Forecaster Tornado Warning
Decision Processes in PARISE 2012

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Experiment Design and Execution
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Understanding NWS Verification
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Presented by Harold Brooks
NOAA National Severe Storms Laboratory
2010 PARISE findings suggest faster, adaptive radar scanning can:
1) Improve NWS forecaster ability to warn public of EF0/EF1 tornadoes
2) Increase tornado lead time: Average 12 min vs 0.76 min
3) Increase time available for public response

“When will I get this radar data in my office?”

More direct data collection methods?
Are these results repeatable?
What about null cases?
Objective
Test whether rapid, adaptively scanned radar data aids forecaster ability to make warning decisions during tough, potentially tornadic cases

* 12 NWS Forecasters working individually
  * 2 per week over 6 weeks (June – Aug)

* 4 supercell events
  * 2 tornadic, 2 non-tornadic
Data Collection

Work the Event

AWIPS2

Video and screen recordings

Case Walk Through (Hoffman, 2005)

Warnings issued

Forecaster recalls thoughts & actions
Cognitive task analysis

Protocols for CTA (Hoffman, 2005)

Three Sweeps

Sweep 1: Forecaster talks through their actions

Sweep 2: Corrections and additions, identify decision points

Sweep 3: Conceptual diagram and probing questions

Tool provides rich qualitative data regarding the warning decision processes of forecasters
Situational Awareness

“The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.”

Endsley, 1995
Situational Awareness

Level 1
Perception

Level 2
Comprehension

Level 3
Projection
Null Case

2055 – 2120 UTC 14 May 2011
PARISE 2012 Results
Probability of Detection / Prob. of False Alarm

\[ PPOD = \frac{\text{sum}(\% \text{ Event Warned})}{\text{Total \# Events}} \]

\[ \text{POFA} = \frac{\# \text{ Unverified Warnings}}{\text{Total \# Warnings}} \]
PARISE 2012 Results: Tornado Lead Time

21 min Average Tornado Lead Time

- EF0 11 May 2010
- 1 EF0 22 May 2011
- 2 EF0 22 May 2011
- 3 EF1 22 May 2011

Legend:
- National Mean EF2+ TOR Lead Time
- National Mean EF0/EF1 TOR Lead Time
## Randy Gains SA at Start of Null Case

<table>
<thead>
<tr>
<th>Time (UTC)</th>
<th>Situational Awareness</th>
<th>Judgments, Projections, &amp; Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2055</td>
<td>Ø No severe weather threats of immediate concern</td>
<td>Have left- and right-moving supercells</td>
</tr>
<tr>
<td>2057</td>
<td>Ø Pronounced BWER &amp; Midlevel Mesocyclone</td>
<td>Left mover unlikely to produce a tornado</td>
</tr>
<tr>
<td>2059</td>
<td>Ø Inbound velocity is decreasing in intensity</td>
<td>Focus attention on right mover and continue to monitor for tornado development</td>
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</tbody>
</table>

Judgments, Projections, & Decisions:

- Have left- and right-moving supercells
- Left mover unlikely to produce a tornado
- Focus attention on right mover and continue to monitor for tornado development
### SA Leads to heightened concern for tornadogenesis

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<tr>
<td>2101</td>
<td>Inflow weakest its been</td>
<td>Judges midlevel meso is intensifying</td>
</tr>
<tr>
<td>2102</td>
<td>Onset of RFD</td>
<td>2106</td>
</tr>
<tr>
<td>2103</td>
<td>Inflow increasing above 0.5</td>
<td>Projects meso may descend to the ground</td>
</tr>
<tr>
<td>2104</td>
<td>1.1 to 3.0 Dramatic increase in inbounds &amp; outbounds</td>
<td>Decides to monitor low-levels for meso development</td>
</tr>
<tr>
<td>2105</td>
<td>0.5/0.8 Inbounds increasing; are up to 60 kt</td>
<td></td>
</tr>
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Decides a Tornado Warning

*May Be* Needed

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| 2106       | • Inflow strongest its been  
              • 0.5 Vel. couplet forming to west of inflow | Decides to prepare to issue warning. Draws polygon. |
| 2108       | • Inflow weakens a bit  
              • 0.5 couplet intensifies  
              • Midlevel rotation weakens | 2109  
              Monitors next scan to see if G2G couplet develops at lowest 2 tilts |
| 2109       | • 1.1/1.5 G2G couplet forms |                                  |
### Decides Not to Issue Tornado Warning

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| 2110       | - G2G Couplet did not descend to 0.5/0.8  
             - Midlevel G2G couplet has not organized; appears slightly weaker | Decides to hold off on tornado warning. |
| 2111       | - Midlevel G2G couplet has weakened further  
             - Another surge in inflow strength | Continues monitoring storm |

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Decides to hold off on tornado warning.
Maggie, Brad, and Bob also Decide Not to Issue Tornado Warning

Bob
- RFD did not bring the strong midlevel meso down around to the lowest tilt

Randy & Maggie
- G2G Couplet did not descend to 0.5/0.8

Brad
- Never gained SA that triggered concern to warn
Dirk’s decision process similar but decides to warn near end of case

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<td>2111 -- 2115</td>
<td>Velocity data showed increasing LL rotation, but thinks it may be velocity aliasing issue</td>
<td>Judges positioning of the couplet relative to the reflectivity signature doesn’t fit his conceptual model</td>
</tr>
<tr>
<td>2115--2118</td>
<td>Strengthening in meso is maintained at 1.5 deg</td>
<td>2118 Strengthening LL meso, combined with hook suggests that tornadogenesis may be underway</td>
</tr>
<tr>
<td></td>
<td>Storm is headed toward town of Sulphur</td>
<td>Decides to issue a tornado warning</td>
</tr>
<tr>
<td></td>
<td>Mesocyclone continues to descend: now seen down to 1 deg.</td>
<td></td>
</tr>
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Another 7 also Decided to Warn on Right Mover

Situational Awareness

- Extremely well organized supercell
  - tremendous updraft and midlevel mesocyclone.

- Mesocyclone began descending into the lower elevation tilts, increasing risk for tornadogenesis.

- Tightening at 0.5

- Noticed the filling / collapse of BWER at all middle tilts along with collocated tightening of circ

- Circ at lowest tilt was getting tight and persisting
Conclusions

Forecasters gained min-by-min SA and short-duration trends in SA from PAR data that impacted their decision process.

Differences in conceptual model pivot points and SA determined whether a forecaster decided to warn or not to warn.

Decide to Warn

- Strengthening of midlevel circulation and its apparent descent indicates possible tornadogenesis.
- Tightening of circulation at lowest tilt (one forecaster interpreted persistence).

Decide not to Warn

- RFD did not bring the strong midlevel meso down around to the lowest tilt.
- G2G Couplet did not descend to 0.5/0.8.
- Never gained SA that triggered concern to warn.