U. S. Department of Commerce

Weather Bureau

OFFICE NOTE NO. 19
DEVELOPMENT BRANCH
NATIONAL METEOROLOGICAL CENTER

THE PREPARATION OF FIRST-GUESS HEIGHTS FOR USE IN OBJECTIVE ANALYSES

Arthur F. Gustafson

September 1962

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In the system of objective analyses employed at NMC, a first-guess of the heights at 850 and 500 mbs is required for the initial steps [1]. The 12 hr numerical forecast is the basic source of these required "guess" heights. On and near the boundaries of the grid, however, the numerical forecasts are inherently poor. Prior to the fall of 1962, normal heights were introduced south of 30°N to counteract this. Under this system normal heights are gradually implanted near the boundaries of sparse data areas. In March, 1962, a 500 mb low moved unusually far south off the coast of Mexico. The low observed height values to the north of high climatological values on and near the boundary there resulted in analyzed wind speeds and vorticity values which were obviously spurious. Experiments carried out by Dr. Cressman indicated that this resulted in serious numerical forecast errors, particularly in the southeastern portion of the United States.

In the system currently in use, each 12 hr forecast to be used as a first-guess, is first modified in such a way that the north-south height gradients, rather than the heights themselves, tend toward normal values for the month and locality in question. This office note describes the method used to accomplish this modification.

For the 1977 point NWP grid, it is assumed that the 12 hr forecast heights for all points on or north of 27.5°N do not require adjustment. The method then proceeds to compute the hypothetical heights "Z_n" which points south of 27.5°N would have if normal north-south height gradients prevailed in this near-boundary zone. These computations are carried out over successive 5° latitude bands beginning with the band 27.5°N to 22.5°N and proceeding southward to the boundary. Within each 5° band, the normal N-S gradient is assumed to be constant. The constant values used were obtained from the 40 year monthly normal charts described in [2] and [3].

The hypothetical heights, Z_n, are finally combined with the 12 hr forecast heights to obtain weighted averages as the modified guess field.

The ratio of the respective weights used, favors the forecast heights. Nevertheless, repeated twice daily applications of the formula will soon tend to produce normal gradients in sparse data areas. The optimum weighting ratio has not yet been determined. It has been currently set at 7 to 1 but this may be altered based on experience gained through operational use of the method during the winter 1962-1963.

The method for computing the field of Z_n was developed as an adaptation of the regular objective analyses program. This program includes a routine for computing an "analyzed" height for a grid point corresponding to observed heights and winds at nearby radiosonde stations [1]. In making

this computation the wind is converted to a pair of height gradients in the X and Y directions based on the geostrophic wind formula. If in place of observed winds, one were to introduce normal geostrophic winds, the analyses program would compute grid heights whose gradients were essentially normal. This is the basis for the method.

Normal north-south gradients are obtained for each 5° of longitude corresponding to each of the three latitudinal bands mentioned above. These normal gradients are fed in as bogus geostrophic winds at the proper longitudes and at either 27.5°N, 22.5°N, or 17.5°N, depending on the band over which the gradient applies. In contrast to the regular analysis program, however, these "observations" do not influence the heights of grid points north of the "observation" point. Furthermore, the computation is carried out in three stages, the first of which considers only the "observations" at 27.5°N, the second only at 22.5°N, and the third at 17.5°N. This is done so that the heights at 22.5°N will have already been properly adjusted corresponding to the forecast heights at 27.5°N and the proper normal gradients prior to being used in the next stage to compute the heights, Z_n, for points south of 22.5°N.

It is important to note that the Z_n for all three of the latitudinal bands are successively computed prior to combining them with the forecast heights as described above. Finally, it should be emphasized that the above techniques are aimed only at obtaining a better first-guess from

which the regular analyses program can proceed using observational data. Where data is available the first-guess is completely superceded. The imposed normal gradients will therefore prevail only in areas where data is missing or very sparse.

The method was developed jointly by Mr. A. F. Gustafson and Mr. James E. McDonell. Programing was accomplished by Mr. McDonell and Mrs. Thelma M. Smith.

Further details concerning the programming aspects of the method are contained in Appendix I.

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1. Cressman, G. P., Monthly Weather Review, Vol. 87, No. 10, Oct. 1959.
2. Jacobs I., Institut fur Meteorologie und Geophysik der Freien Universitat Berlin, Meteorologische Abhandlungen, Band IV/Heft 2, 1958.
3. Hennig, H., Institut fur Meteorologie und Geophysik der Freien Universitat Berlin, Meteorologische Abhandlungen, Band IV/Heft 3, 1958.

APPENDIX I

The adjustments are made by a special version of the analysis program which requires the climatological data as input. Following is a description of the procedures for obtaining the input data and the special features of the analysis program used to adjust the height fields.

Adjustments are made in the same manner for 850 mb and 500 mb. With reference to the analysis code, the 850 mb Z_n are calculated in FLD2 and 500 mb in FLD7. All gross error checking and smoothing procedures are eliminated. The scheme requires 3 scans through the analysis system with scan radii of 3.2, 3.2, and 4.2 grid lengths on scans 1, 2, and 3 respectively. These radii were determined from the known distribution of data. In correcting the grid points to obtain Z_n the equation used is given by:

$$C = \frac{\sum_{i=1} W_i E_i}{\sum_{i=1} W_i}$$

where E_i is the error at a grid point based on the climatological wind gradients (data) and W_i is the weighting function $\frac{N^2 - d^2}{N^2 + d^2}$.

Input data is obtained by use of present codes (ADP and Analysis-Sort). Climatological height data are used to obtain north-south gradient at each 5° of longitude. These gradients are converted to geostrophic winds and

bogus cards of wind data are prepared. The data are prepared for latitudes 25°N, 20°N, and 15°N. The height difference 30°N - 20°N is used for the wind at 25°N. The height difference 25°N - 15°N is used at 20°N; etc. The boundary test is deleted from the analysis sort so that data at 15°N will not be discarded for points near the 1977 grid boundary.

The program prepares the data as for the regular analysis scheme. A special feature here is the reassignment of location of the data points to new points 2.5° northward after the scaling conversions have been made. The above procedures are required only once for each set of climatological data.

Compatability between the analysis sort program used to prepare the input tape and the analysis program is necessary.

A code is being made available so that punched decks of the data tape can be used as the permanent file of the data for each month. Another code will be available to transfer the card information to a tape in case of tape trouble.