Testimony of

Dr. Scott Weaver
Director
National Windstorm Impact Reduction Program
Engineering Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce

Before the

Committee on Science, Space, and Technology
Subcommittee on Research and Technology

U.S. House of Representatives

November 10, 2021

Introduction

Chairwoman Stevens, Ranking Member Waltz, and members of the Subcommittee, I am Dr. Scott Weaver, Director for the National Windstorm Impact Reduction Program (NWIRP) in the Engineering Laboratory at the Department of Commerce's National Institute of Standards and Technology (NIST). The NIST laboratory programs work at the frontiers of measurement science to ensure that the U.S. system of measurements is firmly grounded in sound scientific and technical principles. With the unique facilities at the NIST laboratories, we address complex measurement challenges on every scale, from the chemical kinetics of cement hydration, to buildings, and the resilience of whole communities including from windstorm-related events.

NWIRP is an interagency science and engineering-based program focused on achieving major measurable reductions in losses of life and property from windstorms, through a coordinated federal effort involving the Federal Emergency Management Agency (FEMA), NIST, the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). Since NWIRP's inception in 2004, the program has made notable progress towards efforts to reduce windstorm impacts. This includes significant improvements in hurricane forecasts and increased tornado warning times, advancements in the science of wind mapping to inform engineering-based design standards, improved coordination practices and research support for post windstorm investigations, and implementation of research-based recommendations into codes, standards, and practices. Despite these achievements, the Nation continues to experience increased loss of life and property due to exacerbating extreme-weather events, as evidenced by the devastating tornado outbreaks in 2011 and 2013, and the recent catastrophic hurricane seasons of 2017, 2018, 2020, and 2021.

Thank you for the opportunity to appear before you today to discuss NWIRP, the progress we've made, and challenges and recommendations for the future.

Windstorm Impacts in the U.S.

Windstorms, and associated flooding, are the largest loss-producing natural hazards in the U.S. The greatest of these losses are associated with tornadoes and hurricanes. Over the last 40 years, windstorms caused over $1 trillion in economic losses (CPI-adjusted) and over 8,000 fatalities in the U.S., with the vast majority of these losses occurring during the last two decades.[1] Every state in the country is exposed to windstorm hazards from one or more storm types, including tornadoes, tropical cyclones (i.e., tropical storms and hurricanes), thunderstorms, nor'easters, winter storms, and others.

Tornadoes occur in all 50 states, but mainly east of the Continental Divide. Over the past 10 years, tornadoes have caused an average loss of approximately $10 billion per year[1]. In 2011, six different tornado outbreaks affected 16 states and produced a combined damage of $29 billion

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[1] NOAA National Centers for Environmental Information, U.S. Billion-Dollar Weather and Climate Disasters, 1980-2016 https://www.ncdc.noaa.gov/billions/events.

and 545 fatalities.[1] The 2011 Joplin Missouri tornado alone killed 161 people, injured over a thousand, and resulted in nearly $3 billion in insured losses.[2]

Hurricanes primarily impact coastal states along the Atlantic Ocean and Gulf of Mexico, as well as Hawaii and U.S. territories in the Caribbean and the Pacific. Hurricane seasons in 2017, 2018, 2020, and 2021 were record breaking years for hurricane-induced losses in the U.S., with Hurricanes Harvey ($139 billion estimated damage), Irma ($56 billion estimated damage), Maria ($100 billion estimated), Florence ($26 billion estimated), Michael ($27 billion estimated), Laura ($20 billion estimated), and Ida ($65 billion estimated), comprising approximately 63 percent of the $691 billion total of all extreme weather and climate events over that period.[1]

In a 14-month span from August 2017 through October 2018, five major hurricanes (category 3 or higher) made landfall in the U.S., not including hurricane Florence, which made landfall as a category 1 storm, but caused catastrophic inland flooding impacts to the Carolinas from extreme rainfall. The 2020 hurricane season established a new record for most named storms in a season with 30 (14 hurricanes, 7 major), twelve of which made landfall in the U.S. Among the most notable stories of the 2020 hurricane season was the occurrence of 2 hurricane landfalls (Laura and Delta) a mere 12 miles apart in Louisiana, separated by only 6 weeks. On August 29, 2021, category 4 Hurricane Ida came ashore in Louisiana causing significant wind damage and 33 fatalities. A few days later the remnants of Ida caused unprecedented flash flooding across the northeast, especially in New Jersey and New York, leading to scores of additional fatalities in those states.

Other notable hurricane events include Hurricane Sandy (2012), which caused over a $70 billion loss,[1] producing extensive damage in seven states, and Hurricane Katrina (2005), which caused over 1,200 fatalities and a loss in excess of $150 billion, resulting in destructive storm surge along the Louisiana, Mississippi, and Alabama coasts, as well as high winds and damage as far inland as Ohio.

The Cost of Inaction

The costs associated with hurricanes are forecast to increase more rapidly than the growth of the economy. The Congressional Budget Office (CBO)[3] projects that average annual losses due to hurricanes will increase from 0.16 percent of gross domestic product (GDP) to 0.22 percent of GDP by 2075. CBO projections include the effects of climate-related sea level rise and increased storm activity, population growth, increased coastal development, and increased per capita income in hurricane-prone areas. These values do not account for potential improvements in construction practices, land use practices, and building stock turnover. Similarly, population growth in tornado-prone central and southeastern U.S. will likely result in increased loss of life

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[2] Final Report, National Institute of Standards and Technology (NIST) Technical Investigation of the May 22, 2011, Tornado in Joplin, Missouri, NIST NCSTAR-3, March 2014. http://nvlpubs.nist.gov/nistpubs/NCSTAR/NIST.NCSTAR.3.pdf.

[3] Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget, CBO, June 2016 https://www.cbo.gov/publication/51518.

and damage, unless cost effective measures are taken to reduce the impact of tornadoes on buildings and infrastructure.

The causes underlying these massive and rapidly increasing windstorm losses are many, varied, and complex. Some are related to long-term societal changes, such as the movement of population towards coastal areas in hurricane-prone regions of the U.S.[4] Others relate to changes in storm activity as the result of global climate change[5], lack of understanding and predictability of surface-level storm characteristics and their associated hazards (e.g., extreme winds and rainfall, wind-borne debris, wind-driven rain, storm surge, and surge-borne debris), interactions of these hazards on the built environment, how to mitigate them, and how to effectively communicate with and educate the public and other stakeholders.

Advances in recent decades in meteorology and Earth system science have led to great improvements in forecasting and warning systems for hurricanes, tornadoes, and other windstorms; however, large knowledge gaps remain in aspects of windstorm climatology and hazards near the surface. This knowledge is critical for risk assessments in a non-stationary climate and for engineering design of the built environment to mitigate the impact of these hazards. Similarly, while great progress has been made in understanding earthquake effects on buildings and engineering design to resist those effects, comparatively less progress has been made in engineering for extreme winds and for coastal inundation hazards of wind-driven storm surge and waves. Without additional actions to mitigate windstorm hazards and thereby reduce windstorm risks, losses due to windstorms will only continue to increase.

Meeting the Challenge

In recognition of the necessary role for the Federal Government and other organizations in supporting windstorm impact reduction, Congress – with leadership from this Committee -- created NWIRP via the National Windstorm Impact Reduction Act of 2004 *(PL 108-360*) to reduce the loss of life and property from windstorms. On September 30, 2015, the National Windstorm Impact Reduction Act Reauthorization of 2015 (*PL 114-52*) was enacted, which reauthorized the program, made changes to leadership, oversight, and reporting requirements, modified the roles of the four program agencies, and updated other program aspects.

With Public Law 114-52, the lead agency function for NWIRP was transferred to NIST from the Office of Science and Technology Policy (OSTP).

In addition to overall leadership and coordination, NIST responsibilities include:

- Ensuring the program includes components necessary to promote the implementation of windstorm risk reduction measures;

[4] http://www.census.gov/topics/preparedness/about/coastal-areas.html.

[5] *The Climate Science Supplemental of the National Climate Assessment:*https://science2017.globalchange.gov/

- Requesting assistance of federal agencies other than the program agencies, as necessary;
- Coordinating all federal post-windstorm investigations to the extent practicable;
- Supporting the development of performance-based engineering tools and working with appropriate groups to promote the commercial application of such tools; and,
- When warranted by research or investigative findings, issuing recommendations to assist in informing the development of model codes, and providing information to Congress on the use of such recommendations.

The four designated program agencies FEMA, NIST, NOAA and NSF work together to implement the program's three statutory components:

- Improved understanding of windstorms,
- Windstorm impact assessment, and
- Windstorm impact reduction.

NWIRP activities span the full spectrum from research through implementation, including basic physical science, social science, and engineering research; problem-focused research and codes and standards development; information dissemination, public education and outreach; and promotion of the adoption of windstorm preparedness and mitigation measures.

An Interagency Coordinating Committee oversees the program's planning and coordination, and consists of the heads or designees of FEMA, NOAA, NSF, OSTP, and the Office of Management and Budget (OMB), and is chaired by the Director of NIST or the Director's designee. A new Windstorm Working Group (WWG) was created in 2016 to provide closer coordination at the programmatic level. Since 2020, the Interagency Council for Advancing Meteorological Services (ICAMS) provides the opportunity for broader interagency coordination on meteorology.

A Vision for Windstorm Impact Reduction in the U.S.

To address the challenges discussed above, in 2018, NWIRP released its Strategic Plan - a comprehensive strategy developed in concert with stakeholders from across government, academia, and the private sector. The plan includes vision and mission statements, and goals to guide holistic windstorm impact reduction actions.

The NWIRP Vision is:

A nation that is windstorm-resilient in public safety and economic well-being.

The NWIRP Mission is:

To achieve major measurable reductions in the losses of life and property from windstorms through a coordinated federal effort, in cooperation with other levels of government, academia, and the private sector. NWIRP will support research aimed at improving the understanding of windstorms and their impacts, and develop technical guidance and support outreach initiatives encouraging the implementation of cost-effective mitigation measures to reduce those impacts.

Three overarching, long-term Strategic Goals have been established to accomplish this mission, consistent with identified needs and the statutory requirements of the program.

Goal A: Improve the Understanding of Windstorm Processes and Hazards

Current understanding of the detailed characteristics of strong winds near the ground, extreme rainfall hazards, and coastal flooding, which are all critical to understanding and mitigating windstorm risk, is very limited. Goal A focuses on filling these gaps in our knowledge. NWIRP research directions and needs include improved measurement and modeling of hurricanes, tornadoes, thunderstorms, and other windstorms, enabling a better understanding of the effects of extreme winds and rainfall, and wind-driven storm surge and waves on civil infrastructure and lifelines in the larger context of community resilience. Tools for windstorm hazard assessment need to be developed, including consideration of long-term trends in windstorm frequency, intensity, and location, and how changes in these storm characteristics affect risk.

Goal B: Improve the Understanding of Windstorm Impacts on Communities

NWIRP needs to support basic and applied research to advance the scientific and engineering knowledge of wind and windstorm-induced impacts. The efforts under Goal B, informed by the results of Goal A, support increased windstorm resilience by nurturing the development of innovative and cost-effective approaches and products to improve the performance of buildings, lifelines, and other structures. Research directions include building a deeper understanding of physical effects of windstorm hazards on buildings and infrastructure as well as the social, cultural, behavioral, and economic factors influencing windstorm impacts and the adoption of windstorm impact mitigation, supported by enhanced post-storm data collection. New computational tools will be developed for modeling interaction between wind and storm surge hazards and the built environment and for risk assessment and loss estimation.

Goal C: Improve the Windstorm Resilience of Communities Nationwide

The results from research and development activities of Goals A and B provide a solid foundation for the application and implementation of the windstorm impact reduction objectives of Goal C. NWIRP will support development of cost-effective windstorm-resistant materials and systems for use in new construction and retrofit of existing construction and development of more windstorm-resilient building codes and standards. NWIRP will also support development and implementation of improved windstorm forecasting methods to increase accuracy and warning time. There is a strong need to integrate results of research on societal response, hazard vulnerability and mitigation, disaster preparedness, emergency response, and disaster recovery into the implementation activities that support hazard mitigation. Accordingly, NWIRP encourages integration of social science research findings into the implementation activities of Goal C, and to increase public awareness of windstorm risks and to promote hazard mitigation policies and programs, as well as improved windstorm readiness, emergency communications and response.

Federal Coordination Following Tornadoes and Hurricanes

As lead agency for NWIRP, NIST coordinates post-windstorm investigations with the other program agencies, NOAA, FEMA, and NSF. In 2020, the NWIRP agencies developed a Tropical Cyclone Coordination Plan for Science and Technology – a living document that outlines the windstorm coordination roles of the NWIRP agencies across all phases of hurricane disasters from pre- to post-landfall. NIST coordinates with NOAA's National Weather Service (NWS) on the planning of research and development for the NOAA Consumer Option for an Alternative System to Allocate Losses (COASTAL) Act (Public Law 112-141). At NIST, the two most recent, long-term, post-windstorm investigations are the 2011 Joplin, Missouri, tornado (completed in 2014) and the ongoing investigation of 2017's Hurricane Maria in Puerto Rico.

NIST Joplin Tornado Investigation

The Joplin tornado caused 161 fatalities and more than 1,000 injuries, making it the deadliest single tornado on record since the official U.S. records began in 1950. It was a record tornado that occurred in a year of record U.S. tornado activity and impacts. The Joplin tornado's high death toll occurred despite an official tornado warning time of about 17 minutes, greater than the NWS national average warning time of approximately 14 minutes.

NIST conducted a multi-year investigation into the wind environment and technical conditions associated with fatalities and injuries, the performance of emergency communications systems and public response, and the performance of residential, commercial, and critical buildings[6]. The investigation led to the development of 16 recommendations, including development of tornado hazard maps for use in engineering design of buildings and infrastructure. Prior to the NIST Joplin investigation, consideration of explicitly designing for the tornado hazard was virtually non-existent. Now, this concept is being actively discussed amongst a wide stakeholder constituency and is under consideration for incorporation into the American Society of Civil Engineers (ASCE) Standard 7-22 – Minimum Design Loads and Associated Criteria for Buildings and Other Structures.

Interagency NWIRP coordination played a direct role in the implementation of Joplin investigation recommendations. A team member from the NOAA National Severe Storms Laboratory (NSSL) served on the NIST investigative team, facilitating the implementation of another recommendation from the NIST Joplin report,

> "*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.*"

Additionally, NIST coordinated with FEMA by sharing NIST preliminary observations of the damage in advance of FEMA's deployment to Joplin, Missouri under their Mitigation Assessment Team (MAT) Program.

NIST Hurricane Maria Program

NIST is currently investigating the effects of Hurricane Maria in Puerto Rico.[7] On September 20, 2017, Hurricane Maria made landfall in Puerto Rico, damaging infrastructure that its

[6] https://nvlpubs.nist.gov/nistpubs/NCSTAR/NIST.NCSTAR.3.pdf

[7] A public announcement of the Hurricane Maria study can be found at: https://www.nist.gov/news-events/news/2018/05/nist-launches-study-hurricane-marias-impact-puerto-rico

communities relied on for medical care, safety, mobility, communications, and more. To better understand how the buildings and infrastructure failed, and how we can prevent such failures in the future, NIST began to study how critical buildings and infrastructure systems performed during the storm.

NIST deployed several disaster experts to Puerto Rico in December 2017 with expertise spanning structural engineering, sociology, emergency communications, and IT support. One of the NIST experts was embedded within a FEMA MAT that was conducting similar preliminary reconnaissance of the damage caused by Hurricane Maria. This pre-planned coordination with FEMA allowed for both agencies to share information and cover a wider range of reconnaissance activities. The NIST embedded team member also served as an author on the subsequent FEMA MAT report for Hurricanes Maria and Irma.[8]

The NIST Hurricane Maria Program seeks to understand Hurricane Maria's multi-hazard impacts (i.e., wind, rainfall, flooding, landslides, storm surge) and the conditions that led to injuries and deaths; how critical buildings and designated safe areas within them performed—including their dependence on electricity, water, transportation, and other infrastructure; how emergency communications systems performed and the public's response to such communications; and the impacts to, and recovery of, selected businesses, hospitals and schools, as well as the critical social functions they provide.

As with the Joplin tornado investigation, NWIRP coordination figures prominently in the Hurricane Maria Program. In collaboration with the University of Florida (UF), wind tunnel testing of various sites in Puerto Rico where critical buildings experienced significant damage from Hurricane Maria is being conducted using the NSF-supported Natural Hazards Engineering Research Infrastructure (NHERI) facility at UF – a signature example of NWIRP post-windstorm coordination activity.

Additional NWIRP coordination on Hurricane Maria includes the NSF investment in 34 Rapid Response Projects (RAPID) to gather ephemeral data following the storm and conduct basic research. The outcomes of the RAPID NSF Hurricane Maria projects are being shared with the wider research community, serving as an important source of additional information for the NIST Hurricane Maria Program, and other similar research efforts aimed at reducing hurricane impacts in the U.S.

After completion of the Hurricane Maria study, NIST will pursue and track implementation of its recommendations in an effort to reduce windstorm impacts Nationwide.

Conclusion

NWIRP continues to make strides in implementing the strategy put forth in its strategic plan. However, as losses continue to mount, there is much work to be done. NWIRP stands ready to engage with this Committee to strengthen this vital program.

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[8] https://www.fema.gov/media-library/assets/documents/173789

We greatly appreciate the efforts of the members of this Committees and other members of Congress to support resilience programs that keep the Nation safe.

I am pleased to answer any questions you may have.