# KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT

WETENSCHAPPELIJK RAPPORT
SCIENTIFIC REPORT
W.R. 79-9

H. Timmerman

# The effect of weatherships on numerical analysis and prediction


De Bilt, 1979

**Publikatienummer:** K.N.M.I. W.R. 79-9 (M.O.)

Koninklijk Nederlands Meteorologisch Instituut,
Postbus 201,
3730 AE De Bilt,
Nederland.

U.D.C.: 551.509.313 :
551.507.22

CONTENTS

## SAMENVATTING

In dit rapport worden de resultaten beschreven van een numeriek experiment, verricht met het doel objectieve argumenten te vinden voor het handhaven van de weerschepen.

Het experiment werd uitgevoerd voor de periode 1 december 1977 tot 15 januari 1978 en het bestaat uit het vervaardigen van twee series analyses en voorspellingen op het octagon-gebied, dat - zoals bekend - vrijwel het gehele noordelijke halfrond beslaat. De twee series onderscheiden zich in het wèl of niet meenemen van de waarnemingen van weerschepen in de analyses en dus ook in de voorspellingen. Met uitzondering van de identieke beginvelden op 1 december 1977 00 GMT kunnen de beide series als onafhankelijk van elkaar worden beschouwd. De analyses werden voor iedere drie uur en voor de gehele periode uitgevoerd, terwijl de voorspellingen tot 24 uur vooruit waren gebaseerd op de 00 GMT en 12 GMT gegevens en ter besparing van rekentijd voor slechts een gedeelte van de periode werden berekend.

Het effect van de waarnemingen van de weerschepen op de analyses werd nagegaan door de gemeten hoogte van 500 mbar te vergelijken met de geanalyseerde waarde mèt en zonder weerschepen. Hieruit bleek dat de r.m.s. fout door weglating van de weerschepen gemiddeld toenam van 2.8 dam tot 4.8 dam. Een soortgelijke statistiek van de voorspelde waarden 24 uur vooruit voor de weerschepen en voor de stations Stornoway in Engeland (58N, 06W) en Emden in West-Duitsland (53N, 07 0) leverde geen noemenswaardig verschil op. Blijkbaar gaat het effect van nauwkeuriger analyses op de voorspelling gemiddeld verloren ten gevolge van de verschillen, die gaan optreden door fouten in de voorspelling. In twee individuele gevallen echter bleek dat de waarnemingen van de weerschepen C (52N, 35W) en L (57N, 21W) een wezenlijke bijdrage vormden tot de analyse van kortgolvige storingen, gesuperponeerd op een grootschalige stroming, welke laatste ook zonder weerschepen bevredigend werd geanalyseerd. In de twee

gevallen (13 december 1977 en 15 december 1977) ontwikkelden deze kortgolvige storingen zich tot stormdepressies. Deze belangrijke ontwikkelingen werden zeer redelijk voorspeld door de serie mèt weerschepen en niet door de serie zonder weerschepen. Volledigheidshalve moet worden opgemerkt, dat omgekeerd er in de beschouwde periode geen gevallen waren waarin de waarnemingen van de weerschepen resulteerden in een slechtere voorspelling van het luchtdrukveld.

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SUMMARY

In this paper the results of a numerical experiment are described. The intention of this experiment was to obtain sustaining arguments for the use of weatherships. It was carried out for the period 1 December 1977 to 15 January 1978. The test consists of two series analyses and forecasts on an octagonal grid, almost covering the northern hemisphere. The only difference between the two series is a difference in the observational data: one set with, the other without weatherships. So with an exception of an identical initial state on 1 December 1977 00 GMT both series may be considered independent of one another. The analyses were carried out with a three-hourly updating for the whole period, while the forecasts, 24 hours in advance, were based on 00 GMT and 12 GMT data, and to save computer time only for a part of the period.

The effect of the observations of weatherships is studied by comparing the measured heights of 500 mbar with values analyzed with and without weatherships. It turned out that omission of the weatherships led to an average increase of the r.m.s. error of 2.8 dam to 4.8 dam. A similar statistic of forecast values 24 hours in advance made up for the weatherships and for the stations Stornoway (58N, 06 W) and Emden (53N, 07E) gave no appreciable differences. Apparently, on the average the effect of more accurate analyses got lost due to differences caused by forecast-errors. However, in two individual cases it appeared that the observations of the weatherships C (52N, 35W) and L (57N, 21W) gave a substantial contribution to the analysis of short-wave disturbances, superposed on a broad-scale circulation. This general circulation was analyzed in a satisfactory way for both series. These two cases (13 December 1977 00 GMT and 15 December 1977 00 GMT) were characterized by a development of a short-wave disturbance into a storm depression. These very important developments were reasonably forecast by the series

with weatherships and not by the series without weatherships. For the sake of completeness it must be remarked that in the period under consideration there were no opposite cases giving better results when omitting the weatherships.

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## 1. INTRODUCTION

Meteorologists all over the world are strongly convinced that the surface and upper-air observations from weatherships cannot be missed in analyses and forecasting of pressure fields. Nevertheless, the use of weatherships is brought up for discussion from time to time.

In the Netherlands a numerical experiment has been carried out in order to obtain supporting arguments in favour of the weatherships. Two series of analyses were produced without human intervention. One series contained information of the weatherships, whereas the second did not. Apart from an identical initial situation the two series were independent of each other and may be regarded as objective. For the experiment observational data of 1000, 850, 500 and 300 mbar were available for the period 1 December 1977 to 15 January 1978. The analyses were carried out for the whole period with a 3-hourly updating over an area almost covering the northern hemisphere, in an octagonal grid spacing 375 km on a stereographic projection at 60 degrees North. The method of analyzing was described by BERGTHORSSEN and DÖÖS [1] in 1955 and by CRESSMAN [2] in 1959. In the KNMI it is improved considerably, especially for 1000 mbar, among other things by the introduction of mutual confirmation of observations (TIMMERMAN [3]).

Forecasts 24 hours in advance were produced on 00 and 12 GMT analyses with a 4-level filtered model. The principles of it were described by HEIJBOER [4]. See also DEN EXTER BLOKLAND [5]. To save computer time the forecasts were restricted to the period 22 December 1977 to 15 January 1978, with the exception of 13 December 1977 and 15 December 1977.

## 2. RESULTS

The effect of the observations from weatherships on analyses has been checked by comparing the observed 500 mbar height at

the location of the weatherships C (52N, 35W), M (66N, 2E), L (57N, 21W) and R (47N, 16W) with a value analyzed with and without the observations of weatherships. In table 1 the r.m.s. errors are given.

Table 1

| r.m.s. error 500 mbar in dam | with weatherships | without weatherships |
|---|---|---|
| C | 2.6 | 4.3 |
| M | 3.1 | 4.9 |
| L | 2.6 | 4.3 |
| R | 3.0 | 5.5 |
| average | 2.8 | 4.8 |

Table 1 clearly demonstrates that the analyzed 500 mbar heights based on data with weatherships agree better with the observed values, and therefore with reality, than the heights analyzed without weatherships. A similar statistic of forecast values for the weatherships and for the stations Stornoway (58N, 06W) and Emden (53N, 07E) gave no appreciable differences. Apparently, the effect of more accurate analyses got lost due to differences caused by forecast errors. Examining the analyses throughout the whole period, it turned out that the differences shown in table 1 were in general not so large that they led to different analyzed general circulation patterns (GWL-systems), but that in individual cases they were large enough to give a considerable deterioration of the analyzed short-wave disturbances, superposed upon these patterns. The importance of these short-wave disturbances with respect to forecasting can be shown by two examples of developing depressions. These cases were not found in the period 22 December 1977 to 15 January 1978, but they were selected out of the period 1 December 1977 to 22 December 1977 by Heijboer, who carefully examined the differences between the two types of analyses. It concerns the weather situation of 13 December 1977 00 GMT and of 15 December 1977 00 GMT, both giving large differences in the two types of forecast. See figures 1-14.

Especially the case of 13 December 1977 with a south to southwesterly jet-stream over the mid-Atlantic is very instructive. The upper-air observations from the weatherships L (57N, 21W) and C (52N, 35W) considerably influence the upper-air analysis in a region of several hundreds of square miles and fix a short-wave disturbance (see fig. 4, --- encloses area where disturbance can be found), which appeared to develop into a severe storm depression in the following 24 hours. See fig. 7. The forecast using weathership data creates a deepening depression and a large storm field (see fig. 6), whereas the forecast without weatherships only shows a moving depression without deepening and much weaker winds around the centre. See fig. 5. When comparing with the hand-drawn analysis of 14 December 1977 00 GMT, the forecast with weatherships appeared to be superior. This may also be concluded in the case of 15 December 1977, where a short-wave disturbance superposed on a southwesterly jet-stream West of the British Isles, which could be analyzed due to the upper-air observations from the weatherships L and C (see fig. 11, --- encloses area where disturbance can be found), also develops into a deep depression East of Iceland in the following 24 hours. See fig. 14. This depression is completely missed in the forecast without weatherships (see fig. 12), whereas the forecast including the observations from the weatherships gives a fairly good indication of the developing depression East of Iceland and of the storm field between Iceland and the northern part of the North Sea. See fig. 13.

Throughout the period 22 December 1977 to 15 January 1978 there were no cases showing the opposite, that is to say a better forecast if based on analyses without weatherships. The examples demonstrate that weatherships cannot be missed. In these two cases one may especially think of ship-routing.

It appeared that the differences in the two types of forecast over the North Sea area were not large. It must be concluded that during this period the effect of weatherships on surge forecasting was negligible. However, one must be careful to draw a general conclusion from the small example, because both

cases indicate the possibility that during a circulation with a westerly to northwesterly jet-stream over the eastern part of the Atlantic Ocean a short-wave disturbance is missed due to absence of the weatherships L and/or R, which may give rise to a poor forecast of a surge depression. The same may occur during a northerly jet-stream if the observations from weathership M should not be available.

## 3. CONCLUSION

The calculated r.m.s. errors show that the weatherships contribute considerably to the accuracy of upper-air analyses. It turned out that in the comparatively short period under consideration there were two cases with large differences in the two types of forecast, one of them being very spectacular. In these two cases the computed forecasts without weatherships should have given but poor guidance to the forecasters, this in contrary to the other type of forecast with weatherships.

It must be kept in mind that similar conditions over the North Sea area may influence storm-surge prediction in an unfavourable way.

## 4. ACKNOWLEDGEMENTS

Thanks are due to the KNMI Computing Division, notably to Mr. A.M.J. Philippa, and to Mr. A. Grendel for the careful preparation of the figures and Dr. L.C. Heijboer for his help with the study of the analyses and forecasts.

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3. H. Timmerman: Improvement of objective analyses by mutual confirmation of observations. (To be published).

4. L.C. Heijboer: 1977, Design of a baroclinic three-level quasi-geostrophic model with special emphasis on developing short frontal waves. KNMI, Mededelingen en Verhandelingen No. 98.

5. A.W. den Exter Blokland: Een baroklien vierlagen-model met gefilterde vergelijkingen. (To be published).

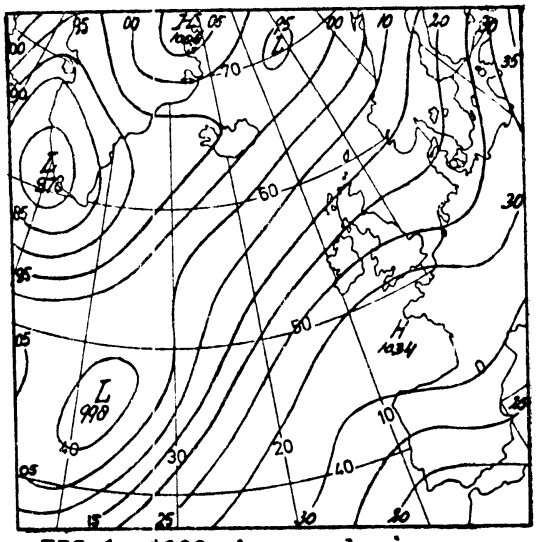
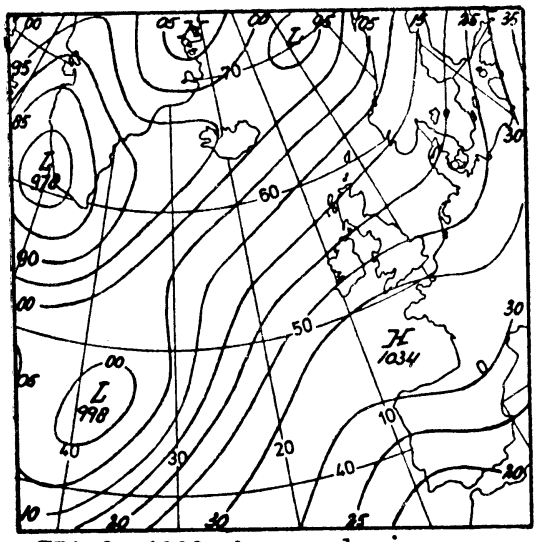


FIG 1: 1000 mbar analysis
13-12-'77 00 GMT
without W.S.



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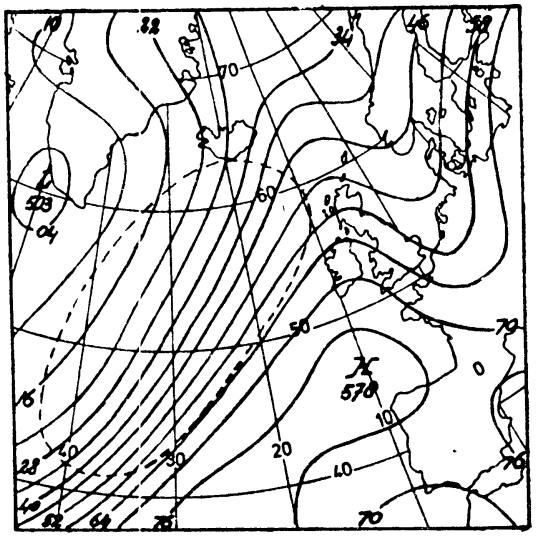

FIG 3: 500 mbar analysis
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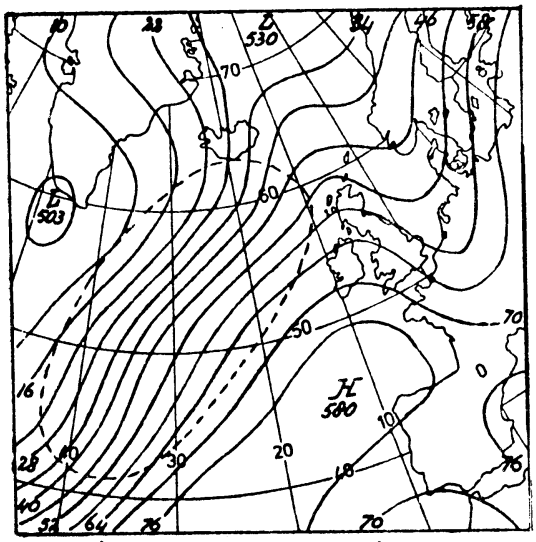

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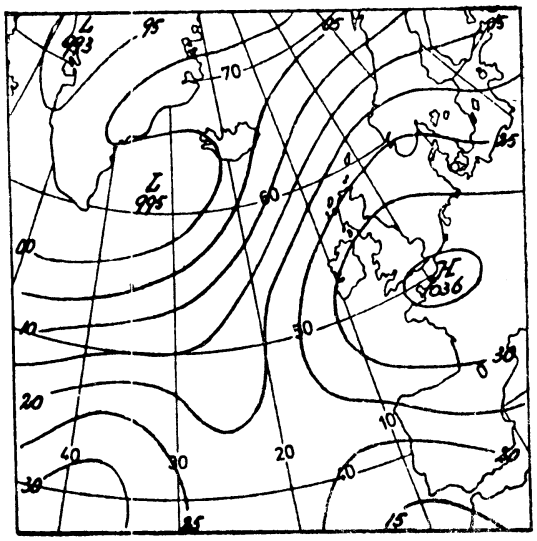

FIG 5: 1000 mbar forecast
13-12-'77 00 GMT + 24
without W.S.

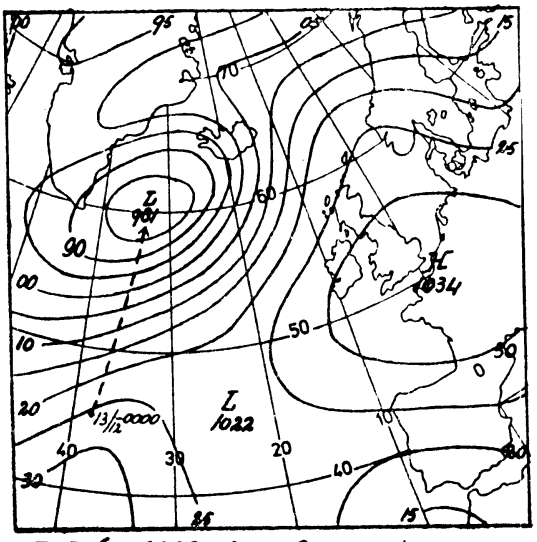

FIG 6: 1000 mbar forecast
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with W.S.

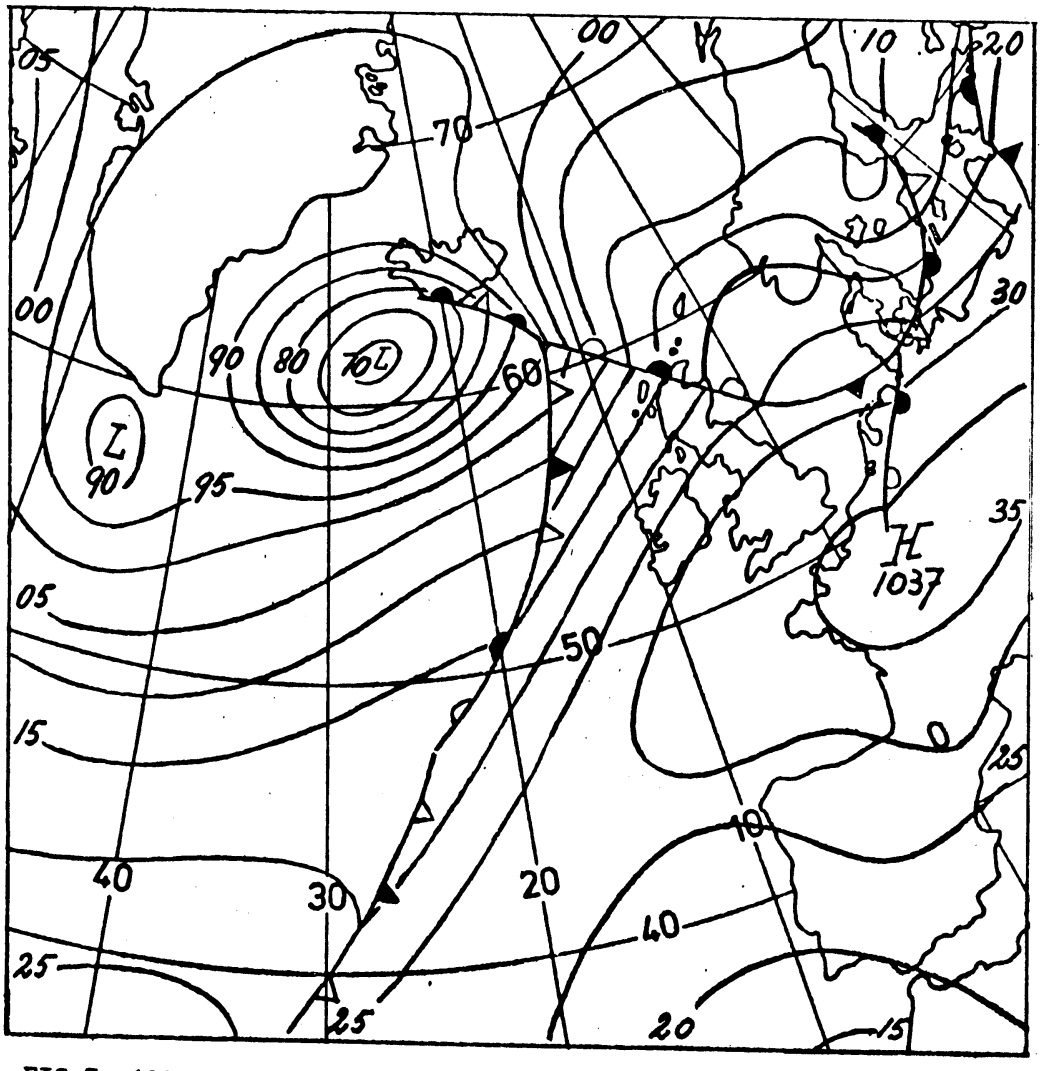


FIG 7: 1000 mbar hand-drawn analysis
14-12-'77 00 GMT
with W.S.

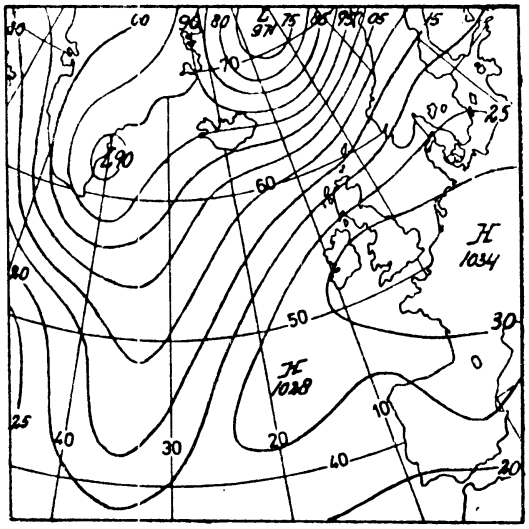

FIG 8: 1000 mbar analysis
15-12-'77 00 GMT
without W.S.

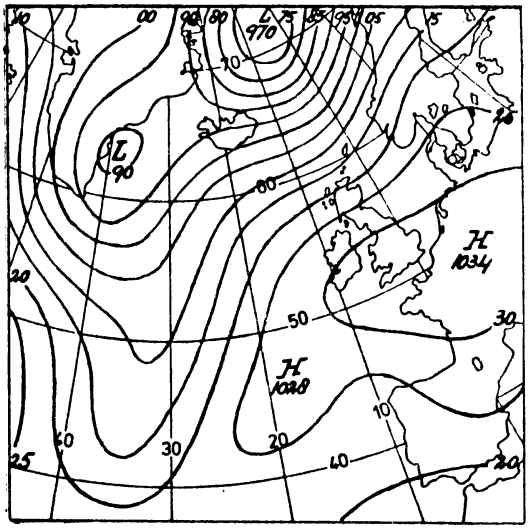

FIG 9: 1000 mbar analysis
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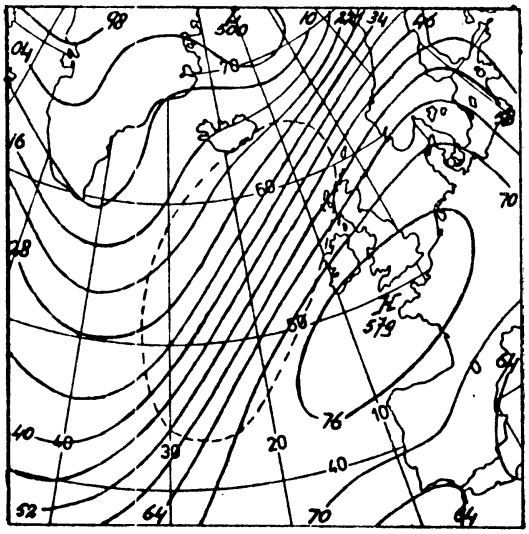

FIG 10: 500 mbar analysis
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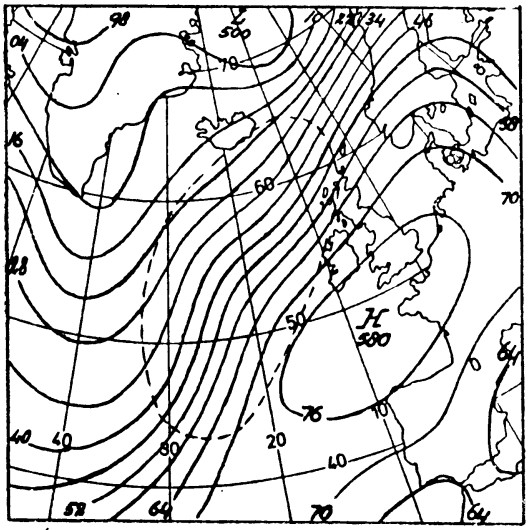

FIG 11: 500 mbar analysis
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with W.S.

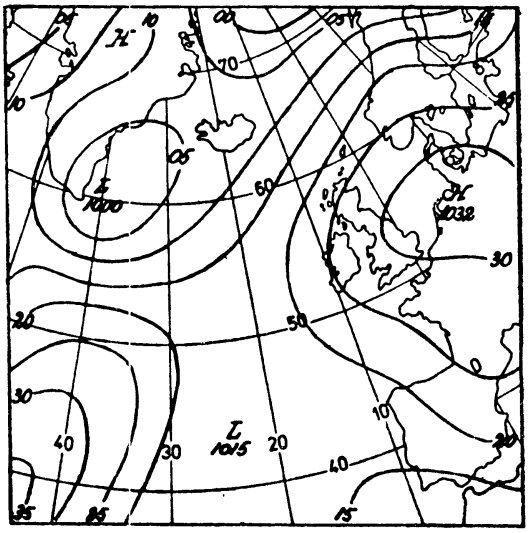

FIG 12: 1000 mbar forecast
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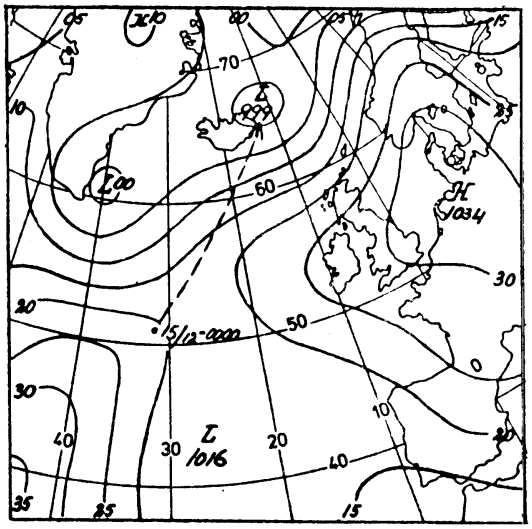

FIG 13: 1000 mbar forecast
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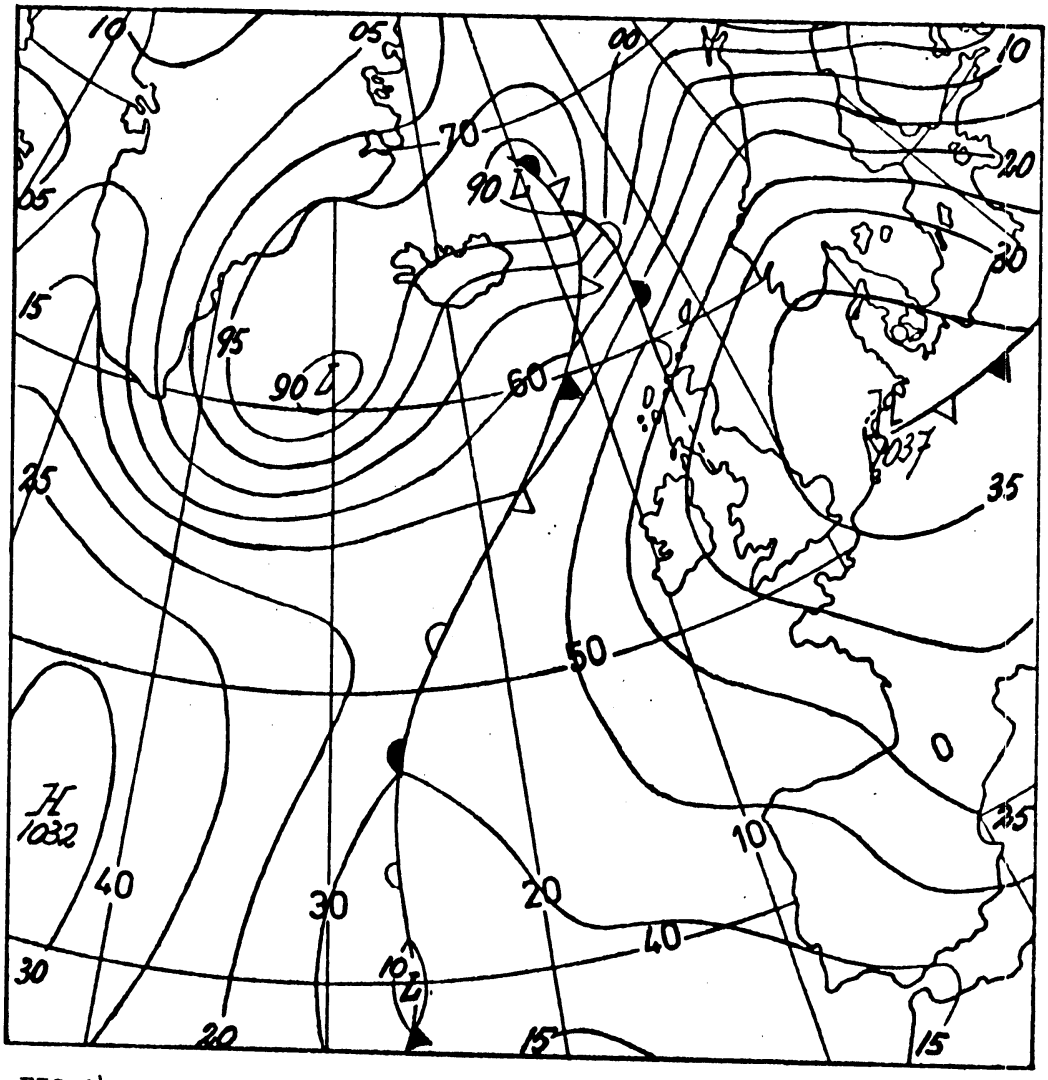


FIG 14: 1000 mbar hand-drawn analysis
16-12-'77 00 GMT
with W.S.