



# Weather Ready Nation: A Vital Conversation on Tornadoes and Severe Weather



## A Community Report



March 2012

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# Weather-Ready Nation: A Vital Conversation on Tornadoes and Severe Weather Report from the December 2011 Symposium

## Prologue

On the 13<sup>th</sup> of December 2011 at the National Weather Center in Norman, Oklahoma, a national conversation began on what it takes for our country to become a “Weather-Ready Nation.” The dialogue brought together social scientists and physical scientists, operational forecasters and TV meteorologists, first responders and emergency managers, and private entrepreneurs and government officials from across the country. The tragic toll from the tornadoes of 2011, in which 550 Americans died and the nation sustained billions of dollars in economic damage, called for diverse concerned communities to come together to build a broader and stronger alliance against future loss. The over-arching goal of this dialog is to identify, prioritize, and set in motion actions to enhance our nation’s preparedness and resilience for severe weather, especially tornadoes, so that fewer American lives are lost and the nation’s economy made more secure. This said, a Weather-Ready Nation needs to be ready for weather in all of its forms. During the second half of 2012, the focusing lens of tornadoes will be replaced by broader considerations of severe weather: hurricanes, droughts, floods, fire, heat waves as well as tornadoes.

*We came together* with a goal to develop a cohesive community of scientists, practitioners, and users who are committed to advancing an emerging and more unified paradigm that focuses more systemically on a warning system that will ultimately reduce the loss of life and mitigate the social and economic impacts from severe weather. We believe we must grow and sustain effective partnerships between those who conduct both physical and social science research as well as with those who create, communicate or receive forecasts. All recognize that only a comprehensive end-to-end warning system combined with appropriate improvements in both our communities and building standards can optimally protect lives and property while also improving the nation’s resilience to severe weather. This partnership supports the promise of a Weather-Ready Nation: a nation that is better informed because of our focused discussions and thus, better prepared by resulting actions.

*We committed* to facilitating a purposeful national conversation focused on actions to reduce the loss of life and social and economic impact of severe weather. Nature, as it always has, will replay the powerful forces unleashed during 2011, and other communities and cities will suffer. But henceforth, we pledge to be ever more ready; informed by new knowledge forged through these new partnerships, enabled by new tools that better serve the needs of people, and united through our shared resolve and focused efforts to change the future. Readiness will not all happen tomorrow or the next day, but it will happen.

*We identified*, through this initial national dialog, a number of challenges to becoming a Weather-Ready Nation. In the months ahead, there will be a series of research- and operations-oriented, interdisciplinary workshops and symposia, designed to energize and integrate a broad coalition of contributors — researchers, emergency managers, first responders, broadcast meteorologists, private and public sectors, and educators.

In partnership with the National Oceanic and Atmospheric Administration (NOAA) and other key partners, future gatherings will refine and prioritize actions directed toward producing both measurable reductions in the loss of life and avoidable damage to the American economy.

*We will see this through*; the United States of America must become a Weather-Ready Nation.

## **Section 1: Overview**

Despite excellent warnings and longer than average lead times, 550 lives were lost in tornadoes in 2011. This made 2011 one of the four deadliest tornado years in U.S. history, joining the tragic death tolls of 1917, 1925, and 1936. On December 13-15, more than one hundred and seventy five national experts and leaders including emergency managers, academics, social scientists, government and private sector weather forecasters, communication experts, news media and decision-makers gathered in Norman, Oklahoma to initiate a focused national conversation. Their goal was to "*identify, prioritize, and set in motion actions to improve the nation's resiliency against severe weather, especially tornadoes, to protect lives and property.*"

This national summit was the first in a series of Weather-Ready Nation conversations that NOAA will facilitate across the country in 2012 to learn from the experience and insights of important weather partners and, where appropriate, to initiate actions to increase readiness. The initial priorities from the December meeting focused on how to improve impact-based forecasts and warnings, sharpen science-service linkages, and identify enhanced communication and service delivery innovations. Other areas will require further definition. As Section 5 notes, there will be ample opportunity for this needed shaping and refining as the base for further actions.

## **Section 2: Presentations and Panel Discussions**

NOAA Administrator Dr. Jane Lubchenco opened the event by videoconference and set the tone for decisions and actions by offering her support, urging a unified effort to listen and learn and to generate sustained interactions that enable the community to collaboratively chart a way forward. Oklahoma Governor Mary Fallin then gave the first Keynote Address and noted the importance of our work that included the safety of our citizens and industries. Jack Hayes, director of the National Weather Service (NWS), echoed this theme, stating "Becoming a Weather-Ready Nation is a shared responsibility from the federal government to the individual citizen and everyone in between." He pledged, "NOAA's National Weather Service is committed to delivering the highest quality of forecast and warning services and fostering innovation. Building a Weather-Ready Nation will take the commitment of everyone we're engaging with through these national conversations."

The days were filled with the expectation that with discussion, collaboration and commitment, there would be opportunity for real progress. Dr. Kathryn Sullivan, Assistant Secretary of Commerce for Environmental Observation and Prediction, closed the meeting. In her summary statements of the meeting, she noted, "conversation is the seminal technology of all societal change."

To contribute to this seminal technology and join the conversation, check out the NWS Facebook page or the Weather-Ready Nation web page: <http://www.weather.gov/com/weatherreadynation>. The complete Workshop Agenda is provided in Appendix A<sup>1</sup>.

Topics covered through presentations and panel discussions included:

- A summary of fundamental physical science knowledge and challenges
- Assessments of the major events of 2011
- Improving NOAA forecasts and warnings for severe weather
- Improving service delivery

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<sup>1</sup> All plenary sessions from "*Weather Ready Nation: A Vital Conversation*" can currently be viewed on the workshop web site: [http://www.joss.ucar.edu/events/2011/weather\\_ready/index.html](http://www.joss.ucar.edu/events/2011/weather_ready/index.html)

- Sharpening the science-service linkage
- Leveraging community planning and impacts mitigation

Poignant personal accounts of the challenges of responding to major disasters in populated areas from Joplin/Jasper County Emergency Management and a fireman from the Fire and Rescue Service in Tuscaloosa were sobering and heightened the sense of community commitment.

### Section 3: Cross Cut Group Discussions

Participants were first grouped into "Communities" of expertise: communications, emergency decision makers, operations, physical scientists, policy specialists, risk management and community resiliency, and senior management (See Section 4). Each community group identified critical issues hindering the nation's resiliency against tornadoes. Participants were then divided into cross-community groups ("Cross Cut Breakouts") in which attendees shared perspectives of events of 2011 and their unique professional insights on the challenges we must overcome to meet our goals. The diversity of participation within the Cross Cut sessions produced a set of themes which were used to inform the community groups as they reconvened during the final sessions of the symposium.



Figure 1: Word Cloud from Cross Cut Session notes. Most common words in notes are in largest font.

The following themes emerged from the Cross Cut Sessions:

- Strongly integrate social and physical science into the future end-to-end weather forecast and warning process – from research to operations. All breakout groups indicated public understanding of warnings and their perceptions of risk are important gaps, and recommended early and more effective integration of social science in warning policy, plans, and programs. The issue of perception of risk may be especially important.
- Carefully review warning false alarms to determine physical science improvements and other strategies that can be used to reduce false alarms without decreasing threat detection and warning lead-time. Breakout groups expressed concern that public responsiveness is negatively affected by a perception that too many warnings are false alarms.
- Assess and update warning dissemination strategies. New wireless technologies afford a great opportunity to improve the speed and effectiveness of severe weather warnings. At the same time, the strategy must not leave behind segments of the population who do not use or have access to more modern technologies.
- Advance physical modeling of severe weather to provide the improved lead-time, accuracy and precision necessary to enable tornado warnings based on weather forecast model output (“Warn on Forecast”). Today’s critical dependence on weather radar observations for warning the public limits warning lead times in most cases to approximately 15-20 minutes.
- Improve outreach and education to supported agencies and groups: Federal Emergency Management Agency (FEMA), emergency managers, threatened communities. Breakout groups agreed that preparation requires credible communication of threat, which leads to proactively planning on the part of communities and individuals. There is also a need for all to better

understand the scientific certainty and uncertainty inherent in extreme weather forecasting and warnings.

- Evolve the National Weather Service (NWS) Assessment process that follows major severe weather outbreaks to be similar to assessments of the National Transportation Safety Board (NTSB) that follow major transportation disasters.<sup>2</sup> The assessment teams would include external/independent experts alongside NWS staff. Increased participation and visibility would trigger broader national action to go beyond simply living with the personal and economic impacts of extreme weather.
- Build coalitions with corporate America. Such coalitions could significantly enhance the effectiveness of government issuances and thereby have great potential to make a difference.

A more complete list of ideas from the Cross Cut sessions is available in Appendix B.

## **Section 4: Recommendations by Community**

Seven community groups that met at both the beginning and the end of the symposium were given the task to identify and prioritize actions to improve the nation's resiliency against severe weather, especially tornadoes, to protect lives and property. The intervening cross cut discussions helped to inform and enrich the community-specific final session during which priority actions to reach our shared goals were developed. There is welcome and important overlap between the recommendations of Section 3 and Section 4. Finally, these recommendations were presented and discussed at a Town Hall at the American Meteorological Society's Annual Meeting in January 2012. These recommendations form the primary set of Action Items.

The top prioritized recommendations from the seven communities (in alphabetical order) are listed below.

### **A. Communications Group**

- Create Research/Resource Centers in which social and physical scientists can work with forecasters and/or forecast users to ensure successful communication of extreme weather threats. Such centers, some of which might be "virtual," would focus on fundamental social science research issues *and* on transitioning social science research on such topics as public threat perception, messaging to improve public understanding and responsiveness to warnings, etc. into operational practice. The centers would also address the limits of the science by both extending the known into the unknown and by better a) defining and communicating what the science has established, and b) identifying what remains uncertain and thus requires further research.
- Review and improve warning dissemination strategies and technologies to increase effectiveness. The population is segmented: by age, income, schedules, technology awareness and access. This creates different vulnerabilities and requires multiple communication strategies. Information access for vulnerable populations, including preparedness efforts, is particularly important. Delivery systems pose several issues including technology access. For instance, the use of geo-

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<sup>2</sup> The National Construction Safety Team (NCST) Act of 2002 (PL 107-231) authorized National Institute of Standards and Technology (NIST) to conduct investigations involving damage to buildings that caused or could have caused substantial loss of human life. This legislation was modeled after the NTSB. The NIST study of the Joplin tornado is being conducted under NCST authority. See [http://www.nist.gov/public\\_affairs/factsheet/constructionact.cfm](http://www.nist.gov/public_affairs/factsheet/constructionact.cfm)



located polygons versus county level warnings (e.g., How do you convey a polygon on NOAA Weather Radio?), language and mobility barriers, hearing/visual impairments, and socio-economic groups. These issues need to be carefully considered and addressed.

- Study the warning false alarm issue and develop/implement strategies that increase public responsiveness to warnings. The issue of false alarm needs to be addressed. There are numerous issues, including perceptions of false alarms. As the science of prediction improves, the issue of false alarm will obviously change but in ways that may not be obvious. This will change both because of operational changes and the scientific gains. Understanding better the various false alarm issues is essential.

## **B. Emergency Decision Makers Group**

- Modernize NOAA Weather Radio (NWR) using a public-private partnership to address the incorporation of polygons or other more refined geo-location techniques. Other topics that need to be addressed are:
  - GPS integrated programmable radio that only activates for tornado warnings where the radio is located.
  - Increase coverage density/number of NWR transmitters to fill “dead areas.”
- Develop clear, consistent, and concise messages issued by NWS, commercial weather services, emergency managers and the media in formats that are easily understood.
- Expand educational opportunities, including beyond the classroom.
  - Distill the existing knowledge base into useable formats that support broader educational needs.
  - Fund and use in-progress work and tools to the point of implementation e.g. training modules.
  - Collaborate with the Natural Hazards Research Center<sup>3</sup> as one approach to expanding linkage to the application community.
  - Identify and extend best practices nationally e.g., OK-First training modules.<sup>4</sup>

## **C. Operations Group**

- Through targeted funding, develop the essential social science research base that will support a Weather-Ready Nation. This is needed, in part, to find out what people need to know to receive information, to prepare, to make decisions, and to take action. This requires:
  - Redesign of the dissemination, education, warning, and forecast services,
  - Incorporation of social science considerations as an integral part of the end-to-end warning system, and
  - Improvement of communication from top-to-bottom and bottom-to-top within organizations that make up the warning to response system.

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<sup>3</sup> <http://www.colorado.edu/hazards/>

<sup>4</sup> <http://okfirst.mesonet.org/train/training.html>

## **D. Physical Science Group**

- Conduct a needs analysis for existing, new and future observation technologies and assess the impact on the forecast process and associated forecast skill.
- Address gaps in understanding with the focus, in part, on being able to predict with adequate lead-time the physical factors that affect the genesis, longevity, track, and intensity of tornadoes (especially to reduce false alarm rates). In considering the relevant physical factors, the community should develop severe storm climatologies on appropriate space-time scales for tornadoes and conduct data mining experiments to extract the most relevant parameters for tornado prediction.
- Assess the feasibility of numerical prediction of convective initiation and tornadoes through assimilation of both current and developmental radar and other fine-scale data into high-resolution numerical forecast models.
- Establish a rapid post-storm assessment system and process similar to NTSB's post-accident investigations. One objective of this post-event investigation would be to determine if we need better warnings, engineering or response (or all/none of the above).

## **E. Policy Specialist Group**

- Integrate social science into NWS product development as well as NWS assessment of current (and future) business practices and workforce evaluation.
- Improve dissemination of an expanded suite of warning technologies including mobile devices, home safety (smoke detectors, security systems enhancements to allow warnings), reverse 911, etc.
- Exploit and expand storm-based warning value-added information into legacy dissemination systems through Common Alerting Protocol (NOAA Weather Radio, emergency systems, siren systems).
- Develop consistent but flexible ways for the NWS to issue warnings, which recognize the need to enhance consistency between NWS Forecast Offices but allowing for the addressing of local needs.
- Engage the Department of Commerce (DoC) in a coordinated assessment of severe weather's impact on the country including DoC agencies such as Bureau of Economic Analysis, and the U.S. Census Bureau. Also include the independent agency, the Small Business Administration.

## **F. Risk Mitigation and Community Resilience Group**

- Conduct trans-disciplinary research and other collaborative research efforts to evaluate success and failure stories and histories in risk management.
- Examine functionally resilient and non-resilient communities with a particular focus on why people survive (or sustain injuries) or not during tornadoes.
- Significantly improve the scientific knowledge and engineering models to understand how buildings fail in tornadoes, leading to better designs that can resist these forces.<sup>5</sup> Ultimately, structurally enhanced, resilient communities must be a part of a Weather-Ready Nation, but these will not occur without better understanding.
- Educate the public in terms of risk awareness and vulnerability. Work with state education boards and develop vulnerability simulations to support classroom activities. Communities must be made aware of the risk including our existing vulnerabilities by community, and we should

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<sup>5</sup> A necessary place to start in assessing risk is to establish the ultimate capacities of existing structural systems. This entails exploratory research to predict how structural framing behaves, and extensive experimental testing for developing relationship between building strengths and tornado loads. Current building codes do not include design procedures for tornado loads, and so the majority of buildings away from hurricane-prone coasts lack details to mitigate tornado effects.



include the separate constituents of leadership at all levels (community, municipal, regional, federal and state).

- Develop an approach for resilient buildings both for existing and new construction. Costs of structural enhancements for existing structures need to be explored and communities need to be aware of the tradeoffs involved in retaining old housing or outdated building codes in the face of the potential for future tornado strikes.

### **G. Senior Management Group**

- Bring Corporate America into the conversation. For example:
  - U.S. Chamber of Commerce; in particular the Business Civic Leadership Center<sup>6</sup>
  - Weather enterprise (e.g., commercial weather services)
  - Professional associations and other affiliated groups
  - Insurance and re-insurance companies
  - Home builders
- Engage social scientists to review and provide recommendations for NWS policies associated with alerts/warnings. One objective will be to achieve more consistency.
  - Identify and share best practices; specifically, determine if the current advice/warnings are the right advice/warnings.
  - Include the risk management community.
- Establish and implement processes to identify basic and applied research questions. This process should include consideration of an assessment of the societal impacts as part of an overall prioritization of research needs. This will require a strong collaborative effort that brings together engineers, social scientists, and physical scientists.
- Conduct a review of the NWS Warning Coordination Meteorologist (WCM) program with a goal of including an improved training program. This review will require social scientists to be there from the beginning.
- Start integrated research efforts related to warning false alarms that reach across the science, technologies, NWS procedures, and incentives and disincentives. One longer-term goal is to optimize the observing strategy and thereby make better investments.

## **Section 5: Follow-on Activities**

The conversation has just begun. This report was discussed with the community at a Town Hall held during the January meeting of the American Meteorological Society in New Orleans, and during the March 2012 National Severe Weather Workshop in Norman.<sup>7</sup> The discussion will continue during the AMS Washington Forum in early April<sup>8</sup> and a late April Severe Weather Research Imperatives Symposium.

The national conversation to build a Weather-Ready Nation will continue throughout 2012 and beyond with a number of symposia, events, town halls, workshops, and speeches.

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<sup>6</sup> For instance, see <http://bclc.uschamber.com/blog/2012-01-18/bclc-leads-business-delegation-joplin-mo>

<sup>7</sup> <http://www.norman.noaa.gov/nsww/>

<sup>8</sup> <http://www.ametsoc.org/meet/fainst/2012washingtonforum.html>

## Completed, Planned or Proposed Symposium and Workshops -- Location/Dates

- 1) Weather Ready Nation - A Vital Conversation (Norman, Okla.): 13-15 December 2011
  - *Completed:* With more than 175 participants from a diverse cross section of key partners and stakeholders.
- 2) AMS Town Hall report on Norman workshop outcomes (New Orleans, La.): 23 January 2012
  - *Completed:* More than 300 community participants. Comments and insights from the Town Hall discussion are integrated in this report.
- 3) National Severe Weather Workshop (Norman, Okla.): 1-3 March 2012
  - *Completed:* Strong cross-cutting community participation, particularly at a regional level.
  - <http://www.norman.noaa.gov/nsww/agenda/>
- 4) *Proposed:* 2012 National Emergency Management Association (NEMA) Mid-Year Conference titled "Extreme Weather – Is it the New Norm" (Alexandria, Va.): 28 March 2012
- 5) AMS Washington Forum titled "Towards a Weather, Water, and Climate Ready Nation" to describe upcoming WRN actions to the community: 10-12 April 2012
  - <http://www.ametsoc.org/meet/fainst/2012washingtonforum.html>
- 6) Weather Ready Nation: Imperatives for Severe Weather Research (Birmingham, Ala.): 23-26 April 2012
- 7) "Working Together Today to Save Lives Tomorrow" – Two high level, half day report out sessions (Washington, D.C.): May 2012
  - Executive Branch Focus (Federal Agencies, Chamber of Commerce, etc.)
  - Capitol Hill Focus (Members of Congress, Relevance to District)
- 8) Annual Natural Hazards Research and Applications Workshop (Broomfield, Colo.): 14-17 July 2012
- 9) *Proposed:* AMS Summer Community Meeting (Boulder, Colo.): August 13-16, 2012
- 10) *Proposed:* Annual Interdepartmental Severe Weather Community Conference: *annual meeting with the Office of the Federal Coordinator for Meteorology (OFCM)*
- 11) *Proposed:* National Weather Association (NWA): Social Sciences and the Weather Ready Nation: Collaboration Leading to Impact Based Decision Support Services (Madison, Wis.): 6-11 October 2012
- 12) *Proposed:* 2012 International Association of Emergency Managers (IAEM) Annual Conference (Orlando, Fla.): 26 October - 1 November 2012
- 13) *Proposed:* AMS Conference on Severe Local Storms (Nashville, Tenn.): 5-8 November 2012

14) *Proposed*: 2013 AMS Annual Meeting (Austin, Texas): 6-10 January 2013

- Include strong local chapter involvement in WRN communication and engagement

15) *Proposed*: 2013 AMS Annual Meeting/Student Conference (Austin, Texas): 6-10 January 2013

## **Section 6: Conclusion**

The Vital Conversation has begun; pathways to a Weather-Ready Nation have been identified, and the President's Proposed FY13 Budget for NOAA highlights the importance of this goal. This report presents more than 25 actions that will move the country to becoming Weather-Ready.

But this is a very large undertaking and additional pathways need to be charted. The opportunities for future dialogues are taking shape, and for the dialogues to be rich and vital, participation by many is needed. The focus on tornadoes is but the beginning; the nation must become Weather-Ready for all weather.

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## APPENDIX A -Final Workshop Agenda



**Weather Ready Nation:  
A Vital Conversation**

**December 13 - 15, 2011  
Norman, OK**

### National Weather Center - University of Oklahoma, Norman, Oklahoma

#### Monday, December 12

<b>5:30 – 8:00</b>	<b>Registration, NWC Entranceway</b>
<b>6:00 – 8:00</b>	<b>Icebreaker, NWC Atrium</b> - Continuous bus service available every half-hour between Embassy Suites and NWC.

#### Tuesday, December 13

<b>7:30</b>	<b>Coffee, outside NWC Auditorium</b>
<b>8:30</b>	<b>Welcome and Motivation, NWC Auditorium, Rm. 1313</b> <ul style="list-style-type: none"> <li>• OU - Dr. Berrien Moore</li> <li>• NOAA - Dr. Jane Lubchenco</li> </ul>
<b>8:45</b>	<b>Keynote Address</b> <ul style="list-style-type: none"> <li>• State Perspective - Governor Mary Fallin</li> </ul>
<b>9:00</b>	<b>Leadership Perspectives &amp; Expectations</b> <ul style="list-style-type: none"> <li>• NOAA/NWS – Dr. Jack Hayes – “Weather Ready Nation”</li> <li>• FEMA – Russell Washington</li> <li>• NCAR/UCAR – Dr. Roger Wakimoto</li> <li>• NSF – Dr. Michael Morgan</li> <li>• Known Challenges – Dr. Harold Brooks, NOAA-OAR-NSSL</li> <li>• NWS: The Historic 2011 Tornado Season – Dr. Russell Schneider, NOAA-NWS-SPC</li> <li>• Meeting Logistics – John Ferree, NOAA-NWS; Tara Torres, JOSS</li> </ul>
<b>10:00</b>	<b>Break</b>
<b>10:20</b>	<b>Impacted by the Events of 2011</b> <p><b>National</b></p> <ul style="list-style-type: none"> <li>• Broadcast Meteorologist: Dr. Greg Forbes, The Weather Channel</li> </ul> <p><b>North Carolina Outbreak</b></p> <ul style="list-style-type: none"> <li>• Broadcast Meteorologist: Greg Fishel, WRAL-TV Raleigh, NC</li> </ul> <p><b>27 April Super Outbreak</b></p> <ul style="list-style-type: none"> <li>• Public Safety Leadership: Ken Horst, Fire and Rescue Service, Tuscaloosa, AL; Bill Bullock, International Association of Fire Chiefs</li> </ul> <p><b>May 22 – Joplin, Missouri</b></p> <ul style="list-style-type: none"> <li>• Emergency Management: Keith Stammer, Jasper County Emergency Management</li> </ul>
<b>11:35</b>	<b>Major Events of 2011 – Initial Assessments</b>

<p><b>12:00</b></p>	<ul style="list-style-type: none"> <li>• NWS Service Assessments (2011 Super Outbreak, Joplin Tornado, North Carolina Outbreak, St. Louis Tornado): David Caldwell, NOAA-NWS</li> <li>• Post 27 April Outbreak Survey: Dr. Gabriela Carrasco, University of North Alabama; Dr. Laura Myers, Mississippi State University</li> </ul> <p><b>Lunch, NWC Atrium</b></p> <ul style="list-style-type: none"> <li>• An Economic Analysis of U.S. Severe Weather: Steve Bowen, AON Impact Forecasting</li> </ul>
<p><b>1:00</b></p> <p><b>2:00</b></p> <p><b>3:00</b></p> <p><b>3:20</b></p>	<p><b>Panel Discussions, NWC Auditorium</b></p> <p><b><u>Improve NOAA Forecasts and Warnings for Severe Weather:</u></b>  This panel discussion will focus on the integrated warning team actions from long term forecasts through watches and warnings.</p> <p><b>Moderator:</b> Dr. Joe Friday, Director, National Weather Service (Retired)</p> <p><b>Panelists:</b>  Physical Science Academic: Dr. Yvette Richardson, Penn State University  Private Sector Meteorologist: Mike Smith, Accu-Weather  Emergency Management: Bob Goldhammer, IAEM  Emergency Management: Russell Washington, FEMA National Watch Center  Broadcast Meteorologist: Jacqui Jeras, CNN  Social Science Academic: Dr. Joe Trainor, University of Delaware</p> <p><b><u>Improve Service Delivery:</u></b>  This panel discussion will focus on improving communication to the public, leveraging recent and future advances in communications technologies to reach larger segments of the population, and improving public response.</p> <p><b>Moderator:</b> Dr. John Snow, College Of Atmospheric and Geographic Science, University of Okla.</p> <p><b>Panelists:</b>  Private Sector Meteorologist: Mike Eilts, Weather Decision Technologies  Emergency Management: Wade Witmer, FEMA IPAWS Deputy Director  Media: Ray Ban, The Weather Channel  Social Science Academic: Dr. Joe Downing, Penn State University  Social Science Academic: Dr. Baruch Fischhoff, Carnegie-Mellon University</p> <p><b>Break</b></p> <p><b><u>Sharpen Science-Service Linkage:</u></b>  This panel discussion will focus on science and research challenges and priorities from both the physical and social science/research community.</p> <p><b>Moderator:</b> Dr. Michael Morgan, National Science Foundation</p> <p><b>Panelists:</b>  Physical Science Academic: Dr. Paul Markowski, Penn State University  Physical Science Academic: Dr. David Stensrud, NOAA National Several Storms Lab  Private Sector Research: Dr. Josh Wurman, Center for Severe Weather Research  Social Science Academic: Dr. Hank Jenkins-Smith, Univ. of Oklahoma, Center for Applied Social Research  Social Science Academic: Dr. Shirley Laska, Univ. of New Orleans, Center for Hazards Assessment</p>

<b>4:20</b>	<p><b><u>Leverage Community Planning and Impacts Mitigation:</u></b> This panel discussion will focus on improving community resilience to severe weather and tornadoes allowing communities to plan and respond effectively to save lives, reduce community impacts, and support rapid recovery.</p> <p><b>Moderator:</b> Dr. Bill Hooke, American Meteorological Society, Policy Office</p> <p><b>Panelists:</b> NIST: Dr. Mark Levitan, NIST NGO: Tim Reinhold, Insurance Institute for Business and Home Safety Civil Engineer/Academic: Dr. David Prevatt, University of Florida, American Society of Civil Engineers (ASCE) Emergency Management: Albert Ashwood, Oklahoma Department of Emergency Management</p>
<b>5:20</b>	<b>Introduction to Cross-Cut Breakout Groups - Goals and Logistics</b>
<b>5:30</b>	<b>Adjourn, break before dinner</b>
<b>6:30</b>	<b>Dinner at Embassy Suites Hotel - Tables seated by Cross Cut Groups</b>
<b>7:30</b>	<p><b>Dinner Speaker:</b></p> <ul style="list-style-type: none"> <li>• Dr. Baruch Fischhoff, Carnegie-Mellon University, Challenges in communication of risk</li> </ul>

### Wednesday, December 14

<b>7:30</b>	<b>Coffee, outside NWC Auditorium</b>
<b>8:30</b>	<p><b>Keynote Address, NWC Auditorium</b></p> <ul style="list-style-type: none"> <li>• Margaret Davidson, NOAA Coastal Services Center</li> </ul>
<b>8:50</b>	<b>Charge to the Community Breakouts, John Ferree, NOAA-NWS</b>
<b>9:00</b>	<b>Breakout Community Groups - meeting rooms throughout NWC</b>
<b>10:10</b>	<b>Break</b>
<b>10:30</b>	<p><b>Charge to the Cross Cut Groups and Group Logistics, NWC Auditorium</b></p> <p><b><u>Cross Cut Groups Questions</u></b> – Some of the key questions listed below will be discussed in the three cross-cut groups. Note: questions may change based on outcome from panel discussions.</p>
<b>10:40</b>	<p><b>Breakout to Cross Cut Groups - meeting rooms throughout NWC</b></p> <p><b><u>Cross Cut 1:</u></b></p> <ol style="list-style-type: none"> <li>1. What did you learn from the events of 2011?</li> <li>2. If the lead time and accuracy of forecasts of tornadic outbreaks increases, how can we expect society to function differently?</li> </ol>
<b>12:00</b>	<b>Lunch, NWC Atrium</b>
<b>1:00</b>	<p><b>Presentation, NWC Auditorium</b></p> <ul style="list-style-type: none"> <li>• Economic Costs of Warnings: Dr. Kevin Simmons, Austin College</li> </ul>

<b>1:30</b>	<b>Breakout to Cross Cut Groups (continued from Morning Session)</b> <b><u>Cross Cut 2:</u></b> 3. In the entire end-to-end process, what are the largest gaps in our current understanding: science, cultural understanding, societal impacts, planning, coordination, decision-making, and/or resiliency? 4. What kind of information is needed to incite the appropriate level of response by the public?
<b>3:00</b>	<b>Break</b>
<b>3:20</b>	<b>Breakout to Cross Cut Groups (continued)</b> <b><u>Cross Cut 3:</u></b> 5. What are the near-term and long-term actions that can improve public response and resiliency to tornadoes? 6. How should these actions be prioritized and implemented?
<b>5:00</b>	<b>Adjourn, break before dinner</b>
<b>5:15-6:00</b>	<b>National Weather Center Building Tours, meet in NWC Atrium</b>
<b>6:00</b>	<b>BBQ Dinner, NWC Atrium</b> Dinners by community – informally discuss priorities & gaps for your community
<b>7:30</b>	<b>End of Day 2</b> Breakout session summaries will be integrated for a unified presentation and discussion on Thursday morning.

Thursday, December 15	
<b>7:30</b>	<b>Coffee, outside NWC Auditorium</b>
<b>8:30</b>	<b>Opening Session Remarks, NWC Auditorium</b> <ul style="list-style-type: none"> <li>• Introduction: Dr. Kelvin Droegemeier, University of Oklahoma</li> <li>• How will the Workshop inform NOAA’s future? Dr. Kathryn Sullivan, NOAA</li> </ul>
<b>8:45</b>	<b>Summary and Discussion of Findings by Cross Cut Groups</b>
<b>10:15</b>	<b>Break</b>
<b>10:30</b>	<b>Community Breakout – Critical Gaps, Short and Long Term Priorities for your specific community, for the weather enterprise, and for NOAA.</b>
<b>11:45</b>	<b>Closing Remarks, NWC Auditorium</b> <ul style="list-style-type: none"> <li>• Dr. Kathryn Sullivan, Deputy Administrator, NOAA</li> </ul>
<b>12:00</b>	<b>Adjourn General Meeting - End of Workshop</b>
<b>1:00</b>	<b>Executive Session - synthesize key outcomes; organize efforts toward creation of workshop report and AMS Annual Meeting presentation</b>  <b>Charge to Executive Session: Dr. Kathryn Sullivan &amp; Dr. Jack Hayes</b>



## APPENDIX B

### Summary of Discussions within Cross Cut Breakout Groups

The seven "Cross Cut Breakout" groups based their discussions on six pre-selected questions.

1. What did you learn from the events of 2011?
2. If the lead-time and accuracy of forecasts of tornadic outbreaks increases how can we expect society to function differently?
3. In the entire end-to-end process, what are the largest gaps in our current understanding: science, cultural understanding, societal impacts, planning, coordination, decision-making, and/or resiliency?
4. What kind of information is needed to incite the appropriate level of response by the public?
5. What are the near-term and long-term actions that can improve public response and resiliency to tornadoes?
6. How should these actions be prioritized and implemented?

More than 50 pages of notes from these groups were distilled into 11 themes by a team charged with summarizing the discussions for a Workshop plenary session. These themes were discussed during the plenary session, and attendees were asked, "What is missing from this list?"

Under each theme below is the session synthesis from the original Workshop summary (denoted by bullets) and post workshop additions from key statements made during the summary plenary session (denoted by double exclamation points !!).

#### *1) Integrate meteorology and social science*

- Establish "Think Tanks" to establish regular physical/social science collaboration.
- Invite WFO meteorologists to shadow social scientists – and vice-versa.
- Embed social scientists and end users in various NOAA test beds to observe and address the end-to-end process
- Weather Enterprise should engage social scientists to define the most pressing issues and design messaging to fit these findings.
- Have social scientists assess NWS Severe Storms Directives.
- !! Strengthening the "think tanks" that are already established (e.g., NCAR's Societal Impacts Program); Doesn't capture Baruch Fischhoff's concept of "resource centers."
- !! We need to have a "clearing house" so that work from different communities can be centralized on these issues. A persistent space for the dialog to continue.

#### *2) Foster physical science improvements*

- With social science, assess requirements for and consequences of extending warning lead time.
- Address gaps in understanding physical factors that affect the genesis, track, longevity and intensity of tornadoes.
- Assess how dual-polarization radars will impact the severe thunderstorm forecast process and associated forecast skill.
- Conduct needs analysis for new observation technologies (e.g., gap filler radars and phased array, adaptive scanning radars with very high temporal updates).
- !! NOAA is considering moving toward "Warn-on-Forecast"; Need to have model improvements if we are to meet the challenge.

- !! The engineering community needs better information on surface level winds to optimize designs for tornado resilient structures.
- !! Understanding the physical processes around tornado-genesis – especially weak tornadoes; this should inspire new research.
- !! Extend 2<sup>nd</sup> bullet to ability to detect and track rapidly evolving tornadoes – especially weaker, short-lived tornadoes.
- !! Statistics show most deaths occur in strong tornadoes – need to have better analysis of the effects of spatial and temporal scales on strong tornadoes.
- !! What do we do with improved accuracy? Could be lead-time or reducing the size of the warned areas – geospatial accuracy. Social science can help here.
- !! Non-tornadic supercells, tornadic supercells – the whole spectrum of severe storms must be accurately predictable.
- !! We are not strictly just talking about tornadoes. Eighty mph winds also have significant impacts. Need to look at user based impacts.
- !! Dr. Kathryn Sullivan: Identify which physical science improvements will have the biggest impacts on social responses (joint social and physical science leveraging for investments). Has this part of the loop really happened? How informative can the current state of social science be in determining next steps?
- !! Bridge theme 1 and 2 – end-to-end process – to elicit the best response from people that cuts across the themes.

### 3) *Address dissemination issues*

- NOAA Weather Radio (NWR) must transmit polygons.
- End users must have geo-targeting mobile devices with graphical-based capability.
- Incorporate social media as an observing/early warning system (e.g., tweets).
- Recommend to governors to adopt an interoperable, CAP-based public alerting system.
- !! IAEM and NOAA are starting a pilot program in Alabama to start transmitting polygons from NWR.
- !! The patent for GPS enabled NWR receivers has been in place for five years. Industry is waiting for the signal to be available to enable a new line of radios.
- !! We can't pass a law that requires everyone to carry a smart phone. Need to translate polygons into text for wider dissemination. Need a standardized way to describe geographical information so scrolls at the bottom of screens do not confuse – but reinforces the warning information.
- !! Many people do not use NWR. Need a new paradigm of NWR. Make it simple (not programmable) and rethink what should be included.
- !! We have a heterogeneous public – need a suite of public outlets to get the word out – not just NWR.

### 4) *Ensure community resilience*

- Need to plan for sufficient sheltering and address associated societal issues.
- Provide incentives for public and/or insurance companies to enhance building standards.
- Consider “*Storm-Worthy*” home construction concept.
- Explore “Smart Vehicle” technology to communicate impacts via GPS.
- Work with smoke detector industry to convey when individual homes are within warnings.
- !! TV ads exhort used car buyers to say “Where’s the Car Fax?” - why not have home buyers demand the “home fax” that lists the structural integrity of homes, including a rating system to knowledge on the strength of connections, remaining structural capacity, hazard-mitigating design elements, etc.
- !! There are already existing coalitions in communities – need to have facilitation to communicate across communities to spread the knowledge to new communities.

- !! Community resilience does not just refer to structures; there are many definitions such as in public health – how can weather and NOAA be used – resiliency is much more complex; public health, local health departments, social science can help to flesh out and further enhance this piece.
- !! Improvement in forecasting associated with community resilience (e.g., mobile resources) – allows for communities to prepare for events in advance.
- !! This list is way too narrow; there are many types of community resilience to encompass many different ways and definitions for resilience.
- !! Social networking must be discussed when talking about resilience.
- !! What would it look like if we made our decisions to help people be resilient – what actions do people need to take to be resilient – instead of focusing on meteorological elements.

#### 5) *Address warning performance issues*

- Define scope of “False Alarm Problem” for tornadoes.
- Research optimizing performance (“sweet spot”): Balance lead time against false alarm.
- Need to develop metrics that reflect societal impact.
- !! 3<sup>rd</sup> bullet – have population and community at risk provided information (e.g., highway risk information, outdoor venues, when do school buses get released, when do big box stores prepare) – information is not available in the warning process.
- !! Suggest not using acronyms such as TORs.
- !! Forecasters have increasing data overload issue in an increasing stress environment; need to develop data mining and fusing capabilities so that forecasters can identify threat and get the word out; GOES-R data, Dual Polarization, mesonet data, high res models, etc.
- !! Need a sub-bullet to 2<sup>nd</sup> – add probability of detection (POD); relationship between lead time and POD.
- !! Researching the forecaster mindset needs to be addressed.
- !! FEMA already has a metric they use to measure impacts on society (demographics, socio economic status, etc.) – don’t need to start over.

#### 6) *Improve forecast process*

- “The Last Mile:” Engage partners to support communication of warnings to public.
- Explore use of tiered warnings to reflect urgency and seriousness of a situation (not all tornado warnings are created equally).
- Update forecaster training for new science and knowledge to ensure consistent process.
- Utilize scan-by-scan radar data to communicate impacts to smallest possible scales.
- !! Understanding the culture of different NWS forecast offices; this has a huge impact on how warnings and forecasts get made and how forecasters develop; we don’t know how this impacts the warning process.
- !! Need for WFOs to have coordination not just for large tornado situations.
- !! We need to do more with what we have – how do we prioritize where to put dollars – both in government and in industry; there has been no economic prioritization; funding is an issue.
- !! Enhancing the collaborative forecast process beginning at the national centers – the climate to weather linkage – truly end-to-end.

#### 7) *Increase standardization*

- Need consistent use of warning thresholds across WFOs.
- Standardize use of “Tornado Emergency.” – “Preserve the Superlatives.”
- Align outdoor warning sirens with interoperable, geo-targeted warning systems.
- Need national siren policy.
- Need consistent application of NWS outreach, product issuance, and use of NWS-Chat.

- !! Take advantage of heterogeneity that is currently out there to determine how best to “standardize” (who is on chat, what is the volume on chat rooms across CWA).
- !! Every broadcaster is different along with their relationships with WFOs; caution to have forecasters make decisions based just on standards – needs flexibility to build in societal impact thresholds as well.
- !! Limited numbers of social scientists – need to have them engaged early in the process. How do we develop an institutional approach at national center and WFOs where they can collect information using social science methods to provide to social scientists for analysis? If we are to change the culture at WFOs, need to institutionalize the processes to make sustainable.
- !! Discussion of population density in standardization.
- !! Need to stay away from the word policy and use standardization and guidelines (as in for sirens).

#### 8) *Improve public education*

- Educate youth so they can teach their parents.
- Use AMS Science Education Program to train school teachers.
- Use milk cartons, utility bills, etc. for messaging.
- Address “tornado can’t happen here” syndrome.
- Educate public on limits of science and technology.
- Families must have a plan prior to event.
- Develop basic training on NWS capabilities to stakeholders.
- !! Not everyone has kids – especially those who retire often move to a different climate area and are vulnerable to new weather impacts.
- !! There are restrictions on public education – can’t get permission to bring tornado safety into the classroom; challenge to access kids in today’s schools.
- !! Tuscaloosa Fire is in schools one hour per month working directly with principals; these are life/safety issues.
- !! Break down population into four groups:
  - Vulnerable populations
  - Populations that are already engaged, savvy
  - Those that could be engaged
  - Those who do not wish to be engaged
- Focus on the first three population groups and not on the last.
- !! Hurricane strike module by NWS has been seen by four million school children (COMET). Introducing as a curriculum in schools is impossible but can be introduced into other venues (joint projects with Home Depot, Weather Channel, etc.).
- !! There are partnerships with McDonalds for outreach. Working with curriculum design staff in schools to include resilience in weather courses (e.g., Katrina impacts); school curriculum can be made to be specifically about weather.
- !! Many children are home alone after school who need to know what to do to save themselves.
- !! These can be solved by engaging partners – school science centers, teachers looking for curriculum, etc.
- !! If you want to educate the people, engage the fire department – everyone knows “stop, drop and roll.”
- !! We cannot write off a portion of the population that will be impacted by hazardous weather since first responders will have to rescue them later.

9) *Clarify hazard communications*

- Address confusion on the terms “Watch” and “Warning.”
- Consider interim updates between Watch and Warning.
- One size does not fit all - warnings are local with respect to culture and community.
- Assess best formats for communicating forecast uncertainty.
- Fund research cited within AMS “Completing The Forecast.”
- Ensure “Call to Action” statements are actionable.
- Multi-lingual and vulnerable population alerting needed.
- Engage social scientists to determine best plain language.
- !! Don’t see the word “risk” on this slide. NWS needs to do more “risk communication” to allow people to connect dots in their head to go from situational awareness to situational understanding.
- !! Can’t forget EMs when discussing bringing social science on board.
- !! EM community has traditional definition – but has also 15 other portions that make up the larger group of EMs.
- !! Early career people really want to engage in this cross-disciplinary work. How can we cultivate this community of people so that there are opportunities for them and they are not stuck within one stovepipe. Could help us get out of trapped perspectives to build capacity.

10) *Strengthen collaborations*

- Examine best practices of other risk-based professions (e.g., financial services, health care, insurance, engineering).
- Within six months, partner with NSF to create a “Weather and Society Initiative.”
- Partner with Chambers of Commerce to better convey threat potential to users.
- Modernize NOAA Weather Radio via public private partnership.
- Incorporate best practices of international partners.
- !! Support concept of local integrated warnings teams – at grassroots levels – collaborating on the local level.

11) *Address human concerns*

- WFOs are staffed for the event; but not for the “after-event.”
- Need to account for human impacts beyond the analytical.