Using Numerical Model Output to Provide Initial Forecasts of Surface Weather for the AFPS

USING NUMERICAL MODEL OUTPUT TO PROVIDE INITIAL FORECASTS OF SURFACE WEATHER FOR THE AFPS
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Table of Contents

1. INTRODUCTION
2. OVERVIEW
    2.1 Initialization Sources
    2.2 Operations concept
3. SURFACE FORECASTS FROM MODEL OUTPUT
4. COMPARISON OF SURFACE FORECASTS AND SAO STATION OBSERVATIONS
5. PLANS
6. CONCLUDING REMARKS
7. REFERENCES

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1. INTRODUCTION

The AWIPS Forecast Preparation System (AFPS) is being developed at the NOAA Forecast Systems Laboratory (FSL) in Boulder, Colorado, and the National Weather Service (NWS) Techniques Development Laboratory (TDL) in Silver Spring, Maryland. AFPS will support preparation of most routine forecasts at NWS Weather Forecast Offices (WFOs) when it is deployed in the late 1990s as an upgrade to the AWIPS forecaster workstation.

The AFPS concept and development work comprise three broad categories: initializing graphical depictions of weather elements, editing those depictions, and generating forecast products. This paper describes current FSL work on the first of these topics.

2. OVERVIEW

2.1 Initialization Sources

Forecasters draw upon many sources of data to use in deciding what conditions to expect in the forecast period. As in current operations, AFPS-era forecasters will use graphics and grids from the National Centers for Environmental Prediction (NCEP), local conceptual models, manual forecast products from NCEP, Model Output Statistics (MOS), climate records, and recent observations and current forecasts. All of this information is weighed and tempered by the forecasters' experience and knowledge of local effects and model biases, to produce their best prediction of hydrometeorological phenomena.

As part of the multi-year development of the Interactive Computer Worded Forecast system (ICWF) (Ruth and Peroutka, 1993), TDL has developed MOS-based initialization methods that have been adapted for use with AFPS. FSL has begun initial work on direct-from-model initialization of surface weather elements, which is described below.

2.2 Operations concept

To provide graphical access to various sources of data, AFPS provides several reference databases. Forecasters can view grids based on MOS and one or more numerical models, compare them with each other and with the current forecast, and select all or part of any of these to use as the first-guess forecast for the day.

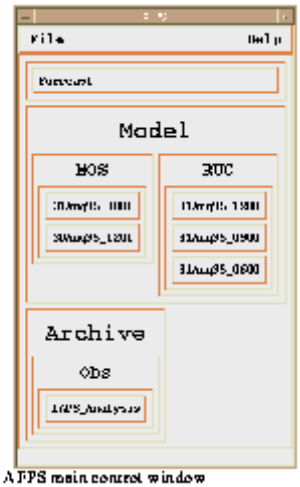

Figure 1. AFPS main control window

Figure 1

Forecasters are presented with a list of initialized, read-only, databases, as shown in Figure 1, above. Each of the selectors in this menu represents a complete database of forecast weather elements. Clicking on one database selection launches a read-only worksheet (Figure 2, below), allowing access to the individual grids in the database. After examining these first-guess forecasts, forecasters may copy their choice of data to the writable Forecast worksheet, where they may be edited, or they may choose to use these data as a (visual) guide while modifying the current data in the Forecast database.

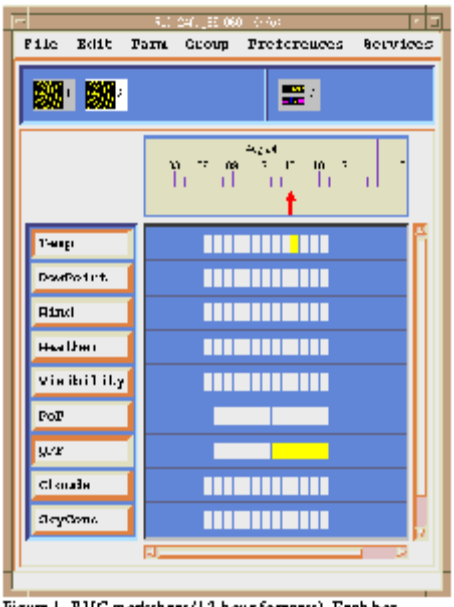

Figure 1. RUC worksheet (12 hour forecast). Each box represents one forecast grid. In this example, the user has opened two spatial editors and one temporal editor, and has set the clock for spatial editor 2 to 1500 UTC.

Figure 2

3. SURFACE FORECASTS FROM MODEL OUTPUT

At FSL we are making surface forecasts from the Rapid Update Cycle (RUC), developed at FSL (Benjamin *et al*. 1994). The current version of the RUC running at NCEP, implemented in September 1994, produces a three-dimensional analysis and short-range forecast (for 1 to 12 hours after analysis time) every three hours. RUC forecasts are made at 25 levels on an 81 by 62, 60-km grid covering the lower 48 United States. RUC terrain is of the same resolution as its grid, that is, 60 km, which naturally smooths out many important features in variable terrain. An advanced version of the RUC is in development at FSL; it will offer 40-km resolution, 40 levels, cloud microphysics with cloud water, rain water, snow water and ice, and improved surface treatment (Benjamin *et al*. 1995).

NCEP sends the native RUC output to FSL, including all hybrid-b (isentropic-sigma vertical coordinate) levels, and native variables such as the virtual potential temperature. This information is input to algorithms making forecasts of surface conditions. Presently we are diagnosing surface temperature, dewpoint, wind speed and direction, visibility, hourly precipitation amount, and up to five layers of cloud base heights and coverage.

The algorithms were developed for generating forecasts at specific stations for aviation purposes (Ramer 1993; Smith *et al*. 1995). AFPS is applying them to a grid using high-resolution topography, which can be higher or lower than the RUC's lowest model level, due to the model's coarse terrain. Where the high-resolution terrain is higher than the lowest model level, temperature, dew point, and so on are determined by interpolation from model results. Where the terrain falls below the lowest model level extrapolation is necessary. In the case of temperature, for example, the lapse rate in the lowest 25 hPa of the model is used for extrapolation. The

details of extrapolation are now the most difficult part of surface forecast generation. Wind is not extrapolated; the nearest values from the model layers are used. This has proved to give satisfactory wind forecasts.

Forecast values are generated on a 73 by 73 10-km grid which can be located anywhere in the RUC domain. Since the AFPS grid points do not match the RUC points, the values for each AFPS grid point are determined from nearby RUC grid positions using first bilinear interpolation to the correct latitude and longitude, and then making the adjustment for elevation.

From the basic surface weather elements extracted from the RUC grids, we also derive 6-hour QPF, 6-hour PoP (Schaefer and Livingston 1990), text descriptors of weather (precipitation, type, and intensity), and a text descriptor of clouds (coverage and height for five layers) used by AFPS; these elements can be displayed on AFPS editors (see Figure 2, above). Some of these require a little thought. For example, precipitation amount everywhere may be much less than 0.01 inches each hour, and yet the QPF will sum to over 0.01 inch in places. Without special checks in the code, QPF would be nonzero, yet "weather" would indicate no precipitation. PoP is determined using horizontal averaging and threshold values of precipitation amount which are adjusted for best results. Forecasters eventually will be able to views the forecasts, adjust such parameters, and create the forecast which best agrees with their judgment and model output.

The final forecasts derived from RUC and displayed by AFPS are highly detailed, as illustrated in Figure 3, both due to model resolution and topographic effects. Using AFPS, these automatic surface forecasts can be easily examined, enabling better evaluations and revisions of the algorithms.

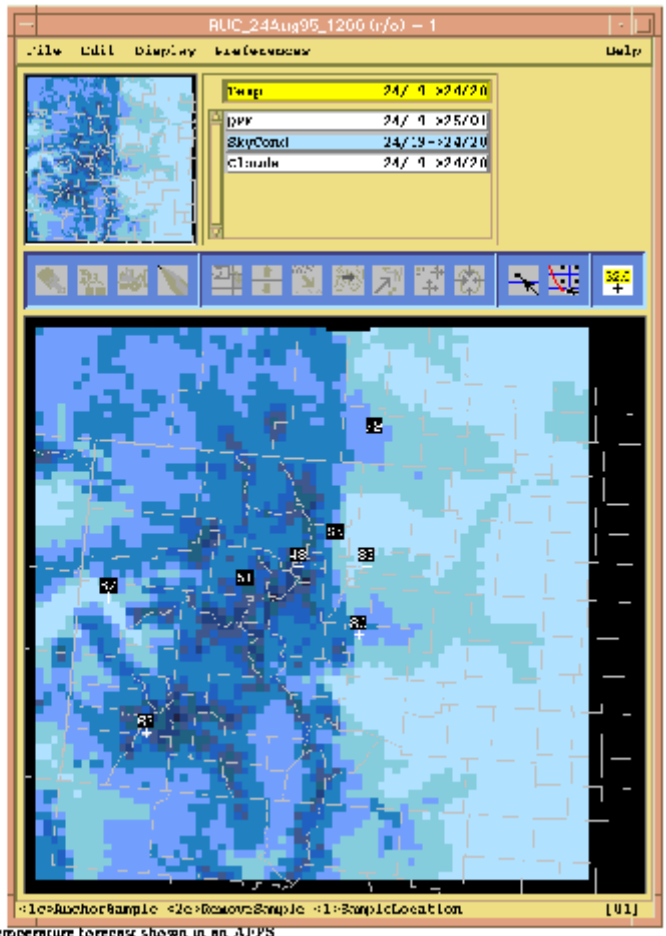

Figure 1. RUC temperature forecast shown in an AFPS spatial editor. A few reference samples are shown.

Figure 3

It is clear that, in general, the forecasts correctly represent the weather. The remaining concern is how accurately this system forecasts numeric weather values, and if it can be used as a basis for preparing forecasts without significant adjustments or additional information.

4. COMPARISON OF SURFACE FORECASTS AND SAO STATION OBSERVATIONS

Forecasts for surface conditions derived from RUC model output (including temperature, dewpoint, wind speed, wind direction, visibility, and hourly precipitation accumulation) are stored for twenty SAO sites in Colorado (thirteen stations), Wyoming (three), Nebraska (two), and Kansas and New Mexico (one each). The stations range in elevation from 1000 meters (IML, Imperial, Nebraska) to 3096 meters (LXV, Leadville, Colorado). For each hour of the day there are four forecasts from RUC data. SAO station observations for each hour and each element are also stored.

The difference between the forecast and the observation is recorded for each hour and forecast at each station. The biases or average forecast-observation differences for each weather element at each hour are determined for each station, an indication of the accuracy of the forecast. Also

recorded are the average absolute differences, RMS errors, and standard deviations, indications of the precision of the forecasts.

To date only hot summer conditions have occurred during these tests. As a whole, the forecasts have been acceptable. No correlation with elevation has been seen, indicating that the strong influence of elevation has been properly handled. The only significant biases noted so far are surface temperatures are consistently too high between 0600 UTC and 1200 UTC, and too low during the afternoon. A problem in the handling of the ground substrate temperature in the RUC has been identified that is likely responsible for this behavior. An updated version of the RUC model scheduled for September 1995 will include improvements to surface temperatures. Forecasts of precipitation amount and wind are very good, though both tend to be light at this time of year in Colorado. No significant episodes of reduced visibility has occurred at the time of writing, so model forecast success of visibility has not been tested.

5. PLANS

FSL will conduct a forecasting exercise in October and November, 1995, using the FSL WFO-Advanced workstation (MacDonald and Wakefield, 1996) for display of all available weather observations and models. The AFPS prototype will be used for editing depictions of forecasts and for generating text forecast messages. This will be a near-operational WFO simulation with three shifts each day, staffed with NWS forecasters, and FSL meteorologists. Forecasts produced with AFPS will be compared to NWS forecasts and observed conditions to assess the capability and potential of the AFPS approach. Naturally, the adequacy of the initial surface conditions provided by AFPS will be an important factor in the ease of use of AFPS. We expect that the model initialization described here will prove useful during this time of the year when the weather is usually highly variable and disturbed.

We will continue gathering comparison statistics through the fall and early winter seasons. It is premature to give measures of fit of the forecasts to observed conditions now. We will report detailed comparisons at the conference. The results of our analysis of forecast quality will be used, and already have been used, to improve both the RUC and the algorithms to estimate surface conditions from the RUC model output. By the time this paper is printed, we plan to derive similar surface forecasts from Eta or NGM grids; other models will follow. From all, we will evaluate the fit of forecasts to observations, and revise the surface algorithms where necessary.

FSL plans to install the WFO-Advanced system and the AFPS in the Denver WSFO in the spring of 1996, for evaluation by forecasters. We hope to begin operational testing of AFPS and these initialization algorithms by mid-1996. As noted in the introduction, long-range plans call for AFPS to be added to AWIPS toward the end of the decade.

6. CONCLUDING REMARKS

Providing the best possible initial conditions is essential to the success of AFPS. In the final form, AFPS will offer the forecaster a choice of initial conditions based on MOS, LAMP (Local

AWIPS MOS Program), NCEP manually prepared grids, Eta, NGM, AVN, MRF, RUC, and, where available, local numerical models. Algorithms or local models for special weather conditions or specific elements, such as lake-effect snow or wave heights, can also be used. Other available data will include the current forecast database, recent observations, and climate.

Initial surface forecasts based on RUC, NGM, Eta, and other numerical models are expected to be one of the strengths of using AFPS. Preliminary results indicate that surface conditions derived from numerical model output will provide satisfactory initial values for forecaster use in AFPS.

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