P1.11 THE RTMA BACKGROUND – HOURLY DOWNSCALING OF RUC DATA TO 5-KM DETAIL

Stan Benjamin*, John M. Brown, Geoff Manikin[1], Greg Mann[2]

NOAA Earth System Research Laboratory / Global Systems Division, Boulder, CO
[1] Environmental Modeling Center, National Centers for Environmental Prediction, NOAA, Camp Springs, MD
[2] National Weather Service, White Lake, Michigan

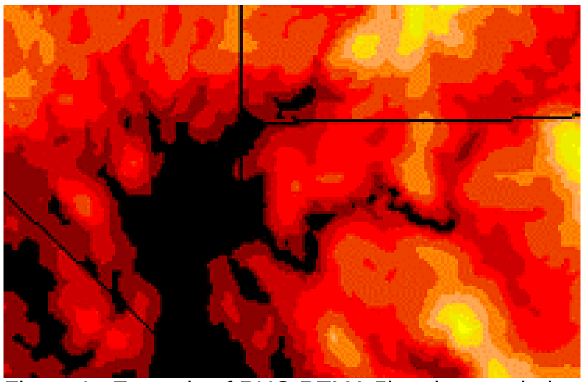

Figure 1. Example of RUC-RTMA 5km downscaled temperature over NV, UT, and AZ (including Grand Canyon). (See Fig. 3 for more details).

1. INTRODUCTION

The Real-Time Mesoscale Analysis is designed to provide the best 5-km gridded estimate of current surface and near-surface conditions on an hourly basis in support of National Weather Service operational activities and the NWS National Digital Forecast Database (NDFD). Even with availability of increasingly dense mesonet observations, the RTMA must incorporate a 3-d atmospheric/land-surface model to ensure some measure of physical consistency with land-surface conditions, land-water contrasts, terrain elevation, as well as with the 3-d effects of realistic thermal stability, boundary-layer structure, and local circulations. Therefore, the RTMA relies on a background field fully consistent with these 3-d model-based effects by using the previous 1-h forecast from the Rapid Update Cycle (RUC). The RUC, with its detailed hourly assimilation of 3-d atmospheric observations and special emphasis on 3-d variational assimilation of METAR and mesonet data, is appropriate for providing the RTMA background field for a subsequent GSI-2dVAR enhancement (see Pondeca et al. 2007 at this same conference).

Corresponding author address: Stan Benjamin, NOAA/ESRL/GSD, R/E/GS1, 325 Broadway, Boulder, CO 80305, stan.benjamin@noaa.gov

As part of the hourly post-processing in the NCEP-operational 13-km RUC, a downscaling technique was developed to produce 5-km gridded fields from the full-resolution native (hybrid sigma-isentropic) RUC coordinate data to calculate values consistent with the higher-resolution 5-km RTMA terrain elevation field (e.g., Fig. 1). The RUC-RTMA downscaling technique includes both horizontal and vertical components. The vertical component uses near-surface stability from the RUC native data to adjust to the RTMA 5-km terrain. In the horizontal, for example, coastline definition is enhanced as part of this RUC-RTMA downscaling using a 5-km roughness length field used to distinguish land-water boundaries on the 5-km RTMA grid. The fields downscaled to the 5-km grid include

- 2-m temperature
- 2-m dewpoint
- surface pressure
- 10-m wind components
- 2-m specific humidity
- gust wind speed
- cloud base height (ceiling)
- visibility

Ceiling and visibility (not yet required for RTMA) are defined with some accuracy due to RUC hourly assimilation of METAR cloud and visibility observations.

RTMA downscaling for temperature uses virtual potential temperature, the related prognostic/analysis variable in the RUC model/assimilation system, an advantage for interpolation in irregular terrain in mixed layer conditions. Different techniques were developed for these different variables, including special approaches for vertical extrapolation vs. interpolation dependent on whether RTMA terrain elevation is higher or lower than RUC terrain. The accuracy of the RTMA fields is dependent on this RUC-RTMA downscaling, and therefore, of considerable interest to NWS RTMA users.

2. Characteristics of RUC analysis appropriate for Real-Time Mesoscale Analysis

Use of the RUC analyses or 1-h forecasts as the background for the RTMA brings unique advantages for accuracy of the RTMA. NOAA/ESRL/GSD has been able to show that assimilation of the latest observations using the RUC analysis / 1-h forecast cycle adds value in forecast accuracy (Benjamin et al.

2004a). In particular, improved accuracy has been shown specifically for 2-m temperature, 2-m dewpoint, and ceiling/visibility down to the 1-h duration for RUC forecasts. By this, we mean that RUC 1-h forecasts are more accurate than 3-h, 6-h, or 12-h forecasts valid at the same time.

We summarize the key aspects of the RUC below that make it suitable for the RTMA background. These are discussed in more detail in the analysis/1-h cycle and model descriptions in Benjamin et al. (2004a,b):

- Hourly mesoscale analysis (DFI - Digital Filter Initialization essential for "quiet" 1h forecast)
- Designed to fit observations (within expected error) [including surface 2-m temperature (as virtual potential temperature), dewpoint (as mixing ratio), altimeter, wind]
- Full-physics 1-h forecast (most important aspects of physics – boundary layer, land-surface contrasts (vegetation type, satellite-derived vegetation fraction, roughness length, soil type, land/water contrasts, albedo, snow cover, ice cover) (Benjamin et al. 2004b)
- Accounting for local mixed-layer depth in assimilation of surface data (implemented in RUC analysis in June 2005, Benjamin et al. 2004d)
- Accounting for land-water contrast in assimilation of coastal surface observations and buoys (improved in June 2006)
- Assimilation of METAR cloud, visibility, current weather (to infer cloud depth) (Benjamin et al. 2004c)
- Assimilation of mesonet observations (T, Td, sfc pressure)
- Assimilation of GPS precipitable water, boundary-layer profiler observations
- QC criteria for mesonet different than those for METAR observations (to account for different siting standards)
- Assimilation of GOES cloud-top data into initial fields of 3-d hydrometeor fields cycled in the RUC (mixing ratios for cloud water, ice, rain, snow, and graupel).

3. RTMA-RUC downscaling

Currently, the RTMA-RUC downscaling runs at NCEP on an hourly basis at the end of the RUC post-processing from each RUC hourly cycle. The RTMA-RUC downscaling is currently run only for the analysis (00h) and the 1-h forecast.

Three fixed fields for the 5-km RTMA grid are used, all extracted from the WRF Standard Initialization (SI) program:

- 5-km topography (no smoothing)
- 5-km roughness length
- 5-km vegetation type.

The RTMA-RUC downscaling has three primary components:

- horizontal component
- vertical component
- horizontal adjustment for coastline sharpening.

We discuss these three steps below:

3.1 <u>Horizontal interpolation</u>

The first step is to simply bilinearly interpolate the appropriate RUC 13-km fields to the RTMA 5-km grid, initially without any adjustment or variable transformation. The RUC post-processing diagnoses all of these variables on the RUC 13-km grid, so these are horizontally interpolated – p, z, 2-m T/Td/q, u/v, wind gust, ceiling, visibility.

In preparation for Step 3, two additional fields are also interpolated to the 5-km RTMA grid: roughness length, and land/water (0/1) determined from the vegetation fraction. These fields are used for the coastline sharpening in Step 3.

3.2 <u>Vertical component</u>

Determination of the 2-m temperature is the most critical part of RTMA downscaling. We consider this under two conditions:

- If z-RUC > z-RTMA (RTMA terrain lower than RUC)

In this condition, the procedure uses the local lapse rate from native RUC lowest 25 hPa, constrained between dry adiabatic and isothermal to extrapolate down to RTMA terrain.

- If z-RUC < z-RTMA

In this condition, the procedure *interpolates* from native RUC vertical levels, but maintains shallow, surface-based inversions such that 2mT-RTMA cannot exceed 2mT-RUC in this condition. This last constraint was found to be critical for the accurate estimate over irregular terrain at nighttime, especially when snow cover is present producing very sharp thermal inversions near the surface.

Diagnosis of 2-m dewpoint, wind components, and wind gust all followed a similar procedure, but with different constraints for each.

3.3 <u>Coastline sharpening</u>

A procedure has been developed (with some modifications still in testing) to sharpen expected coastline gradients consistent with the 5-km RTMA land-water fields. Currently, this is a nearest neighbor adjustment using only those nearby 5-km RUC-interpolated grid-point values having the matching land-water type indicator. This indicator is based on a roughness-length criterion. This is now being modified to use a land-water indicator derived from vegetation type. This will be discussed at the conference.

4. Conclusions

The RUC-RTMA downscaling has been successful in providing background fields for the RTMA. As is shown in the 2-m temperature example in Fig. 3 (RTMA background) compared with Fig. 2 (RUC analysis) and Fig. 4 (final RTMA analysis), most of the detail in the RTMA fields are provided by the RUC-RTMA downscaling itself. Ongoing discussions between RTMA users and NOAA/ESRL/GSD developers have been critical in this effort and development of refinements that continue as of this writing.

GSD is currently working in collaboration with NCEP toward a new 1-h cycle assimilation/model system to replace the current RUC, retaining the unique aspects developed for the RUC including assimilation of surface data and cloud observations from GOES and METARs. The RUC replacement, to be called the Rapid Refresh (Benjamin et al. 2006), will use a version of the WRF model and a version of the Gridpoint Statistical Interpolation (GSI) assimilation. Its 1-h forecasts will also provide a downscaled background field for the RTMA over a larger North American domain.

5. References

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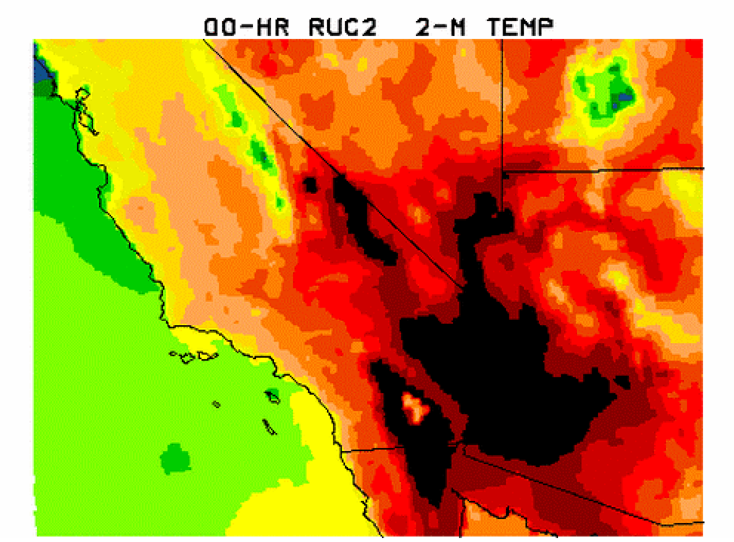
Figure 2. 2-m temperature from 13-km RUC using 13-km RUC terrain. For analysis at 2100 UTC 7 August 2006.



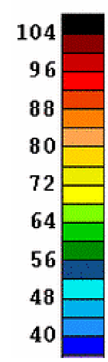


Figure 3. RUC data from 1-h forecast initialized at 2000 UTC valid at 2100 UTC downscaled from 13-km RUC grid/terrain to 5-km RTMA grid/terrain.

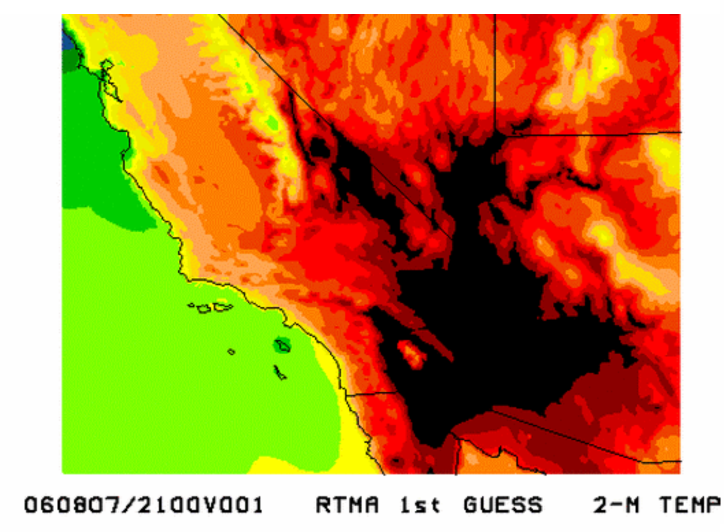


Figure 4. Final RTMA 2-m temperature analysis valid at 2100 UTC using RTMA background (Fig. 3) as its preliminary field.