

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

**Winifred Lambert and David Short**

NASA KSC / AMU / ENSCO, Inc.

**William P. Roeder**

USAF 45th Weather Squadron / Patrick AFB



# Outline



- Importance of Peak Wind to Operations
- Previous Work
- Current Project Goals
- Wind Data Source
- Climatology Products
- 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
  - Previous period of record (POR) 7 years, new POR 13 years
  - Towers used for LCC evaluation
  - Stratify cool season data by month
  - Hourly/directional mean and peak speed climatologies
  - Peak speed distributions
- Two new elements
  - Create 2-, 4-, 8-, and 12-hour peak speed distributions
  - Create a GUI



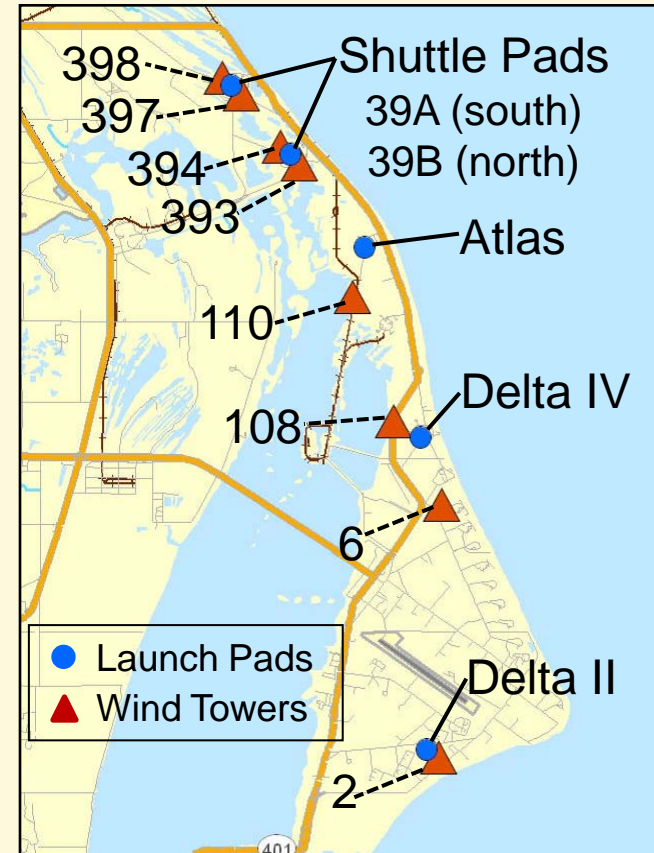




# Wind Data Source

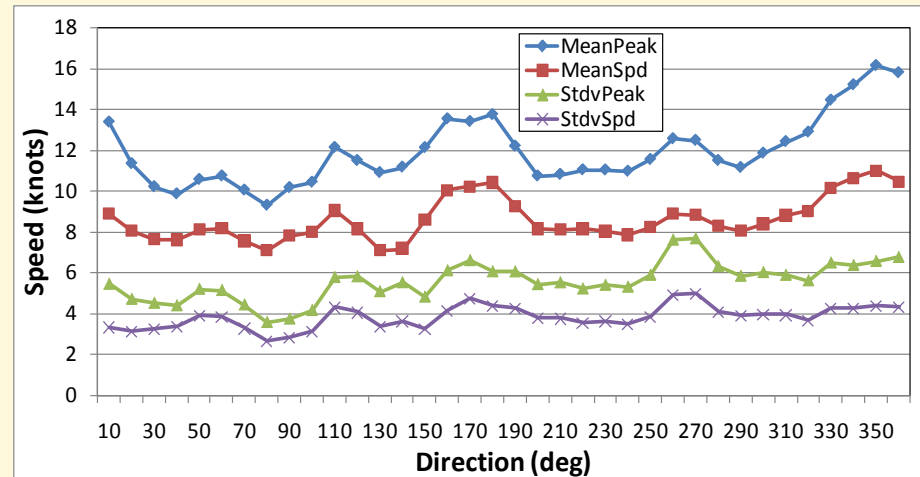
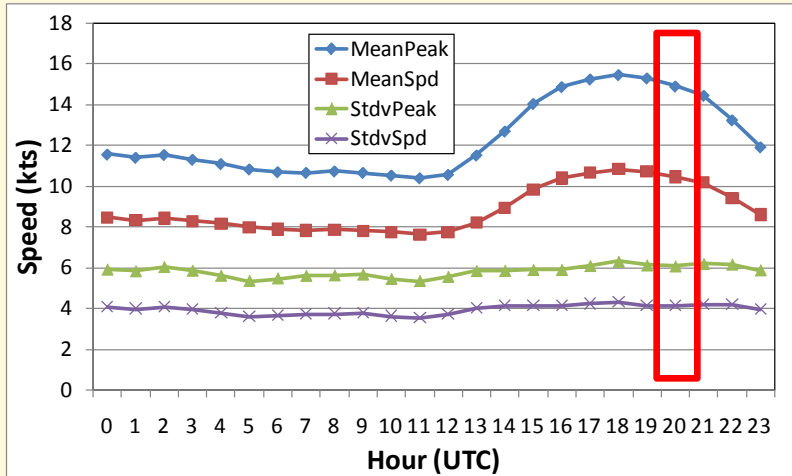
- Towers in network used to evaluate LCC
- 5-minute speeds/directions
  - 5-min mean calculated from 1-sec obs
  - 5-min peak highest 1-sec ob
- POR: October – April, 1995 – 2007
- Stratified by month

<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

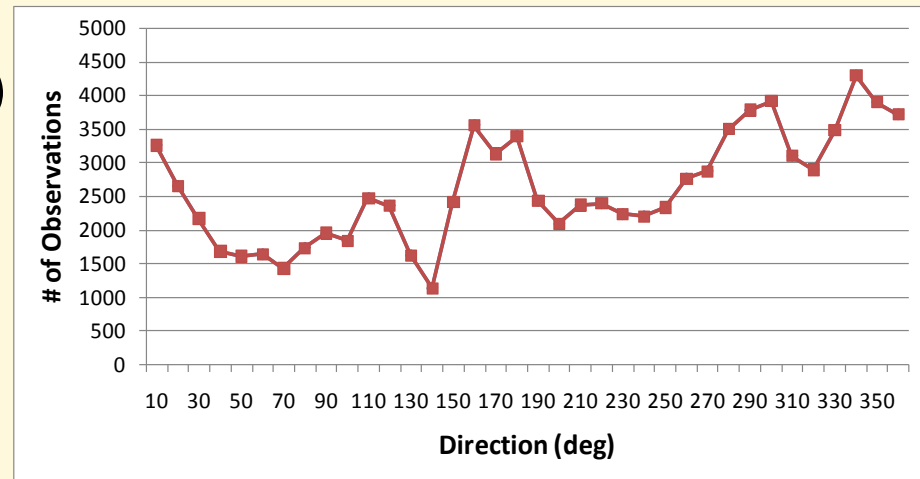




# Climatology Products



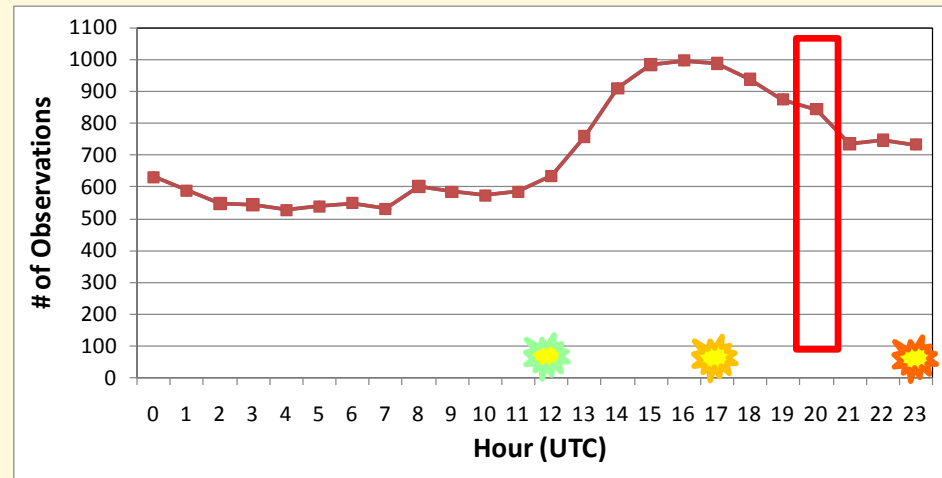
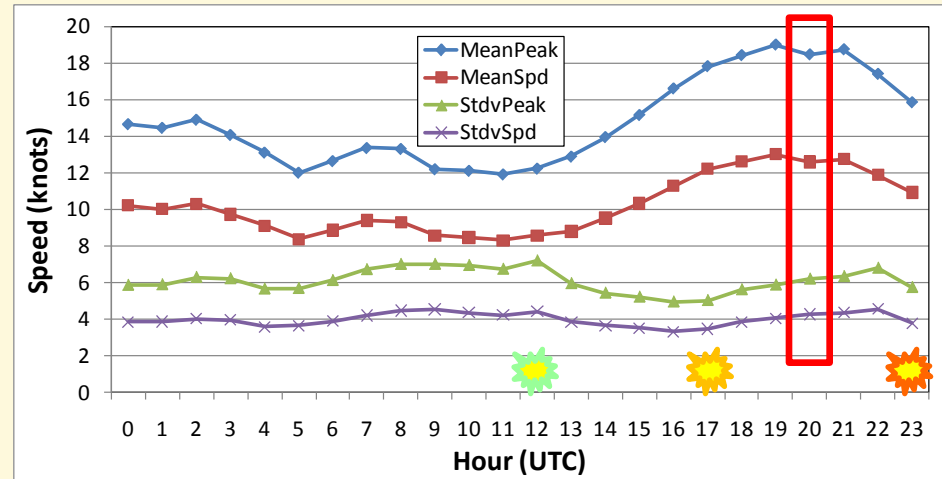
- Shuttle Atlantis launch  
7 Feb 1447 EST (1947 UTC)
- Hourly and directional
- February 1995 – 2007
- Tower 393, 60 ft





# Climatology Products

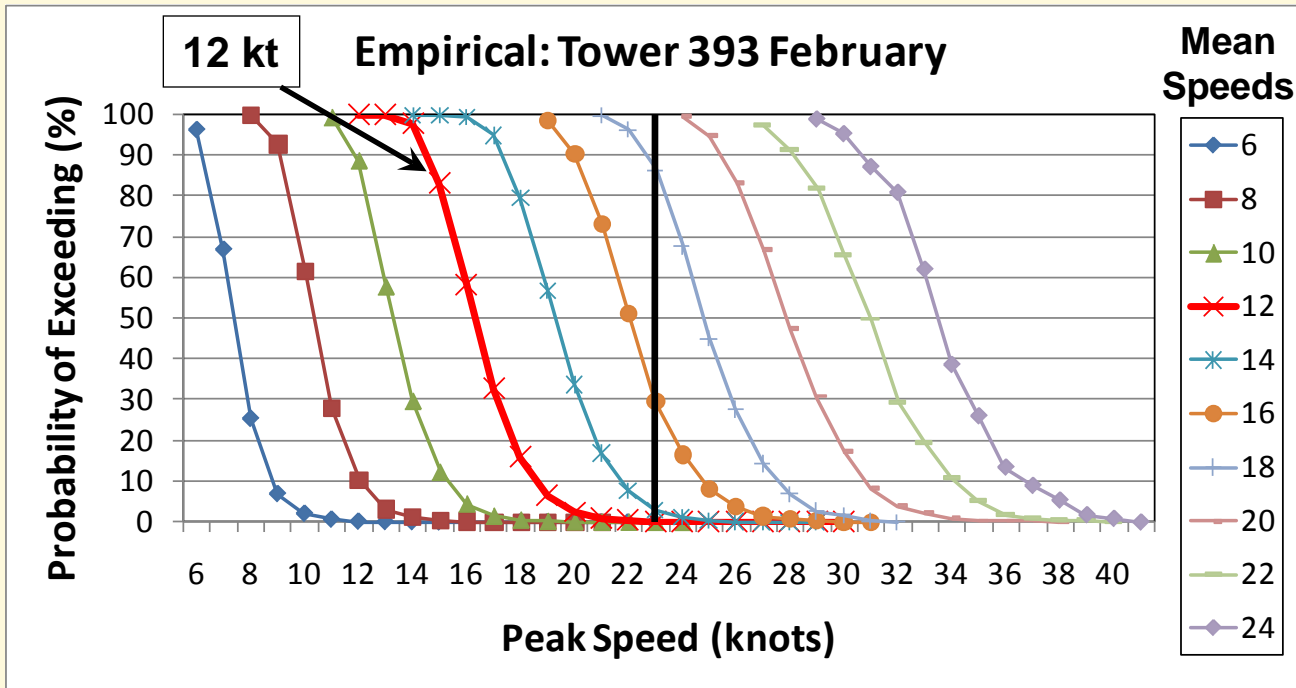
- Strongest winds from the north
- Threshold: 23 kts
- Hourly/directional (45°)
- NNW bin (315 – 360°) max mean/peak btwn noon (☀️) and sunset (🌇)
- Northerly occurrence increases at sunrise (🌅), max at noon





# 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

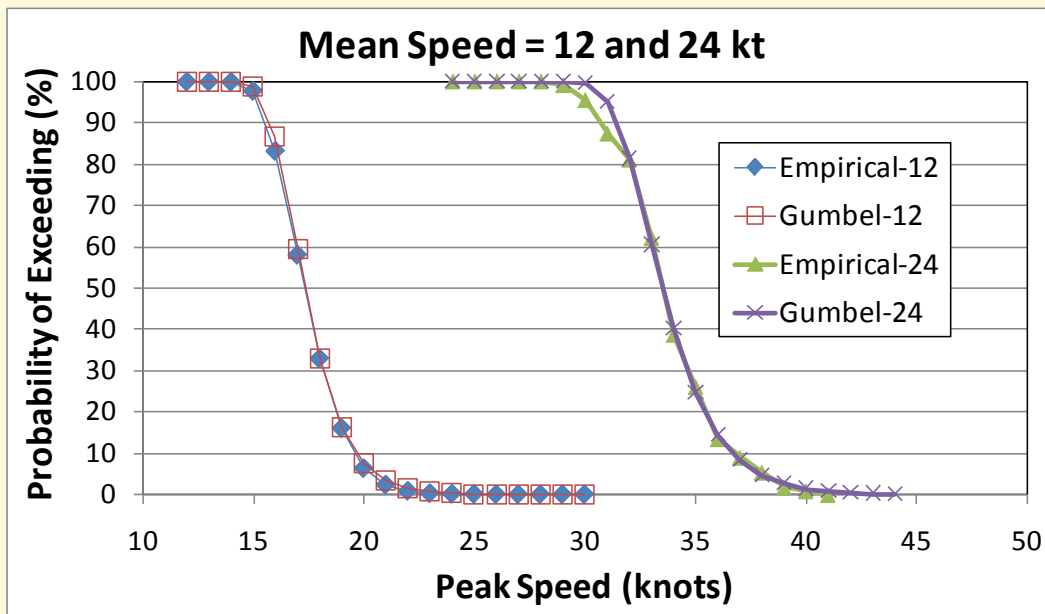






# Probability Products

- 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  $\chi^2$  goodness-of-fit





# Continuing Work



- Creating complementary Gumbel CDFs
- 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
- Create a 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 in making peak wind forecast for launch team

