An Update to the Warm-Season Convective Wind Climatology of KSC/CCAFS

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Background

- 17-year (1995-2011), warm-season (May-Sep) Kennedy Space Center / Cape Canaveral Air Force Station convective wind climatology

- Initially developed as an update to the 4-year climatology by Sanger (1999)

- 1995-2003 warning level (≥35kt) convective events by Loconto et al. (2006)

- 1995-2005 all convective events by Cummings et al. (2007)

Additional Previous Research

• Cummings (2007) – Case study of 23 Jul 2005 event
• Dupont (2007) – Case study of 31 Aug 2005 event
• Dinon et al. (2008) – Developed a radar climatology
• McCue (2010) – Evaluation of convective wind forecasting techniques and development/evaluation of new statistical forecasting methods based on 1500Z* KXMR soundings
• Harris (2011) – Evaluated use of dual-polarization radar techniques (updraft melting layer height) in forecasting strength of convective winds
• Anderson (2011) – Evaluation of McCue (2010) results and additional development of statistical forecasting techniques
Wind Tower Network

- 30 km x 40 km area around KSC/CCAFS
- 5-minute wind data from 82 anemometers across 36 towers (heights of 12, 20, 54, 60, 90, 145, 162, 204, 295 ft)
  - Originally 45 towers, 9 did not meet data availability thresholds (≥70% over entire climatology, without a single month below 65%)
  - Most low data availability towers were significantly west of KSC/CCAFS
  - Koermer and Roeder (2008) showed that data from the westernmost towers were of little significance in anticipating convective winds at KSC/CCAFS

- 1995-2003 tower data provided & prepared by the NASA Applied Meteorology Unit (AMU)
- 2004-2011 raw 5-minute tower data provided by Computer Sciences Raytheon (CSR)
Map of KSC/CCAFS weather towers used to collect wind data for this climatology. Only data from towers with black numeric identifiers were used in this study. Towers with white identifiers were eliminated due to low data availability.
Additional Data

- Added WSR-88D NEXRAD radar data from National Weather Service-Melbourne (MLB) and Tampa (TBW) from NCDC in 2007
- GOES satellite data
- KXMR soundings
  - 1995-2007 raw data obtained from CSR, were not encoded according to old WMO dewpoint depression convention
    - Soundings from GTS transmissions prior to Nov. 2007: RH ≤ 20% automatically set dewpoint depression = 30°C
- Surface observations from KTTS, KXMR, KTIX, KCOF
- Unisys tropical system archives
- Plymouth State Weather Center Archives
Identification of Convective Periods

• Begins at top of the hour when convection first occurs in the area, ends at the top of the hour after the last evidence of convection in the area, and is followed by a ≥6 hr break in convective activity (Cummings et al. 2007)

• NWS-KMLB NEXRAD radar base reflectivity images refine start and end times using a 40 dBz threshold

• Strong synoptic pressure gradients (fronts, nearby tropical systems) eliminated from the climatology

• 1100 identified in the 17-year climatology
Additional QC & Refining of Convective Periods

- Further refined start and end times of convective periods using KMLB NEXRAD radar 40 dBz threshold
  - 6-hour break rule allowed some convective periods to be broken down into multiple events, while others were merged
- Identified gaps in KMLB radar data where KTBW could be substituted
- Identified incorrectly counted convective periods which crossed between months
- Remaining synoptic events identified and removed from the climatology
- Updates to climatological statistics and figures
May-Sep Convective vs. Non-Convective Days by Year
1995-2011

Number of Occurrences

Years


Convective
Non Convective
Convective vs. Non-Convective Days by Month
1995-2011

Month
- May
- June
- July
- August
- September

Number of Occurrences
- Non Convective
- Convective
Convective Periods vs. Month
1995-2011

- Minimum
- Average
- Maximum
<table>
<thead>
<tr>
<th>FLOW REGIME</th>
<th>SUBTROPICAL RIDGE POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW-1</td>
<td>Subtropical ridge south of Miami</td>
</tr>
<tr>
<td>SW-2</td>
<td>Subtropical ridge between Miami and Tampa</td>
</tr>
<tr>
<td>SE-1</td>
<td>Subtropical ridge between Tampa and Jacksonville</td>
</tr>
<tr>
<td>SE-2</td>
<td>Subtropical ridge north of Jacksonville</td>
</tr>
<tr>
<td>NW</td>
<td>Subtropical ridge far to south and extending far into Gulf of Mexico and stronger than normal</td>
</tr>
<tr>
<td>NE</td>
<td>Subtropical ridge far to north and extending into SE US and much stronger than normal</td>
</tr>
<tr>
<td>Other</td>
<td>Subtropical ridge position not defined</td>
</tr>
<tr>
<td>Missing</td>
<td>Missing synoptic data to determine flow regime</td>
</tr>
</tbody>
</table>
Warm Season Flow Regimes for Convective vs. Non Convective Days 1995-2011

- Non Convective
- Convective

Flow Regime: Missing, NW, NE, Other, SE-1, SE-2, SW-1, SW-2

Percentage of Occurrence (%)

14
12
10
8
6
4
2
0

- SW-2
- Other
Seasonal Peak Wind Events and Flow Regime (%)
1995-2011

Average Peak Wind Speed (kt)

<table>
<thead>
<tr>
<th>Average Peak Wind Speed (kt)</th>
<th>Percentage of Events (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE-2</td>
<td>28.98</td>
</tr>
<tr>
<td>SE-1</td>
<td>28.02</td>
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<tr>
<td>SW-2</td>
<td>33.32</td>
</tr>
<tr>
<td>SW-1</td>
<td>35.9</td>
</tr>
<tr>
<td>NW</td>
<td>32.04</td>
</tr>
<tr>
<td>NE</td>
<td>28.2</td>
</tr>
<tr>
<td>Other</td>
<td>28.66</td>
</tr>
<tr>
<td>Missing</td>
<td>32.06</td>
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</tbody>
</table>
Warm-Season Diurnal Distribution of Convective Wind Observations
1995-2011

Time (UTC)
Warm-Season Convective Winds ≥ 35 knots vs. Time 1995-2011

- 25 Sep 2001---
- 134 warning-level obs during 0100Z hour
September Convective Winds $\geq 35$ knots vs. Time
1995-2011

Start: 24/15Z  End: 25/03Z  Flow Regime: SW-2

<table>
<thead>
<tr>
<th>Range/Hour</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>93</td>
<td>33</td>
<td>308</td>
<td>28</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5-9</td>
<td>385</td>
<td>163</td>
<td>415</td>
<td>39</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10-14</td>
<td>301</td>
<td>179</td>
<td>173</td>
<td>11</td>
<td>0</td>
<td>0</td>
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<tr>
<td>15-19</td>
<td>112</td>
<td>130</td>
<td>21</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20-24</td>
<td>12</td>
<td>80</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>25-29</td>
<td>9</td>
<td>74</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30-34</td>
<td>5</td>
<td>44</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>35-39</td>
<td>1</td>
<td>49</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>40-44</td>
<td>4</td>
<td>27</td>
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<td>0</td>
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<td>26</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>50-54</td>
<td>1</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>55-59</td>
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<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>60-64</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
May Convective Winds ≥35 knots vs. Time
1995-2011

2005
Start: 31/02Z  End: 31/17Z  Flow Regime: SW-1

<table>
<thead>
<tr>
<th>Range/Hour</th>
<th>0-4</th>
<th>5-9</th>
<th>10-14</th>
<th>15-19</th>
<th>20-24</th>
<th>25-29</th>
<th>30-34</th>
<th>35-39</th>
<th>40-44</th>
<th>45-49</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>3</td>
<td>125</td>
<td>259</td>
<td>280</td>
<td>196</td>
<td>137</td>
<td>49</td>
<td>17</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>44</td>
<td>250</td>
<td>221</td>
<td>257</td>
<td>198</td>
<td>111</td>
<td>51</td>
<td>43</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>35</td>
<td>82</td>
<td>307</td>
<td>359</td>
<td>163</td>
<td>50</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Number of Observations

Time (UTC)
Directions Associated with the Maximum Peak Winds for all Convective Periods with Average Maximum Speed 1995-2011

- North: 30.85%
- NE: 26.82%
- East: 27.54%
- SE: 27.26%
- South: 31.96%
- SW: 35.47%
- West: 35.35%
- NW: 35.31%

Average Peak Wind Speed (Knots)

Direction of Peak Maximum Wind
# Radar Studies

<table>
<thead>
<tr>
<th>Cell Initiation</th>
<th>Cell Structure</th>
<th>Cell Strength</th>
<th>Group Movement</th>
<th>Individual Cell Movement</th>
<th>Location of MPW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Breeze Front (SBF)</td>
<td>linear</td>
<td>weak/broken (&lt;45 dBz)</td>
<td>16 cardinal wind directions</td>
<td>16 cardinal wind directions</td>
<td>behind</td>
</tr>
<tr>
<td>Outflow Boundary (OFB)</td>
<td>individual</td>
<td>moderate (45-55 dBz)</td>
<td>variable/ stationary</td>
<td>variable/ stationary</td>
<td>overhead</td>
</tr>
<tr>
<td>SBF &amp; OFB</td>
<td>cluster</td>
<td>strong (&gt;55 dBz)</td>
<td></td>
<td></td>
<td>ahead</td>
</tr>
<tr>
<td>No SBF or OFB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dinon et al. (2008)
Cell Strength (%) 1995-2011
Warning vs. Non Warning

- Weak/Broken
- Moderate
- Strong

Percentage of Occurrences

<table>
<thead>
<tr>
<th>Weak/Broken</th>
<th>Moderate</th>
<th>Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning</td>
<td>Non Warning</td>
<td>Warning</td>
</tr>
<tr>
<td>0-10%</td>
<td>10-50%</td>
<td>60-70%</td>
</tr>
</tbody>
</table>

Graph showing the percentage distribution of cell strength for warning versus non-warning categories.
Individual Cell Movement (%) 1995-2011
Warning vs Non Warning

Cell Group Movement (%) 1995-2011
Warning vs Non Warning
Summary

• Total of 1100 convective events in the 17-year warm-season climatology at KSC/CCAFS
• July and August typically are the peak of convective events, May being the minimum
• Warning and non-warning level convective winds are more likely to occur in the late afternoon (1900-2000Z)
• Southwesterly flow regimes and wind directions produce the strongest winds
• Storms moving from southwesterly direction tend to produce more warning level winds than those moving from the northerly and easterly directions
Future Research Possibilities

- Use of 1000Z KXMR sounding data to forecast occurrence and strength of convective events

- Detailed case studies of individual convective events
Ander C. J., A. J. Frumkin, J. P. Koermer and W. P. Roeder, 2009: Study of sea-breeze interactions which can produce strong warm-season convective winds in the Cape Canaveral area. *16th Conf. on Air-Sea Interaction/8th Conf. on Coastal Atmospheric and Oceanic Prediction and Processes*, January, Phoenix, AZ.


Dupont, E. J., 2007. A case study of a warm-season convective wind period on the Florida Space Coast. Senior Research paper, Dept. of Chemical, Earth, Atmospheric and Physical Sciences, Plymouth State University, Plymouth, NH.


References


Sanger, N., 1999. CCAS microburst climatology. M.S. thesis, Dept. of Meteorology, Texas A&M University, College Station, TX. [Available from College of Geosciences, Texas A&M University, College Station, TX 77843-3148.]

Thank you