9.4 USING 20-KM RAPID UPDATE CYCLE (RUC) MODEL OUTPUT IN REDEVELOPING THE LOCAL AWIPS MOS PROGRAM (LAMP)

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1. INTRODUCTION

The Meteorological Development Laboratory (MDL) of the National Weather Service (NWS) furnishes a full spectrum of objective forecast guidance for use at NWS Weather Forecast Offices (WFO). A suite of Model Output Statistics (MOS) products, produced on the National Centers for Environmental Prediction (NCEP) computers, provides forecasters with objective guidance for forecasting aviation and public forecast elements. The shortest range MOS products vary in temporal range from 6 to 72 hours at 3-h or greater time steps for the Global Forecast System (GFS) MOS, while the Eta-based MOS varies from 6 to 60 hours at 3-h or greater time steps (Dallavalle et al. 2004).

The traditional MOS approach statistically relates the model output to the corresponding sensible weather, and provides objective forecasting guidance (Glahn and Lowry 1972). However, there is no *traditional* MOS product that addresses the shorter time range of less than 6 hours, or has time steps shorter than 3 hours. Of particular interest is guidance for the time period of the first 24 hours at hourly time steps for use in preparing the Terminal Aerodrome Forecast (TAF). Forecasters must amend their TAFs promptly when new guidance or information indicates a change to the existing TAF is in order. They must do this especially during the "Critical TAF Period" of 2-6 hours from the current valid time within the TAF (NWS 2002). To address this need for guidance in the shorter range and at a higher temporal resolution, MDL developed the Local AWIPS MOS Program (LAMP).

LAMP was developed in the 1980's and early 1990's to update the existing Nested Grid Model (NGM) MOS using recent surface information. LAMP is a MOS-like system which statistically relates sensible weather to the most recent surface observations, some simple model output, and MOS output. It provides guidance for sensible weather elements of interest to aviation and public forecasters from 1 to 20 hours at hourly time steps. It also provides analyses of meteorological variables hourly. LAMP was first implemented at the WFOs on the Advanced Weather Interactive Processing System (AWIPS) beginning in 1997 and still runs locally in AWIPS today. (Kelly and Ghirardelli 1998)

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MDL is currently in the process of redeveloping the LAMP system to update the GFS MOS instead of the older NGM MOS guidance. In doing this, new datasets for inclusion into the LAMP system are being investigated. The Rapid Update Cycle (RUC) model output data seems to be a logical candidate for inclusion in the LAMP system. The RUC's output is intended for general public forecasting and also "special short-range needs of aviation and severe-weather forecasting" (Benjamin et al. 2002) and therefore has a use very consistent with LAMP's intended use. It is believed that the RUC output will provide valuable information to the LAMP system.

2. THE LOCAL AWIPS MOS PROGRAM (LAMP)

LAMP is a system of objective analyses, simple models, and multiple linear regression equations and related thresholds which together provide guidance for sensible weather. The predictors used in the regression equations fall into three categories: 1) the most recent observations, 2) NGM MOS forecasts, and 3) LAMP Model Output (LMO) from three simple locally run models: a moisture model, a sea level pressure model, and an advective model. (Kelly and Ghirardelli 1998).

The LAMP system currently produces guidance every 3 hours at the WFOs in the contiguous United States (CONUS). Guidance is currently provided for the sensible weather elements of temperature, dew point, probability of precipitation occurring on the hour, probably of precipitation in a 6-h period, precipitation type, visibility, obstruction to vision, cloud height and amounts for up to three layers of clouds, wind speed and direction, and quantitative precipitation forecasts. (Kelly and Ghirardelli 1998)

The new LAMP system will produce similar guidance, with the addition of a gridded thunderstorm guidance product. Other notable differences are that the MOS guidance which is input as predictors will be from the Global Forecast System (GFS) MOS and no longer from the NGM MOS. In addition, other sources of predictors are being investigated, such as the RUC model data being discussed here, but also satellite, radar, and lightning data. The new LAMP system will produce guidance for approximately 1500 stations covering the CONUS, in addition to points in Alaska, Puerto Rico, and Hawaii (Glahn and Ghirardelli 2004). These stations are displayed in Figure 1.

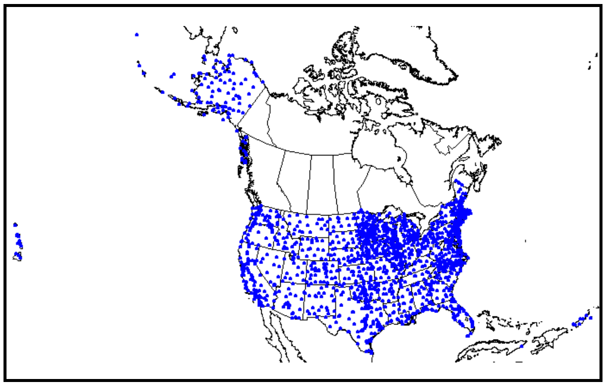

Figure 1. Map display of the stations for which there will be LAMP guidance in the redeveloped system.

3. THE RUC MODEL

The RUC Model is an analysis system and a numerical weather prediction model intended for short-range forecasting guidance. It is on a 20-km horizontal grid, with 50 levels in the vertical. It runs out to 3 hours on an hourly basis, and out to 12 hours every 3 hours. The 20-km RUC grid is AWIPS/GRIB grid 215, which is a subset of the AWIPS Lambert conformal grid, and covers the CONUS. (Benjamin et al. 2002)

MDL will be testing the utility of the RUC output in the LAMP system. Various fields from the RUC will be offered to the regression system as potential predictors. This testing plan is outlined in Section 6.

4. ANTICIPATED BENEFITS OF RUC INCLUSION

It is anticipated that the RUC will offer valuable information to the LAMP system. LAMP acts as an update to the MOS system basically by running more frequently than MOS. By running more frequently, LAMP can ingest surface observations that are more recent than those that went into the MOS. A method for using *forecasts* from the more recent data is to incorporate forecast output from a model run more recently than the large scale dynamical model from which MOS is based. For this purpose, LAMP creates analyses of the most recent surface observations, and uses these analyses to initialize the simple LAMP models. These analyses and simple model output are a way of incorporating forecasts from the most recent surface observations into the forecast.

A more sophisticated approach, which until recently has not been available operationally, would be to use the forecast output from a dynamical model that runs more often than the GFS. The RUC is initialized with more recent data than available to the GFS at the time it is run (Benjamin et al. 2002). With the RUC model, we now have an additional source for dynamical forecast output which has indeed taken into account the most recent information.

There are a number of aspects of the RUC which are likely to translate into an improved LAMP product. The three dimensional analysis used incorporates a number of data sources, and observations included undergo sophisticated preprocessing and quality control (Benjamin et al. 2003). It is run frequently enough (every hour out to 3 hours, and every 3 hours out to 12 hours), and at a fine enough resolution (20-km) to provide us with the updated, detailed information and the forecast projections that are of use to LAMP. LAMP forecasts cloud heights and amounts for up to three layers of clouds, as required in the TAF. The RUC could also be instrumental to LAMP in that guidance since a goal of the 20-km RUC is to produce skillful cloud forecasts (Benjamin et al. 2002). Also, the RUC model output is available for use in LAMP in a timely manner, which is an important consideration to LAMP operations.

5. POTENTIAL CHALLENGES OF RUC INCLUSION

There are however some concerns or hindrances in using the RUC output, and while these may be surmountable, they need to be considered. First of all, the ideal rapid update type of model output for LAMP inclusion would be produced hourly out to at least 15 or 18 or even 20 hours. The RUC currently goes out in NCEP operations only 12 hours, and this extended run is produced only every 3 hours. The other hourly runs extend out only 3 hours. In addition to this, at NCEP not every projection is archived and available retrospectively (personal communication G. S. Manikin 2003). Table 1 shows the projections available in the archive. This issue of the availability of the projections in the archives poses not only a developmental challenge, it poses an implementation challenge as well.

A larger hindrance is getting a large enough archive of the RUC model output to develop stable regression equations. The 20-km RUC began running in operations at NCEP in April 2002. We will develop the new LAMP system using a seasonal stratification of data from warm seasons which extend from April through September, and data from cool seasons which extend from October through March. We therefore have at the time of this writing only two complete seasons of warm season RUC data and one complete season of cool season data. Of this sample, some of the data would need to be reserved for testing as independent data.

Table 1. RUC projections run and archived at NCEP.

RUC start times (UTC)	Projections available retrospectively (h)
0000, 0300, 0600, 0900, 1200, 1500, 1800, 2100	0, 1, 2, 3, 6, 9, 12
0100, 0200, 0400, 0500, 0700, 0800, 1000, 1100, 1300, 1400, 1600, 1700, 1900, 2000, 2200, 2300	0, 1, 2, 3

We are planning to reserve some portion of the last full season, perhaps the last 15 days of each month, for such independent testing. This would reduce our developmental sample further to merely one and a half seasons. We will assess whether stable equations can be developed using such a limited developmental sample.

Lastly, the domain of the RUC model is not consistent with the domain of the LAMP guidance. The RUC grid information given in Section 3 above delimits a grid that covers the CONUS, but does not cover Alaska, Hawaii, or Puerto Rico, areas for which LAMP guidance is needed. It is therefore not possible to include RUC model output in the LAMP guidance produced for those areas.

6. TESTING PLAN

Plans for testing the utility of including the RUC output in the LAMP system are presented here. The most basic question we hope to answer is whether the RUC output adds value to the LAMP forecast guidance given the challenges presented above. To this end we will be comparing LAMP forecasts developed using the basic LAMP predictors plus the RUC model output as predictors (LAMP = GFS MOS + OBS + LMO + RUC) to LAMP forecasts developed without RUC input and using only the basic LAMP predictors (LAMP = GFS MOS + OBS + LMO). Both of these forecast systems will be developed with the shorter developmental data sample for which the RUC data is available. This will quantify the contribution of the RUC used as input into the LAMP system.

In addition, a similar comparison of LAMP including RUC and LAMP not including RUC will be made, where the former system will be developed using the shorter developmental data sample (for which the RUC is available) and the latter system will be developed using the longer developmental data sample which is available if one does not include the RUC data. This will address the issue of the utility of the additional data source of the RUC over a short sample compared to the utility of the longer data sample without the additional information from the RUC. In other words, which system will have better predictive value: the system developed from a longer data sample but incorporating one less type of data source, or the system developed from a much shorter data sample but incorporating one additional type of data source?

6.1 Basic archive

The "basic" archive available, which does not include the RUC data, is from April 1997 to September 2003. This covers 6 years of warm season data and 7 years of cool season data. Predictors from the data sources listed in Table 2 are available for selection in the regression system. The radar data are unavailable for a period of 4 months in 2001, and the 0600 and 1800 UTC GFS MOS data are missing for 3 months in 1999 because the GFS data were unavailable.

Table 2. Predictor sources

Data	Cycles/Times available
GFS MOS	0000 UTC 0600 UTC 1200 UTC 1800 UTC
METAR observations	Hourly
10-km radar	every 15 or 30 minutes
LAMP Model Output	Hourly

6.2 RUC archive

Our RUC archive for testing covers the time period of April 2002 through September 2003. For testing, we are archiving only the runs that extend out 12 hours, and we are archiving all projections available. They are the 0-h analysis, 1-, 2-, 3-, 6-, 9-, and 12-h projections. The RUC fields available in our archive for testing are from the isobaric files stored at NCEP**.**

6.3 Cycles to test

It is intended that the LAMP guidance will be produced every hour. In determining which LAMP cycles to test, many issues were considered. Of primary consideration is the fact that LAMP is designed to be an update to MOS, and in the case of the redeveloped LAMP, the MOS we are updating is the GFS MOS. The GFS MOS is run at NCEP four times a day, representing 0000, 0600, 1200, and 1800 UTC cycles.

However, there is a lag time between these "start times" and the release and availability times of the cycles. For example, the 0000 UTC GFS MOS is available on the NCEP computers around 0400 UTC. The hourly observations are available shortly after the top of the hour, as are the radar data. The LAMP model output would be available shortly after that. The RUC output from the runs that extend out 12 hours is available about 1 hour after the RUC start times of 0300, 0600, 0900, 1500, 1800, and 2100 UTC, and about one and a half hours after the RUC start times of 0000 and 1200 UTC. Additionally, since we plan for the LAMP guidance to be available for making the TAF, we considered the TAF issuance windows.

Given all of these considerations, depicted in Figure 2, we decided to test the utility of the RUC in the LAMP start times of 0700 and 0900 UTC. These two times would both be updates to the 0000 UTC GFS MOS, since the 0600 UTC GFS MOS is not available yet. These times, especially the 0900 UTC run of LAMP, would give LAMP the greatest advantage in updating the GFS MOS since the GFS MOS is at its "oldest" at this point. LAMP developed at these times would use the 0600 UTC RUC output, since the 0900 UTC RUC is not yet available. It is our belief that

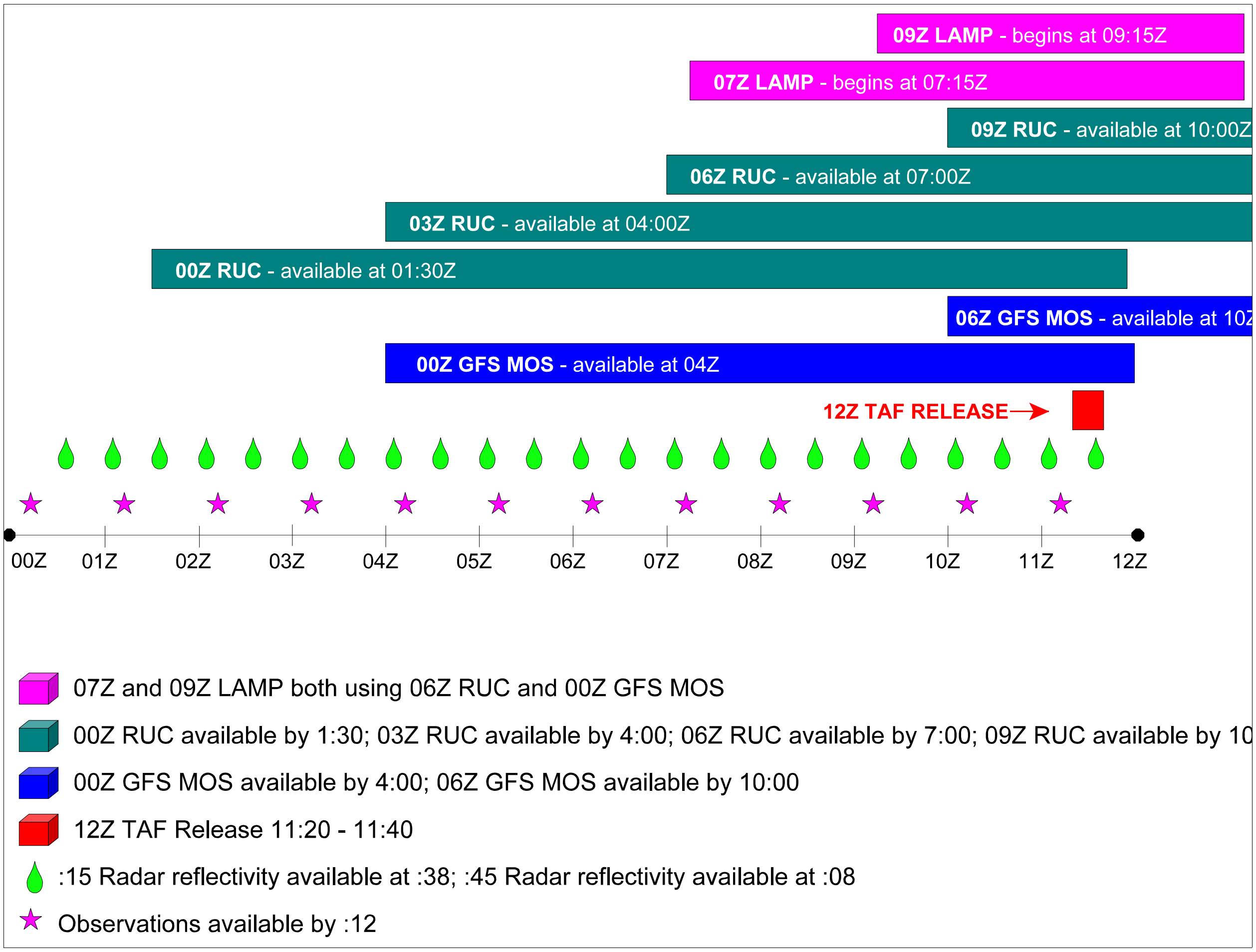

Figure 2. Time line of available data sources.

using the 0600 UTC RUC output in the 0700 LAMP run will show RUC at it's most useful, since it is only 1 hour old at the time of the LAMP running. By using the 0600 UTC RUC output in the 0900 LAMP run, we will demonstrate RUC at its "oldest" and relatively least useful since the next RUC run out to 12 hours will be available at the next hour. Since the RUC will be newer than the GFS MOS at these times, it is expected it will have a predictive advantage. At times when the GFS MOS output is rather recent, it is conceivable that the RUC output will not contribute as much as at other times since the recent data incorporated into the RUC is already in the GFS MOS.

7. FUTURE PLANS

At the time of this writing, the archiving of the data through the 2003 warm season has just been completed, and testing on the 0700 and 0900 UTC start times has begun. Results will be presented at the conference, and will be made available from the LAMP web site http://www.nws.noaa.gov/mdl/lamp.

Acknowledgments

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