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VERIFICATION OF NDFD GRIDDED FORECASTS IN THE WESTERN UNITED STATES

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1. INTRODUCTION

The National Weather Service (NWS) is undergoing a major shift in the way it creates and distributes its forecasts. Rather than having forecasters type text forecast products, they now use graphical editors to create (currently experimental) high-resolution gridded forecasts of weather elements that are viewed graphically, interrogated by customers and partners, and linked to formatting software to produce traditional NWS text products. Although this Interactive Forecast Preparation System (IFPS; Ruth 2002) continues to evolve and improve in its mostly experimental state, little has been done to verify these forecasts against a robust gridded analysis derived at resolutions nearly equivalent to that of the grids available to the end users.

Developing an effective gridded verification scheme is critical to identifying the capabilities and deficiencies of this new forecast process, especially in areas of complex terrain. This paper presents a preliminary attempt to verify a sample of NWS gridded forecasts of temperature and wind over the western United States against analyses created at the Cooperative Institute for Regional Prediction (CIRP) at the University of Utah, using the Advanced Regional Prediction System Data Assimilation System (ADAS).

2. IFPS GRIDDED FORECASTS

Forecast grids of various fields at resolutions of 1.25, 2.5, or 5 km are produced at each NWS Warning and Forecast Office (WFO) and cover their respective County Warning Area (CWA). These grids – which are created through collaborative efforts primarily between WFOs – are combined to form one National Digital Forecast Database (NDFD; Glahn and Ruth 2003) at 5-km resolution. Primary NDFD elements currently produced include maximum and minimum temperature, probability of precipitation, and weather. Other elements include but are not limited to temperature, dewpoint, and sky cover. Elements are available at up to hourly temporal intervals (with the exception of maximum and minimum temperature) with lead times up to 7 days.

Only gridded temperature and wind forecasts are used for this initial gridded verification effort. The forecasts available from NDFD for a particular grid box are intended to be representative of the conditions throughout that area (a 5 x 5 km^2 region). Forecast skill can be assessed by either interpolating the forecasts to locations where observations are available or comparing directly the gridded forecasts to a gridded analysis of the current state based upon the available observations. While each approach has strengths and weaknesses, we will use the latter.

3. VERIFYING ANALYSES

Surface data from weather observing stations across the United States have been linked together into a common database as part of MesoWest (Horel et al. 2002). The Automated Surface Observing System network maintained by the NWS, Federal Aviation Administration, and the Department of Defense is supplemented by

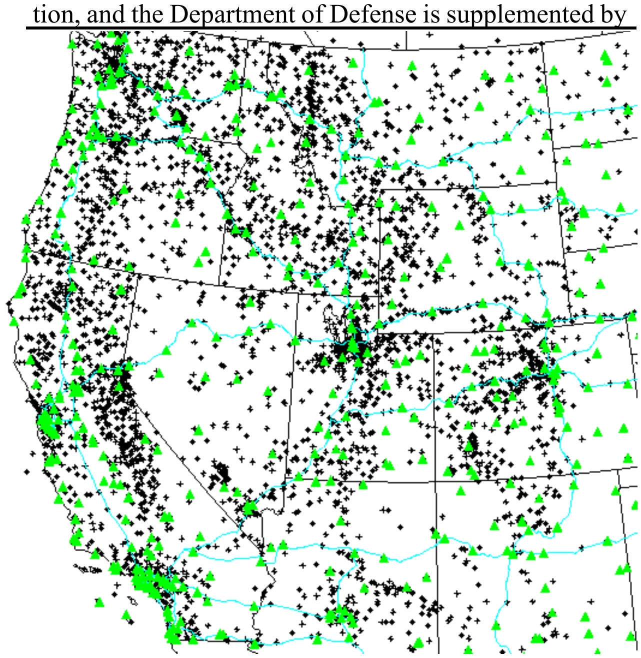

Figure 1. Stations available in MesoWest in the western United States. NWS/FAA stations- triangles; other stations- plus symbols.

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networks supported by over 120 government agencies and commercial firms. Our validation of the IFPS forecast grids relies upon 5 km ADAS analyses on the NDFD grid over the western United States. ADAS employs the Bratseth method of successive corrections, an inexpensive analysis procedure that can be run in near-real time over a large horizontal domain at high horizontal resolution (Lazarus et al. 2002). The background field used by ADAS is the 20 km version of the Rapid Update Cycle (RUC; Benjamin et al. 2002), which is downscaled to the 5km NDFD grid. The ADAS analysis procedure typically incorporates over 2,000 surface weather observations each hour from Mesowest to correct the RUC background field (see Fig. 1).

4. PRELIMINARY RESULTS

NDFD experimental forecast grids of temperature and wind at lead times from 12-60 h during the latter half (1-15 July 2003) of the NWS IFPS Operational Readiness Demonstration period are being compared to ADAS grids valid at 0000 UTC. In addition, NDFD forecast grids during October and November 2003 are being collected for validation.

A case study of a vigorous cold front crossing the Intermountain West at 1200 UTC 10 October 2003 is used to demonstrate our methodology. The RUC sea level pressure analysis in Fig. 2 indicates that the trough

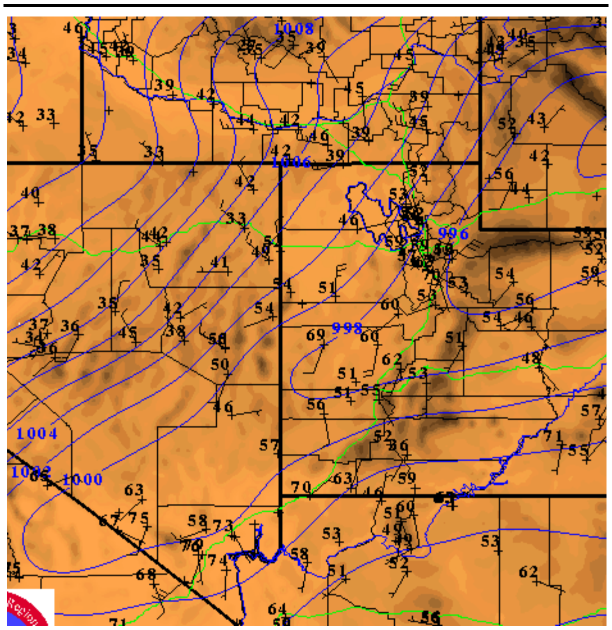

Figure 2. MesoWest graphic of surface wind (kts) and temperature (^{o}F) superimposed on the RUC sea level pressure analysis (mb) valid at 1200 UTC 10 October 2003. Not all available observations are plotted. A full barb denotes 10 kts; a half barb denotes 5 kts.

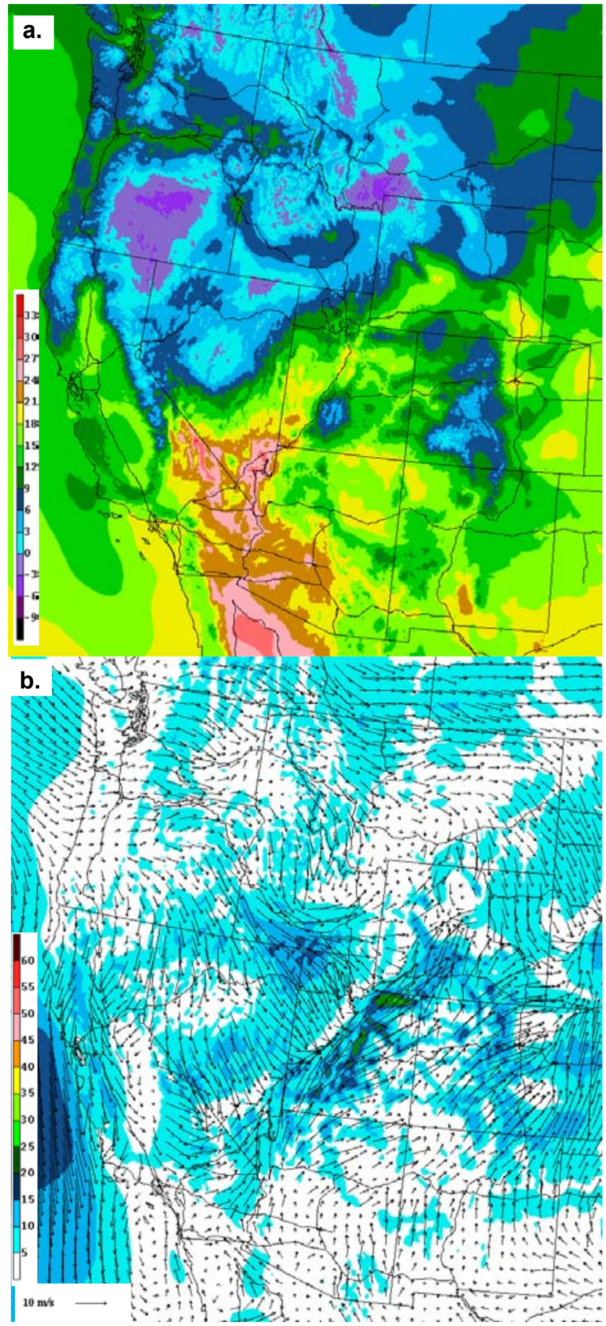

Figure 3. RUC analysis at 1200 UTC 10 October 2003 of: (a) surface temperature (^{o}C) and (b) wind (m s^{-1} vectors) and wind speed (shading).

axis stretches from southern Nevada to northeastern Utah. Strong pre-frontal southerly winds are observed in southern Nevada and central Utah with strong post-frontal northerly winds over northwestern Utah. However, the wind observations behind the front in eastern Nevada are highly variable. For example, some wind observations are consistent with the strong synoptic-scale north-

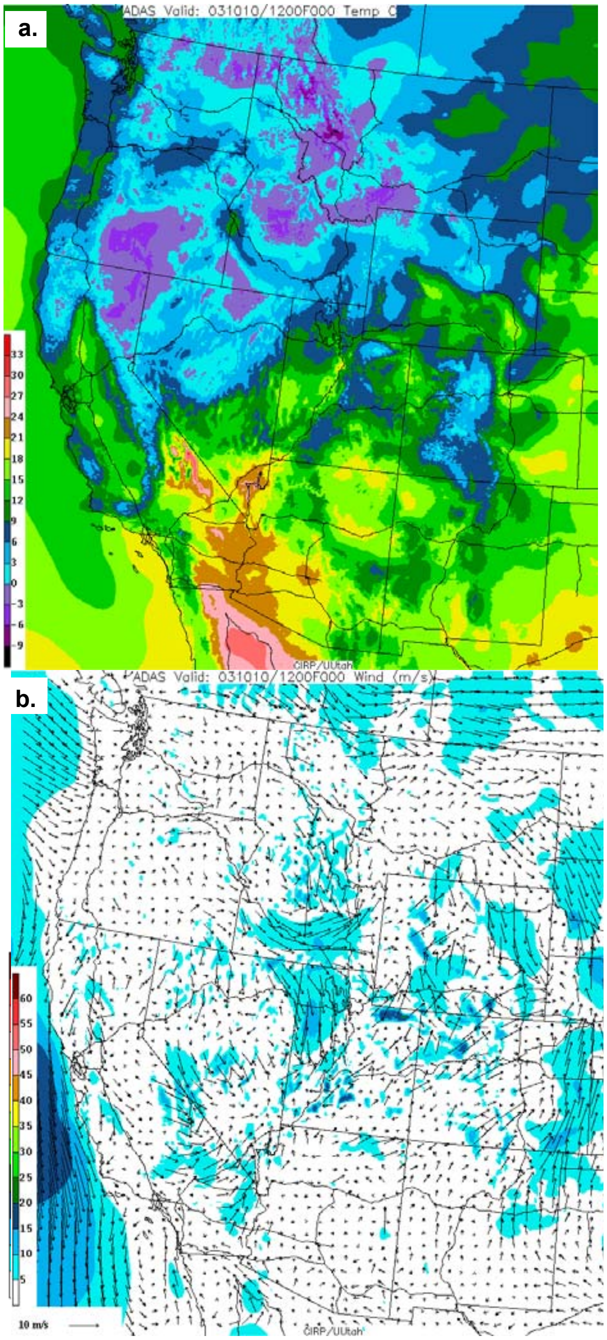

Figure 4. ADAS analysis at 1200 UTC 10 October 2003 of: (a) surface temperature (^{o}C) and (b) wind (m s^{-1} vectors) and wind speed (shading).

westerly pressure gradient while other are weak or blowing in other directions presumably as a result of local terrain and blocking effects that decouple the nocturnal surface winds from the strong synoptically-forced winds aloft.

The RUC analyses of surface temperature and wind downscaled to the 5km NDFD grid capture the large-scale features of the front, with cold temperatures and strong northwesterly winds behind the surface trough and cold front (Fig. 3). For example, the RUC winds, which are representative of the planetary boundary layer over the complex terrain, are very strong over eastern Nevada.

The ADAS analyses of surface temperature and wind valid at 1200 UTC 10 October are shown in Fig. 4. The ADAS temperatures are lower than the RUC temperatures in most regions. Further southward penetration of the cold front is evident over northwestern Utah in the ADAS analysis compared to the RUC analysis, which is in agreement with the large number of surface observations in that region (many of which are not plotted in Fig. 2). Since the ADAS analysis is constrained sharply by local observations, the ADAS winds over eastern Nevada are significantly weaker than those in the RUC.

The experimental IFPS forecasts of hourly temperature and wind issued by NWS forecasters in the West at 0000 UTC 10 October 2003 and valid twelve hours later are shown in Fig. 5. Sharp discontinuities in the temperature and wind forecasts align along some boundaries between adjacent CWAs, demonstrating the challenge to produce a national seamless database. For example, along the Utah-Nevada border that separates the Elko, NV, and Salt Lake City, UT, WFOs, the Salt Lake City forecast had stronger post-frontal winds forecasts compared to those forecast by Elko. Strong temperature discontinuities are evident as well, for example, along the CO-WY state boundary between the Grand Junction, CO, and Riverton, WY, CWAs.

Differences between the 12h IFPS forecasts and the corresponding ADAS analyses are shown in Fig. 6. Temperature differences within a few ^{o}C and wind speed differences less than 4 m s^{-1} are evident in many parts of the West. However, temperature differences in excess of 10^{o}C are found in several areas. For example, the large negative temperature differences in south central Nevada reflect discrepancies in the timing of the cold front. In other regions, such as northeastern Arizona and Death Valley, CA, there are few observations available. Hence, the ADAS analysis tends to relax towards the RUC background, which in these regions may be too warm. However, inspection of MesoWest observations available in New Mexico, Colorado, and Wyoming (not shown) suggest that the temperature forecast was significantly too cold.

5. SUMMARY

Efforts are underway to validate the skill of experimental NDFD gridded forecasts issued by WFOs in the western United States. A case study of the 12h IFPS forecasts available on the NDFD grid valid at 1200 UTC 10 October 2003 was presented. Forecasts at longer lead

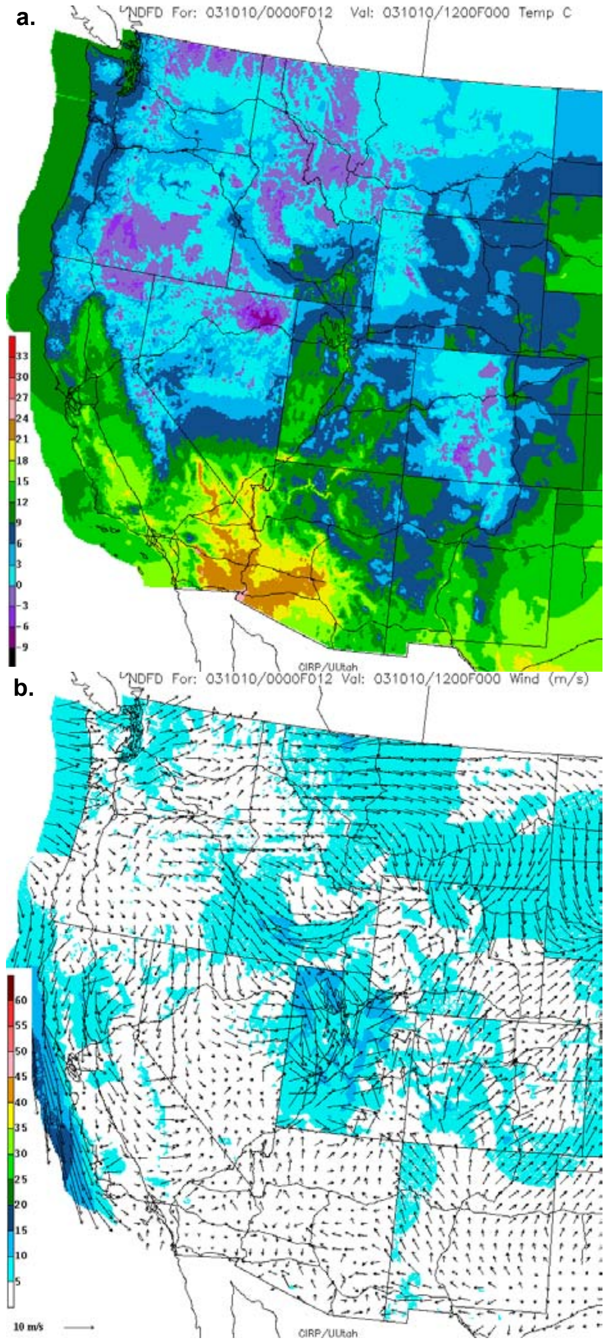

Figure 5. Experimental 12h NWS IFPS forecast valid at 1200 UTC 10 October 2003 of: a) surface temperature (^{o}C) and b) wind (m s^{-1} vectors) and wind speed (shading).

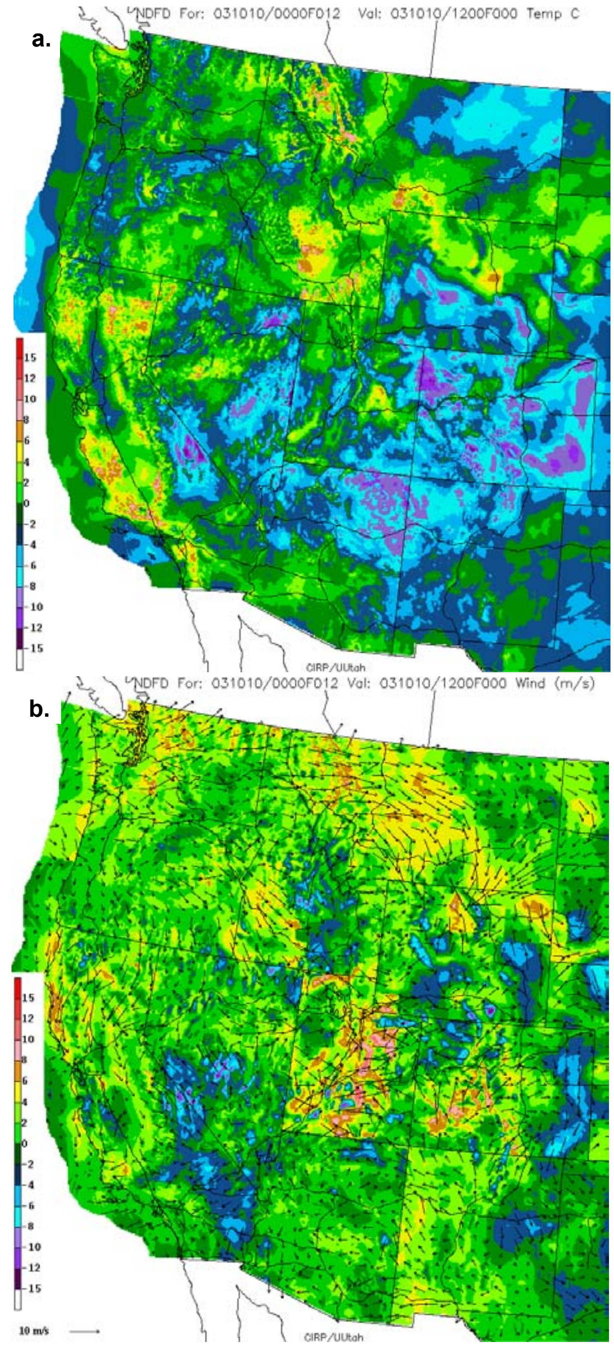

Figure 6. Difference between experimental 12h NWS IFPS forecast valid at 1200 UTC 10 October 2003 and ADAS analyses. (a) Surface temperature (^{o}C) and (b) wind (m s^{-1} vectors) and wind speed (shading).

times for this case have also been evaluated and had similar large differences in some regions when compared with the ADAS analyses (not shown). For example, wind and temperature errors in the vicinity of the cold front across Nevada and Utah tended to be related to discrepancies in the projected position of the front. However, large systematic positive and negative differences in temperature were observed at all lead times in other regions of the West. In addition, large forecast discrepancies across the boundaries between some CWAs were evident at all lead times. Additional results, including estimates of systematic biases, based upon a larger sample of forecast grids will be presented orally.

It is important to emphasize the preliminary nature of this study to verify the NWS IFPS gridded forecast process. More work is needed to develop a robust analysis system and associated techniques to validate the IFPS forecast grids with respect to this system. Nonetheless, these initial results demonstrate the challenge inherent in creating high-resolution gridded forecasts, and creating them with spatial consistency across NWS CWAs. Revealing and resolving deficiencies through verification is a critical step to improve the IFPS system.

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