8.4 AN ANALYSIS OF THE SPATIAL DISTRIBUTION OF ETA SURFACE TEMPERATURE FORECASTS THROUGH THE GRIDDED FORECAST EDITOR

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1. INTRODUCTION

The National Weather Service Forecast Office in Tulsa (WFO Tulsa) began making gridded forecasts of weather parameters in early 2001. This is in addition to the standard suite of alphanumeric forecast products. These gridded forecasts have a grid resolution of five kilometers (5 km). Through the Gridded Forecast Editor (Mathewson, 2002), developed by the Forecast Systems Laboratory (FSL) in Boulder, Colorado, these gridded forecasts can provide much greater spatial resolution to our customers than current alphanumeric forecasts.

The techniques to produce grid fields of temperature vary considerable. A meteorologist may simply draw contours starting from a blank grid field. Those contours can then be interpolated to produce a temperature at each grid point in the field. However, it may be preferable that meteorologists start with an initialized grid field from one of the numerical models. The Eta model provides the greatest spatial resolution of surface temperature, due to the high resolution topography in that model. Through the GFE application described in section 3, meteorologists can initialize temperature grids at a resolution of 5 km, which will account for variations in terrain that a forecaster cannot. It may therefore be best that meteorologists use the Eta/GFE grids and adjust entire temperature grid fields up or down by one or more degrees to arrive at the most accurate forecast. This uniform adjustment preserves the temperature variations based on topography. Other methods of modifying the initialized grid fields will destroy much or all of the topographically adjusted resolution provided by the model.

If the Eta model surface temperature forecasts have a uniform bias across the grid field, that bias will be carried through the GFE application to the high resolution forecast grids. Then, a single, uniform adjustment for that bias should result in the most accurate forecast for each grid block. However, if the model derived spatial distribution is not uniform, single adjustments to the grid fields will not result in the most accurate forecast to the customer, even though the level of detail in the grid field is quite high.

To resolve the issue, an analysis was conducted to determine the accuracy of the spatial distribution of surface maximum/minimum (max/min) temperatures in the Eta forecast grids. Specifically, do single, uniform adjustments to Eta max/min temperature grids result in the lowest mean absolute errors (MAEs)? More plainly, if the grid is adjusted to correct the bias at one site, will that correction reduce the error at all other sites? The results of that analysis are presented.

2. IMPORTANCE OF A UNIFORM BIAS

By making gridded forecasts, NWS offices can provide highly detailed temperature forecasts, especially when topography is used in arriving at the initialization grid fields. It is not possible to convey the level of detail shown in Figure 1 through the standard NWS Zone Forecast. The normal WFO Tulsa Zone Forecast configuration provides about five to nine discrete temperature regimes across the county forecast area. Gridded forecasts will provide approximately 2000 discrete grid point temperatures for each forecast time interval in the WFO Tulsa area of responsibility.

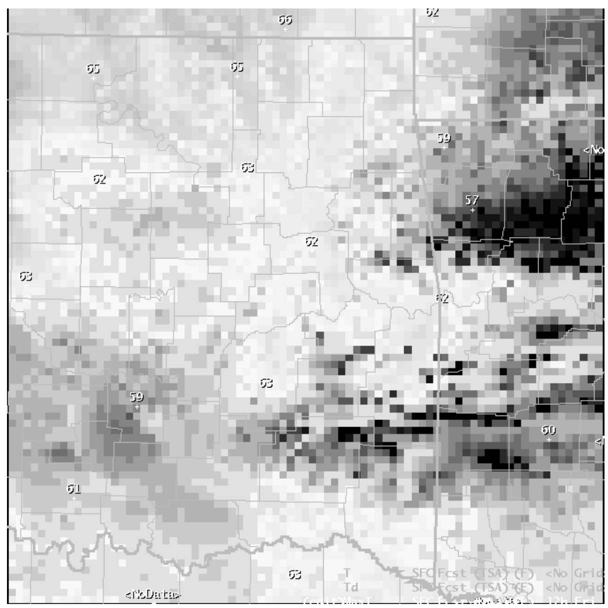

Figure 1. Eta/GFE initialized maximum temperature forecast for eastern Oklahoma and northwest Arkansas.

Terrain in eastern Oklahoma and northwest Arkansas varies from about 500 feet msl to just over 2500 feet msl. By considering the effects of terrain (even in eastern Oklahoma and northwest Arkansas), the detail level of the gridded forecast increases dramatically. Figure 1 shows an Eta/GFE, 5 km initialized temperature grid where the effects of topography were included. Figure 2 shows a standard grid field where contours of temperature were drawn by

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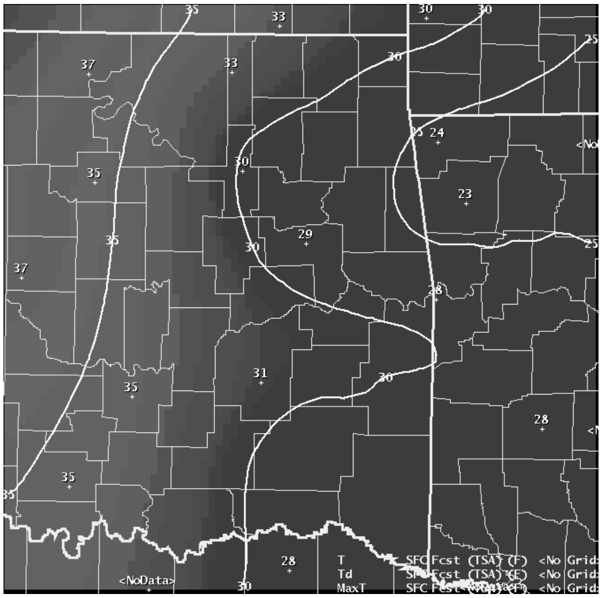

Figure 2. Manually contoured minimum temperature forecast grid field.

a meteorologist. Figure 2 includes no adjustment for topography, and appears to have a much lower degree of detail. Clearly, it is desirable to include the effects of topography in the forecast grids.

3. GFE Application

Through the GFE, MesoEta forecast temperatures are interpolated to the GFE 5 km resolution grid. The algorithm uses model-scale topography, GFE 5 km resolution topography, MesoEta two-meter temperatures, and MesoEta forecast lapse rates. The forecast lapse rate is applied to the MesoEta temperature, using the difference between the topography from the MesoEta and the higher resolution topography from the GFE (Eq. 1). This new forecast temperature is then used to initialize the Eta/GFE grid field (LeFebvre, 2002) .

$$T_{Eta/GFE} = T_{eta} + \text{LapseRate} * (\text{EtaTopo} - \text{GFE Topo}) \quad (1)$$

4. Data

Forecast max/min temperatures were gathered at four sites across northeast Oklahoma and northwest Arkansas (TUL, MLC, FSM, FYV) from July 1, 2001 through January 28, 2002. These data included four periods of max/min temperature forecasts from the Eta model, the Aviation MOS (AVN) guidance (Dallavalle, 2000), the NGM MOS (FWC) guidance (Dallavalle, 1992), and the WFO Tulsa official forecast (CCF).

Eta two-meter max/min temperature forecasts were obtained from netCDF files of the CONUS 215 grid (20 km resolution) received in AWIPS (Advanced Weather Interactive Processing System) from the National Center for Environmental Prediction (NCEP). Station locations were identified by latitude/longitude in the grid and forecast temperatures were linearly interpolated to those station locations from the model grid points. No other adjustments were made.

5. Analysis Procedure

For each forecast period, a bias (correction) was determined for one of the four sites, using verification data. That bias was then applied to the other three sites, as would occur if making a uniform adjustment to the grid field. The MAE was then calculated at the other three sites to determine the effect of the uniformly applied correction. The site used in determining the bias was not used in calculating the MAE, since the bias-site error would automatically become zero. This technique was applied at each of the four sites, and MAEs were calculated for the four groups of three forecast sites each. If the spatial distribution of temperature in the Eta initialization was correct, use of the bias to correct the grid field would not only result in a zero error at the site where the bias was determined, but also should eliminate or significantly reduce the errors at the other verification sites.

As an example, suppose the Eta forecast at TUL for a given forecast period was found to be three degrees too warm. Three degrees was then subtracted uniformly from the “grid field” (MLC, FSM, FYV) to determine the Eta adjusted forecast. MAEs were then calculated at MLC, FSM, and FYV, and averaged (Fig. 3, “TUL based”). This is the “Eta adjusted” forecast.

However, applying the bias from another site might result in a lower average error. That hypothesis was tested using the error at each site as a correction to the others. Where the correction was based on the MLC bias, MAEs were averaged from errors at TUL, FSM, FYV (MLC based MAEs). Where the FSM bias was used as a correction, the MAEs were averaged from TUL, MLC, FYV (FSM based MAEs). Where the FYV bias was used as a correction, MAEs were averaged from TUL, MLC, FSM (FYV based MAEs).

6. Results

Results of the study indicated that the spatial distribution of Eta two-meter max/min temperatures were not sufficiently accurate to justify making single uniform bias adjustments to forecast grid fields. These results are shown in Figures 3 through 6. The worst MAEs came when applying biases determined at TUL and FYV. The lowest Eta adjusted MAEs occurred when MLC or FSM biases were applied to the grid fields. MAEs from the unadjusted Eta two-meter temperature forecasts were also evaluated, but also had higher MAEs when compared to the MAV MOS or CCF (Figs. 7, 8, 9, 10).

In every period, the WFO Tulsa forecast (CCF) had the lower MAE than the Eta adjusted forecasts.

The MAV MOS also had a lower MAE than the Eta adjusted forecasts. In the fourth period, the Eta adjusted forecast actually outperformed the FWC MOS when either the MLC or FSM biases were used to adjust the remaining sites. It was found that if a forecaster knew, on a given day, which site bias to use, the Eta adjusted MAEs could be reduced, although still not below the MAV MOS or CCF official forecast (results not shown).

7. Conclusions

The spatial distribution of Eta max/min surface temperatures were not sufficiently accurate to be used in making single, uniform adjustments to entire forecast grid fields. Although these Eta grid fields can provide highly detailed temperature forecasts when applied through the GFE application, results of this study indicate that MOS guidance and official CCF forecasts resulted in lower mean absolute errors. It appears that MOS guidance and CCF forecasts are better able to discern variations in temperature at the WFO scale than the topographically adjusted Eta. It also appears that site specific forecasts (or guidance) will need to be incorporated when grid fields of forecast temperature are adjusted for topographic effects.

The concept of topographically adjusting temperature forecasts should ultimately result in better forecasts for areas away from the typical verification sites. Through model initializations and the GFE application, meteorologists can make impressive, high resolution forecasts, especially for areas with varied topography. However, it is important that forecast techniques be developed which will maintain a degree of accuracy which can parallel the new resolution capabilities. This study of the spatial distribution of Eta two-meter, max/min surface temperatures indicates that much progress has been made, but also that more work needs to be done.

8. Acknowledgments

Special thanks goes to James Frederick, WFO Tulsa who had been collecting the data that was used in this study. Special thanks also goes to Greg Patrick, WFO Tulsa, who shared Eta surface temperature data which he is collecting for another project.

9. References

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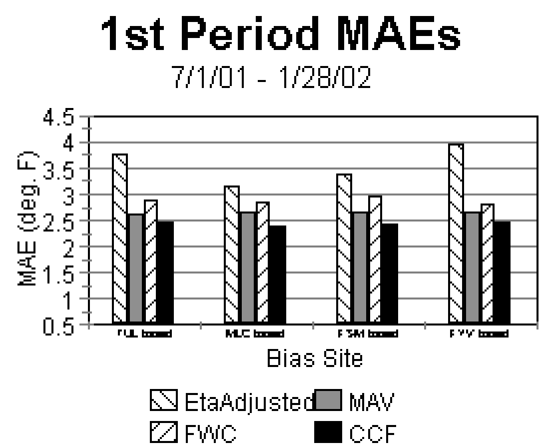

Figure 3. First period max/min temperature mean absolute errors (MAEs) at forecast sites, from guidance and official WFO CCF

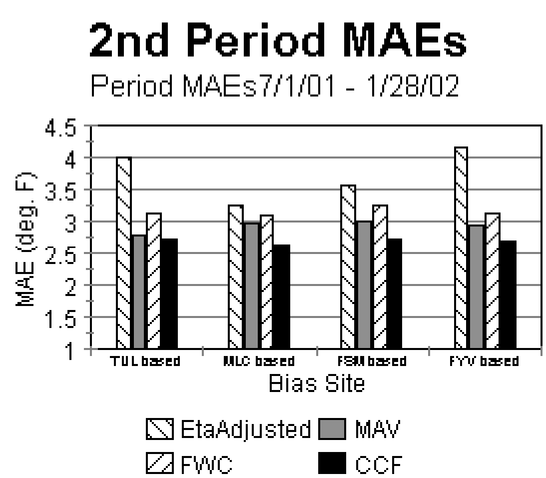

Figure 4. Same as Fig. 3, but for second period.

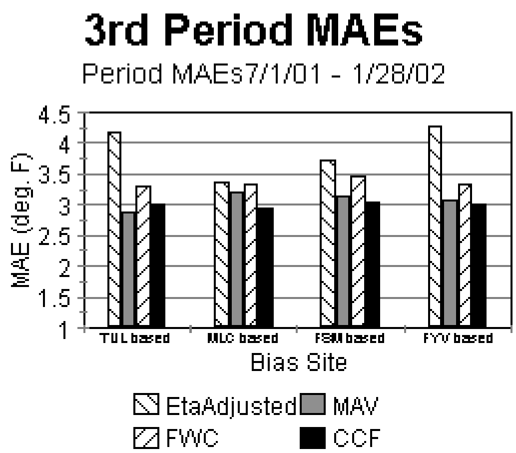

Figure 5. Same as Fig. 3, but for third period.

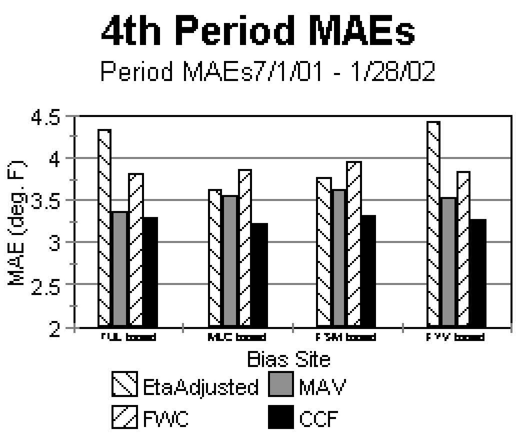

Figure 6. Same as Fig. 3, but for fourth period.

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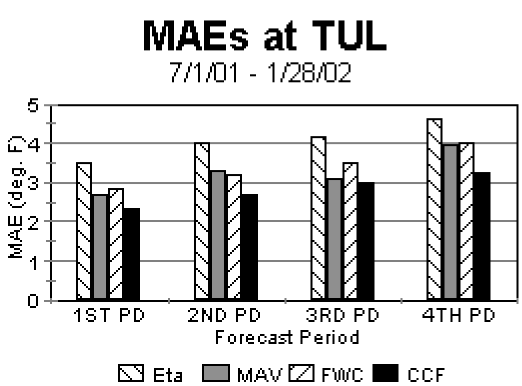

Figure 7. Unadjusted max/min temperature MAEs by forecast period for TUL, derived from Eta, MAV MOS, FWC MOS, and official CCF.

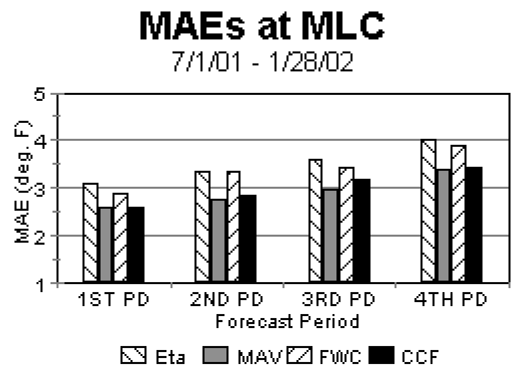

Figure 8. Same as Fig. 7, but for MLC.

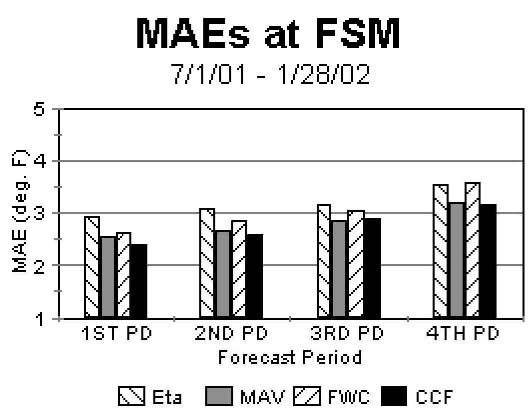

Figure 9. Same as Fig. 7, but for FSM.

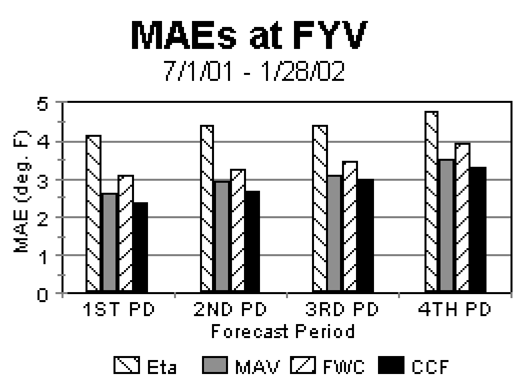

Figure 10. Same as Fig. 7, but for FYV