A Comparison of Tropical Storm (TS) and Non-TS Gust factors for Assessing Peak Wind Probabilities at the Eastern Range

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Overview

- Motivation and Goals
- Data sets
- Gust factor (GF) definition
- Data preparation
- Comparison results
- Conclusion

Motivation and Goals

- Motivation:
  - Peak winds important for space operations, difficult to forecast
  - Model for TS peak winds developed by Merceret (2009)
  - AMU task: create non-TS peak wind climatologies/probabilities
- Goals:
  - Compare TS to extratropical (non-TS) GF over same range of wind speeds and heights
  - Determine if TS model can be adapted to non-TS environment

TallTowerTSPeakWindTool_v2.xls [Compatibility Mode]

	A	B	C	D
1	Tropical Storm Peak Wind Probability Climatology Model Tool for KSC/CCAFS			
2	Version 2.0		2009-01-09	
3	Author:	F.J. Merceret		NASA/KSC Weather Office
4				
5	This tool uses regression-based models to provide an estimate			
6	of the probability that the peak wind speed will exceed a specified value.			
7	It is derived from least squares fits to gust factors in 2004 hurricanes Frances and Jeanne.			
8	The fits were verified using independent data from 2005 hurricane Wilma			
9	It is valid only for winds measured from Eastern Range towers 002, 006, 110 and 313.			
10	It is valid only for tropical storm environments.			
11	It was derived from data with mean windspeeds between 15 and 70 knots.			
12	Extrapolation beyond those limits is not recommended.			
13				
14	Required inputs:			
15	Height of measurement (ft)			204
16	Mean windspeed (kt)			25
17	Peak Windspeed Threshold (kt)			35
18				
19	The Probability of exceeding the specified peak wind threshold is			
20	39	% according to the Gaussian model		
21	35	% according to the lognormal model		
22	33	% according to the Gumbel model		
23				
24	Computed probabilities are estimates.			
25	Actual occurance frequencies may vary by as much as 20%.			
26				
27	Probability statistics:			
28	Maximim	39 %		
29	Median	35 %		
30	Mean	36 %		
31	Minimum	33 %		
32	Range	7 %		
33				

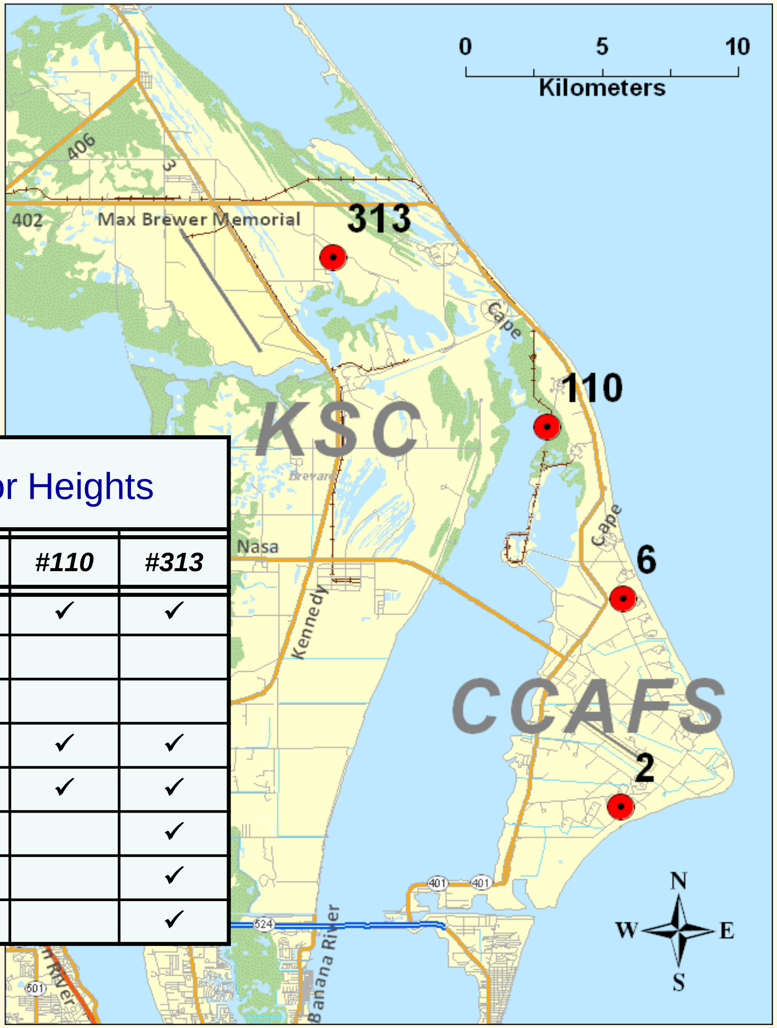
UserInterface | GaussianSingleValue | Logn

Data: Towers

- Prop/vane anemometers
- Sensors on opposite sides of each tower
- Automated and manual QC
- ***Same*** towers, ***Same*** sensors, ***Same*** site: eliminates location and instrument differences

Wind Tower Sensor Heights

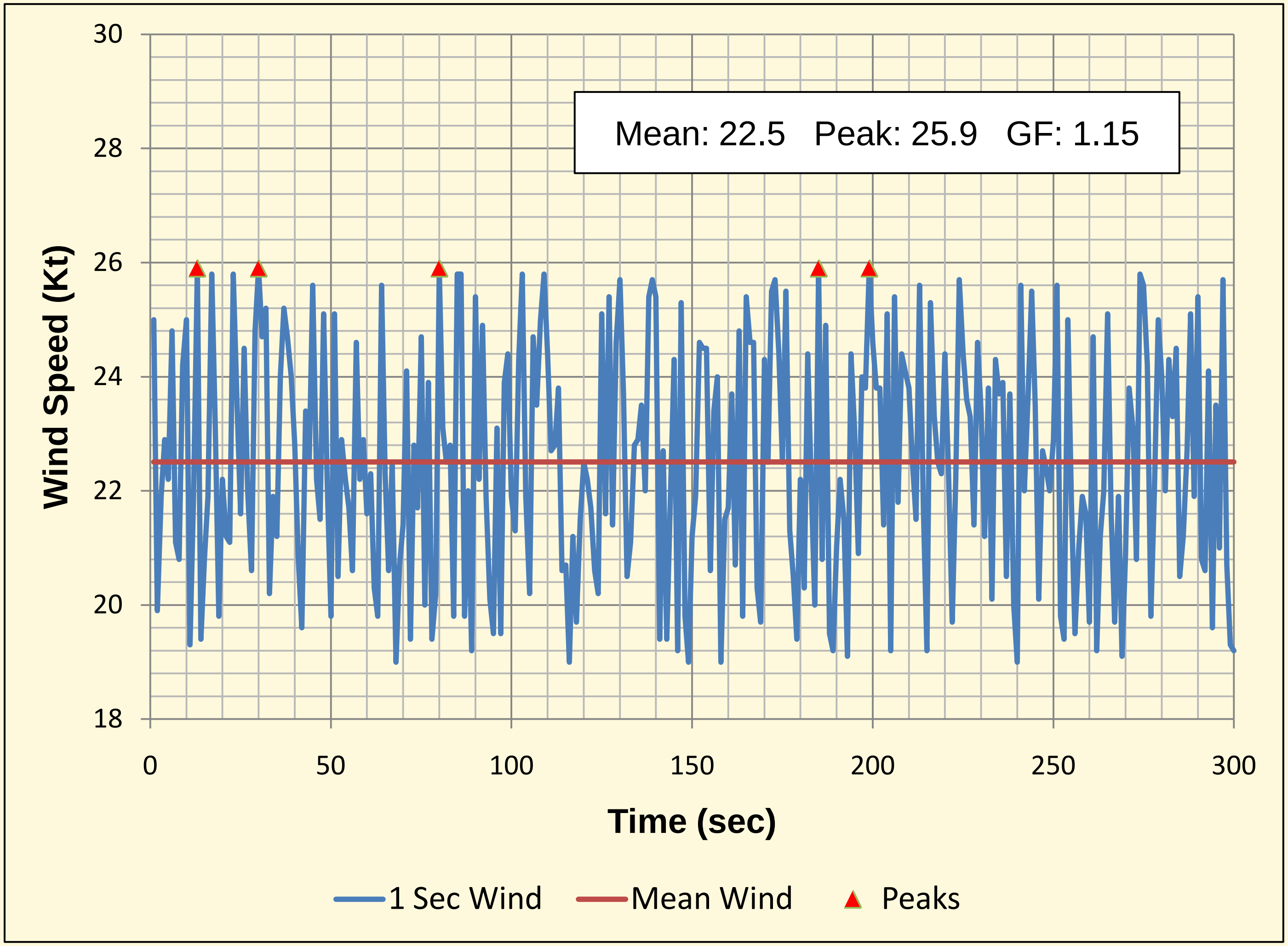
Tower #	*#2*	*#6*	*#110*	*#313*
54 ft	✓	✓	✓	✓
90 ft	✓			
145 ft	✓			
162 ft		✓	✓	✓
204 ft	✓	✓	✓	✓
295 ft				✓
394 ft				✓
492 ft				✓



Data: Stratifications

- TS data set:
  - Hurricanes Frances and Jeanne (September 2004)
    - Towers 2, 110, and 313
    - Empirical models for GF $\boldsymbol{\mu}$ and $\boldsymbol{\sigma}$ as function of speed and height
  - Validated with Hurricane Wilma data (October 2005)
- Non-TS data set
  - Cool-season (October – April) 1995 – 2007
  - Towers used for launch decisions
  - Stratifications for TS comparison study:
    - NE wind sector (0° to 60°)
    - Daytime data
    - Mean speeds ≥ 15 kt

How Gust Factor is Determined



Comparison: Mean GF

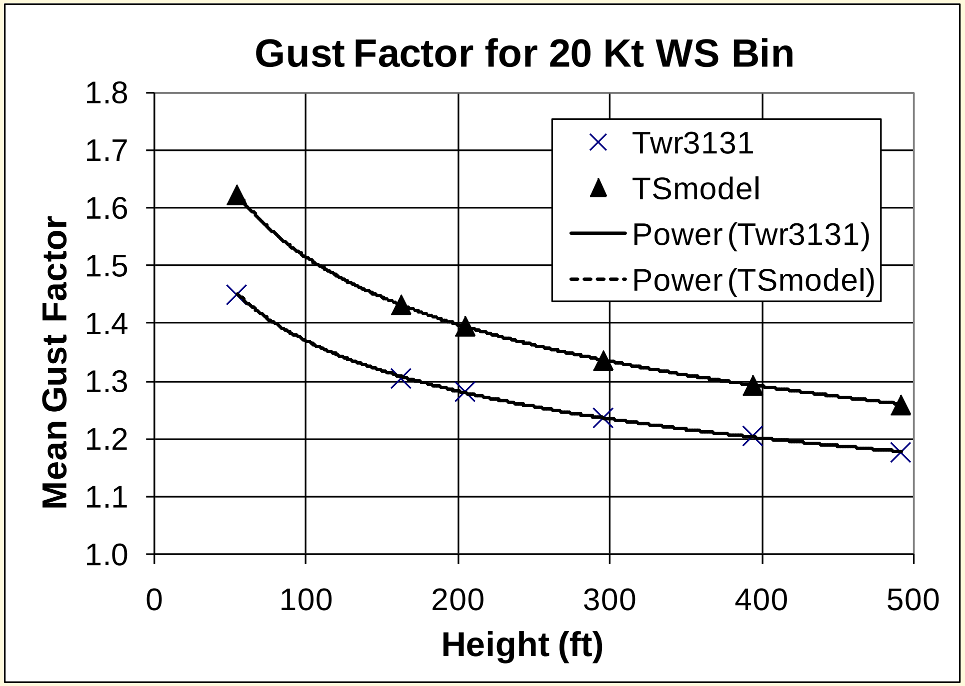
- Non-TS GF < TS GF at same height and wind speed
- Consistent with most previous results

Ratios of non-TS to TS GF

Tower	*Speed Bin (kt)*	*54 ft*	*90 ft*	*145 ft*	*162 ft*	*204 ft*	*295 ft*	*394 ft*	*492 ft*
2	20	0.951	0.939	0.932		0.940			
	30			0.978		0.970			
6	20	1.010			0.863	0.862			
	30				0.878	0.878			
110	20	0.947			0.915	0.911			
	30				0.917	0.906			
313	20	0.893			0.912	0.919	0.925	0.932	0.934
	30				0.952	0.950	0.928	0.920	0.919

GF Change with Height/Speed

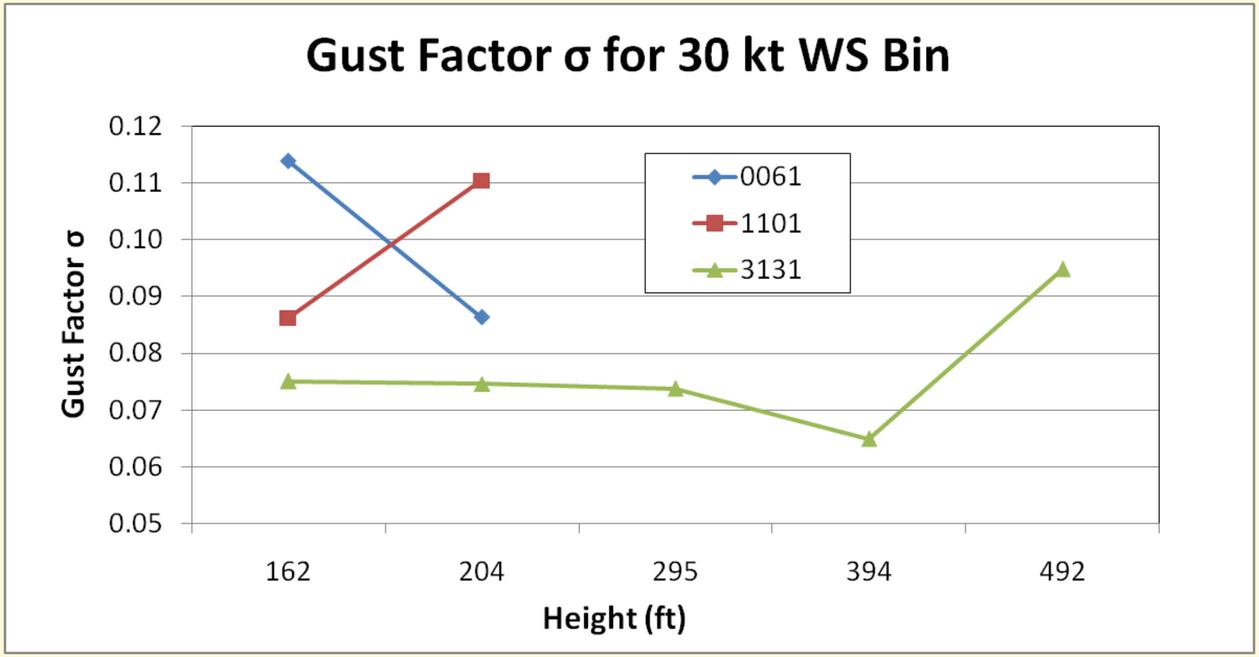
- Height
  - Non-TS GF change with height same form as TS: aH^b
  - Non-TS $R^2 = 0.9998$
  - No such comparison found in literature
- Speed
  - TS GF decrease with increasing mean speed
  - Non-TS GF show no consistent variation
    - Limited speed range
    - Lower speeds



Regression coefficients		
Source	***a***	***b***
Tower 313 non-TS	2.1096	-0.0941
TS Model	2.5668	-0.1148

GF Standard Deviation

- TS GF ***σ*** decreased monotonically with height/speed
- Non-TS ***σ*** showed no consistent variation with height or wind speed
- Ratios of non-TS to TS ***σ*** ranged from about 0.7 to 1.3 with no consistent height/speed patterns



Conclusions

- Use of same sensors/location reduce sources of comparison variance
- Non-TS GF < TS GF
- Result consistent with most studies in the literature
- Non-TS GF decrease with height similar to TS GF
- Unable to model the probability of exceeding specified peak speeds for non-TS due to inconsistent GF ***σ*** patterns