engineering laboratory

Technical Investigation of the May 22, 2011, Tornado in Joplin, MO

December 10, 2012
NCST Advisory
Committee Meeting

Tornado Hazard Characteristics

Frank Lombardo
Investigation Task Leader
Research Structural Engineer, NWIRP
David Jorgensen
Investigation Task Co-Leader
Research Meteorologist and Chief, NOAA/National Severe Storms Lab/Warning R&D Division

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Objective #1

- Determine the tornado hazard characteristics and associated wind fields in the context of historical data

Presentation Outline

- Task 1.1: Data Collection
- Task 1.2: Meteorological Conditions
- Task 1.3: Develop Wind Speed Estimates
- Task 1.4: Tornado Hazard Climatology
- Task 1.5: Spatial Characteristics and Consequences
- Task 1.6: EF-Scale Rating Assessment

Data Collection

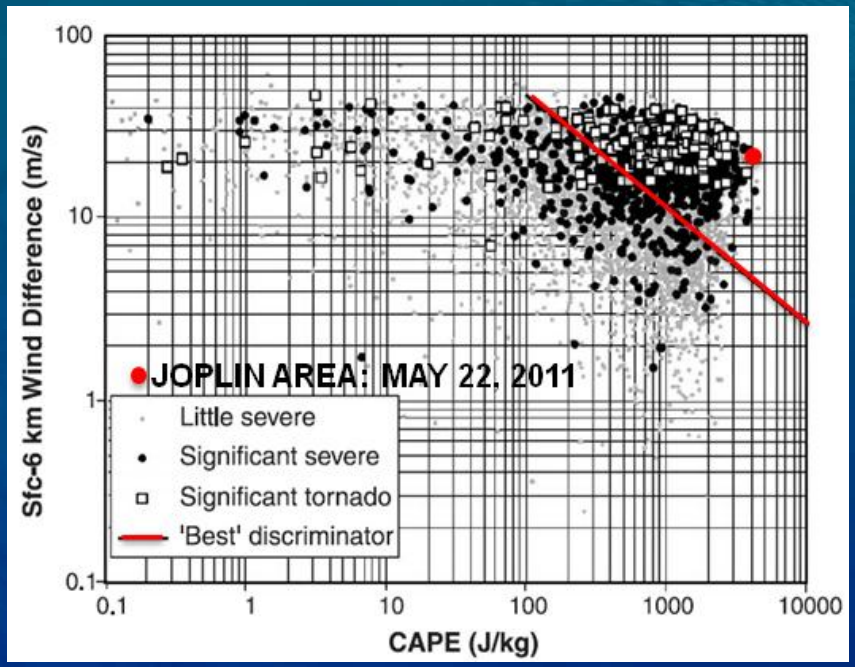
- Data collected on meteorological conditions; pre-storm and post-storm conditions and damage; historical and climatological information on tornadoes

Table: Data collected in support of investigation Objective 1

Data type	Data list
Meteorological/ Wind	Joplin Airport meteorological/wind data, WSR–88D radar data, National Oceanic and Atmospheric Administration (NOAA) graphics and text, Wind Profiler and Model Sounding data, other meteorological data, NOAA tornado database
Photographs	Building and infrastructure damage, street sign damage
Videos	Surveillance and other videos made during the tornado, videos of post-tornado damage
GIS Based	Post-storm aerial photos, tornado path, local roads/boundaries, structural damage databases, tax assessor data, fatality locations
Miscellaneous	Street sign damage database, lifeline information

Meteorological Conditions

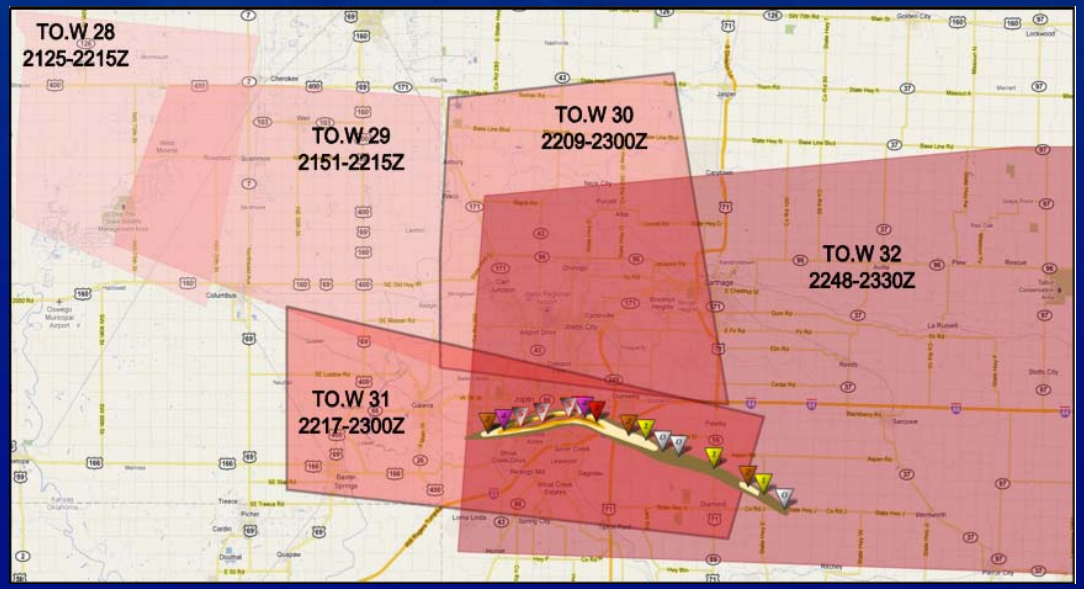
- Environmental parameters were favorable for tornado development; reflected by NOAA's Storm Prediction Center (SPC) issuing of severe weather outlooks and tornado watches



Source: NOAA
Enhancements: NIST

CAPE: Convective Available Potential Energy

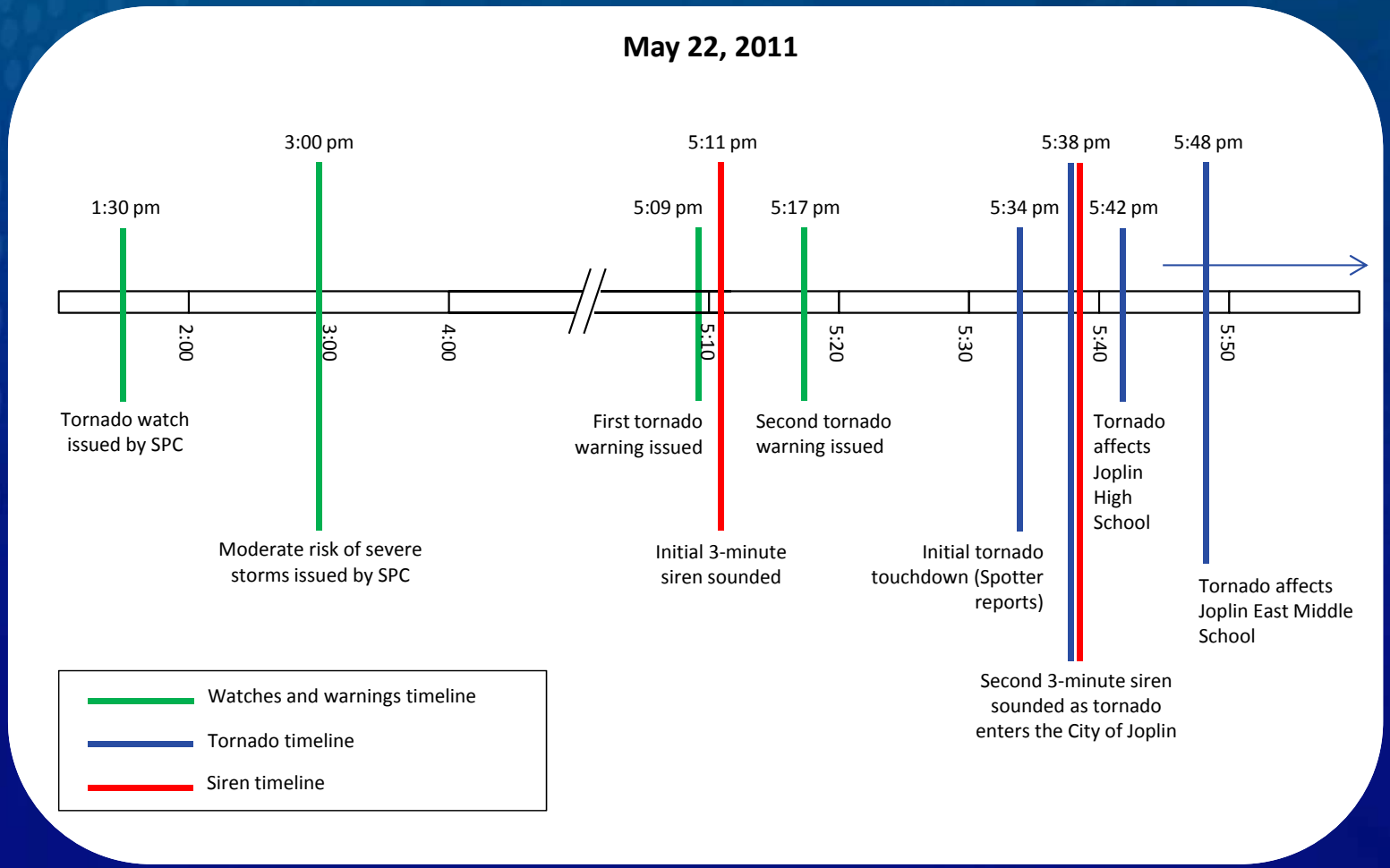
- Thunderstorms developed and a number of tornado warnings were issued by the Springfield National Weather Service (NWS) office



Source: NOAA

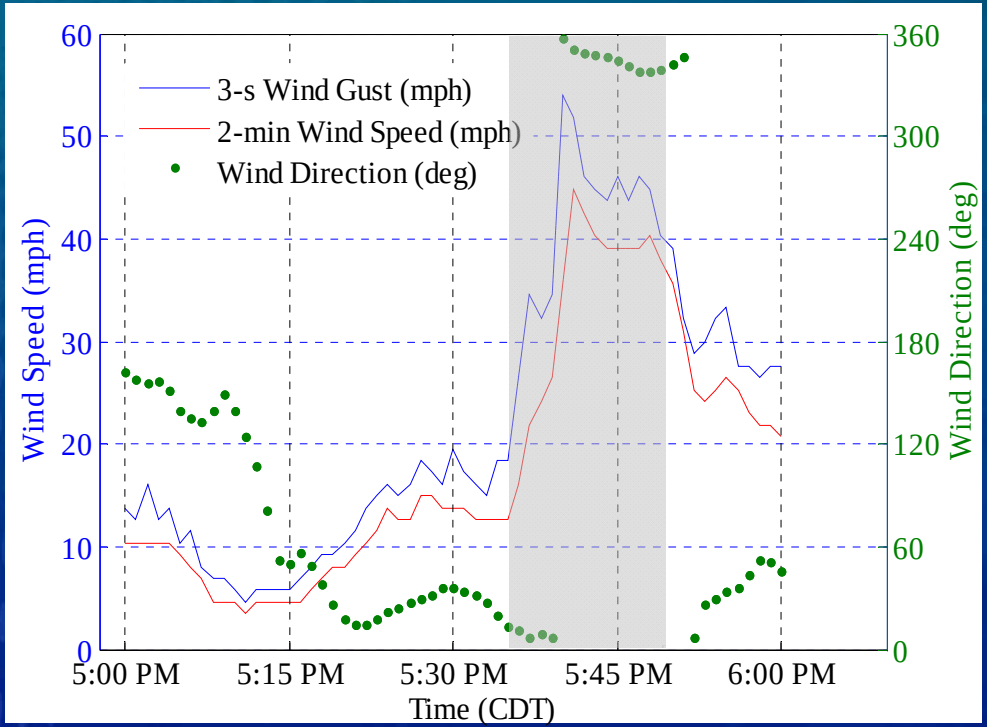
Meteorological Conditions

- Sirens in Joplin were sounded twice; tornado was spotted on the ground and went through the City of Joplin
- NIST constructed a timeline of these events based on information obtained from watches and warnings, sirens and surveillance videos



Wind Speed Estimation

- Direct Wind Speed Observations (Joplin Airport)



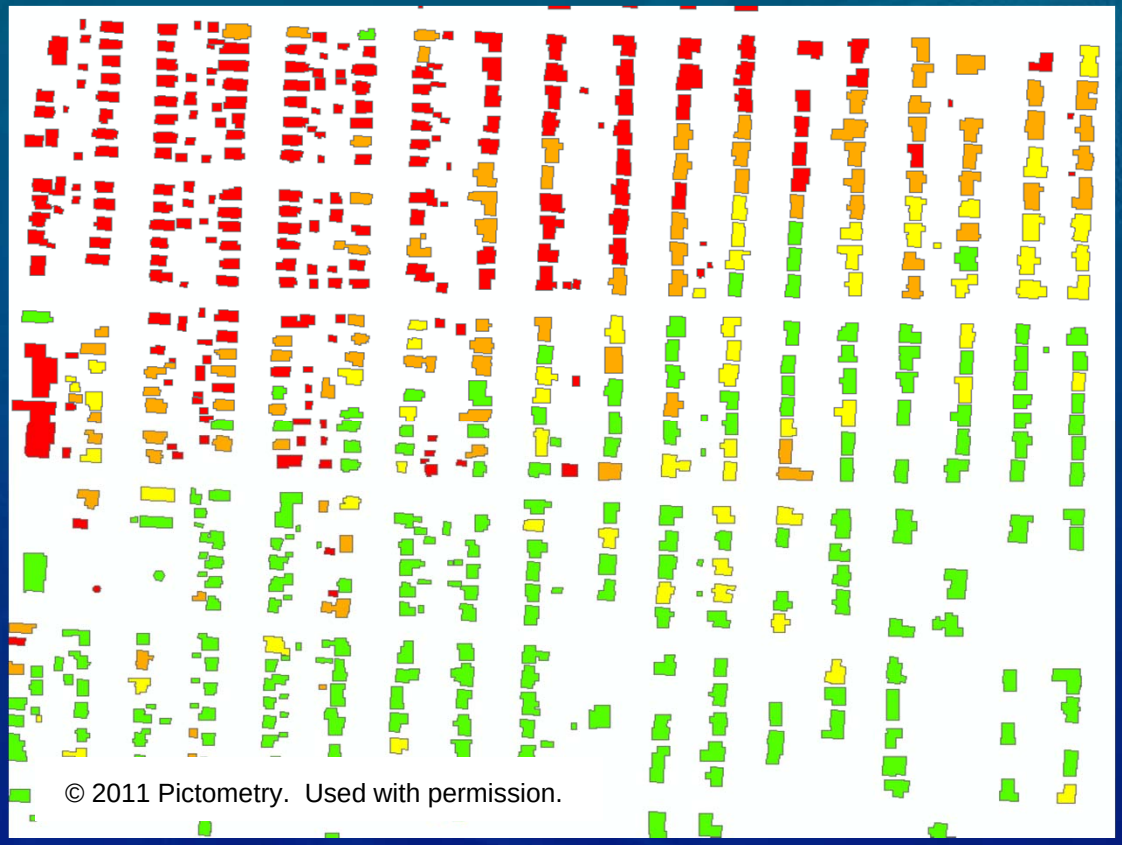
- Although 5-6 miles north of tornado, wind speed and wind direction still shows effects (gray shading)

Data Source: National Climatic Data Center

- Indirect Wind Speed Estimation
  - EF-Scale Estimation
  - Tree Fall

Wind Speed Estimation

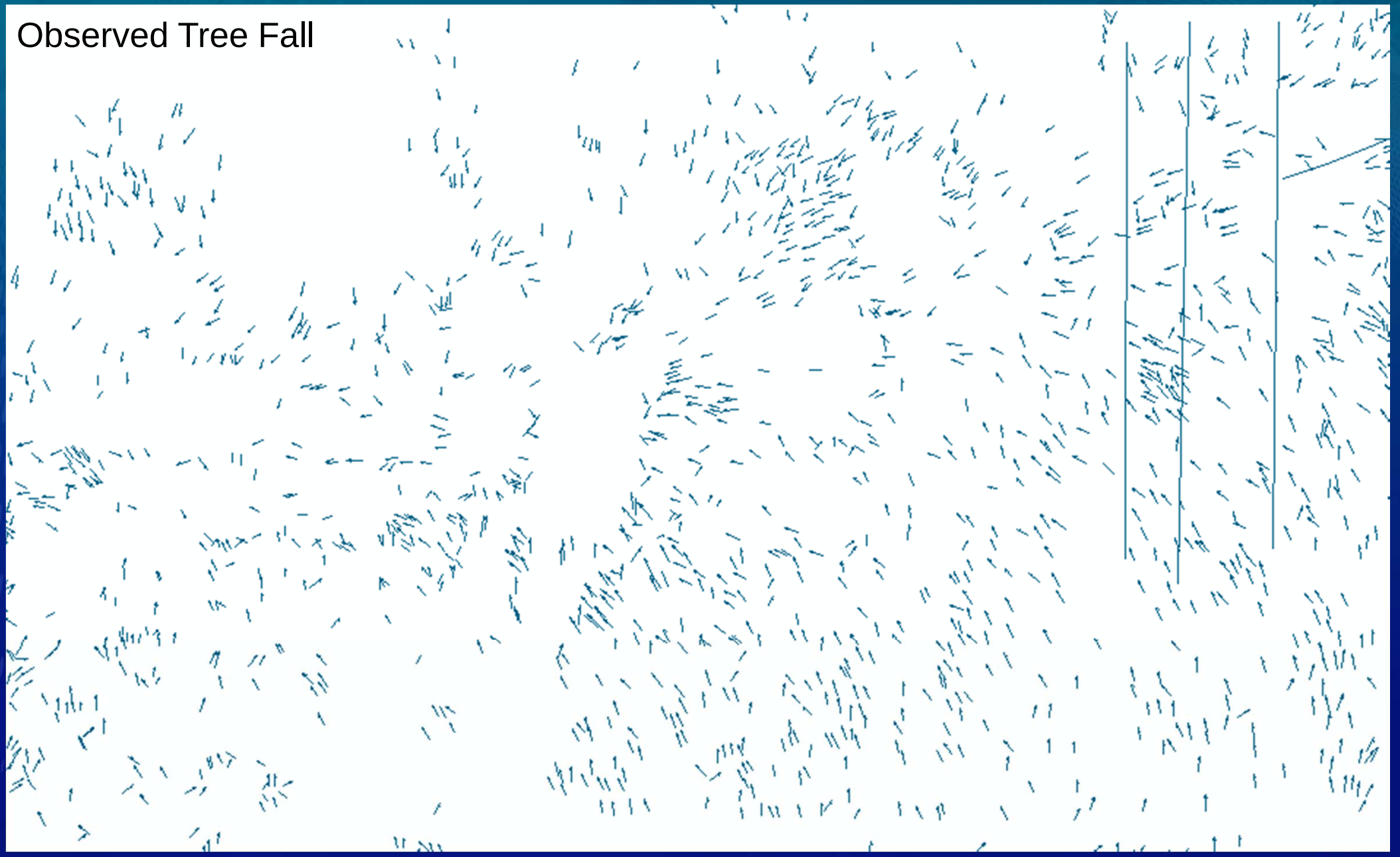
- EF-Scale Estimation
  - NIST Surveyed
    - Home Depot Store #3023, Walmart Supercenter Store #59, St. John's Regional Medical Center, Joplin High School, Joplin East Middle School, Franklin Technology Center
  - Residential
    - Estimated 7,500 residential structures damaged per information provided by Jasper Co. GIS and other sources
    - Basic classification as "light", "medium", "heavy to totaled", "demolished"
    - Random sampling of 10 structures in each category rated



Residential Only	Light	Medium	Heavy/Totaled	Demolished
Mean (mph)	78	93	117	144
Standard Deviation (mph)	8	15	11	23
Approximate EF Number	0	1	2	3
Total Number of Residential Structures	3562	608	1010	2058

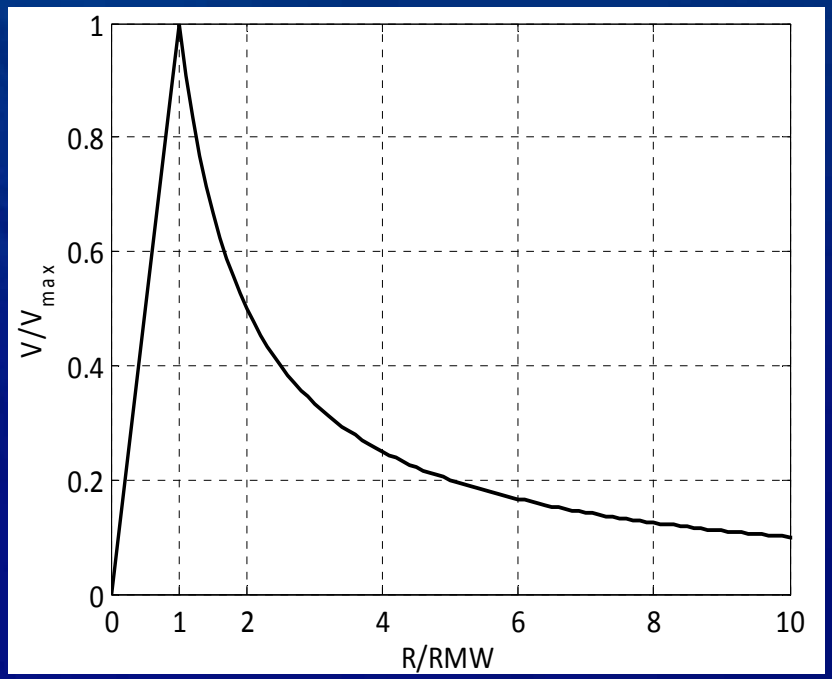
Wind Speed Estimation

Observed Tree Fall



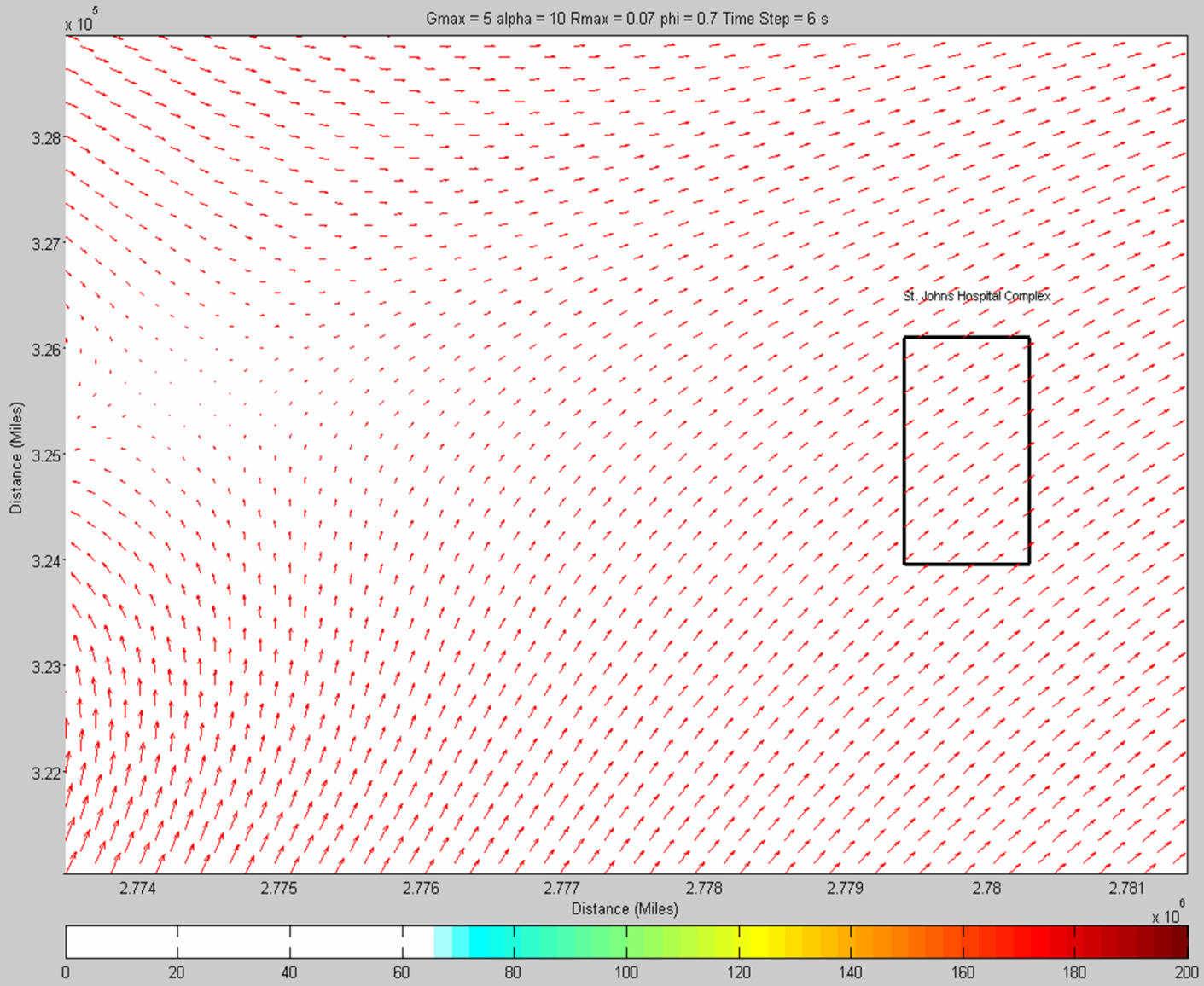
Wind Speed Estimation

- Wind Field/Tree Fall
  - Uniform grid (32 m x 32 m) throughout Joplin (representative of trees)
  - Parameterize Rankine vortex model
    - Location of tornado (post-storm aerial imagery, radar imagery)
    - Speed and direction of tornado (radar data, surveillance video)
    - Rankine parameters (radius of maximum wind, etc…) → aerial imagery, peer-reviewed literature
    - Survivor interviews
    - Critical tree fall wind speed
  - Translate model through grid
  - Iterate Rankine model
  - Make comparisons with observed tree fall
    - aerial imagery analyzed using GIS tools



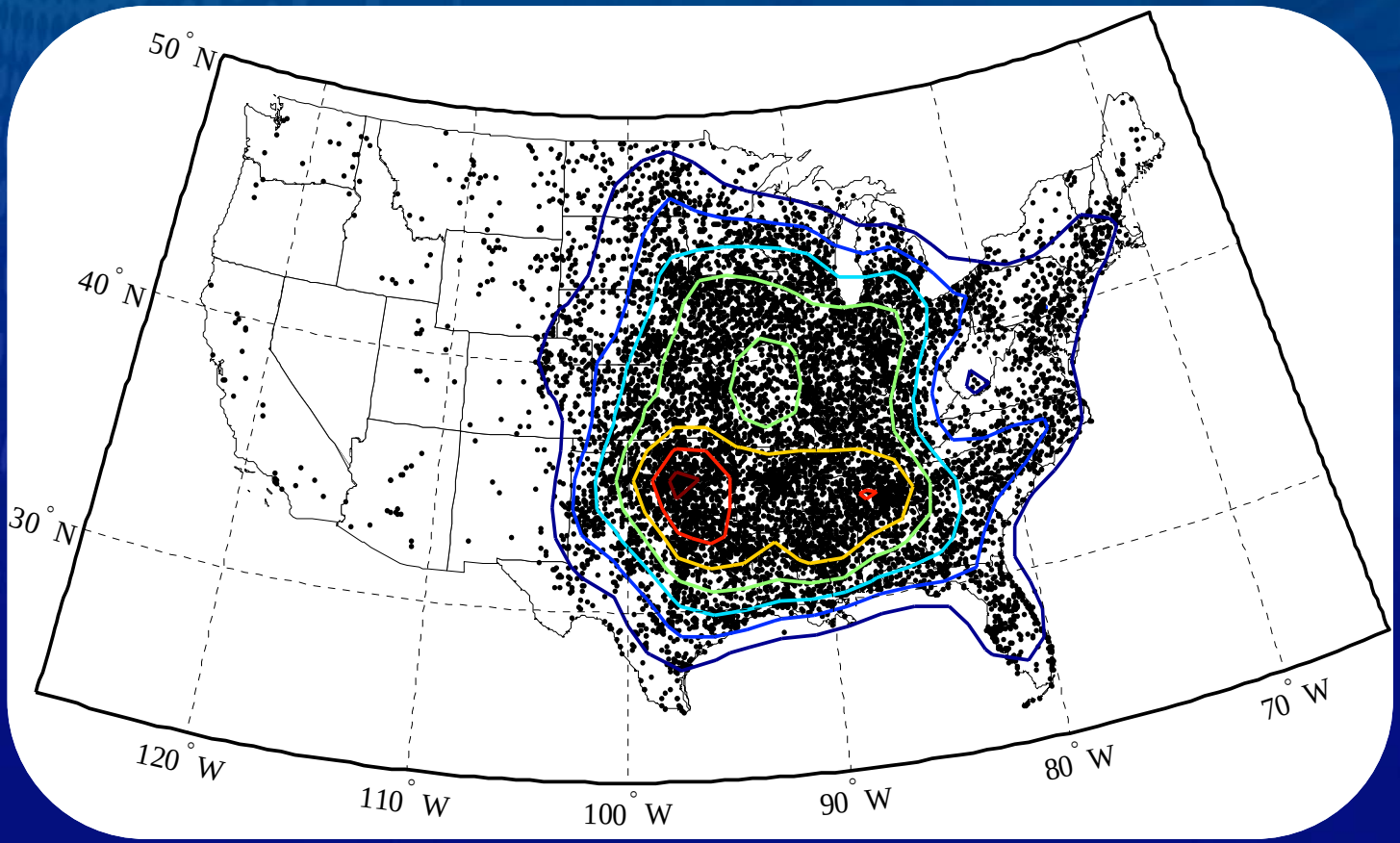
Wind Speed Estimation

- Each arrow represents grid point
- Red: current wind direction
- Black: direction of tree fall
- Contour: wind speed
- Can create wind speed and direction time histories



Tornado Hazard Climatology

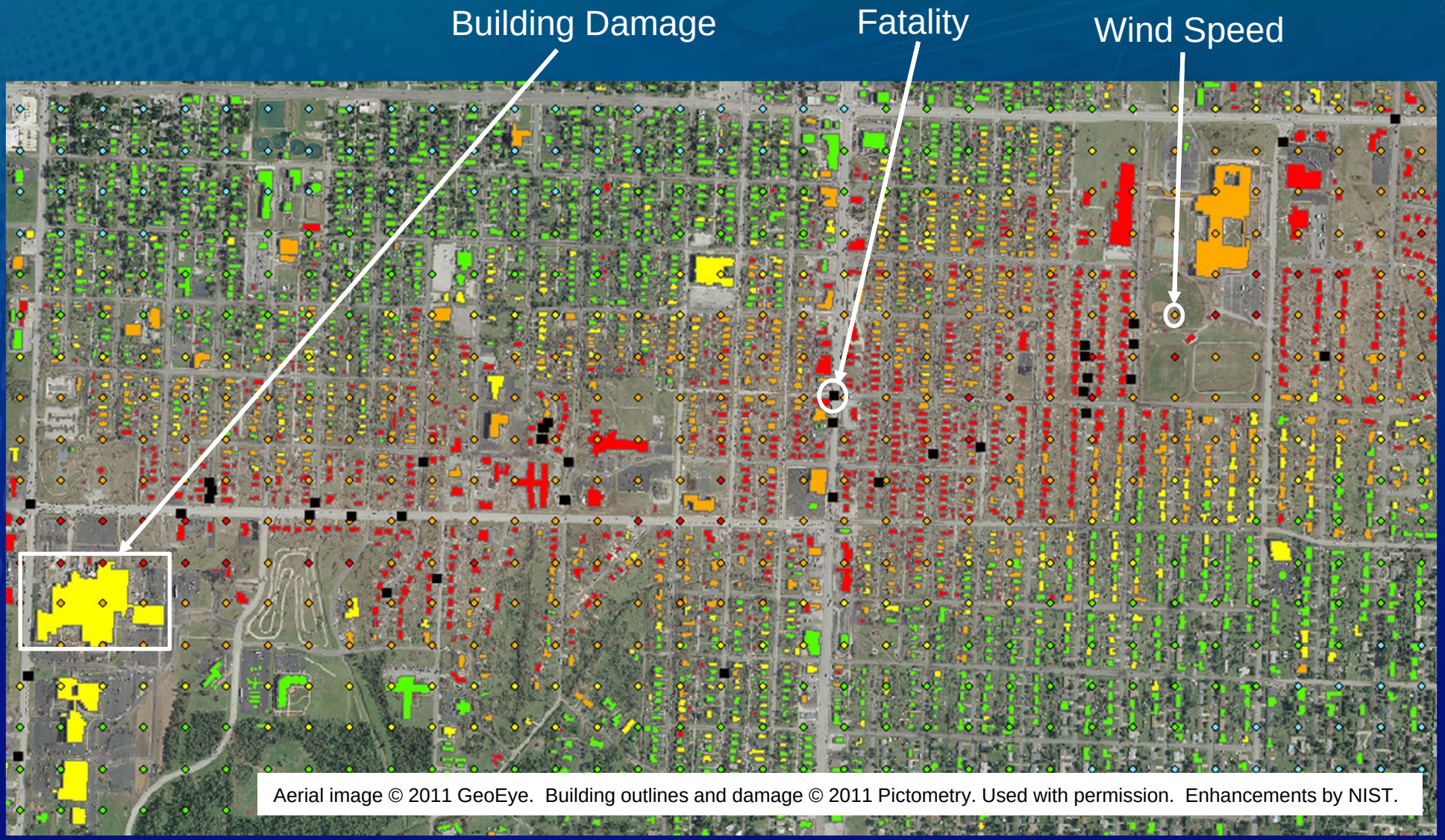
- Assess tornado hazard at local, regional, national levels
  - Probabilistic methods (e.g., NRC, DOE)
  - Design guidance (e.g., ASCE 7-10, FEMA 361)
- NOAA Tornado Database (1950-2011) → baseline for this investigation



- Touchdown locations of EF-2+ tornadoes (~11,000)
- Highest density in axis from Oklahoma to Alabama

Spatial Characteristics

- Involves integrating information from Objective 1, Tasks 2-4 (wind hazard) and Objectives 2-4 (fatality/injury and building damage)



EF-Scale Assessment

- Official guidance for EF-3+ tornadoes researched to determine possible methods of improving the process
- Guidance compared to its use in practice for recent significant tornado events (e.g., Greensburg, KS, Tuscaloosa, AL)
- Appropriateness and sufficiency of indicators used for damage being explored

Latest Progress/Next Steps

- Tasks 1-4, 6 are complete
- Finalize Task 5 integration with Drs. Phan and Kuligowski
- Rough draft of chapter near complete
- Findings pertaining to tornado hazard characteristics are being developed
- Develop recommendations, as warranted, for potential changes to building codes, standards, and practices to increase tornado resilience of buildings, lifelines, and communities