The Success of 72-hour Barotropic Forecasts in Relation to Mean Flow Patterns

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In a recent article entitled "Automation of 500 mb Forecasts through Successive Numerical Map Analysis" Bo R. Döös (1956) displayed charts showing the geographical distribution of correlations between observed and barotropically-computed height changes for periods of 24, 48, and 72 hours in advance. His chart showing the 72-hour correlations, reproduced in Figure 1, possesses a number of features which appear to be related in some manner to the mean monthly mid-tropospheric flow patterns for the period covered by the forecasts (mainly mid-November to mid-December) and shown in Figure 2. Indeed Mr. Döös first drew my attention to the similarity of certain parts of the patterns and noted in his paper that it was "interesting to compare the two charts".

The large scale features which seem to bear more than accidential correspondence comprise the axis of maximum correlation in the eastern Atlantic where an anomalously strong ridge was observed, and also a maximum in the vicinity of the European trough. A pronounced area of minimum correlation separates the maxima.

Although low correlations between forecast and observed values are frequently encountered when actual changes are small, this does not seem to be the explanation of the correlation minimum over Scandinavia. For example, the standard deviation of 72-hour height changes is about the same over Sola (in southern Norway) (157 m) as over Valencia, Ireland, (153 m) even though the correlation coefficient over Valencia is more than twice that over Sola.

The following considerations may be pertinent in seeking an explanation for the pattern correspondence. In the first place this particular 30-day mean, in common with virtually all consecutive 30-day meteorological means (NAMIAS, 1953), is composed not of random but rather of serially correlated daily charts. This serial correlation is due not only to day-to-day persistence but also to persistent recurrence of similar large-scale flow patterns. Hence on several days during the 30-day period there occurred a strong westerly jet along and off the east coast of the United States, a strong ridge (or closed anticyclonic cell) over the eastern Atlantic and a strong trough (or closed cyclonic cell) in the area extending from western Russia to the Mediterranean. Cyclones forming and intensely developing off the east coast of the United States appear to have drawn upon the baroclinic energy indicated by the accentuated temperature contrast between the east coast and the western Atlantic established during this period (see Fig. 3). These cyclones were apparently associated with

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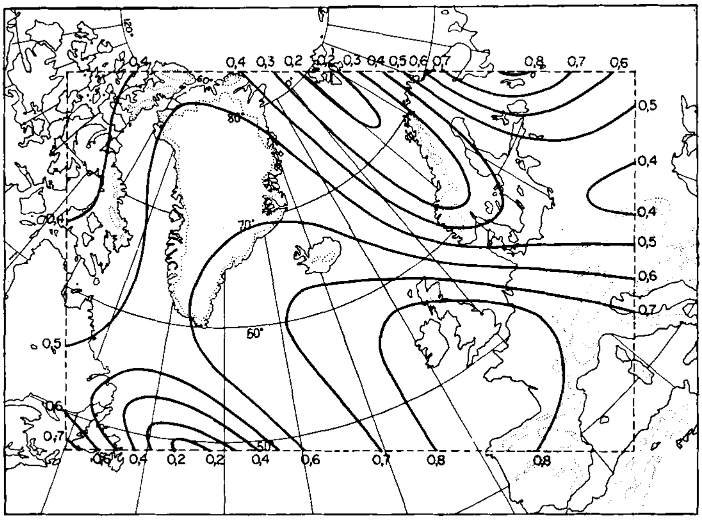

Fig. 1. Geographical distribution of the correlation between observed and computed 72-hour height changes (reproduced from 1).

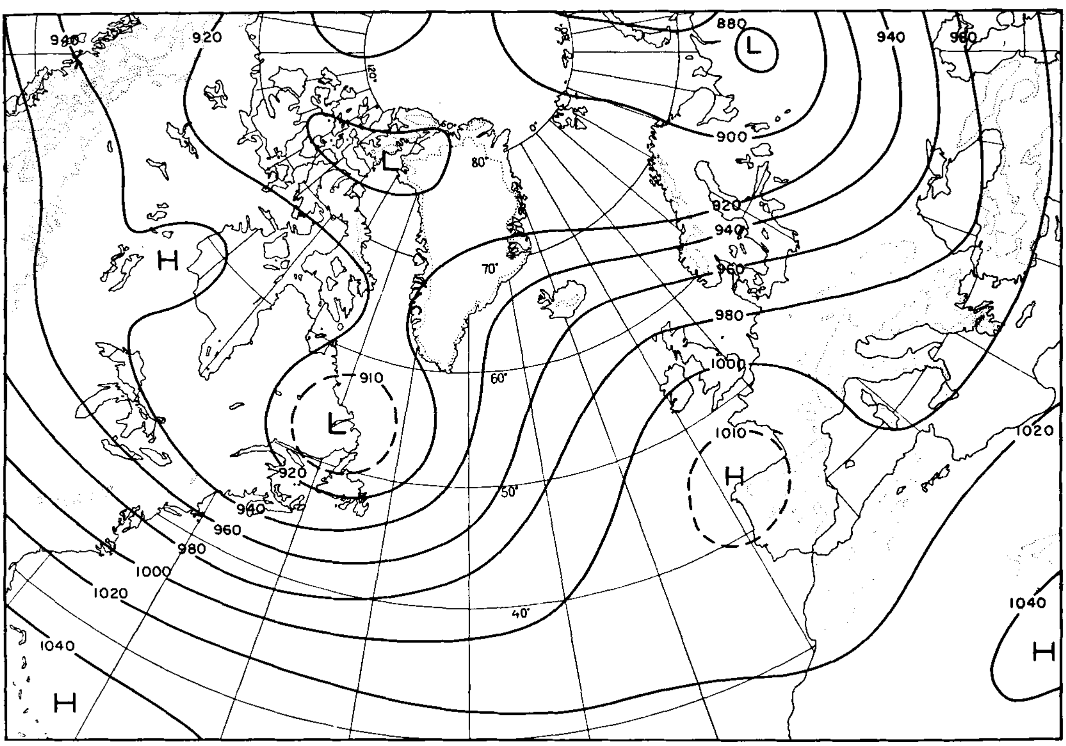

Fig. 2. 30-day mean contours of the 700 mb surface (in tens of feet) for the period from mid-November to mid-December, 1955.

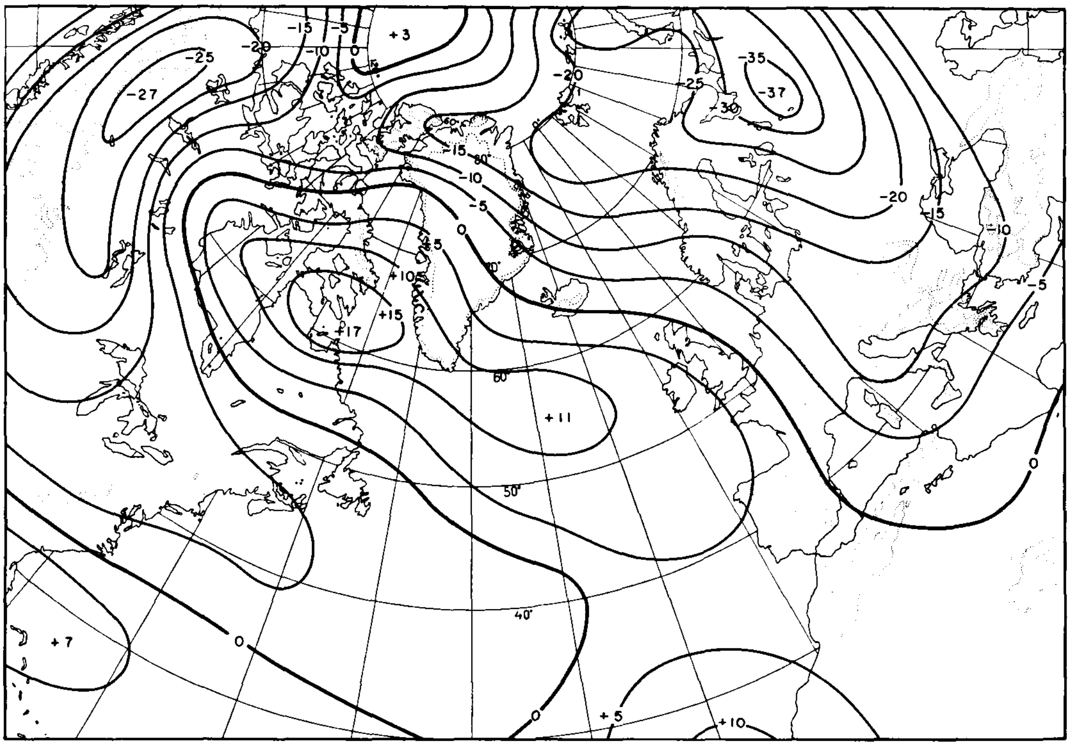

Fig. 3. Mean departure from normal (in tens of feet) of the 1 000—700 mb thickness for the 30-day period from mid-November to mid-December. 1955.

maintaining the strong westerly jet in this area. Farther downstream the jet frequently developed the diffluent flow pattern commonly associated with blocking. Still farther eastward great troughs (or low pressure centers) developed as cyclones plunged southeastward through Scandinavia, Finland and western Russia.

It seems quite likely that persistently recurrent cyclone developments along and off the east coast of the United States, perhaps to a considerable extent baroclinic, may have been responsible for the more or less geographically-fixed ridge in the eastern Atlantic and the trough over west Russia. In other words the mean trough and jet off the east coast of the United States may in this case have been one of the great "forced" perturbations of the general circulation while farther downstream the mean ridge and trough were essentially barotropically-conditioned responses. If this is so, the areas of high correlation appearing in Fig. 1 could be looked upon as seats of major response. The existence of low correlations off New Foundland lends support to the idea that here the cyclone developments may have been largely baroclinic. Besides, the tongue of minimum correlation extending from Spitzbergen southward and southeastward lies in a generally accentuated baroclinic zone, which in fact was a frequent zone of confluence between very cold Arctic air and relatively warm maritime air, clearly indicated in Fig. 2 and by the departures from normal of 1,000—700 mb thickness (fig. 3). A number of southeastward plunging disturbances were embedded in this baroclinic zone during the 30-day period, and probably account for the relatively low success of the 72-hour forecasts there in the following manner.

The average time for dispersion of large scale effects from the east coast of America to Europe is of the order of three days. The height changes produced by planetary wave reactions of this sort are naturally of great scale, so that 72-hour correlation coefficients over areas characterized largely by barotropic response would be uniformly high unless interference (non-barotropic) influences were set up in certain areas. Apparently the plunging cyclones associated with the baroclinic area from Spitzbergen southeastward have in this case provided the interference. In other words the correlation stays high in areas not materially affected by the plunging cyclones. On the other hand correlation fields for 24 and 48 hour forecasts (not reproduced from Döös' paper) do not reflect the minimum, presumably because for these shorter time intervals the individual plunging cyclones are reflected in the vorticity patterns.

Apparently for 72-hour periods the barotropic model can predict only phenomena of the scale of the great centers of action. These centers may, however, channel the prevailing air mass flows so that deformation fields are created in certain areas which favour or inhibit cyclone formation and development. The timing of the smaller scale (i. e. cyclone) systems may be more or less independent of the long waves obtained by averaging in time and may be sufficiently baroclinic that the areas in which they occur are characterized by "poor" barotropic response.

In the current search for methods of improving numerical forecasting it would appear profitable to explore further the mean field of errors in month-long series of forecasts. In this manner one might discover how the errors are related not only to geographical and seasonal characteristics but particularly to the eternally anomalous positions, orientations and intensities of the centers of action. In this way an answer might be formed to the important question regarding which mean perturbations are primary or forced and which are secondary or responsive.

REFERENCES

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