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HIGH-RESOLUTION RUC FORECASTS FOR PACJET: REAL-TIME NWS GUIDANCE AND RETROSPECTIVE DATA IMPACT TESTS

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1. INTRODUCTION

During the past two winter seasons, the Forecasts Systems Laboratory (FSL) has produced real-time high-resolution weather predictions for the western United States using an advanced version of the Rapid Update Cycle (RUC) model (Benjamin et al. 2001, 2002). Model output from these predictions has been provided to National Weather Service (NWS) forecasters for display within AWIPS. These real-time model predictions have been complemented by retrospective data impact tests designed to quantify the forecast improvement from the addition of experimental rapid-scan satellite-derived winds (Velden and Stettner 2001).

This experimental modeling effort has been coordinated with two related experiments, the Pacific Landfalling Jets Experiment (PACJET) and the GOES Rapid-Scan Winds Experiment (GWINDEX). PACJET (Ralph et al. 2002) is a multiyear project aimed at improving short-term (0-24 h) forecasts of damaging weather along the U.S. West Coast. Accurate prediction of West Coast storms, which emerge from a data-sparse region over the Pacific Ocean, is a difficult but important challenge for operational modelers and forecasters. GWINDEX (Velden and Stettner 2001) is another multiyear project, in which special rapid-scan images from the GOES-10 satellite are used to derive high-resolution wind observations over the eastern Pacific Ocean and western U.S. These wind observations have the potential to improve forecasts of landfalling Pacific storms.

Our goals for the Pacific RUC (PACRUC) forecast exercise have been to 1) provide NWS forecasters with real-time guidance products from an advanced version of the RUC model, 2) obtain forecaster feedback on model strengths and weaknesses, and 3) evaluate the impact on forecast skill from ingest of the experimental GWINDEX winds. In this paper, we summarize the PACRUC modeling efforts during 2001 and 2002 and present some initial results from the GWINDEX data impact tests.

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2. 2001 REAL-TIME PACRUC FORECASTS

For the 2001 experiment, a prototype version of the RUC20 model (recently implemented operationally at NCEP and described in detail by Benjamin et al. 2002) was used for both the 20-km coarse grid and the one-way nested 10-km fine grid (see Fig. 1). This new RUC formulation features an

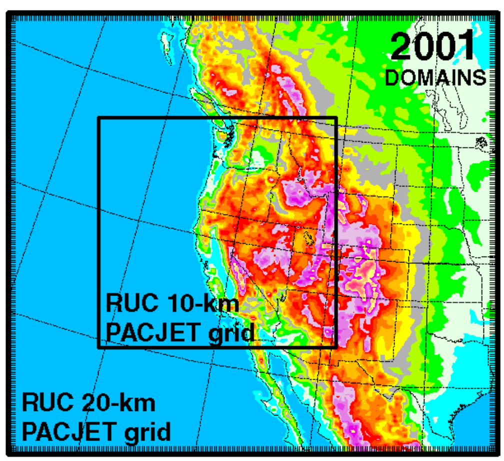

Fig. 1. The 2001 PACJET RUC 20-km domain (topography contour bands every 200 m) and nested 10-km domain. Both domains have 217 x 197 horizontal grid points.

updated version of the Reisner explicit microphysics scheme (Brown et al. 2000), an enhanced land-surface model package (Smirnova et al. 2000), the new ensemble form of the Grell cumulus parameterization (Grell and Devenyi 2001), and improved cycling of hydrometeor fields using GOES cloud-top data (Kim and Benjamin 2001). In addition to these improvements, the number of vertical levels has been increased from 40 to 50.

An hourly, intermittent update cycle was used to assimilate observations on the 20-km coarse grid. Observations included rawinsondes, profilers (404 and 915 MHz), RASS, VAD, ACARS, GPS precipitable water, and surface observations. In addition to these conventional observations, hourly sets of several thousand GWINDEX wind observations were ingested into the 20-km assimilation cycle. GWINDEX winds are obtained by tracking cloud or water vapor brightness features among subsequent satellite images (Velden and Stettner 2001). The enhanced temporal resolution provided by the GWINDEX rapid-scan strategy improves both the quantity and quality of the retrieved vectors. Special automated post-processing steps are used to ensure optimal observation height assignments and provide objective data quality information.

For the 20-km coarse grid, 36-h forecasts were produced every 6 h and 12-h forecasts were made every 3 h. One-way nested 10-km forecasts were run out to 24 h every 6 h. Model output from the 20-km domain was made available to NWS and PACJET forecasters through web-based display. Additionally, Vis5d loops of the 10-km forecasts were transferred to the PACJET operations center.

Besides providing NWS and PACJET forecasters with guidance products from an advanced version of the RUC model, the 2001 real-time forecast exercise provided an ideal test environment for refining enhancements to the RUC20 prior to operational implementation at NCEP. Near the end of the 2001 real-time forecast period, two project milestones were achieved. First, an automated procedure for displaying 20-km PACRUC forecast products within AWIPS at NWS Western Region forecast offices was implemented. Second, a real-time comparison of two parallel 20-km forecast cycles (one with and one without GWINDEX observations) was completed. Results from this comparison as well as results from a retrospective data impact test are presented in section 4.

3. 2002 REAL-TIME PACRUC FORECASTS

Building upon the experience gained in 2001, a more ambitious PACRUC forecast exercise was undertaken in 2002. Twenty-four hour forecasts on a 10-km domain covering the entire Western Region were made available to NWS forecasters (in AWIPS format) every 6 h. The 10-km grid was nested within an hourly cycled CONUS 20-km RUC (see Fig. 2). Conventional observations were supplemented by 3-hourly GWINDEX wind observations.

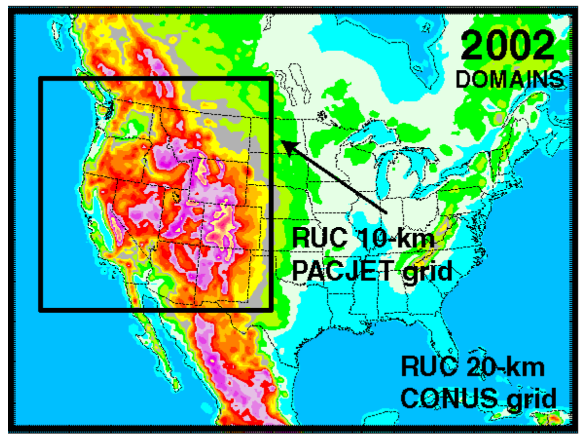

Fig. 2. The CONUS RUC 20-km domain (301 x 225 grid points, topography contour bands every 200 m) and 2002 PACJET RUC nested 10-km domain (249 x 241 horizontal grid points).

The decision to focus on AWIPS display of the 10-km fields was based on discussions with NWS Science and Operations Officers, which indicated that 1) the AWIPS display would significantly increase forecaster use of the model guidance and 2) the experimental 10-km forecast fields (as opposed to the 20-km fields provided in 2001) would be the most useful to Western Region forecasters. A total of 13 local offices (Billings, Eureka, Flagstaff, Great Falls, Los Angeles, Monterey, Portland, Reno, Sacramento, San Diego, Seattle, Spokane, and Tucson) received 10-km PACRUC AWIPS files from mid-January 2002 through the end of March.

A further enhancement for 2002 was the creation of a web-based feedback form for NWS forecasters. A number of useful comments were received on this form and 11 references to the PACRUC model forecasts were found in Western Region area forecast discussions.

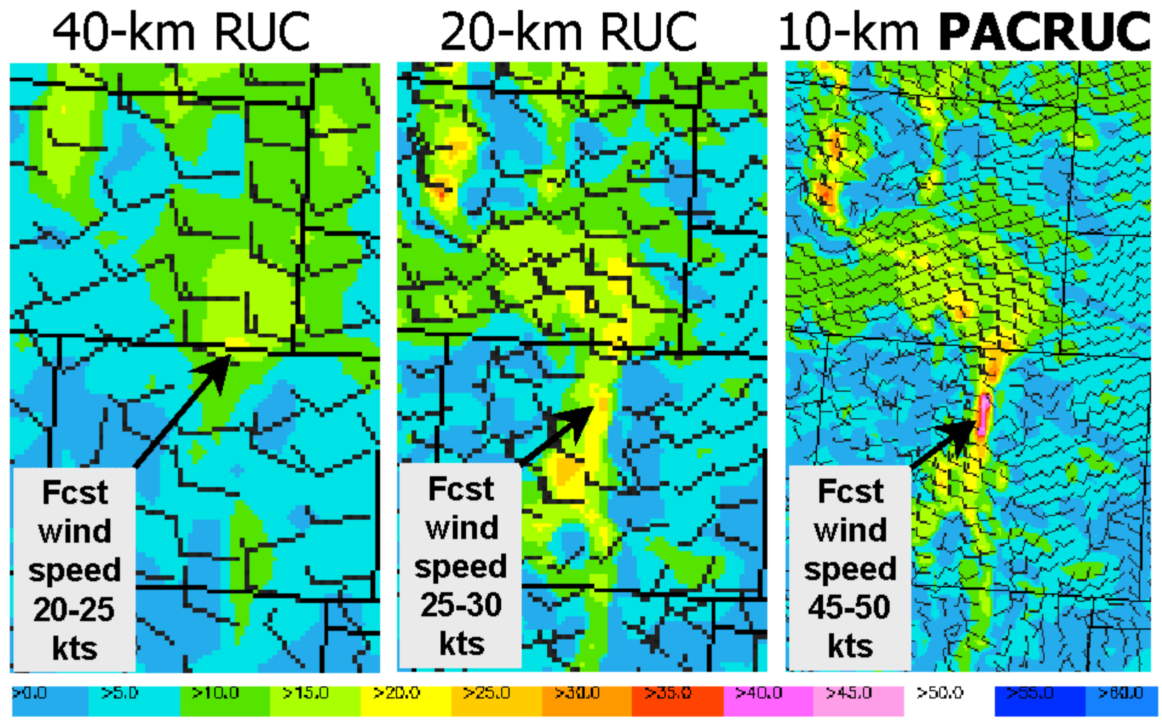

Fig. 3. Comparison of (a) operational 40-km RUC, (b) 20-km RUC, and (c) 10-km PACRUC 9-h predicted surface winds (kts) for the Wyoming and Colorado region, valid 1500 UTC 28 March 2002.

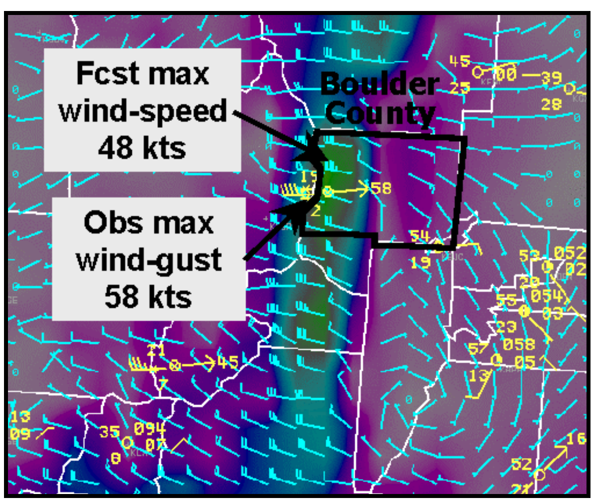

Fig. 4. AWIPS display of 10-km PACRUC 9-h predicted winds (kts) and wind speeds (shading) along the Colorado Front Range, valid 1500 UTC 28 March 2002. Surface observations are overlaid.

As anticipated, PACRUC 10-km forecasts provided an improved depiction of terrain-related precipitation features (compared to larger-scale model forecasts), as evidenced by a feedback-form comment from the Monterey, CA office: "12z March 15 t0 + 6h precip totals remarkably good."

Enhanced terrain-related detail was also seen in the 10-km surface wind forecasts. Figure 3 illustrates the impact of increased horizontal grid resolution (and associated improvements in model terrain) on RUC forecasts of a topographically forced high wind event along the Colorado Front Range. Examination of Fig. 4 indicates that the 10-km PACRUC forecast reproduced much of the observed county-scale variation in the surface wind speed and direction. In particular, note the agreement between the north-south oriented band of strong westerlies predicted along the crest of the continental divide and the observed 58-kt wind gust on Niwot Ridge in western Boulder County.

4. GWINDEX SENSITIVITY RESULTS

Two sets of GWINDEX data impact tests have been completed, a real-time test from 26-29 March 2001 and a retrospective test covering a more active period from 6-8 February 2001. In both tests, 12-h predictions were made for a control forecast cycle in which all conventional observations were assimilated (CNTL) and for an experimental forecast cycle that added the GWINDEX wind observations (GWIN). Forecasts were verified against 35 rawinsondes located within the PACJET domain. For both the real-time and retrospective tests, the forecast impact was generally positive for upper-level winds and neutral for other fields. For the real-time test, the improvement from the GWINDEX observations was greatest for the 3-h forecast, while for the retrospective test, the improvement was greatest for the 12-h forecasts (see Fig. 5). Examination of the GWINDEX observational data from the two test periods (not shown) suggests that the proximity of the GWINDEX wind observations to the verification rawinsonde network may explain the difference in the forecast lead-time for the maximum improvement. During the real-time test, a large number of GWINDEX observations were located over the western U.S. in close proximity to the verification rawinsondes. In contrast, during the retrospective test period, most of the GWINDEX observations were over the Pacific Ocean, upstream from the rawinsonde verification network.

5. FUTURE WORK

The RUC 10-km nested domain has been moved from the U.S. West Coast to the Southern Plains to provide high-resolution guidance for the International H_2O Project (IHOP). During the summer of 2002, the 10-km RUC domain will be shifted to New England for a pilot Temperature and Air Quality project. An important component of these projects is a comparison of 10-km RUC forecasts with 10-km WRF forecasts, both nested within the CONUS 20-km RUC.

Additional work is also planned to complete the GWINDEX data sensitivity test. Initial results have shown some forecast improvement from inclusion of these experimental observations. Results from a longer retrospective experiment will be compiled and the dependence on observation frequency will be examined.

Finally, we plan to again provide real-time model products to NWS forecasters and obtain feedback from them during the 2003 winter season. The next-generation RUC model, currently targeted for possible implementation in 2004 at a resolution of 10-12 km, should benefit greatly from these experimental forecast exercises.

6. ACKNOWLEDGMENTS

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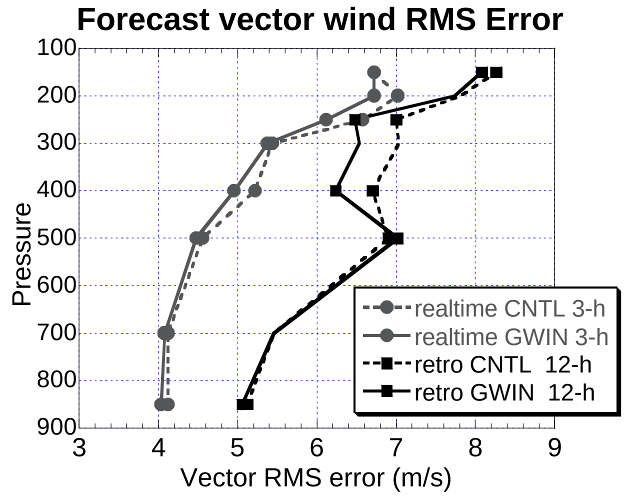

Fig. 5 RMS vector wind errors as a function of pressure for the real-time (26-29 March 2001) 3-h forecasts (left) and for the retrospective (6-8 February 2001) 12-h forecasts (right).

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