NOTES AND CORRESPONDENCE

A Relationship Between Persistence and Numerical Weather Prediction

NORMAN J. MACDONALD AND RALPH SHAPIRO

Air Force Cambridge Research Laboratories, Bedford, Mass.

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1. Introduction

The importance of short-term (day-to-day) persistence in subjective weather prediction has been recognized by forecasters for some time. In fact, persistence almost invariably is one of the most important parameters in statistical forecasting procedures. However, little attention has been given to the possibility of a relationship between persistence and the results of numerical-dynamical forecasts. It is the purpose of this note to show that an association exists between persistence and the accuracy of forecasts of the height distribution at the 500-mb level prepared by the Joint Numerical Weather Prediction (JNWP) barotropic model. The sense of the relationship is not unexpected; that is, forecasts are more accurate when persistence is high, and vice versa.

2. Data and analysis

The average height error of the JNWP barotropic, 36-hour 500-mb prognosis (verifying time 0000Z) as prepared by the U. S. Weather Bureau was used as a measure of the accuracy of the dynamical forecasts. The daily average height errors were computed by JNWP from the absolute sum of the individual errors at 42 grid points covering much of North America (10-deg intervals of longitude from 130W to 70W and 5-deg intervals of latitude from 30N to 55N). The period covered by this study is August 1958 through March 1960 (20 months).

Three-day mean persistence correlations, R_k , were computed from the heights of the 500-mb surface at 107 equally spaced grid points over an area slightly larger than that covered by the JNWP grid. R_k is a measure of the extent to which the 3-day mean 500-mb height distribution over North America for days k , $k+1$ and $k+2$ resembles the mean height distribution for days $k+3$, $k+4$ and $k+5$.

The superposed epoch method of analysis was used to determine whether the persistence correlations and height errors are related. Key days (day 0) were selected

FIG. 1. The distribution of the 3-day mean persistence correlation ($\bar{R}_k$) as a function of the occurrence of small (1a) and large (1b) 500-mb height forecast errors.

FIG. 2. The distribution of the average height error, $\bar{E}_k$, as a function of the occurrence of low (2a) and high (2b) persistence correlations.

from the 20-month sample using the following criteria:

- 1) The three days each month with the smallest height error;
- 2) The three days each month with the largest height error;
- 3) The three days each month with the lowest persistence correlations;
- 4) The three days each month with the highest persistence correlations.

Average values of the persistence correlations or the height errors were computed for the ten days before and the ten days after each set of 60 key days.

3. Results

The results of the four superposed epoch analyses are shown in Figs. 1 and 2. In Fig. 1, the solid horizontal line represents the population average of the 3-day mean persistence correlation for the entire 20-month period. Curves 1a and 1b show, respectively, the average behavior of the persistence correlations from ten days before to ten days after the three smallest and three largest height errors each month. Fig. 2 shows the complementary analysis of the height errors around the times of low (curve 2a) and high (curve 2b) persistence. In this case the solid horizontal line represents the population-average height error during the 20-month period.

The circled points indicate those days on which the average values of the persistence correlations (Fig. 1) and average height errors (Fig. 2) are significantly different from their respective population means. In the case of the single circle the departures are significant at or below the 5 per cent level as computed from Student's "t" test assuming $(N-1)$ or 59 degrees of freedom. However, the 3-day mean persistence correlation and the average daily height errors are not independent of the few adjacent correlations or height errors. Since in each of the superposed epoch analyses a number of key days are adjacent to each other, there are in fact fewer than 59 degrees of freedom. If the degrees of freedom are reduced to the number of key days separated by 5 days or more and new estimates of "t" are made, most of the departures still remain significant at or below the 5 per cent level as shown by double circles.

The differences in the timing of the significant departures from the key day in both figures does not represent a real lag relationship, but is simply a result of the definition of the persistence correlation. It should be recalled that the persistence correlation on day k involves the 6-day period from days k through $k+5$.

4. Discussion

From curve 1a of Fig. 1 it can be seen that the persistence correlation is high when the height errors are small. The converse (curve 1b of Fig. 1) is also true; persistence is low when the error is large. Similarly, in Fig. 2, the results show the height error to be large around the time of low persistence (2a) but small when persistence is high (2b). In curve 2b, the smallest height error occurs on day 5; however, the average height errors on days 3 and 4 are almost equally as small. The greater statistical significance of the average on day 5 is a result of a somewhat lower standard deviation for the day-5 values as compared with either days 3 or 4. On the other hand, the significance of the difference between the a and b curves is greatest on day minus 3 in Fig. 1 and on day plus 3 in Fig. 2. In each of these cases, the difference is significant at less than the 0.1 per cent level as determined by Student's "t" test.

From these results it is quite clear that a relationship exists between persistence and the accuracy of the 36-hour, 500-mb barotropic forecasts prepared by JNWP during the 20-month period of this study. Although these results are not unexpected, it should be reiterated that they cannot be used as a forecast aid since the relationship is essentially simultaneous.

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