engineering laboratory

The Joplin Tornado: Lessons Learned from the NIST Investigation

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Joplin Tornado Overview

- Touched down at 5:34 PM CDT, Sunday, May 22, 2011.[1] Stayed on ground for about 22 miles (6 miles in City of Joplin) and 15 minutes
- Enhanced Fujita Scale EF-5 tornado[1] (highest category)
- Estimated maximum wind speeds: 200+ mph
- Damaged/destroyed ~ 8,000 buildings.[2] Affected ~41% of City's population (20,820 of 50,175[3]). $1.8B in damage.
- 161 fatalities, >1,000 injuries. Deadliest single tornado on record.
  Exceeds U.S. average deaths/year for all tornadoes (91.6) [1], hurricanes(50.8) [1], & earthquakes (7.5) [4]

Sources: [1]National Weather Service, [2]City of Joplin, [3]U.S. Census Bureau, 2010 Census, [4]U.S. Geological Survey

Joplin Investigation Overview

Following a preliminary reconnaissance that began on May 24, 2011, the NIST Director established a Team under the NCST Act on June 29, 2011, to conduct a technical investigation of the Joplin Tornado.

Two plus years of investigation on interdisciplinary aspects of the tornado – overarching goal was to discover the reasons for the magnitude of this disaster (findings) and how the losses incurred in Joplin can be reduced in future events (recommendations)

A total of 47 findings and 16 recommendations – some still being revised

Milestones Reached:

Progress Report Published – November 2012

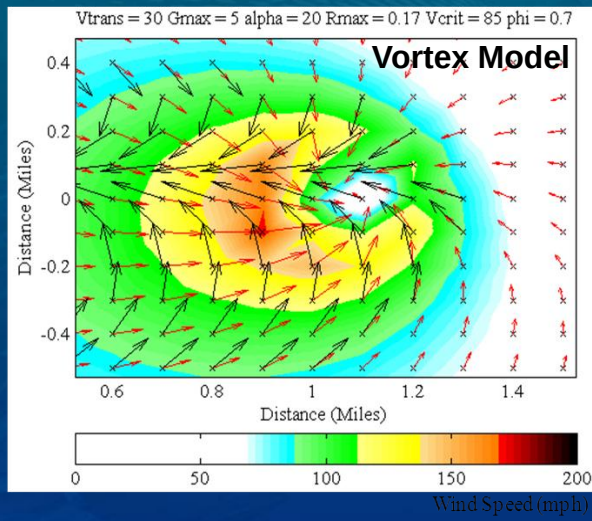
Draft Report Published – November 21, 2013

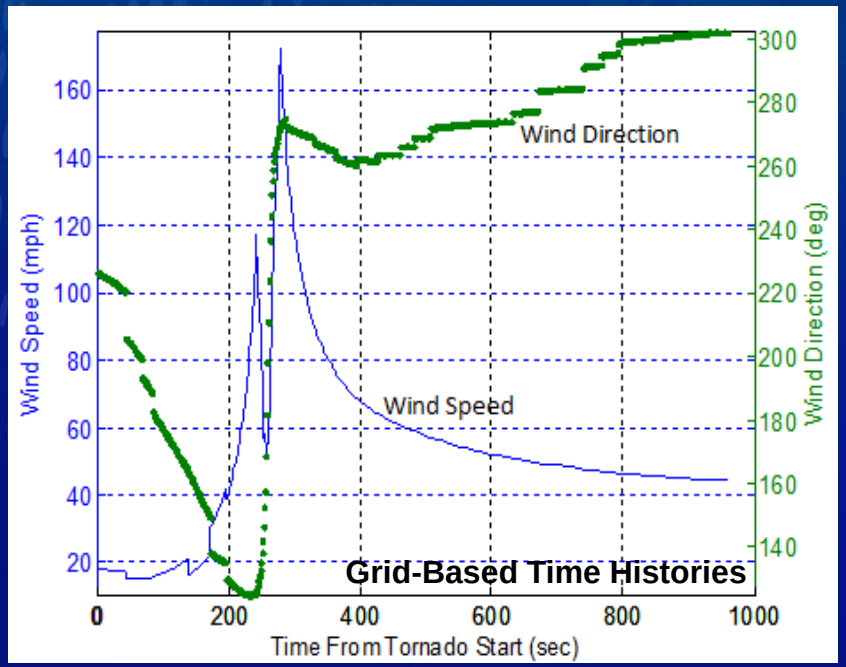
Public Comment Phase – November 21, 2013 – January 6, 2014

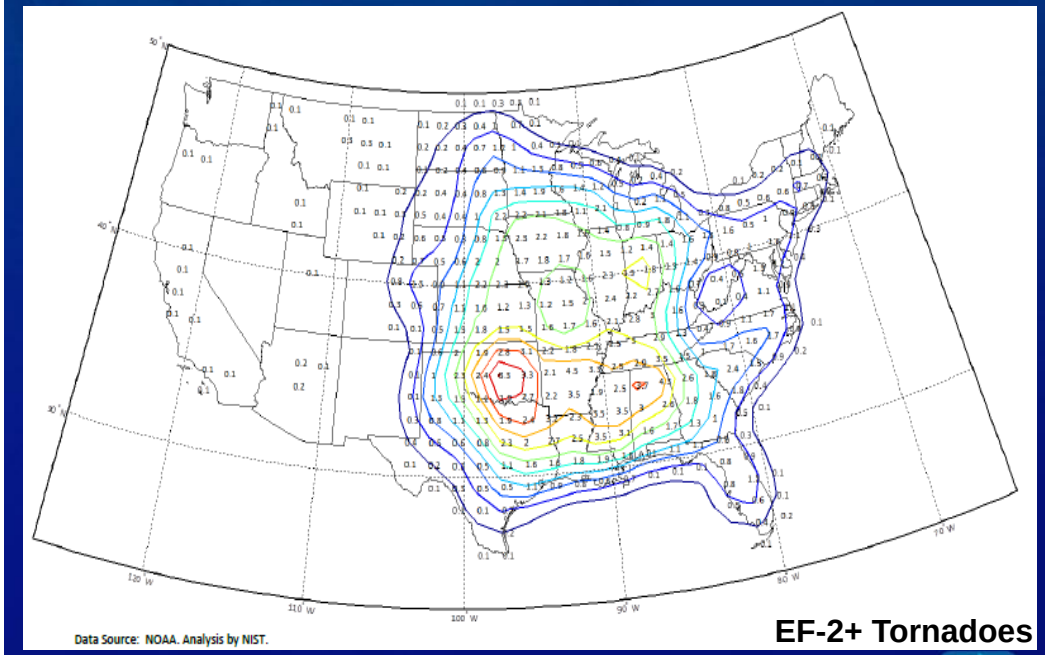
Tornado Hazard Characteristics

- Estimate Wind Speeds
  - EF-Scale and Tree Fall-Based Analyses
- Understand Large-Scale Tornado Hazard
  - Tornado-Based Design


Joplin Tree Fall







Building Performance

- NIST surveyed 25 structures for on-site surveys and additional analysis based of their performance during the tornado.
  - Study the observed failures and compute the loads required to cause such failures.
  - Identify the sequence of occurrences leading to the failures

Public Response, Emergency Communications, Fatalities and Injuries

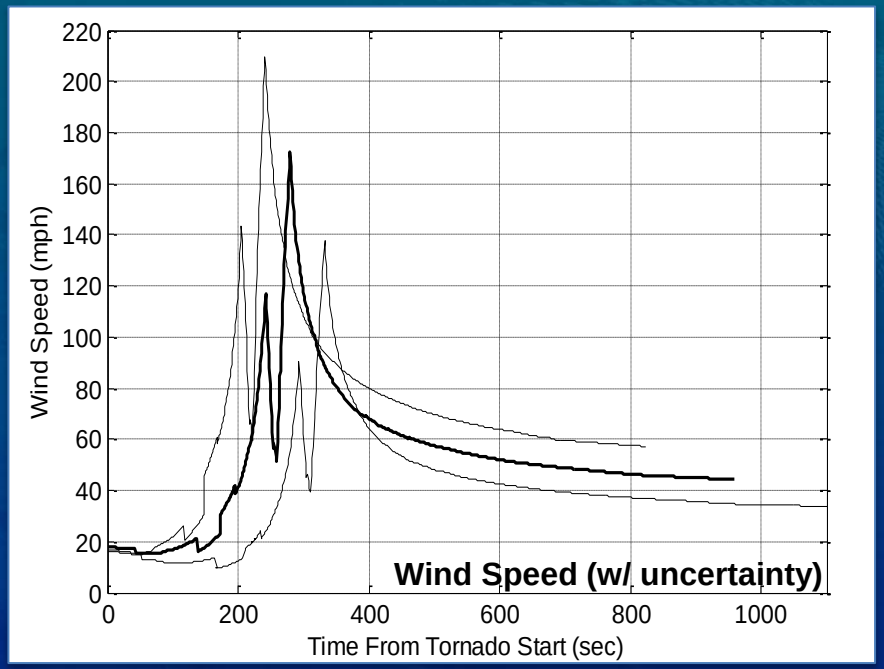
- 168 survivors (telephone/face-to-face interviews)
- Targeted interviews with and data collection from emergency response personnel (inside and outside City of Joplin, MO)
- 161 fatalities
- Information obtained from death certificates*
  - place of injury/death, date of death, cause of injury/death, age, gender, occupation

Location at Time of Injury/Death	# of Victims
AT&T store	1
Elks Lodge	4
Full Gospel Church	4
Greenbriar Nursing Home	19*
Harmony Heights Baptist Church	3
Home Depot	8
Meadows Healthcare Facility	2*
Outside (12 in vehicles)	20*
Pizza Hut	5
Residences - apartments	12*
Residences - single family home	62*
Stained Glass Theater	3*
St. John Regional Medical Center	14*
Walmart	3

* Additional Sources: NWS; MO State Police; Dr. Andrew Curtis; Media accounts; NIST Survivor interviews

Key Findings: Tornado Hazard

- F1: Current radar technology is largely incapable of determining tornado intensity at near-surface. Closest NWS radar to Joplin was 60 miles (100 km away)
- F3: Maximum wind speeds in the Joplin tornado estimated to be 175 mph with an upper bound of 210 mph. Considerable uncertainty.
- F7: The EF Scale lacks adequate damage indicators (DIs) and corresponding degrees of damage (DODs) for distinguishing the most intense tornado events.



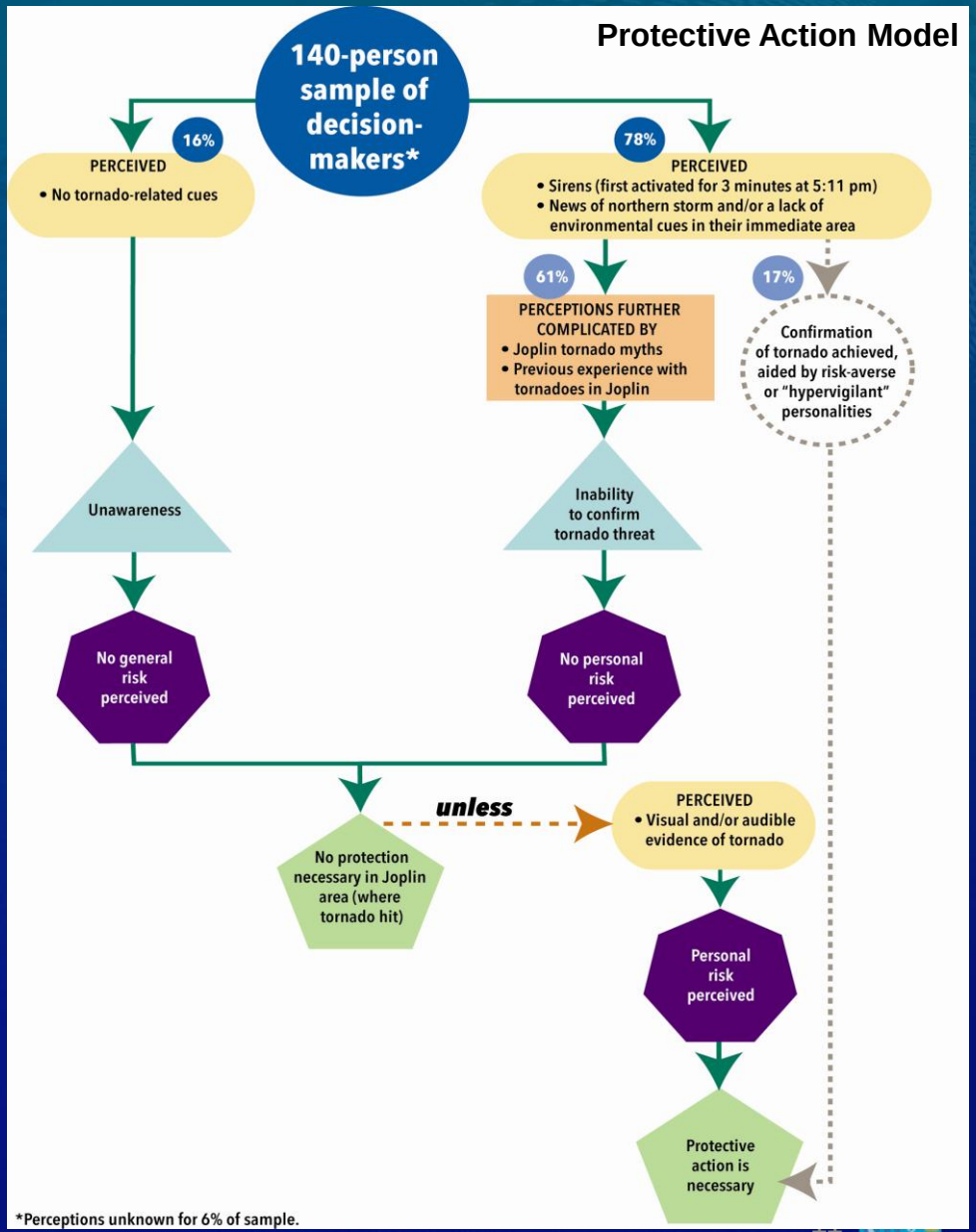
Key Findings: Building Performance

- F9: Regardless of construction type, buildings were not able to provide life–safety protection. Of the 161 fatalities, 135, or 83.8 percent, were related to building failure

- F10: Engineered buildings that:
  - Had redundant lateral load capacity (steel or concrete frames) withstood the tornado without collapse.
  - Had reinforced concrete or composite concrete-steel roof also withstood the tornado without collapse.
  - Relied on a less robust roof system (such as box–type system (BTS) buildings with light steel roof decks) were prone to structural collapse.

Key Findings: Fatalities, Public Response

- F29: Of the 161 deaths resulting from this tornado:
  - 155 (96 percent) were caused by impact–related factors (i.e., multiple blunt force trauma to the body).
- F43: Responses to the approaching tornado among members of the public, in many cases, were delayed or incomplete
- F44: Two factors were found to have contributed:
  - Lack of awareness
  - Inability to perceive personal risk



Key Recommendations: Tornado Hazard

- Capacity be developed and deployed that can measure and characterize near–surface tornadic wind fields. (Lead: NOAA)

- Improvement of the EF Scale, to the extent possible, using scientific methods. The improved EF Scale should be adopted by NWS. (Lead: NOAA/NWS)

Key Recommendations: Building Performance

- Nationally accepted performance–based standards for tornado–resistant design for buildings and infrastructure be developed. (Lead: ASCE)

- Tornado shelters be installed in new buildings with large occupancies. (Lead: ICC)

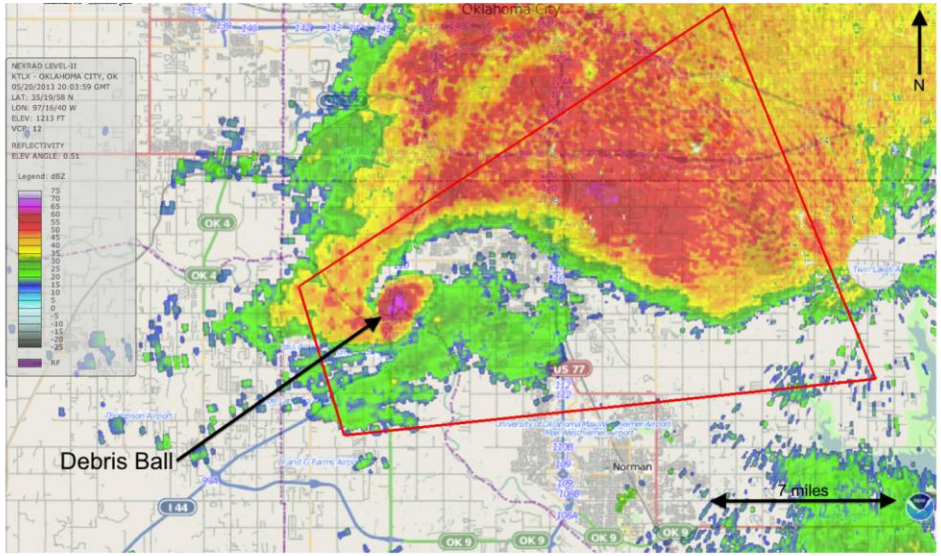
Key Recommendations: Public Response

- Development of national codes and standards and uniform guidance for emergency communication for tornadoes. Emergency managers, the NWS, and the media develop a joint plan to ensure warning information is communicated in a timely manner. (Lead: ICC)

- Tornado threat information be provided on a spatially resolved real–time basis using gridded probabilistic information. (Lead: NOAA)

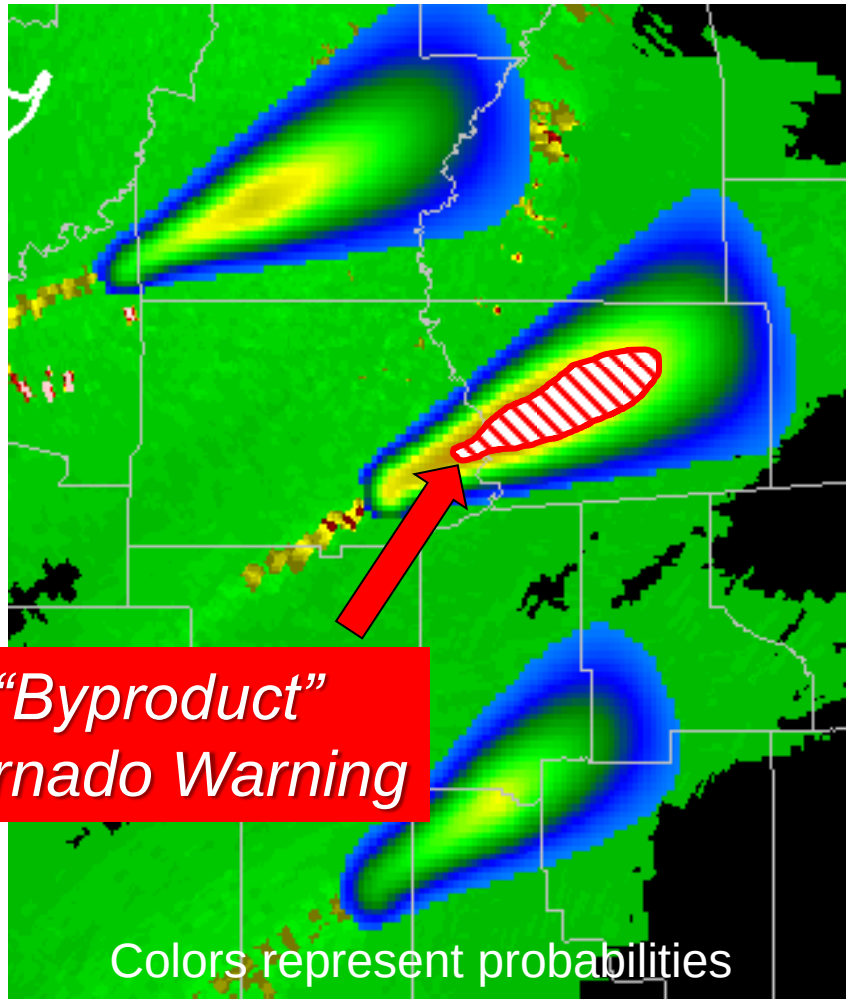
Probabilistic Threat Forecasting

Current Approach



- Polygons (in their current formulation) are blunt instruments for communicating a dynamic, small-scale threat.
- Forecasters have much more info to convey to Emergency Managers and Decision Makers (i.e., uncertainty)

Grid-based Probabilistic Hazard Information



Final Steps

- Spring 2014 – address public comments and publish final report
- Spring 2014 – complete and publish the Joplin Tornado Data Repository
- Spring 2014 – begin effort to implement recommendations

More information and draft report available at

- http://www.nist.gov/el/disasterstudies