Tornado Hazard Characteristics

Performance of Buildings, Shelters, Designated Safe Areas, and Lifelines

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Update on Standards, Code, and Guidance Development (1/3)

Work in progress
Completed

- **Existing Standards**
  - ASCE/SEI 7-22, Minimum Design Loads for Buildings and Structures (R5, R6)
  - ICC 500-2019, Standard for Design and Construction of Storm Shelters (R7)
  - NFPA 1600-2019, Standard on Disaster/Emergency Management and Business Continuity/Continuity of Operations Programs (R13)

- **New Standards**
  - ASCE/SEI Standard for Estimation of Wind Speeds in Tornadoes (R4 and R2)
  - NFPA 1616, Standard for Mass Evacuation, Sheltering, and Re-entry Programs (January 2017) (R8 and R13)
    - requirements and guidance for selection of facilities to use as shelters and best available refuge areas for tornadoes and other natural hazards
    - annex on Emergency Communication: Public Alerts and Warnings
    - annex on Social Media Support

Update on Standards, Code, and Guidance Development (2/3)

Work in progress
Completed

- **Building Codes**
  - 2018 International Existing Building Code (IEBC) (R7)
    - require tornado shelters in additions to school bldgs. in 250 mph zone
    - requirements for shelter capacity and travel distance
  - 2018 International Building Code (IBC) (R7)
    - require tornado shelters in new buildings at existing schools in 250 mph zone
    - requirements for shelter capacity and travel distance
    - require designated community storm shelters to be Risk Category IV
    - code change proposal to ban roof aggregate was not accepted (R10)

Update on Standards, Code, and Guidance Development (3/3)

Work in progress
Completed

- **Guidelines**
  - FEMA P-431, Tornado Protection: Selection Refuge Areas in Buildings (R9)
  - FEMA P-320, Taking Shelter from the Storm: Building a Safe Room for Your Home or Small Business, 4th ed. (December 2014) (R8)
  - FEMA P-361, Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms, 3rd ed. (March 2015) (R8)
  - ICC 500-2014 Commentary on the Standard for Design and Construction of Storm Shelters (February 2016) (R7)

Improving Tornado Wind Speed & Climate Data

Recommendation 4 (NWS): NIST recommends that new damage indicators (DIs) be developed for the Enhanced Fujita tornado intensity scale to better distinguish between the most intense tornado events. Methodologies used in the development of new DIs and associated degrees of damage (DODs) should be, to the extent possible, scientific in nature and quantifiable. As new information becomes available, a committee comprised of public and private entities should be formed with the ability to propose, accept, and implement changes to the EF Scale. The improved EF Scale should be adopted by NWS.

Recommendation 2 (NWS): NIST recommends that information gathered and generated from tornado events (such as the Joplin tornado) should be stored in publicly available and easily accessible databases to aid in the improvement of tornado hazard characterization.

Tornado Databases

R2 (NWS): Improve publicly available tornado databases

Actively working since May 2016 with multiple NOAA offices, including:

- **NWS Storm Prediction Center (SPC)** on tornado database structure and data collection procedure improvements, including to the NWS Damage Assessment Toolkit
- **NWS Performance Branch (PB)** to improve the Storm Data application and database
- **National Centers for Environmental Information (NCEI – formerly NCDC)** to improve data archival/ease of access
- **Office of the Federal Coordinator for Meteorological Research and Support Services (OFCM)** to develop an annex to the National Plan for Disaster Impacts and Assessments: Wind and Water Data (NPDIA) specific to collection of data for tornadoes and other windstorms

Representatives from each of these offices also participate in the ASCE Tornado Wind Speed Estimation Standards Committee (see R4)

Tornado Wind Speed Estimation (1/2)

R4 (NWS): Standardize the Enhanced Fujita scale & improve through addition of scientific/quantifiable damage indicators

ASCE *Standard on Wind Speed Estimation in Tornadoes*

- Committee approved and began meeting FY15 Q2
- NIST/NWS proposed and co-chair the Committee
- 101 Committee members with expertise in
  - Meteorology, wind & structural engineering, architecture, materials, and emergency management
- Scope includes multiple methods of wind speed estimation:
  - Measurements
    - Radar
    - In-situ
  - Inferred from Damage
    - EF Scale
    - Forensic Engineering
    - Treefall Patterns
    - Remote Sensing Imagery
  - Data and Metadata collection and archival requirements for all methods

Tornado Wind Speed Estimation (2/2)

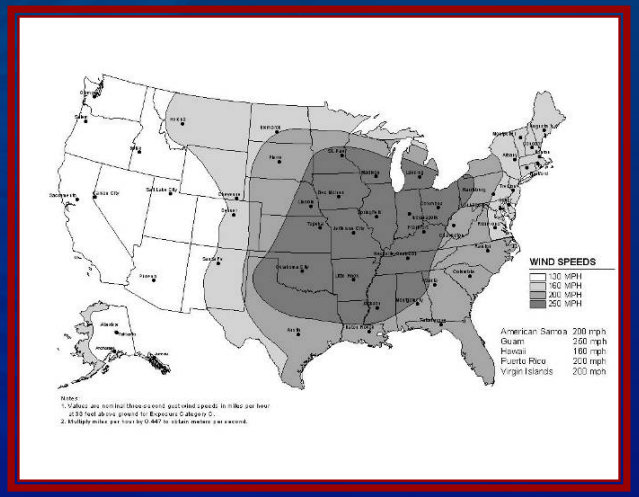
Recent Progress

- Approval of MOU between the American society of Civil Engineers (ASCE) and the American Meteorological Society (AMS), for joint development/publication of the standard
- Subcommittees are in the process of developing and balloting their chapters, prior to submission to the Main Committee
- Many proposed improvements to the Enhanced Fujita Scale, including new Damage Indicators for vehicles and structures
  - Based on wind tunnel testing, modeling, empirical data analysis
  - Include much more guidance for variations in resistance
  - Include explicit estimates of uncertainty
  - NIST/UWO/UI proposed new DI for precast concrete barriers (Jersey Barriers)
  - NIST/ARA have begun developing a new science-based DI for one and two family residences, adapted from the Observed Damage -> windspeed modeling work done for the tornado hazard maps

Progress Update – Codes (1/2)

R7 (ICC): (b) tornado shelters be installed in new and existing multi–family residential buildings, mercantile buildings, schools and buildings with assembly occupancies

- NIST-developed code changes approved for 2018 IBC and IEBC, requiring installation of tornado shelters in new construction at new and existing schools and assembly occupancies associated with schools in 250 mph zone



- **BCAC/NIST/FEMA developed code changes approved for 2018 IBC requiring designated community storm shelters to be designed as Risk Category IV Structures**

Progress Update – Codes (2/2)

R10 (ICC): Prohibition of aggregate used as surfacing for roof coverings and aggregate, gravel, or stone used as ballast on buildings in a tornado–prone region.

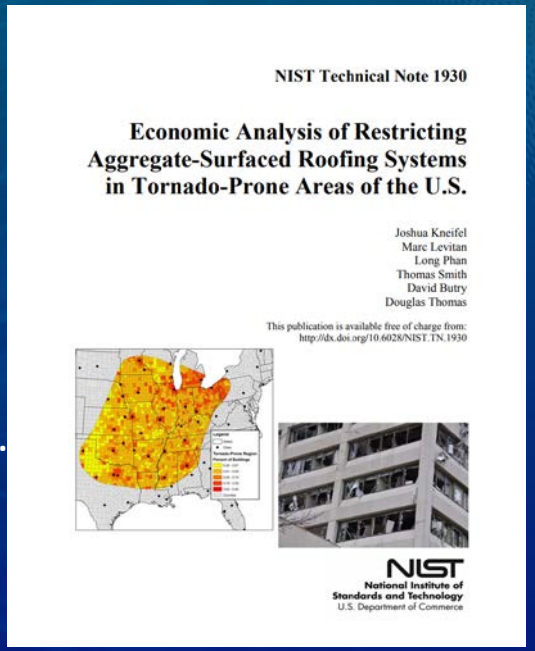
- Developed code change proposal, in coordination with the BCAC and with input from FEMA, to ban loose aggregate, gravel, and stone surfacing and ballast on roofs of Risk Category III and IV buildings in the tornado-prone region of the U.S.
- **Revised proposal in collaboration with the BCAC and submitted as Public Comment in June, 2016**
- **Completed research publication with Applied Economics in Sept. 2016 to show negligible cost impact**
- **Proposal defeated at Public Comment Hearings in Oct. 2016**

Economic Analysis of Restricting Aggregate-Surfaced Roofs

The percentage of new roof construction and re-roofing potentially impacted by the proposed code change was identified by combining building stock data by occupancy type and roofing system construction market share data.

Potential impacts were found to be:

- < 0.1 % of roof construction in the U.S.
- < 1.0 % of all non-low-rise residential roof construction in the U.S.
- < 0.3 % of roof construction in the tornado-prone region
- < 3.0 % of all non-low-rise residential roof construction in the tornado-prone region.


NIST Technical Note 1930

Economic Analysis of Restricting Aggregate-Surfaced Roofing Systems in Tornado-Prone Areas of the U.S.

Joshua Kneifel
Marc Levitan
Long Phan
Thomas Smith
David Butry
Douglas Thomas

This publication is available free of charge from: http://dx.doi.org/10.6028/NIST.TN.1930

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

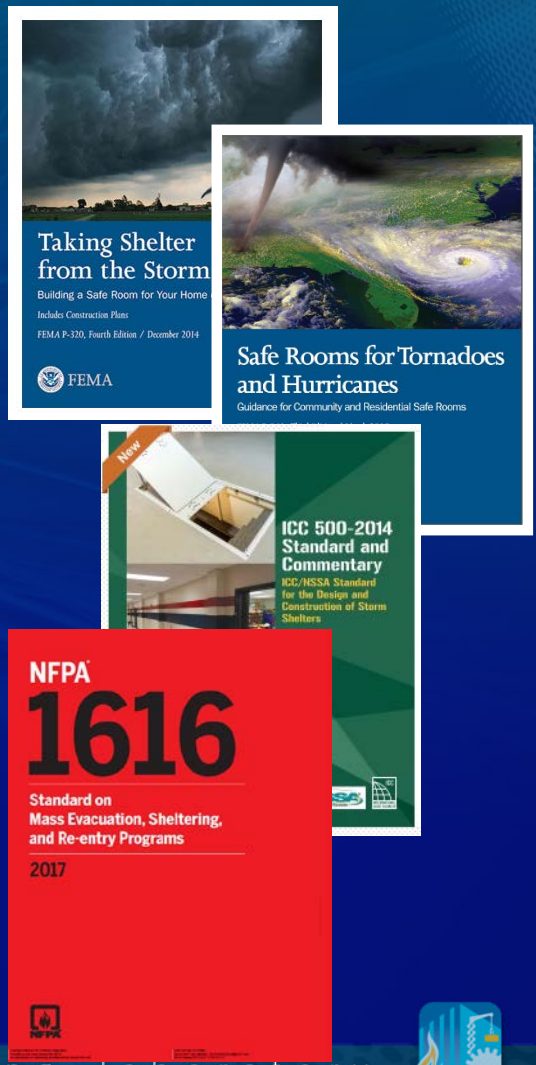
The previously adopted code change that similarly prohibited aggregate-surfaced roofs in the hurricane-prone region impacted more than four times as much roof construction.

Of the five most common types of built-up and single ply roofs, the only type of new roof construction or re-roofing that would be negatively impacted from a construction cost perspective by the code change are those that would have otherwise installed a ballasted single-ply membrane on a concrete deck

Progress Update – Sheltering Strategies

R8 (FEMA): Guidelines that enable communities to create safe and effective public sheltering strategies

- NIST-developed new guidance material was incorporated into two FEMA Safe room publications:
  - FEMA P-320, Taking Shelter from the Storm, 4th ed. December 2014.
  - FEMA P-361, Safe Rooms for Tornadoes and Hurricanes, 3rd ed. March 2015.
- NIST led development of Chapter 3: Structural Design Criteria in the ICC 500 Commentary. February 2016.
- **NIST developed provisions and annex material on building safety considerations for selection of shelters for tornadoes, hurricanes, and other hazards, in the new NFPA 1616-2017: Standard for Mass Evacuation, Sheltering, and Re-entry.**



R16:
NOAA Grid-Based Threat Communication: Forecasting a Continuum of Environmental Threats (FACETS)

Progress Update

Recommendation 16 (NOAA): *NIST recommends that technology be developed to provide tornado threat information to emergency managers, policy officials, and the media on a spatially resolved real–time basis to supplement the currently deployed official binary warn/no warn system.*

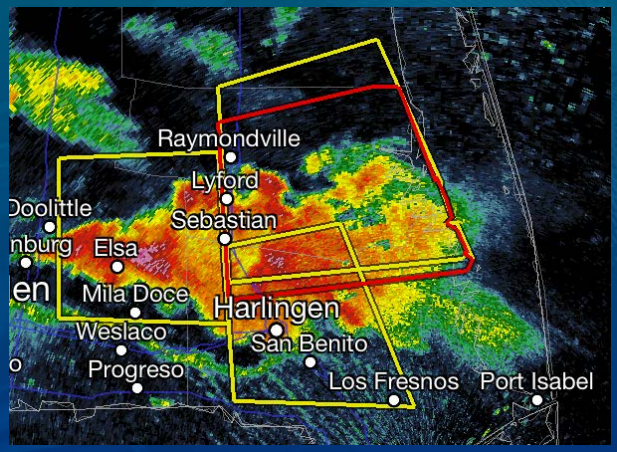
NOAA's National Severe Storms Lab (NSSL) is actively exploring and developing a new grid-based threat communication paradigm, called

Forecasting a Continuum of Environmental Threats (FACETs)

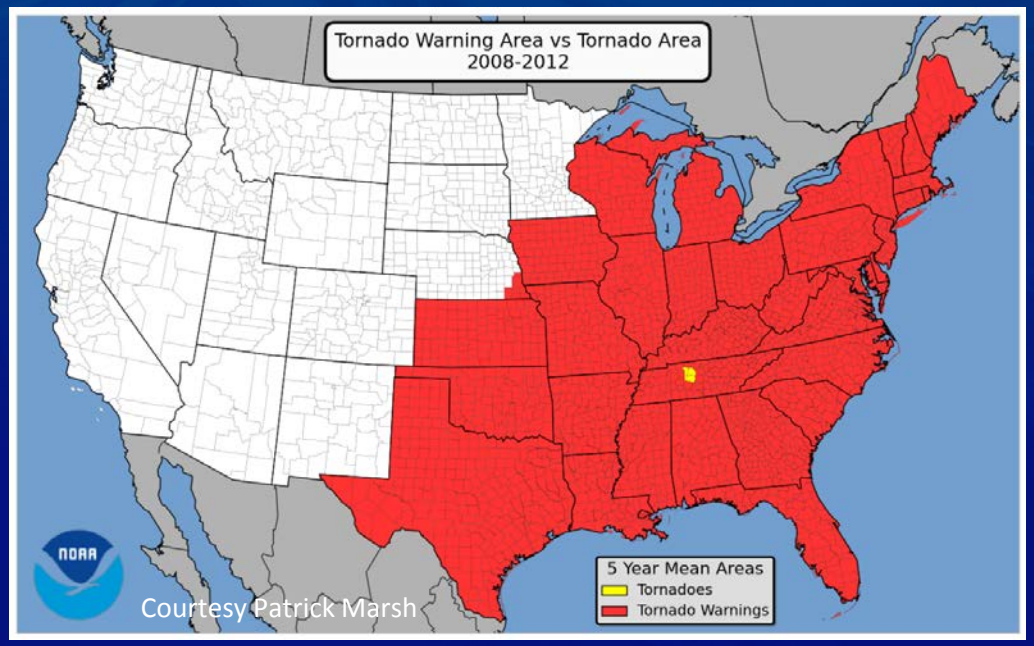
- FACETs is a new, all-hazard watch/warning paradigm (grid-based, probabilistic threats) redesigned with social/behavioral science infused
- Multi-year exploration/development effort.
  - Completed first iteration of probabilistic hazard grids and tools
  - Limited tests with NWS forecasters in Hazardous Weather Testbed
  - 12 years of NWS radar data analyzed and cleaned up in preparation for statistical based methods for warnings.
- See http://www.nssl.noaa.gov/projects/facets/

The Current Tornado Warning System

- Warning polygons are messy!
- Inherently “binary” (on/off; in/out)
- Huge false alarm rate.
- 1950s Teletype-era paradigm.



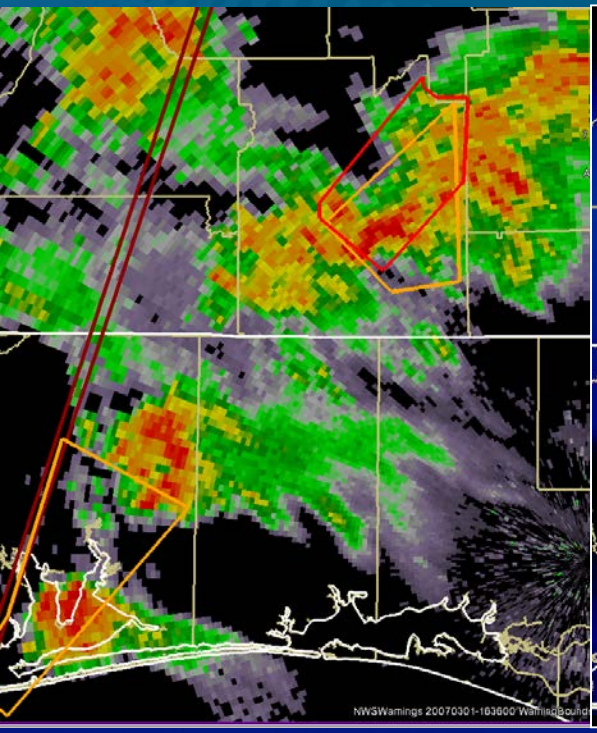
Source: NOAA



Source: NOAA

FACETS Tornado Warning Timeline (est)

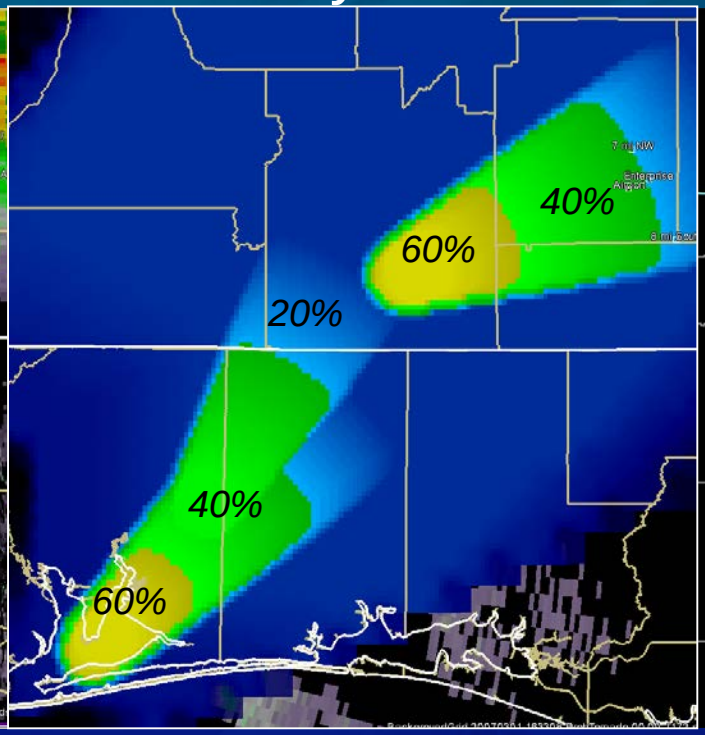
Present



Source: NOAA

Polygons or county based warnings updated ~15 min

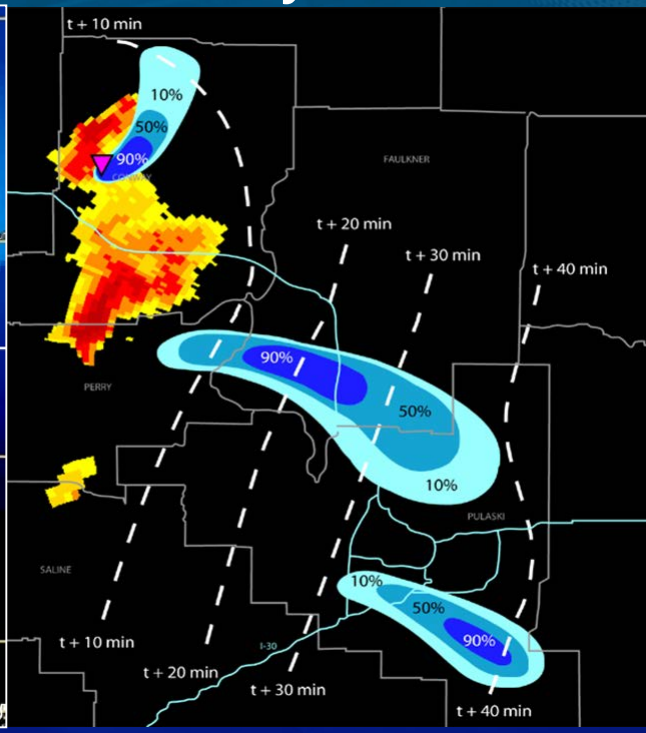
5-10 years?



Source: NOAA

Probabilistic guidance from climatology and human “estimation” updated ~15 min

>10-20 years?



Source: NOAA

Probabilistic guidance using numerical model ensembles and updated continuously

Expected Benefits

- A fully-integrated continuum of weather threat information;
- Reduction in size of “warned” areas;
- Considerable new opportunities for America’s Weather Industry;
- More useful, actionable, and recipient-specific information.
- A Weather-Ready Nation.

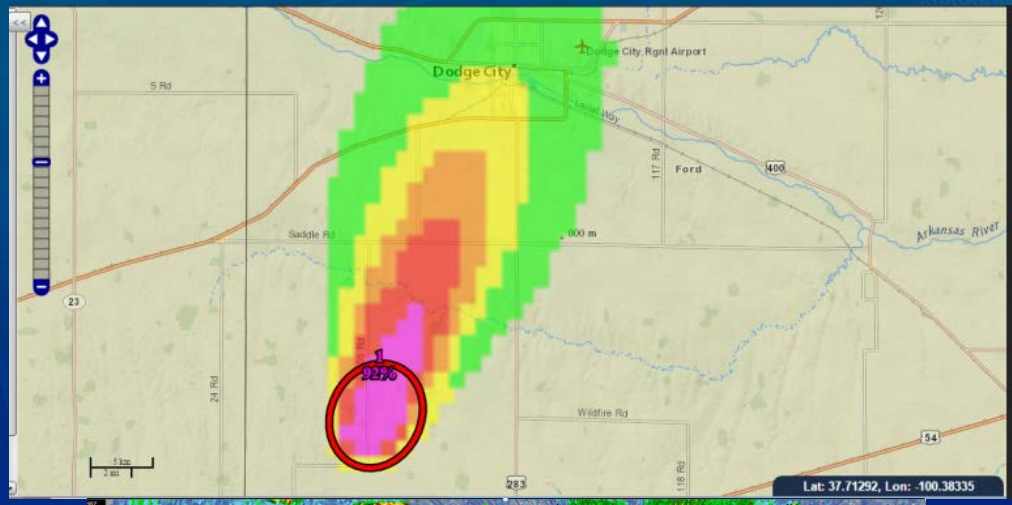
Source: NOAA

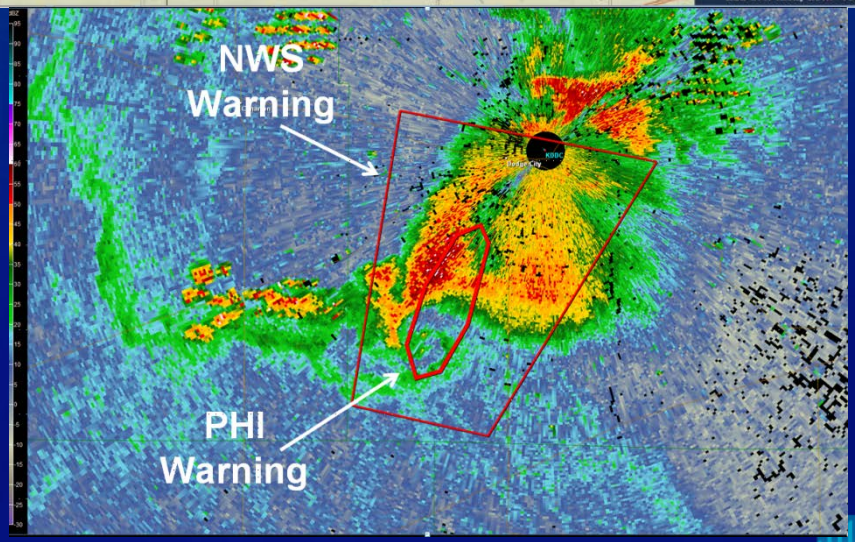
Source: NOAA

FACETs in the Hazardous Weather Testbed (HWT)

Courtesy PI: Chris Karstens, CIMMS/NSSL

- PHI provides a more focused warning than current system
  - —Less false alarm (FA) area in proximity to hazard area; more lead time (and more FA area in some cases?) downstream
  - —Users preferred "plume" and PHI derived polygons over "legacy" warnings





HWT tornado PHI products from 24 May 2016 DDC tornadoes

FACETs in the HWT

- Social and behavioral science fully integrated in R2O process
  - —Researchers from OU, Univ. of Akron, Howard University
  - —Work with forecasters, emergency managers and broadcasters in PHI experiments
  - —Direct work with public through other funded research

FACETs is happening now!