



Developing a Peak Wind Probability Forecast Tool for Kennedy Space Center and Cape Canaveral Air Force Station

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Outline



- Importance of Peak Wind to Operations
- Project Goals
- Wind Data Source
- Climatology / Probability Products
- Continuing Work
- Summary





Peak Winds



- An issue during launch operations
 - Fueling operations
 - Workers on gantries
 - Vehicle colliding with tower
- Important to launch forecasts
 - Speed thresholds defined in Launch Commit Criteria (LCC)
 - Thresholds different for each vehicle
- 45 WS: Peak winds challenging to forecast in cool season (Oct–Apr)
- AMU tasked to develop a tool to support peak-wind forecasting



Project Goals

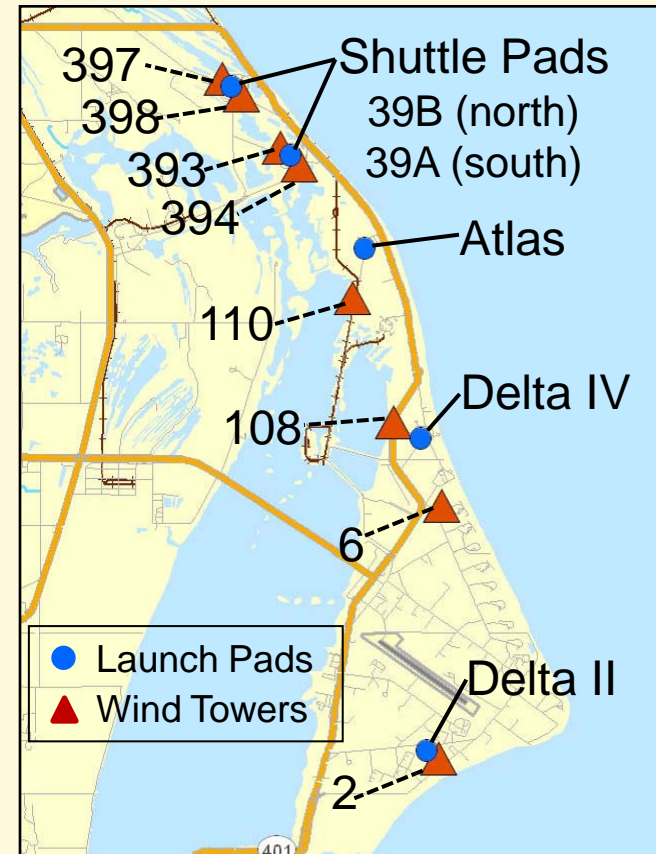
- Previous AMU work
 - 7-year period of record (POR)
 - Towers used for LCC evaluation
 - Stratify cool season data by month
 - Hourly/directional mean and peak speed climatologies
 - Peak speed distributions
- New work
 - 13-year POR (1995 – 2007)
 - Prognostic 2-, 4-, 8-, and 12-hour peak speed distributions
 - Graphical User Interface (GUI)



Wind Data Source

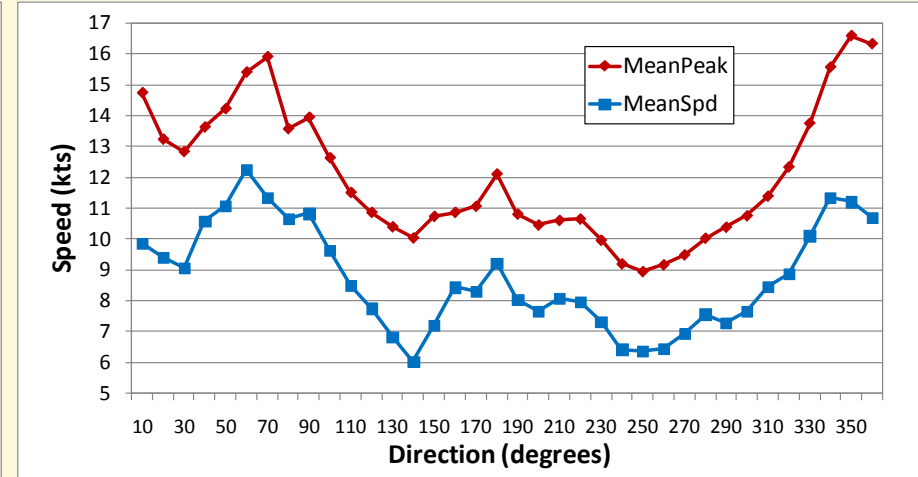
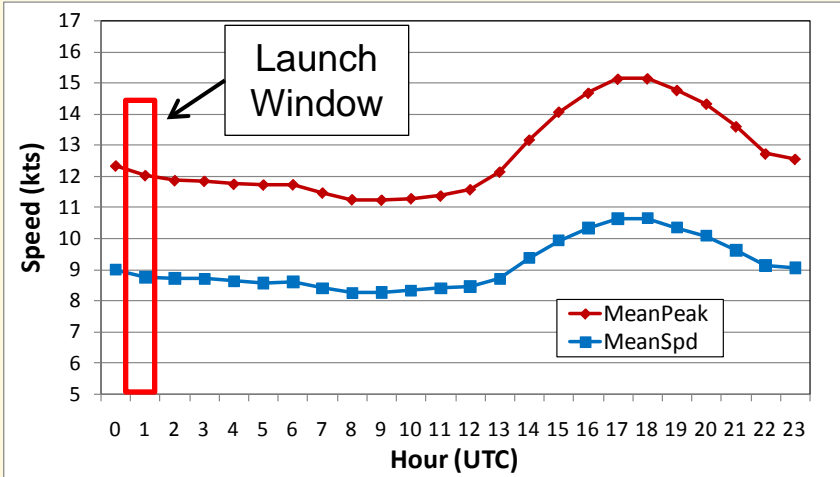
- Towers in network used to evaluate LCC
- 5-minute speeds/directions
 - 5-min mean calculated from 1-sec obs
 - 5-min peak highest 1-sec ob
- POR: October – April, 1995 – 2007
- Stratified by tower and month

<i>Vehicle</i>	<i>Tower(s)</i>	<i>Height</i>
Shuttle	393 / 394 397 / 398	60 ft
Atlas	110	204/54 ft
Delta II	2	90/54 ft
Delta IV	6, 108	54/12 ft

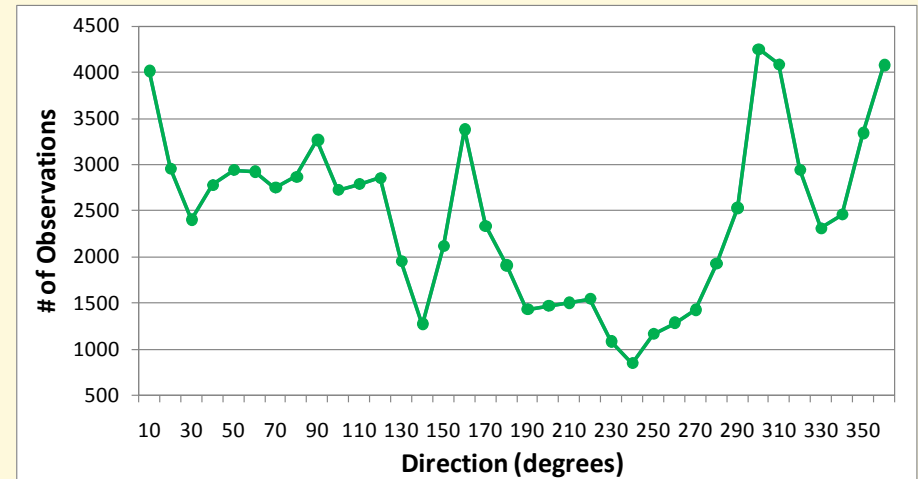




November Climatology Products



- Shuttle Endeavour launch
14 Nov 7:55 pm EST
(0055 UTC 15 Nov)
- Hourly/directional climos
 - November
 - Pad 39A Tower 393 / 60 ft

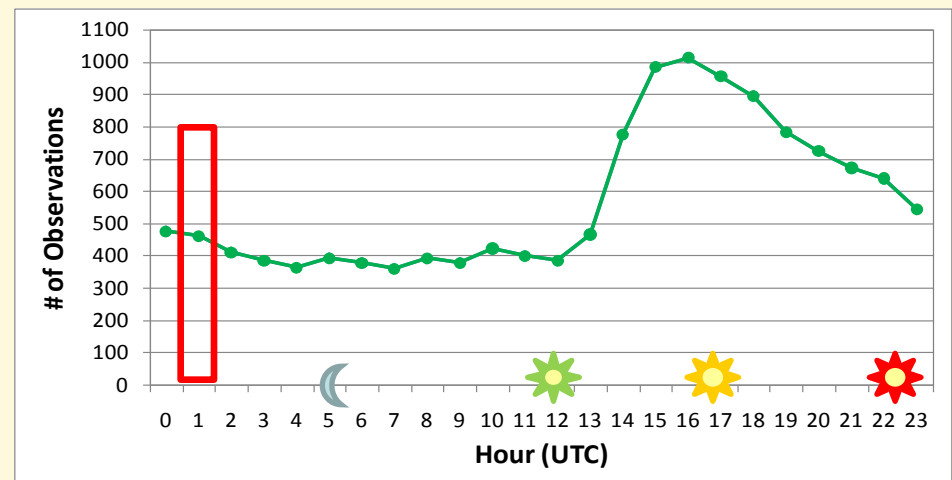
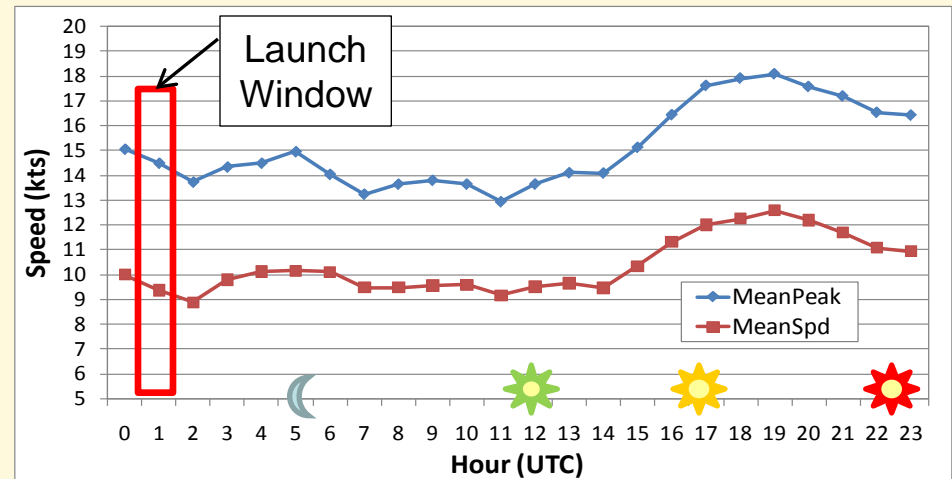




November Climatology Products



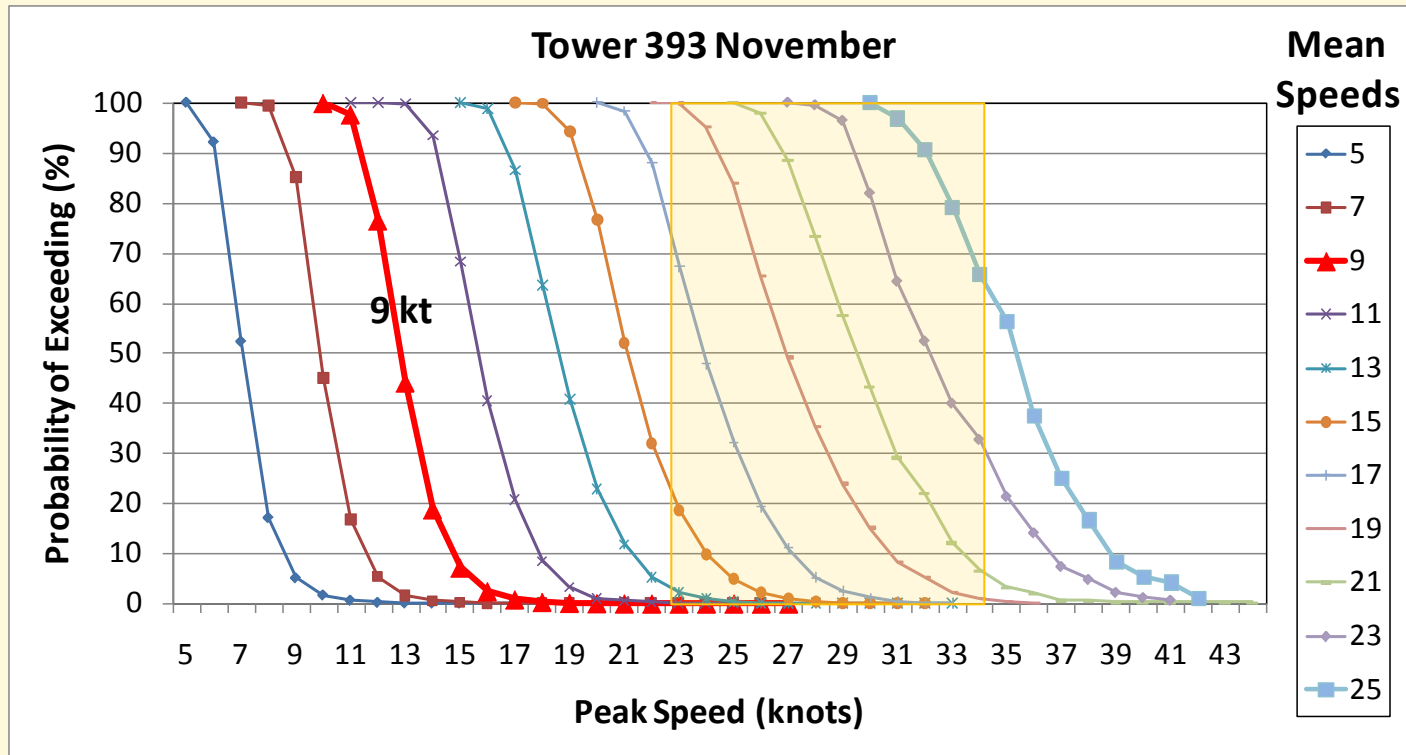
- Strongest/most frequent winds from N-NW sector
- Hourly/directional (45° bins)
- NNW (315 – 360°)
- Peak Speed Threshold: 23 – 34 kts
- Avg 5-min Mean: 9 kts
- Avg 5-min Peak: 14 kts



Midnight (☾) Sunrise (☀) Noon (☀) Sunset (☀)

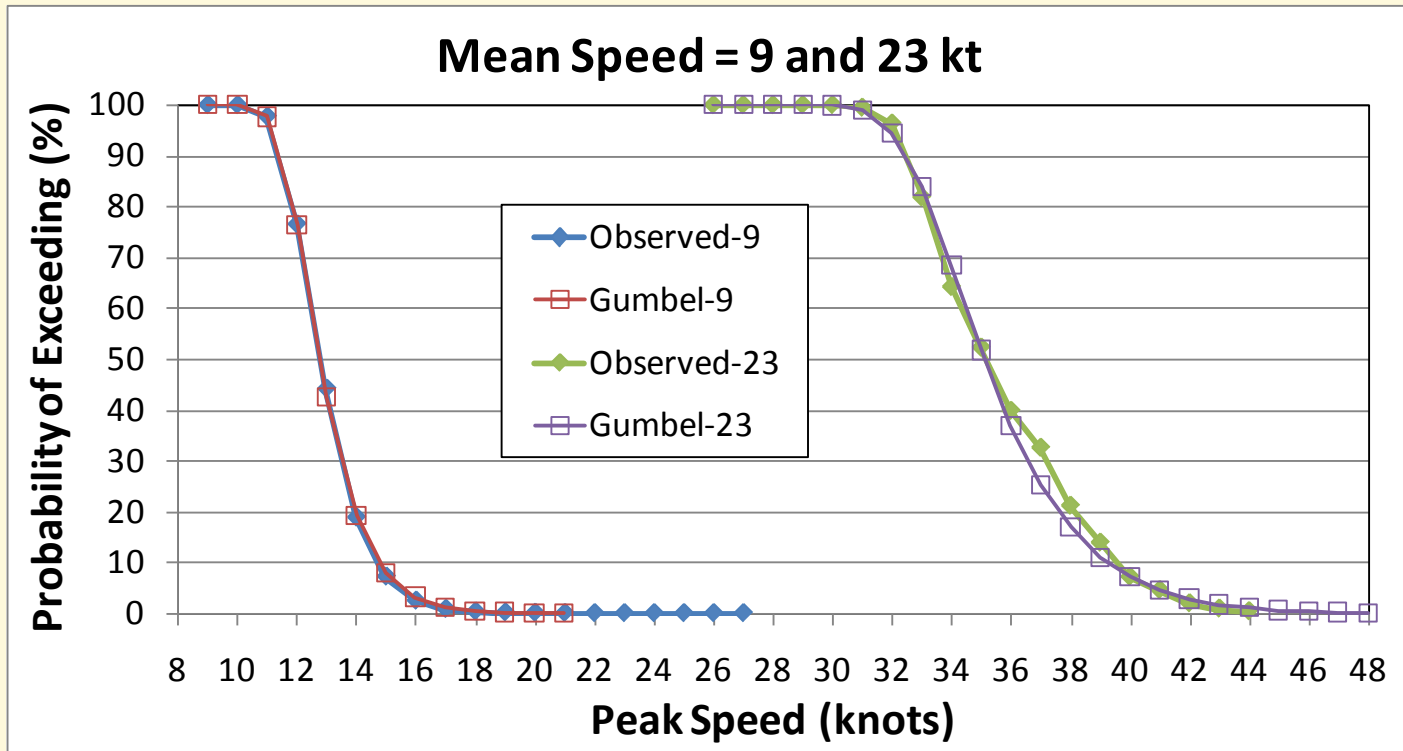
Probability Products

- Complementary cumulative distribution function (1-CDF) of 5-min peaks based on the 5-min mean
- Empirical CDF shows observed distribution
- Parametric CDF: interpolates and extrapolates



Probability Products

- Gumbel CDF used by Marshall Space Flight Center $\exp\{-\exp[-(x - \zeta)/\beta]\}$
- First guess: Method of moments: $\hat{\beta} = (s\sqrt{6})/\pi$ and $\hat{\zeta} = \bar{x} - \gamma\hat{\beta}$
- Optimize β, ζ with iterative Chi-square goodness-of-fit





GUI: Climatology

Choose Analysis

Climatology | Probability

Tower: 0393 | Height: 60 | Month: Nov

Choose Stratification:

- Hour (UTC) [0000]
- Direction [1 - 10 Deg] True North
- Direction / Hour [316 - 360 Deg] Direction [0100] Hour

Cancel | Get Climatology...

Requested Climatology (1995-2007)

LCC TOWER WIND CLIMATOLOGY

for Tower: 0393 at 60 ft During the Month of Nov

Stratification: Hour (UTC) 0100 and Direction 316 - 360 Deg

Wind Statistics

	Mean	Standard Deviation	% of Total in Hour
Peak	14 kts	6.6 kts	12.6
5-Min Avg	9.4 kts	4 kts	12.6

Choose Another Analysis

NOTICE
The statistics shown here reflect historical peak and average wind occurrence for the period 1995-2007. They are not necessarily indicative of future winds.

GUI: Probability

Choose Analysis

Climatology **Probability**

The range of mean and peak speeds depends on the values of each of the parameters below. Make desired choices, then click the "Get Speeds..." button to choose the mean and peak values.

Tower and Month: Tower: 0393, Height: 60, Month: Nov

Forecast Interval: Probability over the next: 0 hours

Distribution Type: Observed, Modeled (Gumbel)

Cancel Get Speeds...

Requested Probabilities (1995-2007)

The probability of meeting or exceeding in the next when the 5-minute mean wind speed is at on Tower during

41 %

NOTICE
The probabilities shown here reflect historical peak wind occurrence for the period 1995-2007. They are not necessarily indicative of future winds.

Retrieve Another Peak Speed Probability

Choose Mean and Peak

Click arrows to choose desired mean and peak speeds from the drop-down lists.

Speeds (knots): Mean: 16, Peak: 23

New Parameter Values: Get Probability...

Continuing Work

- Processing the data for the prognostic CDFs
 - Probability of exceeding LCC threshold over next 2, 4, 8, 12 hours based on observed or forecast mean speed
 - Probabilities for each hour
- Complete GUI to display values of interest





Summary



- Operational Products:
 - Hourly, directional, and hourly/directional avg/stdev of 5-min mean and peak speeds
 - Empirical/Gumbel probabilities
 - Stratified by month
- Operational Use:
 - Forecasters monitor obs/models
 - Climatological values used to assist launch team in making peak wind forecast

