CRARP 24-05 Temperature Verification Results of the National Weather Service Forecast Office at Wichita, KS During the 2000 Heat Wave

Philip J. Hysell, Lead Meteorologist
National Weather Service, Wichita, Kansas

1. Introduction

The summer of 2000 brought unusually hot and dry weather to the southern plains, especially in August and early September. In 2000 there were 33 days of 100° F or higher temperatures measured in Wichita, which was the sixth greatest number of 100° readings on record. At the height of the heat wave, from August 19th through September 3rd, Wichita met or exceeded 100° for 16 consecutive days, which was the third longest streak of 100° temperatures on record. Wichita set records for the most 100° days for both the months of August (23) and September (6).

No heat-related deaths were reported due to the excessive heat. This can be attributed, in part, to the forecasts issued by the National Weather Service Forecast Office (WFO) Wichita. The purpose of this paper is to show how verification scores for temperatures in 2000 improved from previous warm seasons, and illustrate the value added to short and long term forecasts during these periods of abnormal weather by human intervention at the local level.

2. Warm Season Verification from 1996-2000

From 1996 through 1999 (Figure 1), , WFO Wichita averaged a 6.7 percent temperature forecast improvement over the Nested Grid Model (NGM) Model Output Statistics (MOS) for the first four forecast periods (48 hours) during the warm season (April through September). Unlike the summer of 2000, there were no substantial periods of abnormally warm or cold conditions during the warm seasons of 1996-1999. During these near 'normal' conditions, improvements over MOS in the short term, in most cases, averaged less than 10 percent. Given the near normal temperatures, it is unclear why the 1996 warm season temperature forecasts exhibited such a large improvement over MOS.

3. Verification for 2000

The percent improvement of the average forecast temperatures over MOS during the first four periods (48 hours) in the warm season of 2000 was 14.2 percent, which more than doubled the average improvement for the previous four years. From August through September 2000, WFO Wichita exhibited a remarkable 31 percent improvement above the average MOS forecast temperatures for the first four periods (including both high and low temperature forecasts). This clearly shows that the WFO Wichita staff added value to the public forecast.

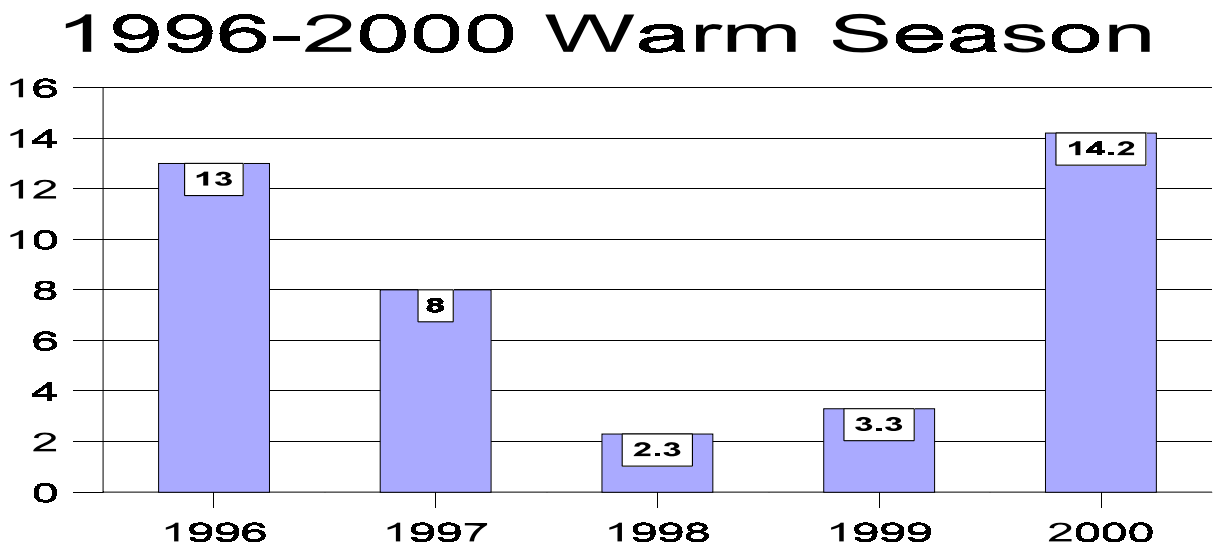

Figure 1. Percent improvement of absolute mean error over MOS for temperatures at Wichita, KS from April through September.

WFO Wichita showed the greatest improvement over MOS for the average high temperature forecast. From June 21, 2000 through September 21, 2000 (Table 1), astronomical summer, WFO Wichita exhibited a 29 percent improvement over MOS average high temperature forecasts. During this same period, MOS produced a substantially larger number of forecast high temperatures that had a six degree error or greater compared to WFO Wichita (Table 2). For the purpose of this paper, a temperature forecast absolute error of six degrees or more will be referred to as "large".

Table 1. MOS and WFO Wichita average absolute errors in maximum temperature forecasts for the period 21 June, 2000 through 21 September, 2000 (° F).

	MOS Max Error (° F)	WFO ICT Max Error (° F)
Day 1	3.52	2.43
Day 2	4.58	3.33

Table 2. Number of 'large' errors where the MOS and WFO Wichita forecast daily maximum temperatures were at least six degrees too cold or warm for the period 21 June, 2000 through 21 September, 2000 (° F).

	MOS > 6 (° F)	ICT > 6 (° F)
Day 1	36	11
Day 2	44	22

For the 16 day period from August 19, 2000 through September 3, 2000, when the temperature reached or exceeded 100 degrees, WFO Wichita showed significant improvement in their average high temperature forecast compared to MOS (Table 3). In fact, of the 32 forecasts created during

this period for the second day, MOS forecast high temperatures 'busted' 28 percent of the time (Table 4). Errors in forecast high temperatures from WFO Wichita were large only nine percent of the time.

Table 3. MOS and NWS Wichita average absolute errors in maximum temperature forecasts for the period 19 August, 2000 through 3 September, 2000 (° F).

	MOS Max Error (° F)	WFO ICT Max Error (° F)
Day 1	3.63	1.97
Day 2	5.13	2.72

Table 4. Number of forecasts where the MOS and WFO Wichita errors in forecast high temperatures were large for the period 19 August, 2000 through 3 September, 2000 .

	MOS > 6 ° F	ICT > 6 ° F
Day 1	5	2
Day 2	9	3

This improvement was also seen in long term forecasting. The MRF (Medium Range Forecast) model-based medium range MOS (FMR) guidance provides temperature forecasts and the probability of precipitation up to seven days in advance. From June 21, 2000 through September 21, 2000, WFO Wichita forecast high temperatures for days three through six, averaged 25 percent better than FMR predictions (Table 5)..

High temperature forecast guidance for Wichita is also provided by the HPC (Hydrological Prediction Center) from three to seven days in advance. The HPC produces high and low temperature forecasts as well as probability of precipitation forecasts for 158 locations across the United States once a day. The HPC values were better than the FMR forecasts, yet WFO Wichita still averaged a 19 percent improvement over the HPC.

The superior high temperature forecasts provided by WFO Wichita during this prolonged heat wave can also be measured by the number of days with large errors in the high temperature forecasts. Again, from June 21,2000 through September 21, 2000, WFO Wichita provided fewer large errors in temperature forecasts compared to the FMR guidance and to the HPC forecasts. (Table 6). This was most evident in the latter periods of the extended forecast, as forecasters recognized that persistence forecasting would be best, without a change in the upper air pattern.

Table 5. FMR, HPC and WFO Wichita average high and low temperature forecast absolute error for the period 21 June, 2000 through 21 September, 2000.

	FMR Max Error (° F)	HPC Max Error (° F)	ICT Max Error (° F)
Day 3	6.1	5.3	4.3
Day 4	6.3	6.1	5.2
Day 5	7.2	6.4	5.3
Day 6	7.6	7.4	5.7

Table 6. Number of days where the FMR, HPC and WFO Wichita errors in forecast high temperatures were large for the period 21 June, 2000 through 21 September, 2000 .

	FMR > 6 (° F)	HPC > 6 (° F)	ICT > 6 (° F)
Day 3	42	37	26
Day 4	42	44	34
Day 5	47	43	34
Day 6	53	49	37

During the peak of the heat wave, from August 19th through September 3rd, the three to six day maximum temperature forecast from WFO Wichita showed a resounding 53 percent improvement on average over the FMR forecast. Again, the HPC provided some improvement over the FMR guidance, but the WFO Wichita forecasts showed increased skill over the HPC by an average of 41 percent (Table 7)..

Table 7. FRM, HPC and NWS Wichita average high temperature forecast absolute error for the period 19 August, 2000 through 3 September, 2000 (error in degrees Fahrenheit).

	FMR max error (° F)	HPC max error (° F)	ICT max error (° F)
Day 3	9.6	7.4	5.8
Day 4	11.8	9.4	5.4
Day 5	13.1	10.6	5.3
Day 6	12.8	10.7	6.0

WFO Wichita also provided fewer large high temperature forecast errors compared to the FMR and HPC forecasts. Because forecasters at WFO Wichita recognized past trends, and were able to focus on a much smaller area of the country, the number of large errors, did not increase with time (Table 8).

Table 8. Number of days where the FMR, HPC and WFO Wichita errors in forecast high temperatures were large for the period 19 August, 2000 through 3 September, 2000 .

	FMR > 6 ° F	HPC > 6 ° F	ICT > 6 ° F
Day 3	13	11	5
Day 4	13	11	5
Day 5	15	13	4
Day 6	16	14	4

4. Discussion

When abnormally adverse weather conditions occur, forecasts issued by the National Weather Service (NWS) are scrutinized more closely by customers. During these rare conditions that affect many people, and place NWS forecasts in the spotlight, it is vital that forecasters examine the data before blindly using computer generated temperature forecasts. The heat wave of 2000 was a stellar example of how human intervention can produce significantly improved forecasts over those of MOS. While large improvements over MOS are difficult during 'normal' climatological conditions, they can be accomplished during stagnant conditions, where a change in the weather pattern is not anticipated. Forecasters at WFO Wichita recognized that with a large scale ridge to prevail, high temperatures would not decrease from one day to the next as short and long term guidance values suggested.

Since the arrival of AWIPS, forecasters have been given additional tools to examine the extended forecast. No longer is the MRF the only medium range model available for examination. With forecasts from ECMWF and UKMET models available on AWIPS, and Canadian and NOGAPS model forecasts posted on the Internet, forecasters are given more choices and data to produce a more accurate forecast. Also, forecasters can examine ensemble data from medium range models. Knowledge of the fact that model medium-range temperature guidance, such as the FMR, trended toward climatological normals with time also helped forecasters issue better temperature forecasts. Experienced forecasters at WFO Wichita recognized that a persistent weather pattern would not yield cooler temperatures as the FMR suggested. In addition, medium range models often forecasted the large scale ridge to shift east, or break down. Forecasters knew from experience that this "blocking" pattern would likely not degenerate as predicted by the models.

HPC forecasters must issue extended forecast guidance for over 180 locations across the United States. At WFO Wichita, and other local offices, forecasters have the luxury to produce the same forecast for a much smaller region. During this heat wave, the familiarity WFO Wichita forecasters had of the area, and the benefit of handling a smaller region, resulted in improved extended forecasts. This case illustrates the benefit of having over 100 WFO's to serve and focus on local areas rather than one office serving the entire county. The heat wave of 2000 illustrated that knowing the limitations of FRM and HPC guidance, in combination with using forecast experience of the local area, can bring improved temperature forecasts not only in the short term, but in the extended forecast as well.

5. Acknowledgments

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