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5.22 THE 20-KM VERSION OF THE RAPID UPDATE CYCLE

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1. INTRODUCTION

The Rapid Update Cycle (RUC), a high-frequency mesoscale analysis and forecast model system, has become a widely used source for aviation weather forecasting guidance in the United States. It has also become an important part of the overall numerical model guidance provided by the NOAA's National Centers for Environmental Prediction (NCEP), and has widespread application throughout the National Weather Service and among other users.

A new, 20-km version of the Rapid Update Cycle has been under development at the NOAA Forecast Systems Laboratory, and is scheduled for implementation at NCEP later in 2000. This paper describes the primary components of the 20-km RUC and how it differs from the 40-km RUC that has run at NCEP since April 1998. The key differences are resolution, an improved version of the RUC forecast model, assimilation of GOES-based cloud-top pressure, and use of a 3-dimensional variational analysis, replacing the current optimal interpolation analysis.

2. RESOLUTION AND DOMAIN

The change in horizontal resolution in the RUC from 40 km to 20 km will result considerable improvement in the effects of topography and land-surface variations on winds and precipitation. Also important for aviation applications, it will improve the ability of the RUC to resolve clouds and areas with super-cooled liquid water will potential for icing, along with areas of explicitly resolved precipitation. The 20-km resolution will also allow the RUC to better delineate areas with potential for turbulence, whether of clear-air, mountain-wave, or convective origin.

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The domain and topography of the 20-km RUC is presented in Fig. 1. The size of the domain remains the same as that for the 40-km RUC. Some enlargement of the RUC horizontal domain is likely in a subsequent upgrade in late 2001 to 2002. Details of various topographical features are much better resolved in the 20-km RUC than in the current 40-km version. This is apparent in the comparison of RUC 40-km and 20-km topography fields for the western United States presented in Figs. 2a-b. The 20-km RUC continues to run with 40 vertical levels, using the same hybrid isentropic/terrain-following coordinate used successfully in the previous versions of the RUC. The vertical spacing in the 20-km RUC is the same as in the 40-km RUC. As in the 40-km version, the isentropic spacing is approximately 2 K through much of the troposphere and the model/analysis top is at 450 K (approximately 50-60 mb). The spacing near the surface is 2, 5, 8, and 10 mb in the first 4 layers, with an explicit model calculation level at 10 m above the surface.

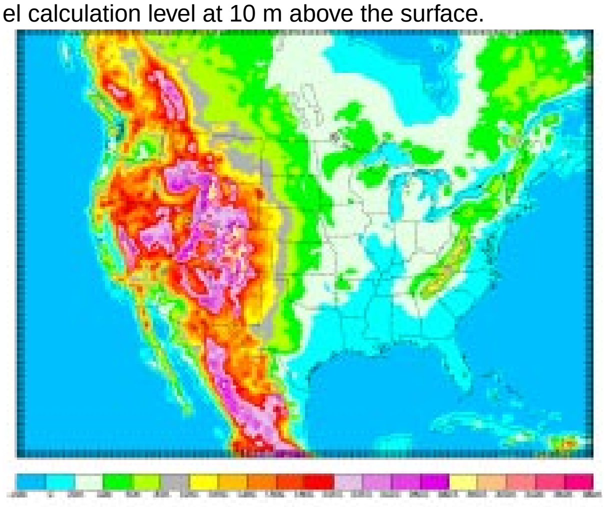

Figure 1. 20-km RUC domain and topography.

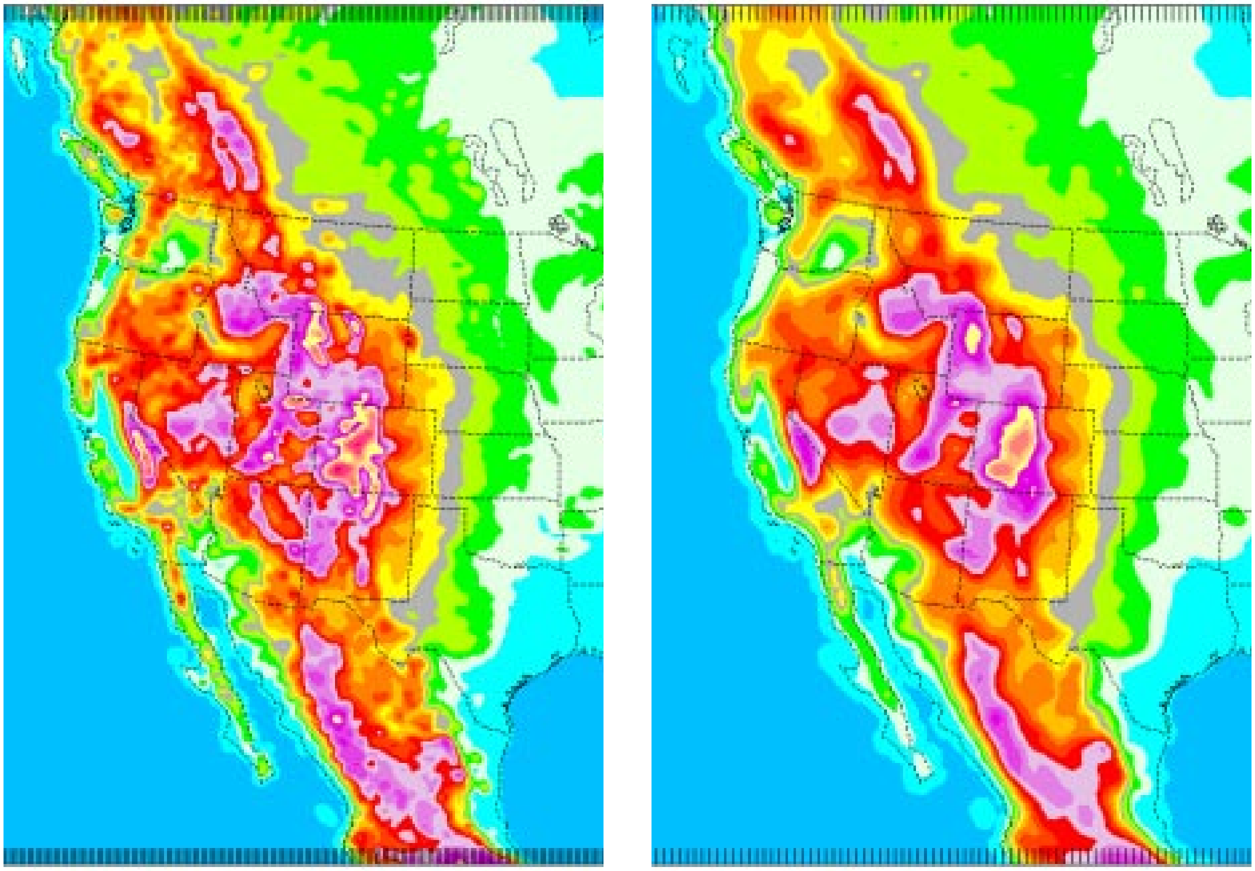

Figure 2. Topography in western United States for a) 20-km RUC, and b) 40-km RUC

3. THE 20-KM RUC FORECAST MODEL

The 20-km RUC forecast model has incorporated a number of improvements that, even without the change in horizontal resolution, result in better RUC forecasts. The key areas of improvement are:

* Improved convective (sub-grid-scale) precipitation (rewritten version of Grell convective parameterization including effects of shallow convection, fixes to problems concerning calling the scheme)

* Improved vertical advection of moisture and stable precipitation (vertical advection of all moisture/cloud variables changed to be conservative)

* Revised version of explicit mixed-phase microphysics in collaboration with NCAR/RAP (Brown et al. 2000). Also, the scheme is now called with a smaller time step, reducing truncation errors that are apparent under close inspection in the current 40-km RUC.

* Improvements to land-surface/vegetation/snow model, including provision for frozen soil and a 2-layer snow model (Smirnova et al. 2000) and more detailed land-surface data

* More accurate diurnal cycle of temperature (due to more frequent call of short-wave radiation (30 min instead of 60 min) and corrected centering within time interval and change to soil thermal conductivity)

In addition to these changes, the RUC forecast model software was rewritten with much greater modularity and also to use a new pre-processor for message passing (FSL, 2000). The message-passing pre-processor allows the RUC model to continue to use local-memory parallel computers, but now with less-intrusive compiler directives.

4. AN INITIAL CLOUD ANALYSIS FOR THE RUC USING ASSIMILATION OF GOES CLOUD_TOP PRESSURE

An explicit mixed-phase cloud microphysics scheme was introduced into operations along with the 40-km RUC in 1998. This scheme includes explicit prediction of mixing ratios for 5 hydrometeors, cloud water, cloud ice, rain, snow, and graupel. For each hourly cycle in the current 40-km RUC, the initial fields for these variables are taken from the previous 1-h forecast without modification. Ongoing research over the last 3 years has led to development of an analysis technique (Kim and Benjamin 2000) that modifies these RUC cloud hydrometeor fields based on information from a GOES sounder-based cloud-top product produced by NESDIS. This technique includes both building of clouds if the 1-h forecast incorrectly indicated clear conditions and clearing of clouds if the forecast incorrectly had predicted cloud. The technique has been shown to consistently improve short-range cloud-top forecasts, especially in 1-h and 3-h forecasts but even out to 12-h forecasts, to reduce errors in relative humidity forecasts, and to improve precipitation forecasts. More details on this are provided by Kim and Benjamin (2000).

5. A RUC 3-D VARIATIONAL ANALYSIS

The current operational 40-km RUC has performed well using initial fields from an optimal interpolation (OI) analysis configured in its native hybrid isentropic/terrain-following coordinates (Benjamin et al. 1999). However, a 3-dimensional variational (3DVAR) analysis approach has been under development for the RUC for a few years in order to allow initial or improved assimilation of remotely sensed observations (e.g., satellite, radar) and to reduce small-scale noise associated with the OI analysis. This technique will be introduced with the 20-km RUC. It has been shown to produce wind and height forecasts of better quality than those initialized by a RUC OI analysis in parallel cycle tests at a 60-km resolution. Further detail on this aspect of the 20-km RUC is provided by Devenyi and Benjamin (1998).

6. SUMMARY

A main features of a new version of the Rapid Update Cycle to be implemented at 20-km resolution have been described. Examples of performance will be presented at the conference.

7. REFERENCES

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