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PRACTICAL USE OF MODEL SURFACE DIAGNOSTIC GUIDANCE

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Introduction

Contemporary forecasters have better computer forecast guidance available to them today than ever before. Technology is rapidly increasing the economy and utility of modern numerical weather prediction. However, these increases have operational forecasters facing the dilemma of rapidly evolving models (and model biases). Model surface diagnostics, using up-to-date comparisons between model forecasts and surface observations, are produced at Western Region Headquarters of the National Weather Service with the intent of providing the forecaster with current guidance on model performance. Operational forecasts from the Eta and Avn models are compared to surface observations twice a day, and measures of model skill are produced on a quasi-real-time basis for use in the field. In a previous Technical Attachment (Cook, 1998), the goals and basic methods behind the surface diagnostics were presented as an introduction. This work is intended as an extension, with a focus on the practical use of the diagnostics as well as an update on available products.

Methods

Eta (grid 211) and Avn (grid 211) model forecasts are evaluated against surface observations from 57 sites in the western United States (Fig.1) in a diagnostic mode daily. Eta 2m temperatures, 2m dewpoints and 10m winds as well as Avn 2m temperatures and the lowest 30 hPa level winds are compared to observed values at 0000 and 1200 UTC. Model bias errors are calculated for each forecast hour and parameter at each site. A more detailed description of the basic data manipulation is provided by Cook (1998). A Barnes objective analysis (Barnes,1964) of the model bias errors has been added to the surface diagnostic suite. Using the General Meteorological Package (GEMAK) routine OABSFC, objective analysis grids are created from the surface bias error fields over the western United States. Plots of the objective analyses as well as meteograms of forecast vs. observation are created and placed on the Western Region homepage (www.wrh.noaa.gov/wrhq/DIAGNOSTICS/kirby.html).

Surface Diagnostics

The surface diagnostics are measures of model performance which allow the evaluation of model skill both temporally and spatially at the lowest forecasted levels (Cook, 1998). Model performance is easily analyzed in detail at each individual surface site within the domain. However, addressing model biases at each individual location proves to be tedious and may have little or no utility in diagnosing overall model skill. The Barnes objective analyses of the Eta 2m temperature bias errors valid on 990407, 0000 UTC are shown in Fig. 2. The objective analyses of the temperature bias errors are shown in color while the forecasts valid at this time are shown as labeled contours. In this case, the Eta 2m temperature bias errors are predominantly negative over much of the domain, indicating an overall cold bias (as much as -10°C) in the forecasted surface temperature fields. In addition, there is some bias error growth with respect to lead time, particularly over northern New Mexico. Many features in the bias analyses remain consistent at all forecast hours. The more negative (cold) biases, that appear at all lead-times over northern Idaho, eastern Montana, Utah, and Colorado, seem to be associated with the colder temperatures forecasted in these areas. This indicates a consistent trend in the model forecasts of over-predicting the cold air in these regions. The warm bias (2-4 °C) over northern Arizona appears to be associated with the slightly cooler temperatures forecasted over the southwestern Colorado Plateau. Unlike the above cold biases, this highlights a situation of a consistently under-forecasted feature (the colder air over northeastern Arizona) in a specific region. In either case, the objective analyses of the model bias errors allow the forecaster to analyze overall model performance as well as connect this diagnosis to details in the actual forecasts. It is important to note that objective analyses of the bias error fields are extrapolated data, and may not be representative of the true bias errors. However, the surface Barnes analyses, at the very least, provide insight into overall issues of current model performance at low levels, allowing the forecaster to further investigate, in detail, skill at each individual site within the domain.

Meteogram plots of forecast vs. observation are simple representations of model skill at each observation site within the diagnostic domain. The meteogram of Eta 2m temperature forecasts and observed values valid at Salt Lake City, UT (SLC) for the period of 990405, 1800 UTC to 990409, 1800 UTC is shown in Fig. 3. The observations are displayed as black asterisks while forecasted values are represented by color-coded positive symbols. Both forecasted and observed values are updated upon availability every six hours, with the most current time being plotted at the mid-mark of each meteogram. Model forecasts that are not yet valid are displayed appropriately to the right of the current time. In this case, SLC lies within the region of largest cold bias at 990407, 0000 UTC (Fig.2). Model forecasts, valid during the 48-h period prior to 990407, 1800 UTC (not just at 0000 UTC), are consistently too cold (Fig. 3). As was shown in the objective analysis fields, forecasts with larger lead-times tend to have the largest biases, which are as much as 10°C too cold. The model does appear to resolve the overall diurnal pattern, particularly early in the period, even though it is dominated by a large cold bias. This knowledge can be applied to forecasts at lead times that have not yet been validated, with the goal of removing some if not all of the projected bias from the forecast.

The meteogram of Eta 2m temperature forecasts and observed values valid at San Francisco, CA (SFO) is shown in Fig. 4. Unlike Salt Lake City, SFO lies in a region of little or no bias along the central California coast at 990407, 0000 UTC (Fig. 2). Model forecasts, valid during the 48-h period prior to 990407, 1800 UTC at San Francisco, are quite close to the observed values, and are neither predominately too cold nor too warm. These forecasts deviate no more than 4°C at any time, with some bias growth with lead time. The magnitudes of 2m temperature bias errors are slightly larger with respect to the later forecast hours (F036 and F048) than those at the initialization or 12-h forecasts. The Eta appears to have even a better grasp of the diurnal variation of surface temperatures at SFO than at Salt Lake City. Again, model biases from forecasts early in the period can be used to adjust future, unconfirmed forecasts.

Summary

The surface diagnostics allow the forecaster to examine contemporary model performance both regionally and locally. The Barnes objective analyses of model bias errors provide guidance on overall model performance throughout the domain, in addition to allowing the connection of model biases directly to details in the actual forecasts. The diagnostic meteogram plots provide the forecaster with the ability to further examine model performance at each individual comparison site. The meteograms also allow for simple extrapolation of current model biases to forecast hours with lead-times not yet validated, thus proving to be a valuable prognostic tool, particularly at sites with consistent forecast biases. The overall utility of the surface diagnostics lies in its use as quantitative guidance on model skill, both general and specific. This utility proves to be crucial in the current age of constantly evolving numerical weather prediction.

References

Barnes, S.L., 1964: A Technique for Maximizing Details in Numerical Weather Map Analysis. *J. Appl. Meteor.*, **3**, 396-409.

Cook, L.K., 1998: Western Region Model Diagnostics. *WR-Technical Attachment.* **98-39**.

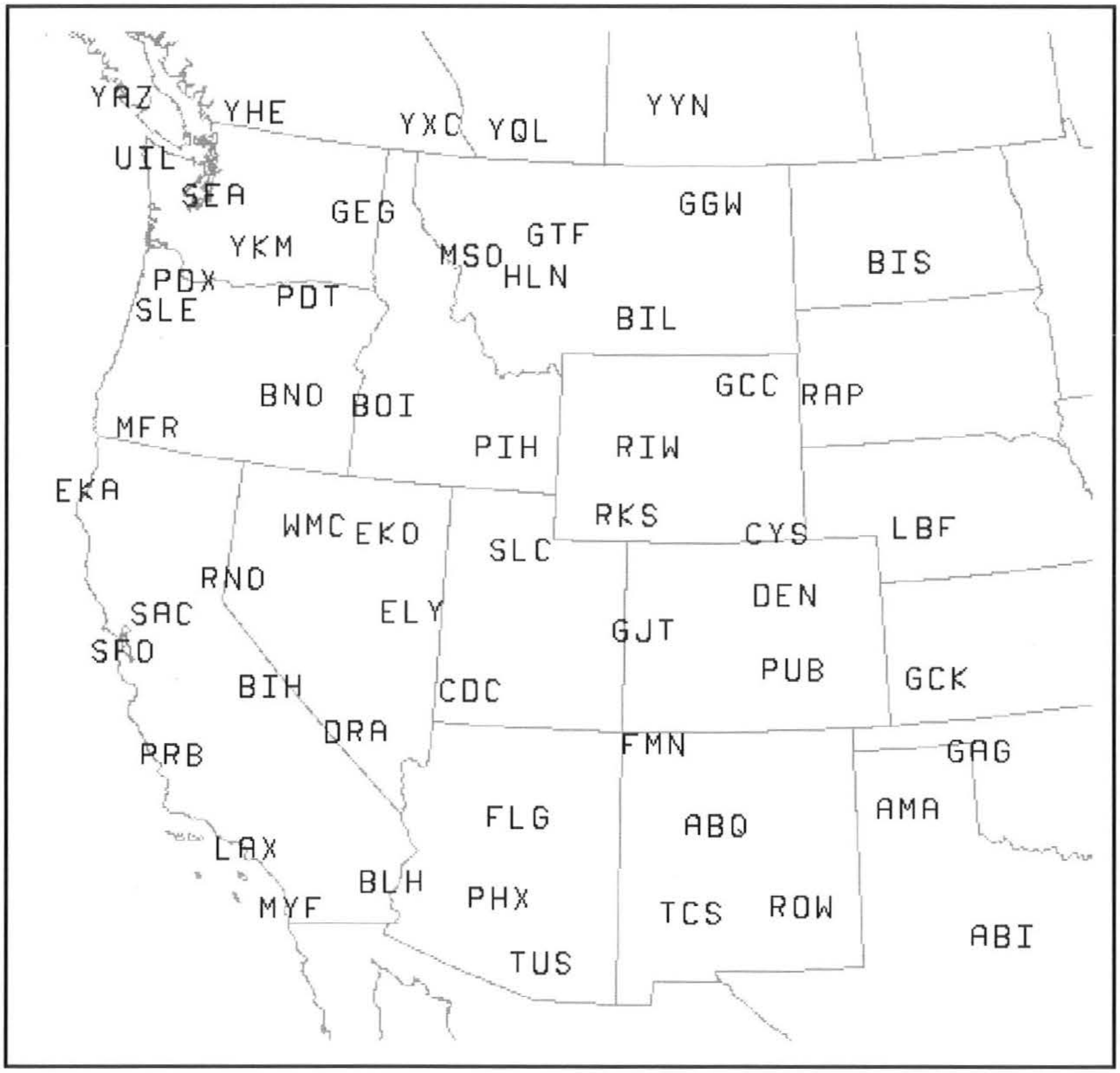

Figure 1. Surface comparison sites located within the diagnostic domain.

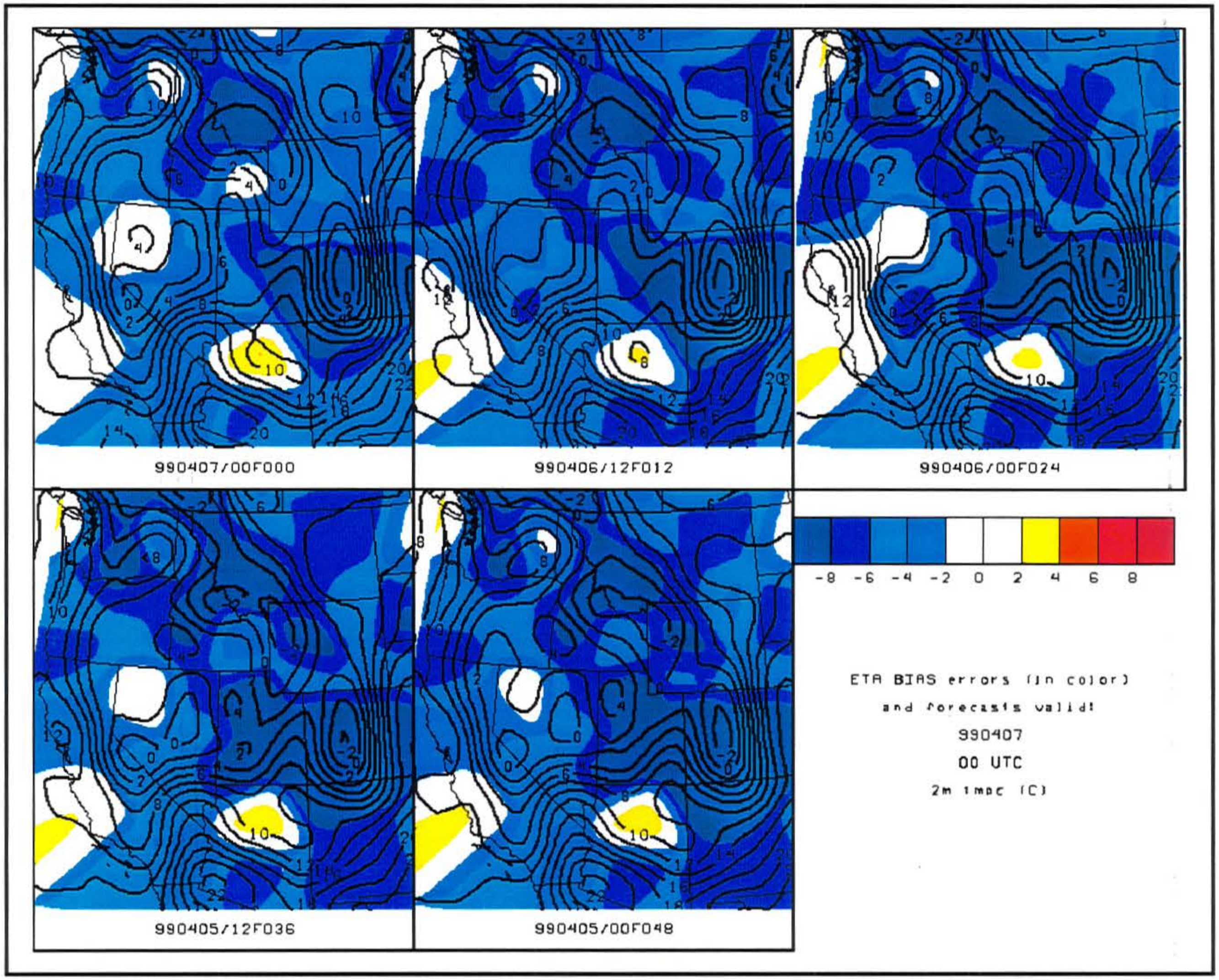

Figure 2. Barnes objective analysis of Eta 2m temperature (° C) bias errors valid on 990407, 0000 UTC. The objective analyses are shown in color, while the actual forecasts are displayed as label contours.

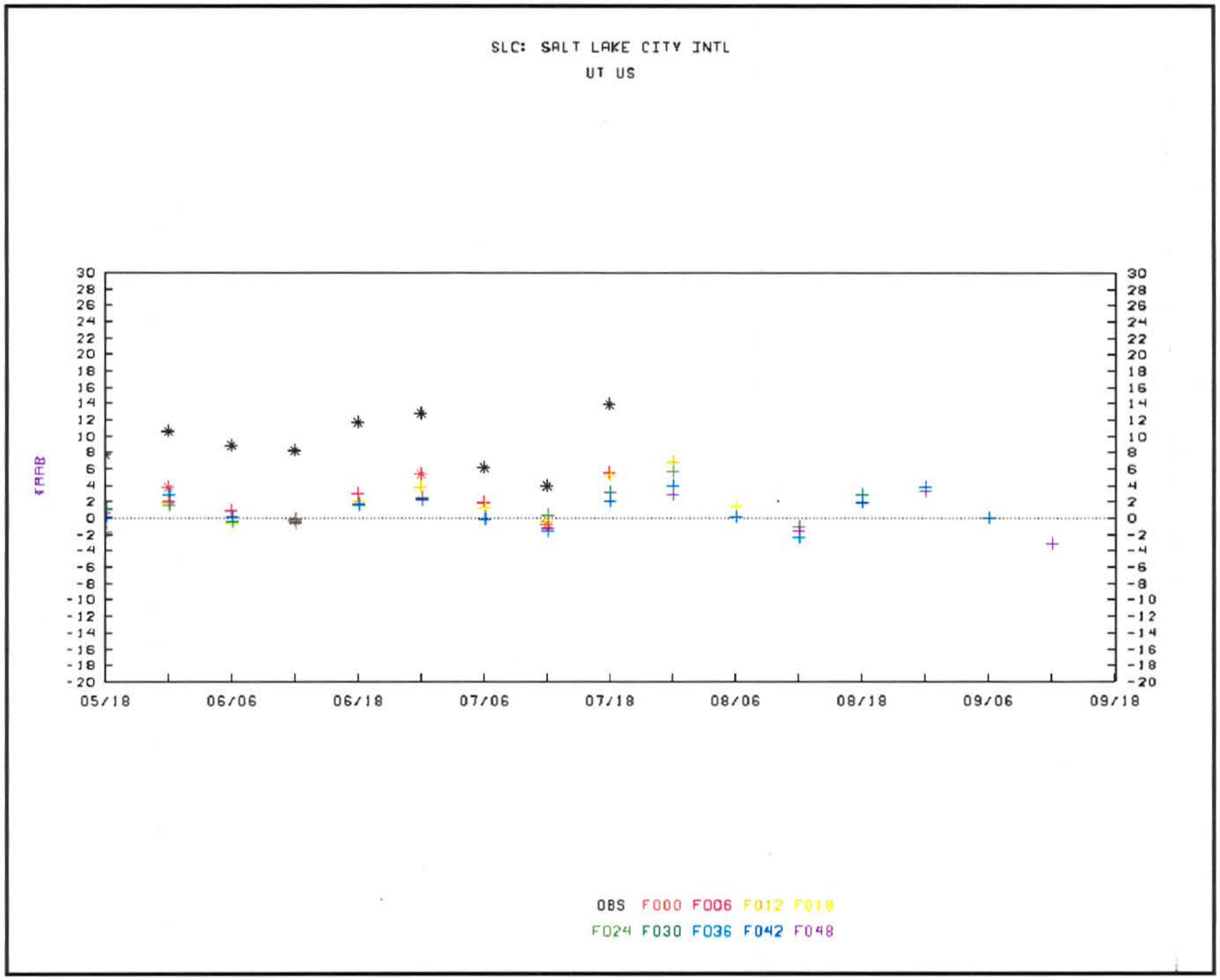

Figure 3. Meteogram plot of forecast vs. observation at Salt Lake City, UT for the period of 990405, 1800 UTC to 990409, 1800 UTC. Observed values are displayed as black asterisks, while forecasted values are shown as color coded positive symbols.

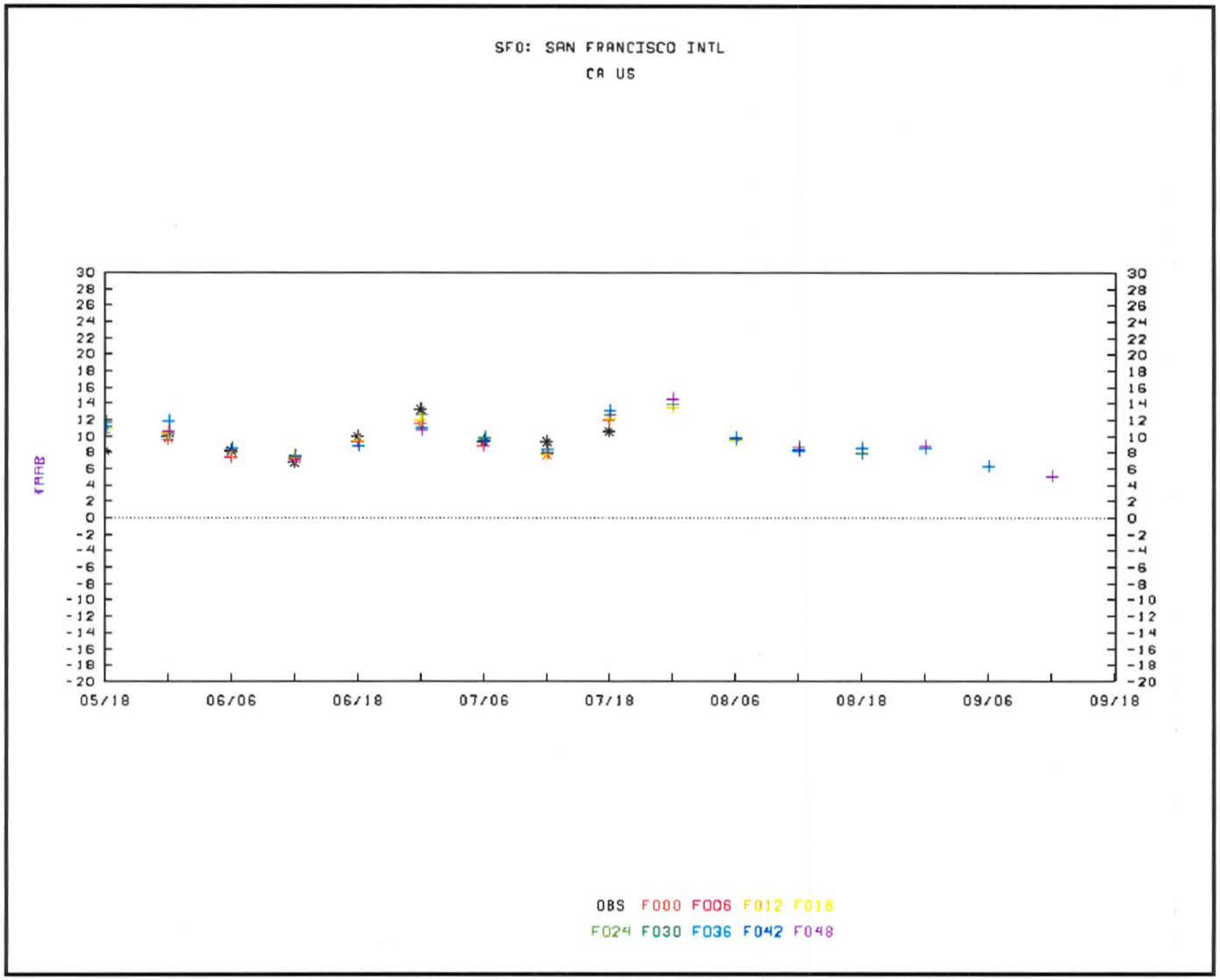

Figure 3. Meteogram plot of forecast vs. observation at San Francisco, CA for the period of 990405, 1800 UTC to 990409, 1800 UTC. Observed values are displayed as black asterisks, while forecasted values are shown as color coded positive symbols.