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SIGNIFICANT ERRORS IN NUMERICAL WEATHER PREDICTIONS PRIOR TO THE NEW YEAR'S DAY 2006 SOUTHERN PLAINS WILDFIRE OUTBREAK

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1. INTRODUCTION

On New Year's Day 2006, westerly wind gusts up to 30 m s^{-1} and single-digit relative humidity values combined with an ongoing drought in the Southern Plains to create widespread weather conditions favorable for extreme fire behavior. Fires that exhibit such behavior are erratic and exercise a degree of influence on their environment; while high spread rates, prolific crowning and/or spotting, the presence of fire whirls, and strong convective columns often preclude the use of direct suppression methods (National Interagency Fire Center 2006). These meteorological conditions, likely aggravated by increased outdoor human activity and fire-start potential during the holiday weekend, contributed to a regional wildfire outbreak (Fig. 1) as discussed by Milne (2004) and Lindley et al. (2007).

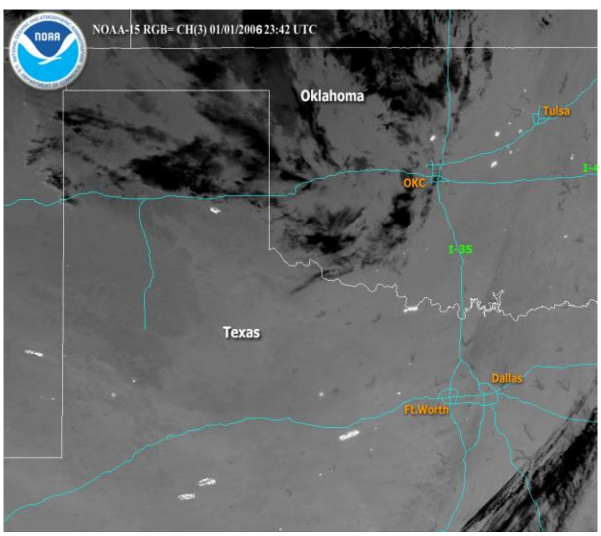

Figure 1: NOAA satellite image depicting numerous large wildfires in progress across the Southern Plains at 2342 UTC 1 January 2006. Fires are visible as white "hot spots" across New Mexico, Texas, and Oklahoma.

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By the early evening hours of 1 January, 73 new fire-starts of varying sizes and severity were reported in Texas alone (GADR 2006). Across the entire Southern Plains, at least 40 major wind-driven wildfires resulted in significant damage and/or were observed via meteorological remote sensing. These fires destroyed approximately 115 structures from southeastern New Mexico to eastern Oklahoma, and scorched more than 300,000 acres of the region's landscape. Two small Texas communities, Ringgold and Kokomo, were virtually destroyed. Property losses across the region exceeded $25 million, and the combined effects of the wildfires and related damaging winds resulted in 2 fatalities and at least 20 injuries (NOAA 2006).

In the days prior to the 1 January 2006 wildfire outbreak, numerical weather forecasts overestimated near-surface moisture and underestimated low-level wind speeds over the impacted region. Model-generated forecasts predicted 10 m afternoon wind speeds between 6 m s^{-1} and 13 m s^{-1} at Lubbock, Texas. Sustained wind speeds, however, were observed between 12 m s^{-1} and 18 m s^{-1} with frequent gusts over 26 m s^{-1}. Likewise, model-derived forecasts of 2 m relative humidity ranged between 14% and 31%, while observed relative humidities fell to 6% during the event. These model forecasted values for wind speed and relative humidity were significant given that they were only marginally indicative of local National Weather Service Red Flag Warning criteria (sustained 6 m winds of 9 m s^{-1} and 2 m relative humidity values of 15% or less), yet catastrophic fire weather conditions were ultimately observed.

Fire management officials have long recognized that atmospheric conditions are the primary variable factors that influence wildfire behavior and severity (Heilman 1995 and Anderson 1998). Relative humidity and winds, along with atmospheric instability, are the most critical meteorological parameters used to predict fire behavior and spread (U.S. Dept. of Commerce 1998). With large guidance errors in relative humidity and wind speeds, forecasts based solely upon numerical weather predictions prior to the New Year's Day winds and wildfires would not have indicated the potential for a significant event. Furthermore, within 24 hours of the event, model generated forecasts failed to depict a cold front that pushed south over the Texas Panhandle and western Oklahoma. The abrupt northerly wind shift associated with the front altered the spread and propagation of several wildfires and created dangerous conditions that threatened equipment, structures, and injured at least one firefighter (NOAA 2006).

This study evaluates five North American Mesoscale (NAM) model and Global Forecast System (GFS) gridded solutions prior to the New Year's Day 2006 Southern Plains wildfire outbreak relative to observed surface conditions over west Texas. The large errors observed in model predicted low-level relative humidity and wind fields will be presented here as previously documented by operational forecasters with forecast and warning responsibility during the outbreak event (Lindley et al. 2006a).

2. METHODOLOGY AND EVALUATION OF NUMERICAL WEATHER PREDICTION GUIDANCE

Five operational model solutions initialized within 72 hours of the outbreak were investigated, three from the ETA configured NAM and two from the GFS. These gridded solutions were available for operational use in the Advanced Weather Interactive Processing System (AWIPS) environment at the following spatial and temporal resolutions; the "40NAM" post-processed at 40 km grid spacing in 3 hour forecast intervals available for forecast hours 3-60, the "80NAM" post-processed at 80 km grid spacing in 6 hour forecast intervals available for forecast hours 6-84, and the "80GFS" post-processed using 80 km grid spacing at 6 hour forecast intervals available for forecast hours 6-240. It is noteworthy that both the NAM and GFS solutions generally provided small errors in low-level temperature fields despite observed record values, and that the observed errors in predicted relative humidity were largely due to overestimates of model-forecasted near-surface dewpoints (EMC 2006).

In order to quantify the errors in model guidance that forecasters observed prior to the New Year's Day wildfire outbreak, subjectively-observed values of 2 m relative humidity and sustained 10 m wind speed were sampled from gridded model output for a single point near the Lubbock International Airport (33.59° N, 101.89° W). These model-predicted values were compared to observed conditions measured by the Automated Surface Observing System (ASOS) located at the Lubbock Preston Smith International Airport (KLBB). The point values were deemed to be centrally located and largely representative of the model error across the geographical outbreak area in west Texas; the southern Texas Panhandle, the South Plains, and the Permian Basin (Fig. 2).

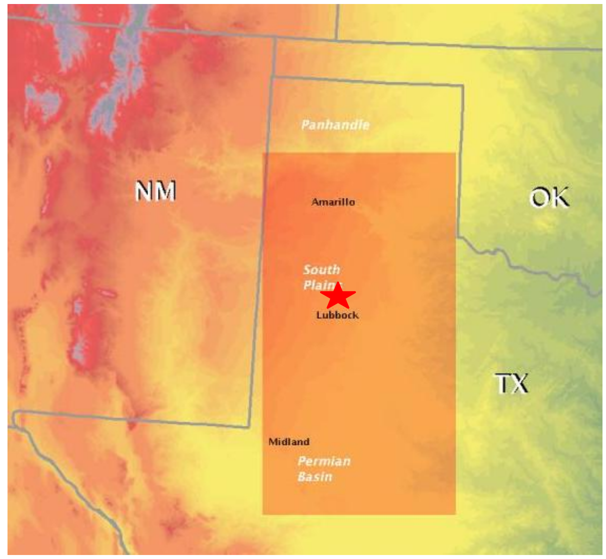


Figure 2: Topographical map highlighting the geographical area of the New Years Day 2006 wildfire outbreak in west Texas. The Lubbock Preston Smith International Airport (KLBB) is marked by a red star.

2.1 Errors in 2 m Relative Humidity and 10 m Wind Speed

The model-predicted values for 2 m relative humidity and sustained 10 m wind speeds, which were found to be in error by as much as 25% and 8 m s^{-1} respectively, are compared to the ASOS observed conditions below in Table 1. Line graphs are used to compare the model-forecasted values to the observed conditions for corresponding forecast hours. Hyperlinks to full resolution graphs are embedded within Table 1 as clickable thumbnail images for Fig. 3 through Fig. 7.

2.2 Model Failure to Depict Cold Frontal Passage and Impacts on Firefighting

Between 2200 UTC and 2400 UTC 1 January a cold front advanced south over active wildfires in the Texas Panhandle and southwestern Oklahoma. The northerly wind shift associated with the frontal passage altered fire propagation. Fire crews battling large blazes in severe westerly winds (gusts greater than 26 m s^{-1}) near the Texas Panhandle communities of Howardwick and Shamrock were adversely impacted by the wind shift after enacting attack strategies based on forecasts for continued west winds and eastward fire propagation. The shifting wildfires threatened 10 structures near Shamrock, and required the emergency evacuation of 100 residents and patrons of a local motel. In addition, a firefighter received burn injuries near Howardwick when that fire shifted and threatened heavy equipment and 70 homes (NOAA 2006).

Table 1: Model-Derived Values of 2 m Relative Humidity (RH), 10 m Wind Speed, and KLBB Observed Values

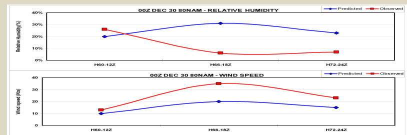
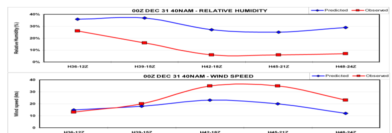
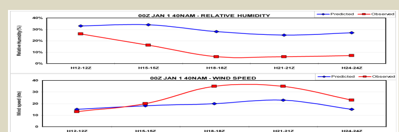
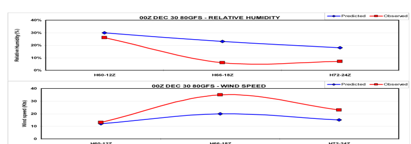
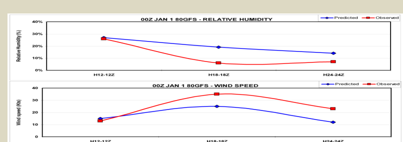
Model Run	Values	Model Forecast and Observation Times For 1 January 2006				
		1200 UTC	1500 UTC	1800 UTC	2100 UTC	2400 UTC
80NAM 0000 UTC 30 December 2005: Forecast Hours 60-72	RH	20%	n/a	31%	n/a	23%
	Wind Speed	5 m s^{-1}	n/a	10 m s^{-1}	n/a	8 m s^{-1}
	Figure 3	 *click to see full resolution figure*				
40NAM 0000 UTC 31 December 2005: Forecast Hours 36-48	RH	36%	37%	27%	25%	29%
	Wind Speed	8 m s^{-1}	9 m s^{-1}	12 m s^{-1}	10 m s^{-1}	6 m s^{-1}
	Figure 4	 *click to see full resolution figure*				
40NAM 0000 UTC 1 January 2006: Forecast Hours 12-24	RH	33%	34%	28%	25%	27%
	Wind Speed	8 m s^{-1}	9 m s^{-1}	10 m s^{-1}	12 m s^{-1}	8 m s^{-1}
	Figure 5	 *click to see full resolution figure*				
80GFS 0000 UTC 30 December 2005: Forecast Hours 60-72	RH	30%	n/a	23%	n/a	18%
	Wind Speed	6 m s^{-1}	n/a	10 m s^{-1}	n/a	8 m s^{-1}
	Figure 6	 *click to see full resolution figure*				
80GFS 0000 UTC 1 January 2006: Forecast Hours 12-24	RH	27%	n/a	19%	n/a	14%
	Wind Speed	8 m s^{-1}	n/a	13 m s^{-1}	n/a	6 m s^{-1}
	Figure 7	 *click to see full resolution figure*				
KLBB Surface Observations	RH	26%	16%	6%	6%	7%
	Wind Speed	7 m s^{-1}	10 m s^{-1}	18 m s^{-1}	18 m s^{-1}	12 m s^{-1}

Table 1: Predicted values of 2 m relative humidity and 10 m wind speed from five initializations of the operational NAM and GFS numerical weather predictions and the corresponding observed values at KLBB. *Click the embedded thumbnails to see full resolution graphical depictions of the data in Fig. 3 through Fig. 7 respectively.*

The failure of numerical weather prediction to forecast a significant frontal passage and wind shift in the Southern Plains on New Year's Day, as evidenced in comparisons of observational and Local Analysis and Prediction System (LAPS) (Albers et al. 1995 and 1996) data (Fig. 8a-b), was a critical element that contributed to a loss of situational awareness for both forecasters and fire managers. A complicating factor was a mesoscale enhancement of the synoptic scale frontal boundary by evaporatively cooled air that originated from post frontal virga showers (Fig. 9). Changes in wind speed and direction are a re-occurring element common to many wildfire-related fatalities (National Wildfire Coordinating Group 1997). The hazards posed by the frontal passage discussed here underscore the importance of maintaining a continuous flow of accurate observational and forecast information between meteorologists in the operational setting and local decision makers at the scene of major wildfires (Lindley et al. 2006b).

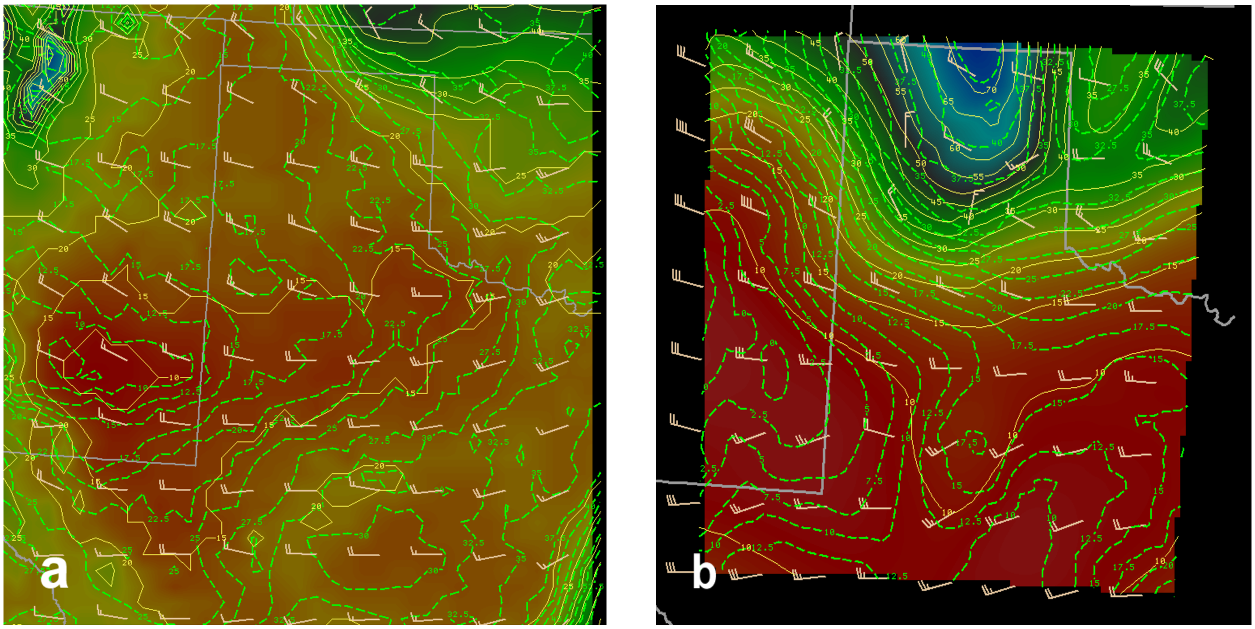


Figure 8a-b: The 0000 UTC 1 January 40NAM valid at 2100 UTC 1 January (8a = left image) forecast for 2 m relative humidity (orange contours and color image), 2 m dewpoint (green dashed line), and 10 m winds (orange barbs) compared to the 2100 UTC 1 January LAPS (8b = right image).

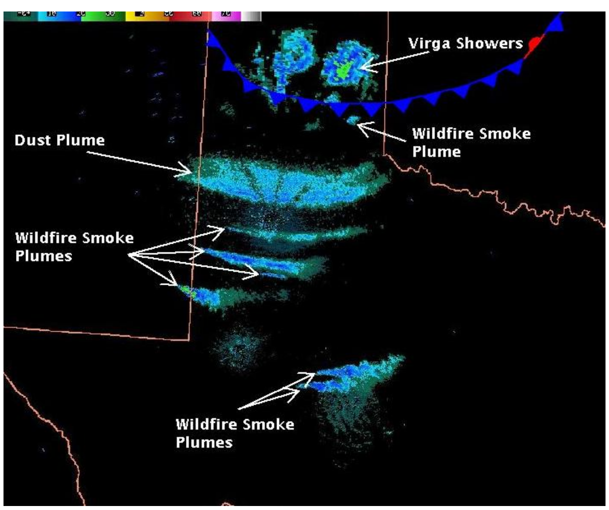


Figure 9: Radar mosaic from 2130 UTC 1 January 2006 showing virga showers north of the surface cold front. Dust and wildfire smoke plumes are also denoted.

3. CONCLUSIONS

This evaluation of the NAM and GFS model solutions prior to the New Year's Day Southern Plains wildfire outbreak documented errors in model-forecast low-level relative humidities and winds. These errors were found to be as high as 8 m s^{-1} for sustained 10 m wind speeds and 25% for 2 m relative humidity as compared to the observed conditions at Lubbock, Texas, per official ASOS observations. Since these meteorological parameters are the primary critical variables in predicting wild land fire behavior, official National Weather Service fire weather planning and public hazard forecasts based solely upon the numerical weather prediction model guidance would have likely been unrepresentative of a regional high-impact and significant wildfire outbreak. Numerical model forecasts also failed to predict a cold front that swept through ongoing wildfires and resulted in a dangerous wind shift.

Although beyond the scope of this study, recognition of model biases and inconsistencies relative to conceptual models by forecasters and effective inter- and intra-agency coordination allowed forecasters and state officials to convey predictions of a significant fire weather event despite numerical guidance that depicted a lesser wildfire threat.

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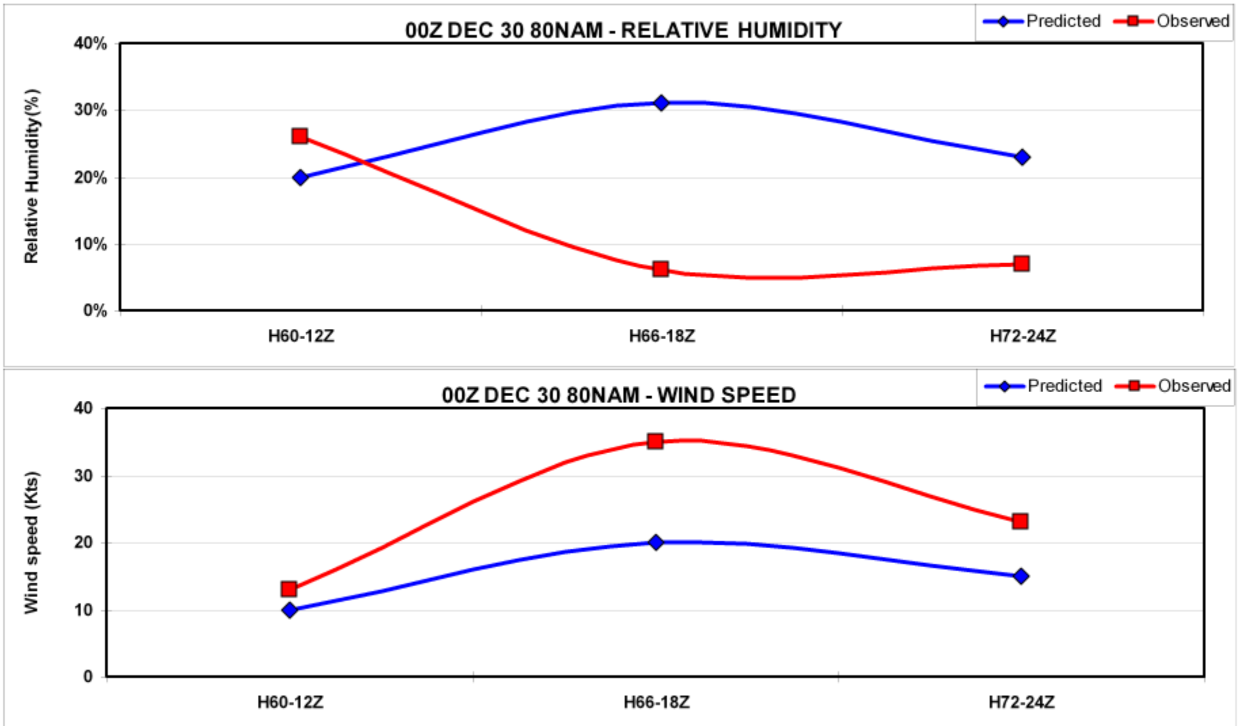
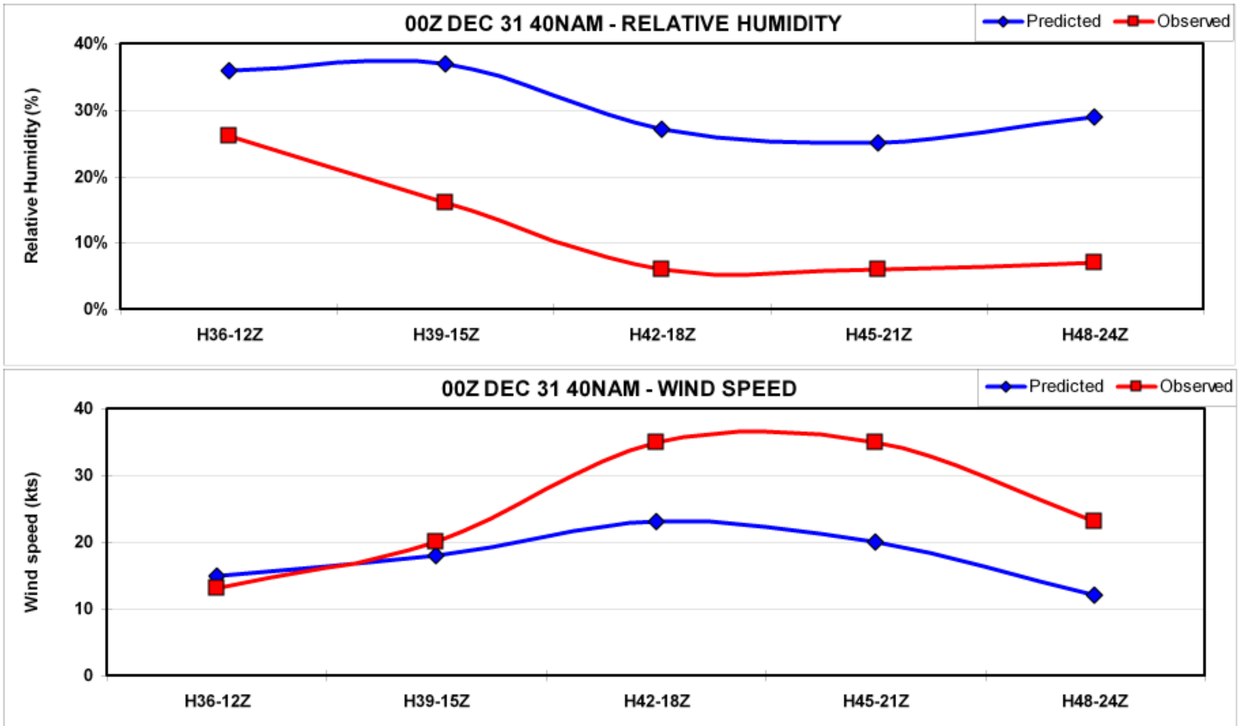


Figure 3: A graphical comparison of model-predicted 2 m relative humidity and 10 m wind speeds to observed values at KLBB using the 60 to 72 hour forecast from the 0000 UTC 30 December 2005 80NAM valid between 1200 UTC and 2400 UTC 1 January 2006. *Click image to return to main manuscript.*



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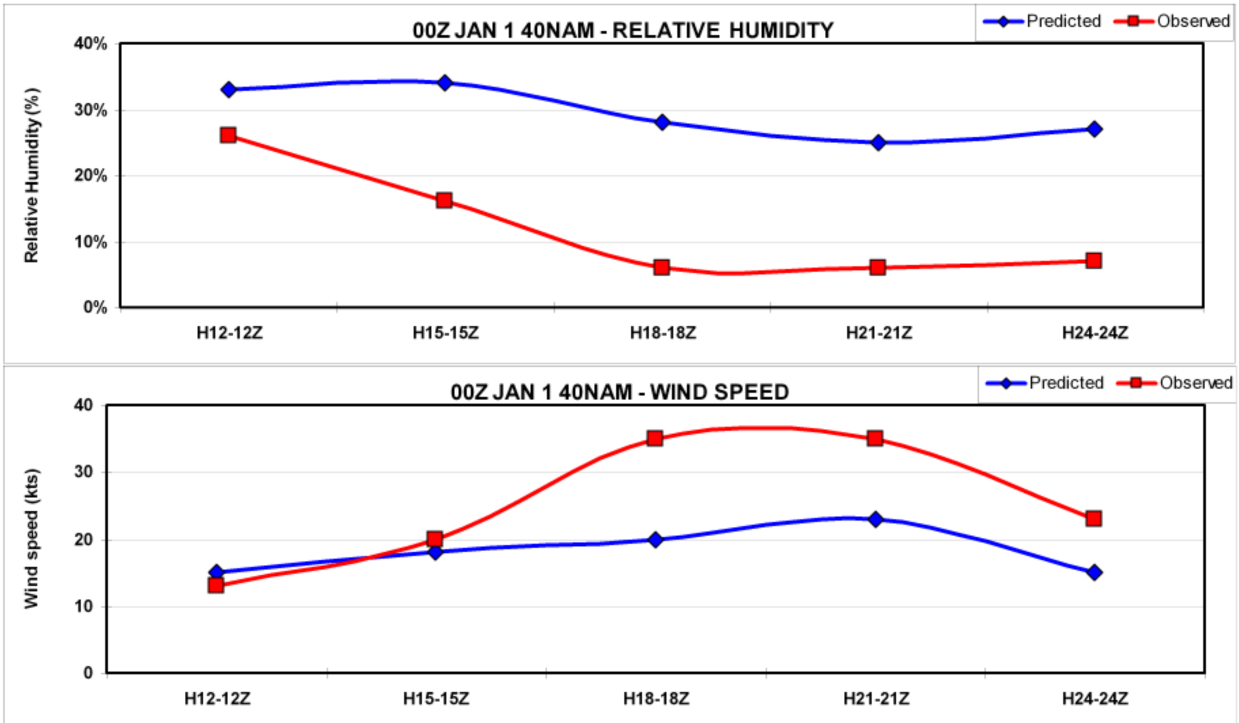

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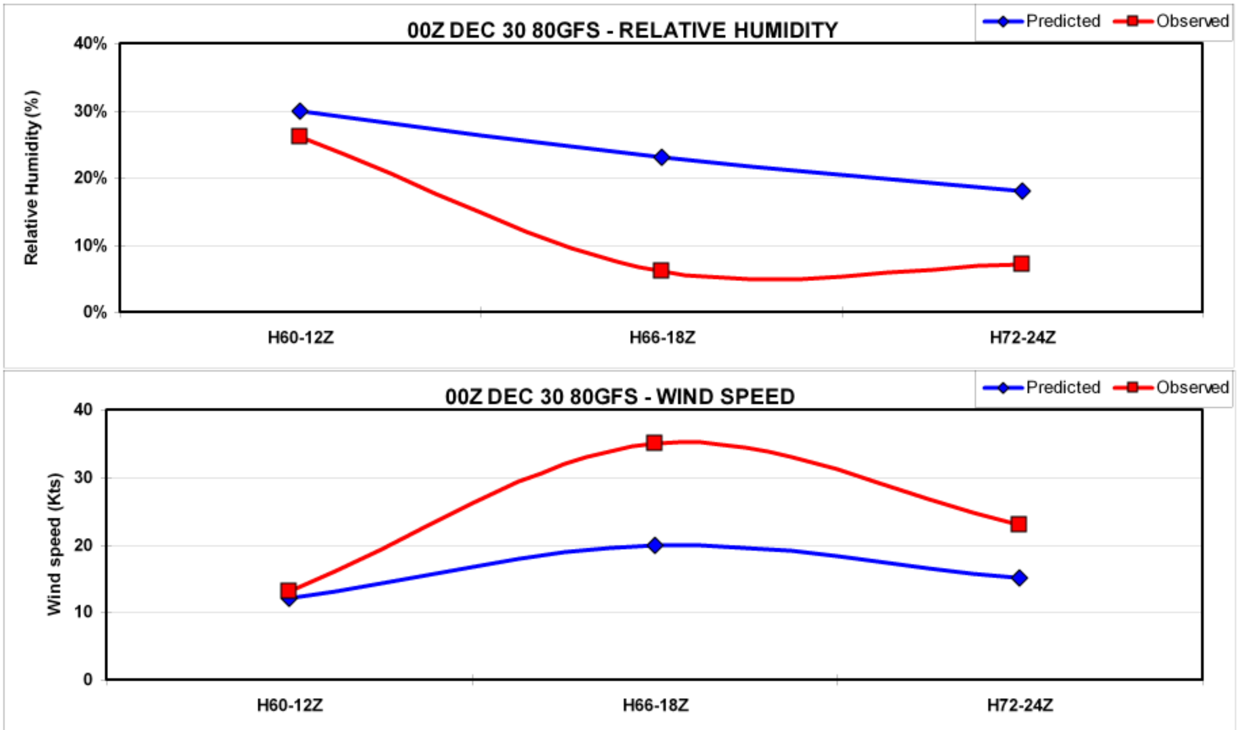

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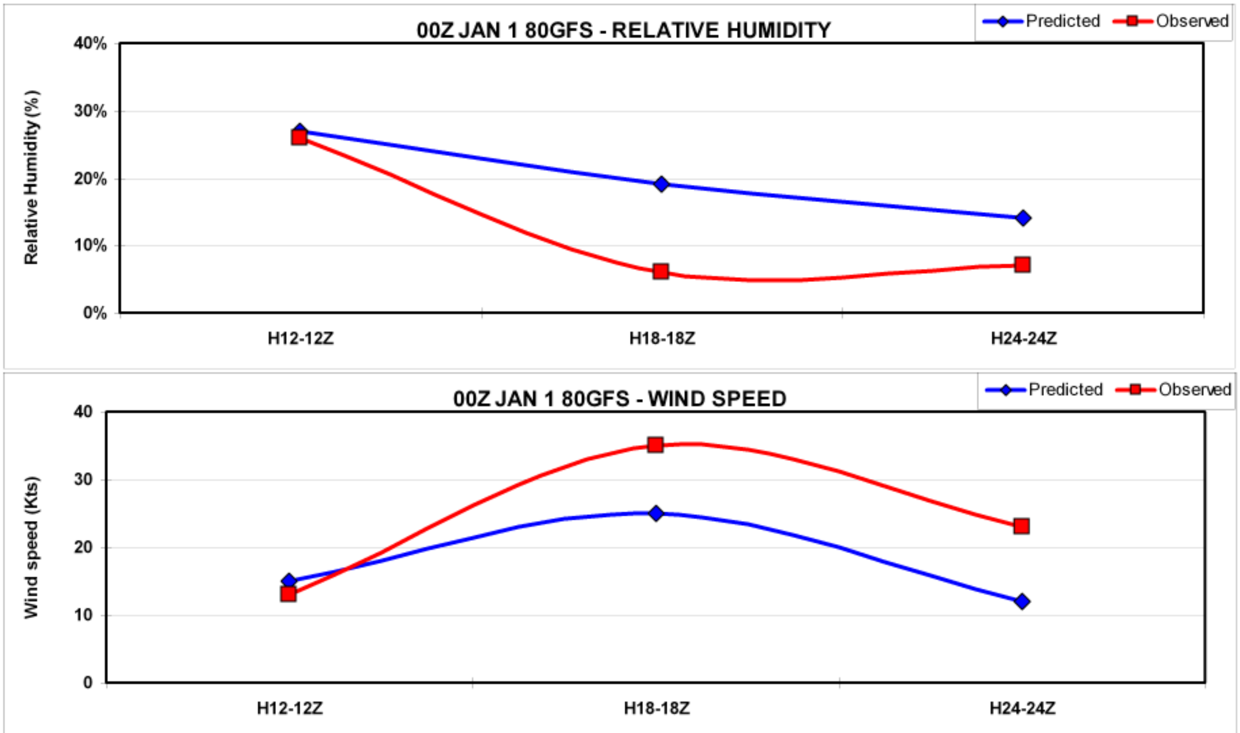

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