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STATISTICAL COMPARISON BETWEEN THE OBSERVED AND PREDICTED HEIGHTS OF THE 500 mb SURFACE

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Abstract

The geographical distribution of the mean algebraic errors of the barotropic forecasts has been compared with some earlier studies concerned with systematic errors of the numerical forecasts. 60 cases treated are from the winter 1956 and 25 cases from the summer of the same year. The mean magnitudes and the distribution of the errors presented in this study seem to be in good agreement with the earlier results concerning the effect of the mountains and the non-adiabatic heating.

The purpose of this note is to record the results of some tests concerning a series of barotropic forecasts, about 60 cases from the winter 1956 and 25 cases from the summer of the same year. The forecasts were computed in Stockholm by the meteorological service of the Royal Swedish Air Force in co-operation with the Meteorological Institute of the University of Stockholm. Regarding a more detailed information about the model used and the operational methods the author refers to numerous publication by Staff Members, University of Stockholm, especially to the articles of BOLIN [1], DÖÖS [4] and SIGTRYGSSON and WIIN-NIELSEN [5]. The first series of 60 forecasts of the 500 mb topography were made for 24, 48 and 72 hours, and the second series, concerning the summer-cases, for 24 and 48 hours only. The location of the

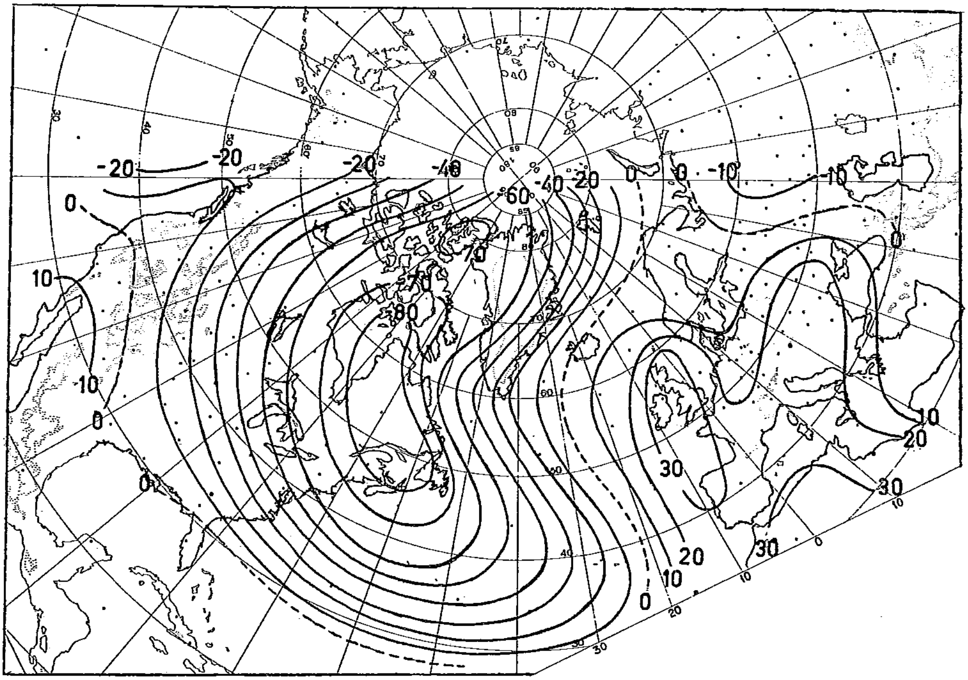

Fig. 1. The areal distribution of the mean algebraic error for 60 winterpredictions for 24 hours. The difference between the observed and forecasted heights. (500 mb).

grid used in the analyses and forecasts is shown in Fig. 1, which presents the distribution of the average algebraic error of 60 winterpredictions for 24 hours. The forecast-errors, representing a difference between the observed and forecasted heights, are here as in the following figures expressed in meters. The »observed» values have been taken from the daily 500-mb circumpolar analysis in »Täglicher Wetterbericht» published by the German Weather Service. Undoubtedly the subjectivity of the conventional analysis influences the accuracy of the error-maps. The most significant features in Figs. 1—3, are the very pronounced areas of maxima and minima, with similar geographical positions in all the three figures. The center of the too high forecasts is situated over western Labrador and its magnitude increases from 80 to 160 and 210 meters following the extension of prediction-ranges. The other very marked error-centre, that of the too low forecasts, is situated over the area covering England and Scandinavia. It is worth of attention, that the magnitudes of the positive errors are only about a half of those of the negative errors. In addition to the two primary centers mentioned it is possible to identify in all error-maps two secondary centers, one on the western and another one on the eastern boundary of the area.

A forecast-error can result from numerous effects and the purpose of the author is not to classify the contribution of different factors to the total error. It proved impossible to separate the sources of errors, boundary conditions, non-adiabatic and orographical effects etc. My aim is merely to compare the results, specially the geographical distribution of the error-field, with some earlier investigations. The geographical distribution and the magnitudes of the maximum values presented by CRESSMAN and HUBERT [3] in their study of numerical forecasting errors are of interest when compared with my results. The grid-area they used was chosen similarly. Because its western boundary laid over the meteorologically very active Pacific Ocean, Cressman and Hubert concluded that the most important sources of error in their cases were the geostrophic

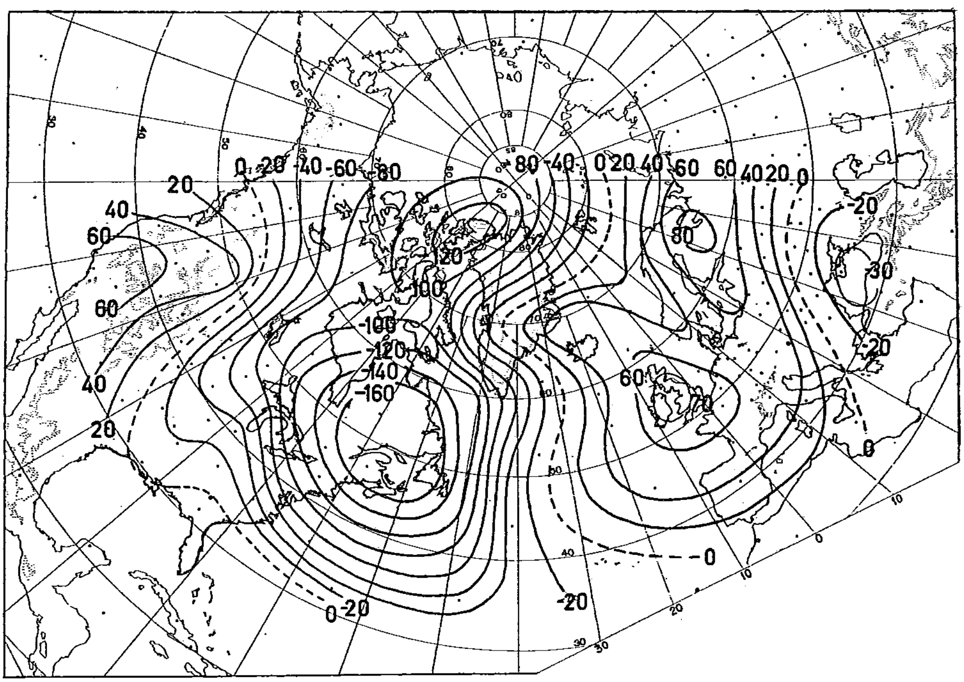

Fig. 2. The same as in Fig. 1. for 48 hours.

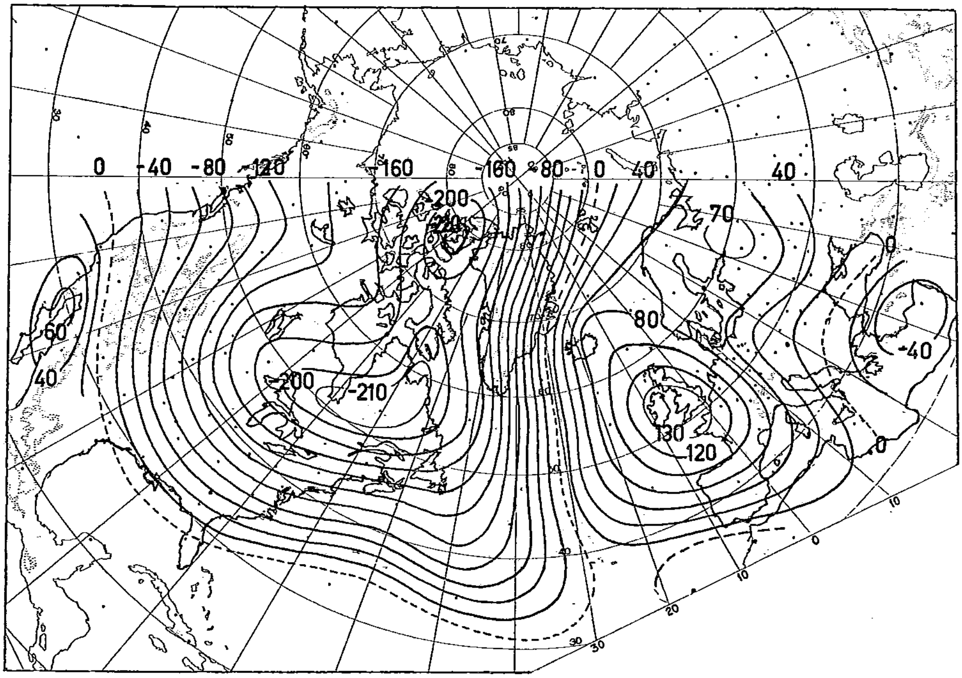

Fig. 3. The same as in Fig. 1. for 72 hours.

assumption and the boundary conditions, and that no really satisfactory boundary conditions had been found for use along boundaries which are synoptically active, characterized by a strong flow or by significant changes in the flow pattern. Referring to the surprising similarity of the longitudinal distribution in both of the investigations, the too high values to the west and too low values to the east of the axis of the grid-area, we could adopt the boundary conditions as the main source of error in the study of Cressman and Hubert and consider my own computations to be valid for the winterforecasts only. The average error-maps corresponding to the 25 summer-predictions for 24 and 48 hours are presented in Figs. 4 and 5. The most pronounced difference between these and the winter-maps is the evident absence of the negative centers, dominating in the winter-maps over Labrador. The two primary maxima in Figs. 4 and 5 are located over the continents showing too low forecasts in both cases. A crude integration around the whole grid-area shows that during the winter the forecasts were too high and during the summer too low and

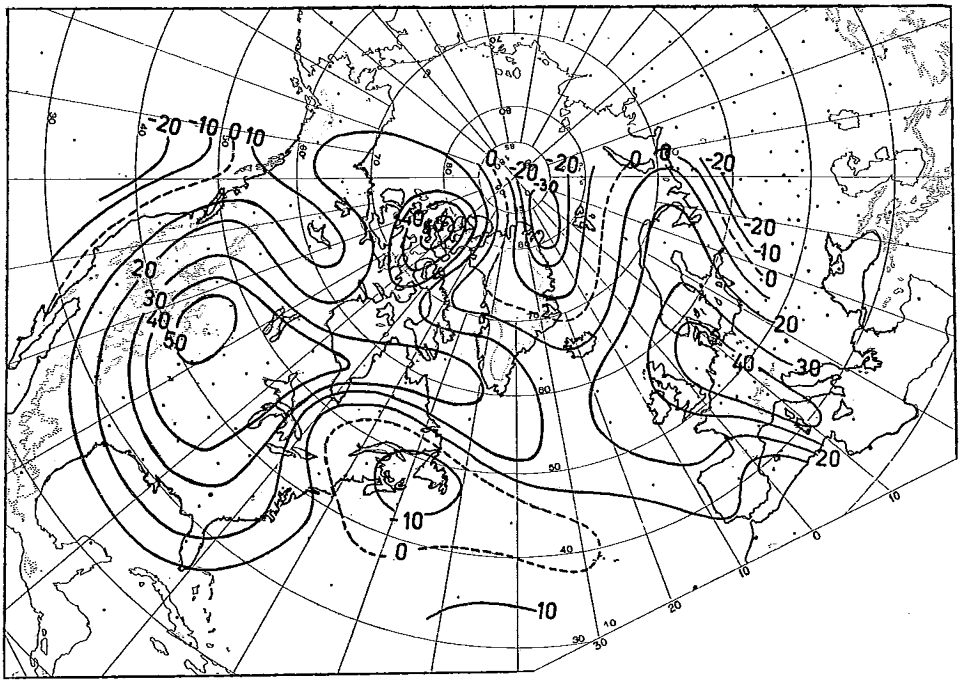

Fig. 4. The same as in Fig. 1. for 25 summerpredictions for 24 hours.

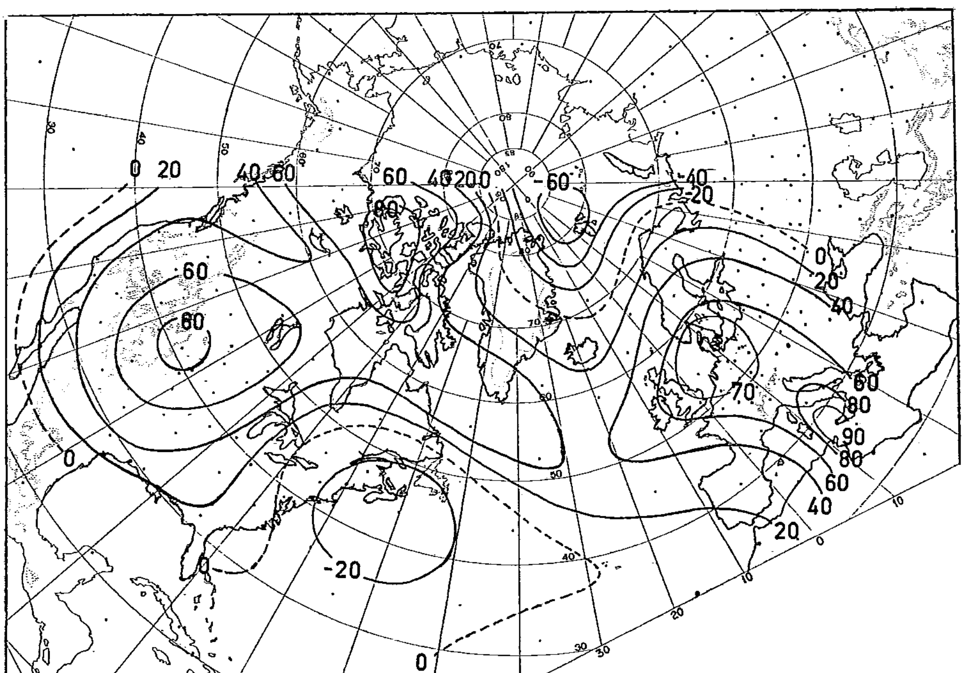

Fig. 5. The same as in Fig. 4. for 48 hours.

furthermore that the magnitudes of the errors were in winter twice as large as in summer. This gives an idea upon a possible relationship between the error-fields discussed and the difference in synoptic activity during the winter- and summertime.

In spite of the difficulties in investigating the relationship between the geographical distribution of the amount of non-adiabatic heating and the forecast error and furthermore the effect of the mountains, the author intends to compare the results with earlier computations regarding these effects. In Fig. 7 I have presented the mean errors of the 60 winter-predictions for 24 hours as a function of longitude along the latitude 45°N. In the same figure I have included the 24-hour height change of the 500-mb surface at 45°N, produced by the motion of an initially straight zonal current over the continents. This curve is computed by CHARNEY and ELIASSEN [2]. Assuming that this effect appears as a standing error in our long-time mean I have subtracted it from the errors assuming that the difference curve will describe the effect of the non-adiabatic heating.

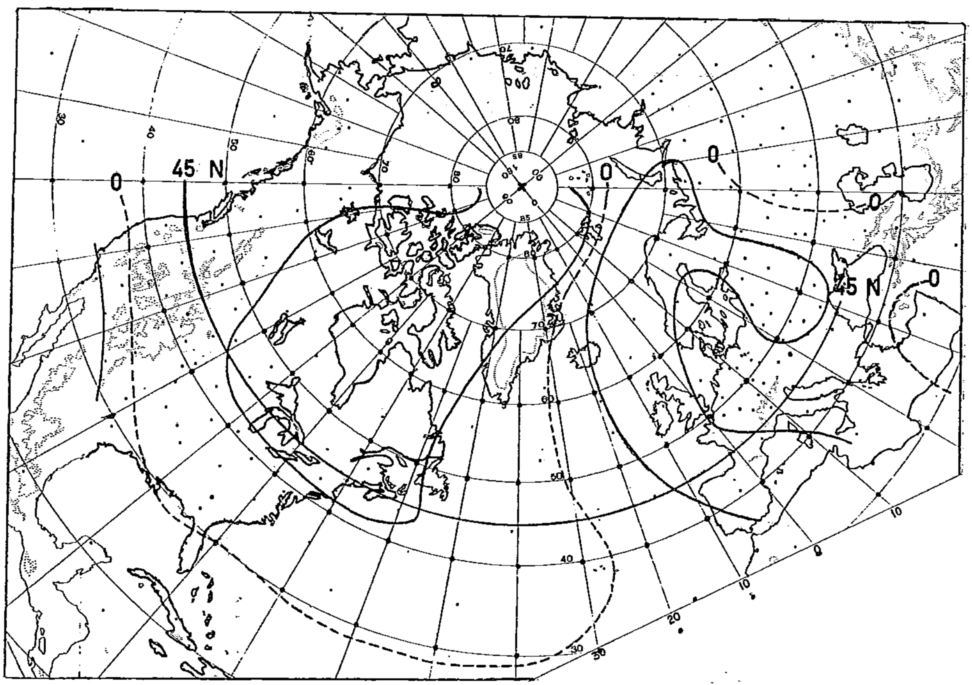

Fig. 6. The heating map according to WEXLER [6].

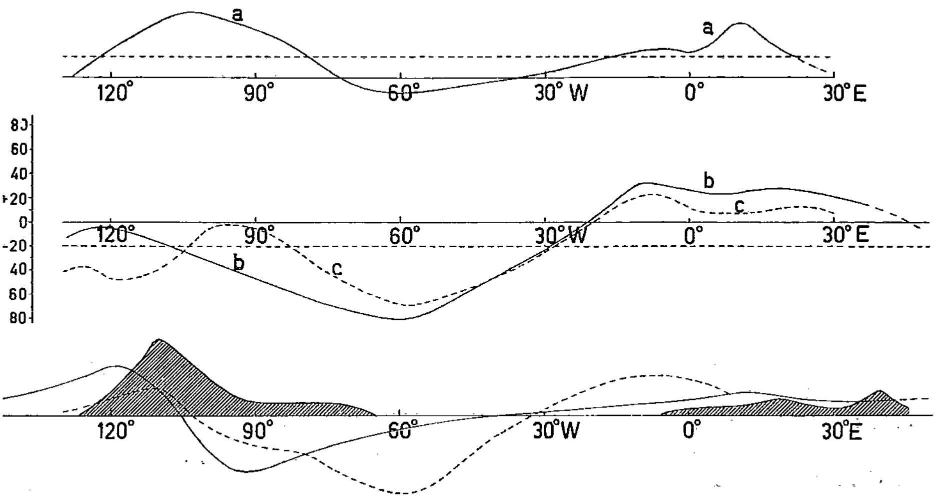

Fig. 7. The lowest solid line represents the mountain effect according to CHARNEY and ELIASSEN [2]. The curve (b) is the mean error of the 60 winterpredictions for 24 hours. The lowest broken line represents WEXLER's values and the curve (c) is the difference between the mean error and the mountain effect.

For the comparison I have inserted the longitudinal heating curve, constructed using values from a heating map computed by WEXLER [6]. I have transformed Wexler's values (unit: gr. cal/cm^2 day) to represent the 24-hour height change of the 500 mb surface (unit: meter) and for the sake of clarity also presented the heating negative.

The agreement between the heating curve and the difference curve is quite remarkable. The original heating map is reproduced in Fig. 6 and the accordance between the areal distribution of the heating values and the forecasting errors, for instance in Fig. 1, is also here surprisingly good.

The purpose of the author is not to try to explain this very complex relationship. The intention of this study, on the base of what has been shown above, is only to emphasize the significans of statistical investigations of the numerical forecasting errors for understanding of those synoptic phenomena, which affect the different terms of the vorticity equation.

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