A High-Wind Prediction Model for Bordeaux, Wyoming

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INTRODUCTION

Strong wind gusts are common across southeast Wyoming during the months of October through March. This is especially true where mountain gaps help to accelerate low-level flow. One area of interest is Bordeaux, WY (BRX), located along Interstate 25 around 66 miles north of Cheyenne. Vehicular transportation can be severely impacted, as the nearby gap results in sudden but intense crosswinds over the highway. Numerous blow-overs of tractor trailers and other high-profile vehicles occur each year, causing considerable disruption to safety and commerce.

Forecasters at the National Weather Service in Cheyenne have commonly used the 850- and 700-mb height gradients between Craig, CO (CAG), and Casper, WY (CPR), as indicators of potential gap winds at Bordeaux. While this technique has proved beneficial in forecasting high winds, the CAG-CPR line does not bisect Bordeaux. It is possible that other gradient orientations, such as Arlington, WY (ARL) to Bordeaux, may be more useful. In addition, forecast variables other than geopotential height may provide additional predictive value. This study aims to develop a high-wind statistical prediction model for Bordeaux using logistic regression. Such a model could be implemented using model data at the Cheyenne office to assist forecasters.

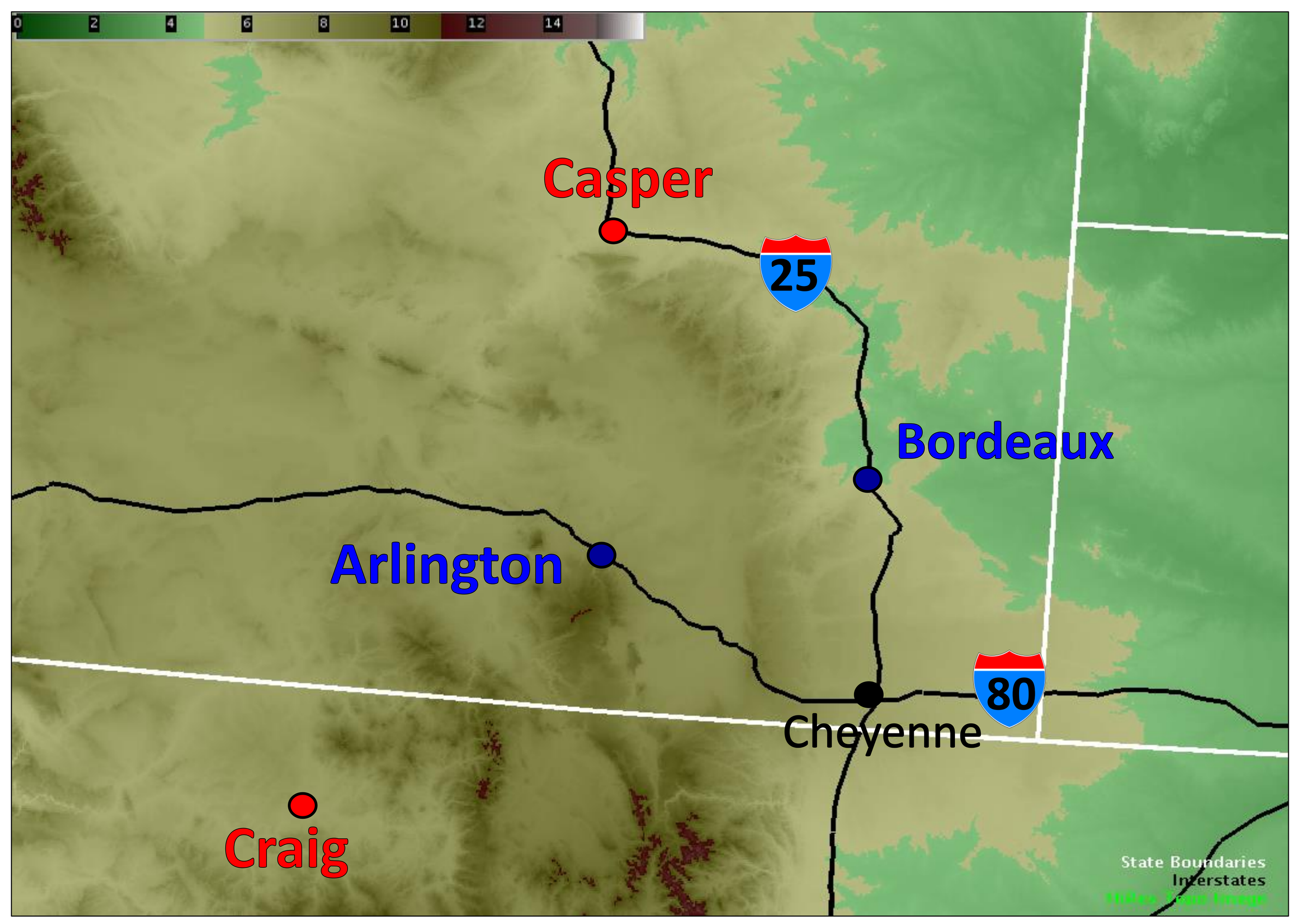

Figure 1. A map of southeast Wyoming, with locations used in the study.

OBJECTIVES

This research has the following objectives:

- Conduct a statistical analysis of the CAG-CPR height gradient, ARL-BRX gradients (both height and MSLP), and winds at BRX, calculating correlation and forecasting scores.
- Develop a high-wind statistical prediction model for Bordeaux using logistic regression. Calculate forecasting scores from the model.

METHODS

1) North American Regional Reanalysis data over six wind seasons (2006-2012 from October-March) were utilized to compute the predictors. The predictors included height gradients (CAG-CPR, ARL-BRX) over 925-700 mb at 25-mb increments, MSLP ARL-BRX gradient, and wind speed at BRX over 850-500 mb.

2) Wind observations from Bordeaux were collected in Mesowest. The 1-hourly max wind gust was logged at 3-hr intervals.

3) The Pearson correlation values were calculated for each predictor vs. wind gust.

4) Forecasting scores (POD, FAR, CSI) were computed for predictor thresholds assuming warning-criterion gusts (≥58 mph).

High-Wind Prediction Model

- A logistic regression model for predicting high winds was developed with the assistance of Dan Lindsey.
- After analysis of the NARR predictors, the following were selected at model variables: *(x_1) 850-mb CAG-CPR height gradient (x_2) ARL-BRX MSLP gradient (x_3) 800-mb wind speed at BRX*
- Probability Equation: $$p = \frac{1}{1+\exp(-b_0 - b_1x_1 - b_2x_2 - b_3x_3)}$$

	850-mb CAG-CPR height gradient (b_1)	MSLP ARL-BRX gradient (b_2)	800-mb windspeed at BRX (b_3)
Normalized Coefficients	1.82	0.865	0.807
Raw Coefficient	0.06	0.328	0.11

Figure 2. Variables used in the linear regression model, and the resulting normalized and raw coefficients. The raw coefficients are used in the probability equation above along with b_o = -9.98.

RESULTS

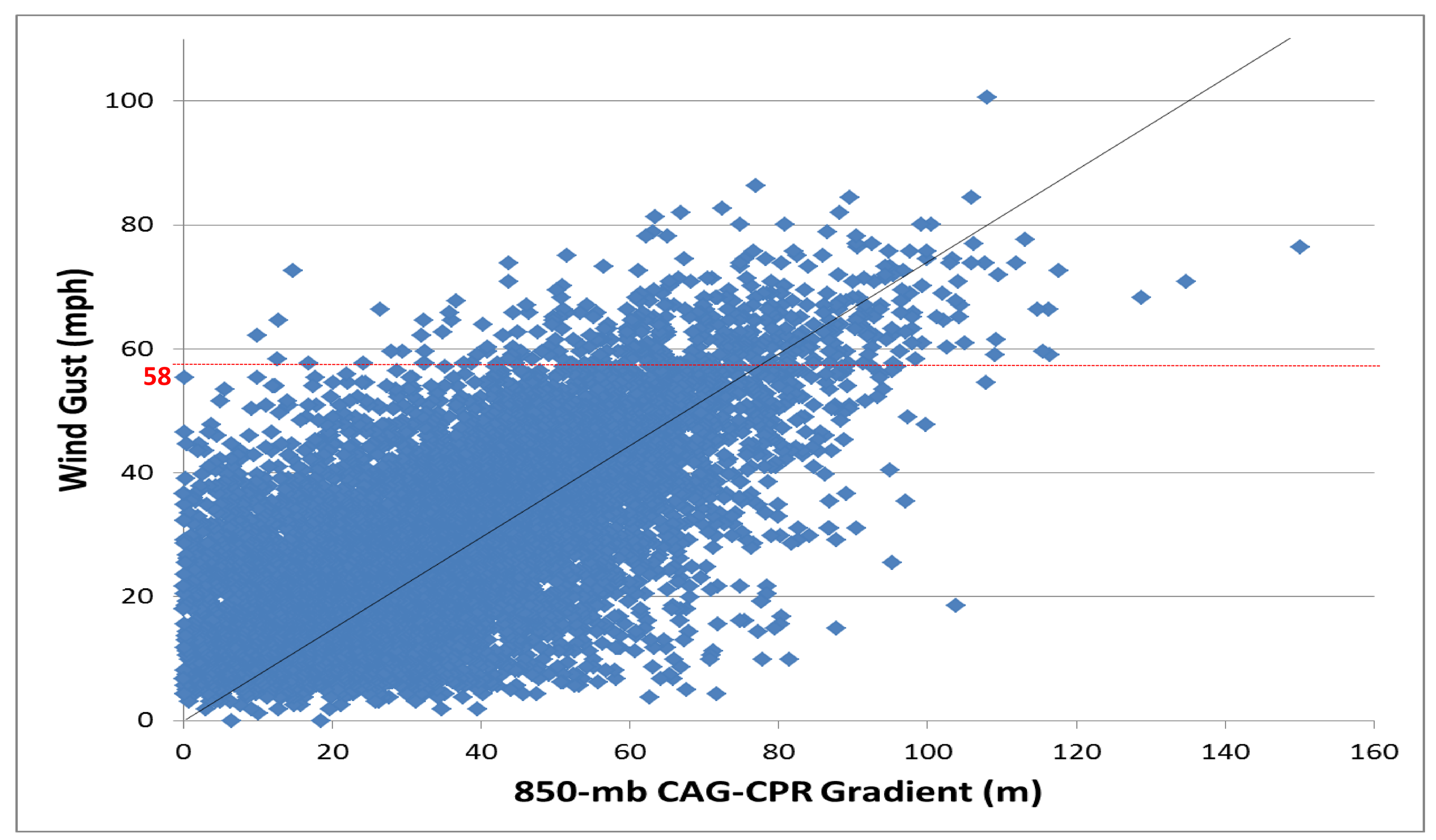

Figure 3. Scatterplot of Bordeaux wind gusts vs. the 850-mb CAG-CPR height gradient. Only positive gradient values are shown. The best-fit line is plotted in black, while the red dashed line indicates the local High Wind Warning criterion of 58 MPH.

	850	825	800	775	750	725	700
CAG-CPR	0.61	0.6	0.6	0.59	0.57	0.54	0.51
ARL-BRX	0.64	0.63	0.62	0.6	0.57	0.53	0.47
BRX Winds	0.67	0.66	0.65	0.66	0.65	0.58	0.49

Figure 4. Table of Pearson correlation values for height gradient orientations (CAG-CPR, ARL-BRX) and wind speeds at BRX (BRX Winds) at each pressure (mb) level. In addition, the correlation for ARL-BRX MSLP was **0.581**

	850-mb CAG-CPR ≥ 70 m	850-mb ARL-BRX ≥ 40 m	MSLP ARL-BRX ≥ 5 mb	800-mb BRX wind ≥ 28 knots	Model Prob ≥ 26 %
POD	0.593	0.341	0.567	0.45	0.55
FAR	0.573	0.507	0.696	0.689	0.498
CSI	0.33	0.252	0.247	0.225	0.356

Figure 5. Table of forecasting scores (POD, FAR, CSI) for chosen variables and thresholds. These thresholds represent the best CSI for that particular variable. The highest CSI (0.356 in yellow) results from using the logistic model.

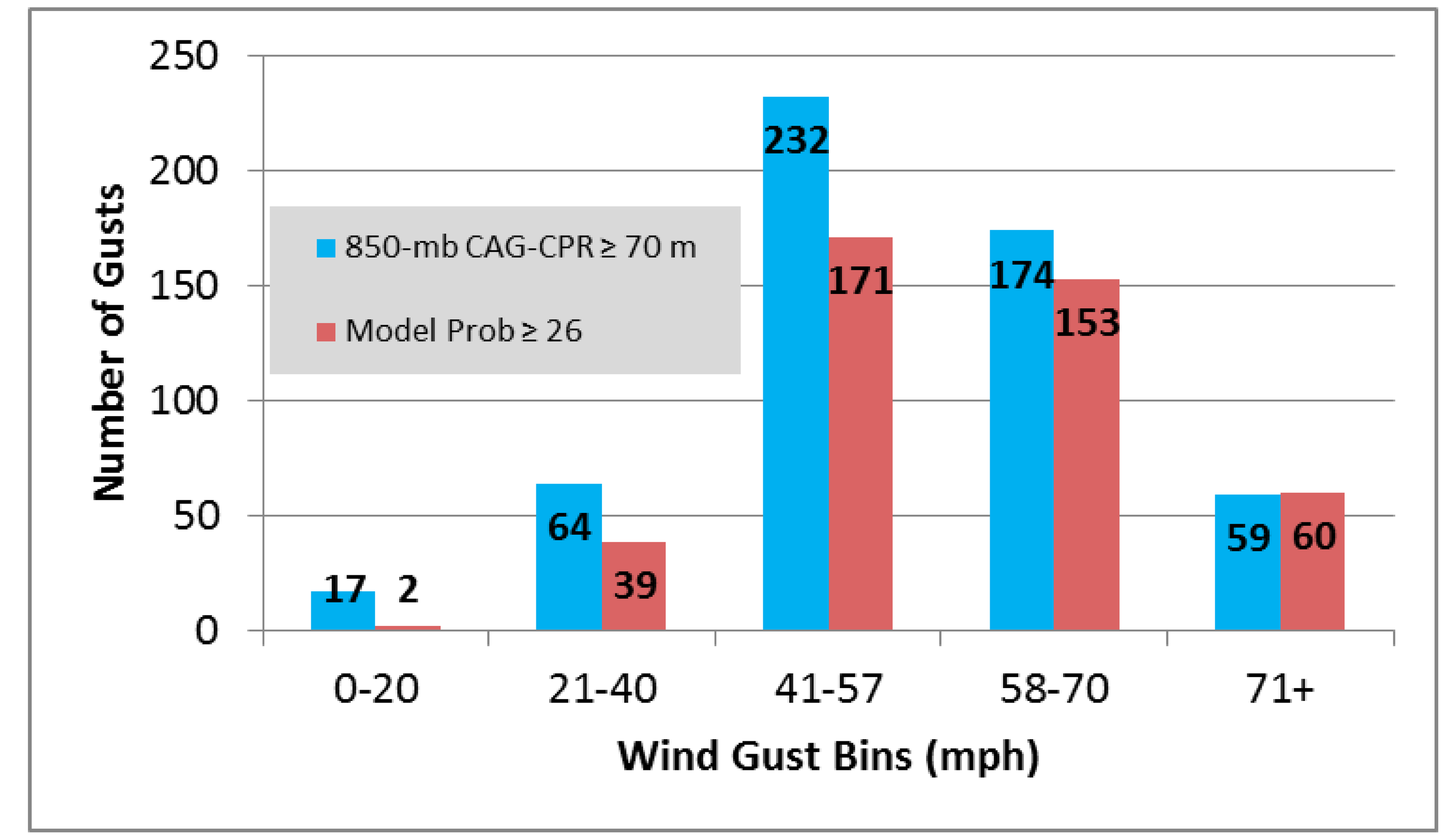

Figure 6. Number of observed wind gusts in particular gust bins when using the following methods: 850-mb CAG-CPR gradient ≥ 70 m (blue), model probability ≥ 26 (red).

CONCLUSIONS

Summary:

- The overall correlation between the predictors and wind gusts at Bordeaux was good (0.50-0.65) for all low-level pressure levels. 850 mb had the best correlations.
- As a single predictor, a 850-mb CAG-CPR height gradient ≥ 70 produced one of the best forecasting CSI scores. Thus, forecasters at NWS Cheyenne focus on the 850-mb CAG-CPR gradient rather than higher levels like 700 mb.
- The high-wind prediction model reduced the number of false alarms and improved CSI scores slightly. Using the model, the number of gusts at lower speed bins (0-40 mph) were reduced by 50% and gusts at the highest speed bin (71+) were unchanged.

Current / Future Work:

- *Implementation into Operations*

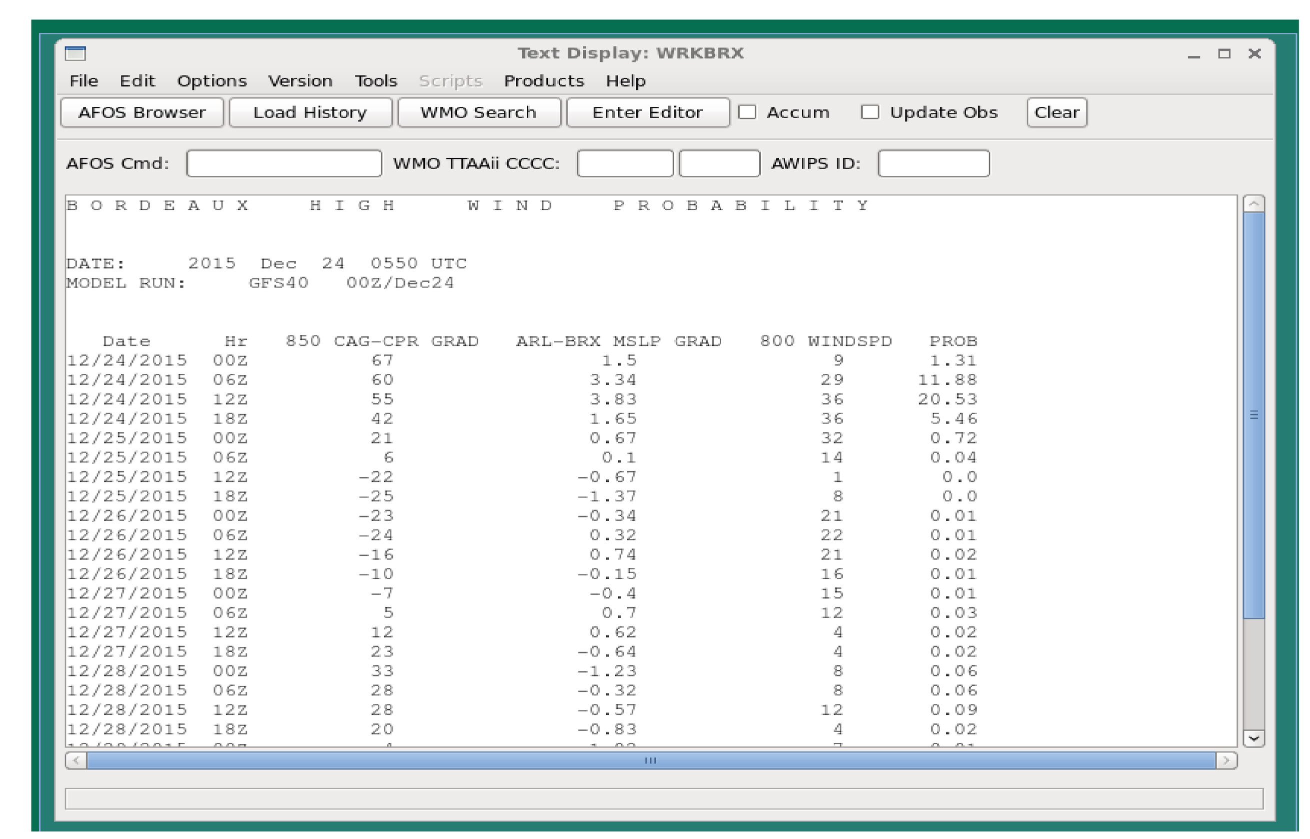

Figure 7. Bordeaux high-wind model as a text product in AWIPS2. This model is currently being run in real-time at WFO Cheyenne.

- Verification of the operational high-wind model will be performed over the next few wind seasons. Real-time model data will also be collected so that biases between the GFS/NAM and NARR can be corrected.
- In order to validate the model, it will be run on an independent NARR dataset over two wind seasons (2013-2014).