FINAL REPORT

CPP PROJECT 9413 REV02
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KERN COUNTY SPECIAL WIND REGION STUDY

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EXECUTIVE SUMMARY

The western side of the Antelope Valley in the southeast corner of Kern County is known for strong downslope wind events, featuring west winds blowing down from the southern tail of the Sierra Nevada Mountains. A portion of this valley is included in an ASCE 7-10 special wind region, and in the Kern county special wind regions. However, the location of the special wind region as indicated in ASCE 7 and on the Kern County Basic Wind Speed Map is not consistent with the location and boundary of the strong downslope winds.

The goal of this study is to collect the available wind data from local weather stations in this area to determine a more accurate special wind region boundary. This study provides variations in design wind speeds measured throughout the county using available historic meteorological data from the National Climatic Data Center (NCDC). Our analysis of wind speeds in this region confirms that a shifting of the boundaries of the current special wind regions is justified. Based on our analysis, CPP has provided recommendations for special region boundaries and corresponding wind loadings in Kern County for mean recurrence intervals (MRI) of 50 years, 100 years, 300 years, 700 years and 1700 years. Figures for each of the MRIs are provided in Appendix A.

BACKGROUND

Maps of basic wind speed for the USA are provided by The American Society of Civil Engineers (ASCE) *Minimum Design Loads for Buildings and Other Structures* (ASCE 7), to be used in the calculation of design wind loads. In some special wind regions, wind speeds are not provided, as described in section C26.5.2 of the ASCE 7-10 commentary:

> *"Although the wind speed map of Fig. 26.5-1 is valid for most regions of the country, there are special regions in which wind speed anomalies are known to exist. Some of these special regions are noted in Fig. 26.5-1."*

Figure 26.5-1 is the basic wind speed map, a portion of which is reproduced in Figure 1. It can be seen that the southern end of the special wind region covering the Sierra Nevada Mountains covers the eastern portion of Kern County.

Figure 1: *ASCE 7-10 wind speed map, showing special wind regions in grey.*

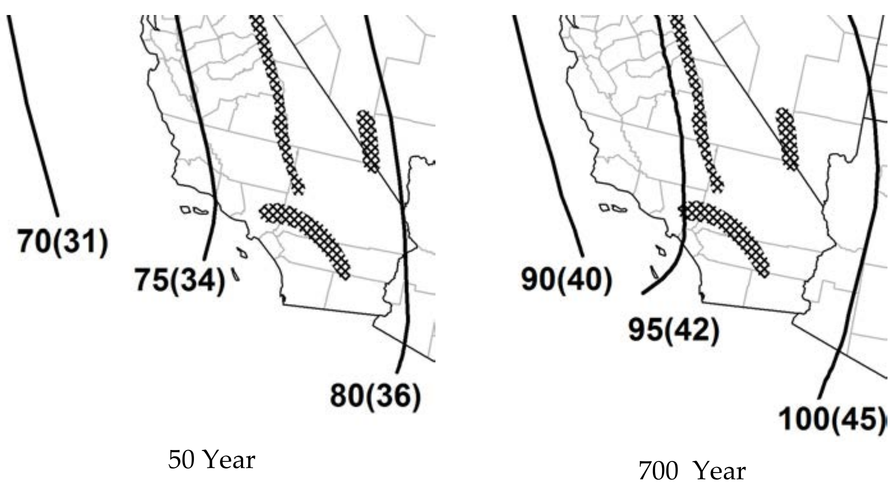


Figure 2: *ASCE 7-16 wind speed map, mph.*

As the above excerpt from the commentary implies, not all special wind regions across the US have been accurately identified in the basic wind speed maps. Section 26.5.2 of ASCE 7-10 requires that local authority having jurisdiction (AHJ) account for this:

> *"The authority having jurisdiction shall, if necessary, adjust the [basic wind speeds] to account for higher local wind speeds."*

It is the purpose of this study to determine where a special wind region is warranted in eastern Kern County, and what the basic wind speeds should be in this region. This includes redrawing the special wind region (SWR) boundaries as necessary.

Special wind region status implies that the basic wind speed is greater than that provided for the surrounding area in the wind map. For ASCE 7-10, this implies a 700-year Mean Recurrence Interval (MRI) wind speed (U_{700}) greater than 110 mph, and a 50-year MRI wind speed (U_{50}) greater than 85 mph (Levitan and Vickery 2014).

The basic wind speed map has been significantly revised in the forthcoming ASCE 7-16 standard. A portion of the map has been reproduced in Figure 2. It can be seen that the special wind regions are considerably smaller than in ASCE 7-10. This is a restoration of the original SWR boundaries from 1982 (Searer et al, 2010).

The basic wind speeds are no longer uniform across the county, but rather are interpolated between the contour lines. Based on the ASCE7-16, it is also apparent that the basic wind speeds in Kern County will decrease significantly from ASCE 7-10. As a result, any location in eastern Kern County with U_{700} above 95 mph should be considered a SWR when using ASCE 7-16. Similarly, any location with $U_{50} > 77$ mph should be classified as a special wind region.

METHODS

Section 26.5.2 of ASCE 7-10 requires that if the AHJ is to adjust the basic wind speed, it must be *"based on meteorological information and an estimate of the basic wind speed obtained in accordance with [accepted practice as described in] Section 26.5.3"*.Section 26.5.3, called "Estimation of Basic Wind Speeds from Regional Climatic Data" provides instructions for determining design wind speeds in these regions:

> *In areas outside hurricane-prone regions, regional climatic data shall only be used in lieu of basic wind speed given in Fig. 26.5-1 (1) approved extreme-value statistical-analysis procedures have employed in reducing the data; and (2) the length of record, sampling error, averaging time, anemometer height, data quality, and terrain exposure of the anemometer have been taken into account. Reduction in basic wind speed below that of Fig. 26.5-1 shall be permitted."*

Recommendations for reductions in basic wind speed below those in ASCE 7 are beyond the scope of this study. This study aims to identify regions of Kern County with wind speeds above those in ASCE 7-10 and ASCE 7-16, and to quantify those speeds where possible.

In order to fulfill these requirements, CPP has been retained to perform an extreme wind speed analysis. CPP's extreme wind speed analysis methods (Peterka 1992) fulfill both ASCE7 conditions (1) and (2), reproduced below. The recommendations in this study are based on the same kind of extreme value statistical analyses that provided the basis for the ASCE 7 wind maps over the past two decades (Peterka and Shahid 1998) and the Colorado Front Range Gust Map (Peterka 2006).

EXTREME VALUE CURVE FITS

The extreme value analysis methods used in this study are well described in Palutikof et al (1999). We have assumed a Fisher–Tippett Type 1 generalized extreme value distribution, also known as the Gumbel distribution. This is potentially conservative for MRIs longer than 300 years, as the severity of winds for any given storm type is not unlimited.

In this study, we fit peak wind gust data to this distribution using a Weighted Least Squares (WLS) method. This is a graphical method, with an alternative fitting strategy to account for the error associated with each point being greatest for the largest extremes. As there were generally too many points for the Lieblein BLUE method, we employed a Monte Carlo simulation to determine the expected errors for each point. The normalized errors were then minimized using least squares. The reduced variate (based on the recurrence intervals) was unbiased using Gringorten's formula, as described by Palutikof et al (1999).

There are other methods of fitting the data, including a linear least squares fit, the Maximum Likelihood Estimates (MLE), and the Method of Moments (MoM). The predictions from these three methods typically varied by under 5%.

The WLS fitting technique described above was applied to both annual peak gusts, and to peak wind gusts from independent storms. A 4-day exclusion window around the peak gust was used to separate independent storms. The results of this Method of Independent Storms (MIS) also vary with the number of storms selected. We have followed the recommendations of Cook (2014) and limited the fitting range to roughly 3 storms per year. The selection of data used in the fitting introduces an uncertainly of around 5%.

The largest source of uncertainty, however, is typically the duration of the weather record. A graph of extreme wind speeds from the China Lake weather station and their associated return periods is shown in Figure 3. The light blue lines indicate the 95% uncertainty bounds associated with the amount of data available. We have predicted U_{700} = 76 mph, with a 2.5% chance that the 20 years of data were unusually calm, and the real U_{700} value is 87 mph. Note that even this upper bound is less than the ASCE 7-10 and ASCE7-16 values.

The Monte Carlo simulation used in the WLS method is also used to interpret the significance of variability in the data (i.e. to examine the goodness-of-fit). If the fit is accurate, then 95% of time the wind speeds should fall between the red lines in Figure 3. There is only a 5% chance that a data point will lie either above or below these lines – 2.5% on each side, so points out side these lines generally indicate a poor fit.

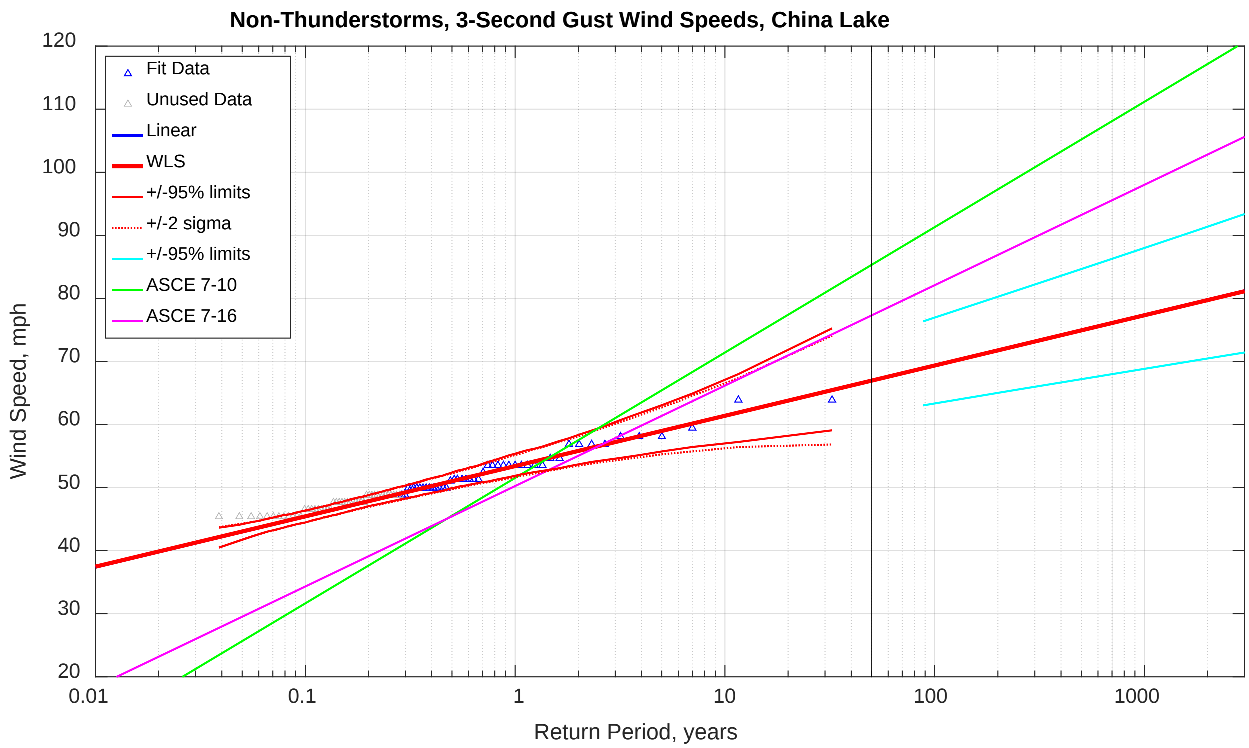


Figure 3: China Lake Wind Station – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust.

SEPARATING BY STORM TYPE

It is well known that different storm types will produce different extreme wind probability distributions. This is one reason why hurricane winds have traditionally been analyzed separately from other winds. The new wind maps in ASCE 7-16 also separate thunderstorms, and Figure 4, taken from the ASCE 7-16 wind map "Rationale for Changes" document, indicates that thunderstorms are not expected to be significant in Kern County.

Storm separation has been performed for this study, and indeed thunderstorms winds were much less severe than other winds at all stations examined. Downslope winds were identified by performing directional wind analysis, since these winds come off the mountains to the west; in some cases, combining all wind directions dilutes the severity of the extreme wind predictions. As estimated by ASCE7 and shown in Figure 3, our analysis confirms that the occurrence of thunderstorms is low and does not significantly contribute to the controlling winds.

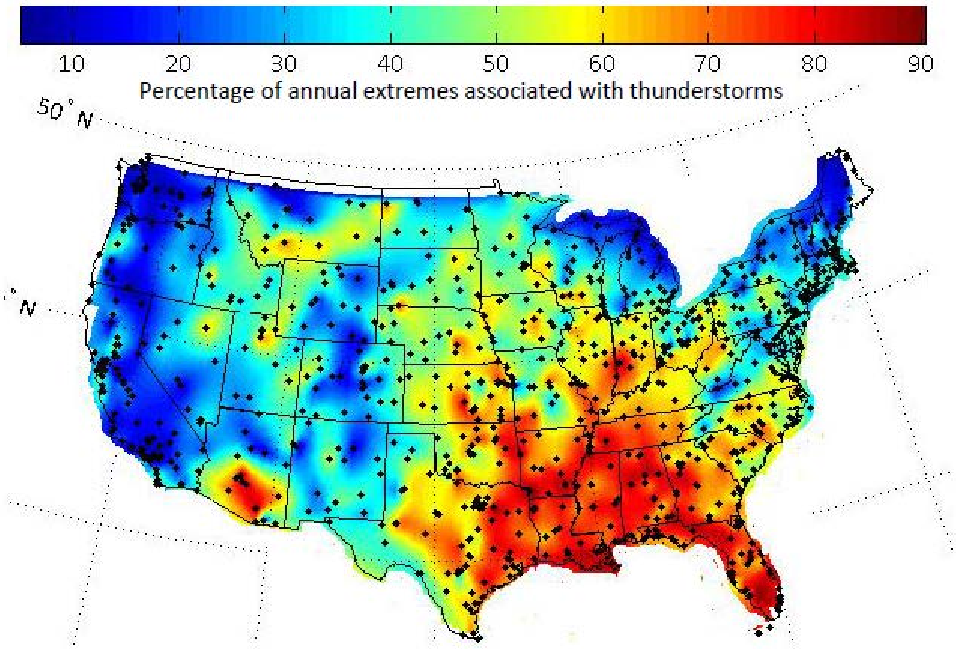


Figure 4: *Percentage of annual extreme wind speeds associated with thunderstorms (excluding annual extremes due to tropical cyclones), from rationale for ASCE 7-16 wind map.*

WIND DATA

We reviewed the available wind data from the National Climatic Data Center (NCDC) for the ground based weather stations located near and inside Kern County to gain an understanding of the wind climate in this area. A list of the local wind data stations is provided in Table 1. Both Global Historical Climatology Network (GHCN) peak daily gust and integrated hourly surface global data (TD3505), as available from the NCDC, were used in this analysis. These records do not generally match perfectly. The NCDC recommends that the GHCN[1] data be used to predict peak gust speeds, rather than the TD3505. However, the ASCE 7-16 wind maps are based on TD3505 data. This is likely because it is easier to isolate peak gusts due to thunderstorms in the hourly data records of TD3505.

The GHCN and NCDC peaks are generally within a few mph of each other, and comparable to the uncertainty associated with the different fitting methods. For return periods over 100 years, the discrepancy is much less than the uncertainty associated with the duration of the records.

[1] GHCN data is described here: http://www1.ncdc.noaa.gov/pub/data/cdo/documentation/GHCND_documentation.pdf

Table 1: *Data from Weather Stations Reviewed.*

Weather Stations Reviewed	Location	Latitude and Longitude
China Lake Weather Station	China Lake	35.688, -117.693
Cuddleback Gunnery Weather Station	Randsburg	35.267, -117.433
Edwards Air Force Base (AFB)	Edwards	34.900, -117.867
Edwards AFB North Auxiliary Airfield	Edwards	34.988, -117.865
General William J Fox Airfield	Landcaster	34.741, -118.212
Gray Butte Field Weather Station	Palmdale	34.564, -117.675
Inyokern Airport	Inyokern	35.667, -117.833
Meadows Field Airport	Bakersfield	35.434, -119.054
Mojave Air and Space Port Weather Station	Mojave	35.067, -118.150
Palmdale Regional Airport	Palmdale	34.629, -118.084
Porterville Municipal Airport	Porterville	36.029, -119.063
Sandberg Weather Station	Sandberg	34.744, -118.724
Southern California Logistics Airport	Victorville	34.583, -117.383
Tehachapi Municipal Airport	Tehachapi	35.135, -118.439

As part of our quality assurance, thorough quality control (QC) procedures were performed on all data to determine what data could be used for our analysis. At many of the stations, there were several years where the wind data were not considered to be reliable and thereby these data were not utilized. For example the wind stations at Cuddleback Gunnery Weather Station and Gray Butte Field Weather Station were not considered due to the lack of wind data. We also looked closely at the data and removed speed measurements that were considered unreliable or inconsistent to ensure that such "bad" data would not affect the overall results. The wind stations where data was utilized in our analysis are shown in Figure 5 and listed in Table 2. Table 2 also provides information on the years that data was utilized for both TD3505 and GHCN, corrections that were required, and the number of bad data points.

Table 2: *Weather Stations Utilized in Analysis.*

Weather Stations Used in Analysis	***TD3505 Years of data***	***GHCN Years of data***	***Corrections***	***# of bad data points***
China Lake Weather Station	1997-2016	1997-2016	Anemometer height corrected to 10 m	0
Edwards AFB North Auxiliary Airfield	2005-2016	2006-2016	No correction	0
Edwards Air Force Base	1993-2016	not used	Anemometer height corrected to 10 m	1
General William J Fox Airfield	1976-2016	n/a	Anemometer height corrected to 10 m	9
Inyokern Airport	1995-2013	n/a	No correction	0
Meadows Field Airport	1973-2016	1971-2016	Anemometer height corrected to 10 m	1
Mojave Airport	2011-2016	n/a	No correction	0
Palmdale Regional Airport	1976-2016	1998-2016	Anemometer height corrected to 10 m	2
Sandberg Weather Station	1996-2016	1998-2016	No correction	8
Southern California Logistics Airport	2005-2016	n/a	No correction	1
Tehachapi Municipal Airport	2010-2016	n/a	No correction	0

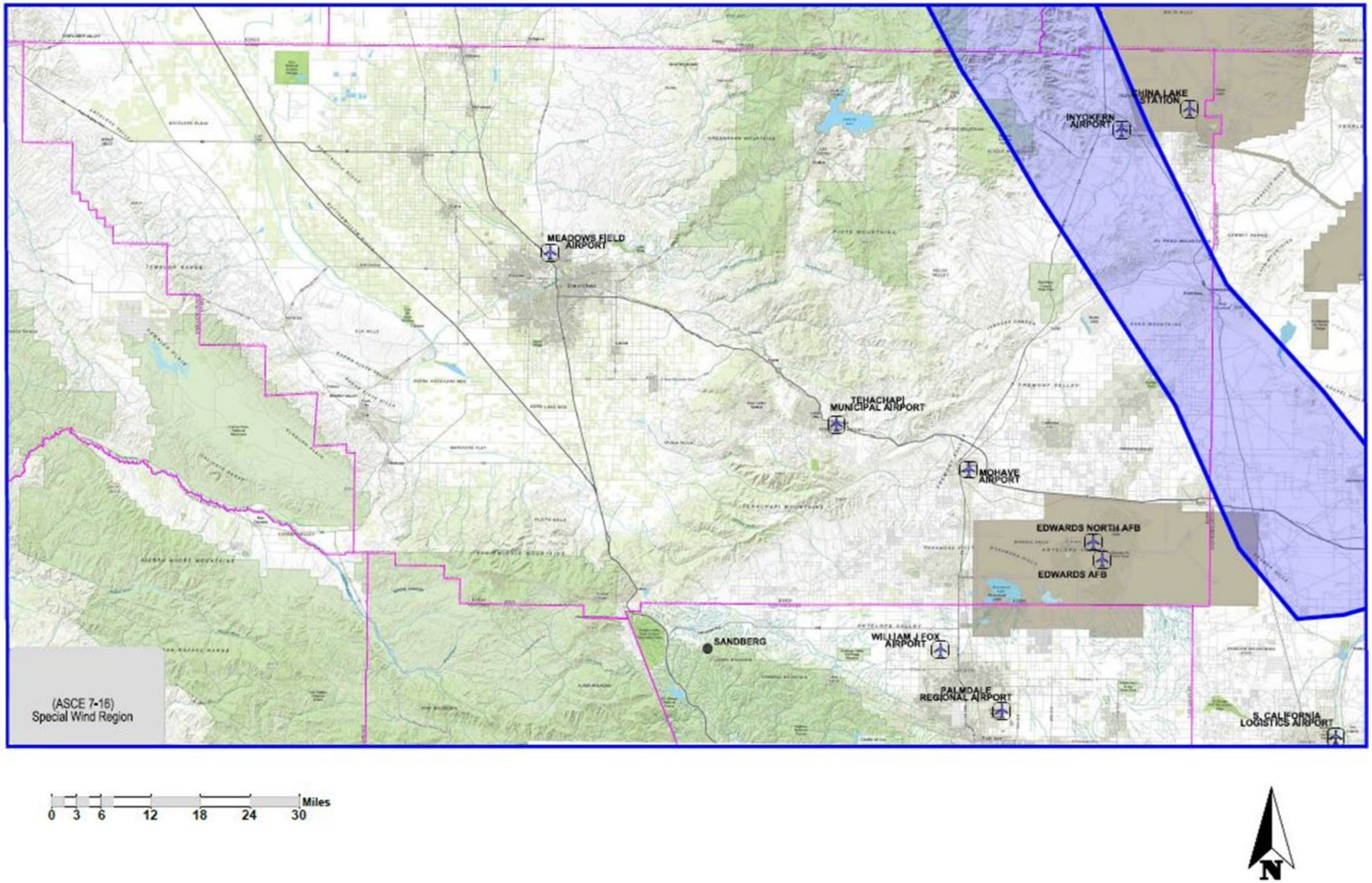


Figure 5: Utilized Weather Station Locations.

DISCUSSION OF ANALYSIS

Wind speeds at Inyokern, Mojave, and Sandberg are all significantly higher than the values provided for this part of California in the ASCE 7-10 and ASCE 7-16 wind maps. Each of these stations has experienced wind gusts above 80 mph in the past 20 years, which is quite unlikely if the 50 year speed is 77 mph, as would be expected from ASCE 7-16 if they were not in a special wind region. The high winds are highly directional and seasonal, which is consistent with a downslope winds.

As a result, we recommend that the special wind region in Kern County be amended to follow the eastern edge of the Sierra Nevada Mountains, largely parallel to the LA aqueduct and highway 14 as shown in Figure 5.

All of the other stations examined in the eastern plains exhibited comparable design wind speeds, from China Lake to Edwards Air Force Base and the airports near Lancaster. For all of the analysis method we used (MIS with variable number of storm, annual peaks, GHCN vs. TD35050 data), these stations all had wind speeds slightly below the values in ASCE 7-16. None of these airports had wind data recorded wind speeds above 73 mph in a combined sampling period of over 100 years. Therefore, it is our recommendation that no special wind region is required along the eastern edge of the county.

REASONS FOR UNCERTAINTY IN THE NEW SPECIAL WIND REGION

Only 6 years of good data were available from Mojave airport, because the anemometer was previously placed on the roof of the air traffic control tower, and as a result it cannot be accurately corrected to 10m in open country without extensive analysis. This short record leads to high uncertainty, as the 6 years in question could have been unusually calm, though data from other nearby airports suggests that this was not the case. Nonetheless, the suggested SWR wind speeds do reflect this uncertainty.

Height information is not available for the Inyokern anemometer; it was assumed to be at 10 m in open country. Data from this airport is quite sparse (for example, gaps overnight and in the early afternoon), and upward corrections to the expected wind speeds are needed to account for this.

Sandberg is located atop a 1000 feet tall mesa. It is not clear how much this will increase wind speed above what is seen on the valley floor to the north.

As a result, wind speed estimates within the new special wind region boundaries reflect considerable engineering judgment. Additional data would improve these estimates. This data may be able to be attained from independent weather stations such as wind farms.

LIMITATIONS

We do not have enough information to characterize how quickly the wind speeds drop with distance from the mountains. The maps provided conservatively assume that the wind speeds begin rising immediately to the west of Edwards, Fox, and China Lake. The rapid decrease in wind speeds from Inyokern to China Lake suggests that the contours provided may be conservative.

We do not have enough information to determine whether the wind speeds continue to increase between the aqueduct and the mountains. We have assumed that they do continue to increase, but the rate of increase is not something we can substantiate.

We did not examine the western half of the county, other than Bakersfield, as this is beyond the scope of our study, and we have no reason at this time to expect wind speeds above ASCE 7 levels in that part of the county. Bakersfield experiences occasional downslope events from the east (notably the dust storm of 1977), but design wind speeds are below the values in ASCE 7-16.

The mountainous regions of Kern County do not contain any NCDC wind stations or wind data for this region. Due to the configuration of the mountain region that contains valleys and canyons due to discontinuity in the mountains and the lack of wind data, there is a great deal of ambiguity in the wind speeds in these areas. While wind data suggests that the wind region on the northeast side of the county is not warranted, the mountainous region on the northwest side of Kern County remains uncertain. Based on the terrain and our experience, it is likely that the mountainous portion should be considered a special wind region making the existing ASCE7-10 special wind region larger to the west. The only station located within the mountainous region of Kern County was Tehachapi. Wind speeds were below those in ASCE 7-16. More information is needed to determine how wind speeds in the mountains. This area remains flagged as a special wind region with unknown design wind speeds, as in ASCE 7-10. If more precise wind values are desired, further data collection and analysis will be required.

To summarize, we do not have enough data to estimate the wind speeds in the mountainous region. If you anticipate that there will be developments in this region that will require more precise wind values, further data collection and analysis will be required. As an alternate, you may elect to expand the special region to include the mountainous regions.

RECOMMENDATIONS FOR FURTHER WORK

No wind speed data other than from NCDC airport anemometers has been used, as it was outside of the scope of this pilot study to locate such anemometers and perform quality checks on the data. Non-NCDC data (e.g., for anemometers maintained by local universities, RAWS stations, or other sources) was instrumental in developing the Colorado front range wind maps. This type of data could be investigated to help determine wind speeds in mountain and canyon regions and provide more accurate wind speed maps. The wind farm(s) near Tehachapi pass will certainly have reliable and extensive data.

Downslope winds are highly directional and seasonal. Engineers who are designing structures for which the vulnerability to wind loading as a function of wind direction is known could potentially consider this information where it might result in savings compared to designing for a uniform higher wind speed in all directions. For example, monoslope free roofs will only see significant download forces for winds coming from the direction of the low edge. Wind directionality tables are included in many wind loading standards, such as Australia and Japan, and could be developed for the Kern County special wind region.

REFERENCES:

ASCE, 2010. *Minimum Design Loads for Buildings and Other Structures.* ASCE 7-10, American Society of Civil Engineers (ASCE) Reston, VA.

ASCE, 2016. *Minimum Design Loads for Buildings and Other Structures.* ASCE 7-16, American Society of Civil Engineers (ASCE) Reston, VA.

Cook, N. J. (2014) "Consolidation of analysis methods for sub-annual extreme wind speeds", Meteorological Applications 21: 403–414

Levitan, M., and Vickery, P. (2014) "Attachment 3: New Wind Maps Proposal Rationale, Data, Methods, and Verification" from *Proposal to Revise the 2010 Edition of ASCE/SEI 7*, submitted to the ASCE 7 Standards committee on 3/10/2014.

Palutikof, J. P., B. B. Brabson, D. H. Lister, and S. T. Adcock, (1999) "A review of methods to calculate extreme wind speeds". *Meteorological Applications*, 6, 119–132.

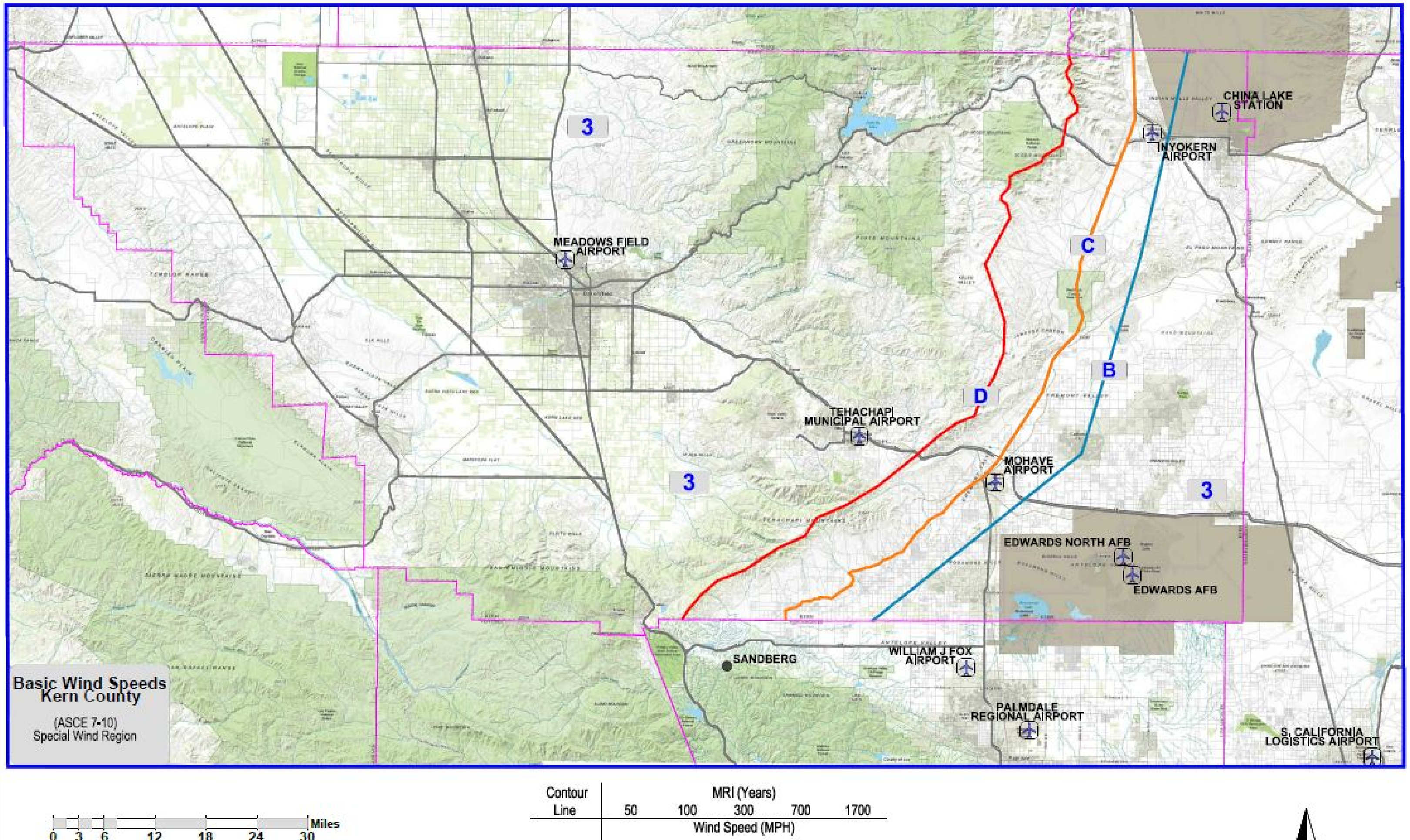
Peterka J.A. (2006), "Colorado Front Range Gust Map", CPP Inc. report for use by Colorado Structural Engineers Association and Colorado Front Range communities. CPP Inc., Fort Collins, CO.

Peterka, J.A. (1992), "Improved Extreme Wind Prediction for the United States," *Journal of Wind Engineering and Industrial Aerodynamics*, Vol. 41, pp. 533-541.

Peterka, J.A. and Shahid, S. (1998), "Design Gust Wind Speeds for the U.S.," *ASCE Journal of Structural Engineering*, Vol. 124, pp. 207-214. American Society of Civil Engineers (ASCE) Reston, VA.

Searer et. al, SEAOSC Summary Report (2010), *Study of Historical and Design Wind Speeds in the Los Angeles Area.* Structural Engineers Association of Southern California (SEAOSC) Los Angeles, CA.

APPENDIX A1: ASCE7-10 WIND SPEED MAP

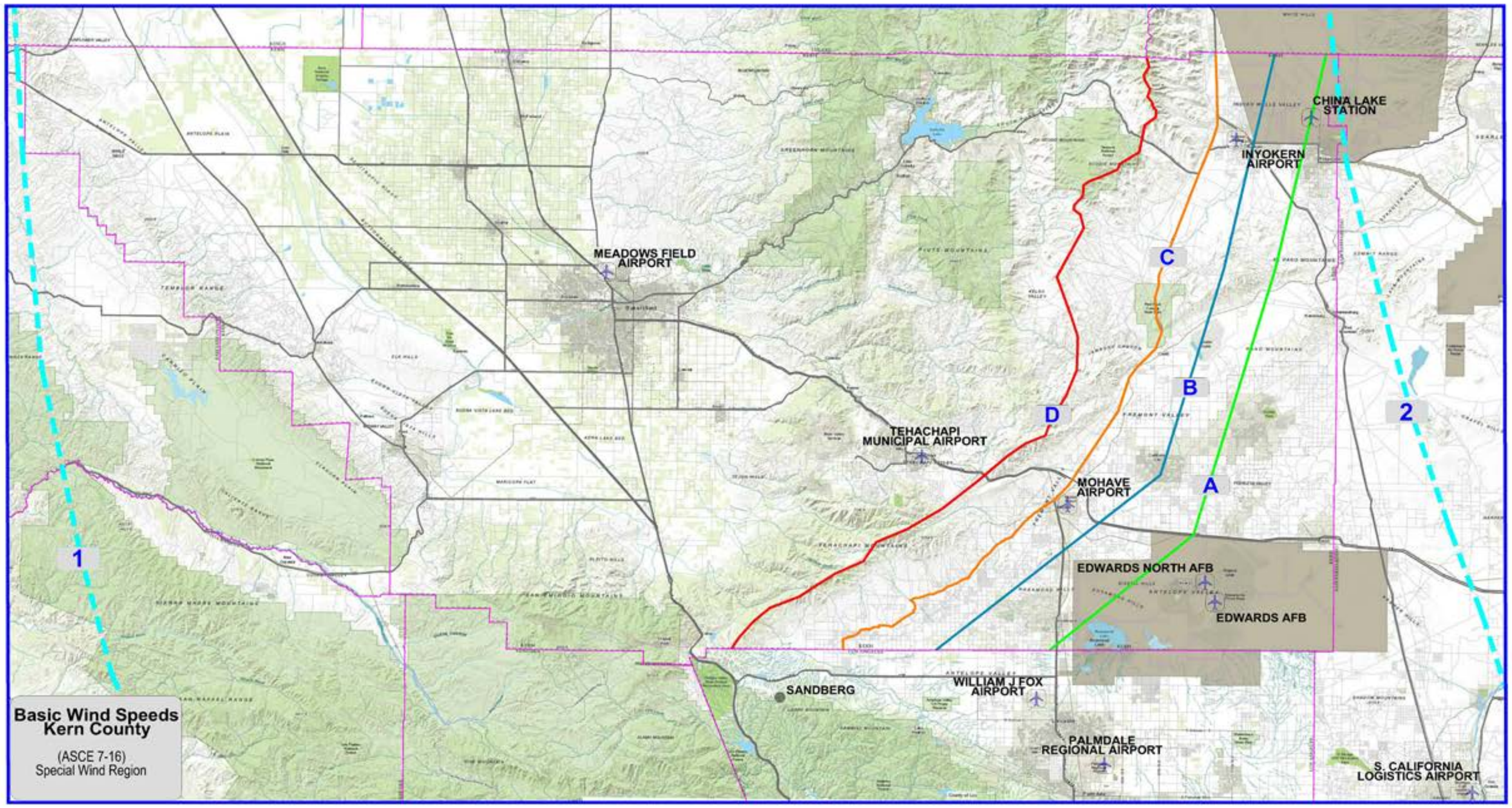


Contour Line	MRI (Years) 50	100	300	700	1700
	Wind Speed (MPH)				
B	85	91	100	110	115
C	95	100	110	120	125
D	105	110	120	130	135
3*	85	90	100	110	115

*Interpolated value recommended by ASCE 7-10 for Kern County

"More information is needed to determine how wind speeds in the mountains. This area remains flagged as a special wind region with unknown design wind speeds, as in ASCE 7"

APPENDIX A2: ASCE7-16 WIND SPEED MAP



0 3 6 12 18 24 30 Miles

Contour Line	MRI (Years) 50	100	300	700	1700	3000
	Wind Speed (MPH)					
A	77	82	90	95	102	106
B	85	91	100	110	115	120
C	95	100	110	120	125	130
D	105	110	120	130	135	140
1*	75	80	87	92	100	104
2*	77	82	90	95	102	106

***Interpolated value recommended by ASCE 7-16 for Kern County**

"More information is needed to determine how wind speeds in the mountains. This area remains flagged as a special wind region with unknown design wind speeds, as in ASCE 7"

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APPENDIX B: WIND DATA SUMMARY FOR EACH WEATHER STATION

CHINA LAKE WIND STATION

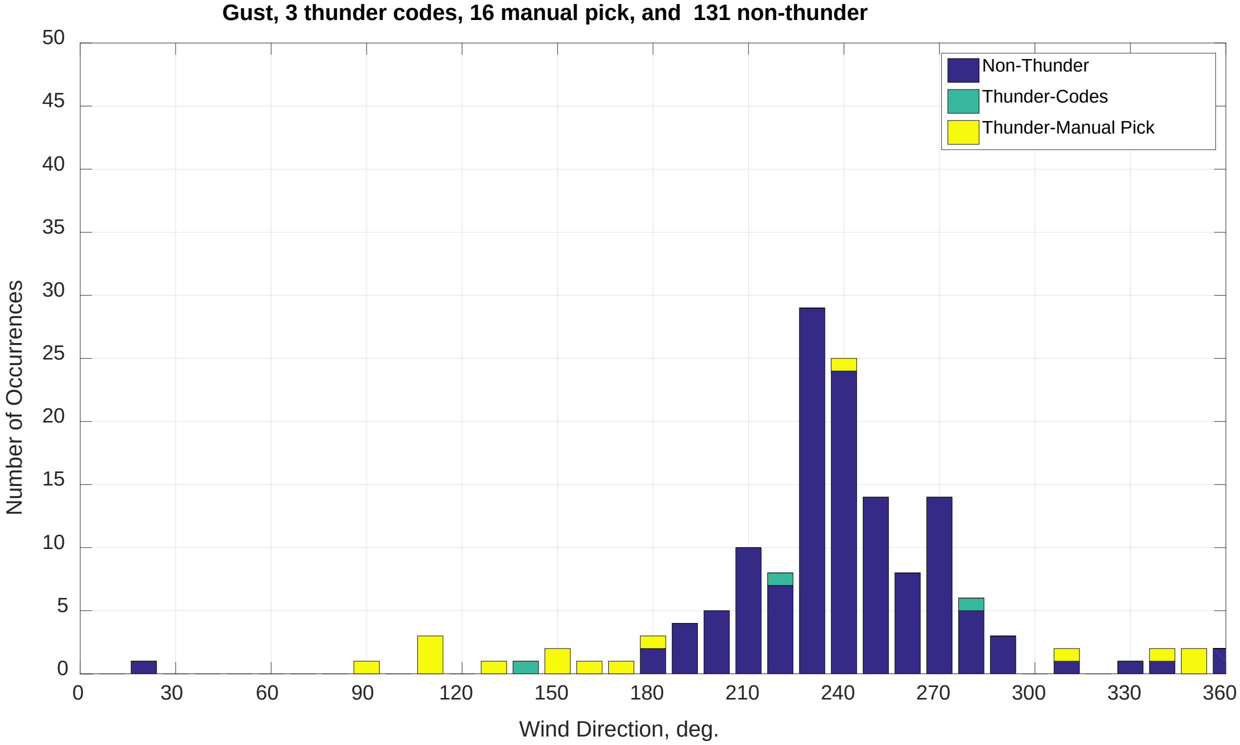
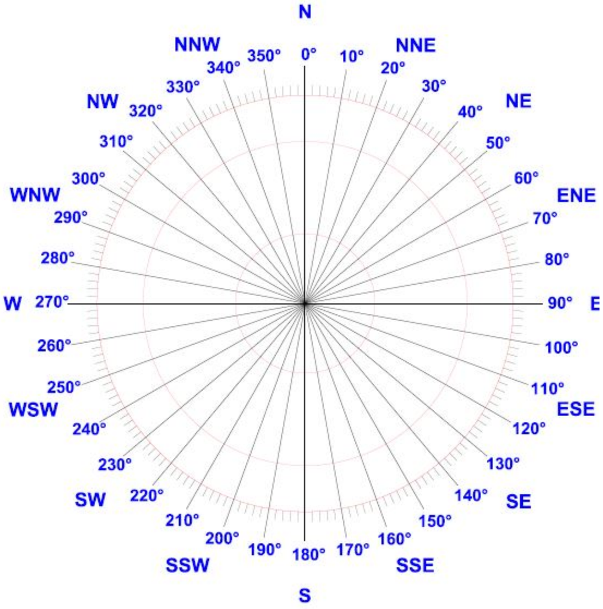


Figure B1a: *China Lake Wind Station – Wind Gust by Direction.*



Key: Wind direction denotes the source wind direction as noted on the compass.

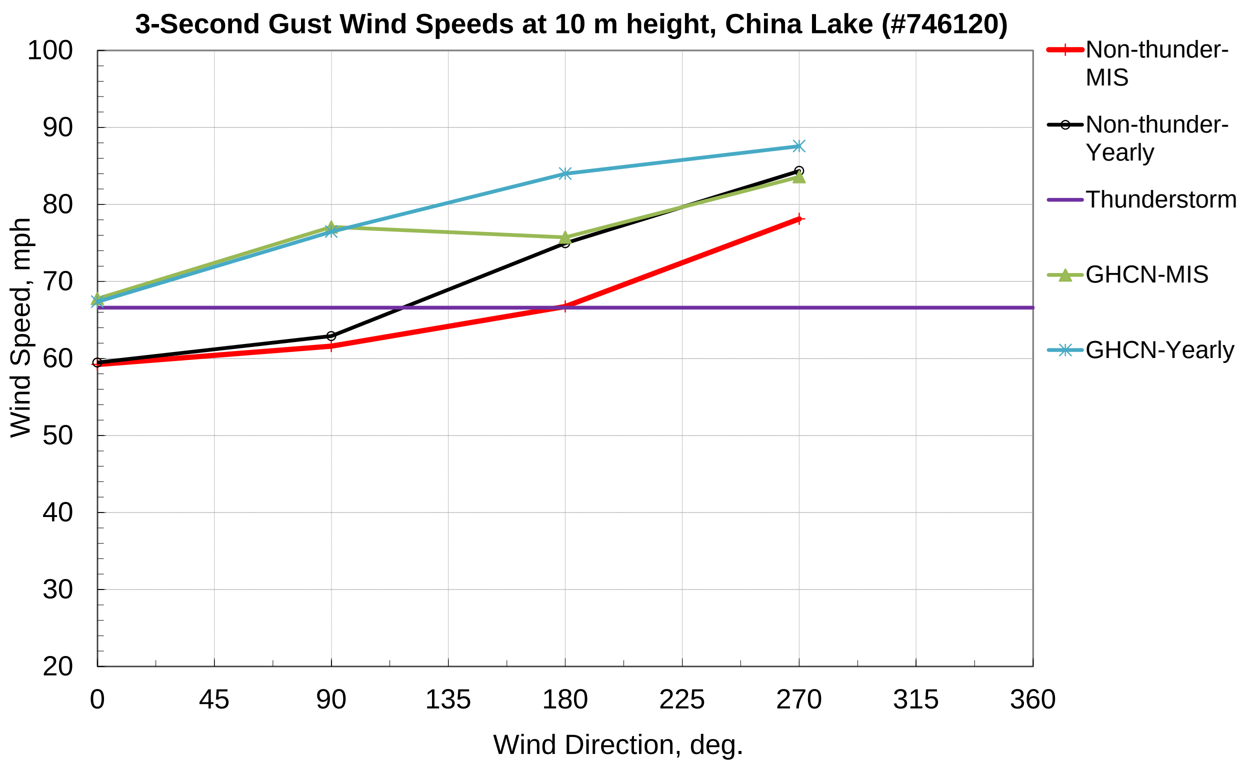


Figure B1b: China Lake Wind Station – Wind Gust Speed by Direction.

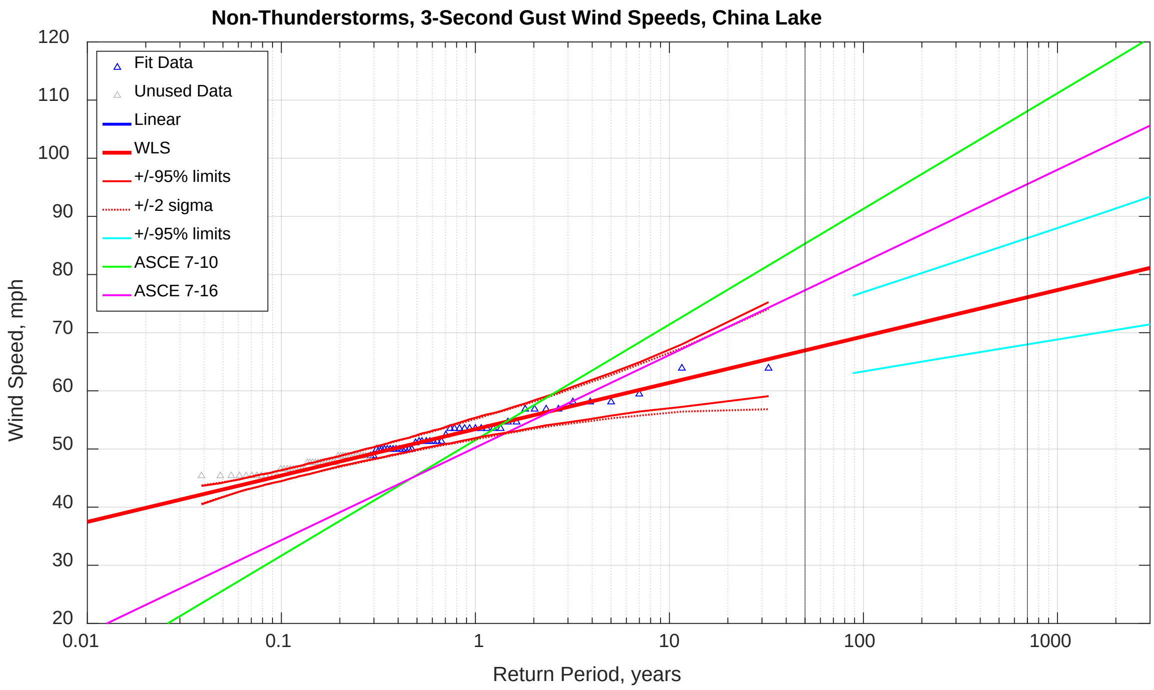


Figure B1c: China Lake Wind Station – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust.

EDWARDS AIR FORCE BASE (AFB) NORTH AUXILIARY AIRFIELD

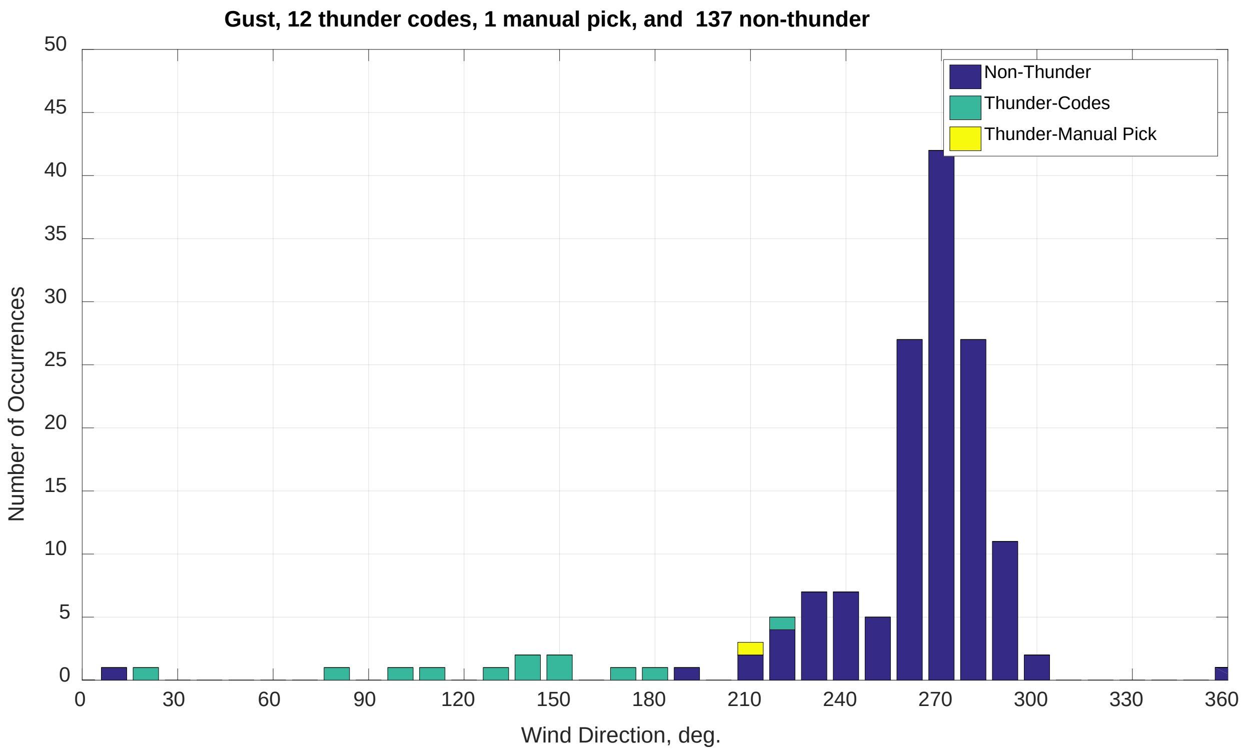


Figure B2a: *Edwards AFB North Auxiliary Field Wind Station – Wind Gust by Direction.*

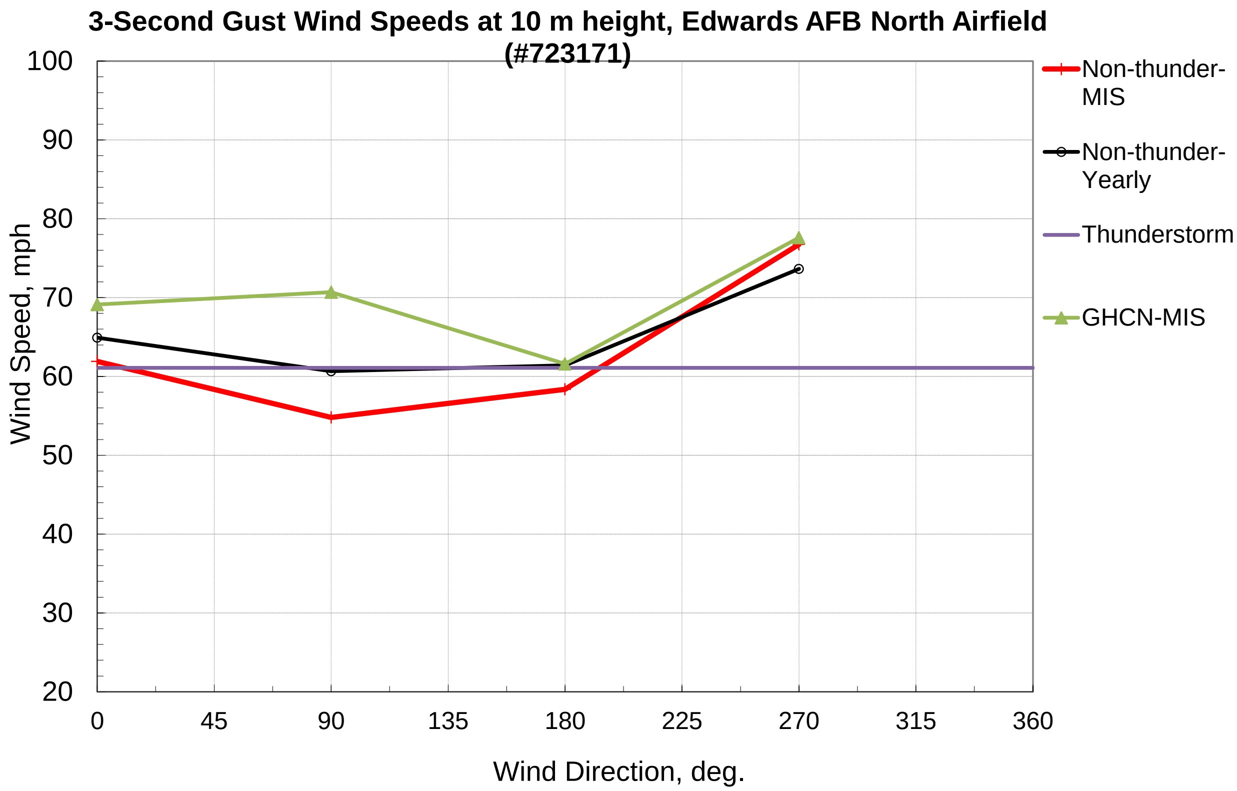


Figure B2b: Edwards AFB North Auxiliary Field Wind Station – Wind Gust Speed by Direction.

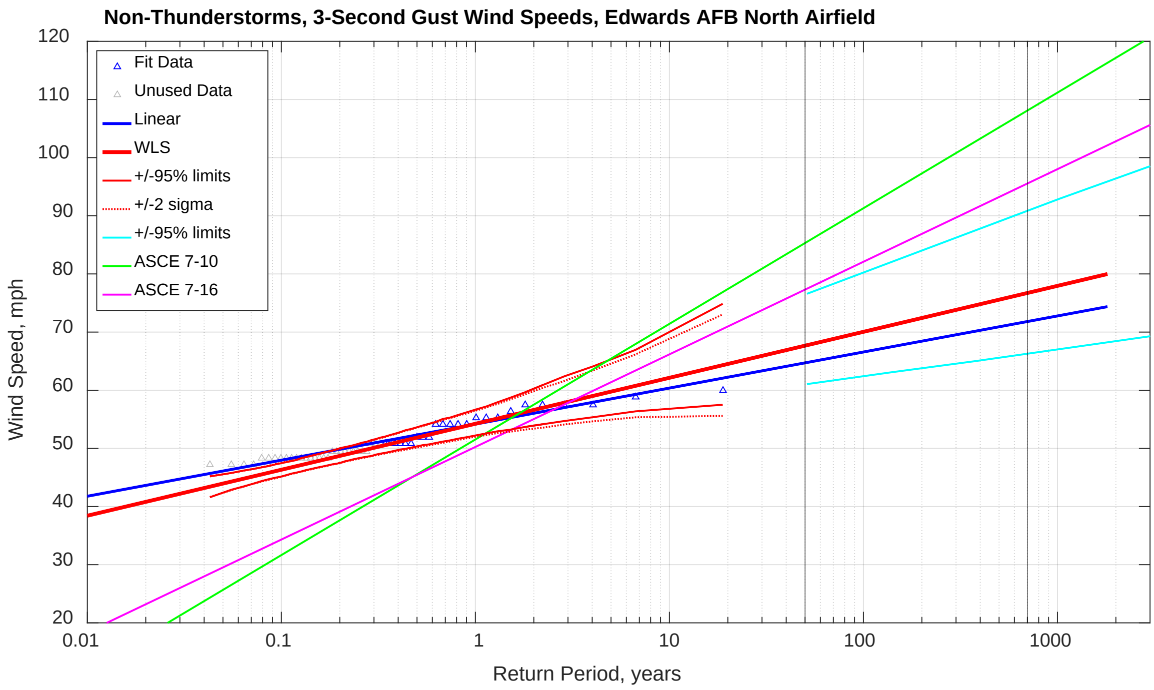


Figure B2c: Edwards AFB North Auxiliary Field Wind Station – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust.

EDWARDS AIR FORCE BASE (AFB)

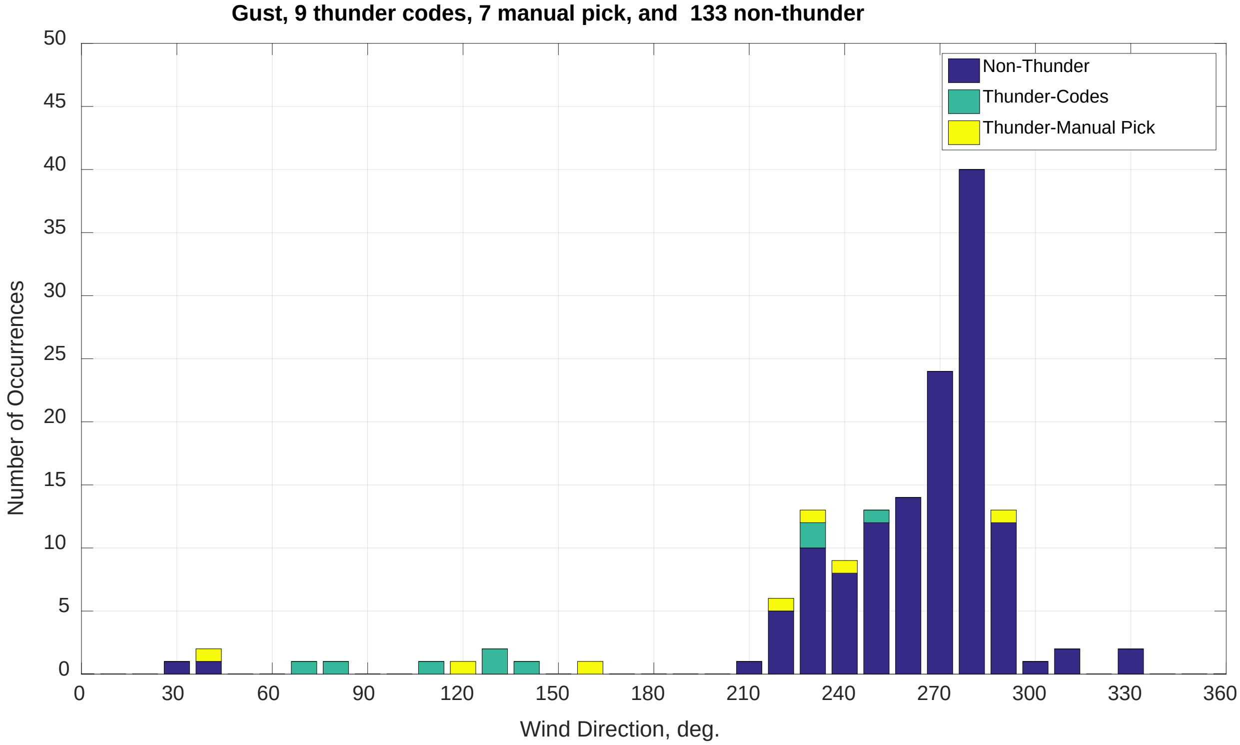


Figure B3a: *Edwards AFB Wind Station – Wind Gust by Direction.*

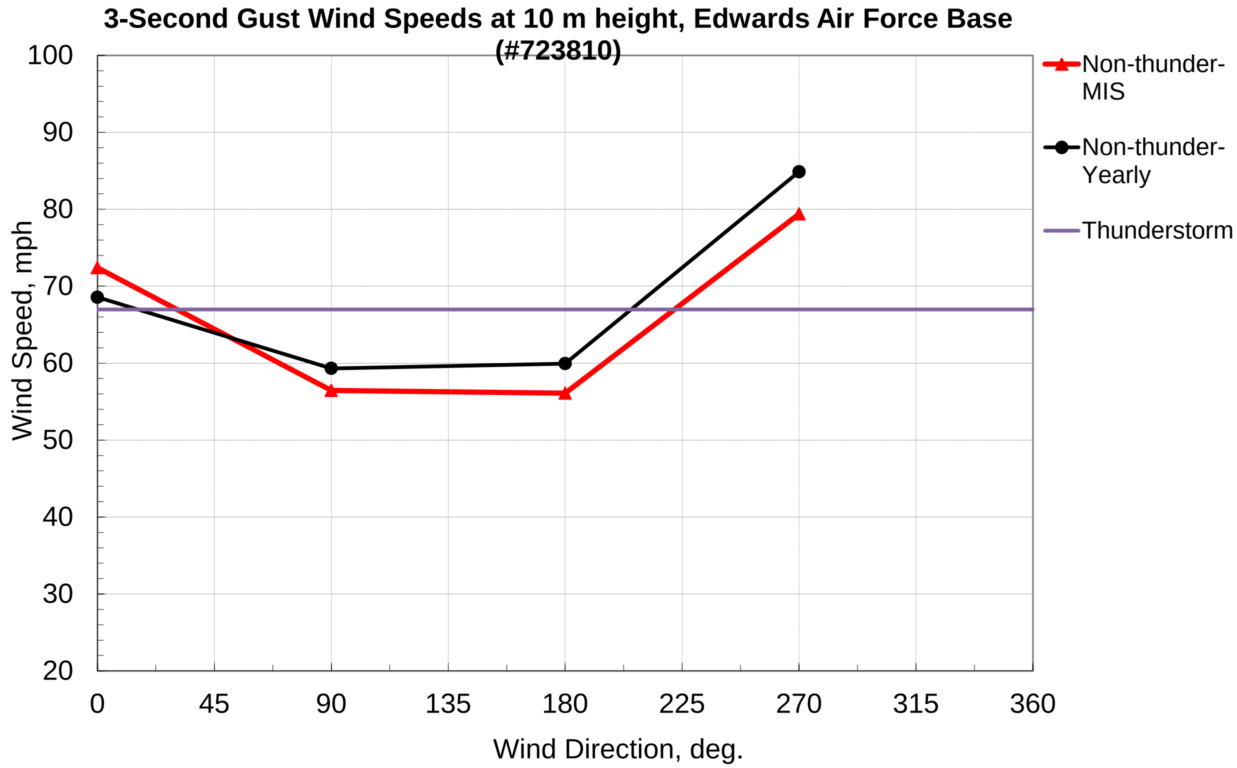


Figure B3b: Edwards AFB Wind Station – Wind Gust Speed by Direction.

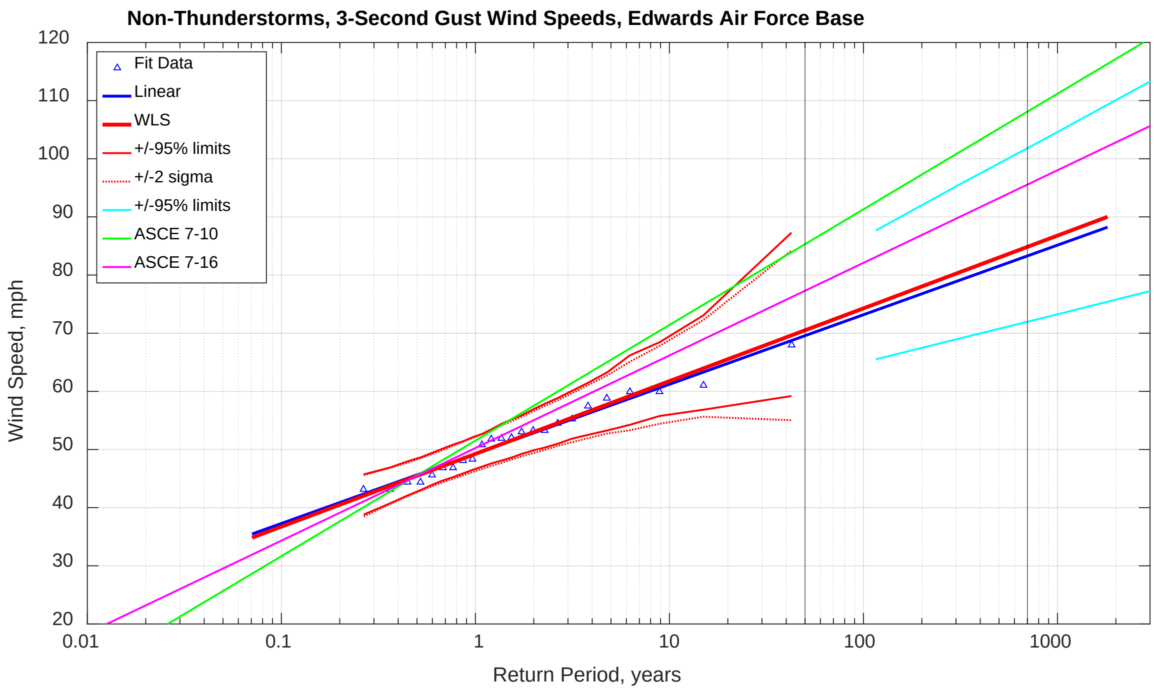


Figure B3c: Edwards AFB Wind Station – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust.

GENERAL WILLIAM J FOX AIRFIELD

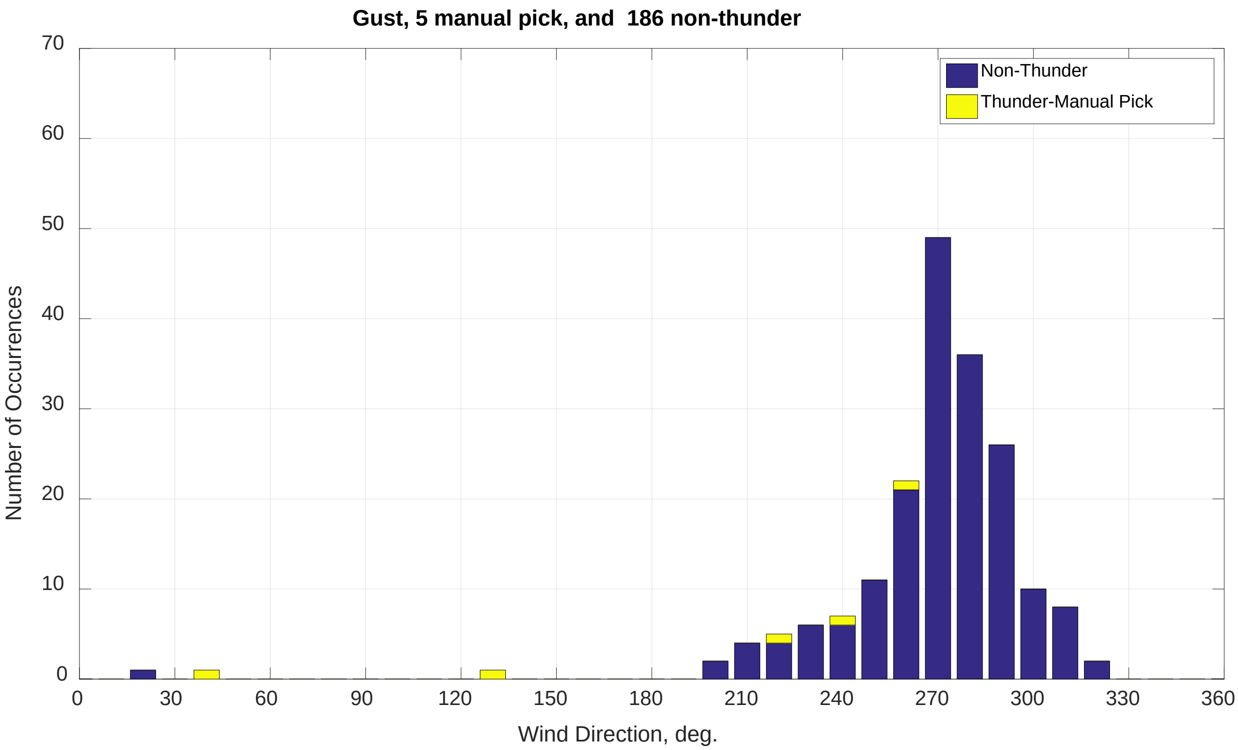


Figure B4a: *General William J Fox Airfield – Wind Gust by Direction.*

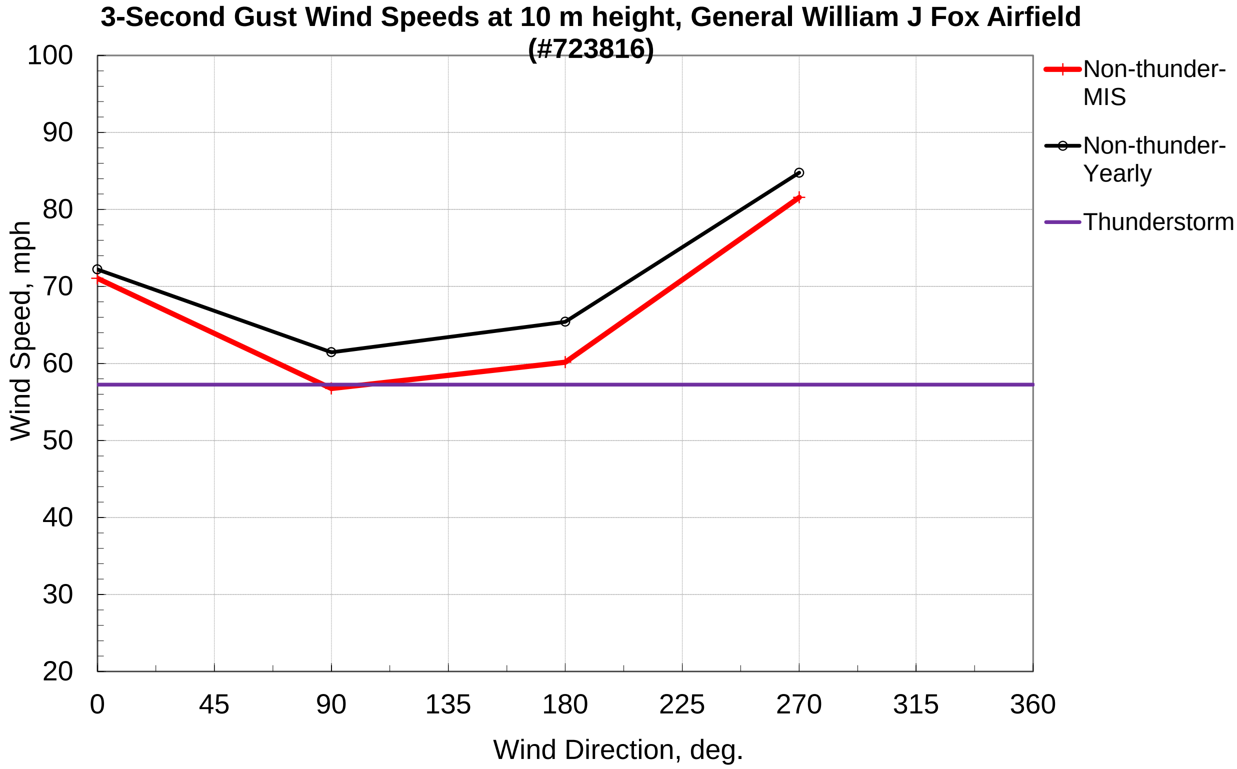
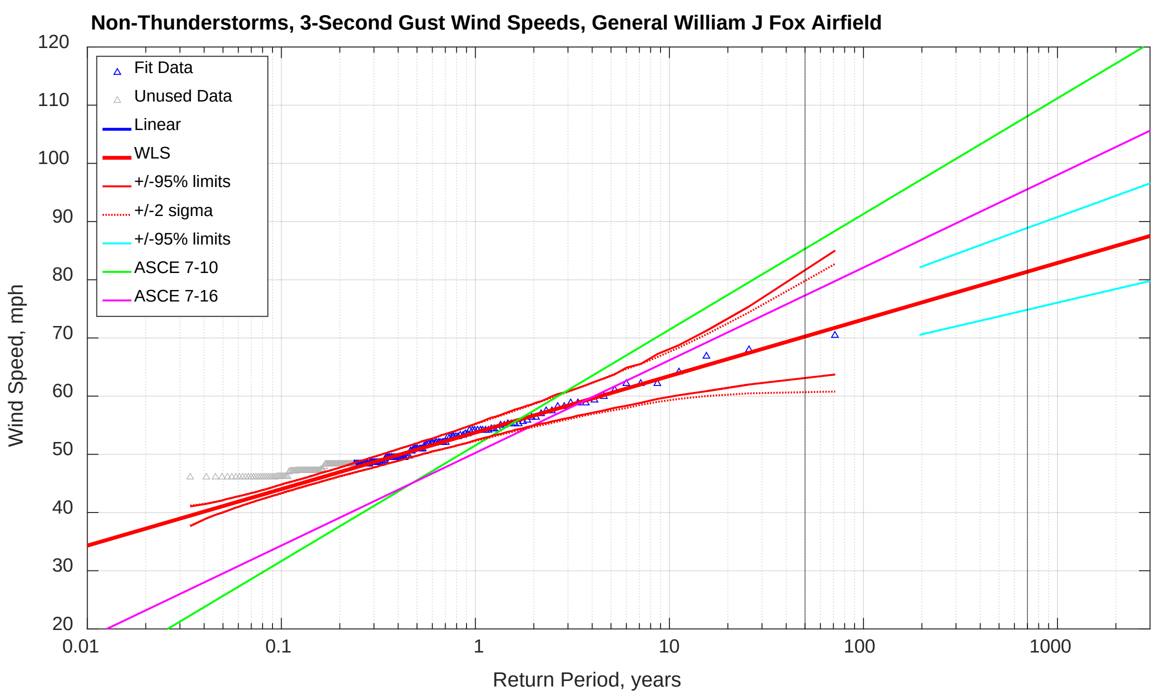


Figure B4b: *General William J Fox Airfield – Wind Gust Speed by Direction.*



FigureB4c: *General William J Fox Airfield – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust*

INYOKERN AIRPORT

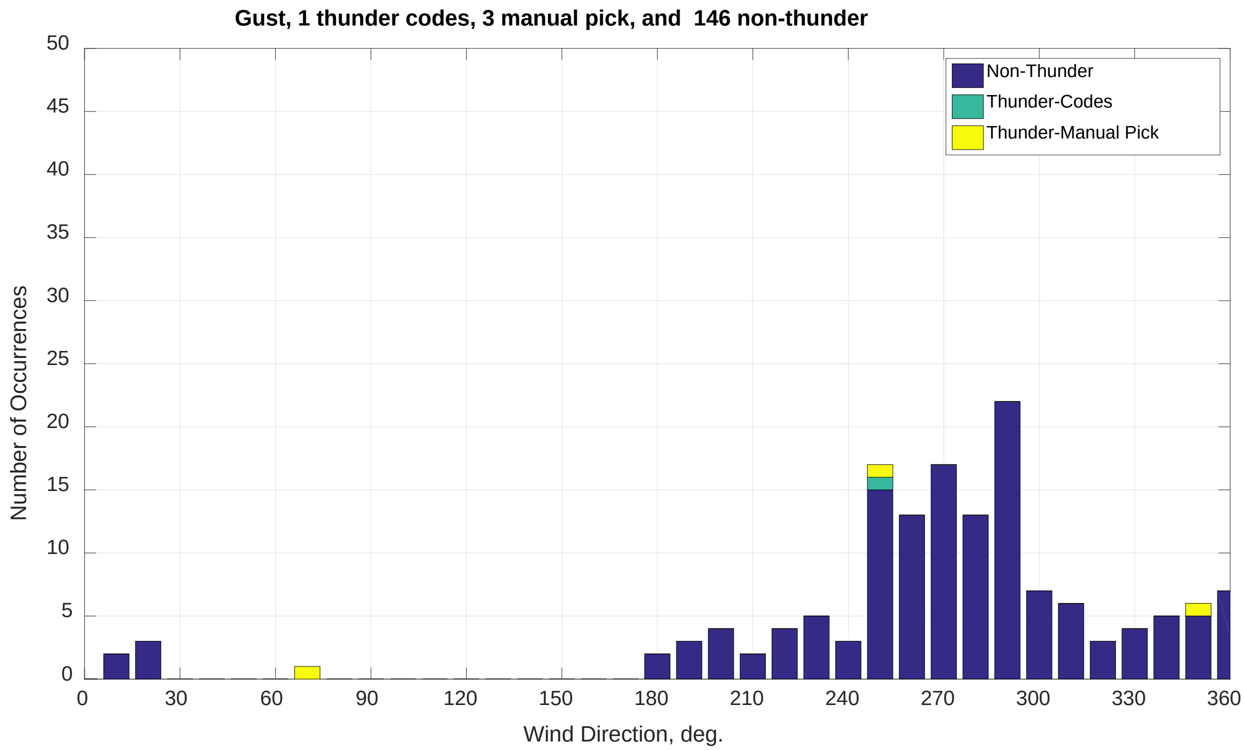


Figure B5a: *Inyokern Airport – Wind Gust by Direction.*

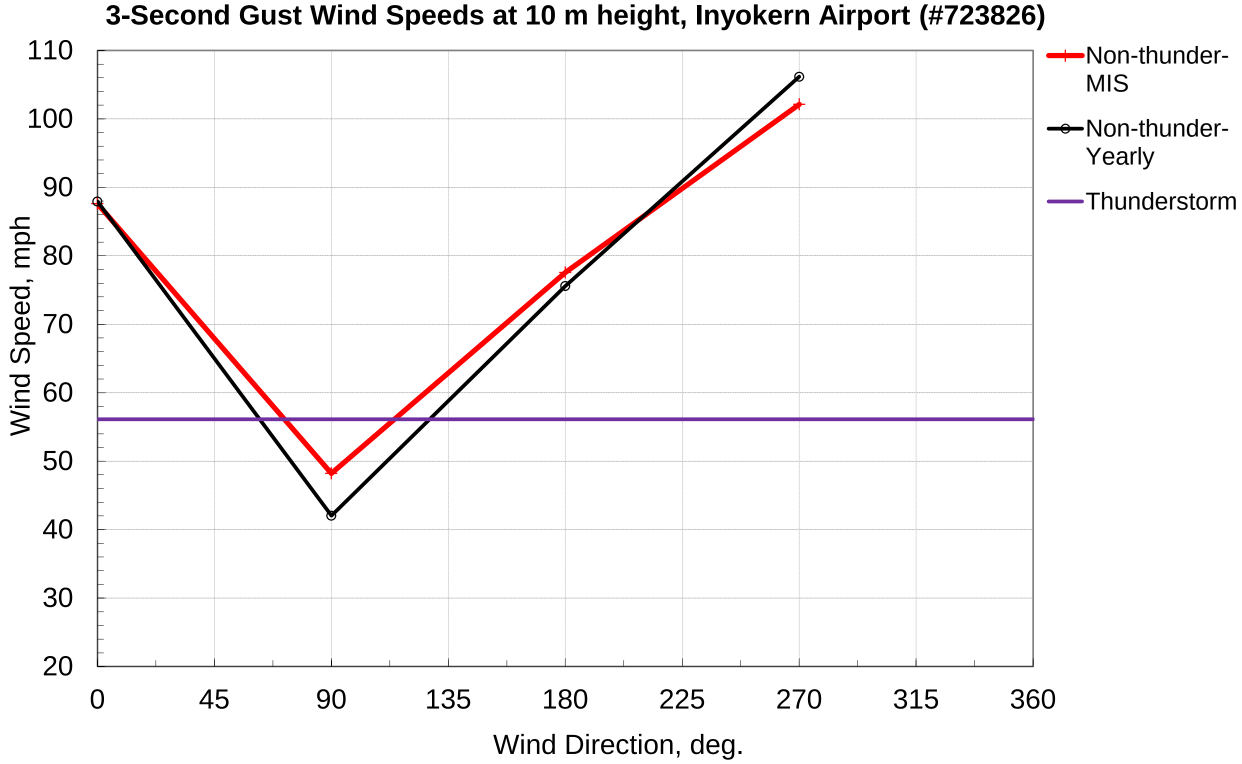


Figure B5b: *Inyokern Airport – Wind Gust Speed by Direction.*

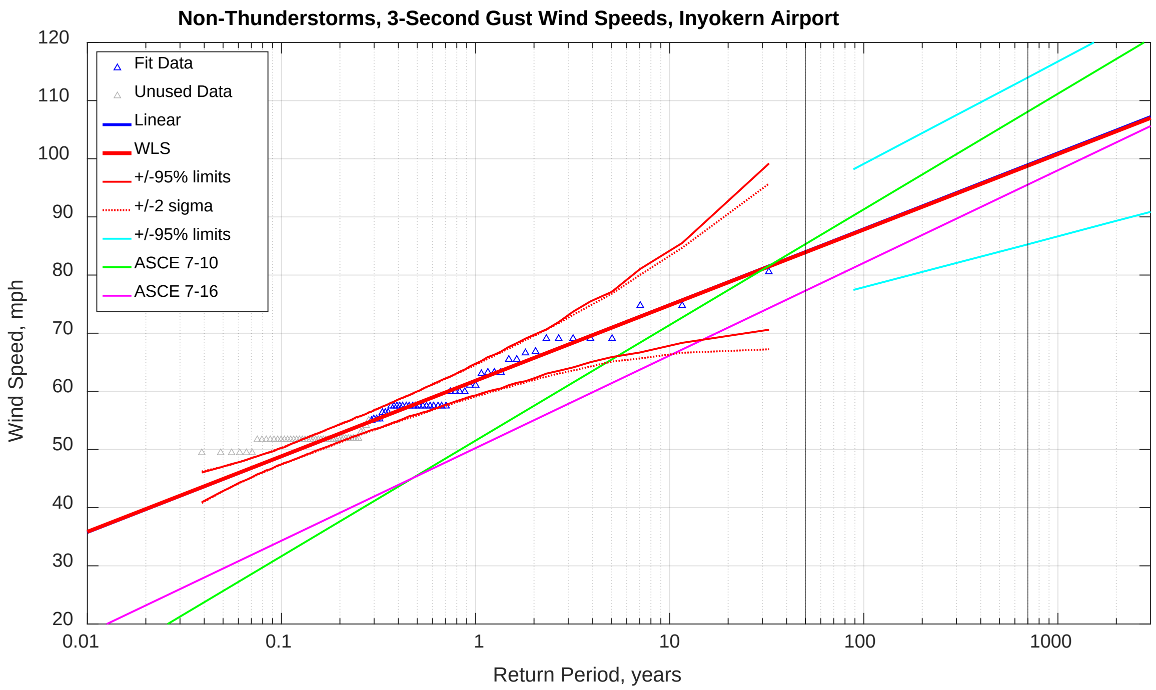


Figure B5c: *Inyokern Airport – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust*

MEADOWS FIELD AIRPORT

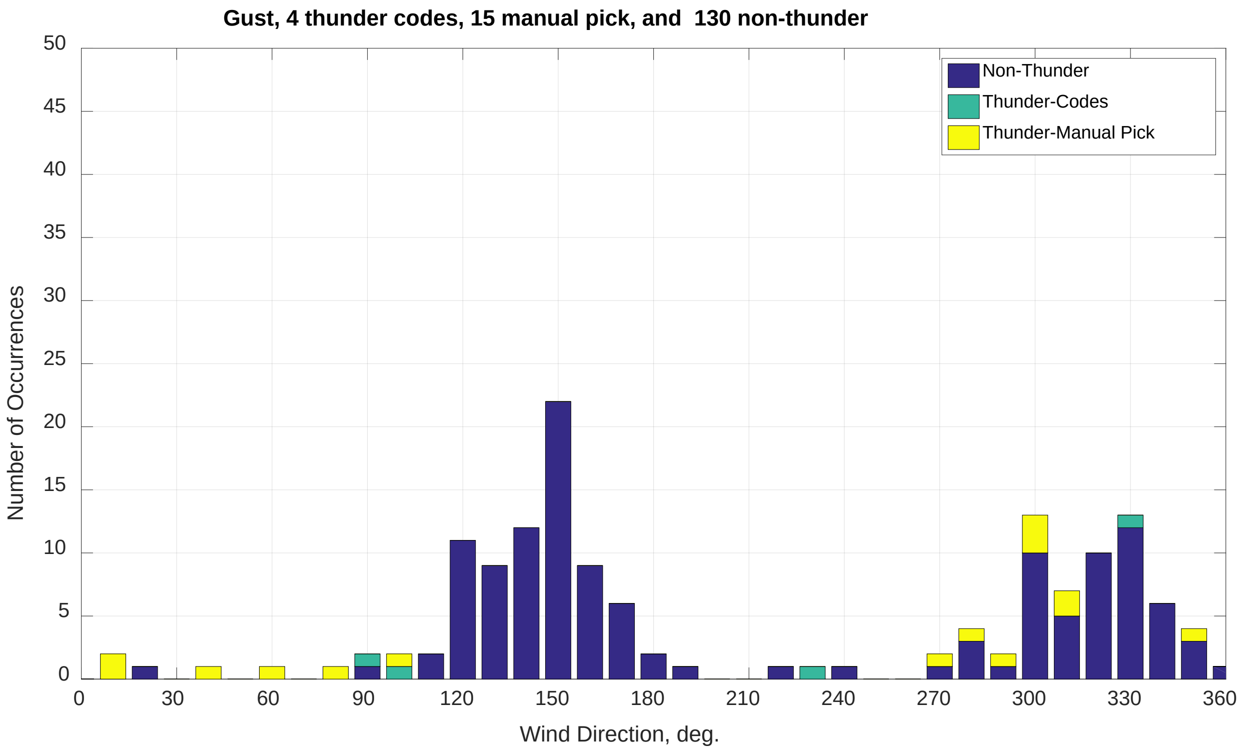


Figure B6a: *Meadows Field Airport – Wind Gust by Direction.*

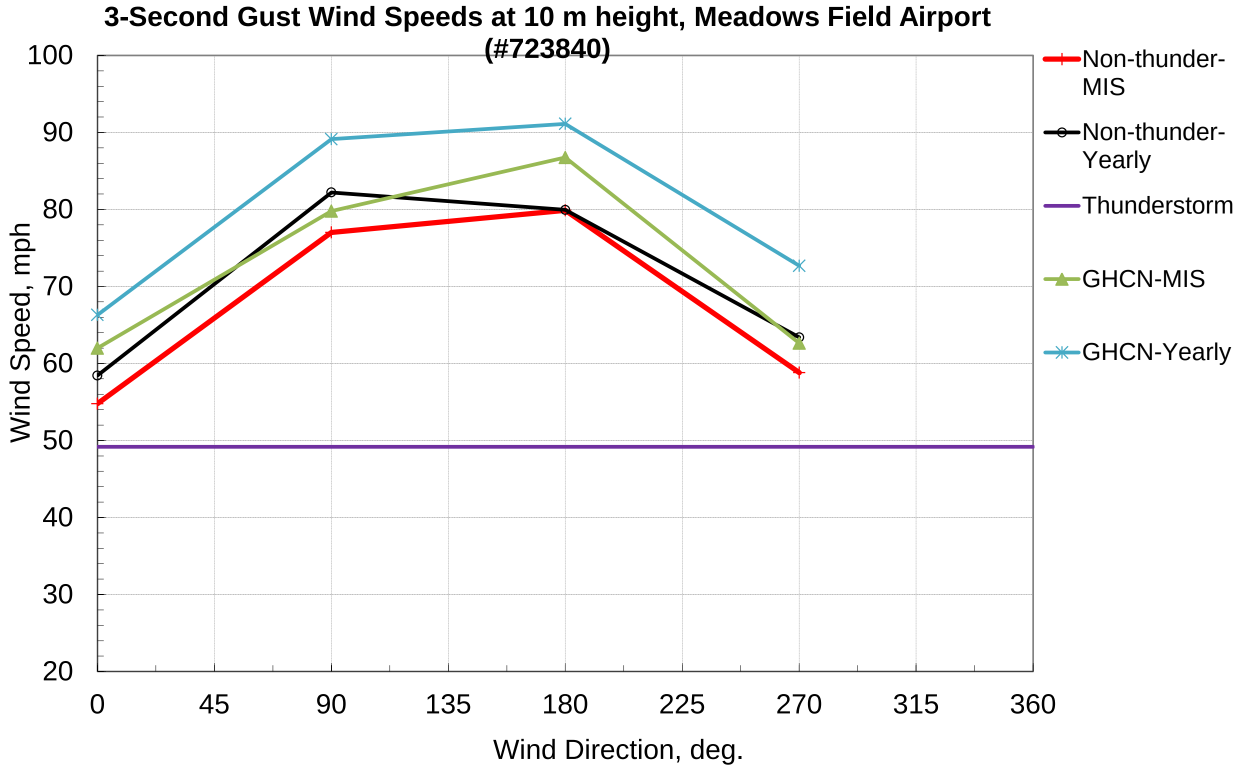


Figure B6b: Meadows Field Airport – Wind Gust Speed by Direction.

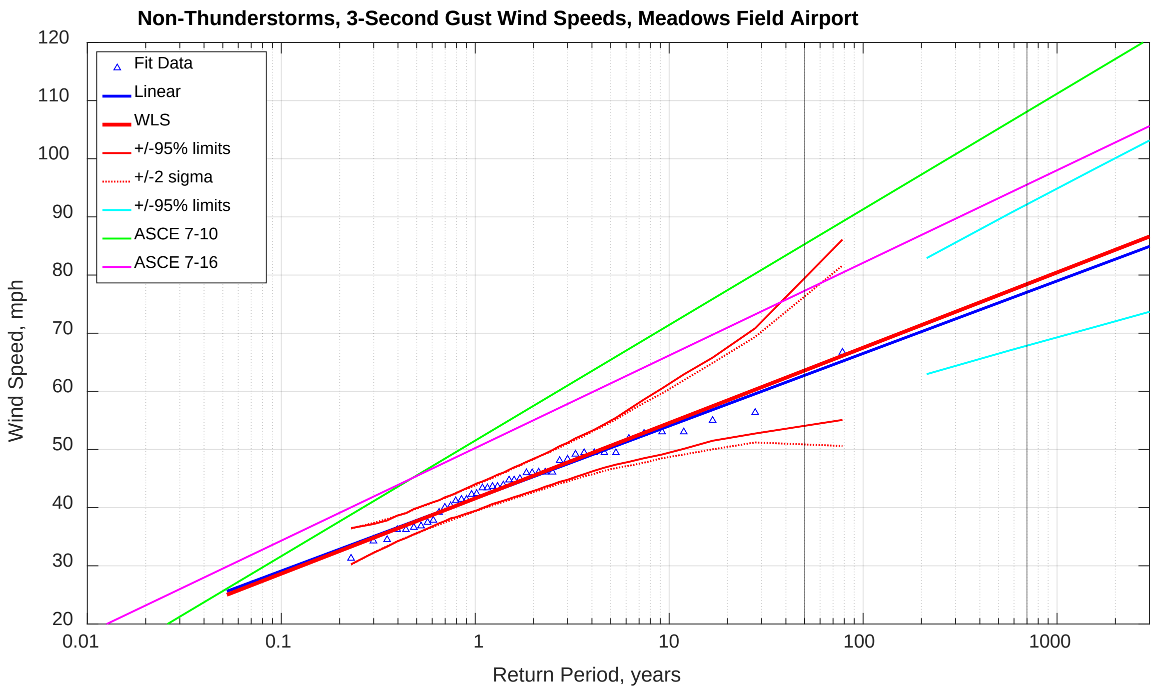


Figure B6c: Meadows Field Airport – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust

MOJAVE AIRPORT

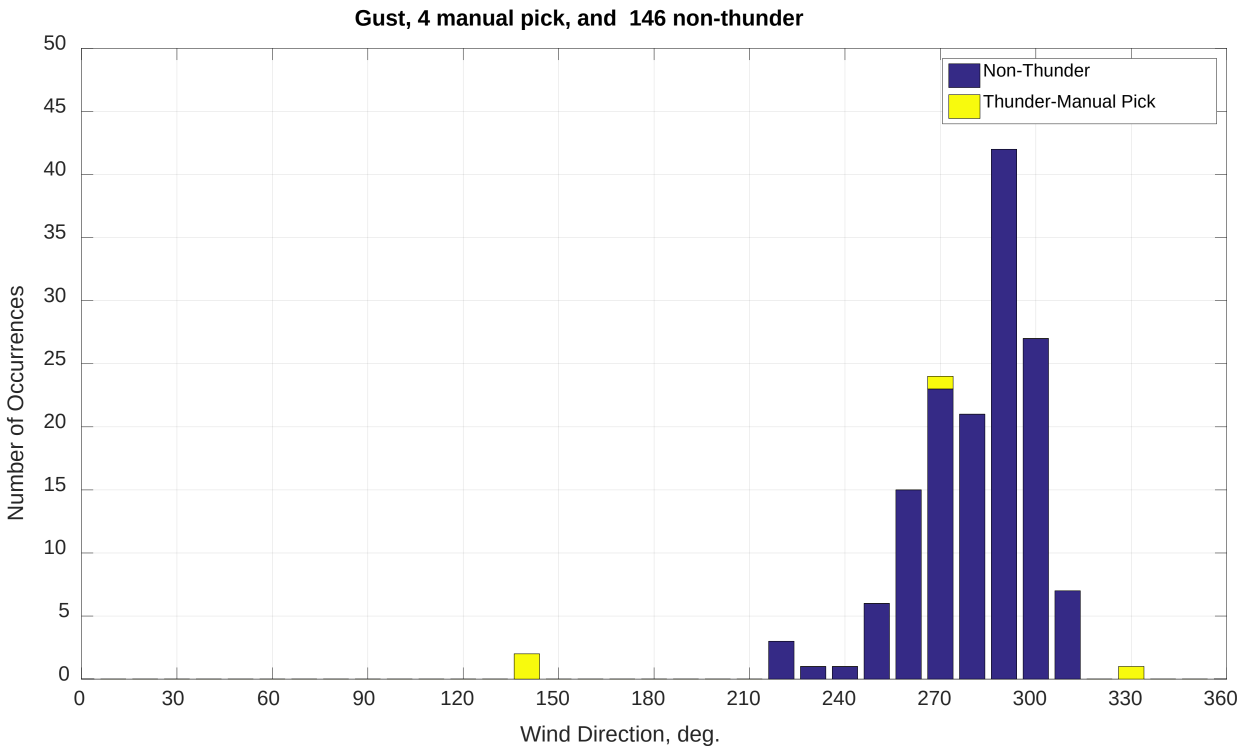


Figure B7a: *Mojave Airport – Wind Gust by Direction.*

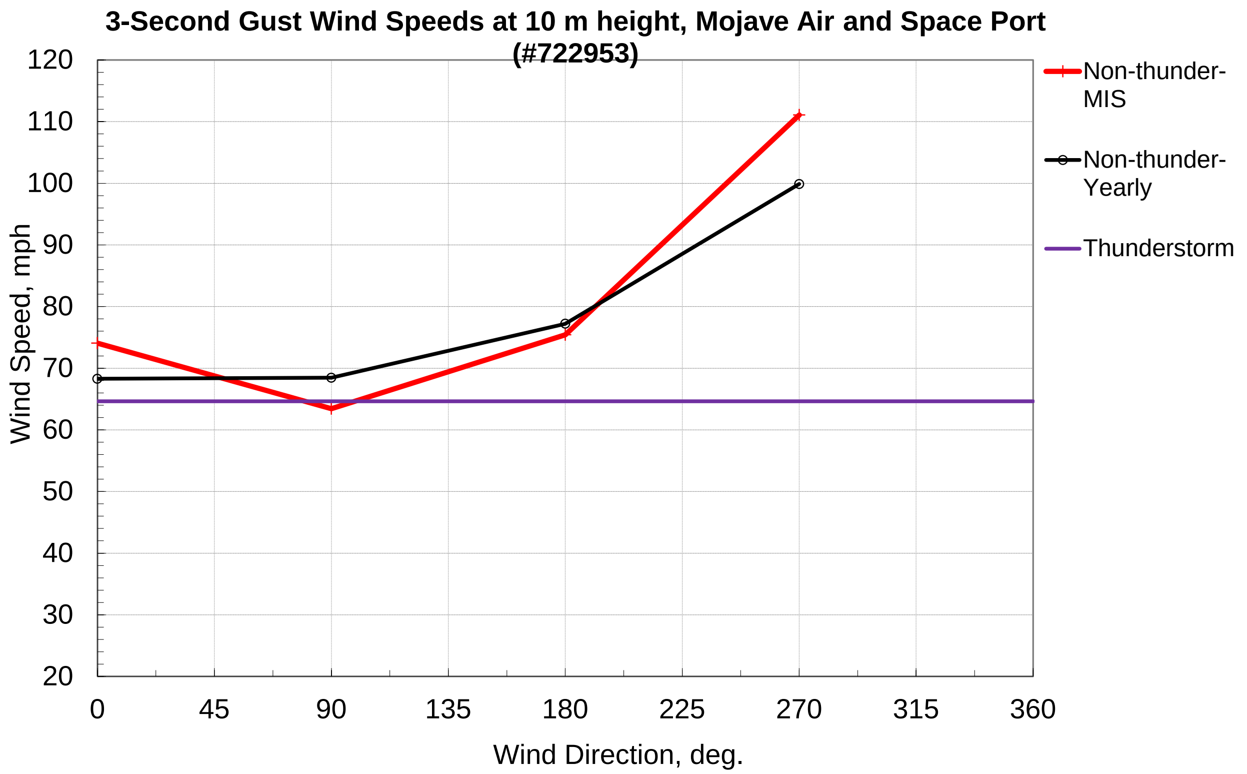


Figure B7b: *Mojave Airport – Wind Gust Speed by Direction.*

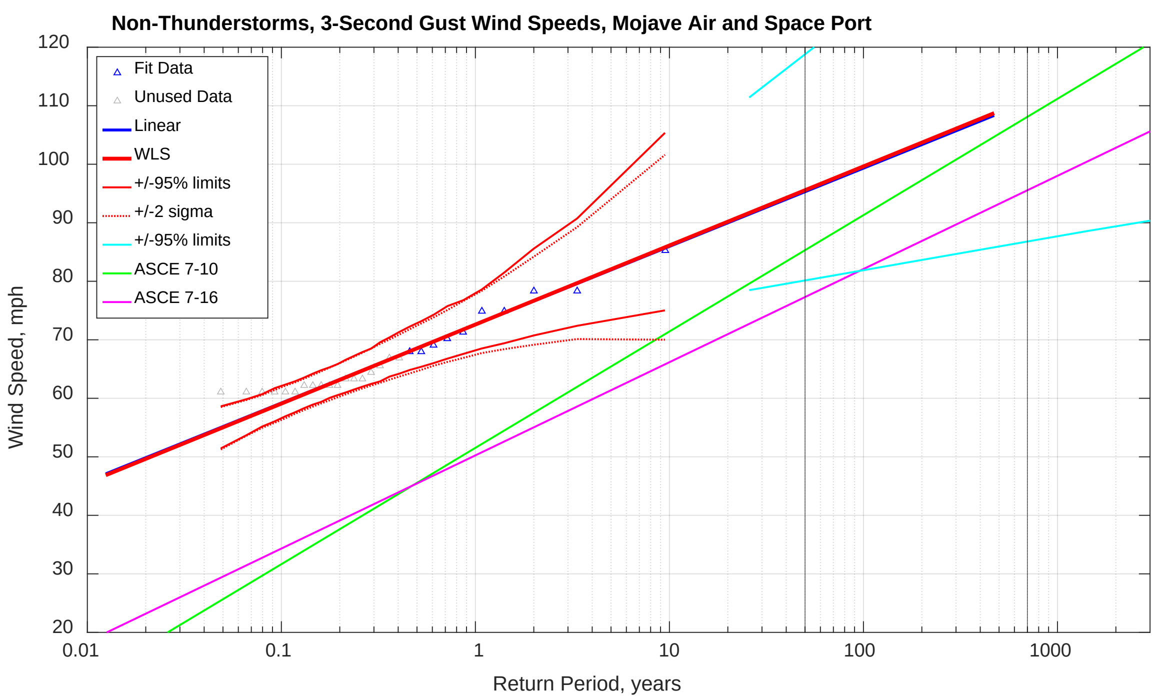


Figure B7c: *Mojave Airport – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust*

PALMDALE REGIONAL AIRPORT

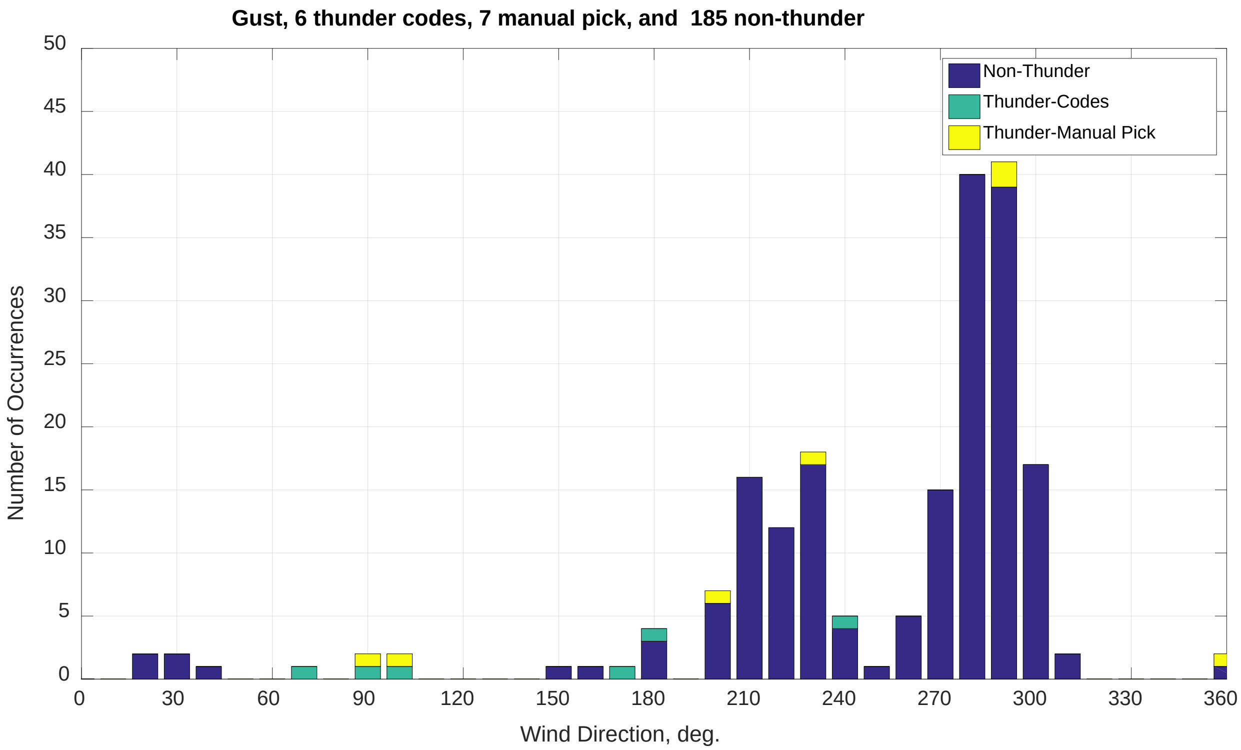


Figure B8a: *Palmdale Regional Airport – Wind Gust by Direction.*

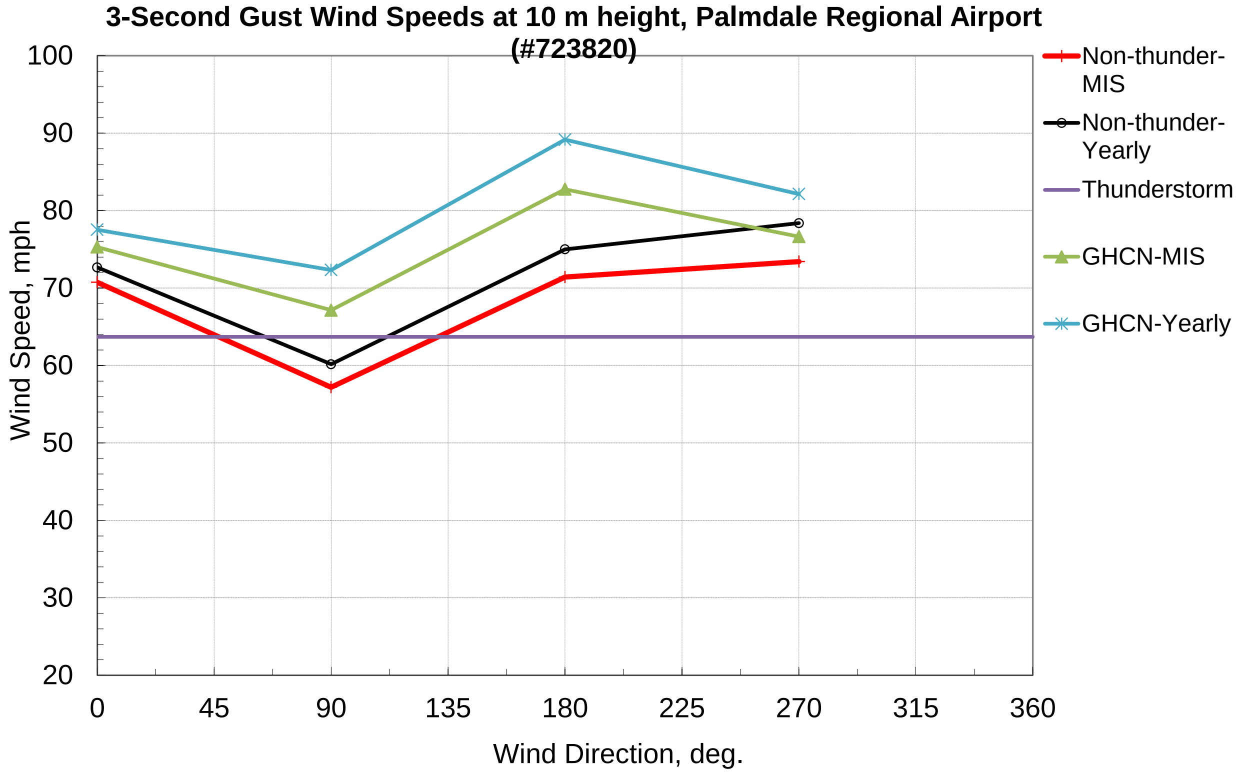


Figure B8b: Palmdale Regional Airport – Wind Gust Speed by Direction.

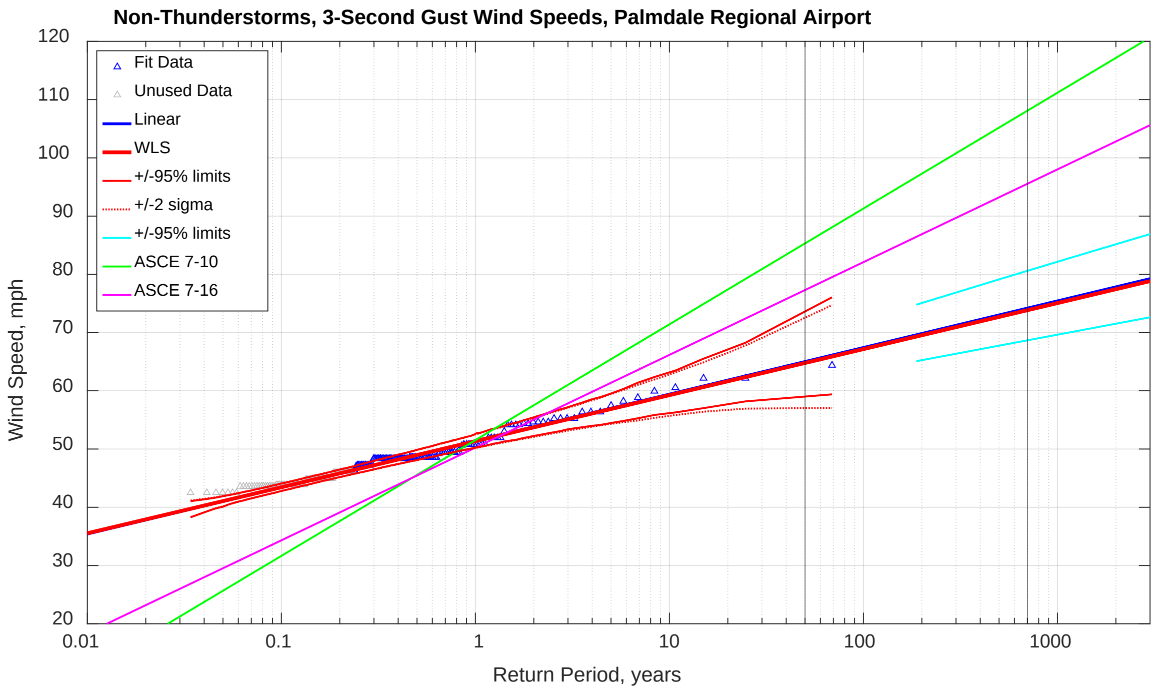


Figure B8c: Palmdale Regional Airport – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust

SANDBERG WEATHER STATION

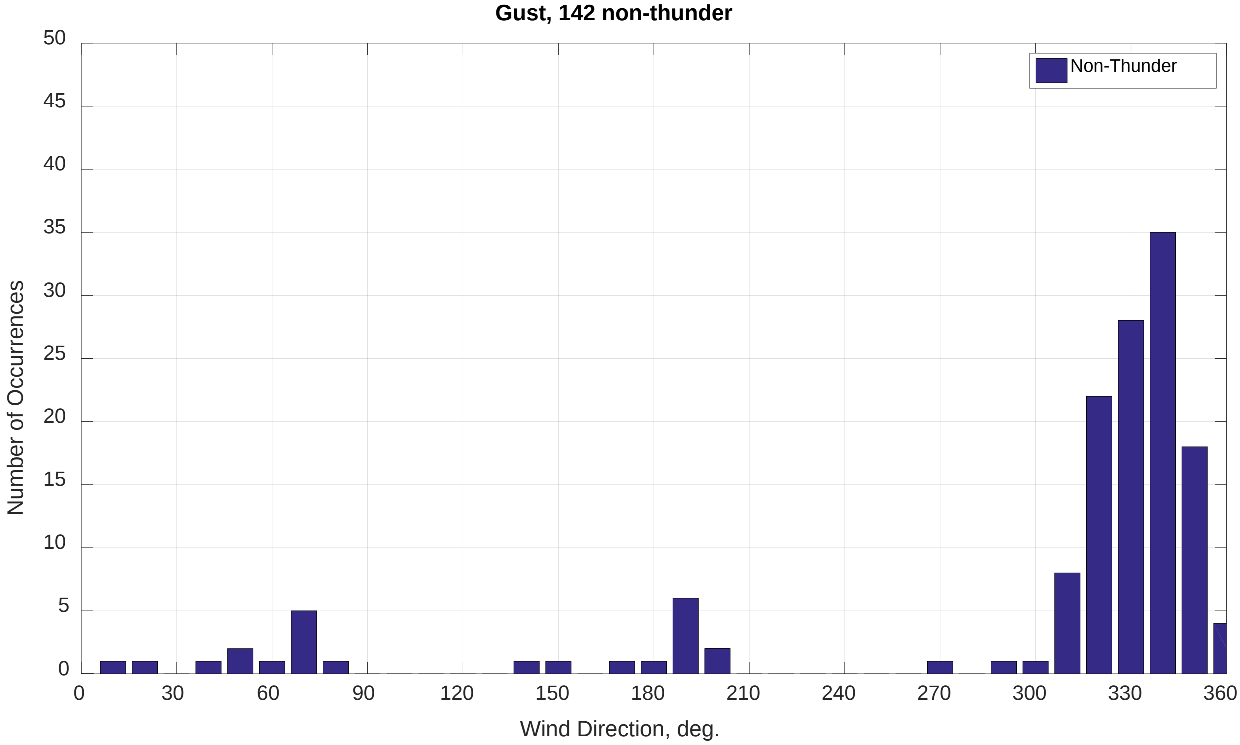


Figure B9a: *Sandberg Weather Station – Wind Gust by Direction*

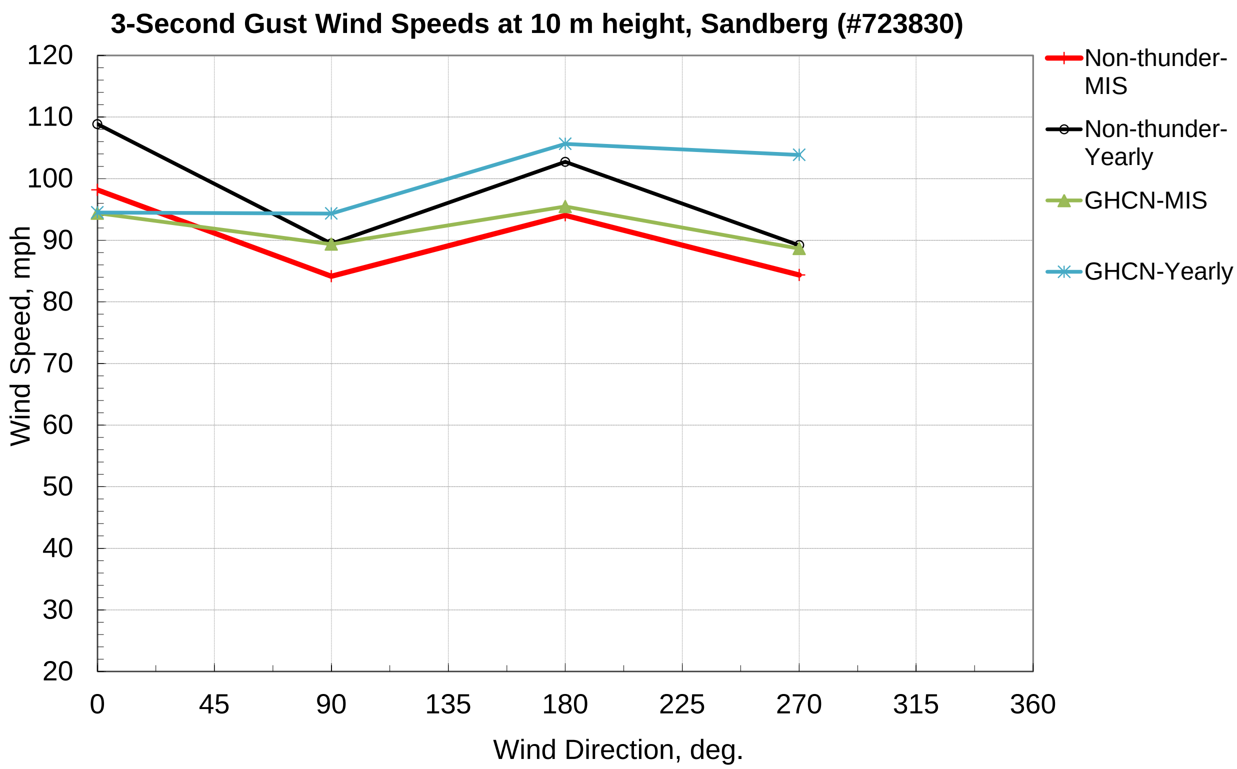


Figure B9b: *Sandberg Weather Station – Wind Gust Speed by Direction.*

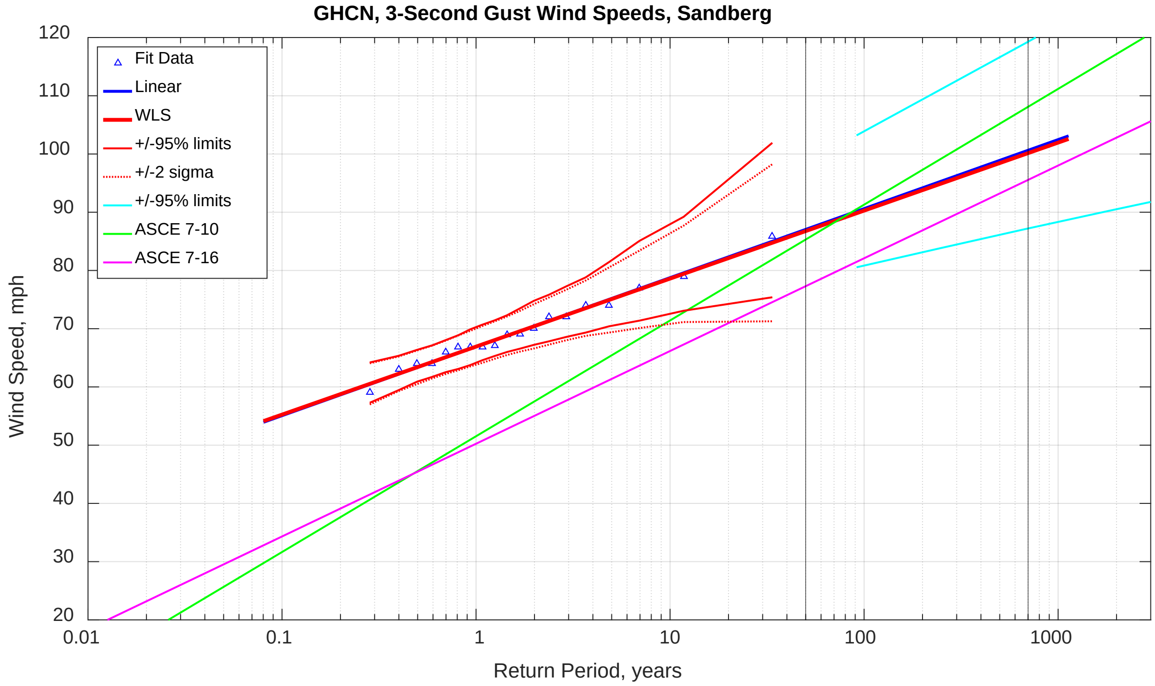


Figure B9c: *Sandberg Weather Station – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust*

SOUTHERN CALIFORNIA LOGISTICS AIRPORT

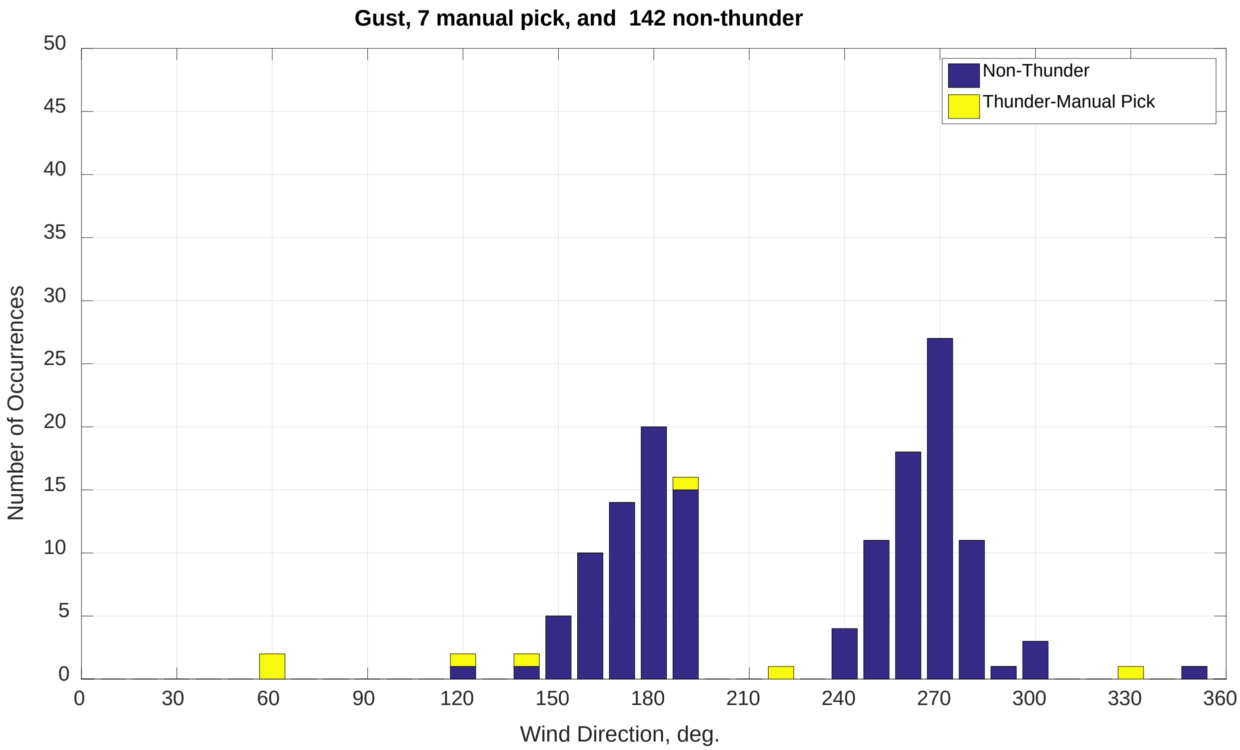


Figure B10a: *Southern California Logistics Airport – Wind Gust by Direction.*

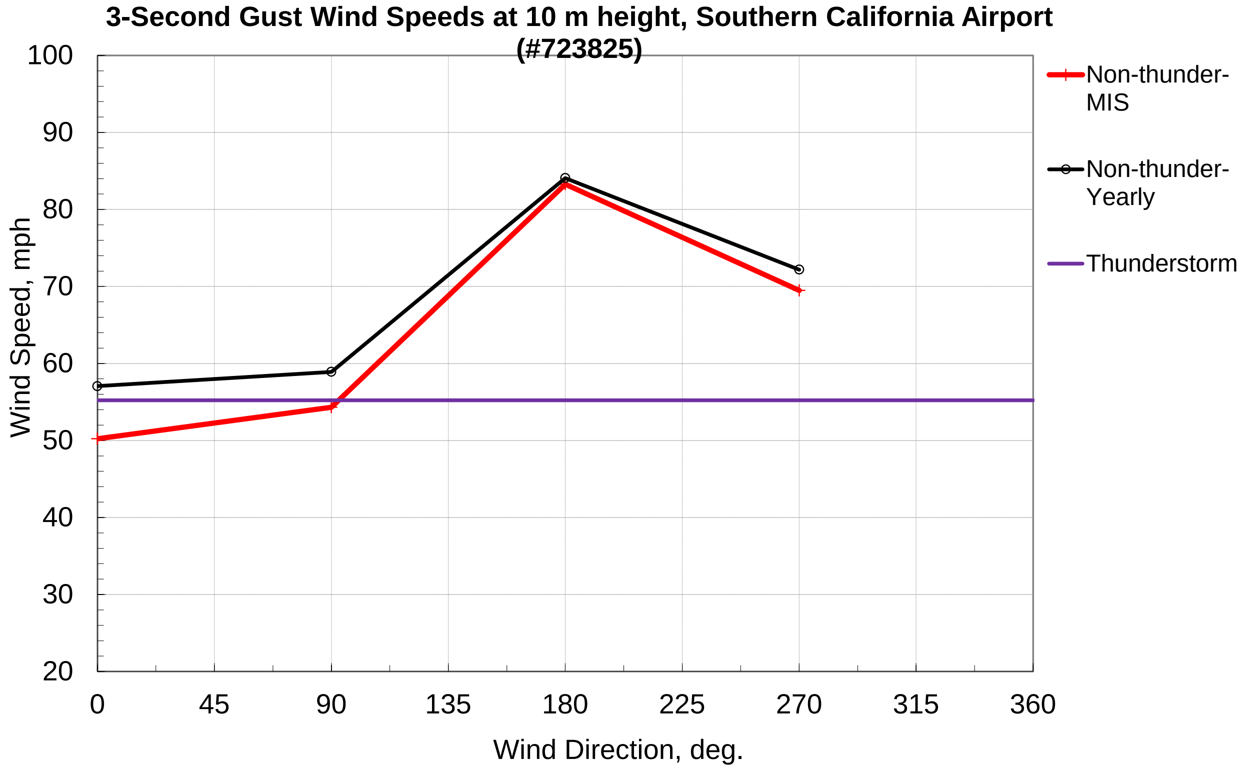


Figure B10b: Southern California Logistics Airport – Wind Gust Speed by Direction.

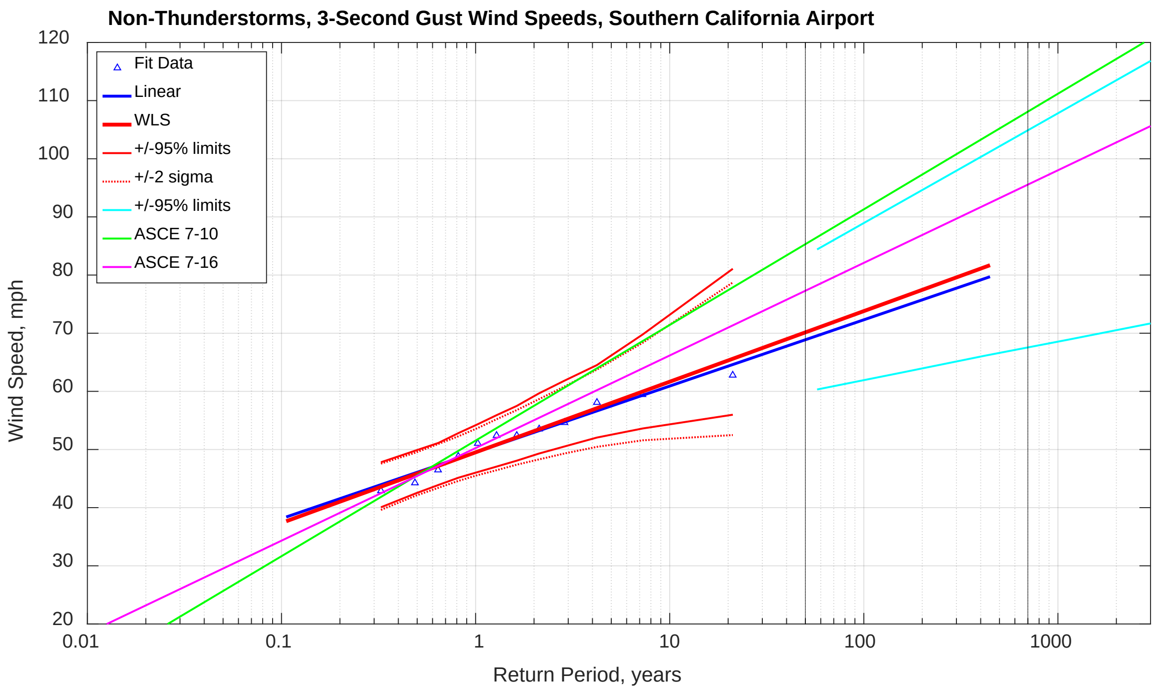


Figure B10c: Southern California Logistics Airport – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust

TEHACHAPI MUNICIPAL AIRPORT

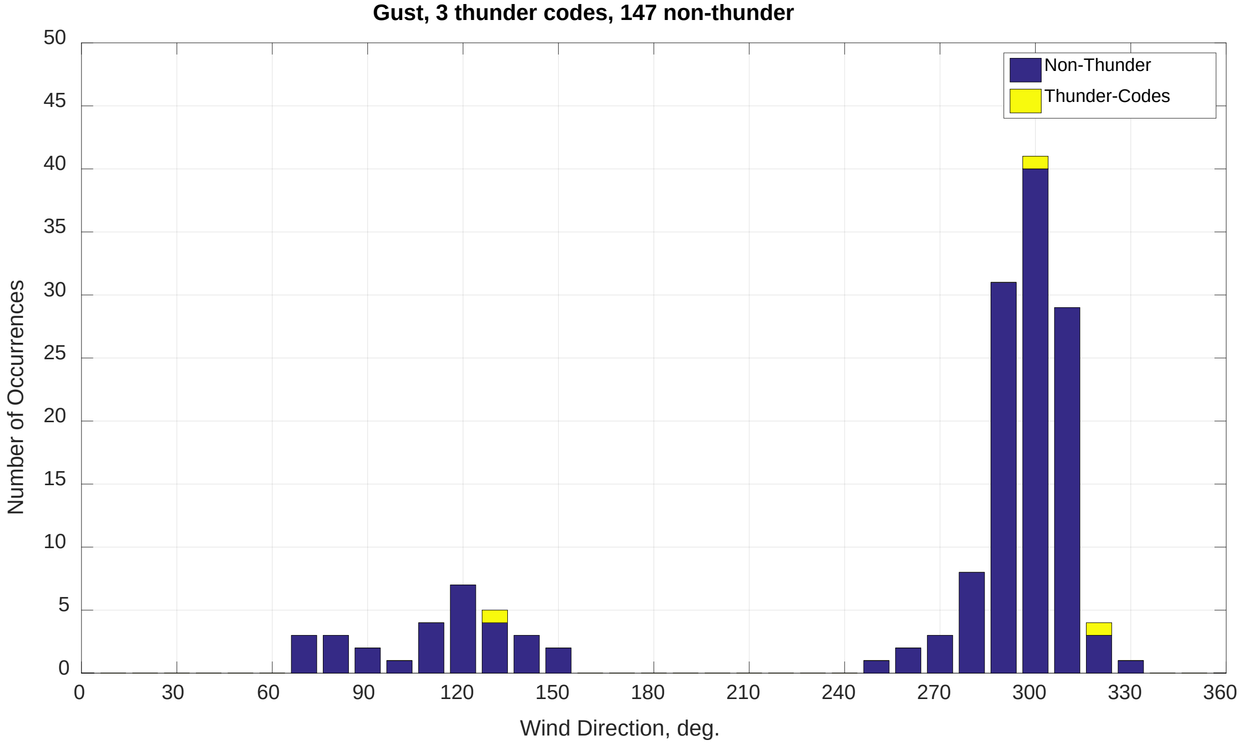


Figure B11a: *Tehachapi Municipal Airport – Wind Gust by Direction.*

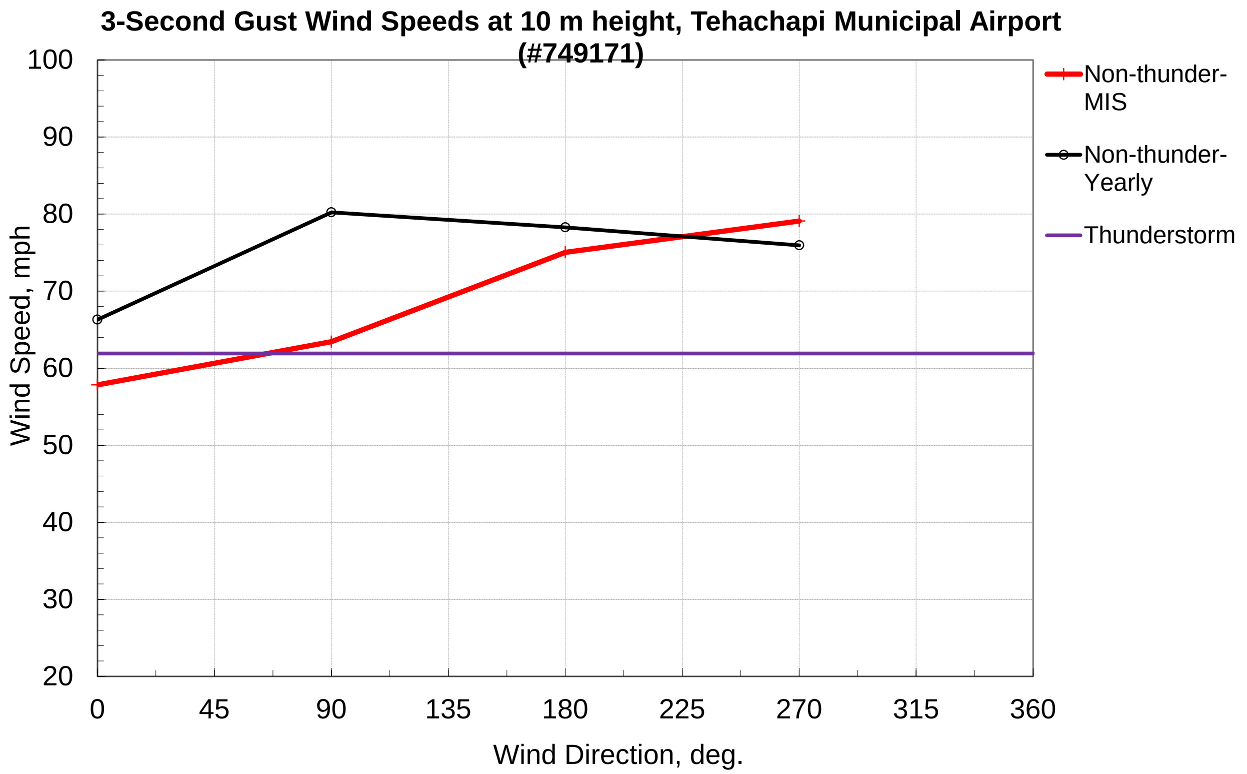


Figure B11b: *Tehachapi Municipal Airport – Wind Gust Speed by Direction.*

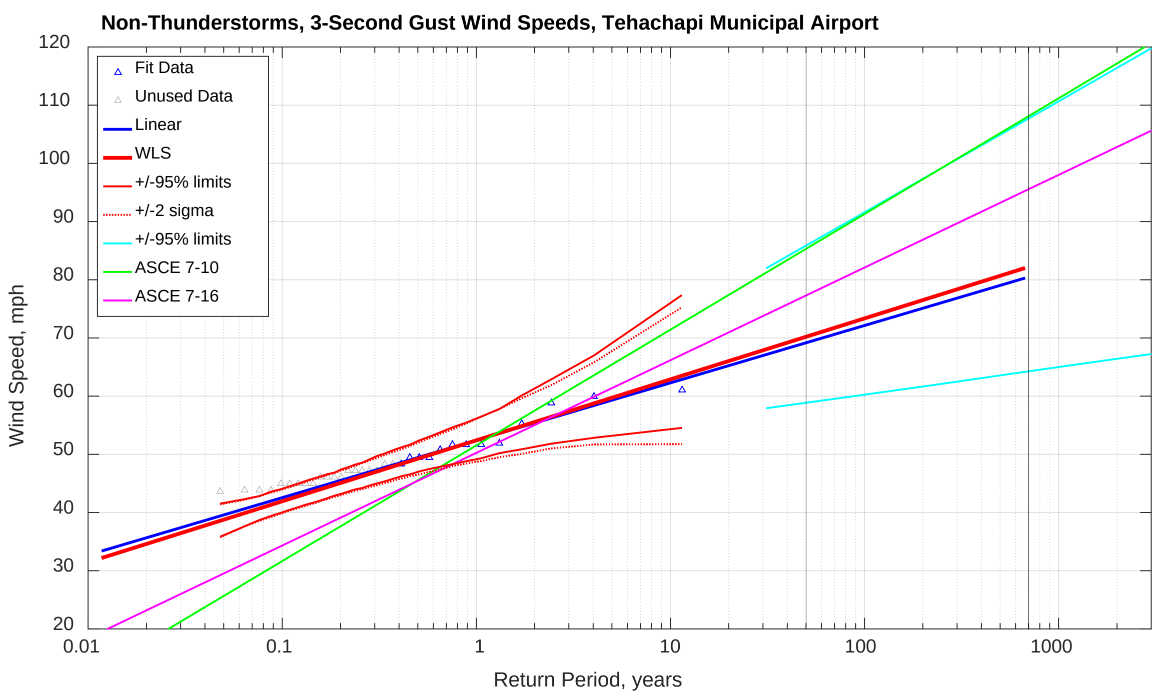


Figure B11c: *Tehachapi Municipal Airport – Wind Speed Gumbel Fit for Non-Thunderstorm Wind Gust*