P1.36 EVALUATION OF THE REAL-TIME MESOSCALE ANALYSIS OVER COMPLEX TERRAIN

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1. INTRODUCTION

The Real-Time Mesoscale Analysis (RTMA; Pondeca et al. 2007) is the first step in a multi-year project to build an "Analysis of Record" (Horel and Colman 2005). The RTMA is available on the same 5-km grid as the National Digital Forecast Database (NDFD; Glahn and Ruth 2003) for locations over the conterminous United States. Using the National Centers for Environmental Prediction (NCEP) Gridpoint Statistical Interpolation Analysis System run in 2Dvar mode, surface objective analyses of temperature, dew-point temperature, wind and pressure are created using background fields from a downscaled version of the NCEP-operational 13-km Rapid Update Cycle (RUC; Benjamin et al. 2007).

The RTMA project is motivated by a need across the National Weather Service (NWS) for a high resolution surface objective analysis to support forecast operations. Specifically, NWS Western Region (WR) has plans to use the RTMA in grid-based verification studies (Pomeroy et al. 2007).

2. TERRAIN CROSS-SECTION EXAMPLE

Operational and developmental versions of the RTMA are currently available. The developmental or parallel version has been used as a test-bed for analysis tuning experiments over the past six months. To support the development of the RTMA, NWS/WR Scientific Services Division has been evaluating surface temperature analyses along a terrain cross section in northern Utah. The cross section begins near the floor of the Salt Lake Valley at 1250 m and ends near the crest of the Wasatch Mountains at 3000 m (denoted by the red line on Fig. 1).

Figure 2 is an example of a terrain cross section valid at 1100 UTC 4 March 2007. On the cross section, the operational and parallel RTMA are compared to the NCEP-operational 13-km downscaled RUC, a 5-km Advanced Regional Prediction System Data Assimilation System (ADAS) analysis from the University of Utah (Lazarus et al. 2002; Myrick et al. 2005), and the downscaled version of the NCEP-operational 13-km RUC used as a background field for the ADAS analyses. The RTMA analyses are also compared to surface observations (denoted by boxes on Fig. 2) that are located within the black box on Fig. 1 and the 1200 UTC upper air sounding taken at Salt Lake City, UT.

The impact of analysis tuning is clearly evident (Fig. 2). The operational RTMA (blue line) makes a small adjustment to the downscaled RUC analysis (orange line). The parallel RTMA (black line) has been tuned so that it more closely reflects the surface observations, similar to the ADAS objective analysis from the University of Utah (red line).

3. POINT VERIFICATION

To quantify the improvement in analysis accuracy from tuning, results from a point verification study comparing the operational RTMA (ORTMA), parallel RTMA (PRTMA), and NCEP-operational downscaled RUC temperature analyses are presented. Using a nearest neighbor approach, the analyses are compared to surface observations located within a ~3600 km^2 area near Salt Lake City, UT (denoted by the black box on Fig. 1). Verification measures are presented for the period 1 February – 30 April 2007 and are broken down by day, hour and elevation range.

The point verification results are influenced by two time constraints. First, the RTMA is configured to accept surface observations that are valid ±12 minutes from analysis time. This constraint was introduced so that the analysis represents the conditions at the time it is valid. Second, the intent of the RTMA is to be

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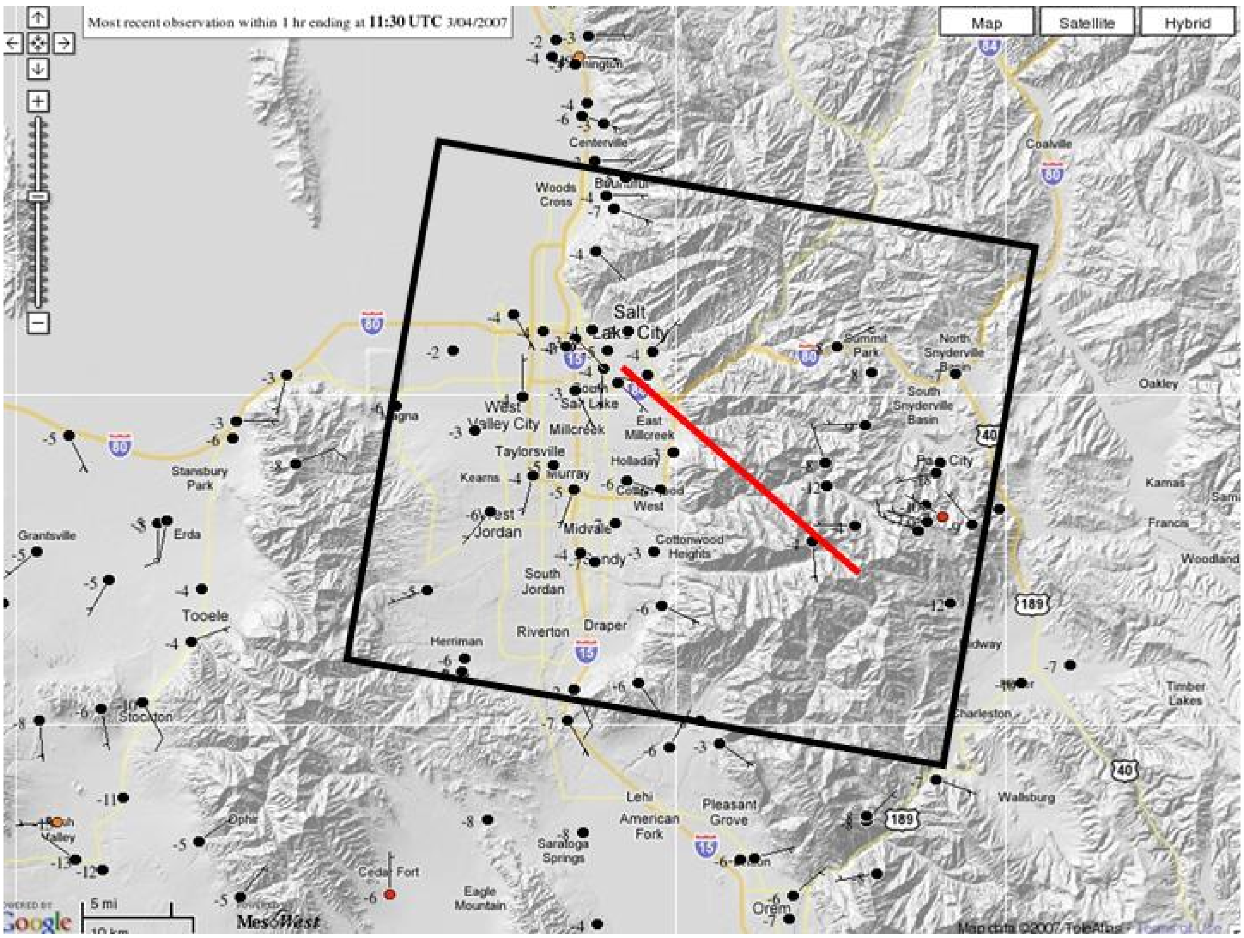

Figure 1: Mesonet temperature (^oC) observations valid at 1100 UTC 4 March 2007. The position of the terrain cross section is denoted by the red line. The point verification study area is denoted by the black box.

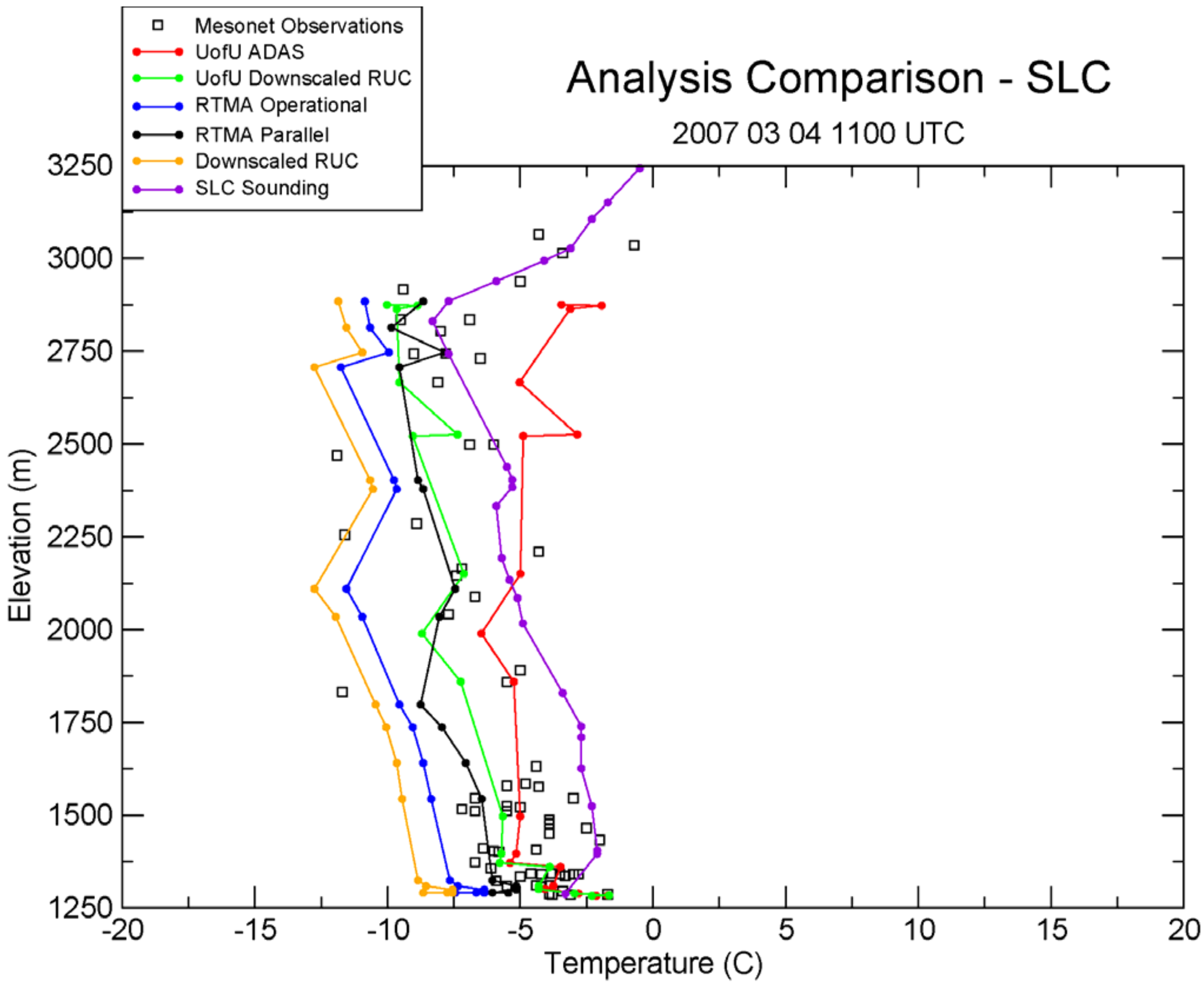

Figure 2: Terrain cross section of temperature (^oC) objective analyses (colored lines), mesonet observations (boxes), and KSLC sounding (purple line) valid at 1100 UTC 4 March 2007. The position of the cross section is denoted by a red line on Fig. 1. The mesonet observations are located inside the black box on Fig. 1.

available in “near-real-time” (e.g., before the top of the next hour). Many observations miss the cut-off time to be included in the analysis due to transmission issues. To investigate these constraints, the point verification results are calculated against the observations that were assimilated into the RTMA in the ±12 minute window (Assimilated Obs), all observations available within a ±30 minute window (All Obs), and against those observations in the ±30 minute window that were not assimilated (Missed Obs). The surface observations not assimilated into the RTMA were provided by MesoWest (Horel et al. 2002).

3.1 *Daily Point Verification*

All three analyses exhibit a gradual increase in rmse over the entire date range (Fig. 3a). On average, the PRTMA errors are smaller (2.4^{o}C) than the RUC (3.4^{o}C) and ORTMA (2.8^{o}C). The errors are based on an average of 73 observations available on an hourly basis within ±30 minutes of the analysis time. The rmse of the PRTMA (Fig. 3b) on average is 0.6°C less when compared only to the observations that were assimilated (approximately 20 observations each hour). There is a noticeable drop in the PRTMA rmse when compared to the assimilated observations after 27 March 2007. The drop coincides with a modification to the observational quality control algorithm used by the RTMA, causing the number of assimilated observations to decrease (see bar graph on Fig. 3b).

Each analysis exhibits a warm bias (Fig. 4a). The warm bias of the ORTMA and PRTMA can be attributed to the background field provided by the RUC. The average bias of the RUC was 0.9^{o}C, compared to 0.6 and 0.3^{o}C for the ORTMA and PRTMA, respectively. The PRTMA exhibited no bias when compared only to the assimilated observations (Fig. 4b).

3.2 *Hourly Point Verification*

The pattern of the hourly distribution of rmse (Fig. 5a) is similar for all 3 analyses with larger errors during the daylight hours (1500-0100 UTC) and smaller errors at night (0200-1400 UTC). The RUC (PRTMA) exhibits the largest (smallest) errors at all (most) analysis times. The rmse of the PRTMA improves roughly 1^{o}C when it is calculated against the assimilated observations (Fig. 5b).

The hourly biases also exhibit a diurnal pattern (Fig. 6). At night (0200-1400 UTC), the analysis biases are near zero. During the daylight hours (0200-1400 UTC), all three analyses contain a warm bias, with the RUC having the largest biases (Fig. 6a). When compared only to the assimilated observations, the PRTMA had a near zero bias at all analysis times (Fig. 6b).

3.3 *Elevation Range Point Verification*

When calculated by elevation range (in 500 m increments), the rmse of the RUC, ORTMA, and PRTMA is found to be larger at high elevations (Fig. 7). The number of observations in each elevation range (denoted by triangles in Fig. 7) was not consistent, with more observations located in the Salt Lake Valley and foothills (below 2000 m) than in the Wasatch Mountains (above 2000 m). Similar to the daily and hourly statistics, the RUC (PRTMA) exhibited the largest (smallest) errors for all elevation ranges (Fig. 7a). The rmse of the PRTMA improved when compared to only the assimilated observations (Fig. 7b). The larger errors at high elevations can be attributed to a number of factors including differences in elevation between the observations and analysis, and many observations being representative of only a small area.

The bias of the RUC, ORTMA, and PRTMA is large over the Wasatch Mountains while it is near zero over the Salt Lake Valley and foothills (Fig. 8a). The PRTMA performed particularly well over the Salt Lake Valley, especially when compared to the assimilated observations (Fig. 8b). It should be noted that the number of observations assimilated over the mountains (above 2000 m) was relatively small (on average 1 or 2 observations per elevation range) compared to the number of available observations (on average 7-12 observations per elevation range).

4. SUMMARY/DISCUSSION

To support the development of the RTMA, NWS/WR Scientific Services Division evaluated surface temperature analysis performance along a terrain cross section in northern Utah.

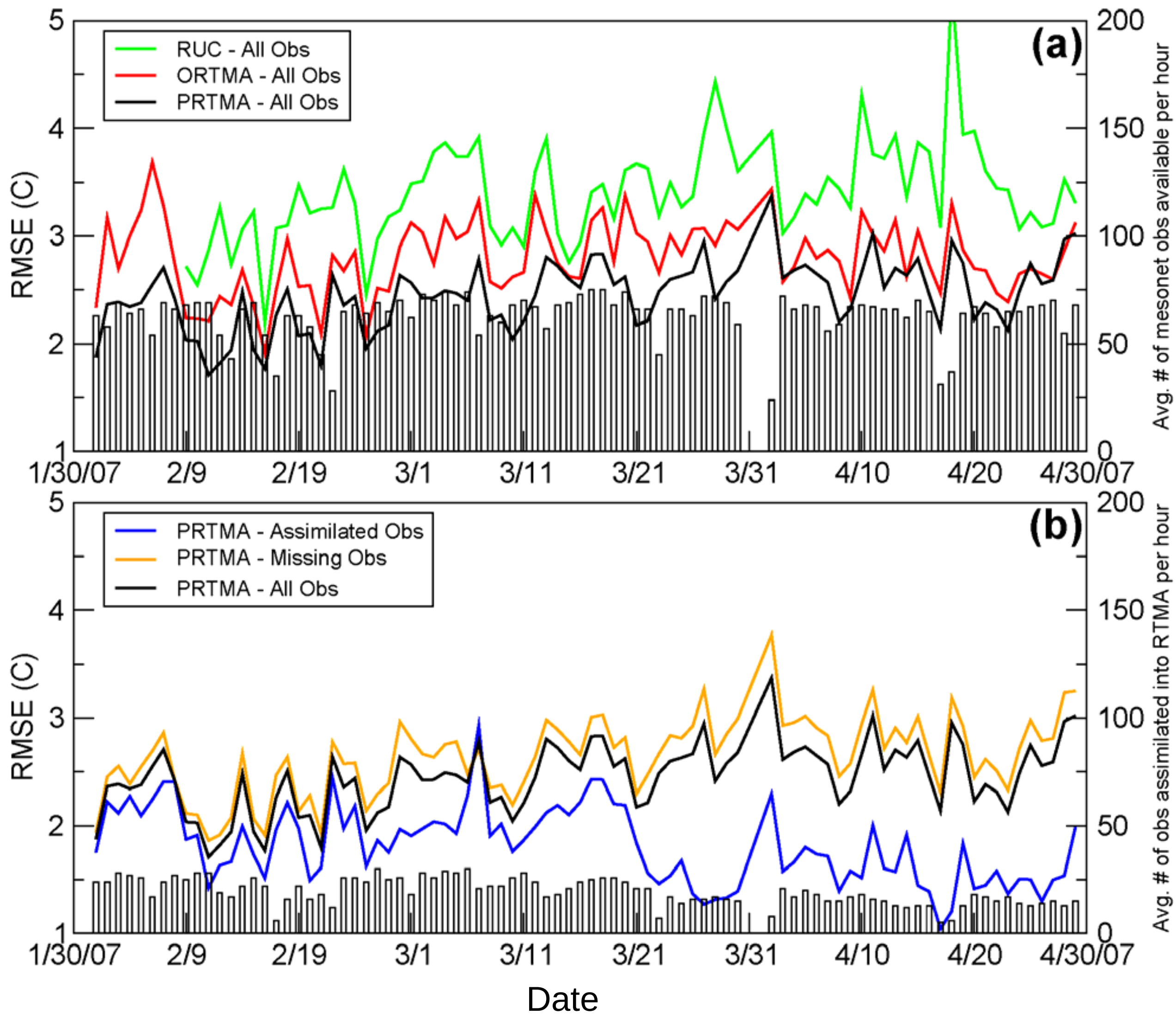

Figure 3: Daily averaged rmse (^{o}C) for (a) RUC, ORTMA, and PRTMA against all available observations, and (b) PRTMA against all assimilated, all missing, and all available observations. The bar graphs depict the average number of (a) available observations each hour and (b) observations assimilated into the RTMA each hour.

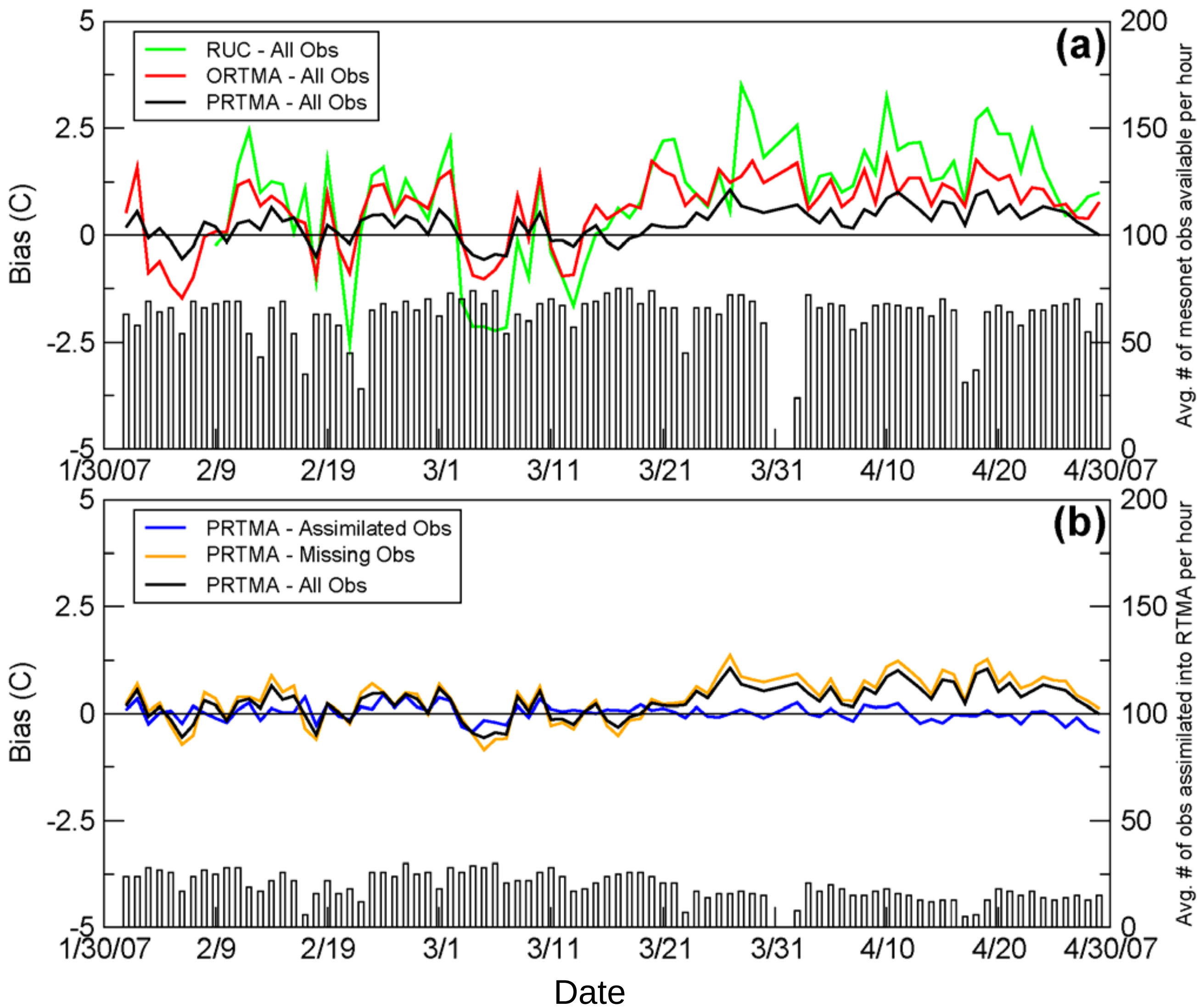

Figure 4: Daily averaged bias (^{o}C) for (a) RUC, ORTMA, and PRTMA against all available observations, and (b) PRTMA against all assimilated, all missing, and all available observations. The bar graphs depict the average number of (a) available observations each hour and (b) observations assimilated into the RTMA each hour.

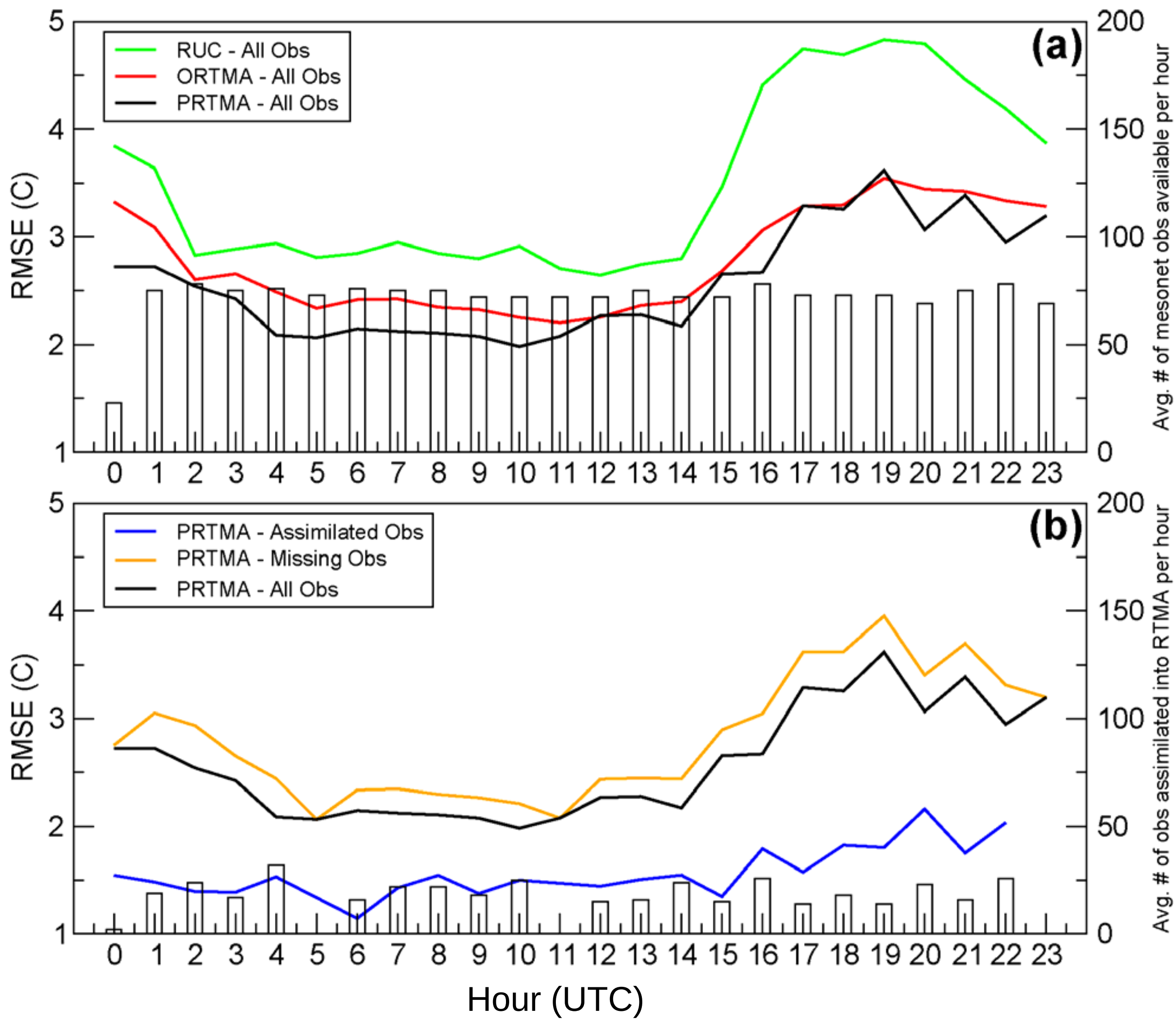

Figure 5: Hourly averaged rmse (^{o}C) for (a) RUC, ORTMA, and PRTMA against all available observations, and (b) PRTMA against all assimilated, all missing, and all available observations for the period 1 Feb – 30 Apr 2007. The bar graphs depict the average number of (a) available observations each hour and (b) observations assimilated into the RTMA each hour.

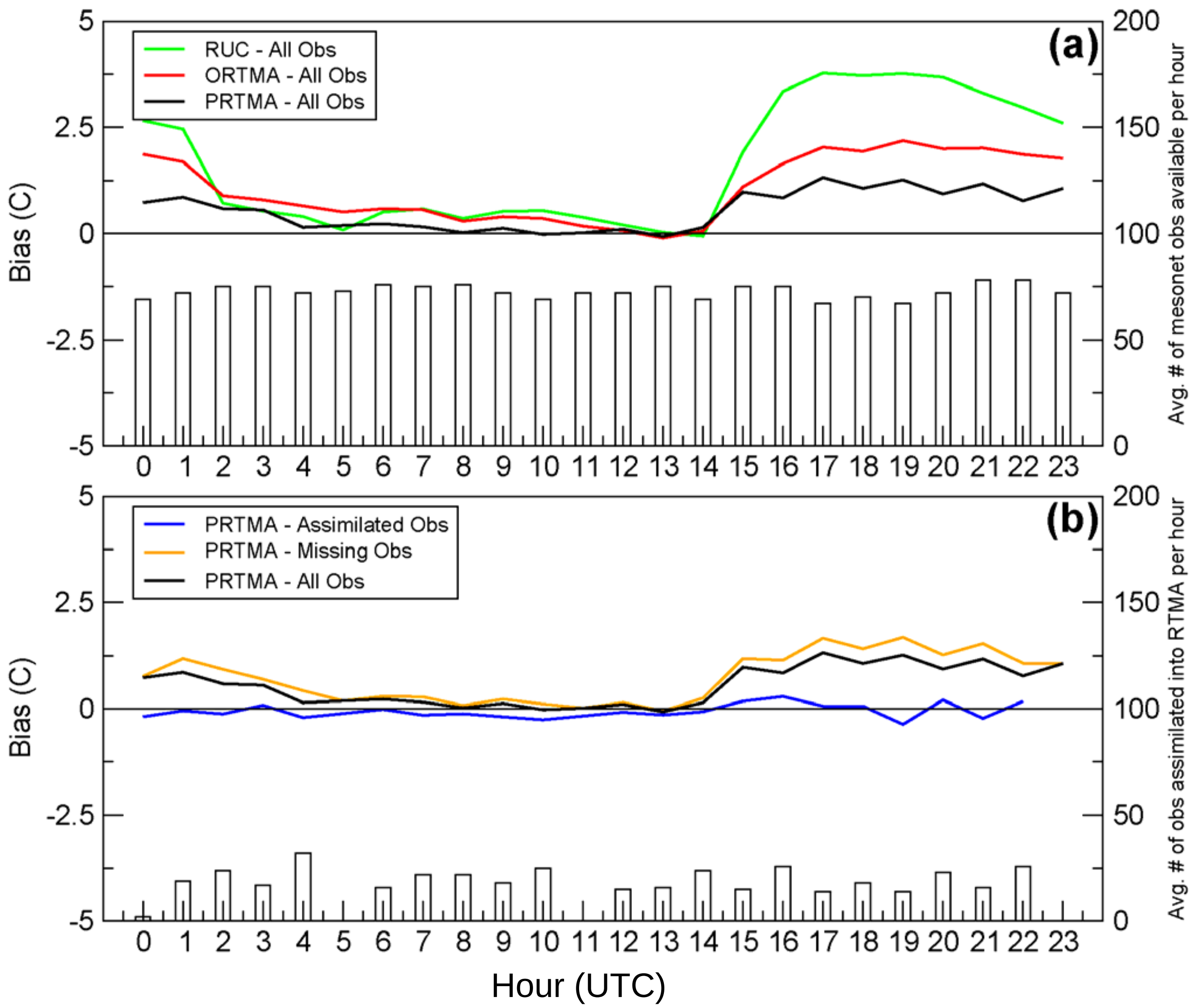

Figure 6: Hourly averaged bias (^{o}C) for (a) RUC, ORTMA, and PRTMA against all available observations, and (b) PRTMA against all assimilated, all missing, and all available observations for the period 1 Feb – 30 Apr 2007. The bar graphs depict the average number of (a) available observations each hour and (b) observations assimilated into the RTMA each hour.

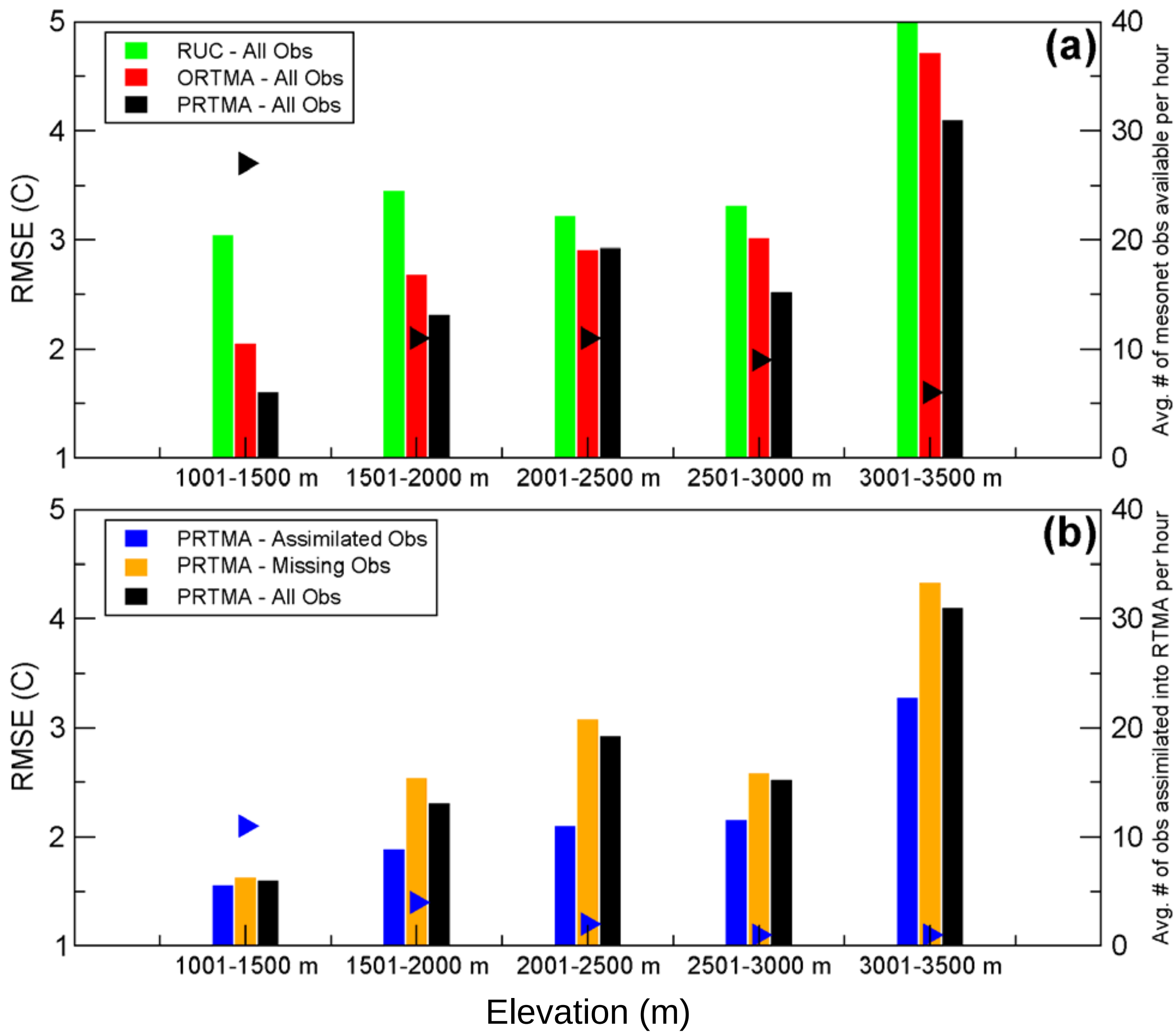

Figure 7: Average rmse (^{o}C) by elevation range for (a) RUC, ORTMA, and PRTMA against all available observations, and (b) PRTMA against all assimilated, all missing, and all available observations for the period 1 Feb – 30 Apr 2007. The right facing triangles depict the average number of (a) available observations each hour and (b) observations assimilated into the RTMA each hour.

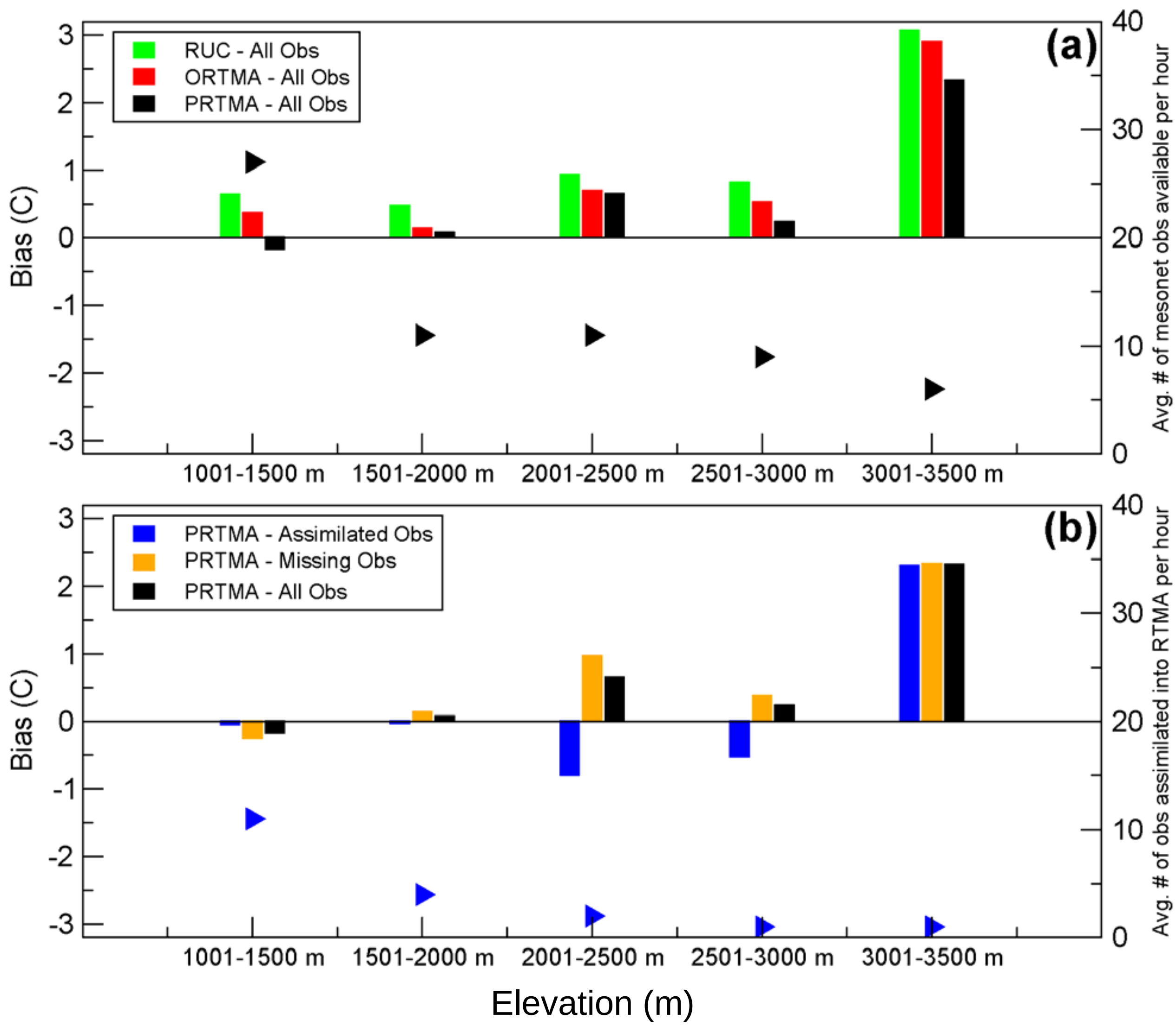

Figure 8: Average bias (^{o}C) by elevation range for (a) RUC, ORTMA, and PRTMA against all available observations, and (b) PRTMA against all assimilated, all missing, and all available observations for the period 1 Feb – 30 Apr 2007. The right facing triangles depict the average number of (a) available observations each hour and (b) observations assimilated into the RTMA each hour.

Inspection of temperature analyses from numerous case studies during the 2006/07 winter season has shown that tuning of the developmental or parallel version of the RTMA has resulted in an improved performance over the operational RTMA that was frozen in Fall 2006 (an upgrade to the operational RTMA is planned for late June 2007). Daily, hourly and elevation based point verification statistics also demonstrate the improved accuracy of the PRTMA over the ORTMA and RUC.

Time constraints cause many observations to be withheld from the RTMA. For the analysis to be available in near-real time, the process of collecting observations begins 30 minutes after the top of the hour. Conversely, many mesonet observations are not received until after this time due to transmission issues. The resulting analysis suffers, especially over areas of complex terrain where the majority of observations are from mesonets. The future "Analysis of Record" will account for this issue by pushing back the assimilation time.

This study examined the performance of RTMA surface temperature analyses over a relatively small, data dense area. Future evaluations should be staged for other analysis variables and over a larger domain containing both data dense and sparse configurations of observations. Future plans at NCEP include assessing the uncertainty of the RTMA analyses via cross-validation withholding experiments (M. Pondeca, personal communication).

5. REFERENCES

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