3.4 VERIFICATION OF 20-KM RUC SURFACE AND PRECIPITATION FORCASTS

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1. INTRODUCTION

The Rapid Update Cycle (RUC) model running operationally at the National Centers for Environmental Prediction (NCEP) provides high-frequency mesoscale analyses and short-range numerical weather prediction guidance for aviation, severe weather, and general weather forecasting. In early summer 2001, a new 20-km version of the RUC will replace the operational 40-km version running at NCEP. In addition to higher horizontal resolution, the new version will feature a three-dimensional variational (3DVAR) analysis and cloud analysis schemes. In addition, the 20-km RUC will include changes to cloud microphysics, land-surface, and convective parameterizations, and more detailed specifications of topography, land-use, and soil fields. These enhancements are expected to lead to improvements in surface temperature, humidity, wind, and precipitation forecasts.

The purpose of this paper is to provide some initial comparisons of precipitation and surface forecast accuracy between the 40-km and new 20-km versions of the RUC. As of this writing, we have a limited sample of representative forecasts that are appropriate for verification because of recent modifications to the 20-km RUC code in preparation for implementation. Here, we present verification of RUC surface forecasts for a short period (late April to early May 2001), and for RUC precipitation forecasts (mid-March to early April 2001). At the conference, we expect to have a larger sample of forecast verification to present. Forecasts from the operational 40-km and 20-km test versions of the RUC are compared to surface METAR observations. For precipitation forecasts, 24-h forecasts are derived from two 12-h forecasts of both RUC versions and compared against the NCEP 24-h precipitation analysis.

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2. WHAT IS DIFFERENT IN THE 20-KM RUC?

The 20-km RUC includes horizontal and vertical resolution changes as well as significant changes in both its data assimilation and forecast model. These changes are described in more detail in Benjamin et al. (2001).

The change from 40-km to 20-km resolution allows for much improved resolution of topographically induced circulations, especially near the surface, and for orographically enhanced precipitation. The number of vertical levels has been changed from 40 to 50, although the impact of this change is more significant for upper-level fields than for surface or precipitation fields.

The modification to a 3DVAR analysis for the RUC has been designed to draw closely for observational data, including surface METAR observations. The cloud analysis, consisting of cloud clearing and building from assimilation of GOES cloud-top data (Kim and Benjamin 2001), has been shown to provide some statistical improvement in precipitation forecast at larger thresholds and certainly has a significant effect on precipitation forecasts at a given time.

The 20-km RUC forecast model changes relevant to precipitation forecasts include a revised convective parameterization (Grell and Devenyi 2001), fixes to problems with moisture advection and interfaces with parameterizations, and a modified version of the RUC/MM5 cloud microphysics. Changes to the land-surface scheme and radiation scheme, along with more detailed fixed land-use and soil fields, are aimed at producing more accurate near-surface forecasts (Smirnova et al. 2000).

3. QPF VERIFICATION

One of the goals for improved forecasts from the 20-km version of the RUC is to improve upon the known low bias for operational 40-km precipitation forecasts. This bias is especially problematic for forecasts with higher thresholds (24-h totals > 0.50 in., Schwartz and Benjamin 2000).

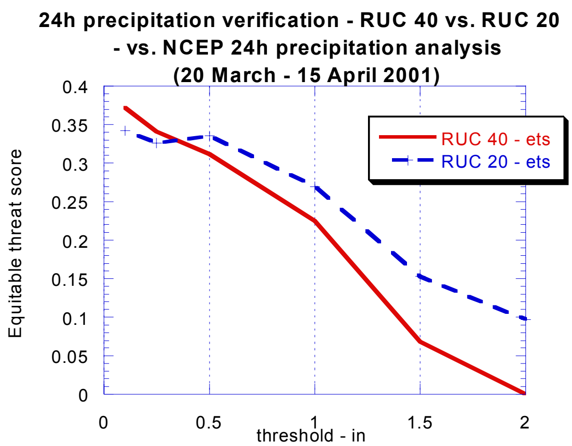


Fig.1 Equitable threat score (ETS) for 40-km and 20-km RUC 24-h precipitation forecasts.

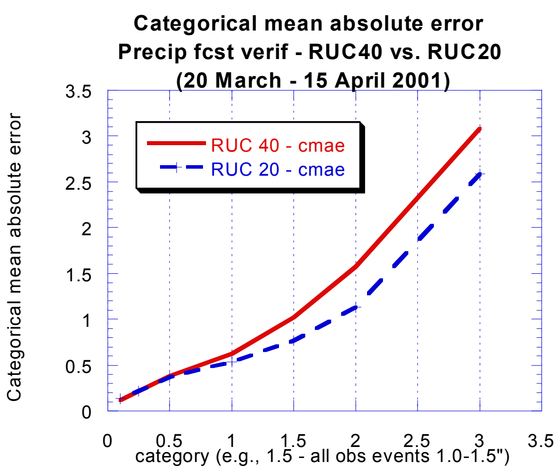


Fig 2 Categorical mean absolute error (CMAE) scores for 40- and 20-km RUC 24-h precipitation forecasts.

Figures 1-3 show the improvement of 20-km RUC forecasts over the operational RUC during the 15 March - 20 April, 2001 time frame. This period included a number of heavy precipitation events. These three figures show, respectively, equitable threat score (ETS), categorical (interval-based) mean absolute error (CMAE), and bias for 24-h totals (from two 12-h forecasts summed) for the 40-km RUC vs. the 20-km RUC. The ETS (Fig. 1) and CMAE (Fig. 2) both indicate improved precipitation forecasts from the 20km RUC for thresholds of 0.5 in. 24 h^{-1} and above. The bias (Fig. 3) shows a substantial increase in events forecast from the 20-km RUC for all thresholds, with a bias of slightly over 1.0 out to the 1 in. 24 h^{-1} threshold. The 20-km bias for the 2 in. threshold increases to about 0.6 from nearly 0.0 for the 40 km version.

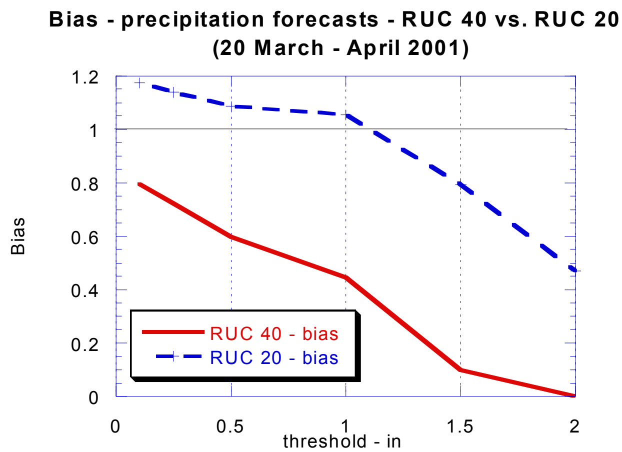


Fig.3 Bias (forecast – observed) scores for 40-and 20-km RUC 24-h precipitation forecasts.

An example of an improved 20-km forecast for a heavy convective precipitation event is shown in Fig. 4. In this case, there were observed amounts in excess of 3 in. over parts of the southeast United States caused by heavy imbedded convection The 20-km RUC maximum values were about 2.5 in.which were considerably more accurate than the maximum values of 0.75 in. forecast by the 40-km RUC. We believe that the improvement in the forecast precipitation amounts of the 20-km RUC can be attributed to improvements and fixes to the convective parameterization scheme discussed previously.

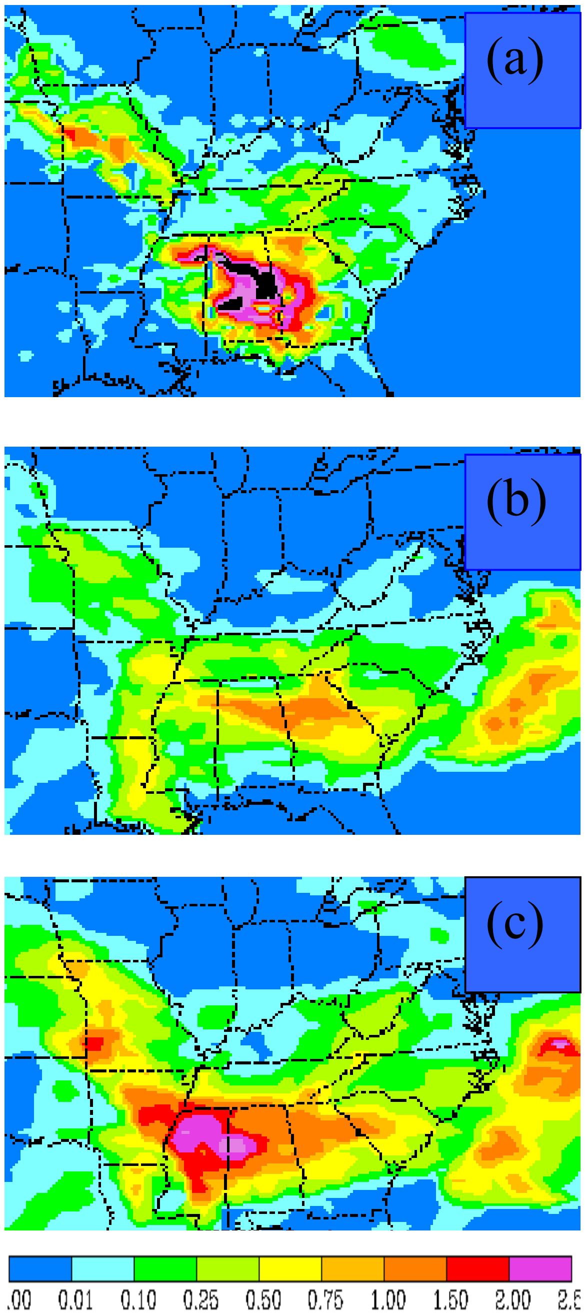
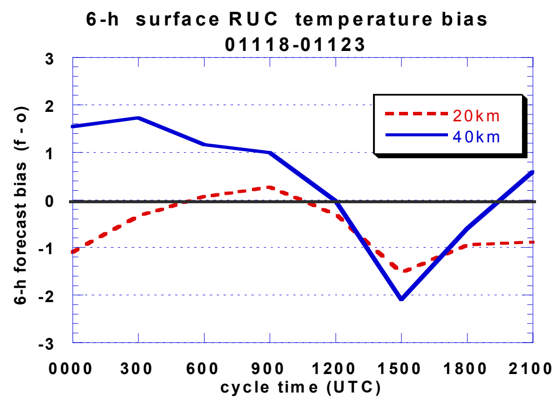
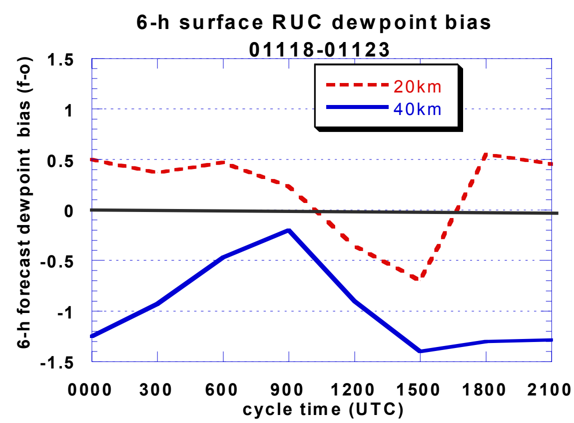


Fig. 4 24-h Observed preciptation (a) and 24-h forecasts from the 40-km RUC (b), and 20-km RUC (c) valid 1200 UTC 19 November 2000.

4. SURFACE TEMPERATURE, DEWPOINT, AND WIND VERIFICATION

Another goal for the 20-km RUC development has been to reduce diurnally related biases in surface forecasts. In particular, the 40-km RUC has exhibited a warm bias at night and cool bias in the daytime, i.e., an underforecast of the diurnal cycle. Figure 5 shows the bias in 6-h surface temperature forecasts from the 40-km and 20-km version of the RUC. These biases are shown by valid time every three hours. The period shown is for 27 April – 4 May 2001, corresponding to a





Figs. 5 and 6 Bias (forecast – observed) for 40-km and 20-km RUC surface temperature (top) and dewpoint (bottom) forecasts.

recent improved version of the 20km RUC analysis. For this period, the 20-km RUC still shows some underestimate of the diurnal cycle, but the biases are reduced from the 40 km version, especially at night. For dewpoint forecasts, the 40-km RUC showed a consistent dry bias in 6h forecasts for this period at all times of day (Fig 6). The dry bias in dewpoint has been replaced with a much smaller bias from 20-km RUC forecasts. Surface wind forecasts (not shown) generally verify worse for the 20-km RUC for this time period. Reasons for this behavior are under investigation; possible explanations are mentioned briefly below.

5. CONCLUSIONS

The goals in development of the 20-km version of the Rapid Update Cycle being implemented in summer 2001 include improving precipitation forecasts and reducing diurnal cycle errors for surface forecasts. In this paper, we show results indicate some success for both of these goals. Verification of 24-h precipitation totals indicates that the 20-km RUC provides better guidance especially for heavier precipitation events. For surface temperature and dewpoint forecasts, verification of 6-h RUC forecasts from the 40-km and 20-km versions indicates reduced bias from the 20-km version. Verification against wind forecasts for this same period indicates poorer skill from the 20-km version. A possible reason for this result is that all of the surface verification has been done with 40-km grids extracted from 20-km original gridded fields. Additional investigation needs to be done to see if subsetting or averaging procedures are affecting the 20-km skill for all forecasts of surface variables. Another possible factor that might affect the accuracy of 20-km RUC surface forecasts is the use of a similarity-theory-based reduction from the RUC prognostic level at 5 m above the surface to a 10-m level for wind and a 2-m level for temperature and dewpoint. This reduction is new to the 20-km version, and will be re-examined before the final implementation.

Verification for both precipitation and surface forecasts presented in this paper was for very limited periods, due to changes in the 20km RUC during the development period. Verification over longer periods will be presented at the conference.

6. REFERENCES

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