METEOROLOGICAL OFFICE

CENTRAL FORECASTING TECHNICAL NOTE NO. 10

INVESTIGATION INTO THE IMPACT OF NORTH ATLANTIC TEMPSHIPS ON THE FORECASTS FROM THE U.K. METEOROLOGICAL OFFICE'S GLOBAL AND LIMITED AREA MODELS

J.T.Heming & A.M.Radford

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Headquarters, Bracknell

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Central Forecasting Division
Meteorological Office
London Road
Bracknell, Berkshire
RG12 2SZ

1. INTRODUCTION

In the past, various studies have been conducted to investigate the impact of radiosonde observations from ships (TEMPSHIPs), e.g. Pailleux (1990). These have generally concluded either a neutral or very modest positive impact, but occasional significant impacts have been found, e.g. Graham (1990), Heming (1990). Some radiosonde ascents are made routinely from former Ocean Weather Ships (OWS) while others are made from merchant ships equipped with ASAP (Automated Shipboard Aerological Program) systems. In 1989 there were 13 ASAP ships operating in the North Atlantic area, but since then the number has decreased and further reductions are planned, mainly due to financial constraints.

At the second session of the SEG (Scientific Evaluation Group) of COSNA (the Composite Observing System for the North Atlantic), held in October 1991, it was decided that there was a need for further impact studies in order to demonstrate the utility of the ASAP observing system. It was agreed that several centres would try to identify suitable cases during the winter of 1991/92. In the first instance these cases were identified on the basis of large differences between the ASAP observations and the numerical models' background fields. The UK Met Office, Germany, France, ECMWF and the HIRLAM group all produced a list of likely cases. These were collated by Dr A.Kaestner of Deutscher Wetterdienst (DWD), the coordinator of the experiment, who then chose the period of 2-5 March 1992. This was based on the additional criteria that (a) there were a larger than normal number of ASAPs reporting, and (b) they were in an area of strong baroclinic flow. It was originally intended that as many centres as possible should perform the study; however only DWD and UKMO had resources available.

2. EXPERIMENT DETAILS

The period chosen for the experiment was 2-5 March 1992 inclusive, with assimilation of observations to start 3 days beforehand. Forecasts out to 3 days were produced during this period with TEMPSHIPs (including ex-OWS, other research ships and ASAPs) excluded from the area 20-90°N 100°W-30°E.

In the case of the UKMO's experiment an exact replication of the operational model run (without TEMPSHIPs only) could not be achieved since the version of the model operational in March and the archive of observations used operationally were no longer available. Therefore the experiment had to made using a later version of the model and retrieving observations from the 5-year retention data banks. Apart from any meteorological differences resulting from using the later version of the model, this may have resulted in a larger sample of observations being used than were available operationally. It also meant the exclusion of manual intervention on observations (e.g. rejections or corrections) and pseudo-observations known as "bogus" which are used operationally. Two separate experiments were made: a "No TEMPSHIP" run (NOTS) and a "Control" run (CNTL).

The experiments were performed on the global model with forecasts out to 3 days run every 12 hours. This model has a horizontal resolution of approximately 100km and had 20 vertical levels during the period in question. The global model was used to provide boundary conditions to the Limited Area Model (LAM) which operates with a horizontal resolution of approximately 50km and the same vertical resolution. LAM forecasts were run every 12 hours out to 36 hours. In the NOTS run all TEMPSHIP upper air observations in the defined area were not assimilated into the model, although their surface reports were retained since it was not possible to eliminate these without eliminating all other surface ship data.

The positions of all TEMPSHIPs (both ASAPs and ex-OWSs) included in the CNTL runs are marked on Figures 8(a)-(g). At all intermediate hours (06UTC and 18UTC) during the experiment period only ex-OWSs GACA and LDWR reported observations.

3. SUBJECTIVE VERIFICATION

It was decided to verify forecasts from individual cases against their own analyses (i.e. NOTS forecast against NOTS analysis and CNTL forecast against CNTL analysis). It is clearly desirable to verify against the best analysis, but using either the CNTL or NOTS analysis as the standard could bias the verification; the impact of a TEMPSHIP on an analysis and subsequent forecast is likely to feed through to have an impact on the later verifying analysis.

Since the area of interest is the North Atlantic, subjective verification concentrated on the Limited Area Model runs. The analysis and forecast charts were examined and seven cases identified where there were significant differences between the NOTS and CNTL runs. The differences are described below, with charts provided in Figures 1 to 7.

CASE 1: DT 06UTC 03.03.92 T+0

In this case ship GACA (formerly OWS 'Lima') at 56°N 25°W had an impact in the analysis of a secondary low causing it to be shifted to the west when compared with the NOTS run (see Figures 1(a) and (b)). The 500hPa height, 1000-500hPa thickness and 850hPa relative humidity patterns (not shown) were similarly shifted. Since LAM forecasts were only run from 00UTC and 12UTC analyses the impact of these analysis differences on a forecast could not be assessed.

CASE 2 DT 12UTC 03.03.92 T+12

Figures 2(a) and (b) show differences between the CNTL and NOTS runs in the forecast of the complex depression between Iceland and Greenland. When compared with their analyses (Figures 2(c) and (d)) the NOTS forecast appears to have located the depression immediately to the west of Iceland better, but the CNTL run had a better forecast of the low complex to the south-east of Greenland since it has only one distinct centre.

CASE 3 DT 00UTC 04.03.92 T+36

In this case the CNTL forecast featured a trough extending east near 68°N 0-10°E not present in the NOTS forecast (Figures 3(a) and (b)). The verifying analyses (Figures 3(c) and (d)) indicate there was a troughing in this area, but not as marked as in the CNTL forecast. Hence, the NOTS forecast could be said to be the better of the two in this area.

Associated with the trough there were some differences in the rainfall forecasts for the T+30 and T+36 periods. However these were mainly over sea areas and so would have little impact on the objective rainfall statistics (described in section 4). The objective statistics for the LAM European land area are slightly better for the CNTL run than for the NOTS run for these times, possibly due to minor differences near the Norwegian coast.

CASE 4 DT 00UTC 04.03.92 T+0,T+12

The 250hPa wind speed analysis shows differences in the rearward extension of the jet over southern Scandinavia near the position of ship LDWR (formerly OWS 'Mike') at 66°N 2°E (Figures 4(a) and (b)). This results in different T+12 forecasts as shown in Figure 4(c). The CNTL forecast (Figure 4(d)) retains the 80 knot isotach through the axis of the ridge over the Norwegian Sea whereas the NOTS forecast (Figure 4(e)) has less strength. The verifying analyses (Figures 4(f) and (g)) both indicate that the NOTS forecast was the better of the two.

CASE 5 DT 00UTC 04.03.92 T+0,T+24

Figure 5(a) shows the 850hPa relative humidity differences between the CNTL and NOTS analyses. The large difference over the Norwegian Sea indicates that ship LDWR has produced a drying out of more than 50% relative humidity in its vicinity. This difference is maintained into the forecast as a comparison of Figures 5(b) and (c) shows. However, the CNTL and NOTS T+24 forecasts both verify well against their own analyses (Figures 5(d) and (e)). It is difficult to say which forecast is the better, but this case clearly shows the large impact that radiosonde relative humidities can have on an analysis, the forecasts from this analysis and the analyses from subsequent runs.

CASE 6 DT 00UTC 04.03.92 T+36

The 250hPa wind speed difference chart for T+36 (Figure 6(a)) shows differences of up to 16 knots near 40°N 35°W. Tracing the difference back to the analysis, it seems to have originated from a point near the North African coast.

Following investigation it was found that this was due to a TEMPSHIP DBBH reporting twice, the second report being 2° further east than the first (see Figure 8(d)). Both observations were used in the CNTL run since there is no duplicate check for TEMPSHIPs; moreover the increments were not so large as to cause a flag to be raised in the quality control.

Figures 6(b) and (c) show the CNTL and NOTS T+36 forecasts and Figures 6(d) and (e) the verifying analyses. The CNTL forecast can probably be said to be the poorer of the two since its jet maximum of over 100 knots near 40°N 30°W is not present in either analysis. However, this is not a clear-cut case since the duplicate observations complicate the situation. If, in fact, the forecast has been made worse by the duplication of the observation in the wrong position, it highlights the need for duplicate and position checks (which are planned) at the observation processing stage.

CASE 7 DT 12UTC 05.03.92 T+24,T+36

This was the last forecast run for the experiment and therefore, since the assimilation did not continue beyond the end of the period, there were no subsequent CNTL and NOTS analyses to use in the verification of its forecasts. Hence, in this case, the operational analyses were used for verification. Consequently it must be borne in mind that the verifying analyses may be biased towards the CNTL run since they both include TEMPSHIP observations.

Figures 7(a) and (b) show the T+36 forecasts of mean sea-level pressure (pmsl) and indicate that the depression to the north of Shetland is slightly further north and deeper in the CNTL run. This is highlighted in Figure 7(c), the difference chart for the same time. The verifying analysis (Figure 7(d)) shows that the depression was, in fact, further south and shallower and hence the NOTS forecast was the better of the two.

At T+24 there was a significant difference in the 250hPa wind speed over the Brittany peninsula - the CNTL forecast had a local maximum of 39 knots while the NOTS run had a local minimum of 2 knots (see Figures 7(e) and (f)). The verifying analysis (Figure 7(g)) indicated that NOTS was the better forecast.

At T+24 a dry plume extending over Cumbria in the CNTL run was not present in the NOTS run (Figures 7(h), (i) and (j)). The verifying analysis (Figure 7(k)) indicates that the moist air was further west and hence the CNTL forecast appears to be the better of the two. By T+36 the difference is similar to that at T+24 with the NOTS forecast pushing the moist air south-east quicker than the CNTL forecast. The verifying analysis once again suggests that the CNTL forecast was closer to the truth (charts not shown).

Figures 7(l) and (m) show the precipitation forecasts for this case and reflect the differences in the relative humidity fields. The U.K. LAM rainfall verification statistics (described in section 4) indicate that at T+30 the NOTS forecast was over 4% better on the Yes/No score, but the CNTL forecast had a better Bias. The T+36 statistics suggest the CNTL forecast was better overall for the UK area with a 7% advantage over the NOTS run on the Yes/No score.

4. OBJECTIVE VERIFICATION

Objective verification figures were obtained for LAM rainfall forecasts and other global model forecast fields over the period of the study.

(a) LAM Rainfall

Each LAM run produces forecasts of rainfall rate and 6-hour accumulation for every 6-hour period of the forecast up to T+36. In the experiment, LAM forecasts were run every 12 hours between 00UTC 3 March and 12UTC 5 March. The forecast rainfall accumulation figures were verified against observations using the Met. Office's standard rainfall verification package (Law, 1986).

There are many different ways of scoring rainfall forecasts but two of the most useful scores, which were examined in this experiment, are the Bias and Yes/No scores. The Bias is the ratio of the total number of forecast rain events and the number actually observed. Hence, values under 1 indicate the model is underestimating rainfall and values over 1 indicate the reverse. The Yes/No score is simply the percentage of occasions when rainfall or no rainfall was forecast correctly. In isolation this score is not always very helpful since high scores will result from easily forecast rainfall situations e.g. large anticyclones. However, the score is useful in this case since an experimental run is being compared against a control run.

Tables 1 and 2 show the Bias and Yes/No scores for the CNTL and NOTS runs split into 6-hour forecast periods averaged over the 6 forecasts for the U.K. and North-West European areas respectively. A "√" indicates the better of the two results in each category - i.e. a Bias nearer to 1 and a higher Yes/No score. It is clear from the tables that all Biases are greater than 1 indicating an overprediction of rainfall - this is a known feature of the LAM and is mostly related to light rain events.

TABLE 1

LAM Rainfall Verification Figures for the U.K. Land Area Only

Score / Forecast Time	BIAS CNTL	BIAS NOTS	YES / NO Score (%) CNTL	YES / NO Score (%) NOTS
T+6	1.33	1.12 √	79.3	83.2 √
T+12	1.62	1.55 √	80.6 =	80.6 =
T+18	2.23	2.02 √	76.5	79.3 √
T+24	2.47 √	2.67	77.7 √	75.9
T+30	1.47 √	1.57	81.1 √	78.6
T+36	2.57 √	2.72	77.1 √	74.8

√ indicates the better score

TABLE 2

LAM Rainfall Verification Figures for the North-West Europe Land Area

Score / Forecast Time	BIAS CNTL	BIAS NOTS	YES / NO Score (%) CNTL	YES / NO Score (%) NOTS
T+6	0.83 √	0.77	88.7	89.2 √
T+12	1.38	1.33 √	88.7 √	88.6
T+18	1.30 √	1.33	85.6 √	85.3
T+24	1.92 √	2.00	83.6 √	82.5
T+30	1.63 √	1.68	81.8 √	80.7
T+36	2.05	2.03 √	81.3 √	80.7

√ indicates the better score

Table 1 shows that the NOTS run was better for the first 18 hours of the forecast but the CNTL run was better thereafter. The largest difference in the Yes/No score between the two runs was 4%. Table 2 shows a rather more consistent story with the CNTL run better in 4 of the 6 forecast times for the Bias score. For the Yes/No score the CNTL run was better for all forecast times after T+6, but the differences were small (near 1% maximum).

(b) Global Model

Objective verification of fields other than rainfall was carried out by examining mean and RMS error figures averaged over all forecast runs (every 12 hours between 12UTC 2 March and 00UTC 5 March). It was performed on global model fields limited to the area of TEMPSHIP rejection in the North Atlantic (20-90°N, 100°W-30°E). In this case the CNTL and NOTS fields were verified against the operational global analysis. The mean error scores are shown in Table 3 and RMS errors in Table 4. A "√" indicates the run with the smaller error value.

The pmsl error statistics show that the CNTL analyses are closer to the operational analyses (as would be expected), but that performance is mixed in the forecast. Mean errors come out in favour of the NOTS run whereas the CNTL run has better RMS statistics overall.

TABLE 3

Global Model Mean Errors (Difference from Operational Analysis)

F/C time	T+0		T+24		T+48		T+72	
Field	CNTL	NOTS	CNTL	NOTS	CNTL	NOTS	CNTL	NOTS
MSLP	0.19 √	0.21	-0.14	-0.12 √	-0.12	-0.06 √	-0.32	-0.24 √
500hPa Ht	0.01 =	0.01 =	-1.02	-0.98 √	-1.17	-1.12 √	-1.23	-1.19 √
850hPa RH	-0.30	-0.18 √	1.28 √	1.35	2.96	2.71 √	3.61	3.42 √
250hPa WS	-0.14 √	-0.19	-0.38	-0.36 √	-0.49	-0.46 √	-0.75	-0.73 √
250hPa U	-0.11 √	-0.13	-0.06 =	-0.06 =	0.17	0.15 √	0.37 √	0.38
250hPa V	-0.06	-0.03 √	-0.18	-0.16 √	-0.20	-0.19 √	-0.11 √	-0.16

√ indicates the smaller error

Ht : Height (dam) RH : Relative Humidity (%) WS : Wind Speed (knots)
U : U-component of wind (knots) V : V-component of wind (knots)

TABLE 4

Global Model RMS Errors (Difference from Operational Analysis)

F/C time	T+0		T+24		T+48		T+72	
Field	CNTL	NOTS	CNTL	NOTS	CNTL	NOTS	CNTL	NOTS
MSLP	0.53 √	0.57	1.86	1.85 √	3.02 √	3.07	4.32 √	4.41
500hPa Ht	0.47 √	0.51	1.79	1.76 √	2.93 =	2.93 =	4.29 √	4.32
850hPa RH	4.68 √	5.37	11.64	11.55 √	14.70	14.47 √	16.98	16.82 √
250hPa WS	1.55 √	1.62	4.47 √	4.51	6.40 √	6.47	8.06 √	8.15
250hPa U	1.48 √	1.55	4.43 √	4.45	6.60 √	6.69	8.46 √	8.61
250hPa V	1.49 √	1.56	4.35 √	4.38	6.30 =	6.30 =	7.91 √	8.01

√ indicates the smaller error

Ht : Height (dam) RH : Relative Humidity (%) WS : Wind Speed (knots)
U : U-component of wind (knots) V : V-component of wind (knots)

The differences in 500hPa height errors are small. Once again the NOTS run appears to be the better from the mean errors while the CNTL run has the better RMS error statistics.

At 850hPa the relative humidity error statistics clearly show that the NOTS runs gave better results. This is perhaps indicative of the fact that radiosonde relative humidities have a significant and lasting impact on the model. However, despite an improvement in the analysis RMS errors, the impact which feeds through to the forecast is generally negative. This could be due to the radius of influence of relative humidity observations being too large in model. Often, radiosonde relative humidities will only be representative of a small area around the observation and, hence, could negatively influence the wider area. A particular instance was noted subsequent to this experimental period (Heming, 1992).

The mean error statistics for 250hPa wind speed and wind components show mixed results with the NOTS runs coming out slightly better overall. However, the RMS errors indicate a positive impact of TEMPSHIPs for all forecast times (except for one "nil" impact).

5. CONCLUSIONS

The impact of TEMPSHIPs has been assessed over a short period in March 1992 by omitting them from a rerun of the U.K. Met. Office's global and limited area models. Global forecasts were run out to 3 days and LAM forecasts out to 36 hours at 12 hour intervals. Three verification methods have been employed: (i) a subjective examination of various fields from LAM forecasts where significant differences occurred between the CNTL and NOTS runs; (ii) objective verification of LAM rainfall forecasts over land against observations; (iii) objective verification of global model mean and RMS error statistics over the North Atlantic.

Overall, the impact of TEMPSHIPs can be said to be mixed if not slightly negative during this period. Certainly in the cases examined subjectively, the majority showed a small negative impact of TEMPSHIPs. However, the rainfall statistics were far more encouraging with a small positive impact being seen particularly over the European area. The global objective errors were mixed but the statistics indicate a clear positive impact on jet level wind forecasts.

Despite the best intentions of trying to pick an 'ideal' scenario when it was thought most likely to obtain a positive impact, the period chosen for the study was not ideal for verification purposes; high pressure dominated mainland Europe and most mobile systems skirted this area to the north-west away from the area of densest observation coverage. The results of this study clearly cannot be used to make a firm case for the retention of the ASAP observing system, but at the same time the usefulness of the observations has not been disproved. Indeed their importance on individual occasions has been illustrated in a number of previous case studies. It would appear that whilst TEMPSHIP observations do not have a significant positive day-to-day impact, they can be most effective in the fairly infrequent crucial situations when the NWP models have not picked up the rapid deepening or movement of a system and a good quality upper air ascent is vital to provide the model with the missing information it requires.

REFERENCES

Graham, R.J. "The impact of North Atlantic TEMPSHIP observations on global model analyses and forecasts during a case of cyclogenesis". UK Met Office Short-Range Forecasting Research Technical Note No.46, 1990.

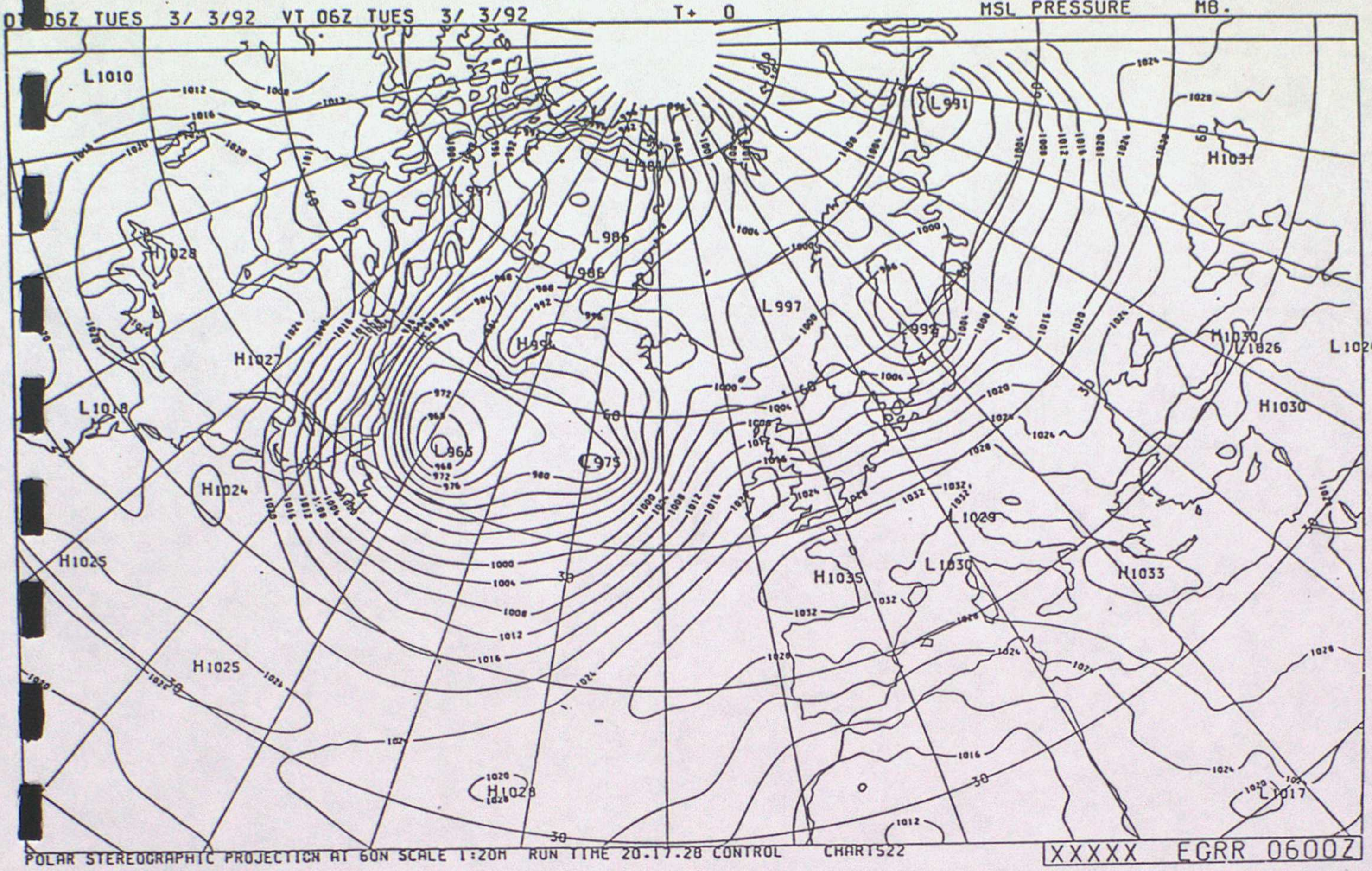
Heming, J.T. "The impact of surface and radiosonde observations from two Atlantic ships on a numerical weather prediction model forecast for the storm of 25 January 1990". Meteorological Magazine 119 1990.

Heming, J.T. "The negative impact of a radiosonde observation on a rainfall forecast". Central Forecasting Case Study No.32, 1992. Not published - internal report.

Law, K.S. "The Fine Mesh rainfall verification scheme". Met O 2b Technical Note no.113, 1986. Not published - internal report.

Pailleux, J. "The impact of North Atlantic TEMPSHIP radiosonde data on the ECMWF analysis and forecast". ECMWF Technical Memorandum No.174, 1990.

G. 1(a) CNTL



IG. 1(b) NOTS

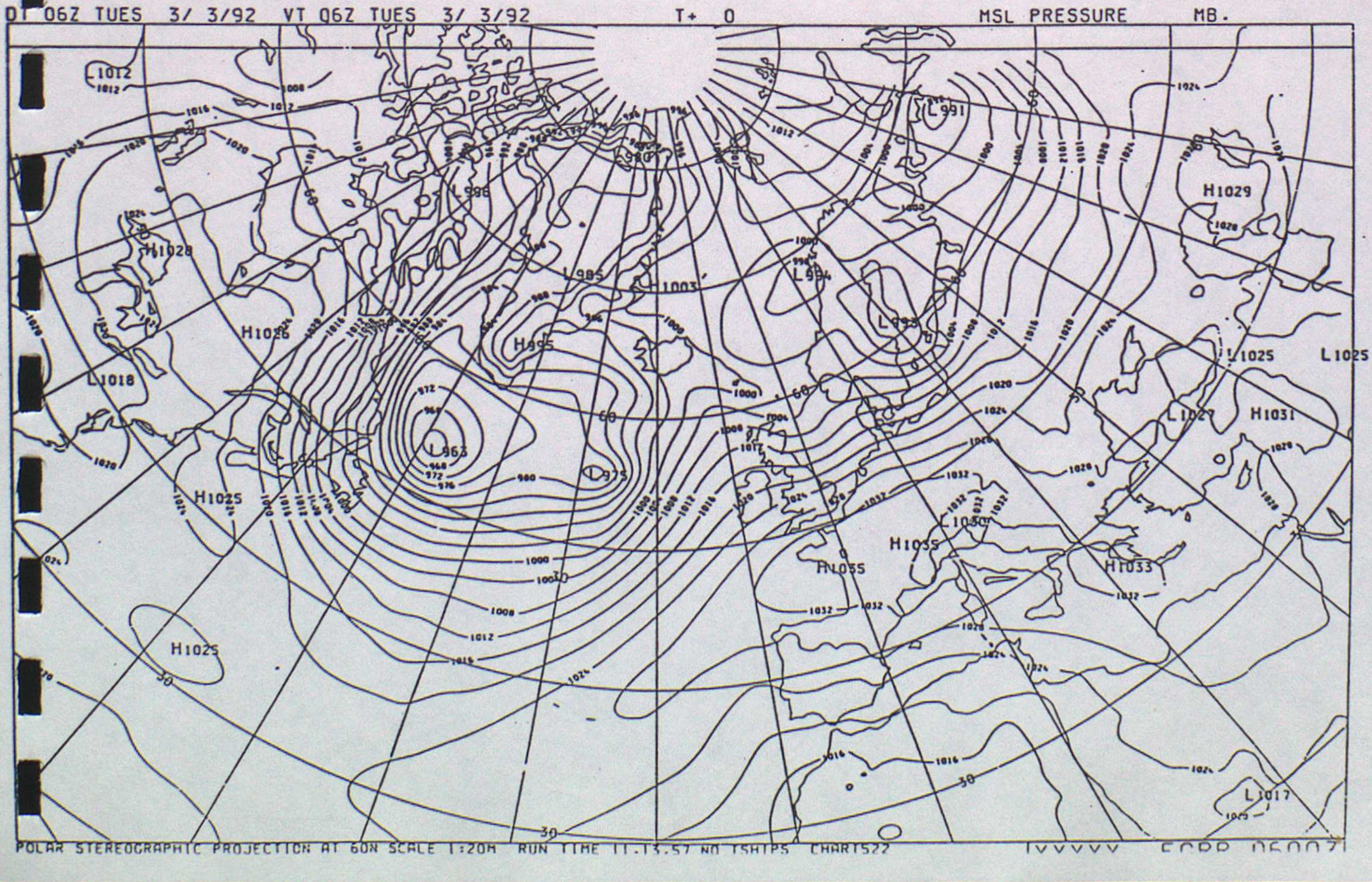


FIG. 2(a) CNTL

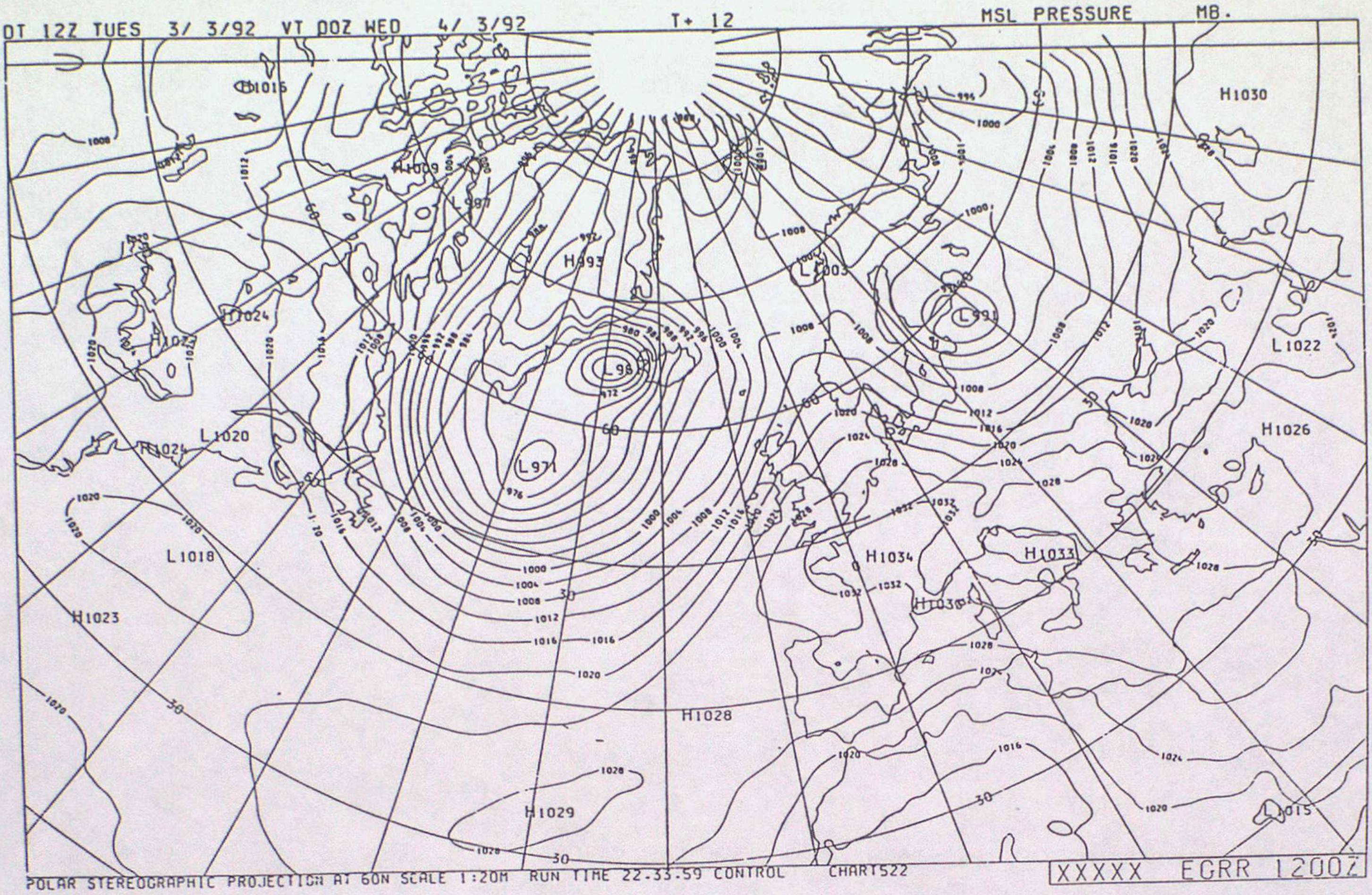


FIG. 2(b) NOTS

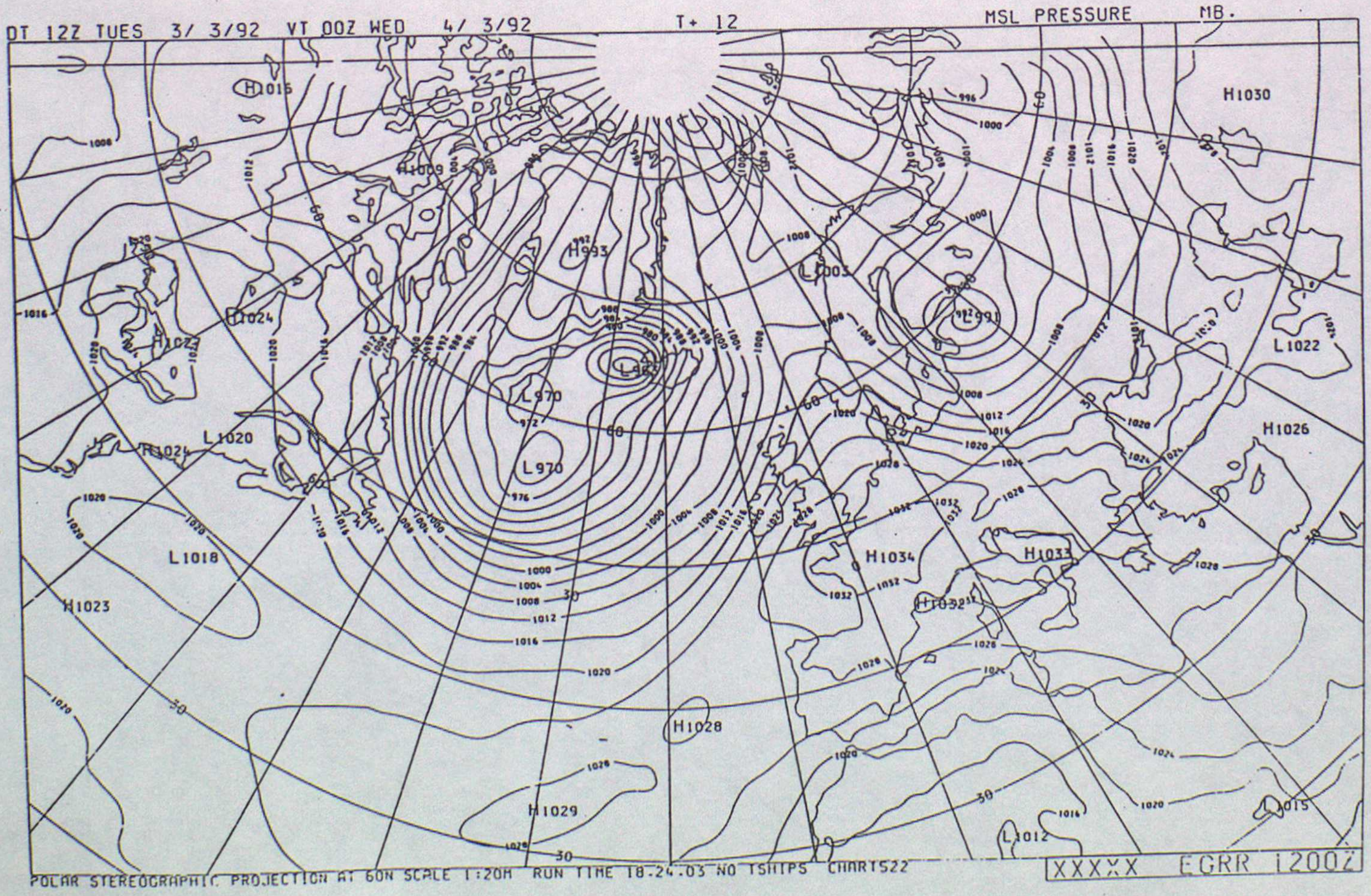


FIG. 2(c) CNTL

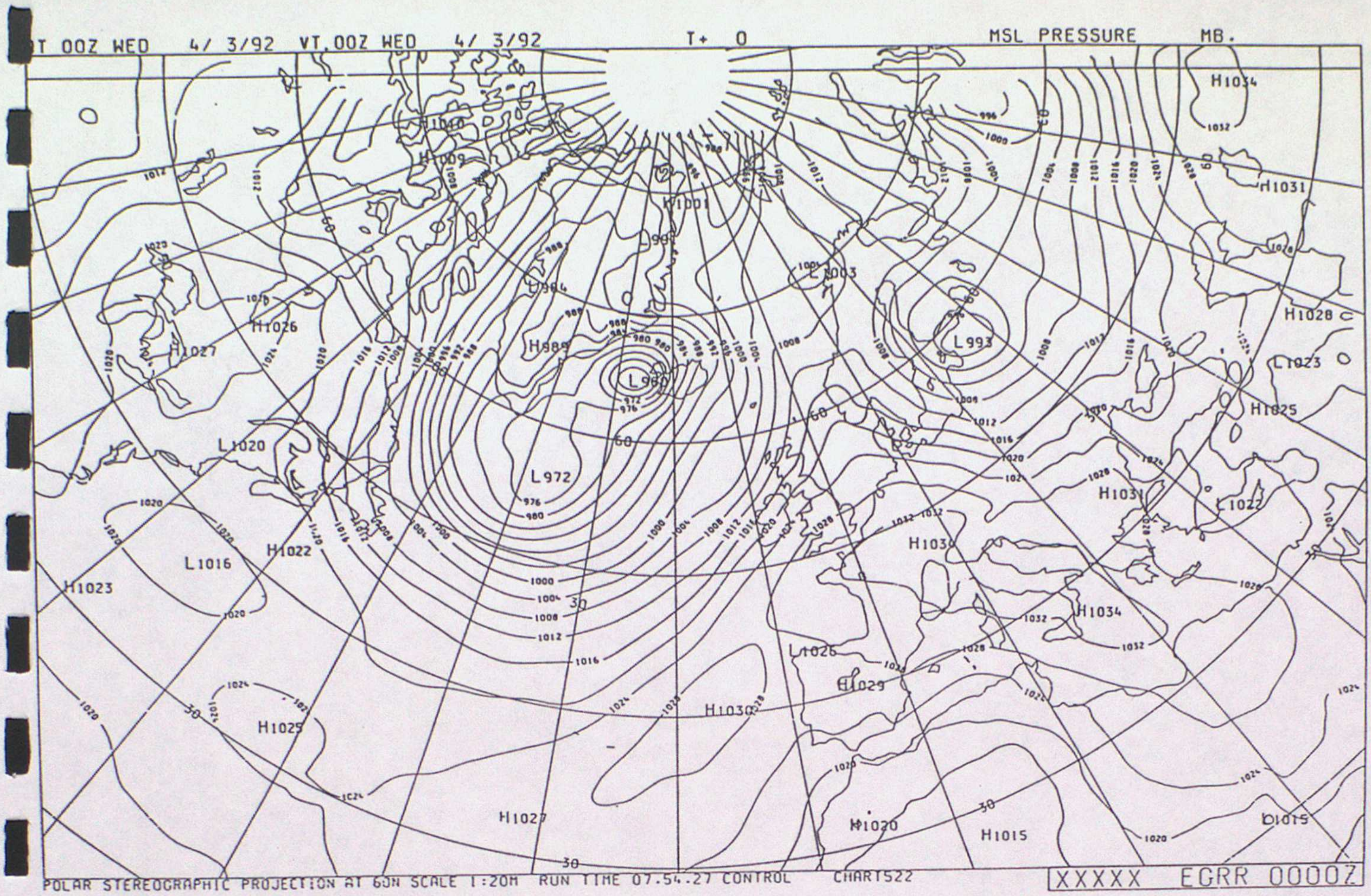


FIG. 2(d) NOTS

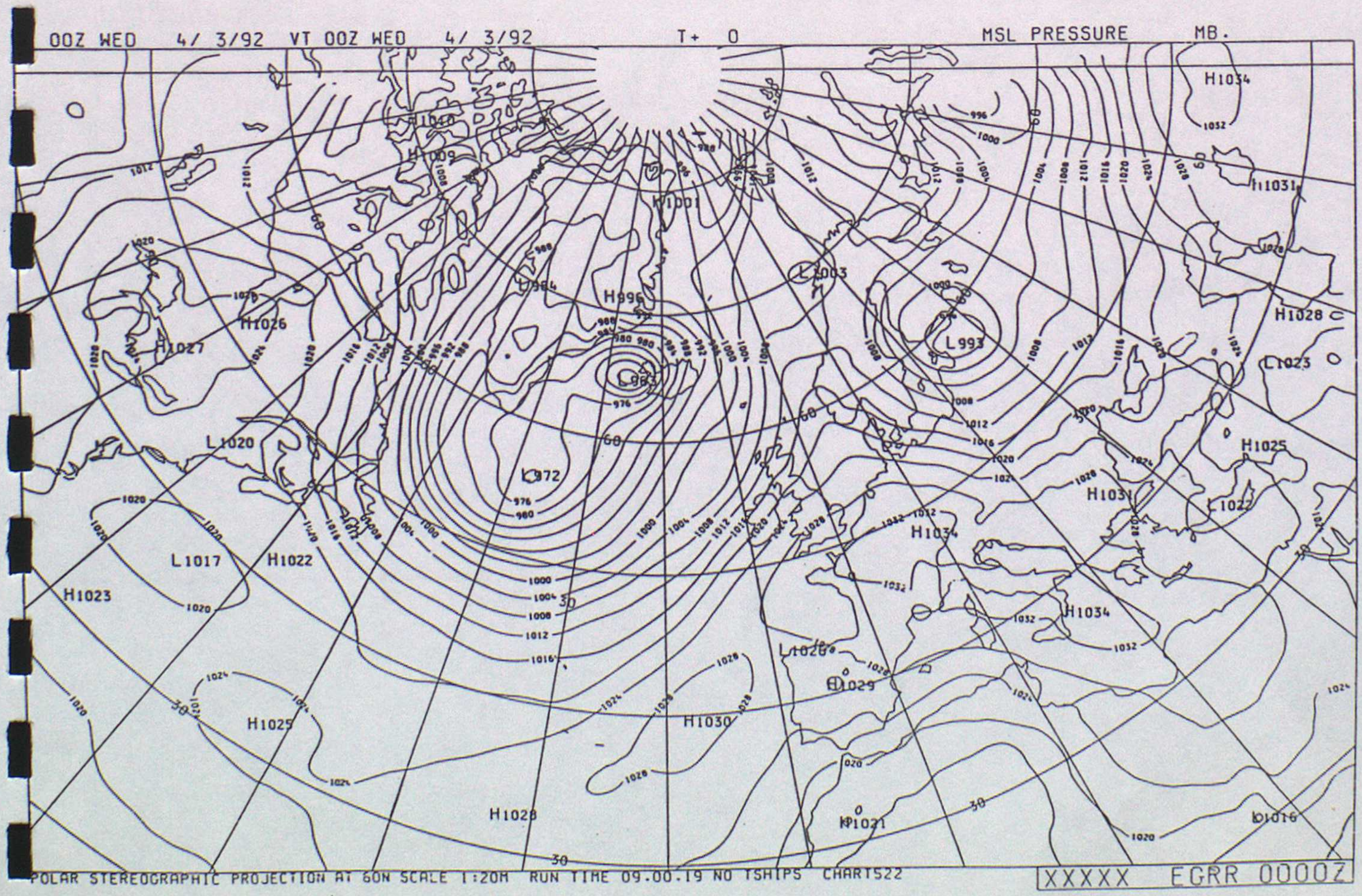
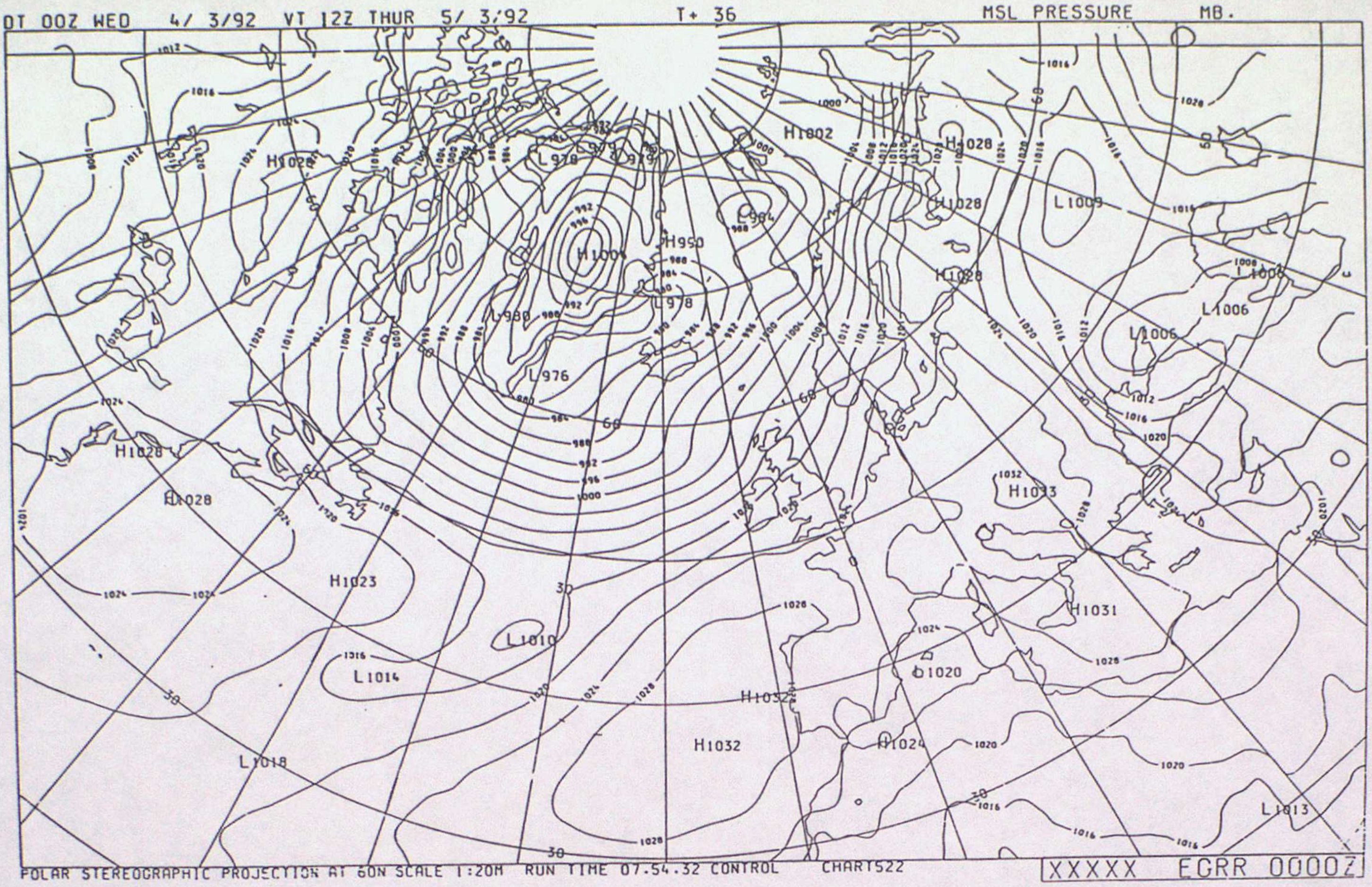


FIG. 3(a) CNTL

DT 00Z WED 4/ 3/92 VT 12Z THUR 5/ 3/92 T+ 36 MSL PRESSURE MB.



FOLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 07.54.32 CONTROL CHART522 XXXXX EGRR 0000Z

FIG. 3(b) NOTS

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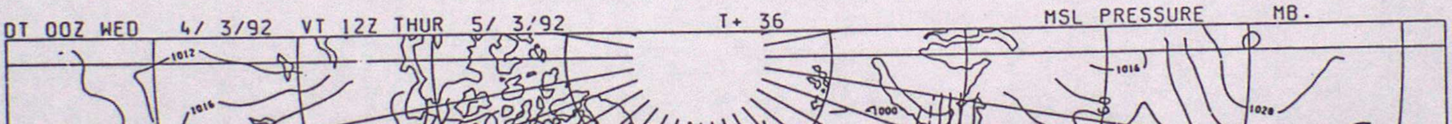

FOLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 09.00.24 NO TSHIPS CHART522 XXXXX EGRR 0000Z

Fig. 3(c) CNTL

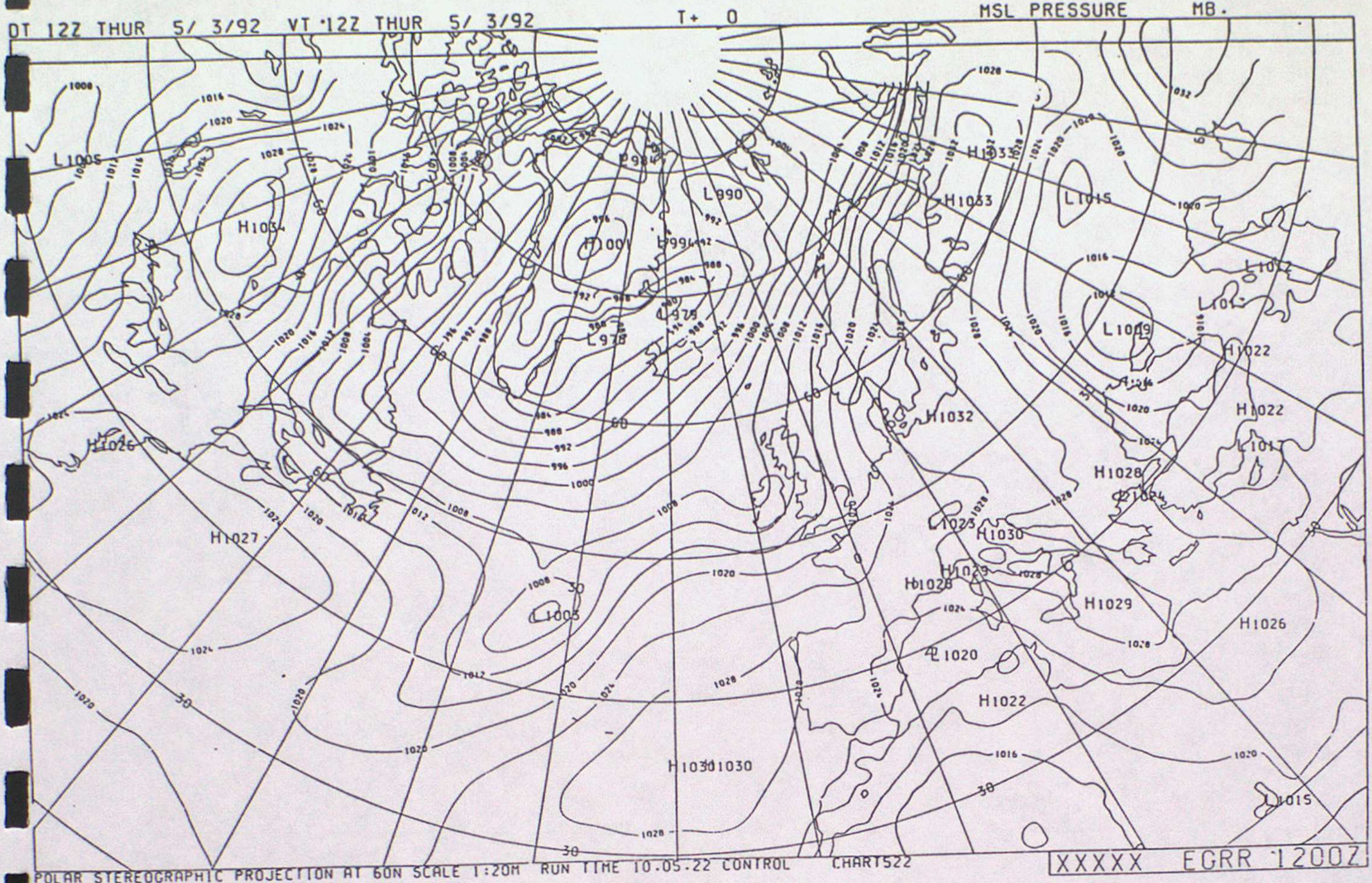

FIG. 3(d) NOTS

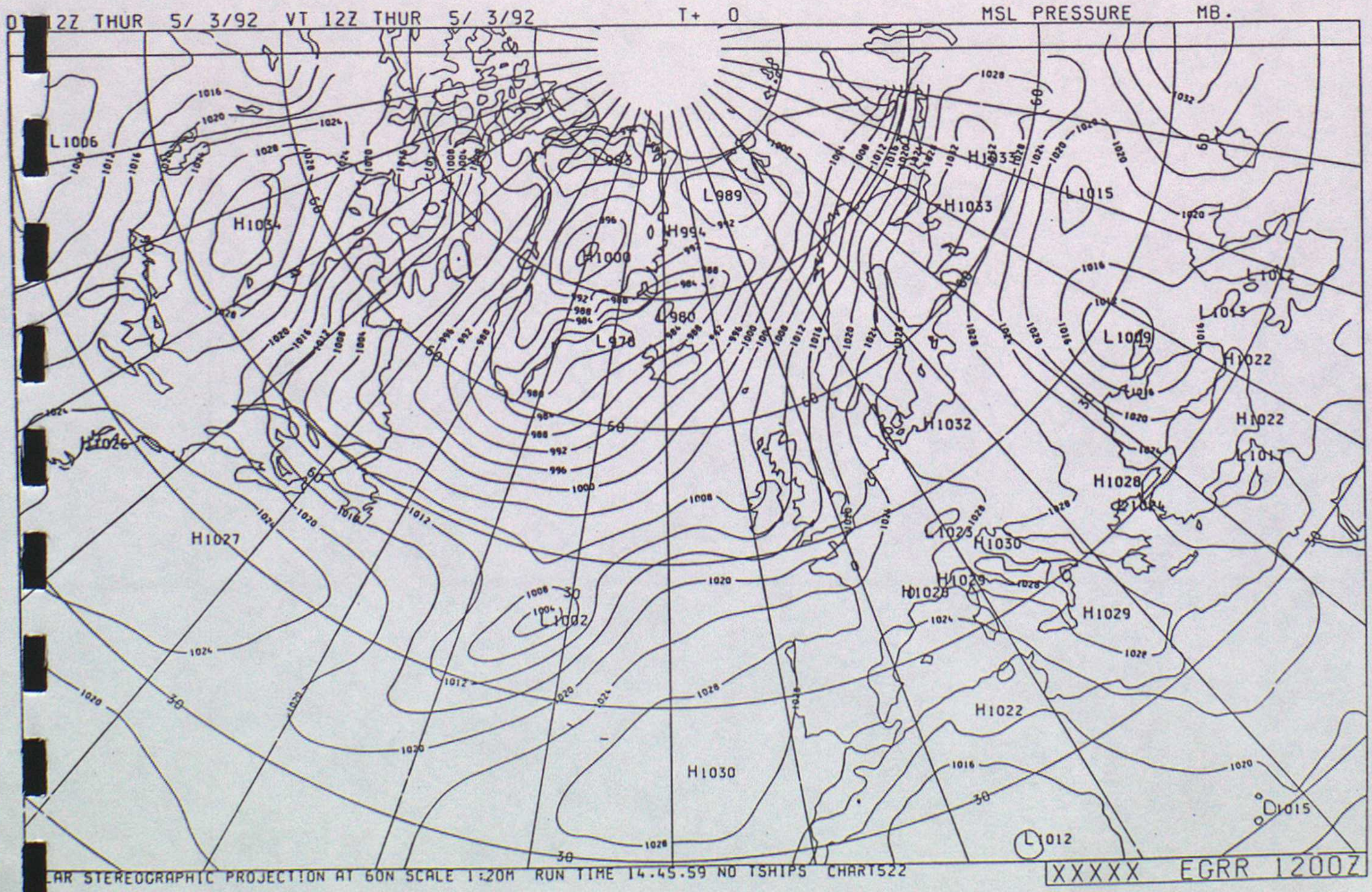

FIG. 4(a) CNTL

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LEVEL: 250 MB

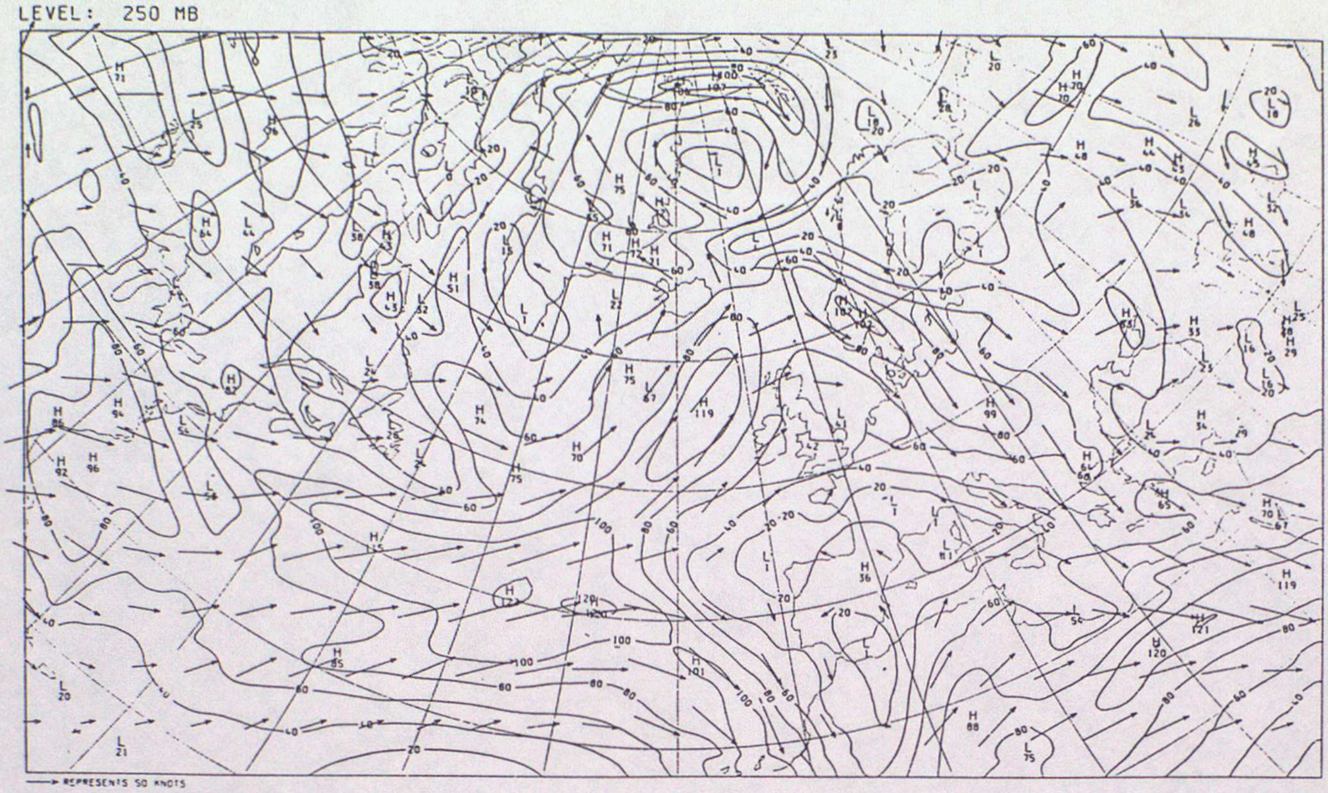

FIG. 4(b) NOTS

250MB ISOTACHS AND WIND ARROWS
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VALID AT 0Z ON 4/3/1992 DAY 64 DATA TIME 0Z ON 4/3/1992 DAY 64
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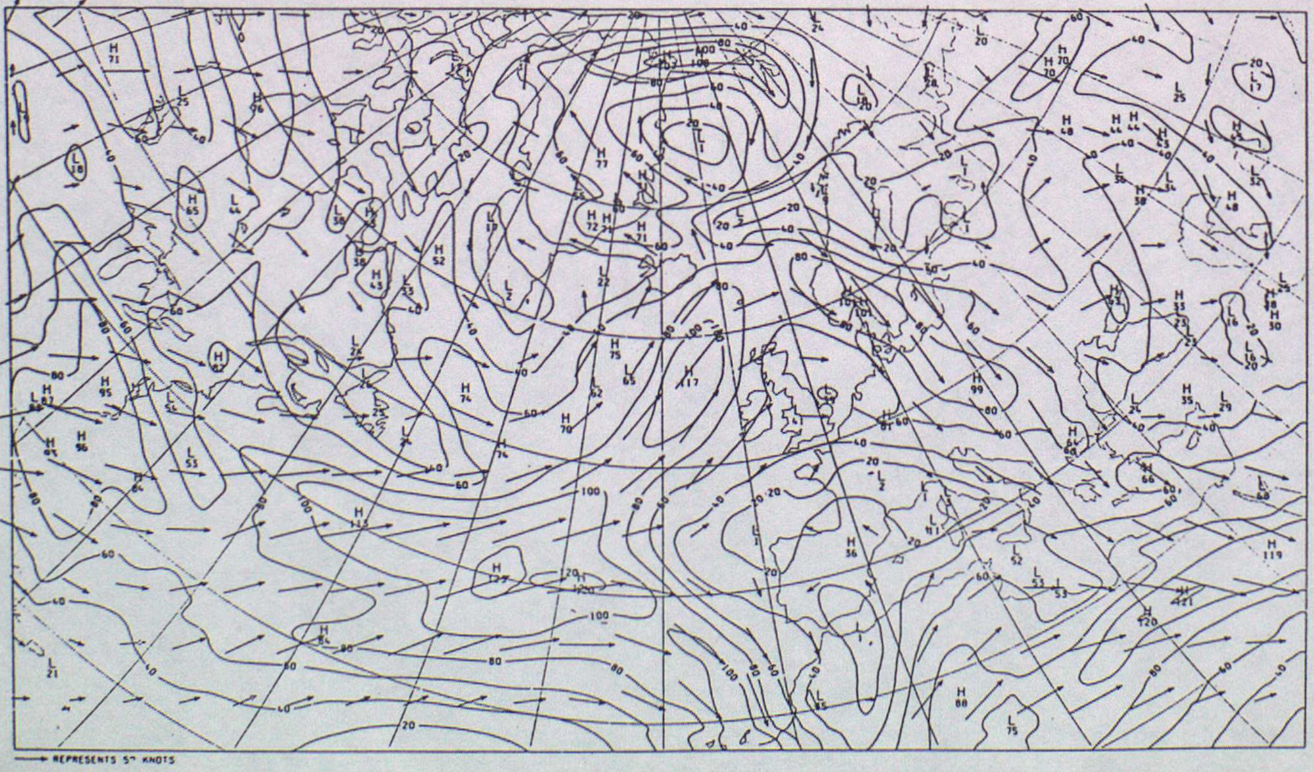

Fig. 4(c) CNTL-NOTS

250MB WIND SPEED DIFFERENCE CHART (KNOTS)
CONTROL - RERUN WITHOUT TEMPSHIPS
VALID AT 12Z ON 4/3/1992 DAY 64 DATA TIME 0Z ON 4/3/1992 DAY 64
T+12

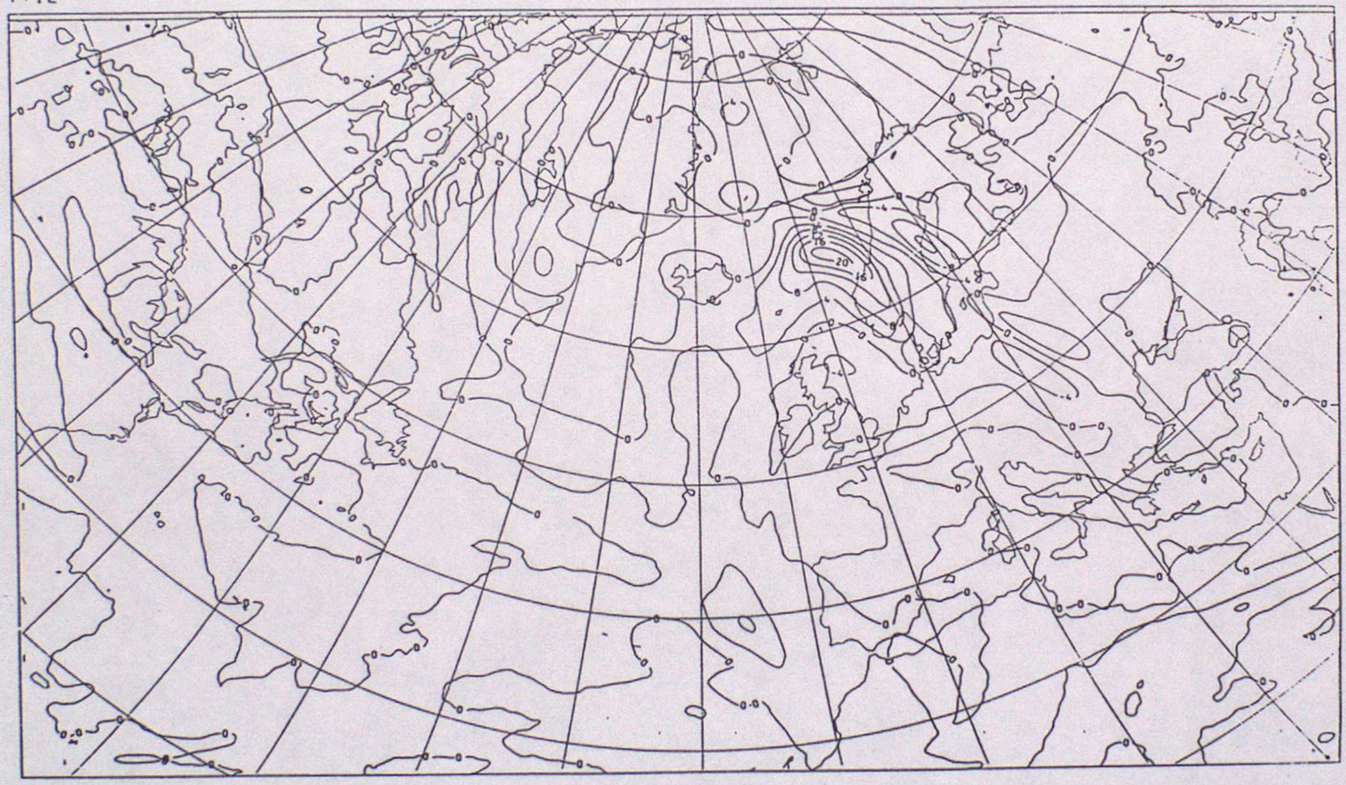

FIG. 4(d) CNTL

250MB ISOTACHS AND WIND ARROWS
CONTROL FORECAST
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LEVEL: 250 MB T+12

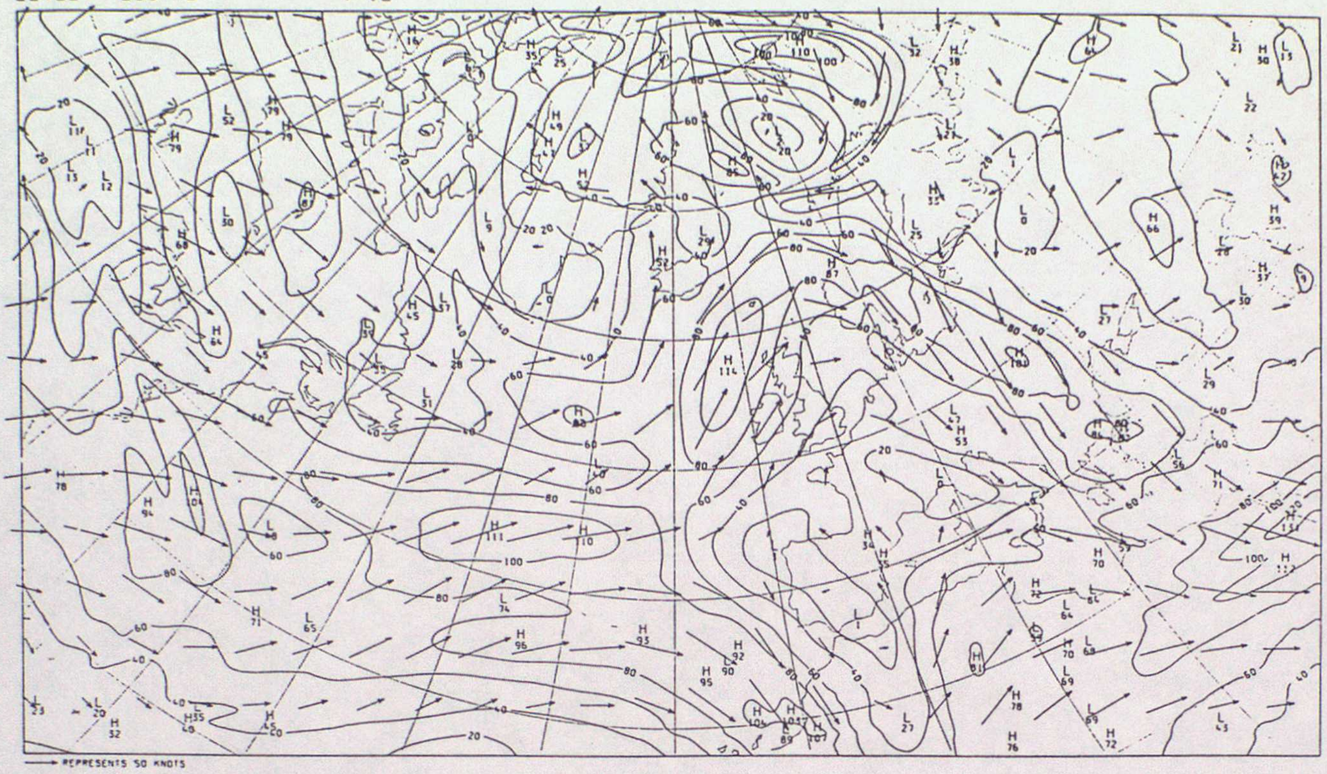

FIG. 4(e) NOTS

250MB ISOTACHS AND WIND ARROWS
NO TEMPSHIP FORECAST
VALID AT 12Z ON 4/3/1992 DAY 64 DATA TIME 0Z ON 4/3/1992 DAY 64
LEVEL: 250 MB T+12

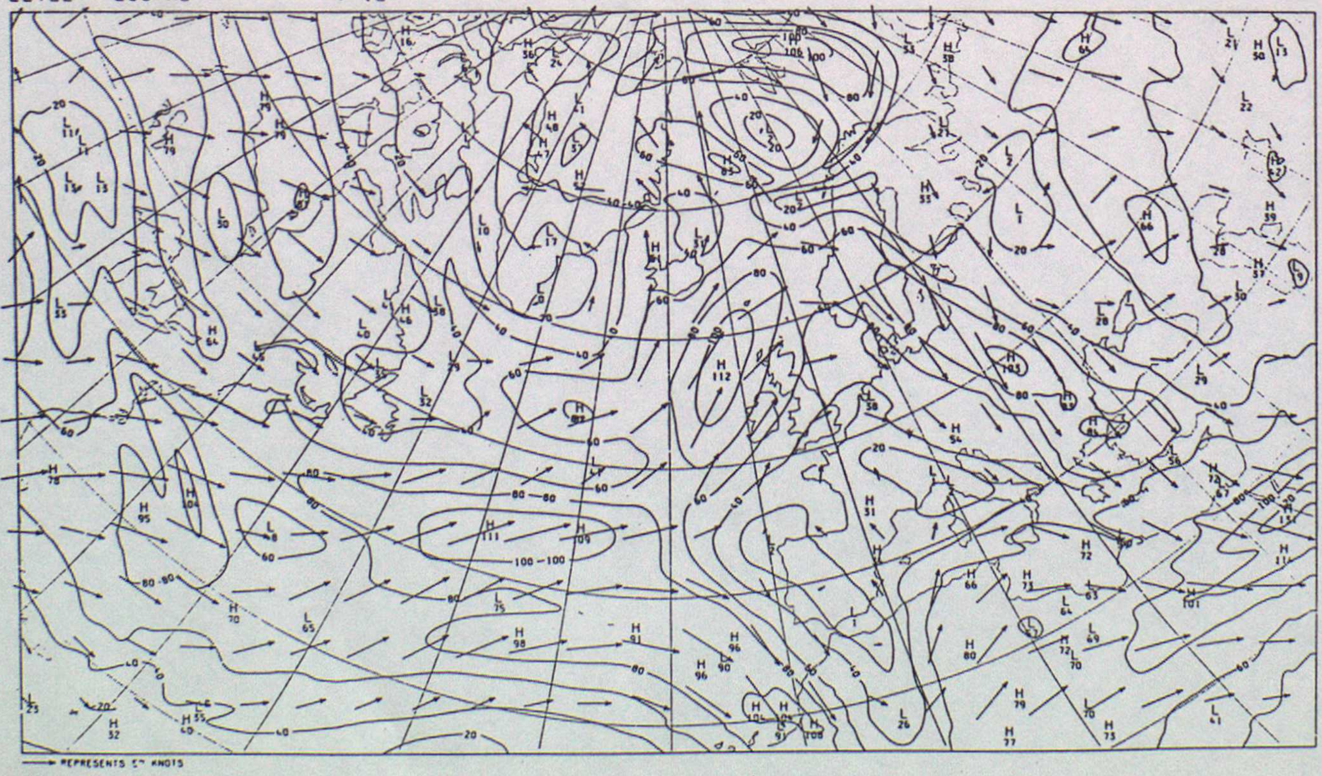

FIG. 4(f) CNTL

250MB ISOTACHS AND WIND ARROWS
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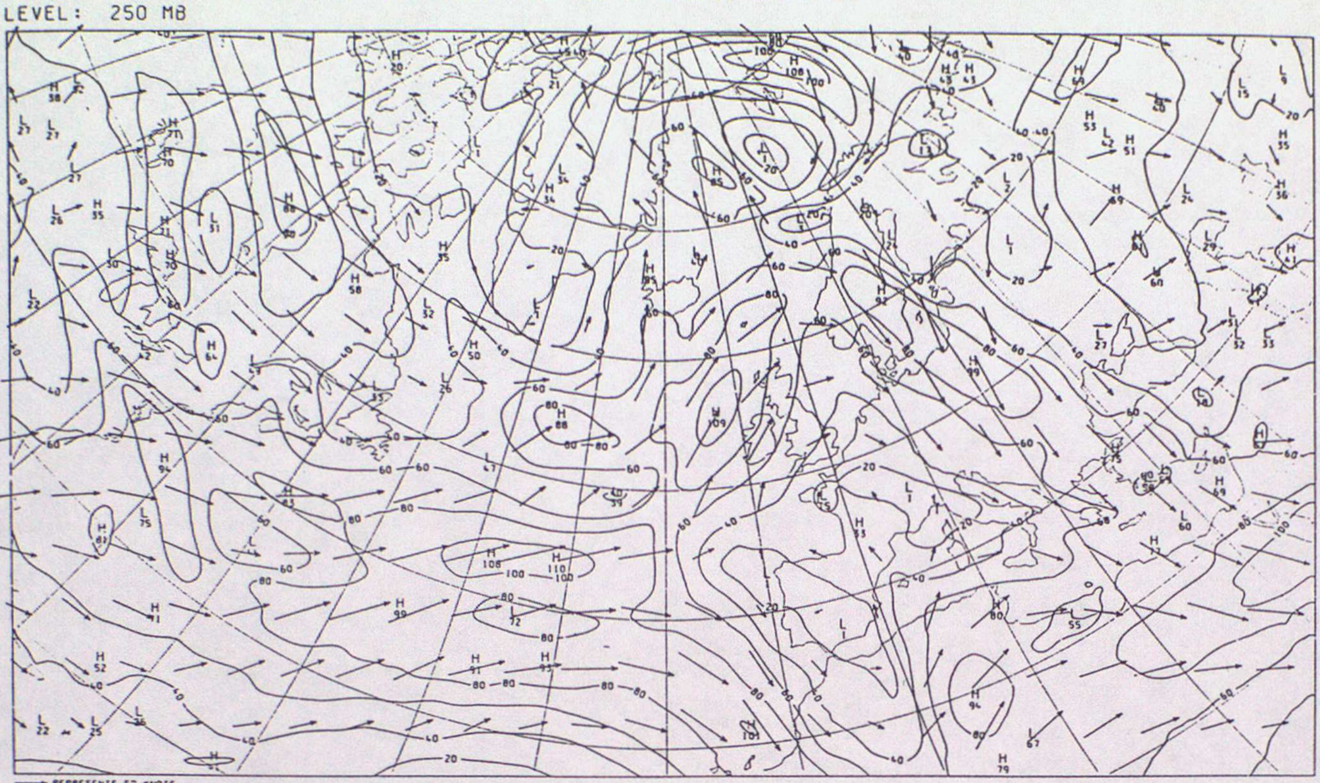
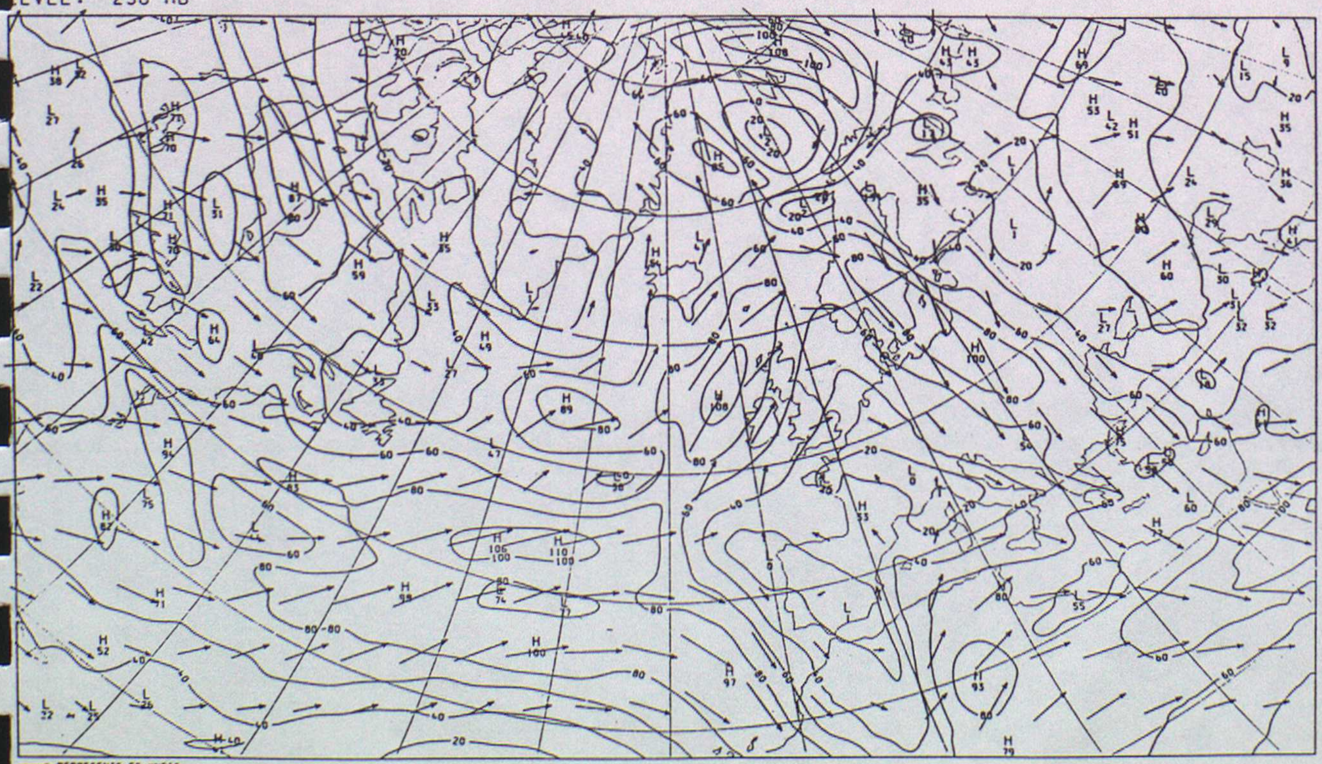
LEVEL: 250 MB



REPRESENTS 50 KNOTS

FIG. 4(g) NOTS

250MB ISOTACHS AND WIND ARROWS
NO TEMPSHIP ANALYSIS
VALID AT 12Z ON 4/3/1992 DAY 64 DATA TIME 12Z ON 4/3/1992 DAY 64
LEVEL: 250 MB



REPRESENTS 50 KNOTS

FIG. 5(a) CNTL - NOTS

850MB RELATIVE HUMIDITY DIFFERENCE CHART (%)
CONTROL - RERUN WITHOUT TEMPSHIPS
VALID AT 0Z ON 4/3/1992 DAY 64 DATA TIME 0Z ON 4/3/1992 DAY 64

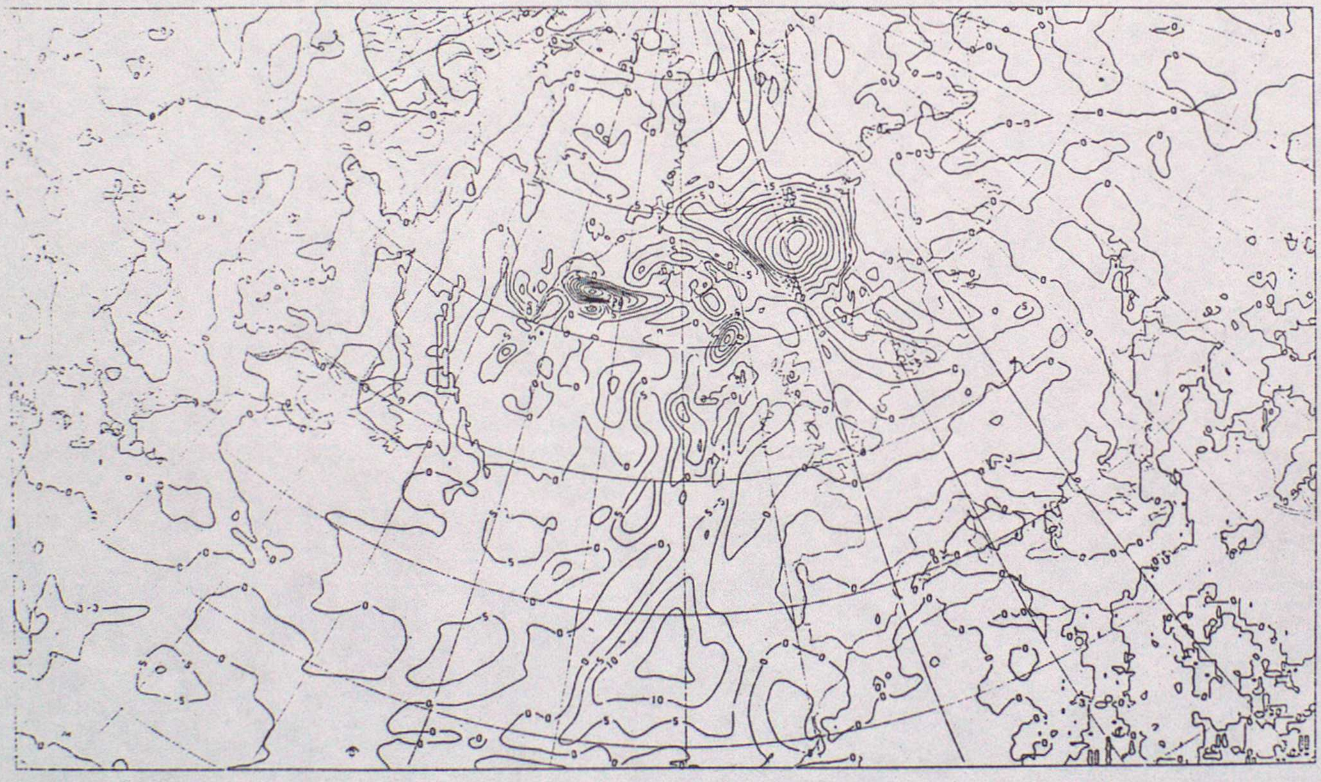
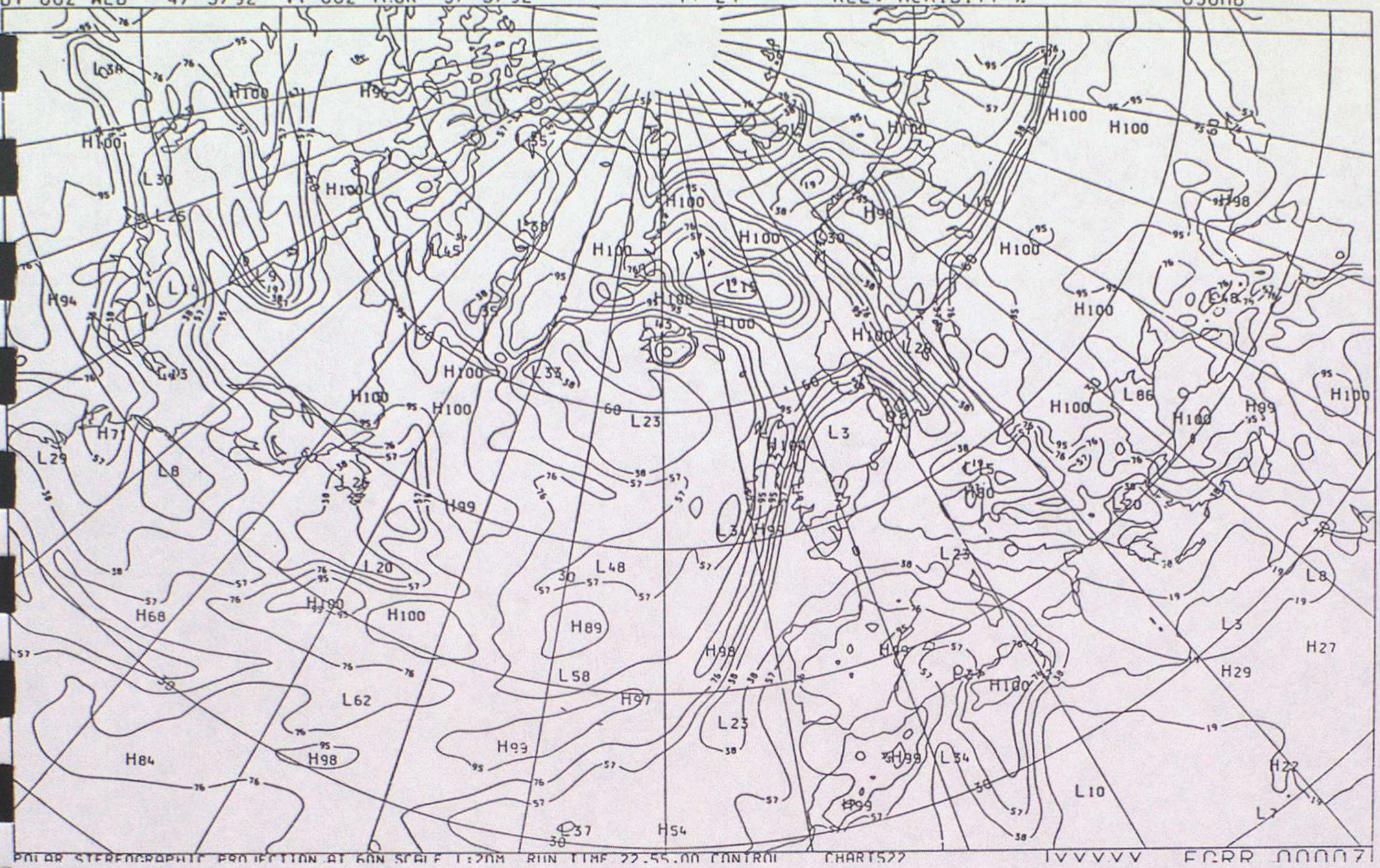


FIG. 5(b) CNTL

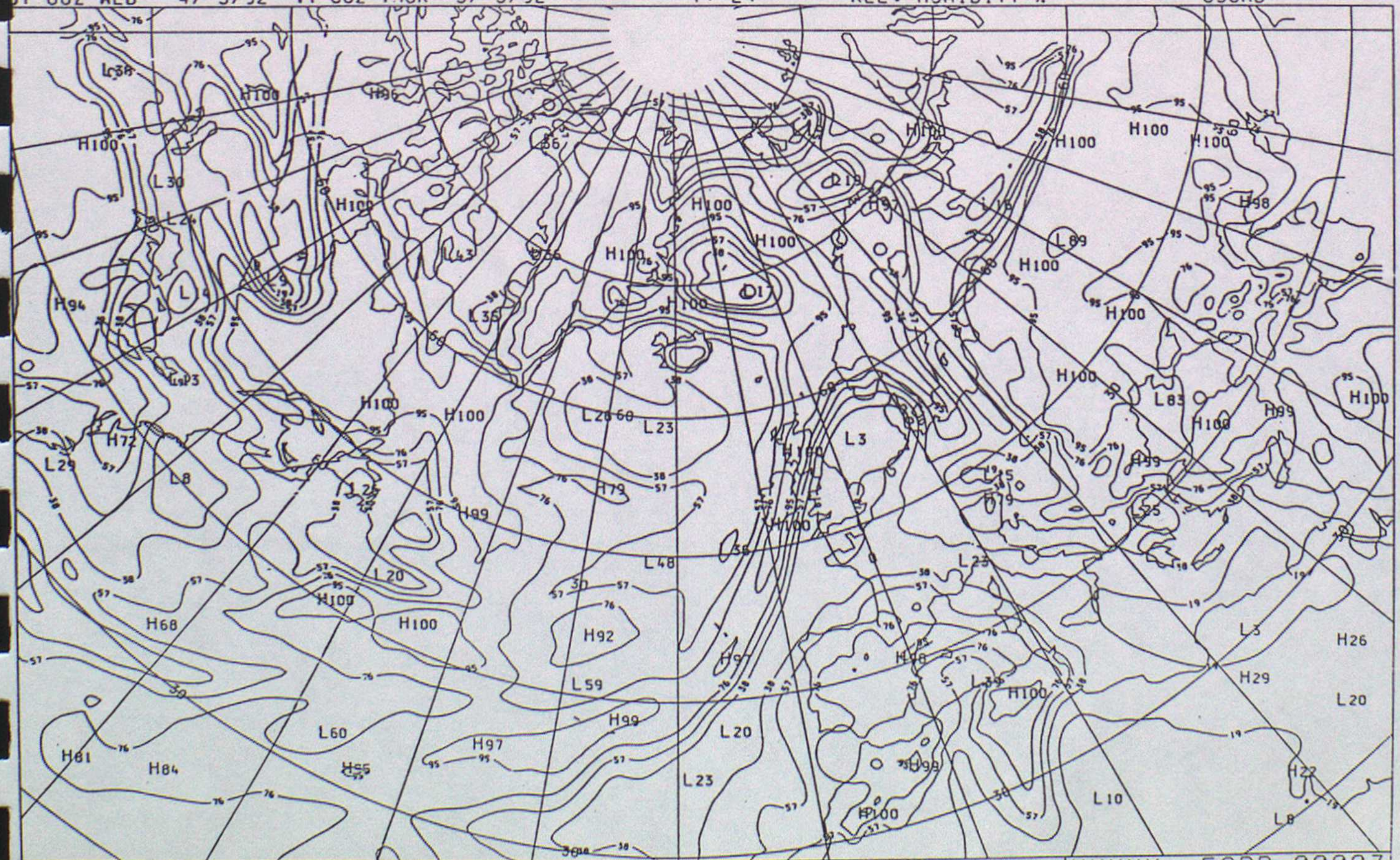
DT 00Z WED 4/ 3/92 VT 00Z THUR 5/ 3/92 T+ 24 REL. HUMIDITY % 850MB



POLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 22.55.00 CONTROL CHART522 XXXXX EGRR 0000Z

FIG. 5(c) NOTS

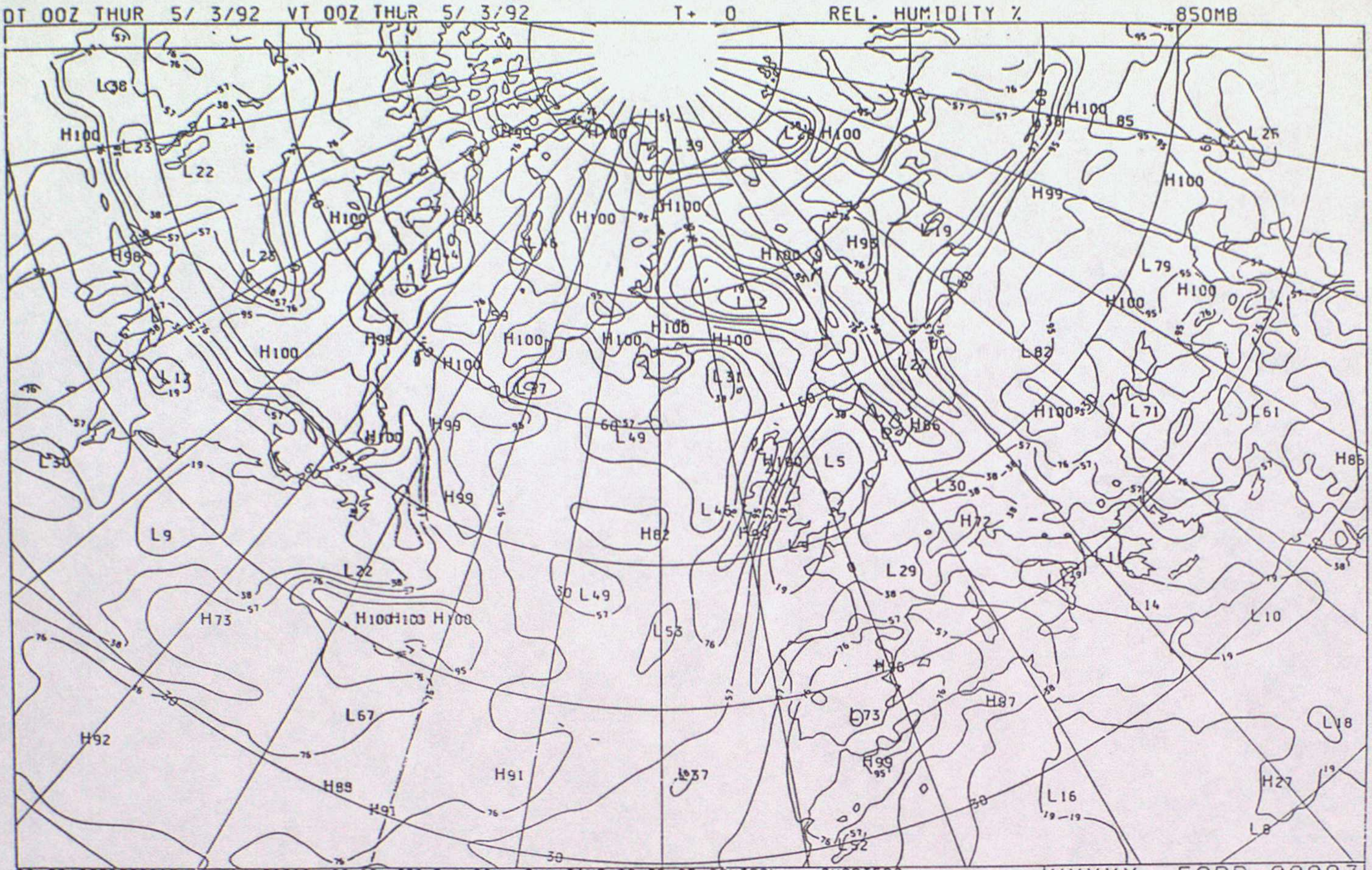
DT 00Z WED 4/ 3/92 VT 00Z THUR 5/ 3/92 T+ 24 REL. HUMIDITY % 850MB



POLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 22.54.46 NO TSHIPS CHART522 XXXXX EGRR 0000Z

FIG. 5(d) CNTL

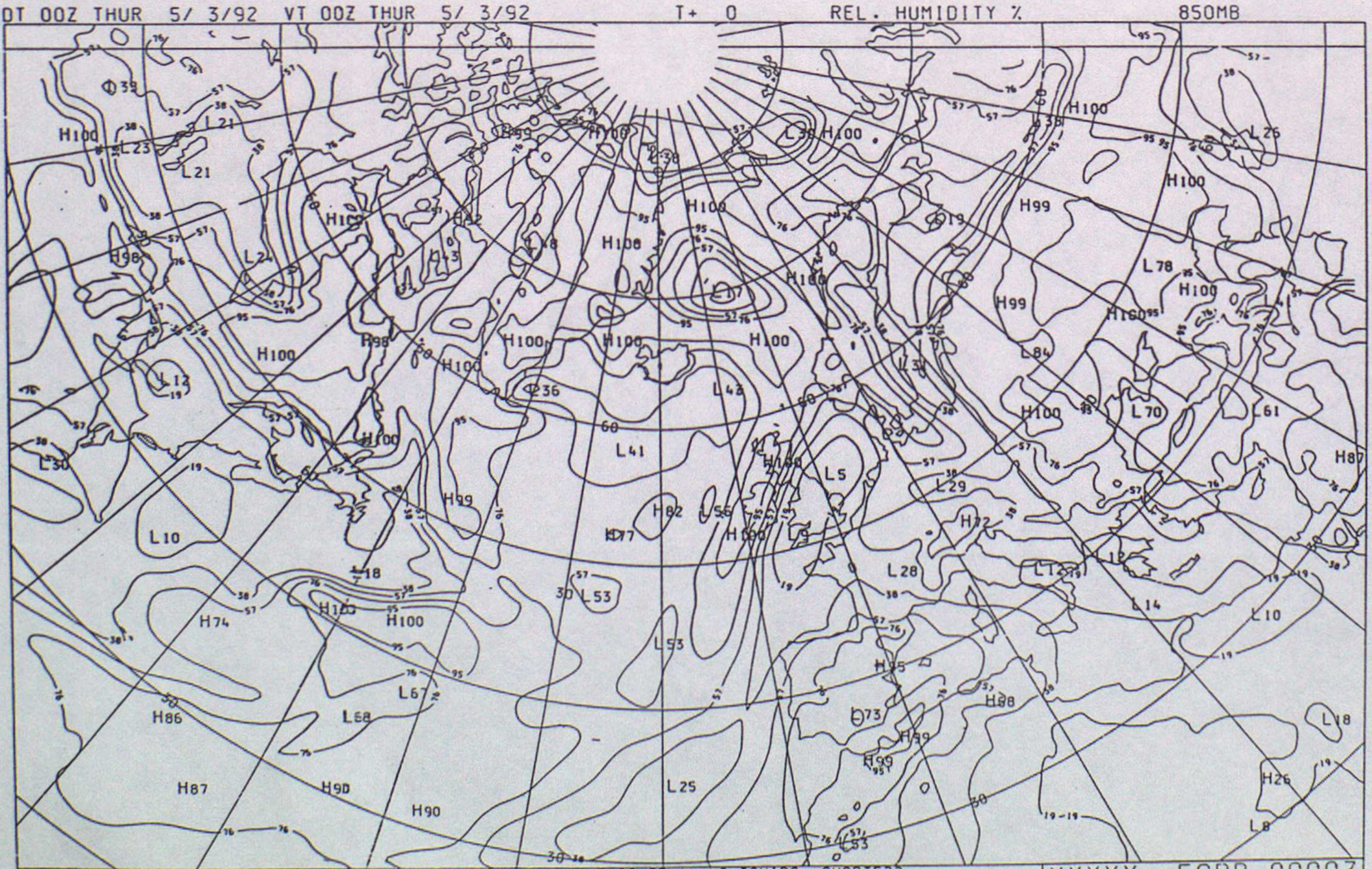
DT 00Z THUR 5/ 3/92 VT 00Z THUR 5/ 3/92 T+ 0 REL. HUMIDITY % 850MB



POLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 09.35.25 CONTROL CHART522 XXXXX EGRR 0000Z

FIG. 5(e) NOTS

DT 00Z THUR 5/ 3/92 VT 00Z THUR 5/ 3/92 T+ 0 REL. HUMIDITY % 850MB



POLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 09.35.14 NO TSHIPS CHART522 XXXXX EGRR 0000Z

FIG. 6(a) CNTL-NOTS

250MB WIND SPEED DIFFERENCE CHART (KNOTS)
CONTROL - RERUN WITHOUT TEMPSHIPS
VALID AT 12Z ON 5/3/1992 DAY 65 DATA TIME 0Z ON 4/3/1992 DAY 64
T+36

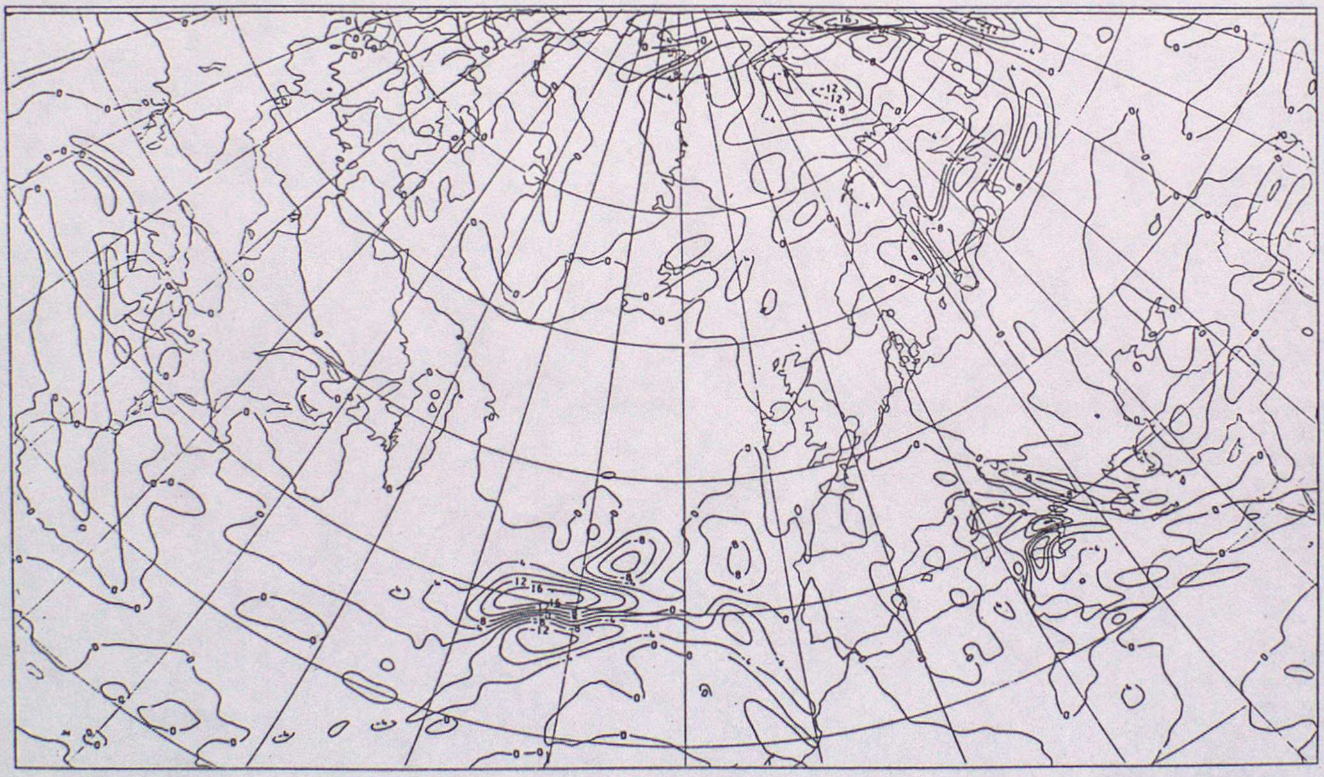
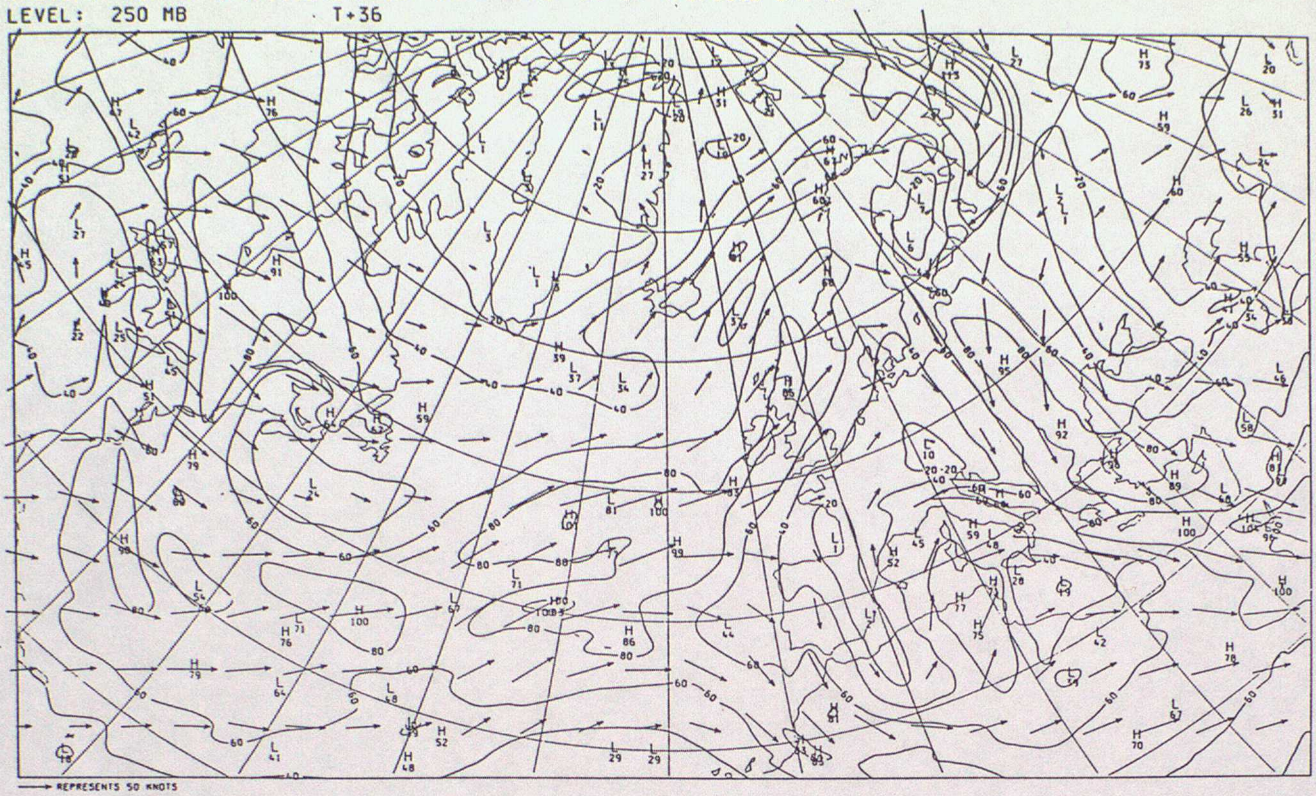


FIG. 6(b) CNTL

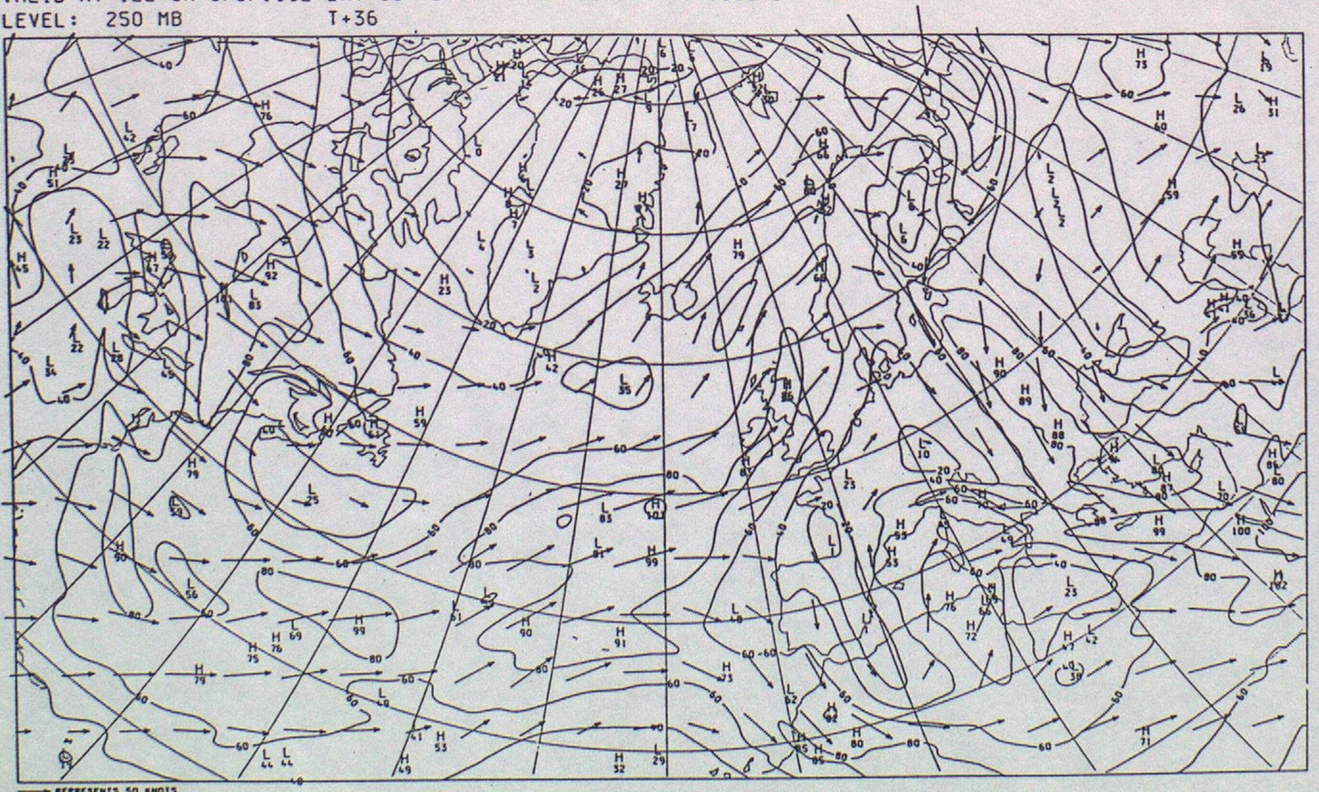
250MB ISOTACHS AND WIND ARROWS
CONTROL FORECAST
VALID AT 12Z ON 5/3/1992 DAY 65 DATA TIME 0Z ON 4/3/1992 DAY 64
LEVEL: 250 MB T+36



→ REPRESENTS 50 KNOTS

FIG. 6(c) NOTS

250MB ISOTACHS AND WIND ARROWS
NO TEMPSHIP FORECAST
VALID AT 12Z ON 5/3/1992 DAY 65 DATA TIME 0Z ON 4/3/1992 DAY 64
LEVEL: 250 MB T+36



→ REPRESENTS 50 KNOTS

FIG. 6(d) CNTL

250MB ISOTACHS AND WIND ARROWS
CONTROL ANALYSIS
VALID AT 12Z ON 5/3/1992 DAY 65 DATA TIME 12Z ON 5/3/1992 DAY 65
LEVEL: 250 MB

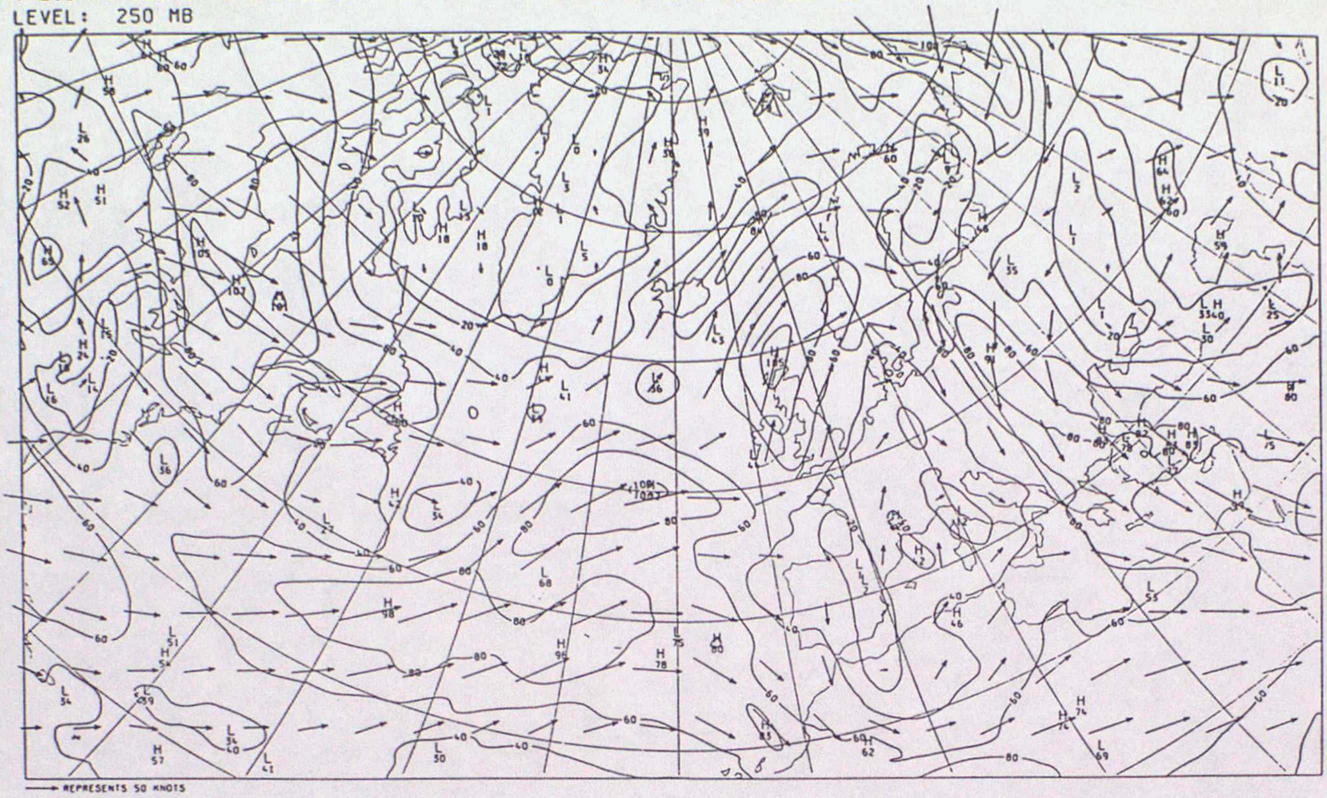


FIG. 6(e) NOTS

250MB ISOTACHS AND WIND ARROWS
NO TEMPSHIP ANALYSIS
VALID AT 12Z ON 5/3/1992 DAY 65 DATA TIME 12Z ON 5/3/1992 DAY 65
LEVEL: 250 MB

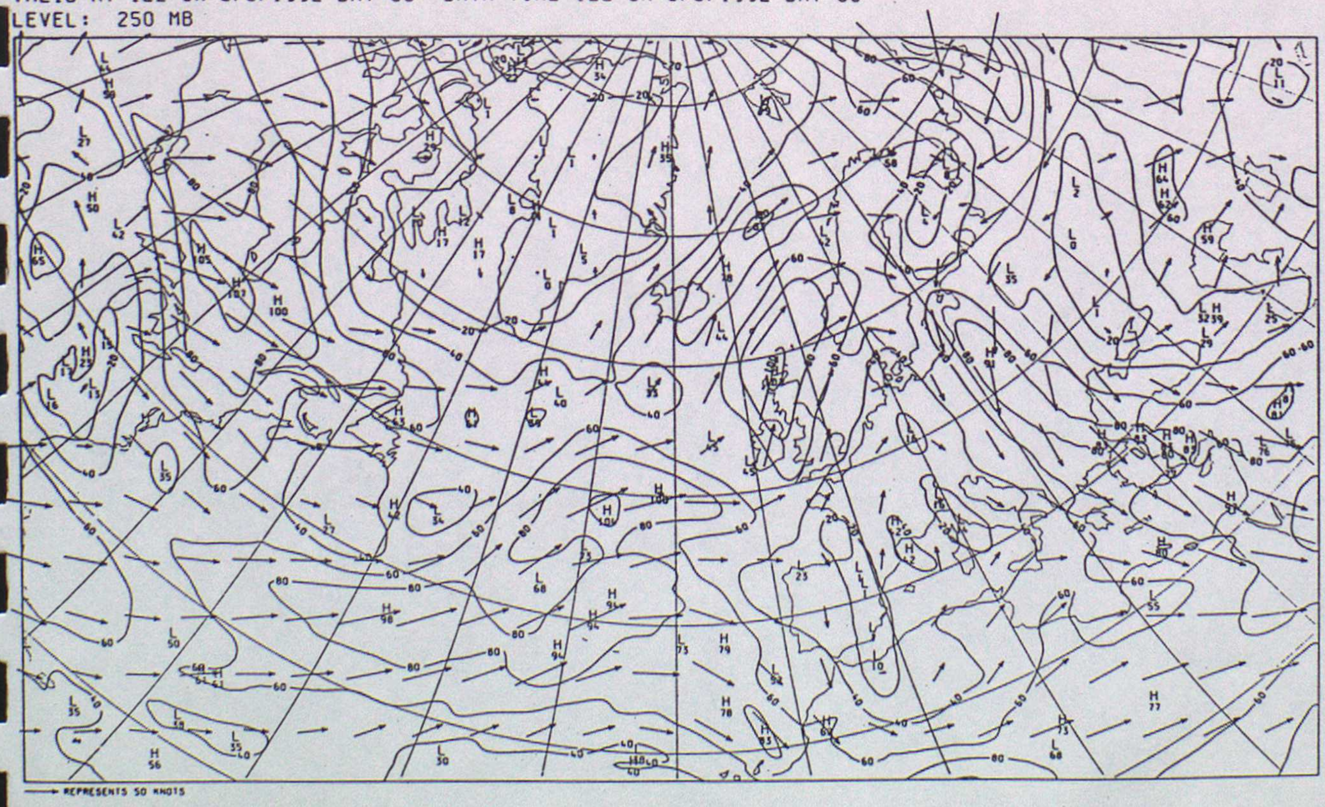


FIG. 7(a) CNTL

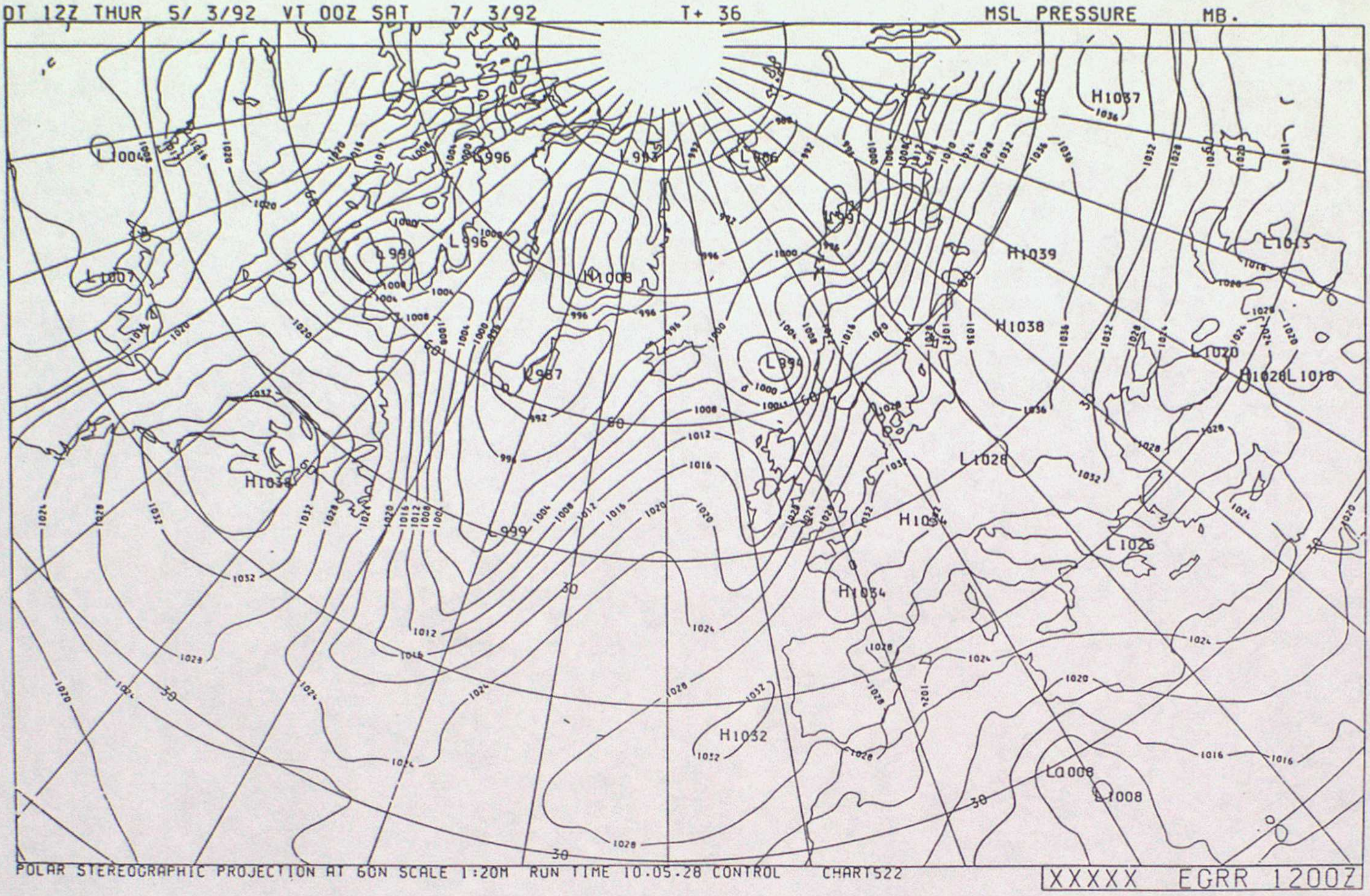


FIG. 7(b) NOTS

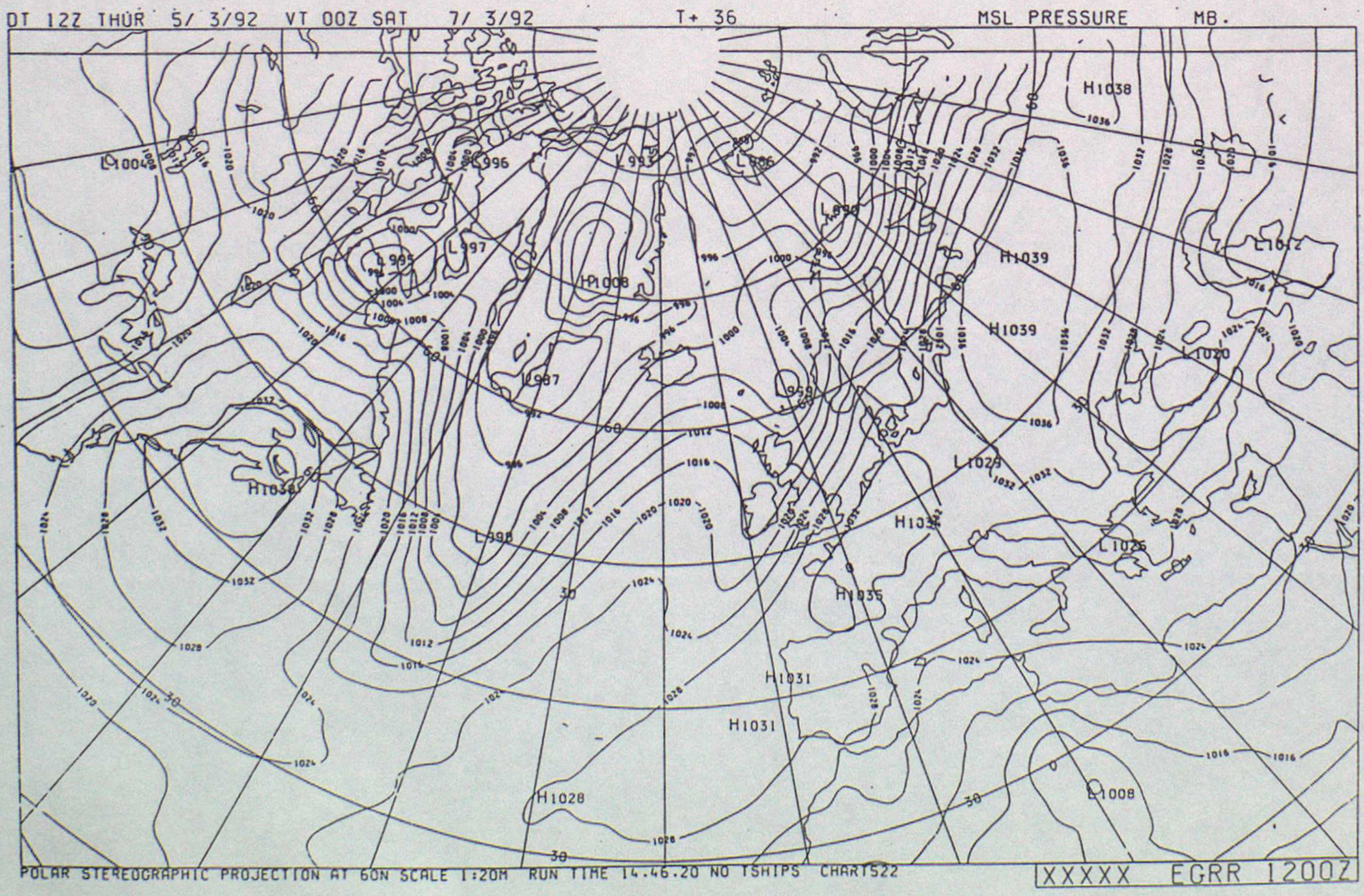


FIG. 7(c) CNTL-NOTS

MSLP DIFFERENCE CHART (MB)
CONTROL - RERUN WITHOUT TEMPSHIPS
VALID AT 0Z ON 7/3/1992 DAY 67 DATA TIME 12Z ON 5/3/1992 DAY 65
T+36

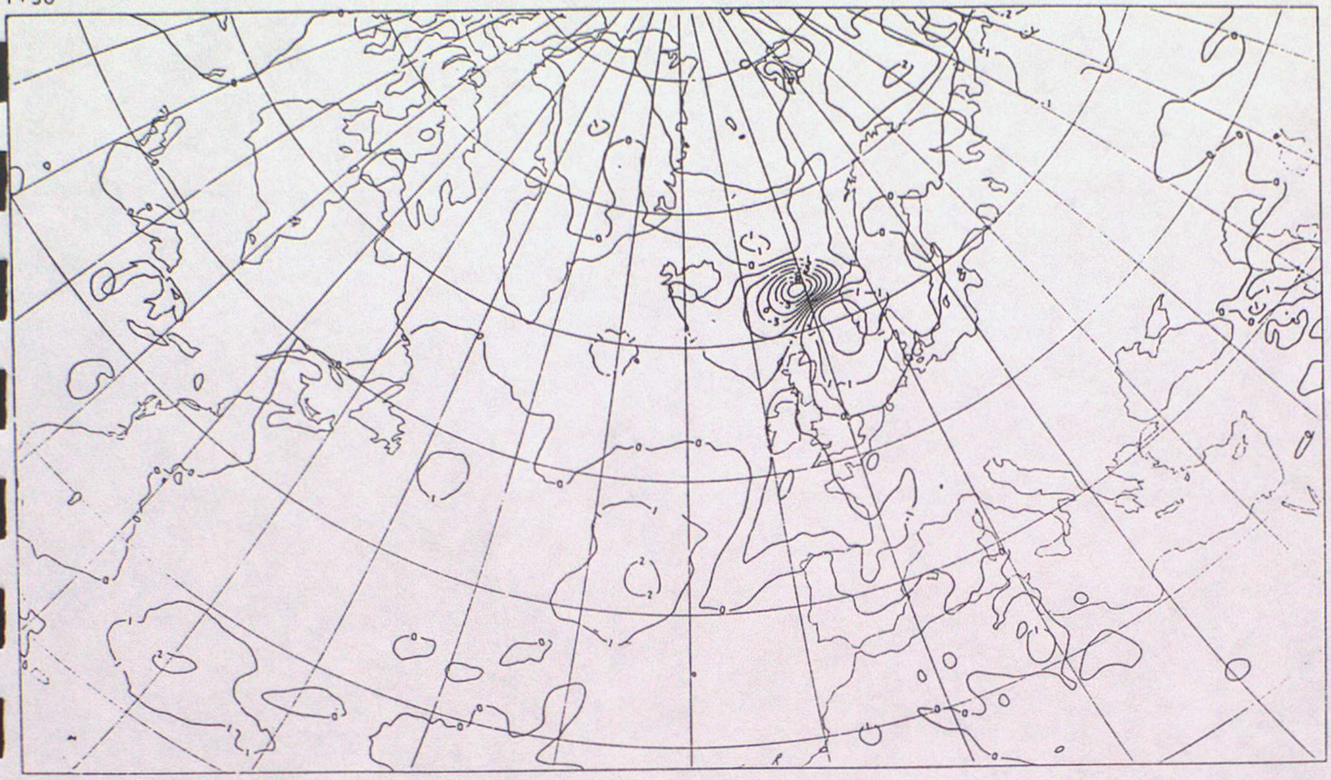
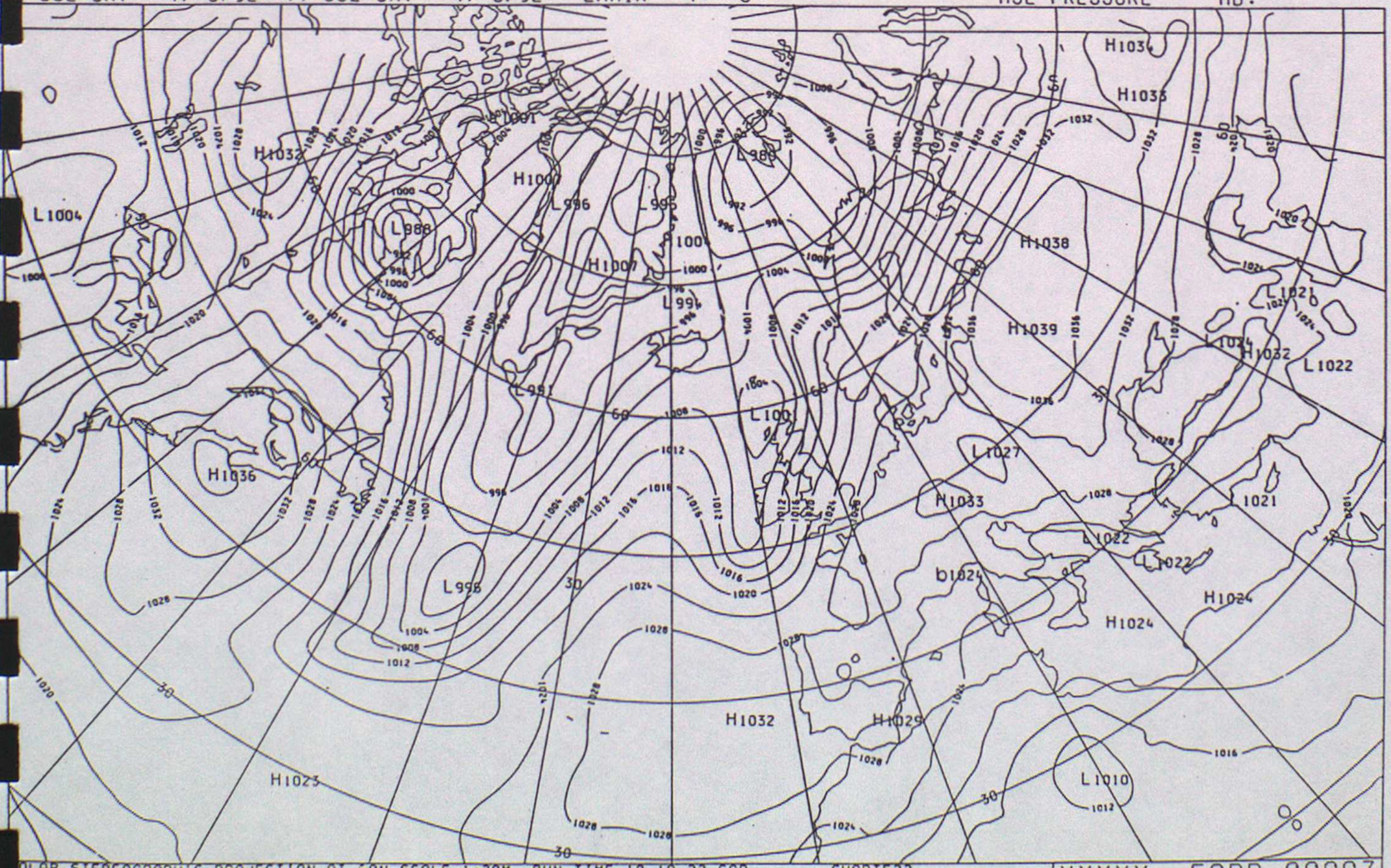


FIG. 7(d) OPER

00Z SAT 7/ 3/92 VT 00Z SAT 7/ 3/92 LMAIN T+ 0 MSL PRESSURE MB.



POLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 10.18.22 COP CHART522 XXXXX EGRR 0000Z

FIG. 7(e) CNTL

250MB ISOTACHS AND WIND ARROWS
CONTROL FORECAST
VALID AT 12Z ON 6/3/1992 DAY 66 DATA TIME 12Z ON 5/3/1992 DAY 65
LEVEL: 250 MB T+24

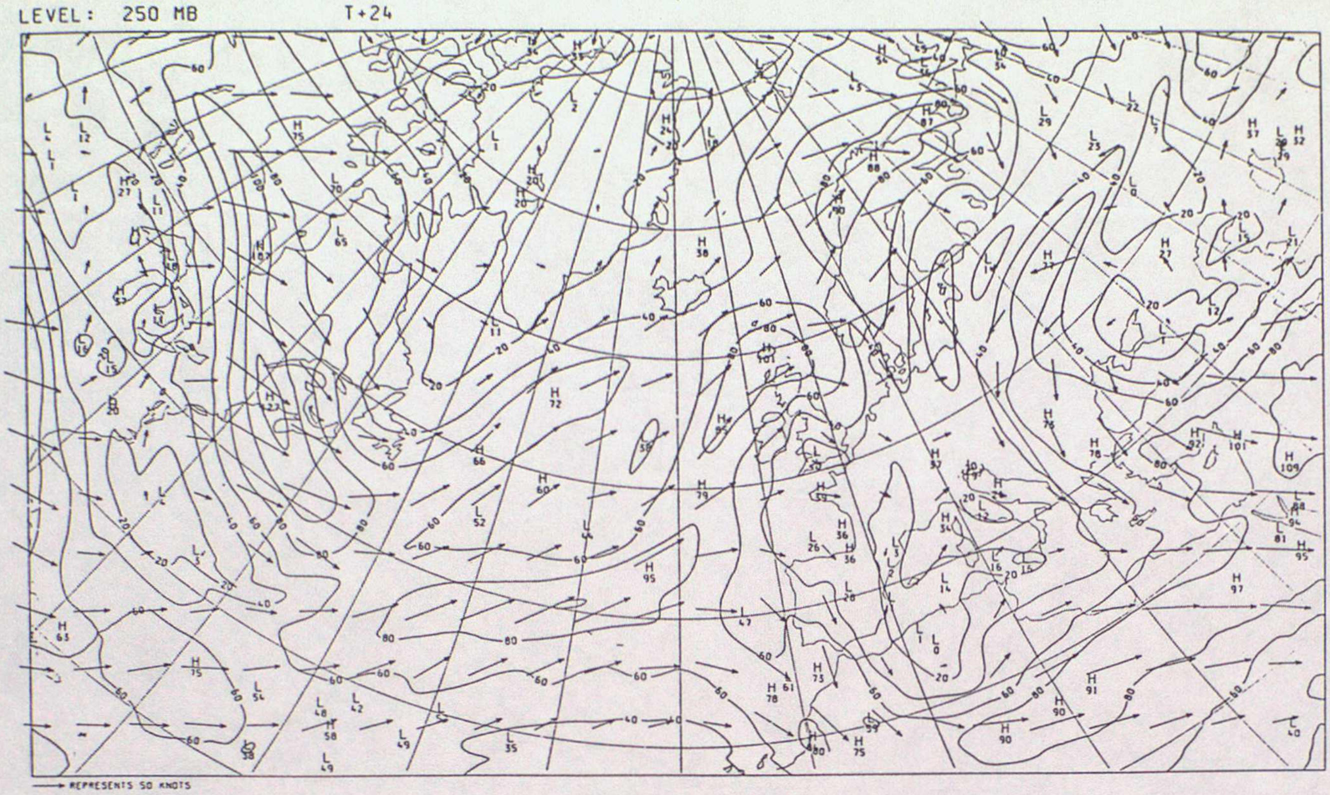


FIG. 7(f) NOTS

250MB ISOTACHS AND WIND ARROWS
NO TEMPSHIP FORECAST
VALID AT 12Z ON 6/3/1992 DAY 66 DATA TIME 12Z ON 5/3/1992 DAY 65
LEVEL: 250 MB T+24

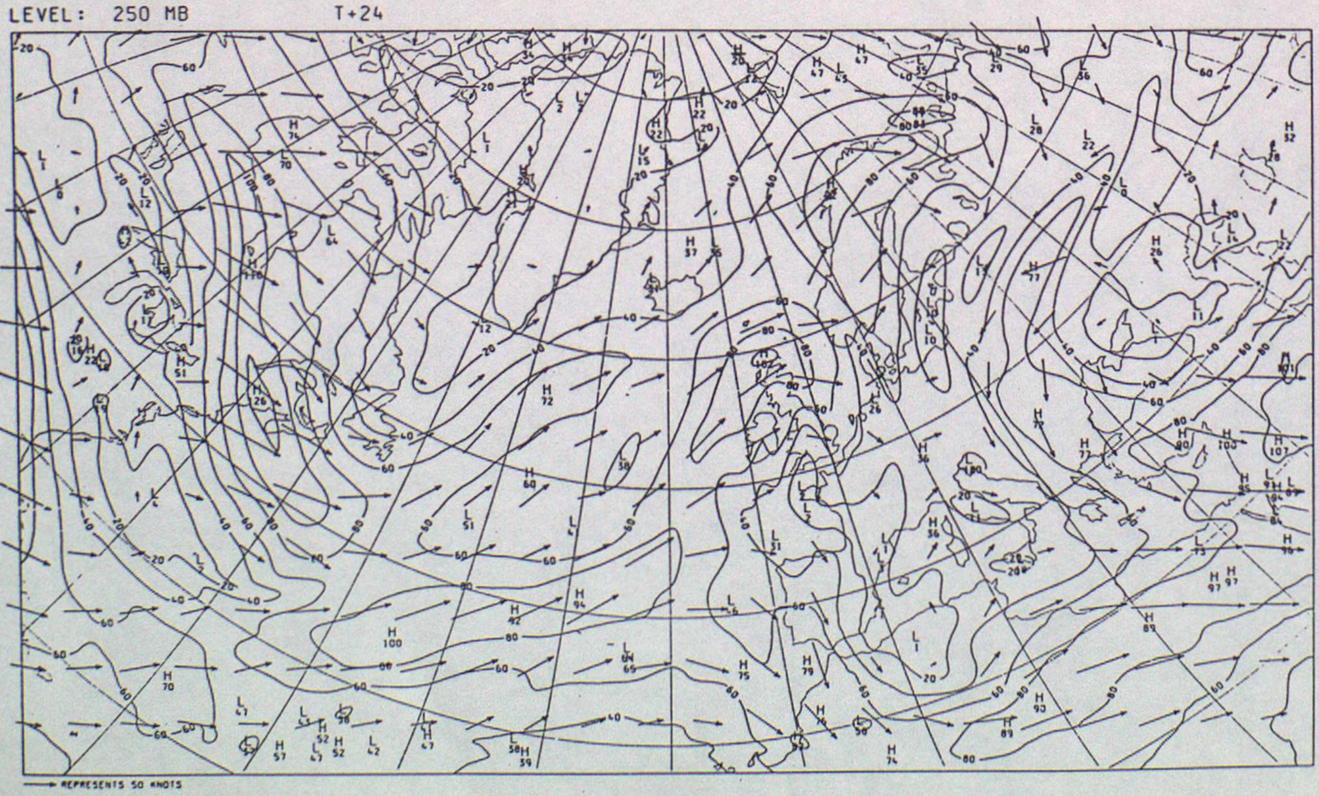
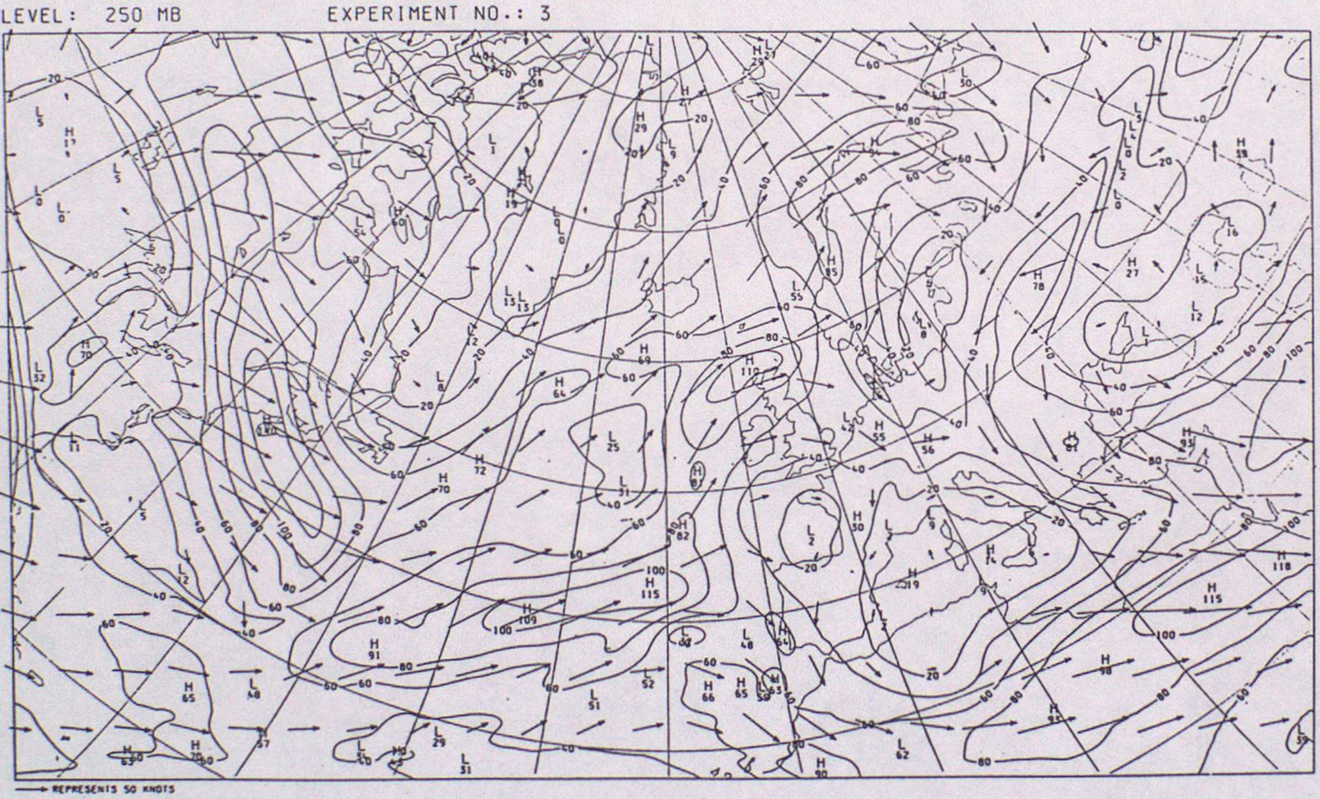


FIG. 7(g) OPER

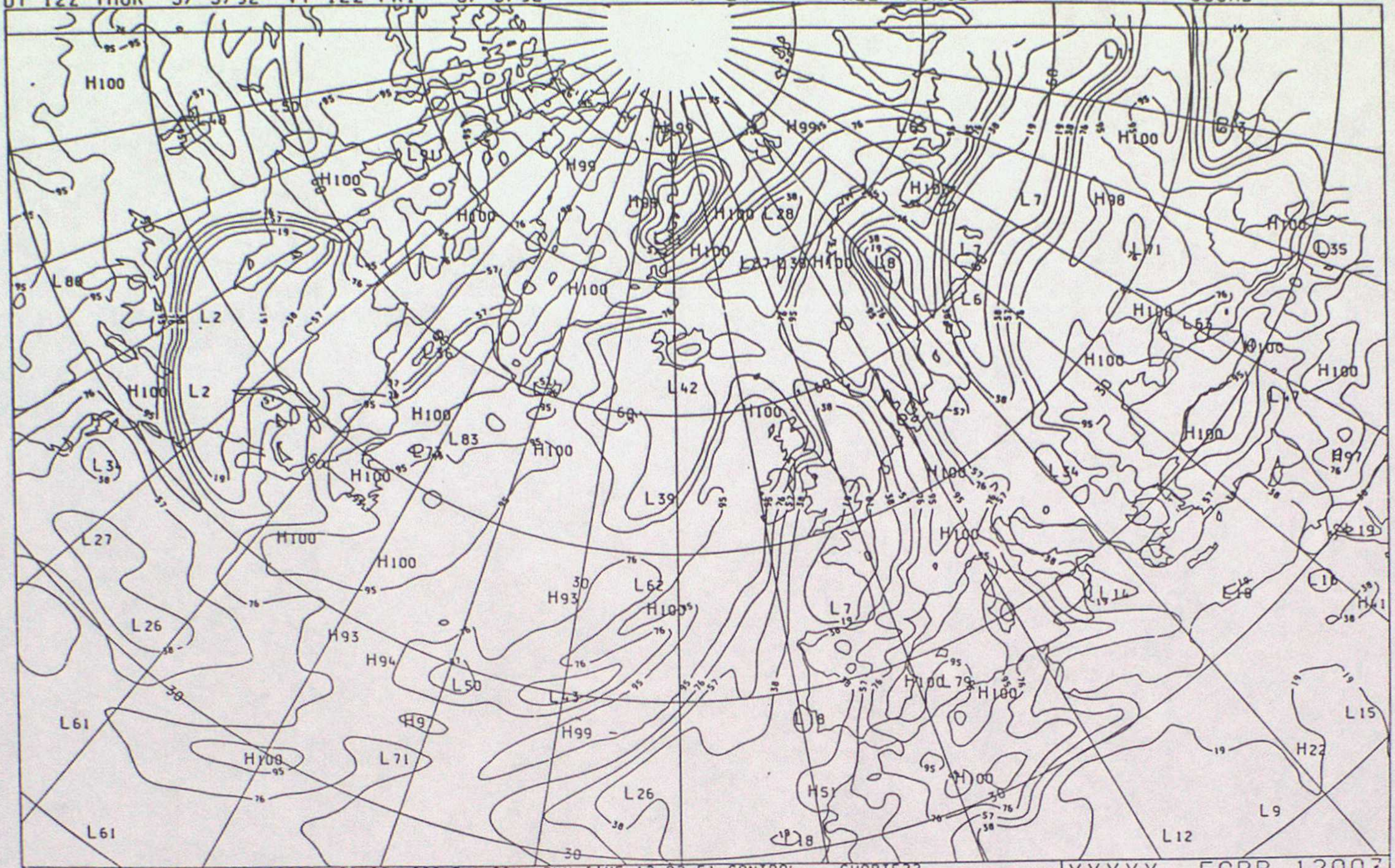
250MB ISOTACHS AND WIND ARROWS
OPERATIONAL ANALYSIS
VALID AT 12Z ON 6/3/1992 DAY 66 DATA TIME 12Z ON 6/3/1992 DAY 66
LEVEL: 250 MB EXPERIMENT NO.: 3



→ REPRESENTS 50 KNOTS

FIG. 7(h) CNTL

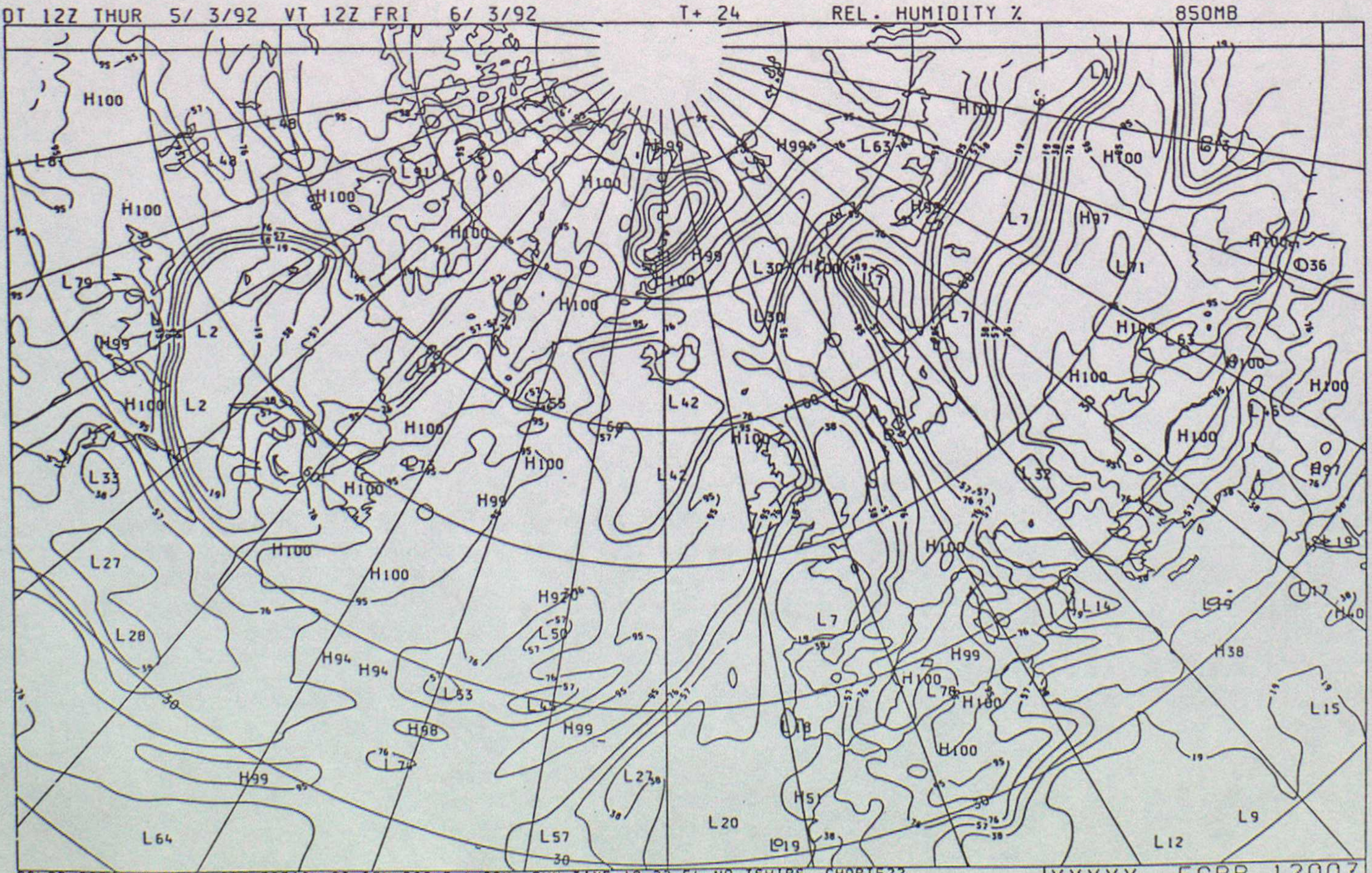
DT 12Z THUR 5/ 3/92 VT 12Z FRI 6/ 3/92 T+ 24 REL. HUMIDITY % 850MB



POLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 12.02.51 CONTROL CHART522 XXXXX EGRR 1200Z

FIG. 7(i) NOTS

DT 12Z THUR 5/ 3/92 VT 12Z FRI 6/ 3/92 T+ 24 REL. HUMIDITY % 850MB



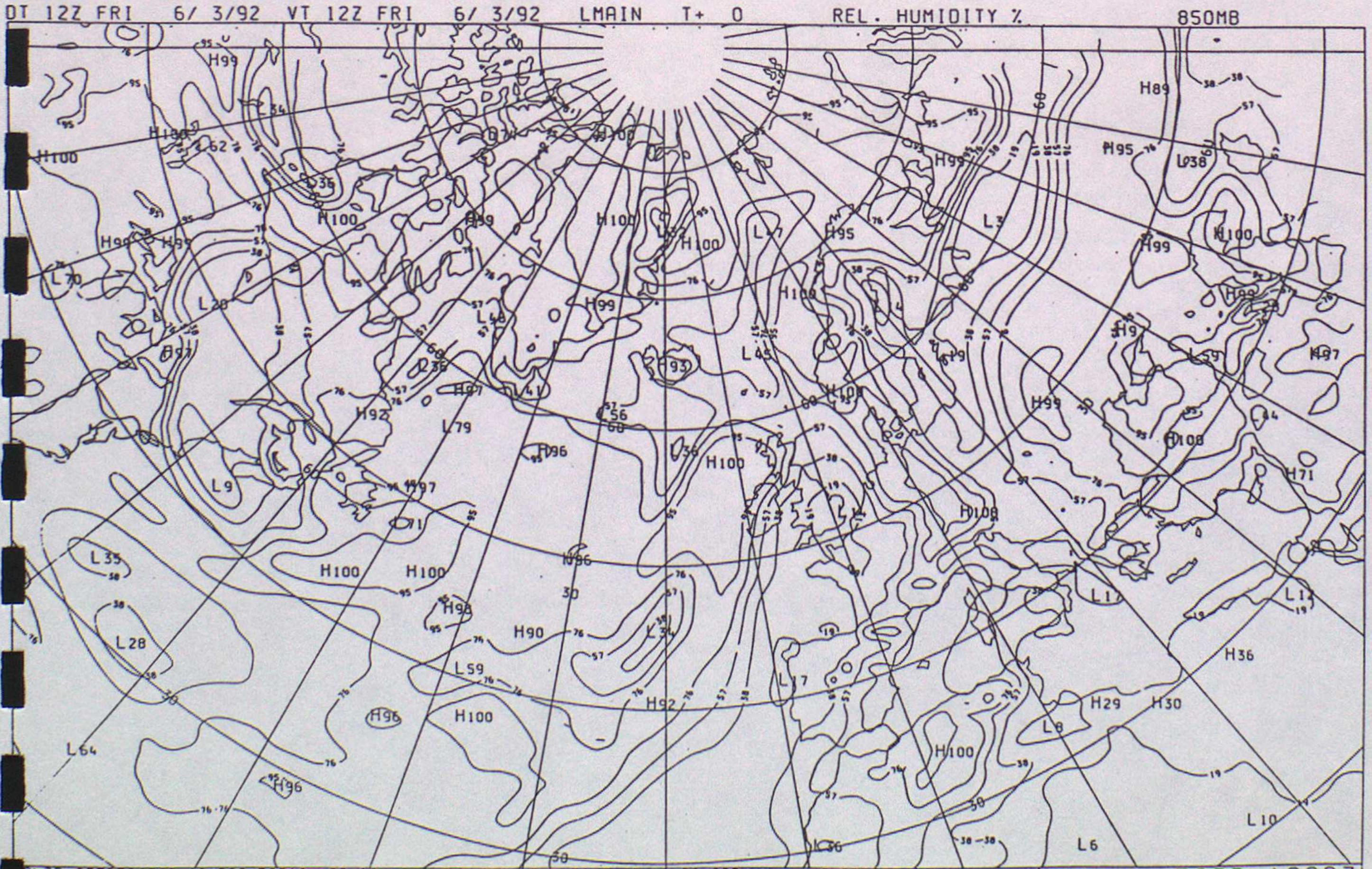
POLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 10.22.54 NO TSHIPS CHART522 XXXXX EGRR 1200Z

FIG. 7(j) CNTL – NOTS

850MB RELATIVE HUMIDITY DIFFERENCE CHART (%)
CONTROL - RERUN WITHOUT TEMPSHIPS
VALID AT 12Z ON 6/3/1992 DAY 66 DATA TIME 12Z ON 5/3/1992 DAY 65
T+24

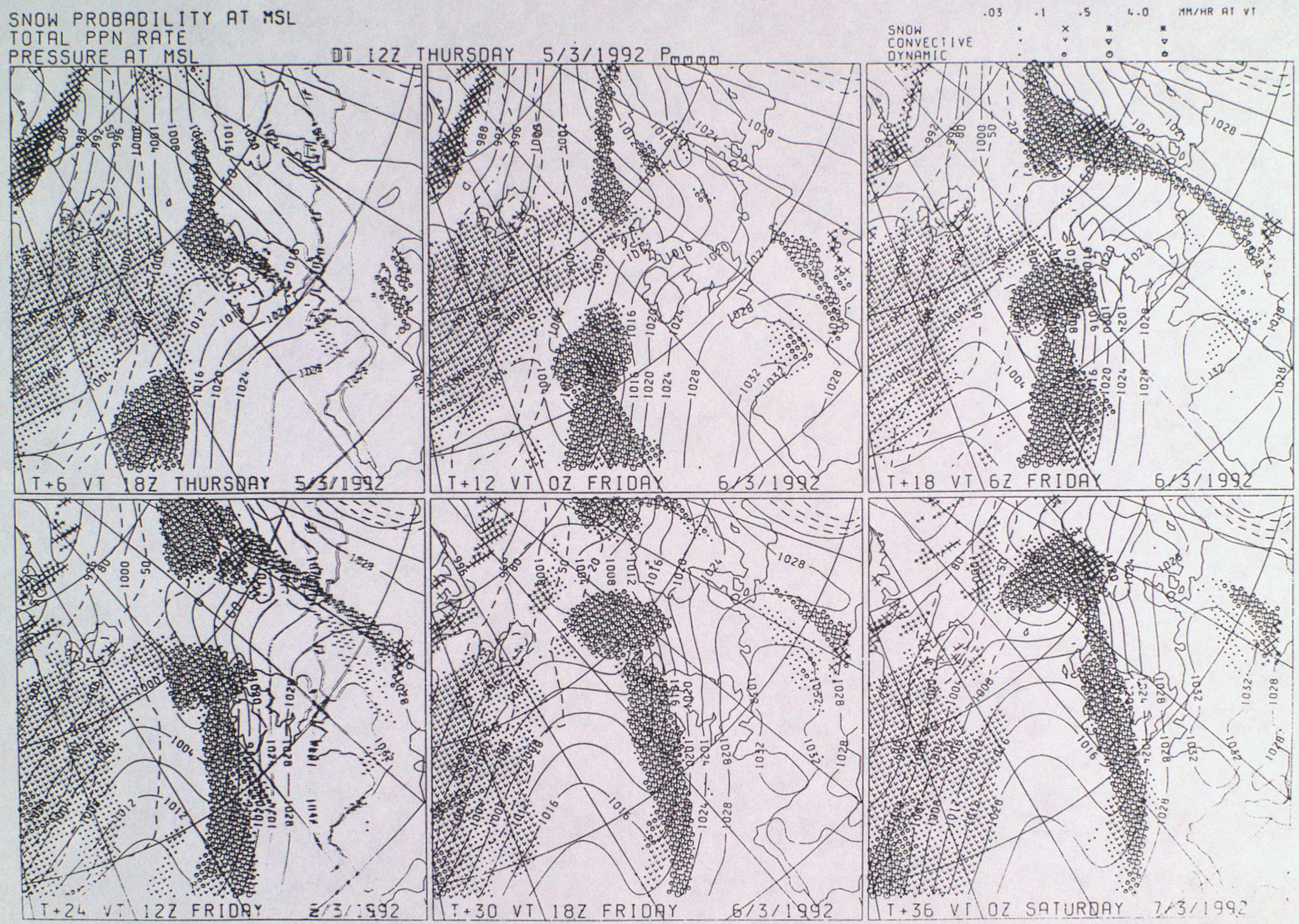
FIG. 7(k) OPER

DT 12Z FRI 6/ 3/92 VT 12Z FRI 6/ 3/92 LMAIN T+ 0 REL. HUMIDITY % 850MB



POLAR STEREOGRAPHIC PROJECTION AT 60N SCALE 1:20M RUN TIME 10.16.26 COP CHART522 XXXXX EGRR 1200Z

FIG. 7(l) CNTL



SNOW PROBABILITY AT MSL
TOTAL PPN RATE
PRESSURE AT MSL
DT 12Z THURSDAY 5/3/1992
.03 .1 .5 4.0 MM/HR AT VT
SNOW
CONVECTIVE
DYNAMIC
T+6 VT 18Z THURSDAY 5/3/1992
T+12 VT 0Z FRIDAY 6/3/1992
T+18 VT 6Z FRIDAY 6/3/1992
T+24 VT 12Z FRIDAY 6/3/1992
T+30 VT 18Z FRIDAY 6/3/1992
T+36 VT 0Z SATURDAY 7/3/1992

Fig. 7(m) NOTS

SNOW PROBABILITY AT MSL
TOTAL PPN RATE
PRESSURE AT MSL

DT 12Z THURSDAY 5/3/1992 P

	.03	.1	.5	4.0	MM/HR AT VT
SNOW	.	×	✱	✱	
CONVECTIVE	.	v	∇	∇	
DYNAMIC	.	o	⊙	⊙	

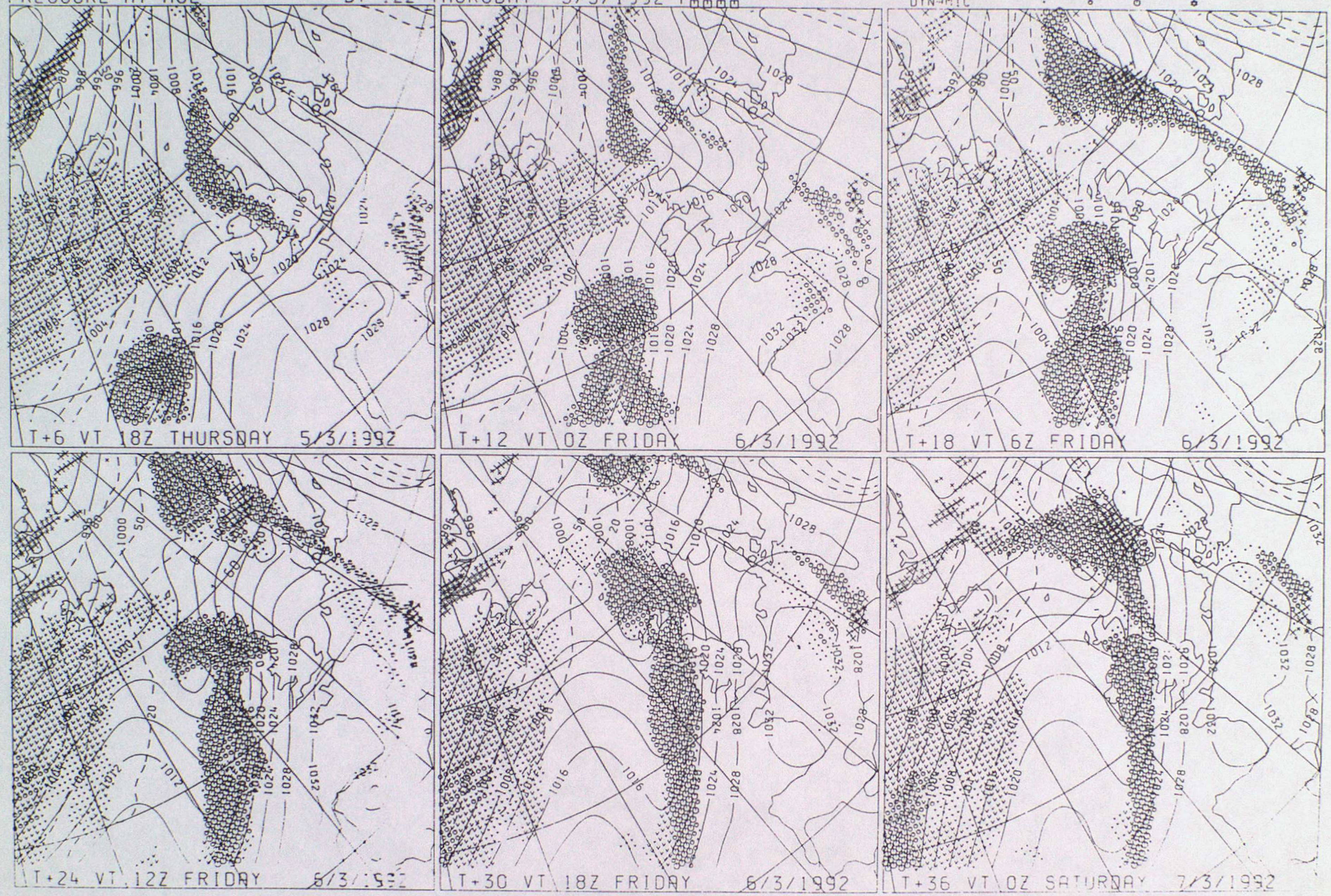


FIG. 8(a)

DATA TIME 1200 GMT 02.03.92
NORTH ATLANTIC TEMPSHIPS
✡ = EX-OCEAN WEATHER SHIPS
⏀ = MERCHANT SHIPS (ASAPS)

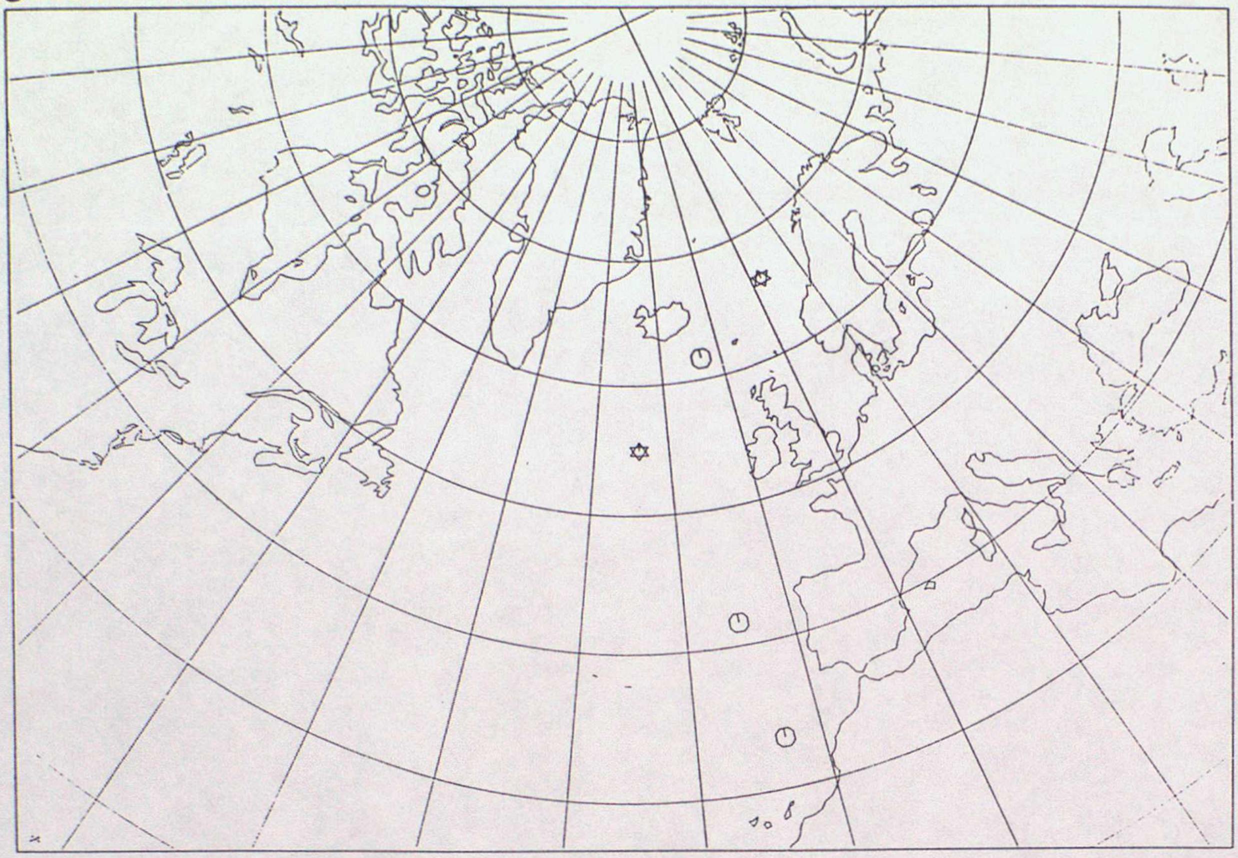


FIG. 8(b)

DATA TIME 0000 GMT 03.03.92
NORTH ATLANTIC TEMPSHIPS
✡ = EX-OCEAN WEATHER SHIPS
⏀ = MERCHANT SHIPS (ASAPS)

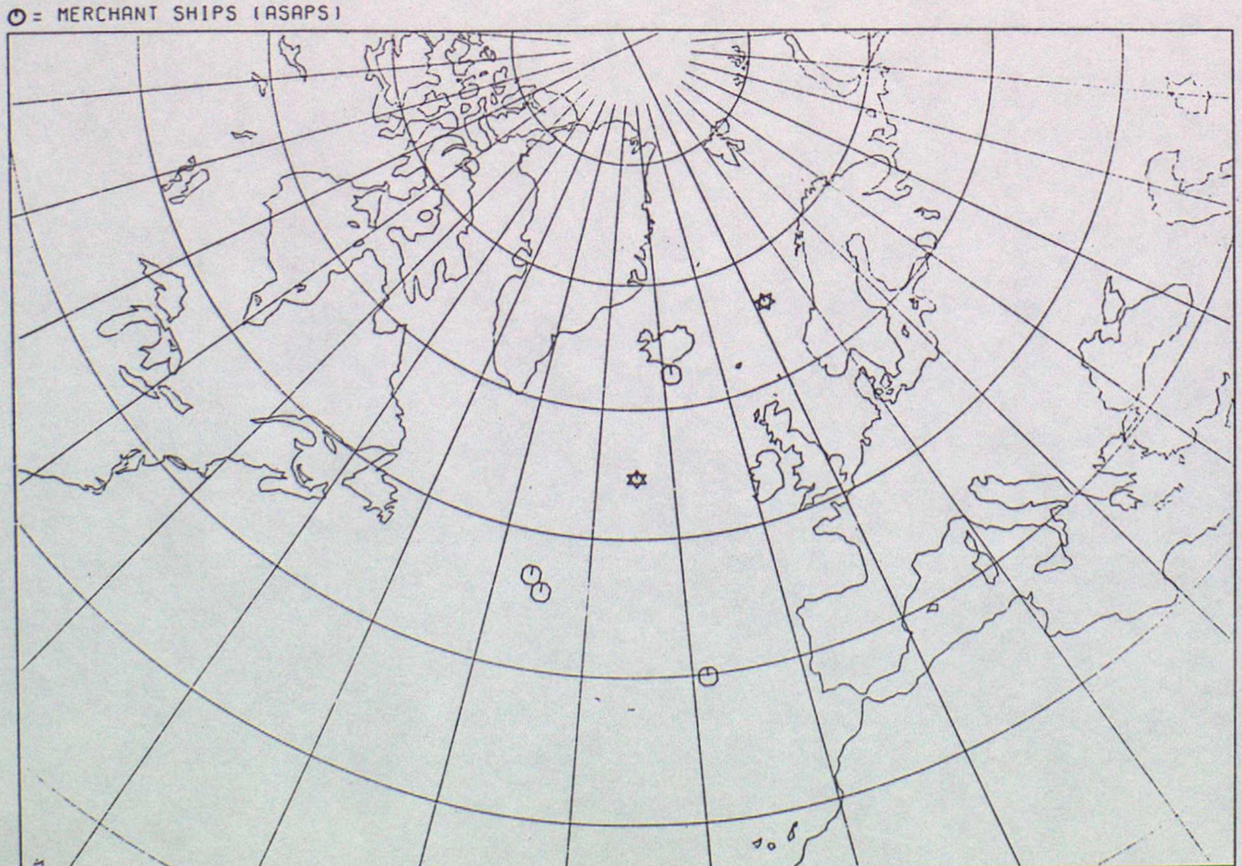


FIG. 8(c)

DATA TIME 1200 GMT 03.03.92
NORTH ATLANTIC TEMPSHIPS
✡ = EX-OCEAN WEATHER SHIPS
ʘ = MERCHANT SHIPS (ASAPS)

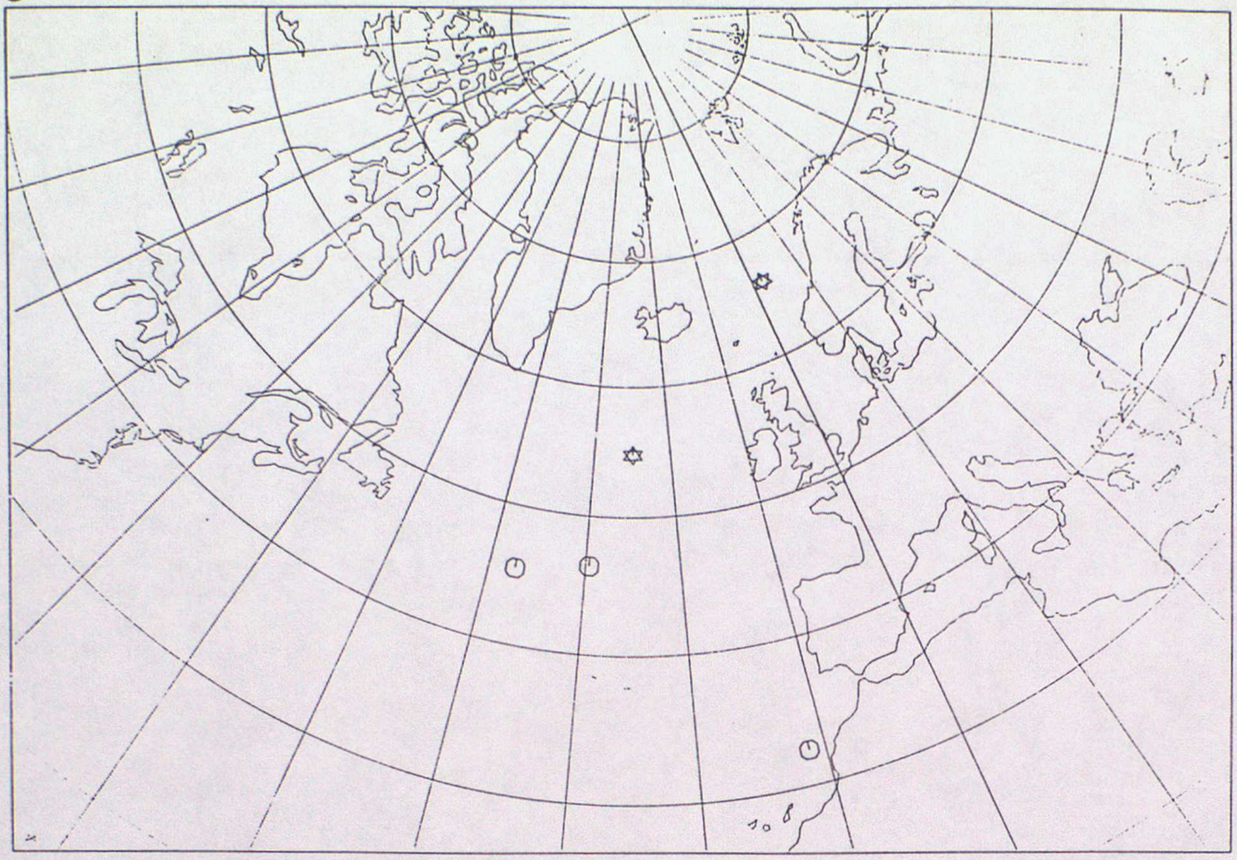


FIG. 8(d)

DATA TIME 0000 GMT 04.03.92
NORTH ATLANTIC TEMPSHIPS
✡ = EX-OCEAN WEATHER SHIPS
ʘ = MERCHANT SHIPS (ASAPS)

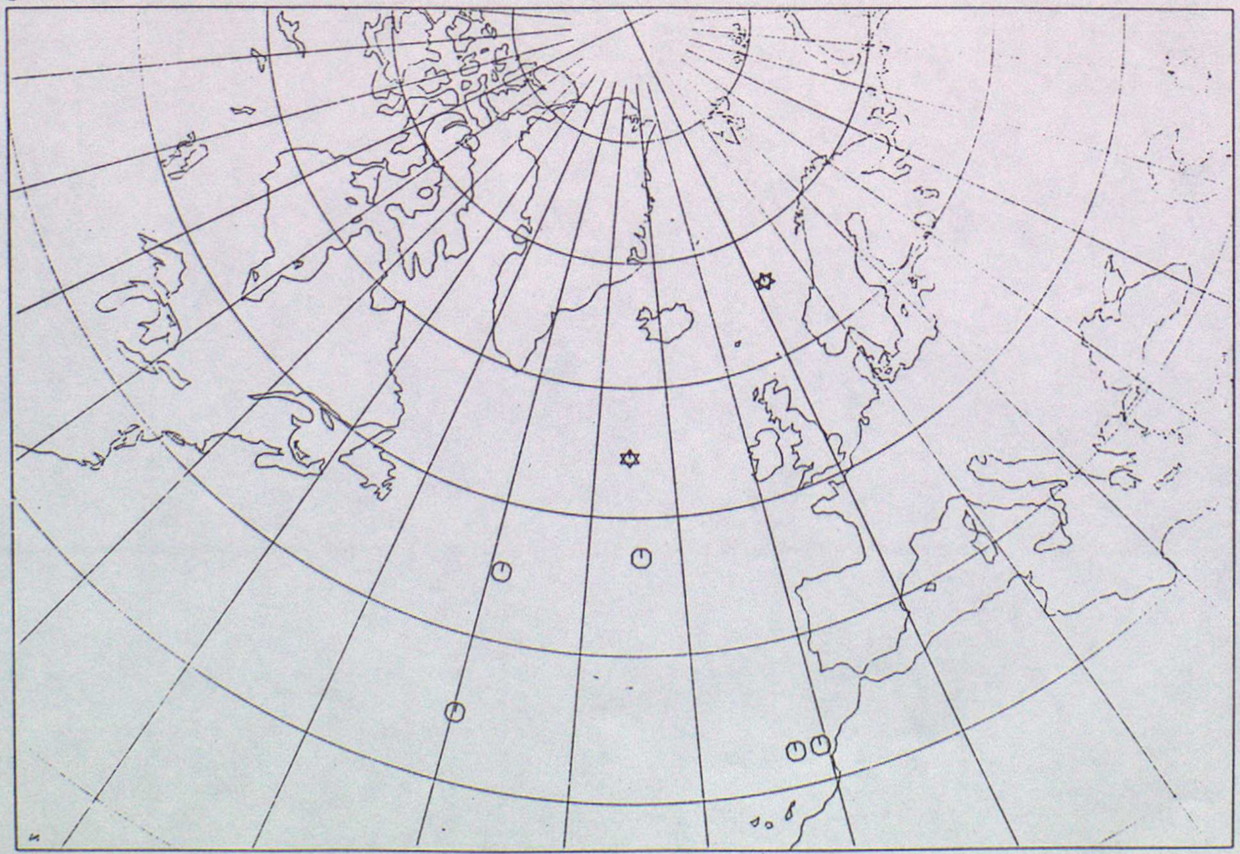


FIG. 8(e)

DATA TIME 1200 GMT 04.03.92
NORTH ATLANTIC TEMPSHIPS
✡ = EX-OCEAN WEATHER SHIPS
⏱ = MERCHANT SHIPS (ASAPS)

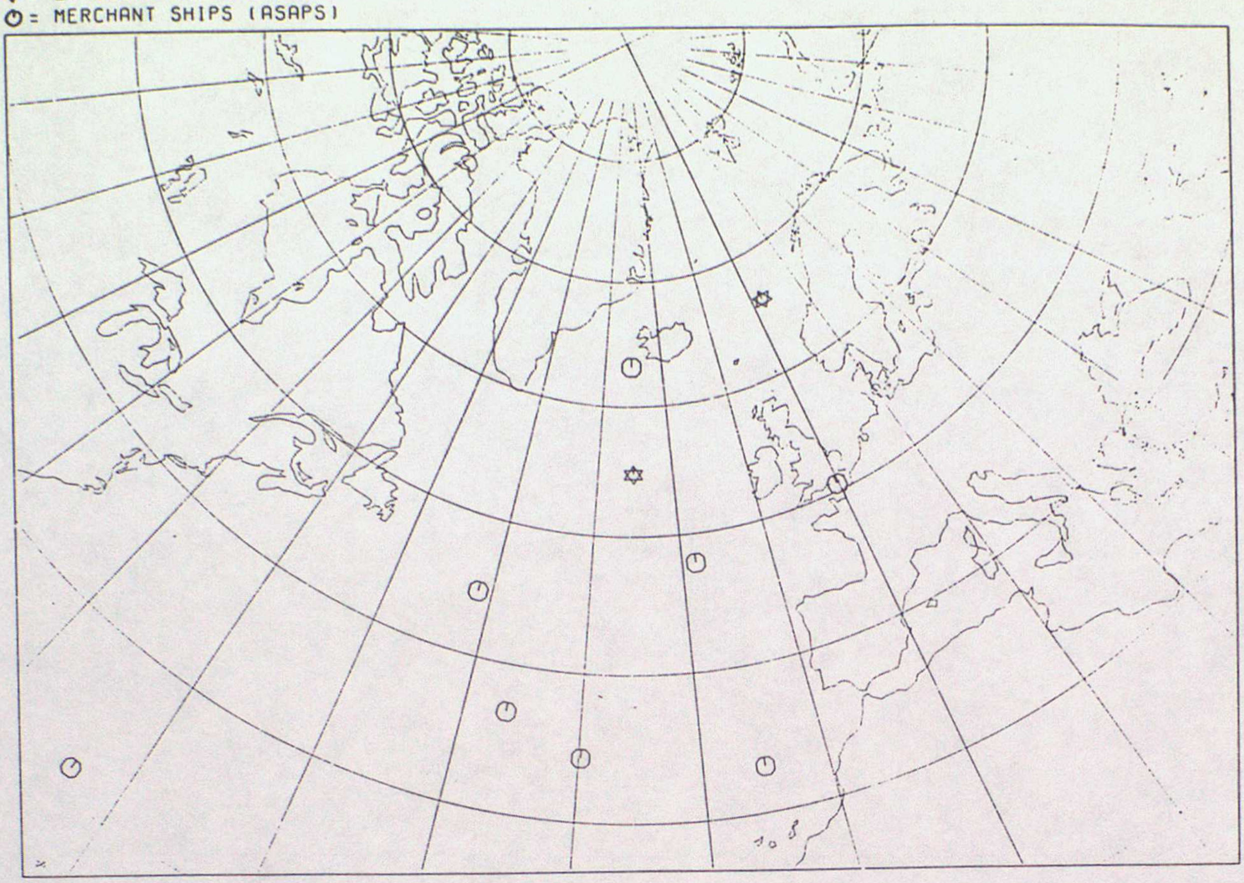


FIG. 8(f)

DATA TIME 0000 GMT 05.03.92
NORTH ATLANTIC TEMPSHIPS
✡ = EX-OCEAN WEATHER SHIPS
⏱ = MERCHANT SHIPS (ASAPS)

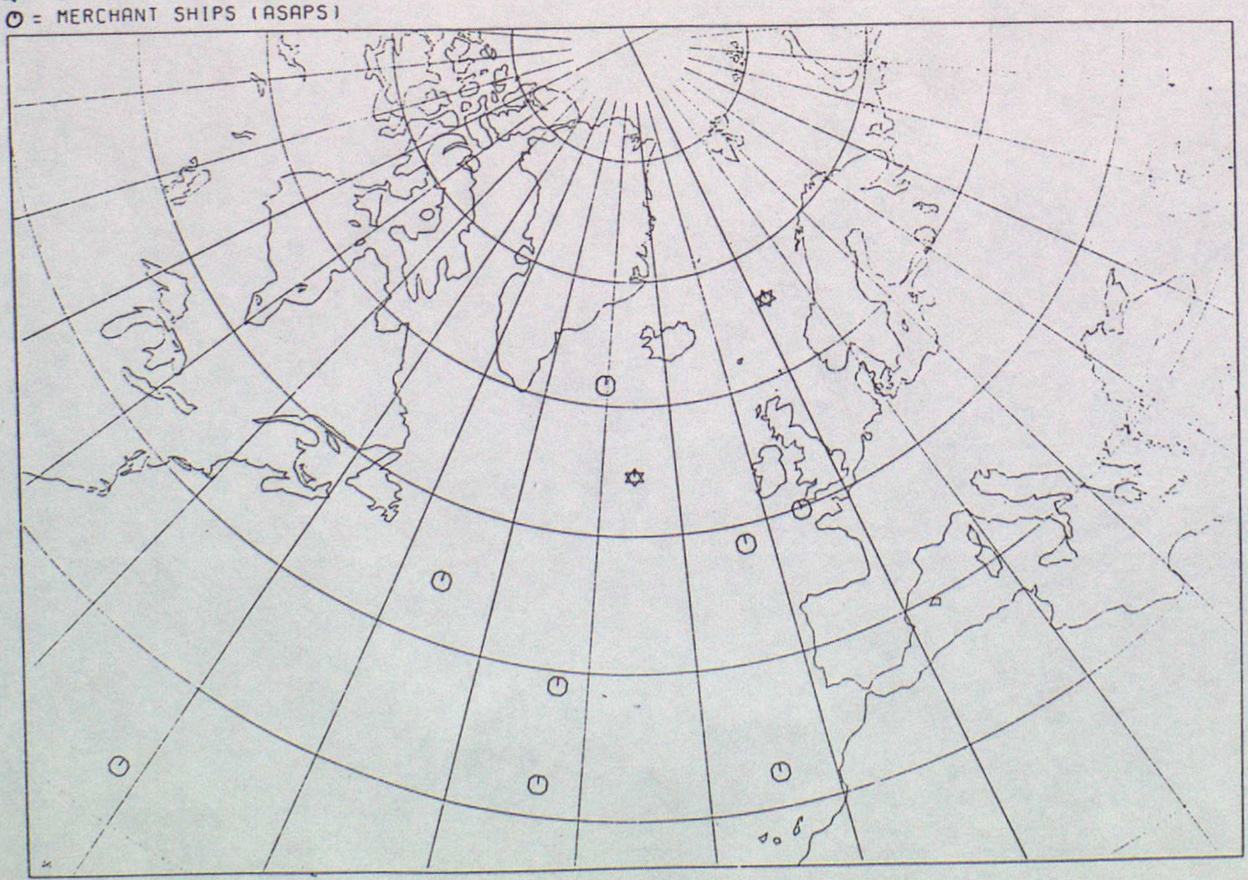
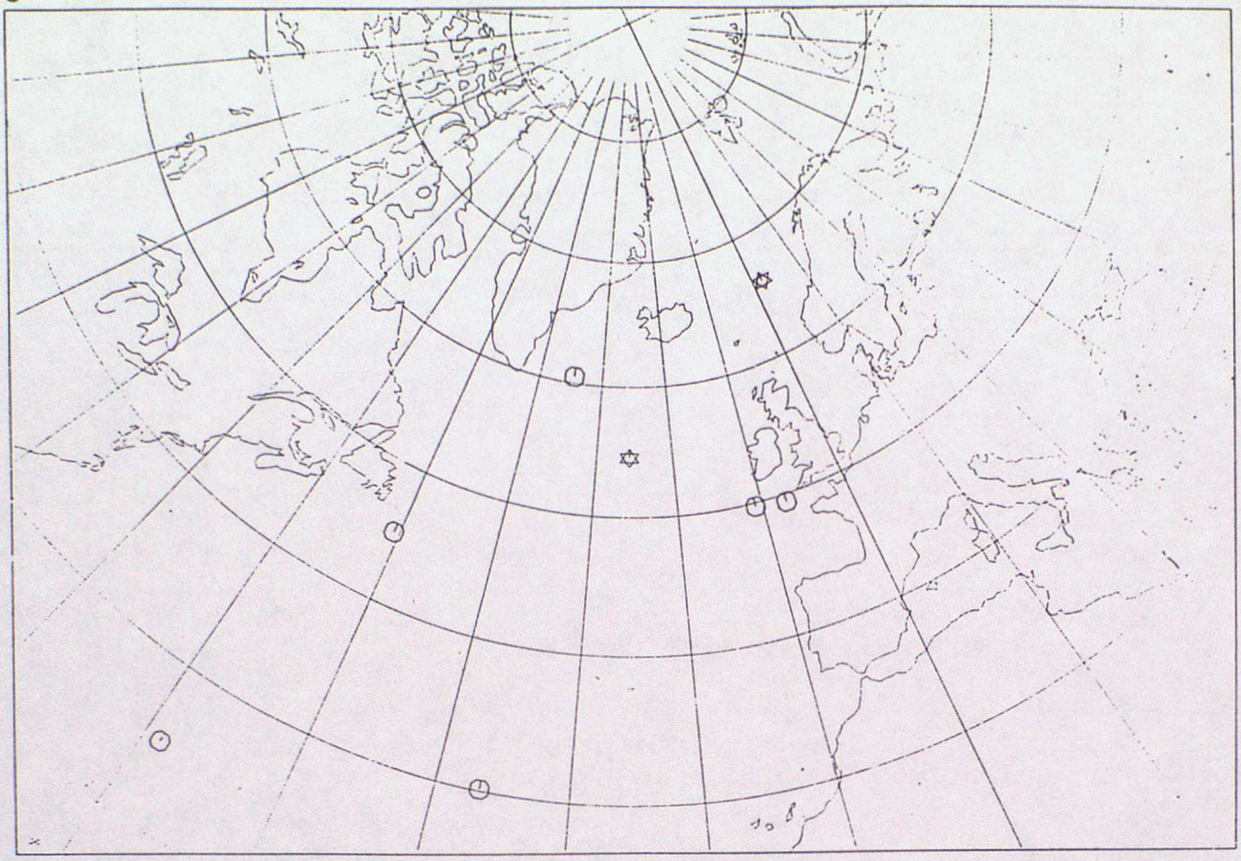


FIG. 8(g)

DATA TIME 1200 GMT 05.03.92
NORTH ATLANTIC TEMPSHIPS .
✡ = EX-OCEAN WEATHER SHIPS
ʘ = MERCHANT SHIPS (ASAPS)



CENTRAL FORECASTING TECHNICAL NOTES

NUMBER	TITLE	AUTHOR	DATE
2	A trial of a scheme to correct the analysed position of tropical cyclones in the operational coarse mesh model.	M. Carter	1988
3	The impact of data on fine mesh forecasts for the storm of January 25th 1990.	J. T. Heming	1990
4	Trial of the impact of bogus data in the fine mesh model.	J. T. Heming	1990
5	A guide to numerical weather prediction models and their output.	C. D. Hall	1991
6	Results of the trial of the scheme to reposition features in a model analysis by use of bogus data.	J. T. Heming	1992
7	Operational forecasts of tropical cyclone formation in the western north pacific in 1991.	C. D. Hall	1992
8	Aviation climatology derived from the opeational model. May 1983 - May 1991	P. M. Grimes	1992
9	Investigation into the impact of North Atlantic tempships on the forecasts of U.K. Meteorological office's global & Limited area models	J. T. Heming A. M. Radford	1993