Tropical Cyclone Tornadoes

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Don’t forget about the Tornadoes!

- Tornadoes are possible with any tropical system.
- Tornadoes are likely in the right front quadrant of the storm.
- It is difficult to predict how great the risk of tornadoes will be with an individual tropical system.
- Hurricane Ivan (at right), produced a considerable number of tornadoes.
- Hurricane Dennis was not a prolific tornado producer, although had a similar track.
- Agnes (1972) produced tornadoes up to 300 miles from center!
Tornadoes with hurricanes

- Just over ½ of land-falling hurricanes produce tornadoes.
  - These are generally EF0-EF2, and normally only 1 or two tornadoes.
  - Occur without hail and often with no lightning.
  - Develop anytime - day or night
- Some factors found favorable:
  - ‘Dry’ air at the mid levels of atmosphere drawn into system.
  - Accelerating and/or strengthening systems at land-fall.
- Tornado threat can linger for days and can both increase and become more dependant on aften heating 12+ hrs post-land.
  - Could see an extended period under tornado watches, especially if storm stalls just inland.
What about FL?

- Studies have shown north to northeastward moving TCs are the most active tornado producers for FL.
- A storm moving N-NE over the Gulf places FL within ‘favored’ tornado region the longest.
- West to east moving storms tend to produce less tornadoes, but still can.
- Couple of examples:

Plots of TC tracks associated with ‘significant’ tornado events in FL (Hagemeyer 1998)
Ivan (2004)

- 34 tornadoes were reported in FL and adjacent areas of AL/GA
- 119 tornadoes were reported across the Southeast/Mid Atlantic over 3 days
- Six tornado fatalities occurred in FL panhandle
Agnes (June 17-20, 1972)

- 28 tornadoes were reported in FL and adjacent southeast GA
- 2- F3, 9- F2, 11- F1, 6- F0
- 7 tornado fatalities, 140 injured
Debby Tornadoes

- 24 tornadoes reported in Florida
- Most occurred during an outbreak on June 24, 2012
- 200-300 mi from ‘center’ of Debby!
- Strongest were EF-2s in Venus (Highlands Co.) and Winter Haven (Polk Co.)

St. Petersburg, FL (Oriana Sofia)

Lake Placid, FL (Skip Dent)
Hagemeyer (1998)

• “The essence of this forecast problem is predicting the occurrence of significant tornadoes outside the area where people are prepared for the maximum winds (near the eyewall),

• ...and predicting significant outer rainband tornadoes, especially from weaker tropical and hybrid cyclones, where tornadoes, rather than storm surge and high winds, may pose the greatest threat to life and property.” - i.e. TS Debby
Forecasting TC tornadoes

- The Storm Prediction Center produces national forecasts for severe thunderstorms, beginning 8 days out.
- These forecasts use probability of large hail/damaging tstm winds or tornadoes within 25 mi of a single point.
- NOTE: THESE ARE NOT PROBABILITY OF A single occurrence within THE OUTLOOK AREA!
5% means a 1 in 20 chance of a tornado in Orlando, not a 1 in 20 chance of a tornado anywhere within the outlook area at right.

If you knew this morning there is a 1 in 20 chance of a commuter plane crash within 25 mi of your house today, wouldn’t you be paying attention?!

How about a 1 in 10 chance?

That’s the equivalent of 5% and 10% tornado probs
• ‘Instability’ (measure of how strong or tall a storm will be) is usually quite shallow with TCs.
  – Results in storms that are smaller and shorter than normal.
  – Gives a less impressive radar signature than typical supercells.
• Shear is very intense, creating a tendency to rotate for any persistent shower/tstm.
Forecasting TC tornadoes

• In these environments, storms can develop and lose rotation very quickly!
  – A challenge to give adequate warning.
  – Warning polygons/areas may extend far downstream from the storm given the very fast storm motions.
• Typically small, fast moving and rain-wrapped.
• As mentioned, favored area of shear is east through north of the center:
Fig. 1. Display of locations of 1973–80 tornadoes located relative to tropical cyclone center. Closed curve includes 95% of the cases. Range marks are at 50 km intervals.

Gentry, R. C. (1983)
A few other things to consider

Our ability to distinguish ‘bigger’ tornado TCs is not very good

- It will be rare to see anything more than a ‘SLGT’ risk for severe thunderstorms from SPC.
- Typically we will see 2% and 5% tornado contours with TCs.
  - Occasionally a 10% risk area will be forecast
- Very rare to see a ‘MDT’ risk, or higher than 10% probabilities for TCs.
  - If you do, WATCH OUT!
Tornado Watches

- Issued by the SPC in close coordination with local NWS offices.
- Issued within the favored ‘right-front’ quadrant of the storm or right of the center.
- Given the state of the science, watches are nearly always issued as a hurricane (and most tropical storms) threaten the coast.
- Can be in effect for 12 hrs.
A warning challenge!

- Generally small, fast moving storms with little advance notice!
  - Especially near the center
  - Storm in bands well removed from center may appear more ‘traditional.’

- Excessive storm speeds mean large warning areas.

- Short-lived radar signatures
  - Could spin-up between scans
Tornado intensity

- Only way to determine is after it hits.
  - No way to know ahead of time.
- Local experts from the WFOs assess damage to determine tornado occurrence.
- Use an ‘EF-Scale’ to match the type of structure, quality of construction and extent of damage.
  - Damage research from wind engineers used to estimate wind strength and update Fujita Scale.
Enhanced Fujita Scale

**EF SCALE**

<table>
<thead>
<tr>
<th>EF Rating</th>
<th>3 Second Gust (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>65-85</td>
</tr>
<tr>
<td>1</td>
<td>86-110</td>
</tr>
<tr>
<td>2</td>
<td>111-135</td>
</tr>
<tr>
<td>3</td>
<td>136-165</td>
</tr>
<tr>
<td>4</td>
<td>166-200</td>
</tr>
<tr>
<td>5</td>
<td>Over 200</td>
</tr>
</tbody>
</table>

Uses 28 ‘damage indicators’

Example ‘damage indicator’

2. ONE-AND TWO-FAMILY RESIDENCES (FR12) (1000 – 5000 sq. ft.)

Typical Construction
- Asphalt shingles, tile, slate or metal roof covering
- Flat, gable, hip, mansard or mono-sloped roof or combinations thereof
- Plywood/OSB or wood plank roof deck
- Prefabricated wood trusses or wood joist and rafter construction
- Brick veneer, wood panels, stucco, EIFS, vinyl or metal siding
- Wood or metal stud walls, concrete blocks or insulating-concrete panels
- Attached single or double garage

<table>
<thead>
<tr>
<th>DOD*</th>
<th>Damage description</th>
<th>EXP</th>
<th>LB</th>
<th>UB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Threshold of visible damage</td>
<td>65</td>
<td>53</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>Loss of roof covering material (&lt;20%), gutters and/or awning; loss of vinyl or metal siding</td>
<td>79</td>
<td>63</td>
<td>97</td>
</tr>
<tr>
<td>3</td>
<td>Broken glass in doors and windows</td>
<td>96</td>
<td>79</td>
<td>114</td>
</tr>
<tr>
<td>4</td>
<td>Uplift of roof deck and loss of significant roof covering material (&lt;20%); collapse of chimney; garage doors collapse inward; failure of porch or carport</td>
<td>97</td>
<td>81</td>
<td>116</td>
</tr>
<tr>
<td>5</td>
<td>Entire house shifts off foundation</td>
<td>121</td>
<td>103</td>
<td>141</td>
</tr>
<tr>
<td>6</td>
<td>Large sections of roof structure removed; most walls remain standing</td>
<td>122</td>
<td>104</td>
<td>142</td>
</tr>
<tr>
<td>7</td>
<td>Exterior walls collapsed</td>
<td>132</td>
<td>113</td>
<td>153</td>
</tr>
<tr>
<td>8</td>
<td>Most walls collapsed, except small interior rooms</td>
<td>132</td>
<td>127</td>
<td>178</td>
</tr>
<tr>
<td>9</td>
<td>All walls</td>
<td>170</td>
<td>142</td>
<td>198</td>
</tr>
<tr>
<td>10</td>
<td>Destruction of engineered and/or well constructed residence; slab swept clean</td>
<td>200</td>
<td>165</td>
<td>220</td>
</tr>
</tbody>
</table>

* DOD is degree of damage
Straight-line wind damage

- Not all damage is from tornadoes!
- Enhanced wind speeds just off the surface can easily be brought down by stronger storms.
- Might see pockets/swaths of wind damage well removed from the TC center.
Damage Assessment

• NWS employees assess AFTER a ‘tornado’ hits.

• Look at nature of the damage to make an assessment of:
  – Was this caused by a tornado or straight-line winds?
  – How strong were the winds and/or EF scale ranking?
### 28 Damage Indicators

#### Table 3. Damage Indicators for EF Scale

<table>
<thead>
<tr>
<th>DI No.</th>
<th>Damage Indicator (DI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small Barns or Farm Outbuildings (SBO)</td>
</tr>
<tr>
<td>2</td>
<td>One- or Two-Family Residences (FR12)</td>
</tr>
<tr>
<td>3</td>
<td>Manufactured Home – Single Wide (MHSW)</td>
</tr>
<tr>
<td>4</td>
<td>Manufactured Home – Double Wide (MHDW)</td>
</tr>
<tr>
<td>5</td>
<td>Apartments, Condos, Townhouses [3 stories or less] (ACT)</td>
</tr>
<tr>
<td>6</td>
<td>Motel (M)</td>
</tr>
<tr>
<td>7</td>
<td>Masonry Apartment or Motel Building (MAM)</td>
</tr>
<tr>
<td>8</td>
<td>Small Retail Building [Fast Food Restaurants] (SRB)</td>
</tr>
<tr>
<td>9</td>
<td>Small Professional Building [Doctor’s Office, Branch Banks] (SPB)</td>
</tr>
<tr>
<td>10</td>
<td>Strip Mall (SM)</td>
</tr>
<tr>
<td>11</td>
<td>Large Shopping Mall (LSM)</td>
</tr>
<tr>
<td>12</td>
<td>Large, Isolated Retail Building [K-Mart, Wal-Mart] (LIRB)</td>
</tr>
<tr>
<td>13</td>
<td>Automobile Showroom (ASR)</td>
</tr>
<tr>
<td>14</td>
<td>Automobile Service Building (ASB)</td>
</tr>
<tr>
<td>15</td>
<td>Elementary School [Single Story; Interior or Exterior Hallways] (ES)</td>
</tr>
<tr>
<td>16</td>
<td>Junior or Senior High School (JSHS)</td>
</tr>
<tr>
<td>17</td>
<td>Low-Rise Building [1-4 Stories] (LRB)</td>
</tr>
<tr>
<td>18</td>
<td>Mid-Rise Building [5-20 Stories] (MRB)</td>
</tr>
<tr>
<td>19</td>
<td>High-Rise Building [More than 20 Stories] (HRB)</td>
</tr>
<tr>
<td>20</td>
<td>Institutional Building [Hospital, Government or University Building] (IB)</td>
</tr>
<tr>
<td>21</td>
<td>Metal Building System (MBS)</td>
</tr>
<tr>
<td>22</td>
<td>Service Station Canopy (SSC)</td>
</tr>
<tr>
<td>23</td>
<td>Warehouse Building [Tilt-up Walls or Heavy-Timber Construction] (WHB)</td>
</tr>
<tr>
<td>24</td>
<td>Transmission Line Towers (TLT)</td>
</tr>
<tr>
<td>25</td>
<td>Free-Standing Towers (FST)</td>
</tr>
<tr>
<td>26</td>
<td>Free-Standing Light Poles, Luminary Poles, Flag Poles (FSP)</td>
</tr>
<tr>
<td>27</td>
<td>Trees: Hardwood (TH)</td>
</tr>
<tr>
<td>28</td>
<td>Trees: Softwood (TS)</td>
</tr>
</tbody>
</table>
## Damage Indicator FR12

One and Two Family Residences

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<thead>
<tr>
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<td>80</td>
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<td>2</td>
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<td>97</td>
</tr>
<tr>
<td></td>
<td>loss of vinyl or metal siding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Broken glass in doors and windows</td>
<td>96</td>
<td>79</td>
<td>114</td>
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<td>4</td>
<td>Uplift of roof deck and loss of significant roof covering material (&gt;20%);</td>
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<td>81</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>collapse of chimney; garage doors collapse inward or outward; failure of porch or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>carport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Entire house shifts off foundation</td>
<td>121</td>
<td>103</td>
<td>141</td>
</tr>
<tr>
<td>6</td>
<td>Large sections of roof structure removed; most walls remain standing</td>
<td>122</td>
<td>104</td>
<td>142</td>
</tr>
<tr>
<td>7</td>
<td>Top floor exterior walls collapsed</td>
<td>132</td>
<td>113</td>
<td>153</td>
</tr>
<tr>
<td>8</td>
<td>Most interior walls of top story collapsed</td>
<td>152</td>
<td>127</td>
<td>178</td>
</tr>
<tr>
<td>9</td>
<td>Most walls collapsed in bottom floor, except small interior rooms</td>
<td>170</td>
<td>142</td>
<td>198</td>
</tr>
<tr>
<td>10</td>
<td>Total destruction of entire building</td>
<td>200</td>
<td>165</td>
<td>220</td>
</tr>
</tbody>
</table>
Comparing the Two Scales
Wind speed in MPH

The Enhanced F-scale still is a set of wind estimates (not measurements) based on damage. It uses three-second gusts estimated at the point of damage. These estimates vary with height and exposure. Important: The 3 second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured, "one minute mile" speed.

<table>
<thead>
<tr>
<th>F Scale</th>
<th>Wind Speed</th>
<th>EF-Scale</th>
<th>Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0</td>
<td>45-78 (40-72)</td>
<td>EF0</td>
<td>65-85</td>
</tr>
<tr>
<td>F1</td>
<td>79-117 (73-112)</td>
<td>EF1</td>
<td>86-109</td>
</tr>
<tr>
<td>F2</td>
<td>118-161 (113-157)</td>
<td>EF2</td>
<td>110-137</td>
</tr>
<tr>
<td>F3</td>
<td>162-209 (158-206)</td>
<td>EF3</td>
<td>138-167</td>
</tr>
<tr>
<td>F4</td>
<td>210-261 (207-260)</td>
<td>EF4</td>
<td>168-199</td>
</tr>
<tr>
<td>F5</td>
<td>262-317 (261-318)</td>
<td>EF5</td>
<td>200-234</td>
</tr>
</tbody>
</table>

3-second wind gust (1/4 mile wind speed)

3-second wind gust
EF-Scale not designed for hurricanes

- The wind speed/damage relationships established in the EF-scale are for short-bursts of winds you see in tornadoes.
- The stress loads/damage potential in longer duration events (such as TCs) may be just as high in some cases, but with lower wind speeds.
- In a post-TC survey this greatly complicates tornado surveys if the tornado impact area experienced significant winds from a TC.
Why We ARE Needing You to Help Us

• You help make the process more efficient for the NWS by providing preliminary information before we arrive for a survey.
  – Where does damage start/stop?
  – Where are the worst hit areas?
• You will be better handled to answer questions within your own county.
• You often see the damage first hand before it is cleaned up by the time NWS personnel arrive.
Tornadoes, yet another risk!

Most land-falling tropical cyclones produce at least one tornado!

Some are prolific and produce outbreaks of many tornadoes, while some fail to develop a single tornado.

Tornadoes occur with rainbands swirling around the TC’s center, sometimes hundreds of miles away.

Tornadoes most common in ‘right-front’ or northeast part of the storm.

TC Tornadoes in FL most common in north or northeastward moving systems (usually over Gulf)-reference TS Debby or Hurricane Agnes.

TC intensity not necessarily equates with tornado risk

Questions:
jeffry.evans@noaa.gov
Thank You!

- NWS Tallahassee: [http://www.srh.noaa.gov/tae/?n=tropical](http://www.srh.noaa.gov/tae/?n=tropical)
- National Hurricane Center: [http://hurricanes.gov](http://hurricanes.gov)