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REPORT ON AN EXPERIMENT TO DETERMINE THE VALUE OF OCEAN WEATHER SHIP AND SATELLITE DATA IN NUMERICAL FORECASTING - Part I

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1. Introduction

In 1973, the USA announced that during the twelve months from June 1973 its weather ships would be withdrawn one by one from service at Ocean Weather Stations (OWS) B,C,D and E in the Western Atlantic Ocean and that the experimental Satellite Infra-Red Spectrometer (SIRS) soundings would be transmitted operationally. As a consequence it was necessary to evaluate the SIRS data as an operational source of data. (Data transmitted in SIRS code are sometimes described as VTPR - Vertical Temperature Profile Radiometer - data).

As the general question of supply and maintenance of Atlantic Weather Ships was also under review, it was felt that the opportunity should be taken to evaluate the effect that loss of all weather ship data would have on the forecasts issued by the Meteorological Office.

Two related experiments were undertaken:-

(1) to evaluate the effect of removing all weather-ship data, but including SIRS data, in the numerical forecast suite.

(2) to evaluate the SIRS data by allowing them to supplement existing data in the numerical forecast suite.

These two experiments will be denoted by "Expt 1" and "Expt 2" respectively.

Expt 2 was run on data from 00Z on 7th March 1974 to 00Z on 15th March 1974. Expt 1 also began on 7th March, but was discontinued on 11th March because of the lack of a strong westerly synoptic situation (see Paras 3 and 4, and Fig.XIV). However, a single run of Expt 1 was performed on data for 12Z on 14th March 1974 (See Para 8).

Part II of this report will present the results of a further period of running Expt 1, which took place from 2nd to 11th May 1974.

2. Organisation of the Experiments

2.1. General Remarks

Because of, and in spite of, the large amount of computer time involved in running three forecast suites for each 12-hour datum time over a period, the three were run "in real time", thereby avoiding problems of recovering data from an archive.

Each of the octagon and rectangle height and humidity analysis programmes was made flexible, so that the choice of data to be used was controlled externally. Thus the three programme suites all automatically used the same analysis method and were therefore directly comparable. However some effort was required in advance to ensure that the octagon and rectangle versions of the height analysis were comparable, particularly with respect to the method of incorporating SIRS data.

The exclusion of surface data from ocean weather ships was achieved for both on- and off-station ships (using call signs). Unfortunately it was not possible to distinguish upper-air weather ship reports in this way, but since such reports from merchant ships are seldom received, it was expedient to exclude <u>all</u> upper air ship reports.

It was necessary to use the same background fields of height and humidity in each of the three suites for the first datum time, but thereafter, each suite produced its own background field. The implications for assessment of the results are described in Para.2.5.

2.2. Limitations

In the operational suite, incoming data are read from paper tape, and at fairly frequent times of the day a "data-bank" is updated with the most recently received data. Prior to the height and humidity analyses a set of "Basic Analysis Data Sets" (BADS) is compiled from the current data bank for both octagon and rectangle. In order to justify comparison of the three suites, it was necessary to arrange identical cut-off times for the data. This requirement was satisfied most readily by starting each experiment from the set of operational BADS, since decisions about inclusion or exclusion of data can be made during the height and humidity analyses.

Such an arrangement greatly alleviates the data storage problem, but there are a few difficulties, involved with intervention and with exclusion of OWS data:-

(i) All intervention except the addition of artificial observations (known within the Office as "bogus" observations) will have been effective by the time the BADS are produced. Therefore any differences of intervention between the three suites must be carried out in the form of "bogus" observations.

(ii) Certain data-bank quality-control checks will have been carried out with reference to a background field from the operational forecast, which is affected by OWS data.

(iii) Before transmission the SIRS data themselves are inverted from radiance data, a process which involves initial guess temperature profiles. The profiles in turn are provided by the Washington NMC numerical forecast which takes account of OWS data.

Until raw radiance data are transmitted by Washington NMC there is no way of avoiding contamination of Expt 1 by OWS data due to (iii) above.

Contamination due to (ii) could be avoided by filling a separate data bank for Expt 1 using a background field produced by Expt 1, and then extracting BADS from that data bank. The paper-tape reading time and the data storage problems mentioned above totally outweigh the benefit that would be achieved, since the quality control tests mentioned in (ii) are applied to about half the data, and a much smaller percentage fail the tests.

CFO accepted the limitation imposed by (i), since corrections and rejections of data that had been based on knowledge of OWS data could be swamped by bogus observations.

2.3. Intervention

For the period of the experiments an extra roster of forecasters was on duty in CFO, to provide "bogus" intervention appropriate to Expt 1 and Expt 2. The task required both integrity and care, since for Expt 1 the forecaster was to ignore all OWS data and to avoid all encounters with material (charts, forecasts etc) influenced by OWS data; while for Expt 2 he was allowed such encounters, and could use as much SIRS information as he could acquire, whether or not it had been included in the BADS. He was provided with machine plotted charts appropriate to the two experiments, and of course the computer output from the experiments themselves. The operational forecaster was not allowed access to any SIRS information.

2.4. The Programme Suites

In the remainder of this report, the adjective "main" refers to runs with a data cut-off time of 0300Z or 1515Z, whereas "update" refers to those runs with a cut-off time of 1200Z or 2400Z.

In order to reduce the computer usage for the experiments, full 72-hour (octagon) and 36-hour (rectangle) main forecasts were done only for the midnight data times. A midday update run was necessary to provide background fields, and this required abbreviated midday main runs (stopping after initialisation) to provide the forecaster with sufficient information to be able to intervene for the update run. A background field is of course essential to the abbreviated midday operational run, so it must be provided by a midnight update run.

A complete cycle of main and update runs was therefore necessary for octagon and rectangle in both experiments, although the requirements for output were considerably less than in the operational suite. It is convenient to assign letters to the various suites as in Table I. The arrangement of the suites in real time is depicted in Figure I. The timing of the runs was chosen to enable the forecaster to intervene sensibly under pressure similar to that experienced on the operational bench.

Details of data storage and output are set out in Appendices 1 and 2 respectively. Appendix 3 is a summary of the major features of the suites.

2.5. Assessment of Results

The forecasts were assessed both subjectively and objectively (Paras. 5 and 6 respectively). The latter made use of a verification scheme essentially similar to that used in the octagon operational suites, although special provision had to be made for use over a limited period. Two days were allowed to elapse before beginning the verification (the "run-up" period), so that the transient influence of various data types present or absent in the original background field, but foreign to the experiments, would not invalidate the statistics.

Furthermore, in order to verify the forecasts from the final datum time, special jobs were run for 3 days from the end of the experiment (the "run-down" period). Also included were jobs to verify the operational forecasts over the same period, for comparison with the experiments.

Objective verification of rectangle rainfall forecasts will be described in Para.7. The quantity of SIRS data received for each analysis is shown in Table II.

3. Conduct of the Experiments

The experiments began with the A1 run on the 7th March 1974, and objective verification began in the C2 run of 9th.

On 11th it was decided that Expt 1 would be inconclusive, since the synoptic situation was not one in which the Atlantic OWS reports would have much influence on UK weather. (See Para.4). Accordingly Expt 1 was discontinued after the C1 run on 11th.

Expt 2 ran to completion, in order to assess the method of incorporating SIRS data, ending after the B2 run on 15th. There followed a "run-down" period of 3 days for the objective verification.

4. Synoptic Situation 9th to 15th March 1974

The first part of the period of the experiment began with high pressure over Scandinavia and a ridge extending over the British Isles, lower pressure over Northern France and a deep depression in the West Atlantic between Newfoundland and Greenland. Small lows moved round the main depression and some broke away and ran into Northern France and Southern Britain. These were fairly shallow features with small amounts of rain and they dissipated as they moved towards the main high. A similar pattern was reflected in the upper air with troughs moving around the Atlantic low and ridges building between them. A cut-off 500mb low remained over the British Isles until 14th March. The region of high pressure moved slowly eastwards leaving a cut-off high near Iceland. On 14th March the block broke down and a secondary low running round the old West Atlantic low became dominant, deepened and ran forward across the British Isles with associated belts of rain. This was associated with the eastward extension to the south of Iceland of an upper trough from the old West Atlantic low and the return of westerly flow over the southern part of the British Isles. Figure XIV is reproduced from "Weather Log" March 1974 (published by Royal Meteorological Society), and shows the sequence of midday hand-drawn analyses for the period.

5. Subjective Assessment

All verification began with the forecasts based on 00Z 9/3/74. This was to allow any effects from the operational forecast, present in the background fields of the experimental runs, to become insignificant. The area considered in the subjective assessment was centred on the British Isles and included parts of Western Europe and the Eastern Atlantic. The charts assessed from the octagon were the surface pressure and 500mb analyses and 24, 48 and 72-hour forecasts. The surface pressure and 500mb analyses and 12, 24 and 36-hour forecasts of surface pressure, rate of rainfall and 500mb contour height were assessed from the rectangle. The comparisons between two charts, e.g. from the operational forecast and from Expt 1, were divided into 5 categories defined as follows:-

Operational v Expt 1

- A Operational significantly better than Expt 1
- B Operational better than Expt 1
- C Operational and Expt 1 equally good
- D Operational worse than Expt 1
- E Operational significantly worse than Expt 1.

In addition there was a category 'X' used for analyses only, which implied that the charts were different but owing to lack of conventional data it was impossible to decide which was better. A combined marking was given for the surface and 500mb charts.

Comparisons were made between the operational forecast and Expt 1, the operational forecast and Expt 2 and between Expt 1 and Expt 2 for the forecasts based on 00Z 9/3/74, 00Z 10/3/74 and 00Z 11/3/74. After this time Expt 1 was discontinued as the synoptic situation continued to be blocked and showed no signs of changing. Expt 2 continued as it was hoped that some useful results would be obtained on the use and value of satellite data. Tables III and IV show the results of the subjective assessment.

As can be seen from Table IV there were no A or E markings, i.e. occasions when the inclusion of satellite data would have affected the forecast issued for the British Isles. In most cases, especially for forecasts of more than 24 hours the forecasts were closer to each other than to the actual situation. In particular none of the forecasts predicted the change of type to westerly conditions which occurred on 14th March. Nevertheless the results show that on the whole the inclusion of satellite data is beneficial. There were only two occasions when the operational forecast was better than Expt 2. The first was 00Z 9th March. The operational forecast was better for some forecast times due to better pre-intervention, i.e. intervention in the main run. The problem of providing suitable pre-intervention in the experimental runs was made easier when Expt 1 was discontinued. However it is impossible to eliminate entirely the differences which may occur due to two different people doing the intervention, as can be seen from the case of 12th March where different pre-intervention improved the experimental forecast. The second case when the operational forecast was better than Expt 2 was 00Z 15/3/74. Here the operational forecast was better for the rectangle because in spite of a worse background field it retained the 400 and 500mb winds at OWS I, which were wrongly rejected by the Expt 2 analysis. Both the operational and Expt 2 analyses wrongly rejected the 300mb and 1000/500mb thermal wind. There is no obvious explanation why the operational octagon forecast was better. In this case the 400 and 500mb winds at OWS I were rejected by both the operational and Expt 2 analyses.

The results from Expt 1 for the first three days do not give any reliable indication of the general value of weather ships in forecasting weather for the British Isles as the synoptic situation was blocked and the weather ships in the Eastern Atlantic did not provide much useful information on these occasions. However, the removal of OWS B did have some effect on the forecasts in the Greenland area.

6. Objective Assessment of Octagon Forecasts

Objective verification of the experiments made two basic comparisons:

(i) forecast fields against operational update analysed or initialised fields appropriate to the verification time;

(ii) forecast fields against values observed at various stations at the verification time.

The "forecast fields" referred to are of four kinds: one each from the two experiments, one from the operational suite, and, as a control, "persistence" forecasts (in which analysed or initialised values are maintained throughout the forecast period).

In the comparison of forecast and analysed fields, two regions were used. Region I consisted of 1881 gridpoints covering a large percentage of the octagon area. Region II was a rectangular array of 560 points covering most of Europe, the Atlantic, most of Canada, and the northeast USA. It is with Region II that we are here concerned. (See Figure II)

In the comparison of forecast fields with observations, two groups of stations are used, one of 28 stations in northwest Europe, the other of six mid-Atlantic stations. (See Table VII). The latter group is clearly more prone to influence from a single station, so that caution is necessary when considering its statistics.

6.1. Forecasts v Analyses - Region II

6.1.1. Cumulative Statistics

Table V is a summary of the cumulative statistics for 12, 24 and 36-hour height forecasts from the three suites, over the whole period of the experiment, including the run-down period. Expt 2 should be compared with the operational forecast to assess the effect of SIRS observations. Expt 1 was to have been compared with Expt 2 to assess the effect of removing OWS data, but the comparison is not strictly justifiable, since Expt 1 was curtailed after a few cases.

Table VI is similar to Table V except that the run-down period is excluded, as is Expt 1.

6.1.2. Daily Statistics - Height Errors

Figures IIIa and IIIb represent comparisons of the progress of each individual forecast (operational v Expt 2) at 200mb and 500mb, in terms of RMS (root-mean-square) height differences between the forecast and the update analysis at the verification time. Ignoring for the moment forecast periods of less than 24 hours, it can be seen that all the experimental forecasts have lower RMS height differences than the corresponding operational forecasts, with the exception of the final day's forecast. In the earlier part of each of the 500mb forecasts, the experimental one has worse errors (except for one day), whereas at 200mb the reverse is the case, with the final day again representing an exception.

Figure IV compares equal-period forecasts of height from Expt 2, the operational suite and persistence, on a daily basis for three levels. Again they show in every case except the last that Expt 2 was slightly less in error than the operational forecast and that both were considerably better than persistence.

Another feature of the two curves for Expt 2 and the operational forecast is that they appear to diverge from a verification time of midnight on 11th, having been closely similar beforehand. This may be a consequence of the synoptic situation (Para.4), but a more likely explanation is that it represents a "run-up" period one day longer than anticipated. In other words the influence of the original background field on Expt 2 did not decay until after 3 days.

6.1.3. Daily Statistics - Wind Errors

Figure V a, b and c represent comparisons of persistence, operational and Expt 2 mean vector wind errors for 24, 48 and 72-hour forecasts respectively at 3 levels. The values plotted are of the mean vector departure of the forecast wind from the update-run initialised wind at verification time. An organisational error caused the statistics for a verification time of midnight on 15th to be invalid, so those statistics have not been presented. (Although they could be recovered (with considerable effort) they are unlikely to affect materially any inferences made from Figure V).

In general Figure V shows that Expt 2 is a very slight improvement on the operational forecast in most cases. Figure Vc suggests further that in relatively static synoptic situations a 72-hour persistence forecast is just as good as, or perhaps better than, either the operational or the Expt 2 72-hour forecast! It is probably unwise to make any more detailed inferences, in view of the wide variability displayed by the curves.

6.2. Forecasts v Observations

6.2.1. Europe (28-stations)

Table VIIa is a list of stations in this group, and their positions are plotted as dots in Figure II.

As a guide to the effect of SIRS data on jet-speed forecasts, Figure VI compares 300mb RMS vector wind errors on a daily basis. The experimental and operational curves are very similar for both 24 and 48-hour forecasts, excepting once again the end of the period.

6.2.2. Atlantic (6-stations)

Table VIIb is a list of stations in this group, and their positions are plotted as crosses in Figure II. OWS 'C' and OWS 'D' would have been included if they had been manned !

The number of observations from this group that were available for a day's statistics was very variable, and the results of verification for this group of stations are correspondingly unrepresentative and have not been reproduced here.

6.3. The Final Forecast

The forecast from a datum time of midnight on 15th (which was the last datum time of Expt 2) has been mentioned several times in Para.6 as an exceptional case. Some explanation is therefore in order.

From 13th, SIRS data were transmitted in the form of thicknesses from 1000mb, whereas previously they had been reported as heights above Mean Sea Level north of 18°N. This change had no effect on the height analysis, since the data are reduced to thicknesses in that programme as a matter of course. However, some confusion arose in CFO over values appearing on machine-plotted charts, thus compromising the intervention. Thus a change of character in the statistics could be expected for the last three cases. However, no such change of character is obvious, except in the last case of all, so an explanation of the latter must be found elsewhere.

A study of the Lamb Classifications of weather types at the top of Figure IIIa, or of Para 4 reveals that for most of the period of the experiments there was a blocking anticyclone over Northern Europe, (which was responsible for the curtailment of Expt 1). On 14th and 15th the block subsided, and a brief period of westerlies developed. Figures IV and VI show a tendency toward peaks in the error curves for the penultimate case, which could therefore be considered a relatively poor forecast, as might be expected when a blocking situation suddenly subsides. However, it is for this penultimate case that the improvement in the forecast due to the inclusion of SIRS data in the analysis is greatest.

It is therefore difficult to explain why the last case of all should give worse forecasts in Expt 2. One possibility is that the SIRS data are of poorer quality in this situation, based as they are on Washington NMC forecast temperature profiles. If the NMC forecast were a poor one at the cessation of a blocked situation, as ours was, then that would be reflected in the quality of the SIRS observations as transmitted. The 48-hour forecast issued by WNMC, based on 00Z data for 14th March, has been assessed by CFO as relatively poor in the vicinity of the UK (compared with the previous and the subsequent forecast). This may be an indication that shorter period forecasts based on the same data were also relatively poor, in which case the above hypothesis is supported.

7. Objective Verification of Rainfall from Rectangle Forecasts

Rainfall accumulations were verified for the 14 areas shown in the map in Figure VII for the forecasts based on data from 00Z 9th to 00Z 15th March . An average rainfall was calculated for each area for the periods T+12 to T+24 and T+24 to T+36 for both the operational and Expt 2 forecasts. These were verified against actual average values obtained for the same areas from rainfall data from synoptic stations kept in the climatological data bank.

The results, illustrated in Tables VIII, IX and X show very little difference between the two forecasts. Certainly they show that Expt 2 is no worse than the operational forecast. Table VIII shows the accuracy of the forecasts in distinguishing between wet and dry periods. For accumulations over the 24-hour period T+12 to T+36 the two forecasts were identical. For the two 12-hour periods T+12 to T+24 and T+24 to T+36 combined Expt 2 was marginally better. Table IX contains 4 x 4 contingency tables where the amounts of rain have been divided into three categories. These again show that over the 24-hour period the forecasts were equally good and that over the combined 12-hour periods Expt 2 was marginally better. These results indicate that Expt 2 was slightly better at timing the rain than the operational forecast but that the differences are so small as to be insignificant, especially in view of the errors inherent in the actual rainfall data. Table X compares the sum of the forecast values in each area for both forecasts and the sum of the actual mean values. These show that, except for the forecast beginning 00Z 15/3/74, there was no significant difference in the total rain predicted by the two forecasts, Expt 2 being marginally better than the operational forecast. For 00Z 15/3/74 there was a significant decrease in the amount of rain predicted when satellite data were included, but this appears to be nearer the truth in this case.

It is unfortunate that there was only one occasion (00Z 15/3/74) during the experiment when there was a belt of widespread frontal rain in the verification area and these results therefore do not give any reliable information about the effect of satellite data on frontal situations with widespread moderate or heavy rain. However, some additional runs based on data for 12Z 14/3/74 were made for this occasion and the results are described in Para.8.

8. Additional forecasts to investigate the effects of omitting weather-ship data.

8.1. Data included in the forecasts

The situation on 12Z 14/3/74 was suggested by CFO to be one where the weather ships were vitally important in the analysis. The operational octagon background field was very poor and did not indicate the extension of the upper trough giving a strong south easterly wind at OWS I. It was decided to examine the effects of the inclusion of satellite data and the removal of weather ships on this occasion and three forecasts were made with the fine-mesh model as it was thought that it would be of interest to examine the rainfall forecasts as well as the pressure patterns. The three forecasts included the following combinations of weather-ship and satellite data:-

A Weather ships, satellite data from the update run, 2400Z cut-off
B No weather ships, satellite data from the update run, 2400Z cut-off
C No weather ships, satellite data from the main run 1515Z cut-off (none received)

These were compared with the operational forecast which included weather-ship data, but no satellite data. Satellite data from the update run were used in order to avoid any criticism which suggested that the forecast which included satellite data but no weather ships was poor because the satellite data had not been received rather than because they were inadequate.

This update run satellite data consisted of 18 reports at 13Z and two reports at 15Z both of which were in the Davis Strait and therefore unlikely to affect the forecast for the British Isles. The background field for the three runs A, B and C was taken from Expt 2 and therefore included the effects of both weather-ship and satellite data. It was in fact a better background field in the region of OWS I than the operational one, which did not include the effects of satellite data. The boundary values for all three forecasts were taken from the operational octagon. It is true that these do not contain the effects of satellite data but this is thought to be of secondary importance.

8.2. Subjective assessment of results

Figure VIII shows the 500mb analyses used for each forecast. The low near OWS I is deeper in the analyses which included weather ships. Figures IX, X, XI and XII show the surface pressure and rate of rainfall patterns for the forecasts A, B, and C and the operational forecast. Both the 24-hour and more noticeably the 36-hour forecasts show significant differences in the surface pressure and rainfall between those forecasts using weather-ship data and those without. The trough over the British Isles was deeper with more intense rainfall and further advanced in those forecasts which used weather-ship data. Forecast A using both satellite and weather-ship data advanced the rainfall further than the operational forecast. Figure XIII shows the surface analyses taken from the Daily Weather Report for comparison with Figures IX, X, XI, and XII. At the 36-hour forecast time the trough had passed well through the British Isles.

8.3. Objective verification of rainfall

Tables XI and XII show the effects of satellite and weather-ship data on the forecasts of accumulated rain. Table XI consists of 4 x 4 contingency tables for the two 12-hour periods T+12 to T+24 and T+24 to T+36 combined and shows that both forecasts without weather ships were significantly worse than the operational forecast and the forecast including both ships and satellite data in predicting rainfall amounts of greater than 2mm. Table XII, which may be compared with Table X, shows that the total mount of rain predicted by the forecasts without weather ships was significantly lower and worse than the forecasts including weather-ship data. This is probably due to the effect of weather ships on the height analysis, as the humidity analysis without weather ships is wetter than that with weather ships. It is also true that the forecast including weather-ship and satellite data predicted less rain than the operational forecast, as it did for the data time 00Z 15/3/74, but on this occasion this was less good than the operational forecast. The decrease was caused by errors in the areas 6, 11, 12 and 13 and in fact for the areas 4, 5 and 7 the forecast including satellite data (A) produced more rain and was better.

9. Conclusion

Both the objective and subjective assessments of the coarse- and fine-mesh forecasts show that except for one occasion the inclusion of satellite data in the objective analyses did not have any harmful effects on the forecasts in the region of the British Isles and North Atlantic during the period of the experiment. On the majority of occasions the results were similar or there was a very slight improvement and on some occasions there was a noticeable improvement. The occasion (00Z 15/3/74) when the forecast was worse did not produce any serious errors. These results indicate that the use of SIRS data operationally should on the whole be beneficial and not produce any worsening of the forecasts. Experience in using satellite data operationally should lead to improved methods of incorporating them into objective analyses and in the long term, as their quality hopefully improves, careful monitoring should ensure that the best use is made of them.

Due to the blocked synoptic situation during the first part of the period of the experiment, Expt 1 was discontinued after three days and the results from these three days concerning the value of weather ships are inconclusive. Towards the end of the period the situation became westerly and some additional forecasts were run for 12GMT 14th March 1974 which demonstrate that the removal of weather ships can have a serious effect on the quality of the forecasts and that the inclusion of satellite data does not compensate for this effect. However, this is only one occasion and a second experiment to determine the effects of removing weather-ship data on a series of forecasts has been run from 2nd to 11th May 1974 and the results will be described in a second report.

10. Subsequent Introduction of SIRS Data into the Operational Analyses

In consequence of the preliminary results of Expt 2, namely that SIRS data had no large adverse effect on the forecast, the octagon and rectangle height analyses began to use SIRS data on the operational midnight update run (C run) on 26th March 1974. The facility to omit SIRS data for a run at the request of CFO was also provided.

Some complaints had been received from CFO concerning SIRS data in low latitudes which sometimes gave spurious warm ridges along the orbital track of the satellite, particularly at 100mb. In these ridges the reported temperatures were often as much as 5 Centigrade degrees warmer than nearby radio-sonde temperatures, and the SIRS data were swamping the sonde data. Therefore a facility to reject individual SIRS reports via the usual intervention procedures was incorporated.

However, the elimination of warm ridges by individual rejection of SIRS reports proved to be time-consuming, so on 9th April, the octagon height analysis was modified to reject all SIRS data south of 25°N. At the same time the climatological check was corrected (previously it had been operating on thicknesses from 1000mb as reported, instead of geopotential heights), and less weight was given to SIRS data at 100mb. (This latter change did not take place in the rectangle height analysis until 30th April).

A facility was introduced on 29th May to enable CFO to reject whole latitude bands of SIRS easily. This may be extended later to restrict the meridional extent of the bands, so that small regions of SIRS data (e.g. individual orbits, or oceans) may be rejected.

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Appendix 1. Data Storage

Three dedicated disk packs were required for data storage - one each for Expt 1 and Expt 2, and the third for verification data. The first two were to contain data sets which were different from the corresponding operational ones, viz.

Forecast data sets
Print disks
Background fields
Analysis and Initialisation data sets
Various essential housekeeping data sets

Each of these disks was "dumped" to tape once a day to provide firstly a means of quick recovery in case of hardware or software failure, and secondly a means of retaining results for future use.

Other input data, e.g. BADS and monthly climatological fields were accessed directly from the operational disk packs.

Appendix 2. Output

The terms of reference of the experiments were of a limited nature, viz. to assess the effect of various data on forecasts of weather in the vicinity of UK and NW Europe at multiples of 12 hours (rectangle) and 24 hours (octagon). Thus the full range of output produced in the operational suites was not required. In the experiments, output was required for two purposes: intervention, and subjective assessment.

For intervention, analyses and update forecasts were produced for both rectangle and octagon, and in addition for the octagon, analysed minus initialised fields were printed. The areas used were Chart 14 (N.Hemisphere, 1:50 million), Chart 15 (Atlantic, 1:30 million), Chart 16 (Rectangle area, 1:20 million) and Chart 19 (Pacific, 1:30 million).

For subjective assessment the requirements for rectangle and octagon were different. Octagon analyses, and forecasts to 24, 48 and 72 hours over the Chart 15 area at mean sea level and at 500mb were produced on the CALCOMP microfilm line drawer and printed at 1:30 million scale in CFO. (1000/500mb thickness charts were also produced, but not used in the assessment). Calcomp microfilm was also the medium for rectangle assessment output, viz. "four-in-one" displays of surface pressure with rate of rainfall and accumulated rainfall at T+0, T+12, T+24, T+36.

All the above output is normally produced for CFO in the operational suites, except the last mentioned Calcomp rectangle output, where the four-in-one charts are produced for T+0, T+24, T+30 and T+36.

Appendix 3. Summary of Experiments

Part 1 indicates the major differences between the experiments and the operational suite. Part 2 indicates the tasks performed by each run of the experiments.

Part 1. Major Differences

Expt 1. Includes SIRS data
Excludes all Upper Air Ship reports
Excludes all Surface OWS reports
(Slight contamination from OWS data (see Para.2.2))
Intervention without reference to OWS data.

Expt 2. Includes SIRS data
Includes all OWS and Upper Air Ship data
Intervention refers to all data

Operational: Excludes SIRS data
Includes all OWS and Upper Air Ship data
Intervention without reference to SIRS data.

Part 2 Details of Runs

A run: Midnight main octagon to 72 hours
Limited chart and Calcomp output

B run: Midnight main rectangle to 36 hours
Calcomp output and chart analyses
Rainfall verification

C run: Midnight update octagon to 12 hours
Limited chart output
Midnight update rectangle to 12 hours
Limited chart output
Produce background fields from T+12 forecasts
Octagon verification (all three jobs in C2 for convenience)
Disk dumps (following C2)

D run: Midday main octagon - analyses and initialisation only
Chart analyses and analysed-minus-initialised

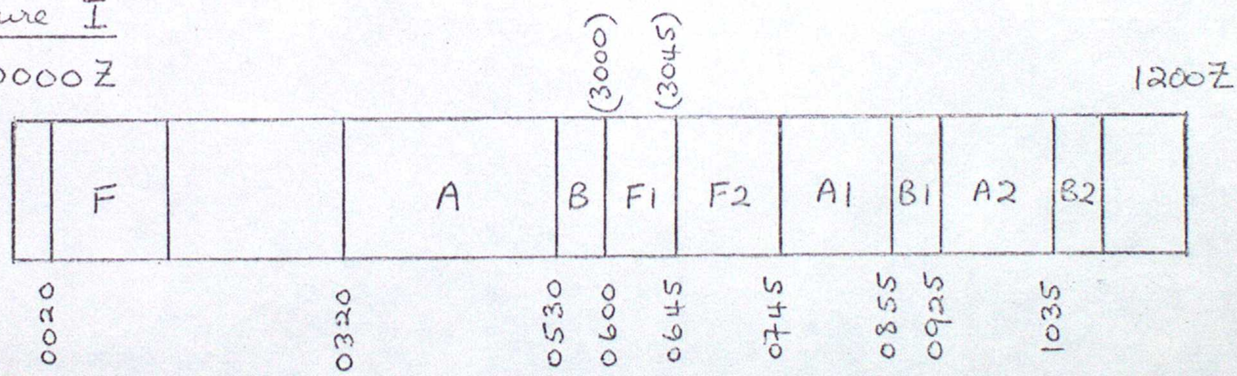
E run: Midday main rectangle - analyses and initialisation only
Chart analyses

F run: Midday update octagon to 12 hours
Limited chart output
Midday update rectangle to 12 hours
Limited chart output
Produce background fields from T+12 forecasts
Octagon verification (all three jobs in F2 for convenience)

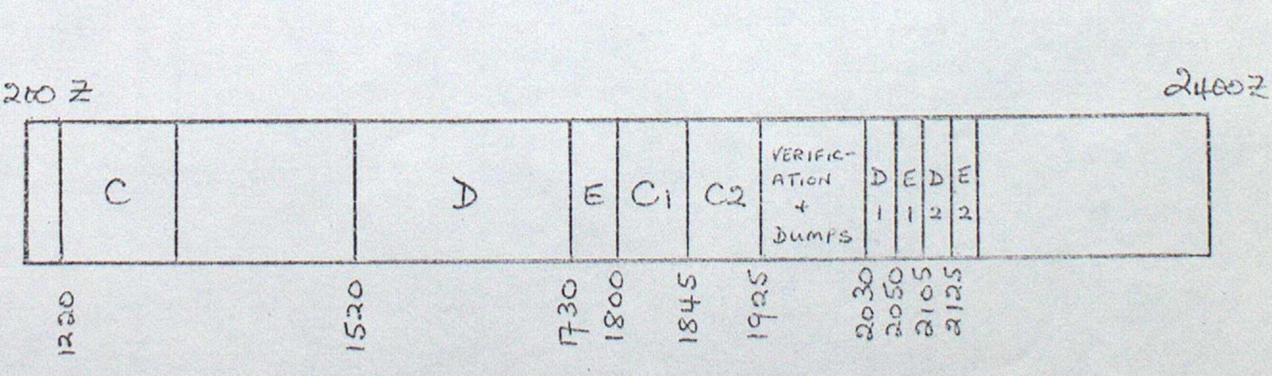
Table I Designation of particular runs.

Run	Operational	Expt 1	Expt 2
Midnight main octagon	A	A1	A2
Midnight main rectangle	B	B1	B2
Midnight update octagon + rectangle	C	C1	C2
Midday main Octagon	D	D1	D2
Midday main rectangle	E	E1	E2
Midday update operational + rectangle	F	F1	F2

Figure I



Morning.



Afternoon.

Arrangement of runs in real time during the Experiments.

Table II. Number of Satellite Reports used in each run of Expt 1 + 2

a. Octagon:

Date	"0000Z" data		"1200Z" data
	main run (0300Z cut-off)	update run (1200Z cut-off)	update run (2400Z cut off)
7	91	137	111
8	103	126	108
9	43	106	56
10	53	71	104
11	102	121	7
12	30	36	56
13	16	31	118
14	120	142	56
15	62		

b. Rectangle:

Date	"0000Z" data		"1200Z" data
	main run (0300Z cut off)	update run (1200Z cut off)	update run (2400Z cut off)
7	16	16	32
8	28	28	36
9	2	17	10
10	15	15	35
11	16	16	0
12	14	14	17
13	5	5	36
14	34	34	20
15	11		

"0000Z" data means data observed within 6 hours (inclusive) of 0000Z, south of 25°N, or within 3 hours north of 25°N

"1200Z" data means data observed within 6 hours (inclusive) of 1200Z, south of 25°N, or within 3 hours north of 25°N

TABLE IIIa

RESULTS OF SUBJECTIVE ASSESSMENT 00Z 9th to 00Z 11th MARCH 1974

		RECTANGLE			OCTAGON		
DATA TIME	F/C TIME	Op V Expt 1	Op V Expt 2	Expt 1 V Expt 2	Op V Expt 1	Op V Expt 2	Expt 1 V Expt 2
00Z 9/3/74	ANALYSIS	B*	B*	D	B*	B*	C
	T+12	C	D	C			
	T+24	C	C	C	D	B	B
	T+36	C	C	C			
	T+48				C	B	B
	T+72				C	D	D
00Z 10/3/74	ANALYSIS	C	C	C	C	C	C
	T+12	C	C	C			
	T+24	C	C	C	D	D	D
	T+36	C	D	D			
	T+48				D	D	C
	T+72				D	D	D
00Z 11/3/74	ANALYSIS	C	C	C	D	D	C
	T+12	C	C	C			
	T+24	D	D	C	D	D	C
	T+36	B	C	D			
	T+48				C	C	C
	T+72				C	C	C

EXPLANATION OF LETTERS:

FORECAST X v FORECAST Y

A X SIGNIFICANTLY BETTER THAN Y
B X BETTER THAN Y
C X AND Y EQUALLY GOOD
D X WORSE THAN Y
E X SIGNIFICANTLY WORSE THAN Y

* DUE TO PRE-INTERVENTION AT SURFACE

TABLE III 6

RESULTS OF SUBJECTIVE ASSESSMENT 00Z 12th TO 00Z 15th MARCH 1974

DATA TIME	F/C TIME	RECTANGLE Op v Expt 2	OCTAGON Op v Expt 2
00Z 12/3/74	ANALYSIS	X	D*
	T+12	D	
	T+24	D	D
	T+36	C	
	T+48		D
	T+72		C ‡
00Z 13/3/74	ANALYSIS	C	C
	T+12	C	
	T+24	C x	C
	T+36	C	
	T+48		D
	T+72		D
00Z 14/3/74	ANALYSIS	X	X
	T+12	D	
	T+24	D ‡	C ‡
	T+36	C ‡	
	T+48		C ‡
	T+72		C ‡
00Z 15/3/74	ANALYSIS	C	C
	T+12	B	
	T+24	B	B
	T+36	C	
	T+48		C
	T+72		C

EXPLANATION OF LETTERS

OP v Expt 2

A Operational significantly better than Expt 2

B Operational better than Expt 2

C Operational and Expt 2 equally good

D Operational worse than Expt 2

E Operational significantly worse than Expt 2

X Analysis only - unable to assign mark due to lack of conventional data

* Due to pre-intervention at surface

‡ Both forecasts poor

x Both rectangle forecasts worse than octagon.

TABLE IV

Totals in each category from TABLES III (a), (b) for operational v Expt. 2.

CATEGORY	RECTANGLE	OCTAGON
A	0	0
B	3	4
C	16	12
D	7	11
E	0	0

EXPLANATION OF LETTERS

A OPERATIONAL SIGNIFICANTLY BETTER THAN EXPT 2
B OPERATIONAL BETTER THAN EXPT 2
C OPERATIONAL AND EXPT 2 EQUALLY GOOD
D OPERATIONAL WORSE THAN EXPT 2
E OPERATIONAL SIGNIFICANTLY WORSE THAN EXPT 2

TABLE V

Ship Experiment Verification of Octagon 10 level model. March 1974
Cumulative Statistics – maximum period.

	*Number of cases	Period	1000mb	500mb	300mb	200mb	100mb
1. Heights against Objective Analyses (Region 2 560 grid points)							
Experiment 1.							
T+12 Forecast RMS height differences (metres)	3	ØØZ 9/3 – 12Z 10/3	27	34	40	41	47
Height change correlation			0.80	0.83	0.87	0.82	0.80
T+24 Forecast RMS height differences (metres)	1	"	43	57	72	69	97
Height change correlation			0.80	0.85	0.87	0.83	0.76
T+36 Forecast RMS height differences (metres)	1	"	55	77	96	99	138
Height change correlation			0.79	0.84	0.87	0.83	0.73
Experiment 2		ØØZ 9/3 – 12Z 14/3					
T+12 Forecast RMS height differences (metres)	11	"	26	31	40	41	51
Height change correlation			0.83	0.84	0.86	0.82	0.74
T+24 Forecast RMS height differences (metres)	7	ØØZ 9/3 – ØØZ 18/3	42	51	64	64	87
Height change correlation			0.82	0.85	0.88	0.8[illegible]	0.75
T+36 Forecast RMS height differences (metres)	7	"	56	70	86	88	116
Height change correlation			0.80	0.84	0.88	0.86	0.80
Operational							
T+12 Forecast RMS height differences (metres)	11	ØØZ 9/3 – 12Z 14/3	25	31	40	41	50
Height change correlation			0.84	0.85	0.88	0.84	0.73
T+24 Forecast RMS height differences (metres)	17	ØØZ 9/3 – ØØZ 18/3	42	51	65	65	80
Height change correlation			0.82	0.85	0.88	0.86	0.75
T+36 Forecast RMS height differences (metres)	16	"	57	72	93	91	112
Height change correlation			0.79	0.84	0.86	0.85	0.77
Persistence (from operational analyses)							
T+12 Persistence forecast RMS height differences (metres)	11	ØØZ 9/3 – 12Z 14/3	41	51	71	57	50
T+24 Persistence forecast RMS height differences (metres)	17	ØØZ 9/3 – ØØZ 18/3	65	86	120	101	85
T+36 Persistence forecast RMS height differences (metres)	16	"	82	112	154	135	121

*__NOTE__ Cases for Experiment 1 and Experiment 2 are for ØØZ only, whereas the operational includes 12Z forecasts runs as well as the ØØZ cases. Also the operational run has picked up a few additional cases at the end of the experiment.

This does not apply to the T+12 as 12Z cases were available for the experiment.

TABLE VI

Ship experiment

Verification of Octagon 10 level model March 1974
Cumulative Statistics - to end of period before rundown

	*Number of cases	Period	1000mb	500mb	300mb	200mb	100mb
1 Heights against objective analyses (Region 2 560 grid points)							
Experiment 2 T+12 Forecast RMS height differences (metres)	12	ΦΦZ 9/3 - ΦΦZ 15/3	25	30	40	40	51
Operational T+12 Forecast RMS height differences (metres)	12	ΦΦZ 9/3 - ΦΦZ 15/3	25	30	39	40	49
Experiment 2 T+24 Forecast RMS height differences (metres)	6	"	43	52	65	66	89
Operational T+24 Forecast RMS height differences (metres)	11	"	45	55	69	70	89
Experiment 2 T+36 Forecast RMS height differences (metres)	5	"	59	73	87	92	127
Operational T+36 Forecast RMS height differences (metres)	10	"	62	76	97	97	123

* NOTE Cases for Experiment 1 and Experiment 2 are for ΦΦZ only, whereas the operational includes 12Z forecasts as well as the ΦΦZ cases. Also the operational run has picked up a few additional cases at the end of the experiment.

This does not apply to the T+12, as 12Z cases were available for the experiment.

Table VII: Observations used in Octagon Verification

a. 28 Stations in Europe

01415	Stavanger	06447	Uccle
02084	Göteborg	06610	Payerne
03005	Lerwick	07110	Brest
03026	Stornoway	07145	Trappes
03170	Shanwell	07480	Lyon
03322	Aughton	07510	Bordeaux
03496	Hemsby	07645	Nîmes
03774	Crawley	10035	Schleswig
03808	Camborne	10338	Hannover
03920	Long Kesh	10384	Berlin
03953	Valentia	10739	Stüttgart
06011	Thorshavn	10866	Munich
06181	Copenhagen	12330	Poznan-Lawica
06260	De Bilt	16080	Milan

b. 6 Atlantic Stations

04018	Keflavik	O.W.S.	B
04270	Narssarssuaq	O.W.S.	I
		O.W.S.	J
		O.W.S.	K

TABLE VIII

2 X 2 CONTINGENCY TABLES FOR WET AND DRY PERIODS COMBINING ALL THE AREAS SHOWN IN FIGURE VII

OPERATIONAL

ACTUAL	DRY	WET
DRY	57	16
WET	40	83

(a) All 12-hour periods T+12 to T+24 and T+24 to T+36

EXPT 2

ACTUAL	DRY	WET
DRY	58	15
WET	39	84

(b) All 12-hour periods T+12 to T+24 and T+24 to T+36

OPERATIONAL

ACTUAL	DRY	WET
DRY	23	6
WET	21	48

(c) 24-hour periods T+12 to T+36

EXPT 2

ACTUAL	DRY	WET
DRY	23	6
WET	21	48

(d) 24-hour periods T+12 to T+36

Table IX

4 x 4 contingency tables for 4 categories of rainfall amount, for all areas shown in Figure VII.

Operational

Rain in mm	0	<2	≥2 <5	≥5
0	57	15	1	0
<2	32	48	6	3
≥2 <5	7	15	3	2
≥5	1	4	1	1

Actual

(a) All 12-hour periods T+12 to T+24 and T+24 to T+36

Experiment 2

Rain in mm	0	<2	≥2 <5	≥5
0	58	14	1	0
<2	32	48	7	2
≥2 <5	7	16	3	1
≥	0	3	3	1

Actual

(b) All 12-hour periods T+12 to T+24 and T+24 to T+36

Operational

Rain in mm	0	<2	≥2 <5	≥5
0	23	5	1	0
<2	15	15	1	5
≥2 <5	5	10	5	2
≥5	1	4	3	3

Actual

(c) 24-hour periods T+12 to T+36

Experiment 2

Rain in mm	0	<2	≥2 <5	≥5
0	23	5	1	0
<2	15	14	3	4
≥2 <5	5	11	5	1
≥5	1	4	3	3

Actual

(d) 24-hour periods T+12 to T+36

Table X.

Daily totals of the mean values of accumulated rain (mm) in each of the 14 areas shown in Figure VII.

Data Time	Verification Period T+12 to T+24			Verification Period T+24 to T+36		
	Actual	Operational	Expt. 2	Actual	Operational	Expt. 2
00Z 9/3/74	2·9	2·7	2·8	8·1	1·8	2·2
00Z 10/3/74	12·4	4·1	4·6	9·2	3·8	4·3
00Z 11/3/74	8·1	7·0	7·1	9·4	7·3	7·6
00Z 12/3/74	14·5	5·5	6·3	14·8	5·1	6·1
00Z 13/3/74	8·8	6·3	6·2	7·7	10·1	8·3
00Z 14/3/74	14·4	9·0	9·1	27·5	8·8	10·4
00Z 15/3/74	24·3	40·7	30·1	17·1	25·6	18·4

TABLE XI

4 x 4 contingency tables for four categories of rainfall amount for the forecast beginning 12Z 14/3/74. All areas in figure VII and 12-hour periods T+12 to T+24 and T+24 to T+36 combined.

OPERATIONAL

	Rain in mm.	0	<2	≥2 <5	≥5
Actual	0	8	1	0	0
	<2	1	6	1	1
	≥2 <5	2	2	3	3
	≥5	1	0	1	1

Weather ships no satellites

A

	Rain in mm.	0	<2	≥2 <5	≥5
Actual	0	8	1	0	0
	<2	1	7	1	0
	≥2 <5	1	2	4	0
	≥5	0	1	1	1

Weather ships update satellite data

B

	Rain in mm.	0	<2	≥2 <5	≥5
Actual	0	7	2	0	0
	<2	0	8	0	1
	≥2 <5	2	5	0	0
	≥5	1	1	1	0

No weather ships update satellite data.

C

	Rain in mm	0	<2	≥2 <5	≥5
Actual	0	7	2	0	0
	<2	0	8	0	1
	≥2 <5	2	5	0	0
	≥5	1	1	1	0

No weather ships main run satellite data (none)

TABLE XII

TOTALS OF MEAN VALUES OF ACCUMULATED RAIN (MM) IN EACH OF THE 14 AREAS SHOWN IN FIGURE VII FOR THE FORECAST BEGINNING 12GMT 14/3/74.

VERIFICATION PERIOD	ACTUAL	OPERATIONAL	A	B	C
00Z TO 12Z 15.3.74	27.5	22.8	18.8	11.8	11.6
12Z TO 24Z 15.3.74	24.3	16.5	15.4	12.0	10.6

10 LEVEL - MODEL VERIFICATION REGIONS

REGION I 1881 grid points

REGION II 560 grid points

⊘ 28 Upper-air observing stations (Europe)

× 6 Upper-air observing stations (Atlantic)

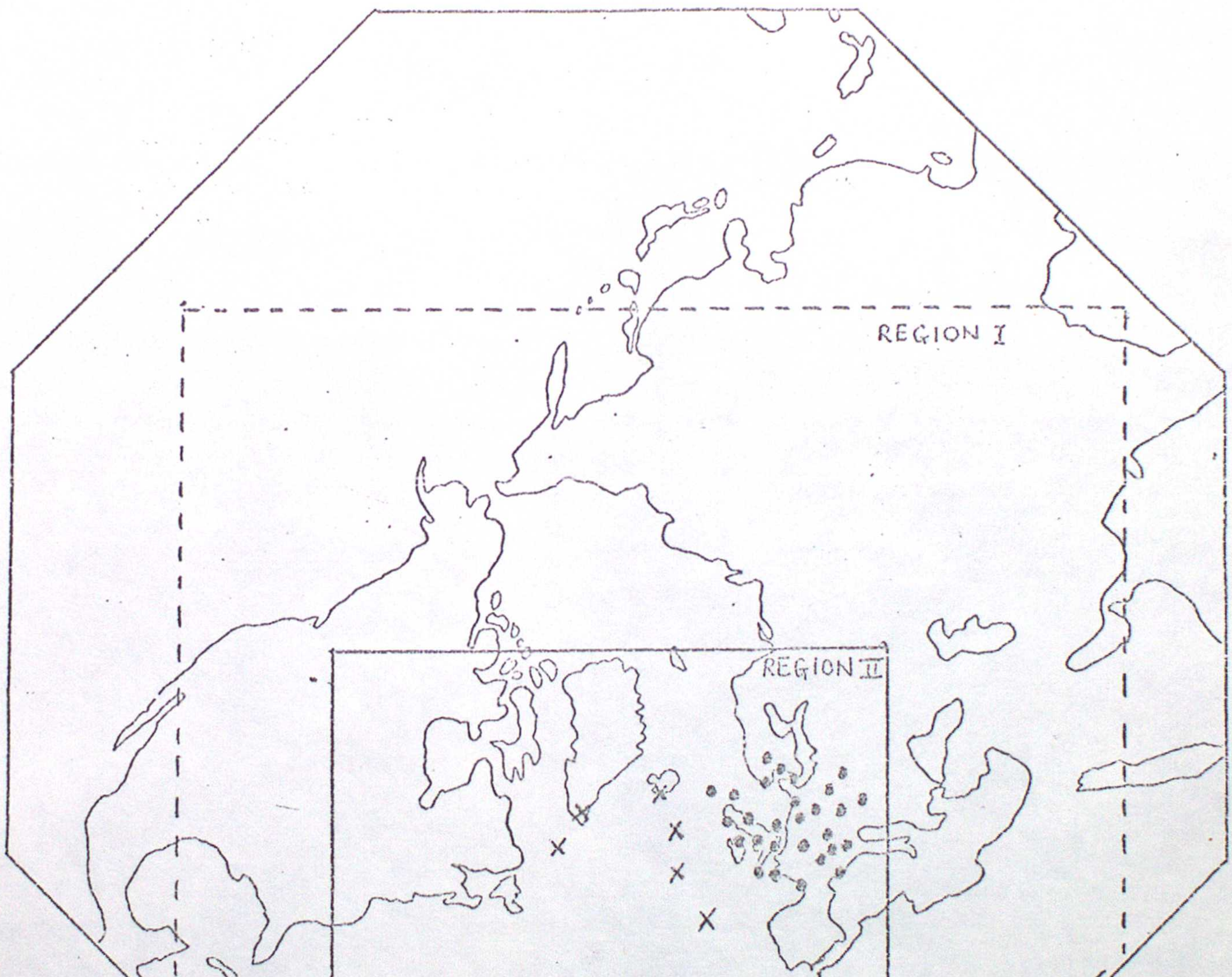


Fig II

Graph Data Ref. 5501 mm, ½ and 1 cm

RMS Height Differences for Forecasts v. update analyses for increasing forecast periods. SMALL AREA (Region 2) 560 grid points

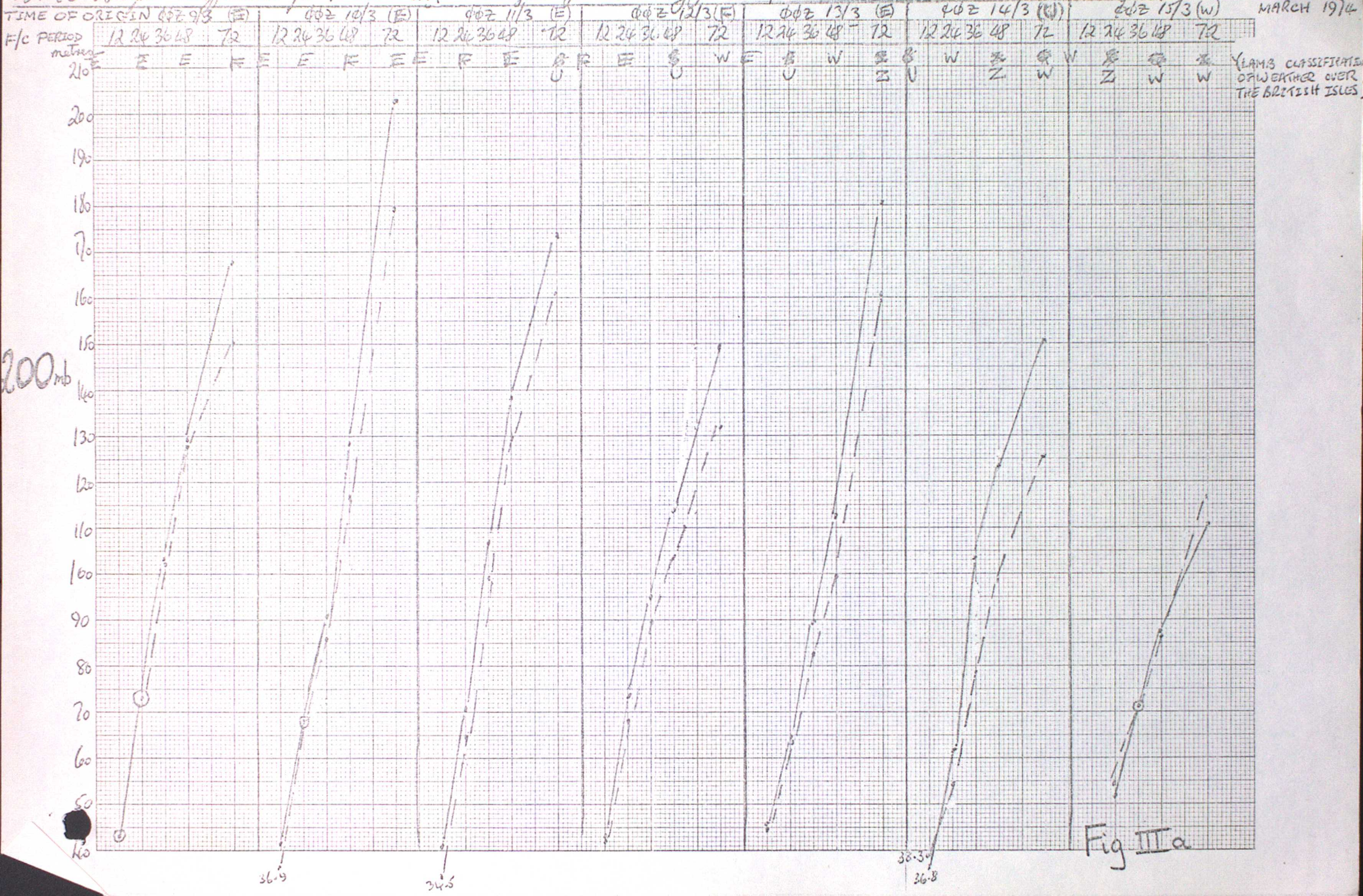


Fig IIIa

RMS Height Differences for forecasts v Update Analyses for increasing forecast periods SMALL AREA (Region 2) 560 gridpoints

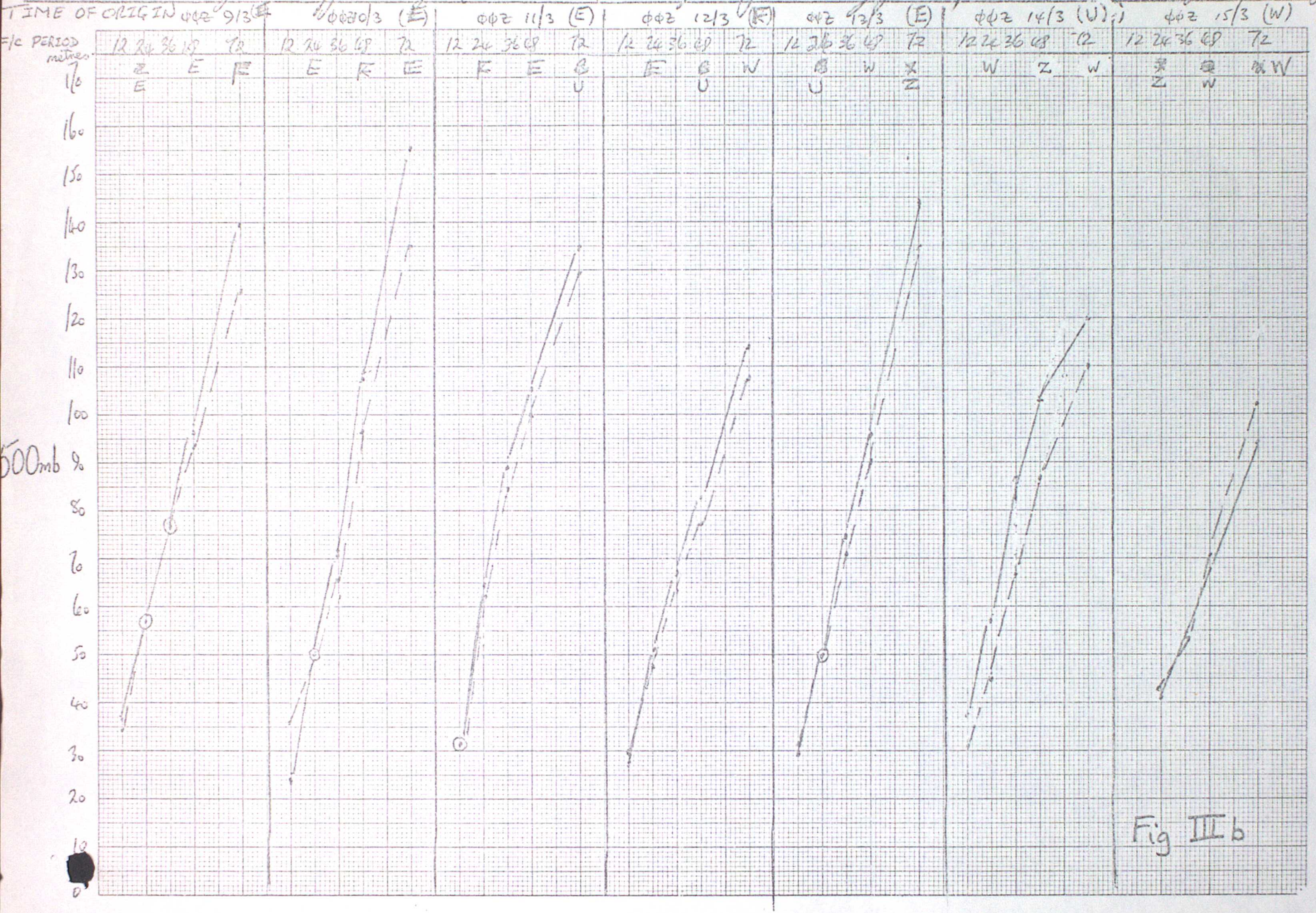


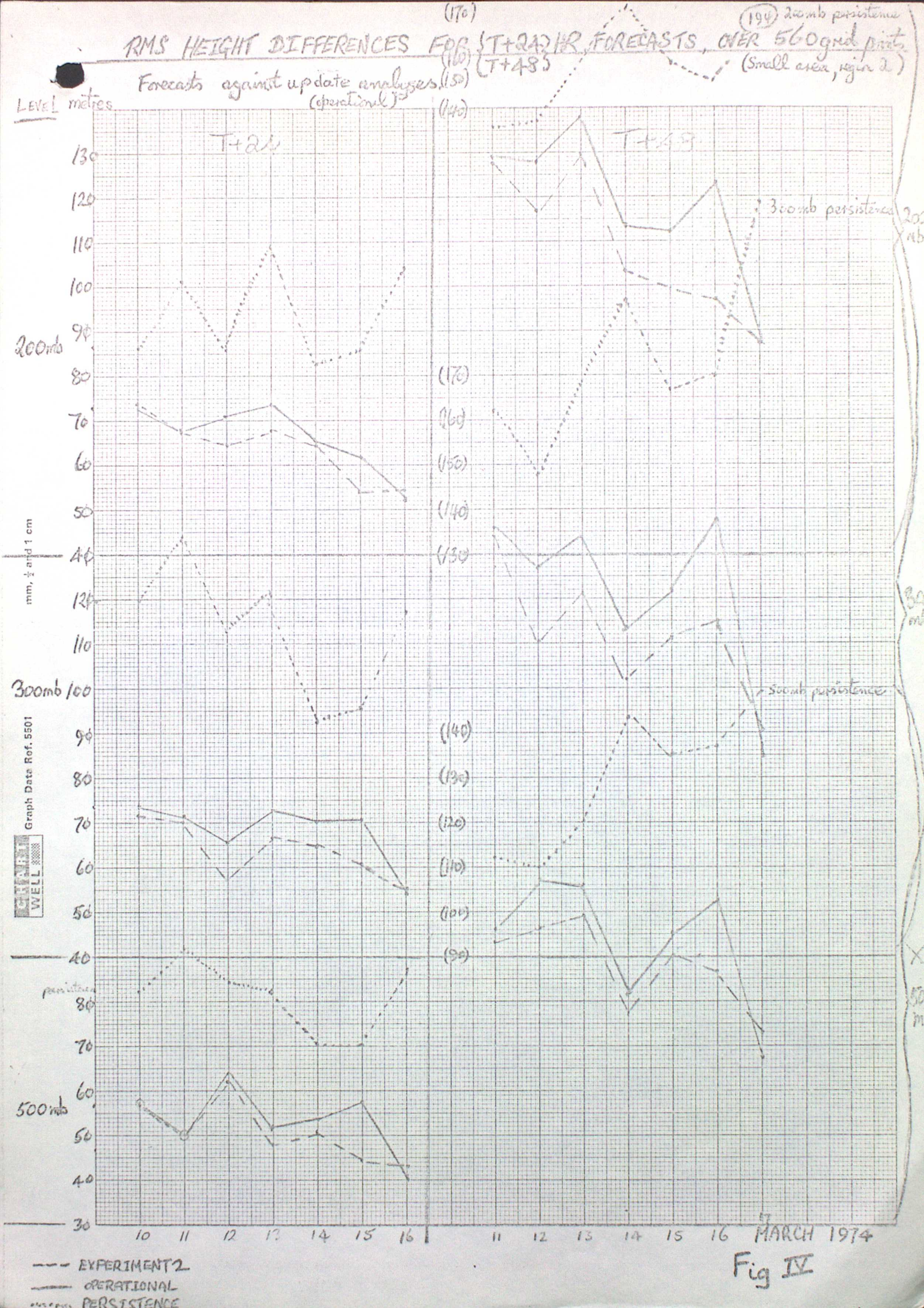
Fig III b

LAMB CLASSIFICATION

The days are classified into one of the following categories:-

A	Anticyclonic North Westerly
B	North Westerly
C	Cyclonic North Westerly
D	Anticyclonic Easterly
E	Easterly
F	Cyclonic Easterly
G	Anticyclonic North Easterly
H	North Easterly
I	Cyclonic North Easterly
J	Anticyclonic SouthEasterly
K	South Easterly
L	Cyclonic South Easterly
M	Anticyclonic Northerly
N	Northerly
O	Cyclonic Northerly
+	Anticyclonic South Westerly
P	South Westerly
Q	Cyclonic South Westerly
R	Anticyclonic Southerly
S	Southerly
T	Cyclonic Southerly
U	Unclassifiable
V	Anticyclonic Westerly
W	Westerly
X	Cyclonic Westerly
Y	Anticyclonic
Z	Cyclonic

FIG.IIIC.



RMS HEIGHT DIFFERENCES FOR {T+24, T+48} HR. FORECASTS, OVER 560 grid points
(Small area, region 2)
Forecasts against update analyses (operational)
LEVEL metres
T+24
T+48
200mb
300mb
500mb
200mb persistence
300mb persistence
500mb persistence
persistence
10 11 12 13 14 15 16
11 12 13 14 15 16 17
MARCH 1974
EXPERIMENT 2
OPERATIONAL
PERSISTENCE

Fig IV

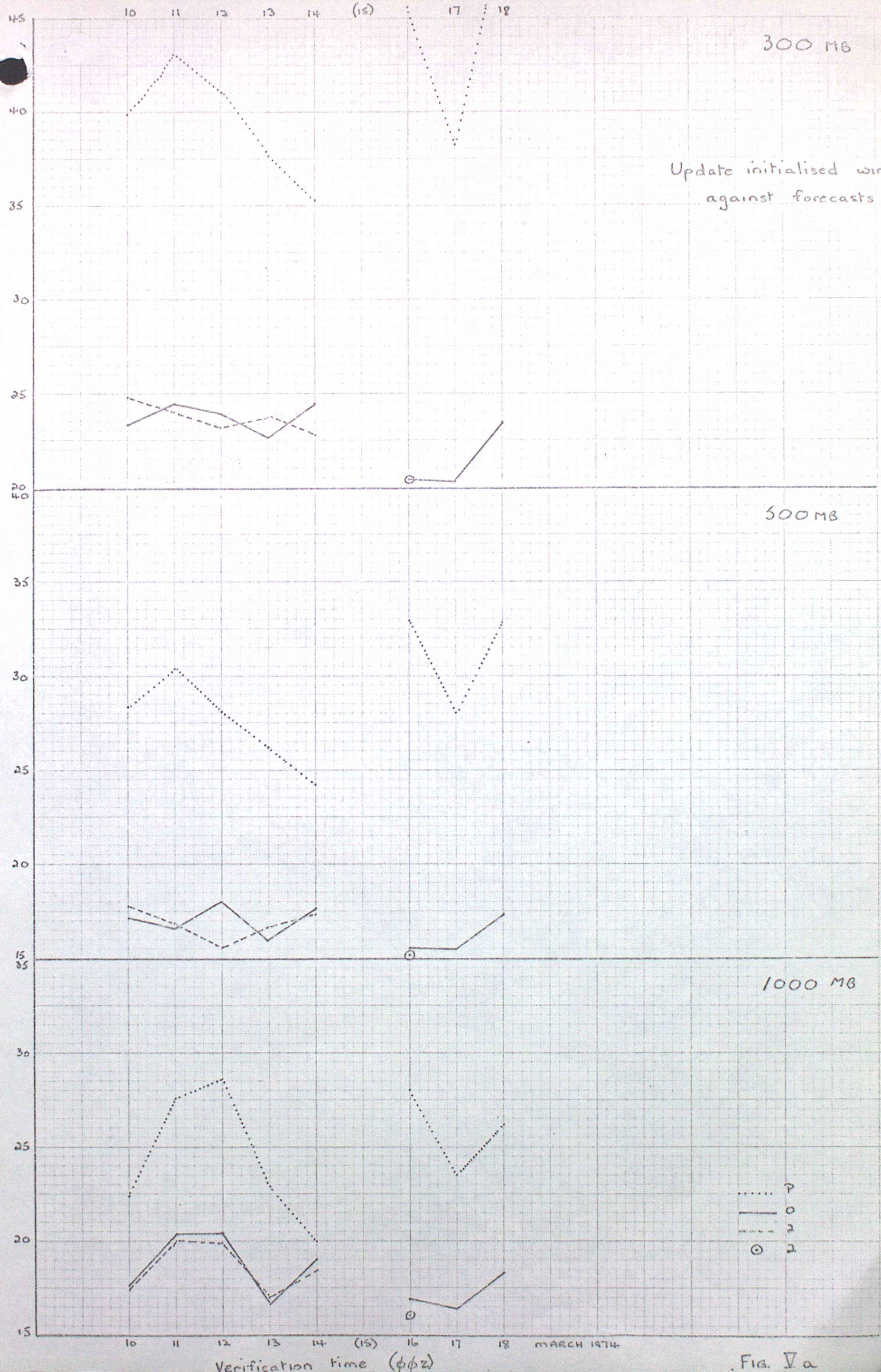

300 MB
500 MB
1000 MB
Update initialised winds against forecasts
45
40
35
30
25
20
15
10 11 12 13 14 (15) 16 17 18
P
0
2
2
MARCH 1974
Verification time (φφz)

Fig. V a

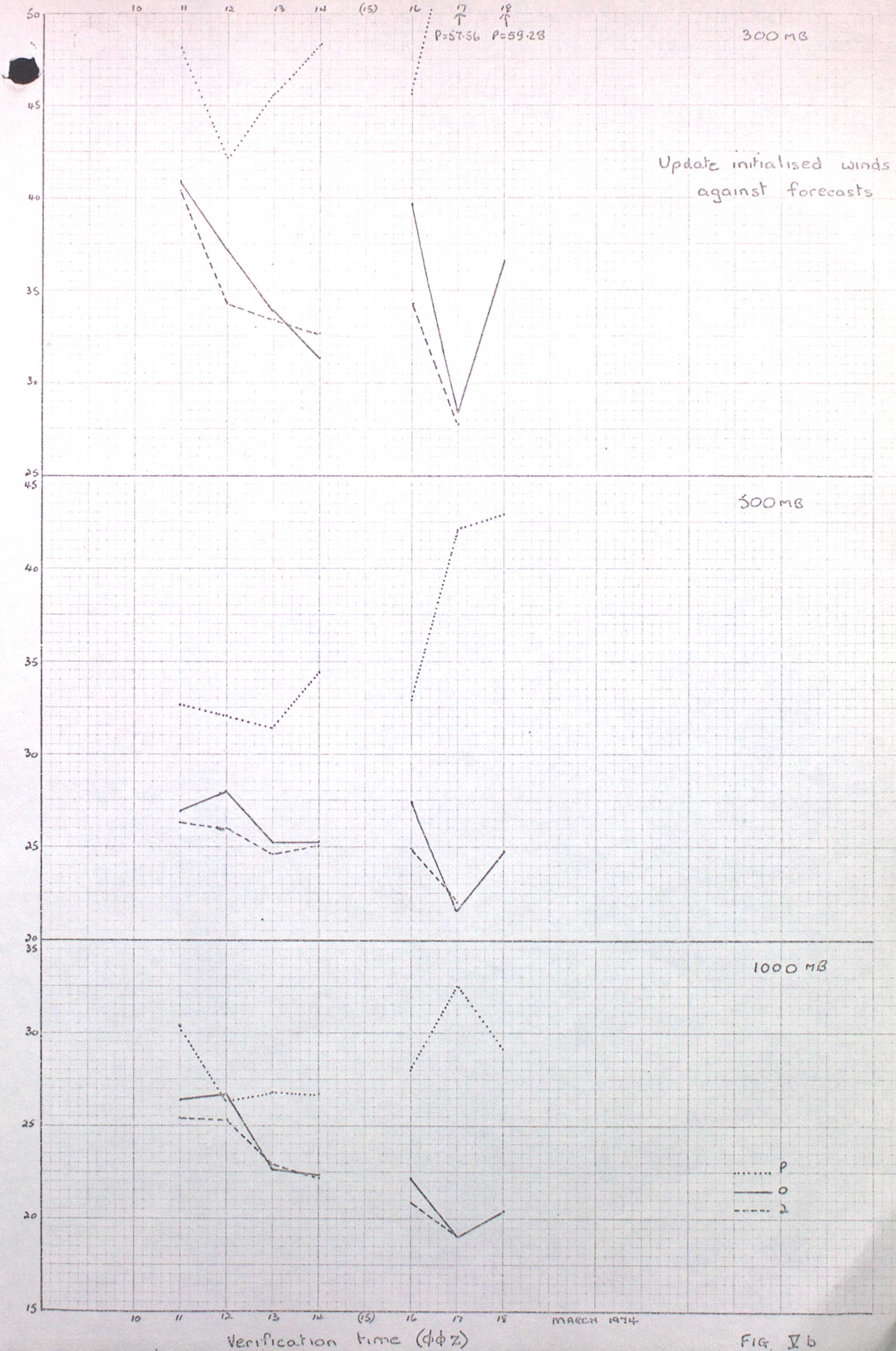
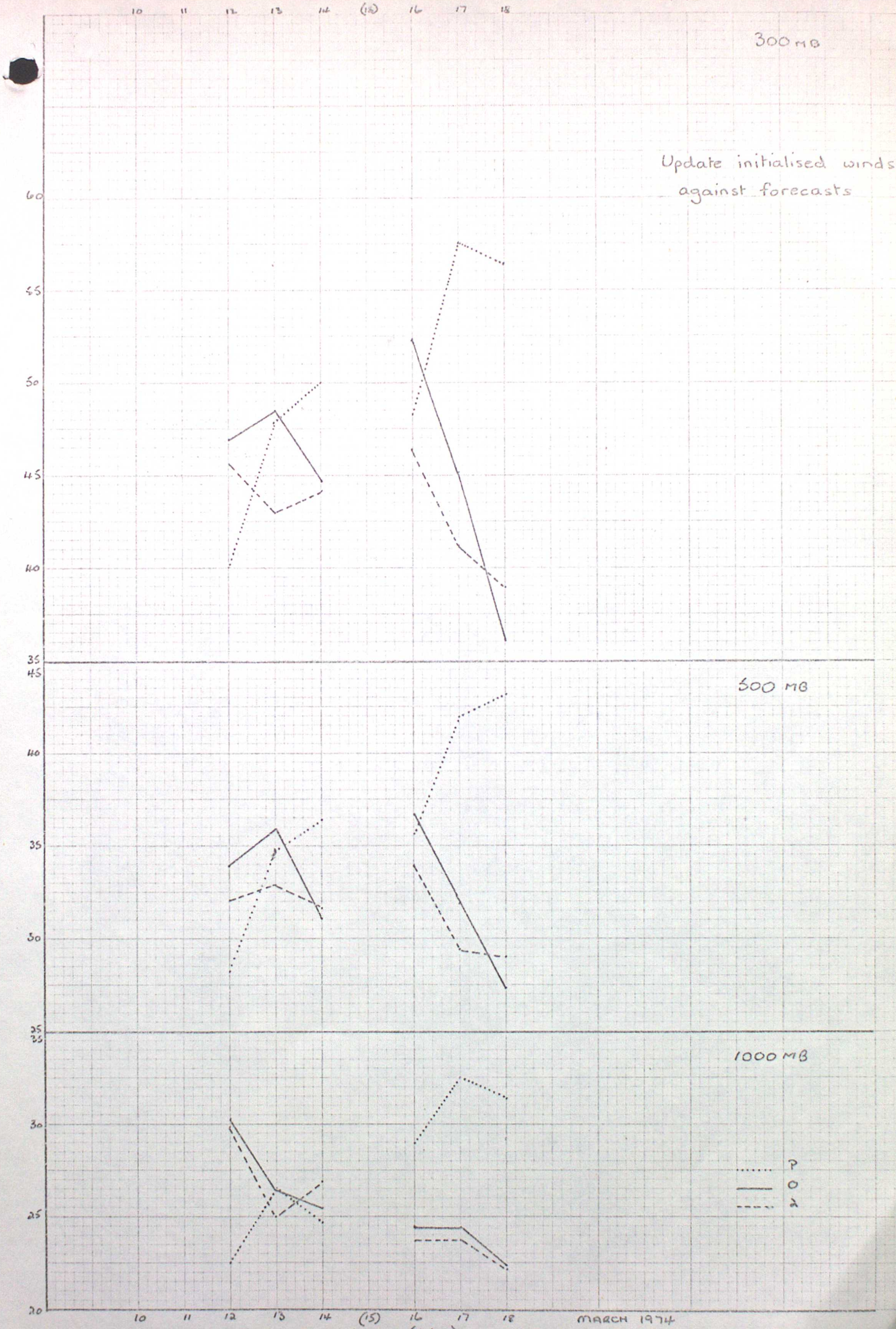

300 MB
500 MB
1000 MB
Update initialised winds against forecasts
P=57·56
P=59·28
P
O
2
10 11 12 13 14 (15) 16 17 18
MARCH 1974
Verification time (ΦΦZ)

FIG. V b



Verification time (ØØZ)

FIG V c

WESTERN EUROPE (28 STATIONS)

RMS VECTOR WIND ERRORS AT 300mb 24 HR FORECASTS & 24 HR PERSISTENCE

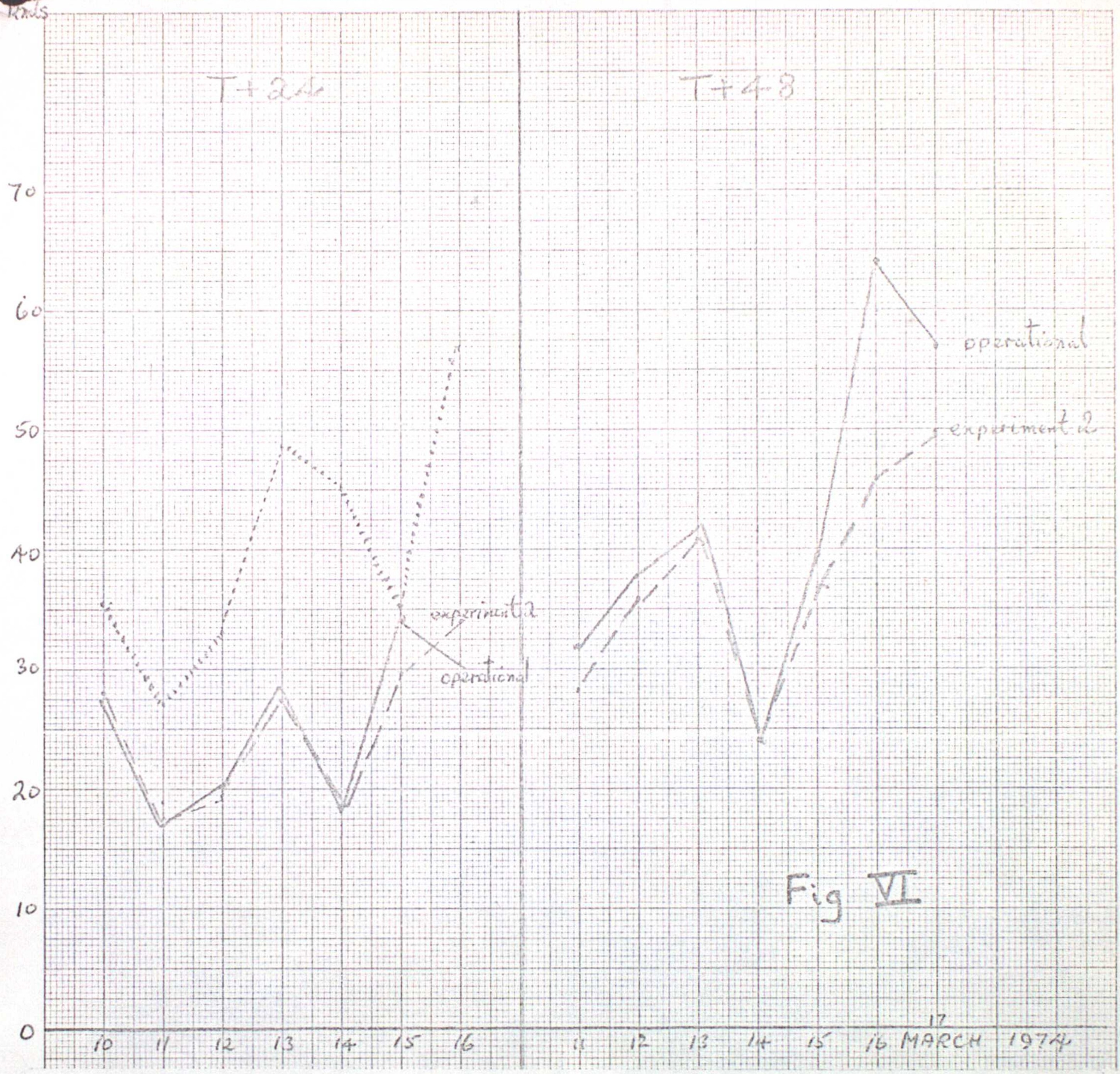


Fig VI

---- Expt 2
——— Operational
.... Persistence

Stations used:

01415	03920	07480
02084	03953	07510
03005	06011	07645
03026	06181	10035
03170	06260	10338
03322	06447	10384
03496	06610	10739
03774	07110	10866
03808	07145	12330
		16080

FIGURE VII AREAS USED FOR OBJECTIVE RAINFALL VERIFICATION

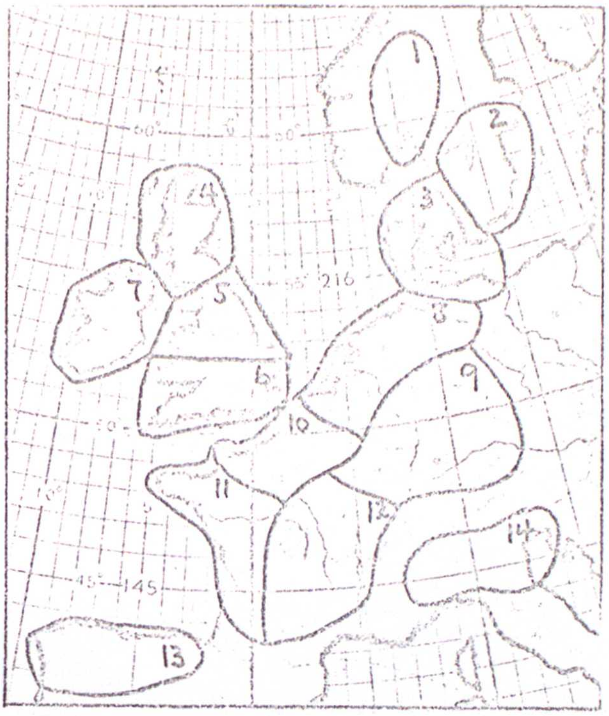
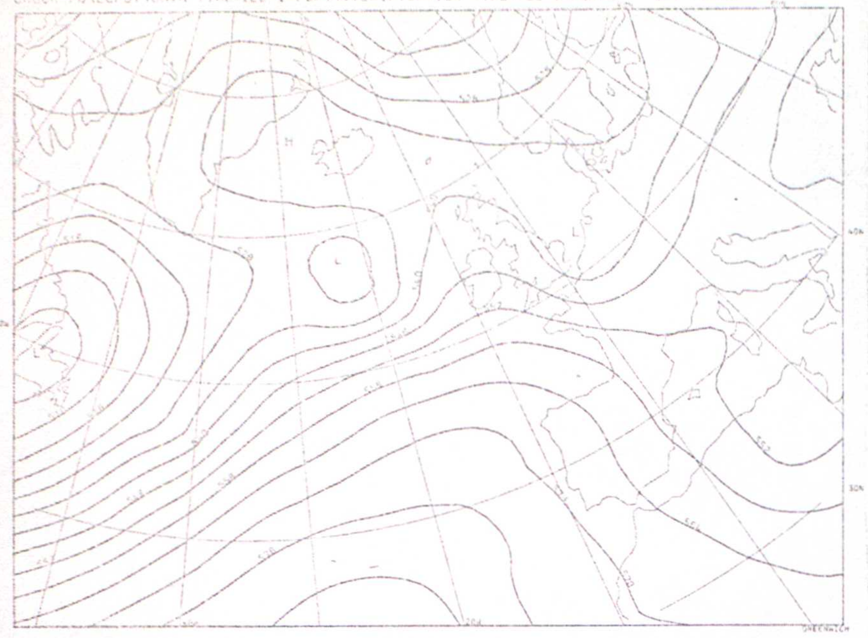


FIG VIII

500 MB ANALYSIS

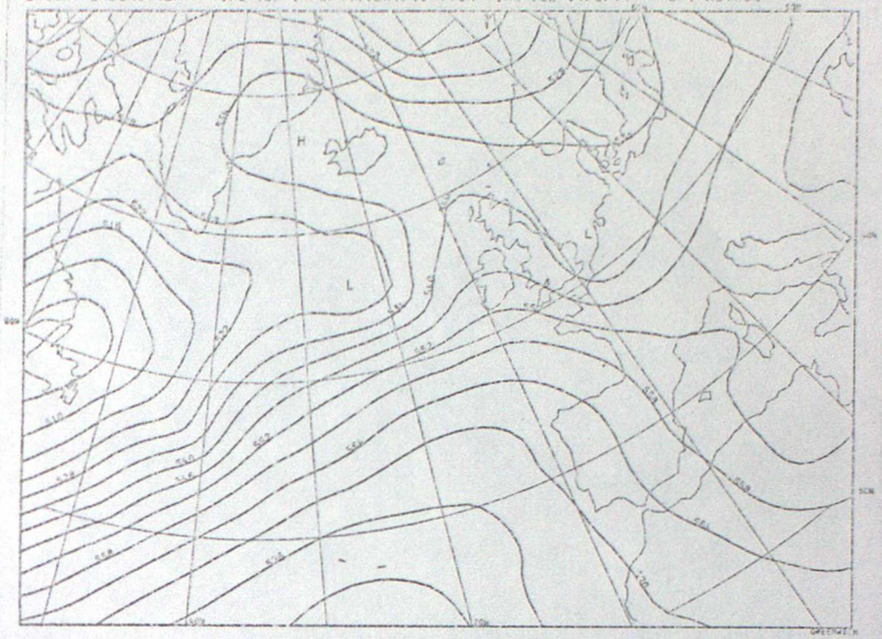
OPERATIONAL WEATHER SHIPS NO SATELLITES

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS
0HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 14/3/74 S-I METHOD



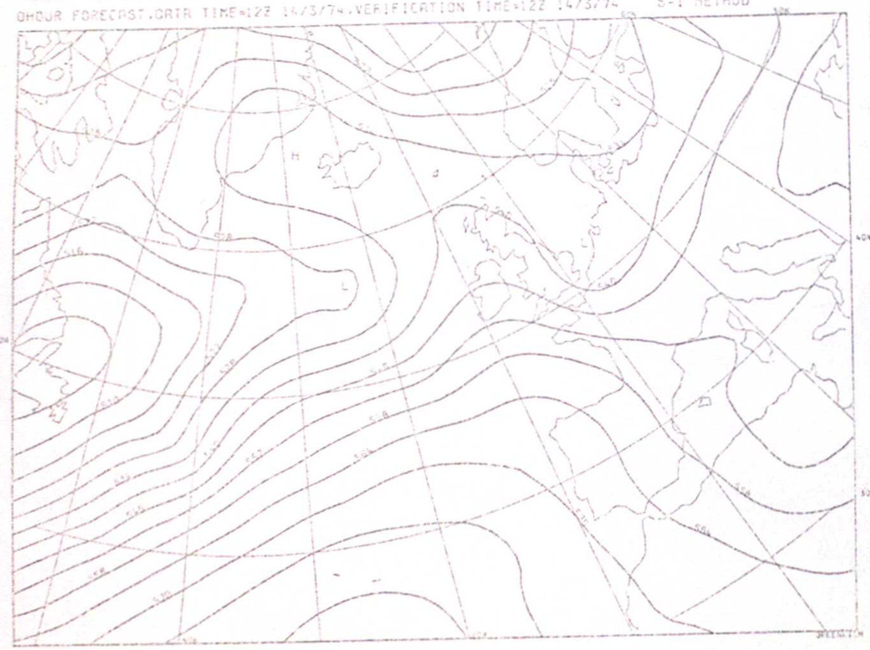
A WEATHER SHIPS UPDATE SATELLITE DATA

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS
0HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 14/3/74 S-I METHOD



B NO WEATHER SHIPS UPDATE SATELLITE DATA

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS
0HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 14/3/74 S-I METHOD



C NO WEATHER SHIPS MAIN RUN SATELLITE DATA (NONE)

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS
0HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 14/3/74 S-I METHOD

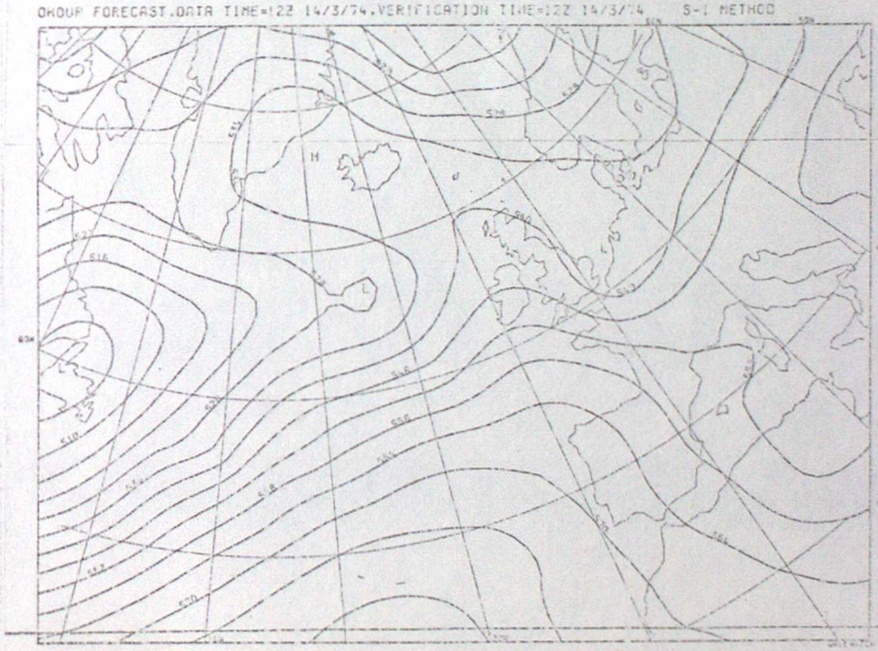


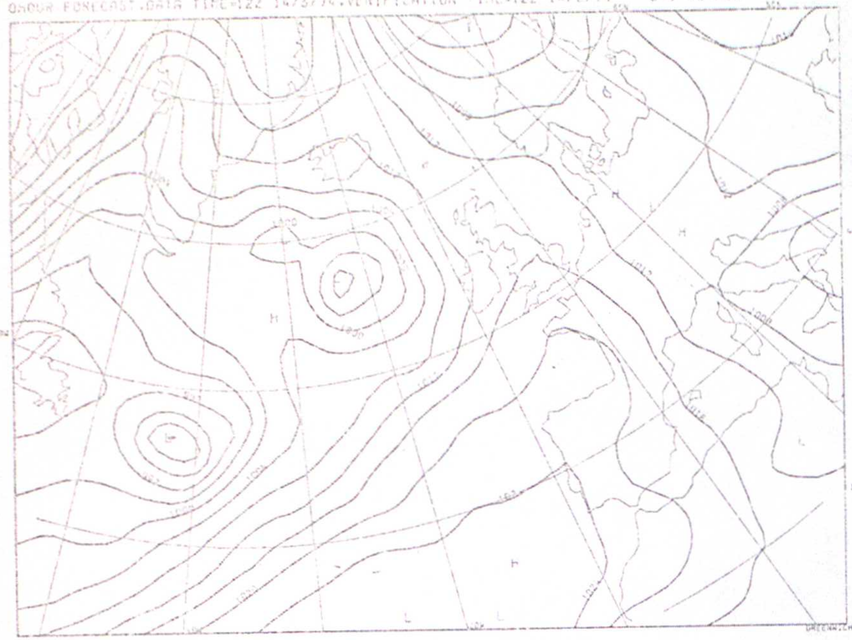
FIG IX

SURFACE PRESSURE ANALYSIS

OPERATIONAL WEATHER SHIPS NO SATELLITES

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

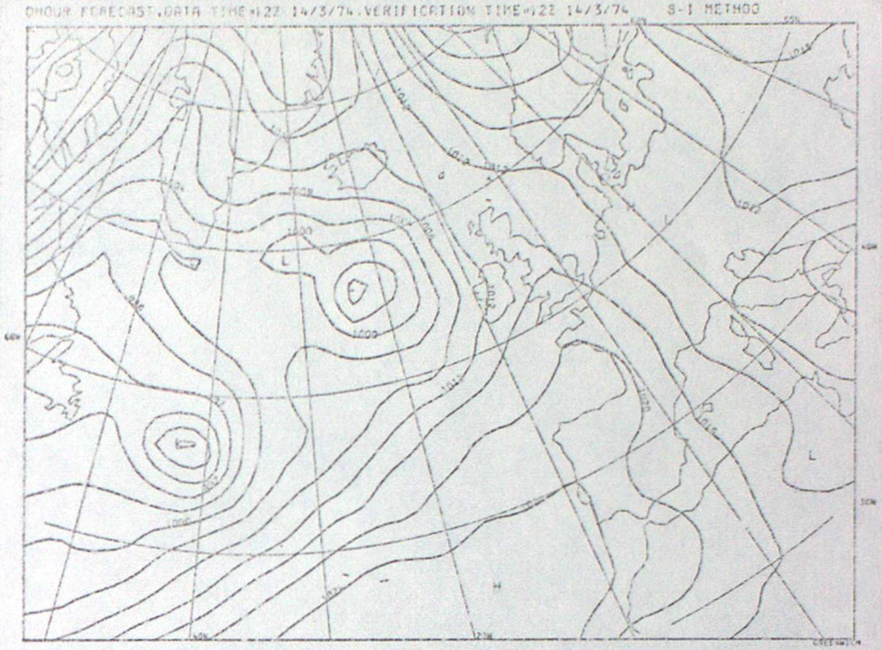
0HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 14/3/74 S-I METHOD



A WEATHER SHIPS UPDATE SATELLITE DATA

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

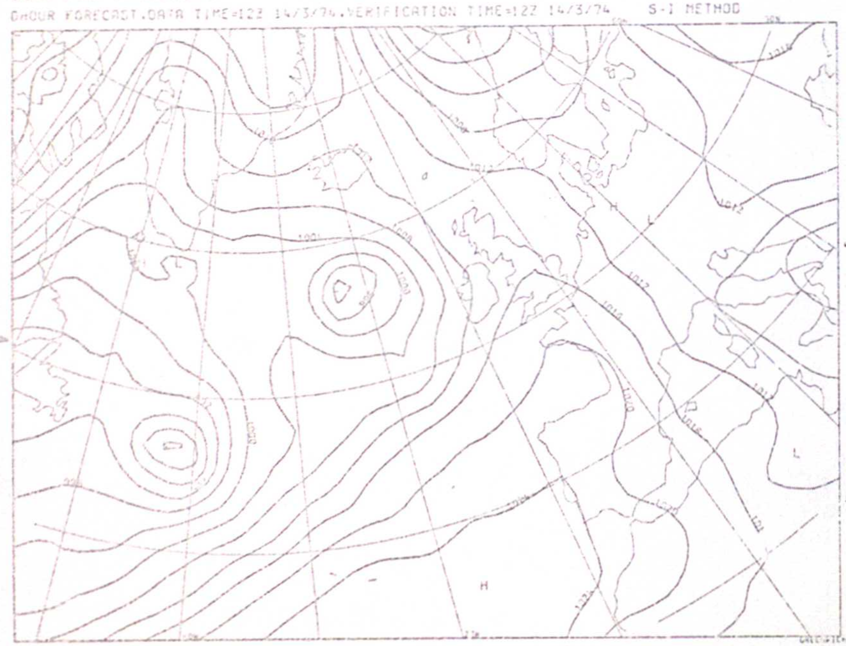
0HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 14/3/74 S-I METHOD



B NO WEATHER SHIPS UPDATE SATELLITE DATA

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 14/3/74 S-I METHOD



C NO WEATHER SHIPS MAIN RUN SATELLITE DATA (NONE)

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 14/3/74 S-I METHOD

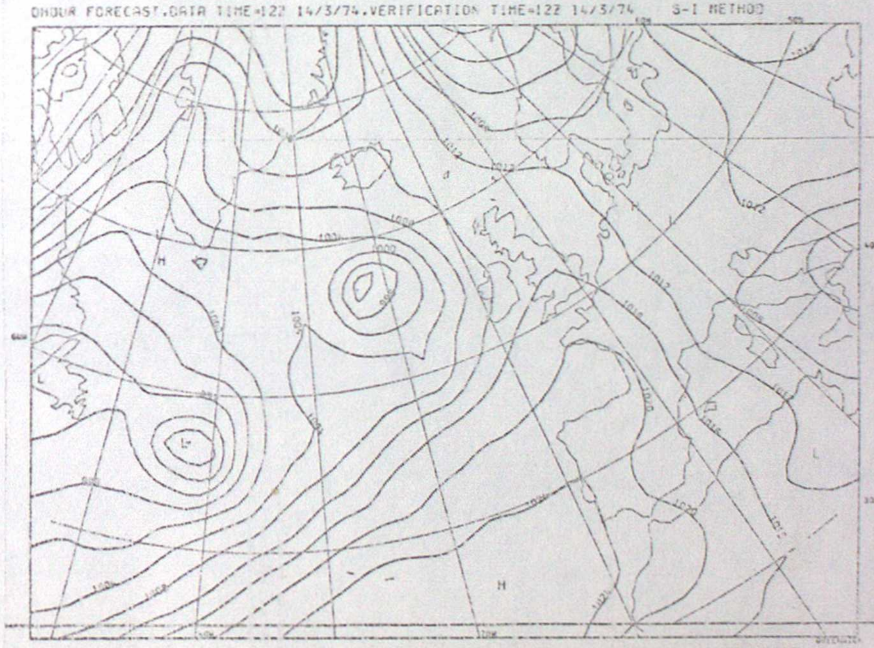


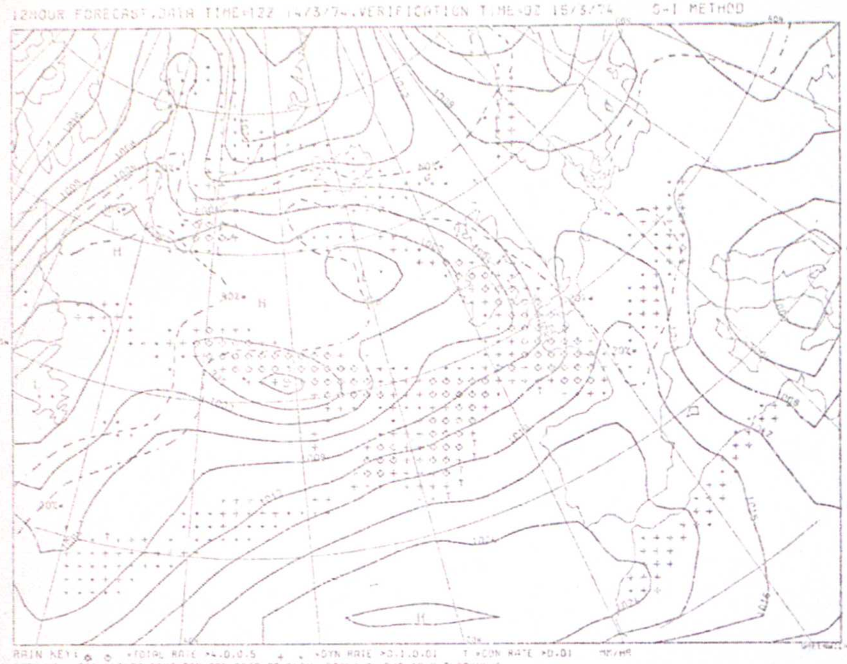
FIG V

SURFACE PRESSURE AND PRECIPITATION 12-HOUR FORECAST

OPERATIONAL WEATHER SHIPS NO SATELLITES

FORECAST SURFACE PRESSURE AND PRECIPITATION

12HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=0Z 15/3/74. S-I METHOD

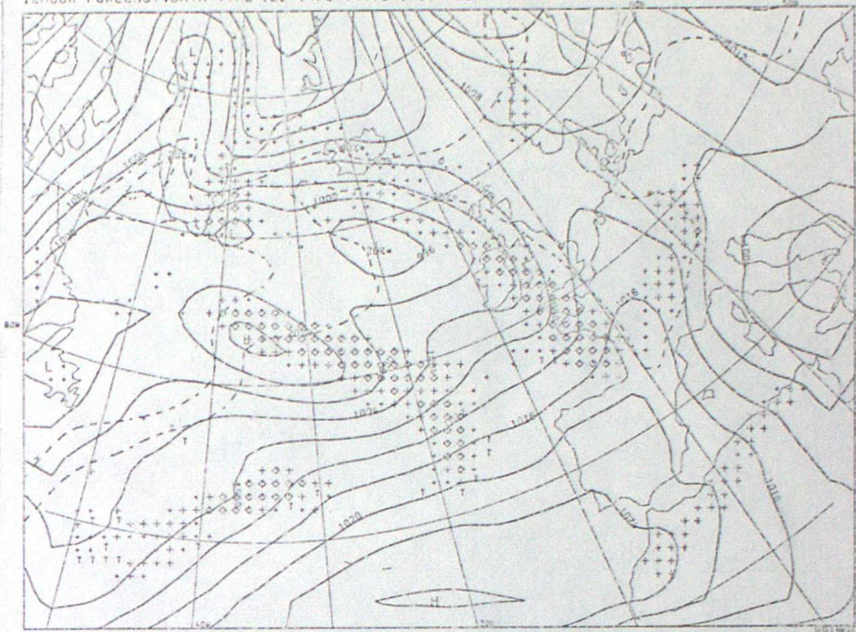


RAIN KEY: ◦ ◦ +TOTAL RATE >4.0,0.5 + +DYN RATE >0.1,0.01 T +CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW, BASED ON F/C 10-9 THICKNESS

A WEATHER SHIPS UPDATE SATELLITE DATA

FORECAST SURFACE PRESSURE AND PRECIPITATION

12HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=0Z 15/3/74. S-I METHOD

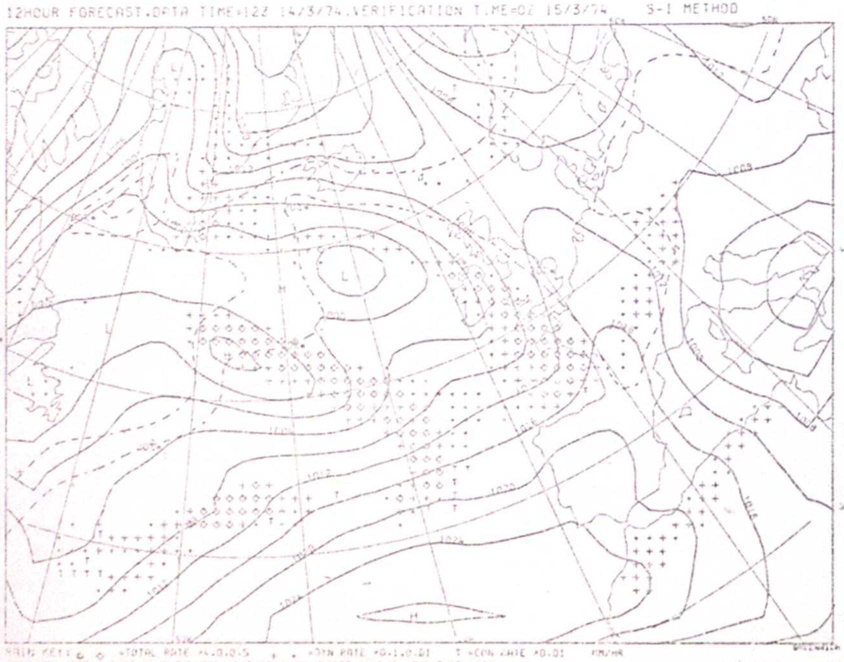


RAIN KEY: ◦ ◦ +TOTAL RATE >4.0,0.5 + +DYN RATE >0.1,0.01 T +CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW, BASED ON F/C 10-9 THICKNESS

B NO WEATHER SHIPS UPDATE SATELLITE DATA

FORECAST SURFACE PRESSURE AND PRECIPITATION

12HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=0Z 15/3/74. S-I METHOD

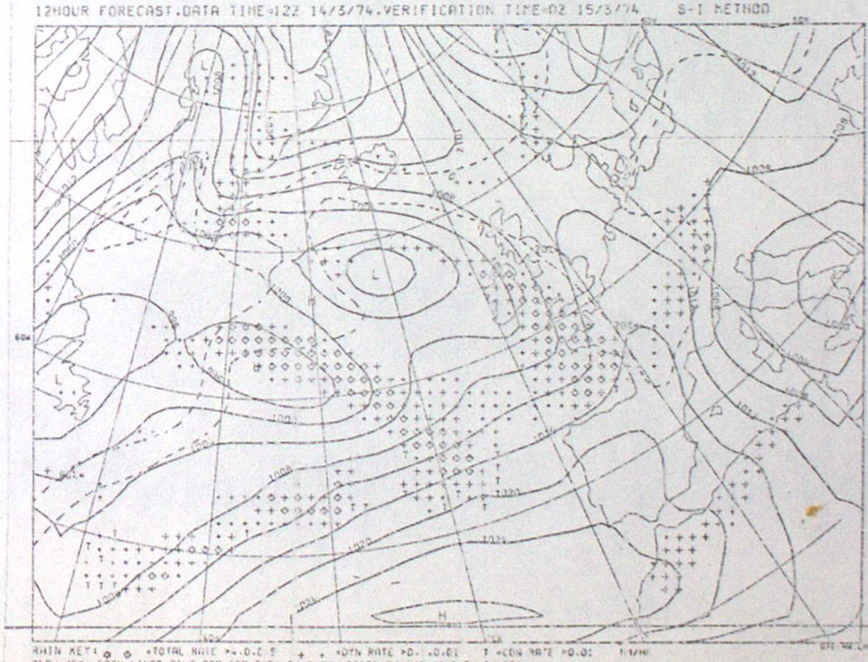


RAIN KEY: ◦ ◦ +TOTAL RATE >4.0,0.5 + +DYN RATE >0.1,0.01 T +CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW, BASED ON F/C 10-9 THICKNESS

C NO WEATHER SHIPS MAIN RUN SATELLITE DATA (NONE)

FORECAST SURFACE PRESSURE AND PRECIPITATION

12HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=0Z 15/3/74. S-I METHOD



RAIN KEY: ◦ ◦ +TOTAL RATE >4.0,0.5 + +DYN RATE >0.1,0.01 T +CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW, BASED ON F/C 10-9 THICKNESS

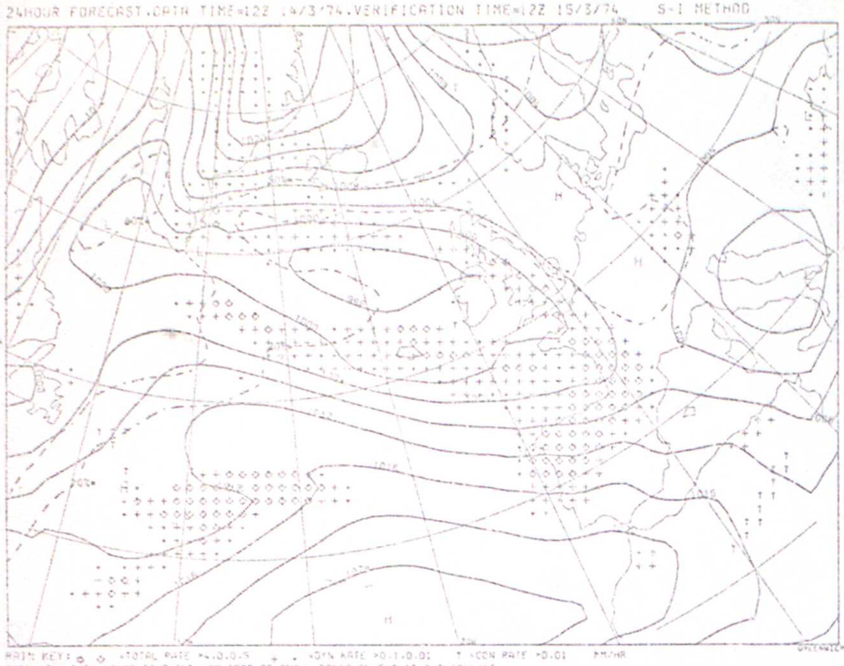
FIG XI

SURFACE PRESSURE AND PRECIPITATION 24-HOUR FORECAST

OPERATIONAL WEATHER SHIPS NO SATELLITES

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 15/3/74. S-I METHOD

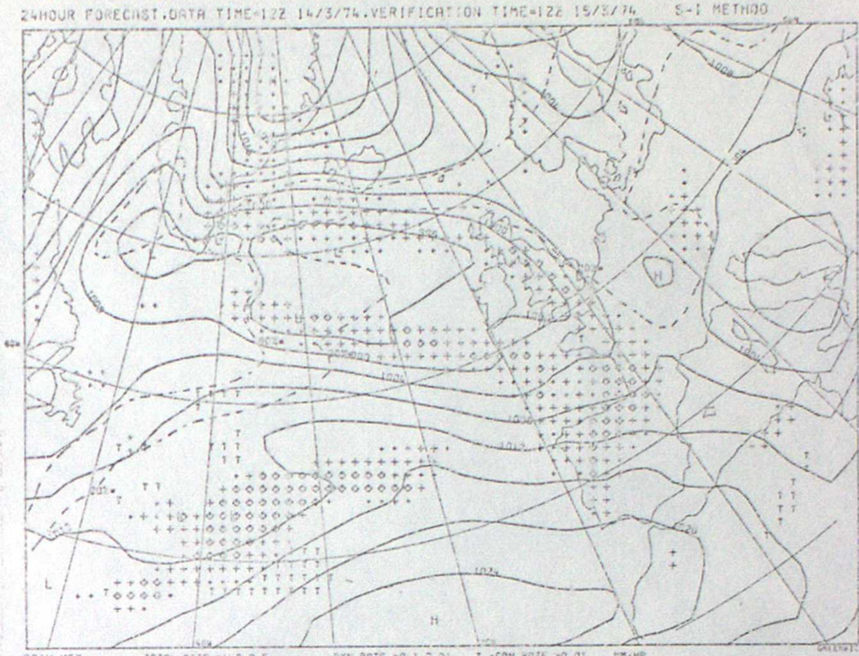


RAIN KEY: ◦ ◇ =TOTAL RATE >4.0,0.5 + . =DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

A WEATHER SHIPS UPDATE SATELLITE DATA

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 15/3/74. S-I METHOD

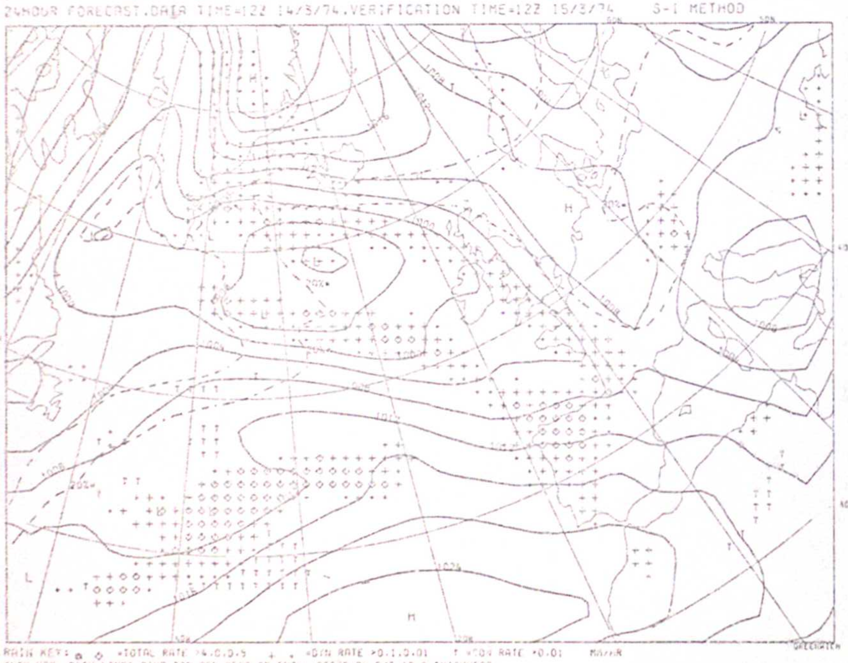


RAIN KEY: ◦ ◇ =TOTAL RATE >4.0,0.5 + . =DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

B NO WEATHER SHIPS UPDATE SATELLITE DATA

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 15/3/74. S-I METHOD

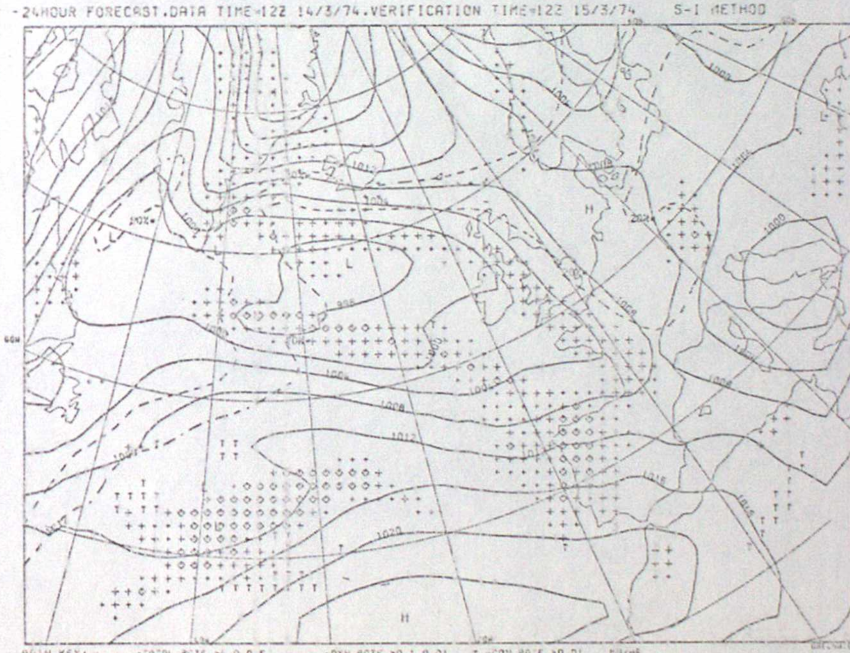


RAIN KEY: ◦ ◇ =TOTAL RATE >4.0,0.5 + . =DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

C NO WEATHER SHIPS MAIN RUN SATELLITE DATA (NONE)

FORECAST SURFACE PRESSURE AND PRECIPITATION

-24HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=12Z 15/3/74. S-I METHOD



RAIN KEY: ◦ ◇ =TOTAL RATE >4.0,0.5 + . =DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

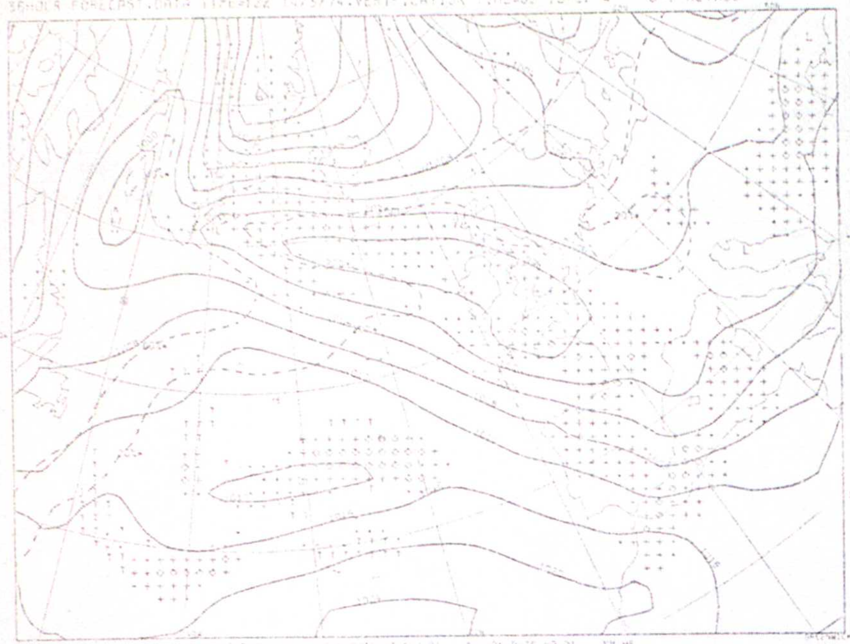
FIG XII

SURFACE PRESSURE AND PRECIPITATION 36-HOUR FORECAST

OPERATIONAL WEATHER SHIPS NO SATELLITES

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=0Z 16/3/74 S-I METHOD

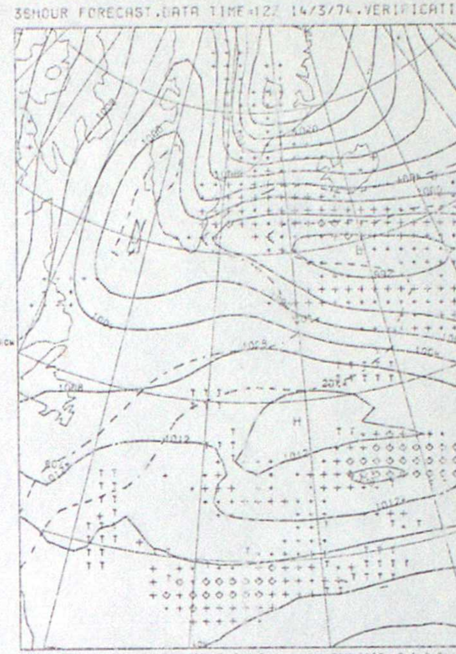


RAIN KEY: +TOTAL RATE >4.0,0.5 DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%-80% PROB OF SNOW. BASED ON F/C 10-8 THICKNESS

A WEATHER SHIPS UPDATE SATELLITE DATA

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=0Z 16/3/74 S-I METHOD

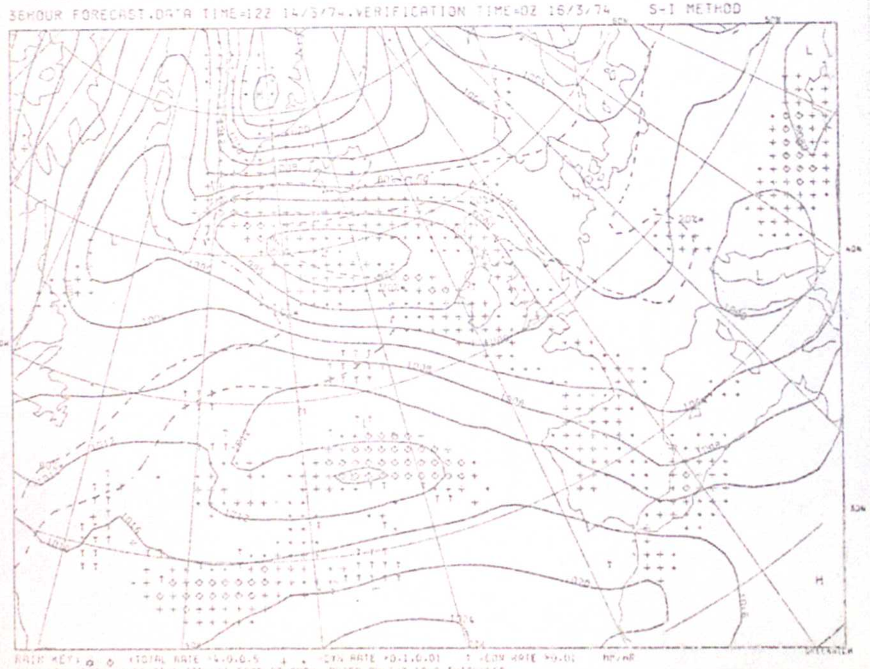


RAIN KEY: +TOTAL RATE >4.0,0.5 DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%-80% PROB OF SNOW. BASED ON F/C 10-8 THICKNESS

B NO WEATHER SHIPS UPDATE SATELLITE DATA

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=0Z 16/3/74 S-I METHOD

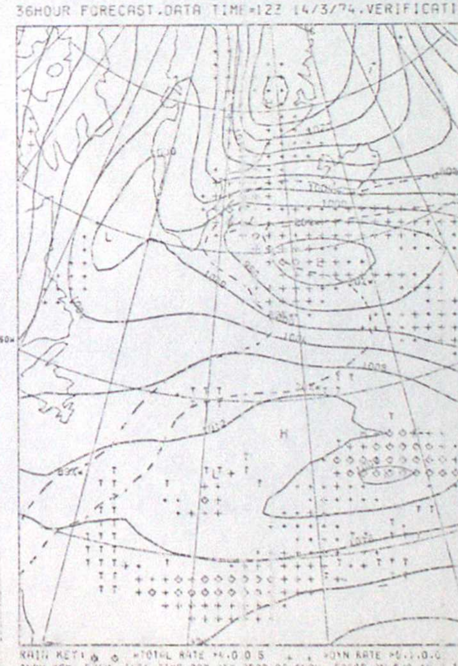


RAIN KEY: +TOTAL RATE >4.0,0.5 DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%-80% PROB OF SNOW. BASED ON F/C 10-8 THICKNESS

C NO WEATHER SHIPS MAIN RUN SATELLITE DATA (NONE)

FORECAST SURFACE PRESSURE AND PRECIPITATION

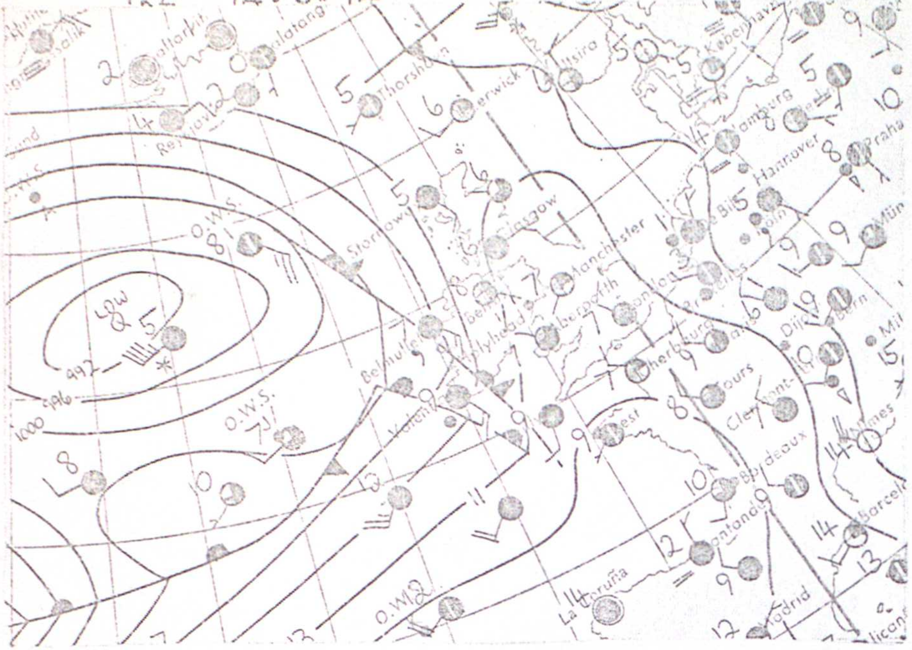
36HOUR FORECAST.DATA TIME=12Z 14/3/74.VERIFICATION TIME=0Z 16/3/74 S-I METHOD



RAIN KEY: +TOTAL RATE >4.0,0.5 DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%-80% PROB OF SNOW. BASED ON F/C 10-8 THICKNESS

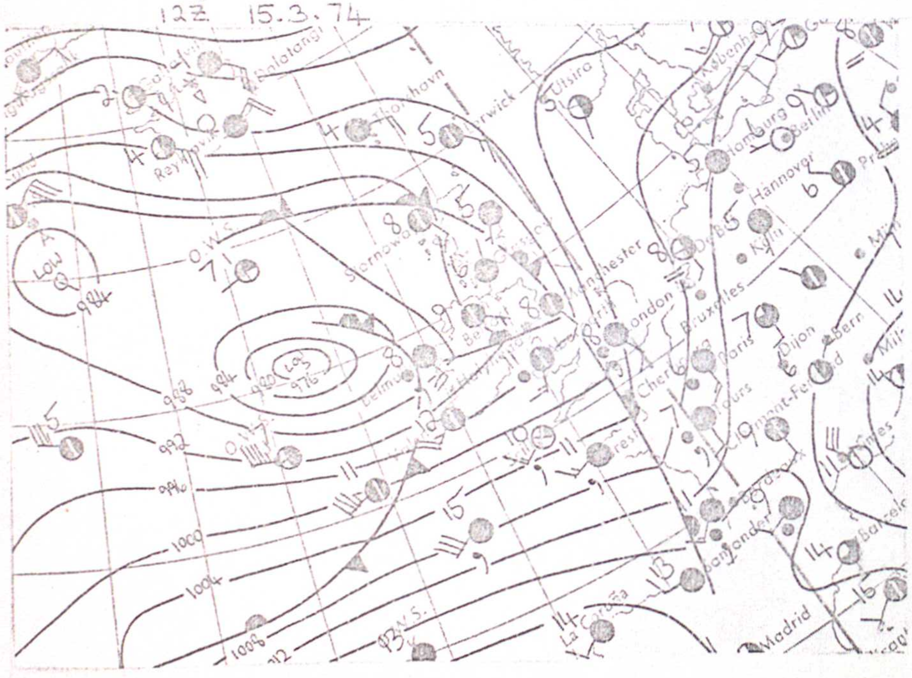
FIG XIII   SUBJECTIVE ANALYSIS SURFACE PRESSURE

12Z 14.3.74

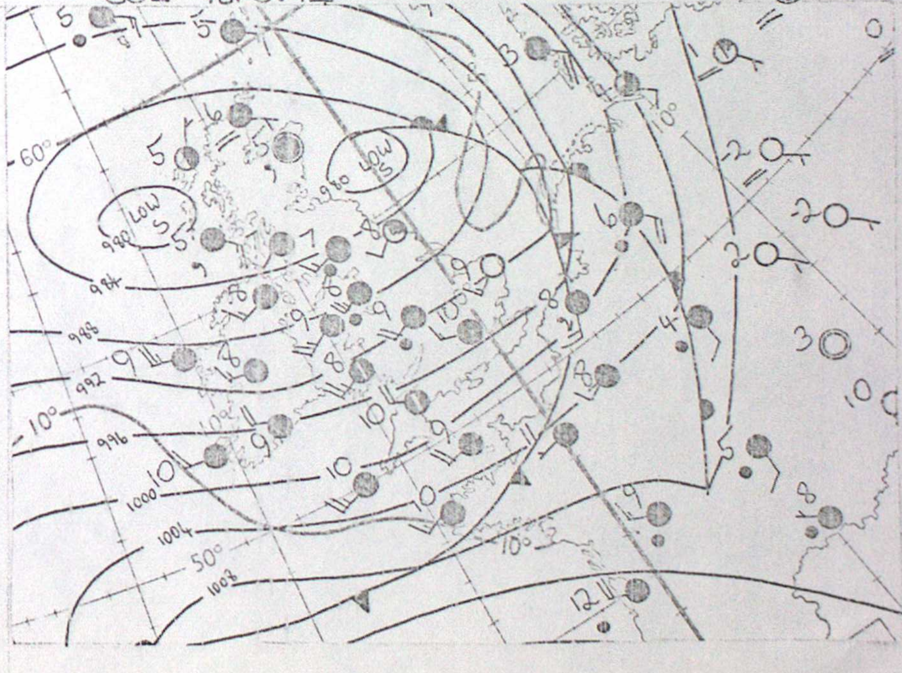


00Z 15.3.74

12Z 15.3.74



00Z 16.3.74

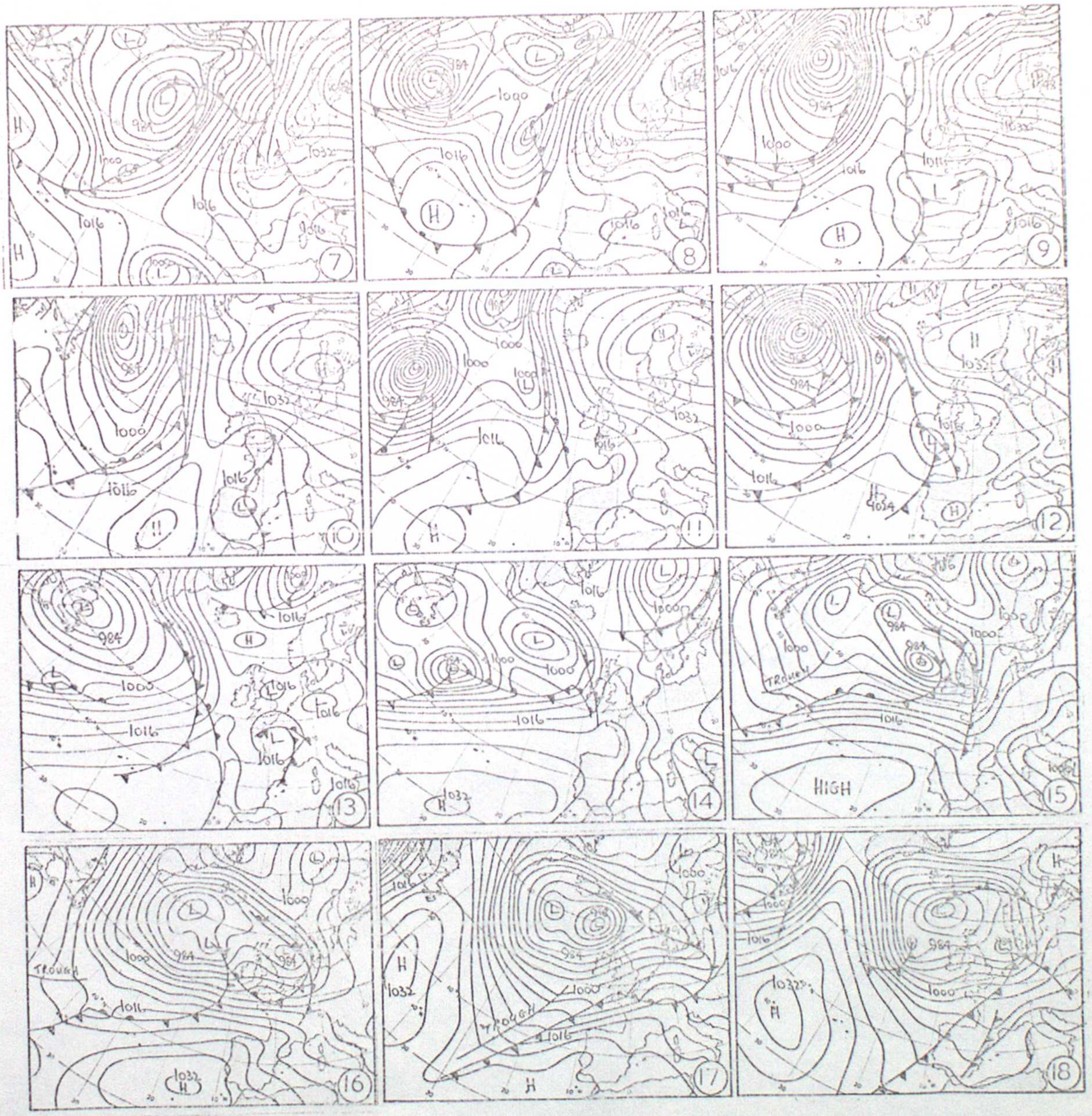


MARCH 1974

DAILY WEATHER MAPS

12 GMT

Dates are ringed at
lower right-hand corner
of each map



M.S.L. isobars are drawn at
4 mb intervals

Fig XIV

Met.O.11 Technical Note No.47 and Met.O.2b Technical Note

No.5.

REPORT ON AN EXPERIMENT TO DETERMINE THE VALUE OF OCEAN WEATHER SHIP AND SATELLITE DATA IN NUMERICAL FORECASTING - PART II

by

Margaret J. Atkins

and

Martin V. Jones

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2.2. Intervention

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8. Conclusion.

1. INTRODUCTION

Part I of this report described the first period of running the experiments, with particular emphasis on the value of SIRS data as an operational source of upper-air information. Part II presents the results of the second period, in which the prime objective was to evaluate the contribution of Ocean-Weather-Ship (OWS) data to the quality of numerical forecasts in the vicinity of the British Isles.

During the second period (00Z 2nd to 00Z 11th May 1974) only one experimental forecast suite was run. This is referred to as "Expt 1" and, as in Part I, included satellite data but did not use weather-ship data. The operational forecast suite during the second period was equivalent to Expt 2 of Part I and included both satellite and weather ship data (see Part I para. 10). Expt 1 was run in a similar manner to that described in Part I, the principal differences being discussed in the following paragraph.

2. ORGANISATION OF THE EXPERIMENT

2.1. Period.

The second period of Expt 1 began with the A1 run on 2nd May 1974 and ceased after the B2 run on 11th. There followed a "run-down" period of 3 days for the objective verification.

Subsequently forecasts based on data for 12Z on 11th and 00Z on 12th were done - out of real time, but on the same basis, except that no octagon objective verification was done.

2.2. Intervention.

The Expt-1 runs took place at the scheduled times described in Part I (Figure I), to allow the intervenors a realistic time to prepare "bogus" observations (see Part I, Para 2.2.(i)).

There was insufficient time before the second period to develop machine-plotted 1:30 million circumpolar charts without weather-ship observations for the experimental forecaster, so that when preparing his intervention he used the 1:20 million Atlantic "working area" charts with opaque patches covering weather-ship observations. Of principal interest was the Atlantic area, which contains the ocean weather ships whose continued operation was under review, so that lack of separate intervention in the Pacific area for Expt 1 and operational analyses was not a serious limitation.

The selection of output charts was amended to reflect the changed requirements for intervention.

2.3. Objective Assessment

The wide variability of sample sizes displayed in Tables V and VI of Part I (Octagon Verification) showed that cumulative statistics for a limited period do not provide very firm bases for inference, and therefore no "run-up" period was allowed for the octagon verification programme. Daily statistics for the whole of the second period have been produced, whilst cumulative statistics, although available, have been ignored.

2.4. Changes to Operational Suite

The following significant changes took place in both operational and experimental suites between the March and May periods, in addition to those described in Part I, Para 10:

(i) A revision of the diffusion formula in the forecast programme took place in April, at the request of CFO; as a result, spurious ridge-building was substantially eliminated.

(ii) Minor changes were made to data-bank storage routines and quality-control checks, including temporary provision for a new Chinese upper-air data transmission code, which was introduced without warning.

3. SYNOPTIC SITUATION 2nd to 15th MAY 1974

The period began with a depression moving eastwards into northern France and bringing rain into southern parts of the United Kingdom. At the same time there was a complex 500mb low over the British Isles and eastern Atlantic. This was followed by the rebuilding of high pressure over the British Isles and the intensification of an upper ridge. The 500mb low in the western Atlantic moved slowly eastwards and on 8th May fronts associated with a secondary depression moving around the main surface low moved into Ireland but became slow moving. Another depression to the west of Ireland and its associated fronts brought rain to most parts of the British Isles on 10th May. The surface pressure and 500mb height remained low to the west of Ireland for the rest of the period. A third frontal system moved across the British Isles on 12th and 13th May, high pressure becoming re-established over eastern parts on 14th May.

Table I shows the Lamb Classifications officially assigned to each day of the period. Figure I is reproduced from "Weather Log" (published by the Royal Meteorological Society) and shows the sequence of midday hand-drawn analyses for the period.

4. SUBJECTIVE ASSESSMENT

4.1. General remarks

Assessment was made on a similar basis to the first run of the experiment. The rectangle forecasts of 500mb height, surface pressure and rate of rainfall were assessed at 12-hourly intervals and the octagon forecasts of surface pressure and 500mb height were assessed at 24-hourly intervals. In addition the surface pressure and 500mb analyses were assessed for each area. For each of the rectangle and octagon forecasts, a combined mark was given for each forecast time and a separate mark was given for the surface and 500mb analyses from the following scale:

A Operational significantly better than Expt 1.
B Operational better than Expt 1.
C Operational and Expt 1 equally good.
D Operational worse than Expt 1.
E Operational significantly worse than Expt 1.

The area considered in assessing the octagon included the British Isles, Western Europe and the North Atlantic. The results are shown in Table II. The rectangle forecast charts were given a dual marking: one mark for the British Isles and eastern Atlantic and the other for the whole area. These were generally the same, based on the forecast for the British Isles area but there were a few forecasts (based on data for 00Z 4th, 5th, 6th and 7th May) where the main changes in the synoptic situation were taking place in the western Atlantic and where differences between the two forecasts showed in this region. The analyses were assessed for the whole area. The results are shown in Table III. Table IV shows the weather ships used by the operational analyses.

It is difficult to summarise these results as in almost every case there are factors other than the removal of weather ships, such as differences in intervention, contributing to the results. The total number of marks in each category are shown in Table V(a) and (b). The totals for the analyses and forecasts are shown separately as they are marked on a slightly different basis. No A's or E's were given to analyses as it is difficult to assess analyses as significantly different except in so far as the forecasts produced from them are significantly different. The last two columns in each table give the totals and percentage in each category from all the forecasts. In the case of the rectangle the totals shown are those of marks for the British Isles and eastern Atlantic. Assuming that the factors other than the removal of weather ships affect both the operational and experimental run equally, these tables show that on average during the period of the experiment the removal of weather ships produced worse forecasts for both the octagon and rectangle. For the rectangle the operational forecast was better on 47% of occasions and worse on 6%; for the octagon the operational forecast was better on 22% of occasions and worse on 14%. The rectangle forecasts were affected more adversely than the octagon and this was largely due to the effect of omitting weather ships on the rainfall predictions. Moreover the marks bear little or no relation to the number of satellite reports within the forecast area. (Tables II and III). Even in the presence of a reasonable number of satellite data the removal of weather ships can give rise to a significant deterioration in forecasts. It is true however that the positions of both the satellite and more particularly weather ship data in relation to the synoptic features are more important than the numbers of such data.

4.2. Factors affecting individual cases

The assumption that factors other than the removal of weather ships affect both runs equally may not be valid and some explanation of individual markings is necessary. Table VI is a summary of these factors.

4.2.1. 00Z 2nd and 00Z 3rd May

The previous experiment allowed two days to elapse before verification began. As the weather was interesting for the first two days of this experiment the results have been included, but the influence of the weather ships in the experimental runs for 2nd and 3rd May was probably still quite large both from the background fields and the charts used by the forecaster for intervention.

4.2.2. 00Z 4th and 00Z 11th May

The cases of 00Z 4th and 00Z 11th May show differences between the two runs which can be traced to slightly different procedures used by the operational and experimental forecasters.

The A's in the rectangle assessment for 4th May arise from differences in the upper air pattern which were caused by a satellite observation being rejected by the Expt-1 analysis but not by the operational analysis. This happened because the background fields were different due to different intervention in the previous update run. This in turn was caused by two vital observations being missing on the experimental chart causing a 500mb low to be drawn less deep. The difference in the upper air pattern was not apparent in the octagon analyses.

The differences for 00Z 11th May were also caused by different intervention in the previous update run, arising from different 500mb charts. In this case the operational forecaster had drawn an upper vortex based on gridding the surface and thickness charts whereas the experimental forecaster was unable to do this as he did not have a thickness chart. However, in this case the results from Expt 1 were better, the corresponding surface low being deepened further. There were differences in the surface analyses for 00Z 11th which were caused by surface intervention in the operational but not the experimental main run. These differences had disappeared by T+12 for the rectangle and T+24 for the octagon.

4.2.3. Pre-intervention in the main run

One major difference which often occurred between the two runs was that pre-intervention in the form of artificial or "bogus" data was introduced into one or other of the main runs. This usually happened at the surface and resulted, for example, in a difference of a few millibars in the depth of a depression persisting for a large part of the forecast. As the operational and experimental forecasters had separate surface charts, the experimental one being drawn without weather ships, one might expect this intervention to be different. However, the difference usually occurred because two different people, with differing experience, did the job rather than because the charts they used were different. Often bogus data were introduced into one main run and not the other. Cases where bogus data were introduced into the operational but not the experimental main run were 00Z 8th, 10th, 11th and 12th May. Cases where bogus data were introduced into the experimental but not the operational main run were 00Z 5th, 6th, 7th and 9th May. There were different bogus data for 00Z 3rd and 12Z 11th May.

4.2.4. 00Z 5th, 6th and 7th May

There was pre-intervention in the experimental run for 00Z 5th, 6th and 7th May mainly around depressions in the west Atlantic. It affected both the octagon and rectangle forecasts in that region for up to 36 hours. The experimental rectangle forecast for 5th May was affected by pre-intervention around a low outside the boundary. This caused the rectangle boundary values which are updated by the octagon forecast to be different and produced a deeper low within the rectangle area. The experimental run for 00Z 5th May was re-run without any pre-intervention and the results are shown in brackets in Tables II and III. The D's have been replaced by C's and it is probable that the D's for the 6th and 7th result from similar pre-intervention and would be replaced by C's if this were removed.

4.2.5. 00Z 9th May

For the rectangle the pre-intervention in the experimental run for 00Z 9th produced an overdeepening of the low pressure area to the west of Ireland. This resulted in the depression being deeper than the operational one for the whole of the forecast period, and in fact produced a better pressure pattern in the experimental than in the operational forecast. The results of this forecast are shown in Figures V(a) to (d). The rainfall predictions however are significantly better in the operational run (see Para 4.4.)

For the octagon the pre-intervention produced a better surface analysis in the experimental run and the difference persisted throughout the forecast, the Expt-1 depression being deeper than the operational one.

4.2.6. OOZ 10th May

It is not clear whether the better operational forecast for OOZ 10th was caused by a better 500mb analysis or by surface pre-intervention. The justification for different surface pre-intervention is somewhat uncertain as the experimental surface chart had some missing observations and some incorrectly plotted ones.

4.2.7. OOZ 12th May

The operational pre-intervention for OOZ 12th did not have much effect on the comparisons up to 36 hours. The bogus data were around a depression in the west Atlantic whereas the differences in the forecast were associated with the depression to the west of Ireland. The bogus data may have had some effect on the octagon 48-hour forecast where the differences were associated with the west Atlantic depression, which by this time was deepening and moving eastwards. Figures II(a) to (f) illustrate the octagon forecast.

4.2.8. OOZ 8th May

As there was pre-intervention in the operational forecast based on OOZ 8th May and it was marked as significantly better than the experimental forecast for both the octagon and the rectangle, it was thought worthwhile to re-run the experimental forecast with suitable pre-intervention. The intervention actually used was the surface bogus data from the experimental update run and the upper air bogus data from the operational main run. The latter consisted of a few Pacific observations.

The situation consisted of a main low (O) in the western Atlantic with a secondary low (T) moving round it and lying to the south east of O.W.S"I" at the beginning of the forecast period. Fronts associated with low T moved into western parts of the British Isles giving rain over Ireland, southwest England, Wales, Northwest England and Scotland. Figures III(a)(b)(d) and (e) show the analyses and 24-hour forecasts from the two runs. The comparison was marked A at T+12 for the rectangle and at T+24 for the octagon because the operational forecast gave much stronger gradients of surface pressure to the south east of Iceland. C.F.O. in fact issued a warning of imminent Northeasterly gales, force 8 for South East Iceland on 8th May at 2000GMT. The re-run of Expt 1 went about half way towards making up the difference in gradient (see Figures III(c),(f)) and corresponding comparisons with this forecast were marked B instead of A (see bracketed letters in Tables II and III). However, the remaining difference was largely due to the surface observation at O.W.S."I" which enabled the operational forecaster to draw low T 4mb deeper. The rectangle was marked A at T+24 because of differences in the rainfall forecasts (see Para.4.4). The re-run of Expt 1 made no difference to the rainfall predictions.

4.2.9. OOZ 3rd and 12Z 11th May

On both OOZ 3rd and 12Z 11th May there were different bogus data inserted into the operational and Expt-1 analyses. On 3rd May the operational analysis was better at the surface near the British Isles partly due to better pre-intervention and partly due to the surface observation at OWS"K". This difference persisted for 12 hours in the rectangle forecast and was just noticeable after 24 hours in the octagon forecast.

On 12Z 11th May the difference in pre-intervention resulted in the operational rectangle surface analysis producing a depression which had a larger central isobar although not necessarily deeper central value than in the experimental analysis. (see Figure VI(b)). The two subjective charts did not justify any different pre-intervention and the Expt-1 analysis was in fact nearer CFO's drawing. The larger surface low in the operational analysis made the

1000mb height used as a base for satellite observations 2dkm lower than in Expt 1 for one particular SIRS observation. This resulted in a deeper trough at 500mb (Figure VI(a)) which in turn resulted in a significantly better rainfall forecast at 24 and 36 hours (Figures VI(d) and (e)). The operational upper air forecaster drew an even deeper trough based on a southerly wind at OWS "K". This wind was rejected at 500 and 300mb by the operational objective analysis.

It was decided to re-run the operational rectangle forecast using the pre-intervention from Expt 1, thus ensuring that the satellite data were similar to those in Expt 1, and changing the analysis programme to avoid the rejection of upper air ships winds. This produced a slightly deeper trough than the operational analysis at 500mb and the resulting synoptic development at 36 hours was slightly better than the operational forecast (see Figure VI(e)). The rainfall forecast at 24 hours was not quite as good as the operational one but at 36 hours it was better, the operational forecast giving too much rain at 36 hours. The comparison of the re-run forecast with Expt 1 is shown by marks in brackets in Table III.

In the case of the octagon the pre-intervention did not produce such a large depression and the operational analysis was in fact better than the Expt-1 analysis.

4.3. Revised Assessment

In the light of the discussion in para.4.2, Tables V (a) and (b) may be revised by removing 00Z 2nd, 3rd, 10th and 11th, changing D's to C's for 5th, 6th, 7th, 9th and using values obtained in re-runs. Tables VII (a) and (b) show the revised assessment. The number of cases where the operational forecast was worse have been reduced. For the rectangle the operational forecast was better on 46% of occasions and worse on 4%; for the octagon the operational forecast was better on 25% of occasions and worse on 4%.

4.4. Subjective Assessment of Rainfall Forecasts

It has already been stated that the significant differences in the rectangle forecasts were largely due to significant differences in the rainfall predictions. All the occasions of frontal rain have been re-examined to see on how many of them significant differences occurred. The results are summarised in Table VIII in which marks are assigned specifically to rainfall forecasts for the British Isles. Where no mark is given there was no rain. The forecasts were verified against British Isles hourly or significant weather charts.

As has already been mentioned the first two forecasts should not be compared directly with the others as Expt 1 was probably still influenced by weather ships. Considering the 24-and 36-hour predictions of rain from the remaining forecasts it can be seen that on all occasions there were significant differences at either 24 or 36 hours. Although the case of 00Z 11th May was marked B there was a significant difference on this occasion but neither forecast was correct. The operational forecast produced a better shaped rain area in association with the fronts but was too slow. All these significant differences arose from occasions when the 500mb operational analysis was marked as better than the 500mb analysis without weather ships. The improvement due to the weather ships is not so noticeable in the 12-hour forecasts. This is not surprising as the humidity field is only just adjusted to the dynamics at this stage. The forecasts based on 00Z 8th, 9th, 12Z 11th, 00Z 12th May are illustrated in Figures IV to VII. The main differences are summarised below -

00Z 8th May.

The operational forecast is compared to the re-run of the experimental forecast.

At T + 24 the operational forecast had advanced the front edge of the rain much further into Scotland and the Irish sea. This was correct. At T + 36 the operational forecast took the rain right into northern England whereas the experimental forecast had brought it into Scotland. The experimental forecast was in fact better for this time but the evolution was wrong. The grid point values of accumulated rain (Figures IV(c) and (d)) show some differences mainly caused by the different positions of the rain areas in the two forecasts. It is not possible to verify the accumulated rain until rainfall data have been processed by Met.O.8.

OOZ 9th May

At T + 24 the front edge of the moderate rain was about 140km ahead and the rear edge about 70km ahead in the operational forecast, which was better than Expt 1. At T + 36 the operational forecast had cleared the rain right into the North Sea, which was correct, whereas Expt 1 still had rain along the east coast of England. In fact the rain cleared the east coast six hours earlier. The grid point values of accumulated rain show some large discrepancies which are again mainly caused by the difference in timing.

12Z 11th May

The operational forecast/and the re-run of the operational forecast are compared to Expt 1.

At T + 12 the two forecasts which included the weather ships produced rain areas which corresponded more closely with the fronts than Expt 1. At T + 24 in the Expt-1 forecast the front edge of the rain was further back than in the re-run of the operational forecast, and this in turn was further back than in the operational forecast. At T + 36 the Expt-1 forecast had cleared the rain to the north whereas a narrow belt of rain actually crossed the country. This was forecast very well by the operational re-run, but the operational forecast itself gave too widespread an area of rain. Figure VI(f) compares the accumulation from T+24 to T+36 for the re-run of the operational forecast and Expt 1 and shows that Expt 1 gave very little rain over eastern England.

OOZ 12th May

At T+12 the operational forecast had brought the rain further eastwards by about 140km over the Irish Sea. At T+24 the operational forecast had correctly moved the rain to the North of England with the rain belt lying in a north-west/south-east direction in a similar manner to the front. The Expt-1 forecast had moved the rain eastwards to lie in a north/south direction. At T+36 the rainfall forecasts were similar but the centre of the depression was much better placed in the operational forecast. The accumulated rain from T+12 to T+24 shows some large differences in the amounts, and that from T+24 to T+36 reflects the different positions of the rain areas.

5. WEATHER-SHIP WIND REJECTIONS

It was somewhat disturbing to find weather-ship winds rejected by the objective analysis when they were particularly important as for example on the occasions of 12Z 11th May and OOZ 15th March. The latter case was discussed in Part I of this report. All the analyses during the second period of the ship experiment were examined to see how often weather-ship winds were rejected. Table IX shows the results. Most of the 300 and 500mb winds have been drawn to by CFO although some of them did not fit the analyses very well. The wind rejection criterion used in the objective analysis has remained unaltered since before the 10-level model became operational. It was devised for a full network of Atlantic weather ships and may need amending as a consequence of the loss of the U.S. weather ships.

The loss of the U.S. weather ships could have caused a deterioration in the background fields which therefore would be less consistent with the remaining weather ship winds, in particular those from I, J and K. These winds would therefore be more likely to be rejected. This would be particularly true when they were giving valuable information, as OWS "K" was towards the end of the period of the experiment. It may be impossible to devise a satisfactory objective test, in which case it would be better if all the weather ship winds were retained by the analysis but examined by CFO before every run and rejected by them if necessary.

6. OBJECTIVE ASSESSMENT OF OCTAGON FORECASTS

The verification regions and stations are shown in Figure VIII and Table XI.

6.1. Forecasts v Analyses - Region II

6.1.1. Cumulative Statistics

Due to the variable number of forecasts included (i.e. sample size for Expt 1 is approximately half the operational sample size), the cumulative statistics have not been inspected.

6.1.2. Daily Statistics - Height Errors

Figure IX (a) and IX(b) represent comparisons of the progress of each individual forecast (Operational v Expt-1) at 200mb and 500mb, in terms of RMS (root-mean-square) height differences between the forecast and the update analysis at the verification time.

Bearing in mind that "Expt 2" in Part I has become "operational" in Part II, a comparison of Figure IX with Part I, Figure III reveals a marked reduction in the mean value of operational 72 hour forecast height differences by approximately 44 metres at 500mb, and 51 metres at 200mb. This is mainly a seasonal variation, although there is probably a small contribution due to the change of diffusion formula in the forecast model (see Para.2). This variation must be taken into account when comparing statistics for the March and May periods. (See Table X).

At 200mb (Figure IX(a)) the Expt-1 differences are greater than the operational ones throughout four of the ten forecasts, whilst the reverse is the case for none of them. At 500mb (Figure IX (b)) the Expt-1 differences are greater throughout four forecasts, and smaller throughout three. The separation between the two curves never exceeds 10metres, and is considerably less during most of the period, at both levels. It is curious that the forecasts based on 00Z on 8th, which were subjectively assessed as most different, should produce such similar curves in Figure IX.

Figure X (a), (b) and (c) compare equal-period forecasts of height from Expt 1, the operational suite and persistence, on a daily basis for 500 and 1000mb. The height differences from the operational and Expt-1 forecasts are much closer to each other than to either the perfect forecast or persistence. However, there is no consistent improvement in the forecast due to inclusion or exclusion of OWS data.

6.1.3. Daily Statistics - Wind Errors

Figure XI(a), (b) and (c) compare persistence, operational and Expt-1 mean vector wind errors for 24, 48, 72-hour forecasts respectively at

300mb and 1000mb. The operational 24-hour forecasts (Figure XI(a)) are consistently slightly better than the corresponding Expt-1 forecasts except for the 1000mb forecast based on 00Z on 8th. The same can be said of 1000mb 48-hour forecasts (with the same exception), but not of 300mb 48-hour forecasts or of 72-hour forecasts.

6.2. Forecasts v. Observations

6.2.1. Europe (28 stations)

The stations included in the statistics presented in Figure XII are listed in Table XI. Figure XII compares 300mb RMS vector wind errors on a daily basis. The operational 24-hour forecast has consistently slightly smaller errors than its Expt-1 counterpart, except for one day. The separation between the two curves is at maximum approximately 5kt, but more often approximately 1kt. For 48-hour forecasts, the separation averages 3kt, and is in either sense.

6.2.2 Atlantic Region (6 stations)

Figure XIV shows 300mb RMS Vector Wind errors for 24 and 48-hour operational and Expt-1 forecasts. Since the sample of observations is so small (usually 4 or 5 stations) care must be taken in interpreting the statistics. For example, on 5th, 9th, 12th and 13th, the quality-control checks applied to observations before they are used for comparison accepted an extra observation in one or other of the two verification programmes, which suggests that the extra observation is not particularly good. This hypothesis is supported by the large separation between the Expt-1 and operational curves on 9th, 12th and 13th in Figure XIV.

Taking the whole period, the mean difference between operational and Expt 1 wind errors is -0.98kt (i.e. operational errors less than Expt 1) at T+24, and -1.76kt at T+48; but if the 5th, 9th, 12th and 13th are ignored, the values are -0.14kt and -0.83kt respectively. Over the whole period, the separation between the curves (i.e. ignoring the sign of the difference) averages 3.07kt (T+24) and 4.83kt (T+48), and the corresponding figures discounting the four dates are 1.47kt and 2.05kt. The loss of OWS data leads to changes in the wind error of magnitude one or two knots, but the changes are in both senses, with a small bias towards increase of error. The largest changes during the period were approximately 3kt (excluding the dubious dates).

As with forecast errors, the two verification programmes rejected a different number of observations for use in persistence statistics on 5th, 9th, 12th and 13th. The persistence curve in Figure XIV is taken from the operational verification programme, since quality-control comparisons are made between observations and the operational analysis.

7. OBJECTIVE VERIFICATION OF RAINFALL FROM RECTANGLE FORECASTS

The rectangle rainfall forecasts have already been mentioned in Para 4.4, where assessment was made subjectively. As was stated in that paragraph it is not possible to verify grid point values of accumulated rain until all the rainfall data have been processed by Met.O.8. However, it is possible to make some objective verification using rainfall data from synoptic stations contained in the Climatological Data Bank in the same way as was described in Part I of this report. Rainfall accumulations were verified for the 14 areas shown in Figure XIII. An average value was calculated for each area for the two 12-hour periods T+12 to T+24 and T+24 to T+36 from both the operational and Expt-1 forecasts, and these were verified against actual average values from the autographic rainfall data.

The results of the objective verification are shown in Tables XII, XIII and XIV. Table XII, which compares the sum of the mean values in each of the 14 areas with the sum of the actual values, shows that there was no general increase or decrease in the rainfall amounts when weather ships were removed. Tables XIII and XIV show that there is little difference between the operational forecast and Expt 1 in distinguishing between wet and dry periods or between different categories of rainfall amount. In fact Expt 1 appears to be marginally better in dealing with wet and dry periods and with small amounts of rain.

These results show that the removal of weather ships does not affect the rainfall predictions over a large area. The significant differences in the rainfall predictions mentioned in Para 4.4. were localised and are not apparent in these results. This is also partly due to the shape of the areas used for the British Isles, which divide the country into north and south instead of east and west.

8. CONCLUSION

Even allowing for the complications caused by different intervention this experiment shows that the removal of weather-ship data does not give rise to a consistent deterioration in the quality of the forecasts. This is confirmed by the results of Expt 1 during the first few days of the March run of the experiment. However, when weather ships are in critical positions relative to the synoptic features large differences do occur in the forecasts even when there are a fairly large number of satellite data present. These differences are most noticeable in the rainfall forecasts for the British Isles, where on all occasions of frontal rain except the first two days, there were significant differences in the rainfall predictions at either 24 or 36 hours. Of these, all except one forecast showed significant deteriorations when weather ships were removed. Overall, taking other factors into account, the octagon forecasts were worse on 25% of verification times and the rectangle forecasts were worse on 25% and significantly worse on a further 21% of verification times when the weather ships were removed. It is unfortunate that the objective analysis often rejected vital weather-ship wind observations: the effects of removing the weather ships might have been greater if this had not been the case.

The objective statistics for both the octagon and rectangle show that when quantities are averaged over a large area the differences caused by the removal of weather ships were small. However the lack of weather-ship data did give rise to a small deterioration in short period wind forecasts from the octagon.

Table XV summarises the effects of including satellite and weather-ship data in numerical forecasts. Firm conclusions cannot be drawn from two short experimental runs, where the synoptic situation was different when satellite data was considered (during the March run) from that when weather ships were removed (during the May run). However, the table indicates that the satellite data have most effect on the larger scale features whereas the weather-ship data from the existing network have most effect on the smaller scale features, and thus implies that satellite data are best used to complement weather-ship data rather than to replace them.

A second conclusion which may be drawn from this experiment is that subjective intervention is important. This is particularly true where it affects the upper-air analyses such as in the update run where upper-air bogus data very largely determine the shape of the features in the west Atlantic in the absence of weather-ship data. Similarly, pre-intervention at the surface is also important because the 1000mb analysis acts as a base for the satellite observations and this affects the upper-air analyses.

LAMB CLASSIFICATION

May	2	Z		] cyclonic
	3	E		
	4	E	easterly	
	5	H	(north-)	
	6	D		
	7	Y		Anticyclonic
	8	R		
	9	S		
	10	T		Cyclonic
	11	T	southerly	
	12	S		
	13	S		
	14	Y		] Anticyclonic

Table I

TABLE II

RESULTS OF SUBJECTIVE ASSESSMENT - OCTAGON

DATA TIME	ANALYSIS		T+24	T+48	T+72	NO. OF SIRS	NO. OF OWS
	SURFACE PRESSURE	500MB					
00Z 2/5/74	B	B	B	C	C	0	6
00Z 3/5/74	B	C	C	C	C	69	6
00Z 4/5/74	C	C	C	C	C	61	7
00Z 5/5/74	D	C	D	B	C	72	6
	(C)	(C)	(C)	(B)	(C)		
00Z 6/5/74	D	C	D	C	C	71	5*
00Z 7/5/74	D	C	D	B	C	0	7
00Z 8/5/74	B	B	A	B	C	38	7
	(B)	(B)	(B)	(B)	(C)		
00Z 9/5/74	D	C	C	B	C	44	4
00Z 10/5/74	C	C	B	C	C	70	6
00Z 11/5/74	C	B	C	D	C	73	6
12Z 11/5/74	B	C	C	C	C	60	7
00Z 12/5/74	C	B	B	D	C	58	7

A OPERATIONAL SIGNIFICANTLY BETTER THAN EXPT I

B OPERATIONAL BETTER THAN EXPT I

C OPERATIONAL AND EXPT I EQUALLY GOOD

D OPERATIONAL WORSE THAN EXPT I

E OPERATIONAL SIGNIFICANTLY WORSE THAN EXPT I

LAST TWO COLUMNS REFER TO NUMBERS OF SIRS AND WEATHER SHIPS USED IN THE ANALYSIS (SEE TABLE IV)

* I and J missing

MARKS IN BRACKETS REFER TO COMPARISONS USING RE-RUNS OF EITHER EXPT I OR THE OPERATIONAL FORECAST.

TABLE III

RESULTS OF SUBJECTIVE ASSESSMENT - RECTANGLE

	ANALYSIS		T+12		T+24		T+36		NO. OF	NO. OF
DATA TIME	SURFACE PRESSURE	500MB	B.I.	WHOLE	B.I.	WHOLE	B.I.	WHOLE	SIRS	OWS.
00Z 2/5/74	B	B	B	B	B	B	C	C	0	6
00Z 3/5/74	B	C	B	B	C	C	C	C	27	5
00Z 4/5/74	C	B	C	A	C	A	C	A	18	6
00Z 5/5/74	C	B	C	D	C	D	C	D	28	5
	(C)	(B)	(C)	(C)	(C)	(C)	(C)	(C)		
00Z 6/5/74	D	C	C	D	C	D	C	D	30	3*
00Z 7/5/74	D	B	C	C	C	D	C	C	0	6
00Z 8/5/74	B	B	A	A	A	A	D	D	13	6
	(B)	(B)	(B)	(B)	(A)	(A)	(D)	(D)		
00Z 9/5/74	C	B	B	B	B	B	A	A	17	4
00Z 10/5/74	B	B	B	B	C	C	C	C	22	5
00Z 11/5/74	B	B	B	B	D	D	B	B	20	6
12Z 11/5/74	C	B	B	B	A	A	A	A	33	6
	(C)	(B)	(B)	(B)	(B)	(B)	(A)	(A)		
00Z 12/5/74	C	B	A	A	A	A	B	B	20	6

B.I - BRITISH ISLES AND EASTERN ATLANTIC

WHOLE - WHOLE RECTANGLE

A OPERATIONAL SIGNIFICANTLY BETTER THAN EXPT I

B OPERATIONAL BETTER THAN EXPT I

C OPERATIONAL AND EXPT I EQUALLY GOOD

D OPERATIONAL WORSE THAN EXPT I

E OPERATIONAL SIGNIFICANTLY WORSE THAN EXPT I

LAST TWO COLUMNS REFER TO NUMBERS OF SIRS AND WEATHER SHIPS IN THE ANALYSIS AREA. (SEE TABLE IV)

MARKS IN BRACKETS REFER TO COMPARISONS WITH RE-RUNS.

* I and J missing

TABLE III

WEATHER SHIPS USED IN OPERATIONAL ANALYSES

DATE	WEATHER SHIPS USED (MAIN RUN)
00Z 2/5/74	A B I J K M
00Z 3/5/74	I J K M N 49N 46W(B)
00Z 4/5/74	A I J K M N 47·2N 49·2W(B)
00Z 5/5/74	A I J K M N
00Z 6/5/74	K M N P 48N 45W (B)
00Z 7/5/74	A I J K M N 52·3N 47·5W (B)
00Z 8/5/74	A B I J K M N
00Z 9/5/74	I J K 51N 46W (B)
00Z 10/5/74	A I J K M N
00Z 11/5/74	A I J K M 48N 50W (B)
12Z 11/5/74	A I J K M N 50·1N 49·8W (B)
00Z 12/5/74	A I J K M 53·6N 50·2W(B) 3·5N 164E

NOTE; THESE INCLUDE ALL SHIPS IN THE DATA BANK AT 0300Z. SOME SHIPS HAD BEEN RECEIVED AND PLOTTED IN CFO BUT WERE NOT IN THE DATA BANK, AT THIS TIME.

TABLE V

(a)

RECTANGLE. TOTALS IN EACH CATEGORY FOR ANALYSES AND FORECASTS FOR BRITISH ISLES AND EASTERN ATLANTIC

CATEGORY	ANALYSIS		T+12	T+24	T+36	TOTALS FROM FORECASTS	% IN CATEGORY
	SURFACE PRESSURE	500MB					
A	0	0	2	3	2	7	19
B	5	10	6	2	2	10	28
C	5	2	4	6	7	17	47
D	2	0	0	1	1	2	6
E	0	0	0	0	0	0	0

(b)

OCTAGON. TOTALS IN EACH CATEGORY FOR ANALYSES AND FORECASTS.

CATEGORY	ANALYSIS		T+24	T+48	T+72	TOTALS FROM FORECASTS	% IN CATEGORY
	SURFACE PRESSURE	500MB					
A	0	0	1	0	0	1	3
B	4	4	3	4	0	7	19
C	4	8	5	6	12	23	64
D	4	0	3	2	0	5	14
E	0	0	0	0	0	0	0

A OPERATIONAL SIGNIFICANTLY BETTER THAN EXPT 1

B OPERATIONAL BETTER THAN EXPT 1

C OPERATIONAL AND EXPT1 EQUALLY GOOD

D OPERATIONAL WORSE THAN EXPT 1

E OPERATIONAL SIGNIFICANTLY WORSE THAN EXPT 1

TABLE VI

SUMMARY OF FACTORS, NOT RELATED TO THE REMOVAL OF WEATHER SHIPS, AFFECTING RESULTS.

DATE	
00Z 2/5/74	"RUN-UP" PERIOD
00Z 3/5/74	"RUN-UP" PERIOD, DIFFERENT PRE-INTERVENTION
00Z 4/5/74	DIFFERENT INTERVENTION IN PREVIOUS UPDATE RUN
00Z 5/5/74	PRE-INTERVENTION IN EXPT I BUT NOT IN OPERATIONAL RUN
00Z 6/5/74	PRE-INTERVENTION IN EXPT I BUT NOT IN OPERATIONAL RUN
00Z 7/5/74	PRE-INTERVENTION IN EXPT I BUT NOT IN OPERATIONAL RUN
00Z 8/5/74	PRE-INTERVENTION IN OPERATIONAL RUN BUT NOT IN EXPT I
00Z 9/5/74	PRE-INTERVENTION IN EXPT I BUT NOT IN OPERATIONAL RUN
00Z 10/5/74	PRE-INTERVENTION IN OPERATIONAL RUN BUT NOT IN EXPT I
00Z 11/5/74	DIFFERENT INTERVENTION IN PREVIOUS UPDATE RUN AND PRE-INTERVENTION IN OPERATIONAL RUN BUT NOT IN EXPT I
12Z 11/5/74	DIFFERENT PRE-INTERVENTION
00Z 12/5/74	PRE-INTERVENTION IN OPERATIONAL RUN BUT NOT IN EXPT I

TABLE VII

AS TABLE V REMOVING AS FAR AS POSSIBLE FACTORS OTHER THAN THE REMOVAL OF WEATHER SHIPS.

(a) RECTANGLE

CATEGORY	ANALYSIS		T+12	T+24	T+36	TOTALS FROM FORECASTS	% IN CATEGORY
	SURFACE PRESSURE	500MB					
A	0	0	1	2	2	5	21
B	1	7	3	2	1	6	25
C	7	1	4	4	4	12	50
D	0	0	0	0	1	1	4
E	0	0	0	0	0	0	0

(b) OCTAGON

CATEGORY	ANALYSIS		T+24	T+48	T+72	TOTALS FROM FORECASTS	% IN CATEGORY
	SURFACE PRESSURE	500MB					
A	0	0	0	0	0	0	0
B	2	2	2	4	0	6	25
C	6	6	6	3	8	17	71
D	0	0	0	1	0	1	4
E	0	0	0	0	0	0	0

A OPERATIONAL SIGNIFICANTLY BETTER THAN EXPT 1.

B OPERATIONAL BETTER THAN EXPT 1

C OPERATIONAL AND EXPT 1 EQUALLY GOOD

D OPERATIONAL WORSE THAN EXPT 1

E OPERATIONAL SIGNIFICANTLY WORSE THAN EXPT 1.

TABLE VIII

RESULTS OF SUBJECTIVE ASSESSMENT OF BRITISH ISLES RAINFALL PREDICTIONS

DATA TIME	T+12	T+24	T+36
00Z 2/5/74	C	C	C
00Z 3/5/74	C	C	C
00Z 8/5/74	B	A	E
00Z 9/5/74	D	B	A
00Z 10/5/74	C		
00Z 11/5/74			B
12Z 11/5/74		A (B)	A (A)
00Z 12/5/74	A	A	

A OPERATIONAL SIGNIFICANTLY BETTER THAN EXPT 1

B OPERATIONAL BETTER THAN EXPT 1

C OPERATIONAL AND EXPT 1 EQUALLY GOOD

D OPERATIONAL WORSE THAN EXPT 1

E OPERATIONAL SIGNIFICANTLY WORSE THAN EXPT 1

BRACKETS REFER TO RE-RUN FOR 12Z 11/5/74.

TABLE IX

OWS WINDS REJECTED BY OBJECTIVE ANALYSIS

DATE	OCTAGON		RECTANGLE	
	OWS	LEVELS	OWS	LEVELS
00Z 2/5/74	B	200mb	I	500mb, 1000/500mb THERMAL
00Z 3/5/74	NONE		NONE	
00Z 4/5/74	J	300, 400mb	J	300mb
	B	500mb*	B	400*, 500mb*
00Z 5/5/74	NONE		NONE	
00Z 6/5/74	NONE		NONE	
00Z 7/5/74	B	500mb	NONE	
00Z 8/5/74	B	300mb	B	300mb
00Z 9/5/74	NONE		NONE	
00Z 10/5/74	K	300mb	K	300, 500mb
00Z 11/5/74	B	200mb	NONE	
12Z 11/5/74	K	300, 500mb	K	300, 500mb
00Z 12/5/74	K	300, 400mb	K	300mb

* CORRECTLY REJECTED

NOTE: (1) OWS B WAS OFF-STATION FOR MOST OF THE PERIOD

(2) 200 AND 400MB WINDS HAVE <u>NOT</u> BEEN CHECKED AGAINST HAND-DRAWN CHARTS.

TABLE X

VERIFICATION OF OCTAGON 10 LEVEL MODEL

Cumulative Statistics

1. Heights against objective analysis (region 2 - 560 grid points)

T + 72 forecast rms height differences in metres.

DATE	1000mb	850mb	500mb	300mb	250mb	200mb	100mb
Aug. 1972	49.1	50.1	71.3	98.9		98.8	90.1
Sept "	60.8	59.6	81.8	116.4		111.5	87.9
Oct "	71.6	72.7	94.5	129.0		120.6	95.2
Nov "	77.5	74.1	95.9	127.3		123.6	105.5
Dec "	88.2	88.1	109.8	143.3		134.1	126.4
Jan 1973	93.5	96.3	121.8	157.1		152.5	165.7
Feb "	96.1	108.5	127.8	162.1		156.9	144.8
Mar "	76.1	83.5	105.7	136.7		128.2	103.6
Apr "	76.3	79.4	101.3	129.3		116.9	92.7
May "	61.8	65.7	74.1	97.3		86.3	59.2
Jun "	53.5	56.3	63.3	87.0		85.4	65.1
Jul "	51.8	57.9	58.8	79.7		82.3	74.4
Aug "	50.0	52.2	57.6	82.4		86.4	83.0
Sept "	59.7	63.6	77.6	113.0		109.3	94.0
Oct "	68.8	72.7	82.2	120.5		119.2	100.9
Nov "	81.6	91.0	96.2	130.5		125.5	110.6
Dec "	95.5	102.1	118.2	156.7		152.8	142.9
Jan 1974	83.8	88.5	112.2	160.5		168.1	181.4
Feb "	102.6	107.4	138.4	183.4		175.3	188.7
Mar "	88.7	87.0	132.5	180.1		175.8	183.0
Apr "	68.3	66.1	103.1	142.2		134.8	111.8
May "	61.5	61.1	85.3	118.0		107.9	76.7

Table XI : Observations used in Octagon Verification

a. 28 Stations in Europe

01415	Stavanger	06447	Uccle
02084	Göteborg	06610	Payerne
03005	Lerwick	07110	Brest
03026	Stornoway	07145	Trappes
03170	Shanwell	07480	Lyon
03322	Aughton	07510	Bordeaux
03496	Hemsby	07645	Nîmes
03774	Crawley	10035	Schleswig
03808	Camborne	10338	Hannover
03920	Long Kesh	10384	Berlin
03953	Valentia	10739	Stüttgart
06011	Thorshavn	10866	Munich
06181	Copenhagen	12330	Poznan-Lawica
06260	De Bilt	16080	Milan

b. 6 Atlantic Stations

04018	Keflavik	O.W.S	B
04270	Narssarssuaq	O.W.S	I
		O.W.S	J
		O.W.S.	K

10 LEVEL - MODEL VERIFICATION REGIONS

REGION I 1681 grid points

REGION II 560 grid points

⊗ 28 Upper-air observing stations (Europe)

× 6 Upper-air observing stations (Atlantic)

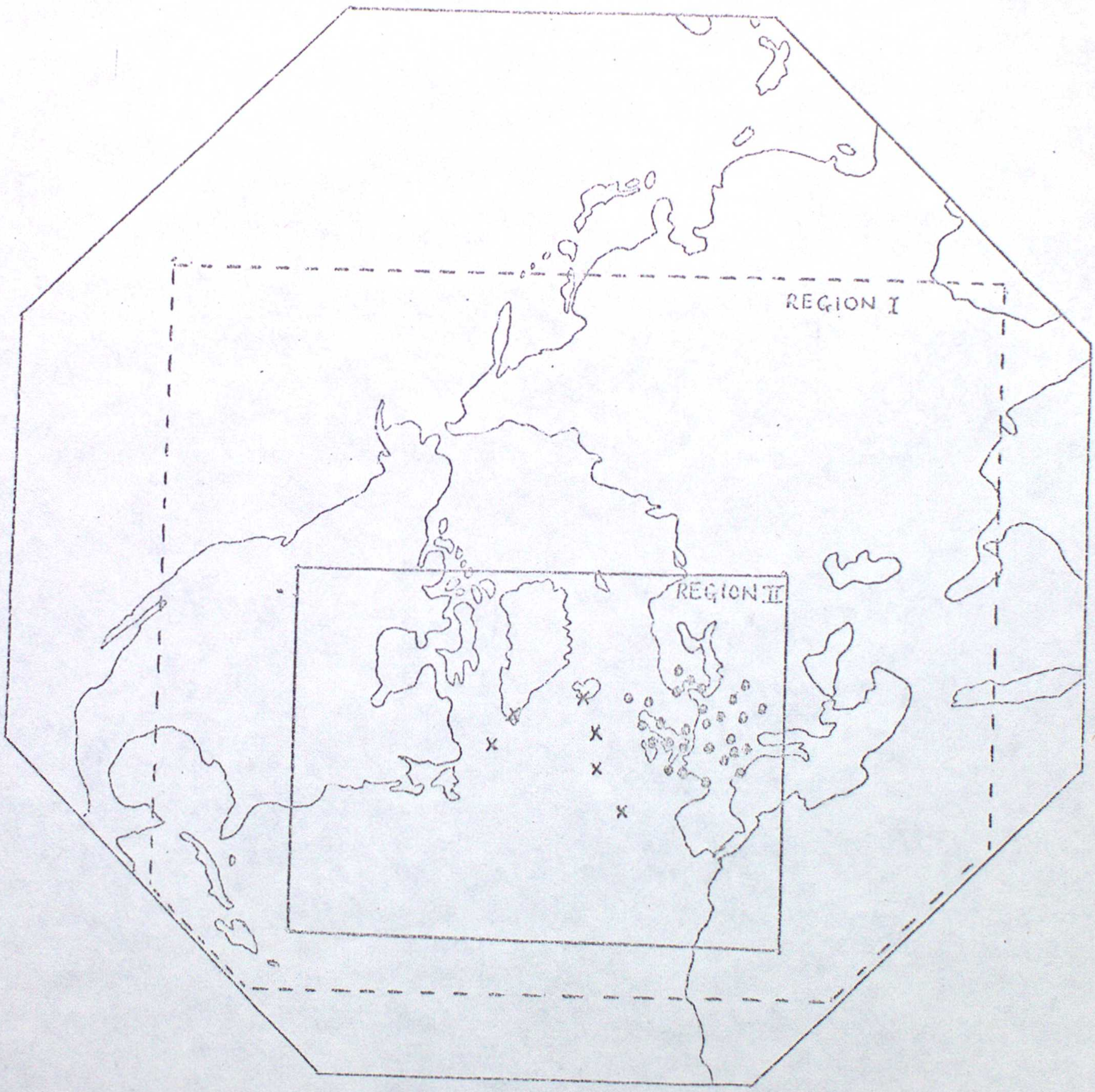


Figure VIII

TABLE XII

Daily totals of the mean values of accumulated rain (mm) in each of the 14 areas shown in Figure XIII

(a)

DATA TIME	VERIFICATION PERIOD T+12 to T+24			VERIFICATION PERIOD T+24 to T+36		
	Actual	Operational	Expt 1	Actual	Operational	Expt 1
00Z 2/5/74	31·7	9·4	8·3	19·4	8·6	9·2
00Z 3/5/74	25·4	13·1	12·0	17·2	13·1	18·8
00Z 4/5/74	18·3	3·2	3·2	13·7	5·5	6·2
00Z 5/5/74	12·3	7·8	7·4 (7·4)	7·3	9·7	9·4 (9·3)
00Z 6/5/74	6·4	3·7	3·5	6·9	4·2	4·1
00Z 7/5/74	8·7	0·5	0·3	9·1	3·0	2·5
00Z 8/5/74	6·9	4·3	4·7 (4·5)	5·3	3·0	2·3 (2·2)
00Z 9/5/74	23·9	15·1	6·8	21·7	9·4	17·8
00Z 10/5/74	20·6	6·7	7·0	22·2	6·3	5·2
00Z 11/5/74	14·1	5·5	4·8	8·3	0·8	6·2
12Z 11/5/74	8·3	4·7 (4·8)	4·2	8·0	6·1 (5·7)	4·2
00Z 12/5/74	8·0	11·3	4·4	7·7	4·1	4·4

(b)

DATA TIME	VERIFICATION PERIOD T+12 to T+36		
	Actual	Operational	Expt 1
00Z 2/5/74	51·1	18·0	17·5
00Z 3/5/74	42·6	26·2	30·8
00Z 4/5/74	32·0	8·7	9·4
00Z 5/5/74	19·6	17·5	16·8 (16·7)
00Z 6/5/74	13·3	7·9	7·6
00Z 7/5/74	17·8	3·5	2·8
00Z 8/5/74	12·2	7·3	7·0 (6·7)
00Z 9/5/74	45·6	24·5	24·6
00Z 10/5/74	42·8	13·0	12·2
00Z 11/5/74	22·4	6·3	11·0
12Z 11/5/74	16·3	10·8 (10·5)	8·4
00Z 12/5/74	15·7	15·4	8·8

NOTE: FIGURES IN BRACKETS REFER TO RE-RUNS.

TABLE XIII

2X2 CONTINGENCY TABLES FOR WET AND DRY PERIODS COMBINING ALL THE AREAS IN FIGURE XIII AND ALL 12-HOUR PERIODS T+12 TO T+24 AND T+24 TO T+36

OPERATIONAL

ACTUAL		DRY	WET
	DRY	98	27
	WET	59	152

EXPT 1

ACTUAL		DRY	WET
	DRY	99	26
	WET	57	154

TABLE XIV

4X4 CONTINGENCY TABLES FOR 4 CATEGORIES OF RAINFALL AMOUNT COMBINING ALL AREAS IN FIGURE XIII AND ALL 12-HOUR PERIODS T+12 TO T+24 AND T+24 TO T+36

OPERATIONAL

	Rain in mm	0	<2	≥2 <5	≥5
ACTUAL	0	98	27	0	0
	<2	52	93	7	0
	≥2 <5	7	28	9	0
	≥5	0	8	6	1

EXPT 1

	Rain in mm	0	<2	≥2 <5	≥5
ACTUAL	0	99	26	0	0
	<2	50	97	5	0
	≥2 <5	5	31	7	1
	≥5	2	6	6	1

TABLE XV

COMPARISON OF THE EFFECTS OF INCLUDING SATELLITE AND WEATHER-SHIP DATA IN NUMERICAL FORECASTS.

(a)

	INCLUSION OF SATELLITE DATA	INCLUSION OF WEATHER-SHIP DATA
1)	Improves octagon more than rectangle. (see part (b))	Improves rectangle more than octagon. (see part (b))
2)	Improves heights more than winds.	Improves winds more than heights
3)	Effects often persist to 72 hours.	Effects disappear after 48 hours.
4)	Shows small improvements to most forecasts.	Some forecasts improved considerably, others not affected.

(b)

PERCENTAGE OF FORECAST VERIFICATION TIMES IN EACH CATEGORY COMPARING FORECASTS WITH AND WITHOUT SATELLITE DATA AND WITH AND WITHOUT WEATHER-SHIP DATA.

	Including Satellite Data		Including Weather-Ship Data	
	RECTANGLE	OCTAGON	RECTANGLE	OCTAGON
SIGNIFICANTLY BETTER	0%	0%	19%	3%
BETTER	33%	43%	28%	19%
EQUALLY GOOD	57%	43%	47%	64%
WORSE	10%	14%	6%	14%
SIGNIFICANTLY WORSE	0%	0%	0%	0%

NOTE: (1) EFFECTS OTHER THAN THE INCLUSION OF SATELLITE OR WEATHER SHIP DATA HAVE NOT BEEN REMOVED

(2) FORECASTS ONLY INCLUDED.

MAY 1974

DAILY WEATHER MAPS

12 GMT

Dates are ringed at
lower right-hand corner
of each map

Fig I

FIGURE II (a)

ANAL SURFACE PRESSURE VT 00Z 12 MAY 74 OPERATIONAL

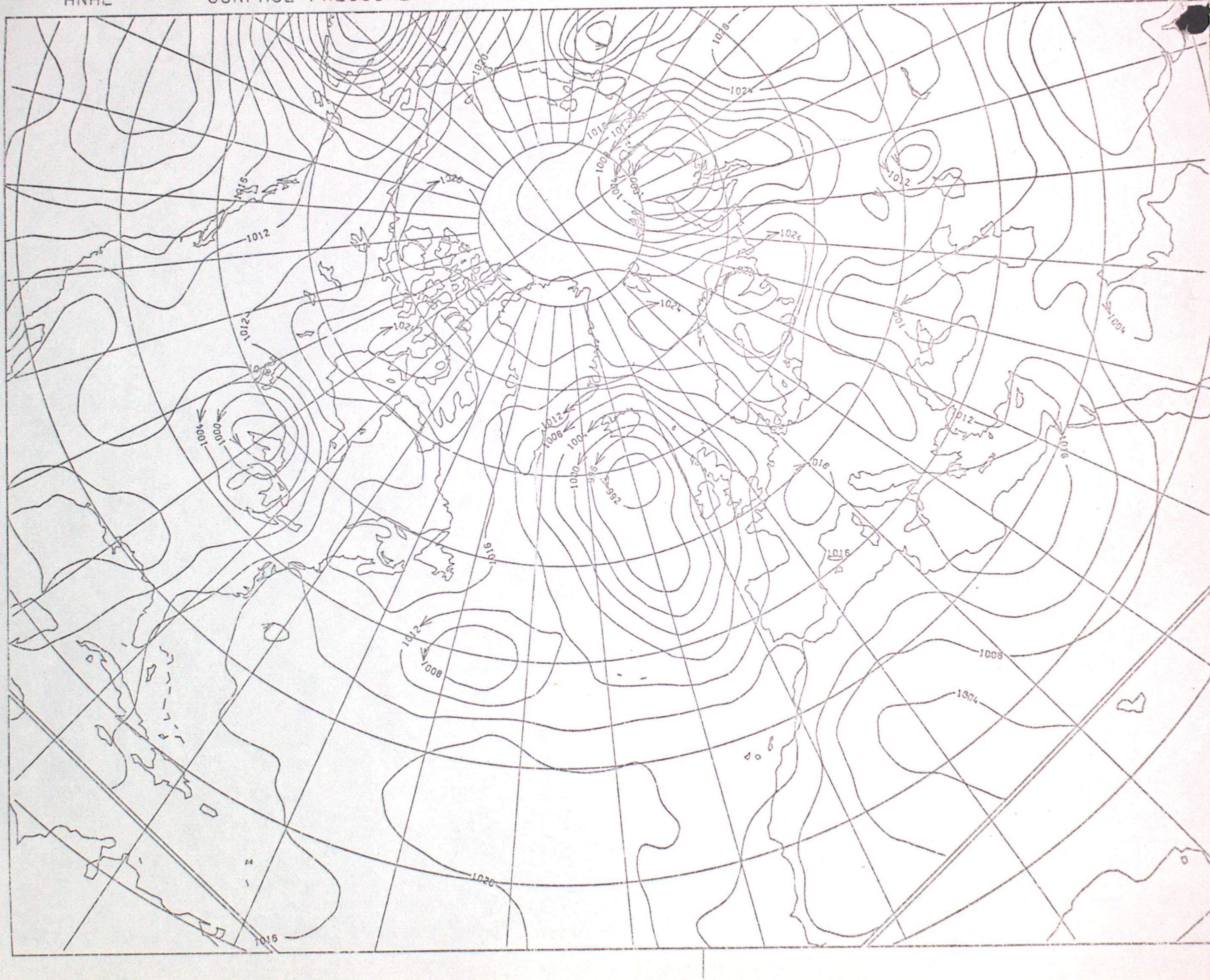


FIGURE II (c)

ANAL SURFACE PRESSURE VT 00Z 12 MAY 74 EXPT 1 NO WEATHER SHIPS

FIGURE II(c)

ANAL 500 MB CONTOUR VT 00Z 12 MAY 74 OPERATIONAL

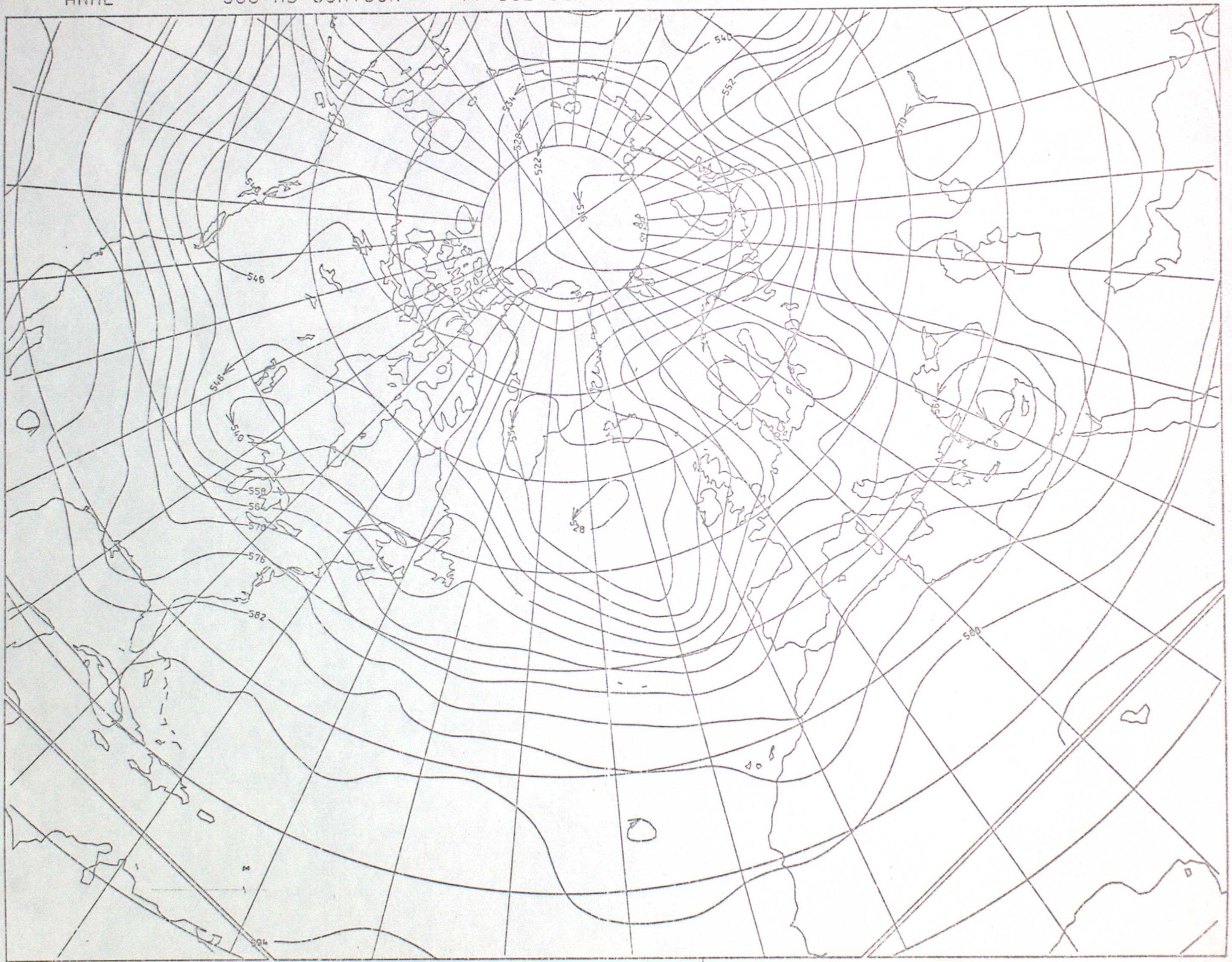


FIGURE II (d)

ANAL 500 MB CONTOUR VT 00Z 12 MAY 74 EXPT 1 NO WEATHER SHIPS

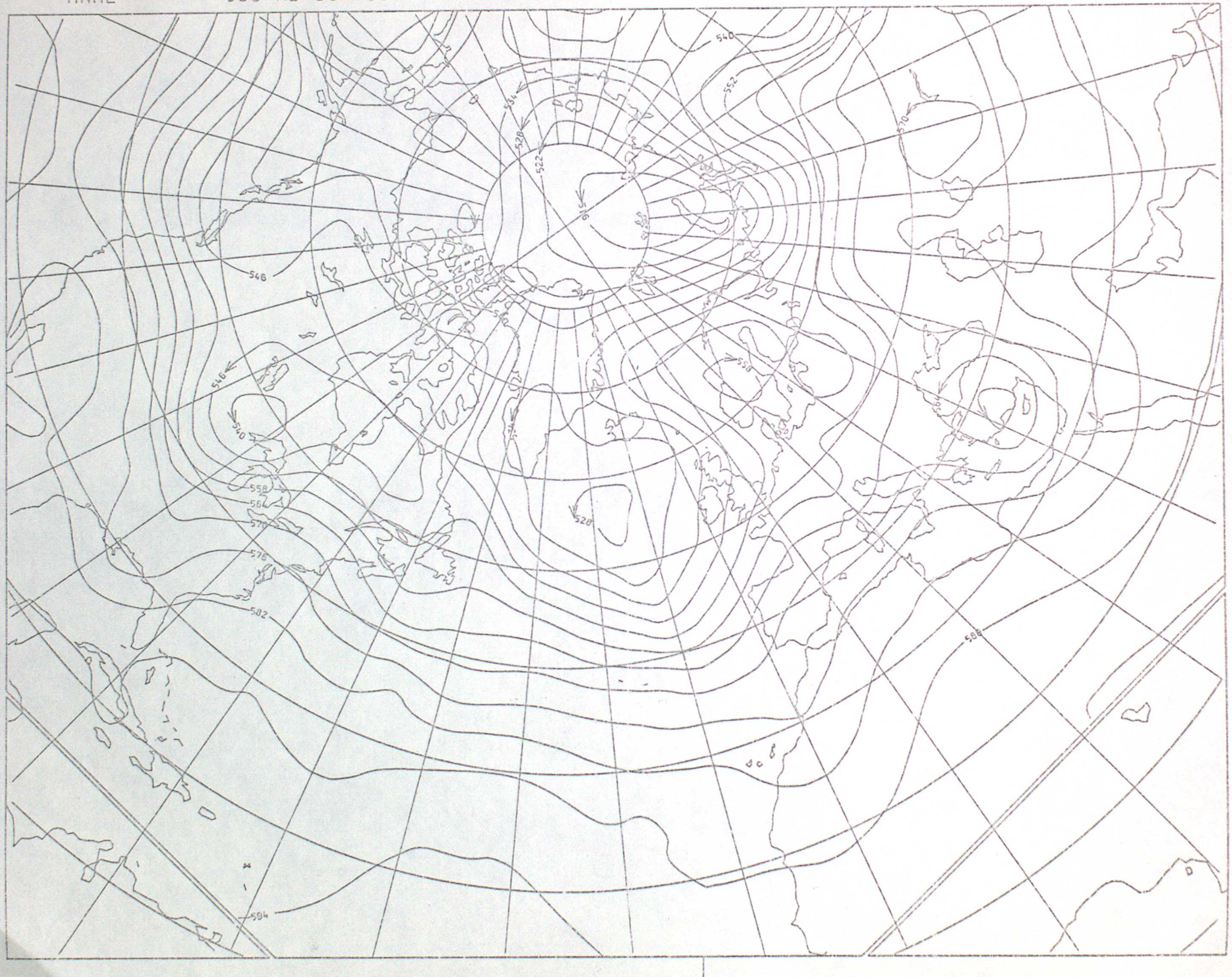
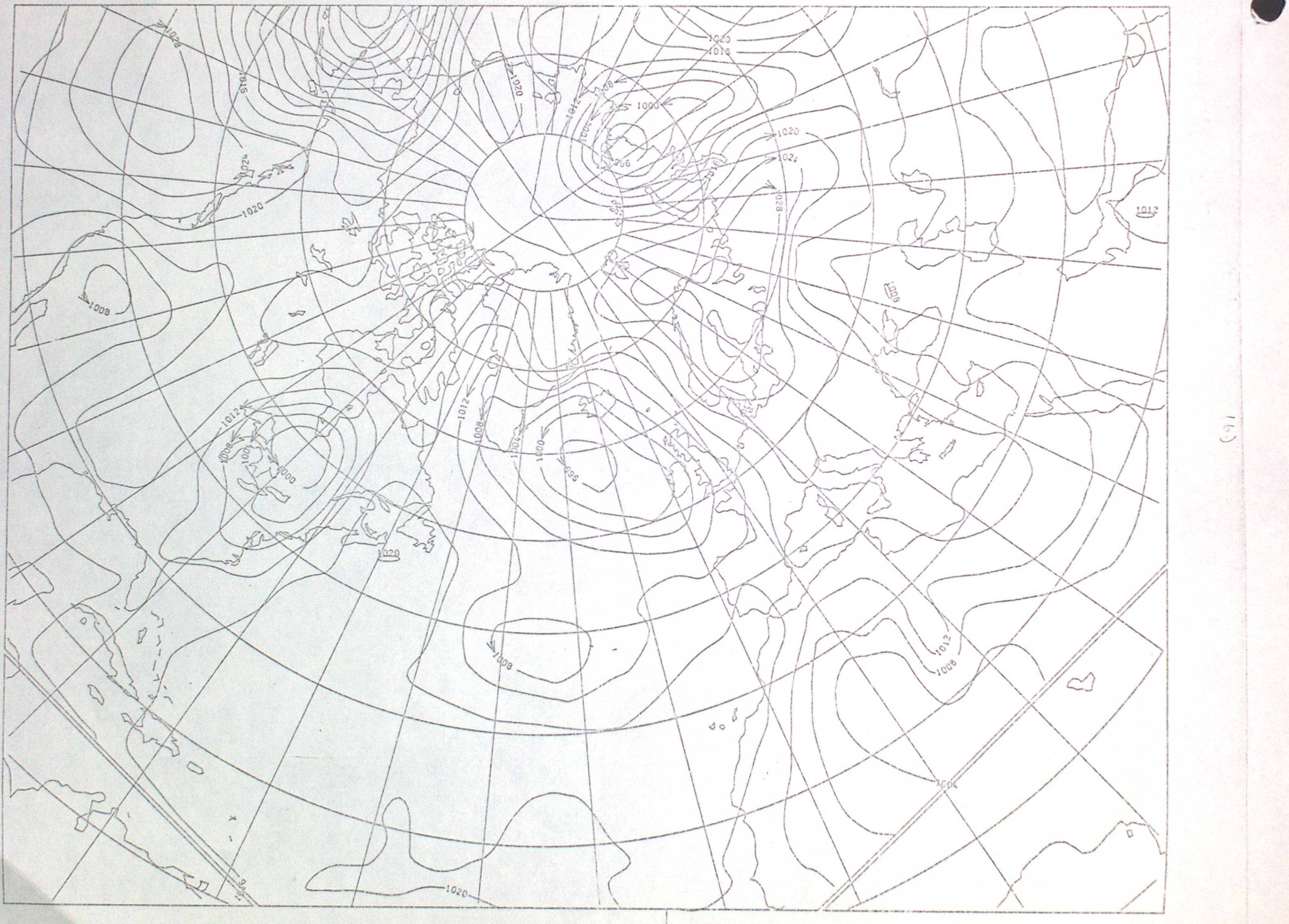


FIGURE II (e)

PROG T+24 SURFACE PRESSURE VT 00Z 13 MAY 74 OPERATIONAL

FIGURE II (f)

PROG T+24 SURFACE PRESSURE VT 00Z 13 MAY 74 EXPT I NO WEATHER SHIPS



(6)

FIGURE III (a)

ANAL SURFACE PRESSURE VT 00Z 08 MAY 74 OPERATIONAL

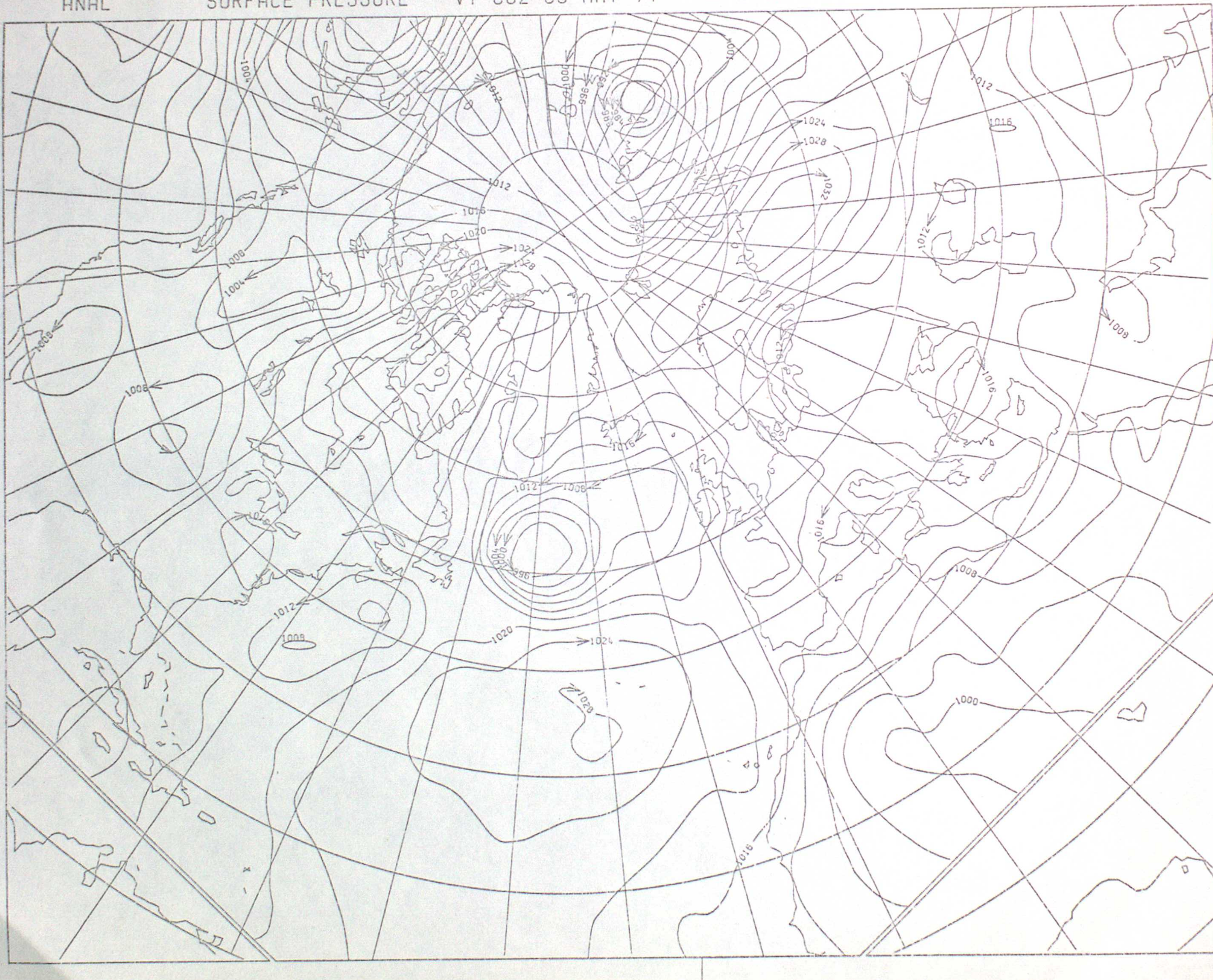
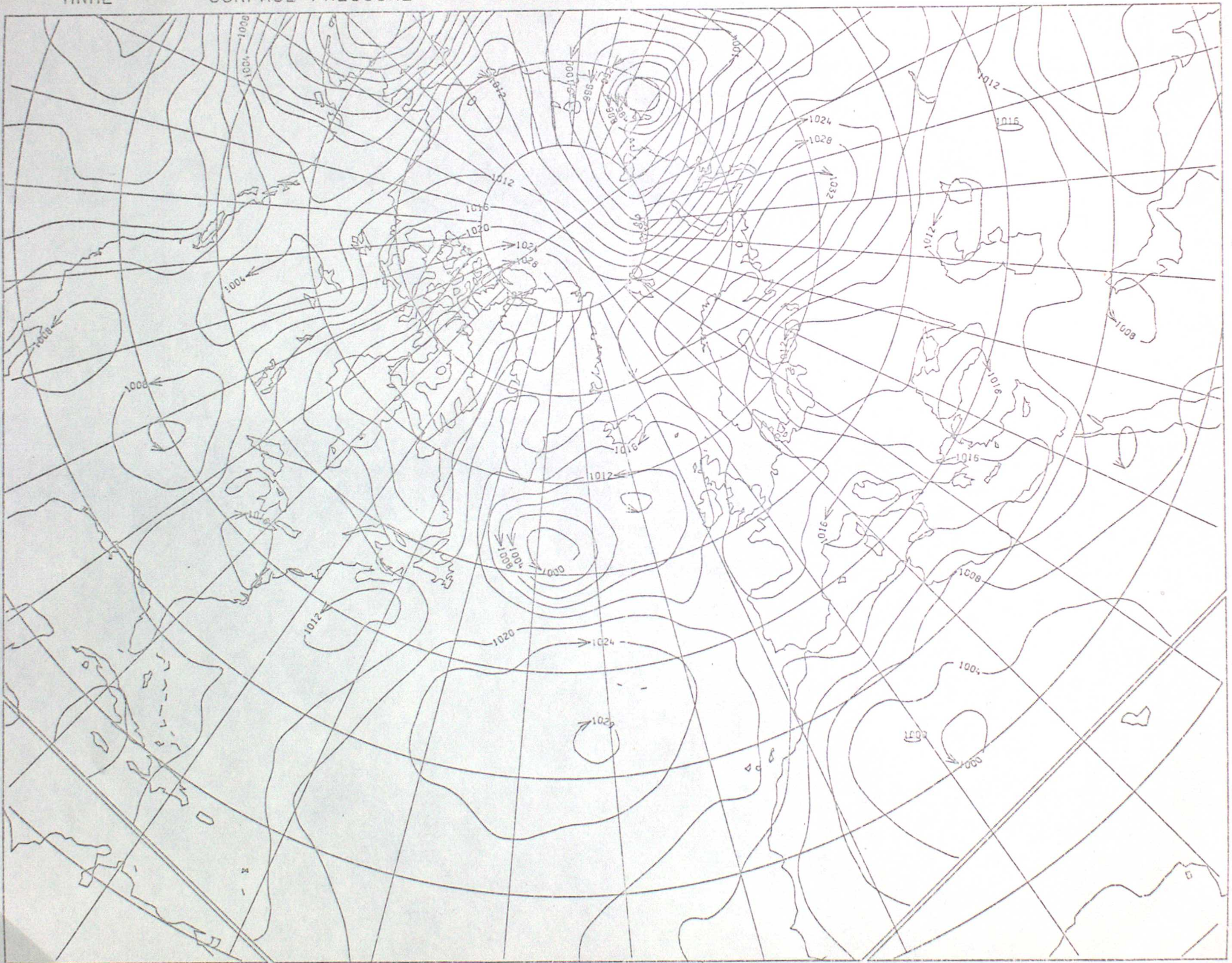


FIGURE III (6)

ANAL SURFACE PRESSURE VT 00Z 08 MAY 74 EXPT 1 NO WEATHER SHIPS



(8)

FIGURE III (c)

ANAL SURFACE PRESSURE VT 00Z 08 MAY 74 EXPT1 RE-RUN NO WEATHER SHIPS

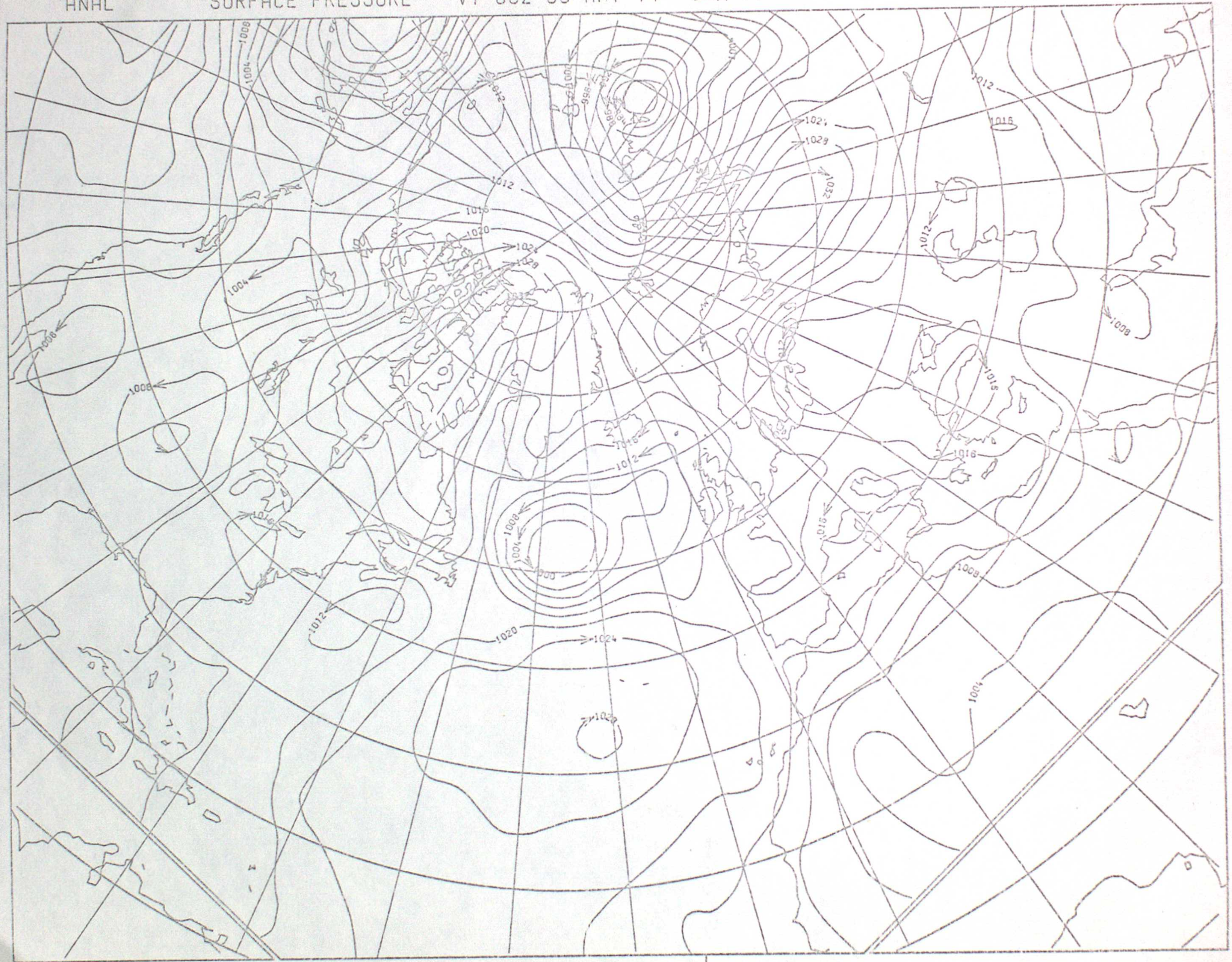


FIGURE III (d)

PROG T+24 SURFACE PRESSURE VT 00Z 09 MAY 74 OPERATIONAL

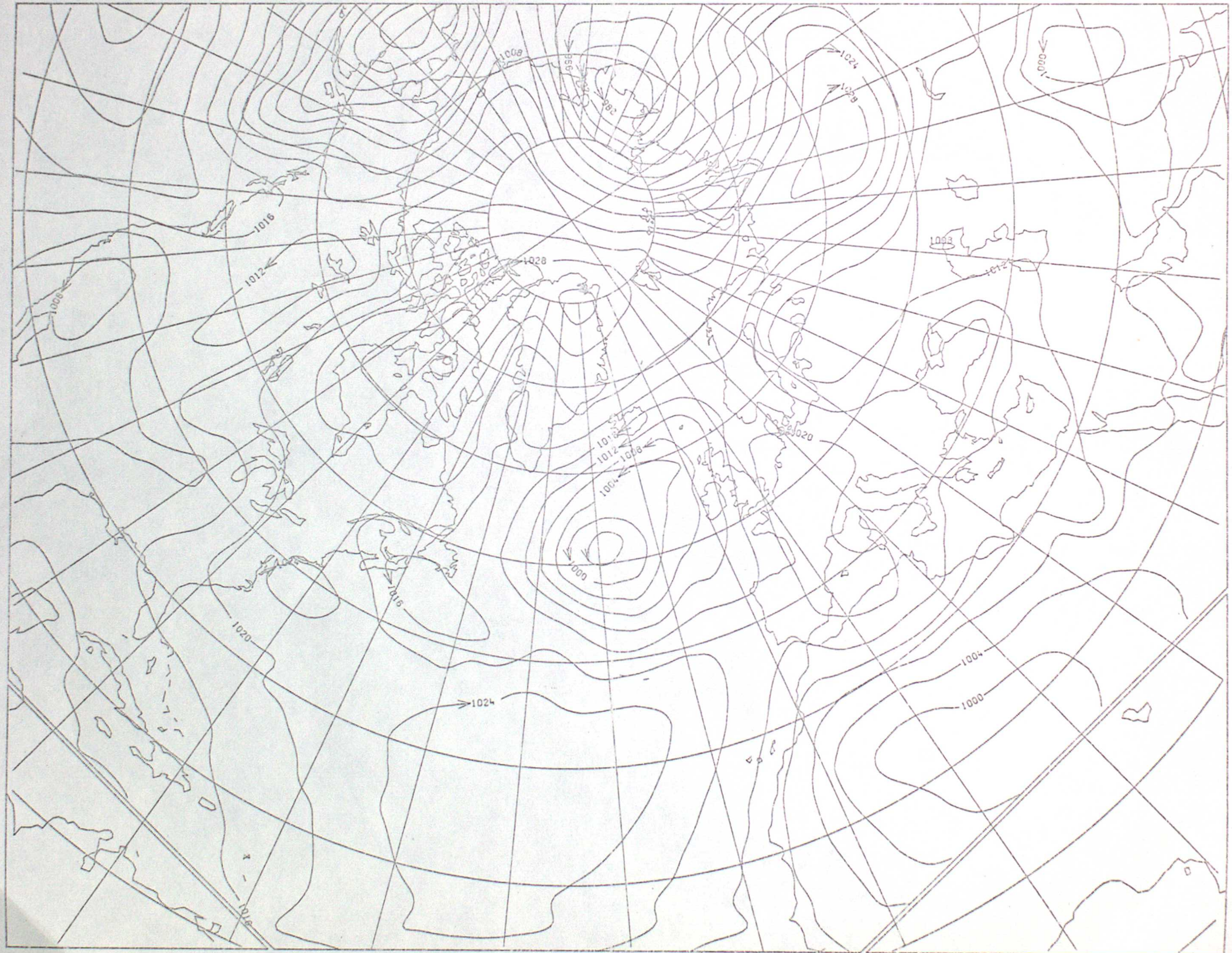


FIGURE III (e)

PROG T+24   SURFACE PRESSURE   VT 00Z 09 MAY 74   EXPT 1   NO WEATHER SHIPS

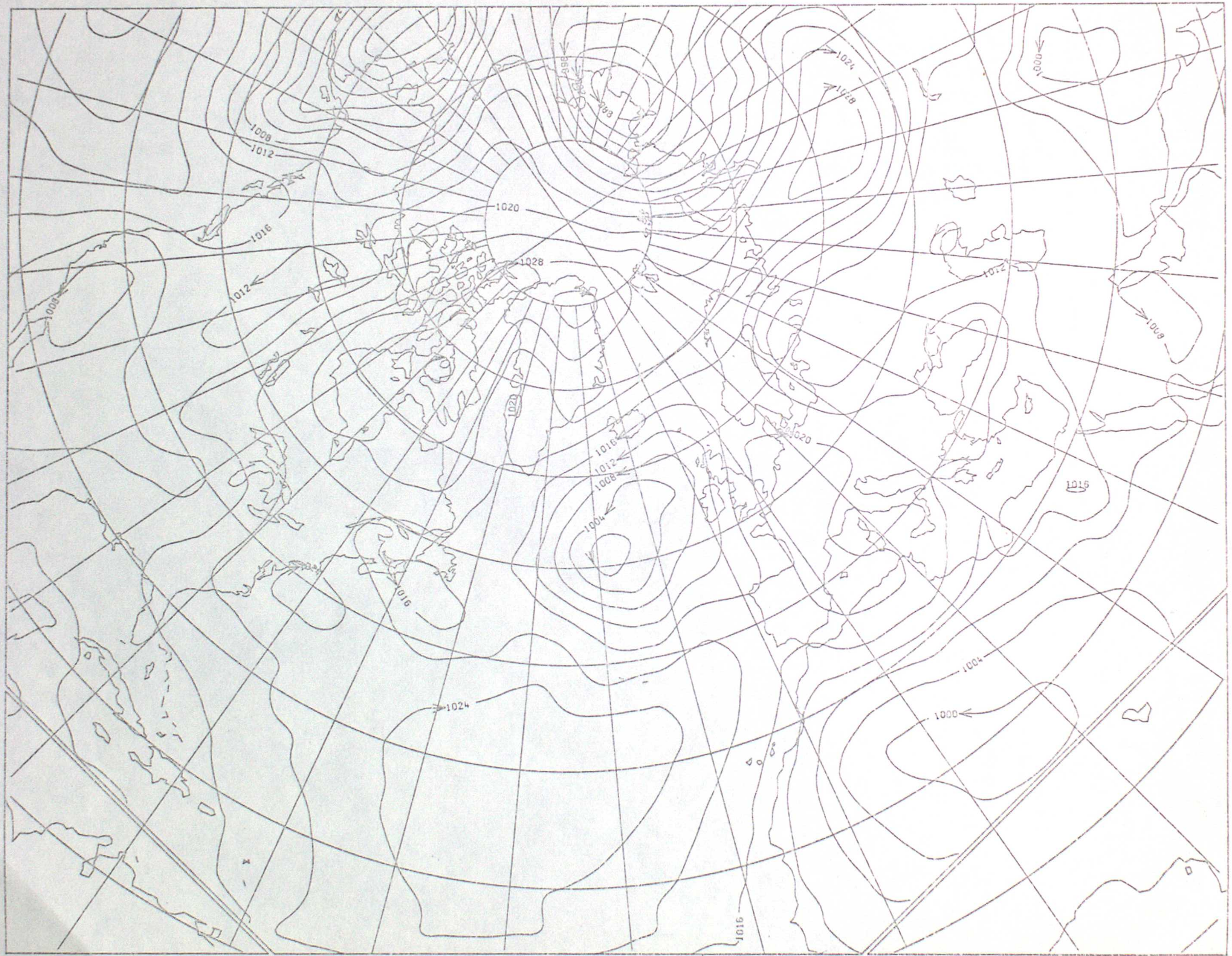
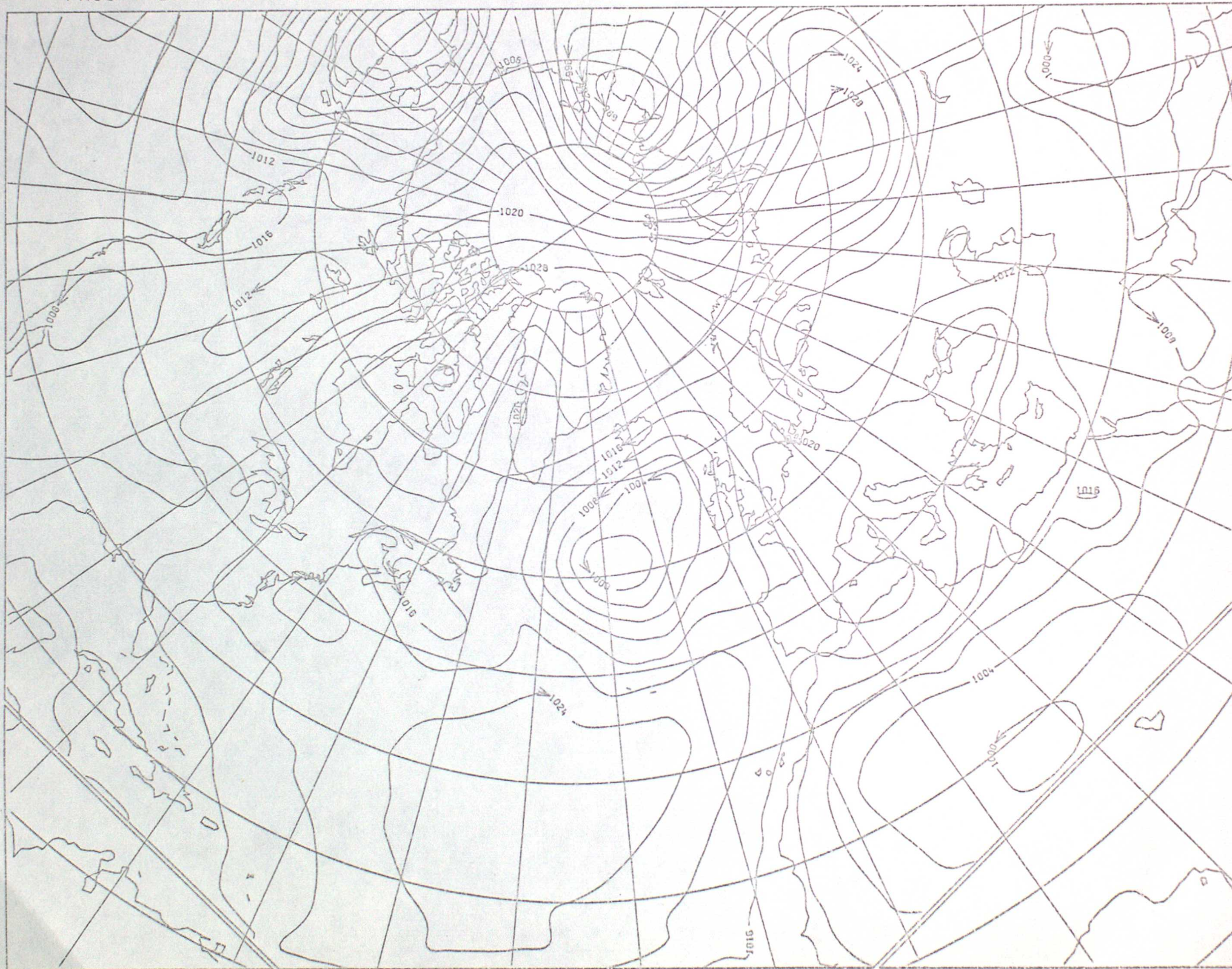


FIGURE III (f)

PROG T+24 SURFACE PRESSURE VT 00Z 09 MAY 74 EXPT 1 RE-RUN NO WEATHER SHIPS

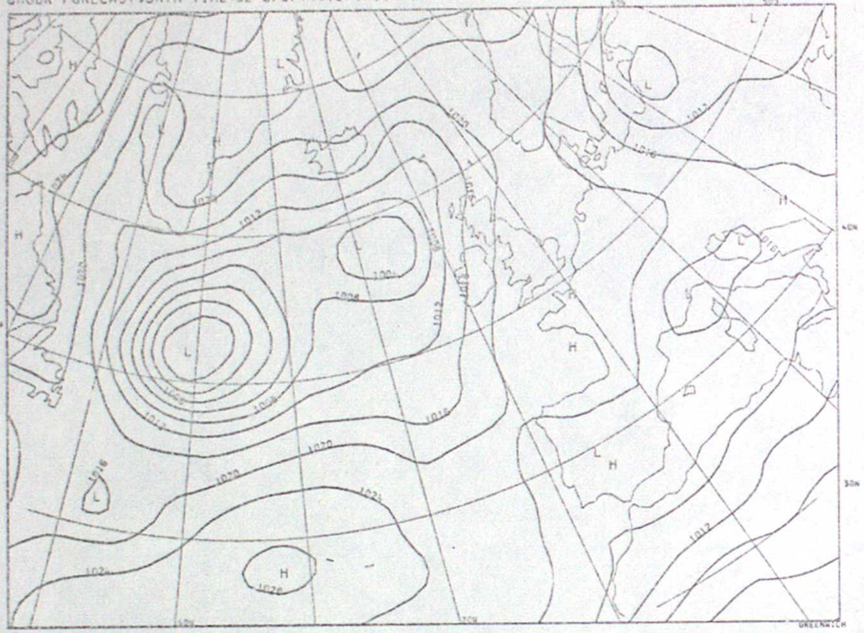


CURE IV (a)   SURFACE PRESSURE AND 500MB ANALYSES 00Z 8/5/74

OPERATIONAL

SURFACE PRESSURE   ISOBARS AT 4MB INTERVALS

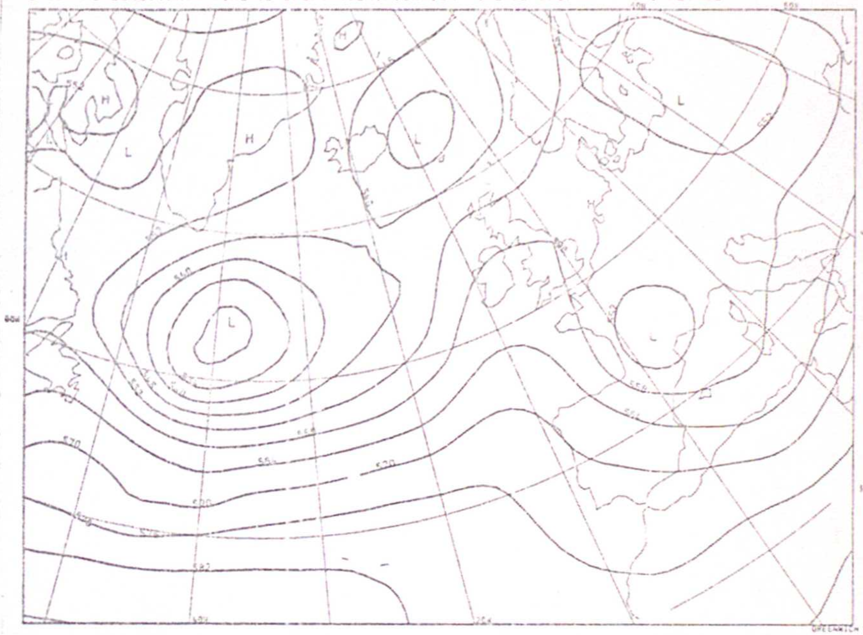
OHOUR FORECAST.DATA TIME=OZ 8/5/74.VERIFICATION TIME=OZ 8/5/74   S-I METHOD



OPERATIONAL

500 MB CONTOURS   ISOPLETH INTERVAL=6   DECAMETERS

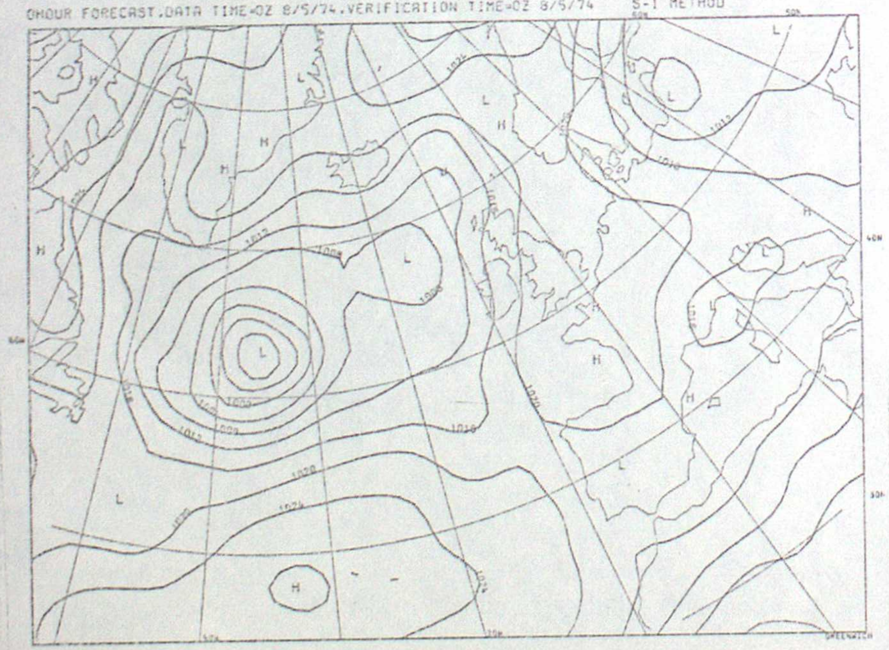
OHOUR FORECAST.DATA TIME=OZ 8/5/74.VERIFICATION TIME=OZ 8/5/74   S-I METHOD



EXPT I RE-RUN

SURFACE PRESSURE   ISOBARS AT 4MB INTERVALS

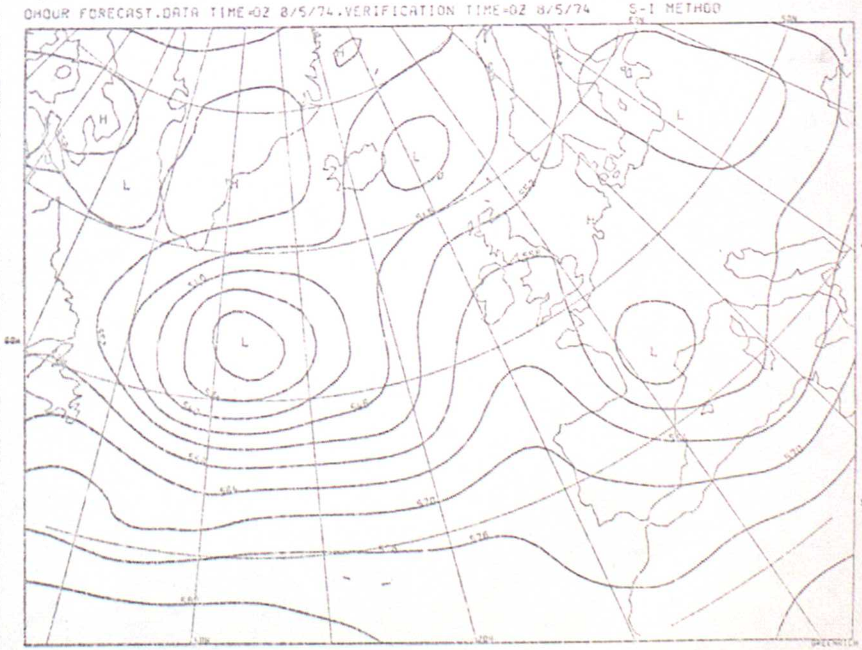
OHOUR FORECAST.DATA TIME=OZ 8/5/74.VERIFICATION TIME=OZ 8/5/74   S-I METHOD



EXPT I RE-RUN

500 MB CONTOURS   ISOPLETH INTERVAL=6   DECAMETERS

OHOUR FORECAST.DATA TIME=OZ 8/5/74.VERIFICATION TIME=OZ 8/5/74   S-I METHOD



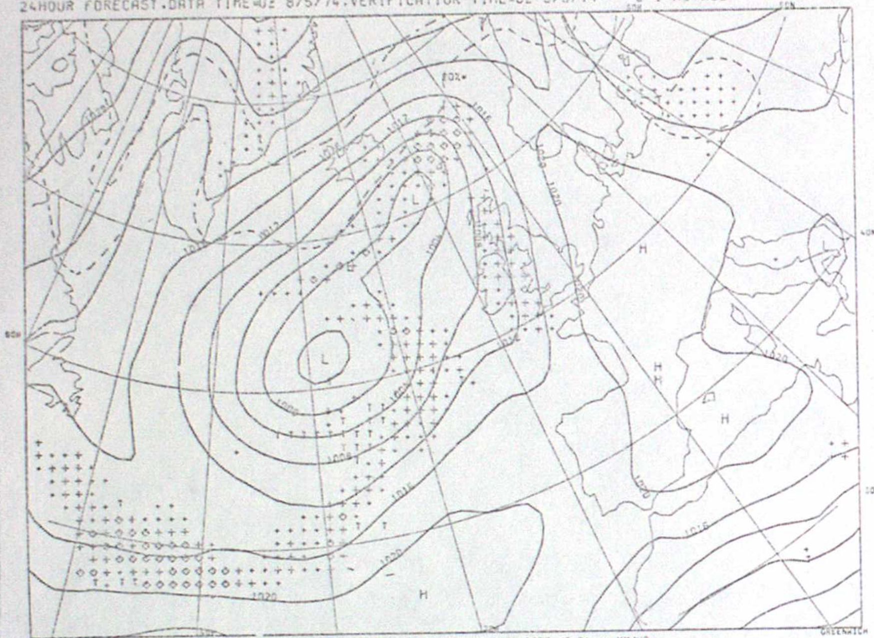
SURFACE PRESSURE AND PRECIPITATION 24- AND 36-HOUR FORECASTS BASED ON 00Z 8/5/74

FIGURE IV(b)

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=0Z 8/5/74.VERIFICATION TIME=0Z 9/5/74 S-I METHOD

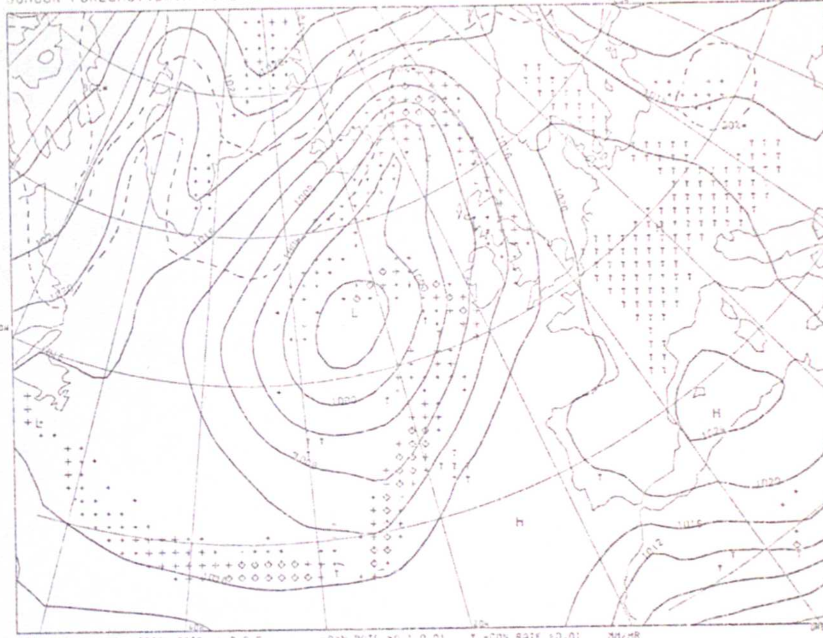


RAIN KEY: ◇ ◇ =TOTAL RATE >4.0.0.5 + + =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=0Z 8/5/74.VERIFICATION TIME=12Z 9/5/74 S-I METHOD

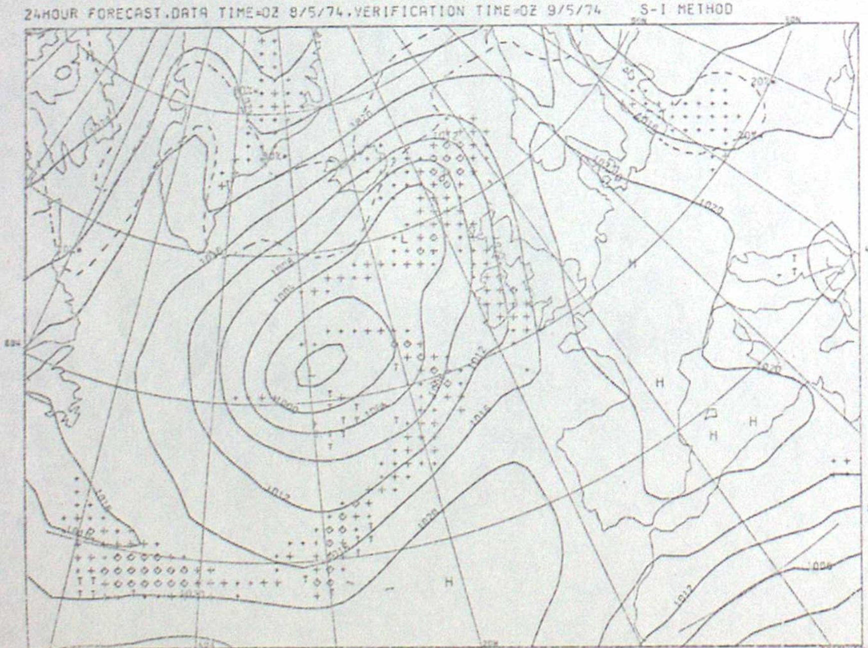


RAIN KEY: ◇ ◇ =TOTAL RATE >4.0.0.5 + + =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

EXPT 1 RE-RUN

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=0Z 8/5/74.VERIFICATION TIME=0Z 9/5/74 S-I METHOD

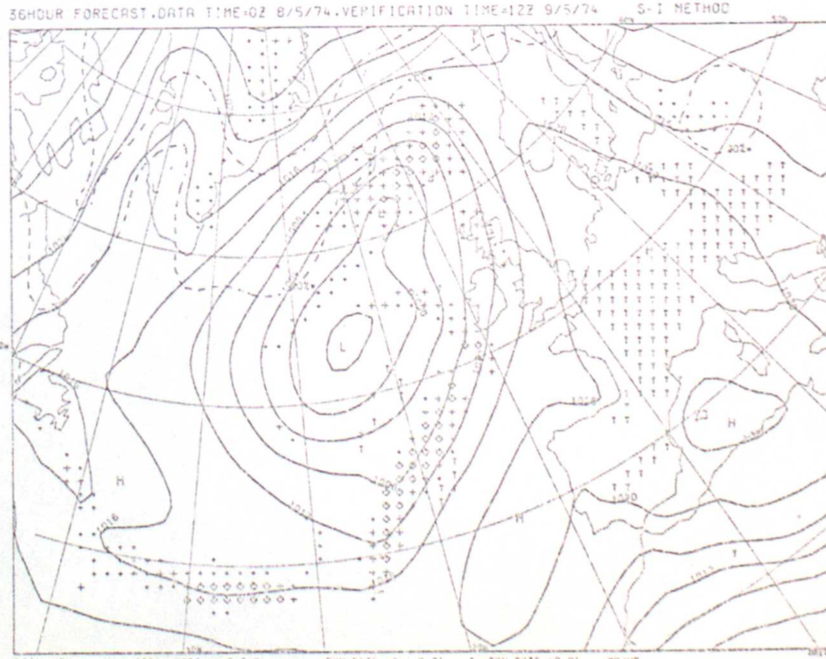


RAIN KEY: ◇ ◇ =TOTAL RATE >4.0.0.5 + + =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

EXPT 1 RE-RUN

FORECAST SURFACE PRESSURE AND PRECIPITATION

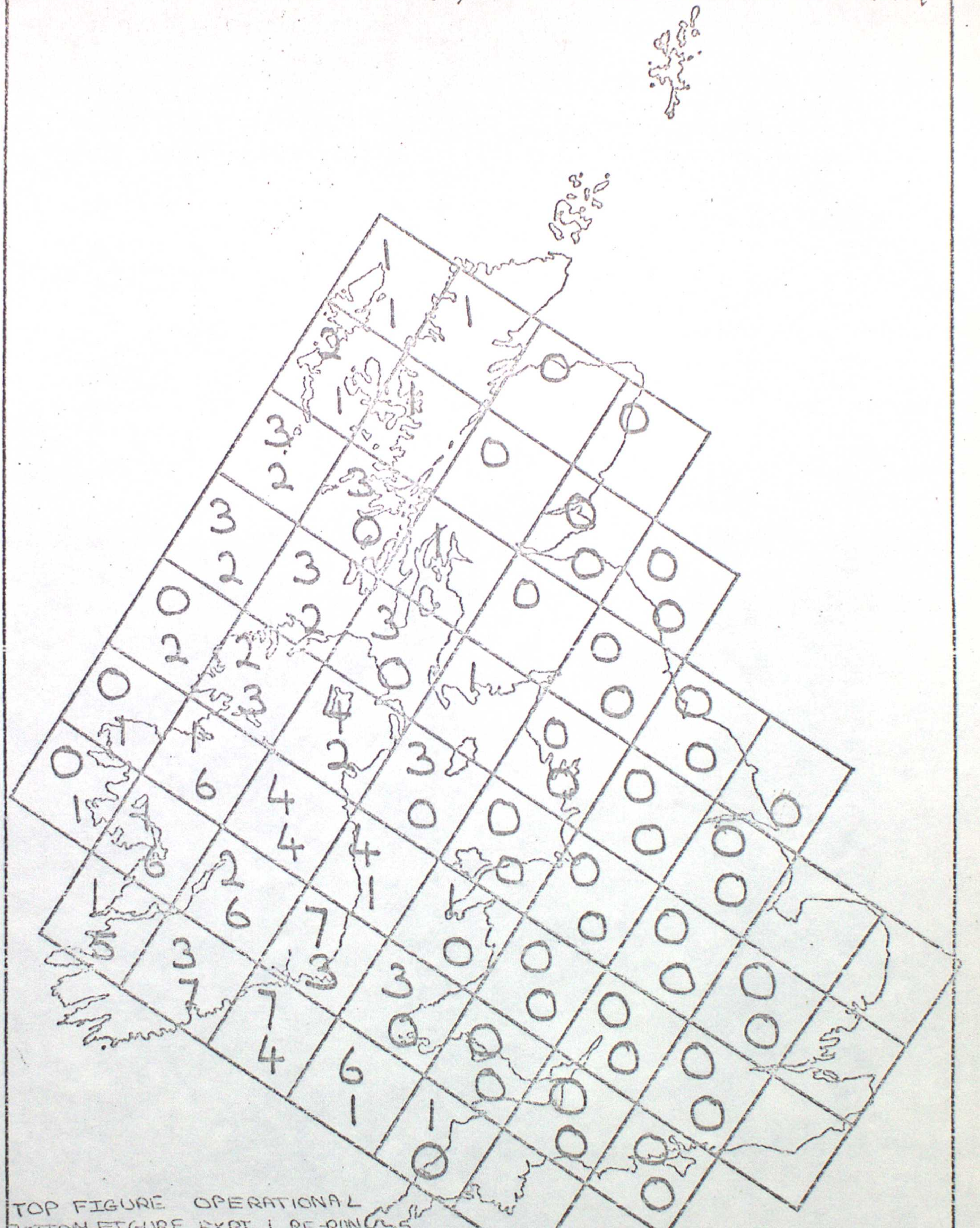
36HOUR FORECAST.DATA TIME=0Z 8/5/74.VERIFICATION TIME=12Z 9/5/74 S-I METHOD



RAIN KEY: ◇ ◇ =TOTAL RATE >4.0.0.5 + + =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

FIGURE IV (c)

FORECAST ACCUMULATED RAIN(MM) T+12 TO T+24 BASED ON 00Z 8/5/74



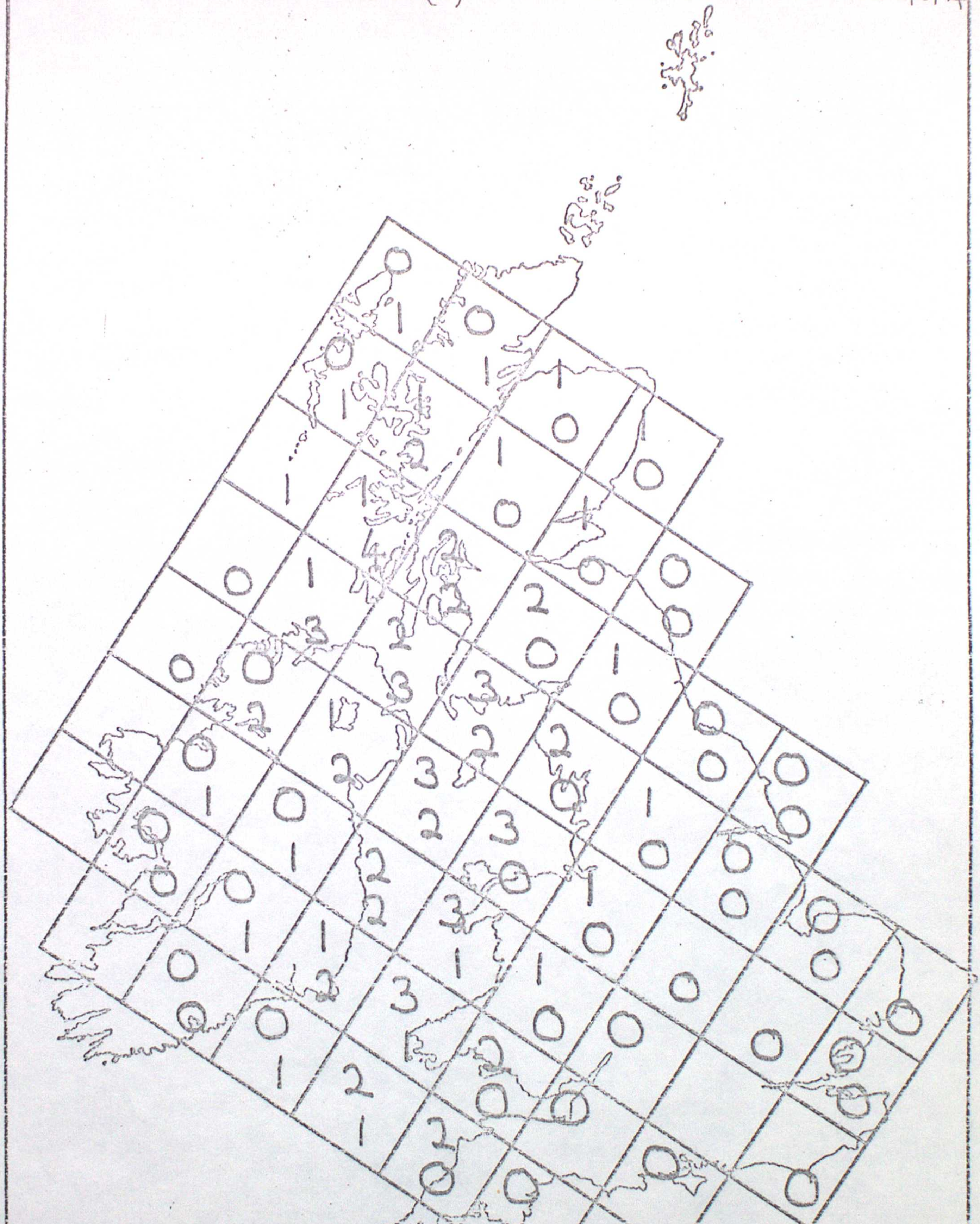
TOP FIGURE OPERATIONAL
BOTTOM FIGURE EXPT i RE-RUN

0 - < 0·5 MM

BLANK - NO RAIN

FIGURE IV (d)

FORECAST ACCUMULATED RAIN(MM) T+24 TO T+36 BASED ON 00Z 8/5/74



TOP FIGURE OPERATIONAL
BOTTOM FIGURE EXPT I RE-RUN

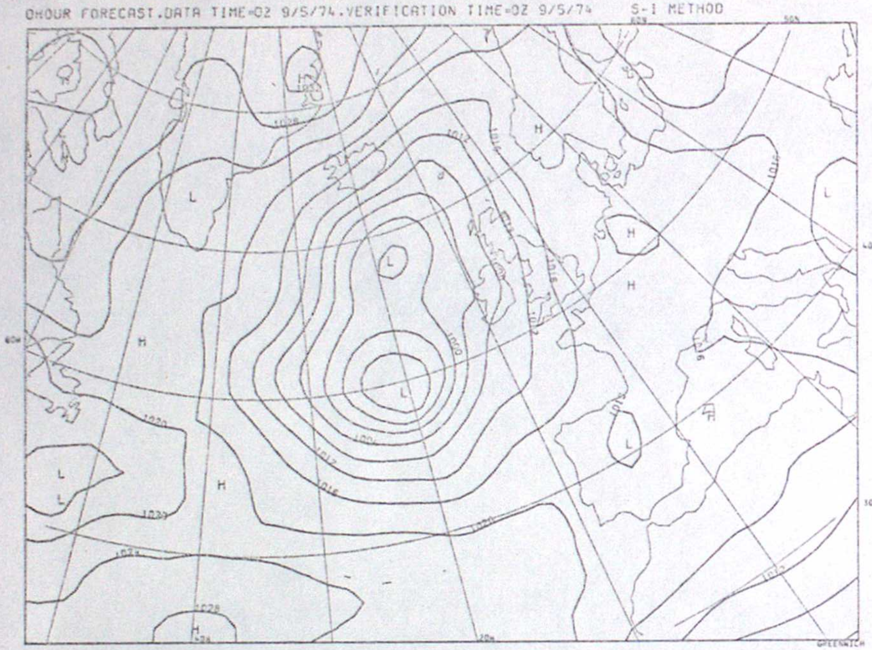
0 - < 0.5 MM
BLANK - NO RAIN

FIGURE V(a) SURFACE PRESSURE AND 500MB ANALYSES 00Z 9/5/74

OPERATIONAL

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

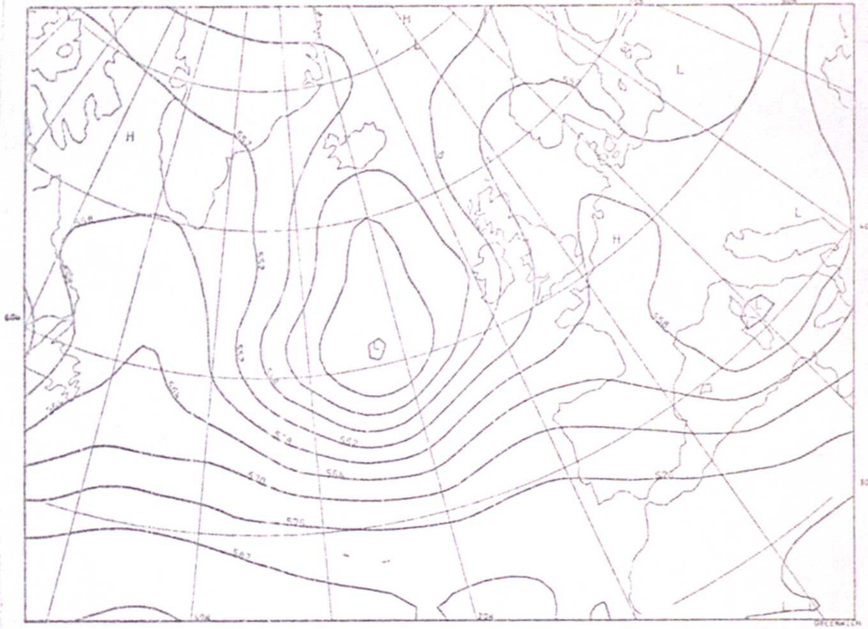
OHOUR FORECAST.DATA TIME=0Z 9/5/74.VERIFICATION TIME=0Z 9/5/74 S-I METHOD



OPERATIONAL

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS

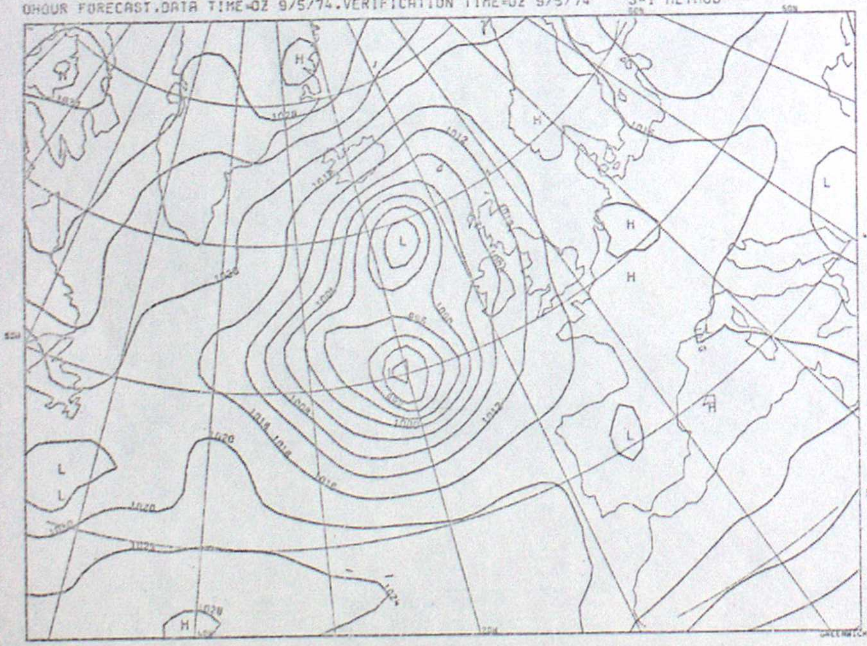
OHOUR FORECAST.DATA TIME=0Z 9/5/74.VERIFICATION TIME=0Z 9/5/74 S-I METHOD



EXPT 1

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

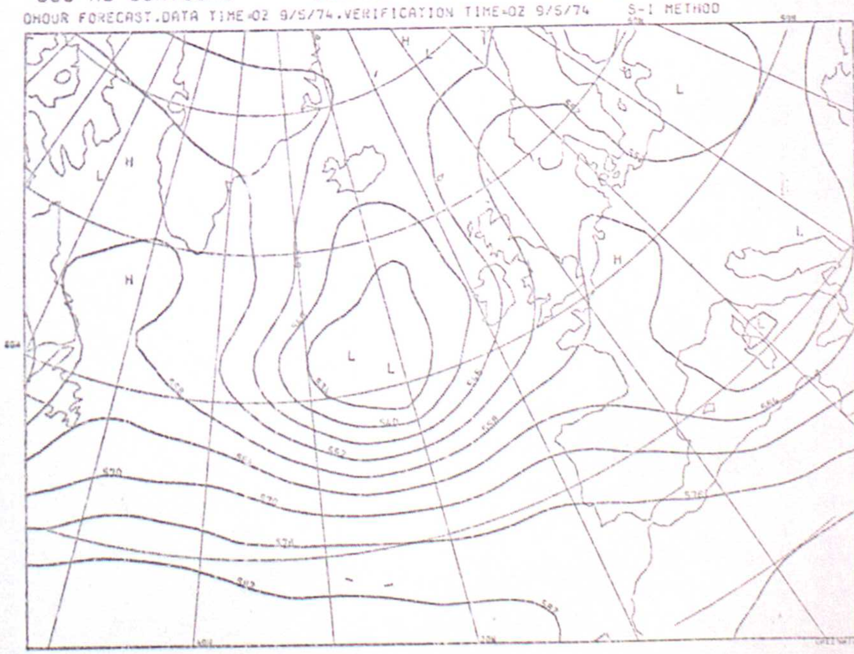
OHOUR FORECAST.DATA TIME=0Z 9/5/74.VERIFICATION TIME=0Z 9/5/74 S-I METHOD



EXPT 1

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS

OHOUR FORECAST.DATA TIME=0Z 9/5/74.VERIFICATION TIME=0Z 9/5/74 S-I METHOD



(17)

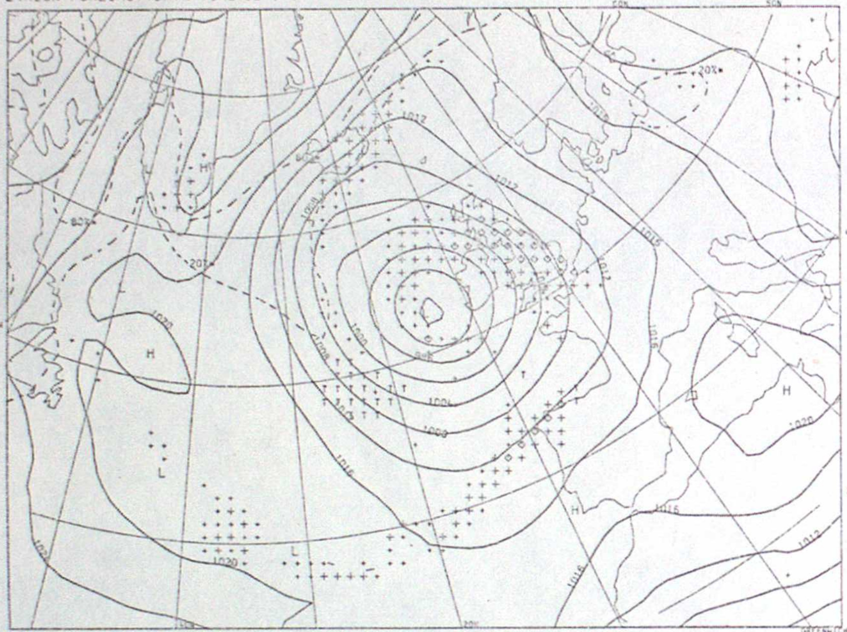
SURFACE PRESSURE AND PRECIPITATION 24- AND 36-HOUR FORECASTS BASED ON 00Z 9/5/74

FIGURE V(U)

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=0Z 9/5/74.VERIFICATION TIME=0Z 10/5/74 S-I METHOD

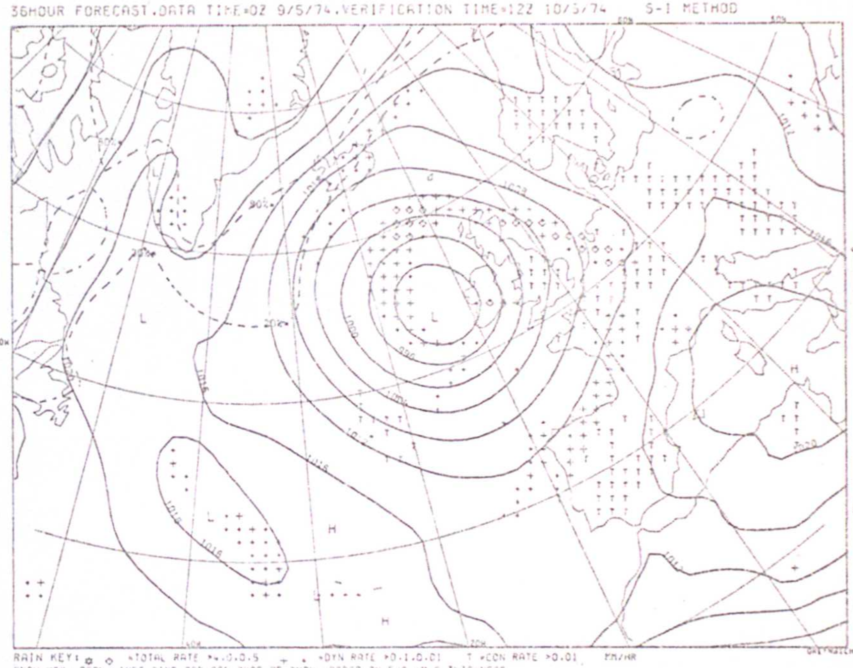


RAIN KEY: ◦ ◇ =TOTAL RATE >4.0.0.5 + . =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=0Z 9/5/74.VERIFICATION TIME=12Z 10/5/74 S-I METHOD

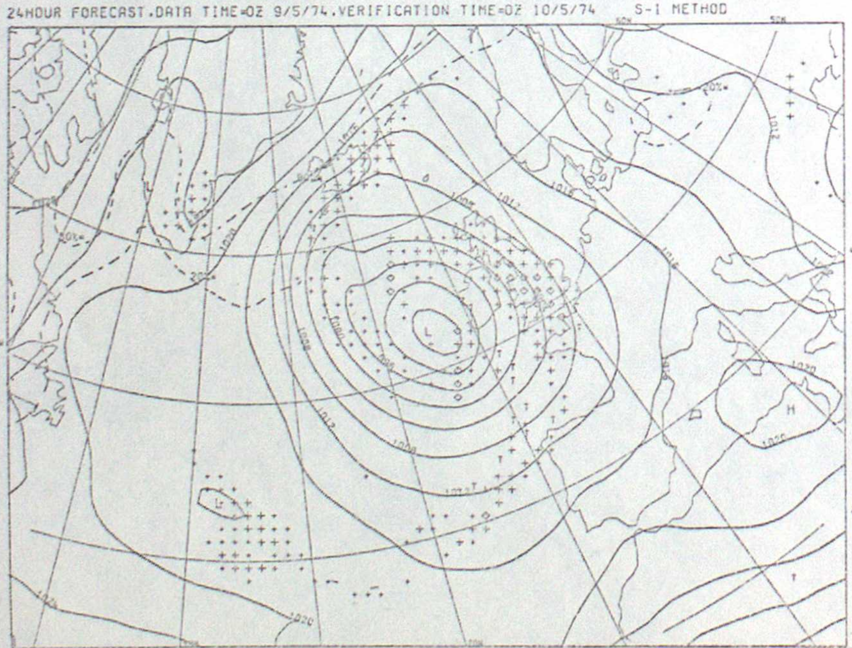


RAIN KEY: ◦ ◇ =TOTAL RATE >4.0.0.5 + . =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

EXPT 1

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=0Z 9/5/74.VERIFICATION TIME=0Z 10/5/74 S-I METHOD

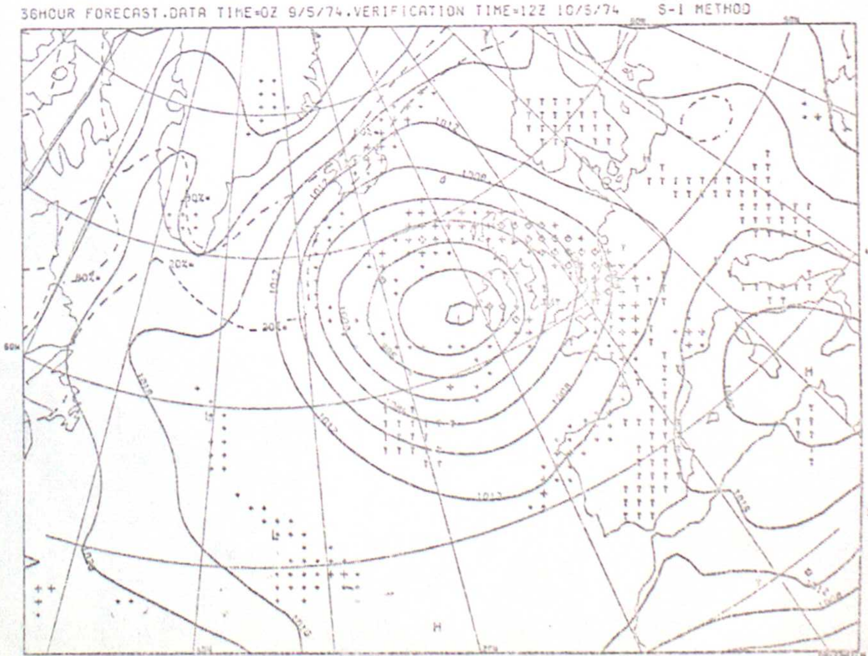


RAIN KEY: ◦ ◇ =TOTAL RATE >4.0.0.5 + . =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

EXPT 1

FORECAST SURFACE PRESSURE AND PRECIPITATION

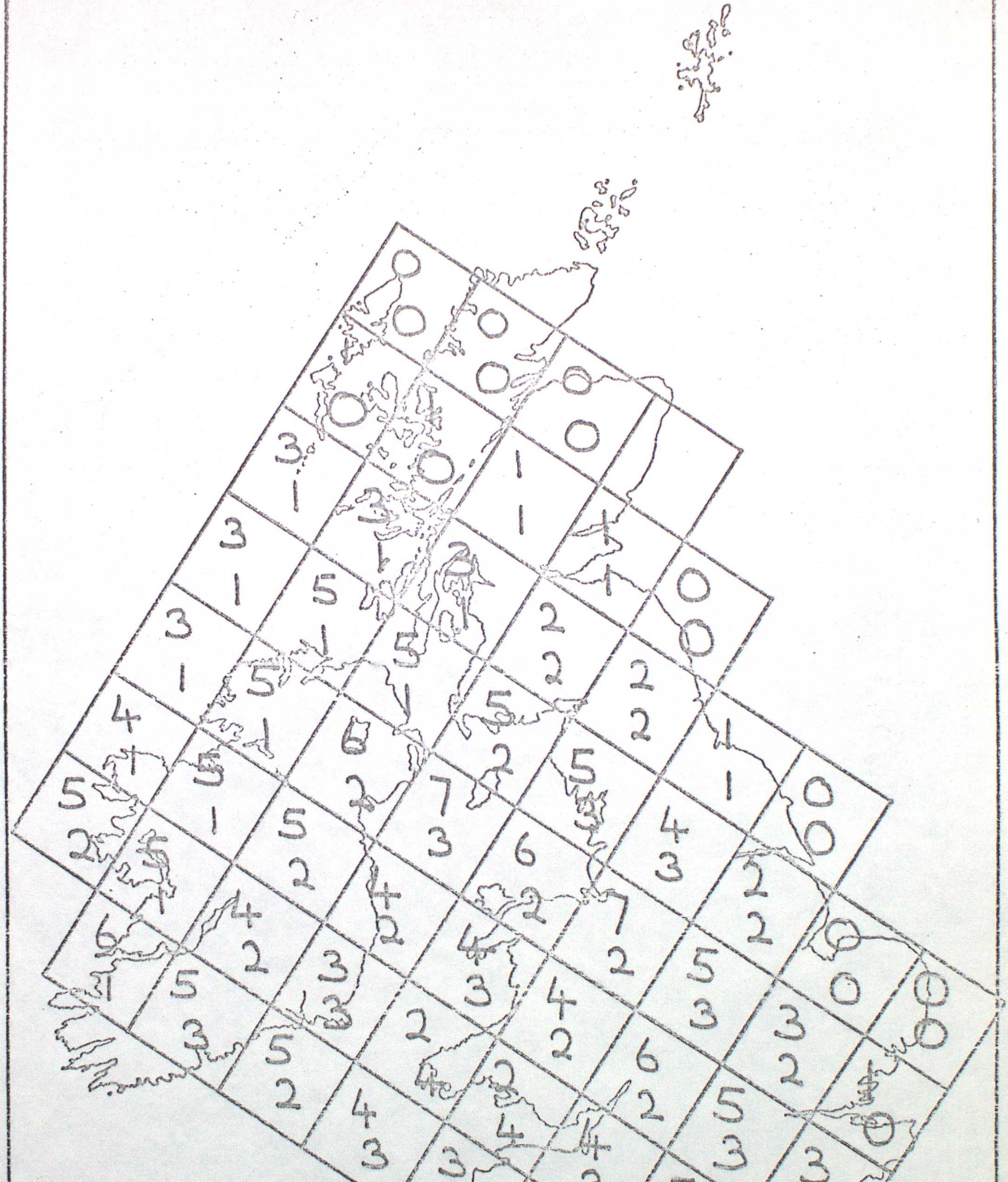
36HOUR FORECAST.DATA TIME=0Z 9/5/74.VERIFICATION TIME=12Z 10/5/74 S-I METHOD



RAIN KEY: ◦ ◇ =TOTAL RATE >4.0.0.5 + . =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

FIGURE V(c)

FORECAST ACCUMULATED RAIN (MM) T+12 TO T+24 BASED ON 00Z 9/5/74



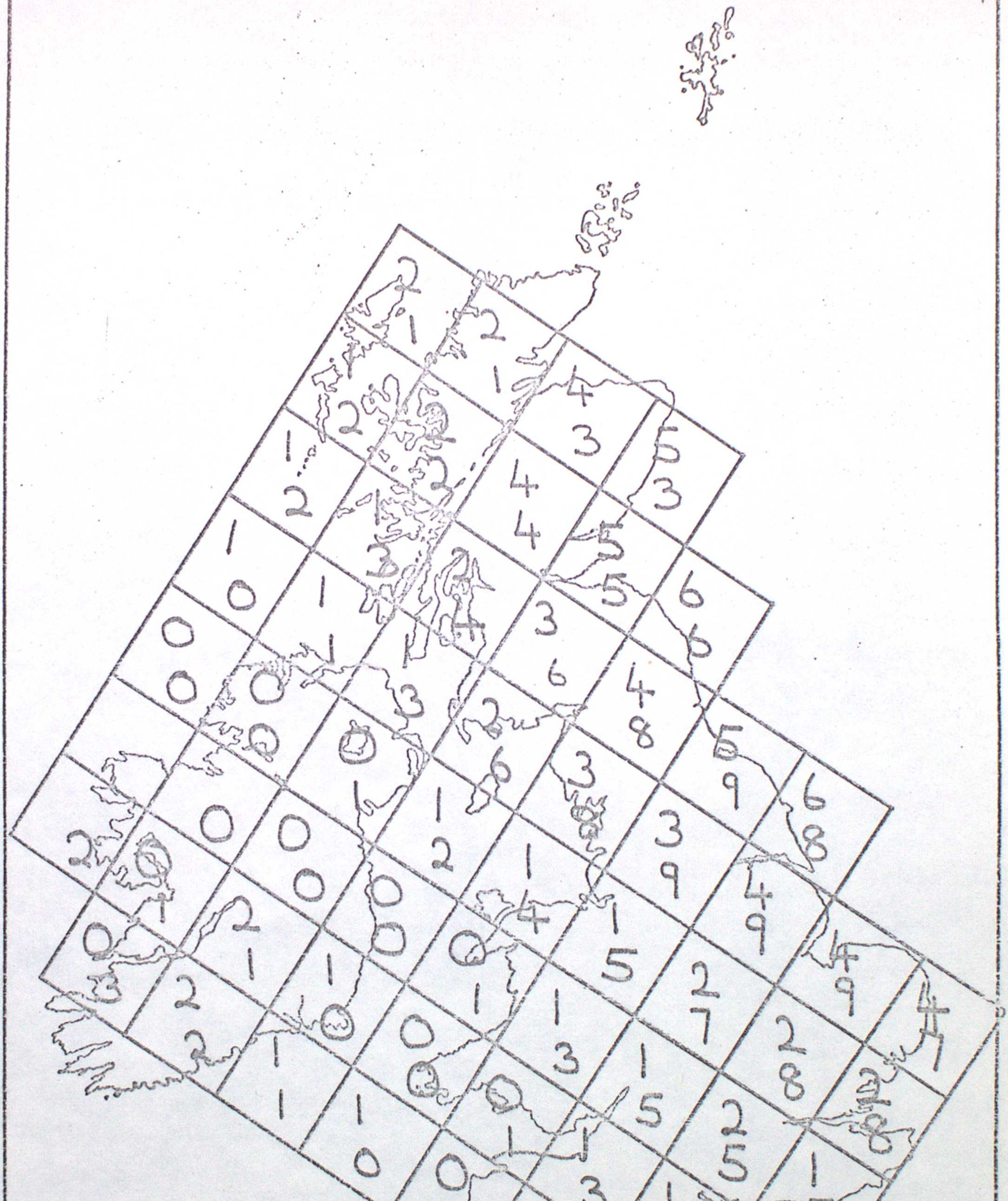
TOP FIGURE - OPERATIONAL

BOTTOM FIGURE - EXPT 1

0 - < 0.5 MM

BLANK - NO RAIN

FORECAST ACCUMULATED RAIN (MM) T+24 TO T+36 BASED ON 00Z 29/5/74



TOP FIGURE - OPERATIONAL

BOTTOM FIGURE - EXPT 1

0 - <0·5MM

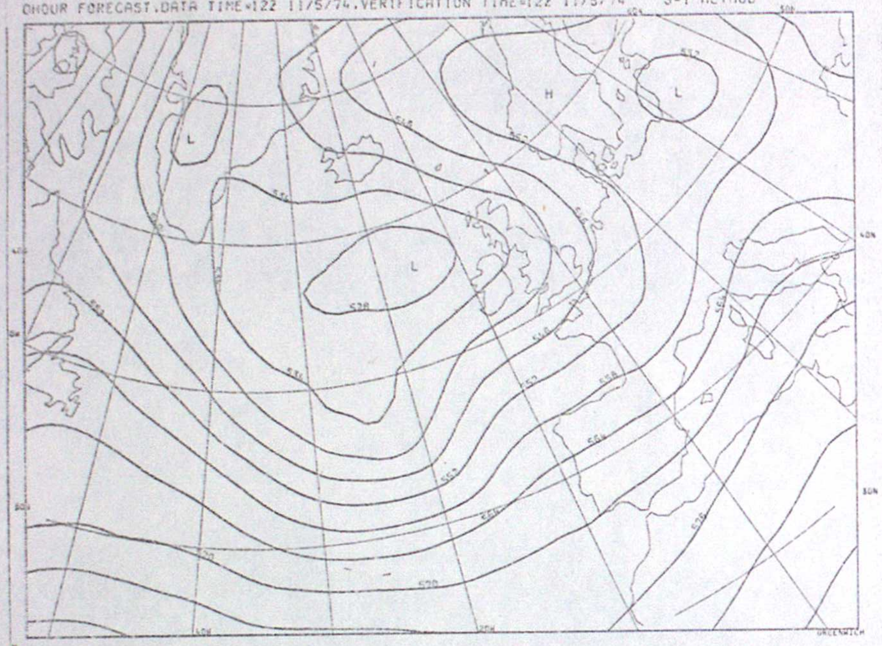
BLANK - NO RAIN

FIGURE VI (a) 500MB ANALYSIS 12Z 11/5/74

OPERATIONAL

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS

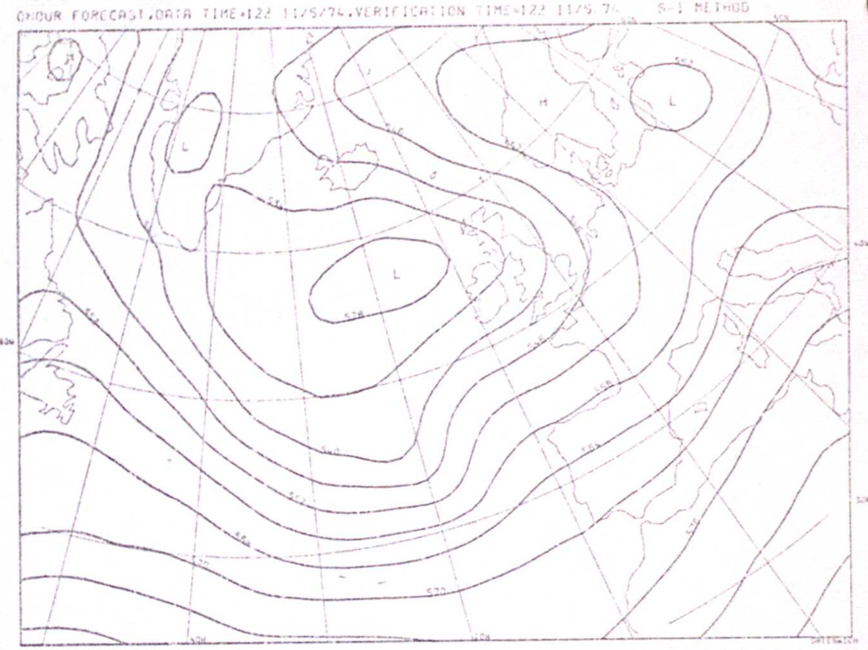
0HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 11/5/74. S-1 METHOD



OPERATIONAL RE-RUN

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS

0HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 11/5/74. S-1 METHOD



EXPT 1

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS

0HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 11/5/74. S-1 METHOD

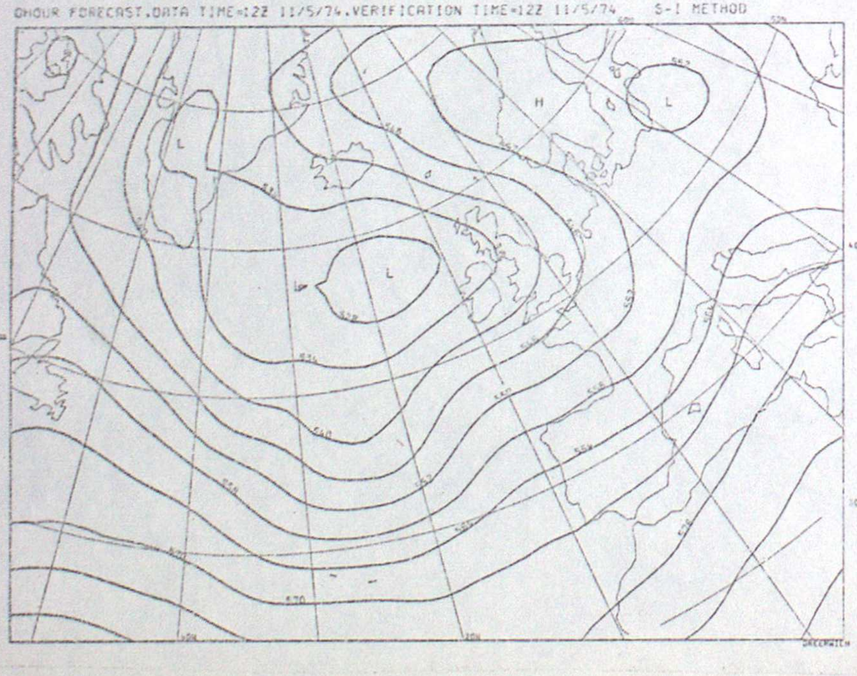
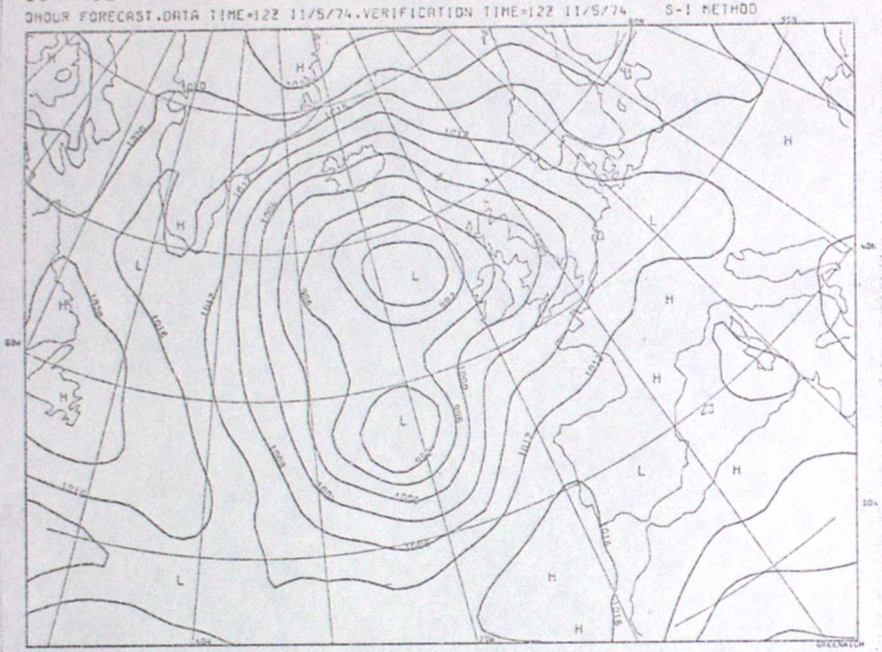


FIGURE VI (b) SURFACE PRESSURE ANALYSIS 12Z 11/5/74

OPERATIONAL

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

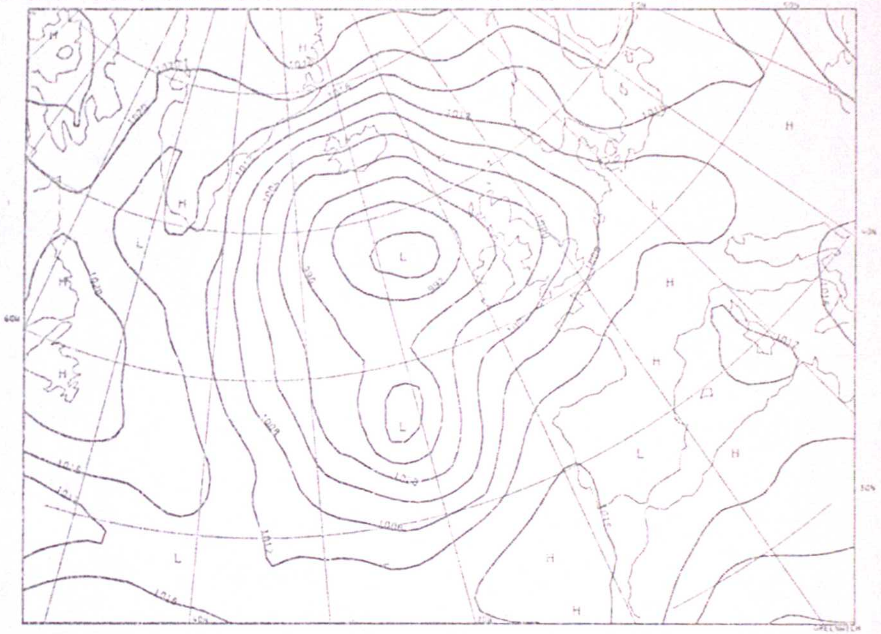
0HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 11/5/74 S-I METHOD



OPERATIONAL RE-RUN

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

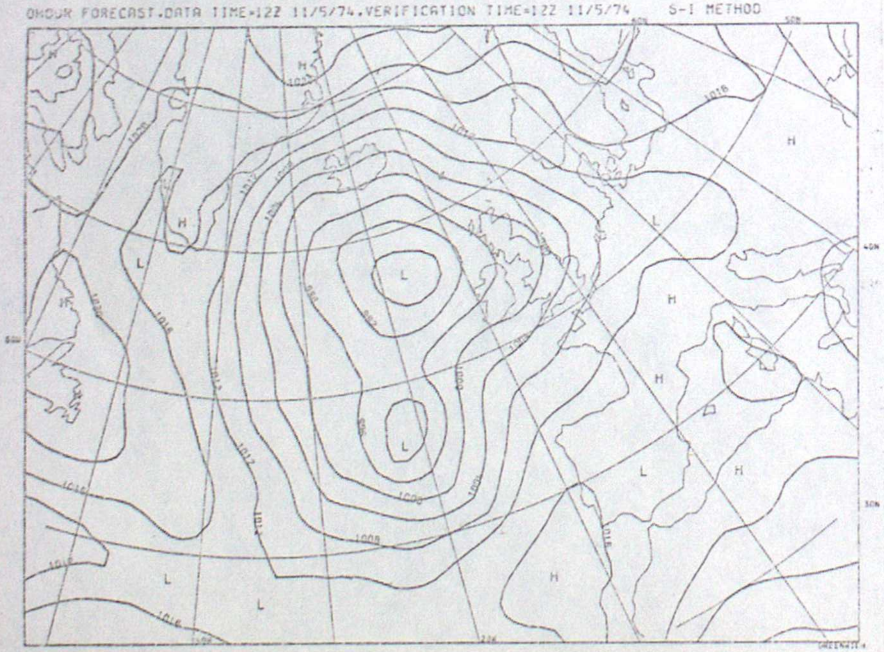
0HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 11/5/74 S-I METHOD



EXPT 1

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 11/5/74 S-I METHOD

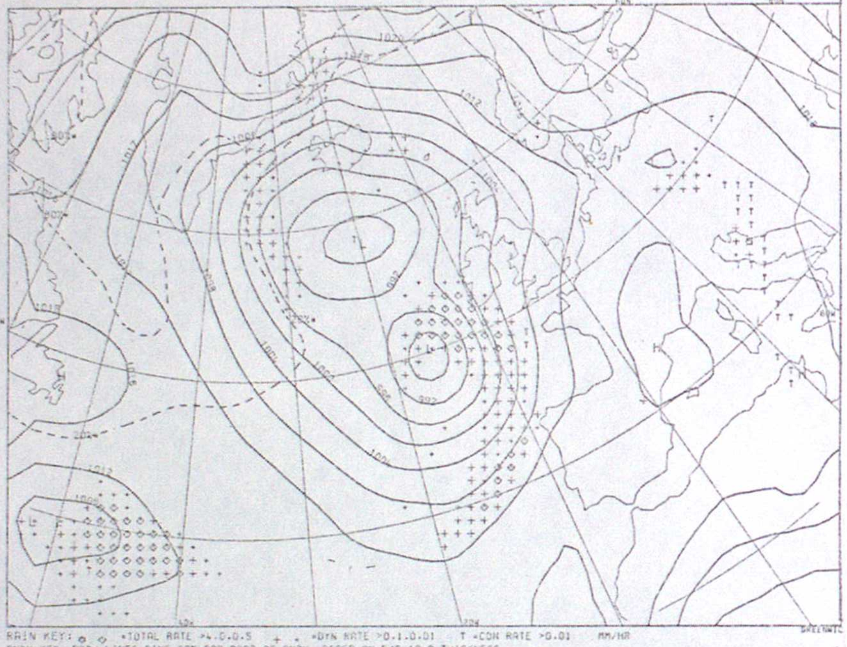


SURFACE PRESSURE AND PRECIPITATION 12-HOUR FORECAST BASED ON 12Z 11/5/74

FIGURE VI(c)

OPERATIONAL

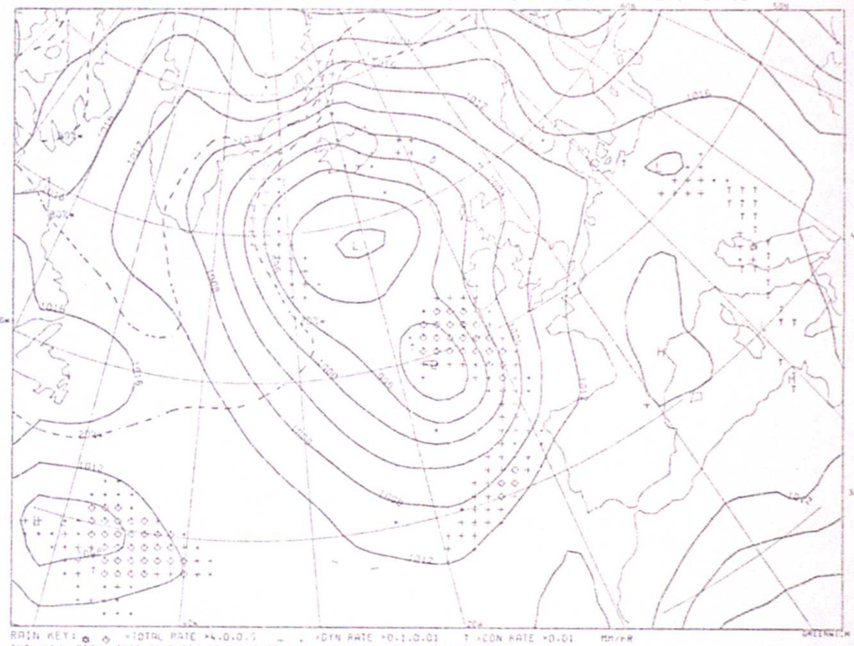
FORECAST SURFACE PRESSURE AND PRECIPITATION
12HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=0Z 12/5/74 S-1 METHOD



RAIN KEY: ○ ◇ +TOTAL RATE >4.0.0.5 + . +DYN RATE >0.1.0.01 T +CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

OPERATIONAL RE-RUN

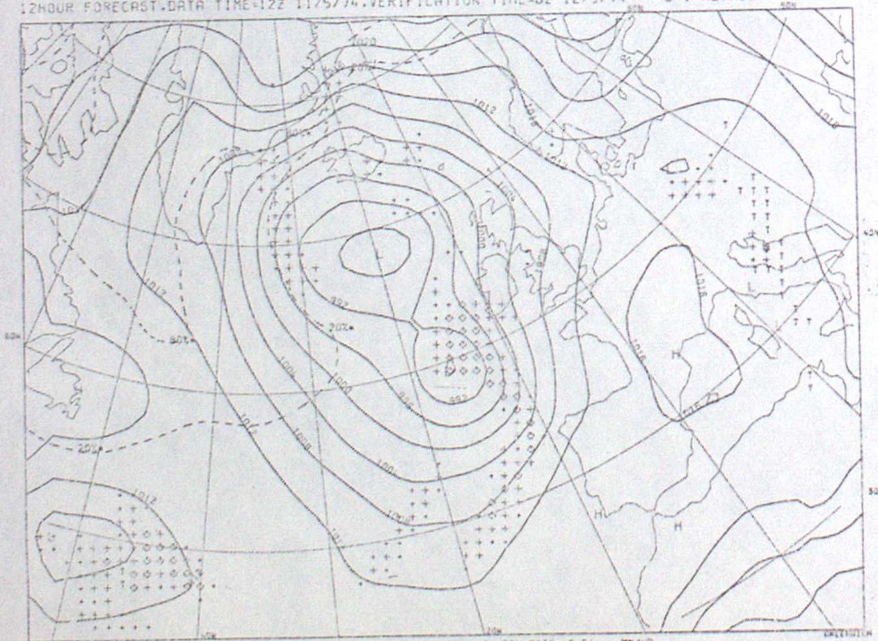
FORECAST SURFACE PRESSURE AND PRECIPITATION
12HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=0Z 12/5/74 S-1 METHOD



RAIN KEY: ○ ◇ +TOTAL RATE >4.0.0.5 + . +DYN RATE >0.1.0.01 T +CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

EXPT 1

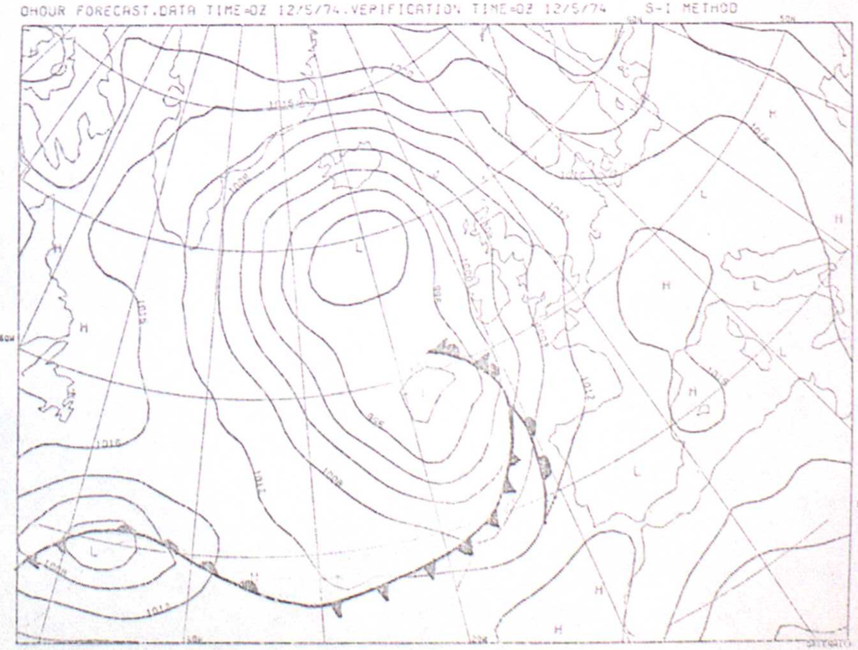
FORECAST SURFACE PRESSURE AND PRECIPITATION
12HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=0Z 12/5/74 S-1 METHOD



RAIN KEY: ○ ◇ +TOTAL RATE >4.0.0.5 + . +DYN RATE >0.1.0.01 T +CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

VERIFYING ANALYSIS (OPERATIONAL)

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS
0HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=0Z 12/5/74 S-1 METHOD



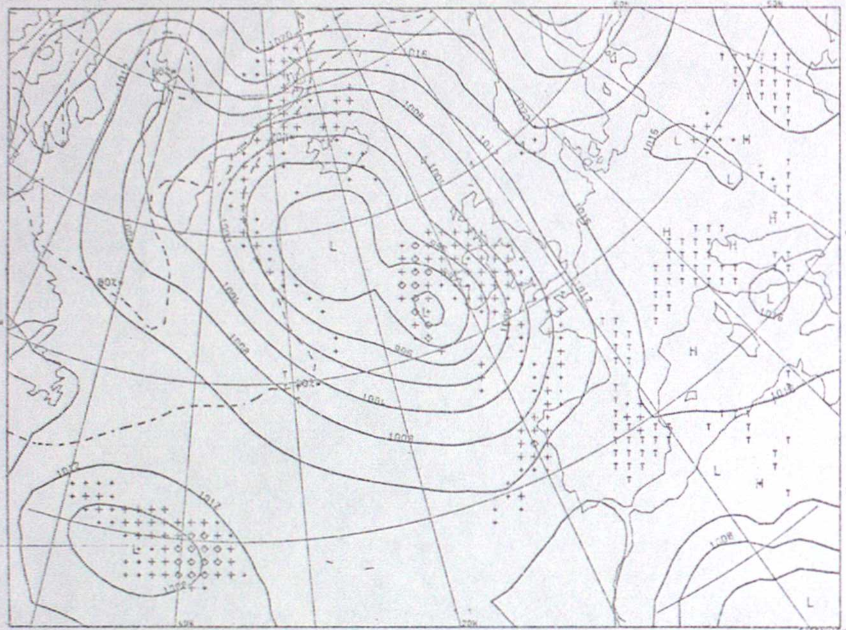
SURFACE PRESSURE AND PRECIPITATION 24-HOUR FORECAST BASED ON 12Z 11/5/74

FIGURE II (d)

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 12/5/74. S-I METHOD

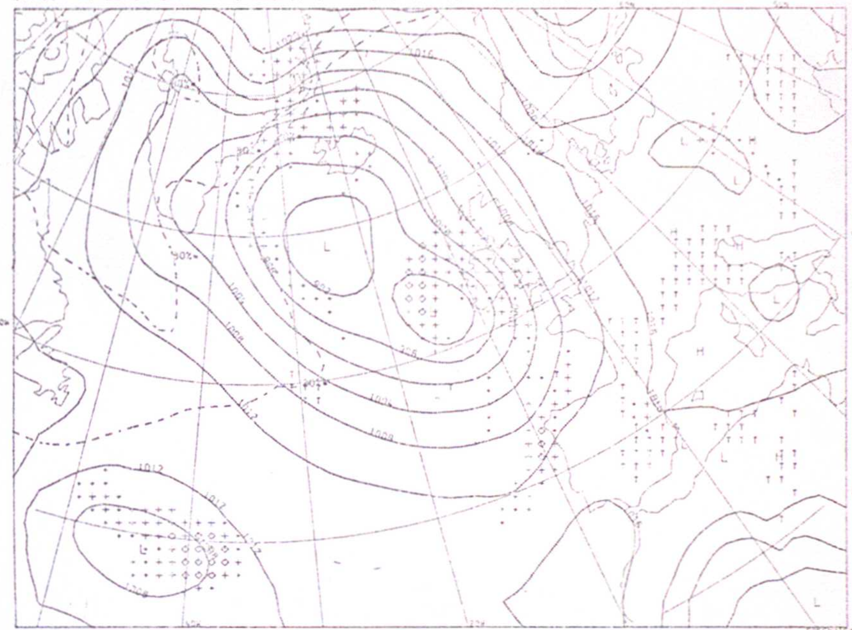


RAIN KEY: ◎ ◇ =TOTAL RATE >4.0,0.5 + . =DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-5 THICKNESS

OPERATIONAL RE-RUN

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 12/5/74. S-I METHOD

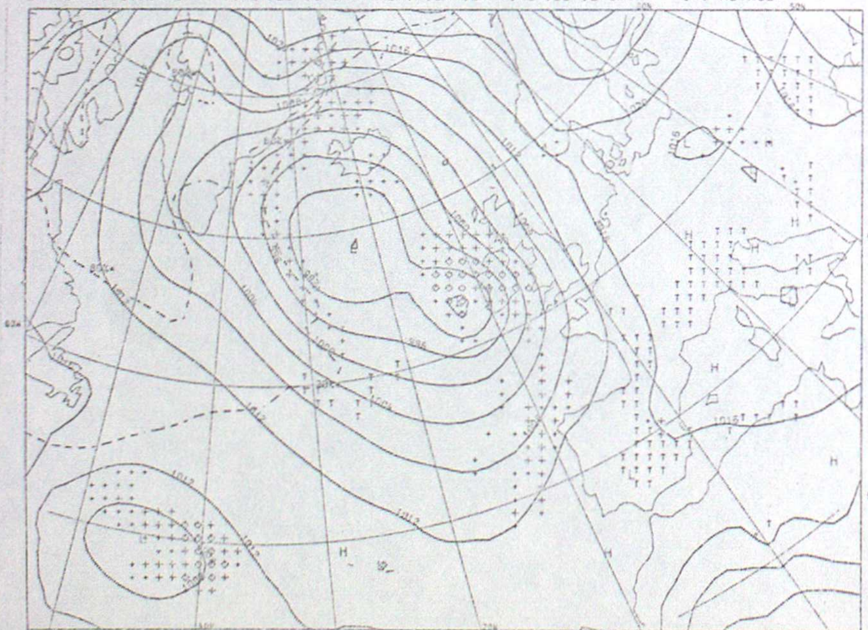


RAIN KEY: ◎ ◇ =TOTAL RATE >4.0,0.5 + . =DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-5 THICKNESS

EXPT I

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=12Z 12/5/74. S-I METHOD

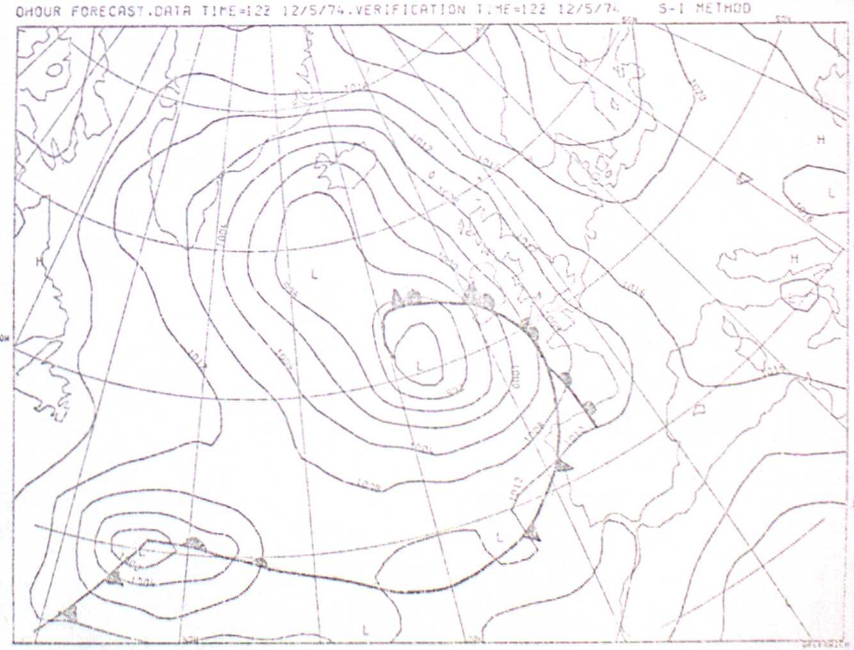


RAIN KEY: ◎ ◇ =TOTAL RATE >4.0,0.5 + . =DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-5 THICKNESS

VERIFYING ANALYSIS (OPERATIONAL)

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0HOUR FORECAST.DATA TIME=12Z 12/5/74.VERIFICATION TIME=12Z 12/5/74. S-I METHOD



(24)

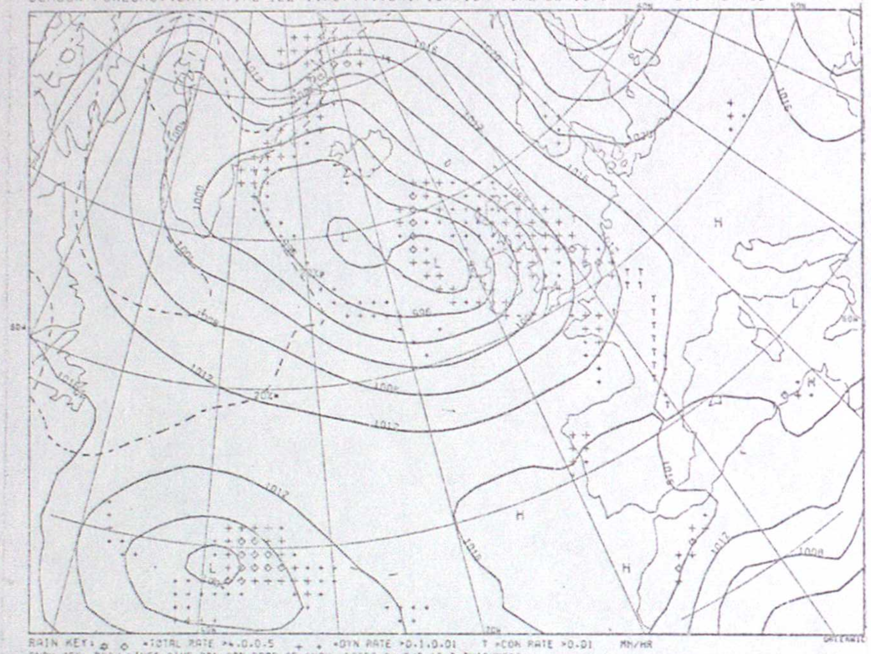
SURFACE PRESSURE AND PRECIPITATION 36-HOUR FORECAST BASED ON 12Z 11/5/74

FIGURE VI(e)

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=0Z 13/5/74 S-I METHOD

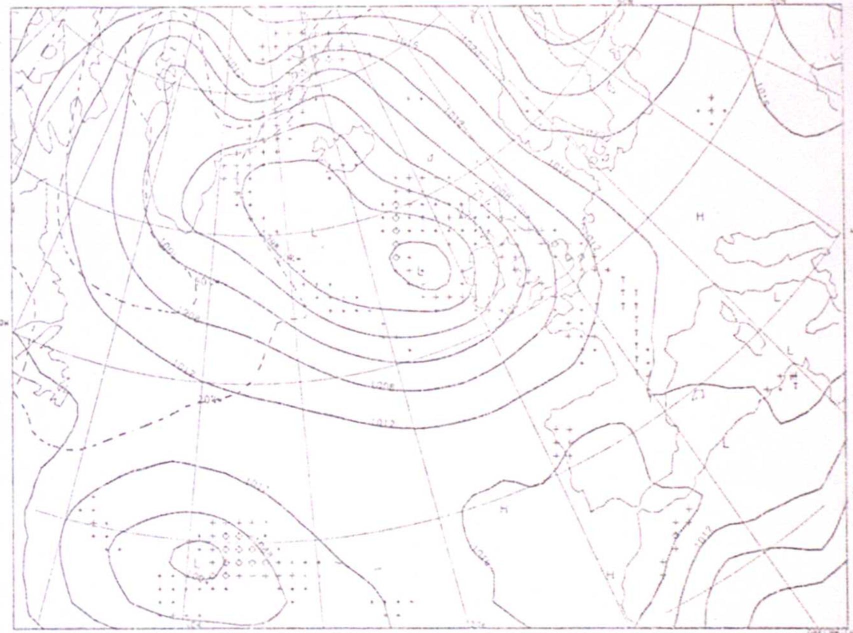


RAIN KEY: TOTAL RATE >.0.0.5 DYN RATE >0.1.0.01 T >CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

OPERATIONAL RE-RUN

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=0Z 13/5/74 S-I METHOD

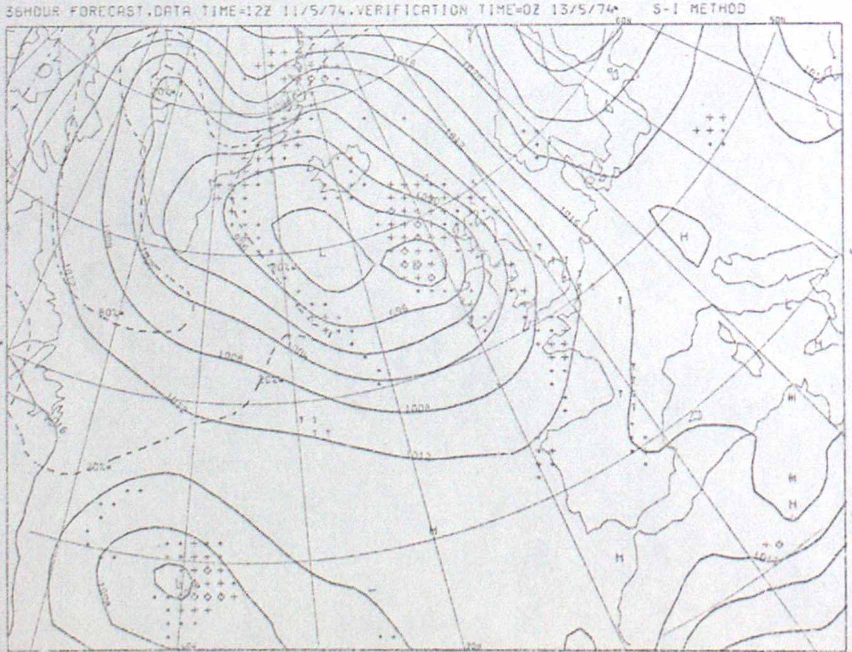


RAIN KEY: TOTAL RATE >.0.0.5 DYN RATE >0.1.0.01 T >CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

EXPT 1

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=12Z 11/5/74.VERIFICATION TIME=0Z 13/5/74 S-I METHOD

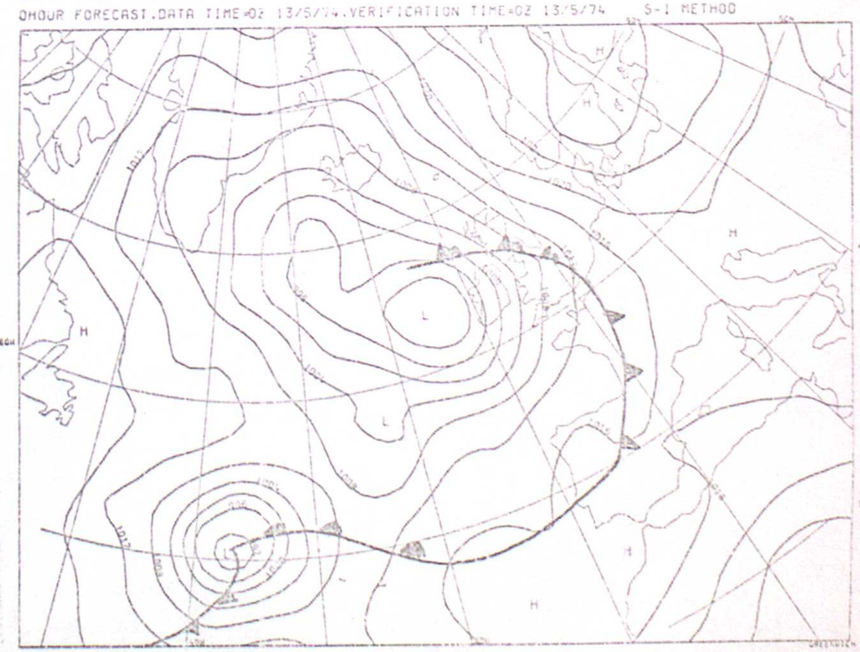


RAIN KEY: TOTAL RATE >.0.0.5 DYN RATE >0.1.0.01 T >CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

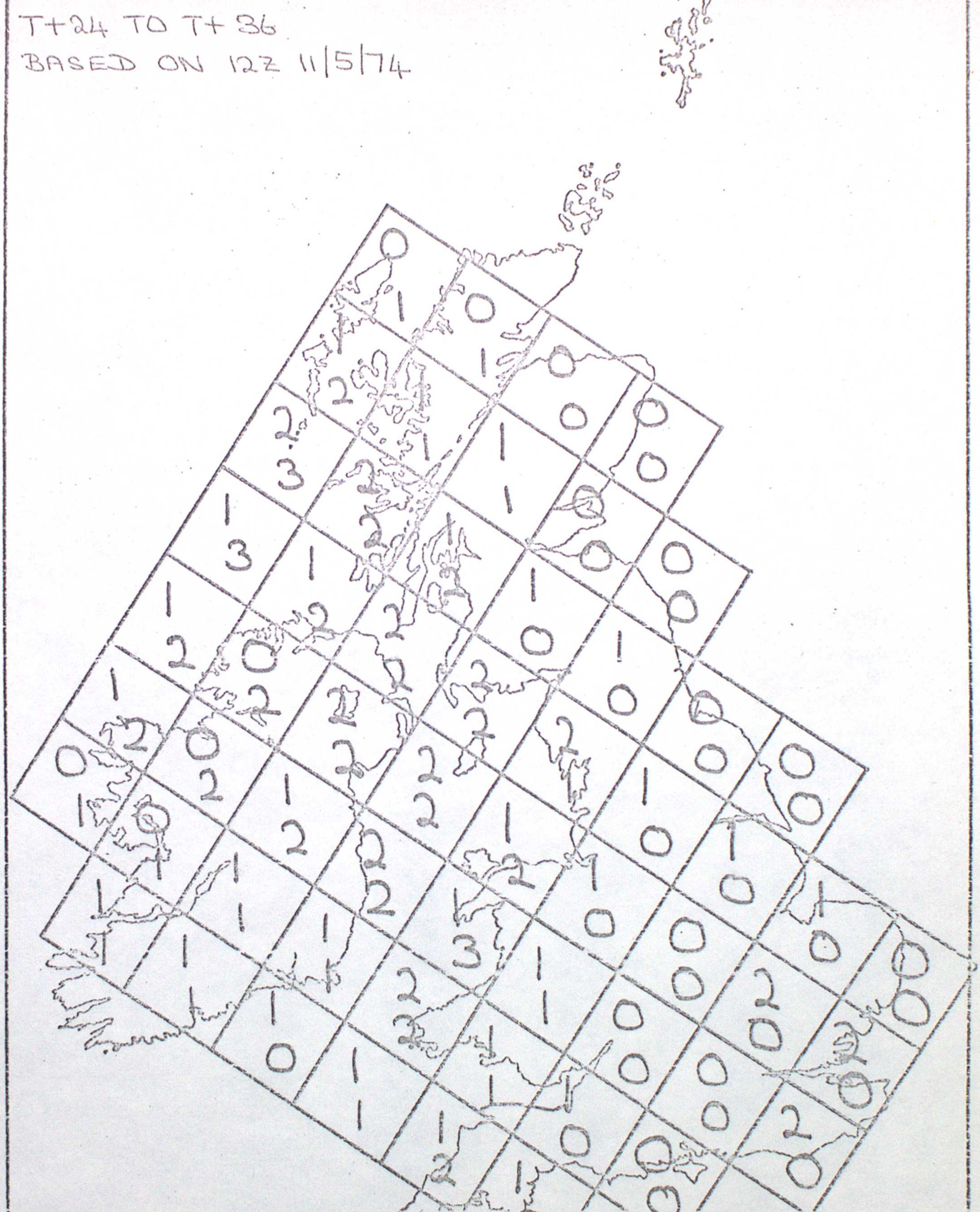
VERIFYING ANALYSIS (OPERATIONAL)

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0HOUR FORECAST.DATA TIME=0Z 13/5/74.VERIFICATION TIME=0Z 13/5/74 S-I METHOD



FORECAST ACCUMULATED RAIN (MM)
T+24 TO T+36
BASED ON 12Z 11/5/74



TOP FIGURE - RE-RUN OPERATIONAL

BOTTOM FIGURE - EXPT 1

0 - < 0.5MM

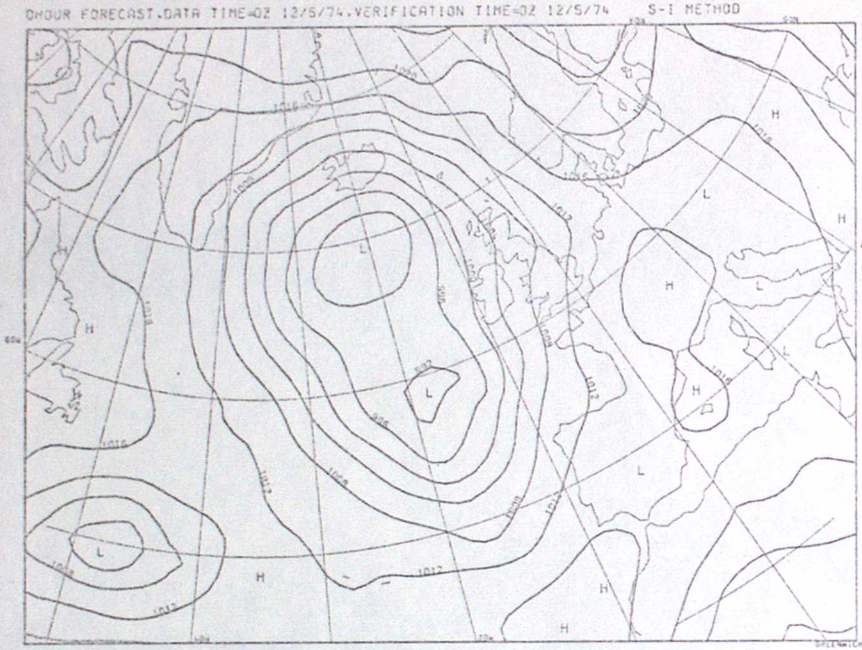
BLANK - NO RAIN

FIGURE VII(a) SURFACE PRESSURE AND 500MB ANALYSIS 00Z 12/5/74

OPERATIONAL

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

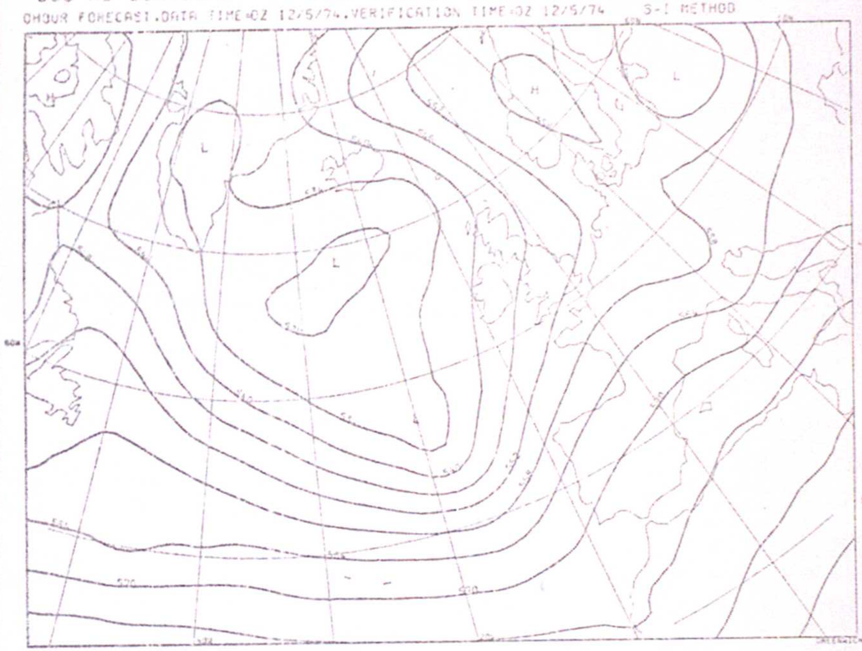
0HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=0Z 12/5/74 S-I METHOD



OPERATIONAL

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS

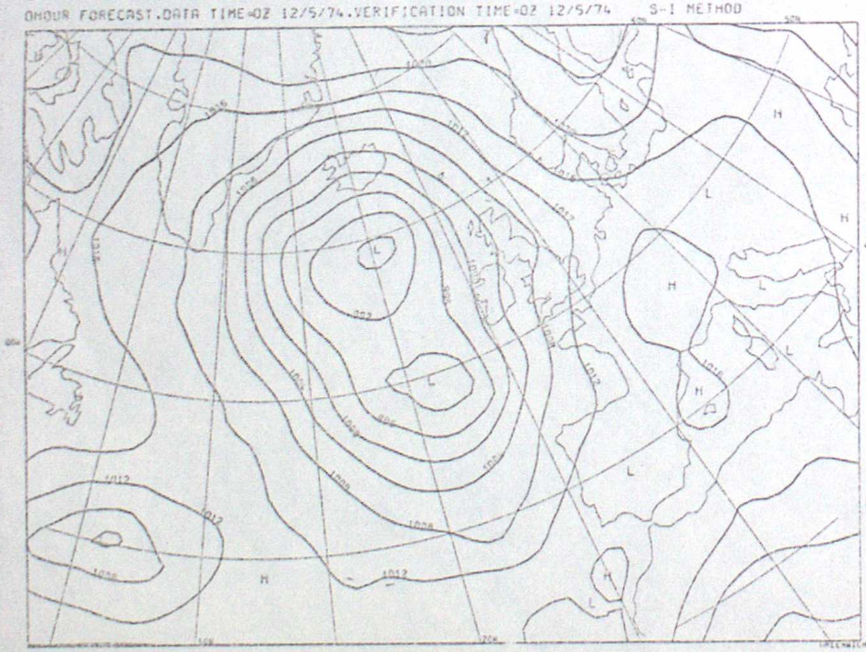
0HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=0Z 12/5/74 S-I METHOD



EXPT 1

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=0Z 12/5/74 S-I METHOD



EXPT 1

500 MB CONTOURS ISOPLETH INTERVAL=6 DECAMETERS

0HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=0Z 12/5/74 S-I METHOD

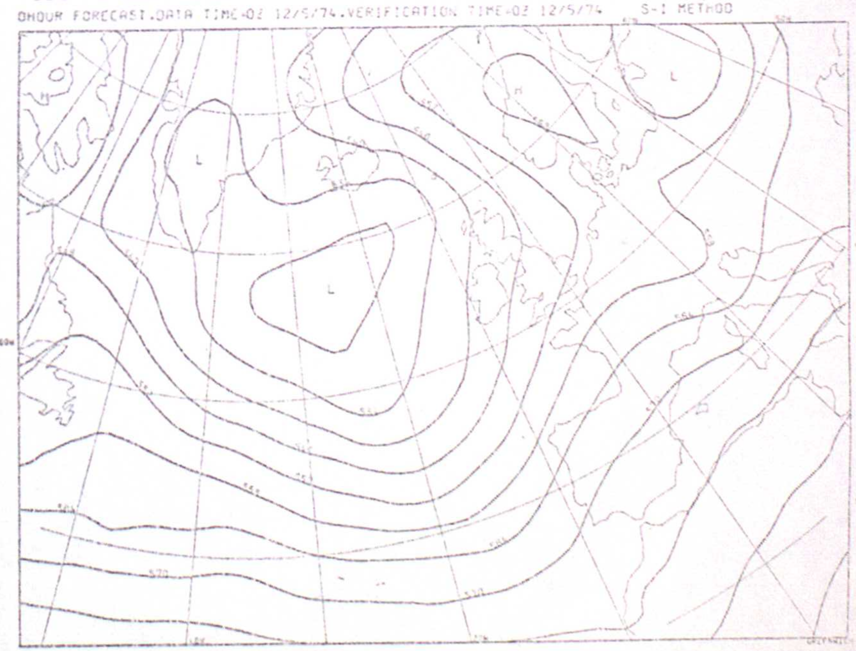
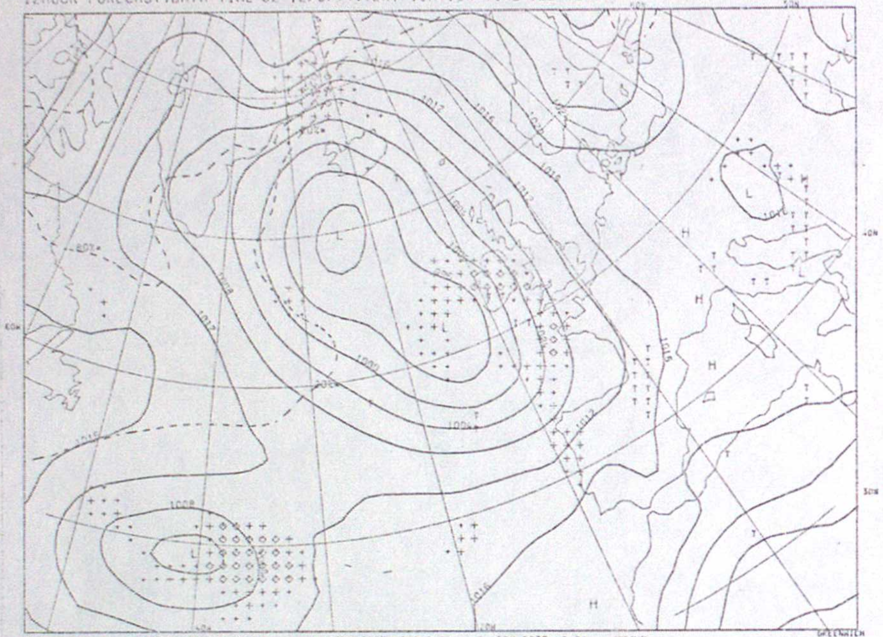


FIGURE VII(6) SURFACE PRESSURE AND PRECIPITATION 12-HOUR FORECAST BASED ON 00Z 12/5/74

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

12HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=12Z 12/5/74.   S-I METHOD

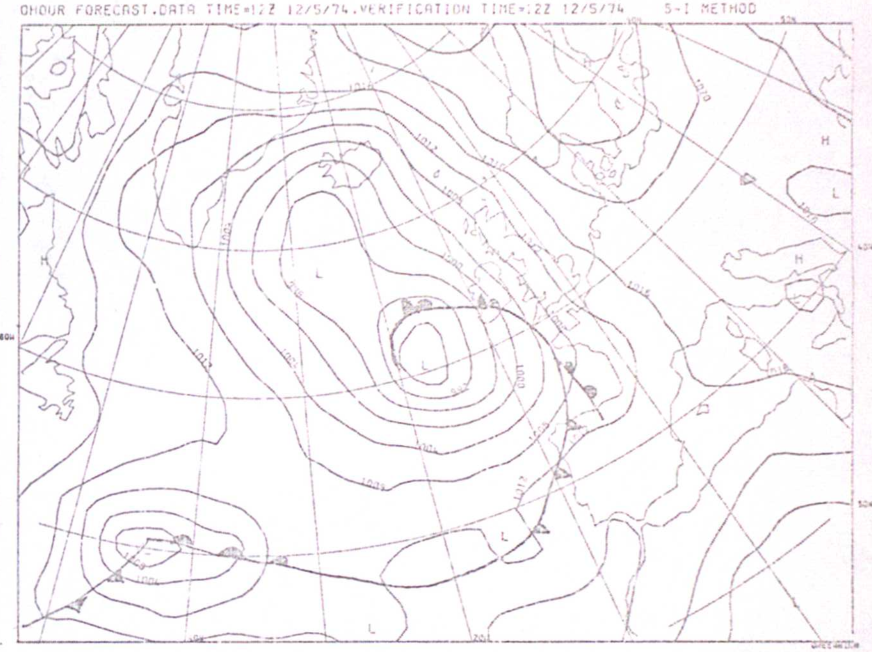


RAIN KEY: TOTAL RATE >4.0,0.5   DYN RATE >0.1,0.01   T =CON RATE >0.01   MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

VERIFYING ANALYSIS (OPERATIONAL)

SURFACE PRESSURE   ISOBARS AT 4MB INTERVALS

0HOUR FORECAST.DATA TIME=12Z 12/5/74.VERIFICATION TIME=12Z 12/5/74.   S-I METHOD

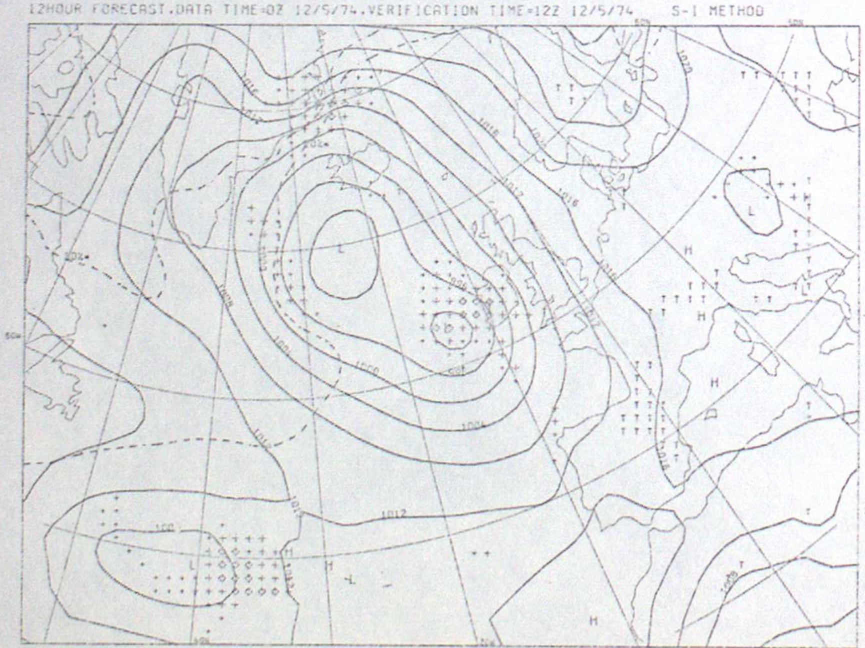


(28)

EXPT 1

FORECAST SURFACE PRESSURE AND PRECIPITATION

12HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=12Z 12/5/74.   S-I METHOD



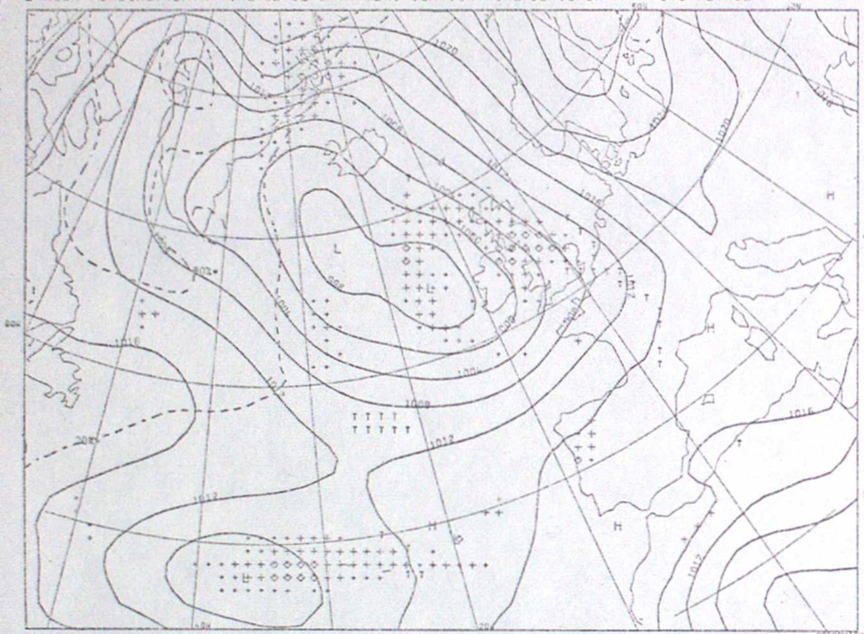
RAIN KEY: TOTAL RATE >4.0,0.5   DYN RATE >0.1,0.01   T =CON RATE >0.01   MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

URE VII (c) SURFACE PRESSURE AND PRECIPITATION 24-HOUR FORECAST BASED ON 00Z 12/5/74

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=0Z 13/5/74 S-1 METHOD

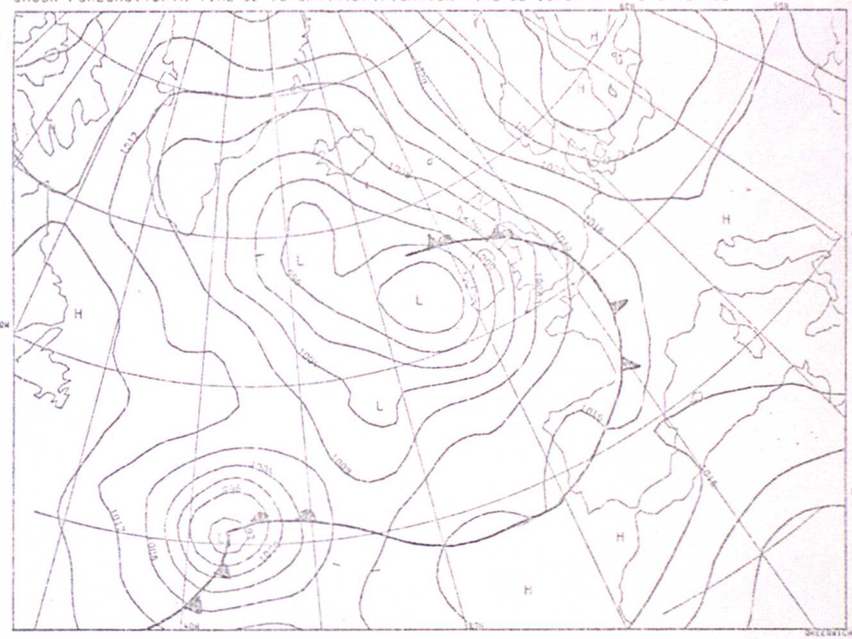


RAIN KEY: TOTAL RATE >4.0,0.5 DYN RATE >0.1,0.01 T CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

VERIFYING ANALYSIS (OPERATIONAL)

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

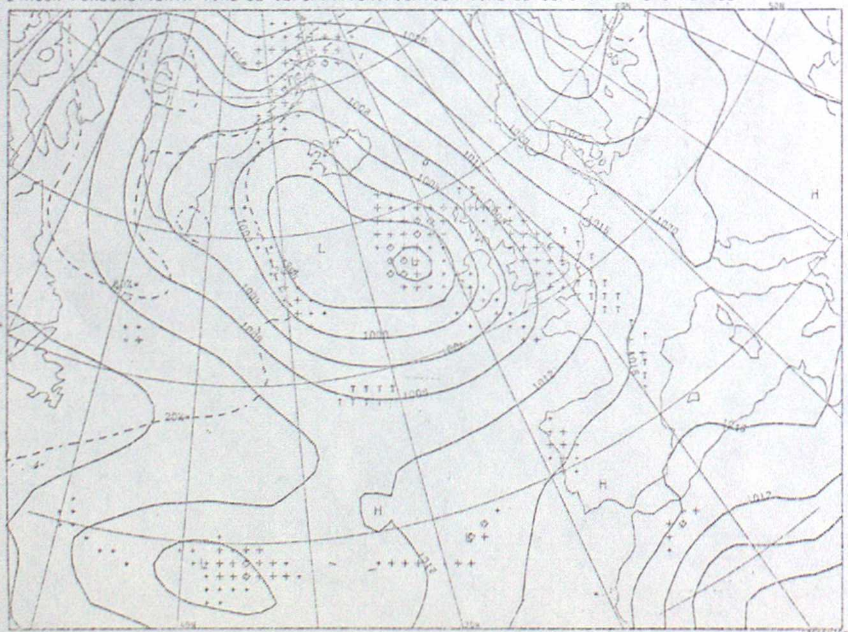
0HOUR FORECAST.DATA TIME=0Z 13/5/74.VERIFICATION TIME=0Z 13/5/74 S-1 METHOD



EXPT 1

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=0Z 13/5/74 S-1 METHOD



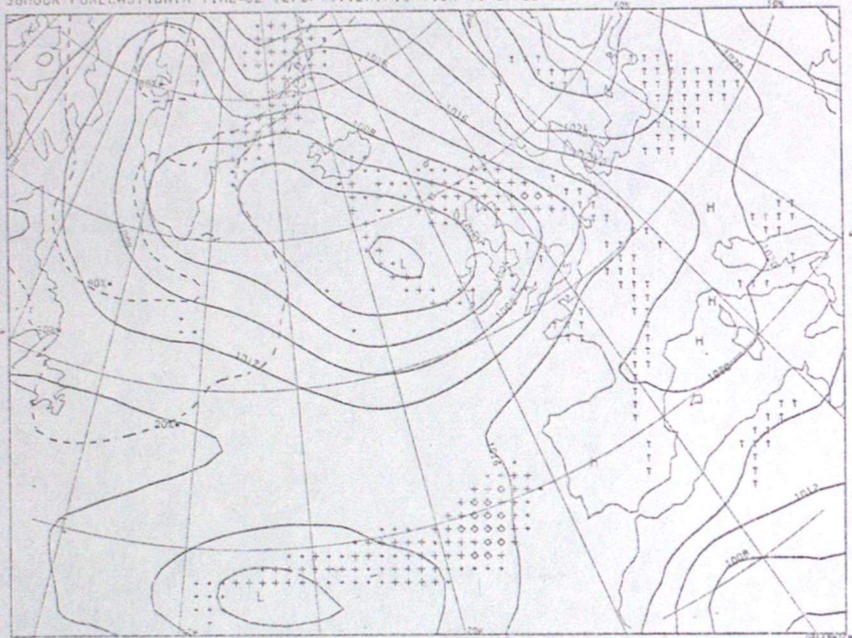
RAIN KEY: TOTAL RATE >4.0,0.5 DYN RATE >0.1,0.01 T CON RATE >0.01 MM/HR
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

FIGURE VII (d) SURFACE PRESSURE AND PRECIPITATION 36-HOUR FORECAST BASED ON 00Z 12/5/74

OPERATIONAL

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=12Z 13/5/74 S-I METHOD



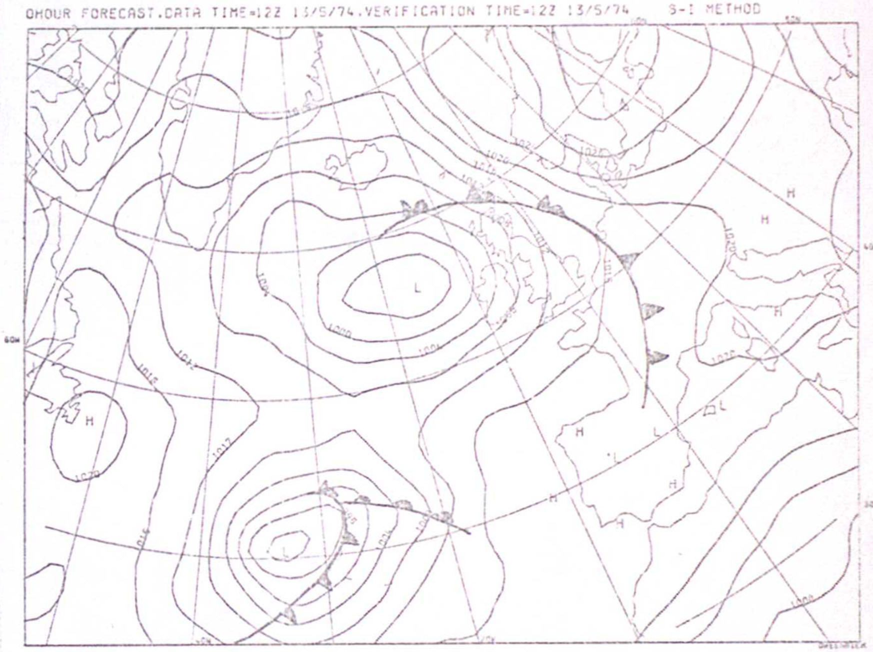
RAIN KEY: TOTAL RATE >4.0,0.5 DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR

SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

VERIFYING ANALYSIS (OPERATIONAL)

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

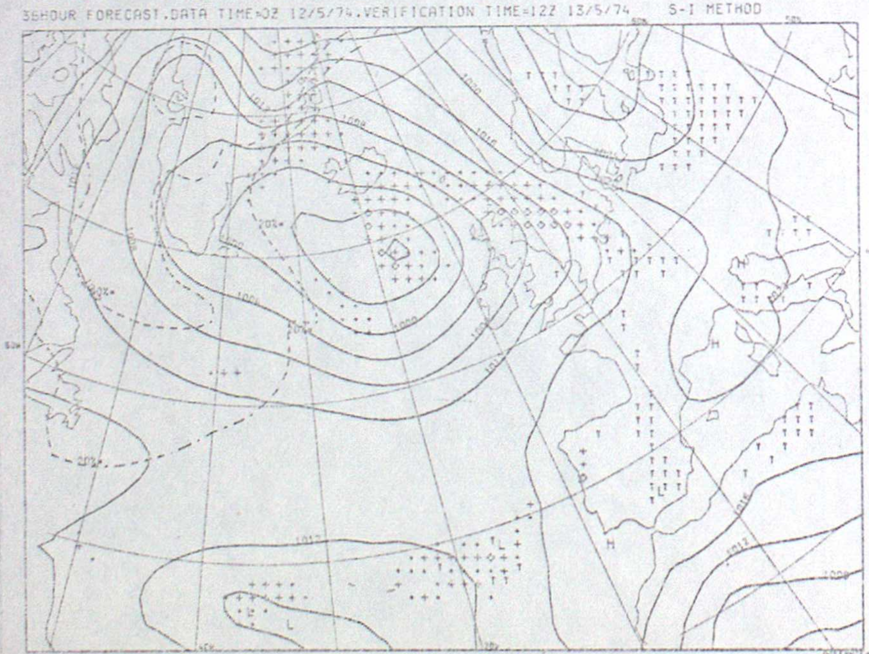
0HOUR FORECAST.DATA TIME=12Z 13/5/74.VERIFICATION TIME=12Z 13/5/74 S-I METHOD



EXPT 1

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=0Z 12/5/74.VERIFICATION TIME=12Z 13/5/74 S-I METHOD



RAIN KEY: TOTAL RATE >4.0,0.5 DYN RATE >0.1,0.01 T =CON RATE >0.01 MM/HR

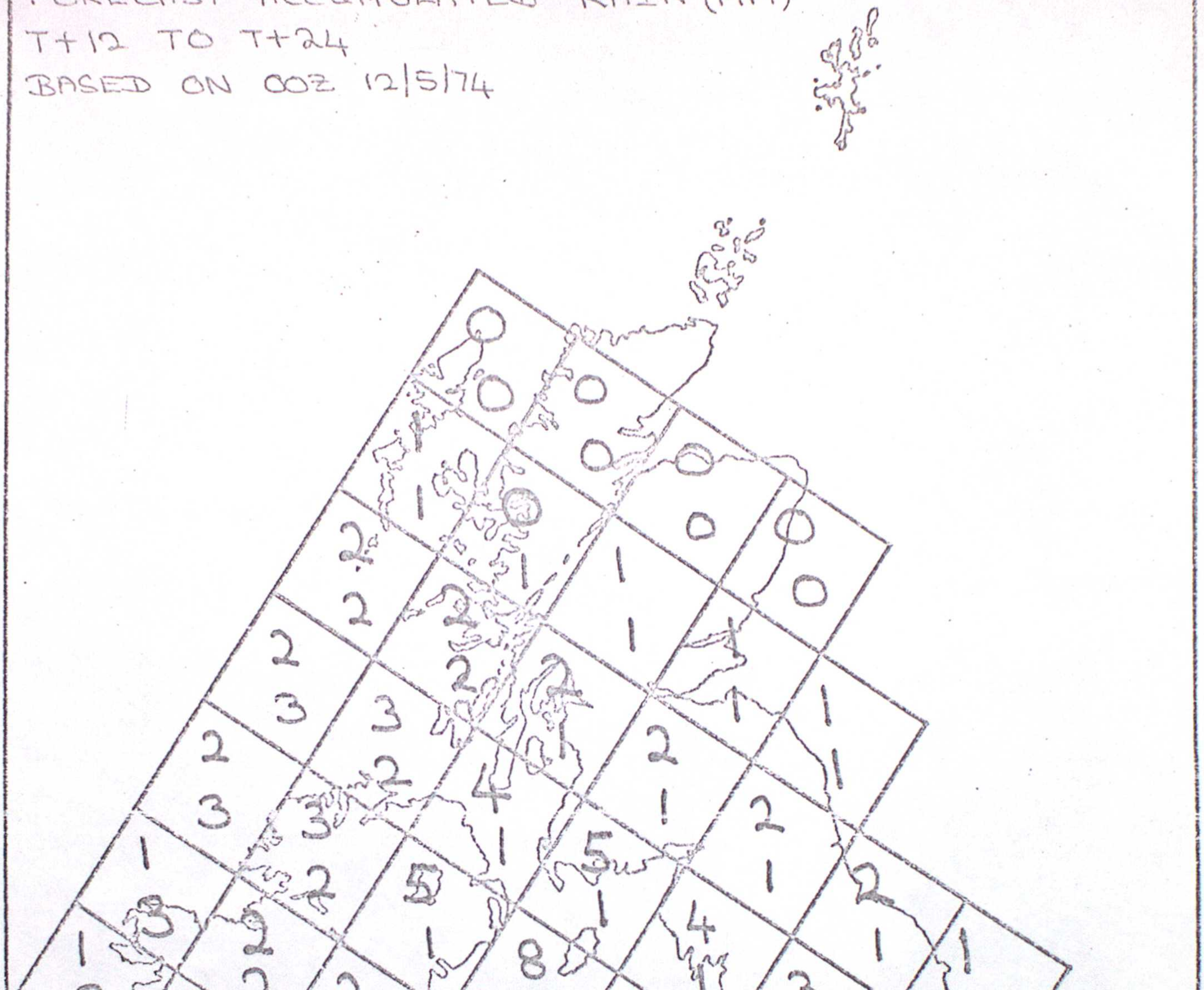
SNOW KEY: DASH LINES GIVE 20%,80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

(30)

FORECAST ACCUMULATED RAIN (MM)

T+12 TO T+24

BASED ON 00Z 12/5/74



TOP FIGURE - OPERATIONAL

BOTTOM FIGURE - EXPT 1

0 - < 0.5MM

BLANK - NO RAIN

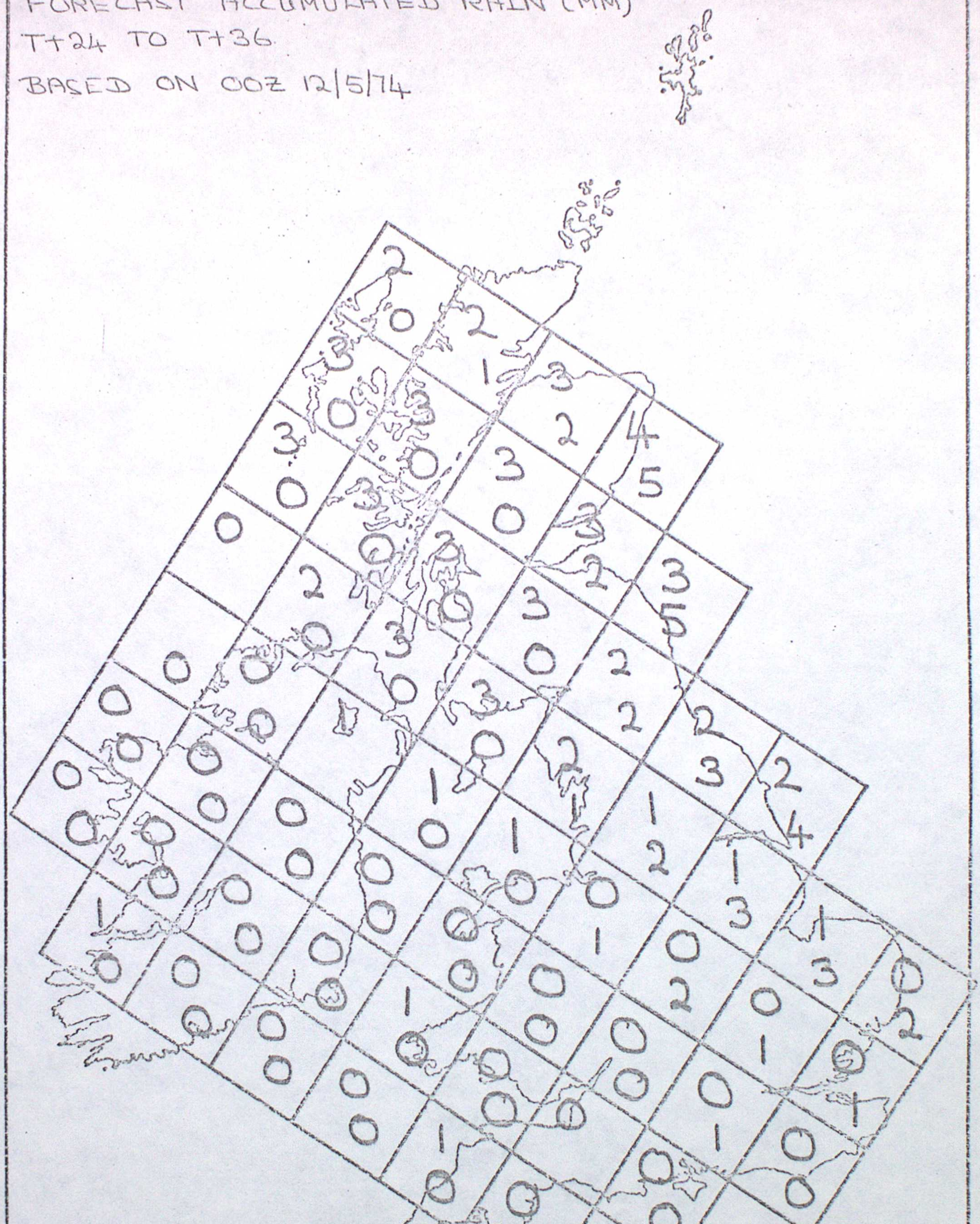
FIGURE VII (f)

(32)

FORECAST ACCUMULATED RAIN (MM)

T+24 TO T+36

BASED ON 00Z 12/5/74



TOP FIGURE - OPERATIONAL

BOTTOM FIGURE - EXPT 1

0 - <0.5MM

BLANK - NO RAIN

FIGURE IX (a)

RMS HEIGHT DIFFERENCES FOR FORECASTS V UPDATE ANALYSES FOR INCREASING FORECAST PERIODS SMALL AREA (REG 2) 560 GRIDPOINTS

MAY 1974

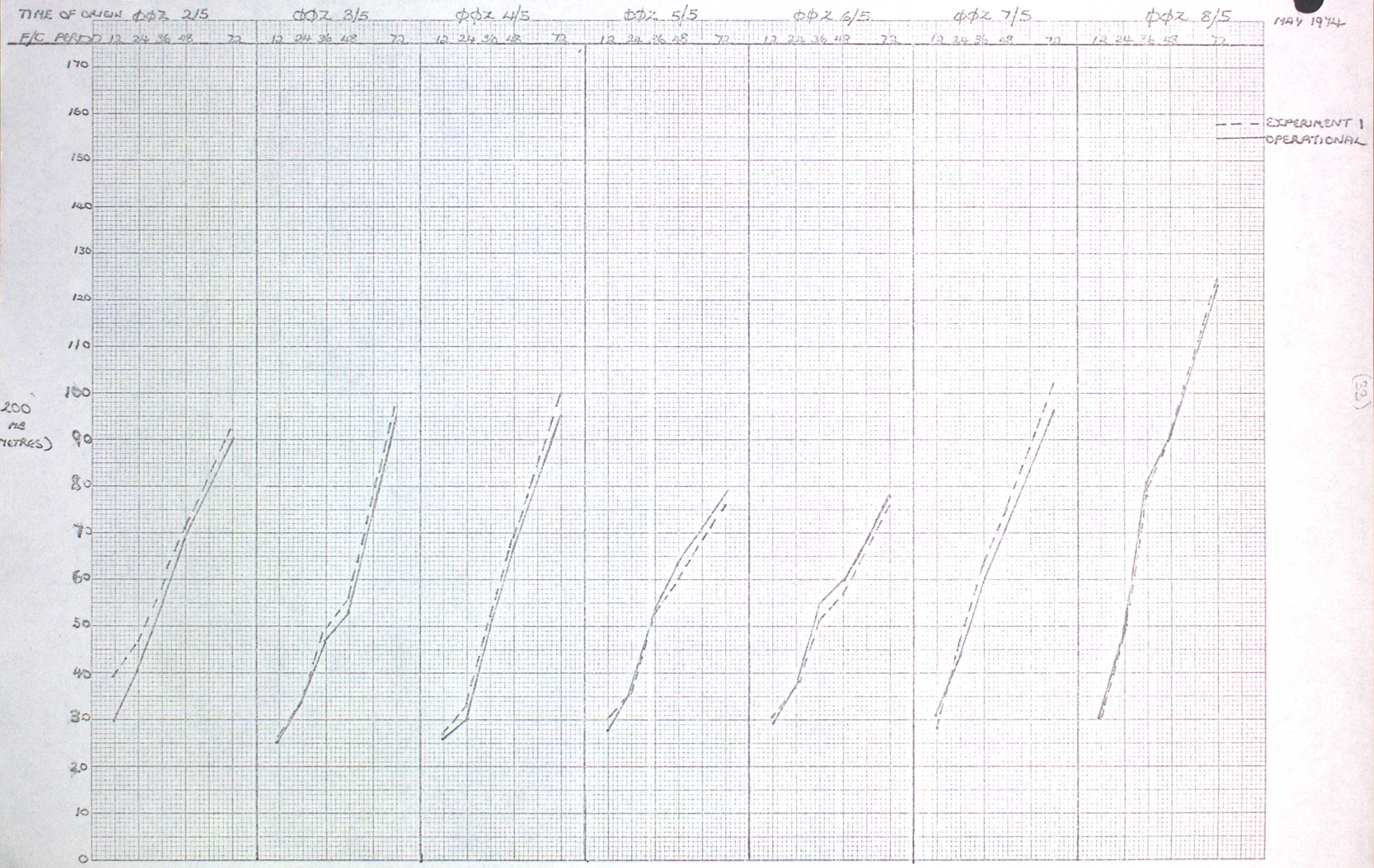


FIGURE IX (a)

SHEET 2.

Chartwell Graph Data Ref. 5501 mm, ½ and 1 cm

RMS HT DIFFERENCES F/C v UPDATE ANALYSES FOR INCREASING F/C PERIODS SMALL AREA (REG 2) 560 GRID POINTS 1974

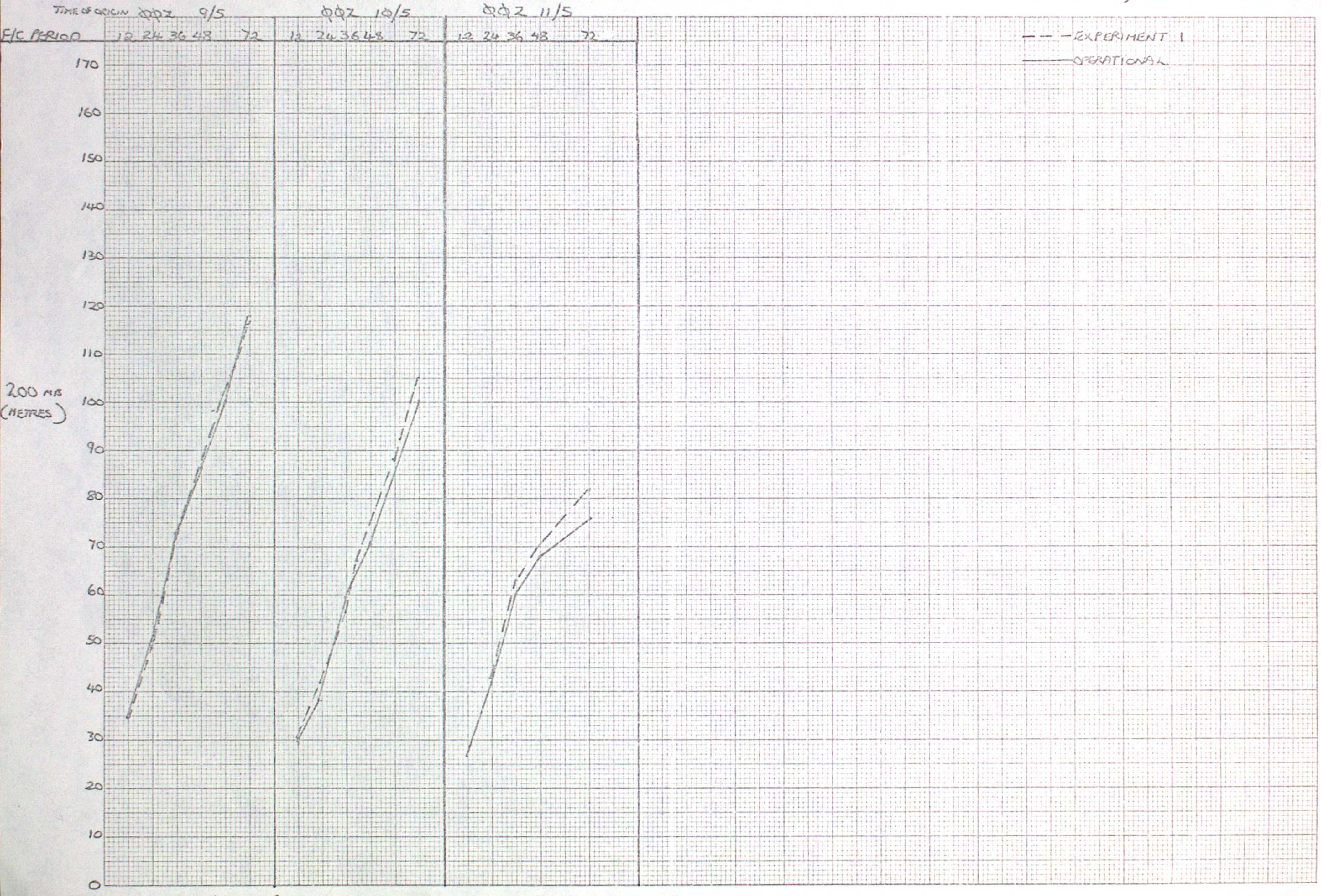
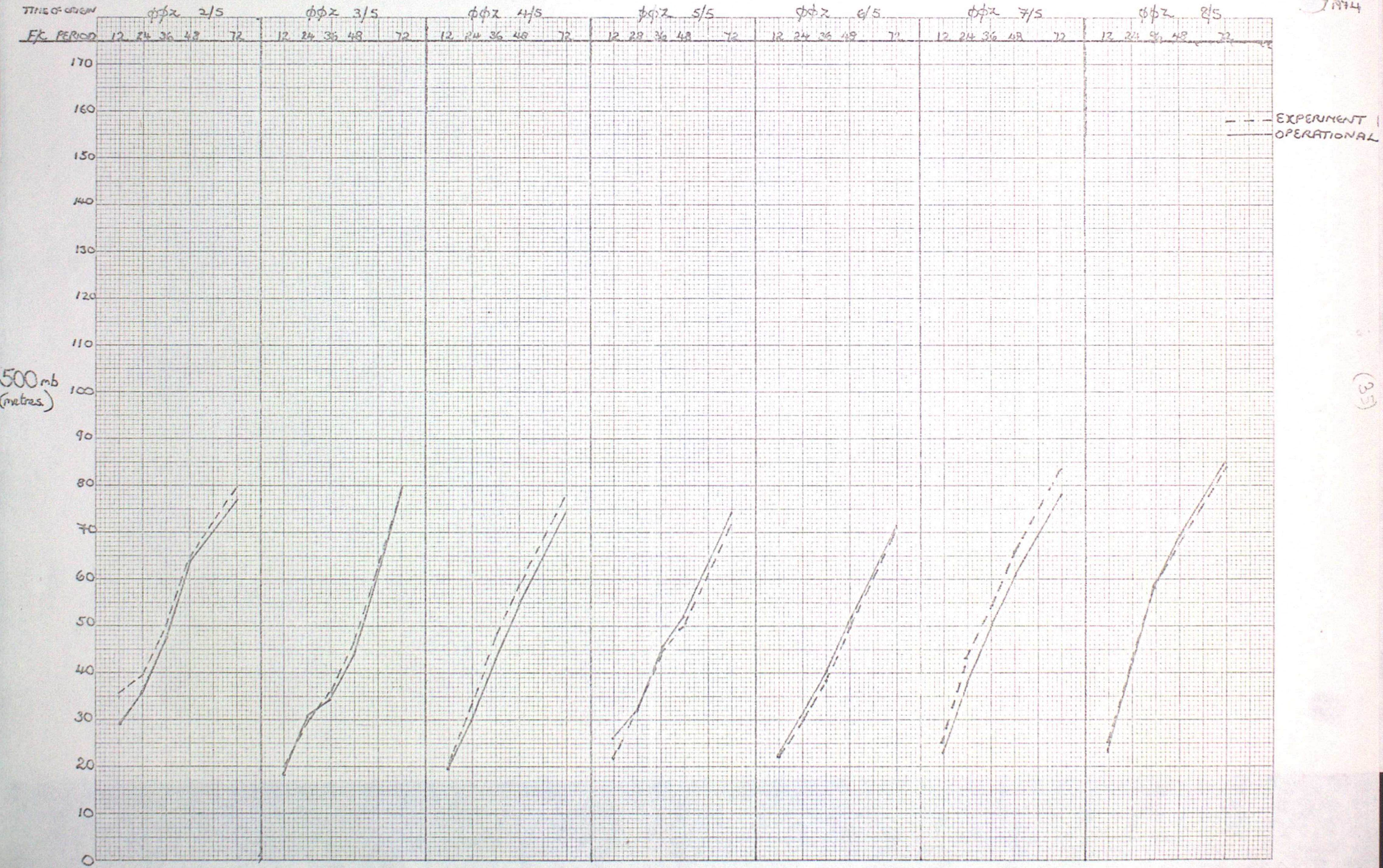


FIGURE IX (b)

SHEET 1.

R.M.S HEIGHT DIFFERENCES FOR FORECASTS v UPDATE ANALYSES FOR INCREASING FORECAST PERIODS SMALL AREA (REG 2) 560

1974



(35)

FIGURE IX (6)

R.M.S. HT. DIFFERENCES. F/C v UPDATE ANALYSES FOR INCREASING F/C PERIODS. SMALL AREA (REG 2) 560 GRID POINTS 1974.

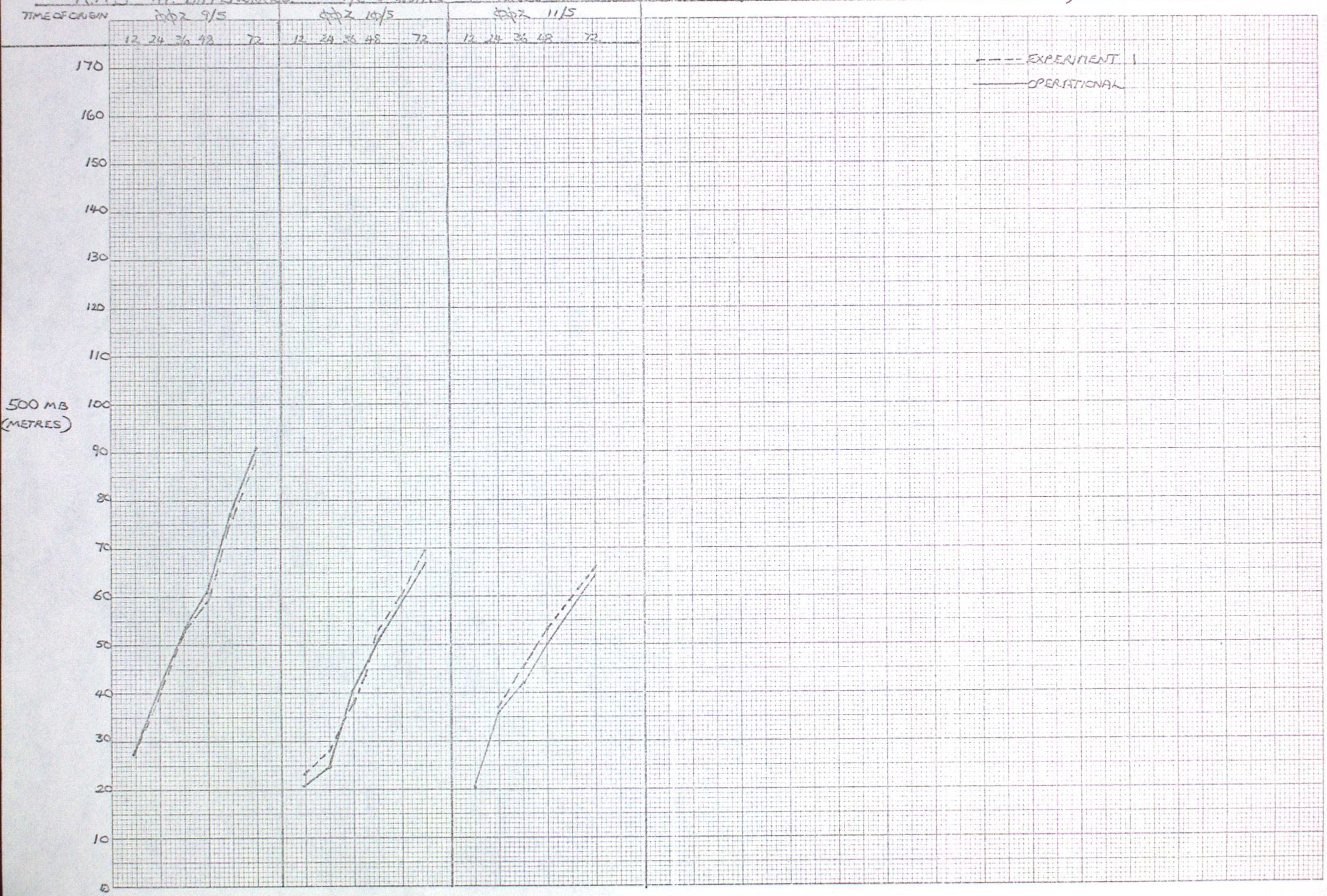
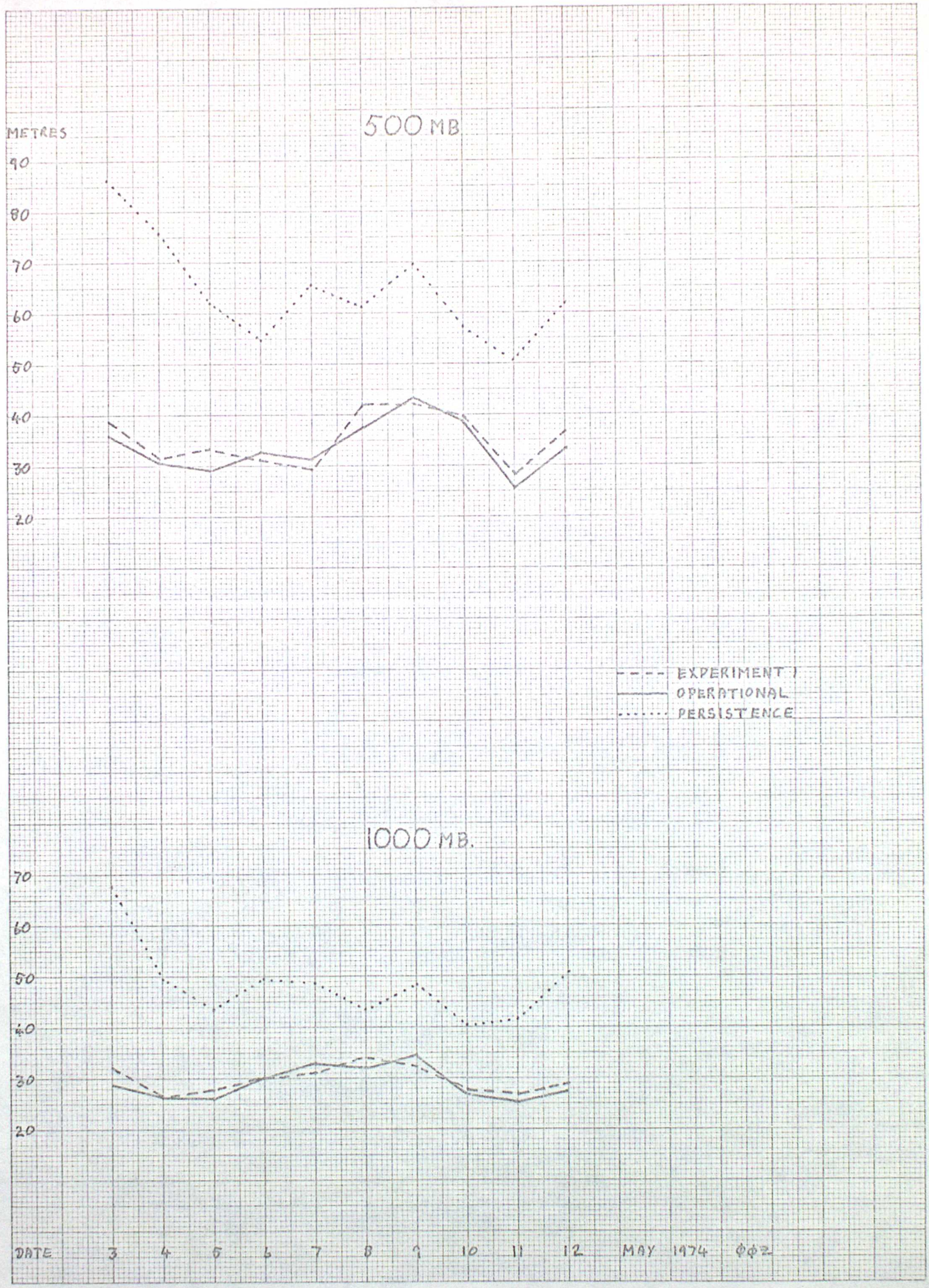


FIGURE X (a)

R.M.S. HEIGHT DIFFERENCES. T+24 FORECASTS. 560 GRIDPOINTS.
FORECASTS v. UPDATE ANALYSES (OPERATIONAL). (SMALL AREA, REGION 2)



VERIFICATION TIME

FIGURE X(b)

R.M.S. HEIGHT DIFFERENCES. T+48 FORECASTS. 560 GRIDPOINTS.
FORECASTS v. UPDATE ANALYSES (OPERATIONAL) (SMALL AREA, REGION 2)

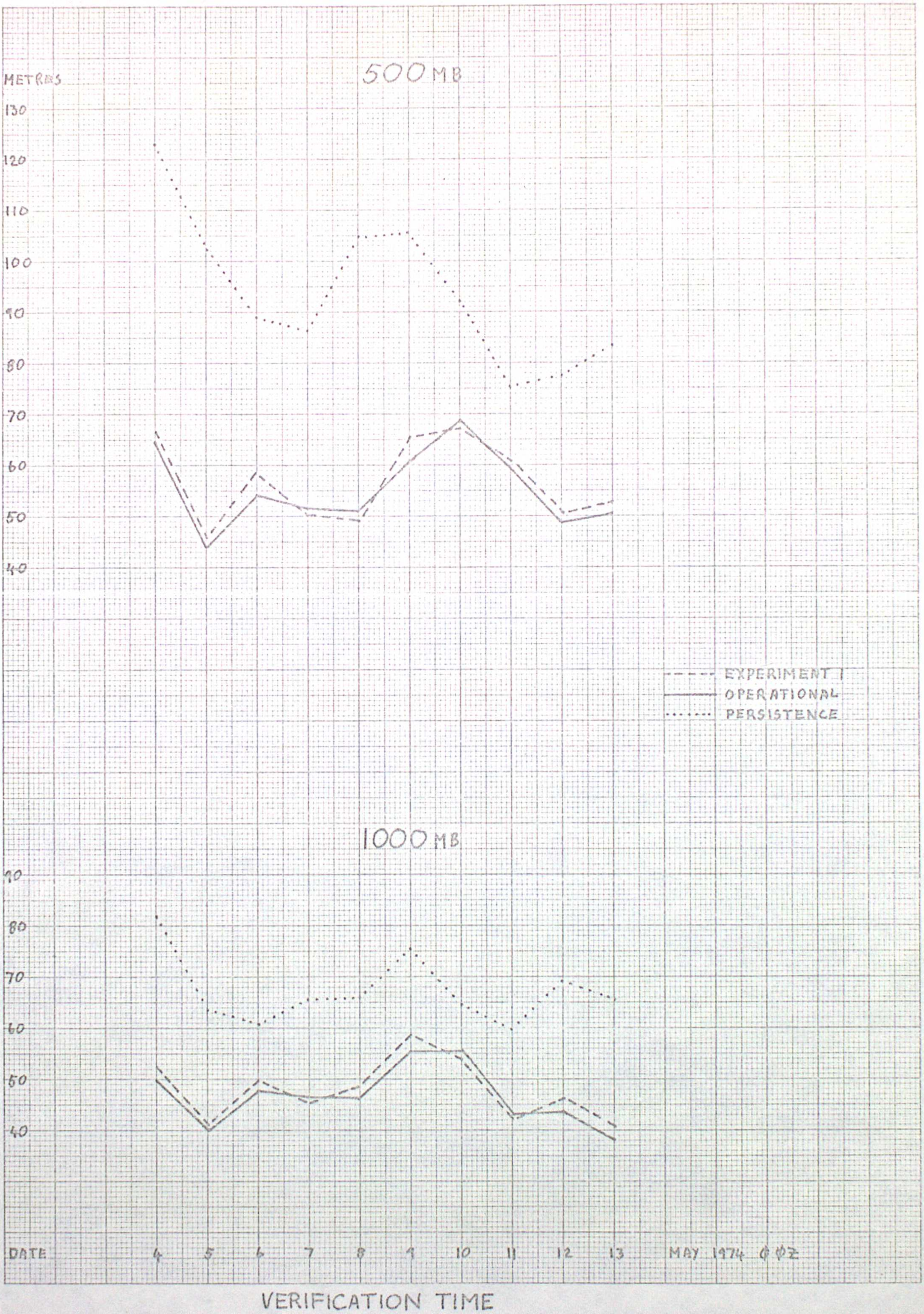
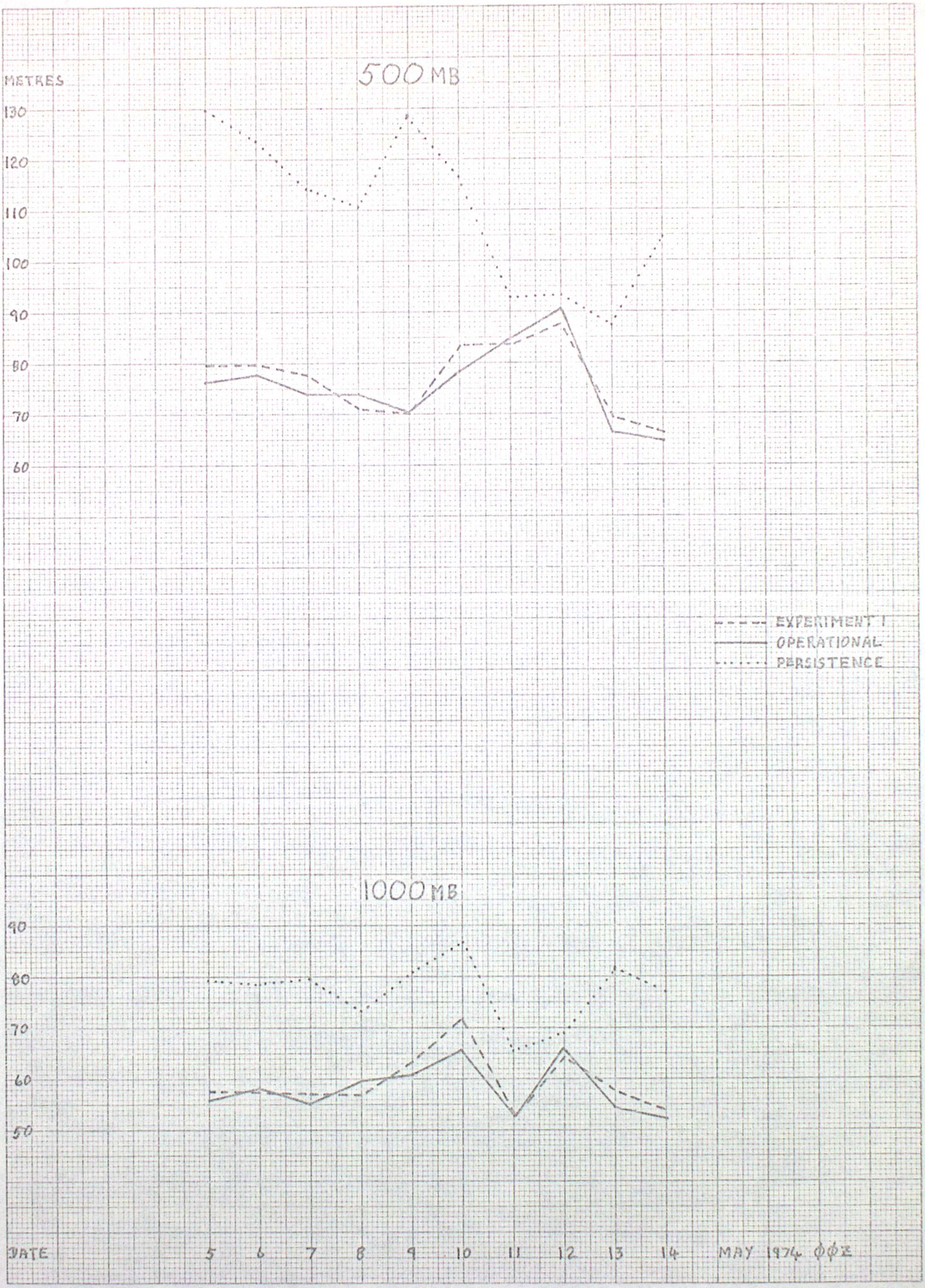


FIGURE X (c)

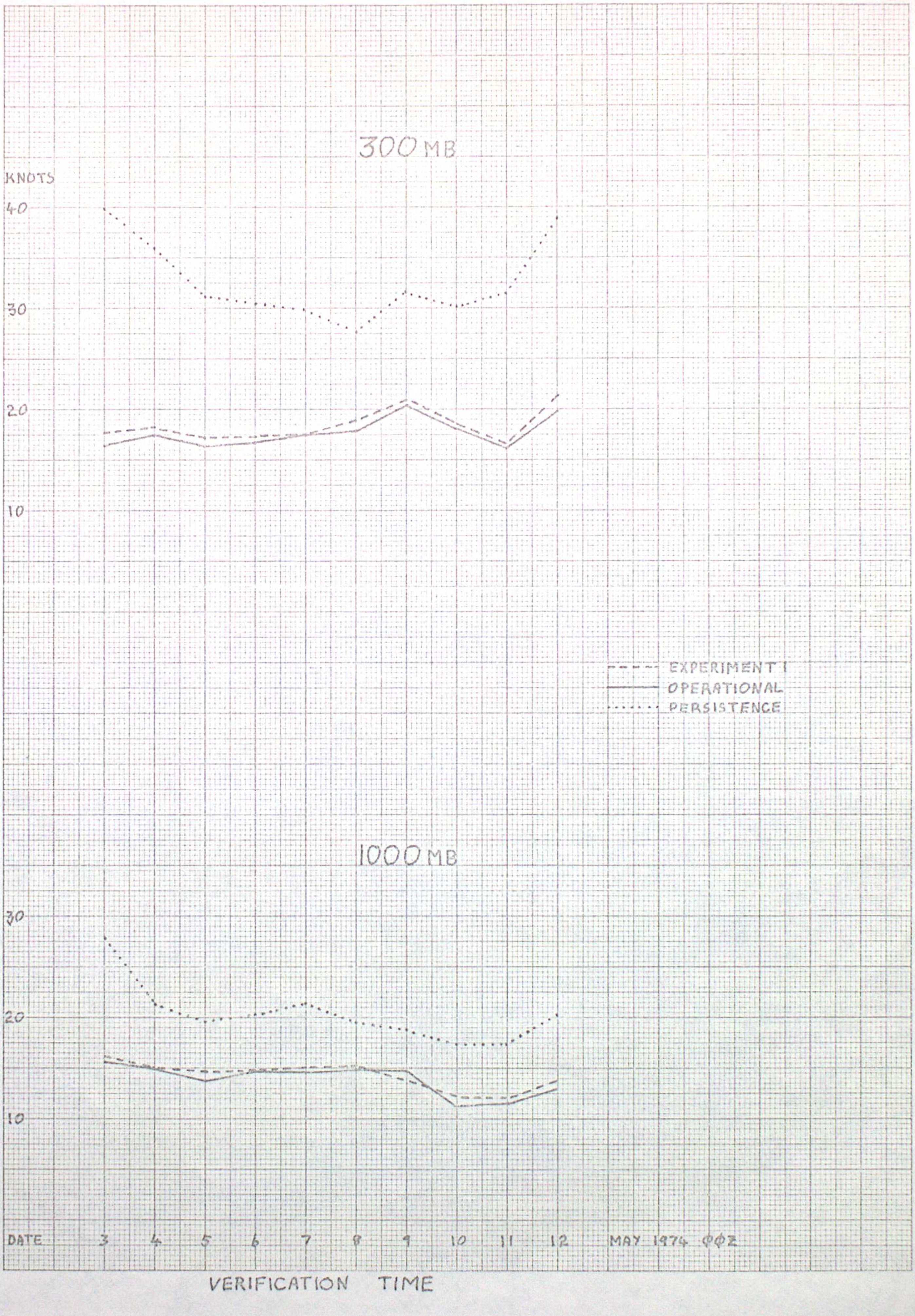
R.M.S. HEIGHT DIFFERENCES. T+72 FORECASTS. 560 GRIDPOINTS
FORECASTS v. UPDATE ANALYSES (OPERATIONAL) (SMALL AREA, REGION 2)



VERIFICATION TIME

FIGURE XI (a)

R.M.S. VECTOR WIND DIFFERENCES. T+24 F/C. 560 GRIDPOINTS.
F/C v. UPDATE INITIALISED U AND V FIELDS. (SMALL AREA, REGION 2)



VERIFICATION TIME

FIGURE XI (6)

R.M.S. VECTOR WIND DIFFERENCES. T+48 F/C. 560 GRIDPOINTS.
F/C v. UPDATE INITIALISED U AND V FIELDS. (SMALL AREA, REGION 2)

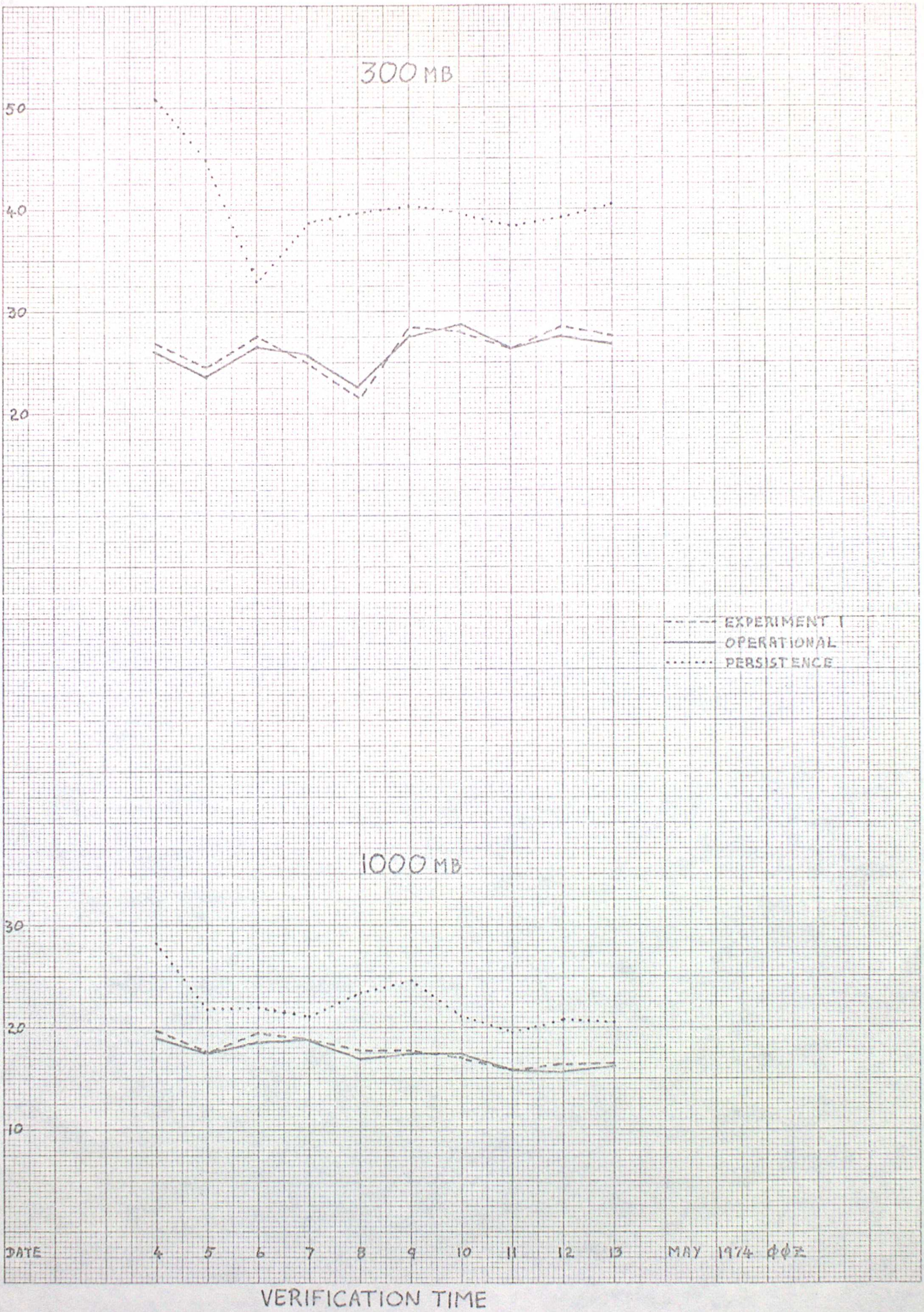
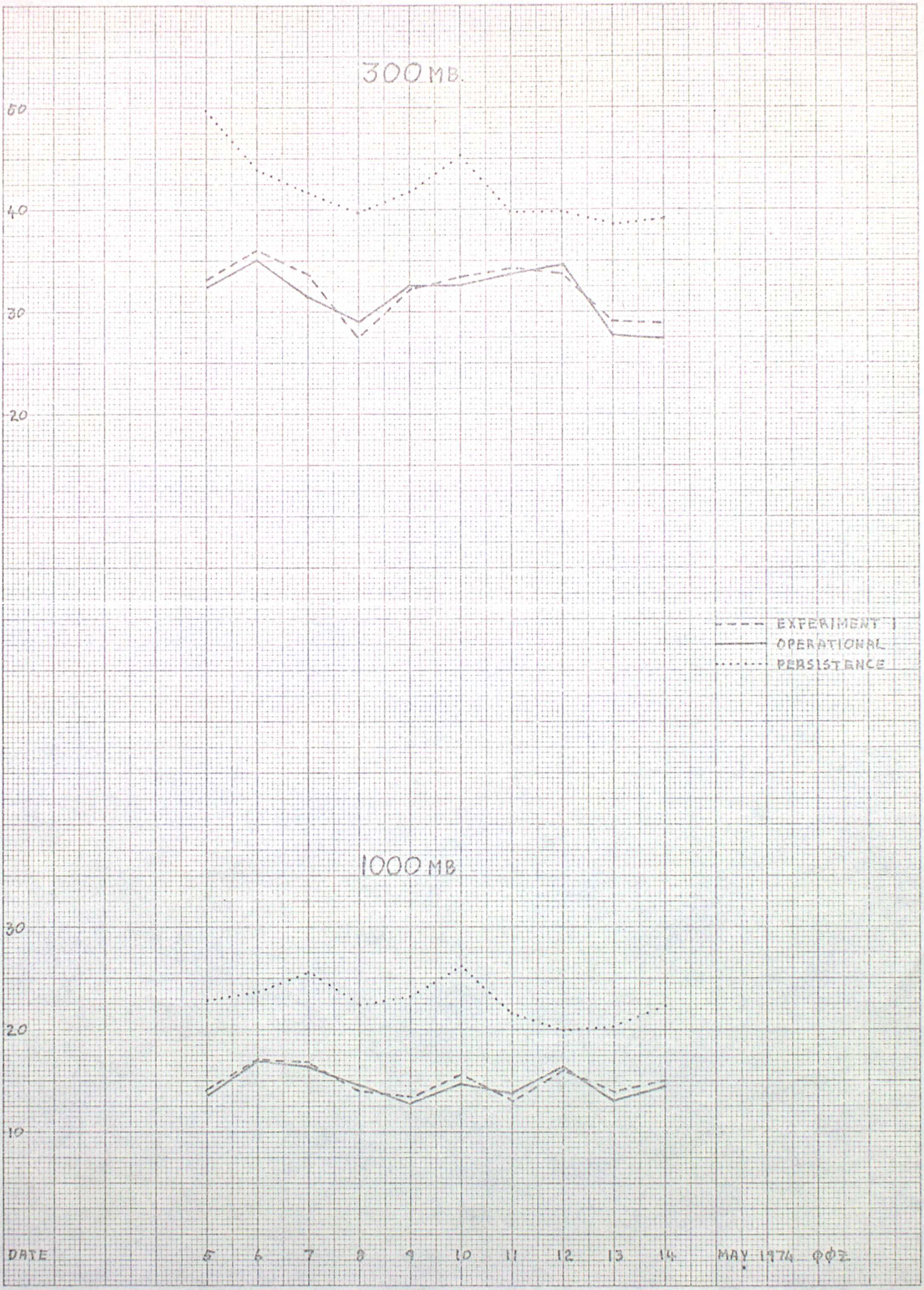


FIGURE XI (C)

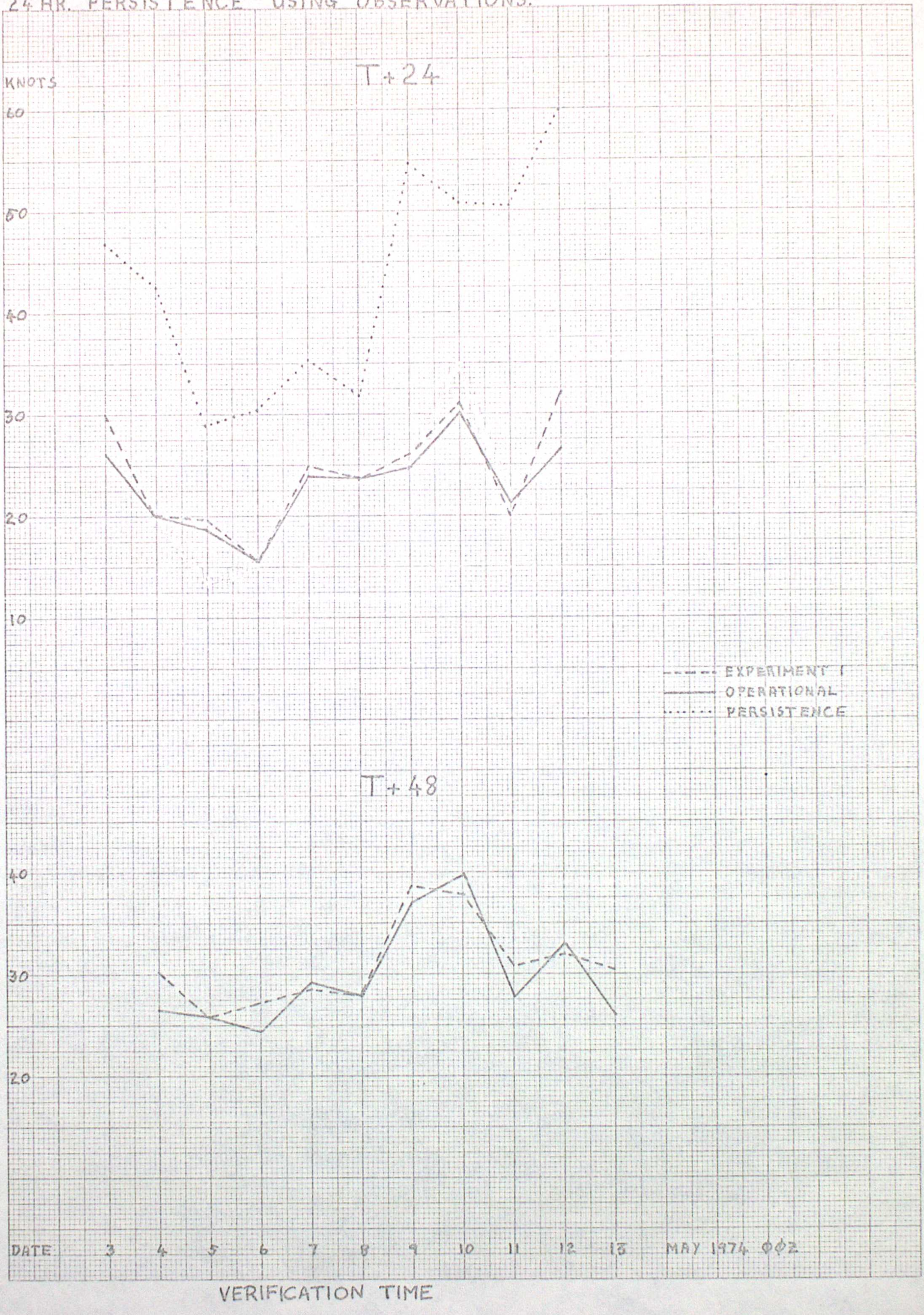
R.M.S. VECTOR WIND DIFFERENCES. T+72 F/C. 560 GRIDPOINTS.
F/C v. UPDATE INITIALISED U AND V FIELDS. (SMALL AREA, REGION 2)



VERIFICATION TIME

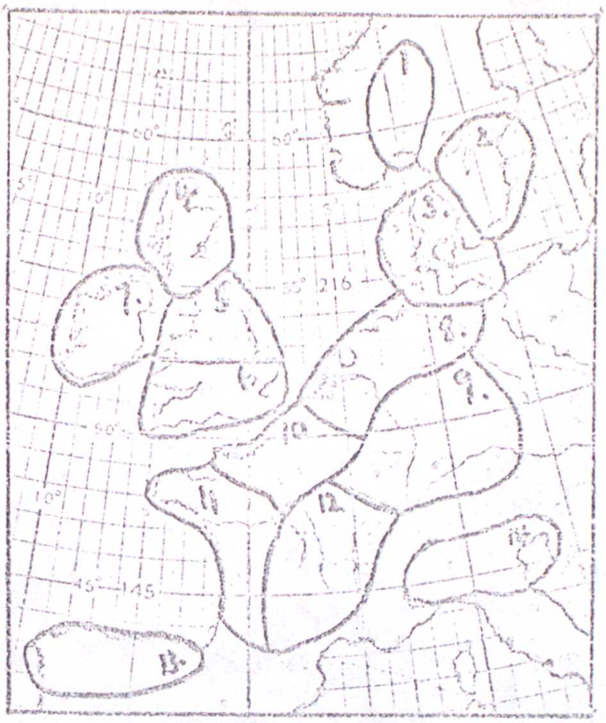
FIGURE XII

R.M.S. VECTOR WIND DIFFERENCES. 300 MB. 28 EUROPEAN STNS.
F/C FIELDS v. OBSERVATIONS (REG 1)
24 HR. PERSISTENCE USING OBSERVATIONS.



VERIFICATION TIME

FIGURE XIII AREAS USED FOR OBJECTIVE RAINFALL VERIFICATION



300 mb RMS Vector Wind Errors REGION 2 (6 Atlantic Stations) F/c v Obs

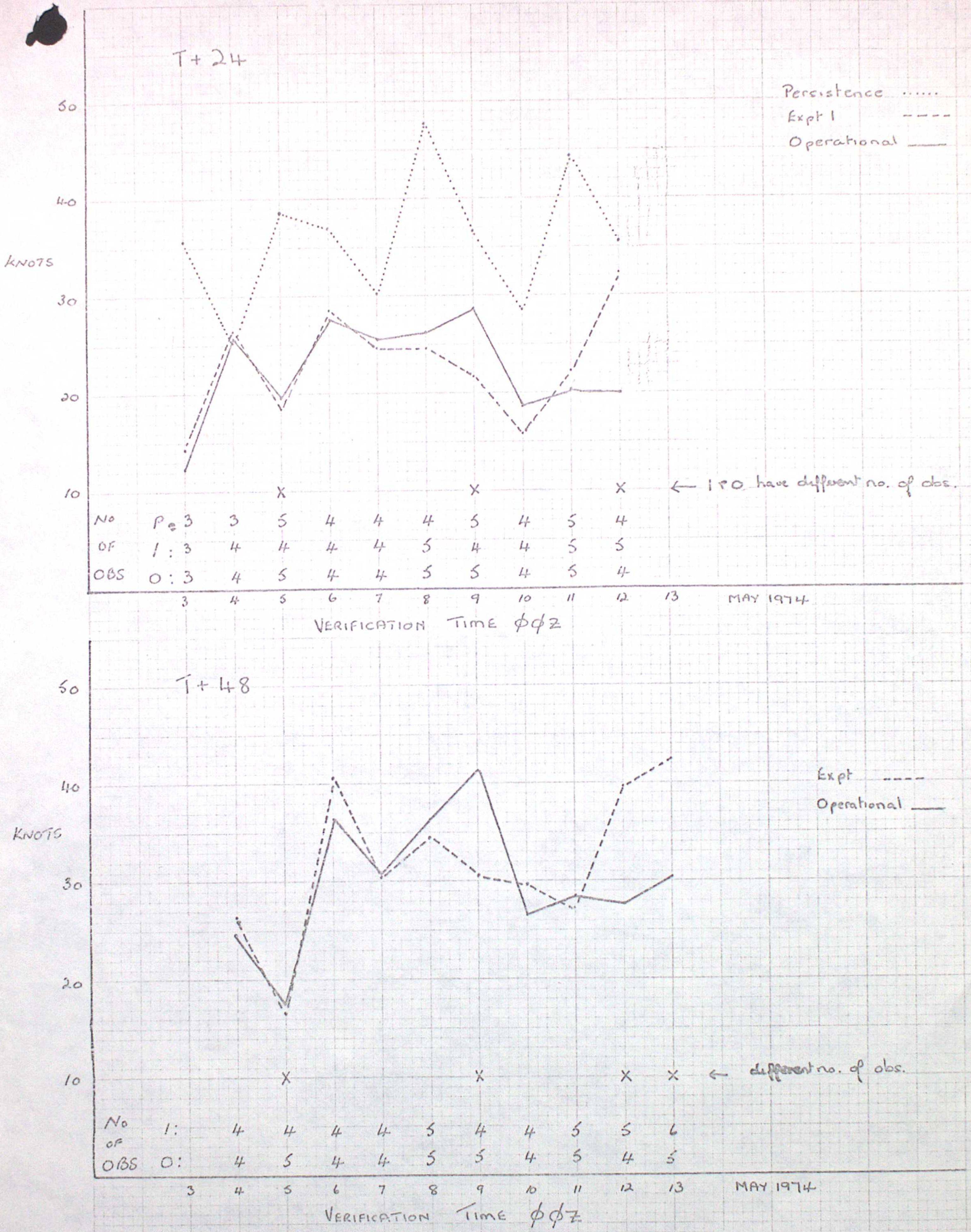


Fig XIV