Climatology

DECREASE OF FORECAST ACCURACY WITH INCREASING DISTANCE FROM WSFO

Alexander F. Sadowski [1]
5906 Holland Road
Rockville, MD 20851

A study of weather forecast scores for (a) probability of precipitation and (b) temperatures shows a decrease of forecast accuracy with relation to increasing distance from the Weather Service Forecast Office (WSFO) where the forecast is prepared. For this study, only the first forecast periods from the 0600Z map (for 1200 - 0000Z period - TODAY) and the 1800Z map (for 0000 - 1200Z period - TONIGHT) were used. The short period forecast does, in theory at least, have the greatest advantage due to nearness to the point for which the forecast is prepared. In general, this is due to several factors, including forecaster familiarity of local terrain effects, and local weather spotter networks.

The graphs of these two weather elements show a gradual decrease in forecast accuracy with increasing distance from the WSFO; however, there is a great deal of scatter about the line of best fit as can be seen on the attached graphs. Statistical data used in Graphs 1, 2, and 3 were based on a four year sample (April 1966 through March 1970) which included 189,600 forecasts made by 21 WSFOs for their own stations and 44 Weather Service Offices (WSO). Graphs 4 and 5 were based on more recent data (October 1972 through March 1973) that is a smaller sample consisting of 68,442 forecasts by 43 WSFOs for their stations and for 135 WSOs. Though the time sample was smaller, the increased number of stations with varying distances from the forecast point gave more weight to the concept of decreasing forecast efficiency with distance. Graph No. 1 shows the increase of Brier Scores (B) with greater distance from the forecast station (the drawn line is by eye fit). Use of the Brier Score for this purpose does not compensate for differences in climatology.

Brier Scores were computed as:

$$B = \frac{1}{F} \sum_{i=1}^{F} (K_i - O_i)^2$$

$$O_i = 0, 1$$

K_i = Probability forecast

F = Number of forecasts

P = Number of precipitation occurrences

$$= \frac{1}{F} \sum_{i=1}^{F} \left[P_i (K_i - 1)^2 + (F_i - P_i) (K_i)^2 \right]$$

Graph No. 2 shows the decrease in mean improvement with distance from the forecast station. Because precipitation (PF) and Brier Score were available, improvements (SS) over sample Brier Score were used rather than improvement (S) over long-term climatology. Since the verification period is so long, the sample climatology approached long-term climatology. Even though there is some scatter around the regression line, this score (SS) compensated somewhat for difference in precipitation climatology. The correlation coefficient was $-$ .378 which is significant at the one (1) percent level.

Mean Brier Score improvement over Sample Brier Score was computed as:

$$SS = \frac{1}{N} \sum_{i=1}^{N}$$

N = Number of six month periods

$$SS_i = \frac{(BS_i - B_i)}{BS_i} \times 100.0$$

$$BS_i = PF_i (1 - PF_i)$$

P = Precipitation occurrences

$$PF = \frac{P}{F}$$

F = Number of forecasts

Graph No. 3 is the most meaningful presentation of decrease of temperature forecasts with distance. It is a presentation of Percent Temperature Forecast Improvement (TC) over temperature variability (24-hour change of minimum and maximum temperatures) computed as follows:

$$\text{Mean Improvement} = \overline{TC} = \frac{1}{N} \sum_{i=1}^{N} TC_i$$

N = Number of six month periods

$$\text{Percent Temperature Improvement} = TC = \frac{(TV-TE)}{TV} \times 100$$

$$\text{Temperature Variability} = TV = \sum_{i=1}^{N} \frac{\left| TO_i - TO_{i+1} \right|}{N-1}$$

$$\text{Temperature Error} = TE = \sum_{i=1}^{N} \frac{\left| TF_i - TO_i \right|}{N}$$

Temperature Forecast = TF
Temperature Observation = TO

The correlation coefficient is - .164.

Graph No. 4 shows improvement over long-term climatology decreasing with distance for the six-month period, October 1972 - March 1973. The skill score used by the National Weather Service for precipitation forecasts shows more clearly the decrease in forecasting ability with increasing distance from the office where the forecast is prepared. The correlation coefficient is - .4108 which is higher than any of the other graphs. Its linear regression line has a steeper slope than any of the other graphs.

Percent Improvement over long-term climatology (S) was computed as follows:

$$S = \frac{(BC-B)}{BC} \times 100$$

Climatological Brier Score (BC):

$$BC_i = \left[\left(C_i - \frac{P_i}{F_i} \right)^2 + \frac{P_i}{F_i} \left(1 - \frac{P_i}{F_i} \right) \right] F_i$$

C_i = Climatological probability for each month at each station (15 years record)

i = Denotes number for a month

P = Number of precipitation occurrences at a station

F = Number of probability forecasts at a station

The plotted data was computed as a weighted mean Climatological Brier Score = BC.

$$BC = \frac{\sum\limits_{i=1}^{N} BC_i}{\sum\limits_{i=1}^{N} F_i}$$

Graph No. 5 is similar to Graph No. 3; however, it is a more recent (October 1972 - March 1973) and smaller sample. However, the correlation coefficient of - .2137 is higher.

There are, in view of the large scatter, many other factors involved in accuracy of forecasting that could require further study.

In conclusion, the comparison was confined to the first forecast period. The short period forecasts would, in theory at least, gain the greatest advantage from nearness to the point for which the forecasts are prepared. The study is presented in two time groups; i.e., a four-year sample (April 1966 through March 1970) and a six month sample (October 1972 through March 1973). Both, the long term sample and the short period sample, have about the same slope to their lines of approximate best fit. Of the five graphs, the graph that best shows the decrease of forecast with increasing distance from the WSFO is Graph No. 4. Graph No. 4 is a presentation of the decrease of percent improvement over long-term climatological probability of precipitation with distance. The graph represents data from 43 WSFOs and 135 WSOs. Also, Graph No. 2 is noteworthy. To a large degree, the sample climatology is a measure of the difficulty of making a forecast. However, there are intangibles, such as the threat of precipitation, which contribute to the forecast difficulty. The improvement over sample climatology gives some measure of the skill of a forecaster or forecast technique.
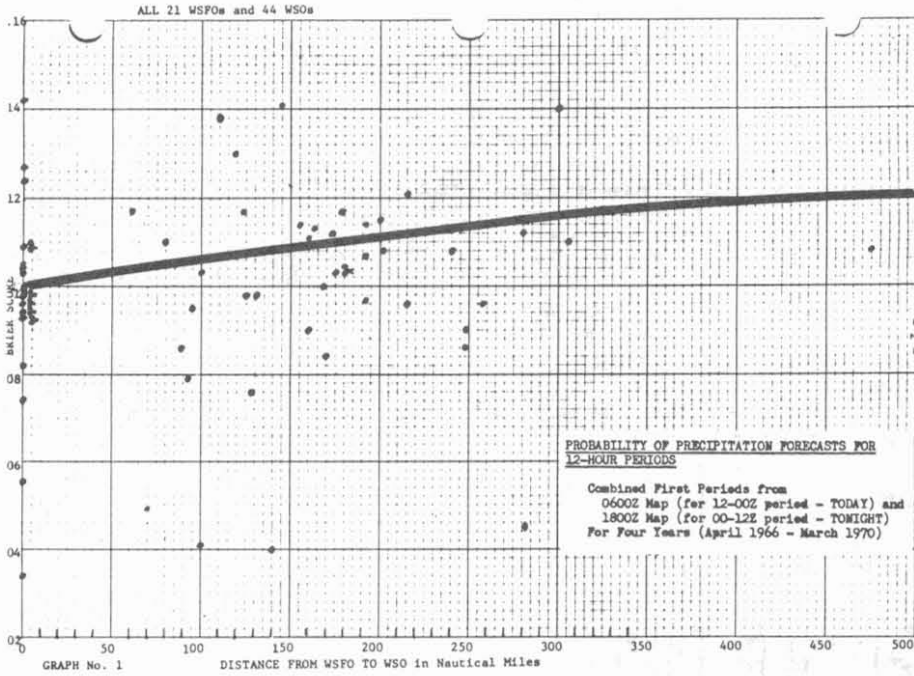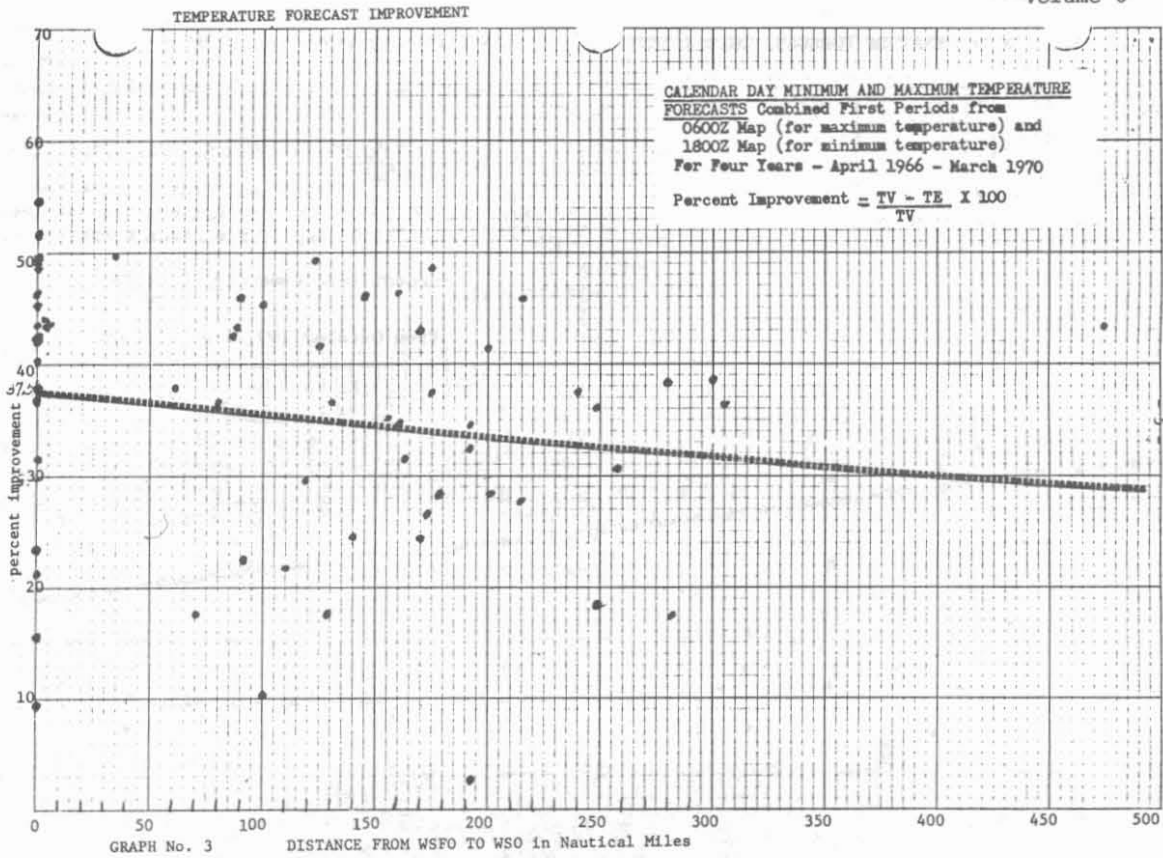

Graph 1.

Probability of Precipitation Forecasts for 12-Hour Periods
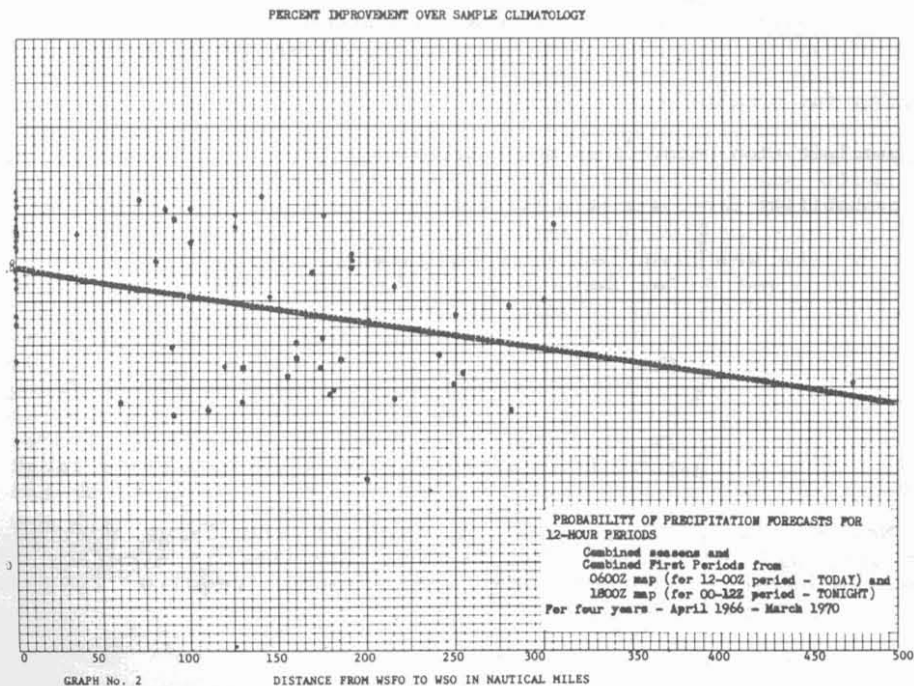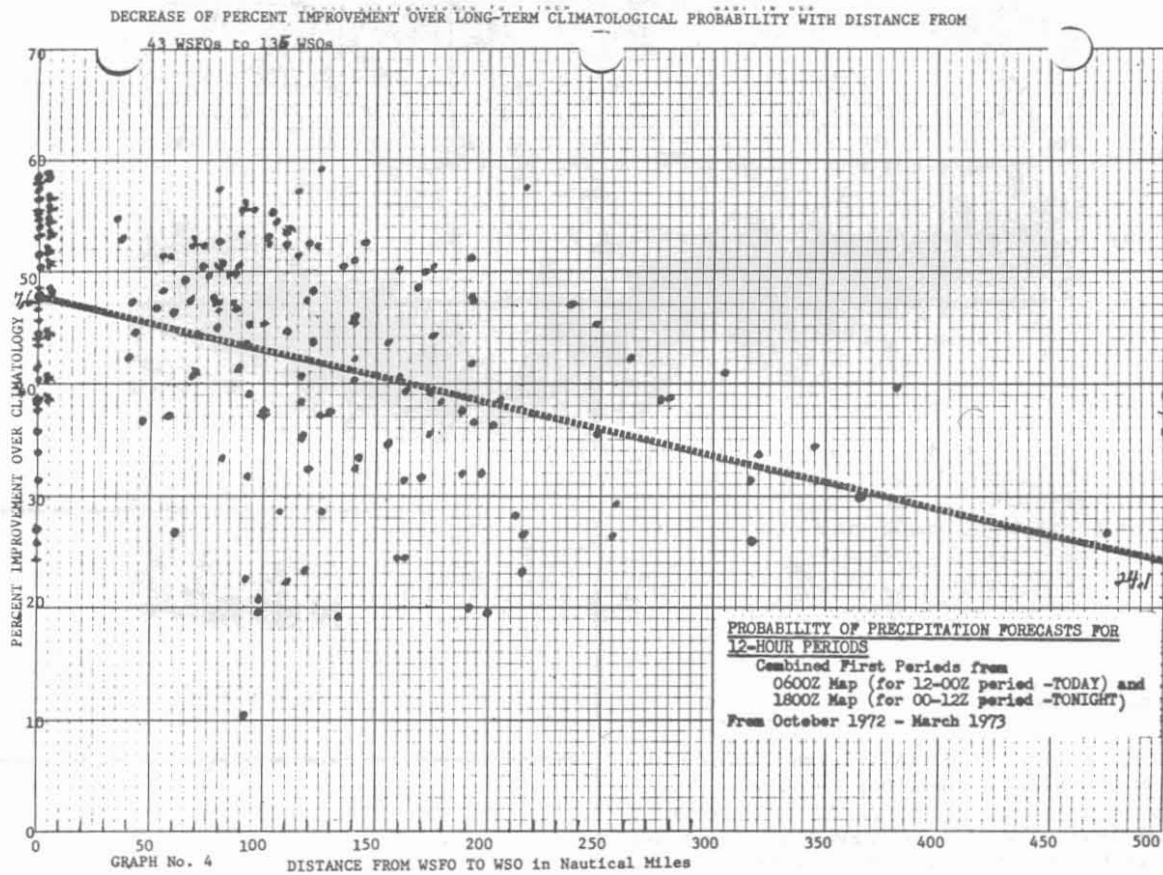

Graph 2.

Probability of Precipitation Forecasts for 12-Hour Periods

Graph 3. Calendar Day Minimum and Maximum Temperature Forecasts

Graph 4. Probability of Precipitation Forecasts for 12-Hour Periods