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

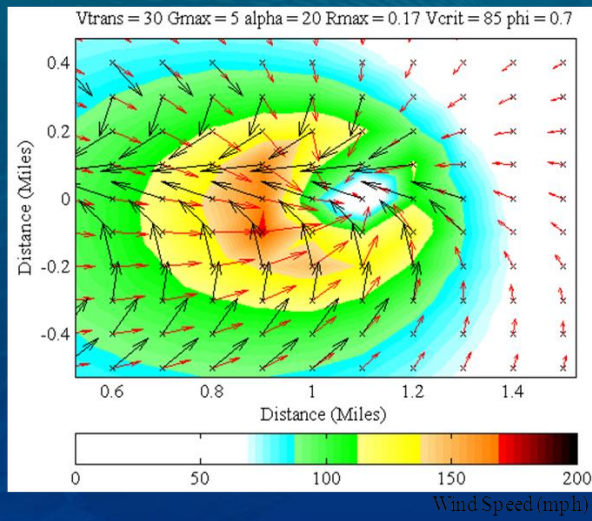
Public Comment Phase – November 21, 2013 – January 6, 2014

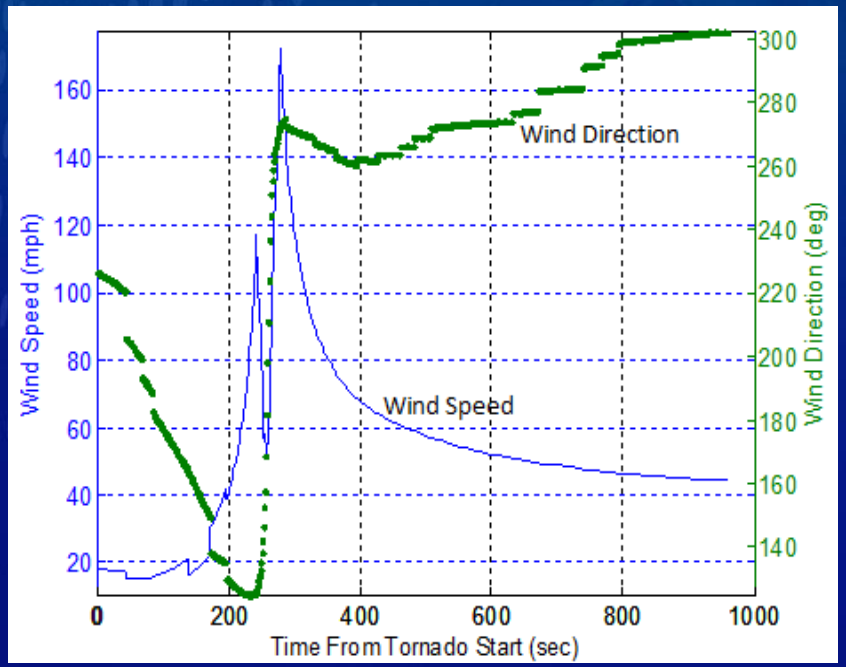
Objectives

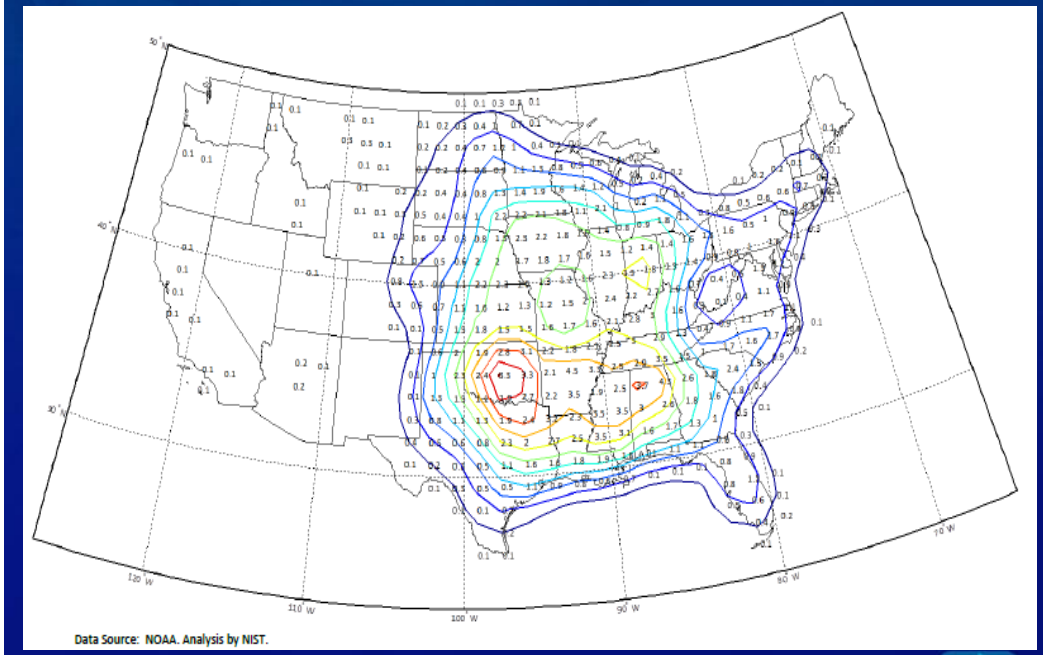
1. Determine the tornado hazard characteristics
2. Determine the response of buildings, including the performance of designated safe areas
3. Determine the performance of lifelines as it relates to buildings
4. Determine the pattern, location, and cause of fatalities and injuries, and associated emergency communications and public response
5. Identify areas in current codes, standards, and practices that warrant revision

Tornado Hazard Characteristics

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







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

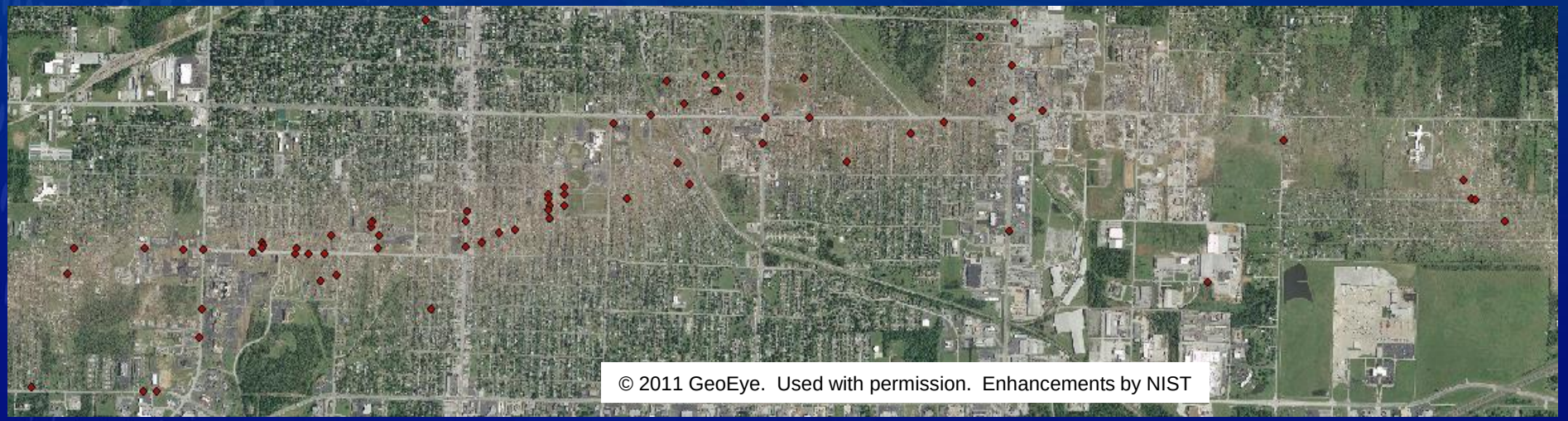
Public Response, Emergency Communications, Fatalities and Injuries

- 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

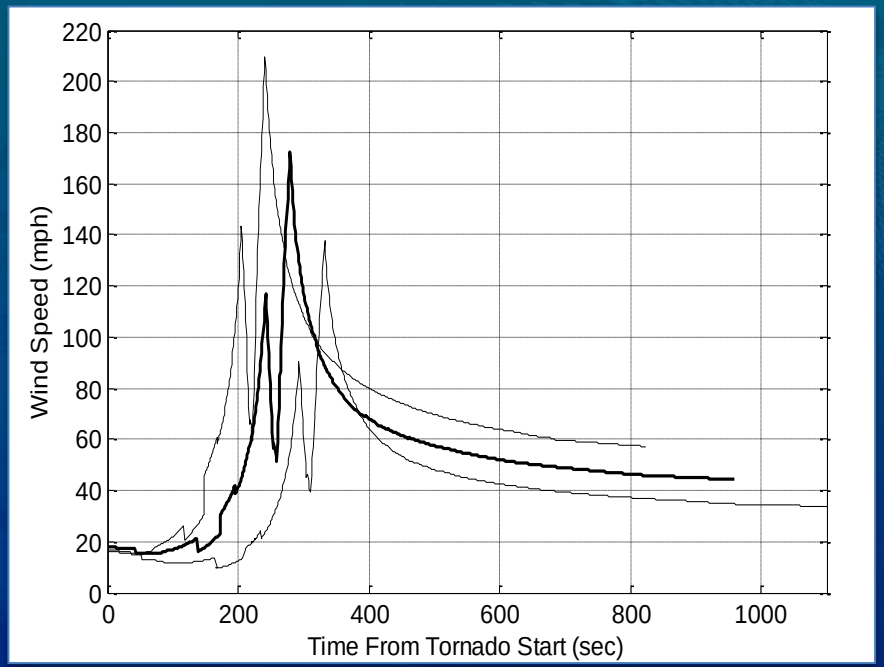
* Additional Sources: NWS; MO State Police; Dr. Andrew Curtis; Media accounts; NIST Survivor interviews

Locations of Interviewees and Fatalities



Key Findings: Tornado Hazard

- F1: Current radar technology is largely incapable of determining tornado occurrence and 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.



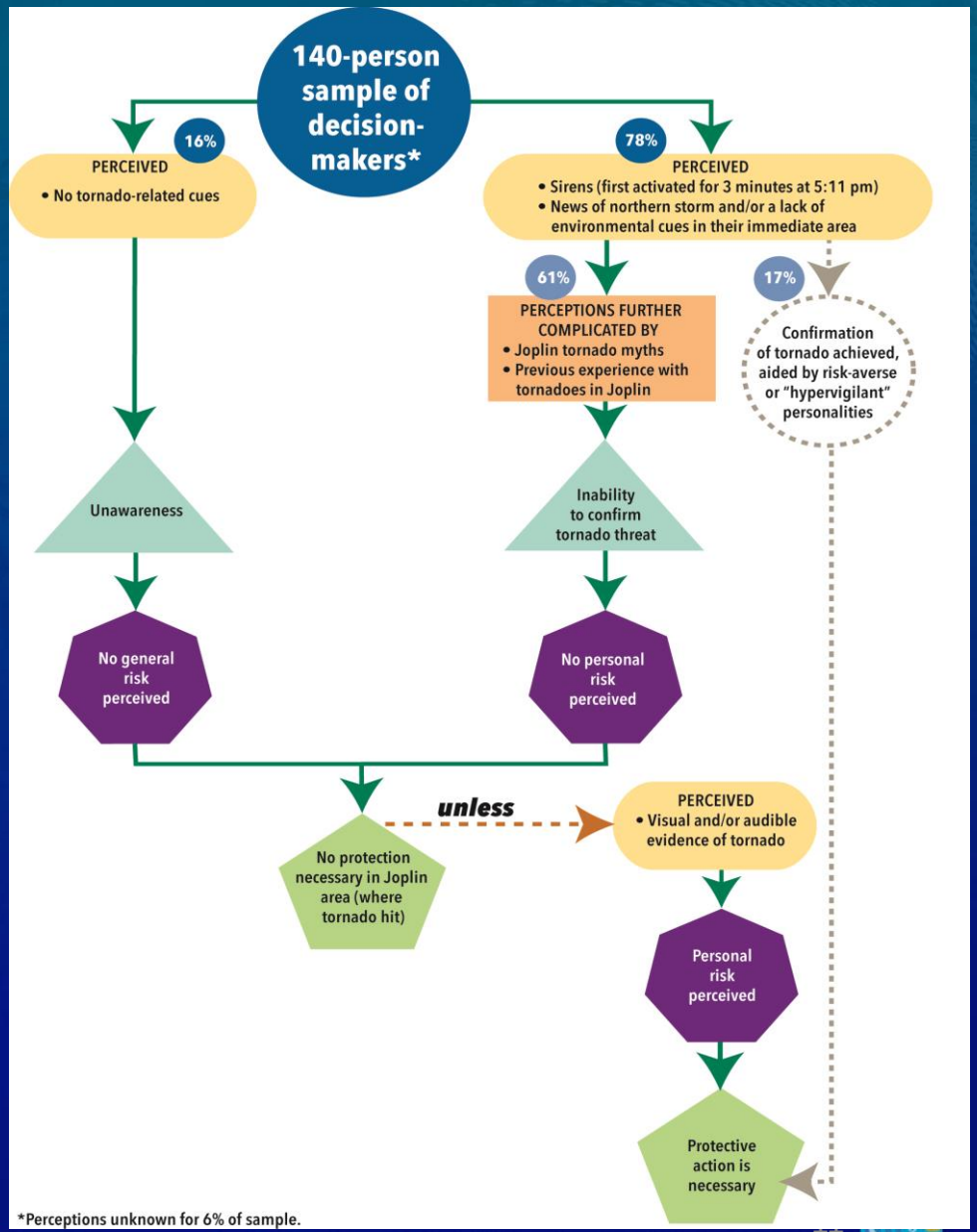
Key Findings: Building Performance

- 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)

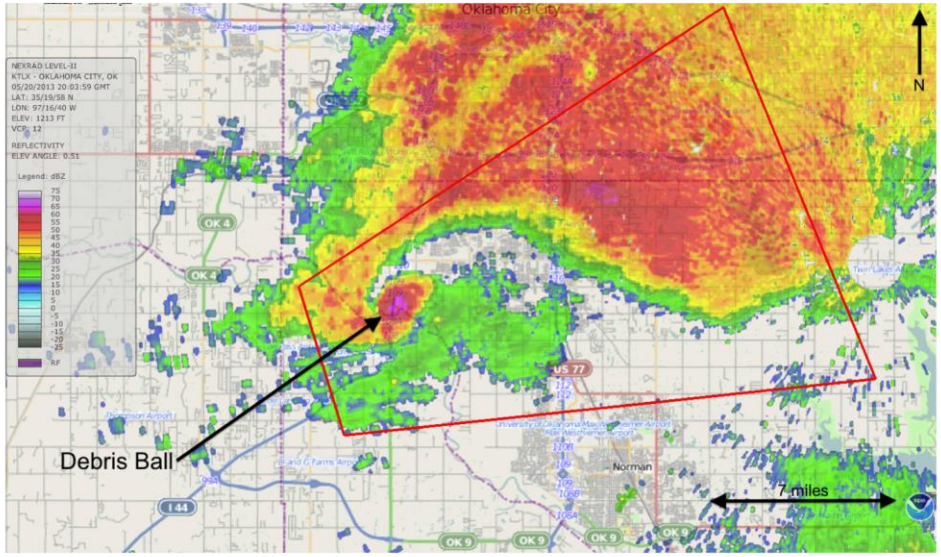
Key Recommendations: Public Response

- 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)

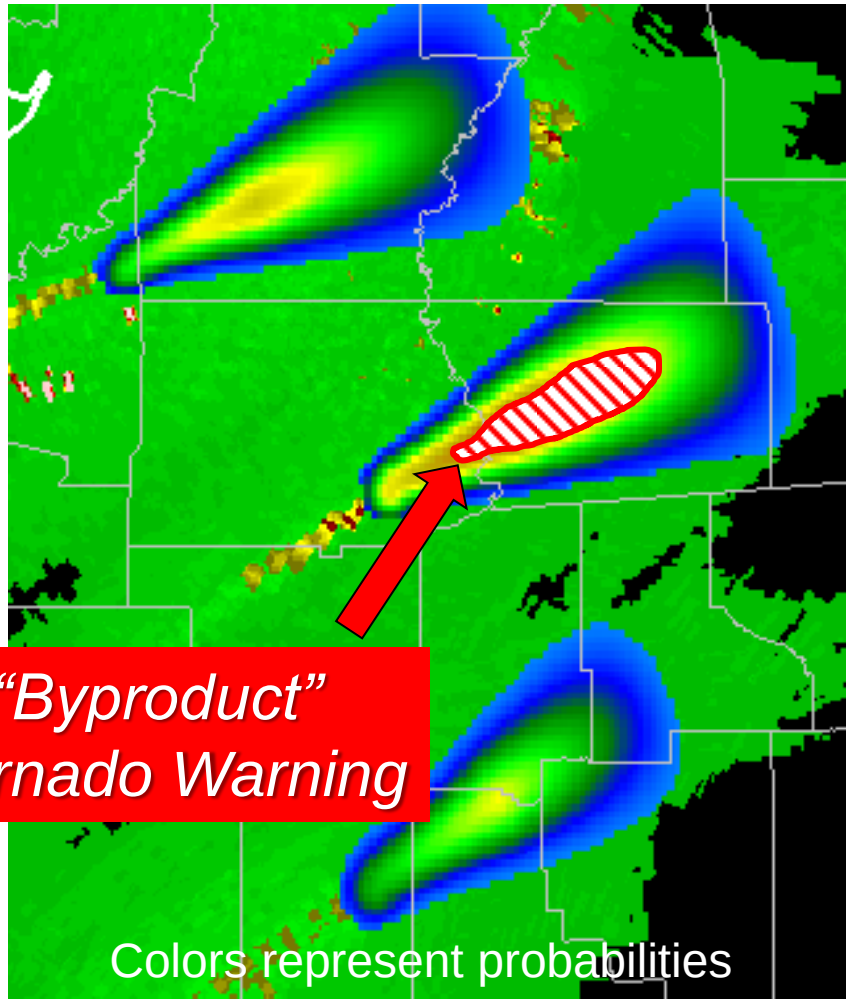
Probabilistic Threat Forecasting

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