Temperature Forecast Opportunities Across the NWS Southern Region

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Abstract

As the skill of the guidance from numerical weather prediction models continues to improve, the role of National Weather Service forecaster is evolving from primarily producing forecasts to interpreting the forecasts for its core partners. Nevertheless, there remains a fraction of days for which the forecaster can add substantial value to the numerical guidance. The purpose of this study was to identify the number of Forecast Opportunities, days for which the maximum and/or minimum temperature guidance is in error by ten or more Fahrenheit degrees. We compared the forecast daily maximum and minimum temperatures from the extended Global Forecast System-based Model Output Statistics for 32 sites in the NWS Southern Region to the observed temperatures for the period January 2007-May 2009. Forecast Opportunities typically occurred as frequently as 15-20% of the time during the cold half of the year, but were much less frequent, or even absent, during the summer. Forecast Opportunities occurred most often for Days Three through Six, indicating forecasters should not focus their efforts on the short-term only. For most sites, the number of Forecast Opportunities increased from 2007-2009; research to date did not yield a clear explanation for that increase.

1. Introduction

Previous research has indicated that there are frequent opportunities for the local office forecasters to add substantial value to the numerical temperature guidance, especially during the cool season when the numerical guidance can be in error by as much as 10^{o}F. Such Forecast Opportunities typically occur when the observed tempe-rature departs substantially from the climatological norm.

The National Weather Service (NWS) has been using Model Output Statistics (MOS) to provide point numerical guidance for a number of meteorological parameters since the 1970s. The MOS were developed in 1972 by Harry R. Glahn and Dale A. Lowry from the NWS Meteoro-logical Development Lab (MDL) (Glahn and Lowry, 1972). The MOS uses a statistical relationship between a predicated such the temperature in a particular location at some projection time and gridded forecast data from a numerical prediction model. Prediction equations have been developed for each parameter, lead time, model run and season. The MOS guidance corrects the bias of the raw numerical model output and also accounts for some of the effects of terrain and surface conditions that are not resolved by the model.

As the skill of the numerical guidance models - and the MOS guidance - increases, the role of the forecaster is evolving from primarily producing forecast products to interpreting the forecast for our primary partners. Nevertheless, there remains a faction of days for which the forecaster can add substantial value to the forecast guidance.

The purpose of this study was to identify the number of Forecast Opportunities, days for which the maximum /minimum temperature guidance was in error by ten or more degrees Fahrenheit, across the NWS Southern Region. We wanted to examine the distribution of Forecast Opportunities with regarded to lead time, geographic location (particularly coastal vs. inland stations), and time of year. Baars and Mass (2005) compared MOS guidance with official forecasts for Days One and Two (0-24 and 25-48 hr lead times) and found that human forecasters are most skillful compared to MOS during the Day One and for periods when temperatures differ greatly from climatology.

In addition to the days with large departures from climatology we also wanted to investigate any relationship between Forecast Opportunities and large day-to-day tempe-rature variations. Since the MOS equations are regression-based we expected they might be less accurate in predicting extreme values. Similarly, we expected the numerical model might have more difficulty accurately predicting the timing of frontal passages. Based on some initial studies, we anticipated that the Forecast Opportunities would be more frequent during the cold season and at inland locations, while at coastal areas with smaller annual temperature changes over the year, there would be fewer Forecast Opportunities.

2. Data

Daily extended range (Days One – Day Seven) MOS forecasts of maximum and minimum temperatures from January 2007 through May 2009 for 32 sites across the NWS Southern Region were used in this study (Figure 1). The sites were chosen to be at or near each of the Weather Forecast Offices (WFOs) in the Region. The MOS forecasts came from the 0000 and 1200 UTC runs of the National Centers for Environmental Predictions Global Forecast Sys-tem (GFS).

Observed daily maximum and minimum temperatures were obtained from the Preliminary Climatology Data (CF6), supplemented with data from the National Climatic Data Center (NCDC) Local Climatological Data when the CF6 data were missing or incomplete.

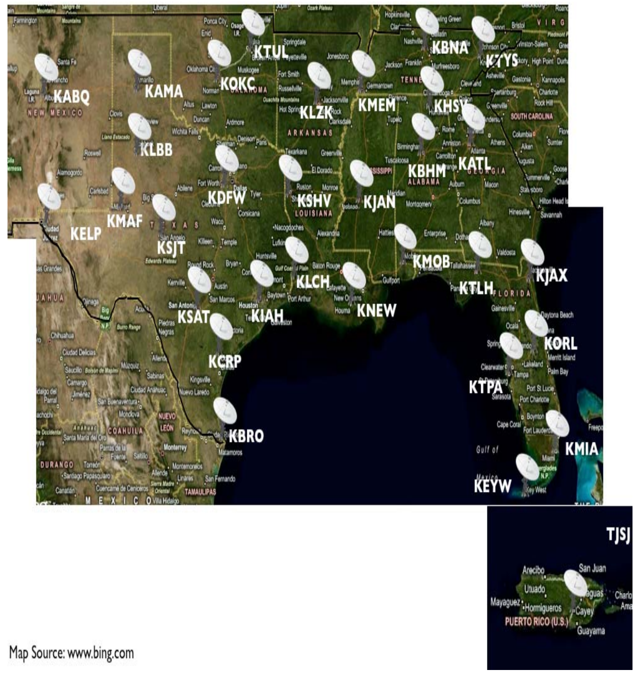


Figure 1: Sites in the NWS Southern Region used in this study. Sites were chosen to be at or near each of the Weather Forecast Offices in the Region.

Monthly average maximum and minimum temperatures were obtained from the NCDC's Climatography of the U.S. No. 81, for the period 1971 through 2000.

3. Analysis

Spreadsheets were used to analyze the forecast and observed temperatures. Forecast Opportunities, maximum/minimum tempe-rature guidance that differed by ten or more degrees from the observed temperatures, were identified. Days with large changes in temperature from one day to next, and days with large departures from climatological normals were also identified. A sample spreadsheet is shown in Figure 2. Graphs were produced showing the variation of observed maximum and minimum tempe-ratures within each month at each site, and the distribution of Forecast Opportunities by location, month and lead time (Day One through Day Seven).

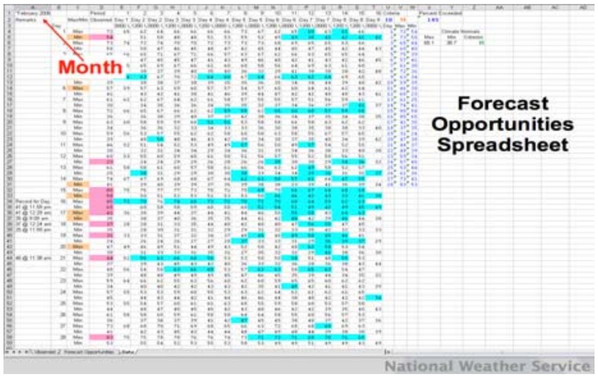


Figure 2: Forecast Opportunities Spreadsheet. Blue cells are the Forecast Opportunities, times when the MOS guidance was in error by ten or more degrees. Pink cells are the observed maximum and minimum temperatures that departed from the monthly normals by ten or more degrees. Brown cells show when the day to day change in observed temperature was ten or more degrees.

Temperature variability spreadsheets were used to calculate the percent of temperature anomalies at each of the stations during the meteorological winter of the last three years. A temperature variability was defined as the percentage of the observed maximum and/or minimum temperatures which were $\pm 10^{o}$F from the climate normal temperature (Average monthly maximum and minimum temperature from 1971 through 2000) during the months of the meteoro-logical winter (December through February). Plots were used to identify a rela-tionship between the percentage of Forecast Opportunities and the temperature variability for each station during the cold season of the year (Fig. 3).

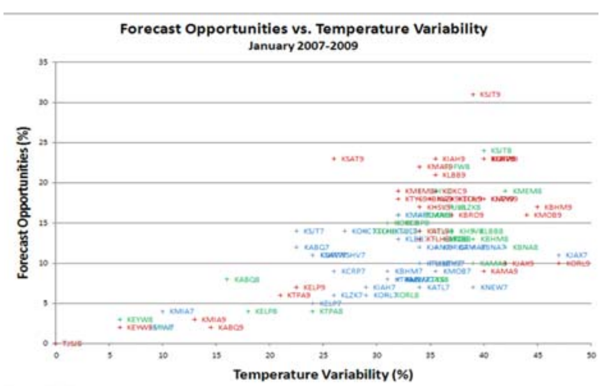
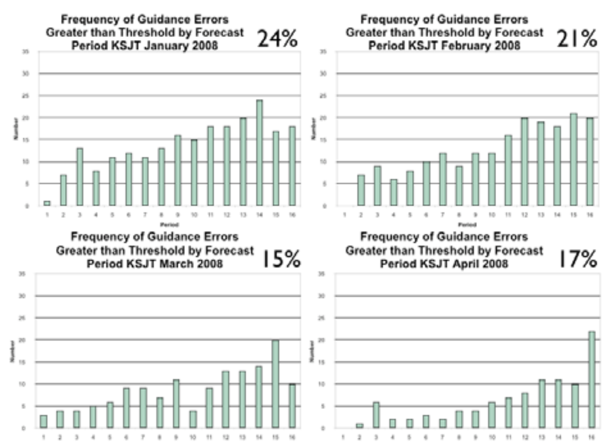


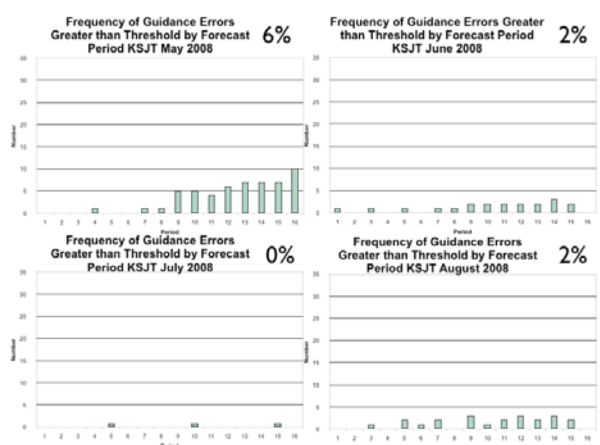
Figure 3: Scatter plot of Temperature Variability and Forecast Opportunities for January 2007(Blue), 2008 (green) and 2009 (Red).

4. Results

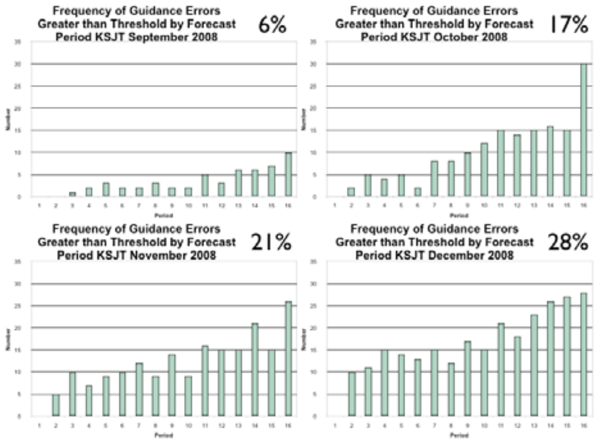
Forecast Opportunities were most frequent in the cold months of the year (Figures 3 -5), especially in meteorological winter (December-February), when they typically occurred 15-20% of the time (Figure 5). As expected, many (but not all) Forecast Opportunities occurred for days on which the observed maximum and/or minimum temperature was far from the climatological normal. Forecast Opportunities were less common when the day-to-day temperature change was large. Forecast Opportunities were more common for the extended lead times (Day Three – Day Seven) than for the short lead times (Figure 3). With a few exceptions (discussed below) there were no substantial differences between the number of Forecast Opportunities at inland sites and most coastal sites.



(a)



(b)



(c)

Figure 3: Annual variation in the frequency of Forecast Opportunities at San Angelo, TX during 2008. (a) January-April, (b) May-August and (c) September-December. For each month the number indicates the percentage of Forecast Opportunities, bars indicates the number of Forecast Opportunities for each lead time.

MOS guidance did a really good job in the warm part of the year. There were almost no Forecast Opportunities during summer for the 32 stations in the Southern Region (Figure 4). This was somewhat expected, since the weather patterns are more stable during the summer, and temperatures don't change that much from one day to another.

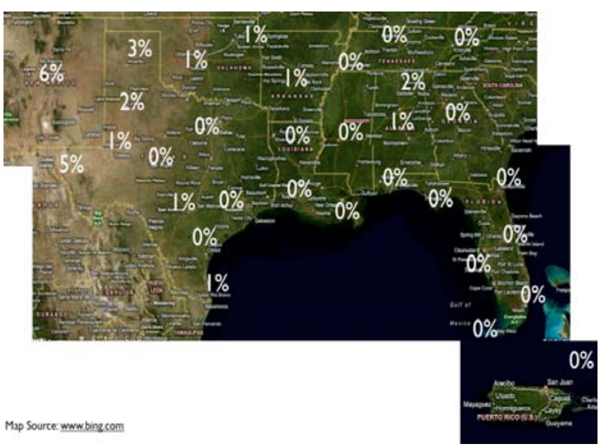


Figure 4: Percentage of Forecast Opportunities for July 2008.

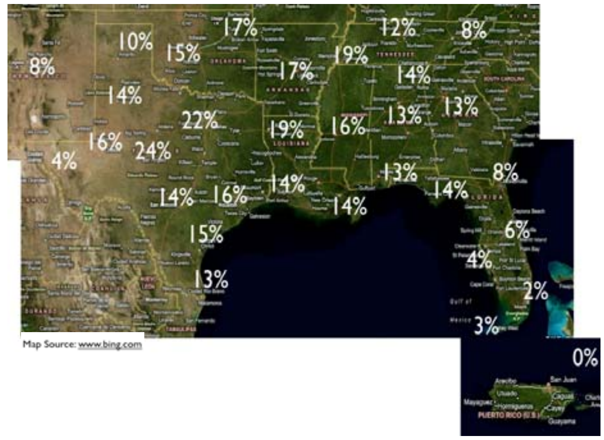


Figure 5: Percentage of Forecast Opportunities for January 2008.

We noted that the number of Forecast Opportunities increased over the last three years for most sites in the NWS Southern Region (Figure 6). The exceptions were Miami, Key West, Tampa and Melbourne, FL , San Juan, PR, Albuquerque, NM and El Paso, TX where the interannual variation in the frequency of Forecast Opportunities varied by less than 5% from 2007-2009.

As expected, the number of Forecast Opportunities at the peninsular Florida sites and San Juan, PR was small, since the temperatures at those stations are strongly moderated by the neighboring large bodies of water. The MOS temperature guidance is particularly accurate for those sites, large departures from climatological normal temperatures are rare.

The frequency of Forecast Opportunities at Albuquerque, NM and El Paso, TX also did not vary much during the study period. The topography around these two stations is important because it shields them from many of the fronts that typically affect the sites in central Texas and eastward. The weather at Albuquerque and El Paso is dominated by desert conditions, which are characterized by stationary high pressure systems which don't allow large day-to-day temperature changes.

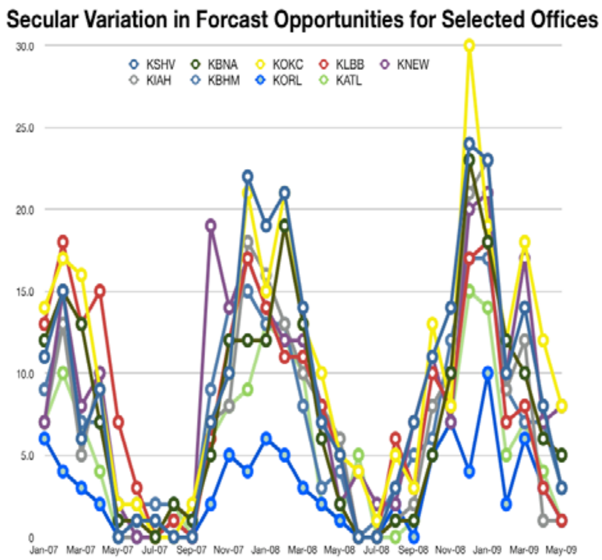


Figure 6: Secular variation in Forecast Opportunities for selected offices.

There were marked increases from 2007 to 2009 in the frequency of Forecast Opportunities at most other sites (Figure 6). The station with highest frequency of Forecast Opportunities was San Angelo, in central Texas. At San Angelo, and the four neighboring stations, the frequency of Forecast Opportunities increased an average of 10% from 2007 to 2009 (Figure 7). A separate study showed that the frequency of MOS forecasts within ± 5°F of the observed temperature decreased by about 7% during the period, which is consistent with the results of our research (Figure 8).

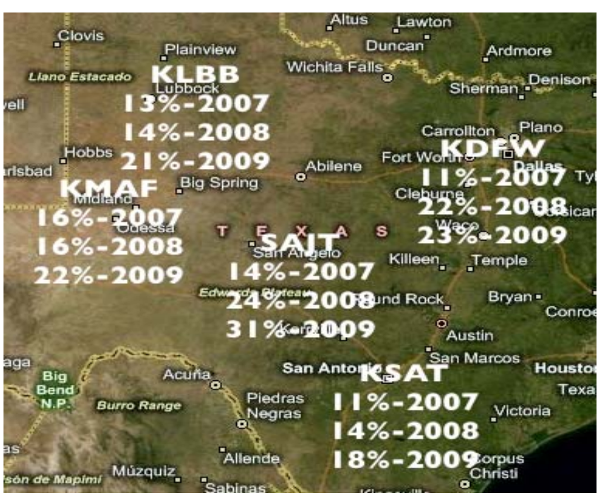


Figure 7: Increase in the percentage of Forecast Opportunities for stations in central Texas. Sites are Lubbock (KLBB), Dallas-Fort Worth (KDFW), Midland (KMAF), San Angelo (KSJT) and San Antonio (KSAT).

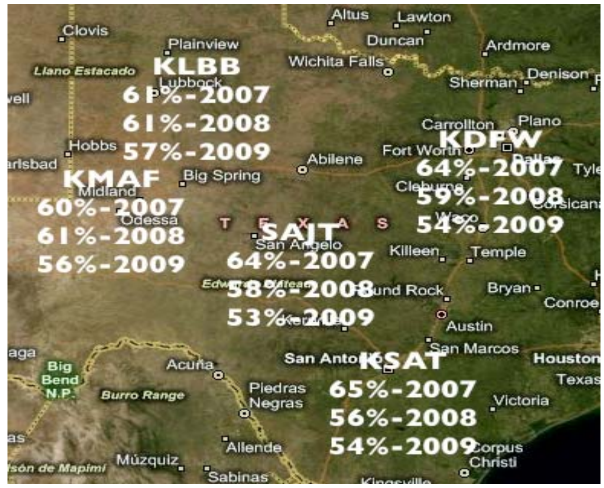


Figure 8: Decrease in the percentage of Acceptable MOS Temperature Forecast for the same stations as in Figure 7. Acceptable Forecast are those within 5 degrees of the observed temperature (after Meisner and Fox, 2008).

During the cold half of the year central Texas experiences frequent strong frontal passages, which cause the temperatures to depart greatly from the monthly normals. As Low pressure systems develop in the lee of the Rocky Mountains and move eastward, warm air is drawn northward from the Gulf of Mexico, alternating with cold air from Canada that is drawn southward and channeled by the Rocky Mountains. The result is frequent large variations in temperature that are often not well represent-ted in the MOS temperature guidance.

The seasonal temperature anomalies for January-March 2007-2009 are shown in Figure 9. In 2007 average seasonal tempe-ratures were above normal in the central part of the NWS Southern Region. Seasonal temperatures averaged near normal across most of the region in 2008 while, in 2009, seasonal temperatures averaged above normal in the western part of the Region and below normal in the eastern part. There was no apparent relationship between the interannual variations in the seasonal temperatures and those of the Forecast Opportunities.

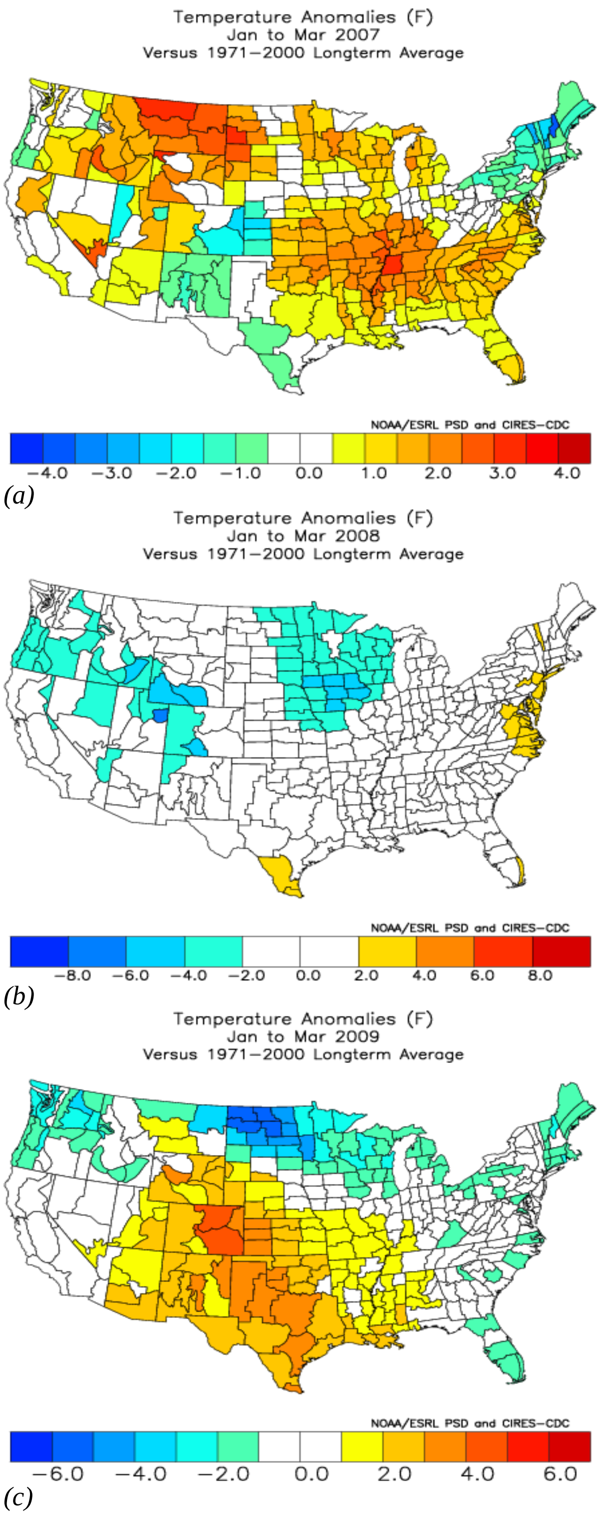


Figure 8: Seasonal (January – March) Temperature Anomalies for (a) 2007, (b) 2008 and (c) 2009.

5. Concluding Remarks

As the role of the forecaster evolves from primarily making forecasts, to interpreting forecasts for our partners, it becomes critical to recognize when the forecaster should substantially modify the numerical guidance in order to add value to the forecast, the Forecast Opportunities.

The results of this study indicate Forecast Opportunities are most frequent in the cold months of the year, with many (but not all) Forecast Opportunities occurring for days on which the observed maximum and/or minimum temperature is far from the clima-tological normal. Forecast Opportunities are more common for the extended lead times (Day Three – Day Seven) than for the short lead times, which suggests the forecaster should not merely focus on the shortest lead times.

So far, there is no clear explanation for the increase in Forecast Opportunities over the last three years. Similarly, there appears to be no clear relationship between the variations in temperature at a station during a month and the number of Forecast Opportunities that might be expected.

Potential future research will focus on the identification in advance of those days which represent Forecast Opportunities. Preliminary examination of potential predict-tors such as the relative spread of the GFS ensemble forecasts has not proved promising.

This study looked at temperature Forecast Opportunities. Future work might include additional parameters, such as precipitation.

6. References

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