P4.5 ASSIMILATION OF RAPID-SCAN CLOUD MOTION VECTORS INTO THE RUC MODEL IN SUPPORT OF THE PACJET EXPERIMENT

Stephen S. Weygandt[1*], Stanley G. Benjamin[1], and Christopher S. Velden[2]

[1]NOAA Research-Forecast Systems Laboratory, Boulder, CO
[2]Cooperative Institute for Mesoscale Satellite Studies, University of Wisconsin, Madison, WI

1. INTRODUCTION

One of the principal challenges confronting the U.S. operational modeling and forecasting communities is the prediction of land-falling Pacific storms along the West Coast. Accurate prediction of these storms, which can incur significant economic and societal cost, is hindered by their emergence from the data sparse Pacific Ocean. Thus, a significant research effort has recently focused on these storms, with the objective of improving short-range prediction of them. As part of this effort, two related experiments were conducting during the period of January-March 2001. The first of these was the Pacific Landfalling Jets Experiment (PACJET), an intensive observational field project built upon the foundation provided by the previous CALJET experiment (Ralph et al. 2000). The second of these was the GOES rapid-scan winds Experiment (GWINDEX), a three-month trial period during which 7.5 min rapid-scan images from the GOES-10 were used to derive high-resolution cloud motion vectors over the eastern Pacific Ocean and along the western U.S. Coast (Velden 1996).

In conjunction with these two experiments, a special 20-km version of the Rapid Update Cycle (RUC) model was run quasi-operationally during the months of January-March 2001. This facilitated the assimilation of the specially collected cloud drift vectors and provided real-time guidance to the PACJET scientists. In addition, the collection of these special data has provided a unique opportunity to assess the potential impact of the GWINDEX winds on high-resolution numerical predictions of landfalling Pacific storms.

* *Corresponding author address:* Stephen S. Weygandt, NOAA/FSL, R/FS1, 325 Broadway, Boulder, CO 80305
e-mail: weygandt@fsl.noaa.gov

In this paper, we summarize the model configuration and data assimilation system used for the numerical predictions, provide an overview of the GWINDEX data, and present a sampling of prediction results. More detailed prediction comparisons with and without the GWINDEX data will be presented at the conference.

2. RUC MODEL/ASSIMLATION SYSTEM

The latest version of the RUC model features an updated formulation of the Reisner explicit microphysics scheme (Brown et al. 2001), a detailed land-surface-model (Smirnova et al. 2000), and an ensemble form of the Grell cumulus parameterization (Grell and Devenyi 2001). In addition to the improvements in model physics, model resolution is increased to 20 km in the horizontal and 50 levels in the vertical. Further information on the 20km version of the RUC is presented by Benjamin et al. (2001). The PACJET experiment was used as a testbed for this new enhanced version of the model, which is now being implemented at NCEP as the new operational RUC.

Improvements to the model used for the PACJET experiment were complemented by an update from the previous Optimum Interpolation (OI) analysis procedure to a three-dimensional variational (3DVAR) analysis system. The 3DVAR scheme (detailed by Devenyi et al. 2001) includes a multivariate analysis of the height and wind fields, and univariate analyses of virtual potential temperature and moisture. Advantages over the OI procedure include the avoidance of data selection, smoother analysis increments and better balance between the mass and wind fields. The 3DVAR formulation also provides a better framework for inclusion of non-conventional data sources such as precipitable water and radial velocities.

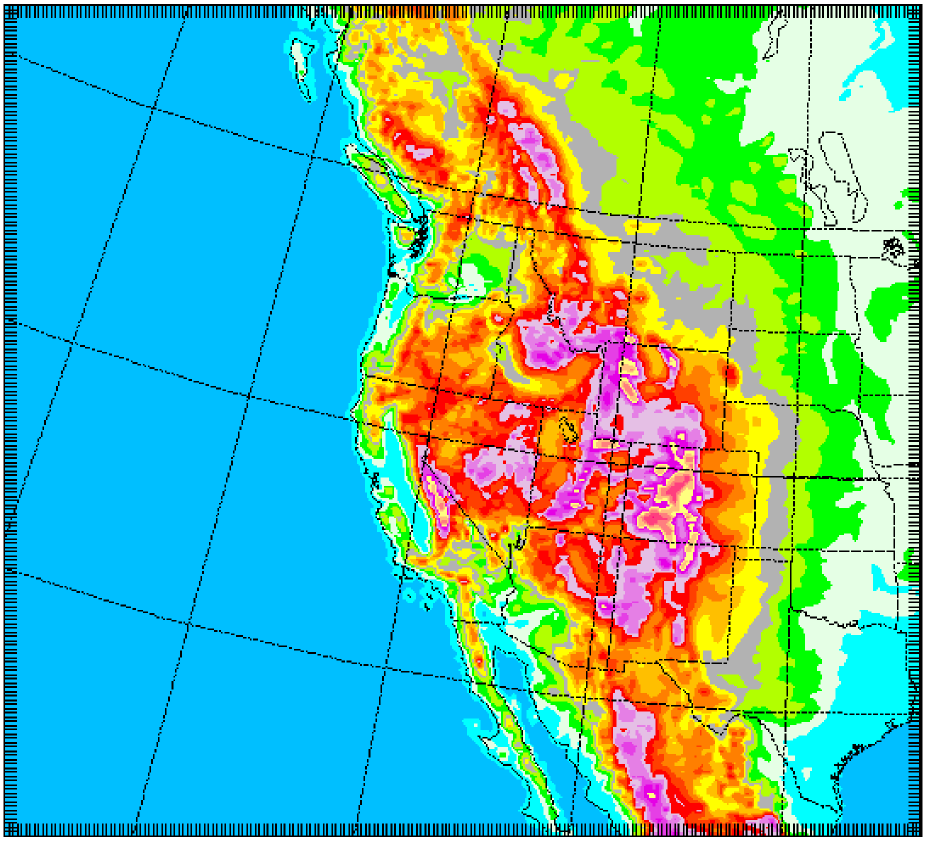

Fig. 1. 20-km (217 x 197 gridpoints) PACJET RUC domain and topography (contour bands every 200 m).

Figure. 1 shows the 20-km domain used for the PACJET experiments. The domain was extended as far west over the Pacific Ocean as possible within the AWIPS 212 grid, consistent with the specification of lateral boundary conditions from the Eta model. This maximized the time period during which information about Pacific storms (principally GWINDEX cloud-motion vectors) could be assimilated into the prediction before storm landfall.

Utilizing an hourly intermittent update cycle, 36-h predictions were made every 6 h and 12-h forecasts were made every 3 h. In addition, a one-way nested 10-km version of the RUC model (centered along the central California coast) was run out to 24 h during the early part of the PACJET experiment. Model output was made available to the PACJET forecasters through web-based display. Additionally, Vis5d movie loops were transferred to the PACJET operations center in Monterey, CA, and model fields were made available to NWS Western Region Forecast Offices for display on their local AWIPS systems.

3. GWINDEX RAPID-SCAN DATA

The GWINDEX cloud-motion vectors are obtained by tracking cloud brightness features between subsequent satellite images (Velden 1996). The enhanced temporal resolution provided by GWINDEX rapid-scan strategy improves both the quantity and the quality of the retrieved vectors. Special automated post-processing steps are used to ensure optimal observation height assignments and provide objective data quality information. GWINDEX data files, composed of latitude, longitude, pressure level, Cartesian wind components, and data quality information at several thousand "observation" locations, were provided to FSL by the Cooperative Institute for Mesoscale Satellite Studies (CIMSS), at hourly intervals with an approximate one hour latency.

Figure. 2 provides an illustration of the sample data coverage at mid-levels (400-700 mb) for an active storm day (2100 UTC 21 Feb 2001). At this particular time, there were 5097 GWINDEX observations extending from 925 mb

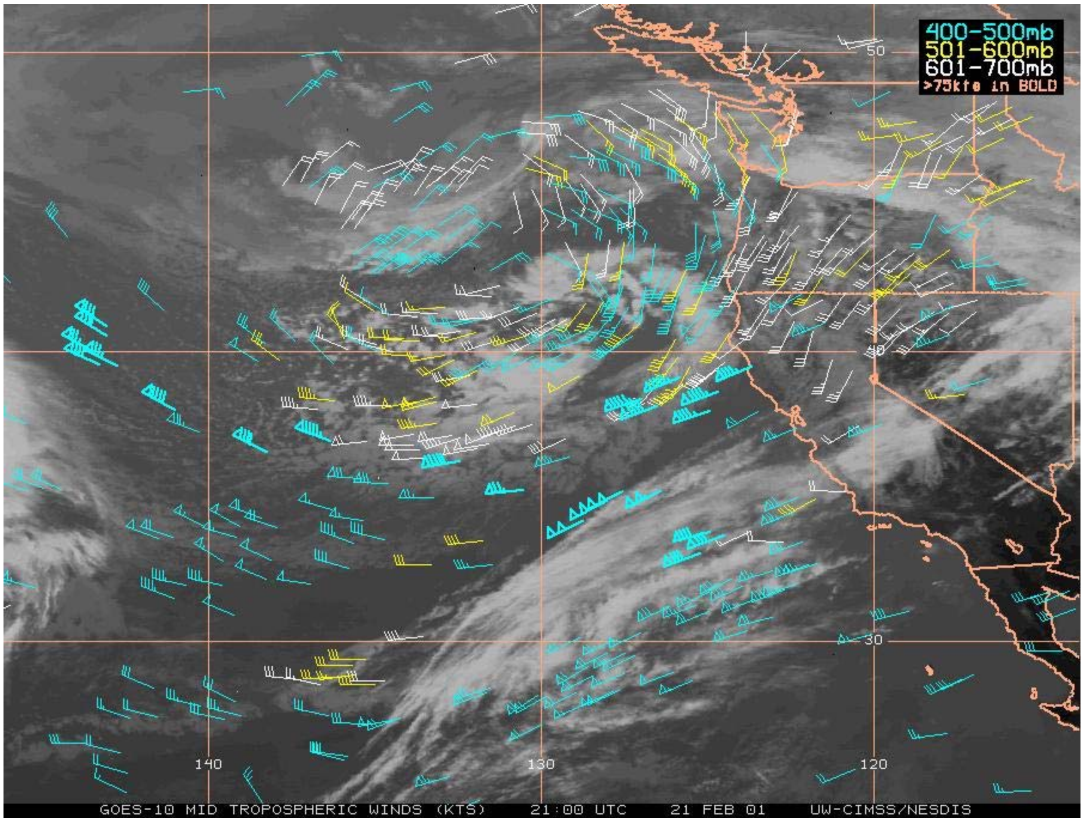

Fig. 2. Sample GWINDEX image from 2100 UTC 21 February 2001, showing mid-level cloud-motion vectors overlaid upon satellite imagery.

to 122 mb. Figure 3a is a histogram illustrating the distribution of these observations by 50-mb thick pressure layers, showing that they were primarily at low levels at this time. Figure 3b shows the average (over all GWINDEX observation points in each pressure layer bin) vector magnitude of the background wind field (provided by the previous 1-h RUC forecast) interpolated to the GWINDEX observation locations. Also shown is the corresponding average vector magnitude of the GWINDEX innovations. Comparison of the two values for each layer provides a measure of

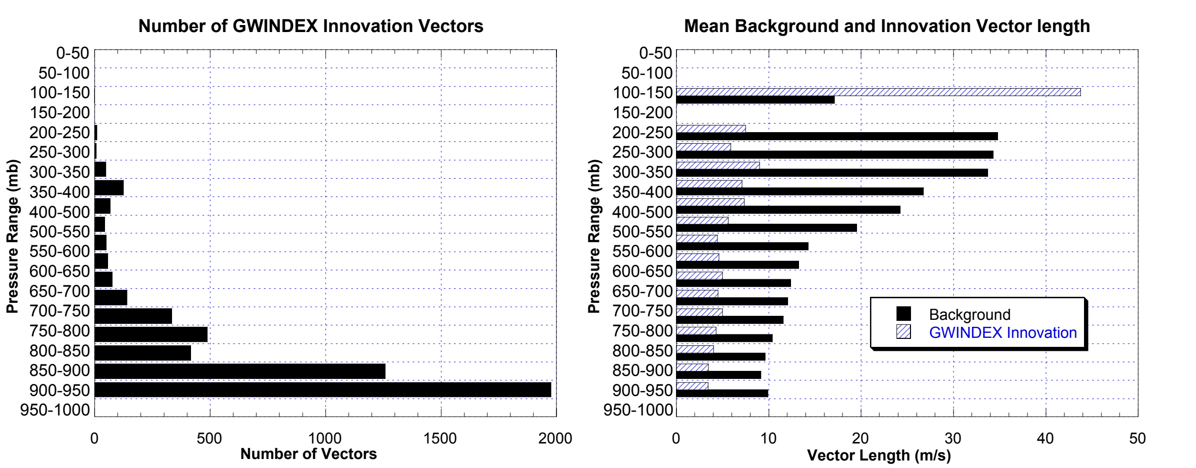

Fig. 3. a) Histogram showing the number of GWINDEX cloud-motion vectors in each 50-mb pressure bin from 0-1000 mb for 2100 UTC 21 Feb 2001. b) Mean background vector length (from previous 1-h RUC forecast) and mean GWINDEX innovation (difference from background) vector length for the same 50-mb pressure bins.

the relative deviation of the GWINDEX wind observations from the background field. The mean innovation magnitude is 20-30% larger than typical RMS vector differences over land between RUC 1-h forecasts and rawinsonde observations, presumably because the GWINDEX observations are primarily over ocean where forecast skill is lower. The background values show the mean wind speed where GWINDEX observations were available. The extremely large mean GWINDEX innovation in the 100-150 mb layer is due to a single GWINDEX observation (not discernible in Fig. 3a).

4. GWINDEX SENSITIVTY RESULTS

While 20-km RUC PACJET predictions using the GWINDEX observations were made on a quasi-operational basis throughout the experiment period, computer limitations reduced the real-time GWINDEX comparison period (requiring a parallel cycle without GWINDEX observations) to the final week of March 2001. During this time, parallel predictions were made utilizing all available observations except the GWINDEX winds and all available observations including the GWINDEX winds. The other observations included rawinsondes, profilers (404 and 915 MHz), RASS, VAD, ACARS, and surface observations. These data were assimilated hourly using the RUC 3DVAR analysis procedure.

Unfortunately, the last half of the real-time comparison period was compromised by computer down periods during crucial rawinsonde assimilation times. Thus, we are only able to show statistical results from a three-day period, 1200 UTC 25 March 2001–1200 UTC 28 March 2001. 3-, 6-, 9-, and 12-h forecasts from the GWINDEX and NO GWINDEX experiments, valid at the synoptic times, were verified against 35 rawinsondes located within the PACJET domain. The results indicate that the addition of the GWINDEX winds produces a slight improvement in the 3-h wind forecast (see Fig. 4), especially at mid- and upper-levels. Figure 4. also shows that by 12-h the impact of the GWINDEX winds was negligible. Verification of other fields (temperature, height, relative humidity, not shown), indicated either a neutral or slightly negative impact from the GWINDEX winds.

5. RETROSPECTIVE CASE STUDIES

We plan to supplement our very limited real-time prediction comparison test with a set of retrospective comparison experiments. This comparison test will consist of rerunning the full hourly assimilation cycle for both the GWINDEX and NO GWINDEX experiments for a multi-day test period. Two potential test periods of active weather along the Pacific Coast have been identified: 10-14 February 2001 and 20-24 February 2001. We will show more extensive results and detailed analyses from these retrospective experiments at the conference.

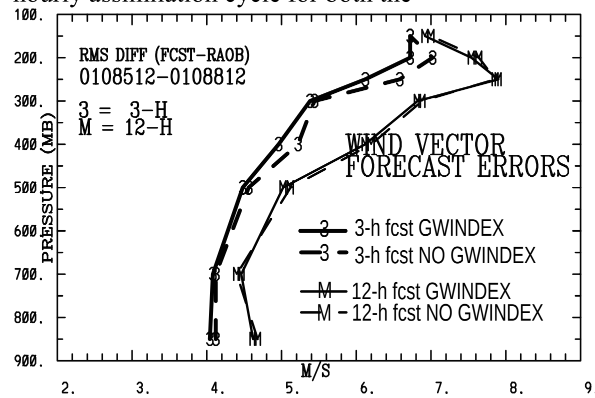

Fig. 4 RMS vector wind error for 3-day test period 26-29 March 2001.

5. ACKNOWLEDGMENTS

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