 Operational analysis of mean sea level pressure for 00z on 9 February 1987

GEOPOTENTIAL HEIGHT
VALID AT 0Z ON 9/2/1987 DAY 40 DATA TIME 0Z ON 9/2/1987 DAY 40
LEVEL: 500 MB



CONTOUR INTERVAL: 60 M

Figure 2.2 Operational analysis of 500mb height for 00z on 9 February 1987

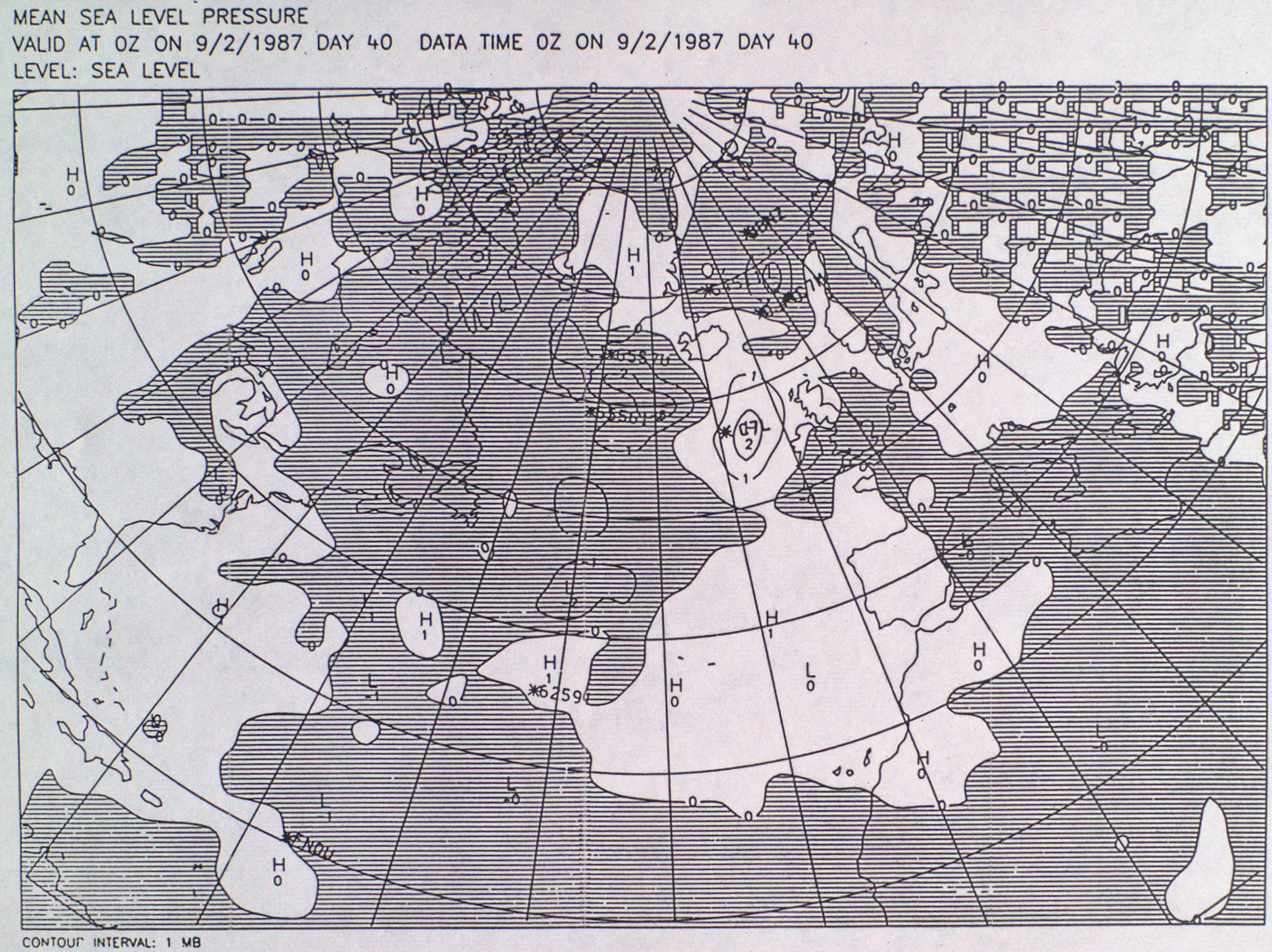
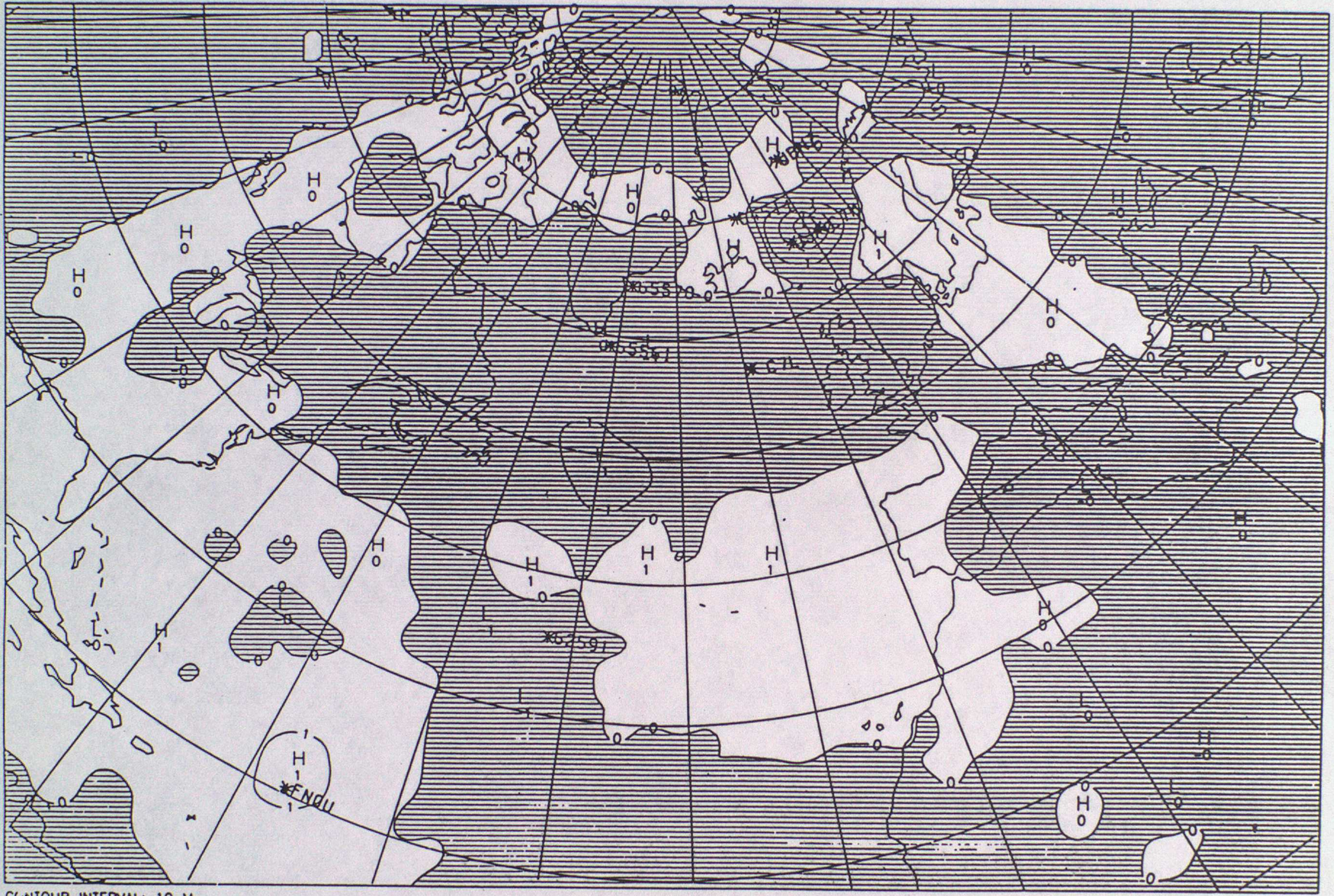


Figure 3.1 Differences between the operational and reduced analyses of mean sea level pressure for 00z on 9 February 1987

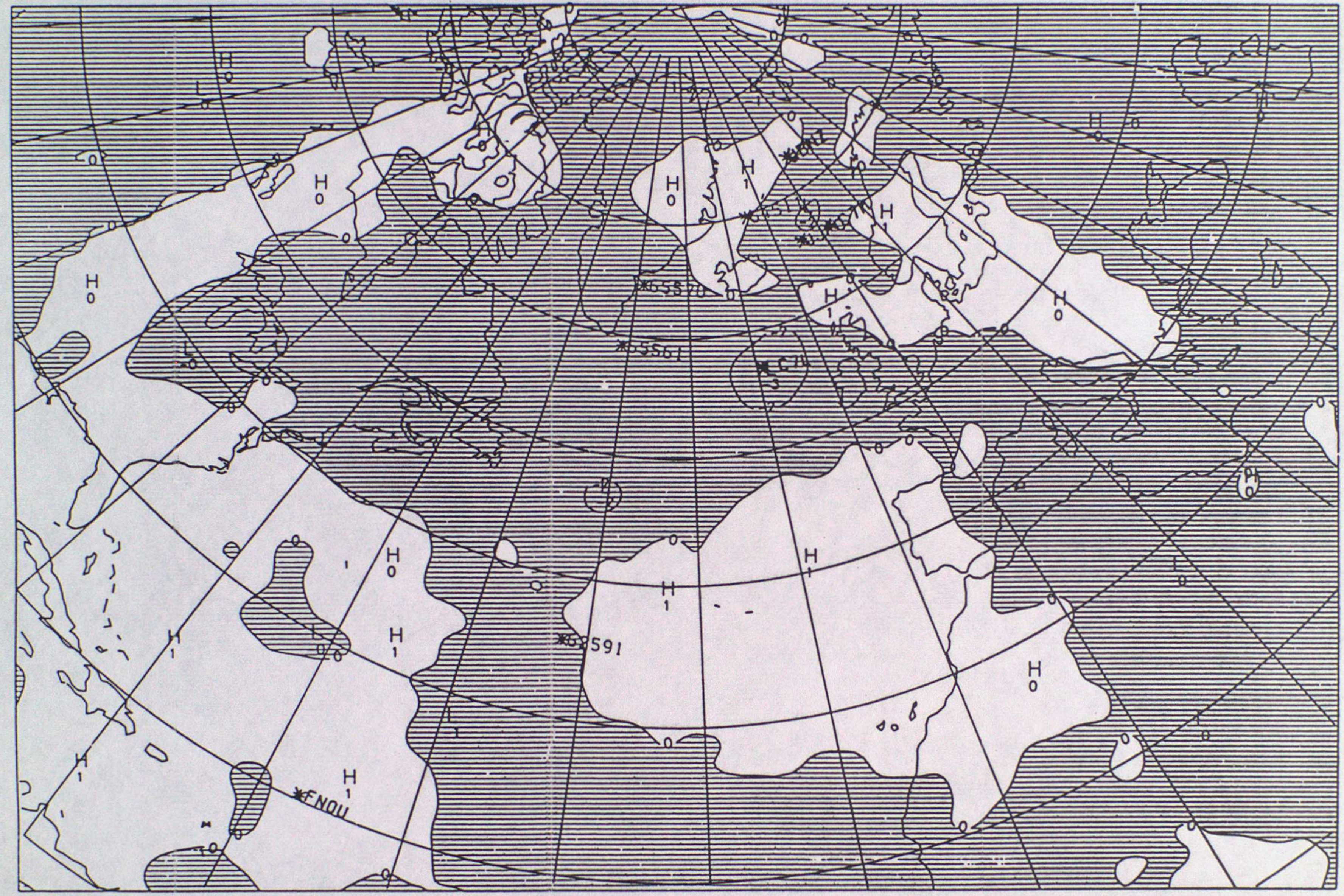
GEOPOTENTIAL HEIGHT
VALID AT 0Z ON 9/2/1987 DAY 40 DATA TIME 0Z ON 9/2/1987 DAY 40
LEVEL: 500 MB



CONTOUR INTERVAL: 10 M

Figure 3.2 Differences between the operational and reduced analyses of 500mb height for 00z on 9 February 1987

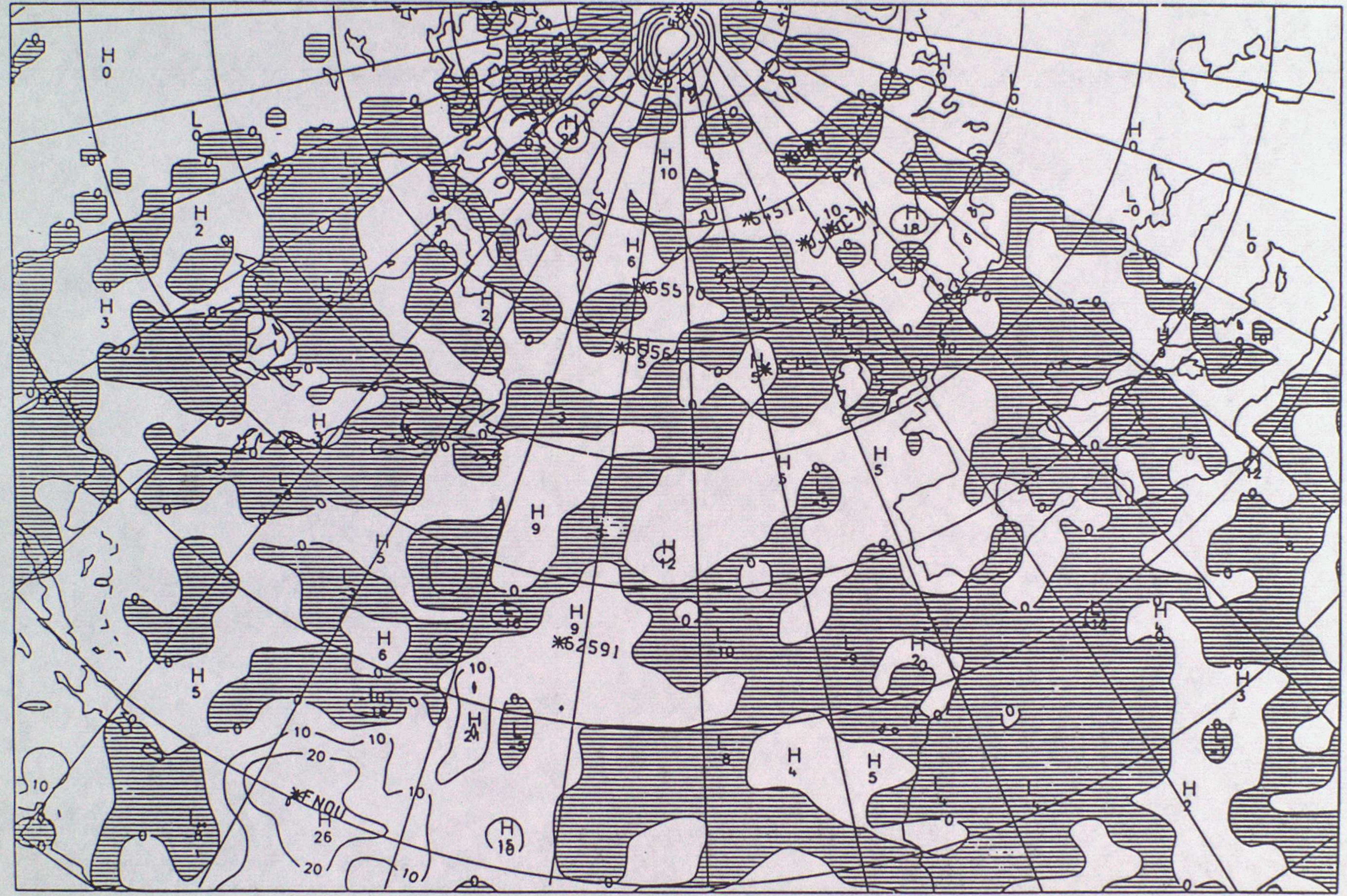
GEOPOTENTIAL HEIGHT
VALID AT 0Z ON 9/2/1987 DAY 40 DATA TIME 0Z ON 9/2/1987 DAY 40
LEVEL. 250 MB



CONTOUR INTERVAL: 20 M

Figure 3.3 Differences between the operational and reduced analyses of 250mb height for 00z on 9 February 1987

RELATIVE HUMIDITY
VALID AT 0Z ON 9/2/1987 DAY 40 DATA TIME 0Z ON 9/2/1987 DAY 40
LEVEL: 850 MB



CONTOUR INTERVAL: 10 PER CENT

Figure 3.4 Differences between the operational and reduced analyses of relative humidity at 850mb for 00z on 9 February 1987

MEAN SEA LEVEL PRESSURE
VALID AT 0Z ON 9/2/1987 DAY 40 DATA TIME 0Z ON 9/2/1987 DAY 40
LEVEL: SEA LEVEL

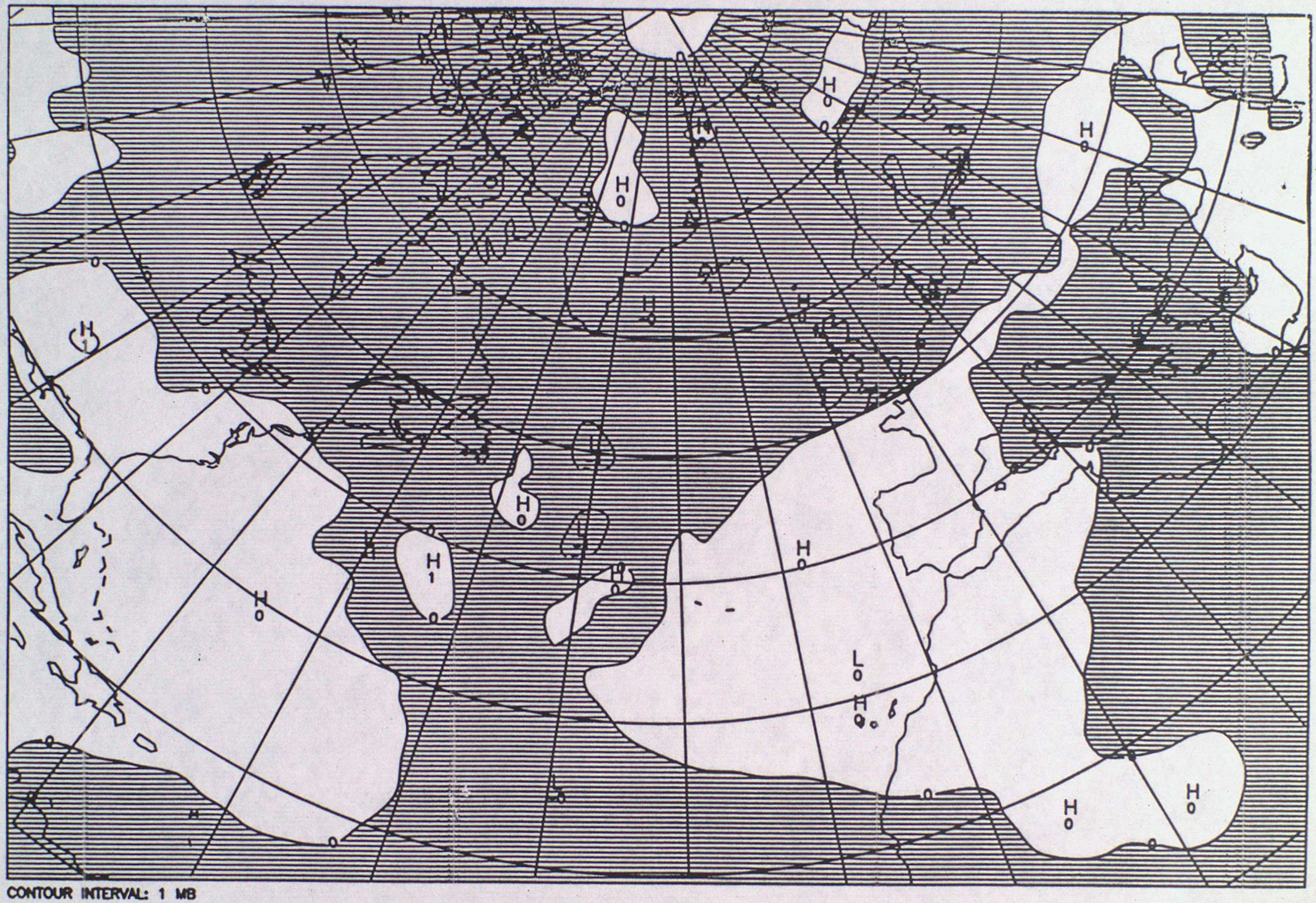


Figure 4.1 Differences between the operational and hemispheric analyses of mean sea level pressure for 00z on 9 February 1987

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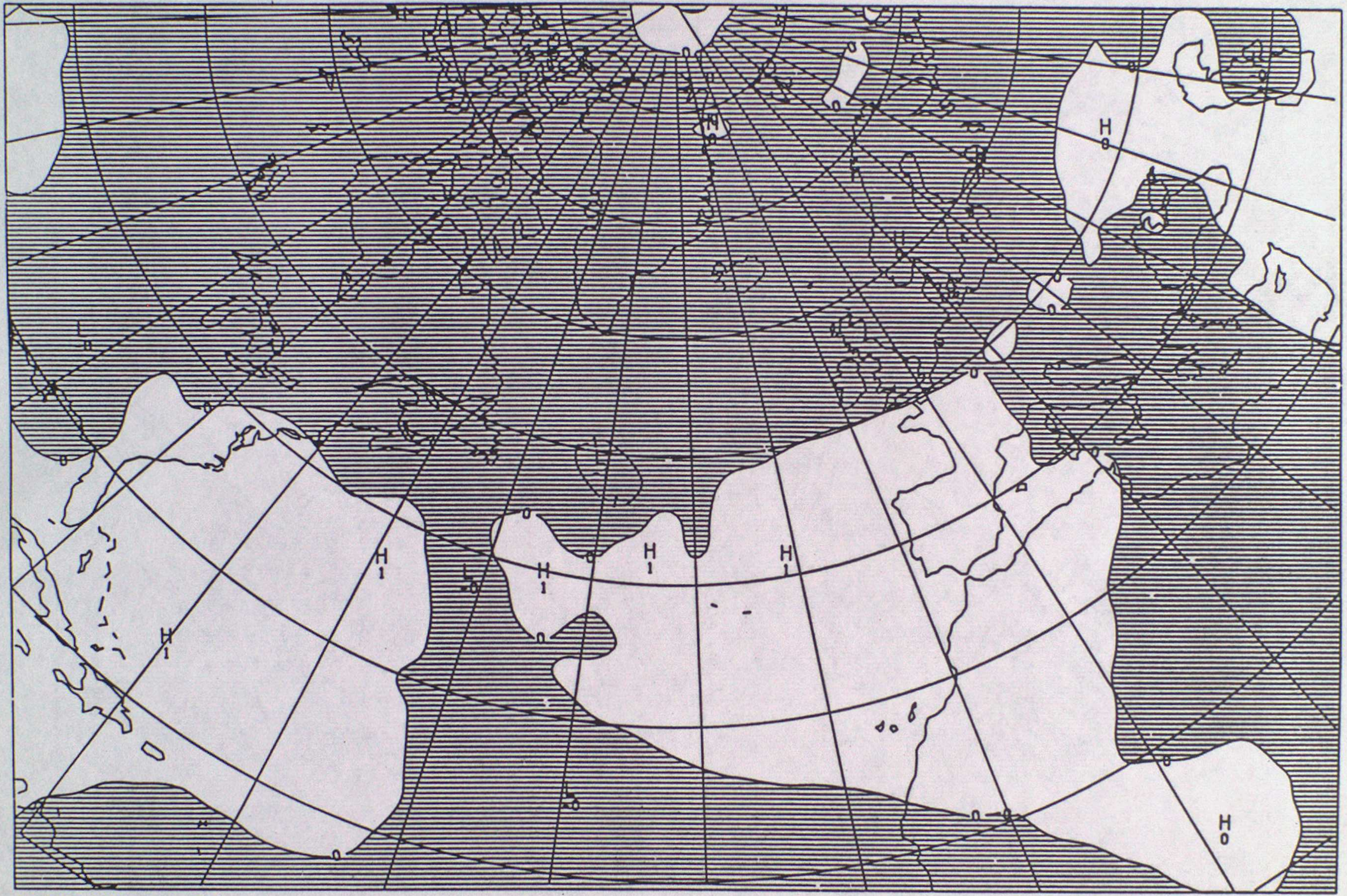
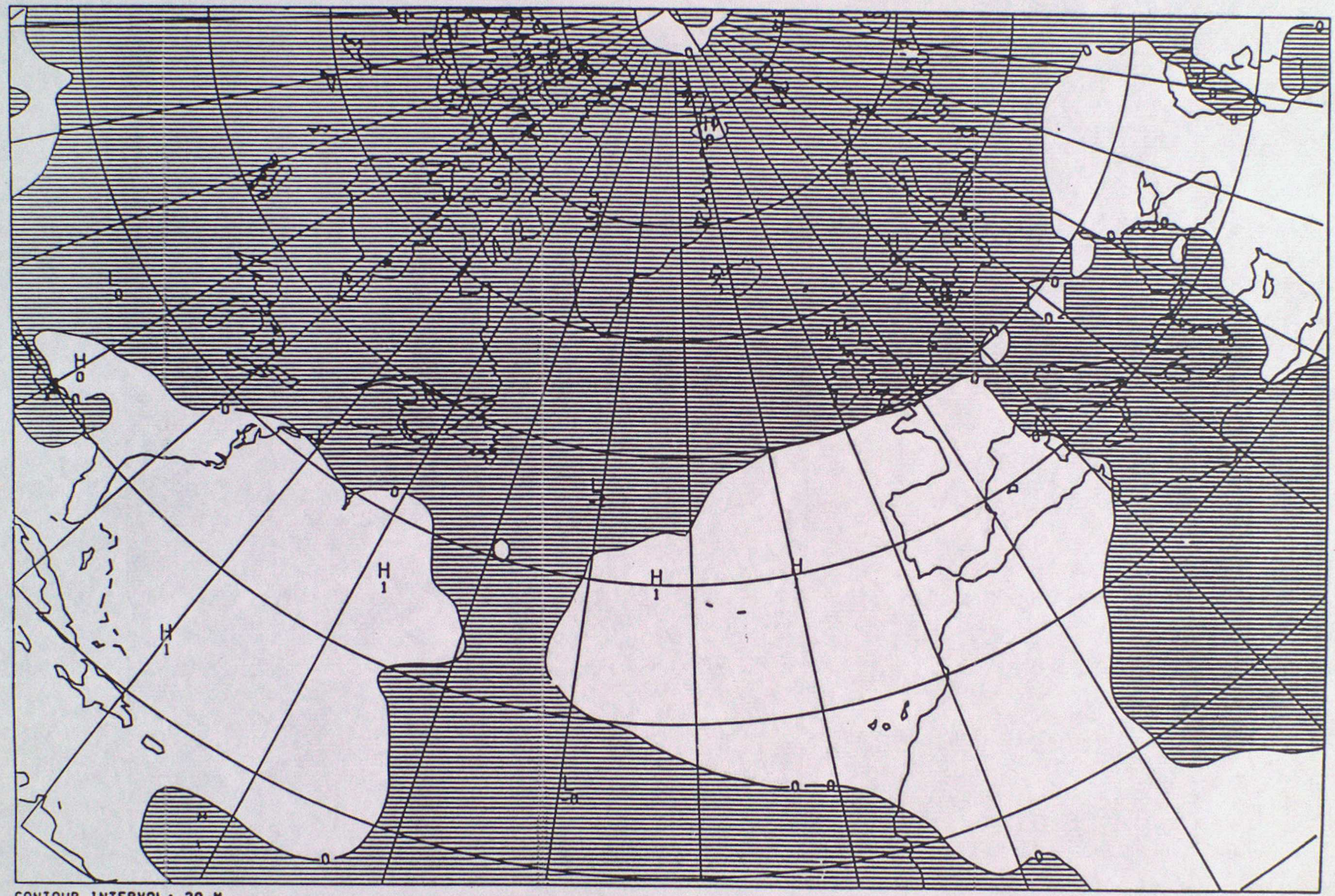
LEVEL: 500 MB



CONTOUR INTERVAL: 10 M

Figure 4.2 Differences between the operational and hemispheric analyses of 500mb height for 00z on 9 February 1987

GEOPOTENTIAL HEIGHT
VALID AT 0Z ON 9/2/1987 DAY 40   DATA TIME 0Z ON 9/2/1987 DAY 40
LEVEL: 250 MB



CONTOUR INTERVAL: 20 M

Figure 4.3 Differences between the operational and hemispheric analyses of 250mb height for 00z on 9 February 1987

RELATIVE HUMIDITY
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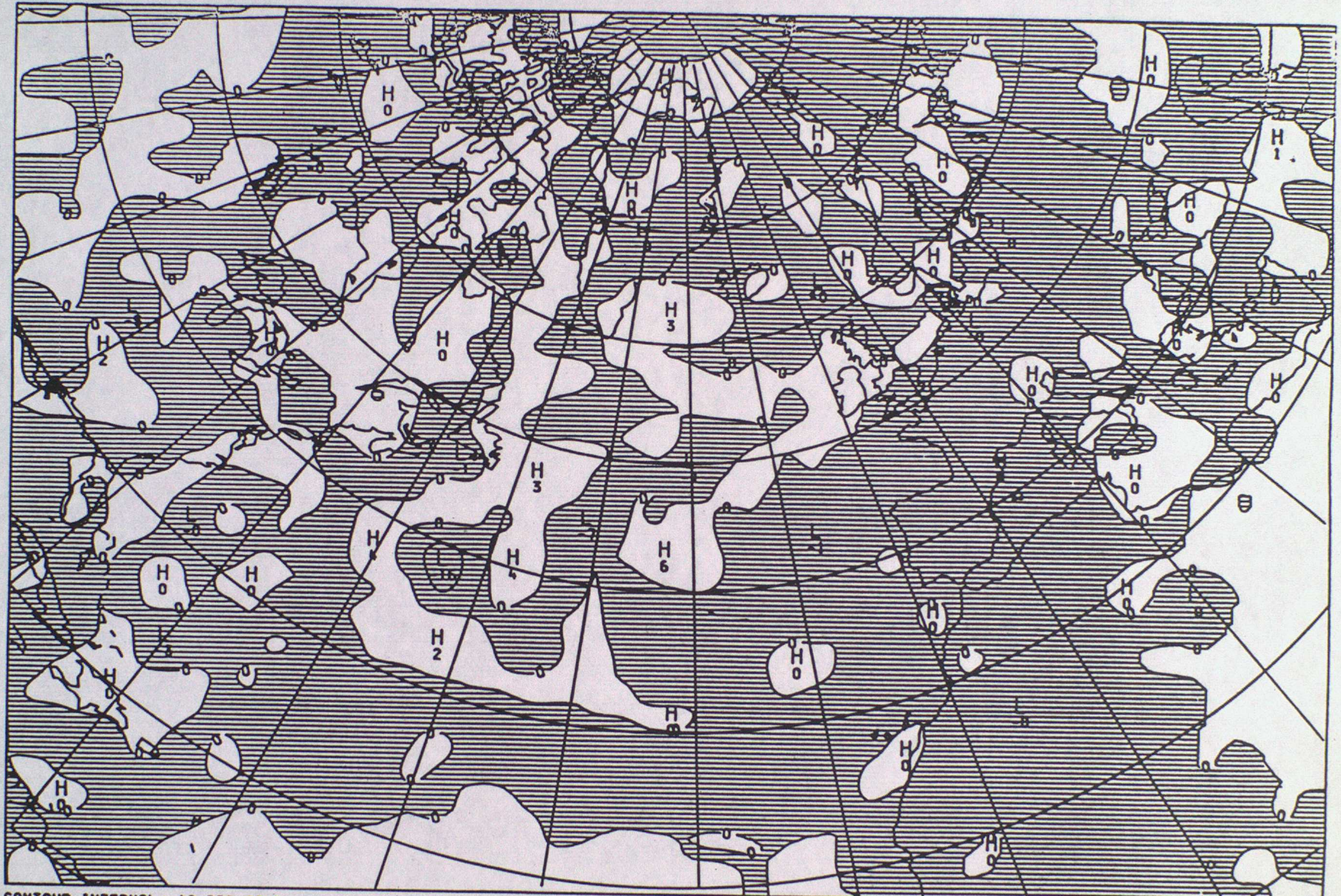
LEVEL: 850 MB



CONTOUR INTERVAL: 10 PER CENT

Figure 4.4 Differences between the operational and hemispheric analyses of relative humidity at 850mb for 00z on 9 February 1987

MEAN SEA LEVEL PRESSURE
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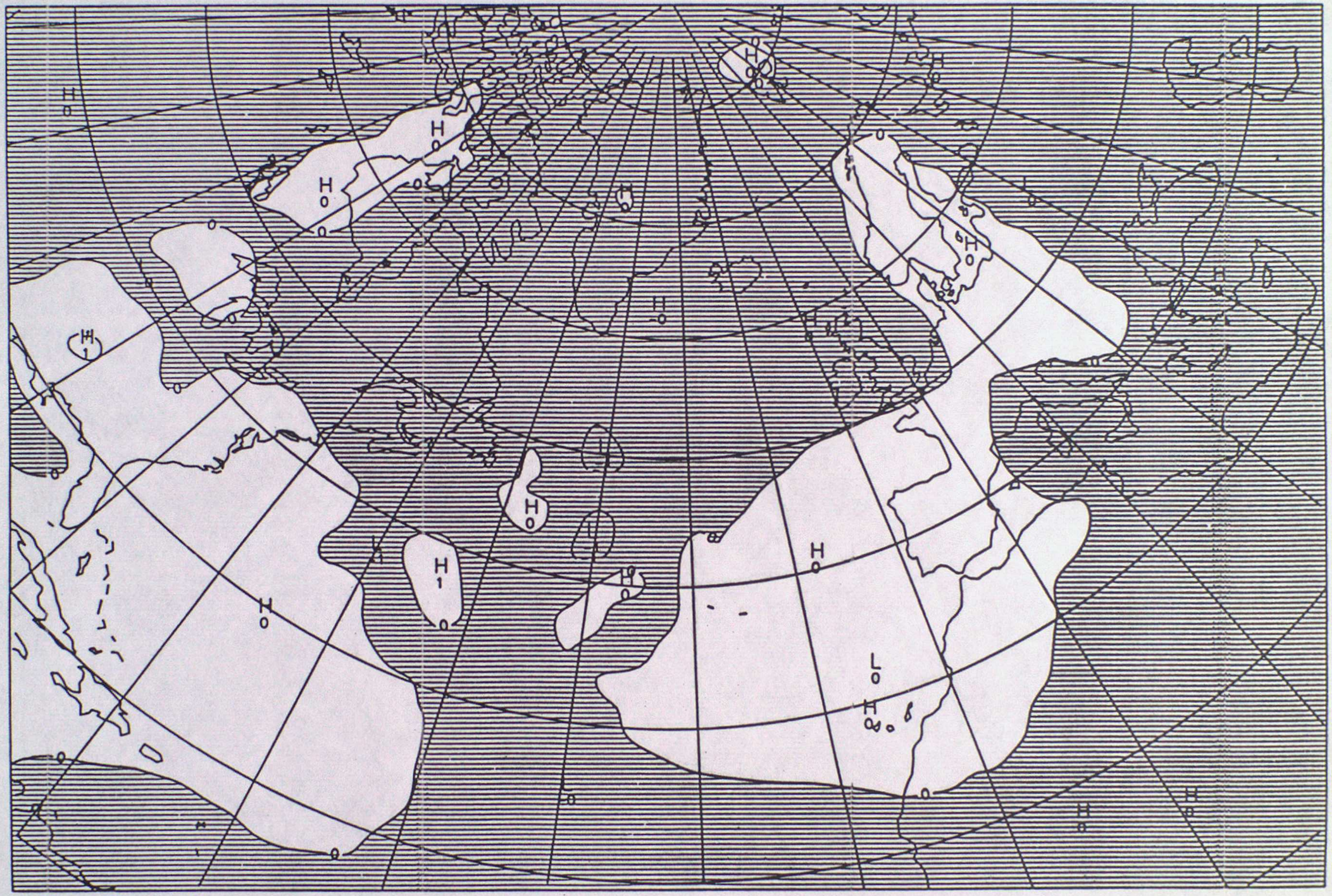
LEVEL: SEA LEVEL



CONTOUR INTERVAL: 1 MB

Figure 5.1 Differences between the operational and patched analyses of mean sea level pressure for 00z on 9 February 1987

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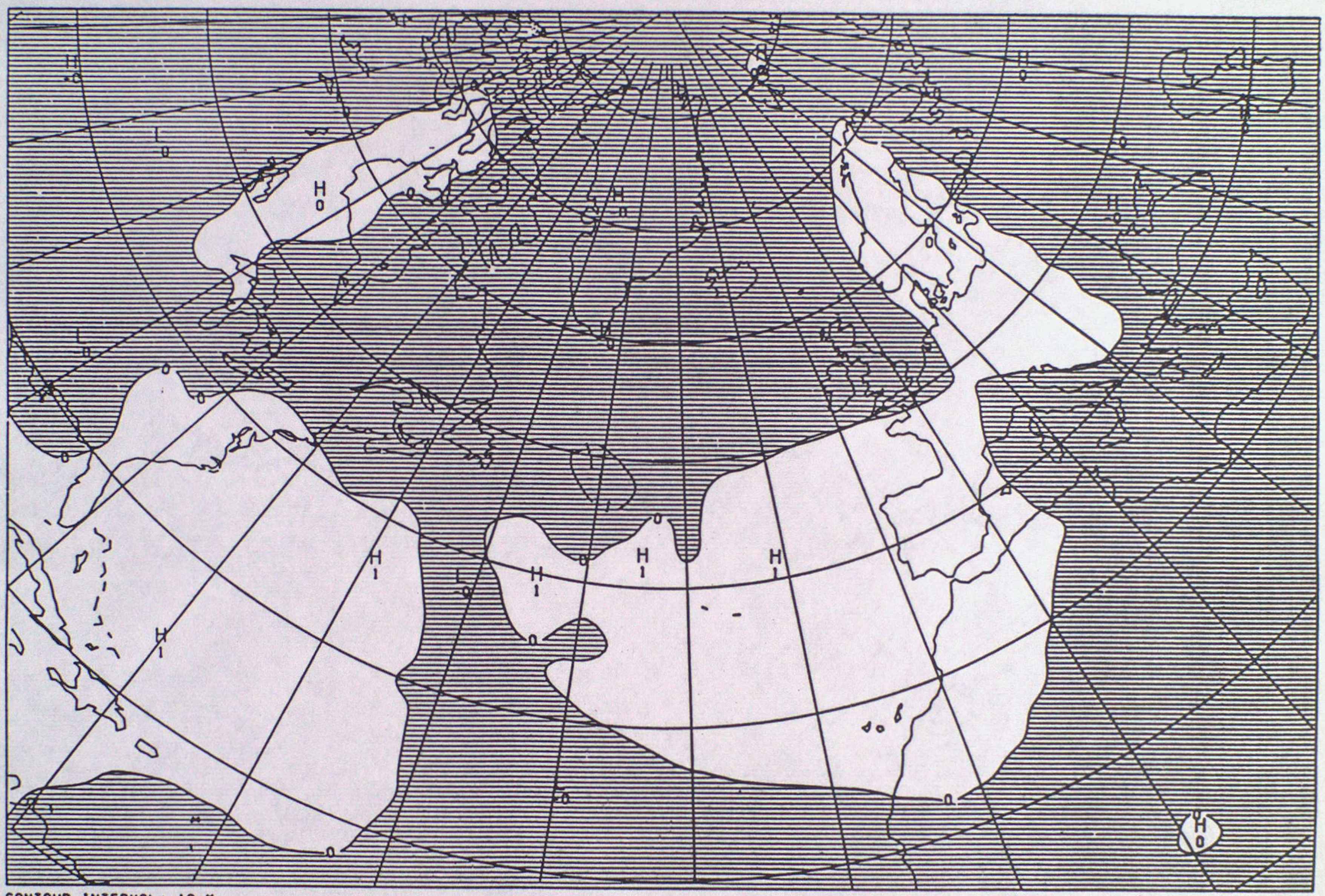
LEVEL: 500 MB



CONTOUR INTERVAL: 10 M

Figure 5.2 Differences between the operational and patched analyses of 500mb height for 00z on 9 February 1987

GEOPOTENTIAL HEIGHT
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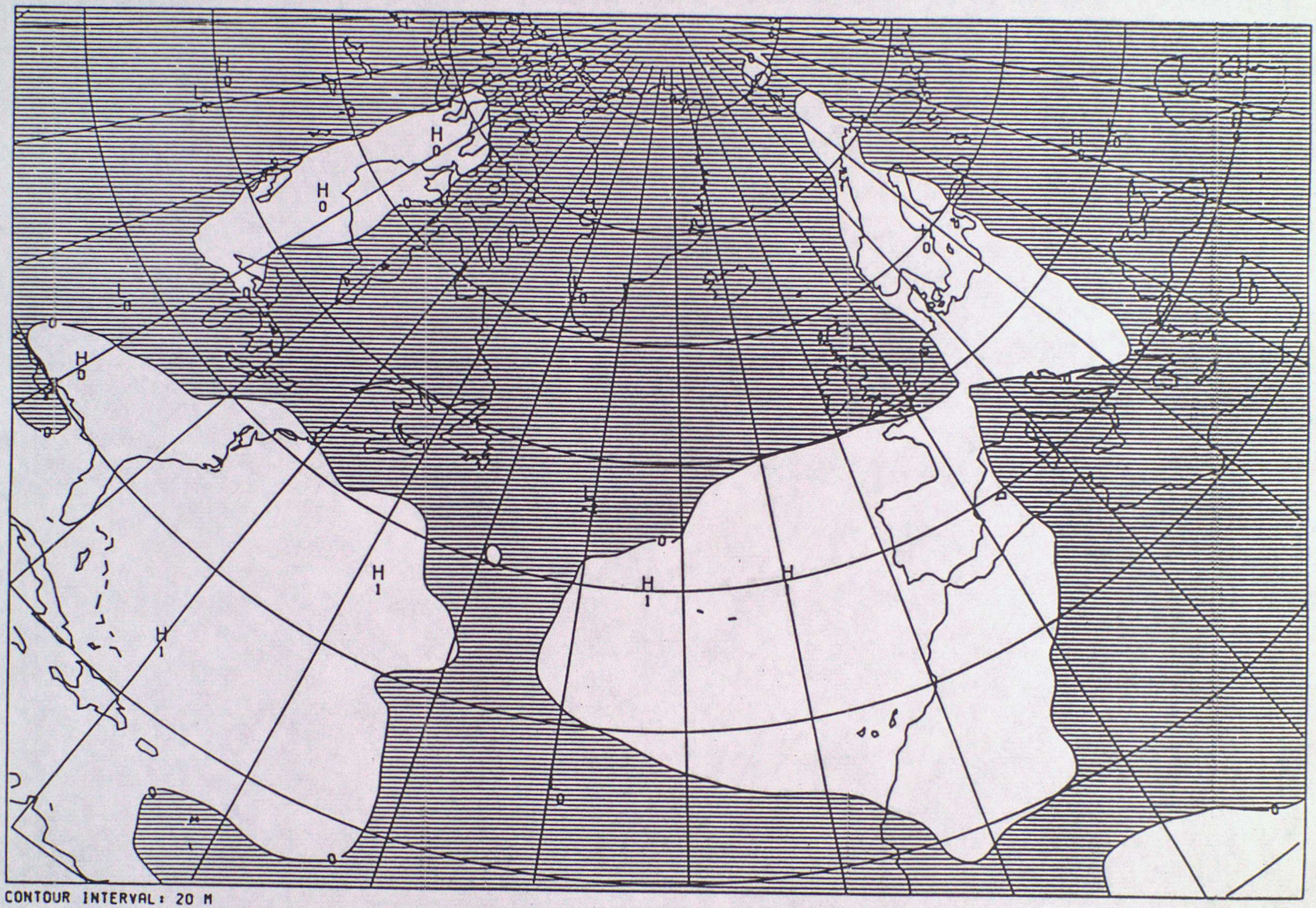
LEVEL: 250 MB



CONTOUR INTERVAL: 20 M

Figure 5.3 Differences between the operational and patched analyses of 250mb height for 00z on 9 February 1987

RELATIVE HUMIDITY
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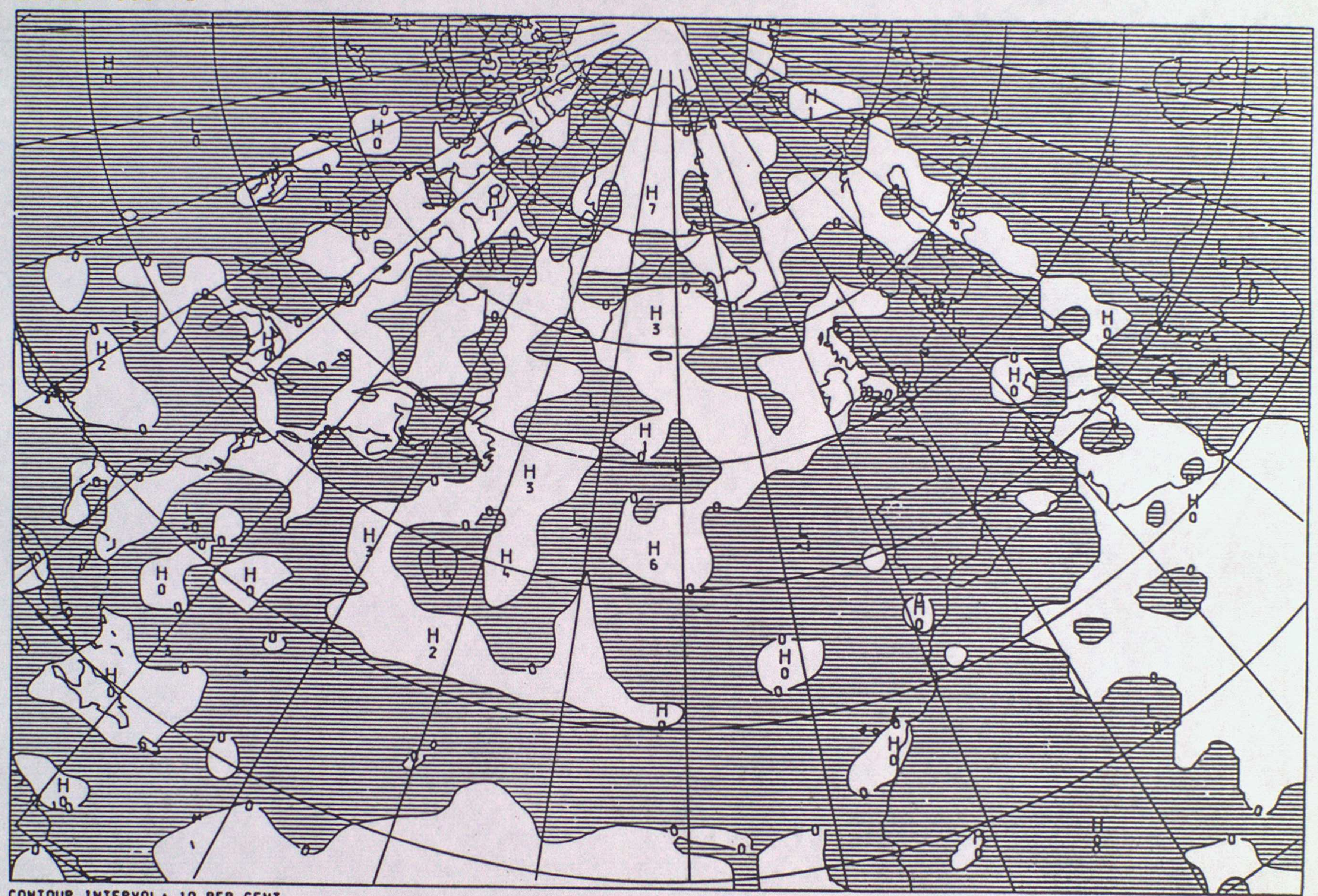
LEVEL: 850 MB



CONTOUR INTERVAL: 10 PER CENT

Figure 5.4 Differences between the operational and patched analyses of relative humidity at 850mb for 00z on 9 February 1987

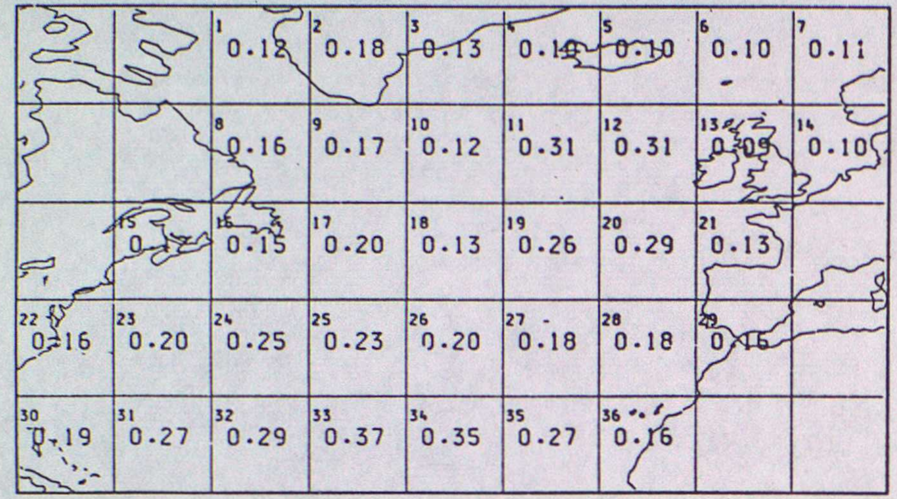


Figure 6.1 Rms differences between the parallel run and the operational run for mean sea level pressure from 00z on 19 October 1987 to 18z on 27 October 1987.

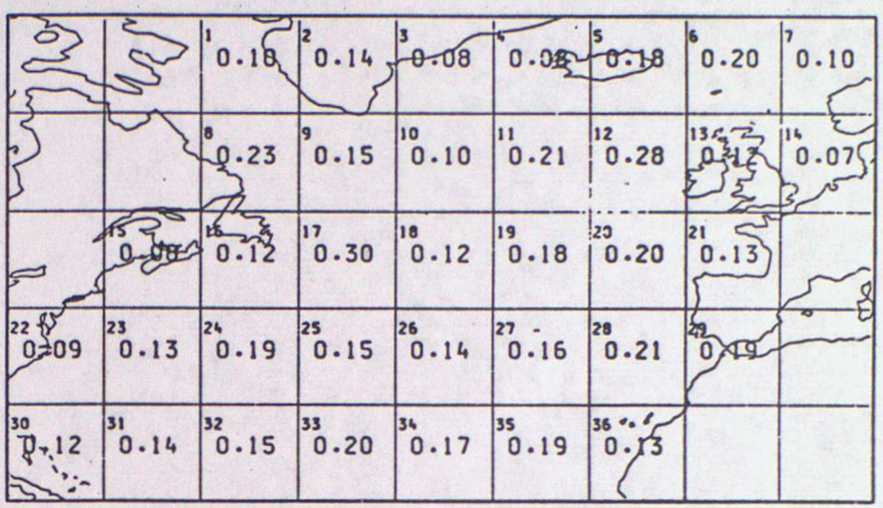


Figure 6.2 Rms differences between the parallel run and the operational run for potential temperature at σ=.870 from 00z on 19 October 1987 to 18z on 27 October 1987.

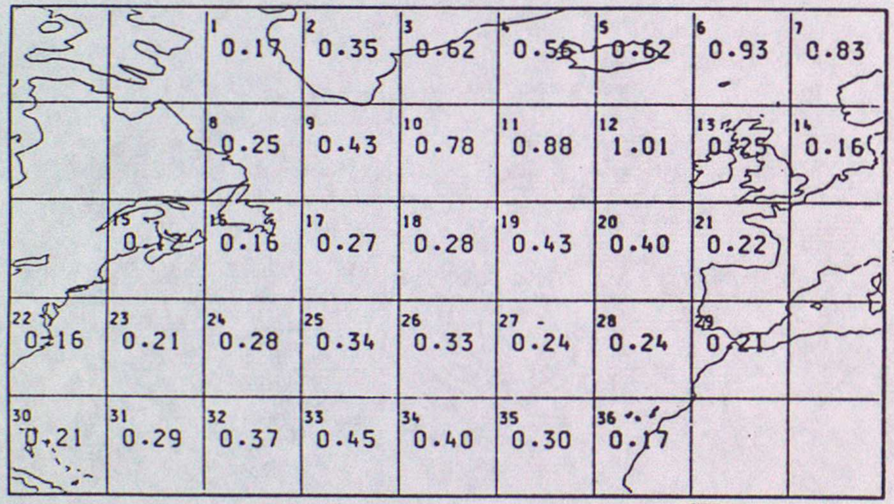


Figure 6.3 Rms differences between the OWSE-NA run and the operational run for mean sea level pressure from 00z on 19 October 1987 to 18z on 27 October 1987.

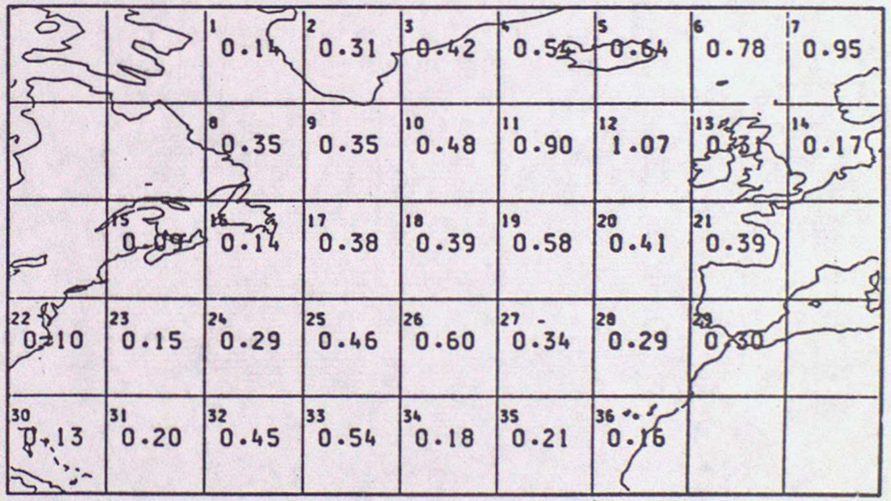


Figure 6.4 Rms differences between the OWSE-NA run and the operational run for potential temperature at σ=.870 from 00z on 19 October 1987 to 18z on 27 October 1987.

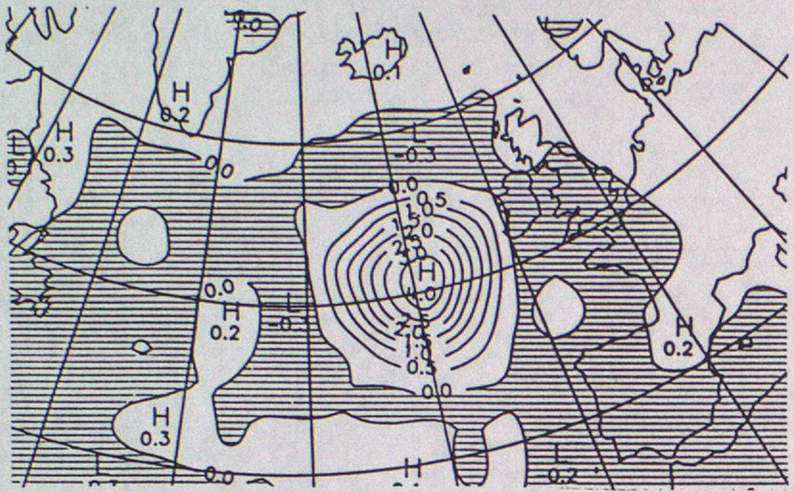


Figure 7.1 Differences of mean sea level pressure between the operational and no deactivation analyses for 00z on 20 October 1987.

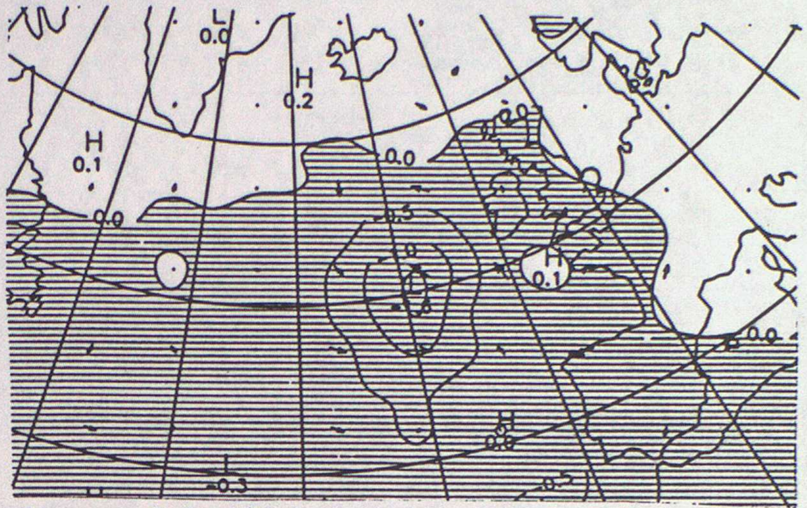


Figure 7.2 250mb height and vector wind differences between the operational and no deactivation analyses for 00z on 20 October 1987.

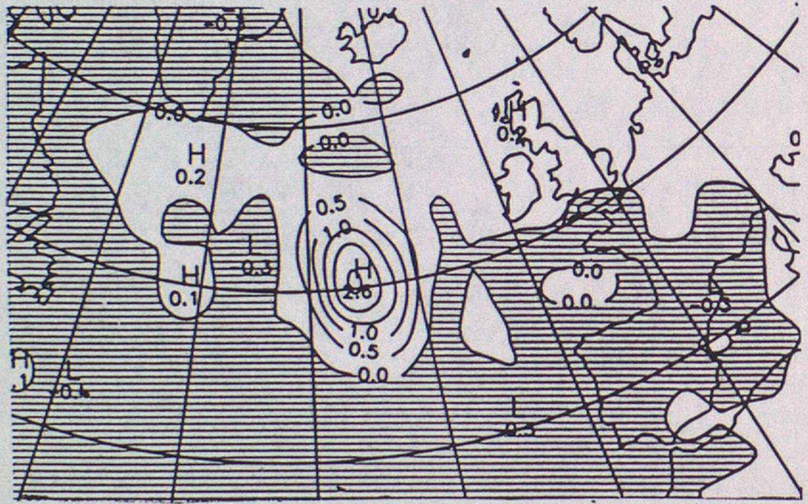


Figure 7.3 Differences of mean sea level pressure between the operational and no deactivation analyses for 00z on 23 October 1987.

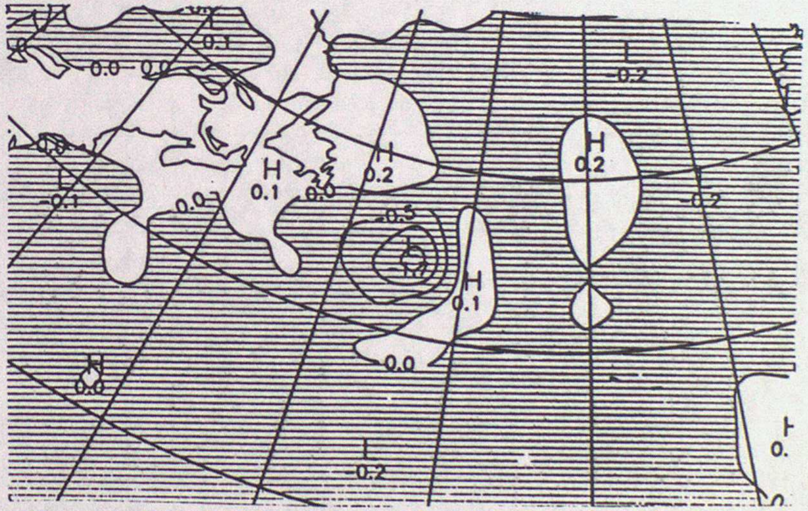


Figure 7.4 Differences of mean sea level pressure between the operational and no deactivation analyses for 00z on 26 October 1987.