COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT
U.S. HOUSE OF REPRESENTATIVES
HEARING CHARTER

"Weathering the Storm: Improving Hurricane Resiliency through Research"

Monday July 22, 2019
3:00 p.m. CDT

Houston Community College, West Loop Campus, Auditorium
5601 West Loop South, Houston, TX 77081

PURPOSE

The purpose of the hearing is to understand the state of current hurricane and coastal resilience research in the U.S., and to identify knowledge gaps and improvements to current research efforts. This will also be an opportunity to discuss what steps coastal communities like Houston, are, or should be, taking to prepare for, and rebound from, hurricane impacts such as high winds, heavy rains, and storm surge.

WITNESSES

- **Dr. Louis W. Uccellini (Ooh-che-LEE-knee),** Assistant Administrator for Weather Services, National Oceanic and Atmospheric Administration (NOAA), and Director, National Weather Service (NWS)
- **Dr. Hanadi Rifai (RIFF-eye), P.E.,** John and Rebecca Moores Professor; Director, Environmental Engineering Graduate Program; Associate Dean Research and Facilities, Director of Hurricane Resilience Research Institute (HuRRI), University of Houston
- **Ms. Emily Grover-Kopec,** Director of Insurance Practice, One Concern, Inc.
- **Mr. Jim Blackburn**, Co-Director, Severe Storm Prediction, Education & Evacuation from Disasters (SSPEED) Center; Professor, Department of Civil and Environmental Engineering, Rice University

OVERARCHING QUESTIONS

- What is the current state of hurricane research?
- How can we improve our understanding and prediction of hurricane impacts, namely, heavy precipitation, storm surge, and high winds?
- What can we do to mitigate hurricane impacts?
- How can coastal communities build resilience to hurricanes and their associated impacts?
- What improvements can be made to research on hurricane impacts and coastal resilience?

BACKGROUND

The National Hurricane Center

The National Hurricane Center (NHC), a division within the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service (NWS), was formed in 1956.[1] It is responsible for forecasting tropical cyclones in the Atlantic Ocean and the eastern Pacific Ocean. The NHC issues estimates of the path or track of a tropical cyclone, its intensity, the size and structure of the storm, storm surge, rainfall, and presence of tornadoes. The NHC also provides hurricane watches, warnings and public advisories; which are released with increasing frequency as a tropical storm strengthens and advances toward the U.S. coastline.[2]

To create a hurricane forecast, the NHC coordinates observations, modeling and computing capabilities, and communication systems from across the line offices[3] at NOAA. Evidence to support the forecast begins as observations from satellites, aircraft, ships, buoys, and radar, which track Atlantic hurricanes from the moment they form.[4] NOAA's Geostationary Operational Environmental Satellites (GOES) provide remote sensing data as the storms cross the Atlantic. The *Hurricane Hunters (*NOAA and U.S. Air Force aircraft), as well as the National Aeronautics and Space Administration (NASA) unmanned aircraft the Global Hawk, fly directly into the center of the storms to collect additional data. Land-based observations are taken by terrestrial radars and the Automated Surface Observations System (ASOS).[5]

The NHC uses these data to build an understanding of the state of the atmosphere, and through mathematical calculations, the models generate the hurricane forecasts.[6] When the NHC issues its forecast, local NWS Weather Forecast Offices use the information to deliver their own forecasts, which take into consideration local conditions.

Hurricane Research

The NHC engages with NOAA's intramural hurricane research and development programs such as the Atlantic Oceanographic and Meteorological Laboratory's Hurricane Research Division (HRD), the Joint Hurricane Testbed, and the Hurricane Forecast Improvement Project (HFIP).

The Hurricane Research Division (HRD) conducts research to advance the understanding and prediction of hurricanes and other tropical weather. HRD's research uses computer models, academic theorizing, and observations, particularly from research aircraft that collect data from the inner structure and surrounding environment of hurricanes.[7] NOAA's Joint Hurricane Testbed (JHT) was established in 2001 in conjunction with the US Weather Research Program (USWRP), to facilitate the transfer of tropical storm research into operations. The program has successfully contributed advances to hurricane forecasting; most of the 62 projects funded in its

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[1] The National Hurricane Center. The National Hurricane Center – Past, Present, and Future. February 15, 1990. https://www.nhc.noaa.gov/pdf/NHC_Past_Present_Future_1990.pdf

[2] Congressional Research Service. The National Hurricane Center and Forecasting Hurricanes: 2017 Overview and 2018 Outlook. August 23, 2018. https://fas.org/sgp/crs/misc/R45264.pdf

[3] NOAA Line Offices: Office of Marine & Aviation Operations (OMAO), Marine Fisheries Service (NMFS), National Ocean Service (NOS), Office of Oceanic and Atmospheric Research (OAR), National Environmental Satellite, Data, and Information Service (NESDIS)

[4] Ibid.

[5] Ibid.

[6] Ibid.

[7] NOAA, Atlantic Oceanographic & Meteorological Laboratory: Hurricane Research Division https://www.aoml.noaa.gov/hrd/

first decade were implemented operationally, including work on dynamical modeling, statistical modeling, observations, improved satellite and aircraft observations, model post-processing, and forecaster efficiency and quality control.[8]

The National Science Board (NSB), which provides oversight to the National Science Foundation (NSF), established the Task Force on Hurricane Science and Engineering (Task Force) in 2005 to assess U.S capacity to mitigate the effects of, and respond to, hurricanes. In 2007, The Task Force recommended the creation of a national hurricane research initiative that would coordinate federal agencies in interdisciplinary research to expand the understanding of hurricanes and identify effective strategies for dealing with them.[9] In response to the recommendations outlined in the NSB report and others,[10] NOAA established the Hurricane Forecasting Improvement Project (HFIP) in 2009, which is managed by the HRD.[11] It met its five-year goal to reduce track and intensity errors by 20 percent from the 2009 average.[12]

In the last decade, major disasters have prompted additional federal investments for hurricane research and improvements to hurricane forecasting. The Disaster Relief Appropriations Act of 2013, known as the Sandy Supplemental, provided $74.8 million to NOAA's Office of Oceanic and Atmospheric Research (OAR) for research to improve observing systems, global modeling, localized predictions, as well as funds to acquire high performance computing capacity. The research included both intramural research and extramural grants.[13] Following the active 2017 hurricane season, the Disaster Supplemental passed in 2018 provided $400 million for NOAA, with $50 million dedicated to improving forecasting capabilities to protect life and property in the face of future hurricanes.[14]

The Weather Forecasting and Improvement Act of 2017 required the HFIP to report to Congress on their research, development and technology transfer activity to achieve three focus areas: "1) improving the prediction of rapid intensification and track of hurricanes, 2) improving the forecast and communication of storm surges from hurricanes, and 3) incorporating risk communication research to create more effective watch and warning projects."[15] HFIP submitted

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[8] American Meteorological Society. The Joint Hurricane Testbed: Its first Decade of Tropical Cyclone Research-to-Operations Activities Reviewed. March 2012. https://www.jstor.org/stable/26218649?seq=1#page_scan_tab_contents

[9] National Science Board. Hurricane Warning: The Critical Need for a National Hurricane Research Initiative. January 12, 2007. https://www.nsf.gov/nsb/publications/2007/hurricane/initiative.pdf

[10] NOAA, through its Science Advisory Board (SAB), established a Hurricane Intensity Research Working Group (HIRWG), which released recommendations for improving hurricane intensity forecasts in 2006 (NOAA SAB. Hurricane Intensity Research Working Group Majority Report. 2006. ftp://ftp.oar.noaa.gov/SAB/sab/Reports/HIRWG_final73.pdf). In addition, the Office of the Federal Coordinator of Meteorological Services (OFCM) released a 2007 report in calling for a federal investment of $70-85 million annually over the next 10 years for tropical cyclone research and development, transition of research to operations, and operational high performance computing (OFCM. Interagency Strategic Research Plan for Tropical Cyclones - The Way Ahead, FCM-P36-2007. 2007. https://www.amazon.com/Interagency-Strategic-Research-Tropical-Cyclones-ebook/dp/B01IC02IWW)

[11] Hurricane Research Division Webpage - https://www.aoml.noaa.gov/hrd/about_hrd/hfip_era.html

[12] NOAA. Hurricane Forecast Improvement Project Years Five to Ten Strategic Plan. 2014. http://www.hfip.org/documents/HFIP_StrategicPlan_Yrs5-10_Nov05_2014_Update.pdf

[13] NOAA, Office of Oceanic and Atmospheric Research. "NOAA Research Program Overview: Sandy Supplemental." https://research.noaa.gov/sites/oar/Documents/oarProgramOverview_SandySupplemental_CC.pdf

[14] Miami Herald. NOAA gets $400 million in disaster funds in latest spending bill. February 12, 2018. https://miamiherald.typepad.com/nakedpolitics/2018/02/noaa-gets-400-million-in-disaster-funds-in-latest-spending-bill.html

[15] P.L. 115-25

this report to Congress on May 28, 2019. It outlined specific goals that the next generation of HFIP must meet to make progress on the focus areas:[16]

- Reduce numerical forecast guidance errors, including during rapid intensification, by 50 percent from 2017;
- Produce seven-day forecast guidance that is similar to the 2017 five-day forecast guidance;
- Improve guidance on pre-formation disturbances, including genesis timing, and track and intensity forecasts, by 20 percent from 2017; and
- Improve hazard guidance and risk communication, based on social and behavioral science, to modernize the Tropical Cyclone product suite

To reach these goals, HFIP plans to advance an operational Hurricane Analysis and Forecast System (HAFS), improve probabilistic guidance, enhance communications of risk and uncertainty, support dedicated high performance computing allocation, and enhance research to operations (R2O).[17] In addition to NOAA, the National Science Foundation (NSF) also provides extramural grants for hurricane research through its Engineering (ENG), Geosciences (GEO), and Social, Behavioral, and Economic Sciences (SBE) Directorates.[18] Following Hurricane Harvey, NSF awarded $5.3 million in grants to study the effects of hurricanes.[19]

Hurricane Forecasting

The NHC issues estimates of the path or track of a tropical cyclone, its intensity, the size and structure of the storm, storm surge, rainfall, and presence of tornadoes. Track forecasts help predict where on the coastal U.S. a hurricane will make landfall. The accuracy of NHC's hurricane track forecasts has improved significantly since the 1960s due to investments on both the research and operational side of hurricane forecasting. For example, federal efforts have reduced errors in track and intensity forecasts, and extended reliable forecasts from three to five days.[20] Advanced satellites, and other data collection instruments, have contributed to those improvements, as have better forecasting models and advances in computing capabilities.

NOAA is continuing to improve predictions of hurricane intensity (highest sustained wind speeds, over the course of a storm's life), storm size and structure, rainfall, flooding, and storm surge (abnormal rise of water over the predicted tide due to a storm). [21] Intensity forecasts are particularly important as storms are predicted to more rapidly intensify with a changing climate.[22] Predictions of rainfall and storm surge are also important because the majority of casualties from hurricanes are caused by flooding. Further, some studies show that the amount of

[16] NOAA. Report to Congress Hurricane Forecast Improvement Program. May 28, 2019. (not yet released to the public)
[17] Ibid.
[18] National Science Foundation. FY 2020 Budget Request to Congress. March 18, 2019. https://www.nsf.gov/about/budget/fy2020/pdf/fy2020budget.pdf
[19] NSF, "NSF awards $5.3 million in 59 grants to study effects of recent hurricanes," October 10, 2017, https://www.nsf.gov/news/news_summ.jsp?cntn_id=243293
[20] Congressional Research Service. The National Hurricane Center and Forecasting Hurricanes: 2017 Overview and 2018 Outlook. August 23, 2018. https://fas.org/sgp/crs/misc/R45264.pdf
[21] National Hurricane Center Webpage: Storm Surge Overview. https://www.nhc.noaa.gov/surge/
[22] Kieran T. Bhatia, Gabriel A. Vecchi, Thomas R. Knutson, Hiroyuki Murakami, James Kossin, Keith W. Dixon & Carolyn E. Whitlock. *Recent increases in tropical cyclone intensification rates.* Nature Communications. Volume 10, Article number: 635. 2019. https://www.nature.com/articles/s41467-019-08471-z

rainfall may not be related to the intensity of the hurricane.[23] Given this, the NWS developed a Storm Surge Forecast that is separate from its track and intensity forecasts. The first operational storm surge forecasts were issued during Hurricane Harvey in 2017, which had no deaths related to storm surge.[24]

Coastal Resilience

Coastal resilience can be defined as building the ability of coastal communities, infrastructure, and resources to withstand, and recover from, human and naturally occurring hazardous events such as hurricanes, coastal storms, and flooding, rather than just reacting to impacts.[25,26] With 39% of Americans living in coastal counties, building coastal resilience is a key factor in protecting lives and retaining the homes, businesses, and civic institutions that support these communities.[27]

Tropical cyclones alone have caused $927.5 billion in total damages since 1980; this accounts for the majority of the damage of all 246 weather-related disasters in this time period with an average cost of $22 billion per event. [28] The rainfall, intensity, and frequency of hurricanes is likely to increase globally due to climate change. Given the likely human contributions to rising sea levels, higher levels of coastal inundation are also expected when hurricanes do occur.[29]

Much of the current public infrastructure was designed and built using historic flood and rainfall data. This design approach, which includes risk assessment of infrastructure, assumes that the frequency and intensity of these weather events do not change significantly over time.[30] Since climate change is leading to increased precipitation and flooding associated with tropical cyclones and other weather events, current infrastructure was not designed to withstand these levels of repeated impacts. Designing or updating infrastructure to incorporate resilience can help mitigate future disaster and recovery costs. The National Institute of Building Sciences found that every $1 invested in resilience can save $4-$11 in future disaster costs.[31]

Building coastal resilience will depend not only on improvements to forecasting hurricanes and their impacts, such as rainfall and storm surge, but also on understanding the future climate and weather patterns and utilizing that information to guide infrastructure design and development. Forecast improvements can also help inform decision-makers and emergency managers in coastal communities on what to expect during a hurricane, and how they can prepare their communities.

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[23] Congressional Research Service. Forecasting Hurricanes: Role of the National Hurricane Center. July 11, 2019. https://aquadoc.typepad.com/files/crs_infocus_hurricane_center_11july2019.pdf
[24] National Hurricane Center. Hurricane Harvey. May 9, 2018. https://www.nhc.noaa.gov/data/tcr/AL092017_Harvey.pdf
[25] Texas General Land Office, "Texas Coastal Resiliency Master Plan", March 2019, https://coastalstudy.texas.gov/resources/files/2019-coastal-master-plan.pdf
[26] NOAA, National Ocean Service, "What is resilience?" accessed here: https://oceanservice.noaa.gov/facts/resilience.html
[27] NOAA, National Ocean Service, "What percentage of the American population lives near the coast?" https://oceanservice.noaa.gov/facts/population.html, 6/25/18.
[28] NOAA, https://coast.noaa.gov/states/fast-facts/weather-disasters.html
[29] NOAA, "Global Warming and Hurricanes: An Overview of Current Research Results," Geophysical Fluid Dynamics Laboratory, July 3, 2019, https://www.gfdl.noaa.gov/global-warming-and-hurricanes/
[30] USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.
[31] National Institute of Building Sciences, Natural Hazard Mitigation Saves: 2017 Interim Report, https://www.nibs.org/page/mitigationsaves

NOAA Coastal Resilience Grants

NOAA's Coastal Resilience Grants Program provides competitive grants to fund projects in coastal communities to help them prepare for, and recover from, extreme weather events. The Coastal Resilience Grants Program partners with nonprofit and regional organizations.[32] The demand for these grants has exceeded the number of projects that are funded each year. Since 2015, grant applicants have requested approximately $327 million in federal funds. In this time period, NOAA has funded projects totaling $35.8 million with an additional $22.3 million in matching funds.[33] In May 2018, the National Fish and Wildlife Foundation (NFWF) established the National Coastal Resilience Fund to restore and enhance natural coastal infrastructure to protect coastal communities from natural events. The initial round of funding of about $29 million for 35 grants was provided by NFWF, NOAA, Shell Oil Company, and TransRe. The program leveraged matching grants totaling $38 million.[34]

Additional Reading

Blake, Eric S. and Zelinsky, David A., "Tropical Cyclone Report: Hurricane Harvey," National Hurricane Center, May 9, 2018, https://www.nhc.noaa.gov/data/tcr/AL092017_Harvey.pdf

[32] NOAA, "NOAA Coastal Resilience Grants Program," https://coast.noaa.gov/resilience-grant/
[33] NOAA, "Coastal Resilience Grants for Coastal Communities," https://www.coast.noaa.gov/data/resilience/factsheet-resilience-grants.pdf
[34] NFWF, "National Coastal Resilience 2018 Grant Slate," https://www.nfwf.org/coastalresilience/Documents/2018grantslate.pdf