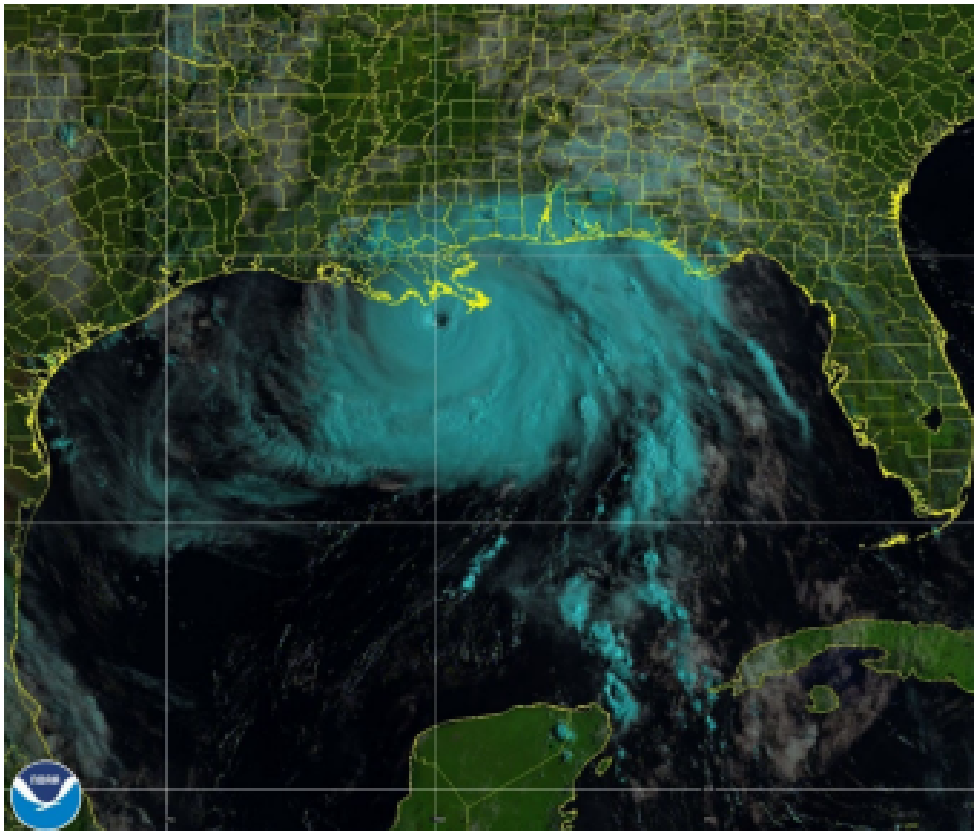
Service Assessment

2021 Hurricane Ida



GOES-16 Day Cloud Convection Image of Ida a few hours before landfall at Port Fourchon, Louisiana, at 1400 UTC 29 August 2021 – NOAA/NESDIS/STAR GOESEast A/BI DayLandCloud

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Silver Spring, Maryland

Service Assessment

August-September 2021 Hurricane Ida

April 2023

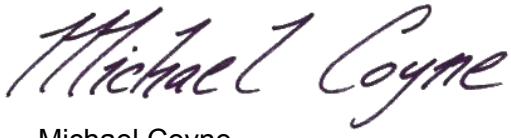
National Weather Service
Michael Coyne
Chief Operating Officer (Acting)

Preface

Hurricane Ida began as a tropical depression early on August 26, 2021, near Kingston, Jamaica, and quickly intensified to a tropical storm only six hours after genesis. Ida continued to intensify rapidly, reaching hurricane strength by midday on August 27 and making landfall as a Category 4 hurricane near Port Fourchon, Louisiana, during the late morning hours of August 29. Ida struck Louisiana on the same day as Hurricane Katrina in 2005.

Given its rapid development and subsequent fast movement to landfall along the Louisiana coast, Ida presented challenges to the entirety of the Weather, Water, and Climate Enterprise, as well as to emergency management and first responders. Ida went from an incipient depression to a landfalling Category 4 hurricane in just three days. Specific to the National Weather Service (NWS), this unique scenario challenged forecasters to react and work quickly to recognize the potential for rapid development of the event, to issue watches and warnings, and to provide Impact-Based Decision Support Services (IDSS) to Core Partners. The rapid intensification prompted lead times that challenged emergency management and first responders; Ida severely compressed the time frame to make critical decisions related to mitigation and evacuation efforts. Ida produced significant wind, storm surge, and flash flooding across the Gulf Coast states. Well after landfall, the remnants of Ida posed significant impacts to the highly populated Interstate 95 (I-95) corridor in the Mid-Atlantic and the Northeast with a regional outbreak of tornadoes and intense rainfall that led to catastrophic flooding.

Because of the highly significant impacts of both the tropical and post-tropical phases of Ida, the NWS assembled a service assessment team to evaluate its performance before and during Hurricane Ida. NWS leadership will review and consider the findings and recommendations from this assessment. As appropriate, the agency will integrate these recommendations to best meet the NWS mission, improve the quality of operational products and services, and enhance the NWS public education and awareness materials related to flooding, tornadoes, and other tropical cyclone hazards.



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April 2023

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Service Assessment Team

Assessment Team Co-Leads:

Michael J. Hudson	Chief, Integrated Services Division, NWS Central Region Headquarters, Kansas City, MO
Tony Coventry	Department of Transportation - Federal Highway Administration, Washington, DC

East Sub-Team Members:

John "JJ" Brost	Sub-Team Lead. Director, Operations Proving Ground, Kansas City, MO
Eric Jones	Development and Operations Hydrologist, Arkansas-Red Basin River Forecast Center (RFC), Tulsa, OK
Michael "Sean" Ryan	Senior Hydrologist, Office of Water Prediction (OWP), Tuscaloosa, AL
Joshua Scheck, PhD.	Chief, Aviation Support Branch, NWS Aviation Weather Center, Kansas City, MO
Mike Cantin	Meteorologist in Charge, Weather Forecast Office (WFO) Boise, ID
Valerie Were, PhD.	Social Scientist, Cooperative Institute for Research in the Atmosphere, Silver Spring, MD
Gina Eosco, PhD.	Social Scientist, NOAA Office of Oceanic and Atmospheric Research (OAR), Silver Spring, MD

South Sub-Team Members:

Ariel Cohen, PhD.	Sub-Team Lead. Meteorologist in Charge, WFO Los Angeles/Oxnard, CA
Marcus "Landon" Aydlett	Warning Coordination Meteorologist, WFO Guam
Brian Astifan	Development and Operations Hydrologist, Ohio Basin RFC, Wilmington, OH
Freddie Ziegler	Warning Coordination Meteorologist, WFO Cleveland, OH
Rob Hart	Warning Coordination Meteorologist, WFO Great Falls, MT
Laura Myers, PhD.	Social Scientist, University of Alabama, Tuscaloosa, AL
Chandra Clark, PhD.	Social Scientist, University of Alabama, Tuscaloosa, AL

Internal Sub-Team Members:

Kelly Allen	Sub-Team Lead. Deputy Chief, Integrated Services Division, Central Region Headquarters, Kansas City, MO
Christopher Landsea, PhD.	Branch Chief, Tropical Analysis and Forecast Branch, National Hurricane Center, Miami, FL
Leticia Williams, PhD.	Social Scientist, University Corporation for Atmospheric Research, Silver Spring, MD
Castle Williamsberg, PhD.	Social Scientist, FedWriters, OAR/Weather Program Office, Silver Spring, MD
Lance Wood	Science and Operations Officer, WFO Houston/Galveston, TX
Paul Miller	Service Coordination Hydrologist, Colorado Basin RFC, Salt Lake City, UT
Wendy Pearson	Hydrologist in Charge, Missouri Basin RFC, Pleasant Hill, MO

Other Valuable Contributors:

John Gagan	Science and Operations Officer, WFO Milwaukee WI
Pablo Santos	Meteorologist in Charge, WFO Miami, FL
Mike Richards	Senior Meteorologist, National Transportation Safety Board, Minneapolis, MN
Brian Walawender	Chief, Systems and Facilities Division, NWS Central Region Headquarters Kansas City, MO
Lora Wilson	Forensic Services Program Manager, NWS Headquarters, Silver Spring, MD

Executive Summary

In the late morning of August 29, 2021, Category 4 Hurricane Ida made landfall near Port Fourchon, Louisiana on the same date as Hurricane Katrina in 2005. This anniversary added to the significance of this event to many residents who remembered Katrina's devastation 16 years prior. Hurricane Ida had quickly intensified over the three days prior to landfall, rapidly going from a tropical depression to a Category 4 hurricane. Hurricane Ida produced significant wind damage, storm surge, and flash flooding across the Gulf Coast states. Its remnants later produced deadly flooding across parts of the Northeastern United States, including New York City, and a regional tornado outbreak along the Interstate 95 (I-95) corridor from Virginia to New England.

Given the storm's rapid development, intensification, and subsequent landfall, the National Weather Service (NWS), its Core Partners, and the Weather, Water, and Climate Enterprise worked together to quickly alert the public of the rapidly developing event. The National Hurricane Center (NHC) and affected Weather Forecast Offices (WFOs) moved up the time frame of when a typical issuance of the Hurricane Watch occurs, from 4 am on August 27 to 10 pm on August 26, so the headlines went out before most people went to bed that night. Core Partners and broadcast media appreciated the approach of the NWS issuing the watches during the evening hours to avoid activation of the Wireless Emergency Alert (WEA) system with the 4 am hurricane advisory cycle.

The majority of casualties associated with Ida occurred after its extratropical transition across portions of the Mid-Atlantic region. Overall, Hurricane Ida caused 87 deaths and an estimated $75 billion in property damage from Louisiana to New England[1]. These statistics strongly contrast when compared to Hurricane Katrina in 2005, which caused a total of 1,833 fatalities[2]. The combination of wind, storm surge, and flash flooding during Ida's landfall along the Gulf Coast directly resulted in six fatalities, and 28 additional fatalities in its aftermath. Areas along the Gulf Coast received 10 to 15 inches of rainfall during Ida's landfall. As Ida transitioned to a post-tropical cyclone over the Northeastern United States, its remnants produced another area of five to 10 inches of rainfall from northern Maryland, north and east across eastern Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, and Massachusetts. This rainfall resulted in catastrophic flooding, including flash flood emergencies for the boroughs of New York City. Flooding from this rainfall directly led to 49 fatalities, including 13 deaths during the flash flood event in New York City. An EF2 tornado on the Enhanced Fujita (EF) Scale[3] also caused one fatality during a regional outbreak of tornadoes in the Northeast and Mid-Atlantic. Four additional fatalities occurred in the aftermath of the storm across the South and Northeast.

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[1] NHC Tropical Storm Report on Hurricane Ida - https://www.nhc.noaa.gov/data/tcr/AL092021_Ida.pdf
[2] NHC Tropical Storm Report on Hurricane Katrina - https://www.nhc.noaa.gov/data/tcr/AL122005_Katrina.pdf
[3] The Enhanced Fujita Scale or EF Scale, which became operational on February 1, 2007, is used to assign a tornado a 'rating' based on estimated wind speeds and related damage. See https://www.weather.gov/oun/efscale for more information.

NWS services, including timely watches, warnings, and Impact-based Decision Support Services (IDSS), saved lives during Hurricane Ida. WFOs, National Centers, NWS regional and national Headquarters worked together to marshal the agency's capabilities in response to the hurricane and its aftermath. Assessment Team members who investigated the event found this teamwork evident in many outcomes.

The Assessment Team took a different approach in preparing the service assessment report for Hurricane Ida, as compared to prior assessments on landfalling hurricanes and their aftermath. In prior assessments, the Team considered tactical findings related to specific issues discovered during interviews and provided recommendations to address these findings. For this assessment, the Team used this methodology and also broadened its approach by leaning forward into how NWS can grow capacity based on findings in critical areas such as Mutual Aid, IDSS, and improving service equity and its reach to vulnerable populations. Thus, many of the recommendations in this report focus on transformative concepts to improve services as well as addressing findings that occurred during Ida itself.

In particular, the report proposes transformational recommendations that attempt to resolve the root cause of several higher-order findings in the report that include:

- Leveraging the Incident Command System (ICS) to better align NWS operations with Core Partners and ensure clear roles and responsibilities during events.
- Supporting all aspects of operations through a continuously available Mutual Aid framework.
- Establishing a robust Geographical Information System (GIS) program to meet the needs of partners who desire dynamic, interactive, real-time and configurable data.
- Incorporating research-guided recommendations, provided by National Oceanic and Atmospheric Administration (NOAA) funded social and behavioral science research, on effectively communicating probabilistic information to Core Partners and the public.
- Supporting NWS employees with an emphasis on mental health and office culture.
- Improving service equity by:
    - Transforming traditional outreach and education approaches to better meet the needs of vulnerable and/or underserved communities.
    - Using technology and mobile device friendly design strategies to increase the accessibility of information.
    - Developing capability and leveraging partner capabilities to provide information in several languages to better serve people with limited English proficiency.

This assessment contains many acronyms to describe items and functions. Readers may need to reference Appendix A for descriptions of acronyms that, while spelled out the first time they appear, may appear in subsequent sections without the same re-definition.

1. Introduction

1.1 NWS Mission

The mission of the National Oceanic and Atmospheric Administration's (NOAA) NWS is to provide weather, water, and climate data, forecasts, warnings, and Impact-based Decision Support Services (IDSS) for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and enhancement of the national economy. NWS disseminates data, weather products, and guidance from 122 local Weather Forecast Offices (WFOs), 13 River Forecast Centers (RFCs), 21 Center Weather Service Units (CWSUs), the National Water Center (NWC), and seven National Centers within the National Centers for Environmental Prediction (NCEP) to users outside the NWS.

Forecasters at WFOs and RFCs issue forecasts and hazardous watches, warnings, and advisories to the public. They also interface closely with local emergency managers (EMs) and other federal, state, local, tribal, and territorial government partners in the provision of weather, water, and climate IDSS. WFOs and RFCs also collaborate significantly with media partners and other non-government entities in the distribution and explanation of information. CWSUs, co-located with Federal Aviation Administration (FAA) Air Route Traffic Control Centers (ARTCCs), provide comprehensive IDSS to air traffic controllers, traffic management units, traffic control centers and control towers in their areas of jurisdiction. NCEP Centers produce guidance and forecasts for use by WFOs, RFCs, and CWSUs, as well as external customers.

The National Hurricane Center (NHC) in Miami, Florida issues forecasts for tropical cyclones. It also collaborates with its NWS partners to issue hurricane, tropical storm, and storm surge watches and warnings for the U.S. coast, and a variety of probabilistic products for tropical cyclone hazards, in addition to providing national and state-level IDSS and messaging for tropical cyclone events. The NHC serves as a key member of the Federal Emergency Management Agency (FEMA) Hurricane Liaison Team.

The Ocean Prediction Center (OPC) in College Park, Maryland and the Tropical Analysis and Forecast Branch (TAFB) of the NHC provide marine and tropical forecasts, warnings, and support to NWS Core Partners.

The Storm Prediction Center (SPC) in Norman, Oklahoma issues outlooks, watches, and discussions for severe local storms, heavy snowfall, and fire weather.

The Weather Prediction Center (WPC) in College Park, Maryland produces a wide range of national weather forecast and analysis products, including Quantitative Precipitation Forecasts (QPF), excessive rainfall products, medium-range and probabilistic rainfall guidance, surface analysis, and a daily weather map.

These NCEP centers collaborate closely with NWS field offices and with EMs and media partners in the creation, distribution, and interpretation of NWS guidance, outlooks, and hazardous watch/warning information.

The NWC in Tuscaloosa, Alabhama delivers timely national hydrologic analyses and water forecast information, data, and guidance.

The NWS Headquarters (NWSH), in Silver Spring, Maryland, and six Regions provide policy and administrative guidance to the National Centers, WFOs, RFCs, and CWSUs. Regional offices also operate Regional Operations Centers (ROCs) that, along with the NWS Operations Center (NWSOC) and the Water Prediction Operations Division (WPOD) at the NWC, provides tactical field office support and IDSS to state and region-level federal partners.

1.2 Purpose of Assessment Report

NWS may conduct national service assessments for significant hydrometeorological, oceanographic, or geological events when they result in one or more of the following conditions:

- Multiple fatalities
- Numerous injuries requiring hospitalization
- A significant impact on the economy of a large area or population
- Extensive national public interest or media coverage
- An unusual level of attention to NWS operations by the media, EM community, or elected officials

Service assessments evaluate NWS performance and ensure the effectiveness of NWS products and services in meeting its mission. The goal of service assessments is to improve the ability of NWS to protect life and property by identifying and sharing best practices in operations and procedures, recommending service enhancements, and addressing service deficiencies.

This document presents findings and recommendations resulting from the evaluation of NWS performance during Hurricane Ida (August 26–September 1, 2021). Assessment objectives were to identify significant findings and issue recommendations and best practices related to the following key areas:

- Fully Integrated Field Structure (FIFS).
- Systems and Facilities.
- Service Backup and Mutual Aid.
- IDSS: Provision, Service Equity, Results, and Best Practices.
- Training and Proficiency.
- Transportation.

1.3 Methodology

NWS formed a service assessment team on November 4, 2021. The 23-member team and five subject matter experts (SME) consisted of personnel from WFOs and RFCs, NWSH, Regions, Central Region ROC, Aviation Weather Center (AWC), Office of Water Prediction (OWP), Federal Highway Administration, NOAA Oceanic and Atmospheric Research (OAR), Cooperative Institute for Research in the Atmosphere (CIRA), University Corporation for Atmospheric Research (UCAR), and the Center for Advanced Public Safety at the University of Alabama. The Team completed the following activities:

The Ida "South Sub-team" performed on-site evaluations in Louisiana and Mississippi from December 5-10, 2021. The Sub-team

- visited and conducted interviews at:
    - WFO New Orleans/Baton Rouge, Slidell, LA
    - Lower Mississippi River RFC, Slidell, LA
    - United States Army Corps of Engineers (USACE), New Orleans District, New Orleans, LA
    - Louisiana Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP), Baton Rouge, LA
    - New Orleans Homeland Security and Emergency Preparedness, New Orleans, LA
    - Port of Mobile, AL
    - United States Coast Guard (USCG), Sector New Orleans
    - United States Geological Survey (USGS), Baton Rouge, LA
- interviewed local, state, and federal EMs, media, and other government officials in the primary impacted areas and jurisdictions.
- assessed damaged areas in Lafourche Parish and Grand Isle, LA.

The Ida "East Sub-team" performed on-site evaluations in New York, Pennsylvania, and New Jersey from December 5-10, 2021. The Sub-team

- visited and conducted interviews at:
    - WFOs New York, NY and Philadelphia/Mt. Holly, NJ
    - New York City (NYC) Emergency Management
    - Port Authority of New York and New Jersey
    - New Jersey Office of Emergency Management
    - Pennsylvania Emergency Management Agency
    - Philadelphia Office of Emergency Management
    - Metropolitan Transportation Authority (MTA) of NYC
    - New York State Department of Transportation (NYSDOT)
    - Pennsylvania Department of Transportation (PENNDOT)
    - Mississippi State Department of Transportation (MDOT)[4]

[4] Conducted by the team co-lead only in early 2022.

- interviewed local, state, and federal EMs, media, and other government officials in the primary impacted areas and jurisdictions.

The Ida “Internal Sub-team” performed virtual evaluations for National and Regional Centers, and other impacted offices not covered by the East and South Sub-teams from December 5-10, 2021. The Sub-team conducted interviews with:

- Southeast RFC, Peachtree City, GA
- Mid-Atlantic RFC, State College, PA
- Northeast RFC, Norton, MA
- WFOs Jackson, MS; Mobile, AL; Boston/Norton, MA; and Baltimore/Washington, VA
- CWSUs Houston, TX; Atlanta, GA; Jacksonville, FL; Washington DC; Boston, MA; New York, NY, and Memphis, TN
- National Hurricane Center (NHC)
- National Water Center (NWC)
- Water Prediction Operations Division (WPOD) at the NWC
- NWS Southern Region Headquarters (SRH)
- Southern Region ROC (SR ROC)
- NWS Eastern Region Headquarters (ERH)
- Eastern Region Operations Center (ER ROC)
- NWS Operations Center (NWSOC)
- Ocean Prediction Center (OPC)
- Weather Prediction Center (WPC)
- Storm Prediction Center (SPC)
- NCEP Central Operations (NCO)
- Office of Water Prediction (OWP)
- NWSH Analyze, Forecast, and Support Office (AFSO):
    - Digital and Graphical Information Support Branch
    - Water Resources Services Branch
    - Marine, Tropical, and Tsunami Services Branch

From January to March 2022, these Sub-teams reviewed all the material gathered. The Sub-teams considered interviews, evaluated products, messages, and other services produced by involved NWS offices, and compiled a core list of common themes in Google Jamboards™ that the groups discovered independently from one another. In April 2022, a cross-cutting small group, composed of members from all three Sub-teams, met in Kansas City, MO, to review these Jamboards™ and to begin organizing the service assessment report. The Team then wrote the service assessment over the summer of 2022.

After a series of internal reviews, the NWS Chief Operating Officer (COO) reviewed the service assessment report, then approved and signed it so NWSH could issue the report to the American public.

2. Event Review - August 26 through September 2

The National Hurricane Center's Tropical Cyclone Report on Hurricane Ida provides a detailed chronological history on the meteorological origins and evolution of Hurricane Ida. This service assessment includes key points from the NHC report[5].

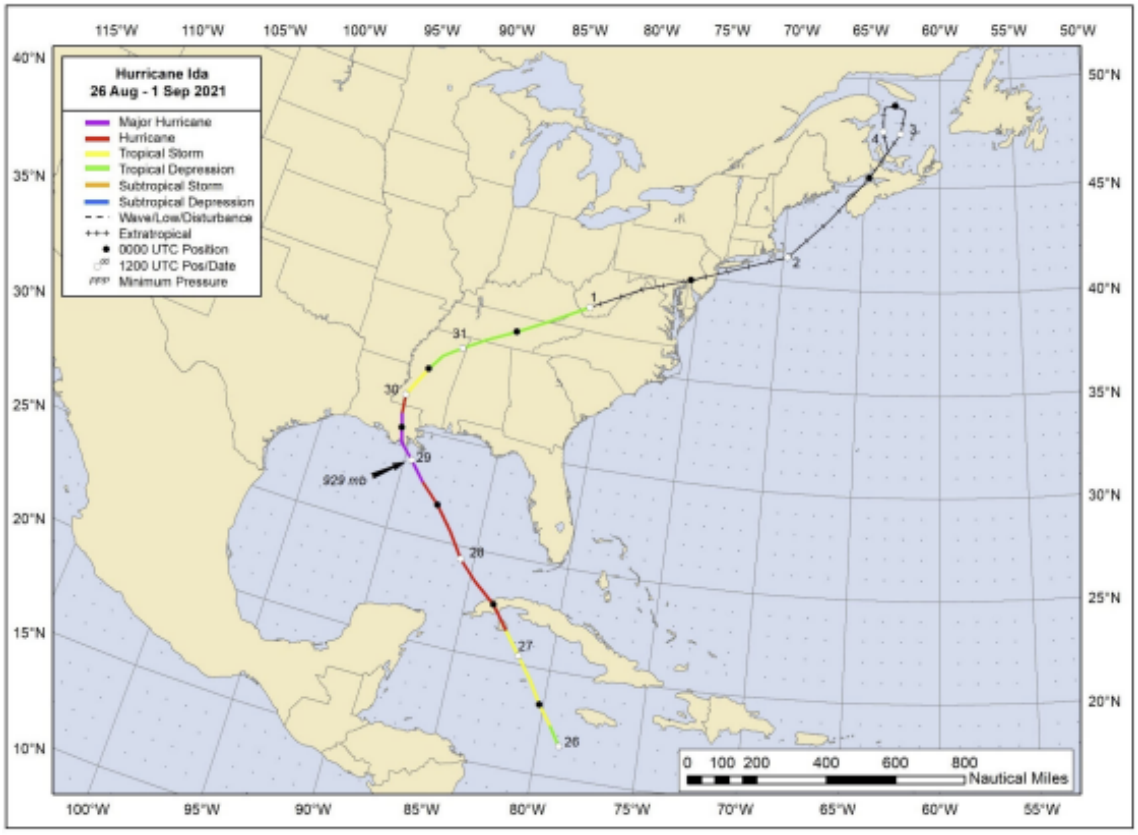


Figure 1: Hurricane Ida tropical cyclone track and intensity.

Figure 1 shows the "best track" reanalysis of the tropical cyclone's path. Ida formed from a combination of multiple low-latitude weather systems, starting with a tropical wave emerging from the coast of Africa on August 14, 2021. NHC estimated that a tropical depression formed near 1200 Coordinated Universal Time (UTC) on August 26, about 150 nautical miles (nm) southwest of Kingston, Jamaica. The cyclone strengthened to a tropical storm six hours after genesis and slow strengthening continued as the center passed northeast of Grand Cayman Island early on August 27.

[5] Users can find a digital record of the complete best track, including wind radii, in the 'archive' directory at ftp.nhc.noaa.gov/atcf.

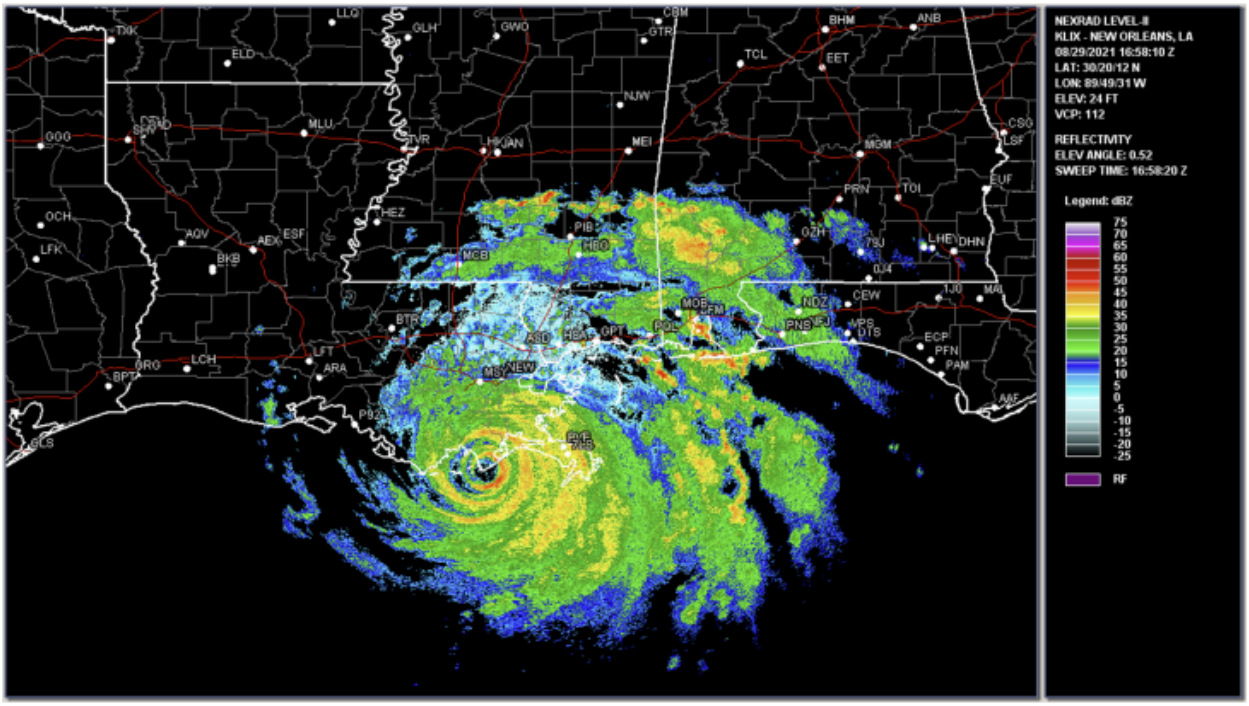


Figure 2: NWS New Orleans/Baton Rouge radar reflectivity image of the eye of Ida making landfall at Port Fourchon, Louisiana, at 1658 UTC 29 August 2021.

Rapid strengthening occurred after the center passed Grand Cayman and Ida became a hurricane with 70 knot (kt) winds before the center reached the Isle of Youth, Cuba, at 1800 UTC on August 27. After crossing the Isle of Youth, the center made landfall in mainland Cuba near Playa Dayaniguas in the province of Pinar del Rio near 2325 UTC that day. Continuing northwestward, Ida's center subsequently emerged over the southeastern Gulf of Mexico between 0100–0200 UTC on August 28. A second round of rapid strengthening started at 1200 UTC on August 28 and continued for the next 24 hours. During this intensification phase, the maximum winds increased from 70 kt to 90 kt in the first 12 hours, and then from 90 kt to a peak of 130 kt in the next 12 hours. By the end of this rapid intensification period, Ida had moved northwestward to a position southwest of the mouth of the Mississippi River. A continued northwestward motion brought the 15-nm-wide eye to the Louisiana coast at Port Fourchon at 1655 UTC on August 29 (**Figure 2**).

Ida had maximum sustained winds at landfall of 130 kt, making the storm a Category 4 on the Saffir-Simpson Hurricane Wind Scale, and a central pressure near 931 millibars (mb). The NHC determined that the 130 kt landfall intensity equaled that of Hurricane Laura in August 2020 and the Last Island Hurricane of August 1856. These three Category 4 storms tied for the strongest on record to make landfall in Louisiana west of the Mouth of the Mississippi River[6].

[6] Hurricane Camille in August 1969 is the strongest hurricane on record to hit Louisiana. It was Category 5 on the Saffir-Simpson Hurricane Wind Scale when it passed over coastal Louisiana east and north of the mouth of the Mississippi River en route to its final landfall in Mississippi.

Shortly after landfall, Ida turned north-northwestward and this motion brought the eye across southeastern Louisiana between Houma and New Orleans. A continued north-northwestward motion early on August 30 brought the center just west of LaPlace and then between Baton Rouge and Hammond. The cyclone's intensity steadily decreased as it moved inland and it weakened to a tropical storm before the center moved into southwestern Mississippi between 0600–1200 UTC that day. Ida then turned northeastward, with the center passing just west of Jackson, Mississippi around 1800 UTC. Soon thereafter, the cyclone weakened to a tropical depression as it moved into northeastern Mississippi. The system then accelerated northeastward across northwestern Alabama, central and eastern Tennessee, and portions of Kentucky and Virginia before reaching southern West Virginia near 1200 UTC on September 1. Ida began an extratropical transition as it moved through the Tennessee Valley, and the system became an extratropical low as it moved over West Virginia later that day.

Once it became extratropical, Ida moved east-northeastward across West Virginia, northern Virginia, and central Maryland to southeastern Pennsylvania by 0000 UTC on September 2. At that time, the system acquired gale-force winds[7] over the Atlantic Ocean east of the center. A continued east-northeastward motion brought the center across northern New Jersey and into the Atlantic Region just south of Long Island, New York, to near Nantucket, Massachusetts by 1200 UTC that day. The low then turned northeastward and strengthened slightly, reaching western Nova Scotia late on September 2, before moving into the Gulf of St. Lawrence on September 3. The low took a counterclockwise loop over the Gulf of St. Lawrence on September 3-4 while the low maintained maximum winds of 40–45 kt. The low degenerated to a trough late on September 4.

Hurricane Ida caused 87 deaths and an estimated $75 billion in property damage from Louisiana to New England. A total of 34 deaths occurred during the tropical phase, while the remaining 53 deaths, the majority of casualties associated with Ida, occurred after its extratropical transition across portions of the Mid-Atlantic region into New England (**Figure 3**). All but one of the fatalities during Ida's post-tropical phase occurred due to flooding; the other fatality occurred due to an EF2 tornado.

[7] Gale force winds are defined as speeds between 34 and 47 knots (39 to 54 miles per hour).

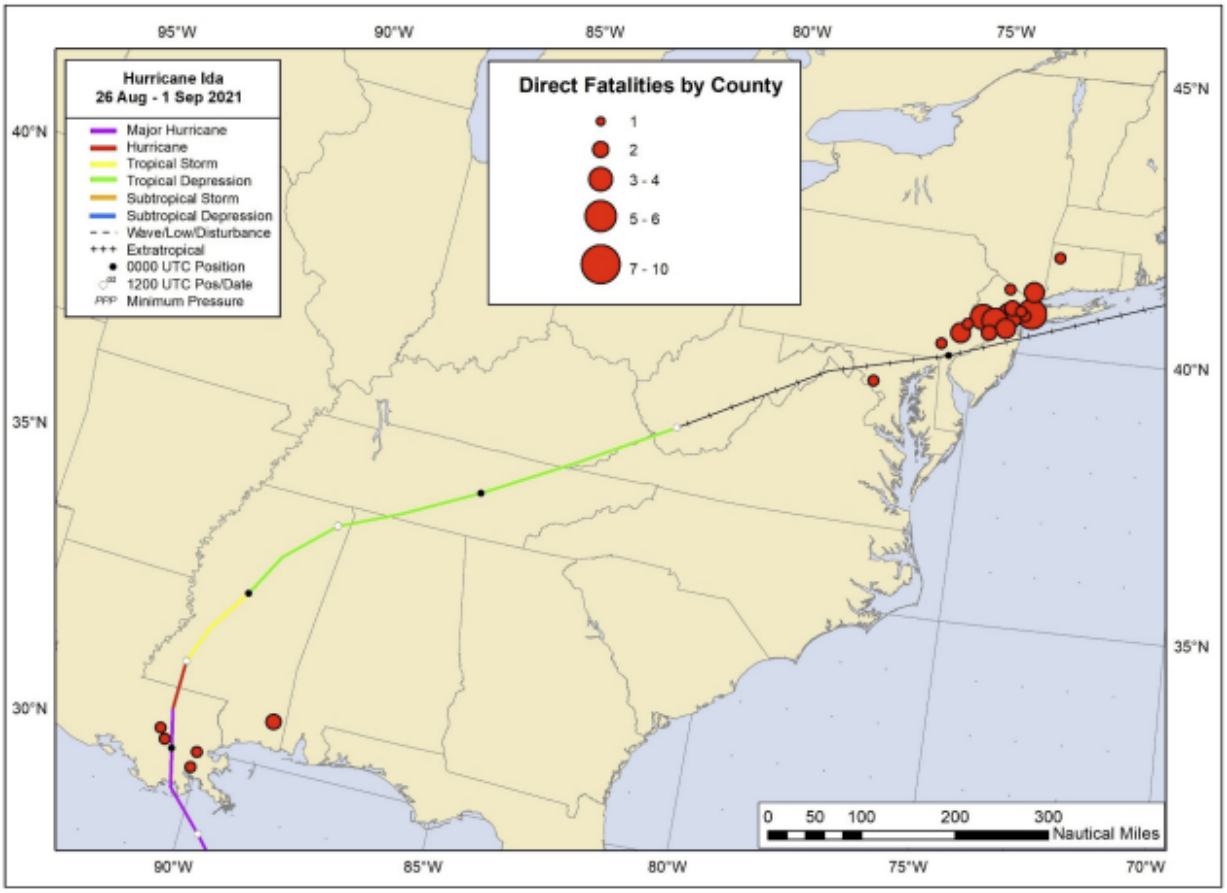


Figure 3: Locations of deaths directly caused by Hurricane Ida, 26 August–1 September 2021.

2.1 Hurricane Ida and Post-Tropical Remnant Rainfall and Flooding

Ida produced widespread heavy rainfall along its track (**Figure 4**)[8]. As a tropical cyclone, Ida produced widespread heavy rains along portions of the northern Gulf coast states northward and eastward into the Tennessee Valley. Rainfall totals of more than 10 inches occurred over portions of southeastern Louisiana, southeastern Mississippi, and southwestern Alabama, with a maximum storm total of 15.04 inches at Ponchatoula, Louisiana, and a storm total of 13.65 inches near Kiln, Mississippi. These rains produced freshwater flooding, especially along the Tangipahoa, Tchefuncte, Tickfaw, and Bogue Falaya Rivers in southeastern Louisiana and the Tchoutacabouffa, Biloxi, Wolf, and Jourdan Rivers in southeastern Mississippi.

[8] Additional detailed tables can be found in the NHC Tropical Cyclone Report for Hurricane Ida.

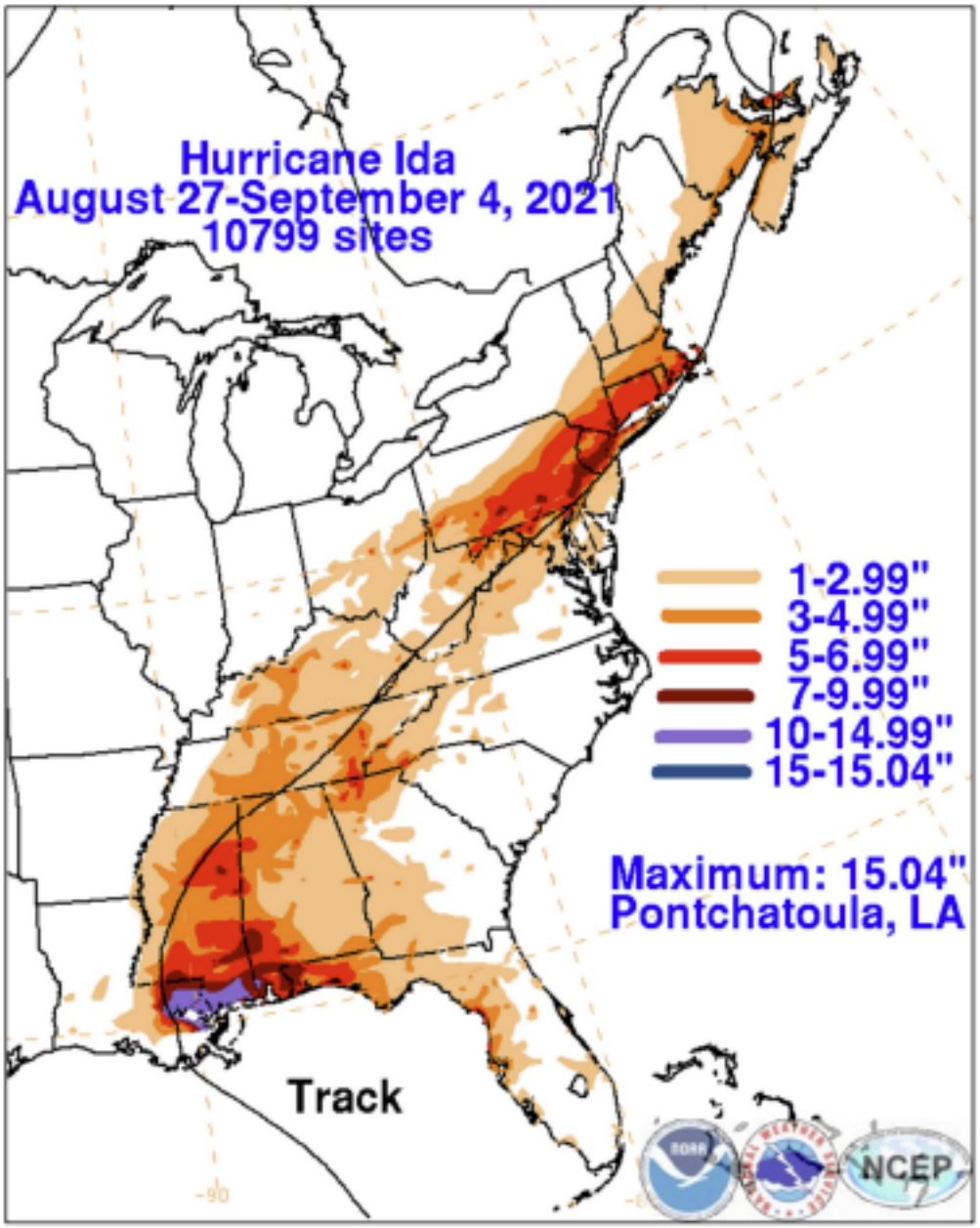


Figure 4: Analysis of storm total rainfall (inches) for Hurricane Ida.

When Ida became extratropical, a swath of heavy rains with local rainfall rates near or above three inches per hour developed north of the center and affected a long area extending from northern West Virginia across western Maryland, southeastern Pennsylvania, northern New Jersey, southeastern New York, Connecticut, and Rhode Island to southeastern Massachusetts, including the New York City metropolitan area[9]. Maximum storm total rainfalls in these areas include 10.10 inches at Downingtown, Pennsylvania, 10.06 inches at Manville, New Jersey, 9.64

[9] Extreme precipitation analysis also available at https://hdsc.nws.noaa.gov/hdsc/files25/202109_Ida.pdf.

inches at Staten Island, New York, 9.22 inches at Uncasville, Connecticut, and 8.16 inches near Frederick, Maryland. The New York City Central Park Automated Surface Observing System (ASOS) reported 3.15 inches of rain between 8:51 p.m. and 9:51 p.m. Eastern Time on Wednesday, September 1. The extreme rainfall rates of three to five inches per hour in portions of northeast New Jersey and the New York City metropolitan area caused major freshwater flooding in these areas, including deadly flash flooding and urban flooding across portions of the New York City metropolitan area and northern New Jersey. Flash flooding in these areas resulted in 13 fatalities, and significant impacts to the mass transit systems (**Figure 5**) in New York City alone.

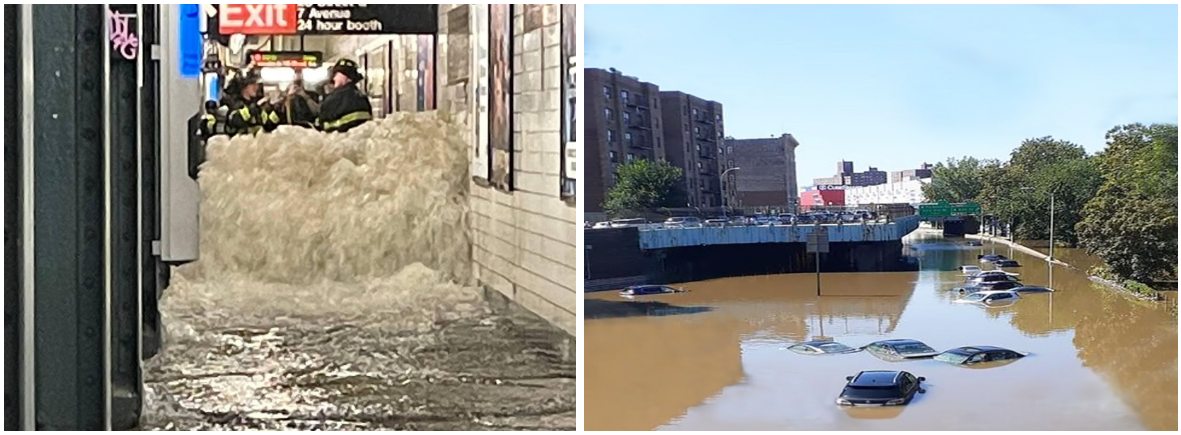


Figure 5: Pictures of flooding in the New York City area. *Left photo from New York Daily News. Right photo from Columbia University "State of the Planet".*

2.2 Hurricane Ida Storm Surge

Ida produced a devastating storm surge that penetrated well inland from the immediate coastline across portions of southeastern Louisiana, including on both the east and west banks of the Mississippi River and bordering portions of Lake Pontchartrain. Storm surge levels were high enough in some locations to overtop local levee systems (**Figure 6**).

Maximum inundation of nine to 14 feet above ground level (AGL) occurred along the east bank of the Mississippi River in Plaquemines Parish, where the United States Geological Survey (USGS) gauges at American Bay near Pointe à la Hache and Black Bay recorded water levels of 11.5 feet above Mean Higher High Water (MHHW) and 11.3 feet above MHHW, respectively (**Table 1**) before falling. Storm surge hindcast shows that water levels of 12 to 14 feet AGL likely occurred against the east bank levee in lower portions of the Parish.

Figure 6: Before (top) and after (bottom) imagery of a part of Grand Isle, Louisiana, showing the damage caused by Hurricane Ida.

Significant flooding occurred on the western side of Lake Pontchartrain due to strong easterly winds pushing water into the lake. In St. John the Baptist Parish, two high water marks of 9.9 feet AGL were surveyed near Frenier Landing, while a high-water mark of 8.8 feet AGL was measured at Ruddock. In Laplace, the highest measured mark was 8.2 feet AGL. The highest mark surveyed in St. Charles Parish was 5.9 feet AGL in Norco, although the storm surge hindcast indicates that water levels as high as 11 feet likely occurred north of town closer to the lake.

Location	Initial Peak Inundation Forecast	Final Peak Inundation Forecast	Estimated Peak Inundation
Plaquemines Parish (East Bank)	7 to 11 ft	8 to 12 ft	9 to 14 ft
Plaquemines Parish (West Bank)	7 to 11 ft	12 to 16 ft	6 to 12 ft
Lafourche Parish	7 to 11 ft	12 to 16 ft	6 to 12 ft
St. Bernard Parish	7 to 11 ft	8 to 12 ft	6 to 11 ft
Terrebonne Parish	7 to 11 ft	8 to 12 ft	3 to 6 ft
Around Lake Pontchartrain	3 to 5 ft	5 to 8 ft	6 to 11 ft
Mississippi	7 to 11 ft (West) 4 to 7 ft (East)	8 to 12 ft (West) 6 to 9 ft (Central) 4 to 7 ft (East)	4 to 7 ft
Alabama	3 to 5 ft	3 to 5 ft	2 to 4 ft

Table 1: Comparisons of initial peak inundation forecast ranges, final peak inundation forecast ranges, and estimated peak inundation ranges at select locations across southeastern Louisiana, Mississippi, and Alabama during Hurricane Ida, 26 August–1 September 2021.

2.3 Tornadoes from Hurricane Ida and its Remnants

Ida produced 35 known tornadoes[10]. As a tropical cyclone, the system produced 24 tornadoes, including two in Louisiana, 13 in Mississippi, seven in Alabama, and two in Virginia. All of the tornadoes were rated EF1 or EF0 on the EF scale. A tornado in Mobile County, Alabama injured three people; otherwise,these tornadoes generally had minor impacts. The tornadoes in Mississippi were concentrated in the coastal counties of Harrison, Hancock, and Jackson, and several of them began as waterspouts that moved onshore.

[10] Table 5 in the NHC Tropical Cyclone Report

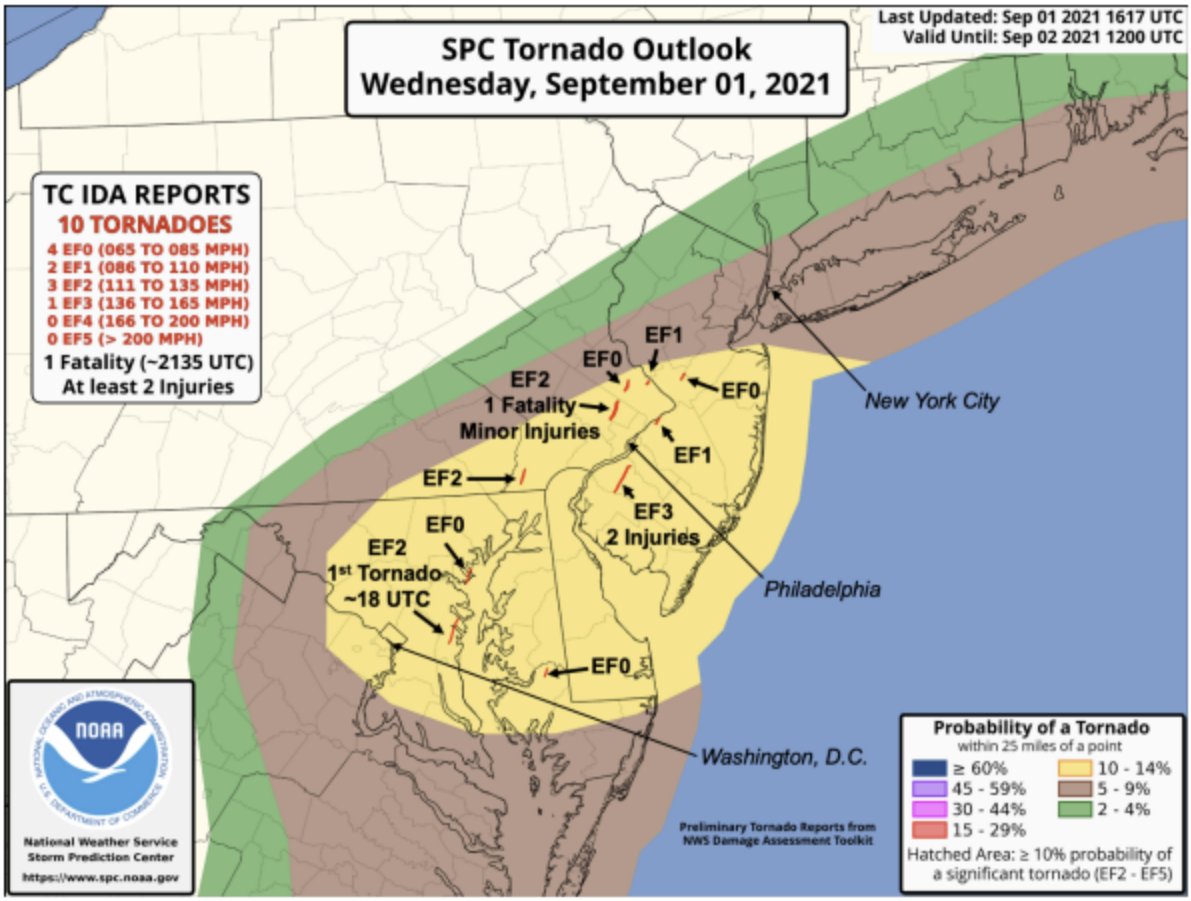


Figure 7: Tornado reports and the forecast probabilities of tornado occurrence on 1 September 2021 as the remnants of Ida moved through the northeastern United States.

Ida produced 11 more tornadoes after it became extratropical. Ten of these occurred in an outbreak across portions of eastern Maryland (three), southeastern Pennsylvania (five), and southern New Jersey (two) on the afternoon of September 1 (**Figure 7**). The strongest of these tornadoes, an EF3, occurred in Gloucester County, New Jersey (**Figure 8**) and caused two injuries.

Figure 8: Gloucester County, New Jersey, tornado on 1 September 2021. *Image courtesy of Anna Weis, @NashWX, and the New Jersey Weather Network*.

An EF2 tornado in Montgomery County, Pennsylvania, caused one fatality and other injuries, and additional EF2 tornadoes occurred in Anne Arundel County, Maryland, and Chester County, Pennsylvania. The last known tornado associated with Ida occurred in Barnstable County, Massachusetts, early on September 2.

3. Facts, Findings, Recommendations, and Best Practices

The Ida Assessment Team focused its work with an emphasis on themes that address the six key areas asked for in the assessment charter:

1. Operations.
2. Systems and Facilities.
3. Service Backup and Mutual Aid.
4. Impact-Based Decision Support Services.
5. Service Equity and Vulnerable Populations.
6. Training and Proficiency.
7. Transportation Services.

The findings, recommendations, and best practices advocated by the Assessment Team follow this organizational structure. Some cross-cut more than one primary theme and others touch all themes.

3.1 Operations

To facilitate consistent messages from different components of the NWS, the agency employed a Collaborative Messaging Process (CMP) to construct a consistent forecast message from National Centers to field units. The CMP ultimately entailed the coordination of key messaging delivered through outlooks, weather headlines, etc. between national centers, ROCs, and field offices. During Ida, the CMP worked very well, even within the Coronavirus disease 2019 (COVID-19) environment. Virtual collaboration tools and methods explored during the COVID-19 pandemic proved beneficial in many areas. However, opportunities exist to improve collaboration, coordination, and messaging across the agency.

3.1.1 Storm Surge Forecasting and Message Collaboration

The NHC communicated a high probability of Ida becoming a dangerous hurricane five days before landfall. This knowledge proved important for operational meteorologists in the field, emergency managers, and other partners. One fatality occurred due to storm surge associated with Hurricane Ida; the frequent and early communication about the storm surge impacts and risk may have led in part to this low fatality rate. On Wednesday, August 25, 2021, the NHC introduced Key Messages (**Figure 9**) that highlighted the potential for dangerous storm surge, wind, and heavy rainfall impacts for Louisiana, Texas, and northern Mexico. These key messages provided members of the public, emergency managers, and other partners information about the storm surge potential 95 hours before landfall.

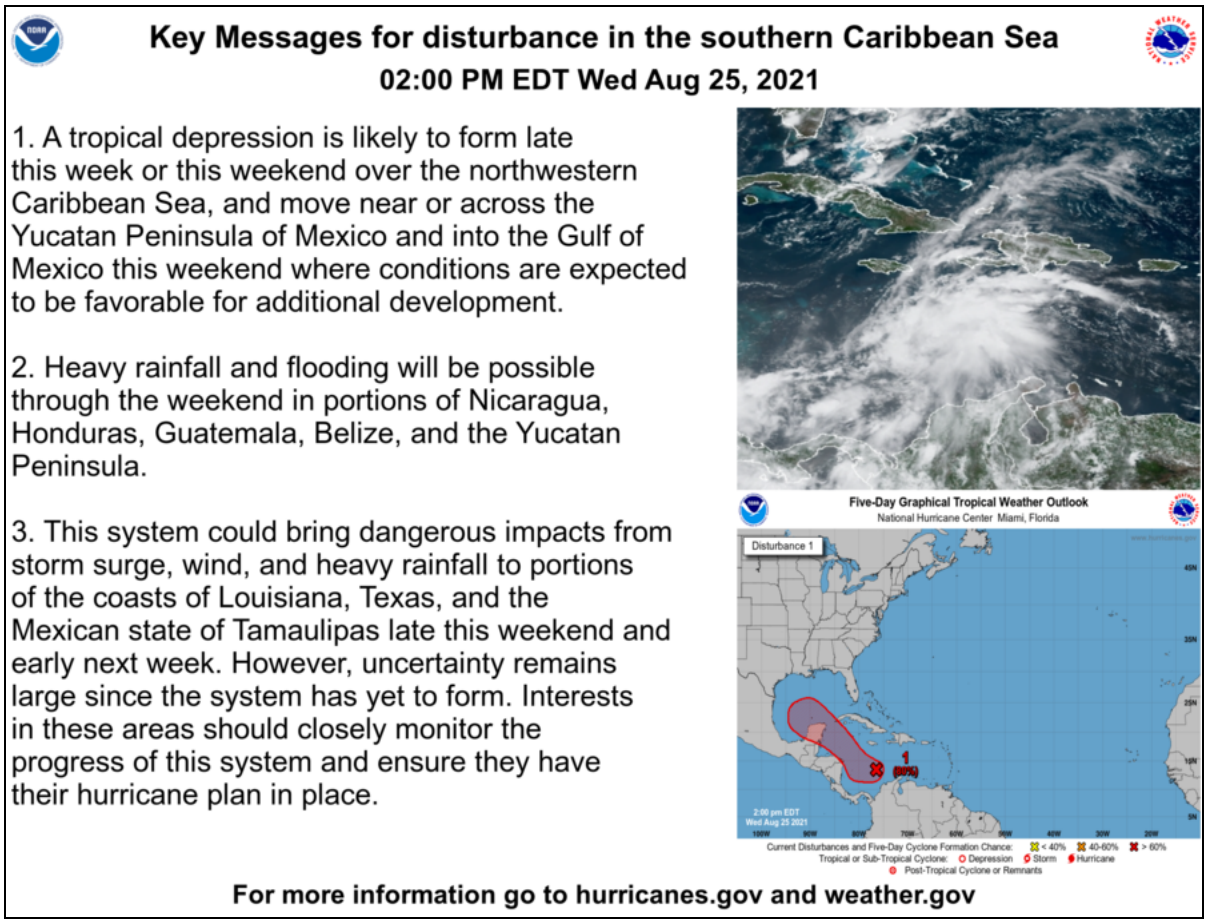


Figure 9: Key Messages introduced on Wednesday, August 25, 2021 highlighting the potential for dangerous storm surge, wind, and heavy rainfall impacts across Louisiana, Texas, and northern Mexico.

As more up-to-date information about the storm surge threat became available, the NHC collaborated with local WFOs to identify areas to include in the Storm Surge Watch and Warning products. Prior to issuing the Storm Surge Warning, both the NHC and WFO New Orleans/Baton Rouge, Louisiana collaborated on the grid points to include in the warning. However, Storm Surge Watch and Warning products use predetermined zones to delineate the area affected, which made this collaboration more challenging, especially for the New Orleans area. WFO New Orleans/Baton Rouge has large zones that do not always align well with the collaborated grid points for a zone-based dissemination. Zone-based dissemination led to issues with alerting, as the product itself did not contain polygon coordinates that could give a more precise alerting mechanism.

Fact: Storm surge products are grid-based. Collaboration of the Storm Surge Watch and Warning products occurs via grid exchange with consideration of associated break points and zones included in the coordination process. The Storm Surge Warning grid frequently does not cover an entire zone especially if the zone contains leveed areas. However, the zones included in the Hurricane Local Watch/Warning Product (TCV) drive dissemination and notifications, including WEA, and those zones have less precision than the associated grids.

Finding 1: Zone-based Storm Surge Warnings made messaging difficult due to the fact that zones around Orleans and Jefferson Parishes contained both leveed and unleveed areas.

Recommendation 1: NWS should place additional emphasis on ongoing work to convert Storm Surge Warnings from grids overlaid into predetermined zones to products that use the gridded information to generate polygon coordinates that delineate the area in the resulting text product. If not possible, NWS should continue its efforts to refine zones in areas prone to surge to improve the efficacy of these products.

Interviews with the US Army Corps of Engineers (USACE), Orleans Parish Emergency Management, and Louisiana GOHSEP indicated they had considered external input for the potential of storm surge flooding, as well as what NWS had previously issued, prior to conducting a briefing with the Louisiana Governor. Around the same time of this briefing, the NHC attempted to coordinate information about the Storm Surge Warning with these partners but could not get ahold of key individuals with these groups in a timely fashion to coordinate the update. The NHC then issued a Storm Surge Warning that, when issued, alerted for areas both outside and inside the New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS). However, no storm surge flooding occurred inside the New Orleans HSDRRS. This led to a situation with inconsistencies between the Governor's briefing and the new Storm Surge Warning. Partners indicated they would have preferred the heads-up of the pending change and the chance to share their perspectives and local considerations for the pending warning decision and consider other inputs into the decision (including storm surge modeling provided by Louisiana State University), prior to warning issuance.

Fact: The NHC attempted to coordinate information about the pending Storm Surge Warning with key local Core Partners at the USACE, Orleans Parish Emergency Management, and Louisiana GOHSEP but were not able to get in contact with key individuals in a timely fashion.

Fact: Partners indicated they would have preferred the heads-up of the pending Storm Surge Warning issuance, and the chance to provide input for the pending warning decision and consider other inputs into the decision (including storm surge modeling provided by Louisiana State University), prior to warning issuance.

Fact: The NHC issued a Storm Surge Warning that, when issued, alerted for areas both outside and inside the New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS). However, no storm surge flooding occurred inside the New Orleans HSDRRS.

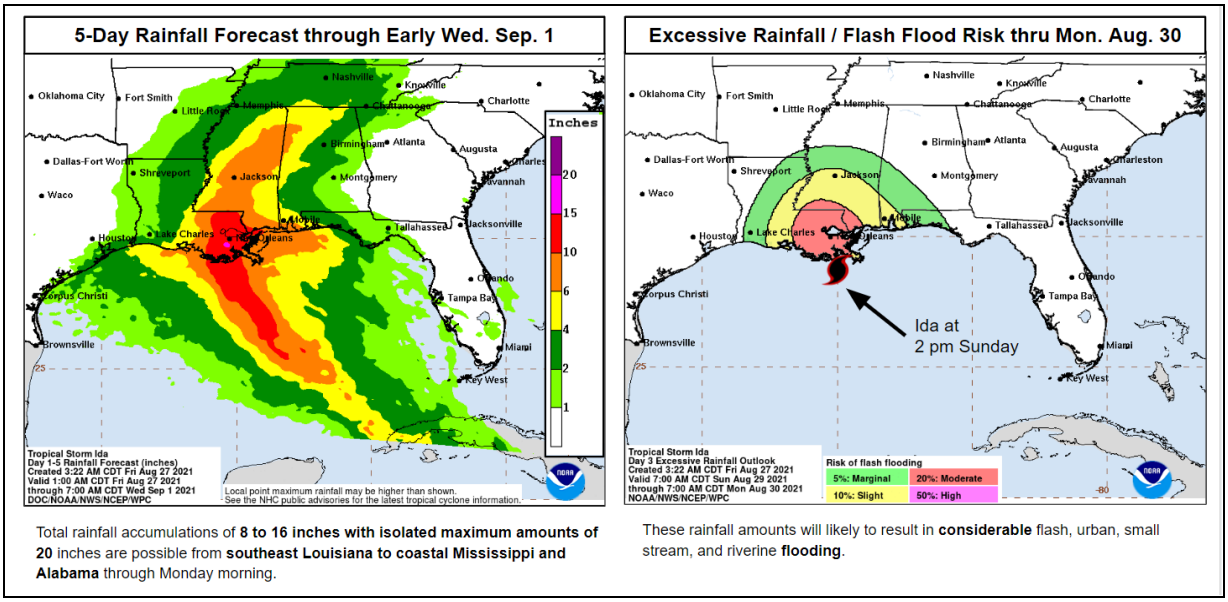
Fact: Louisiana State and Parish officials did not take any action on the NWS Storm Surge Warning that alerted for areas inside the New Orleans HSDRRS, as they used other information, from the Louisiana State University storm surge model, stating there was no risk of storm surge flooding in those areas.

Finding 2: NWS had a less than desired response from Core Partners, to the urgency of a Storm Surge Warning that alerted for areas inside the New Orleans HSDRRS. Had the storm evolved even slightly differently, it could have resulted in a heightened threat for flooding in these areas, potentially leading to a disastrous result.

Recommendation 2: The NHC and WFO New Orleans/Baton Rouge should develop a more comprehensive collaboration mechanism that would be used before issuing a Storm Surge Warning that affects areas inside the New Orleans HSDRRS. This mechanism should include a deep bench of contacts from the State of Louisiana GOHSEP, the USACE , and others as appropriate. These partners can provide their perspectives on the likelihood of storm surge flooding in these areas and share local impact considerations. Inclusion of these partners, before the NHC makes the final warning decision, ensures a consistent Integrated Warning Team (IWT) approach. Tabletop exercises should be conducted at least annually to strengthen this collaboration, establish depth in the chains of contact, and build in the importance of these relationships into the warning process.

3.1.2 Messaging Abnormally High Impact Flooding, High-End Tornado Potential

Ida brought flooding and severe weather impacts to both the Gulf Coast and the Northeast. SPC first mentioned the potential for severe weather along the Gulf Coast in their Day 5 Outlook, issued on August 25. This was followed by the first mention of the potential for tornadoes and other severe weather on August 28. Similarly, the WPC messaged that the New Orleans area was in a 'Moderate Risk' area on the Excessive Rainfall Outlook (ERO) 36 hours before the first Flash Flood Warnings were issued for New Orleans (**Figure 10**). WFOs, RFCs, CWSUs, and ROCs used this information to amplify messaging to partners and the public as much as five to seven days in advance.



Total rainfall accumulations of **8 to 16 inches with isolated maximum amounts of 20** inches are possible from **southeast Louisiana to coastal Mississippi and Alabama** through Monday morning.

These rainfall amounts will likely to result in **considerable** flash, urban, small stream, and riverine **flooding**.

Figure 10: Rainfall forecasts and flood potential messaged to partners on August 27, 2021.

After impacting the New Orleans area, and other Gulf Coast states, Hurricane Ida moved toward the Northeast, and caused both flooding and severe weather impacts for the region. The SPC introduced a 'Marginal Risk' on the Day 3 Convective Outlook on August 30. The SPC updated to a 'Slight Risk' on the Day 2 Convective Outlook on August 31, and then updated to an 'Enhanced Risk' later that day. SPC's update marked the first time a Day 2 Convective Outlook upgrade to 'Enhanced Risk' has occurred for a tornado-driven event from a tropical cyclone since SPC added the Enhanced Risk Category in October 2014. Both the WFOs and the SPC identified this as a successful designation and collaboration; these offices spent over an hour coordinating the messaging for this tornado event before making the decision to include an 'Enhanced Risk' on the Day 2 Convective Outlook.

After Ida's landfall along the Gulf Coast, WFOs and the WPC worked to heighten awareness as Ida moved inland. WFO New York highlighted the potential for four to six inches of rainfall across the New York metropolitan area the day prior to the event. WPC staff used FEMA briefings, social media, and other mediums to continue messaging the threat of flash flooding impacts for the Northeast. Core Partners in the Northeast stated they valued the ERO, because it conveyed probabilities and presented the spatial variability of both the likelihood of occurrence and severity (**Figure 11**).

> **Best Practice:** Core Partners in the Northeast stated that the ERO was a standout product as they felt the product provided valuable context to help them understand the potential magnitude of the event.

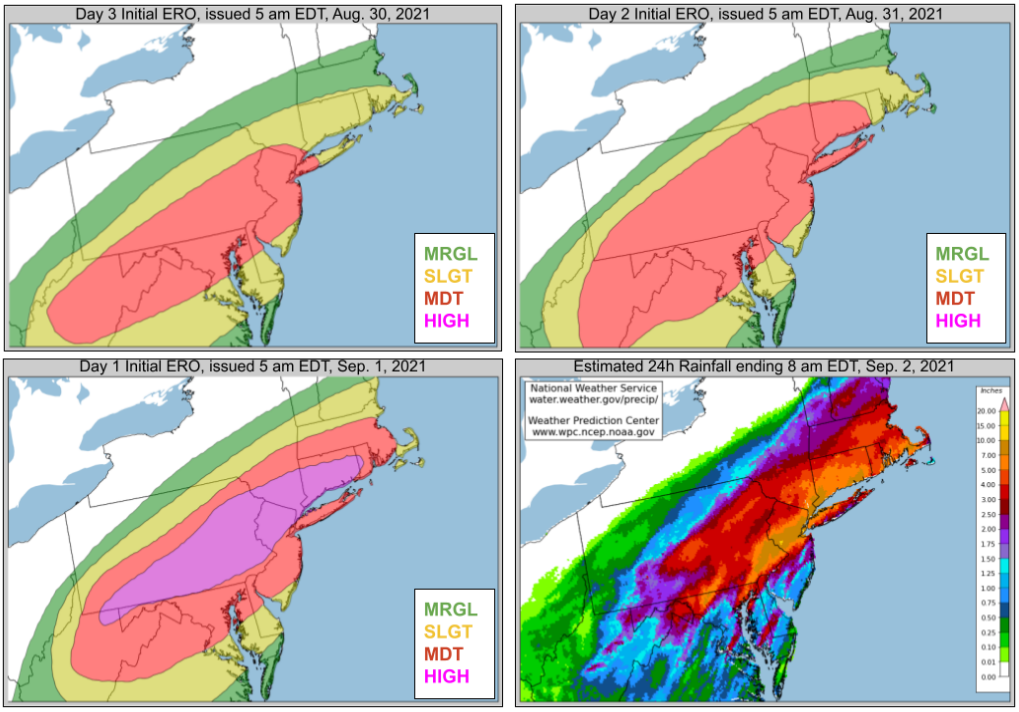


Figure 11: Excessive Rainfall Outlooks leading up to the significant flooding in the Northeast.

In particular, Mesoscale Precipitation Discussion (MPD) #925 mentions for the first time ever "flash flood emergency level rainfall impacts" as a prediction (**Figure 12**). MPD #925 describes the potential extreme impacts as:

> "...Widespread flash flooding is expected, and some of it is likely to be significant and potentially life-threatening given the high rainfall rates and storm total potential. **Flash flood emergency level rainfall impacts** [emphasis added] will be possible as we head into the evening hours, and this will include some of the major cities of the I-95 urban corridor from Philadelphia to New York City along with adjacent suburbia."

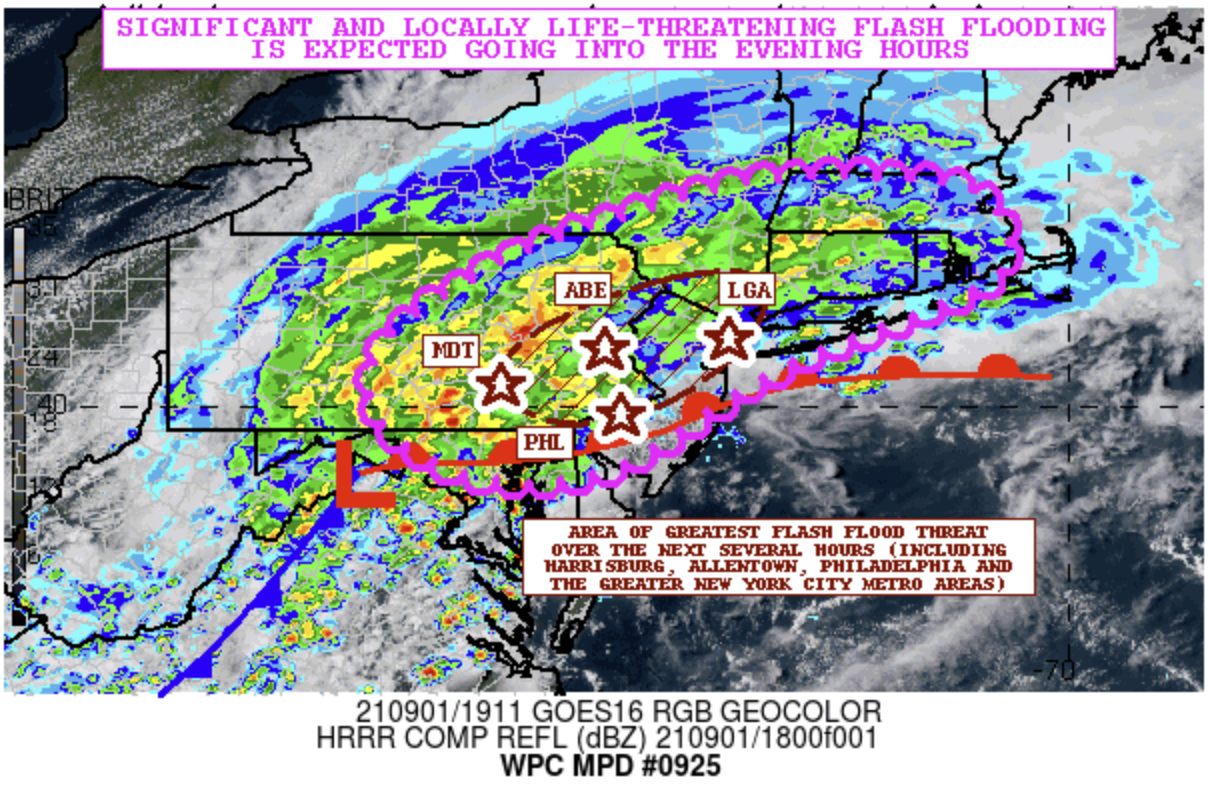


Figure 12: Mesoscale Precipitation Discussion #925.

The WPC wrote this MPD with four to six hours of lead time before WFOs New York and Philadelphia/Mt. Holly issued Flash Flood Emergencies for the New York City and Philadelphia metropolitan areas. The rapid onset of extreme rainfall in the New York City and Philadelphia metropolitan areas led to a shortened response time despite the messaging.

> **Fact:** NWS Flash Flood Warnings issued during this event contained a tag "EXPECTED RAINFALL," which conveyed the forecasted rainfall rate in inches/time during the duration of the warning.

Finding 3: Multiple interviews indicated that some partners did not know how to find rainfall rate forecasts; rainfall rates were a big driver of the impacts and would have helped decision makers. They expressed that rainfall rate information would be a helpful tool for making decisions regarding related impacts.

Recommendation 3: NWS should develop forecast tools, IDSS, and messaging capabilities to communicate not only the expected rainfall, but also the expected hourly rate of rainfall, and a reasonable "worst case scenario" for each of these elements. NWS should also strengthen education and outreach efforts to highlight products which already contain this information.

NYC Emergency Management has reworked their Flash Flood Emergency plan to include tiered action levels. As a result of their new plan, WFO New York will inform the NYC Emergency Management activation level decision via a low, moderate, or high risk of flash flooding messaged by the WFO. Each heightened activation level will increase the New York City agency preparedness and action response. The City of New York, through the Mayor's office, also published a report after Ida detailing the city's response and plans for future changes to their procedures[11].

Finding 4: Flood Watches do not adequately differentiate a high-end life threatening flash flood event from a more typical flash flood event. The overwhelming feedback from EM partners was that they were prepared for river and flash flooding, but had not completely anticipated the severity of impacts.

Recommendation 4: NWS should consider methods to better message the potential severity and impacts of flash flooding within its Flood Watch product. Potential ideas range from the concept of different product labels (e.g. Storm Surge Watch vs Coastal Flood Watch), to the use of an impact based construct with severity tags to mirror the technique used in Flash Flood Warnings.

Fact: WFO New York issued the first Flash Flood Emergencies for the New York City metropolitan area in the area's history.

Finding 5: Some NWS partners expressed a lack of awareness regarding the potential for extreme impacts to occur from flooding into the Northeast.

Recommendation 5a: NWS should encourage local offices to add impacts, reports, and other locally pertinent information to warnings, not just use the boiler-plate template wording, to produce a more detailed message concerning potential impacts in high-end events.

[11] NYC Mayor's report available at https://www.nyc.gov/office-of-the-mayor/news/651-21/mayor-de-blasio-landmark-new-blueprint-combat-extreme-weather.

Recommendation 5b: NWS should routinely update the canned impacts and Call-to-Action statements to ensure forecasters have quick access to vetted statements that will allow them to readily issue watches/warnings and prevent potential errors when working in a high-pressure, short-fused environment.

3.1.3 Fully Integrated Field Structure (FIFS)

Multiple NWS entities have overlapping products and partnerships which work together to create one forecast and consistent message. In many cases, on-site support and/or a singular position can streamline and focus these processes, like the IDSS Coordinator during tropical events. The Assessment Team found a need during Ida for a more coordinated internal agency response, and for role clarity in the provision of IDSS from NWS to external partners. This need existed during the tropical and extratropical phases.

With many incidents, NWS response begins locally and expands out to regional and national offices and centers based on resource needs and/or complexity of response. The NWS Weather-Ready Nation Roadmap (2013) covers the importance of NWS' integration into the National Incident Management System (NIMS), and the use of the Incident Command System (ICS) to manage NWS' internal response to complex IDSS missions. During Hurricane Ida, Southern Region Headquarters used a Regional Response Plan (a variation of an Incident Action Plan (IAP)), within an ICS response, to manage the collective response, messaging, and resources within Southern Region (see Best Practice below). Elsewhere, NWS entities worked to ensure consistency in messaging, but structural, process-based, and organizational issues prevented a more fully unified message. In particular, the lack of role clarity across WFOs, and between WFOs and National Centers, resulted in duplicative efforts when developing IDSS and other messaging. The NWS Operations and Workforce Analysis (2016) White Paper also raises lack of role clarity across local, regional, and national field offices as an organizational challenge.

Best Practice: During Hurricane Ida, Southern Region Headquarters instituted an ICS structure, and developed Regional Action Plans, to coordinate and manage a region-wide response to the storm. Southern Region typically does this for all landfalling hurricanes, and other significant events, through their Regional Operations Center.

Finding 6: The Assessment Team found that NWS faced challenges in role clarity, leading to duplicative efforts from various parts of the agency in IDSS, and difficulty in compiling a unified and consistent message. NWS lacks an organized approach to build capacity to coordinate a common reference point for communications for each situation (including the way in which causative factors for hazards are addressed), as well as a mechanism to ensure role clarity and optimize resources nationally, regionally, and locally, to maximize the provision of IDSS.

Recommendation 6a: NWS should consider leveraging an agency-level ICS response, similar to Southern Region's best practice of a Regional Response Plan, during major land-falling hurricanes, and potentially other large-scale high-impact events. Within this ICS response, the agency should develop and execute IAPs to manage resources, establish role clarity in "who does what," coordinate messaging, and orchestrate IAP execution during defined operational periods. The end result should strengthen a cohesive team effort, and optimize use of agency-wide resources.

Recommendation 6b: NWS Instruction (NWSI) 10-24 on "Impact-based Decision Support Services" should be updated to include new operational entities and clarify the roles of each operational unit with respect to the provision of IDSS and the development and maintenance of partner relationships at the local, regional, and national levels.

Recommendation 6c: As part of an ICS response, and to maximize the effectiveness of IDSS provided to FEMA, NWS should socialize and follow the FEMA regional and national engagement plans that have already been developed by the Change Management Unit[12].

Recommendation 6d: An additional part of the ICS response should include a mental health role into the command structure to focus on employee needs before, during, and after the event.

3.1.4 Transition from Tropical to Post-Tropical

Differences in the messaging around the transition of Hurricane Ida to a post-tropical event created challenges that affected awareness about potential impacts by both partners and the public in the Northeast. While some WFOs and National Centers explained the transition from tropical to post-tropical as "the remnants of Ida," others used different wording to explain the threat. For example, some offices did not use "Ida" in messaging at all, and instead referenced "flooding." In another example, two neighboring WFOs within the same state provided messaging that framed Ida in two different contexts. One office noted Ida as a "Tropical Depression," while the neighboring offices used the phrase, "Remnant of Ida." Technically, all offices used correct nomenclature based on the storm path forecast provided by the NHC. However, the Pennsylvania State Emergency Operations Center (EOC) became confused because they employ a specific response plan for tropical systems, but not for tropical remnants. They interpreted the term "remnant" to imply a lesser impact event compared to a "tropical system." In this case, the impacts from the remnants of Ida far exceeded the impacts of Tropical Depression Ida in many locations. The Assessment Team also found a number of instances where offices framed the flooding threat with different terminology. For example, offices presented a common flood related graphic but defined it as either, "Flooding Rain Threat," "Inland Flooding Impacts," or "Inland Flood Threat."

[12] The Evolve Program Management Office (PMO) was renamed the Change Management Unit (CMU) on October 20, 2022.

Fact: During the inland decay cycle of Ida, NWS offices used different methods to both reference, as well as distribute, information pertaining to hazards associated with Ida. This included differences in the way causative factors for hazards were expressed relative to Ida and its remnants, as well as differences in the way information was distributed on key NWS websites.

Finding 7: The different ways in which Ida was referenced resulted in inconsistencies across NWS messaging and response. References to a tropical system tended to elicit a higher level of response compared to similar hazard communication omitting reference to a tropical system. Moreover, the different levels of information availability among different key NWS web pages created challenges for users to receive this information.

Recommendation 7: ROCs and WPOD should provide internal messaging coordination and support to RFCs and WFOs during high-impact events. This should include the lead-up, duration, and aftermath of the event, and be informed by the operations tempo of the WFOs and RFCs.

Finding 8: Inconsistent messaging during the remnant phase of Ida led to negative impacts to service delivery during the event as local offices used different nomenclatures to reference the system. Some called it “remnants,” others referenced “flooding.”

Recommendation 8: ROCs should collaborate internal key messages with regional field offices. This work would ensure local offices use a coordinated reference to the remnants of a tropical system and support the communication needs of RFCs and WFOs during high-impact events. This should include the lead-up, duration, and aftermath of the event and be informed by the operations tempo of the WFOs and RFCs.

When a tropical event transitions to a post-tropical event, the WPC takes over the responsibility for messaging any potential impacts that may result from the remnants of a tropical system. When this transfer of responsibility occurs, the NHC website no longer contains the Key Message graphics and the WPC’s ERO graphic. This occurred during the post-tropical phase of Ida. NWS has promoted “www.hurricanes.gov” as the one-stop portal for all information related to tropical systems, and this disconnect led to some confusion by Core Partners in finding information about Ida after it transitioned to post-tropical.

Finding 9: Users found it difficult to navigate the NWS web presence to find the post-tropical advisory products for Ida once the transition was made from the NHC to the WPC. The current NWS web and digital presence is heavily steeped in organizational structure, contrary to the philosophy of a FIFS, which would provide information seamlessly regardless of a knowledge of the NWS’ organizational structure.

Recommendation 9a: NWS should use the NHC website as the official source of consistent service delivery regarding tropical cyclones, from development through post-tropical cyclone remnants, for as long as these systems produce hazards affecting areas served by NWS.

Recommendation 9b: WPC should use the same nomenclature as the NHC and should also produce post-tropical advisories until the storm exits areas served by NWS, so long as the storm presents impacts.

3.1.5 Additional Issues Surrounding Tropical Operations

The Assessment Team found that forecasters expressed concern over the complexity of tropical operations and the sustainability of software used to produce tropical products.

Tropical cyclone collaboration and forecast production involves more complex internal and technical processes than other types of weather. Due to this complexity, forecasters found it challenging to train new and existing staff to the highest levels of proficiency needed to effectively work a landfalling tropical event. The Team interviewed a Lead Forecaster who stated that he had to do the tropical grids due to their complex nature and the fact that other staff had not yet developed the experience to do them easily. Had this Lead Forecaster not been at work, the office may have had significant challenges producing these products during his shifts. Section 3.6.2 will elaborate further on this topic.

Staff interviewed also indicated their concerns over the complex nature of the tools used to generate tropical products, and that these tools may not have adequate depth of support, including the AWIPS Network Control Facility (NCF), to address issues in real-time and help troubleshoot and correct issues.

Fact: From the standpoint of technical support, the Team found there were limited primary developers of software used in tropical operations.

Finding 10: The Assessment Team found potential vulnerabilities in sustaining operations driven by technical support concerns, the complex nature of the tropical product suite, and the number of forecasters who have not had time to learn the complicated processes involved in producing the tropical suite of products and IDSS[13].

[13] Finding and Recommendation 66, Finding 81 and Recommendation 81a, and Finding 83 and Recommendation 83 from the Hurricane Florence/Hurricane Michael Service Assessment also identify similar issues to this Finding and Recommendation.

Recommendation 10: NWS should develop concepts for streamlining the tropical cyclone service suite and ensuring adequate support to software used to produce tropical products. These concerns should look for opportunities to:

A. Define and use the FIFS for forecast and IDSS production.
B. Reduce the complexity of processes.
C. Consider a strategic approach to identify dedicated resources needed to provide 24 x 7 support for software used to produce tropical products[14].
D. Deepen the agency resources to develop and provide training to ensure staff proficiency in operations. Concepts of this recommendation are captured in the "Hurricane Supplemental Projects and captured for internal use in an NWS Tropical Roadmap."

3.1.6 Collaboration and Coordination Tools and Procedures

Hurricane Ida required staff across different geographic areas and NWS offices to collaborate on forecasts and messaging. The majority of staff interviewed indicated that coordination and collaboration was successful for Hurricane Ida and cited several examples of effective internal coordination between local offices, RFCs, ROCs, National Centers, WPOD, and NWSOC. One such example of effective collaboration resulted in a decision made to move up the time frame of when a typical issuance of the Hurricane Watch occurs six hours, from 4 am on August 27, to 10 pm on August 26, so that the headlines went out before people went to bed that night. Core Partners interviewed felt this decision led to a more effective response to the warnings which went out later on August 27.

Best Practice: NHC and affected WFOs moved up the typical issuance time of the Hurricane Watch six hours, from 4 am on August 27 to 10 pm on August 26, so the headlines were out before people went to bed that night. The Assessment Team received considerable positive feedback on this decision.

WPC collaboration calls to coordinate the QPF and the ERO served as another great example of effective collaboration. Previous findings from the Hurricanes Florence and Michael Service Assessment indicate the timing of QPF collaboration calls between WFOs and the WPC occurred late in the WFO forecast creation process. The Assessment Team did not find any evidence this happened during Ida.

Some staff provided feedback to improve collaboration calls in general. They noted that collaboration calls during Ida were long and included information that did not always apply to the entire group of stakeholders. They noted shorter calls involving smaller geographical areas of offices would help alleviate duration and content concerns.

[14] This bullet is similar to Recommendation 69a from the Hurricane Florence/Hurricane Michael Service Assessment.

Beyond the concerns around the length and scope of the collaboration calls, a majority of WFO staff interviewed indicated collaborations are, “the best [they] have ever been.” Staff that made this statement emphasized Google Meet® as the reason for improved collaboration. One meteorologist interviewed explained, “Google Meet® allows us to actively participate and engage in the call, as well as view their screen in real-time.” Other forecasters highlighted the use of Google Chat™ Rooms and internal Google Docs™ as important collaboration tools. They explained they primarily used these tools to maintain a timeline of events during Hurricane Ida and collaborate messaging with staff from other offices and on other shifts.

Fact: Google Meet®, Google Chat™ Rooms, and internal Google Docs™ proved highly effective for forecast collaboration purposes.

Finding 11: Forecasters noted collaboration calls during Ida were long and included information that did not always apply to the entire group of stakeholders. They noted that, if possible, shorter calls involving smaller geographical areas of offices would help alleviate duration and content concerns.

Recommendation 11: NWS should investigate the possibility of shorter, more geographically focused, collaboration calls to alleviate concerns over call length and scope. This investigation should consider how NWS can optimize technology to alleviate workload concerns, and focus on narrowing collaboration to smaller groups of affected internal parties, in lieu of one process that involves a larger all-encompassing group of all internal parties. ROCs, NWSOC, WPOD, and National Centers should play a role in investigating this idea.

3.1.7 Importance of the National Centers

As Core Partners began to plan for Hurricane Ida, the medium-range time period (Day 3-7) became critical for making important preparation decisions. WFOs used output from the National Centers ahead of providing local IDSS about the possible impacts to their local communities. National partners rely on the National Centers for IDSS as well.

The majority of WFO forecasters and local level partners interviewed by the Assessment Team found the medium-range forecasts provided by National Centers during Hurricane Ida useful and important.

In 2018, the WPC assumed responsibility for the Day 3-7 Hazards Outlook from the Climate Prediction Center (CPC). WPC staff brought up one opportunity for improvement surrounding the product. WPC staff expressed concern that the lack of outlooks issued over the weekend of August 28-29, 2021 may have caused communication challenges during Hurricane Ida, as extreme rainfall from the remnants of the tropical cyclone threatened the Northeast U.S. However, the Assessment Team did not find any mention of this lack of coverage by local WFOs or partners impacted by the remnants of Hurricane Ida.

3.2 Systems and Facilities

3.2.1 AWIPS

NWS relies on the Advanced Weather Interactive Processing System (AWIPS) and related support services to integrate all data with imagery which helps forecasters prepare and issue more accurate and timely forecasts and warnings. The NCF serves as one of the support services and acts as the AWIPS communication and help desk hub. Its staff supports offices to ensure AWIPS functions well. The NCF used a ticketing system that appeared to function properly as designed. The Assessment Team noted continuity and thorough understanding as the main issues affecting offices during Ida.

NCF staff rely completely on the notes in their tickets to understand an issue and its complexity. Even on the same shift, a phone call to the NCF may reach a different employee who does not have continuity with unique issues prior personnel worked to address. Changes in personnel between shifts, and lack of continuity on specific issues raised by WFOs, created challenges during Hurricane Ida, particularly with regard to support of issues at WFO New Orleans/Baton Rouge and the Lower Mississippi RFC (LMRFC). As an example, prior to Hurricane Ida's landfall, a data table discrepancy in Hazard Services[15] resulted in an AWIPS drive quickly filling to capacity. As a result, multiple processing interruptions in AWIPS occurred at WFO New Orleans/Baton Rouge, essentially eliminating the ability to disseminate Flash Flood Warnings. The WFO invoked partial service backup for short-fused products at least twice because of the issue. The same problem also affected WFO Lake Charles while providing service backup for WFO New Orleans/Baton Rouge later in the event. As a result, WFO Lake Charles passed short-fused warning backup responsibility to WFO Mobile at least twice (once for over six hours) so their data table could be fixed.

Finding 12: The involvement of multiple support teams slowed the identification of the data table discrepancy issue,[16] and affected the ability of NCF and the WFOs' technical staff to support WFO New Orleans/Baton Rouge operations.

Recommendation 12: During a major landfalling hurricane, the AWIPS program should explore providing dedicated personnel to support individual offices affected by the storm's landfall. This approach would help quickly resolve recurring issues and/or document more efficient troubleshooting processes. This could be a team of individuals large enough to support the impacted offices 24 x 7 and/or improved documentation which would enable efficient troubleshooting of systems processes, a clearer understanding of efforts already tried, and thus quicker resolution to problems that interfere with operations.

[15] Hazard Services is a multi-year, multi-phase effort involving many project partners to produce a powerful software package that modernizes how the NWS generates hazardous weather products. For more information, see https://esrl.noaa.gov/gsd/eds/hazardservices/.

[16] This problem has occurred periodically since the switch to Hazard Services. As of the time of this assessment's publication, the precise issue causing it has not been identified and there continues to be delays in resolving it; multiple offices have suffered the same issue during similar events, most recently during Hurricane Ian.

Hurricane Ida disrupted telecommunications and power systems, especially at landfall in Louisiana. WFO New Orleans/Baton Rouge and the LMRFC adjusted to these challenges dynamically, utilizing the AWIPS Virtual Private Network (VPN) capability to work from alternate or remote locations when systems failed at the facility. The AWIPS VPN allowed staff to continue meeting the NWS mission from these locations.

Leaning forward and enhancing Mutual Aid capabilities, field offices could benefit from the ability to conduct operations from alternate or remote locations with stable power and internet connectivity. In addition to speeding up the resumption of critical services, the flexibility to connect from these locations would allow staff to resume or continue operations from a safe location.

Fact: Use of the AWIPS VPN enabled Mutual Aid for the LMRFC, such that hydrologists were able to remotely run models and prepare products and services, using government furnished laptops.

Finding 13a: Remote operating capacity was necessary to support efficient mission-critical service delivery when technical disruptions (e.g., power and internet outage) occurred at the NWS facility from Hurricane Ida's impacts.

Finding 13b: The Assessment Team found that the procedure for accessing the AWIPS VPN may not be sustainable.

Recommendation 13: To enhance Continuity of Operations and serve as a bridge between current and future backup capabilities, NWS should investigate developing necessary policy and procedures for remote access to operational systems within the agency.

3.2.2 Dissemination

Effective provision of IDSS requires reliable internet access. Local NWS offices rely on the internet to produce IDSS materials such as DSS packets, briefings, and email blasts to Core Partners. They also use the internet to host webinars and conduct live one-to-many DSS briefings.

The Assessment Team found commodity internet access as important to the completion of the NWS mission as the AWIPS Wide Area Network (WAN) is to disseminating life-saving warnings. The lack of reliable, consistent internet access, to include sufficient bandwidth, would have led to mission failure during Ida if not for extraordinary measures taken by staff at WFO New Orleans/Baton Rouge and the LMRFC. WFO New Orleans/Baton Rouge and the LMRFC sent people to telework from a forecaster’s home, where they had reliable commodity internet, to provide IDSS.

Prior to the landfall of Hurricane Ida, internet access failed at multiple Southern Region offices including WFO New Orleans/Baton Rouge and the LMRFC. This led to difficulties in establishing service backup and Mutual Aid. Southern Region's network configuration presented a vulnerability and mission risk to these offices compared to peer offices in other Regions.

Fact: NWS Southern Region had a different configuration for internet access than the other CONUS regions. This different configuration was developed, and is maintained, nationally.

Fact: Southern Region experienced frequent and debilitating region-wide internet outages for about 24-36 hours (Friday, August 27 through the evening of August 28). These impacts occurred 18-48 hours prior to landfall, a critical communications timeframe for tropical events. SR offices had noticed infrequent internet and VPN dropouts across the region in the weeks prior to Ida. These dropouts would last for a minute and occur once or twice a day.

Fact: WFO New Orleans/Baton Rouge and the LMRFC sent people to telework from a forecaster's home, where they had reliable commodity internet, to provide IDSS.

Fact: Southern Region CWSUs reported unreliable internet bandwidth during Ida. They also stated this occurs routinely, which makes it difficult, or impossible, to post required IDSS products for the FAA.

Fact: After Hurricane Ida, in late 2022, the Office of Dissemination and the NCEP Central Operations (NCO) stood up a project to make Southern Region's network match the rest of the NWS CONUS network.

Finding 14: The network setup in Southern Region caused critical failure of systems (i.e., mission failure), for offices affected by Ida, and those who normally provide service backup and/or Mutual Aid to those offices, requiring significant workarounds.

Recommendation 14: NWS should expedite the existing project stood up by the Office of Dissemination and NCO to implement a consistent solution for internet connectivity in Southern Region.

3.2.3 Troubleshooting and Restoration of Failed/Degraded Systems

Quick recovery of failed systems and networks helps the agency restore the highest level of service. As outlined in Recommendation 6a, ICS can also help improve role clarity and response time to critical system issues. NWS should utilize the ICS structure for systems and facilities by assigning roles to individuals in the Logistics Section to take the lead for troubleshooting and resolving issues. Clarity on roles and responsibilities would mean less time wasted by multiple people doing redundant work and increases overall efficiency of operations.

Fact: Several NWS offices reported investing significant amounts of time investigating, troubleshooting, and reporting issues to the NCO, the NCF, and the ROCs. There were at least three operational entities all working to report and/or troubleshoot IT challenges that local offices reported took time away from IDSS, warnings, and other operational duties.

Finding 15: NWS offices needed a better framework to establish clear roles and responsibilities for troubleshooting and restoring critical systems.

Recommendation 15: NWS should consider using the Logistics Section of the ICS structure (Recommendation 6a) to streamline the troubleshooting of IT and maintenance challenges. The Logistics Section could be a facilitator for ensuring each office has dedicated resources to resolving these challenges and coordinate Mutual Aid to accomplish maintenance and IT support.

3.3 Service Backup and Mutual Aid

Through its Regional Response Plan, SRH coordinated the use of Mutual Aid and service backup. Due to the extended loss of power and communications, WFOs Jacksonville, Lake Charles, and Mobile provided backup to WFO New Orleans/Baton Rouge for about a week. The LMRFC used a combination of service backup from the NWC and remote work capabilities developed during the COVID-19 pandemic to facilitate RFC operations. Offices in the Northeast used Mutual Aid from the Supplemental Assistance Volunteer Initiative (SAVI) for social media and Multimedia Assistance in Spanish (MAS) programs.

The risk of service delivery failures increases during tropical events, especially for offices along coastlines. Loss of communications or other critical infrastructure makes Mutual Aid a necessary resource for service delivery. Mutual Aid also helps to support and protect staff members and their families during these events.

During Hurricane Ida's landfall and its remnant phases, the constructs of Mutual Aid went beyond operations and into administrative support as well.

3.3.1 Mutual Aid Flexibilities

Adaptation to mandatory telework during the COVID-19 pandemic opened new technological possibilities for conducting operational and support activities at NWS offices, particularly at RFCs. From off-site locations, RFC staff leveraged hardware acquisitions and the AWIPS VPN to access modeling systems both at the RFC and at the backup servers at the NWC. The LMRFC also enlisted help from NWS hydrologists in other offices to assist in performing operational duties. WFOs completed messaging and IDSS work from remote locations as well.

Interviews with WFOs revealed that during Hurricane Ida, some field managers expressed uncertainty when deciding what operational duties they could assign for staff to complete

remotely. The lack of specific guidance and policies surrounding these capabilities created confusion on what response options WFO New Orleans/Baton Rouge and the LMRFC could use when power and communications failed at the facility. More specific guidance and policy work would have helped these offices navigate the best ways to balance in-office and remote capabilities when responding to an event that impacts the primary facility.

Finding 16: Local offices did not fully understand the policy or capacity for providing various services remotely (e.g., social media, local storm reports) which led to inconsistent resource usage across offices and regions.

Recommendation 16: NWS should establish guidance, by office type, on what operational services employees can provide from a remote location.

Existing Mutual Aid programs such as the Remote Mesoscale Analysis (RMA), SAVI, and MAS, have proven the utility of harnessing subject matter experts (SMEs) from across the agency to help local offices during high-impact events. Several NWS offices used these programs to enhance specific service areas during Ida. The Assessment Team also noted the Southern Region ROC used Mutual Aid via temporary duty assignments, which they do routinely, to expand their capacity. This Service Assessment recommends NWS consider an expansion of this construct below, as well as in Section 3.5 , and that NWS investigate a more liberal use of Mutual Aid as a means of leveraging full agency capabilities to enhance IDSS and service equity. Expanded use of Mutual Aid could go beyond individual programs and expand the construct to one where offices working a high-impact event have access to, and routinely use, a continuously available resource of backup and support across operational, administrative, and maintenance programs. This would enable the agency to also address Finding 20 which details the results of interviews with Core Partners indicating their desire for more routine and on-demand IDSS. Mutual Aid would also help offices focus on duties that maximize the importance of their local community presence. Had expanded Mutual Aid been used during Ida, offices could have used resources freed up by Mutual Aid to expand DSS deployments, alleviate stress and workload in the offices, and provide more on-the-job training to less experienced staff.

Finding 17a: Pre-existing Mutual Aid efforts served as examples of an overarching construct of using resources across the agency to assist in the provision of services and support.

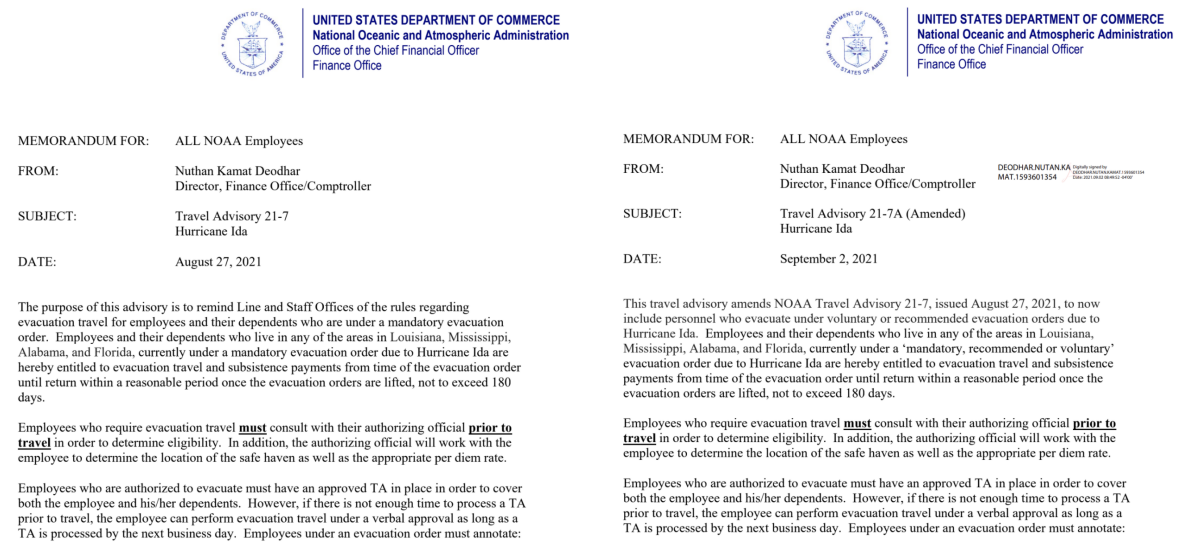
Finding 17b: Mutual Aid and service backup remain vital components for accomplishing the NWS mission, particularly when events cripple the infrastructure near an NWS facility, and also to provide additional capacity for an office working a high-impact event.

Recommendation 17: NWS should investigate using expanded Mutual Aid opportunities for operations, administrative support, and maintenance activities. This expansion could follow a similar construct to how pre-existing Mutual Aid efforts (e.g., RMA, SAVI, MAS) developed in the agency.

3.3.2 Administrative Processes

The Assessment Team found negative effects from administrative guidance issued during Hurricane Ida's landfall. Variances in this guidance, as compared to prior hurricanes, caused confusion and stress for LMRFC staff asked to deploy for service backup at the NWC.

In the first NOAA Travel Advisory issued August 27 (**Figure 13**), the statement applied to, "employees and their dependents who live in any of the areas in Louisiana, Mississippi, Alabama, and Florida, currently under a mandatory evacuation order due to Hurricane Ida are hereby entitled to evacuation travel and subsistence payments from time of the evacuation order until return…." The second NOAA Travel Advisory, issued six days later, modified this wording to phrasing more consistent with some prior hurricanes, and uses the specific wording of, "currently under a 'mandatory, recommended or voluntary' evacuation order…." The initial Travel Advisory led to confusion for employee entitlements when some did not live in areas under a "mandatory" evacuation order at that time. Prior NOAA advisories have typically used wording more consistent with the amended advisory issued on September 2, 2021.



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of the Chief Financial Officer
Finance Office

MEMORANDUM FOR: ALL NOAA Employees

FROM: Nuthan Kamat Deodhar
Director, Finance Office/Comptroller

SUBJECT: Travel Advisory 21-7
Hurricane Ida

DATE: August 27, 2021

The purpose of this advisory is to remind Line and Staff Offices of the rules regarding evacuation travel for employees and their dependents who are under a mandatory evacuation order. Employees and their dependents who live in any of the areas in Louisiana, Mississippi, Alabama, and Florida, currently under a mandatory evacuation order due to Hurricane Ida are hereby entitled to evacuation travel and subsistence payments from time of the evacuation order until return within a reasonable period once the evacuation orders are lifted, not to exceed 180 days.

Employees who require evacuation travel **must** consult with their authorizing official **prior to travel** in order to determine eligibility. In addition, the authorizing official will work with the employee to determine the location of the safe haven as well as the appropriate per diem rate.

Employees who are authorized to evacuate must have an approved TA in place in order to cover both the employee and his/her dependents. However, if there is not enough time to process a TA prior to travel, the employee can perform evacuation travel under a verbal approval as long as a TA is processed by the next business day. Employees under an evacuation order must annotate:

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of the Chief Financial Officer
Finance Office

MEMORANDUM FOR: ALL NOAA Employees

FROM: Nuthan Kamat Deodhar
Director, Finance Office/Comptroller
DEODHAR.NUTAN.KA MAT.1593601354

SUBJECT: Travel Advisory 21-7A (Amended)
Hurricane Ida

DATE: September 2, 2021

This travel advisory amends NOAA Travel Advisory 21-7, issued August 27, 2021, to now include personnel who evacuate under voluntary or recommended evacuation orders due to Hurricane Ida. Employees and their dependents who live in any of the areas in Louisiana, Mississippi, Alabama, and Florida, currently under a 'mandatory, recommended or voluntary' evacuation order due to Hurricane Ida are hereby entitled to evacuation travel and subsistence payments from time of the evacuation order until return within a reasonable period once the evacuation orders are lifted, not to exceed 180 days.

Employees who require evacuation travel **must** consult with their authorizing official **prior to travel** in order to determine eligibility. In addition, the authorizing official will work with the employee to determine the location of the safe haven as well as the appropriate per diem rate.

Employees who are authorized to evacuate must have an approved TA in place in order to cover both the employee and his/her dependents. However, if there is not enough time to process a TA prior to travel, the employee can perform evacuation travel under a verbal approval as long as a TA is processed by the next business day. Employees under an evacuation order must annotate:

Figure 13: NOAA Travel Advisory from August 27, 2021 and amended Advisory issued September 2, 2021.

Fact: The first NOAA Travel Advisory, issued August 27, 2021, contained wording regarding "mandatory evacuation orders," which employees at the LMRFC felt restricted their ability to plan, activate, and deploy for service backup operations at the NWC. Those with families felt they were not able to leave dependents behind nor take them along.

Fact: A review of the 2017 Hurricane Harvey Assessment finds the same issue in Finding 3, "WFO staff members and their families incurred a financial burden as a result of limitations in NOAA evacuation pay policies. NOAA's evacuation policies were also inconsistent throughout the course of the season, impacting employee morale." This generated Recommendation 3 which was marked "closed" in August 2020, but the action taken did not resolve the larger issue.

Fact: The Hurricane Florence/Hurricane Michael Service Assessment includes a four-part recommendation on the complexity of the administrative processes for storms. The Ida Service Assessment Team found a similar finding:

- "Finding 56: The process for making emergency purchases in the NWS is complicated. The rules are unclear, they lack flexibility, and each purchase has a long approval process.
- Recommendation 56a: The NWS should determine if NWS Directive NWSI 1-208 goes far enough in providing sufficient, flexible, and consistent guidance for emergency purchases and procurement of lodging for WFO employees during tropical events.
- Recommendation 56b: The NWS should provide an annual review of administrative processes, guided by NWS Directive NWSI 1-208, that FMCs and WFO leadership should follow in emergencies.
- Recommendation 56c: The Chief Financial Officer (CFO), in conjunction with appropriate finance offices, should develop a "deployment ready" team to promptly support the Financial Management Centers during emergency procurement and evacuation decisions, ensuring that senior officials can maintain employees' safety during a high impact tropical event.
- Recommendation 56d: The NWS should reach out to other federal agencies to gather best practices for handling administrative policies, practices, and procedures in emergencies."

Finding 18: The administrative guidance provided by NOAA for evacuation was different, and perceived by employees as more restrictive, for Hurricane Ida as compared to Hurricane Irma. Similar issues are also noted with Hurricanes Harvey, Florence, and Michael.

Recommendation 18a: NWS should reopen Recommendation 3 from the Hurricane Harvey Service Assessment, "NWS CFO should work with NOAA to clarify, clearly communicate, and ensure a consistent application of the evacuation pay policies for employees and dependents before high-impact events," and ensure continued work on Recommendations 56a-d in the Hurricane Florence/Hurricane Michael Service Assessment.

Recommendation 18b: Within an ICS managed structure (Recommendation 6a), NWS should consider having an agency “Finance/Admin Section” which can quickly help to resolve administrative questions and thus better enable field offices to provide services.

3.3.3 Backup Operations

Despite challenges posed by systems issues documented in Section 3.2, several WFOs used existing backup capabilities to assist WFO New Orleans/Baton Rouge in the aftermath of Ida’s landfall. Elsewhere across the NWS, WFOs did not require service backup beyond short periods of Mutual Aid. Some offices worked from remote locations to complete operations; Recommendation 16 addresses the policy issues surrounding this particular approach.

Best Practice: WFO New Orleans/Baton Rouge used Mutual Aid with partial service backup from WFO Jacksonville for aviation services, starting at 7 pm Central Daylight Time (CDT) on August 27. Four separate WFOs successfully were able to divide and continue New Orleans/Baton Rouge's operations (Grids, Aviation, IDSS) for extended periods, even during very active portions of the event.

Best Practice: The LMRFC used self-backup capabilities afforded by technology advances developed during the COVID-19 pandemic and also used service backup from the NWC.

Initial capabilities at the NWC proved limited in meeting the entire LMRFC service suite, and the Assessment Team found further efforts to expand capabilities would better position RFCs for similar situations in the future. LMRFC staff alleviated this issue by conducting most of their work on their own AWIPS system, either in the office or through the AWIPS VPN. They used NWC backup only for times when power and/or communication systems failed at their facility. Had the LMRFC not been able to connect to its own systems, they would not have been able to produce their entire service suite, which would have led to service gaps.

Fact: Initial capabilities for RFC service backup at the NWC focused on producing and generating river forecasts (RVF), flash flood guidance (FFG), headwater guidance, and/or graphical flash flood guidance (GFFG).

Finding 19: Not all RFC delivered products are currently being issued from the NWC backup system. The NWC does not currently have the capability of issuing all RFC products, including ensemble products and rainfall products that display on the NWS Advanced Hydrologic Prediction Service (AHPS) page.

Recommendation 19: NWS should prioritize developing specific requirements needed to provide additional RFC service backup capabilities at the NWC. Based on its investigation, the Service Assessment Team suggests that efforts could focus on enabling at least some of the following capabilities to close this gap:

A. Hydrometeorological Forcings (e.g., Quantitative Precipitation Estimate (QPE), QPF).
B. Probabilistic Forecasts (e.g., Ensemble Streamflow Prediction (ESP), and Hydrologic Ensemble Forecast System (HEFS)).
C. Water Supply/Resource Forecasts/Outlooks.
D. Flood Outlook Potential (FOP).
E. Distributed Model Output - RFC States output (e.g., ratings, unit hydrographs, soil moisture, Snow Water Equivalent (SWE)).
F. Transmitting gridded rainfall estimates for the purpose of populating the NWS AHPS webpage rainfall graphic.

3.4 Impact–Based Decision Support Services (IDSS)

Public Law No: 115-25, the "Weather Research and Forecasting Innovation Act of 2017," gives specific direction to NOAA, particularly NWS, with respect to IDSS. Specifically, Section 405 of this act requires the NWS Director to, "...designate at least one warning coordination meteorologist at each weather forecast office of the National Weather Service," and assigns the primary role of the Warning Coordination Meteorologist (WCM) to carry out the responsibilities required in this section. These responsibilities include increasing IDSS.

Since the passage of this legislation, NWS updated its Mission Statement to include the provision of IDSS as a core agency function (emphasis added):

> *"*The National Weather Service (NWS) provides weather, water and climate data, forecasts, warnings, **and impact-based decision support services** for the protection of life and property and enhancement of the national economy*."*

NWS has trained, highly motivated, and exceptionally talented individuals to provide IDSS distributed across the Nation in local and regional offices, and National Centers. NWS has provided operational staff with state of the art systems to provide forecasts and warnings, including observing platforms, numerical models, analysis tools (e.g., AWIPS), and dissemination mechanisms (e.g., AWIPS, Emergency Alert System (EAS), and NOAA All-Hazards Weather Radio). Staff used these systems to provide world class information to the Nation and its territories in support of our mission.

By codifying IDSS as a core function of its mission, NWS states that it will provide world-class IDSS as well. The Assessment Team reviewed IDSS content, capacity, and efficacy through this lens. IDSS material used during Ida came from many of the systems stated above, but the dissemination of material typically used systems not directly tied to these more traditional capabilities.

Given the updated Mission Statement, the Assessment Team decided to dive deeper into IDSS. The Team considered IDSS from two perspectives: providing content such as slide deck briefings, emails, web graphics, or other text or graphic based information, and providing human interaction such as conducting webinars, conference calls, or on-site support.

The Assessment Team analyzed IDSS content type, length, production efficiency, and quality based on best practices suggested by the cartographic and visual communication communities. For evaluation work for in-person or virtual live briefings, the Assessment Team primarily relied on feedback from Core Partners to assess the human interaction component of IDSS. When gathering feedback from these partners, the Assessment Team attempted to understand how on-site support, virtual briefings, or other human interactions impacted their decision making process.

In its analysis, the Assessment Team recognized that a major hurricane impacting the Gulf Coast, then proceeding to produce historic rainfall and severe weather across some of the most populated areas in the country, posed a unique set of circumstances that stretched the agency's collective capacity. In spite of these challenges, Core Partners interviewed from Louisiana to Massachusetts complimented forecast and warnings services, as well as IDSS, and overall felt NWS performed extremely well.

This Service Assessment report conveys that Core Partners received, valued, and acted upon IDSS during their response and recovery efforts. The Assessment Team constructed the following from the perspective of what NWS can refine and adjust to further provide world class IDSS and to meet increased demand for IDSS.

3.4.1 IDSS - Onsite Deployment Needs

Local offices produced a significant amount of IDSS content and conducted numerous webinars. NWS conducted four on-site deployments during the entirety of the event. Local and regional offices used virtual deployments to several locations.

The Assessment Team determined two primary causes for the limited number of deployments: the ongoing COVID-19 pandemic, and resource limitations. The Assessment Team identified the COVID-19 pandemic as the primary driver of the greatly reduced on-site support efforts, as compared to the efforts more typically observed during past hurricanes. Both NWS and Core Partners expressed concern about adding people to large group gatherings in confined spaces, so both entities relied more on virtual support.

Interviews with Core Partners revealed that, aside from restrictions created by the pandemic, the overwhelming majority of these groups desired more on-site support, but they did not ask for it in real time. The Jefferson Parish Office of Emergency Management (OEM) in Louisiana asked the Assessment Team if, "...deployed staff could be considered for future events." NYC

Emergency Management, Philadelphia OEM, the State of New Jersey OEM, the State of Pennsylvania OEM, and the New York Port Authority all stated they would want on-site support as a critical piece in their operations during high-impact events. Further, several partners, including NYC Emergency Management, inquired about the potential to increase on-site support. NYC Emergency Management stated they had previously worked on a plan with WFO New York to explore staffing a meteorologist in the EOC on a near-permanent basis.

WFO Jackson, Mississippi typically provides on-site support to the State of Mississippi EOC. Due to COVID-19 restrictions and an IMET deployment, WFO Jackson could only deploy one person for one day during Ida. WFO Jackson could not meet additional days for deployment, despite having an additional person from the NWSOC deployed to the office over the weekend. Additionally, the City of Philadelphia OEM stated they typically request on-site support from WFO Philadelphia/Mt. Holly. When the Assessment Team asked why no on-site support occurred during Ida, the Philadelphia OEM stated, “If we wanted someone, they would probably figure out a way to send someone. But we are also mindful of their limitations, and what we need from them we can get from them remotely, or we get what we need in a way that has been satisfactory.”

Several NWS offices noted resource concerns as reasons, beyond the COVID-19 pandemic, for not providing on-site support. Additionally, offices noted that demand for on-site support continues to increase, especially for WFOs which cover highly populated areas.

Best Practice: Some offices provided a standing, or open time, after a virtual briefing to provide more detailed IDSS to partners.

Best Practice: CWSU Houston staffed an additional employee to cover all tropical briefings and IDSS products.

Fact: NWS conducted four on-site IDSS deployments during Ida. The first deployment occurred for a day to the Louisiana GOHSEP in the form of a briefing and press conference prior to landfall. Another deployment occurred to the Orleans Parish EOC across multiple days. The third occurred for one day at the Mississippi State EOC. The fourth was to FEMA Region VI. NWS conducted other IDSS deployments virtually.

Finding 20: Interviews with Core Partners revealed that many expressed interest in having NWS meteorologists and hydrologists staffed in their EOCs more routinely to support planning (well ahead of an event), mitigation (just prior to an event), response (during an event), and recovery (after an event) efforts. This was a consistent finding between the two external Sub-teams. Interviewees indicated their desire for on-site IDSS would continue to increase; especially for those interviewed who covered high population areas.

Recommendation 20: The NWS Analyze, Forecast, and Support Office should develop policy and procedures, to include the entire forecast process, which will help maximize the use of resources needed to meet existing IDSS needs and provide additional capacity for increasing demand for IDSS.

Fact: Jefferson Parish asked if deployments could be considered in future events. NYC Emergency Management, New Jersey OEM, Pennsylvania Emergency Management Office, Philadelphia OEM, and the New York and New Jersey Port Authority all expressed they want more on-site support. NYC Emergency Management had even designed a plan to make routine support a reality.

Finding 21: The number of deployments during Hurricane Ida were limited by multiple factors, including resource constraints, the COVID-19 pandemic, and operational demands within offices.

Recommendation 21: NWS should develop an agency strategy to help local offices facilitate on-site staffing to Core Partners. This strategy should consider redeployments to an affected office, and/or deployments of personnel to directly provide on-site IDSS, similar to strategies used during the IDSS response to the Deepwater Horizon and Enbridge oil spills in 2010.

As noted in Section 3.3, the Assessment Team noted numerous instances of offices providing Mutual Aid to one another, at times routinely, to increase experience levels. Mutual Aid, working together as “one NWS,” can strengthen the agency’s overall ability to respond to high-impact events, such as Ida, by utilizing resources in quieter areas of the NWS to assist those dealing with a significant workload.

Best Practice: As an example of more frequent Mutual Aid, the LMRFC and West Gulf River Forecast Center (WGRFC) routinely perform each other's functions during busy hydrologic operations, periodically completing cross-training and testing.

Finding 22: The Assessment Team noted that several offices used Mutual Aid, in the form of service backup. If used more frequently, Mutual Aid could present an option to create capacity to provide IDSS.

Recommendation 22: Through Recommendation 17, NWS should consider using Mutual Aid as a means to free up local resources during high-impact events. This could allow local offices to focus solely on work maximizing the importance of their local presence, including IDSS, freeing up resources to honor additional requests for deployments, and warnings.

3.4.2 IDSS Content - Usage, Length, and Workload

Core Partners interviewed from the South to the Northeast stated that NWS-provided IDSS directly informed their decision making to some degree. Further, these partners noticed NWS efforts to improve consistency in briefings. The Louisiana GOHSEP specifically noted how much they appreciated the consistency between the WFO Lake Charles and WFO New Orleans/Baton Rouge briefing templates.

While these partners valued this IDSS, the Assessment Team found evidence these partners saw the format of some IDSS content as not ideal. In several interviews, Core Partners noted that once received they sometimes modify the content provided by the NWS. In some cases, they modified content to reduce the length of, or otherwise simplify, it to better fit within their infrastructure, needs, and/or decision systems. Core Partners modified IDSS content received during Hurricane Ida to better meet their internal needs.

The Assessment Team conducted an internal audit of process, efficiency, and consistency. Local offices used slide decks, typically done through technologies such as Microsoft Powerpoint™ or Google Slides™, when creating or sharing IDSS content. Additionally, offices used these slides as a template to provide “heads-up” or “IDSS Briefing” e-mails. Finally, while not explicitly reviewed for this Service Assessment, several offices have created a local office “IDSS Web Page” that typically provides easy access to a variety of web-based content such as NCEP center products, local forecasts, and observations. The Assessment Team reviewed the production of IDSS materials from the TAFB, and 15 offices across NWS Southern and Eastern Regions, during Ida.

Region or Center Statistics	Number of Slide Decks Reviewed	Total Number of Slides	Average Number of Slides per Deck
11 Southern Region Offices	97	1046	11.5
4 Eastern Region Offices	13	115	8.8
TAFB	9	126	14
TOTAL	**119**	**1,287**	**10.9**

Table 2: Assessment Team review of IDSS materials.

Table 2 demonstrates these points:

1. On average, the TAFB produced the longest slide decks with an average of 14 slides per briefing.
2. Southern Region offices' slide decks included about three more slides than Eastern Region offices[17].
3. Overall, the assessed offices and TAFB produced 1,287 slides. The majority of the slide content, at least 55% of the slides, presented information already provided on NWS web pages or as data services.
    a. The highest number of slides provided by any one office was 20 and there were 20 slide decks with 15 or more slides (**Figure 14**).

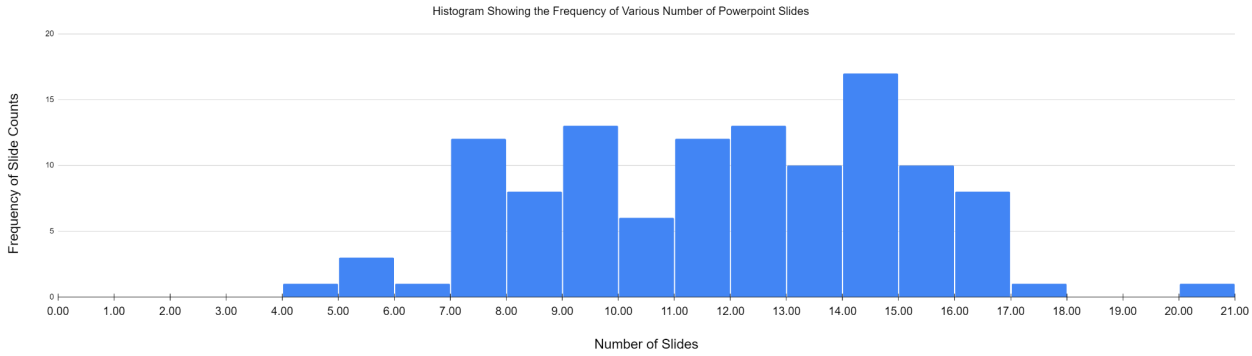


Figure 14: Histogram showing the frequency of the number of slides in each slide deck.

The IDSS slide decks reviewed by the Assessment Team often, but not always, followed a template designed at a regional level or by a team within a region. As such, many slide decks offered much of the same content from briefing package to package and office to office. The Assessment Team also noted a significant investment in time and a considerable duplication of efforts across offices to generate these slide decks.

Slide Deck Content Themes

Table 3 outlines the top 12 most common content types found in local office briefing packages from the IDSS slide decks.

[17] This is largely because coastal offices produced nearly 12 slides per slide deck.

Content Name	Content Description	Percent of slide decks that included the content
Title Slide	Typically text but occasionally included a graphic. Included the office name, the name of the event focus, and time/date stamp.	87%
Key Take-Aways	A summary from the briefing occurring at the end of the slide deck. Typically all text.	85%
Conclusion Slide	A text slide with local office contact information, links to additional content, or details for upcoming briefings including office contact information and links.	82%
NHC Storm Track	The official NHC storm track graphic.	85%
Storm Total Rainfall	A graphic, often based on WPC data, depicting the expected rainfall over the event.	77%
Storm Surge	An NHC graphic depicting either the peak or potential storm surge.	73%
Tropical Storm Wind Speed Probability	An NHC graphic depicting the probability of exceeding tropical storm wind speeds.	58%
Watch, Warning, or Advisory	Graphics showing the current watches, warnings, or advisories in effect.	54%
Key Points	The main focus topics of the briefing presented at the beginning of the slide deck.	46%
Time of Arrival	An NHC graphic depicting the expected or earliest time of arrival of tropical storm winds.	45%
Flood Threat	A graphic produced by local forecast offices based on their “Threat Grids.”	45%

Table 3: Table of key slide deck contents.

The Assessment Team noticed that the most common content provided in briefings fell into one of three categories:

- Text-based information such as the title slide, conclusion slide, and key points slides.
- National Center graphics such as the NHC storm track, timing, storm surge, or WPC rainfall.
- Watch, Warning, and Advisory information.

With the exception of the text information generated by the local office, the majority of content, roughly 55% of the reviewed slides, presented in slide deck briefings already existed in multiple formats on NOAA web pages and often as data services (e.g., the NHC storm track, WPC rainfall, satellite imagery, or radar observations). Further, the overwhelming majority of content presented hazard information such as expected rainfall, storm tracks, severe weather potential as facts of the forecast but without added context. IDSS must both **inform** and also **provide context** to Core Partners not merely repackage existing graphics. IDSS must also help the Core Partner understand impacts so they can make decisions to mitigate them locally.

Fact: The Assessment Team reviewed IDSS and messaging provided from 15 offices (WFOs, RFCs, and CWSUs) and the TAFB. These 16 offices produced 119 slide deck briefings during Ida with an average length of about 11 slides per briefing package. There were an additional nine slide deck briefings made up of three or fewer slides which were formatted more like an infographic than a typical briefing package.

Fact: Prior surveys of local offices and responses during Ida interviews, indicated it took about 45 minutes to produce a set of briefing slides. Many of the briefing packages do include macros (i.e. software routines) that automatically update slide images and titles, but local office staff still need to add information or quality control the content which contributes to the production time.

Fact: The majority of the content presented in slide deck briefings came from NCEP Center graphics (NHC, WPC, and SPC) that already existed across multiple web pages.

Finding 23a: The Assessment Team estimated that these 16 offices spent approximately 80 hours creating slides for Hurricane Ida IDSS and messaging. Multiple people spent a significant number of hours creating slide deck briefings with content that already existed on NWS websites.

Finding 23b: The Assessment Team found examples where slide deck briefings were changed by a Core Partner after distribution. Partners interviewed often noted they modify slide decks for various reasons. The modifications are intended to make NWS content more easily accessible, shareable, or user-friendly. They did not change the forecast, but they changed the format.

Recommendation 23a: The NWS IDSS program should evaluate the effectiveness and return on investment of providing slide deck briefing packages that merely “repackage” existing static NWS information but do not provide context beyond the provision of the graphics against an alternate strategy of providing dynamic data, consultation, and interpretation of the information itself.

Recommendation 23b: As an interim step, the NWS IDSS program should consider requiring the inclusion of a “Key Points” or “Key Messages” slide near the beginning of briefing packages to ensure the slide deck highlights the most important messages up front.

Fact: Eastern and Southern Regions collaborated on a common tropical briefing template which both regions shared with their offices. The ER / SR Tropical Briefings template was modified prior to the beginning of the 2021 tropical season to better implement the NOAA color themes and look and feel.

Fact: WFOs New Orleans/Baton Rouge and Lake Charles collaborated across their County Warning Area (CWA) borders to provide information with a common “look and feel.” In other cases, briefing packages from neighboring WFOs used inconsistent formats.

Fact: Interviews with Core Partners who worked with multiple WFOs indicated that inconsistent formats made it more difficult to find pertinent information from different offices.

Finding 24: While many local offices used common templates (e.g., common fonts, common color theme) for their IDSS briefings, others did not. The Assessment Team found several examples where offices used different templates as well as little consistency in the graphics within the briefing slides.

Recommendation 24: The NWS IDSS program should consider requiring offices to use consistent slide deck templates previously developed within the agency, and contained within the IDSS Toolkit. These templates already follow the NOAA style guide.

3.4.3 IDSS Content - Maps, Geographic Information System, and Graphics

Several Core Partners noted they took IDSS content, such as slide deck briefings, and converted the slides into images. They then added those images to their situational awareness display. The Assessment Team found that many partners used a cloud-based GIS to drive their situational awareness displays. When the Assessment Team asked partners how NWS can provide a more valuable service to them, these partners commonly answered, “provide your information in geospatially-friendly formats.”

IDSS content must apply recognized standards or best practices especially when using imagery (e.g., maps, graphics, colors). The Assessment Team’s membership included outside experts in communication, and several with geography or cartography backgrounds, who relied on such standards when evaluating IDSS content.

These experts explained that cartography is as much an art as it is a science. They advocated a list of several best practices[18] to improve NWS IDSS mapping in IDSS briefings to include the following:

- Maps should include elements such as a legend, a title, a scale, and possibly a compass. The elements should be consistent across all maps used in a briefing package.
- The use of color is complex but should support the message of the map. Generally speaking, maps should include six or fewer colors depending on the complexity of the content; less complex maps should include one to two colors. Also, maps should avoid certain color combinations such as red and green for individuals with color vision deficiency.
- Maps in a briefing package should be as consistent as possible in terms of background, color use, iconography, and scale unless there is a specific need change (e.g., zooming in on a location for more specific information).
- When possible, maps should allow the user to easily "find themselves" to support geospatial reference. In static maps, this would include easily identifiable geo-references such as major cities, roads, or features (e.g., lakes, rivers).
- Maps should limit the number of features on display.
- Data labels or icons on a map should match the underlying data. For example, if a map is displaying rainfall amounts as various colors, then any data labels or icons on the map should align with the colors. That is, the map should include rainfall data labels or icons on a map of rainfall and should **not** include temperature data labels on a map displaying rainfall colors.
- Maps should not arbitrarily eliminate data based on geopolitical boundaries, especially when additional maps are used in a briefing displaying across the same geopolitical boundaries, unless there is a specific need to draw the viewer to a particular location or area on a map.

Figure 15 shows an example of QPF graphics the Assessment Team analyzed that did not follow these cartography practices. These included inconsistent items such as:

- Map background and projections.
- Color bar scales. Note four inch rain amounts are yellow in the left image and orange in the right.
- Iconography. Note use of rainfall values on the lower map, no rainfall values on the top map.
- Banners.
- Graphic templates.
- Labeling. Note NOAA vs NWS logo.

[18] Recommended best practices for map design can be found at https://proceedings.esri.com/library/userconf/fed16/papers/fed_86.pdf.

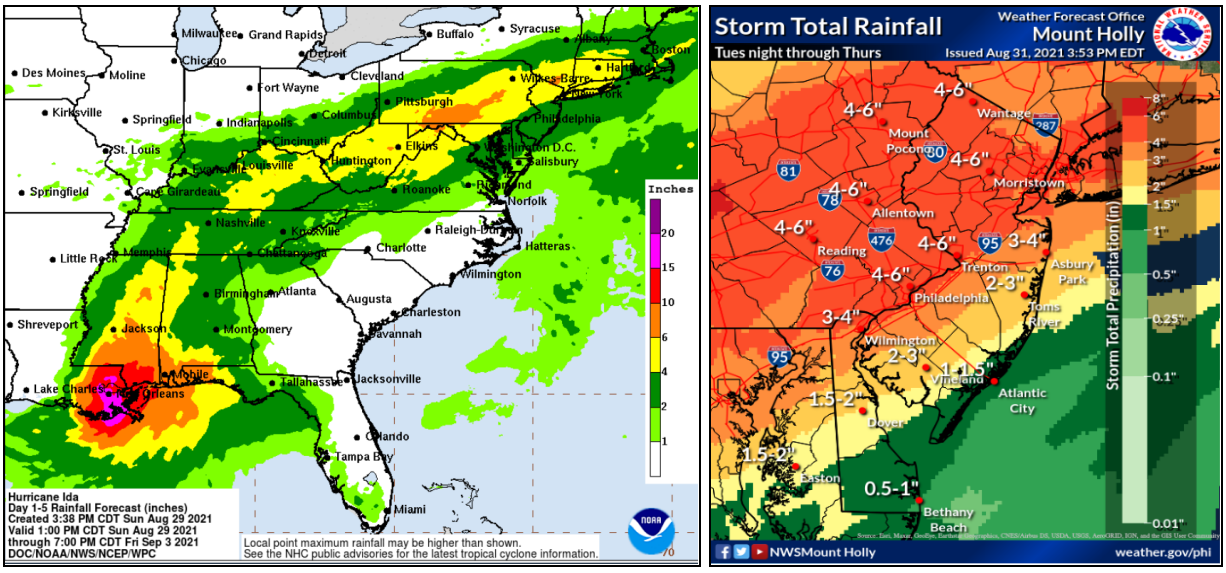


Figure 15: Two Quantitative Precipitation Forecast (QPF) images that highlight several of the cartography issues noted above.

Finding 25: The Assessment Team found a majority of mapped content did not abide by standard cartographic practices. The majority of mapped content reproduced existing information while also being highly inconsistent office by office. Because the mapped content within briefing packages were static images, the Core Partner had no capacity to interact with the data to improve their understanding (i.e., users could not zoom, nor sample information, nor use it within their existing interoperable capabilities).

Recommendation 25: NWS should examine using prioritized GIS data services, in lieu of static maps, to improve its ability to provide IDSS. This includes ensuring geospatial products or services are provided in industry standard formats (e.g., as a data service). This also includes transitioning the majority of static IDSS content with a geospatial component (e.g., slide decks, graphics, text products) into a GIS environment that provides an interactive, dynamic, and consistent user experience.

Finding 26: Interviews with partners indicated their desire for NWS to provide information in a geospatially-friendly format for platform integration as they rely on GIS systems for internal situational analysis and decision making. Partners in the Northeast used an ESRI ArcGIS™ platform to drive their displays.

Recommendation 26: NWS should consider producing its GIS information such that it follows industry standard data formats and data structure conventions, which do not assume the use of proprietary tools, and can be used by commonly available tools and in an interoperable fashion by the GIS platforms used by Core Partners.

The Assessment Team found several examples where offices spent time adding context, an important part of messaging, to an existing graphic, but the offices also remapped the existing

graphic. In other instances, offices downscaled the information in the graphic by creating a high resolution version of the graphic to address partner needs. Offices also sometimes simply remapped graphics to only change aesthetics.

Finding 27a: When mapping the same information (e.g., rainfall amounts, official products, remotely sensed data), NWS maps were inconsistent in their use of color, iconography, background or basemap, use of legends, titles, compasses, and geo-referenced features (e.g., cities, roads, rivers, lakes). This inconsistency occurred within individual briefing packages, across local offices, and across regions.

Finding 27b: The decision to use data clipped to geopolitical boundaries appeared inconsistent. Offices often clipped data to geopolitical boundaries (e.g., CWAs domains, states), even though valid data existed beyond the geopolitical boundaries. Further, offices were inconsistent in their decisions to use boundary clipped, or unclipped, data both within individual briefing packages and across offices.

Finding 27c: NWS offices often re-mapped information that already existed in a digital format, oftentimes on existing online repositories such as NWS web pages, that did not require downscaling to add necessary detail and/or context. Examples included watches, warnings, and advisories, and forecast information mapped within the National Digital Forecast Database (NDFD). The primary reason this information was re-mapped appeared to be based on a perception that its existing mapped format was either not visually appealing or not useful as presented.

Recommendation 27: NWS should identify and implement solutions to static mapping problems as static maps will likely remain a core component of IDSS and messaging even as information transitions to a more dynamic, data service, GIS-based solution. Solutions should utilize input from experts in cartographic design and visual communication.

Fact: NWS graphics did not have a standard for consistency when selecting color bar ranges when presenting confidence, risk, impact, timing, or threat information.

Fact: NWS did not have consistency in graphic choices, color use, and iconography within briefing packages. While there appeared to be certain graphics used commonly across offices, the agency had no nationally consistent set of graphics used to describe risks, impacts, hazards, timing, or confidence.

Fact: Graphics in NWS briefing packages used similar colors but with different meanings. For example, the color yellow was used to highlight the action stage on a hydrograph, the threat of flooding rain, to describe impacts as “limited,” to describe event timing, and in a general gradient without specific definition.

Finding 28: The Assessment Team could not find any standard nor consistency when selecting color bar ranges when presenting confidence, risk, impact, timing, or threat information. As an example, there was partner confusion at the United States Coast Guard (USCG) in the color curves and labels of the Hurricane Threats and Impacts (HTI) graphic and the ERO. The HTI used five levels of threat while the ERO used four. Both products had inconsistencies in color choice and labeling.

Recommendation 28: NWS should develop policy on graphical depictions of its information, similar to policies for text-based products, to establish standards for templates, colors, and verbiage for all graphics that include time-sensitive information critical to life safety decisions. The HTI and ERO serve as an example to which this recommendation applies.

3.4.4 IDSS Content - Words of Estimative Probability

When reviewing the text information in local office IDSS content, the Assessment Team focused on words used to communicate uncertainty or confidence. Particularly in the Northeast, interviews with Core Partners revealed that, despite all the messaging and IDSS they received, they did not fully understand how severe this event would become.

The Assessment Team analyzed the products and DSS materials provided during this event to examine how NWS conveyed the information, as the means of conveyance could have played a role in potentially bridging that gap. The Assessment Team used applied research, conducted under a NOAA grant, focused on probabilistic wording and communicating uncertainty and confidence. The Assessment Team used applied research, cataloged by NOAA's Institutional Repository[19], conducted by Dr. Joseph Ripberger from the University of Oklahoma Center for Risk and Crisis Management. The Team used this research to determine if word choice used during the post-tropical phase of Ida aligned with published findings describing how best to communicate uncertainty or confidence. This analysis served as a proxy for direct surveys of Core Partners in gauging their understanding of the myriad of IDSS products and probabilistic wording produced during Ida, and whether these products met their decision making needs.

Dr. Ripberger's[20] work includes a focus on communicating uncertainty using probabilistic information and avoiding hedge terms also known as "Words of Estimative Probability" (WEPs). Common WEPs include: potential/potentially, possible/possibly, expected, likely, could, chance, may, should, uncertain/uncertainty, probably, and certain.

The Assessment Team ran a word search query across the 119 IDSS slide deck samples using the words listed above. The results showed a high dependence on hedge terms when

[19] For more information on Dr. Ripberger's research, visit https://repository.library.noaa.gov/view/noaa/29110.
[20] Dr. Ripberger has cited several published articles dating back to the 1960s describing the challenges humans experience when interpreting WEPs. For example, based on numerous surveys of the public and other groups, humans will interpret the word "possible" to mean nearly any value between 1% and 99%. This is problematic when NWS describes an event as "possible" without providing a numeric probability to help the end user fully appreciate the potential.

describing uncertainty. By far, offices used the word “possible” (including “possibility” and “possibly”) most often to describe estimative probability; this word appears 446 times in the 119 slide decks, or at a rate of about 3.7 times per slide deck. On the other hand, the words “certain,” “probable,” or “unlikely” seldom appear in these materials.

Figure 16 presents the total number of times a particular WEP appears in all the slides and the number of times the WEP appears per slide deck.

- “Possible” also includes “possibility” and “possibly.”
- “Likely” was often preceded by the word “most” as in “most likely….”
- “Potential” also includes “potentially.”
    - Note: There are many slide titles or legend descriptions that include the word “Potential” as noted in the slide example below. The calculations below do **not** include such use cases and only count the word “potential” when it appears in text fields such as, “There is some potential for heavier rain….”
- “Chance” is often preceded by a numeric probability such as “20%-50% chance” or “a 1 in 4 chance.”
- “Uncertain” also includes “Uncertainty.”

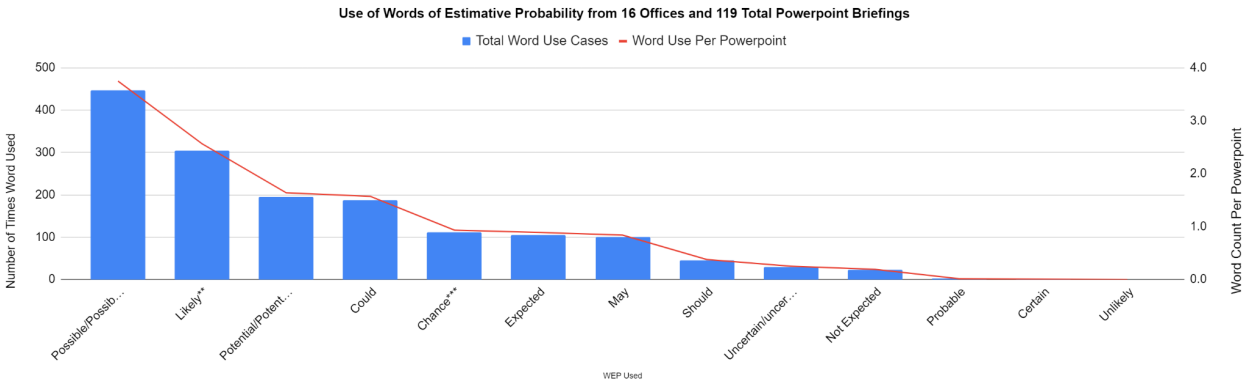


Figure 16: Use of Words of Estimative Probability (WEPs) as analyzed by the Assessment Team.

In total, local offices used WEPs 1,551 times or approximately 13 times per slide deck. A few examples pulled from IDSS material reviewed by the Assessment Team (emphasis added):

> “Depending on the exact location of landfall, some isolated places **could** see surge as high as over 9 feet.”
>
> “Significant impacts are **possible** if the storm tracks further east.”
>
> “**Potential** Impacts: Numerous instances of flash flooding with significant flooding that **could** threaten structures and damage roads.”

> "Tropical Storm Ida is **expected** to make landfall along the Louisiana coast…**possibly** as early as Sunday afternoon."
>
> "The **chance** for sustained tropical storm force winds remains low."
>
> "Heavy rain from the remnants of Ida will bring **potential** flash flooding to the region Wednesday into Thursday."

In some cases, local offices combined a word of estimative probability with a confidence range to describe the outcome:

> "Some slight adjustments to the axis of heavy rainfall **may** occur, but there is **moderate to high confidence** in the threat for flash flooding across the area."

In other cases, offices used WEPs within legends on graphics such as the example in **Figure 17**. The Assessment Team did not include these use cases in the values presented above.

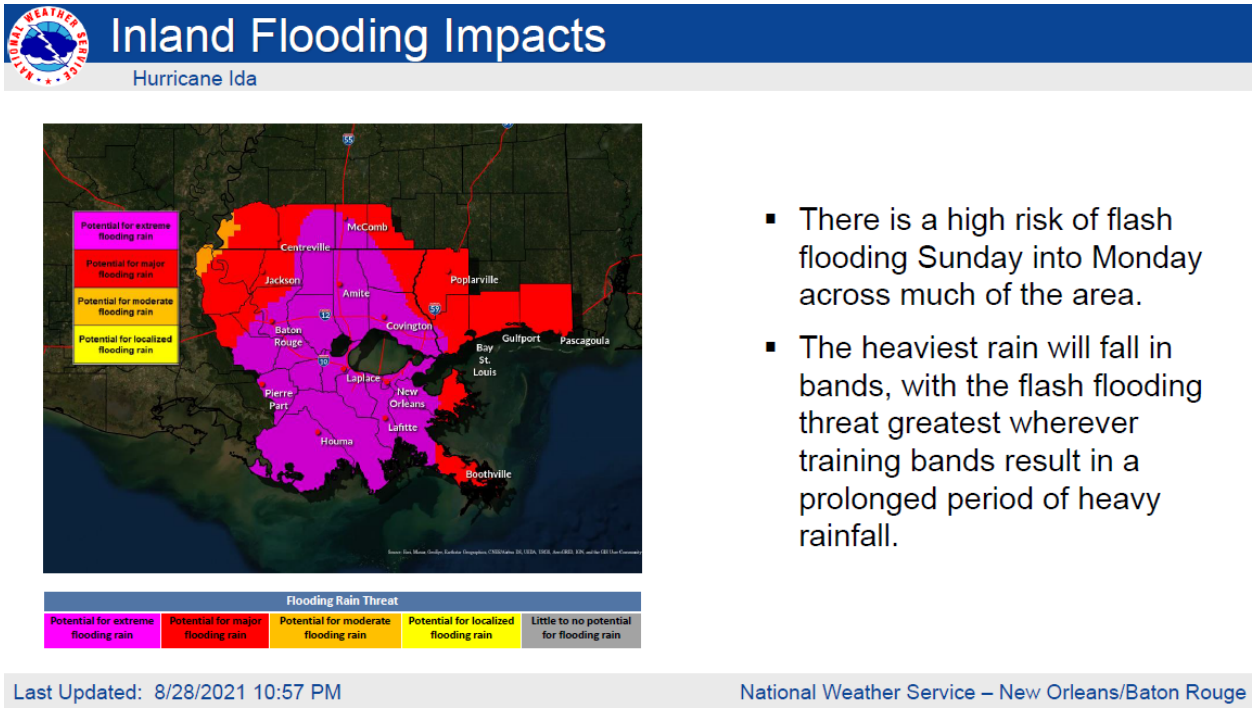


Figure 17: Example showing how the word "potential" shows up several times within the colorized legend and within the mapped image.

Fact: Text information in IDSS content relied heavily on WEPs when describing uncertainty.

Fact: Research from social scientists, who investigate human decision-making in uncertainty across multiple disciplines (including but not limited to atmospheric sciences), indicates that using WEPs poses serious communication challenges to the information receiver (partners or the public). These challenges arise because WEPs are subjective and can be interpreted differently than intended by the information producer (NWS). Dr. Ripberger and his team, as part of a NOAA-funded project, reviewed several peer-reviewed research papers focused on the use of WEPs in a weather forecasting context. Dr. Ripberger and his team concluded that the existing research on the subject strongly advises against using WEPs alone without appropriate qualifiers. They offer several practical recommendations based on the literature as viable alternatives.

Finding 29a: Core Partner interviews, particularly in the Northeast, revealed they did not fully understand how severe this event would become.

Finding 29b: The Assessment Team noted that NWS offices used words to convey uncertainty information in IDSS briefings that were at times in conflict with published research on the topic.

Recommendation 29: The NWS IDSS program should consider how best to incorporate and adopt recommendations provided by research conducted under NOAA grant NA16OAR4320115 on the topic of communicating probability information.

3.4.5 IDSS - Dissemination

Core Partners stated they received numerous email briefings, slide decks, or other IDSS content from local offices. Further, partners stated they participated in webinars or conference calls to discuss Ida and associated impacts. Interestingly, several EM partners interviewed at various EOCs noted they “did not know what IDSS means.”

While listed as a Best Practice below, the Assessment Team could not verify that “all partners” received or read the email content provided by local offices in a timely manner due to the nature of email as a passive dissemination mechanism. For example, the NWS could only send information to individuals identified in an email list, and these lists had capacity restrictions for recipients. Thus, local offices had to rely on partners on the email list to forward the information to others.

Using email to disseminate IDSS presented another major drawback in that local offices could not easily modify IDSS information in a rapidly changing event. Offices could not “take an email back” to modify the information with new data. Rather, these offices had to send additional emails to clarify, correct, or update information.

Some offices provided their IDSS content on local office webpages which expanded the accessibility beyond email but provided no mechanism to ensure partner receipt. Further, the

Assessment Team noted during interviews the extensive use Core Partners made of mobile devices, including tablets and smartphones, as their primary means of accessing online content.

Best Practice: Email briefings and webinars from WFO Mobile were instrumental in supporting Port of Mobile operations after major efforts for partner-building between the WFO and the Port.

Finding 30a: Local offices relied almost exclusively on email as a dissemination system for the majority of IDSS messaging. NWS then relied on the Core Partners in the email distribution lists to forward information to additional partners or relevant response entities.

Finding 30b: Core Partners noted that during high impact events email traffic increases exponentially, causing the potential to miss or delay reception of important emails with IDSS information.

Finding 30c: Partners also expressed the desire that NWS provide its content in a format compatible for display on mobile devices.

Recommendation 30: NWS should investigate improved capabilities to deliver IDSS to Core Partners including the means to directly deliver IDSS material to Core Partners via mobile devices.

3.4.6 IDSS - The Importance of Reliable Internet Connectivity

Local offices depended heavily on the internet to develop and disseminate IDSS messaging, to provide virtual IDSS, and to conduct webinars and other one-to-many IDSS services to Core Partners. An internet connection has become as vital to IDSS provision as AWIPS is to disseminating forecasts and warnings. The Assessment Team found that local offices need prioritized access to the internet to avoid mission risk in providing IDSS.

Fact: Local offices provided numerous webinars and remote briefings, including one-to-many IDSS, using the internet to complete this work virtually.

Finding 31a: The Assessment Team found that the majority of IDSS work was completed using the commodity internet.

Finding 31b: Reliable internet connectivity was as vital to successful IDSS operations as a reliable AWIPS WAN was to issuing warnings.

Finding 31c: Disruptions to internet connectivity for WFO New Orleans/Baton Rouge and the LMRFC resulted in numerous challenges for completing mission delivery which staff overcame by using alternate sources to access the internet such as hot spots, MiFis, and via telework at staff homes.

Recommendation 31a: NWS should prioritize internet connectivity as an operational necessity for providing IDSS. As such, NWS should move away from a shared dependency with AWIPS on Virtual Satellite (VSAT) and instead develop options for providing redundancy for commodity internet (e.g., separate circuits, 5G router, improved satellite capabilities in partnership with the private sector, a combination thereof) with reasonable bandwidth that can be used in the case of the loss of the fiber connection. Offices could then utilize VPN capabilities to access secure networks and resources[21].

Recommendation 31b: NWS should investigate using VSAT solely to back up the AWIPS WAN. As designed, VSAT should be able to handle AWIPS WAN traffic with the commodity internet using a different means of redundancy as noted above.

3.4.7 IDSS - Role Clarity and Enterprise Resources

The Assessment Team found a growing number of Core Partners have hired private meteorologists or hydrologists, or purchased contracts with private weather firms, to provide more routine weather support and interpretive services of NWS provided information.

1. The State of New Jersey has hired an individual who helps provide more routine weather support. This individual received NWS IDSS content, and distilled several slides of content into a single slide with the key points. This person then shared this distilled slide via email, printed and distributed, or shown on situational awareness displays within the EOC.
2. The City of New York hired a private meteorologist several years before Ida to help interpret NWS products and IDSS content along with providing other forecasting services for the city. Officials interviewed noted that the city was in the process of hiring a second meteorologist to support operations as a result of Ida.

Fact: A growing number of Core Partners have hired private meteorologists/hydrologists to provide IDSS beyond the capacity of NWS.

Finding 32: Local offices stated they would like to have a ready resource to point to if asked about private sector capabilities for IDSS. Such a page exists, but these offices did not know of it at the time.

Recommendation 32: NWS should increase internal awareness of its Enterprise Resources website and update this site to explicitly call out the IDSS capabilities of the Weather, Water, and Climate Enterprise.

[21] The Hurricane Florence/Hurricane Michael Service Assessment contains recommendations (Recommendation 72 and 73) similar to Recommendations 31a and 31b in this assessment.

3.5 Service Equity and Vulnerable Communities

This Service Assessment represents the first time NWS has reviewed service delivery formally, through the lenses of equity and underserved communities. For the purpose of this assessment, the Assessment Team considered the concepts of service equity, social vulnerability, and underserved communities as defined in Executive Order 13985 – On Advancing Racial Equity and Support for Underserved Communities Through the Federal Government.

When the Assessment Team interviewed local offices and asked, "How does your office support underserved or socially disadvantaged communities?" the offices commonly noted that, at times, they translated information into Spanish. They also stated that anyone with an internet connection could access NWS webpages. A few offices described specific efforts to identify and communicate with certain communities. For example, prior to Hurricane Ida, and after conducting outreach with the local Hasidic Jewish Community in Lakewood, New Jersey (Ocean County), WFO Philadelphia/Mt. Holly had established an automated phone line to better serve this community. While not done specifically for this event, this work serves as an example of the types of efforts local offices can make to better support these communities.

The Assessment Team found NWS' ability to serve vulnerable or underserved communities boiled down to these main points:

- NWS offices do not fully know who these vulnerable or underserved groups are or how to find them.
- NWS offices do not fully know what to do when they find them. Offices lacked the capacity, tools, or resources to provide enhanced services to meet the needs of these vulnerable groups.
- NWS offices may misunderstand what these communities need.

After considering interviews with local offices, and seeking guidance from NWS Headquarters staff leading the agency's efforts to define a strategy to address service equity, the Ida Assessment Team believes NWS can best attack these challenges from two fronts:

1. Allowing NWS staff to identify and work with vulnerable groups.
2. Using technology to better deliver and personalize information.

3.5.1 Strategies to Understand and Identify Vulnerable Communities

The Assessment Team found that NWS offices need guidance and policy on how to define and find vulnerable and underserved communities. Several interviews revealed that offices did not fully understand how to identify vulnerable and/or underserved communities. They had ideas, and some offices had initiated work to address what they believed appropriate based on their own definitions. However, the lack of policy and guidance had constrained efforts to that point .

The Assessment Team understands the agency has developed concepts within a draft service equity plan. The Team believes this plan will address many of the challenges uncovered during

this service assessment, and that a more thorough analysis of service equity would fit well into a future assessment conducted after the publication of this plan.

Fact: There were existing data services that present vulnerability indices of communities at relatively small scales based on census tract data.

Fact: WFO staff expressed a lack of complete understanding of what service equity meant to their service provision, a lack of understanding of how to identify and reach these communities, and a lack of understanding of what to do once the office identified these communities.

Finding 33a: NWS has not provided a policy definition of the service equity concept to field offices. NWS had not provided tangible methods, tools, or resources to identify and more effectively serve members of vulnerable groups.

Finding 33b: In the absence of policy, the Assessment Team found that at times, offices assigned their own designation of groups as being "underserved," or not receiving equitable services, based upon predetermined notions or assumptions. For example, some communities may have preferred methods to receive information that were not well known; other communities were perceived as not having access to technology, yet they could use it in certain circumstances.

Finding 33c: Offices had a broad understanding of what vulnerable communities they might have in their area. For instance, they noted certain religious communities who generally refrain from using electronic devices, or non-English speaking communities who may struggle interpreting NWS information. However, there were few examples of specific, tangible activities offices were taking to identify vulnerable groups or identify service gaps.

Recommendation 33a: NWS should complete work on its draft service equity plan, and once published, should expedite efforts to execute key components of the plan to assist the field in improving services to vulnerable and/or underserved communities.

Recommendation 33b: NWS should conduct a deeper analysis of service equity in a future service assessment after the agency has published its service equity plan.

3.5.2 Language - Barriers and Translation Capabilities

Interviews revealed that language presented significant challenges to serving some communities. Language issues represented a barrier to service equity in nearly every area affected by Ida. After the storm, the New York State Attorney General issued a press release[22] calling for NWS to increase the language capacity of its information.

[22] The press release by New York State Attorney General James can be found at https://ag.ny.gov/press-release/2022/attorney-general-james-calls-national-weather-service-increase-language

In that press release, the Attorney General's office stated:

> "Currently, warnings from the National Weather Service (NWS), which are issued in advance of a severe weather event, are not accessible in any language except for English and Spanish. In advance of Hurricane Ida, which devastated New York in September 2021, NWS alerts were sent out to New Yorkers in only English and Spanish to warn them of the impending storm. The storm caused 18 deaths in New York, and the majority of those individuals were of Asian descent and did not speak or had limited proficiency in English or Spanish."

Per the New York State Attorney General, in NYC residents speak multiple languages, the most commonly spoken by residents with limited English proficiency were identified as Chinese (both traditional and simplified), Russian, French Creole, Bengali, and Korean, as well as Spanish.

In its investigations, the Assessment Team found some efforts within the NWS to tackle language concerns, especially in the NWS Tropical Weather Program, and also found unique concepts raised by those interviewed on how to potentially improve translation capabilities, and improve service equity, through technology, partnerships, and/or Mutual Aid. Specifically, the Assessment Team found several ongoing activities in this area, including:

A. An NWS team, working under a NOAA developmental assignment program (LANTERN), has developed a series of draft concepts to improve services for people of Limited English Proficiency and the Deaf/Hard of Hearing Community.
B. The NWS Central Processing portfolio has investigated various technology and Artificial Intelligence (AI) capabilities to translate English products into different languages.
C. WFO New York City has worked with their Core Partners to leverage their expertise in completing language translation.
D. NWS has several initiatives which have explored translation capabilities, including the use of Mutual Aid to complete this work.

Fact: NWS produces some Spanish language information. WFO San Juan provides routine translation to Spanish of key NHC products. NWS has MAS, a volunteer, as-available, Spanish language Mutual Aid group, to help translate information into Spanish. However, NWS has no current capacity for the multitude of other languages spoken by residents or visitors to the U.S. and only limited capabilities to address communities with disabilities that limit communications.

Fact: The City of New York leveraged software that translated standard hazard and safety messages in multiple languages, then disseminated this translated information through their mobile application.

Fact: Per the New York State Attorney General, in NYC residents speak multiple languages, the most commonly spoken by residents with limited English proficiency were identified as Chinese (both traditional and simplified), Russian, French Creole, Bengali, and Korean, as well as Spanish.

Fact: As a follow-up action, WFO New York provided a complete list of Call-To-Actions (CTAs) used in its watch and warning products to the New York State Attorney General's Office. The WFO plans to share this list with the New York City Emergency Management (NYCEM). NYCEM plans to incorporate the CTAs into its system for language translation that includes 14 languages.

Finding 34: NWS lacked an agency solution to address the communication challenges faced by people with Limited English Proficiency as well as those who have disabilities that affect their ability to communicate.

Recommendation 34: NWS should develop an agency strategy to better serve people with Limited English Proficiency. NWS' strategy should address multiple common languages spoken in the United States, and help the agency fulfill the intent of Executive Order 13166—Improving Access to Services for Persons With Limited English Proficiency.

3.5.3 Improving Service Equity to Vulnerable Communities

In addition to identifying vulnerable communities and breaking language barriers to service equity, the Assessment Team concluded that community engagement and better direct reach to the public represented the third pillar for improved service equity. Interviews with Core Partners, especially in Louisiana, indicated they often relied on relationships with community leaders like the heads of civic organizations, religious leaders, and community organizers, to serve as trusted voices within the community to improve the reach of their message. These individuals have a level of trust within the communities they serve. NWS could similarly leverage these leaders as "force multipliers" to not only share critical NWS messaging, but also to use their status as a trusted individual to strengthen the impact of the message.

Focusing on this group will help offices establish trust in vulnerable communities and increase NWS name recognition. The Assessment Team recognizes that working to build these relationships will require a significant amount of time and resources, especially in high population areas.

Finding 35: The Assessment Team found that civic organizations and the leaders of houses of worship serve as trusted voices in the community, but are not frequently the target of NWS outreach and recruitment as Weather-Ready Nation (WRN) Ambassadors or StormReady®/TsunamiReady® designations.

Recommendation 35: NWS should encourage local offices to work more closely with leaders of houses of worship and civic organizations to promote their inclusion as WRN Ambassadors or to achieve StormReady®/TsunamiReady® designation, and utilize these leaders as force multipliers to reach broader communities.

Interviews and Assessment Team observations also indicated the importance of mobile devices in reaching vulnerable communities, particularly those with lower than average annual household incomes. Core Partners emphasized the importance of providing information through mobile devices, as a greater percentage of their populations had smartphones than traditional PCs or laptops. The Assessment Team found similar data in published Pew Research Center documents[23] on the same topic. The "digital divide" presents a significant barrier to reaching vulnerable communities in a manner very similar to language barriers. Research completed by the Assessment Team found that the economically disadvantaged rely heavily on mobile devices for online content, a significant group that remains out of reach of many of NWS' current online services.

Fact: Pew Research Center research in 2021, just prior to Hurricane Ida, indicates that approximately 76% of Americans with household incomes below $30K have a smartphone, while within the same group, only 40% had broadband internet services and either a desktop or laptop computer.

Fact: The same Pew Research Center research report noted that the share of Americans with lower incomes who rely on their smartphones for going online has roughly doubled since 2013. Many people in this group do not own PCs nor have wired broadband internet, yet their mobile capacity is constantly increasing. Many programs offer assistance to enable people in this community to gain access to a smartphone and internet connectivity.

Fact: The Assessment Team reviewed a usability study, conducted by Drs. Robert Soden and Scott Miles[24], on the NHC's website as part of the FY18 Hurricane and Disaster Supplemental. Based on their findings, "Mobile technologies such as cellphones and tablets are used by a significant percentage of site visitors, and during some recent storms more than 50% of visitors to the NHC website were using mobile devices."

Finding 36: NWS lacks a robust mobile presence which, per the facts above, would be needed to better support underserved communities with lower incomes who rely on mobile devices as their lifeline for information. This lack of a robust presence represents a significant barrier to better serving the historically underserved.

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[23] Pew Research Center (2021). Digital divide persists even as Americans with lower incomes make gains in tech adoption

[24] Soden, R., Miles, S., Bannister, S., Bicksler, R., Leiva, A. (2022). Optimizing Tropical Cyclone Information: An NOAA Hurricane Website User Experience Study from a Public Perspective. National Oceanic and Atmospheric Administration (NOAA) – Office of Oceanic and Atmospheric Research

Recommendation 36: To better serve historically underserved and vulnerable communities, NWS should establish a robust presence providing services via mobile devices. This outcome could be achieved in many ways such as a mobile application, converting existing web content to adaptable displays for mobile devices (e.g., AWC prototype webpage and Point-and-Click forecast pages), or via partnerships with FEMA and/or the Weather, Water, and Climate Enterprise.

3.6 Human Factors

NWS staff at all levels exhibited exceptional dedication in successfully accomplishing mission delivery throughout the entire Hurricane Ida event. The Assessment Team found multiple examples where this event revealed the self-sacrifice that NWS employees provided to meet the mission:

- Working high-stress operations.
- Incurring large quantities of overtime.
- Completing extended deployments to Core Partners.
- Fixing IT, facilities, and communications issues on the fly during the high-stress operations.
- Finding creative solutions to operational challenges, including using telework from forecasters' homes for IDSS and messaging.

These factors, especially when drawn out over the course of many days and/or across multiple events during the same season, like WFO New Orleans/Baton Rouge, resulted in impacts to people's mental health. According to NOAA's National Centers for Environmental Information (NCEI), "2021 was the seventh consecutive year (2015-2021) in which 10 or more billion-dollar weather and climate disaster events have impacted the United States. Over the last 42 complete years (1980-2021), the years with 10 or more separate billion-dollar disaster events include 1998, 2008, 2011-2013, and 2015-2021."[25] As a result of these increases, NWS staff will spend more time enduring these catastrophic events with less time to recover from them.

During interviews, NWS staff expressed symptoms of fatigue and burnout from the event while also stating their commitment to the agency's mission. Local staff in Louisiana balanced mission-critical responsibilities with preparing themselves, and their families, for life-threatening hurricane impacts and extensive post-storm clean-up. Destructive winds along the Louisiana coast resulted in significant damage directly to some staff members' properties, which challenged their own wellness while they worked to support recovery efforts. The Assessment Team found that recent efforts to build healthier cultures in local offices, and to emphasize the importance of Critical Stress Management, paid dividends.

[25] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

3.6.1 Mental Health and Culture

NWS has recently accelerated efforts to implement initiatives that improve the employee experience and place an increasing emphasis on mental health. NWS hired a Behavioral Health and Wellness Officer, who has worked to facilitate a cultural shift toward advocacy of employee wellness. Moreover, the Organizational Health and Culture focus area of the Office of Organizational Excellence (OOE) has prioritized improving agency culture and the employee experience, with particular emphasis on Diversity, Equity, Inclusion and Accessibility (DEIA) efforts, to empower its success. The Organizational Health Action Plan (OHAP, now called the "National Weather Services Organizational Health Blueprint FY23 - FY26"), and efforts from the Science and Operations Officers (SOO) Culture Team, serve as two examples of recent efforts to connect all levels of the NWS and encourage a healthier culture.

Interviews with staff who worked Ida and its remnants revealed a large range of mental health and wellness during and after peak impacts. NWS staff working the event communicated great pride in mission execution, and many expressed appreciation for empathic leadership at their local offices. NWS employees exhibiting the most optimistic disposition shared examples of local office leadership going above nominal responsibilities to invest significant effort into supporting each person they oversaw. These employees shared stories of local office leadership performing wellness checks on their staff, frequently communicating with their staff to assess and fulfill personal needs when possible, and investing considerable effort into functionally integrating their whole unit as a strong and collaborative team. Some specific examples included WFO New Orleans/Baton Rouge management having "closed the office" and invoked Mutual Aid for a "mental health" day well after landfall, so the staff could recharge. Within the context of culture, staff at WFO Philadelphia/Mt. Holly described their development of a culture of training in their WFO that focused on experiential learning, including simulations-based training, and After Action Reviews.

All of the NWS staff interviewed demonstrated exceptional dedication to providing service delivery, setting aside their own personal needs to work upwards of 200 percent of their normal hours or longer, day-in-day-out through the event while immersed in a continuous posture of emergency operations. NWS staff simultaneously interrogated meteorological data to provide life-saving forecasts and warnings, addressed unexpected technological and systems challenges, facilitated frequent communications with partners, all while dealing with Ida's impacts to their homes and livelihoods.

Some of the NWS staff interviewed communicated clear signs of mental distress, during the peak of the system's impacts, and extending into its aftermath. These NWS staff members passionately shared stories relating the deep emotional effects of Ida's impacts, and the compounding stresses of service delivery, to their mental health. During interviews, a subset of NWS staff exhibited clear symptoms of emotional trauma, which they experienced during and after Ida's peak impacts. They shared how much they needed for their leadership to provide empathy, patience, kindness, offering dignity, respect, validation, and appreciation for their

efforts and for the passion they held so close. These staff communicated the effort that they needed local office leadership to make, in understanding and helping them work through individual struggles as crises compounded, to enable self-empowerment amid the diverse backgrounds of NWS staff.

The Service Assessment Team did not uncover any cases of degraded service resulting from the compromised wellness of this subset of interviewed staff. This speaks to the selfless dedication of NWS employees in executing the mission with excellence. Regardless, the compromised wellness of a subset of NWS staff delivering the mission demonstrated a narrow margin to potential mission failure. The Assessment Team identified a significant need for NWS to continue to solidify a culture where leadership prioritizes employee wellness, balanced with their responsibility to ensure excellence in mission delivery, in order to simultaneously sustain organizational health and world-class service delivery through the inevitable crises of the future.

Best Practice: WFO New Orleans/Baton Rouge management team made the decision to "close the office," invoking Mutual Aid for a "mental health" day well after landfall so their staff could recharge.

Best Practice: The After-Action Review (AAR) process at WFO Philadelphia/Mt. Holly focused on experiential learning, including simulations-based training, and AARs. The AAR process also included a check on employee's well being and mental health.

Finding 37a: A subset of NWS staff interviewed communicated clear signs of significant mental distress, during the peak of the system's impacts, and extending into its aftermath. This distress resulted from the magnitude of the impacts from Ida, extreme and prolonged workplace demands and stresses, and long-term recovery efforts.

Finding 37b: The depth of investment by the local office supervisor into the success of each staff member greatly influenced the amplification or mitigation of mental health challenges.

Finding 37c: This event also revealed opportunities to empower supervisors with tools and resources to create a healthier environment for employees, centered around mental health, especially when high-impact events bring the potential for employees to experience trauma and, in some cases, multiple traumas.

Recommendation 37a: NWS should explore developing a capability to respond in-person to local offices in the aftermath of a significant event, specifically to proactively make available resources for recovery assistance, along with mental health resources and counseling. This is especially important if there has been direct impacts to NWS employees and/or their property.

Recommendation 37b: NWS should require annual training on crisis management and critical stress management for all supervisors, focused on their roles of helping employees and on helping themselves (i.e., self-care). NWS should also provide at least annual updates to all employees which identify resources and tools available to them during a crisis.

Recommendation 37c: NWS offices should prioritize efforts to build an inclusive culture that seek opportunities for learning and growth as a team. In the context of high-impact events, offices should conduct AARs that focus development around training, problem-solving, and camaraderie-building.

3.6.2 Training and Proficiency

Core Partners described the overall high level of service quality provided by the NWS. Overall feedback indicated that Ida did not reveal any clear, service-related proficiency gaps that negatively impacted mission delivery. NWS staff consistently applied best practices from numerous training efforts that the agency has hosted (e.g., IDSS Boot Camp, Mesoanalyst Bootcamp, Effective Hurricane Messaging course, Radar and Applications Course), as well as many self-directed and instructor-led training modules.

The Assessment Team found two examples where the agency can strengthen its training and ensure staff proficiency. The rarity of a Flash Flood Warning issuance for a dam failure presented one opportunity. NWS issued a warning for a possible dam failure in the Johnstown, Pennsylvania area. WFOs occasionally issue Flash Flood Warnings for this type of causative event, but the rarity of such issuances creates a challenge in maintaining proficiency for providing complete and accurate information. This proficiency includes remembering to add specific verbiage for geographical locations as well as coordination with Core Partners ahead of events to ensure NWS acquires such information for inclusion in these warnings.

Fact: The lack of mention of emergency spillway use in a Flash Flood Warning for a possible dam failure in the Johnstown, Pennsylvania area caused confusion among partners. That information was key to their understanding of the issue.

Finding 38: The rarity of a Flash Flood Warning issuance for a dam or levee failure revealed a need for additional training to help maintain proficiency for these processes.

Recommendation 38: NWS should develop dam failure training that specifically emphasizes the importance of accurately communicating the issues at the dam or levee (e.g., overtopping, the use of emergency spillway, and dam or levee failure).

A high turnover rate across NWS presented the second example. The NWS staffing profile has begun to face a pivotal time of change characterized by a large outflux of experienced staff hired during its Modernization. This turnover has challenged offices with a temporary experience imbalance in which some offices have faced a cumulative experience shortage for supporting

operations for rare events such as landfalling hurricanes. New staff simply have not had the time in service to fully complete training and gain operational experience. The Assessment Team observed this challenge at WFO New Orleans/Baton Rouge. In interviews at WFO New Orleans/Baton Rouge, the Assessment Team noted that certain staff members had to take on specific duties with producing gridded forecast information, as other staff members did not have enough experience to work through these processes quickly. Having the right staff on at the right time made all the difference between mission success and failure; this represented a potential “near-miss” situation which may become more common as attrition of experienced personnel continues in the future. Staff stated they believed loss of institutional experience could become a potential vulnerability with an inherent risk for negative effects in subsequent high-impact events.

The Assessment Team noted that the NWS will continue to face the issue of attrition as the “modernization wave” begins to enter retirement eligibility. The Assessment Team recognized that a need exists to find new ways to expedite training, and to more quickly gain operational experience, to protect the NWS mission. The agency should find ways for staff to gain years of experience in much shorter time frames to protect mission integrity and quality.

Fact: WFO New Orleans/Baton Rouge had hired three new meteorologists within the 24 months preceding Hurricane Ida.

Finding 39a: A significant amount of turnover within the operations staff, combined with the complexities involved in tropical operations, yielded a situation where only a subset of staff at WFO New Orleans/Baton Rouge was considered fully trained and capable to produce the entire suite of tropical products and IDSS. While recent efforts have focused on empowering all operations staff to perform all tropical operations, through local, regional, and national efforts, the significant amount of observed and anticipated turnover has made this difficult to accomplish given the training needs and cadence.

Finding 39b: Given these challenges, the lack of ability for all operational staff to perform all tropical operations functions created a potential vulnerability, whereby an office's success in mission delivery could be affected by specific availability of certain staff.

Recommendation 39: NWS should develop a strategy to quickly train new staff, and refresh existing staff, on all aspects of high-impact operations, including but not limited to tropical operations. This training should focus on establishing “muscle memory,” translating to gained experience to offset the loss of experience and knowledge observed, and expected, through retirements. The outcome of this strategy would allow the agency to develop years of experience in just months of training.

3.7 Transportation Services

The Assessment Team conducted interviews with several state and local transportation agencies including MTA, NYSDOT, the Port Authority of New York and New Jersey, and PENNDOT. The Assessment Team co-lead from the FHWA also spoke with representatives from MDOT with regard to evacuation decisions made for the neighboring state of Louisiana prior to Ida's landfall. Most of these agencies interviewed found the NWS forecast products accurate and timely. Interviews revealed that these offices faced a significant challenge with the deficiency in detailed impact information relevant to potential stresses on the transportation system, taking the forecast and applying it to the outcomes.

Both NWS and transportation agency interviews indicated their beliefs in the benefits of the Pathfinder[26] program, a collaborative program sponsored by the Federal Highway Administration, in partnership with NWS and the Weather, Water, and Climate Enterprise. Out of the 25 states that have existing Pathfinder programs with NWS, nearly all of them have initiated the process of determining when and how those programs should expand to include non-winter related severe weather events. Expanding the scope of Pathfinder would also provide opportunities to increase the number of states that may engage in the program, a potential promising step forward in improving and expanding the relationships with transportation agencies. This expansion could build on the partnership between NWS and the Weather, Water, and Climate Enterprise to provide a more complete suite of IDSS to transportation partners, improve collaboration across the entire road weather community, and result in completing the objective of maintaining an efficient, mobile, and safe transportation system.

Overall, the Assessment Team's findings highlighted areas for improvement in the relationships between NWS offices and the transportation agencies they serve. Most NWS personnel agreed during the interviews that opportunities exist to improve the relationship between the WFOs and their transportation Core Partners.

Best Practice: WFO Baltimore/Washington collaborated with local Transportation Operations Coordination groups (e.g., Metropolitan Area Transportation Operations Coordination (MATOC)) in Washington, DC.

Fact: Pathfinder program efforts to align public messaging during significant weather events, directed at state and local departments of transportation, have historically focused on winter weather.

Finding 40: The Assessment Team found differing levels of consideration for state and local Departments of Transportation (DOT) as partners to WFOs.

[26] The Pathfinder initiative, supported by the FHWA and NOAA NWS, facilitates collaborative partnerships between the NWS, State DOTs, and private sector Weather Service Providers (WSP) that support DOTs. More information can be found at https://ops.fhwa.dot.gov/publications/fhwahop18059/fhwahop18059.pdf.

Recommendation 40: NWS should work, both nationally and locally, to expand the Pathfinder program for additional weather hazards, including potential response support for evacuation events.

Appendix A: Acronyms

AAR	After-Action Review
A/BI	Advanced Baseline Imager
AFSO	NWS Analyze, Forecast, and Support Office
AGL	Above Ground Level
AHPS	Advanced Hydrologic Prediction Service
AI	Artificial Intelligence
ARTCC	Air Route Traffic Control Centers
ASOS	Automated Surface Observing System
AWC	Aviation Weather Center
AWIPS	Advanced Weather Interactive Processing System
CDT	Central Daylight Time
CIRA	Cooperative Institute for Research in the Atmosphere
CMP	Collaborative Messaging Process
CMU	NWS Change Management Unit (formerly the NWS Evolve Program Management Office (PMO))
COO	Chief Operating Officer
COVID-19	Coronavirus disease 2019
CPC	Climate Prediction Center
CWA	County Warning Area(s)
CWSU	Center Weather Service Unit
DEIA	Diversity, Equity, Inclusion and Accessibility
DOT	Department of Transportation
EAS	Emergency Alert System
EF	Enhanced Fujita Scale

EM	Emergency Manager
EOC	Emergency Operations Center
ER ROC	Eastern Region ROC
ERH	Eastern Region Headquarters
ERO	Excessive Rainfall Outlook
ESP	Ensemble Streamflow Prediction
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FIFS	Fully Integrated Field Structure
FFG	Flash Flood Guidance
FOP	Flood Outlook Potential
GFFG	Graphical Flash Flood Guidance
GIS	Geographical Information System
GOES	Geostationary Operational Environmental Satellite
GOHSEP	Governor’s Office of Homeland Security and Emergency Preparedness
HEFS	Hydrologic Ensemble Forecast System
HSDRRS	New Orleans Hurricane and Storm Damage Risk Reduction System
HTI	Hurricane Threats and Impacts Graphic
I-95	Interstate 95
IAP	Incident Action Plan
ICS	Incident Command System
IDSS	Impact-based Decision Support Services
IT	Information Technology
IWT	Integrated Warning Team

KT	Knot
MAS	Multimedia Assistance in Spanish
MATOC	Metropolitan Area Transportation Operations Coordination
MB	Millibar
MDOT	Mississippi State Department of Transportation
MHHW	Mean Higher High Water
MMEFS	Meteorological Model Ensemble River Forecasts
MOU	Memorandum of Understanding
MPD	Mesoscale Precipitation Discussion
MTA	Metropolitan Transportation Authority of New York City
NCEI	National Centers for Environmental Information
NCF	Network Control Facility
NCEP	National Centers for Environmental Prediction
NCO	National Centers for Environmental Prediction Central Operations
NDFD	National Digital Forecast Database
NESDIS	National Environmental Satellite, Data, and Information Service
NHC	National Hurricane Center
NIMS	National Incident Management System
NM	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NWC	National Water Center
NWS	National Weather Service
NWSH	National Weather Service Headquarters
NWSI	National Weather Service Instruction

NWSOC	National Weather Service Operations Center
NYC	New York City
NYSDOT	New York State Department of Transportation
OAR	Office of Atmospheric Research
OEM	Office of Emergency Management
OHAP	Organizational Health Action Plan
OOE	Office of Organizational Excellence
OPC	Ocean Prediction Center
OWP	Office of Water Prediction
PENNDOT	Pennsylvania Department of Transportation
PMO	NWS Evolve Program Management Office (now Change Management Unit (CMU))
QPE	Quantitative Precipitation Estimate
QPF	Quantitative Precipitation Forecast
RFC	River Forecast Center
RMA	Remote Mesoscale Analysis
ROC	Regional Operations Center
RVF	River Forecast
SAVI	Supplemental Assistance Volunteer Initiative
SME	Subject Matter Expert(s)
SOO	Science and Operations Officer
SPC	Storm Prediction Center
SR ROC	Southern Region ROC
SRH	Southern Region Headquarters
STAR	Satellite Applications and Research

SWE	Snow Water Equivalent
TAFB	Tropical Analysis and Forecast Branch
TCV	Hurricane Local Watch/Warning Product
UCAR	University Corporation for Atmospheric Research
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USGS	United States Geological Survey
UTC	Coordinated Universal Time (Eastern Daylight Time plus four hours)
VPN	Virtual Private Network
VSAT	Virtual Satellite
WAN	Wide Area Network
WEA	Wireless Emergency Alerts
WEP	Words of Estimative Probability
WCM	Warning Coordination Meteorologist
WEA	Wireless Emergency Alerts
WFO	Weather Forecast Office
WGRFC	West Gulf River Forecast Center
WPC	Weather Prediction Center
WPOD	Water Prediction Operations Division
WRN	Weather-Ready Nation

Appendix B: Findings, Recommendations, and Best Practices

Definitions

Best Practice: An activity or procedure that has produced outstanding results during a particular situation that could be used to improve effectiveness and/or efficiency throughout the organization in similar situations. No action is required.

Fact: A statement that describes something important learned from the assessment for which no action is necessary. Facts are not numbered, but often lead to recommendations.

Finding: A statement that describes something important learned from the assessment for which an action may be necessary. Findings are numbered in ascending order and are associated with a specific recommendation or action.

Recommendation: A specific course of action, which should improve NWS operations and services, based on an associated finding. Not all recommendations may be achievable but they are important to document. Recommendations should be clear, specific, and measurable. The team leader and Performance and Evaluation Branch will compose an action item for each recommendation.

Findings and Recommendations

Finding 1: Zone-based Storm Surge Warnings made messaging difficult due to the fact that zones around Orleans and Jefferson Parishes contained both leveed and unleveed areas.

Recommendation 1: NWS should place additional emphasis on ongoing work to convert Storm Surge Warnings from grids overlaid into predetermined zones to products that use the gridded information to generate polygon coordinates that delineate the area in the resulting text product. If not possible, NWS should continue its efforts to refine zones in areas prone to surge to improve the efficacy of these products.

Finding 2: NWS had a less than desired response from Core Partners, to the urgency of a Storm Surge Warning that alerted for areas inside the New Orleans HSDRRS. Had the storm evolved even slightly differently, it could have resulted in a heightened threat for flooding in these areas, potentially leading to a disastrous result.

Recommendation 2: The NHC and WFO New Orleans/Baton Rouge should develop a more comprehensive collaboration mechanism that would be used before issuing a Storm Surge Warning that affects areas inside the New Orleans HSDRRS. This mechanism should include a deep bench of contacts from the State of Louisiana GOHSEP, the USACE , and others as appropriate. These partners can provide their perspectives on the likelihood of storm surge flooding in these areas and share local impact considerations. Inclusion of these partners, before the NHC makes the final warning decision, ensures a consistent Integrated Warning Team (IWT) approach. Tabletop exercises should be conducted at least annually to strengthen this collaboration, establish depth in the chains of contact, and build in the importance of these relationships into the warning process.

Finding 3: Multiple interviews indicated that some partners did not know how to find rainfall rate forecasts; rainfall rates were a big driver of the impacts and would have helped decision makers. They expressed that rainfall rate information would be a helpful tool for making decisions regarding related impacts.

Recommendation 3: NWS should develop forecast tools, IDSS, and messaging capabilities to communicate not only the expected rainfall, but also the expected hourly rate of rainfall, and a reasonable “worst case scenario” for each of these elements. NWS should also strengthen education and outreach efforts to highlight products which already contain this information.

Finding 4: Flood Watches do not adequately differentiate a high-end life threatening flash flood event from a more typical flash flood event. The overwhelming feedback from EM partners was that they were prepared for river and flash flooding, but had not completely anticipated the severity of impacts.

Recommendation 4: NWS should consider methods to better message the potential severity and impacts of flash flooding within its Flood Watch product. Potential ideas range from the concept of different product labels (e.g. Storm Surge Watch vs Coastal Flood Watch), to the use of an impact based construct with severity tags to mirror the technique used in Flash Flood Warnings.

Finding 5: Some NWS partners expressed a lack of awareness regarding the potential for extreme impacts to occur from flooding into the Northeast.

Recommendation 5a: NWS should encourage local offices to add impacts, reports, and other locally pertinent information to warnings, not just use the boiler-plate template wording, to produce a more detailed message concerning potential impacts in high-end events.

Recommendation 5b: NWS should routinely update the canned impacts and Call-to-Action statements to ensure forecasters have quick access to vetted statements that will allow them to readily issue watches/warnings and prevent potential errors when working in a high-pressure, short-fused environment.

Finding 6: The Assessment Team found that NWS faced challenges in role clarity, leading to duplicative efforts from various parts of the agency in IDSS, and difficulty in compiling a unified and consistent message. NWS lacks an organized approach to build capacity to coordinate a common reference point for communications for each situation (including the way in which causative factors for hazards are addressed), as well as a mechanism to ensure role clarity and optimize resources nationally, regionally, and locally, to maximize the provision of IDSS.

Recommendation 6a: NWS should consider leveraging an agency-level ICS response, similar to Southern Region's best practice of a Regional Response Plan, during major land-falling hurricanes, and potentially other large-scale high-impact events. Within this ICS response, the agency should develop and execute IAPs to manage resources, establish role clarity in "who does what," coordinate messaging, and orchestrate IAP execution during defined operational periods. The end result should strengthen a cohesive team effort, and optimize use of agency-wide resources.

Recommendation 6b: NWS Instruction (NWSI) 10-24 on "Impact-based Decision Support Services" should be updated to include new operational entities and clarify the roles of each operational unit with respect to the provision of IDSS and the development and maintenance of partner relationships at the local, regional, and national levels.

Recommendation 6c: As part of an ICS response, and to maximize the effectiveness of IDSS provided to FEMA, NWS should socialize and follow the FEMA regional and national engagement plans that have already been developed by the Change Management Unit.

Recommendation 6d: An additional part of the ICS response should include a mental health role into the command structure to focus on employee needs before, during, and after the event.

Finding 7: The different ways in which Ida was referenced resulted in inconsistencies across NWS messaging and response. References to a tropical system tended to elicit a higher level of response compared to similar hazard communication omitting reference to a tropical system. Moreover, the different levels of information availability among different key NWS web pages created challenges for users to receive this information.

Recommendation 7: ROCs and WPOD should provide internal messaging coordination and support to RFCs and WFOs during high-impact events. This should include the lead-up, duration, and aftermath of the event, and be informed by the operations tempo of the WFOs and RFCs.

Finding 8: Inconsistent messaging during the remnant phase of Ida led to negative impacts to service delivery during the event as local offices used different nomenclatures to reference the system. Some called it "remnants," others referenced "flooding."

Recommendation 8: ROCs should collaborate internal key messages with regional field offices. This work would ensure local offices use a coordinated reference to the remnants of a tropical system and support the communication needs of RFCs and WFOs during high-impact events. This should include the lead-up, duration, and aftermath of the event and be informed by the operations tempo of the WFOs and RFCs.

Finding 9: Users found it difficult to navigate the NWS web presence to find the post-tropical advisory products for Ida once the transition was made from the NHC to the WPC. The current NWS web and digital presence is heavily steeped in organizational structure, contrary to the philosophy of a FIFS, which would provide information seamlessly regardless of a knowledge of the NWS' organizational structure.

Recommendation 9a: NWS should use the NHC website as the official source of consistent service delivery regarding tropical cyclones, from development through post-tropical cyclone remnants, for as long as these systems produce hazards affecting areas served by NWS.

Recommendation 9b: WPC should use the same nomenclature as the NHC and should also produce post-tropical advisories until the storm exits areas served by NWS, so long as the storm presents impacts.

Finding 10: The Assessment Team found potential vulnerabilities in sustaining operations driven by technical support concerns, the complex nature of the tropical product suite, and the number of forecasters who have not had time to learn the complicated processes involved in producing the tropical suite of products and IDSS.

Recommendation 10: NWS should develop concepts for streamlining the tropical cyclone service suite and ensuring adequate support to software used to produce tropical products. These concerns should look for opportunities to:

A. Define and use the FIFS for forecast and IDSS production.
B. Reduce the complexity of processes.
C. Consider a strategic approach to identify dedicated resources needed to provide 24 x 7 support for software used to produce tropical products.
D. Deepen the agency resources to develop and provide training to ensure staff proficiency in operations. Concepts of this recommendation are captured in the "Hurricane Supplemental Projects and captured for internal use in an NWS Tropical Roadmap."

Finding 11: Forecasters noted collaboration calls during Ida were long and included information that did not always apply to the entire group of stakeholders. They noted that, if possible, shorter calls involving smaller geographical areas of offices would help alleviate duration and content concerns.

Recommendation 11: NWS should investigate the possibility of shorter, more geographically focused, collaboration calls to alleviate concerns over call length and scope. This investigation should consider how NWS can optimize technology to alleviate workload concerns, and focus on narrowing collaboration to smaller groups of affected internal parties, in lieu of one process that involves a larger all-encompassing group of all internal parties. ROCs, NWSOC, WPOD, and National Centers should play a role in investigating this idea.

Finding 12: The involvement of multiple support teams slowed the identification of the data table discrepancy issue, and affected the ability of NCF and the WFOs' technical staff to support WFO New Orleans/Baton Rouge operations.

Recommendation 12: During a major landfalling hurricane, the AWIPS program should explore providing dedicated personnel to support individual offices affected by the storm's landfall. This approach would help quickly resolve recurring issues and/or document more efficient troubleshooting processes. This could be a team of individuals large enough to support the impacted offices 24 x 7 and/or improved documentation which would enable efficient troubleshooting of systems processes, a clearer understanding of efforts already tried, and thus quicker resolution to problems that interfere with operations.

Finding 13a: Remote operating capacity was necessary to support efficient mission-critical service delivery when technical disruptions (e.g., power and internet outage) occurred at the NWS facility from Hurricane Ida's impacts.

Finding 13b: The Assessment Team found that the procedure for accessing the AWIPS VPN may not be sustainable.

Recommendation 13: To enhance Continuity of Operations and serve as a bridge between current and future backup capabilities, NWS should investigate developing necessary policy and procedures for remote access to operational systems within the agency.

Finding 14: The network setup in Southern Region caused critical failure of systems (i.e., mission failure), for offices affected by Ida, and those who normally provide service backup and/or Mutual Aid to those offices, requiring significant workarounds.

Recommendation 14: NWS should expedite the existing project stood up by the Office of Dissemination and NCO to implement a consistent solution for internet connectivity in Southern Region.

Finding 15: NWS offices needed a better framework to establish clear roles and responsibilities for troubleshooting and restoring critical systems.

Recommendation 15: NWS should consider using the Logistics Section of the ICS structure (Recommendation 6a) to streamline the troubleshooting of IT and maintenance challenges. The Logistics Section could be a facilitator for ensuring each office has dedicated resources to resolving these challenges and coordinate Mutual Aid to accomplish maintenance and IT support.

Finding 16: Local offices did not fully understand the policy or capacity for providing various services remotely (e.g., social media, local storm reports) which led to inconsistent resource usage across offices and regions.

Recommendation 16: NWS should establish guidance, by office type, on what operational services employees can provide from a remote location.

Finding 17a: Pre-existing Mutual Aid efforts served as examples of an overarching construct of using resources across the agency to assist in the provision of services and support.

Finding 17b: Mutual Aid and service backup remain vital components for accomplishing the NWS mission, particularly when events cripple the infrastructure near an NWS facility, and also to provide additional capacity for an office working a high-impact event.

Recommendation 17: NWS should investigate using expanded Mutual Aid opportunities for operations, administrative support, and maintenance activities. This expansion could follow a similar construct to how pre-existing Mutual Aid efforts (e.g., RMA, SAVI, MAS) developed in the agency.

Finding 18: The administrative guidance provided by NOAA for evacuation was different, and perceived by employees as more restrictive, for Hurricane Ida as compared to Hurricane Irma. Similar issues are also noted with Hurricanes Harvey, Florence, and Michael.

Recommendation 18a: NWS should reopen Recommendation 3 from the Hurricane Harvey Service Assessment, “NWS CFO should work with NOAA to clarify, clearly communicate, and ensure a consistent application of the evacuation pay policies for employees and dependents before high-impact events,” and ensure continued work on Recommendations 56a-d in the Hurricane Florence/Hurricane Michael Service Assessment.

Recommendation 18b: Within an ICS managed structure (Recommendation 6a), NWS should consider having an agency “Finance/Admin Section” which can quickly help to resolve administrative questions and thus better enable field offices to provide services.

Finding 19: Not all RFC delivered products are currently being issued from the NWC backup system. The NWC does not currently have the capability of issuing all RFC products, including ensemble products and rainfall products that display on the NWS Advanced Hydrologic Prediction Service (AHPS) page.

Recommendation 19: NWS should prioritize developing specific requirements needed to provide additional RFC service backup capabilities at the NWC. Based on its investigation, the Service Assessment Team suggests that efforts could focus on enabling at least some of the following capabilities to close this gap:

A. Hydrometeorological Forcings (e.g., Quantitative Precipitation Estimate (QPE), QPF).
B. Probabilistic Forecasts (e.g., Ensemble Streamflow Prediction (ESP), and Hydrologic Ensemble Forecast System (HEFS)).
C. Water Supply/Resource Forecasts/Outlooks.
D. Flood Outlook Potential (FOP).
E. Distributed Model Output - RFC States output (e.g., ratings, unit hydrographs, soil moisture, Snow Water Equivalent (SWE)).
F. Transmitting gridded rainfall estimates for the purpose of populating the NWS AHPS webpage rainfall graphic.

Finding 20: Interviews with Core Partners revealed that many expressed interest in having NWS meteorologists and hydrologists staffed in their EOCs more routinely to support planning (well ahead of an event), mitigation (just prior to an event), response (during an event), and recovery (after an event) efforts. This was a consistent finding between the two external Sub-teams. Interviewees indicated their desire for on-site IDSS would continue to increase; especially for those interviewed who covered high population areas.

Recommendation 20: The NWS Analyze, Forecast, and Support Office should develop policy and procedures, to include the entire forecast process, which will help maximize the use of resources needed to meet existing IDSS needs and provide additional capacity for increasing demand for IDSS.

Finding 21: The number of deployments during Hurricane Ida were limited by multiple factors, including resource constraints, the COVID-19 pandemic, and operational demands within offices.

Recommendation 21: NWS should develop an agency strategy to help local offices facilitate on-site staffing to Core Partners. This strategy should consider redeployments to an affected office, and/or deployments of personnel to directly provide on-site IDSS, similar to strategies used during the IDSS response to the Deepwater Horizon and Enbridge oil spills in 2010.

Finding 22: The Assessment Team noted that several offices used Mutual Aid, in the form of service backup. If used more frequently, Mutual Aid could present an option to create capacity to provide IDSS.

Recommendation 22: Through Recommendation 17, NWS should consider using Mutual Aid as a means to free up local resources during high-impact events. This could allow local offices to focus solely on work maximizing the importance of their local presence, including IDSS, freeing up resources to honor additional requests for deployments, and warnings.

Finding 23a: The Assessment Team estimated that these 16 offices spent approximately 80 hours creating slides for Hurricane Ida IDSS and messaging. Multiple people spent a significant number of hours creating slide deck briefings with content that already existed on NWS websites.

Finding 23b: The Assessment Team found examples where slide deck briefings were changed by a Core Partner after distribution. Partners interviewed often noted they modify slide decks for various reasons. The modifications are intended to make NWS content more easily accessible, shareable, or user-friendly. They did not change the forecast, but they changed the format.

Recommendation 23a: The NWS IDSS program should evaluate the effectiveness and return on investment of providing slide deck briefing packages that merely "repackage" existing static NWS information but do not provide context beyond the provision of the graphics against an alternate strategy of providing dynamic data, consultation, and interpretation of the information itself.

Recommendation 23b: As an interim step, the NWS IDSS program should consider requiring the inclusion of a "Key Points" or "Key Messages" slide near the beginning of briefing packages to ensure the slide deck highlights the most important messages up front.

Finding 24: While many local offices used common templates (e.g., common fonts, common color theme) for their IDSS briefings, others did not. The Assessment Team found several examples where offices used different templates as well as little consistency in the graphics within the briefing slides.

Recommendation 24: The NWS IDSS program should consider requiring offices to use consistent slide deck templates previously developed within the agency, and contained within the IDSS Toolkit. These templates already follow the NOAA style guide.

Finding 25: The Assessment Team found a majority of mapped content did not abide by standard cartographic practices. The majority of mapped content reproduced existing information while also being highly inconsistent office by office. Because the mapped content within briefing packages were static images, the Core Partner had no capacity to interact with the data to improve their understanding (i.e., users could not zoom, nor sample information, nor use it within their existing interoperable capabilities).

Recommendation 25: NWS should examine using prioritized GIS data services, in lieu of static maps, to improve its ability to provide IDSS. This includes ensuring geospatial products or services are provided in industry standard formats (e.g., as a data service). This also includes transitioning the majority of static IDSS content with a geospatial component (e.g., slide decks, graphics, text products) into a GIS environment that provides an interactive, dynamic, and consistent user experience.

Finding 26: Interviews with partners indicated their desire for NWS to provide information in a geospatially-friendly format for platform integration as they rely on GIS systems for internal situational analysis and decision making. Partners in the Northeast used an ESRI ArcGIS™ platform to drive their displays.

Recommendation 26: NWS should consider producing its GIS information such that it follows industry standard data formats and data structure conventions, which do not assume the use of proprietary tools, and can be used by commonly available tools and in an interoperable fashion by the GIS platforms used by Core Partners.

Finding 27a: When mapping the same information (e.g., rainfall amounts, official products, remotely sensed data), NWS maps were inconsistent in their use of color, iconography, background or basemap, use of legends, titles, compasses, and geo-referenced features (e.g., cities, roads, rivers, lakes). This inconsistency occurred within individual briefing packages, across local offices, and across regions.

Finding 27b: The decision to use data clipped to geopolitical boundaries appeared inconsistent. Offices often clipped data to geopolitical boundaries (e.g., CWAs domains, states), even though valid data existed beyond the geopolitical boundaries. Further, offices were inconsistent in their decisions to use boundary clipped, or unclipped, data both within individual briefing packages and across offices.

Finding 27c: NWS offices often re-mapped information that already existed in a digital format, oftentimes on existing online repositories such as NWS web pages, that did not require downscaling to add necessary detail and/or context. Examples included watches, warnings, and advisories, and forecast information mapped within the National Digital Forecast Database (NDFD). The primary reason this information was re-mapped appeared to be based on a perception that its existing mapped format was either not visually appealing or not useful as presented.

Recommendation 27: NWS should identify and implement solutions to static mapping problems as static maps will likely remain a core component of IDSS and messaging even as information transitions to a more dynamic, data service, GIS-based solution. Solutions should utilize input from experts in cartographic design and visual communication.

Finding 28: The Assessment Team could not find any standard nor consistency when selecting color bar ranges when presenting confidence, risk, impact, timing, or threat information. As an example, there was partner confusion at the United States Coast Guard (USCG) in the color curves and labels of the Hurricane Threats and Impacts (HTI) graphic and the ERO. The HTI used five levels of threat while the ERO used four. Both products had inconsistencies in color choice and labeling.

Recommendation 28: NWS should develop policy on graphical depictions of its information, similar to policies for text-based products, to establish standards for templates, colors, and verbiage for all graphics that include time-sensitive information critical to life safety decisions. The HTI and ERO serve as an example to which this recommendation applies.

Finding 29a: Core Partner interviews, particularly in the Northeast, revealed they did not fully understand how severe this event would become.

Finding 29b: The Assessment Team noted that NWS offices used words to convey uncertainty information in IDSS briefings that were at times in conflict with published research on the topic.

Recommendation 29: The NWS IDSS program should consider how best to incorporate and adopt recommendations provided by research conducted under NOAA grant NA16OAR4320115 on the topic of communicating probability information.

Finding 30a: Local offices relied almost exclusively on email as a dissemination system for the majority of IDSS messaging. NWS then relied on the Core Partners in the email distribution lists to forward information to additional partners or relevant response entities.

Finding 30b: Core Partners noted that during high impact events email traffic increases exponentially, causing the potential to miss or delay reception of important emails with IDSS information.

Finding 30c: Partners also expressed the desire that NWS provide its content in a format compatible for display on mobile devices.

Recommendation 30: NWS should investigate improved capabilities to deliver IDSS to Core Partners including the means to directly deliver IDSS material to Core Partners via mobile devices.

Finding 31a: The Assessment Team found that the majority of IDSS work was completed using the commodity internet.

Finding 31b: Reliable internet connectivity was as vital to successful IDSS operations as a reliable AWIPS WAN was to issuing warnings.

Finding 31c: Disruptions to internet connectivity for WFO New Orleans/Baton Rouge and the LMRFC resulted in numerous challenges for completing mission delivery which staff overcame by using alternate sources to access the internet such as hot spots, MiFis, and via telework at staff homes.

Recommendation 31a: NWS should prioritize internet connectivity as an operational necessity for providing IDSS. As such, NWS should move away from a shared dependency with AWIPS on Virtual Satellite (VSAT) and instead develop options for providing redundancy for commodity internet (e.g., separate circuits, 5G router, improved satellite capabilities in partnership with the private sector, a combination thereof) with reasonable bandwidth that can be used in the case of the loss of the fiber connection. Offices could then utilize VPN capabilities to access secure networks and resources.

Recommendation 31b: NWS should investigate using VSAT solely to back up the AWIPS WAN. As designed, VSAT should be able to handle AWIPS WAN traffic with the commodity internet using a different means of redundancy as noted above.

Finding 32: Local offices stated they would like to have a ready resource to point to if asked about private sector capabilities for IDSS. Such a page exists, but these offices did not know of it at the time.

Recommendation 32: NWS should increase internal awareness of its Enterprise Resources website and update this site to explicitly call out the IDSS capabilities of the Weather, Water, and Climate Enterprise.

Finding 33a: NWS has not provided a policy definition of the service equity concept to field offices. NWS had not provided tangible methods, tools, or resources to identify and more effectively serve members of vulnerable groups.

Finding 33b: In the absence of policy, the Assessment Team found that at times, offices assigned their own designation of groups as being “underserved,” or not receiving equitable services, based upon predetermined notions or assumptions. For example, some communities may have preferred methods to receive information that were not well known; other communities were perceived as not having access to technology, yet they could use it in certain circumstances.

Finding 33c: Offices had a broad understanding of what vulnerable communities they might have in their area. For instance, they noted certain religious communities who generally refrain from using electronic devices, or non-English speaking communities who may struggle interpreting NWS information. However, there were few examples of specific, tangible activities offices were taking to identify vulnerable groups or identify service gaps.

Recommendation 33a: NWS should complete work on its draft service equity plan, and once published, should expedite efforts to execute key components of the plan to assist the field in improving services to vulnerable and/or underserved communities.

Recommendation 33b: NWS should conduct a deeper analysis of service equity in a future service assessment after the agency has published its service equity plan.

Finding 34: NWS lacked an agency solution to address the communication challenges faced by people with Limited English Proficiency as well as those who have disabilities that affect their ability to communicate.

Recommendation 34: NWS should develop an agency strategy to better serve people with Limited English Proficiency. NWS' strategy should address multiple common languages spoken in the United States, and help the agency fulfill the intent of Executive Order 13166—Improving Access to Services for Persons With Limited English Proficiency.

Finding 35: The Assessment Team found that civic organizations and the leaders of houses of worship serve as trusted voices in the community, but are not frequently the target of NWS outreach and recruitment as Weather-Ready Nation (WRN) Ambassadors or StormReady®/TsunamiReady® designations.

Recommendation 35: NWS should encourage local offices to work more closely with leaders of houses of worship and civic organizations to promote their inclusion as WRN Ambassadors or to achieve StormReady®/TsunamiReady® designation, and utilize these leaders as force multipliers to reach broader communities.

Finding 36: NWS lacks a robust mobile presence which, per the facts above, would be needed to better support underserved communities with lower incomes who rely on mobile devices as their lifeline for information. This lack of a robust presence represents a significant barrier to better serving the historically underserved.

Recommendation 36: To better serve historically underserved and vulnerable communities, NWS should establish a robust presence providing services via mobile devices. This outcome could be achieved in many ways such as a mobile application, converting existing web content to adaptable displays for mobile devices (e.g., AWC prototype webpage and Point-and-Click forecast pages), or via partnerships with FEMA and/or the Weather, Water, and Climate Enterprise.

Finding 37a: A subset of NWS staff interviewed communicated clear signs of significant mental distress, during the peak of the system’s impacts, and extending into its aftermath. This distress resulted from the magnitude of the impacts from Ida, extreme and prolonged workplace demands and stresses, and long-term recovery efforts.

Finding 37b: The depth of investment by the local office supervisor into the success of each staff member greatly influenced the amplification or mitigation of mental health challenges.

Finding 37c: This event also revealed opportunities to empower supervisors with tools and resources to create a healthier environment for employees, centered around mental health, especially when high-impact events bring the potential for employees to experience trauma and, in some cases, multiple traumas.

Recommendation 37a: NWS should explore developing a capability to respond in-person to local offices in the aftermath of a significant event, specifically to proactively make available resources for recovery assistance, along with mental health resources and counseling. This is especially important if there has been direct impacts to NWS employees and/or their property.

Recommendation 37b: NWS should require annual training on crisis management and critical stress management for all supervisors, focused on their roles of helping employees and on helping themselves (i.e., self-care). NWS should also provide at least annual updates to all employees which identify resources and tools available to them during a crisis.

Recommendation 37c: NWS offices should prioritize efforts to build an inclusive culture that seek opportunities for learning and growth as a team. In the context of high-impact events, offices should conduct AARs that focus development around training, problem-solving, and camaraderie-building.

Finding 38: The rarity of a Flash Flood Warning issuance for a dam or levee failure revealed a need for additional training to help maintain proficiency for these processes.

Recommendation 38: NWS should develop dam failure training that specifically emphasizes the importance of accurately communicating the issues at the dam or levee (e.g., overtopping, the use of emergency spillway, and dam or levee failure).

Finding 39a: A significant amount of turnover within the operations staff, combined with the complexities involved in tropical operations, yielded a situation where only a subset of staff at WFO New Orleans/Baton Rouge was considered fully trained and capable to produce the entire suite of tropical products and IDSS. While recent efforts have focused on empowering all operations staff to perform all tropical operations, through local, regional, and national efforts, the significant amount of observed and anticipated turnover has made this difficult to accomplish given the training needs and cadence.

Finding 39b: Given these challenges, the lack of ability for all operational staff to perform all tropical operations functions created a potential vulnerability, whereby an office's success in mission delivery could be affected by specific availability of certain staff.

Recommendation 39: NWS should develop a strategy to quickly train new staff, and refresh existing staff, on all aspects of high-impact operations, including but not limited to tropical operations. This training should focus on establishing “muscle memory,” translating to gained experience to offset the loss of experience and knowledge observed, and expected, through retirements. The outcome of this strategy would allow the agency to develop years of experience in just months of training.

Finding 40: The Assessment Team found differing levels of consideration for state and local Departments of Transportation (DOT) as partners to WFOs.

Recommendation 40: NWS should work, both nationally and locally, to expand the Pathfinder program for additional weather hazards, including potential response support for evacuation events.

Best Practices

1. Core Partners in the Northeast stated that the ERO was a standout product as they felt the product provided valuable context to help them understand the potential magnitude of the event.
2. During Hurricane Ida, Southern Region Headquarters instituted an ICS structure, and developed Regional Action Plans, to coordinate and manage a region-wide response to the storm. Southern Region typically does this for all landfalling hurricanes, and other significant events, through their Regional Operations Center.
3. NHC and affected WFOs moved up the typical issuance time of the Hurricane Watch six hours, from 4 am on August 27 to 10 pm on August 26, so the headlines were out before people went to bed that night. The Assessment Team received considerable positive feedback on this decision.
4. WFO New Orleans/Baton Rouge used Mutual Aid with partial service backup from WFO Jacksonville for aviation services, starting at 7 pm Central Daylight Time (CDT) on August 27. Four separate WFOs successfully were able to divide and continue New Orleans/Baton Rouge's operations (Grids, Aviation, IDSS) for extended periods, even during very active portions of the event.
5. The LMRFC used self-backup capabilities afforded by technology advances developed during the COVID-19 pandemic and also used service backup from the NWC.
6. Some offices provided a standing, or open time, after a virtual briefing to provide more detailed IDSS to partners.
7. CWSU Houston staffed an additional employee to cover all tropical briefings and IDSS products.
8. As an example of more frequent Mutual Aid, the LMRFC and West Gulf River Forecast Center (WGRFC) routinely perform each other's functions during busy hydrologic operations, periodically completing cross-training and testing.
9. Email briefings and webinars from WFO Mobile were instrumental in supporting Port of Mobile operations after major efforts for partner-building between the WFO and the Port.

10. WFO New Orleans/Baton Rouge management team made the decision to “close the office,” invoking Mutual Aid for a “mental health” day well after landfall so their staff could recharge.
11. The After-Action Review (AAR) process at WFO Philadelphia/Mt. Holly focused on experiential learning, including simulations-based training, and AARs. The AAR process also included a check on employee's well being and mental health.
12. WFO Baltimore/Washington collaborated with local Transportation Operations Coordination groups (e.g., Metropolitan Area Transportation Operations Coordination (MATOC)) in Washington, DC.