MET O 11 TECHNICAL NOTE No.55

Statistical verification of Octagon and Rectangle height forecasts for the British Isles

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In this report are presented the results of statistical verifications of contour height forecasts in the vicinity of the British Isles obtained from the operational versions of the Rectangle and Octagon forecasting models. The fine mesh Rectangle forecasting model is intended to be an aid in the forecasting of rainfall up to 36 hours ahead while the Octagon forecasts are used to provide forecasts of winds and of the general synoptic situation. It is clear however that in order to obtain a reliable rainfall forecast the synoptic situation must be correctly forecast and also that both versions of the model should predict similar development although more detail might be expected with higher resolution. Where attempts are made to interpret the numerical forecasts in terms of local weather it is desirable to know the accuracy of the numerical forecasts in order that errors of interpretation can be distinguished from errors of the numerical forecast. Until the present there has been little attempt to obtain objective verification of the Rectangle forecasts of contour height although considerable effort has been devoted to the verification of rainfall forecasts. The results presented here have been obtained from numerical forecasts since August 1974 as part of a continuing programme of assessment of the effects of changes in the formulation of the numerical models and of diagnosis of faults in the formulation.

There are several differences between the Rectangle and Octagon versions of the 10-level forecasting model in addition to the areas covered and the resolution of the models. As with all operational models there are frequent changes made both to the models and to the complete operational system. Many changes have been made during the period for which statistics have been derived; the major changes are listed in Table 1.

The data which have been analysed consist of forecast grid point values of mean sea level pressure (derived from the forecast 1000mb height and 1000-900mb thickness) and the heights of the 500, 300 and 100mb surfaces. The data were extracted from the operational 12, 24 and 36hr forecasts at 49 grid points of the Octagon model covering an area around the British Isles shown in Fig.1. The data from the Rectangle forecasts were extracted at the same 49 points so that only one ninth of the data in the verification area was used. Data were extracted from the operational forecasts and not from the forecasts based on updated analyses since these are obtained too late to be used to provide short period forecasts. Verification of the forecasts was made against operational initial fields. This was based on preliminary studies which suggested that the differences between the operational and the updated initial fields from Octagon forecasts were small in the verification area and also because separate updated initial fields were not obtained for the Rectangle model (from September 1974). Octagon forecasts have been verified against Octagon initial fields but Rectangle forecasts have, since December 1974, been verified against both Octagon and Rectangle initial fields. In general verification against Octagon fields produces slightly larger root mean square errors but the difference seldom exceeds about 5% of the error. Changes are being considered which will enable verifications to be made against updated initial fields and also against observations.

The growth of the root mean square errors as the forecast period increases are shown in Fig.2 for months typical of the summer and of the more disturbed winter months. The errors are calculated from all of the forecasts verifying during the months considered. In order to demonstrate the different variability in the atmosphere at different seasons and at different heights the root mean square errors of persistence forecasts are also shown. In the summer where the low variability is reflected in low errors for persistence forecasts there is little difference between the root mean square errors from the two models and, except at 100mb the forecasts from both are better than persistence. However, in the more disturbed winter months there are significant differences between the errors of the two models. In both of the winter periods considered the root mean square errors were significantly larger for Rectangle forecasts than for Octagon forecasts at the surface and for some months at all levels except 100mb. Also the errors in the 36hr Rectangle surface forecasts were little better than persistence. At all levels except 100mb there was a tendency for the growth rate of the error to increase towards the end of a 36hr Rectangle forecast whereas for Octagon forecasts the growth rate decreased as the forecast period increased. At 100mb there is only a small difference between the errors from both models, the Rectangle being slightly better but both are rather better than persistence. It would appear that in winter the errors of 24hr Rectangle forecasts are comparable with those of 36hr Octagon forecasts at the lowest levels.

In order to demonstrate the seasonal variation of the root mean square errors the monthly mean root mean square height errors of 24hr forecasts are displayed in Fig.3. In this diagram the verification of Rectangle forecasts was against Rectangle initial fields whereas the verifications in Fig.2 were against Octagon initial fields; as noted earlier this introduces a difference which is only small compared with the difference between the errors of the two models. It can be seen that both models have larger errors in the more disturbed months, in particular at the lower levels, but that the variation is much larger for the Rectangle forecast as might be expected from the results presented earlier. In view of the large seasonal variation of the errors it is difficult to detect any systematic change in the relative behaviour of the two versions of the model which may be due to changes in the forecast programmes. However, the errors at the surface in the Rectangle forecasts for the autumn of 1975 appear to be less, compared with the errors from the Octagon forecasts than for a year earlier. It is also possible that improvements in the Rectangle errors in the spring of 1975 were not completely seasonal but were the result of changes introduced at about this time, these changes being the use of Octagon background fields in the operational analysis procedures and the improved treatment of the effects of topography in the Rectangle forecasts.

In Fig. 4 are presented the seasonal variations of the correlation coefficient between forecast and initialised height changes over 24hr periods. The correlation coefficients are very similar for both versions of the model but it appears from the values for the surface pressure changes that an improvement in the relative performance of the Rectangle forecasts has been achieved since about February 1975. Prior to this time the Rectangle was frequently worse than the Octagon but in the period following this date for only one month has the Rectangle been worse than the Octagon. This is despite an increase in the root mean square errors in the Rectangle forecasts in autumn 1975 to values similar to those of a year earlier. A similar tendency can be seen in the correlation of the 500mb forecast and actual height changes. It seems plausible therefore that the changes to the operational system in the spring of 1975 have produced a slight improvement in the relative performance of the Rectangle forecasts compared with the Octagon forecasts.

It seems probable that, although changes have effected improvements in the surface forecasts from the Rectangle forecast model, the root mean square errors for Rectangle forecasts for the winter of 1975 will be much larger than for the Octagon in the same way as they were a year earlier. The cause of poor winter Rectangle forecasts has been the subject of some investigation. Higher root mean square errors could be expected from a finer mesh forecast because the presence of fine structure in a forecast containing an error in the position of a feature results in larger root mean square errors than if a smoother forecast was used. The larger root mean square errors do not, of themselves, imply synoptically worse forecasts than those produced by the Octagon model; however, in view of the very large errors for January 1975 a study has been made to detect any systematic differences between the Octagon and Rectangle forecasts for the month.

In Table 2 the mean errors for the 49 print verification area of the surface pressure forecasts are presented. The geographical distribution of the mean errors in the 36 hr 1000mb height forecasts are shown in Fig.5. Both versions of the model underestimate cyclonic development in the Western Atlantic and overestimate it in the area of the British Isles and Western Europe but the magnitude of the error is larger for the Rectangle version of the model. In particular, over the British Isles the 1000mb height error though negative in both cases, is not worse than 40m in the 36hr Octagon forecasts while for Rectangle forecasts the error is over 60m and exceeds 80m in some areas. In the Western Atlantic the Rectangle mean errors are also larger than those of the Octagon forecasts although the error pattern is similar for both forecasts. Some of this inability of both versions of the model to forecast cyclonic development over the sea may be due to insufficient exchanges of heat from the sea in the winter months but the use of increased surface exchange coefficient in both versions of the model does not appear to improve this behaviour. Another possible explanation is that it is due to poor treatment of the very long waves in the Octagon version of the model which is then forced onto the Rectangle version of the model. However, this cannot explain the differences between the two versions of the model in the vicinity of the British Isles unless the Rectangle treatment of the long waves differs from the treatment in the Octagon.

Subjective assessment of the forecasts for January 1975 suggests that where there are discrepancies between the forecasts produced by the two versions of the model the Rectangle forecasts have usually moved depressions in the Western Atlantic too far towards the East and have not developed them sufficiently. On the other hand cyclonic development appears to be greater in the Western Atlantic Octagon forecasts, and corresponding ridge development in the area of the British Isles is present in the Octagon but not the Rectangle forecasts. An extreme example of this type of difference is the forecast for 00GMT 28 January 1975. In this example the Octagon forecast, part of which is shown in Fig.6a gave rise to cyclonic development at about 30W at 24hr with a ridge building to the west of the British Isles. The Rectangle forecast on the other hand (Fig.6b) developed a ridge in the Western Atlantic with a trough over southern England. There are some differences between the initial fields uses for these two forecasts and also the boundary changes used for the operational Rectangle forecast were derived from a previous Octagon forecast. In order to remove any possible effects due to these differences the Rectangle forecast was rerun from interpolated Octagon initial fields and with boundary changes derived from the Octagon forecast on the same data. The resulting surface forecast is shown in Fig.6c and it can be compared with the Octagon forecast and with the verifying initial fields (Fig.6d). It can be seen that the cause of the difference between the forecasts was the failure of the Rectangle forecast to handle the developing depression covering the Western boundary of the model at about 40N. In order to reduce the effects of gravity waves created by the boundary changes in the Rectangle model, a region of high diffusion is included around the edges of the model and it was thought that this could be influencing the development close to the boundaries. The forecast was therefore rerun with the enhanced diffusion zone removed but, apart from some roughness in the forecast at 6hr there was very little difference from the forecast shown in Fig.6c.

Another possibility for the cause of the discrepancies between the Octagon and Rectangle forecasts on this occasion is the treatment of the boundary changes. In the current formulation the boundary change routines do not allow changes in the tangential component of velocity to be advected into the model which gives rise to errors when deep troughs are present on the boundaries of the model. There have been, throughout the winter months in particular, several cases where there have been discrepancies between the Rectangle and Octagon forecasts of this type associated with development on the Western boundary of the model and in these cases the Octagon forecasts have in general been rather better than the Rectangle forecasts. For this reason effort is being devoted to deriving a new boundary scheme for the Rectangle forecasts which it is hoped will improve these forecasts.

The results of the work described in this report have demonstrated that there are large errors in the Rectangle forecasts for the British Isles in winter when compared with the Octagon forecasts. Some improvement in the relative performance possibly resulted from the change in the analysis procedures to use interpolated Octagon forecasts as background fields for the Rectangle analyses instead of fields from updated Rectangle forecasts. This was probably because the lower errors of the 12hr Octagon forecast more than compensated for the lack of resolution of small features in these forecasts. Much of the discrepancy between the two versions of the model is associated with the larger mean errors in the Rectangle forecasts. These may be associated with the effects of the boundaries of the model which appear to have a large range of influence over short periods. More research is required however before this point can be established beyond doubt.

LIST OF FIGURES

TABLE 1

Major differences between Rectangle and Octagon versions of the 10-level model

Date of implementation	Rectangle	Octagon
Before July 1974	Limited area 100km grid semi implicit integration Analysis by quadric fitting	Almost hemispheric 300km grid Explicit integration Orthogonal polynomial analysi
28 August 1974	Rectangle forecast now run before changes derived from an earlier	Octagon using boundary Octagon forecast.
29 October 1974		Semi implicit integration.
November 1974	Increased attention given to intervention procedures in analysis scheme.	
14 January 1975	Revised treatment of topography	
14 February 1975	Analysis usesinterpolated Octagon background fields	
13-20 June 1975	Modifications made to surface exchange and surface drag coefficients. Second order correction to Coriolis term removed.	
5 July 1975	Deep convection scheme.	
30 September 1975		Use of current sea surface temperatures.
21 October 1975		Coriolis correction replaced
18 November 1975	Coriolis correction replaced	
25 November 1975	Smoothing of convection scheme.	

TABLE 2

Growth of mean surface pressure errors for different forecasts in January 1975

Period of Forecast	Rectangle	Octagon	Persistence
12hr	-2.01mb	-0.80mb	0.23mb
24hr	-3.97mb	-2.21mb	0.51mb
36hr	-5.53mb	-3.40mb	0.85mb

Fig 1

OCTAGON AND RECTANGLE FORECAST AREAS WITH INTER-COMPARISON GRID POINTS

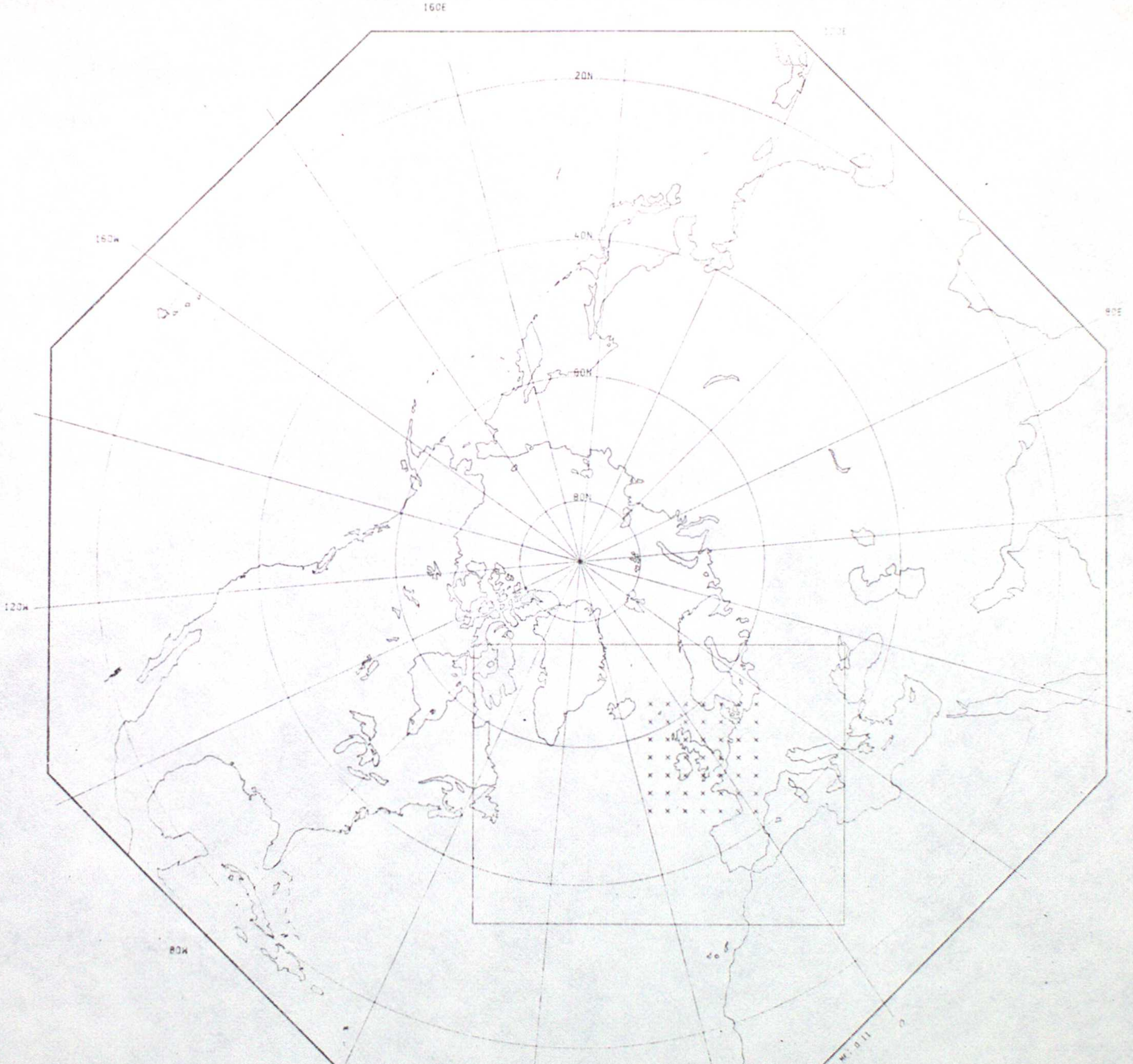
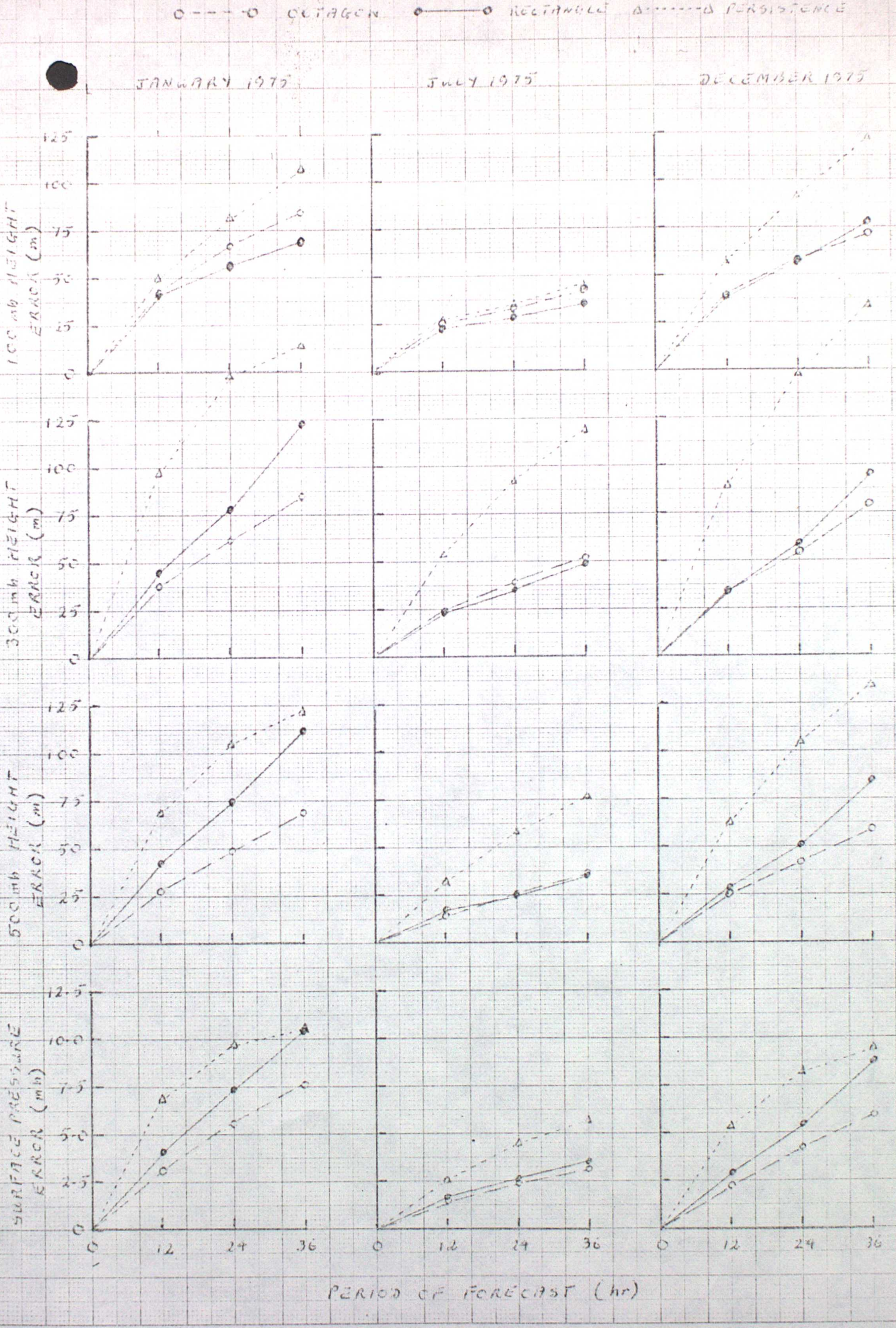
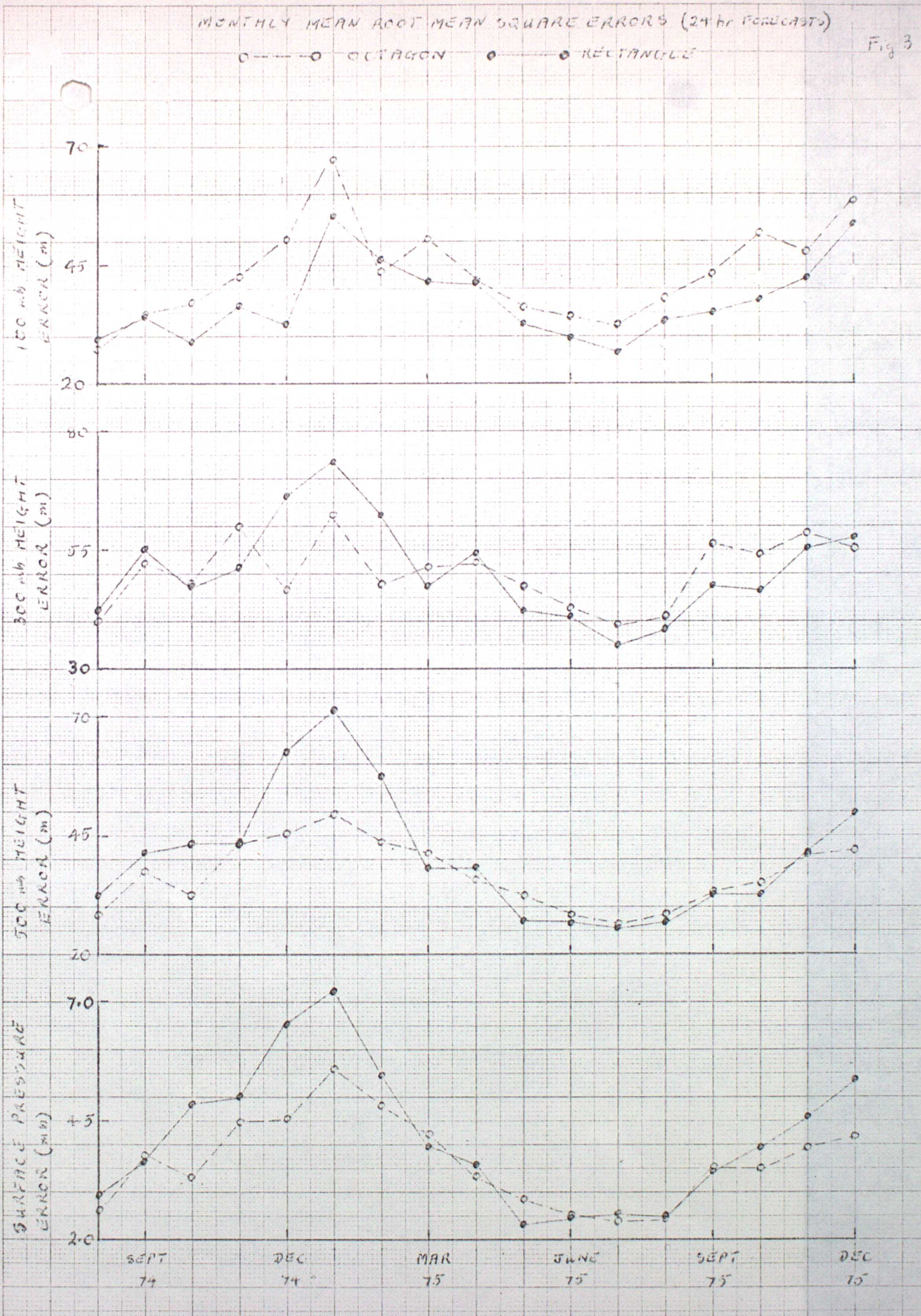


Fig 2

MONTHLY MEAN ROOT MEAN SQUARE ERRORS





MONTHLY MEAN ROOT MEAN SQUARE ERRORS (24 hr FORECASTS)
OCTAGON
RECTANGLE
Fig 3
100 mb HEIGHT ERROR (m)
70
45
20
300 mb HEIGHT ERROR (m)
80
55
30
500 mb HEIGHT ERROR (m)
70
45
20
SURFACE PRESSURE ERROR (mb)
7.0
4.5
2.0
SEPT 74
DEC 74
MAR 75
JUNE 75
SEPT 75
DEC 75

Fig 4

MONTHLY MEAN CORRELATION COEFFICIENT FOR
24 hr FORECAST AND INITIALISED CHANGES

o - - - o OCTAGON   o———o RECTANGLE

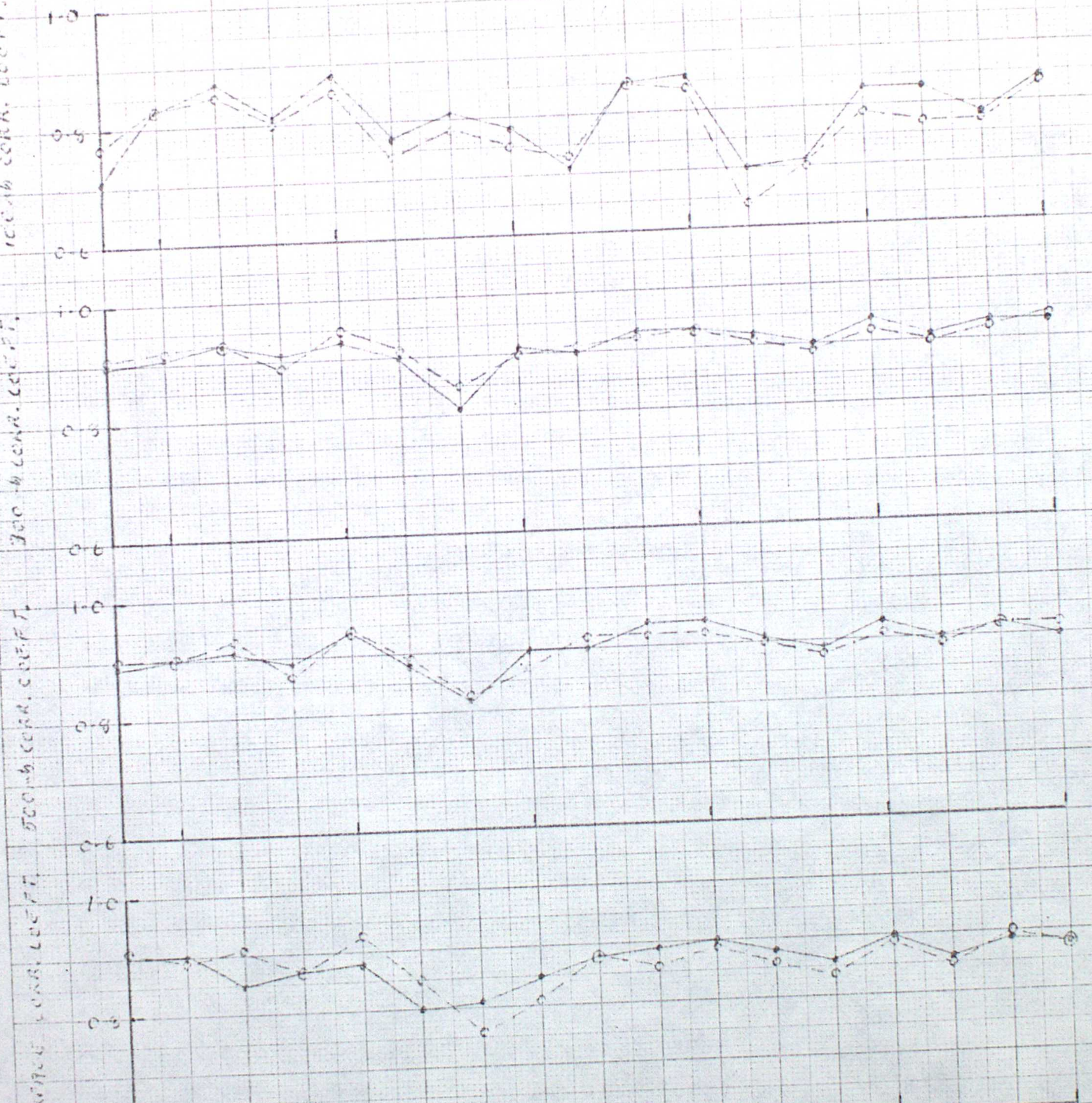
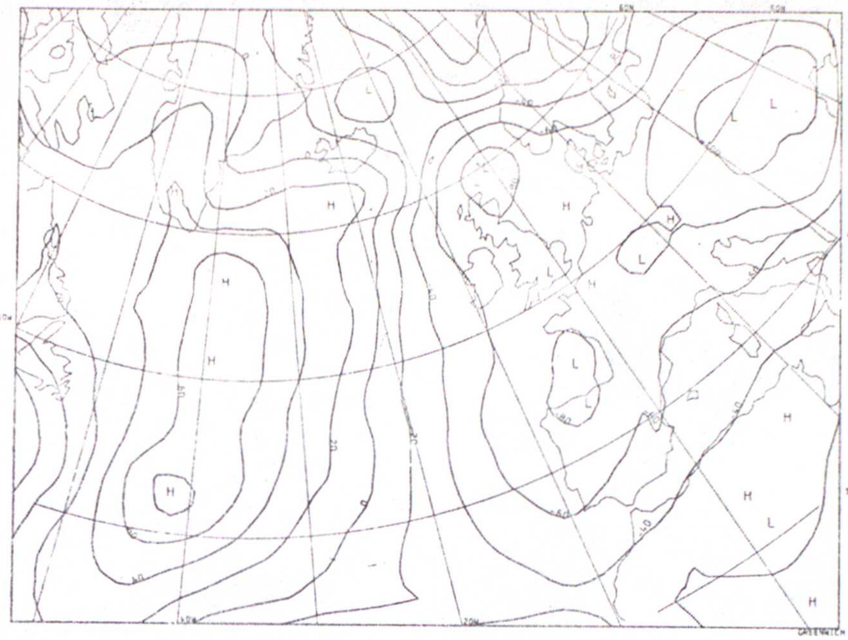


Fig 5

MEAN MONTHLY 1000 MB CONTOUR DIFF.(T+36)-(T+0) JAN 1975
ISOPLETH INTERVAL=20 METRES



MEAN MONTHLY 1000 MB CONTOUR DIFF.(T+36)-(T+0) JAN 1975
ISOPLETH INTERVAL=40 METRES

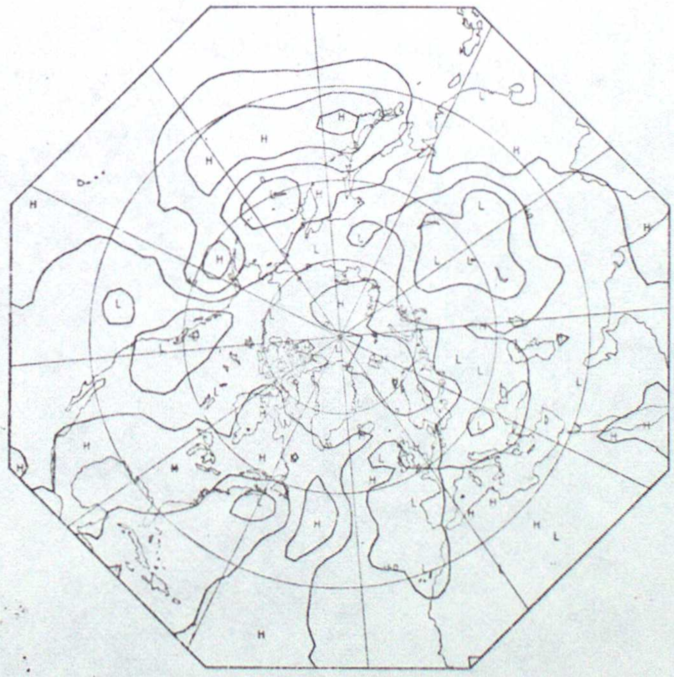
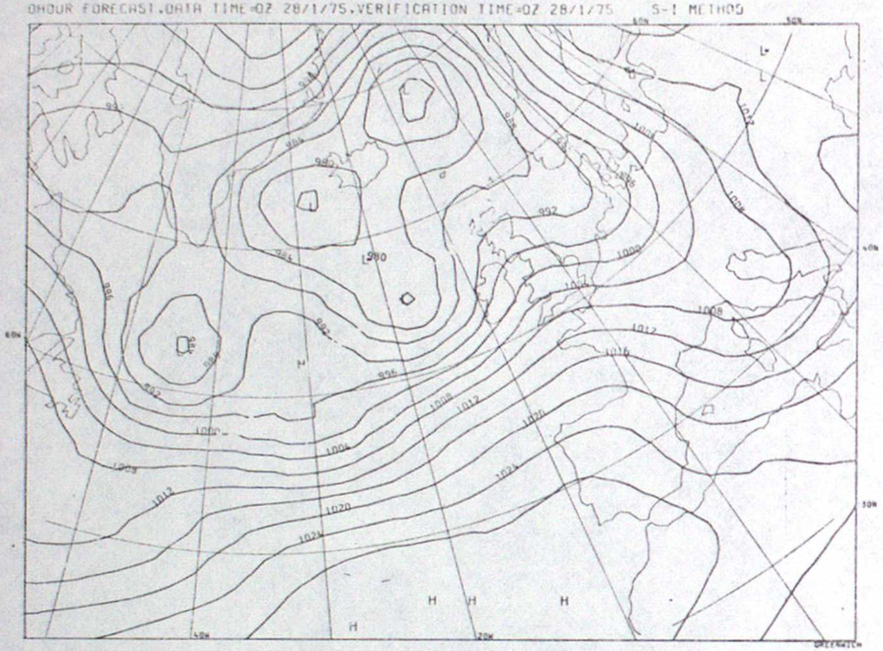


Fig 6a

OPERATIONAL OCTAGON FORECAST

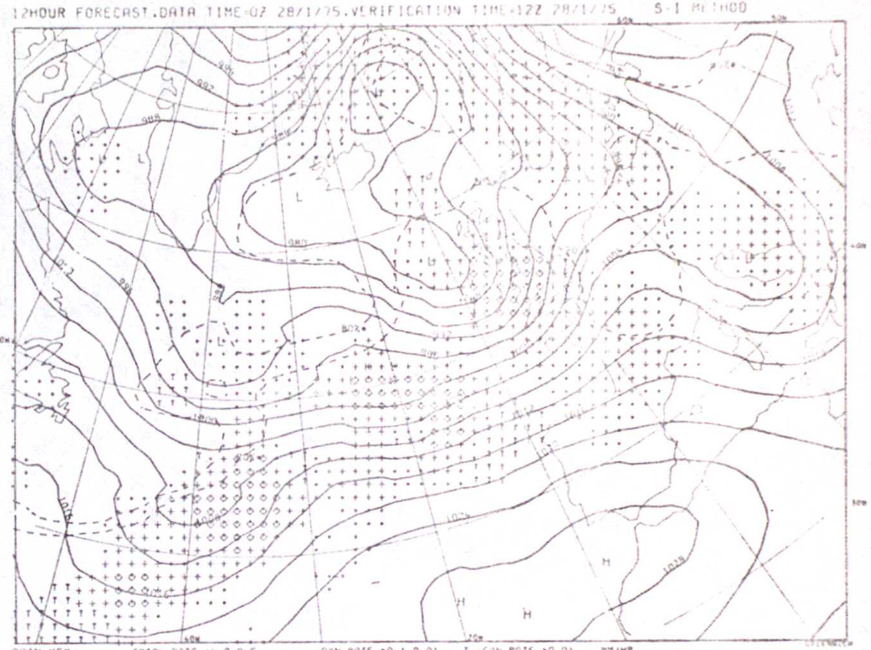
SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0HOUR FORECAST.DATA TIME=0Z 28/1/75.VERIFICATION TIME=0Z 28/1/75 S-I METHOD



FORECAST SURFACE PRESSURE AND PRECIPITATION

12HOUR FORECAST.DATA TIME=0Z 28/1/75.VERIFICATION TIME=12Z 28/1/75 S-I METHOD

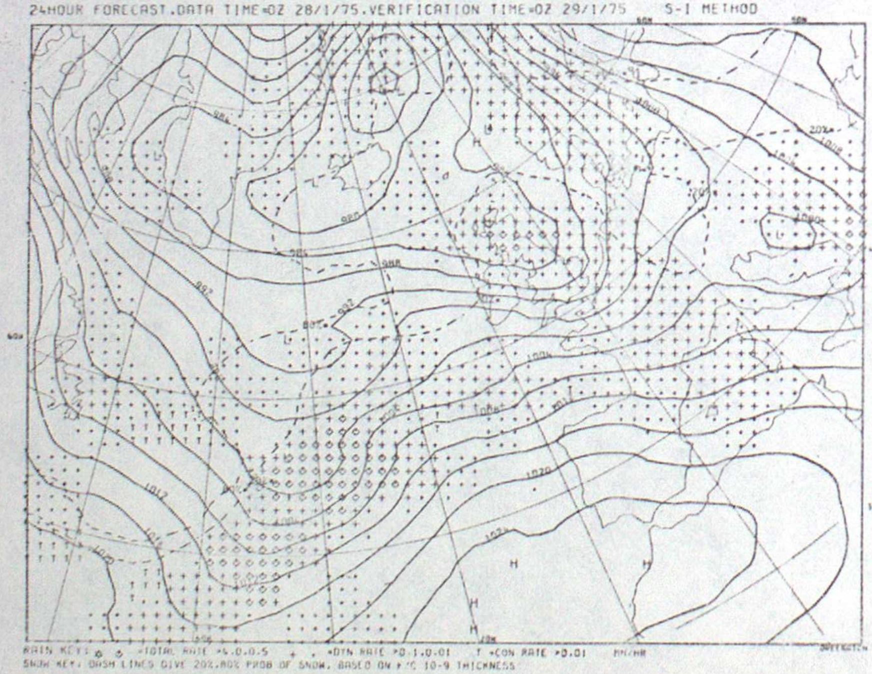


RAIN KEY: ◇ ◇ =TOTAL RATE >4.0.0.5 + + =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR

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

FORECAST SURFACE PRESSURE AND PRECIPITATION

24HOUR FORECAST.DATA TIME=0Z 28/1/75.VERIFICATION TIME=0Z 29/1/75 S-I METHOD

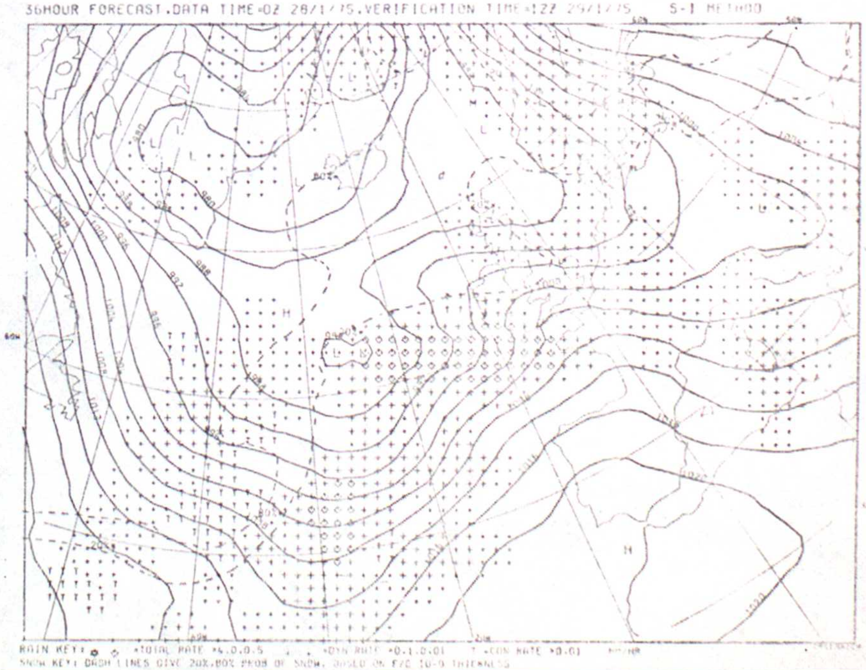


RAIN KEY: ◇ ◇ =TOTAL RATE >4.0.0.5 + + =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR

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

FORECAST SURFACE PRESSURE AND PRECIPITATION

36HOUR FORECAST.DATA TIME=0Z 28/1/75.VERIFICATION TIME=12Z 29/1/75 S-I METHOD



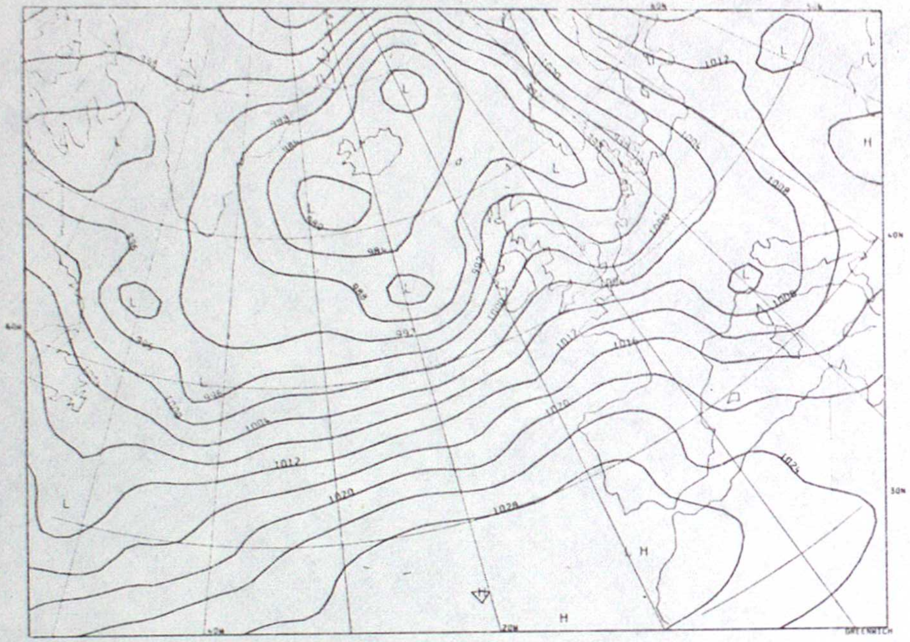
RAIN KEY: ◇ ◇ =TOTAL RATE >4.0.0.5 + + =DYN RATE >0.1.0.01 T =CON RATE >0.01 MM/HR

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

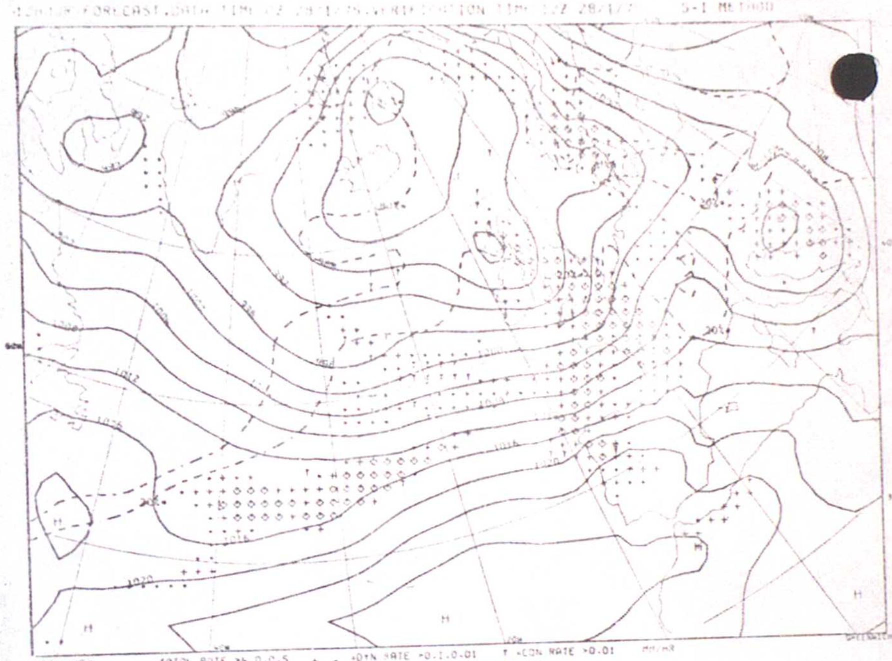
Fig 6b

OPERATIONAL RECTANGLE FORECAST

SURFACE PRESSURE   ISOBARS AT 4MB INTERVALS
24HOUR FORECAST.DATA TIME 0Z 28/1/75.VERIFICATION TIME 0Z 29/1/75   S-I METHOD

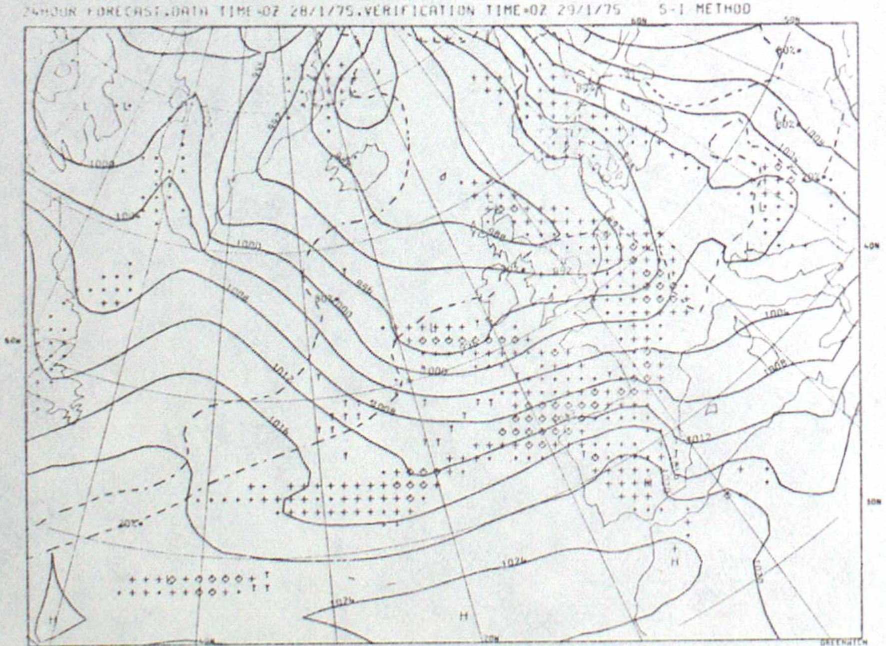


FORECAST SURFACE PRESSURE AND PRECIPITATION
12HOUR FORECAST.DATA TIME 0Z 28/1/75.VERIFICATION TIME 12Z 28/1/75   S-I METHOD



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

FORECAST SURFACE PRESSURE AND PRECIPITATION
24HOUR FORECAST.DATA TIME 0Z 28/1/75.VERIFICATION TIME 0Z 29/1/75   S-I METHOD



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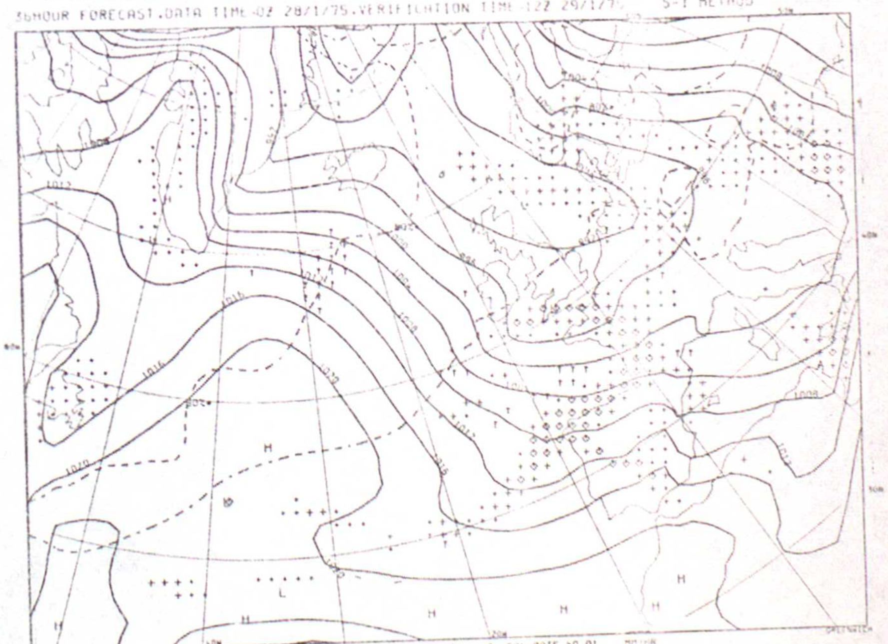
SNOW KEY: DASH LINES GIVE 20%.80% PROB OF SNOW. BASED ON F/C 10-9 THICKNESS

FORECAST SURFACE PRESSURE AND PRECIPITATION
36HOUR FORECAST.DATA TIME 0Z 28/1/75.VERIFICATION TIME 12Z 29/1/75   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

RECTANGLE FORECAST FROM OCTAGON INITIAL FIELDS

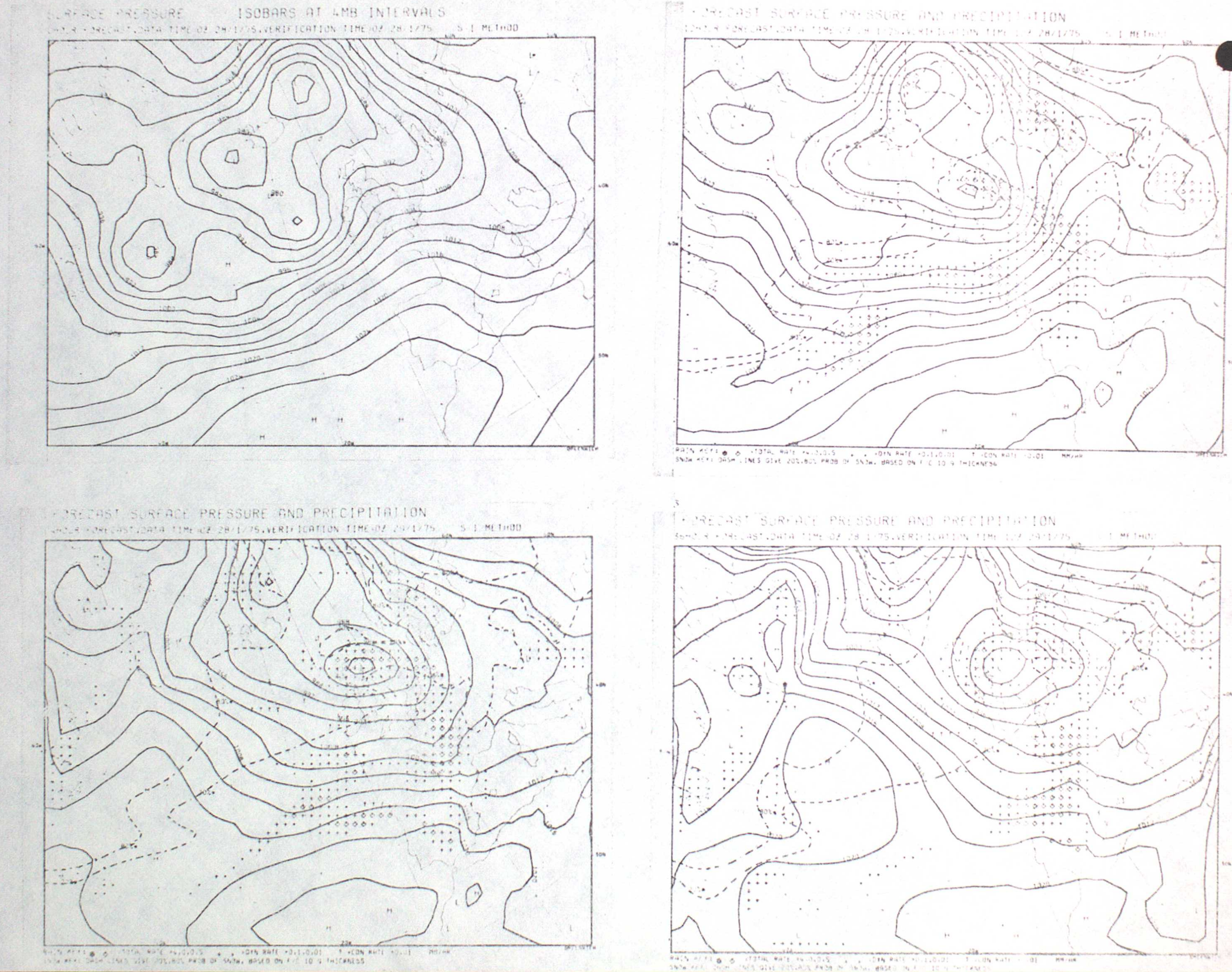
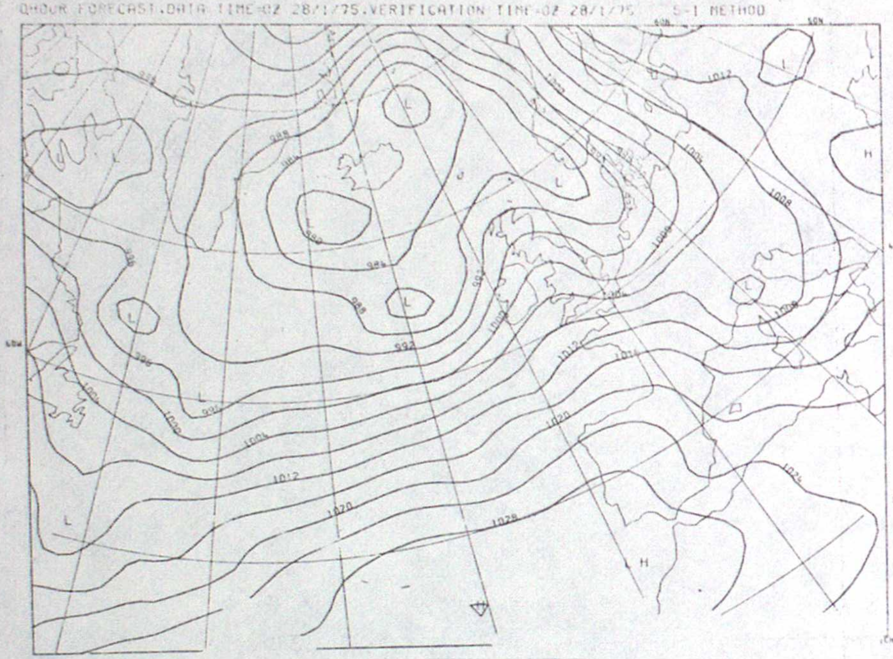


Fig 6c

VERIFYING INITIALIS'ED FIELDS

Fig 6d

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS
0HOUR FORECAST.DATA TIME-0Z 28/1/75.VERIFICATION TIME-0Z 28/1/75 S-I METHOD



SURFACE PRESSURE ISOBARS AT 4MB INTERVALS
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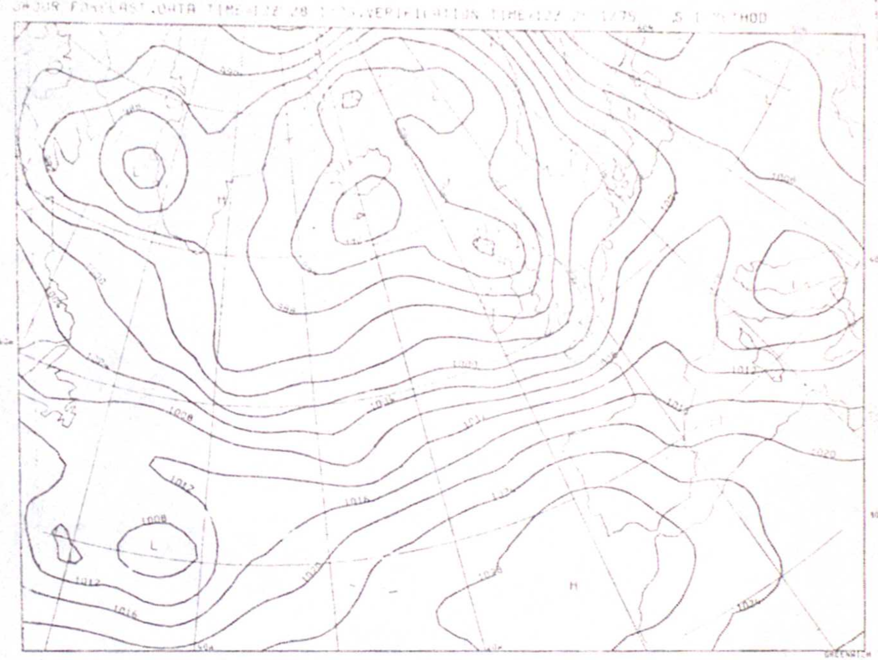
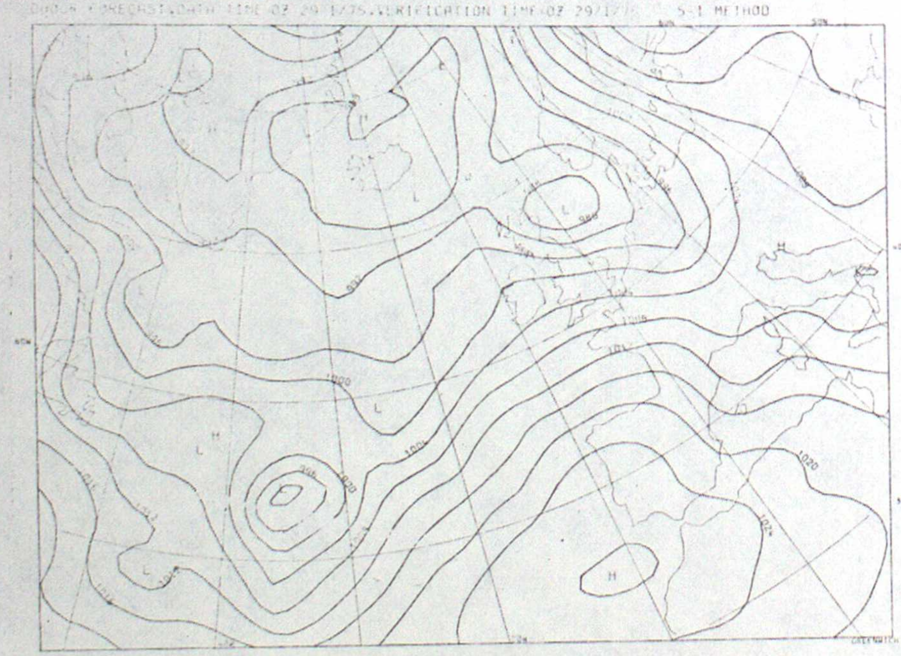


SURFACE PRESSURE ISOBARS AT 4MB INTERVALS
0HOUR FORECAST.DATA TIME-0Z 29/1/75.VERIFICATION TIME-0Z 29/1/75 S-I METHOD



SURFACE PRESSURE ISOBARS AT 4MB INTERVALS
[illegible] FORECAST.DATA TIME [illegible] VERIFICATION TIME [illegible] 1/75 S-I METHOD