

# **SDGE Station Level Wind Gust Machine Learning Modeling**



# SDGE Wind Gust ML Flowchart

Hourly WRF : ens\_cfsr\_004  
ens\_cfsr\_004\_d01  
Period: 2013-07-31 to 2019-07-31

Response Variable: observed gust  
Period: 2012-10-02 to 2019-09-02

Combined Training Data for Each Station

Add 15 more stations: VLC, MGD, LKW, VJS, RNB, FBK,  
SPV, STV, TDS, CPO, LLD, JVR, GTY, MGY, CHH

Model I: Random Forest for All Wind Conditions  
Predictor Selection/Model Parameter Selection  
Rank Importance/Bias Pattern Check

Calculate bias with best predictor/parameter combination  
**Re-train bias** with high wind condition in model II

Model II: Gradient Boosting Tree  
Retrain Bias on High Wind Time-Points Only  
Predictor/Parameter Selection; Resample Strategy

Determine high wind threshold: gust percentile  
Bias correct high wind time-points only

Gust Prediction: bias corrected forecast value  
combining model I and model II

Model Construction

SDG&E provides Major Events and  
important stations

Check Model Results  
Training Performance/Testing Performance  
test six historical events: leave-one-out

Forecast vs Observed vs WRF Gust  
Check Bias/RMSE  
Check event/daily max difference  
Check under- or over-estimation  
Check time-lag issue/timeseries pattern

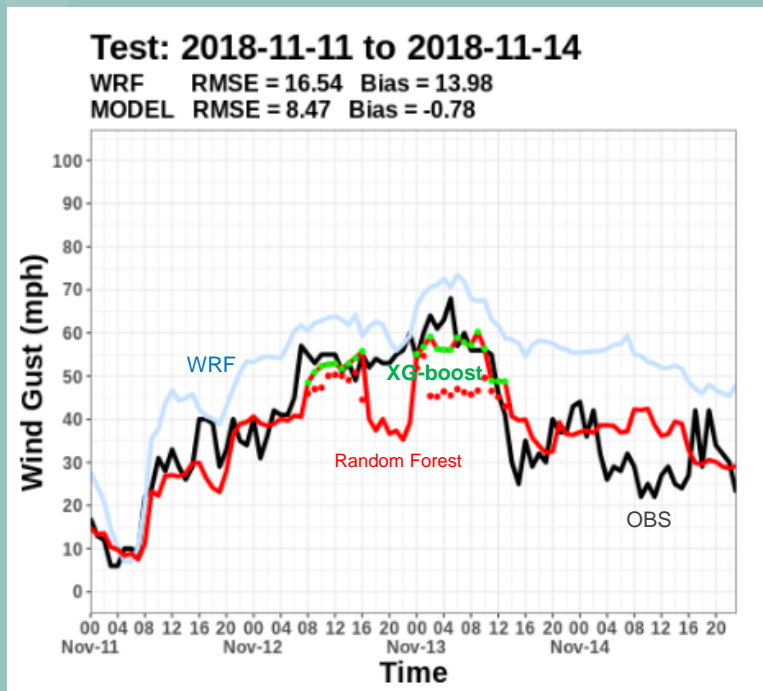
Model Validation



# Validation Results for Additional Stations

# Validation Results for Additional Stations

## Sample Validation Plot



### 15 More Stations:

Valley Center (VLC)  
Mesa Grande (MGD)  
Lake Wohlford (LKW)  
Viejas (VJS)  
Rainbow (RNB)  
Fallbrook (FBK)  
San Pasqual Valley (SPV)  
Santa Teresa Valley (STV)  
Tierra Del Sol (TDS)  
Campo (CPO)  
Loveland (LLD)  
Japatul Valley Rd (JVR)  
Guatay (GTY)  
Mataguay (MGY)  
Chihuahua Valley (CHH)

### RFW and/or Extreme FPI dates:

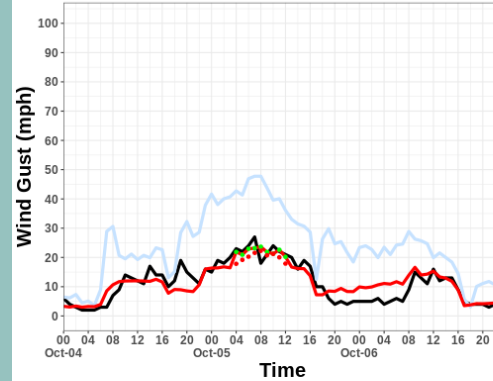
Oct. 4-6, 2013  
Nov. 5, 2013  
Dec. 14-15, 2013  
Jan. 13-17, 2014  
Jan. 23-24, 2014  
Apr. 30-May 1, 2014  
May 11-15, 2014  
Nov. 4-6, 2014  
Nov. 16-18, 2014  
Nov. 24-26, 2014  
Apr. 15-16, 2015  
Oct. 9-10, 2017  
Oct. 14-15, 2017  
Oct. 22-25, 2017  
Dec. 4-10, 2017  
Dec. 14-15, 2017  
Jan. 27-29, 2018  
Jul. 6, 2018  
Oct. 15-16, 2018  
Oct. 19, 2018  
Nov. 8-9, 2018  
Nov. 11-14, 2018

*Note: OC-only RFWs were only included if the event as a whole was significant (i.e. Apr. 30th)*

## Wind Gust ML Validation for Valley Center

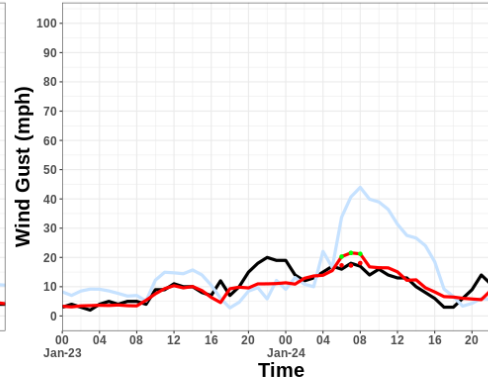
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 14.87 Bias = 12.85  
MODEL RMSE = 3.28 Bias = 0.35



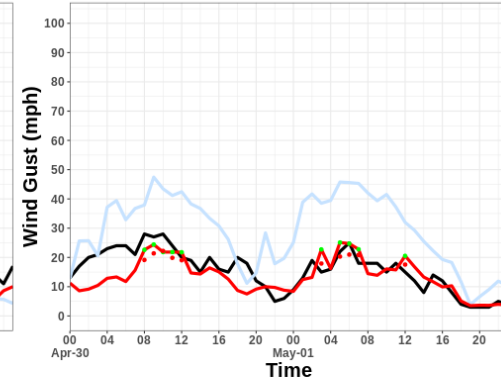
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 10.96 Bias = 4.26  
MODEL RMSE = 3.57 Bias = -0.82



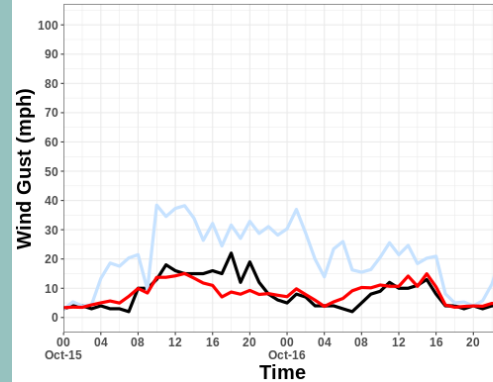
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 15.98 Bias = 13.67  
MODEL RMSE = 5.31 Bias = -2.05



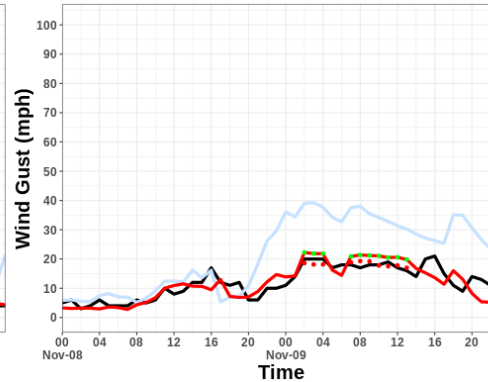
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 14.79 Bias = 12.61  
MODEL RMSE = 3.59 Bias = -0.09



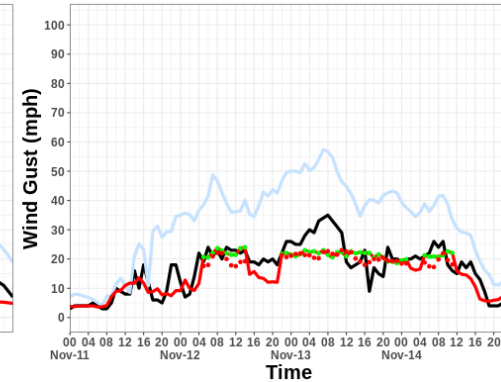
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 12.93 Bias = 9.69  
MODEL RMSE = 3.41 Bias = -0.23



Test: 2018-11-11 to 2018-11-14

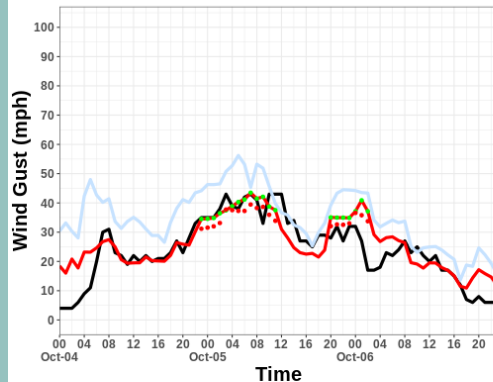
WRF RMSE = 17.76 Bias = 15.79  
MODEL RMSE = 4.94 Bias = -1.61



## Wind Gust ML Validation for Mesa Grande

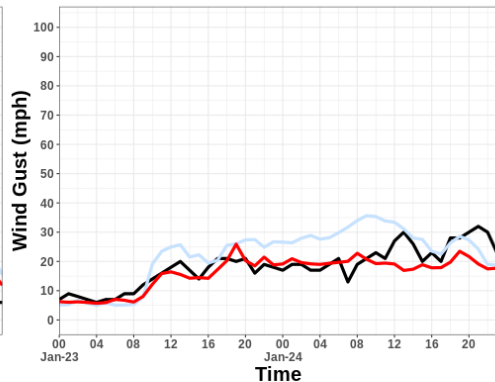
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 13.68 Bias = 10.98  
MODEL RMSE = 6.73 Bias = 1.95



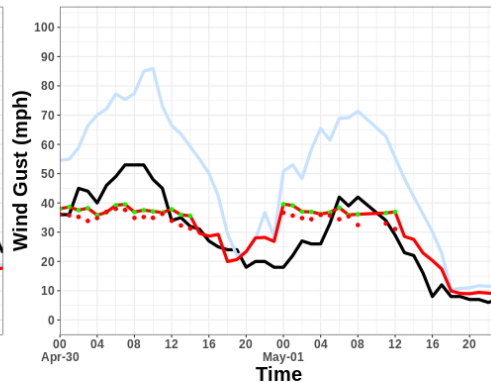
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 7.54 Bias = 3.98  
MODEL RMSE = 4.79 Bias = -2.10



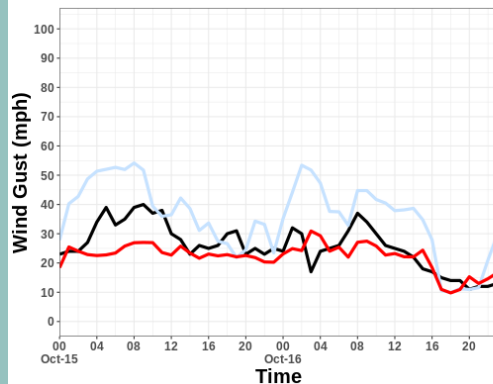
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 23.19 Bias = 20.63  
MODEL RMSE = 8.11 Bias = 1.29



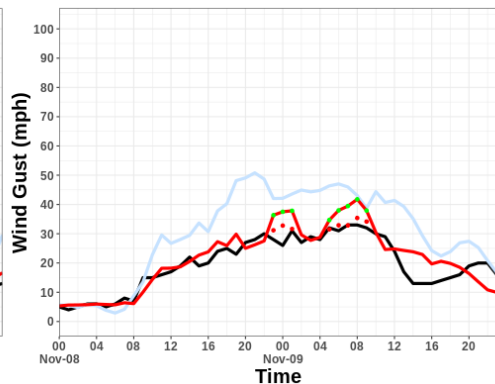
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 13.19 Bias = 9.90  
MODEL RMSE = 6.75 Bias = -3.62



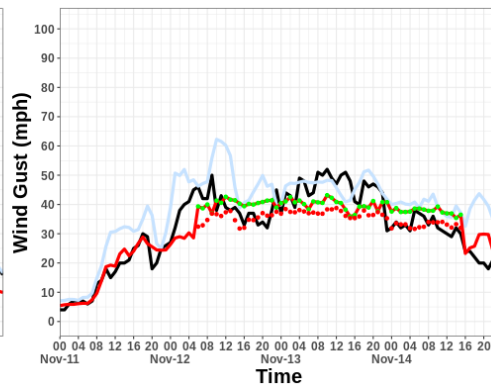
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 12.81 Bias = 10.33  
MODEL RMSE = 4.97 Bias = 1.87



Test: 2018-11-11 to 2018-11-14

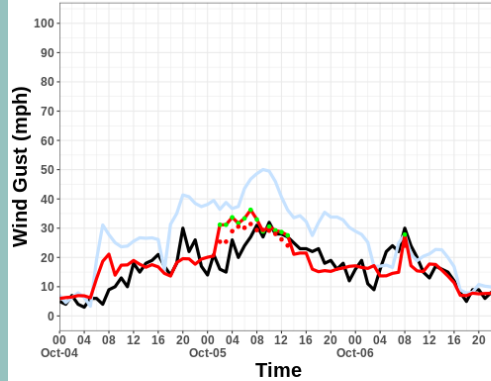
WRF RMSE = 9.65 Bias = 6.79  
MODEL RMSE = 5.99 Bias = -0.22



## Wind Gust ML Validation for Lake Wohlford

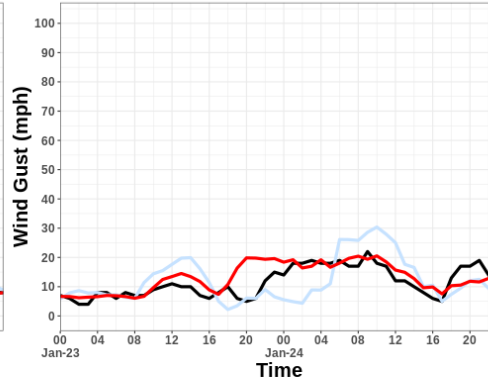
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 12.53 Bias = 9.69  
MODEL RMSE = 5.60 Bias = 0.90



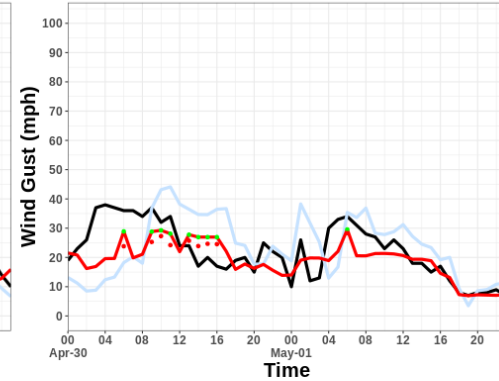
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 6.89 Bias = 0.68  
MODEL RMSE = 4.51 Bias = 1.71



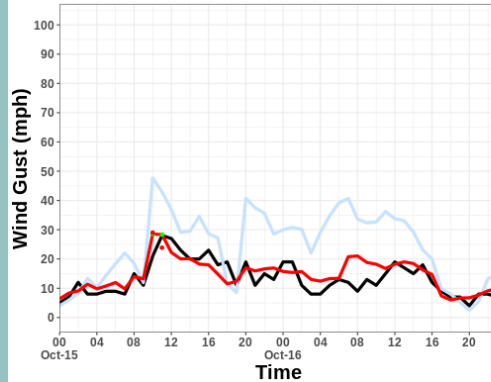
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 12.21 Bias = 1.18  
MODEL RMSE = 7.74 Bias = -3.19



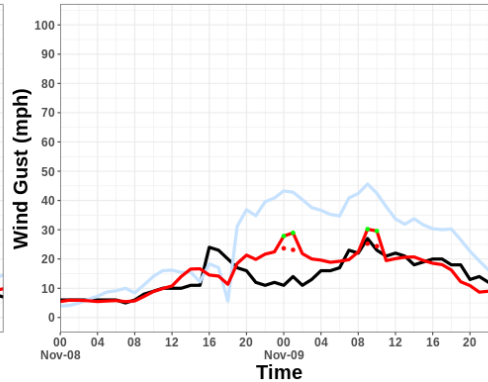
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 14.35 Bias = 10.74  
MODEL RMSE = 3.91 Bias = 1.25



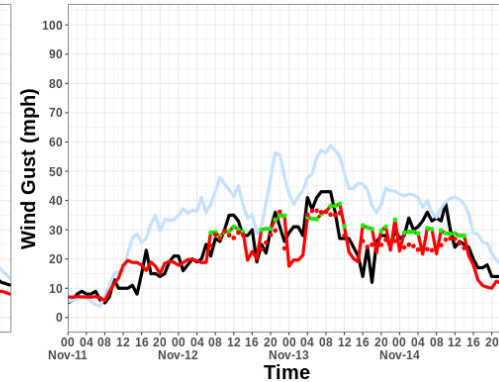
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 14.94 Bias = 10.62  
MODEL RMSE = 5.61 Bias = 1.29



Test: 2018-11-11 to 2018-11-14

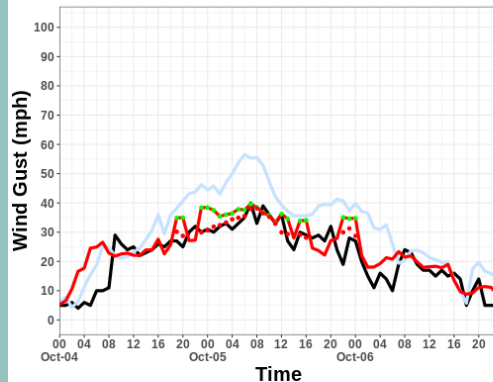
WRF RMSE = 13.97 Bias = 11.75  
MODEL RMSE = 5.81 Bias = -0.56



## Wind Gust ML Validation for Viejas

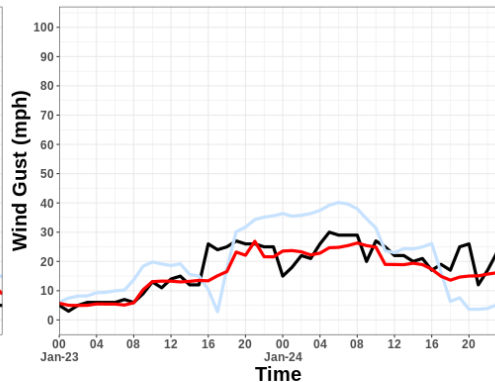
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 11.44 Bias = 8.96  
MODEL RMSE = 6.39 Bias = 3.13



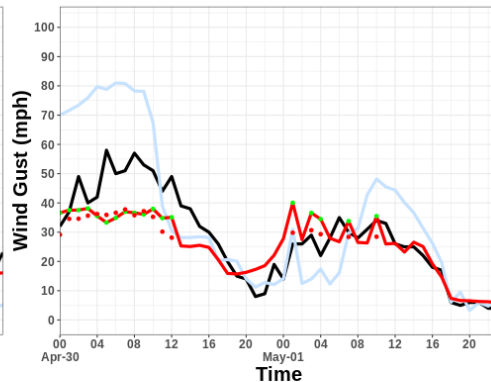
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 10.25 Bias = 2.74  
MODEL RMSE = 4.52 Bias = -1.85



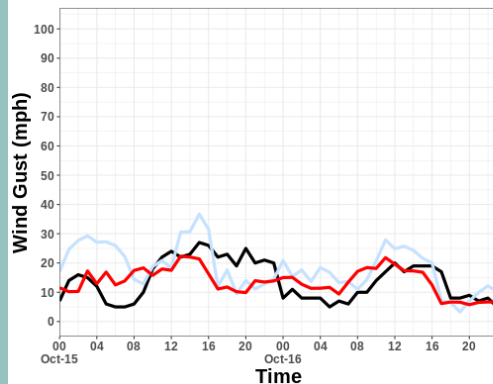
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 16.32 Bias = 6.58  
MODEL RMSE = 8.95 Bias = -2.54



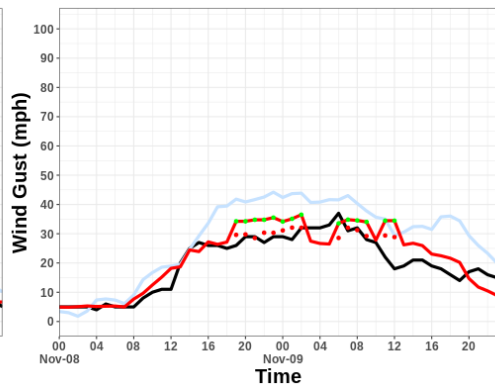
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 9.14 Bias = 4.33  
MODEL RMSE = 6.40 Bias = -0.27



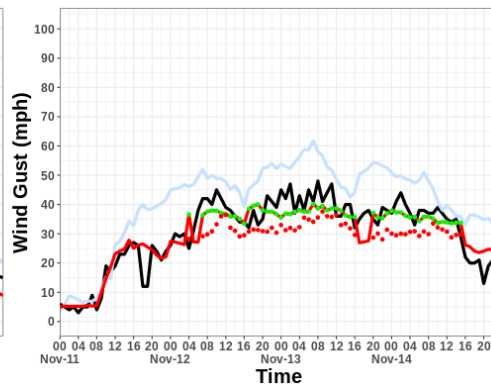
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 10.42 Bias = 8.62  
MODEL RMSE = 5.30 Bias = 2.26



Test: 2018-11-11 to 2018-11-14

WRF RMSE = 12.32 Bias = 10.55  
MODEL RMSE = 4.92 Bias = -0.83

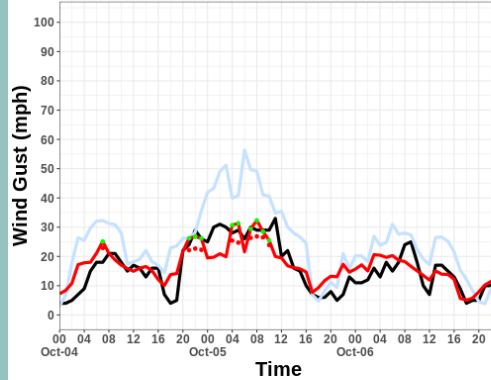




# Wind Gust ML Validation for Rainbow

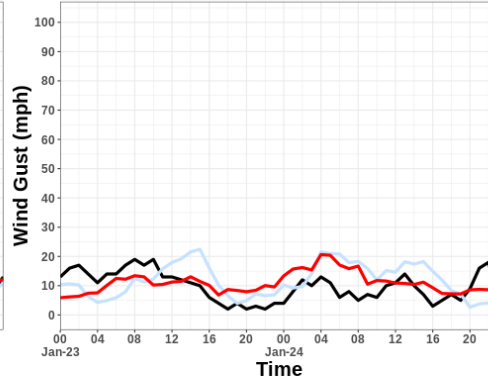
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 11.09 Bias = 8.80  
MODEL RMSE = 4.97 Bias = 0.94



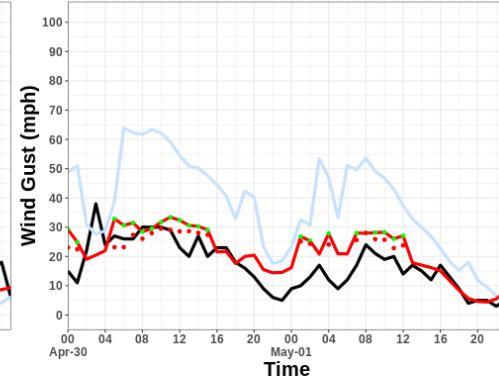
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 7.59 Bias = 2.11  
MODEL RMSE = 5.92 Bias = 1.24



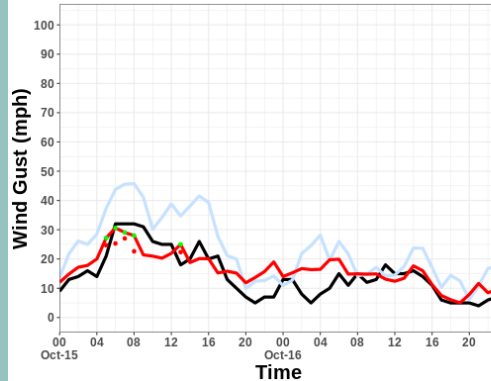
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 23.90 Bias = 20.77  
MODEL RMSE = 7.77 Bias = 4.74



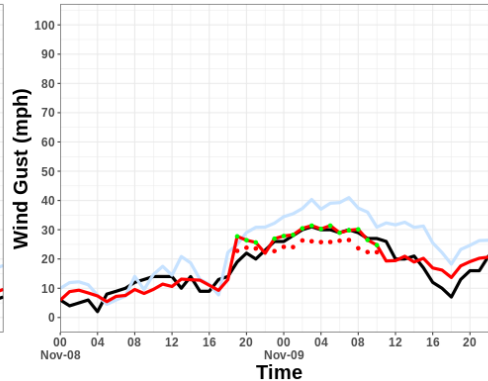
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 10.49 Bias = 8.76  
MODEL RMSE = 5.20 Bias = 2.00



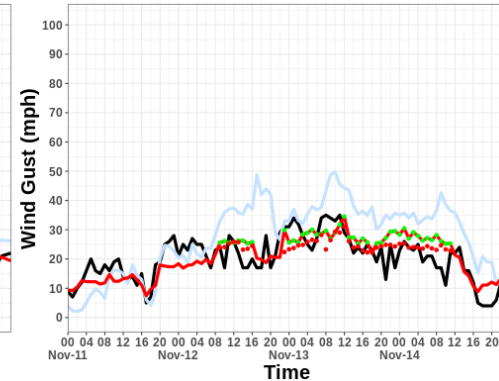
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 7.94 Bias = 6.43  
MODEL RMSE = 3.45 Bias = 0.81



Test: 2018-11-11 to 2018-11-14

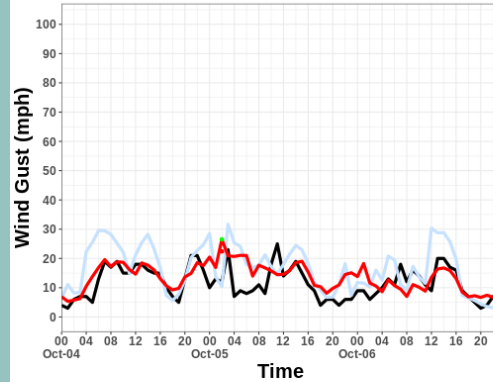
WRF RMSE = 11.98 Bias = 7.19  
MODEL RMSE = 5.63 Bias = 0.53



## Wind Gust ML Validation for Fallbrook

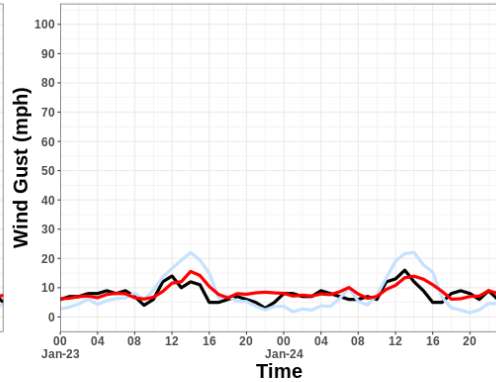
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 8.02 Bias = 5.06  
MODEL RMSE = 5.29 Bias = 2.03



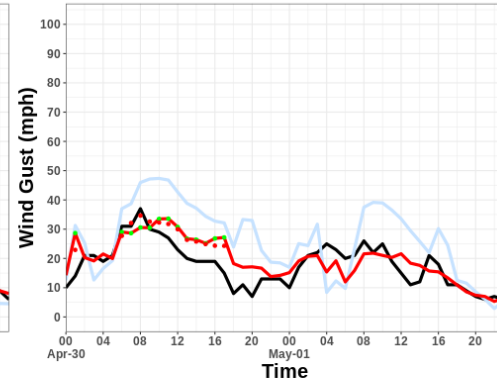
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 4.86 Bias = 0.23  
MODEL RMSE = 2.41 Bias = 0.75



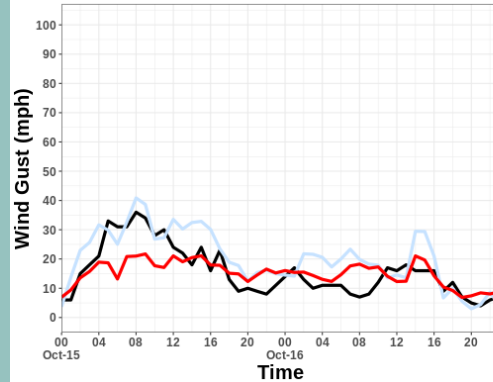
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 12.80 Bias = 8.53  
MODEL RMSE = 5.53 Bias = 1.77



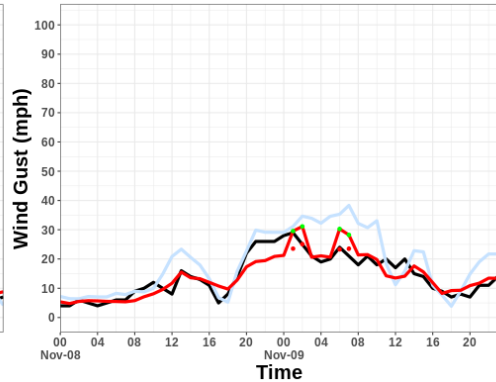
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 7.52 Bias = 4.66  
MODEL RMSE = 6.52 Bias = -0.45



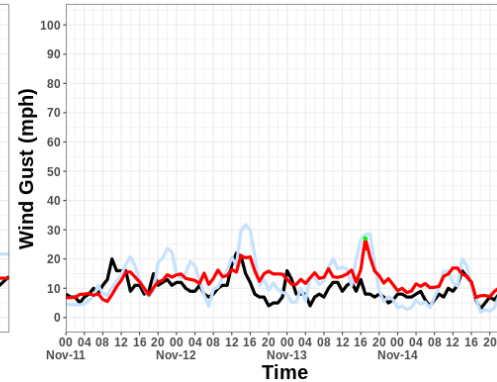
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 7.24 Bias = 4.63  
MODEL RMSE = 3.38 Bias = 0.04



Test: 2018-11-11 to 2018-11-14

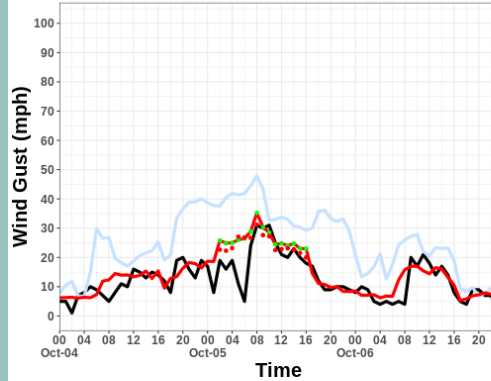
WRF RMSE = 6.63 Bias = 2.52  
MODEL RMSE = 5.43 Bias = 3.03



## Wind Gust ML Validation for San Pasqual Valley

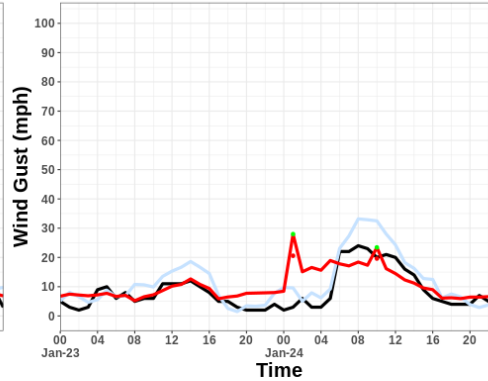
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 15.30 Bias = 12.62  
MODEL RMSE = 4.92 Bias = 1.82



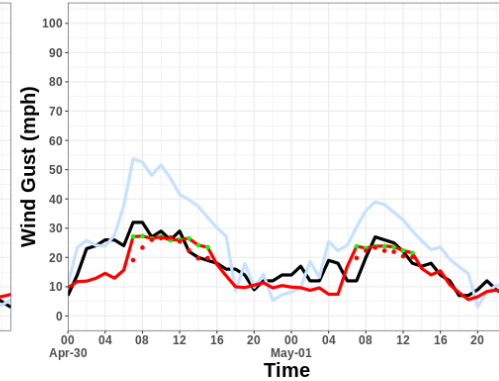
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 4.68 Bias = 3.17  
MODEL RMSE = 5.99 Bias = 2.15



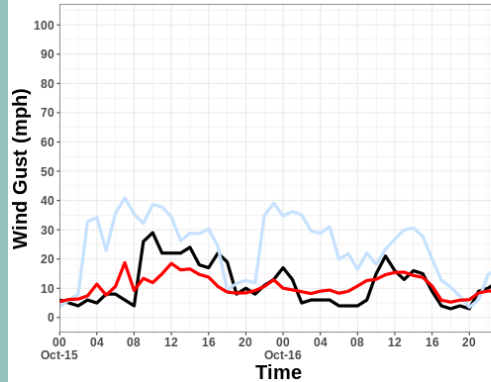
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 11.24 Bias = 7.47  
MODEL RMSE = 5.41 Bias = -2.22



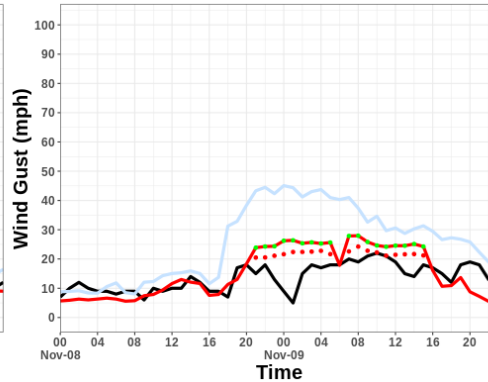
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 16.18 Bias = 12.48  
MODEL RMSE = 5.47 Bias = -0.61



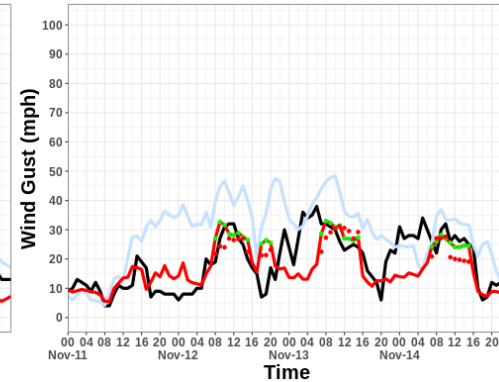
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 16.04 Bias = 12.00  
MODEL RMSE = 6.89 Bias = 1.79



Test: 2018-11-11 to 2018-11-14

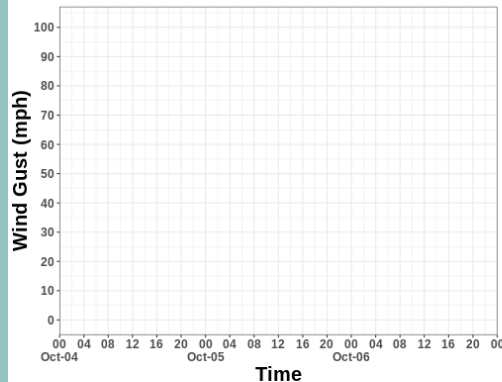
WRF RMSE = 14.80 Bias = 10.22  
MODEL RMSE = 7.77 Bias = -1.53



## Wind Gust ML Validation for Santa Teresa Valley

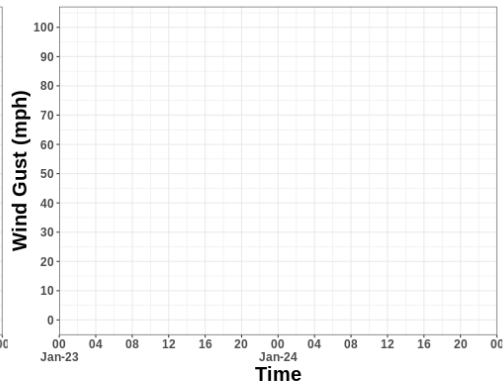
Test: 2013-10-04 to 2013-10-06

WRF RMSE = NaN Bias = NaN  
MODEL RMSE = NaN Bias = NaN



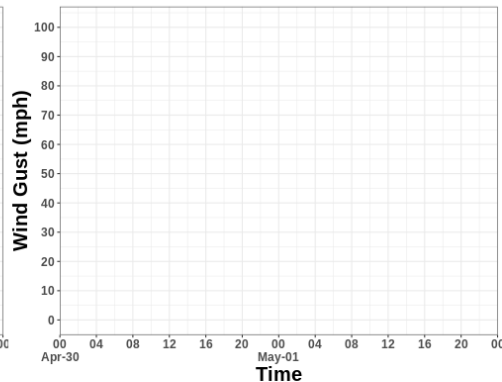
Test: 2014-01-23 to 2014-01-24

WRF RMSE = NaN Bias = NaN  
MODEL RMSE = NaN Bias = NaN



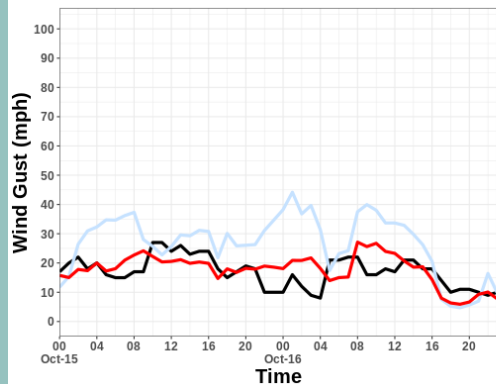
Test: 2014-04-30 to 2014-05-01

WRF RMSE = NaN Bias = NaN  
MODEL RMSE = NaN Bias = NaN



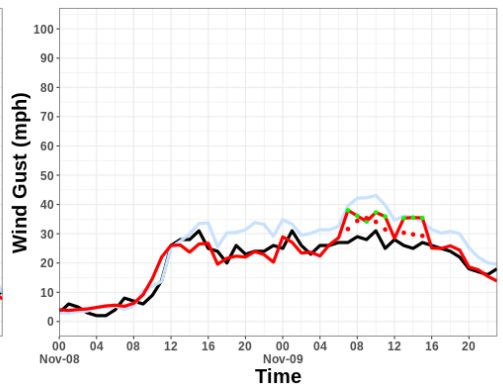
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 14.29 Bias = 9.63  
MODEL RMSE = 5.56 Bias = 0.70



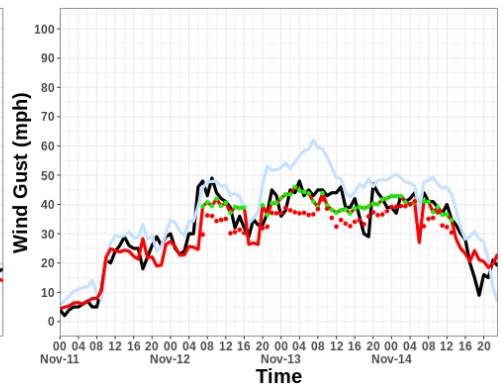
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 6.88 Bias = 5.14  
MODEL RMSE = 4.52 Bias = 1.33



Test: 2018-11-11 to 2018-11-14

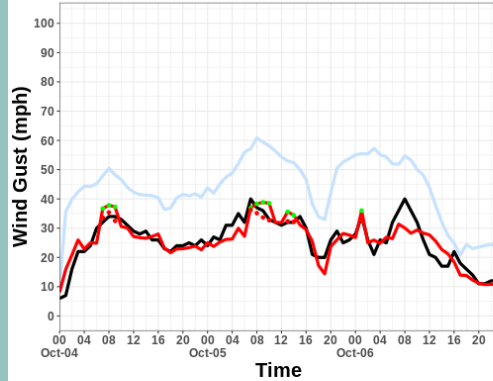
WRF RMSE = 8.58 Bias = 6.25  
MODEL RMSE = 5.13 Bias = -0.92



# Wind Gust ML Validation for Tierra Del Sol

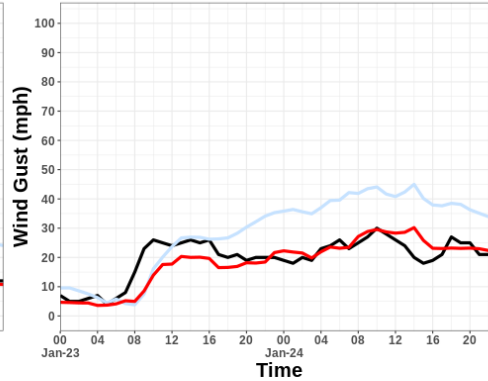
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 18.90 Bias = 17.84  
MODEL RMSE = 3.60 Bias = -0.21



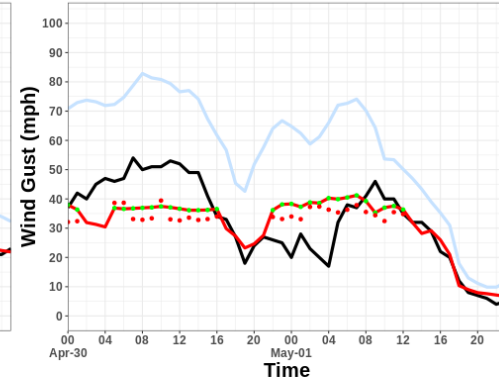
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 12.61 Bias = 8.79  
MODEL RMSE = 4.67 Bias = -1.34



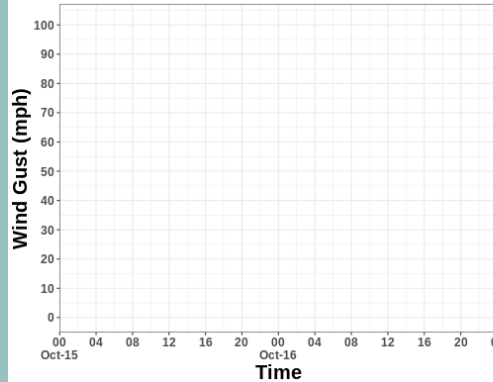
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 27.26 Bias = 24.69  
MODEL RMSE = 9.78 Bias = -1.27



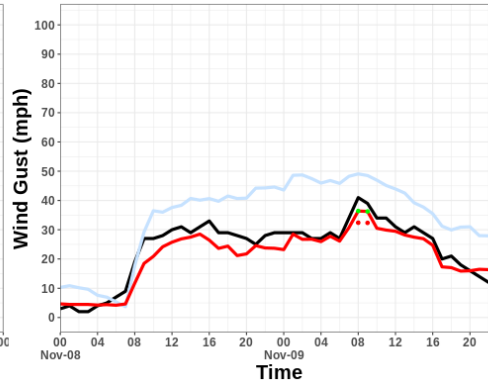
Test: 2018-10-15 to 2018-10-16

WRF RMSE = NaN Bias = NaN  
MODEL RMSE = NaN Bias = NaN



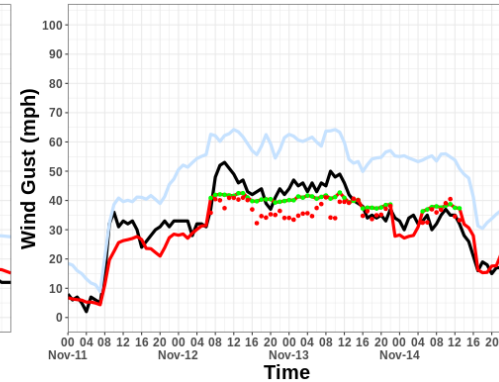
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 12.30 Bias = 10.89  
MODEL RMSE = 3.75 Bias = -2.42



Test: 2018-11-11 to 2018-11-14

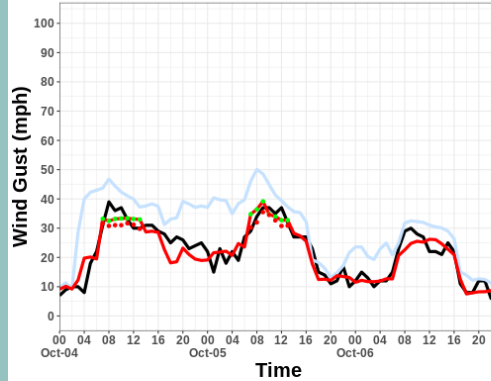
WRF RMSE = 16.56 Bias = 15.61  
MODEL RMSE = 4.92 Bias = -2.07



## Wind Gust ML Validation for Campo

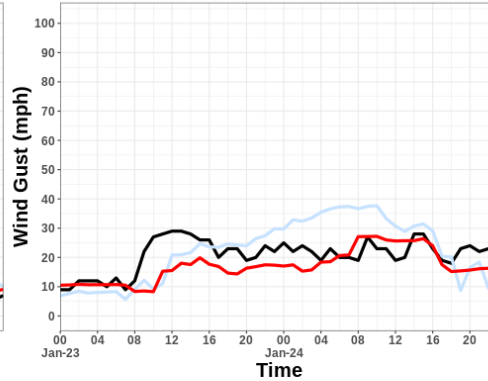
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 10.90 Bias = 8.70  
MODEL RMSE = 3.58 Bias = -0.55



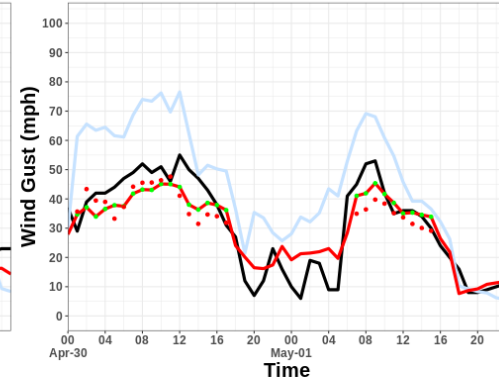
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 9.38 Bias = 1.39  
MODEL RMSE = 6.71 Bias = -3.81



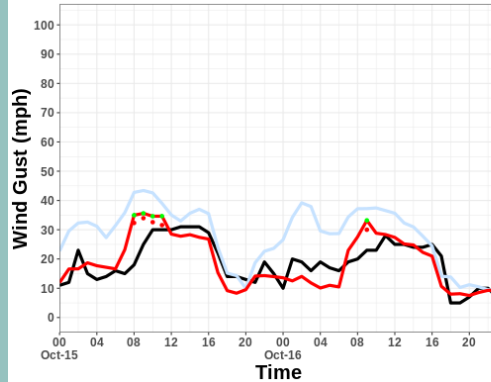
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 17.43 Bias = 13.95  
MODEL RMSE = 6.98 Bias = -0.95



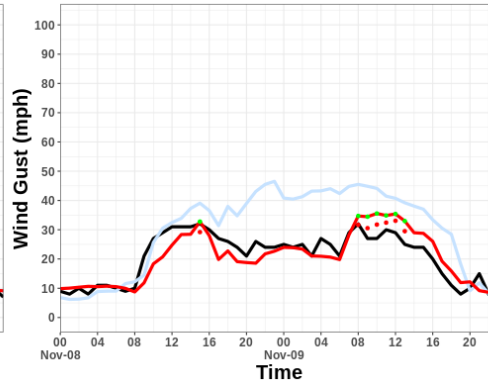
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 11.81 Bias = 9.41  
MODEL RMSE = 5.44 Bias = 0.16



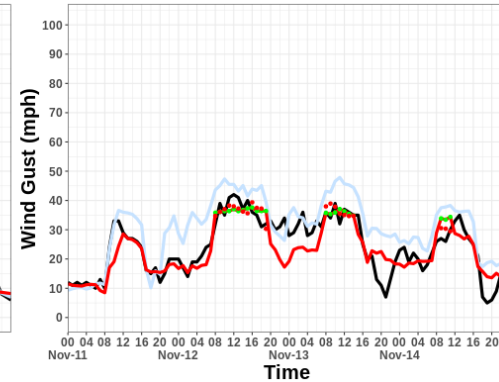
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 12.24 Bias = 8.86  
MODEL RMSE = 4.48 Bias = -0.23



Test: 2018-11-11 to 2018-11-14

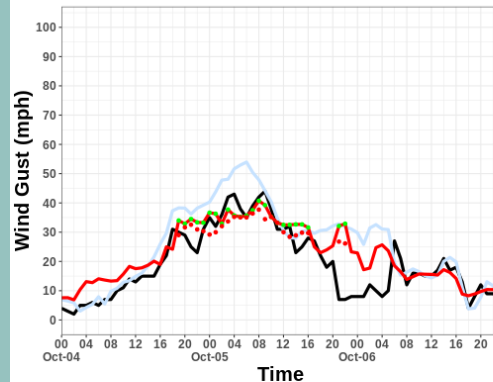
WRF RMSE = 8.62 Bias = 6.41  
MODEL RMSE = 5.27 Bias = -1.03



# Wind Gust ML Validation for Loveland

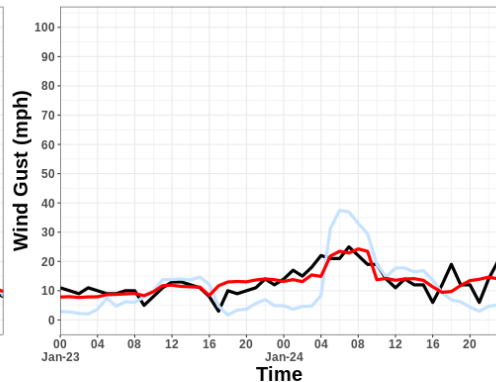
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 9.97 Bias = 6.07  
MODEL RMSE = 7.38 Bias = 3.45



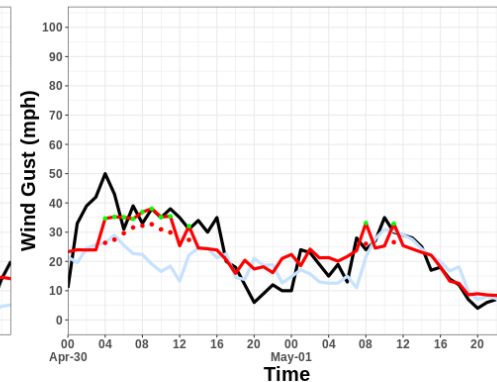
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 7.72 Bias = -2.02  
MODEL RMSE = 3.36 Bias = 0.06



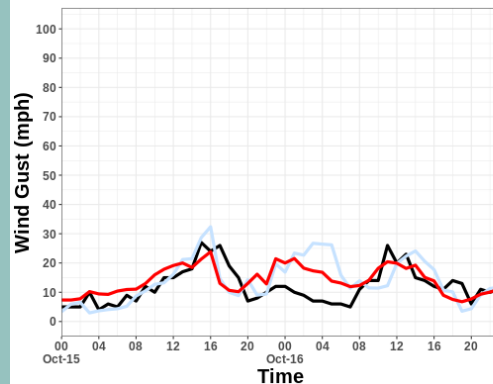
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 10.12 Bias = -4.42  
MODEL RMSE = 7.24 Bias = -0.34



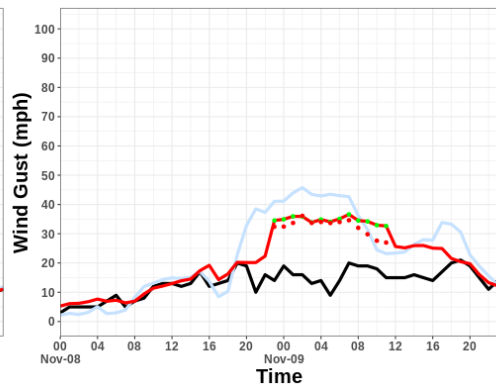
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 7.55 Bias = 1.94  
MODEL RMSE = 5.60 Bias = 2.05



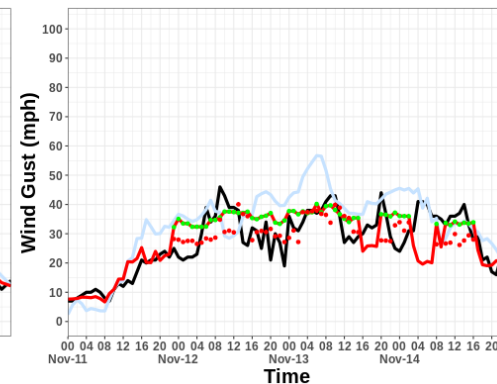
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 14.85 Bias = 9.53  
MODEL RMSE = 10.77 Bias = 7.28



Test: 2018-11-11 to 2018-11-14

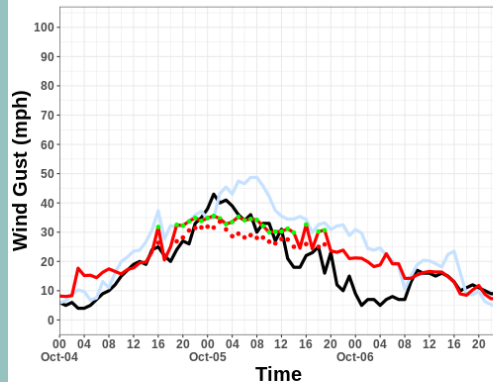
WRF RMSE = 10.02 Bias = 5.66  
MODEL RMSE = 7.12 Bias = 0.82



## Wind Gust ML Validation for Japatul Valley Rd

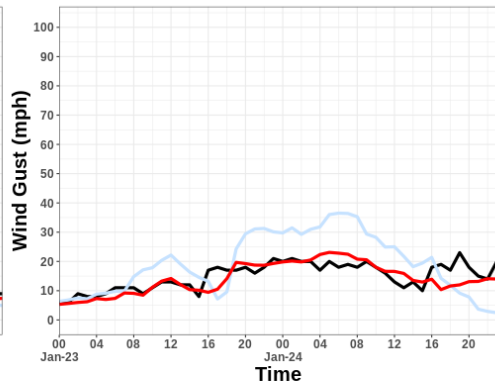
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 10.20 Bias = 7.38  
MODEL RMSE = 7.05 Bias = 3.74



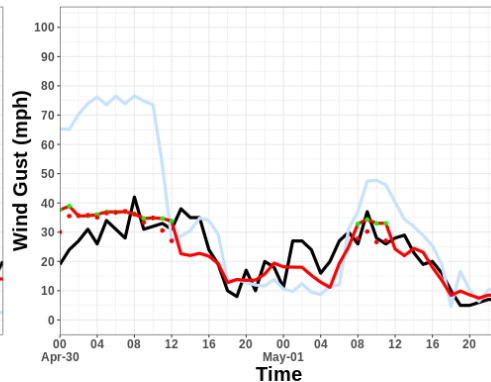
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 9.83 Bias = 4.28  
MODEL RMSE = 3.59 Bias = -0.75



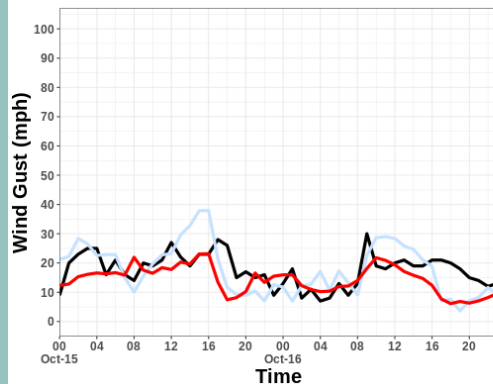
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 22.47 Bias = 11.27  
MODEL RMSE = 6.96 Bias = 0.35



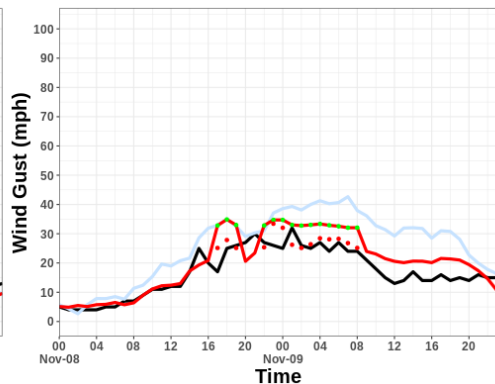
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 7.67 Bias = 0.17  
MODEL RMSE = 6.68 Bias = -3.29



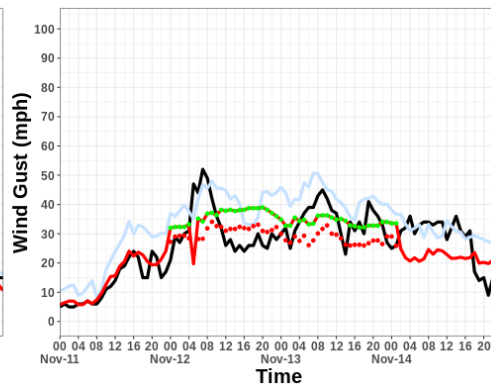
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 10.85 Bias = 9.03  
MODEL RMSE = 5.71 Bias = 3.47



Test: 2018-11-11 to 2018-11-14

WRF RMSE = 9.82 Bias = 7.30  
MODEL RMSE = 8.03 Bias = 0.21

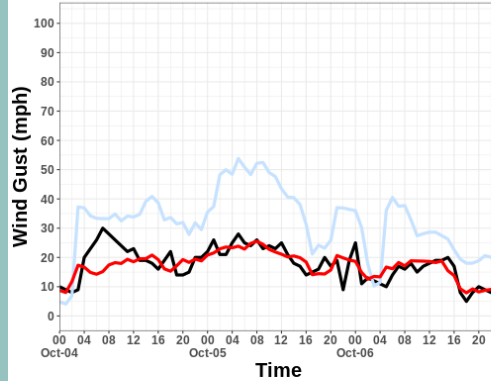




## Wind Gust ML Validation for Guatay

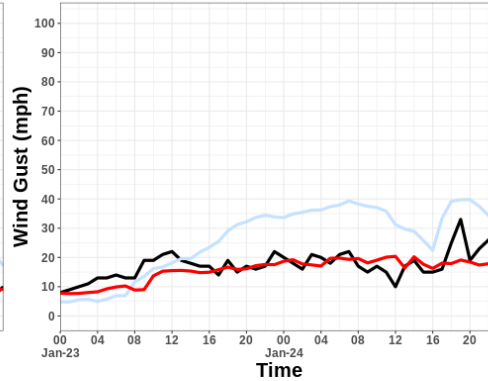
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 16.67 Bias = 14.37  
MODEL RMSE = 4.30 Bias = -0.54



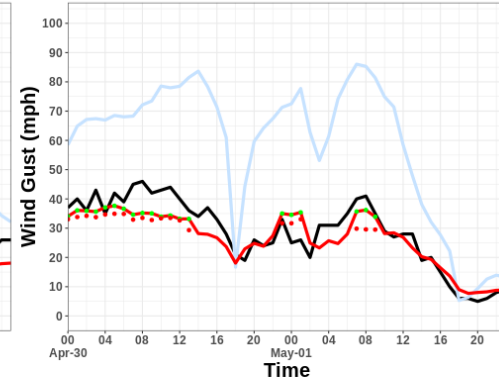
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 13.05 Bias = 8.74  
MODEL RMSE = 4.49 Bias = -1.82



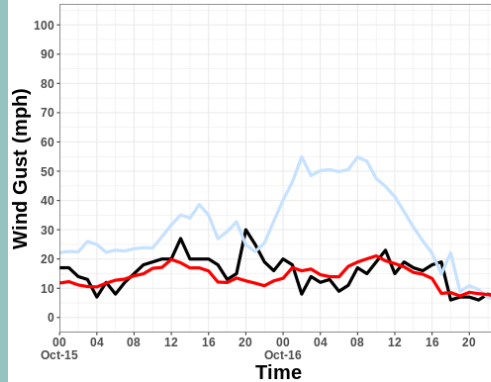
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 32.77 Bias = 29.17  
MODEL RMSE = 5.23 Bias = -2.05



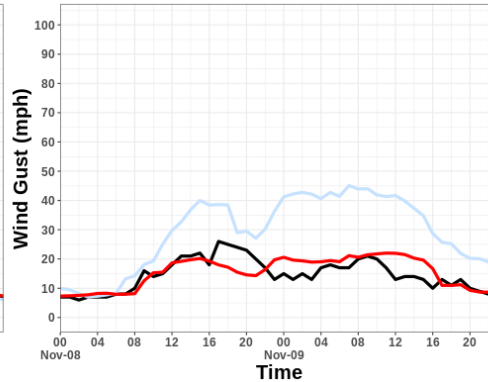
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 20.28 Bias = 15.47  
MODEL RMSE = 5.06 Bias = -1.47



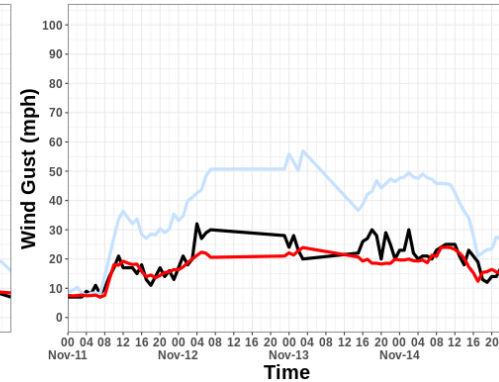
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 17.24 Bias = 14.51  
MODEL RMSE = 4.19 Bias = 0.84



Test: 2018-11-11 to 2018-11-14

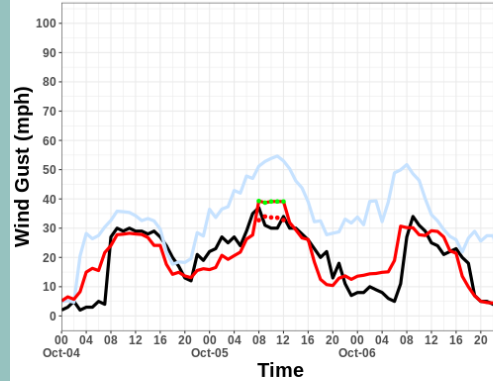
WRF RMSE = 17.90 Bias = 15.69  
MODEL RMSE = 4.37 Bias = -2.05



## Wind Gust ML Validation for Mataguay

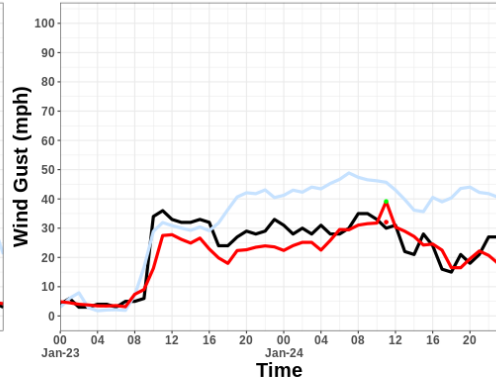
Test: 2013-10-04 to 2013-10-06

WRF RMSE = 17.39 Bias = 14.41  
MODEL RMSE = 6.26 Bias = 0.85



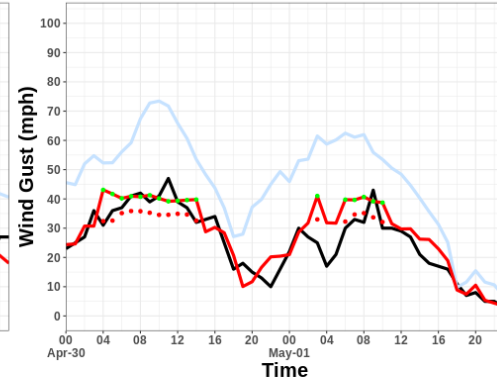
Test: 2014-01-23 to 2014-01-24

WRF RMSE = 12.98 Bias = 9.56  
MODEL RMSE = 5.59 Bias = -2.60



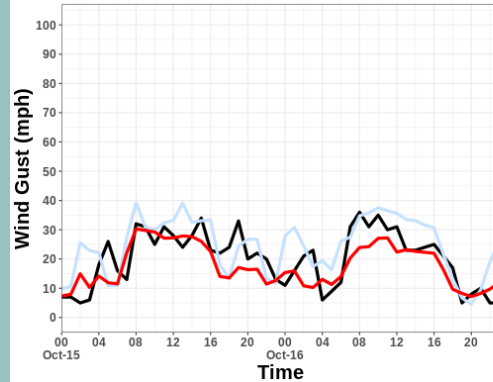
Test: 2014-04-30 to 2014-05-01

WRF RMSE = 22.77 Bias = 20.58  
MODEL RMSE = 6.00 Bias = 2.77



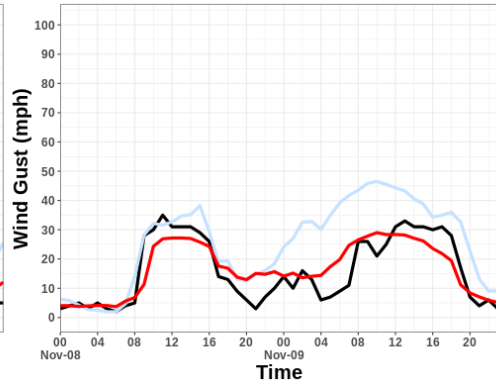
Test: 2018-10-15 to 2018-10-16

WRF RMSE = 9.14 Bias = 4.40  
MODEL RMSE = 6.56 Bias = -2.48



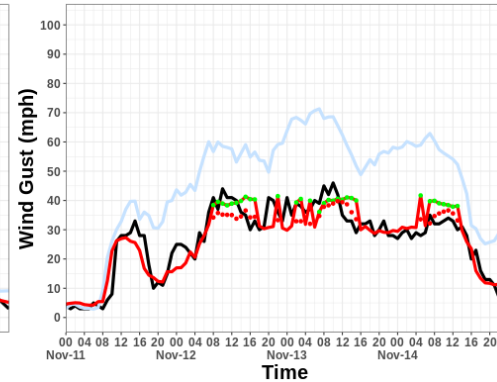
Test: 2018-11-08 to 2018-11-09

WRF RMSE = 12.80 Bias = 9.35  
MODEL RMSE = 5.95 Bias = 0.53



Test: 2018-11-11 to 2018-11-14

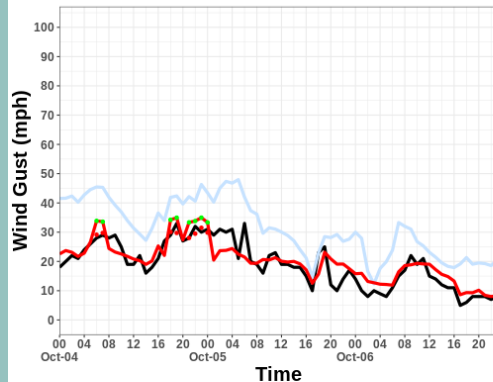
WRF RMSE = 21.29 Bias = 19.23  
MODEL RMSE = 5.12 Bias = 0.29



## Wind Gust ML Validation for Chihuahua Valley

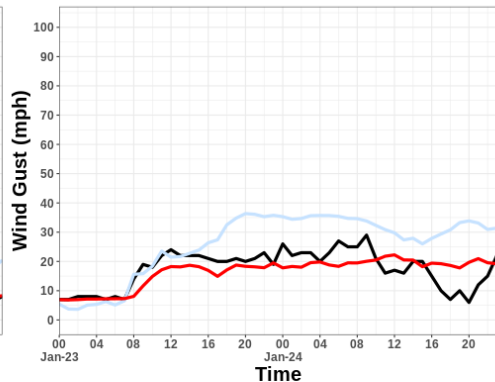
**Test: 2013-10-04 to 2013-10-06**

WRF RMSE = 13.29 Bias = 12.31  
MODEL RMSE = 4.00 Bias = 1.05



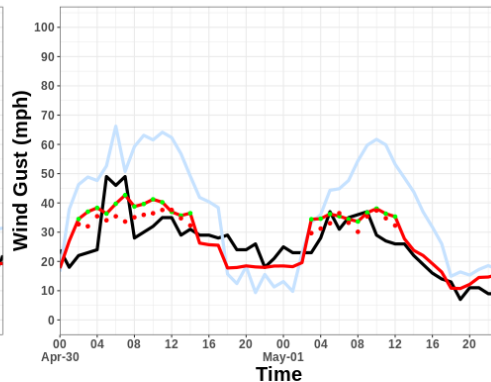
**Test: 2014-01-23 to 2014-01-24**

WRF RMSE = 11.75 Bias = 8.45  
MODEL RMSE = 5.25 Bias = -0.97



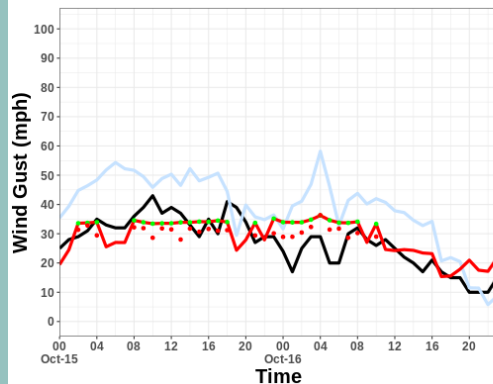
**Test: 2014-04-30 to 2014-05-01**

WRF RMSE = 18.32 Bias = 11.96  
MODEL RMSE = 6.89 Bias = 1.82



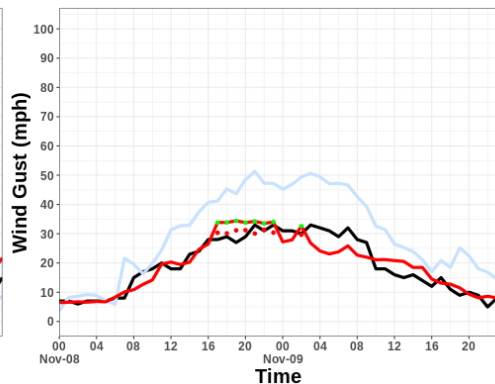
**Test: 2018-10-15 to 2018-10-16**

WRF RMSE = 14.01 Bias = 11.69  
MODEL RMSE = 6.74 Bias = 1.68



**Test: 2018-11-08 to 2018-11-09**

WRF RMSE = 12.19 Bias = 10.49  
MODEL RMSE = 3.72 Bias = -0.01



**Test: 2018-11-11 to 2018-11-14**

WRF RMSE = 20.00 Bias = 16.66  
MODEL RMSE = 7.88 Bias = 1.38

