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
  – 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 obs
- POR: October – April, 1995 – 2007
- Stratified by tower and month

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

![Graph showing probability of exceeding different peak speeds for Tower 393 in November. The x-axis represents peak speed (knots) ranging from 5 to 43, and the y-axis represents probability of exceeding (%). The graph includes lines for mean speeds at 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, and 43 knots. The 9 kt mark is highlighted.](image-url)
Probability Products

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

Choose Analysis

Choose Stratification

- Hour (UTC)
- Direction
- Direction / Hour

Request Climatology (1995-2007)

LCC Tower Wind Climatology

for Tower 0393 at 60 ft During the Month of Nov

Stratification

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

Wind Statistics

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

*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.
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