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# 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
- An important forecast element
  - 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



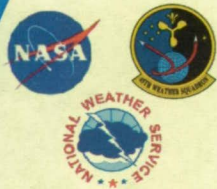


# Project Goals



- Update 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 elements
  - New POR 13 years (1995 – 2007)
  - Create 2-, 4-, 8-, and 12-hour peak speed distributions
  - Create a GUI



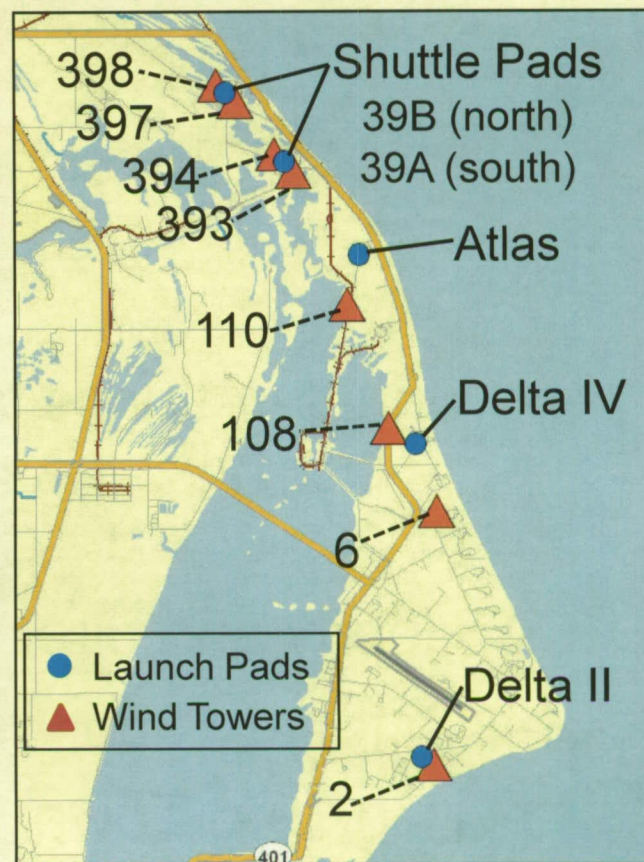


# Wind Data Source



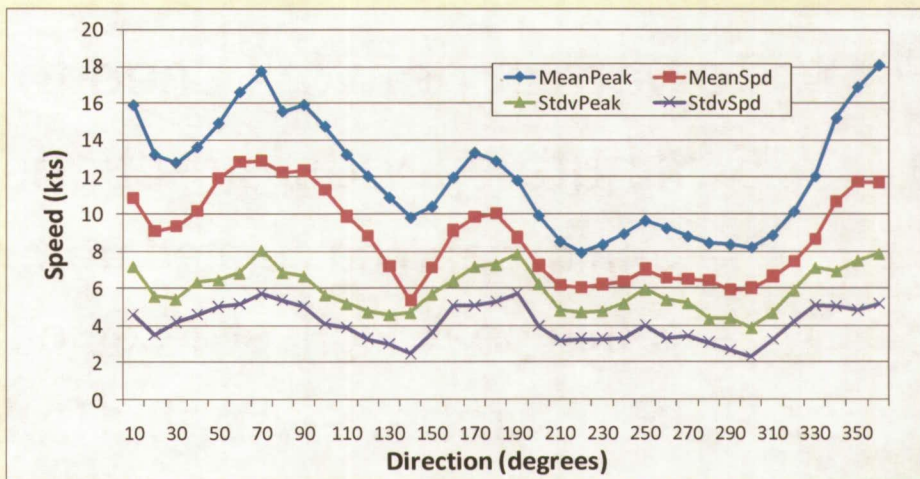
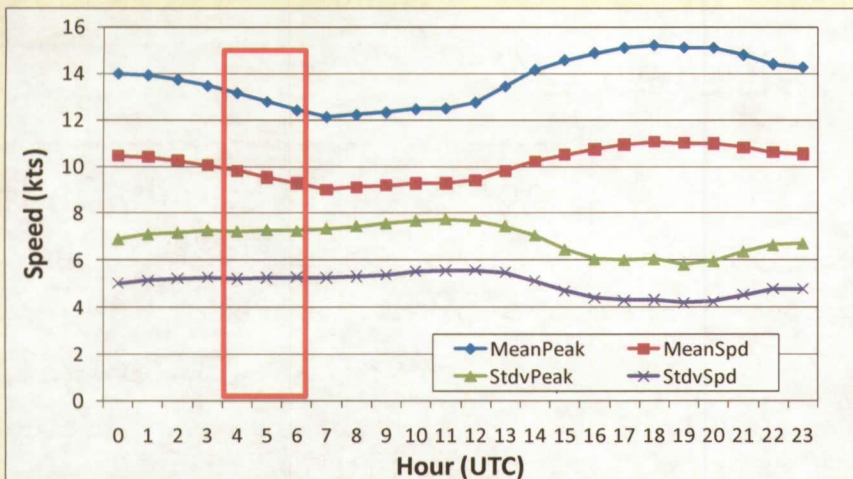
- Towers in network used to evaluate LCC
- 5-minute speeds/directions
  - 5-min mean calculated from 1-sec obs
  - 5-min peak highest 1-sec ob
- POR: October – April, 1995 – 2007
- Stratified by month

| <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      |

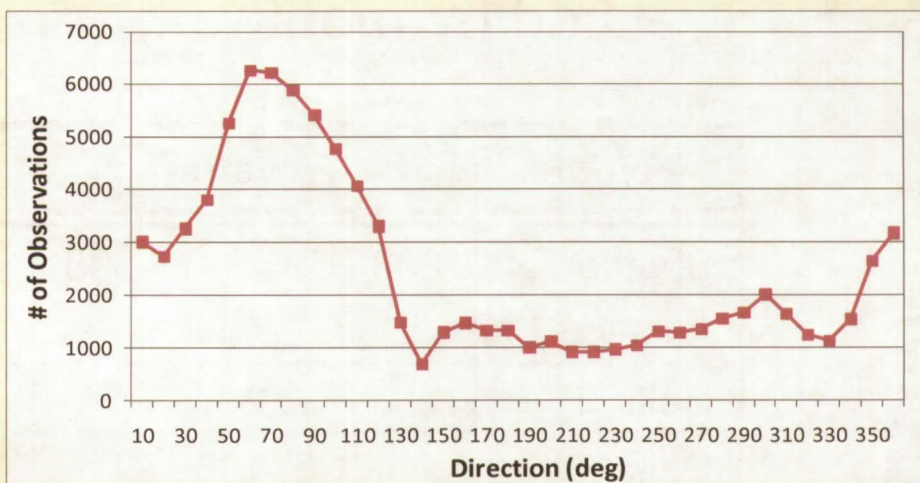




# Climatology Products



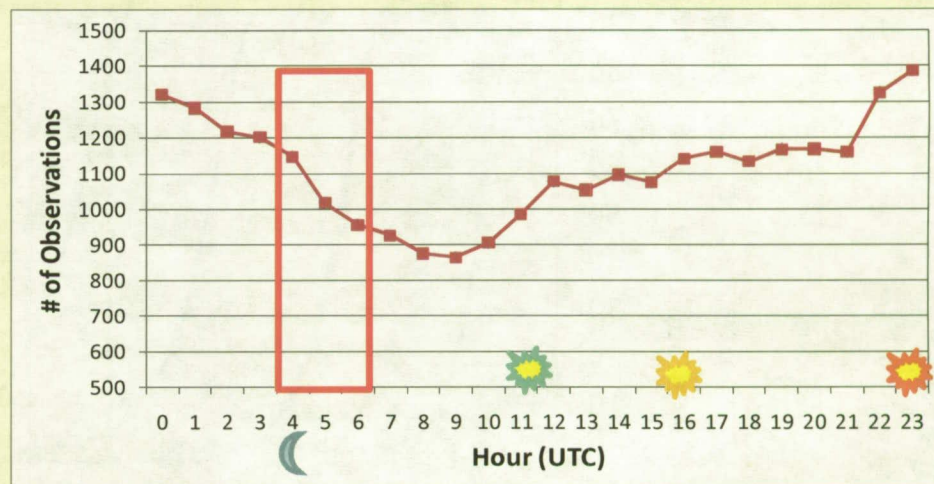
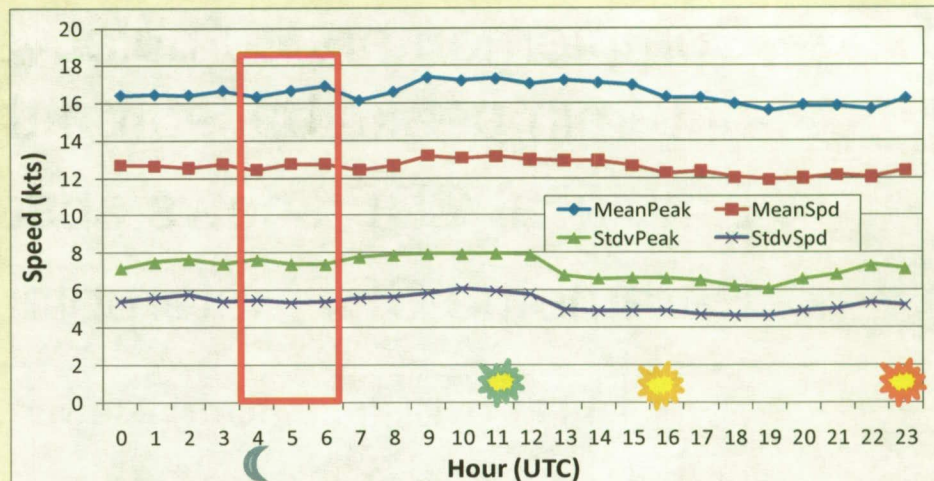
- Shuttle Atlantis launch  
10 Oct 12:33-1:39 am EDT  
(0433 - 0539 UTC)
- Hourly and directional
- October 1995 – 2006
- Pad 39A, Tower 393/60 ft





# Climatology Products

- Strongest and most frequent winds from NE–E sector
- Threshold: 23 - 34 kts
- Hourly/directional
- ENE bin (45 – 90°) steady speed values
- ENE occurrence on decreasing trend



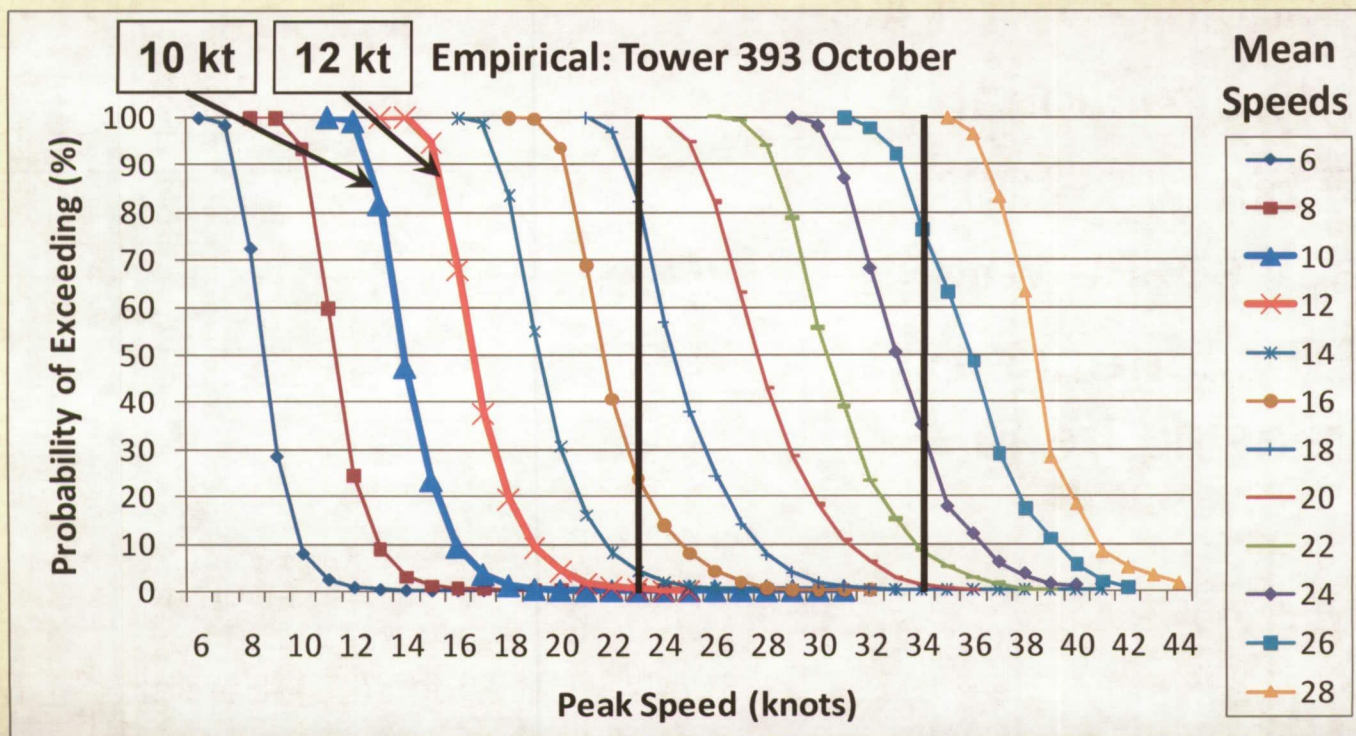
Sunrise (🌻) Noon (🌞) Sunset (🌇) Midnight (☾)





# Probability Products

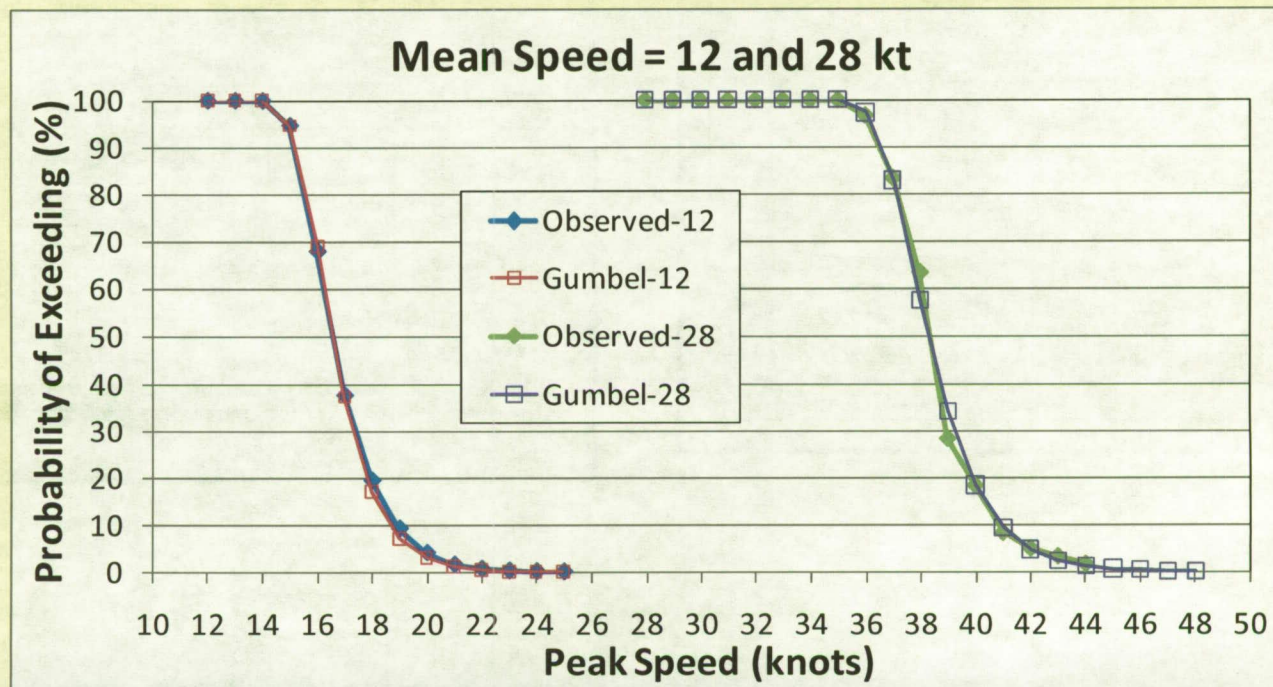
- Complementary cumulative distribution function (1-CDF) of 5-min peaks based on the 5-min mean
- Empirical CDF shows observed distribution
- Parametric CDF: interpolates and extrapolates





# Probability Products

- Gumbel CDF:  $\exp\{-\exp[-(x - \zeta)/\beta]\}$ 
  - Chosen over Weibull
  - Consistency with Marshall SFC
- Method of moments:  $\hat{\beta} = (s\sqrt{6})/\pi$  and  $\hat{\zeta} = \bar{x} - \gamma\hat{\beta}$
- Optimize  $\beta, \zeta$  with  $X^2$  goodness-of-fit





# GUI: Climatology

**Choose Analysis**

**Climatology** | Probability

Tower: 0393 | Height: 60 | Month: Oct

Choose Stratification

Hour (UTC) | 0000

Direction | 1 - 10 Deg | True North

Direction / Hour | 46 - 90 Deg | Direction  
| 0500 | Hour

Cancel | Get Climatology...

**Requested Climatology (1995-2007)**

**LCC TOWER WIND CLIMATOLOGY**

for Tower: 0393 | at: 60 ft | During the Month of: Oct

Stratification

Hour (UTC): 0500 | and | Direction: 46 - 90 Deg

Wind Statistics

|           | Mean     | Standard Deviation | % of Total in Hour |
|-----------|----------|--------------------|--------------------|
| Peak      | 16.8 kts | 7.4 kts            | 27.7               |
| 5-Min Avg | 12.8 kts | 5.3 kts            | 27.7               |

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: Oct

Forecast Interval

Probability over the next: 0 hours

Distribution Type

Observed

Modeled (Gumbel)

Cancel      **Get Speeds...**

**Choose Mean and Peak**

Speeds (knots)

Mean: 12      Peak: 23

New Parameter Values      **Get Probability...**

**Requested Probabilities (1995-2007)**

The **OBSERVED** probability of meeting or exceeding 23 kts  
in the next 0 hrs when the 5-minute mean wind speed is 12 kts  
at 60 ft on Tower 0393 during Oct

**0 %**

**\*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



# Continuing Work



- Processing the data for the prognostic CDFs
  - Probability of exceeding LCC threshold over the next 2, 4, 8, 12 hours
  - Data gathered using a re-sampling technique
  - 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
  - For each tower, height, month
- Operational Use:
  - Forecasters monitor obs/models
  - Climatological values used to assist in making peak wind forecast for launch team

