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A MIXED METHODS ANALYSIS OF HURRICANE TRENDS AND EXPERTS' PERCEPTION OF FUTURE MILITARY HURRICANE READINESS

Ralph E. Scott

A MIXED METHODS ANALYSIS OF HURRICANE TRENDS AND EXPERTS' PERCEPTION OF FUTURE MILITARY HURRICANE READINESS

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by
Ralph E. Scott

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Ralph E. Scott	Dr. Jie Xu

ABSTRACT

A MIXED METHODS ANALYSIS OF HURRICANE TRENDS AND EXPERTS' PERCEPTION OF FUTURE MILITARY HURRICANE READINESS

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Guided by the four theories of disaster, two civil-military theories, and two communication theories, this mixed methods study was an investigation of whether hurricanes in the North Atlantic basin are increasing in frequency and whether Defense Support of Civil Authorities (DSCA) practitioners perceive the DoD is prepared to assist FEMA when the next major hurricane strikes. The DoD is a last resort with a unique and tremendous capability to support FEMA during hurricane response. To better understand hurricane trends and DoD's hurricane response posture, this study was an analysis of 171 years of tropical cyclone data from the National Oceanic and Atmospheric Administration, followed by an evaluation of 30 DSCA professionals' semistructured interview responses. Disagreement about the frequency of hurricanes and responses from interviews indicated the DoD is ready; however, there are a few gaps in overall readiness to address before the next response. This research is timely and significant because property damage from hurricanes is costly, with increasing death rates. A thorough study of the actual frequency of hurricanes and the feedback from DSCA experts regarding the DoD's hurricane readiness posture offers a pathway toward efficacious disaster preparedness and response. The results of this study provide critical information for decision-makers and policymakers in the federal, state, local, tribal, and territorial governments to make sound decisions before the next major hurricane.

DEDICATION

I dedicate this dissertation to my family. My wife, Sylvia, has been a listener and a supporter of my endeavors; her partnership, steadfastness, and love sustain me. To Davine and Georgia: The American dream does exist if your father can immigrate from West Africa and achieve success academically and professionally. Dream big, work hard, and have fun.

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This work would not have been possible without the support from many others. First, I express my deepest appreciation to my dissertation committee. I am deeply indebted to Dr. Jie Xu, the chair of my committee. As my mentor, she taught me more than I could ever give her credit for here. She has shown me, by her example, what a good researcher should be. The thoughtful comments and recommendations provided by Dr. Linda Di Desidero, who specializes in professional writing; Dr. Bernard Jones, an expert in emergency management; and Dr. Chris Landsea, an atmospheric scientist, helped push me to complete this important and timely research.

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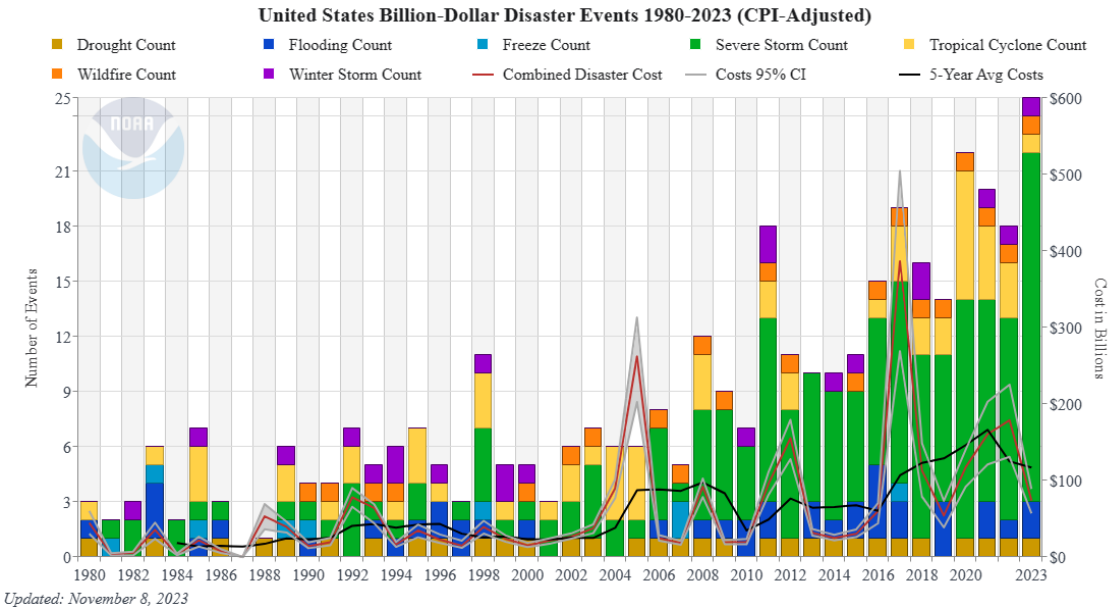
CHAPTER 1: INTRODUCTION

Tropical cyclone (TC) losses account for the largest damage distribution from U.S. billion-dollar disaster events between 1980 and 2023. TCs also account for the highest number of deaths (6,895), followed by drought/heatwave events (4,502) and severe storms (2,094; National Centers for Environmental Information [NCEI], 2023). TCs have caused the most damage ($1,379.9 billion) and have the highest average event cost ($22.6 billion per event), as shown in Figure 1.

Figure 1

U.S. Billion-Dollar Weather and Climate Disasters



Note. From "Costliest U.S. Tropical Cyclones," by NCEI and National Hurricane Center (NHC), 2023. (https://www.ncdc.noaa.gov/billions/dcmi.pdf)

Hurricane Katrina, a Category 3 hurricane, caused over 1,833 deaths and $196.3 billion in damages. Hurricane Sandy, a Category 1 hurricane, caused 159 deaths and $86.5 billion in damages. Hurricane Maria, a Category 4 hurricane, caused 3,000 deaths and $112.5 billion in damages (NCEI & NHC, 2023).

The United States Department of Defense (DoD) is a last resort upon activation of the National Response Framework (NRF). However, the DoD has unique and tremendous capabilities to support the Federal Emergency Management Agency (FEMA) during hurricane response. The NRF guides the national response to disasters and emergencies with scalable, flexible, and adaptable concepts from the National Incident Management System (NIMS). The U.S. government employ the instruments of national power to continuously detect, deter, prevent, and defeat threats (manmade or natural) to the homeland. For the military, this national imperative translates operationally into the Defense Support of Civil Authorities (DSCA), which is the:

> Support provided by federal military forces; DoD civilians; DoD contract personnel; and DoD component assets, to include National Guard forces (when the Secretary of Defense [SECDEF], in coordination with the governors of the affected states, elects and requests to use and fund those forces in Title 32, United States Code [USC], status), in response to a request for assistance (RFA) from civil authorities for domestic emergencies, cyberspace incident response, law enforcement support, and other domestic activities or from qualifying entities for special events (Joint Chiefs of Staff, 2018).

Usually supporting FEMA, the military executes DSCA missions through defense coordinating officers (DCOs) co-located at the 10 FEMA regional headquarters. DCOs are FEMA's single point of contact for military support. As liaison officers between FEMA and the United States Northern Command (USNORTHCOM), DCOs assist with the flow of relief efforts to the most affected areas (U.S. Department of Defense, 2017). The U.S. military progressively worked to improve disaster response after Hurricane

Katrina in 2005, Hurricane Sandy in 2012, and Hurricane Maria in 2017. Despite many lives saved during the massive response to Hurricane Katrina, there were several challenges throughout the response (U.S. Government Accountability Office [GAO], 2006). Despite the substandard response, DoD leaders sought to learn from the organization's mistakes. For example, during the Hurricane Sandy response, two DoD entities, the National Guard and active-duty forces, executed civil support operations under the tactical command of the dual status commander (DSC) for the first time. Although the response was effective and free of major challenges, military leaders continued to gather information from the lessons learned to prepare for the next disaster. After identifying and incorporating lessons into future disaster response, the DoD underwent another test during the 2017 hurricane season. The DoD sought to improve disaster response after Hurricane Sandy; however, the improvements did not fill the gaps in DoD personnel's understanding of the DSC in DSCA operations. Despite lacking understanding, DoD personnel saved many lives and mitigated unnecessary suffering in Puerto Rico during Hurricane Maria (Larson et al., 2020).

Disaster preparedness is a NIMS concept that addresses key roles and responsibilities. The NRF provides guidance for disaster response to jurisdictions, citizens, nongovernmental organizations, and businesses. The NRF includes emergency support functions (ESFs), the federal coordinating structures for grouping resources and capabilities into the functional areas most frequently needed during a national response. The DoD has a supporting but crucial role of executing ESF tasks as part of the NRF and NIMS. Improvements from past lessons could result in the increased capability of military personnel and enhanced knowledge for those unfamiliar with certain concepts to

achieve the goal of DSCA operations: save lives, mitigate suffering, and protect critical infrastructure during disasters.

Throughout FEMA's 44-year history, seven significant disasters caused massive changes in legislation and the national response. Five of the seven disasters were hurricanes: Hurricane Hugo (1989); Hurricane Andrew (1992); the California Northridge earthquake (1994); Hurricane Katrina (2005); Hurricane Sandy (2012); the California wildfires (2017); and Hurricanes Irma, Maria, and Harvey (2017; FEMA Historic Disasters, 2023). The U.S. Military had a vital role and was a reliable partner during the response to these disasters.

TCs include tropical depressions, tropical storms, hurricanes, and major hurricanes. A TC is any low-pressure system that forms over tropical waters with thunderstorm activities near the center of closed, cyclonic winds. TCs gain energy from vertical temperature differences and are symmetrical storms with a warm core (Atlantic Oceanographic & Meteorological Laboratory [AOML], 2023). A TC is a rotating, organized system of clouds and thunderstorms originating over tropical or subtropical waters with closed, low-level circulation. A tropical depression is a TC with maximum sustained winds of 38 mph (33 knots) or less. A tropical storm is a TC with maximum sustained winds of 39–73 mph (34 to 63 knots). A hurricane is a TC with maximum sustained winds of 74 mph (64 knots) or higher. A major hurricane is a TC with maximum sustained winds of 111 mph (96 knots) or higher that corresponds with Category 3, 4, or 5 on the Saffir-Simpson Hurricane Wind Scale (AOML, 2023). *Hurricane* is the term for TCs with winds exceeding 74 mph in the Atlantic or East Pacific Oceans, whereas *typhoon* refers to such storms in the Northern West Pacific. The

Saffir-Simpson Hurricane Wind Scale (see Table 1), which has a 1–5 rating based on the hurricane's maximum sustained wind speed, is the tool used to estimate potential property damage.

As one of Earth's most destructive weather systems, hurricanes have been the subject of intense research. There have been mixed opinions regarding hurricane trends; however, increased hurricane frequency results in more lives lost and more significant recovery costs. In the 2030 Homeland Theater Strategy, the U.S. Army North (ARNORTH), the DoD's lead organization for DSCA, indicated that disasters, including hurricanes, will increase in frequency (2022). The strategy also suggested that hurricanes could exceed the DoD's capability, especially if they occur simultaneously or in close sequence in the United States. Therefore, with the four theories of disaster, two civil-military theories, and two communication theories, this study focused on whether hurricanes in the North Atlantic Basin have increased in frequency and whether DSCA practitioners consider the DoD prepared to support FEMA during the next major hurricane in the United States.

Table 1

The Saffir-Simpson Hurricane Wind Scale

Category	Sustained winds	Types of damage due to hurricane winds
1	74–95 mph 64–82 kt 119–153 km/h	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roofs, shingles, vinyl siding, and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96–110 mph 83–95 kt 154–177 km/h	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111–129 mph 96–112 kt 178–208 km/h	Devastating damage will occur: Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130–156 mph 113–136 kt 209–251 km/h	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157+ mph 137+ kt 252+ km/h	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Note. From the National Hurricane Center.

Purpose of the Study

The purpose of this mixed methods study was to investigate whether hurricanes in the North Atlantic Basin are increasing in frequency and whether DSCA practitioners perceive the DoD as prepared to support FEMA when the next major hurricane occurs in the homeland. This mixed methods study involved analyzing 171 years of TC data from the National Oceanic and Atmospheric Administration (NOAA) and conducting semistructured interviews with 30 DSCA experts. Case studies of the DoD's response to Hurricanes Katrina, Sandy, and Maria and interview data indicated readiness gaps to examine and address before the next major hurricane response. The U.S. military progressively worked to improve disaster response after Hurricanes Katrina, Sandy, and Maria. However, DSCA experts have indicated that some challenges remain.

This research focused on the North Atlantic Basin, including the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. The hurricane season in the North Atlantic Basin runs from June 1 to November 30 yearly. Although only 12% of the world's TCs occur in the North Atlantic (Emanuel, 2021), there are quantitative records dating back to the mid-19th century for the whole basin (Landsea, 2007). Consistent, reliable, and historical data for other regions are limited. This study also included the knowledge and expertise of DSCA experts who were members of the DSCA Phase III forum and had served at tactical and strategic levels at military and support organizations in active and reserve forces across 10 FEMA regions in and outside the continental United States.

The DoD is a last resort upon NRF activation and a major player with a unique and tremendous capability to support FEMA during hurricane response. Limited literature has focused on the DoD's hurricane readiness. Therefore, this study was a

thorough analysis of DoD's hurricane readiness. This study was a means to dissect and understand DSCA complexities, such as authorities, policies, and organizational structures, to suggest how DoD personnel can better prepare for the next major landfall hurricane in the United States. This study was timely and significant due to the increasingly costly property damage and higher death rates caused by hurricanes. Stakeholders, including the average American, could use the study to understand the fluctuations of landfall hurricanes. A thorough study of hurricane trends and DSCA practitioners' feedback regarding the DoD's hurricane readiness could contribute to efficacious disaster preparedness and response. The study could provide decision-makers and policymakers in the federal and state, local, tribal, and territorial (SLTT) governments with critical information to make sound decisions before the next major hurricane.

Research Questions

1. What is the trend of hurricane activity in the North Atlantic Basin?
2. How prepared is the DoD to support the next hurricane that makes landfall in the United States?

Assumptions, Limitations, and Delimitations

The study had the following assumptions:

- The raw data in HURricane DATa (HURDAT) that underwent analysis provided accurate figures for this study.
- Sufficient DSCA professionals participated and answered interview questions honestly and to the best of their ability.

- The participating DSCA professionals did not answer the questions with bias to present a favorable picture of the current DoD hurricane readiness posture.

The study had the following limitations and delimitations:

- Due to ongoing reanalysis of the Atlantic Basin hurricane database, there will likely be updates to TC data in the future.
- There are no long-term data for other global regions comparable to the North Atlantic Basin, thereby limiting global comparison.
- Although the U.S. Army is a major proponent of the DSCA response, there were no participants from the Air Force, Navy, Marines, Coast Guard, or Space Force.

Summary and Organization of the Remainder of the Study

Chapter 1 was an introduction to this mixed methods study, including the purpose, problem statement, research questions, and significance. The chapter also addressed the study's assumptions, limitations, and delimitations. Chapter 2 is a comprehensive literature review of hurricane trends, DSCA operations, and gaps in the current knowledge. The chapter presents an overview of theoretical disaster literature, the four theories of disaster, two civil-military relations theories, and two communication theories. Analysis of case studies of Hurricanes Katrina, Sandy, and Maria provided an in-depth understanding of previous DoD-related responses. Chapter 3 presents the research design, methodology, study concepts, sample, instrumentation, data collection, and analysis. Following the results in Chapter 4, Chapter 5 includes a discussion of the findings, implications, and recommendations for future research.

CHAPTER 2: LITERATURE REVIEW

Introduction

This three-part literature review provides an overview of hurricane trends and responses to three historic hurricanes. Documents on doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTMLPF-P) related to DSCA operations also underwent review. The chapter commences with the four theories of disaster, two civil-military relations theories, and two communication theories. Together, these theories provided an understanding of disasters, the relationship between civil and military authorities, and effective communication. Experts have had varied opinions about hurricane frequency in the North Atlantic Basin. The literature for Part I primarily consists of research papers and articles from prominent journals such as *Nature Communications*, *Geophysical Research Letters*, *Journal of Climate*, and *Bulletin of the American Meteorological Society.* Literature publicly available through the National Centers for Environmental Information, the Atlantic Oceanographic and Meteorological Laboratory, and the Center for Climate and Energy Solutions also underwent review. Evidence has shown the importance of the DoD during hurricane response, such as during Hurricanes Katrina, Sandy, and Maria. Response effectiveness varied despite resources and capabilities. However, DoD leaders reflected on past responses to improve before the next hurricane.

Part II focuses on reports, testimonies, after-action reports (AARs), and research by the Congressional Research Service, the GAO, the Heritage Foundation, and RAND Corporation. DSCA operations are complex, with restrictions for authorities, policies, and laws. Therefore, many DoD leaders face the challenges of conducting operations in the

United States. Documents analyzed for the literature review included the U.S. Constitution; presidential directives; public law; legislation; congressional acts; strategic documents; policies; joint and service doctrine; DoD directives, instructions, and memorandums; and other documents related to DoD and DSCA operations on U.S. soil. The chapter concludes with scholarly DSCA studies on proficiency, training, education, and leadership.

Theoretical Framework

This study on hurricane activities focused on civil and military relationships and involved verbal and nonverbal communication with the participants. Theories provide an understanding of phenomena such as disasters so academics and practitioners can solve problems and advance their fields. In this study, the four theories of disaster, two civil-military relations theories, and two communication theories were the means of expanding the knowledge of DSCA, hurricane trends, and DoD readiness.

The four theories of disaster provided a road map of societal understanding and interpretation of disasters. The civil-military relations theories provided an understanding of the interactions between civilians, the federal and SLTT governments, and the DoD. The communication theories were the means of addressing complex oral, written, and nonverbal communications.

Four Theories of Disaster

The four theories of disaster are (a) an act of God or fate, (b) a purely physical agent as an act of nature, (c) an intersection of society and nature, or (d) an avoidable human creation and prism that shows societal injustices and growing vulnerability. The theories provide insight into temporal explanations of disaster. Scholars have developed

successive theories to better account for how people from different regions explain and understand disasters such as hurricanes.

Disasters as Acts of Fate/Acts of God

Fate theory involves a fatalistic acceptance of disaster as an act of God, where humans are victims and can do nothing to prevent the event (White et al., 2001). Some people may accept their fate during weather disasters such as hurricanes. People who align with fate theory believe disasters occur due to impersonal and uncontrollable forces, such as unfortunate alignments of stars and planets or acts of God beyond human understanding. Individuals who believe in fate theory consider it useless to appeal to a higher being or study the constellations, assuming that hurricanes occur as frequently as decided by the deity or the universe. Therefore, in fate theory, people cannot control the resulting devastation. A variation of this theory is that disasters are cosmic or divine retribution for human failings. Per the theory, hurricanes affect individuals because of personal shortcomings, while major hurricanes (e.g., Category 3, 4, or 5) correlate with community shortcomings.

Disasters as Acts of Nature

The act of nature or objective phenomenon theory indicates that a disaster is a threat for which no one is responsible or accountable for its impact (Montz et al., 2017). The prevalence of scientific knowledge has caused some people to perceive disasters as having natural rather than supernatural causes. Thus, floods occur when large-scale weather systems cause prolonged rainfall or onshore winds; earthquakes occur because of rock breaking and shifting beneath the Earth's surface; and landslides occur when masses of rock, earth, or debris slide down a slope. The act of nature theory indicates major

events occur due to the natural processes of the Earth that cause widespread destruction to the environment and loss of life. Accordingly, natural disaster means "an outside attack upon social systems that 'broke down' in the face of such an assault from outside" (Quarantelli, 1998, p. 266). The resulting conception of man against nature is the driving force behind attempts to mitigate the risks associated with weather disasters such as hurricanes.

Interactive Effects of Nature and Society

The mainstream disaster theory eventually became that hazards occur due to the interaction of a physical event system and a human use system. Carr (1932) stated, "Not every windstorm, earth-tremor, or rush of water is a catastrophe. [S]o long as the levees hold, there is no disaster. It is the collapse of the cultural protections that constitutes the disaster proper" (p. 211). Subscribers of this theory indicate that humans in societies naturally adapt to the prevailing environmental conditions, such as variations in temperature, wind speed, precipitation, and seismic activity. According to this theory, people can avoid disasters if they stay away from coastal regions, and those residing in coastal regions should build structures to resist hurricanes or other disasters.

Disaster as Social Construction

The interactive effects theory focuses on hazard exposure at specific locations and the physical vulnerability of specific structures; in comparison, the social construction theory focuses on the social vulnerability of specific population segments (Weichselgartner, 2001). Recent researchers have recognized that disasters cause systematic harm to people, certain geographic locations, and human use systems. An example of this theory is the devastation of Hurricane Katrina in New Orleans and

Hurricane Maria in Puerto Rico. U.S. residents often have good jobs and comfortable lives and enjoy one of the most democratic governments in the world. Hurricanes Katrina and Maria showed and exacerbated the socioeconomic disparities of certain populations and communities (Fussell, 2007). Emergency managers should focus on how institution leaders can reduce the hazard vulnerability of those with the least psychological resilience, social support, political power, and economic capital.

Each disaster and disaster response can vary due to the vastness and diversity of the United States. The prevalence of each theory has implications for the DoD and federal and SLTT government stakeholders, as they may encounter individuals who subscribe to any of the four theories during disaster response.

Civil-Military Relations Theories

This study focused on military support to civil authorities during disasters. The DoD has a long history of supporting civil authorities during responses to disasters, such as Hurricanes Katrina, Sandy, and Maria. Many people in the United States have supported provisions to ensure civilian control of the military. Civil-military theories address the interactions between the state, institutions, and the military (Huntington, 1957; Janowitz, 1960). According to Neilson (2005), the roots of the civil-military relations theory lie in the early works of Huntington and Janowitz, who built their theoretical foundations on von Clausewitz (1832/1989).

At a hearing before the Subcommittee on Emergency Preparedness, Science, and Technology, 109th Congress (2006), McHale stated that disasters can resemble war; therefore, there is a need to examine relationships between citizens, politicians, and the military to understand disaster readiness. Von Clausewitz, who published *On War* nearly

200 years ago, described the relationships between civilian and military authorities. Von Clausewitz (1832/1989) anticipated and described military and civil disputes as fog and friction, arguing for extensive political influence over military operations. *Fog* is the ambiguous information provided during war and the difficulties of maximizing good information, whereas *friction* is the interaction of chance and action caused by many factors, including enemy forces, friendly actions, and the environment. The concepts of fog and friction could apply to disaster management (Curtis, 2011).

Huntington's Liberal Theory

Huntington (1957) posited that organizational gravity, fog, and friction among principals and agents can affect their relationships. DoD personnel train with FEMA and other federal agencies, SLTT personnel, and the private sector to strengthen and improve relationships before disaster strikes. Huntington identified three main characteristics of professionalism: expertise, responsibility, and corporateness. Huntington also posited that military institution leaders educate officers to expertly manage violence and make the professional officer responsible to society. In addition, Huntington believed that professional soldiers belong to a unified group bound by common experience and separate from citizens. This approach to civil-military relations provides an understanding of relationships between civilian and military authorities during hurricane response. Military leaders have a mission to fight and win the nation's wars, whereas civilian leaders oversee public affairs to provide security for the public, usually in the homeland. Both types of leaders serve the nation's citizens; therefore, bringing divergent mindsets to a hurricane response requires the attention of military and civilian authorities.

The military has a separate culture from civilian authorities. Therefore, using the military to prepare and respond to domestic disasters requires authorities to exercise principled control, a concept that aligns with Huntington's framework of the importance of the principal and agent relationship. Huntington described military effectiveness as a product of civil-military relations and addressed the concepts and patterns of civil-military relations to produce the most effective militaries.

Janowitz: Civic-Republican Theory

Janowitz (1960), a University of Chicago sociologist, focused on civic republicanism, democracy, political participation, civic virtue, the rule of law, and political liberty. Janowitz considered relying on and creating an apolitical military to ensure civilian control unrealistic. Janowitz advocated for increasing legislative oversight, extending civilian control into lower levels of military organizations, and increasing civilian involvement in officer professional education. Janowitz suggested supporting liberal democracy through subjective military control, with the military subordinate to the state in all activities. Such military control occurred in case studies of the DoD's support to civil authorities during three watershed disasters via a thorough analysis of readiness with the DOTMLPF-P framework presented later in this chapter.

Janowitz (1960) advocated for professional participation and convergence among the military and civilian spheres with the four Ps of pragmatism:

- Practical: Focuses on problems, thinking, and action
- Pluralistic: Focuses on diversity of perspectives
- Participatory: Engages in discussion and listening

- Provisional: Involves flexibility, learning from actions and change when necessary

Janowitz (1960) suggested transforming the modern military from a model of the absolute defeat of enemy forces to a constabulary model, where force members organize and apply limited force to achieve societal objectives. The constabulary model is an application often used during DSCA operations.

Communication Theories

Argyle's Theory of Communication Cycle

Collecting data for RQ2 involved significant communication between the researcher and interview participants. Argyle's (1969) theory of the communication cycle focuses on effective communication—specifically, the stages, processes, and key principles of successful interpersonal communication. The theory indicates the importance of feedback and presents communication as a two-way process.

Argyle (1969) identified six key stages in the communication cycle, the basic concepts of which appeared repeatedly during the 30 interviews. The first stage involves the sender generating ideas or thoughts, which are the basis of the message to communicate. For example, the first stage could include sending the interview guide ahead of the scheduled interview. The interview participants in this study received the questionnaire beforehand to inform the interview process. In the encoding stage, the sender converts thoughts into a verbal or nonverbal message. The second stage involves choosing the appropriate words, tone, body language, or gestures to express the intended meaning. In the third stage, transmission, the sender transmits or delivers the encoded message to the receiver through a chosen channel (e.g., face-to-face conversation,

telephone call, email, or text message). The fourth stage is decoding, in which the receiver interprets and decodes the information upon receiving the message. This stage involves understanding the words, analyzing nonverbal cues, and extracting the sender's meaning. In the fifth stage, understanding, the receiver's successful decoding of the message results in understanding if the sender accurately comprehends the message's intended meaning. In the sixth stage, the communication cycle ends with feedback. The receiver responds to the sender, providing a message as feedback. This feedback enables the sender to gauge the effectiveness of the communication and adjust as necessary. Argyle's theory of the communication cycle was the means used in the research to build strong and meaningful connections with the participants and make conclusions about their perceptions of DoD disaster readiness.

The Seven Cs of Effective Communication

The Seven Cs of communication (Cutlip & Center, 1952) includes the following components:

- *Completeness* is one of the most significant aspects of effective communication (Cutlip & Center, 1952). In this study, the expectation was that the participants had full knowledge of DoD readiness.
- *Correctness* includes the legitimacy of factual information, language, and grammar. This study required the genuineness and value of the participants' responses for reliability.
- *Conciseness* involves keeping the conversations short and focused. Each interview lasted between 15 and 30 minutes to remain focused on the topic and theme development.

- *Courtesy* entails communicating with politeness, genuineness, and respect for the person on the other side of the conversation.
- *Clarity* relates to the transfer of accurate and easily comprehendible messages to the receiver. For clarity, the researcher spent the first minute of each interview describing the parameters and the format for asking interview questions.
- *Consideration* requires courtesy and treating the interviewee with dignity and respect while adhering to strict ethical standards.
- *Concrete* communication requires specific, meaningful, and focused messages. The goal was for the participants to avoid vague and ambiguous responses. Therefore, when necessary, the participants received the request to incorporate factual evidence and figures to enhance response authenticity.

Reviewing and understanding the four theories of disaster, the two civil-military relations theories, and the two communication theories were the means of reviewing the literature on hurricane trends and DoD hurricane readiness.

Part I: Tropical Cyclone Trends: Positive, Mixed, or Controversial

The literature on TC frequency has had mixed results. Some scholars have identified a positive trend, whereas others have described trends as mixed, minimal, or nonexistent. Scholars have acknowledged the controversial results of reported trends. This study focused on whether hurricane frequency has increased.

The Frequency of Tropical Cyclones Show a Positive Trend

Studies as early as 2005 and as recent as 2021 have shown a significant increase in TC frequency. Defining an index of the potential destructiveness of hurricanes based

on the total dissipation of power integrated over TC lifetime, Emanuel (2005) found that TCs increased in intensity. Emanuel found that the index had increased markedly since the mid-1970s. Therefore, the author concluded that the increasing trend in power dissipation over the past 30 years has resulted in increased storm intensity on average and longer survival at high intensity (Emanuel, 2005). Similarly, Elsner et al. (2008) noticed a 30-year trend of Atlantic TCs increasing in average strength. The researchers examined trends in the upper quantiles of per-cyclone maximum wind speeds with homogeneous data from archived satellite records. The results showed significant upward trends for wind speed quantiles above the 70th percentile for the strongest cyclones—specifically, the satellite-derived lifetime maximum wind speeds of the strongest TCs globally. Bhatia et al. (2019) used two observational datasets to calculate 24-hour wind speed changes from 1982–2009. The authors compared the observed trends to natural variability in bias-corrected, high-resolution, global-coupled model experiments to simulate the climatological distribution of TC intensification. The results showed significant and unusual increases in TC intensification rates in the Atlantic Basin compared to model-based estimates of internal climate variations (Bhatia et al., 2019).

Lima et al. (2021) evaluated changes in TC frequency in the Northeast Atlantic Basin during 1978–2019. The authors found a correlation between the accumulated cyclone energy (ACE) and number of TCs, major hurricanes and TCs, and hurricanes and TCs and major hurricanes. The ACE index is similar to Emanuel's (2005) Power Dissipation Index. The study showed a significant increase in stronger storms in the North Atlantic Basin. Therefore, Lima et al. concluded that more intense TCs will increase in frequency in a cyclic change in the North Atlantic.

The Frequency of Tropical Cyclones Shows Mixed, Little, or No Trend

Countering the argument for a positive trend in TC frequency, some scholars have described the evidence of positive trends as weak due to regional inconsistencies, timelines, and study types. Nyberg et al. (2007) reconstructed a major Atlantic hurricane frequency record over the past 270 years with proxy records of vertical wind shear and sea surface temperature. The authors found that the average frequency of major hurricanes decreased gradually from the 1760s until the early 1990s, with anomalously low values during the 1970s and 1980s (Nyberg et al., 2007). Nyberg et al. developed a reconstruction to follow variability during the 19th and 20th centuries of U.S. East Coast hurricane landfalls. The authors found a quiet period from the 1850s to the late 1860s, an active period from the 1870s to 1890s, a quiescent period to 1926, and an active phase from 1926 to 1970. The reconstruction also focused on annual zonal wind speed data in the Caribbean, dating back to 1890, a period with low observed major hurricane activity as far back as 1851. The reconstruction showed an approximate average of 3–3.5 major hurricanes yearly from 1730 to 2005. Additionally, a gradual downward trend of an average of 4.1 (1755–1785) to 1.5 major hurricanes occurred during the late 1960s to early 1990s, a period with strong but few major hurricanes compared to other periods since 1730 (Nyberg et al., 2007). Lastly, 1730–1736, 1793–1799, 1827–1830, 1852–1866 and 1915–1926 had similarly low major hurricane activity (Nyberg et al., 2007). Donnelly and Woodruff (2007) examined the centennial and millennial-scale variability of Caribbean hurricane activity over the past 5,000 years based on sediment cores from a Caribbean lagoon with coarse-grained deposits from intense hurricane landfalls. The

authors found that the frequency of intense hurricane landfalls varied on centennial to millennial scales during this interval.

Holland and Webster (2007) found that long-period variations in TC and hurricane frequency in the North Atlantic Ocean over the past century occurred as three relatively stable regimes separated by sharp transitions. Each regime had 50% more cyclones and hurricanes than the previous regime. A substantial 100-year trend resulted in related increases of over 100% in TC and hurricane numbers. Superimposed on the evolving TC and hurricane climatology was an independent oscillation in the proportions of TCs that became major and minor hurricanes, this characteristic had no distinguishable net trend (Holland & Webster, 2007).

Vecchi and Knutson (2008) estimated the expected number of Atlantic TCs missed in the observing system in the presatellite era (between 1878 and 1965). The authors found that Atlantic TC counts had significantly increased since the late 19th century. However, the results were mixed, with some activity measures showing no change or a decrease with time. Total storms per year and U.S. landfall activity showed no increasing trend, and average TC duration significantly decreased over time. The long-term decrease in TC duration in the North Atlantic did not align with most nominal trends in basin-wide storm activity in the literature, as many scholars found a system becoming, at least nominally, more active over the 20th century (Vecchi & Knutson, 2008).

Vecchi and Knutson (2008) found a small nominally positive upward trend in tropical storm occurrence from 1878 to 2006. However, statistical tests indicated the trend as small compared to variability in the series, with results not significantly distinguishable from zero. The authors considered the reported numbers of hurricanes

sufficiently high during the 1860s–1880s, indicating no significant positive trend in numbers from that era. Analysis of U.S. landfalling hurricanes indicated an even weaker upward trend, even suggesting a slight negative trend from the late 1800s or early 1900s (Vecchi & Knutson, 2008).

Mann et al. (2009) contextualized recent activity by comparing two independent estimates of TC activity over the past 1,500 years. The authors based the first estimate on a composite of regional sedimentary evidence of landfalling hurricanes and the second estimate on a published statistical model of Atlantic TC activity based on proxy reconstructions of past climate changes. According to Mann et al., both approaches produced consistent evidence of high activity periods (compared to current levels) during a medieval era of roughly AD 900–1100 and a general decrease in activity after AD 1200 (Mann et al., 2009). Klotzbach et al. (2018) investigated trends in continental United States hurricane activity since 1900 and found no significant direction in the frequency of landfalling hurricanes or major hurricanes consistent with previous studies, including the devastating 2017 season.

The Frequency of Tropical Cyclones Trends Are Controversial

Some studies have suggested that changes in observation practices, reporting, and presatellite era records have resulted in inaccurate TC counts. Landsea (2007) cautioned that improved monitoring in recent years is the reason for most observed trends in increasing TC frequency. Therefore, TC scholars cannot disregard the recommendations of the original database documentation and database extension and should reanalyze missed TC documentation before the mid-20th century. Landsea estimated an undercount bias of zero to six TCs per year between 1851 and 1885 and zero to four per year between

1886 and 1910. According to the researcher, these undercounts roughly account for typical TC size, the density of shipping tracks over the Atlantic Basin, and the amount of populated coastline. Further examination of the data showed that the number of ships and shipping lanes decreased, with fewer people living in tropical and subtropical coastal regions. Therefore, some TCs may have remained uncounted further back in time (Landsea, 2007).

Mann et al. (2007) drew upon a statistical model regarding conditions and expected total Atlantic TC counts based on underlying climate variables. The analyses showed that an undercount in early TC counts approaching three storms per year did not align with the observed statistical relationships between annual TC counts and the underlying climate factors. The long-term record of historical Atlantic TC counts could have reliable data, with an average undercount bias at most of approximately one TC per year back to 1870 (Mann et al., 2007).

Chang and Guo (2007) examined all TC tracks and subjectively classified those that did not make landfall in the United States into three categories. Class CC included TCs that made landfall over any continent (mostly North America, except for the United States) or any of the Caribbean Islands. Class Near Shore included those that passed within 300 km of any continent and island groups (including the Caribbean, Bermuda, the Azores, Cape Verde, Canary Islands, and Madeira) and those that hit islands apart from the Caribbean. Class Open Ocean included those that did not pass within 300 kilometers of any land or islands. The TCs that hit the United States fell into Class U.S. The results showed decadal variations in the number of TCs classified as Class U.S. or CC, with no clear trends in the two. However, TCs in Classes Near Shore and Open Ocean were

underrepresented before the satellite era, especially before World War II. The results suggest that before the availability of satellite observations, the density of ship observations over the North Atlantic has been high enough since World War I (except during World War II) that it is likely for a TC that did not hit land (or islands) to pass close enough to one or more ship observations during its lifetime such that tropical storm like conditions are observed. The results further suggested that the expected total number of TCs in Classes Near Shore and Open Ocean (i.e., TCs that did not make landfall over any continent or the Caribbean) that may have remained undetected during the 1920s and 1930s was about 10 or less per decade. The characteristics of North Atlantic TC track statistics changed during the 20th century. TC statistics derived solely from TCs with U.S. landfall (Class U.S.) may not have included all those in the entire North Atlantic Basin, even on multidecadal time scales (Chang & Guo, 2007).

Vecchi and Knutson (2008) discussed the changes to the methodology used to observe TCs from 1878 to 2020. The authors asserted that before 1944, the only method for identifying TCs was records of landfalling storms or records from ships at sea. Between 1944 and 1965, aircraft reconnaissance flights provided complementary observations to ships at sea. However, aircraft coverage did not extend over the entire basin. Moreover, basin-wide monitoring via satellite began in 1966, and during the ship observation era (pre-1944), there were significant modifications to the preferred ship tracks. Before the opening of the Panama Canal in 1914, most recorded ship traffic remained concentrated in the Northern and Eastern tropical Atlantic and near the East Coast of North America, with a conspicuous hole in many regions of frequent TCs. After 1914, the ship-recorded track density in the Gulf of Mexico, the Caribbean Sea, and the

Western tropical Atlantic increased dramatically. After World War II, the recorded ship density increased further. Disruptions to shipping and missing records from ships during both world wars resulted in minimal data between 1914 and 1918 and 1939 and 1945 (Vecchi & Knutson, 2008).

Vecchi and Knutson (2008) estimated a correction to TC counts in the presatellite era with ship-track data from the presatellite era and TC locations from the satellite era. The authors also explored long-term changes in TC activity measures in the tropical Atlantic, assessing measures of TC activity before the satellite era and the likely impact of missed TCs on these measures. Although the total number of TCs in the North Atlantic has increased nominally since the late 19th century, the average TC duration may have decreased long-term. Therefore, there have been mixed long-term changes in Atlantic TC activity, with different metrics showing either increases, decreases, or no change (Vecchi & Knutson, 2008).

Vecchi and Knutson (2008) found that records of past Atlantic tropical storm numbers (1878 to present) showed a pronounced upward trend. However, records from the early decades showed a relatively sparse density of reporting ship traffic in the Atlantic. Therefore, if storms from the modern era (post-1965) had hypothetically occurred during those earlier decades, a substantial number may not have been directly observed by those from the ship-based "observing network of opportunity" (*p*. 3580). A thorough review of the TC database for the Atlantic showed a substantial increase in the number of shorties (i.e., hurricanes of 2 days or less). In comparison, storms whose duration exceeded 2 days have not shown a statistically significant increase since the late-19th century, particularly when adjusted for likely missing storms. Vecchi and Knutson

interpreted the increase in shorties as further evidence for a significant increase in Atlantic tropical storm counts since the late 19th century.

Neu (2008) noted the controversy over the anomaly of the recent increase in Atlantic major hurricane activity. The author suggested that the uncertainty of average major hurricane activity in the hurricane record before 1945 indicates that the Nyberg et al. (2007) reconstruction differed significantly, with a probable overestimation of past major hurricane activity. Nyberg et al. reconstructed major hurricane activity for the past 270 years using data from coral and sediment cores and sea surface temperature data. However, the reconstruction showed a significant difference from the pre-1944 hurricane record (Neu, 2008). Neu concluded that uncertainties in the record could seriously affect the reliability of the reconstruction, especially before 1940, and the main conclusions of Nyberg et al.

Landsea et al. (2010) contributed to the understanding of the historical Atlantic TC record by examining the century-scale trend behavior of TCs of different duration classes. The researchers explored the influence of TC duration on observed changes in TC frequency with a widely used HURDAT. The findings showed that the occurrence of shorties in the database had increased dramatically, from less than one per year in the late 19th and early 20th centuries to about five per year since 2000. In comparison, medium to long storms had increased little in frequency. Landsea et al. concluded that the previously documented increase in total TC frequency since the late 19th century in the database had resulted from an increase in shorties.

Villarini et al. (2011) focused on North Atlantic tropical storms lasting 2 days or less (shorties) from 1878–2008 and examined whether long-term evolution (including an

increase over the 20th century) associated with a climate signal or with changes in the observational system. The researchers interpreted the long-term secular increase in short-duration North Atlantic tropical storms as substantially inflated after observing system changes over time. Villarini et al. suggested that scholars of North Atlantic tropical storm frequency over the historical era (between the 19th century and the present) should focus on storms of duration greater than 2 days.

Emanuel (2021) used an alternative approach to estimate past hurricane activity. The scholar conducted a dynamical downscaling of three climate reanalyses spanning more than a century, assimilating only surface pressure, sea ice, ocean surface temperature observations, and, in one case, marine surface winds. The results supported earlier statistically based inferences of storms as undercounted in the 19th century. Four features of the downscaled Atlantic TC climatology emerged from Emmanuel's study: (a) a substantial upward trend in most metrics, (b) a local maximum in most metrics in the 1930s and early 1940s, (c) a profound depression of activity in the 1970s and 1980s, and (d) a pronounced uptick in activity after 1990.

Vecchi et al. (2021) claimed that changes in observation practices resulted in significant inhomogeneities in HURDAT, impacting the assessment of long-term change. In particular, the authors noted a substantial increase in monitoring capacity over the past 171 years. Thus, there is a higher probability of observing an Atlantic hurricane in the present than earlier in the record. Vecchi et al. concluded that the recorded increase in Atlantic TC and hurricane frequency in HURDAT2 since the late 19th century aligned with the impact of known changes in observing practices. Thus, adjusted major hurricane

counts for the entire Atlantic Basin showed no significant trend from either 1878 or 1900 (Vecchi et al., 2021).

A May 2023 fact sheet from the NOAA Science Council for the general public presented key research areas of interest and three important and societally relevant questions about Atlantic hurricane activity and climate. A fact sheet question relevant to this study is, “Has there been a change in the number of Atlantic hurricanes?” Several Atlantic hurricane activity metrics have shown pronounced increases since 1980. However, there has been weaker evidence of significant trends from the early 20th century, partly due to observed data limitations (NOAA, 2023).

Several historical Atlantic hurricane activity measures (e.g., annual numbers of tropical storms, hurricanes, major hurricanes, hurricane intensities, Power Dissipation Index, and rapid intensification occurrence) have shown pronounced TC increases since 1980 (NOAA, 2023). Since the 1940s and 1950s, major hurricane annual counts and related measures have shown pronounced multidecadal variations, including a major hurricane drought from the 1970s to the mid-1990s. Observations include an increase in the stalling of near-coastal U.S. TCs and accumulated rainfall since 1950.

On the century time scale, there has been no significant trend in annual numbers of U.S. landfalling tropical storms, hurricanes, or major hurricanes. However, there has been a decreasing trend since 1900 in the propagation speed of tropical storms and hurricanes over the continental United States. Basin-wide annual counts of tropical storms, hurricanes, and major hurricanes since the late 1800s have shown strong rising trends. After considering changes in observing capabilities, studies have suggested no

strong evidence for a significant upward trend in basin-wide storm count metrics (NOAA, 2023).

Part II: DoD Responses to Hurricanes Katrina, Sandy, and Maria

Part II is a literature review of DoD readiness to support civil authorities after Hurricanes Katrina, Sandy, and Maria. The review showed that although the DoD is a valuable partner, there were errors in the response to Hurricanes Katrina, Sandy, and Maria. DoD leaders took feedback from internal and external reviews to improve future responses. This section provides an overview of Hurricanes Katrina, Sandy, and Maria and the challenges and lessons learned from each DoD response.

Overview of Hurricanes Katrina, Sandy, and Maria

Hurricane Katrina was a powerful and deadly hurricane that caused a wide swath of catastrophic damage and a large loss of life. Katrina first caused fatalities and damage in Southern Florida as a Category 1 hurricane on the Saffir-Simpson Hurricane Wind Scale. After reaching Category 5 intensity over the central Gulf of Mexico, Katrina weakened to Category 3 before landfall on the Northern Gulf Coast (Knabb et al., 2005). Despite weakening peak winds, the hurricane became larger due to the wind radius, contributing to devastating storm surge impacts in Mississippi and Louisiana. Hurricane Katrina caused significant damage and loss of life in the two states, with significant effects extending into the Florida panhandle, Georgia, and Alabama.

In 2005, Hurricane Katrina resulted in nearly 1,400 combined direct and indirect fatalities, including 520 direct deaths: 341 in Louisiana, 172 in Mississippi, six in Florida, and one in Georgia. Rappaport and Blanchard (2016) indicated there were 565 indirect fatalities, the majority (n = 318) related to cardiovascular causes. An additional 307

fatalities occurred with an unidentified cause of death (Rappaport & Blanchard, 2016). Therefore, whether those deaths directly or indirectly resulted from the hurricane remains unknown. Hurricane Katrina had a staggering extent, magnitude, and impact. Among all U.S. hurricanes, Hurricane Katrina was the costliest storm on record ($196.3 billion; NCEI, 2023). Floods destroyed thousands of homes and businesses throughout entire neighborhoods in the New Orleans metropolitan area. Strong winds also caused damage to the New Orleans area, while the storm surge impacted the Mississippi coastline. Despite further distance from Katrina's eye, the storm surge over Alabama destroyed or damaged beachfront homes, and heavy rains flooded neighborhoods in Southern Florida (Knabb et al., 2005). There was also considerable damage to homes and facilities in Georgia due to tornadoes, with strong winds causing significant tree damage throughout much of Mississippi and Alabama. Combining all of the areas impacted, Katrina resulted in about three million people lacking electricity, some for several weeks (Knabb et al., 2005).

Seven years after Hurricane Katrina, Hurricane Sandy was a classic late-season hurricane in the Southwestern Caribbean Sea. The cyclone landed as a Category 1 hurricane in Jamaica and as a 100-knots Category 3 hurricane in Eastern Cuba before quickly weakening to a Category 1 hurricane while moving through the Central and Northwestern Bahamas (Blake et al., 2013). Hurricane Sandy underwent a complex evolution and grew considerably over the Bahamas, continuing to grow despite weakening into a tropical storm north of the Bahamas. The system became a hurricane as it moved northeastward, parallel to the coast of the Southeastern United States, with a secondary peak intensity of 85 knots while turning northwestward toward the Mid-

Atlantic states. Hurricane Sandy weakened and then made landfall as a post-TC near Brigantine, New Jersey, with 70 knots maximum sustained winds (Blake et al., 2013).

In 2012, Hurricane Sandy had a widespread impact in the United States. The number of direct deaths caused by Hurricane Sandy was 147 (Blake et al., 2013), including 72 direct deaths in the United States. Thus, Hurricane Sandy was the deadliest U.S. cyclone outside the Southern states since Hurricane Agnes in 1972. Among all U.S. hurricanes, Hurricane Sandy ($86.1 billion) was the fifth costliest storm on record (NCEI, 2023). The cyclone caused damage and destruction to 650,000 houses, with the vast majority of the damage caused by storm surges and waves. Due to Hurricane Sandy, 8.5 million customers lost power for weeks or even months in some areas. Along the immediate coast of Southeastern Florida, gusty winds caused trees to fall, resulting in about 160,000 customers losing power. The combined costs of beach erosion and damage to some structures in Florida was between $50 and $75 million (Blake et al., 2013).

Moderate to major beach erosion occurred along a large part of the South Carolina coast. Severe erosion occurred at the Isle of Palms, with a total loss of the dunes and the destruction of several piers. Hurricane Sandy also significantly impacted the North Carolina Outer Banks, with Dare County facing damage to some infrastructure but not residential or commercial structures. There were estimates of nearly $5 million in residential damage in Maryland. However, the hurricane caused severe beach erosion and storm surge considered the worst along the coast since Hurricane Gloria in 1985 due to up to 4 feet of inundation (Blake et al., 2013). Widespread power outages affected many, including up to 1.2 million customers without power in Pennsylvania. The hurricane

caused about $20 million in overall damage in Pennsylvania and $5.5 million in Delaware.

Hurricane Sandy's storm surge and large, battering waves significantly impacted large portions of the New Jersey and New York coasts. About five million residents lost electrical power across this region, with outages lasting several weeks (Blake et al., 2013). On Long Island, damage in 13 towns and two cities cost more than half a billion dollars. Storm surges and waves also caused severe damage and destruction to around 100,000 homes on Long Island, resulting in more than 2,000 homes deemed uninhabitable (Blake et al., 2013).

Hurricane Sandy's high winds and storm surge also affected New England, with the most severe impact on coastal sections from Connecticut through Massachusetts. Blizzard conditions and heavy, wet snow resulted in impassable roads in West Virginia and Western North Carolina, and snow weight caused several structures to collapse. Damage related to the storm, mainly power outages, extended inland as far west as the Ohio Valley and the Midwest. Strong winds from the post-TC reached west into Wisconsin, producing large waves on Lake Michigan and coastal flooding on the Southern shore (Blake et al., 2013).

Five years after Hurricane Sandy, Hurricane Maria impacted the island of Dominica at Category 5 intensity and Puerto Rico at high-end Category 4 intensity (Pasch et al., 2019). The hurricane also caused serious damage to some islands in the Northeastern Caribbean Sea. Hurricane Maria originated from a well-defined tropical wave from the West Coast of Africa. The system moved westward over the tropical Atlantic for the next few days while producing scattered and disorganized deep

convection (Pasch et al., 2019). After impacting Dominica, Maria shifted west-northwestward into the Northeastern Caribbean Sea. Slight weakening occurred due to the system's interaction with the mountainous island of Dominica, but the hurricane regained and strengthened to peak intensity.

The death toll in Puerto during Hurricane Maria remains uncertain (Pasch et al., 2019). Estimates range from an initial official death toll of 64 to close to 4,000 in a later study (Kishore et al. 2018). In a study commissioned by the government of Puerto Rico, Santos-Burgoa et al. (2018) reported an estimated death toll of 2,975. Maria caused 31 direct deaths in Dominica, with 34 missing (Pasch et al., 2019). In Guadeloupe, Maria resulted in two direct fatalities: one from a falling tree and the other swept out to sea. In St. Thomas, one person died from drowning, and another from a mudslide. Floodwaters swept away four people, and another individual perished in a mudslide in the Dominican Republic. Three people died due to floodwaters in Haiti. In the mainland United States, three people drowned due to rip currents at the Jersey Shore, and another drowned at Fernandina Beach, Florida. The NOAA estimate of damages in Puerto Rico and the U.S. Virgin Islands (USVI) due to Hurricane Maria is $112.5 billion. Hurricane Maria was the fourth costliest hurricane in U.S. history, behind Hurricanes Katrina (2005), Harvey (2017), and Ian (2022; Pasch et al., 2019).

Hurricane Maria was the most destructive hurricane to impact Puerto Rico in modern times. The combined destructive power of storm surge and wave action caused extensive damage to buildings, homes, and roads along the Eastern and Southeastern coasts of Puerto Rico and the Southern coasts of Vieques and St. Croix. Waves and currents from the surge significantly damaged marinas and harbors and caused significant

damage over the Northwestern coastal area of Puerto Rico. Across the island, there were many buildings significantly damaged or destroyed. The storm downed, splintered, or defoliated numerous trees and led to unprecedented river flooding in some areas, especially in the northern portion of the island. The La Plata River flooded the entire alluvial valley, including the municipality of Toa Baja, where hundreds of families required rooftop rescue (Pasch et al., 2019).

Hurricane Maria affected 80% of Puerto Rico's utility poles and all transmission lines, resulting in the loss of power to the island's 3.4 million residents (Pasch et al., 2019). The hurricane damaged or destroyed all wooden structures on the island of Vieques. The island of Culebra had received major damage due to Hurricane Irma, and the remaining structures remained extremely vulnerable to Maria's winds. The hurricane resulted in the destruction of many wooden houses, blown-off roofs, and sunken boats. Among the USVI, St. Croix was the island the most severely affected by Hurricane Maria due to impact from the northern portion of the outer eyewall. Wind damage across the entire island resulted in fallen trees, downed signs, roof damage, and the destruction of many wooden houses. Excessive rainfall caused significant flooding and mudslides across the island. In St. Thomas and St. John, Hurricane Irma destroyed or damaged most roofs, signs and trees, and large rainfall accumulations caused flooding and mudslides across all the islands (Pasch et al., 2019).

Challenges and Lessons Learned From DoD's Hurricane Katrina Response

More than 50,000 National Guard and 20,000 active-duty personnel participated in the Hurricane Katrina response (GAO, 2006). The DoD's massive response to Hurricane Katrina enabled the saving of many lives, yet challenges during the response

provided lessons for the future. Several factors affected the military's ability to gain situational awareness and organize to execute the response, such as a lack of timely damage assessments, communications problems, uncoordinated search and rescue efforts, unexpected logistics responsibilities, and force integration issues (GAO, 2006).

Due to widespread interest in the Hurricane Katrina response, members of Congress, reputable think tank leaders, and other stakeholders conducted investigations, research, and studies to improve future DoD hurricane response. A key lesson was the need for additional action to ensure the military had significant capabilities that were clearly understood, well planned, and fully integrated. This lesson aligned with the extensive 2006 White House report about the federal government's response. The federal report found critical challenges in the integrated use of military capabilities and suggested federal government leaders revise the NRF to delineate the circumstances, objectives, and limitations of when DoD personnel might temporarily assume the lead in the federal response to a catastrophic incident (The White House, 2006). Further, the DoD should have standards for "pushing" the prepositioning of federal assets to states in the case of an imminent catastrophe and assign additional personnel, including General Officers from the National Guard and Reserve, to USNORTHCOM for enhanced integration of active and reserve component forces for Homeland Security missions. Another major recommendation was to revise the DoD Immediate Response Authority (IRA) policy to enable commanders, in appropriate circumstances, to exercise IRA even without a request from local authorities (The White House, 2006).

The military response in the critical first few days of Hurricane Katrina contributed to delays in evacuating the New Orleans Superdome and Convention Center

and accomplishing search-and-rescue operations throughout the storm-ravaged areas of Louisiana and Mississippi (Davis et al., 2007). There were also problems with the lack of a unified command and control (C2) structure, specifically the separation of the command structures for operations involving National Guard and active-duty forces. Davis et al. (2007) recommended four alternatives, including a mix of active duty and National Guard forces, for future responses. Further recommendations included separate federal and state task forces, dual-status command, state joint force headquarters in lead, and USNORTHCOM in lead. These recommendations are significant because the accepted DoD structure tested in 2012 during Hurricane Sandy remains the primary C2 structure for DSCA operations.

Five years after Hurricane Katrina, a 2010 study found that despite DoD progress and documents for coordination, entities still lacked clearly defined roles and responsibilities, and policies and guidance remained outdated (GAO, 2010). Roles and responsibilities remained unclear regarding support for law enforcement and health affairs and the Assistant Secretary of Defense/Homeland Defense, USNORTHCOM, and United States Indo-Pacific Command (USINDOPACOM). The report also showed an incomprehensive joint doctrine on interagency coordination and the need to improve communication with federal partners. Further, there was no way to assess DoD training adequacy because of the lack of identification of requisite knowledge, skills, and abilities for liaison officers (GAO, 2010).

The GAO's (2010) findings aligned with Morral and Wermuth (2010), who described the DoD's guidance for all DSCA forms as fragmented, incomplete, and outdated (Morral & Wermuth, 2010). The authors also discussed the training for military

and civilian leaders in response planning and operations as inadequate. Further, DoD leaders did not conduct domestic military deployments per the comprehensive processes used for overseas deployments, resulting in challenges with tracking responding units and effectively employing their corresponding capabilities. The lack of identification of sufficient military forces for DSCA affected the DoD assessment processes and the lack of integrated planning among federal, state, and local entities. In addition, there was a particular lack of information about potential civilian shortfalls (Morral & Wermuth, 2010).

The Role of the Dual-Status Commander in DoD's Response to Hurricane Sandy

During Hurricane Katrina, leaders from two separate chains of command directed active duty and National Guard operations, even among command chains seemingly identical. The DSC initiative emerged after insufficient direction and coordination between state and federal forces during hampered response efforts to Hurricane Katrina. The DSC construct during Hurricane Sandy allowed state and federal military responders to receive instructions from the same personnel and achieve more streamlined operations. The streamlined command structure and the general National Guard readiness enabled the placement of 60,000 guard personnel on alert status nationwide as Hurricane Sandy approached the United States (Bucci et al., 2013). Due to the nature of the event and robust state force responses from New York and New Jersey, only 12,000 of the 60,000 guard personnel were activated for Hurricane Sandy. National Guard operations include search and rescue on land (the Coast Guard provides search-and-rescue services at sea), food and water distribution, debris removal and route clearance, traffic control, fuel distribution for response vehicles, power generation support, and assistance in

maintaining civil order (Bucci et al., 2013). Four days before Hurricane Sandy's landfall, a 2012 GAO report addressed the notable gaps in homeland defense and civil support guidance, showing some DoD homeland defense and civil support mission guidance was outdated or incomplete, without a routine process for regular updating. DoD leaders had not updated the homeland defense and civil support strategy and did not have a process to ensure such updates. The report also showed the gaps in the guidance regarding the DoD DSC construct (GAO, 2012). Issued days before Hurricane Sandy, the following comments provided an accurate prediction of the state and federal military response under the DSC:

> Gaps in guidance remain because DoD has not yet developed comprehensive policies and procedures regarding the use and availability of dual-status commanders, including specific criteria and conditions for when and how a state governor and the Secretary of Defense would mutually appoint a commander. (GAO, 2012, p. 14)…As a result, DoD's ability to adequately prepare for and effectively use dual-status commanders for a range of civil support events, including those affecting multiple states, may be hindered. (GAO, 2012, p. 18)

Despite notable successes, the state and federal military response to Hurricane Sandy included numerous challenges similar to the Hurricane Katrina response. To prepare the DoD to support a complex catastrophe, a 2013 GAO report focused on civil support plans, guidance, and other documents and included interviews with DoD and FEMA officials. The report showed a gap in the DoD framework for complex catastrophes and other multistate incidents, as DoD leaders had not developed a construct for the C2 of federal military forces during complex catastrophes. In alignment with the

GAO (2013) report, a 2015 RAND Corporation study also found several issues with preparedness. There were conflicting perceptions within the DoD regarding the priority of DSCA, DSCA training exercise objectives, and the DSC construct (McNerney et al., 2015). There existed a lack of visibility regarding the installation and unit-level immediate response plans and the sourcing of DoD forces for DSCA missions.

Hurricane Maria: A Unique Disaster on an Island Away From the Homeland

Hurricanes vary by situation and subsequent response. Hurricane Maria vastly differed from Hurricanes Katrina and Sandy because it occurred outside the continental United States and on an island. Hurricane Maria shattered the Puerto Rico Emergency Management Agency and Puerto Rico National Guard (PRNG). The agency staff were unavailable, and the Puerto Rico National Guard and Puerto Rican U.S. Army Reserve personnel, many of whose homes were damaged or destroyed, initially focused on meeting the urgent needs of their immediate families and neighbors. The destruction of power and communications infrastructures and limited mobility due to extensive debris after the storm's wake impacted the development of situational awareness and a common operational picture.

Due to Hurricane Maria, many individuals in the commonwealth could not carry most of the burden of the needed response and recovery operations or provide clear direction for federal, DoD, and state response efforts. The resulting decision-making vacuum at the local and commonwealth levels in Puerto Rico and the USVI affected the ability of local, commonwealth, federal, and other state responders to quickly and effectively conduct mass response and recovery capabilities. The decision-making vacuum was also a challenge for federal civilian, DoD, and the Emergency Management

Assistance Compact (EMAC) National Guard responders, who based their efforts on the assumption that local and state (or commonwealth) officials make specific requests for assistance (RFAs). Once authenticated, RFAs can translate into mission assignments (MAs) and MA task orders (MATOs) to address identified needs. The response vacuum caused by Hurricane Maria required significant adaptation and improvisation from FEMA, USNORTHCOM, and ARNORTH (Larson et al., 2020).

When Hurricanes Irma and Maria impacted Puerto Rico and the USVI in September 2017, there was a whole-government response involving federal, state, local, state, civilian, and military responders. Approximately 6,200 National Guard personnel from 37 states (Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Washington, Wisconsin, and West Virginia) supported Hurricane Maria relief operations in Puerto Rico (Inserra et al., 2018).

USNORTHCOM designated ARNORTH as the Joint Forces Land Component Command for DoD support to civilian disaster response operations after the two hurricanes until mid-November 2017. The operations included routine support, such as providing food, water, planners, debris removal, and temporary roofing. The support also included federal partners' access to DoD bases and facilities for staging response personnel, equipment, and other capabilities not routinely requested. Examples of these capabilities included using U.S. Navy ships as helicopter platforms, procuring and

installing large generators, providing medical support for prolonged periods, and providing power grid restoration. DoD officials identified several challenges during the disaster to address before the next response, such as FEMA and ESF lead agencies' dependence on DoD capabilities, DoD units and personnel deploying without authorization, and the potential impact on DoD ability to support global contingencies (Larson et al., 2020).

Part III: DoD's Comprehensive Readiness for Defense Support of Civil Authorities Operations

Part III is a review of the documents related to DOTMLPF-P and DSCA operations. The literature has shown that DSCA operations differ from military operations away from the homeland. Counter to typical military operations, the DoD always supports civil authorities. DSCA requires unity of effort, not unity of command, and DoD personnel should anticipate with patience. Ultimately, DoD's goal is never to be late to need when requested.

Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Policy Framework for Understanding the United States Department of Defense Hurricane Readiness Posture

Military leaders and personnel use DOTMLPF-P to conduct capability-based assessments under the Joint Capabilities Integration and Development System (JCIDS). The JCIDS process identify capability requirements and gaps, develop documents that enable gatekeeping and staffing procedures, post-validation, implantation, interaction with other DoD processes, and mandatory training for personnel involved in the requirements processes (Defense Acquisition University [DAU], 2021). This framework

provided an understanding of the literature regarding the overall readiness of DoD DSCA preparedness and contributed to the development of the study's interview guide.

U.S. government leaders employ the instruments of national power to continuously detect, deter, prevent, and defeat threats to the homeland. For the U.S. military, this national imperative translates operationally into homeland security, homeland defense, and DSCA. Homeland security, homeland defense, and DSCA are distinct operations with clear boundaries. Homeland security is a concerted national effort to prevent terrorist attacks and reduce vulnerability to terrorism, major disasters, and other emergencies in the United States (Joint Chiefs of Staff, 2018). Homeland defense provides protection for U.S. sovereignty, territory, and domestic population and supports critical infrastructure against external threats, aggression, or other threats indicated by the President (Joint Chiefs of Staff, 2018). DSCA includes support to prepare, prevent, protect, respond, and recover from domestic incidents. DSCA operations occur only in the United States in response to civil authorities' requests and upon appropriate authorities' approval (Joint Chiefs of Staff, 2018). The DoD has a vital role in all three missions involving the homeland. DoD personnel work with the Department of Homeland Security (DHS) and other U.S. government departments and agencies to accomplish these missions. The key difference between the three purposes is that the DoD addresses the federal response to homeland defense. Also, the DoD supports other federal agencies' homeland security responsibilities.

Part I showed that scholars have disagreed about hurricane frequency trends in the North Atlantic Basin. DoD personnel could use the literature to help decision-makers plan for disasters and prioritize the resources of people, money, and equipment. The

literature in Part II showed the DoD provided valuable support for FEMA during Hurricanes Katrina, Sandy, and Maria. The review also addressed the obstacles to efficient and effective hurricane response due to shortfalls in many important areas. The following subsection is a DOTMLPF-P analysis, providing further context for the research question regarding DoD readiness to provide support during the next major hurricane to land in the United States.

Defense Support of Civil Authorities Doctrine Is for the Homeland and Against Nontraditional Military Threats

Doctrine is "the fundamental principles that guide the employment of U.S. military forces in coordinated action toward a common objective" (DAU, 2021, p. B-G-F-2). *Joint doctrine* is authoritative guidance to follow except when, in the commander's judgment, exceptional circumstances indicate otherwise. Joint Publication (JP) 3-28 is the DoD's overarching doctrine for DSCA operations and covers the following:

- The fundamentals of response
- The federal role in supporting a comprehensive all-hazards response
- DoD support for national special security events, community support activities, sensitive support operations, military training exchanges, and other specialized support
- When and how federal forces may provide support to federal, SLTT, insular areas, and local law enforcement organizations when reacting to civil disturbances, conducting border security and counterdrug missions, preparing for antiterrorism operations, and participating in other related law enforcement activities

- The all-hazards scope of DSCA
- Planning to support and sustain DSCA, including personnel services, intelligence support, meteorological support, logistics, public affairs, health services, mortuary affairs, cyberspace support, and other support and sustainment considerations.

Organizing for Defense Support of Civil Authorities Requires Joint and Reserve Forces

Organization is "a joint unit or element with varied functions enabled by a structure through which individuals cooperate systematically to accomplish a common mission and directly provide or support joint warfighting capabilities" (DAU, 2021, p. B-G-F-3). The members of subordinate units and elements coordinate with other units and elements and, as a whole, enable personnel in the higher-level joint unit or element to accomplish the mission. This coordination includes the joint staffing (military, civilian, and contractor support) required to plan, operate, sustain, and reconstitute joint warfighting capabilities. The 9/11 terrorist attacks on U.S. soil resulted in USNORTHCOM activation on October 1, 2002. The activation was the first time a single military commander received a charge to protect the U.S. homeland since George Washington.

The USNORTHCOM mission is to plan, organize, and execute homeland defense and civil support missions. However, USNORTHCOM has few permanently assigned forces; the command receives assigned forces whenever necessary to execute missions, as ordered by the president or the SECDEF (USNORTHCOM, 2023). The organization provides assistance to a lead federal agency (LFA) when tasked by DoD leaders.

USNORTHCOM operations generally occur via established joint task forces (JTFs) subordinate to the command when providing civil support. There is a unique relationship between USNORTHCOM and USINDOPACOM. For example, Alaska belongs to USNORTHCOM, but USINDOPACOM provides the forces to execute missions in Alaska. USINDOPACOM has ownership of Naval forces and Marines on the West Coast inside the USNORTHCOM area of operations. Hawaii is part of USINDOPACOM; however, USNORTHCOM supports USINDOPACOM with the mission of missile defense of Hawaii (USNORTHCOM, 2023).

Two subordinate unified commands support USNORTHCOM in the DSCA mission. Alaskan Command personnel conduct defense, civil support, mission assurance, and security cooperation within the Alaskan Command area of operations to defend and secure the United States and its interests (USNORTHCOM, 2023). U.S. Special Operations Command North provides enhanced C2 of special operations forces supporting DSCA (USNORTHCOM, 2023).

The DSCA task organization includes component commands of the DoD branches. ARNORTH is the land component of USNORTHCOM and is the Army's dedicated headquarters for DoD operations within the homeland. ARNORTH personnel work with joint, interagency, and international military partners to achieve protection in depth by supporting global operations, securing the approaches to the homeland, and serving within the homeland (USNORTHCOM, 2023). First Air Force/Air Forces Northern is the designated air component for USNORTHCOM. First Air Force/Air Forces Northern provides aerospace control and air defense of the continental United States, USVI, Puerto Rico, and the surrounding seas to approximately 500 nautical miles

(USNORTHCOM, 2023). Similarly, U.S. Naval Forces North (USNAVNORTH) provides maritime forces for homeland defense, civil support operations, and theater security cooperation activities. The U.S. Marine Forces Command/Marine Forces Atlantic personnel coordinate with and support Marines to conduct homeland defense operations and provide DSCA (USNORTHCOM, 2023).

USNORTHCOM also has control over three JTFs. Joint Task Force North is a DoD organization that supports U.S. federal law enforcement agencies in the identification and interdiction of suspected transnational criminal organizations' activities within and along approaches to the continental United States (USNORTHCOM, 2023). Joint Task Force Civil Support focuses on the effects of a chemical, biological, radiological, and nuclear (CBRN) incident after the first and full use of civilian resources (USNORTHCOM, 2023). Joint Force Headquarters National Capital Region focuses on land-based homeland defense, DSCA, and incident management (USNORTHCOM, 2023). Joint Force Headquarters National Capital Region personnel draw together the resources of the Army, Navy, Air Force, Marine Corps, Coast Guard, and North American Aerospace Defense Command (NORAD) into a single-point headquarters for planning, coordinating, and executing the mission in the NCR.

Training for Defense Support of Civil Authorities Includes Individual and Collective Training

Training includes mission rehearsals of individuals, units, and staff with joint doctrine or joint tactics, techniques, and procedures. The purpose of training is to prepare joint forces or joint staff to respond to the strategic, operational, or tactical requirements considered necessary by the combatant commander to execute assigned or anticipated

missions (DAU, 2021 p. B-G-F-3). Essential personnel who support DSCA operations (e.g., military, civilian, or contractor) require certification. The DSCA course, charted by the Office of the SECDEF, sponsored by USNORTHCOM, and executed by ARNORTH personnel, provides students with an introduction to national, state, local, DoD policies, plans and directives, C2 relationships, and capabilities regarding DoD support for domestic emergencies, designated law enforcement, and other activities.

The DoD DSCA course has three phases: an online course, a 3.5-day resident or virtual course, and continuing education in an online environment with updates about DSCA operations, laws, policy, doctrine, and lessons learned. The DSCA Phase I course delivery occurs via the Joint Knowledge Online learning management system. The purpose of Phase I is to orient personnel to the DSCA environment and develop awareness, comprehension, and competence. The DSCA Phase II course is a graduate-level, fast-paced, seminar-style course for senior DSCA personnel. Phase II provides a whole-of-government perspective on homeland defense and DoD support for disasters. Students meet the course objectives by planning, coordinating, and executing homeland defense and DSCA missions, attending interactive lectures, and completing small-group case studies and exercises facilitated by DSCA instructors and subject matter experts (SMEs). Since 2006, ARNORTH leaders have striven to conduct 14 DSCA Phase II classes yearly with at least 50 students in each cohort. Like other military courses, there were modifications to the course delivery during the COVID-19 pandemic. DSCA Phase III provides continuing education through updates on developments in law, policy, strategy, doctrine and operations related to DSCA, homeland defense, homeland security, and emergency preparedness. Only graduates of the DSCA Phase II course can enroll in

Phase III; an ARNORTH training manager confirmed over 11,200 bona fide graduates of the DSCA Phase III.

In addition to individual DSCA training, USNORTHCOM personnel facilitate and ARNORTH staff lead an annual combined command post exercise called Vibrant Response, with a corresponding field training exercise called Guardian Response. The exercises are a means of bringing together military and civilian emergency response organizations to integrate and provide relief during a simulated catastrophic disaster. Vibrant Response and Guardian Response present a scenario of a notional 10-kiloton nuclear device detonated in a major U.S. city. DoD staff use the worst-case scenario to train participants in mass casualty decontamination, urban search and rescue, and other life-saving missions. Practicing for the worst disaster contributes to the DoD staff's ability to provide support during disasters such as hurricanes, tornadoes, and wildfires. Similarly, Ardent Sentry is an annual, Tier 1 large-sale exercise specific to hurricanes, executed by NORAD and USNORTHCOM. The purpose of the exercise is to train the command headquarters and its components to support civil authorities if requested by local governments anywhere in the United States. ARNORTH personnel also execute a rehearsal of concept drill in May before every hurricane season.

Materiel Is an Important Factor for the DoD's Defense Support of Civil Authorities Response

Materiel includes all items (e.g., ships, tanks, self-propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities) necessary to equip, operate, maintain, and support joint military activities without distinction as to the application for administrative or combat

purposes (DAU, 2021, p. B-G-F-4). The military is a valuable partner during large-scale disasters due to a quick response and the availability of resources such as personnel and equipment. Aircraft, all-terrain vehicles, engineering equipment, logistics platforms, and medical and general-purpose troops are some of the resources the military can provide to support efforts to save lives and mitigate suffering during disasters. The military support for Hurricane Katrina included 20 ships, 360 helicopters, and 93 fixed-wing aircraft in the affected area (Kochems, 2005). The response to Hurricane Sandy included an amphibious ready group comprised of three U.S. Navy ships (USS Wasp, USS Carter Hall, and USS San Antonio) (McNeil & Burke, 2015). During Hurricane Maria, DoD leaders repositioned U.S. Navy ships in route to support Hurricane Harvey in the USVI (GAO, 2018). U.S. government and many state government leaders organize their response resources and capabilities under the ESF construct. ESFs are an effective way to organize and manage resources to deliver core capabilities.

Table 2

Emergency Support Functions (NRF-ESF)

	#1 – Transportation	#2 – Communications	#3 – Public Works and Engineering	#4 – Firefighting	#5 – Emergency Management	#6 – Mass Care, Emergency Assistance, Housing, and Human Services	#7 – Logistics Management and Resource Support	#8 – Public Health and Medical Services	#9 – Search and Rescue	#10 – Oil and Hazardous Materials Response	#11 – Agriculture and Natural Resources	#12 – Energy	#13 – Public Safety and Security	#14 – Long-Term Community Recovery	#15 – External Affairs
USDA					S	S	S	S		S	C/P/S	S		P	S
USDA/FS	S	S	S	C/P		S	S	S	S	S			S		
DOC	S	S	S	S	S		S	S	S	S	S	S	S	S	S
DOD	S	S	S	S	S	S	S	S	P	S	S	S	S	S	S
DOD/USACE	S		C/P	S		S	S	S	S	S	S	S	S	S	
ED					S										S
DOE	S		S		S		S	S		S	S	C/P	S	S	S
HHS			S		S	S	S	C/P	S	S	S			S	S
DHS	S	S	S		S		S	S	S	S	S	S	S	P	C
DHS/FEMA	S	P	P	S	C/P	C/P/S	C/P	S	C/P	S	S			C/P	P
DHS/NCS		C/P					S					S			
DHS/USCG	S		S	S				S	P	P			S		
HUD					S	S								P	S
DOI	S	S	S	S	S	S	S	S	P	S	P/S	S	S	S	S
DOJ	S				S	S		S	S	S	S		C/P		S
DOL			S		S	S	S	S	S	S	S	S		S	S
DOS	S		S	S	S			S		S	S	S			S
DOT	C/P		S		S	S	S	S		S	S	S		S	S
TREAS					S	S							S	S	S
VA			S		S	S	S	S					S		S
EPA			S	S	S			S		C/P	S	S	S	S	S
FCC		S			S										S
GSA	S	S	S		S	S	C/P	S		S	S				S
NASA					S		S		S				S		S
NRC			S		S					S		S			S
OPM					S		S								S

	#1 – Transportation	#2 – Communications	#3 – Public Works and Engineering	#4 – Firefighting	#5 – Emergency Management	#6 – Mass Care, Emergency Assistance, Housing, and Human Services	#7 – Logistics Management and Resource Support	#8 – Public Health and Medical Services	#9 – Search and Rescue	#10 – Oil and Hazardous Materials Response	#11 – Agriculture and Natural Resources	#12 – Energy	#13 – Public Safety and Security	#14 – Long-Term Community Recovery	#15 – External Affairs
SBA					S	S							P		S
SSA						S							S		S
TVA			S		S							S			S
USAID								S	S						S
USPS	S				S	S		S			S		S		
ACHP											S				
ARC			S		S	S		S			S			S	
CNCS			S			S								S	
DRA														S	
HEMTF											S				
NARA											S				
NVOAD						S								S	

Note. C = ESF coordinator, P = primary agency, S = support agency

ESFs are means of bringing together the capabilities of U.S. government departments and agencies and other national-level assets. Table 2 shows that the DoD is one of only two federal agencies (the other being the Department of the Interior) involved in all 15 ESFs and potentially tasked with supporting any of them. DoD and the United States Army Corps of Engineers are the coordinating and primary agencies for ESF 3, Public Works and Engineering. The DoD is one of four primary agencies for ESF-9, Search and Rescue.

Educating the Agile Leader for DSCA Response Is Multifaceted

Leadership and education are the focus of joint leader professional development. Professional development is the product of a learning continuum of training, experience, education, and self-improvement (DAU, 2021, p. B-G-F-5) The role of joint professional military education is to provide education to complement training, experience, and self-improvement to produce the most professionally competent individuals possible. The DSCA leadership hierarchy includes the USNORTHCOM commander, who reports to the U.S. president through the SECDEF. In line with the typical military structure, DSCA commanders serve at the strategic, operational, and tactical levels to provide purpose, guidance, and motivation to subordinates to successfully support DSCA operations when indicated by the SECDEF.

Leaders and members of the cadre who support DSCA receive a multifaceted education. All essential personnel must complete the DoD DSCA course independent of their prescribed education level in the Officer Education System pipeline. Military officers typically complete a form of initial entry training via officer candidate school; Reserve Officer Training Corps; military service academies, such as the United States Military Academy at West Point; or the Air Force, Navy, and Coast Guard equivalent. After initial entry, military officers proceed to their military occupation specialty (MOS) course, returning 4 years later for a refresher course and assuming command of a tactical organization. Midcareer officers across various DoD branches also complete a version of command and staff college, which provides joint education so midcareer officers can understand their roles in supporting U.S. government strategies and priorities.

Senior military officers across the DoD must also complete a terminal Officer Education System program commonly referred to as war college or senior service college. Officers may attend their component's war college or a different branch of the military's war college. Some officers complete fellowships at a select few university (Harvard, MIT, Tufts, Carnegie Mellon) or a select few foreign war college equivalents (United Kingdom, Germany, Spain, Australia, Canada). The goal of war colleges is to educate and develop leaders for service at the strategic level and advance their knowledge of the global application of power. A few officers become generals or admirals, which are positions with additional continuing education requirements. DoD decision-makers and leaders who support DSCA—whether civilians, soldiers, sailors, Marines, members of the Air Force or Coast Guard, or Space guardians—progress through required military and pertinent schooling before assuming their roles in warfighting, homeland defense, or DSCA at tactical, operational, or strategic warfare levels.

DSCA Personnel Have Unique Roles and Responsibilities

Qualified personnel support joint capability requirements. Synchronized efforts among joint force commanders and DoD components occur to optimize personnel support to the joint force for ongoing peacetime, contingency, and wartime operations (DAU, 2021, p. B-G-F-5). The DCO, the DoD's single point of contact at the Joint Field Office, represents the SECDEF for DSCA operations. The DCO is a senior Army officer who validates the RFAs before forwarding them to the appropriate DoD entity for approval and sourcing. DCOs remain permanently aligned to each of the 10 FEMA regions. The DCO receives support from the defense coordinating element (DCE), an administrative and support staff. Depending on the severity of the event and the type of

DoD response required, specialty staff, additional personnel from other DoD branches, and additional liaison officers in the form of emergency preparedness liaison officers (ELPOs) may augment the DCE.

ELPO positions, authorized via DoDI 3025.16, exist in each FEMA region and state from Title 10, USC, Reserve forces. The emergency preparedness liaison officers also facilitate planning, coordination, and training for DSCA and national security emergency preparedness; advise federal agencies and organizations on DoD capabilities and resources; advocate mutual support required by DoD; and, on order, augment DoD response for DSCA (Joint Chiefs of Staff, 2018). State National Guards also have EPLOs known as state emergency preparedness liaison officers (SEPLOs). SEPLOs conduct the same missions as EPLOs but report directly to their corresponding state DSCA hierarchy.

The DSC is another important personality in the DSCA enterprise. A DSC is a commissioned officer of the regular U.S. Army or U.S. Air Force, a federally recognized Army National Guard, or Air National Guard officer. The DSC has authorization under Title 32, USC, Section 315 or 325 by the SECDEF with the consent of the applicable state governor to exercise command on behalf of and receive separate orders from a federal chain of command. DSCs also have authorization to exercise command on behalf of and receive separate orders from a state chain of command (Joint Chiefs of Staff, 2018).

The DSC can exercise command on behalf of and may receive orders from two separate chains of command. Therefore, leaders of those chains of command should recognize and respect the DSC's duty to exercise all authority. For example, the DSC has authorization to give orders on behalf of or relay orders from the federal chain of

command to federal military forces and give orders on behalf of or relay orders from the state chain of command to state military forces. However, the DSC may not relay federal orders to state military forces or state orders to federal military forces. The DSC helps achieve unity of effort (vice unity of command) as a military leader by acknowledging the governor's and U.S. president's responsibilities. Title 10 force members answer to the president, while Title 32 forces answer to their corresponding state governor. The DSC is the only one who can control both status of forces.

The forces that conduct DSCA operations may wear the same military uniform, but they receive direction and financing under different rules. Title 10, USC, provides guidance for the U.S. Armed Forces. The guidance has five subtitles: one on general military law and one each for the Army, Navy and Marine Corps, Air Force, and Reserve. Chapter 15 (Sections 271-282) of Title 10, USC, indicates military support for civilian law enforcement agencies. Title 10, USC, provides the basis for federal oversight of and authority for the National Guard to conduct activities in a federal duty status, subject to state control, while accomplishing federal missions and purposes. Most activities conducted pursuant to Title 10, USC, directly relate to training or other readiness requirements established by the U.S. Army and U.S. Air Force to prepare the National Guard for a warfighting mission. Any operational missions approved by the president or SECDEF and otherwise permitted by law can occur federal duty status under Title 10, USC (e.g., DSC; employment of National Guard civil support teams; and other domestic operational use of the National Guard pursuant to Title 10, USC, Section 502[f]; Title 10, USC, Section 502).

The DoD Has Prime Real Estate for DSCA Operations

Facilities are real property consisting of one or more of the following: buildings, structures, utility systems, associated roads and other pavements, and underlying land (DAU, 2021, p. B-G-F-6). *Key facilities* are command installations and industrial facilities of primary importance to the support of military operations or military production programs. During DSCA operations, there may be DoD installations designated as a base support installations (BSIs) to support DoD operations. A BSI is a military installation of any service or DoD agency that provides specified, integrated resource support to DSCA response efforts (Joint Chiefs of Staff, 2018). The BSI-designated installation provides general support for common-user logistics (e.g., food, life-support, medical support, and fuels) to all proximate DoD forces. Commanders and their staff conduct mission analysis to meet logistics requirements and coordinate the potential use of a military installation for base support of DoD forces during DSCA. The BSI may address additional sustainment functions, such as a port of embarkation, point of distribution, forward operating base (FOB), or a joint reception staging onward movement and integration site.

Like BSIs, incident support bases (ISBs) support one or more non-DoD federal departments or agencies as a logistics staging facility for a DSCA response. The normally requested installation support of an ISB includes covered warehouse space and secure (fenced) hard-stand parking areas to stage commercial semitrailers loaded with commodities before direction forward to supply state staging facilities, shelters, or points of distribution. The ISB may also provide airfield facilities for federal-owned commodities and transload from aircraft to trucks for further shipment.

The Policies That Govern DSCA Are Many and Overwhelming

Policy involves any DoD, interagency, or international policy issues that could impact the effective implementation of changes in the other seven DOTMLPF-P elemental areas (DAU, 2021, p. B-G-F-6). The U.S. Constitution gives United States Congress the inherent powers to pass laws (Article I), the United States Supreme Court to review the laws (Article II), and the executive branch to execute the laws (Article III). The SECDEF is a member of the executive branch with authority through Title 5 and Title 10 to direct the armed forces to execute homeland defense and DSCA missions. There are numerous policies for DSCA operations. Therefore, this DSCA study included a review of pertinent documents to the DSCA.

According to Homeland Security Presidential Directive 5, *Management of Domestic Incidents*, the Secretary of Homeland Security is the principal federal official for domestic incident management who coordinates U.S. government resources to prepare for, respond to, or recover from terrorist attacks, major disasters, or other emergencies (Homeland Security, 2003). The U.S. government provides assistance to state and local authorities with overwhelmed resources or based on federal interests. Homeland Security Presidential Directive 5 indicates that the SECDEF shall "provide support to civil authorities for domestic incidents as directed by the President or when consistent with military readiness and appropriate under the circumstances and the law" (Homeland Security, 2003, para. 9). The SECDEF retains command of military forces providing DSCA; however, the DHS secretary leads and manages NIMS development to provide a consistent nationwide approach for federal and SLTT governments to

collaborate effectively and efficiently to prepare for, respond to, and recover from domestic incidents (Homeland Security, 2003, para. 15).

Similarly, the purpose of Presidential Policy Directive 8, *National Preparedness,* is to strengthen the security and resilience of the United States through systematic preparation for the threats that are the greatest risk to national security, including acts of terrorism, cyberspace attacks, pandemics, and catastrophic disasters (Homeland Security, 2011). National preparedness is the shared responsibility of all governmental levels, private and nonprofit sectors, and individual citizens. This directive is a means of galvanizing U.S. government action and facilitating an integrated, all-of-nation, capabilities-based approach to preparedness.

The Robert T. Stafford Disaster Relief and Emergency Assistance Act includes a policy for the U.S. government to provide an orderly and continuing means of supplemental assistance to state and local governments to address suffering and damage from major disasters or emergencies. The act is the primary legal authority for federal participation in domestic disaster relief. Under the Stafford Act, the president may direct federal agencies, including DoD, to support disaster relief. DoD may also receive direction to provide support in one of three different scenarios: (a) a presidential declaration of a major disaster, (b) a presidential order to perform emergency work for the preservation of life and property, or (c) a presidential declaration of emergency (Title 42, USC, Chapter 68, Section 5121).

The Economy Act of 1932 indicates that one federal agency can request the support of another provided that the agency cannot receive the requested services more cheaply or conveniently by contract (Title 31, USC, Section 1535). Under this act,

leaders of a federal agency with lead responsibility may request DoD support without a presidential declaration of an emergency.

DoDI 3025.21, *Defense Support of Civilian Law Enforcement Agencies,* involves implementing the Posse Comitatus Act (PCA) for DoD components. The original PCA which was enacted in 1878 included only the Army; however, a 1959 amendment incorporated the Air Force. Members of Congress amended the PCA in 2021 via Section 1045 of the FY22 NDAA to include the Navy, Marine Corps, and Space Force. The act does not apply to the Coast Guard during peace or war because the Coast Guard is a federal law enforcement agency under Title 14, USC. Federal court justices have recognized exceptions to the PCA, the most notable being the military purpose doctrine and the indirect assistance to civilian law enforcement exceptions. Exceptions and circumstances outside of PCA include actions taken for the primary purpose of furthering a military or foreign affairs function of the United States; federal troops acting pursuant to the President's constitutional and statutory authority to respond to civil disorder; actions taken under express statutory authority to assist officials in executing the laws, subject to applicable limitations; and counterdrug operations authorized by statute (18 USC 1385).

Federal military commanders, DoD component heads, and DoD civilian officials may respond, when requested, to save lives, prevent human suffering, and mitigate great property damage under imminently serious conditions through an IRA provision. The provision indicates that commanders can deploy to save lives, prevent human suffering, and mitigate great property damage. However, the IRA does not include DoD authorization to conduct law enforcement functions. IRA provisions have two time

elements: (a) a commander may respond if time does not enable approval from higher authority and (b) without violating the 72-hour assessment rule (Joint Chiefs of Staff, 2018). The *Standing Rules for the Use of Force* provide operational guidance regarding fundamental policies and procedures for DoD forces on DSCA missions (e.g., military assistance to civil authorities and military support for civilian law enforcement agencies) and routine service functions (including antiterrorism/FP duties) within U.S. territory, including U.S. territorial waters. These rules, approved by the SECDEF, appear in Enclosures L and N of CJCSI 3121.01B (Joint Chiefs of Staff, 2005).

Many DoD directives, instructions, and manuals provide guidance on legally conducting DSCA operations within set standards. The DSCA directives and instructions include *DoDD 3025.18, Defense Support of Civil Authorities; DoDD 3150.08, DoD Response to Nuclear and Radiological Incidents; DoDD 3160.01, Homeland Defense Activities Conducted by the National Guard; DoDI 3025.16 Defense Emergency Preparedness Liaison Officer Programs; DoDI 3025.20 Defense Support of Special Events; DoDI 3025.21, Defense Support of Civilian Law Enforcement Agencies; DoDI 3025.22, The Use of the National Guard for Defense Support of Civil Authorities; DoDI 3025.23, Domestic Defense Liaison with Civil Authorities;* and *DoDM 3025.01, Volumes 1-3, Defense Support of Civil Authorities.* The DoD also provides guidance via execute orders and concept plans (CONPLANs). The current DSCA execute order provides limited approval authority to USNORTHCOM and USINDOPACOM commanders with DSCA responsibilities to provide rapid and flexible DoD critical capabilities when formally requested and validated. Subsequently, USNORTHCOM CONPLAN 3500, *Defense Support of Civil Authorities,* and USINDOPACOM CONPLAN 5001, *Defense*

Support of Civil Authorities, provide a framework for DSCA response with supporting branch plans for complex catastrophes, CBRN response, medical countermeasures, pandemic influenza and infectious diseases response, civil disturbance operations, wildland firefighting, mass migration, and Federal Reserve support.

Previous Scholarship Points to DSCA Weaknesses and Challenges

There is limited current scholarly literature specific to DSCA and hurricanes. However, a few scholars have analyzed DSCA and disaster readiness. Milliman et al. (2006) focused on local emergency managers' understanding of the DSCA process, their ability to trigger support under the DSCA, and their expectations for military collaboration. Many emergency managers in the study did not have a strong understanding of the various aspects of the DSCA process, did not believe that DSCA implementation would occur effectively in the future, and had several concerns about military support provision. Milliman et al.'s work was a precursor to three other studies with similarly worded questions.

Porter (2010) researched DSCA proficiency with a case study of Hurricane Katrina and surveys and interviews with emergency managers in Louisiana. Similarly, Haynes (2014) sought to determine DSCA proficiency in North Carolina. Both researchers determined that the state and parish emergency managers who participated in the research had a nascent understanding of DSCA operations. Brown (2017) sought to determine potential trends to improve or sustain proficiency levels for DSCA operations in the NCR. Brown's findings aligned with other studies on DSCA proficiency. The emergency managers who participated in the study had a nascent knowledge of DSCA operations.

Johnston (2013) examined the effectiveness of the DSCA program through the theoretical lens of adult learning. The main conclusion was that graduates should construct new meaning for themselves and their organizations to make the complexity of homeland security coherent. Similarly, Manrique (2015) examined three instructional delivery modalities to identify the best practices for DoD personnel training and education to support civilian authorities during emergencies, disasters, and catastrophic events. The findings showed that instruction significantly affected participants' course satisfaction and success, even when controlling for educational level, service branch, gender, and instructor teaching experience.

Burke (2015) studied Hurricane Sandy with an objective and systematic analysis of the military response and offered recommendations for improving DSCA operational processes under the DSC construct during no-notice and limited-notice incidents. Burke found that the DSC concept had the potential for success; however, numerous bureaucratic, legal, and political impediments negatively affected employment. Michael (2016) examined the perspectives of Title 10 personnel who responded to natural disasters to better understand the obstacles they faced. The findings aligned with Burke and current DSCA research suggesting that strategic leadership can hamper response operations due to incorrect or mismanaged information. Therefore, communication can be an obstacle for military units and civilians.

Kellum (2021) explored how leaders practice effective leadership when encountering unknown complexities such as disasters. Kellum affirmed that DSCA operations leadership requires supporting discipline, critical thinking, decision-making,

and problem-solving functions and focusing on the importance of relationships, responsibilities, and roles.

Summary

Chapter 2 was a literature review on hurricane frequency; DoD support for FEMA during Hurricanes Katrina, Sandy, and Maria; and DoD readiness through the DOTMLPF-P framework. Part I showed experts' disagreements about hurricane frequency in the North Atlantic Basin. Some hurricane frequency scholars have indicated a positive or a negative trend, whereas others have cautioned against defining trends due to varying observation techniques, undercount bias, and instrumentation improvements.

In Part II, Congressional studies through the GAO, think tanks such as the Heritage Foundation and RAND Corporation, and AARs showed DoD leaders continuously strove to improve DSCA response after each major hurricane. However, despite progress and improvements, further shortcomings occurred with the next hurricane, partly because each disaster presented new and unanticipated challenges. The review indicated that the DoD is a transparent and learning organization with leaders who accept external and internal feedback to improve DSCA operations. Part III showed the sensitivity of DSCA operations because the American public may be wary of DoD operations on U.S. soil, perhaps because the military's mission is to fight and win wars, usually outside the continental United States. Chapter 3 will address the methodology used to answer the two research questions in this study: What is the actual trend of the frequency of hurricanes in the North Atlantic Basin? and, How prepared is the DoD to support the next major hurricane that makes landfall in the United States?

CHAPTER 3: METHODOLOGY

Introduction

The purpose of this mixed methods study was to investigate whether hurricanes in the North Atlantic Basin are increasing in frequency and whether DSCA practitioners perceive the DoD as prepared to support FEMA when the next major hurricane occurs in the homeland. Mixed results of TC frequency and DoD responses to Hurricanes Katrina, Sandy, and Maria have indicated the need to address readiness gaps before the next major landfall hurricane. The DoD has remained transparent in efforts to improve hurricane response, but the need for improved readiness remains. DoD leaders may hesitate to conduct operations in the United States due to authorities, policies, and laws to prevent DoD lead during disaster response. This mixed methods study involved analyzing 171 years of TC data from NOAA, more than 788 minutes of interviews, and 198 pages of transcripts from 30 DSCA professionals to better understand hurricane trends and DoD hurricane readiness posture.

This study focused on hurricane frequency and DSCA practitioner feedback regarding the DoD's hurricane readiness posture. Therefore, the results could contribute to efficacious disaster preparedness and response. Decision-makers and policymakers in federal and SLTT governments could gain critical information to make sound decisions before, during, and after the next major hurricane. Chapter 3 presents the two research questions, methodology, and design. The chapter also addresses the population; sample; and instrument used to collect, manage, and analyze the research data. The chapter concludes with the study's trustworthiness, reliability, and ethical considerations.

Research Questions and Hypotheses

1. What is the trend of hurricane activity in the North Atlantic Basin?

   $H1_0$: There is no trend in the series.

   $H1_a$: There is a positive trend in the series.

2. How prepared is the DoD to support the next major hurricane that makes landfall in the United States?

Table 3 presents the connection between the research hypotheses, the two research questions, the measurements, and the analysis methods.

Table 3

Connection of Hypotheses to Research Questions and Analysis

Hypothesis	Research question	Measure	Method of analysis
$H1_0$: There is no trend in the series	RQ1: What is the trend of hurricane activity in the North Atlantic basin?	HURDAT, count of named storms, hurricanes, major hurricanes, ACE, U.S. hurricanes, and year (1851–2021 & 1991–2020)	Mann–Kendall correlation, time series, and ARIMA
$H1_a$: There is a positive trend in the series	RQ1: What is the trend of hurricane activity in the North Atlantic basin?	HURDAT, count of named storms, hurricanes, major hurricanes, ACE, U.S. hurricanes, and year (1851–2021 & 1991–2020)	Mann–Kendall Correlation, and Time Series, and ARIMA
	RQ2: How prepared is the DoD to support the next major hurricane that makes landfall in the United States?	Semistructured interview with 10 open-ended questions using DOTMLPF-P	Transcription and thematic analysis

The independent variable for RQ1 was year (from 1851 to 2021). The dependent variables were storms, hurricanes, major hurricanes, ACE, and U.S. hurricanes. The variables in this research aligned with the NOAA National Hurricane Center (NHC) HURDAT. Named storms included tropical storms, hurricanes, and subtropical storms. Hurricanes was the number of hurricanes on the 1–5 Saffir-Simpson Hurricane Wind Scale. Major hurricanes consisted of the number of hurricanes in Categories 3, 4, or 5 on the Saffir-Simpson Hurricane Wind Scale. ACE was an index of several systems and their length and intensity. Calculating ACE involves squaring the maximum sustained surface wind in the system every 6 hours the cyclone is a named storm and summing it up for the season. U.S. hurricanes consisted of the number of hurricanes that made landfall on the continental United States.

The ratio scale variables were year, named storms, hurricanes, major hurricanes, ACE, and U.S. hurricanes. A ratio scale is a variable measurement scale that produces the order of variables and shows the difference between variables and information on the value of true zero (Babbie, 2021). Calculating the ratio scale includes assuming the variables have an option for zero, an equal difference between the two variables, and a specific order between the options. The data for RQ1 consisted of secondary data from HURDAT. Secondary data were an inexpensive and fast option due to completed data collection (Bachman & Schutt, 2020). However, secondary data may include unreliable, incomplete, or irrelevant information. Also, a researcher might have no control over the reliability or validity of the data collection procedures (Shadish et al., 2002).

In this study, semistructured interviews comprising 10 open-ended questions were the instrument used to answer RQ2. The interview participants were DSCA experts who

discussed DoD readiness regarding DSCA DOTMLPF-P. Appendix E contains the interview guide. For the first question in the interview guide, the participants described their experience with DSCA operations. Questions 2–9 focused on readiness concerning each DOTMLPF-P area. For Question 10, the participants discussed DoD readiness to respond to the next major hurricane in the United States. Table 4 is a list of the operational definitions for the variables in RQ1 and RQ2.

Table 4

Operationalization of Variables

Variable	Operational definition
Year	1851 to 2021
Named storms	Tropical Storms, Hurricanes and Subtropical Storms
Hurricanes	Saffir-Simpson Hurricane Scale 1–5
Major hurricanes	Saffir-Simpson Hurricane Scale 3–5
ACE	An index that combines the numbers of systems, how long they existed, and how intense they became
U.S. hurricanes	Number of hurricane strikes on the continental United States
Doctrine	Authoritative guidance that will be followed except when, in the judgment of the commander, exceptional circumstances dictate otherwise
Organization	A joint unit or element with varied functions enabled by a structure through which individuals cooperate systematically to accomplish a common mission and directly provide or support joint warfighting capabilities
Training	Mission rehearsals of individuals, units, and staffs using joint doctrine or joint tactics, techniques, and procedures to prepare joint forces or joint staffs to respond to strategic, operational, or tactical requirements considered necessary by the higher echelon to execute their assigned or anticipated missions
Materiel	Items (including ships, tanks, self-propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities) necessary to equip, operate, maintain, and support joint military activities without distinction as to its application for administrative or combat purposes

Variable	Operational definition
Leadership and education	Professional development of the joint leader and is the product of a learning continuum that comprises training, experience, education, and self-improvement
Personnel	Qualification to support DSCA requirements
Facilities	All real property consisting of one or more of the following: buildings, structures, utility systems, associated roads and other pavements, and underlying land
Policy	DoD, interagency, or international policy issues that may prevent effective implementation of changes in the other seven DOTMLPF-P elemental areas

Research Methodology

A mixed methods approach was the means of collecting and analyzing data to answer the study's two research questions. Mixed methods researchers use quantitative and qualitative methods to find answers to the research questions (Tashakkori et al., 2020). The methodology was appropriate to obtain a full understanding of hurricanes and DoD DSCA readiness; quantitative or qualitative data alone could not have sufficiently addressed the two research questions. The two research methods are suitable for placing the findings in context, adding richer detail to the conclusions, and gaining more credible results (Creswell, 2013). This study involved understanding hurricane trends using statistics and operationalizing the results with the qualitative interview responses of experts from an organization with high stakes during hurricane response.

This study included secondary data from HURDAT to address RQ1 and primary data from semistructured interviews to address RQ2. The goal for RQ1 was to classify and count data and construct statistical models to explain the findings. The aim for RQ2 was to collect data from DSCA experts via interviews and analyze codes, themes, and patterns in the data. Combined qualitative and quantitative insights provide a more

complete picture of the problem under study and contribute to the credibility of the conclusions (Creswell, 2013).

Research Design

A research design is a strategy for answering one or more research questions with empirical data. A well-planned research design is a way to ensure the methods match the research aims and that the right kind of analysis occurs to explain the data (Bachman & Schutt, 2020). Mixed methods research entails combining qualitative and quantitative data and analysis in a single study. Scholars can conduct mixed methods research to address complex questions, explore different perspectives, and enrich findings. There are different types of mixed methods designs based on the purpose of the research, data collection timing, and the importance given to each data type (Creswell, 2013). In a convergent parallel design, a researcher simultaneously collects quantitative and qualitative data but analyzes them separately (Pyrczac & Tcherni-Buzzeo, 2020). After the analyses, results undergo comparison to draw overall conclusions. In an embedded design, the researcher simultaneously collects and analyzes quantitative and qualitative data within a larger quantitative or qualitative design, with one type of data secondary to the other. The embedded design is a suitable approach for studies with limited time or resources. Scholars may use the embedded design to strengthen or supplement the conclusions from the primary research design type. In an explanatory sequential design, quantitative data collection and analysis occur before qualitative data collection and analysis (Pyrczac & Tcherni-Buzzeo, 2020). Scholars adopt the explanatory sequential design to use the qualitative data to explain and contextualize the quantitative findings.

With the explanatory sequential design, researchers explore initial questions and develop hypotheses to test or confirm with quantitative data.

This mixed methods study involved analyzing trends and identifying perceptions; therefore, the convergent parallel design was the most appropriate. Data collection for RQ1 and RQ2 differed based on the data type. Quantitative observation is a method of measuring and quantifying the characteristics of a phenomenon (Babbie, 2021). Scholars conducting quantitative observation gather numerical data, such as measurements or counts, to express in quantitative values. In this study, the quantitative observation design was appropriate to answer RQ1 via secondary data collection over time using data from a reputable organization, such as the NOAA. Observations provide the opportunity to gather data on behaviors and phenomena without relying on respondent honesty and accuracy (Leedy & Ormrod, 2019). Because RQ1 focused on hurricane trends, the observation method was the most appropriate for addressing RQ1. However, quantitative observations may include issues of uncertainty in the values and possible biases. Researchers should thoroughly address values and potential biases and not assume they have made accurate, complete, and unbiased observations.

Secondary data obtained from the NHC HURDAT database underwent analysis to answer RQ1. NOAA personnel organize and maintain the freely available HURDAT public domain, providing global TC information for dissemination and use in scientific research. HURDAT is a database of TC measurements over time and includes information for all hurricanes and TCs in the North Atlantic Ocean. Per NOAA, HURDAT is the official record of TCs and hurricanes in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, including those that have landed in the United States.

HURDAT quantitative records date back to the mid-19th century. Although only about 12% of the world's TCs occur in the North Atlantic (Emanuel, 2021), there are quantitative records since the mid-19th century for the whole basin (Landsea, 2007). However, there are no similar data for other regions.

One-on-one interviews are one of the most commonly used data collection tools in qualitative research. Interviews enable the collection of highly personalized information directly from the source (Babbie, 2021). In this study, 30 DSCA professionals who were DSCA Phase III members participated in interviews to answer RQ2. Interviews can provide in-depth information on the participants' opinions and preferences (Babbie, 2021). There were efforts to reduce researcher bias, such as a thorough research plan, careful hypothesis evaluation, a review of the findings with DSCA and hurricane experts, and accurate record-keeping throughout the study.

Population and Sample Selection

This section presents the study population and sample. The population for RQ1 was TCs, and the sample consisted of 171 years (1851–2021) of TC activities in the North Atlantic Basin. The sample came from HURDAT, an open-source database maintained by the NOAA's NHC. The population for RQ2 included over 4,000 DSCA service members, civilians, and contractors who had worked at strategic, operational, and tactical levels for various organizations in different regions to support different incidents. The participants were 30 DSCA Phase III members of the Homeland Defense & Civil Support Operations Forum on milSuite.mil. There was potential overlap membership in the Defense Support of Civil Authorities (Phase III) private Facebook group.

Data collection occurred after permission from the ARNORTH Training Management Directorate, webmaster for the milSuite and Facebook forums. There was a letter simultaneously uploaded to the milSuite and Facebook forums to solicit volunteers for the study. After a week without any response, the webmaster sent the request to an email distribution list, and responses began to come in via email. The email produced enough interest among forum members, resulting in 30 participants.

Nonprobability purposive sampling was the means of selecting the sample for RQ2. Purposive sampling, also known as judgment sampling, involves the researcher using personal expertise to select the most useful sample for the research purposes (Leon-Guerrero & Frankfort-Nachmias, 2018). Qualitative scholars often use purposive sampling to gain detailed knowledge about a specific phenomenon rather than make statistical inferences. Scholars also use purposive sampling for small and specific populations. The 30 participants in this study came from diverse backgrounds with various experience with DSCA operations and contributed to the study's credibility.

Instrumentation: Researcher-Created Interview Guide

This section presents the process of designing the data collection instrument for RQ2. The interview guide included questions on the participants' perceptions of the DOD's ability to respond to the next U.S. landfall hurricane. Table 5 is a list of the 10 questions. See Appendix E for the interview guide.

Table 5

Interview Guide

Number	Open-ended question
Q1	Please describe your experience with DSCA operations.
Q2	Please provide your perspective regarding how well the joint and service doctrine guides DoD forces and organizations to respond to a major hurricane.
Q3	How might the organization of DoD units interfere with its ability to respond quickly and effectively to a major U.S. landfall hurricane?
Q4	Please provide your perspective regarding the quality, content, and outcomes associated with the current training intended to prepare personnel conducting hurricane response.
Q5	What is your opinion regarding the effectiveness of the DoD systems that confirm materiel such as rolling stock and all of the other equipment for hurricane response remains available and in working condition?
Q6	What is your perspective regarding the current professional development education and training to maintain a talent pool of DSCA leaders at various levels?
Q7	What is your opinion regarding the effectiveness of the DoD processes to confirm that the personnel it allocates to a major hurricane response have the necessary qualifications?
Q8	Which DoD facility or infrastructure do you believe might be designated as a base support installation (BSI) or an incident support base (ISB) to support the next major hurricane response in the United States?
Q9	Please provide your assessment as to whether the policies surrounding DSCA operations clearly define the rules, regulations, and limits of hurricane operations in the homeland.
Q10	What is your assessment of the DoD's overall readiness to effectively respond to the next major U.S. landfall hurricane?

Researcher-created instruments should undergo review for validity. Therefore, this study's instrument underwent a field test with an expert panel review. Field tests are appropriate in qualitative and quantitative research. The DOTMLPF-P was the framework used to develop the interview guide; however, the study included original interview questions. The panel reviewed the instrument to determine whether the

questions had face validity, had readability at the appropriate reading level, appeared well-constructed, and had accurate wording. Field tests are a way to improve understanding and ask the best questions without distressing participants while providing for their safety. A field test also indicates interview questions' appropriateness to the participants' knowledge level and sophistication (Creswell, 2018).

Six DSCA and disaster management SMEs provided feedback on comments about the interview questions for relevancy, order, content, and alignment. The first SME was a retired Army CBRN Officer who served as a Deputy DCO during the BP/Deepwater Horizon disaster and the U.S. Army Reserve Safety Officer for Hurricane Katrina. The second was a DSCA scholar and practitioner who published one of the few dissertations about the DSCA and was the president of the premier accrediting body for emergency management and homeland security education. The third SME was a professor and director of emergency and security studies at a major university. The Director of Homeland Security and Strategic Leadership at one of the military's senior service colleges was the fourth SME. The fifth SME was a retired CBRN officer who served as the U.S. Army Reserve Homeland Operations Chief responsible for overseeing the Army Reserve CBRN Response Enterprise. Finally, the sixth SME was a DSCA scholar and practitioner who developed and taught two DSCA courses at a military senior service college. The SMEs received the 10 questions via email to review for validity, credibility, and feedback. All the SMEs provided feedback on the 10 questions. Interview questions received modifications per the SMEs' suggestions before the first interview.

Trustworthiness, Reliability, and Validity

Scholars establish and maintain research trustworthiness through objectivity, credibility, and transparency (Denzin & Lincoln, 1994; Guba, 1981). Hurricane hunters, geostationary satellites, space radars, and buoys were not tools available in decades past. This study showed trustworthiness via the review of experts at the NOAA NHC who ensure database accuracy with updated instruments.

The confounding variables in this research included undercount bias, improved monitoring capabilities, observation system variance, reanalyzed data, and natural causes. Some scholars have argued that there is an undercount of TCs particularly before the availability of aircraft reconnaissance in 1944. Other researchers have indicated that the undercount of medium-to-long-lived TCs was a significant issue before the satellite era (early 1970s; Vecchi et al., 2021) and that the undercount of short-lived TCs (shorties) was an issue before 2000 (Landsea et al. 2010). Also, unexplainable phenomena could affect hurricane trends. However, there has been a complete U.S. hurricane strike record since 1900 due to hurricane monitoring among coastline communities. Before 1900, some hurricanes may have remained uncounted or considered only tropical storms due to sparse populations in parts of Florida, Louisiana, and Texas (Landsea et al., 2004). Scholars have studied storms as far back as 1851; others have reviewed storms in more recent years. However, although some experts have praised enhancing historical meteorological data with modern scientific understanding and analysis techniques, there is significant potential for error. This study occurred with a method, design, and sampling procedure appropriate for the goals and per scientific research standards (Whittemore et al., 2001).

Data Analysis Procedures

IBM SPSS Advanced Statistics was the software used to analyze RQ1 data. Archival data for 1851–2021 and 1991–2020 underwent analysis for trends in Atlantic hurricane activity. The analysis included descriptive statistics, sequence charts, and corresponding Mann–Kendall correlations. R, a programming language for statistical computing and graphics supported by the R Core Team and the R Foundation for Statistical Computing, was the means of performing the Mann–Kendall correlations. The Mann–Kendall trend test (sometimes called the M–K test) involves analyzing data collected over time for consistently increasing or decreasing trends (monotonic) in *Y* values (Leon-Guerrero & Frankfort-Nachmias, 2018).

The analysis also included time series autoregressive integrated moving average (ARIMA) models fitted to the data to show the trends and predictions of future hurricane activity in 1851–2021 and 1991–2020. Time series analysis involves analyzing data points over an interval (Babbie, 2021). Descriptive analysis and forecasting were the two models of time series analysis in this study. Descriptive analysis occurred to identify patterns in time series data, such as trends, cycles, or seasonal variation. The purpose of forecasting was to predict future data (Babbie, 2021). Forecasting occurs based on historical trends, with the historical data as a model for future data and scenarios along future plot points.

Cisco Webex was the platform used for 30 interviews with 10 open-ended questions regarding the participants' perceptions of DoD's hurricane readiness. After confirming their desire to participate, the participants received the informed consent via email for their review and signature. The goal was to complete all interviews within 2

weeks and keep the interviews under 15 minutes to encourage the participants to accept the invitation. The interviews aligned with the first but not the second goal. The average interview length was 30 minutes, as most participants appeared passionate about the topic and excited to answer questions.

Rev was the service used to transcribe all 30 individual WebEx recordings. NVivo was the collaborative qualitative analysis software used to analyze the data and develop codes, themes, and content. The analysis included cleaning the data of information unrelated to the study, such as interruptions from an outside person or source, comments that did not pertain to the study topic, and noises unrelated to the study. The electronic data for this study remained on a computer hard drive, with a backup on an SD card stored in a secure location in the researcher's home. The data will be magnetically erased after 5 years.

Thematic analysis occurred for familiarity with the data, coding, theme development, and revision. There were two coding cycles. The first-cycle coding strategy entailed becoming familiar with and discovering the data segments. The first cycle focused on strategic codes, terms, words, short phrases, or sentences from transcripts from the qualitative data record. The second cycle was pattern coding to categorize the data, followed by theme development and revision (Maguire & Delahunt, 2017). The coding process involves assigning labels to text portions within the data to facilitate theme organization, comparison, and development. The software interface and hand-checking were the tools used to color code, categorize, and feed the codes into themes. Thematic analysis was suitable for this study because the goal of qualitative studies is to

analyze and find patterned meanings in the data for further analysis (Colquhoun et al., 2014).

Data saturation occurs when a sample provides fewer new descriptions and explanations for the data, the frequency of reoccurring statements increases, and there is an inability to collect new information (Fusch & Ness, 2015). In this study, data saturation +2 occurred with Participant 024. Thus, no new themes emerged after coding the data for Participant 024; however, coding occurred for two additional participants for reliability. The sample of at least 30 participants for semistructured individual interviews provided the themes to answer RQ2. This study exceeded the standard with 30 participants, as a minimum of 10 participants is sufficient for theme development (Francis et al., 2010).

Ethical Considerations

This mixed methods study included semistructured interviews as a data collection method. The research aligned with the key principles of the Belmont Report (i.e., respect, justice, and beneficence) in the design, sampling procedures, theoretical framework, research problem, and questions (Babbie, 2021). This study did not include special populations, such as children, people incarcerated, those with disabilities, and older adults. Therefore, there were no ethical concerns regarding the population.

Qualitative researchers have the highest moral imperative to follow a code of ethics. Denzin and Lincoln (2018) outlined four guidelines for every code of ethics: informed consent, opposition to deception, participant privacy and confidentiality, and data accuracy. Scholars can avoid ethical issues by complying with the four guidelines. St. John's University Institutional Review Board (IRB) was the ultimate adjudicator of

ethical guidelines for the study. The university provided clear, systematic guidance for the IRB process and the school's and researcher's code of ethics. Appendices A and B contain the IRB approval letters with the protocol numbers.

The first ethics principle was the starting point for all discussions. St. John's University IRB has informed consent requirements to protect interview participants. The IRB requires scholars to identify the researcher and sponsoring institution, participant selection, the purpose of the research, participation benefits, participant involvement, participant risks, assurance of withdrawal at any time, and persons to contact with questions (Creswell, 2013). This study's informed consent form (see Appendix C) aligned with IRB requirements. Each participant reviewed and signed the informed consent before the interview. Also, there was time allotted before each interview for questions or clarification regarding the research design or process.

The second ethical principle is keeping the study free of active deception. For this study, there was a chance that ambiguity could result as a form of deception. The researcher is a midlevel CBRN officer in the U.S. Army with access to DoD personnel. The researcher's position could have been an ethical issue if the participants perceived that the researcher had DoD sanction or endorsement to access the participants. All the participants understood that the research did not occur on behalf of the DoD and there would be no special compensation upon data collection. Active deception was an ethical consideration addressed throughout the study and on the informed consent form.

The third ethical principle is participant privacy and confidentiality. Researchers must not exert undue influence on the participants and should protect their privacy and confidentiality (Denzin & Lincoln, 2018). In this study, the interviews occurred with a

focus on participant confidentiality and privacy. There was no coercion of the 30 participants, and there were efforts made to protect interview confidentiality.

Scholars should consciously protect participant anonymity (Seidman, 2019). Therefore, this study did not have attributed interview statements. The participants' identities received codes, and only the researcher could access the participants' names. During data collection, all references to each participant's unit, location, region, or organization level underwent masking or removal. There is a need to address the privacy and confidentiality of government and military employees. Complete confidentiality may have been a challenge due to the participants' positions within their organizations. When officials discuss official government matters, there is even less expectation of privacy. Despite the inability to guarantee 100% privacy and confidentiality, the study occurred with the noted efforts to protect the participants' interview data, identities, and roles.

Another aspect of privacy and confidentiality was consideration for the DoD. Social science scholars have always identified a distinction between public and private lives and the expectation of privacy (Denzin & Lincoln, 2018). The DoD (2022) Instruction 3216.02, *Protection of Human Subjects and Adherence to Ethical Standards in DoD-Conducted and Supported Research*, provides details on policies, responsibilities, and procedures for human subject protection and ethical standards in DoD-conducted and -supported research. U.S. Army Regulation 25-98 Information Management Control Requirements Program (2019) indicates the procedures for information collecting and reporting of Army internal, multiservice, and public requirements. Chapter 6 of the regulation presents the policies and procedures for approving and licensing Army internal surveys.

Requests to survey Army personnel may originate with Army or external organizations, including state, local, or tribal governments; other federal agencies; academic institutions; private individuals or organizations; public organizations or individuals; or as required by law with no direct response to Congress required. This study occurred under one of the 24 exemptions from formal review and licensure before the interviews. Exemption U indicates that surveys and focus groups with information collected from 99 or fewer potential respondents in one calendar year, with none of the potential respondents being senior leaders or members of vulnerable populations and no sensitive questions, are exempt from formal review and licensure (Department of the Army, 2019). In addition to the exemption, the ARNORTH Training Management Directorate approved uploading a letter (see Appendix D) to solicit participation from the more than 4,000 DSCA experts on the Homeland Defense & Civil Support Operations forum on milSuite.mil. There was potential overlap membership in the Defense Support of Civil Authorities (Phase III) private Facebook group.

IRB protocol includes precautions to ensure data storage, safeguarding, and destruction. All data from the study underwent coding for participant identity protection. Data aggregation occurred with NVivo collaborative qualitative analysis software. Rev was the service used to transcribe the Webex recordings encrypted and stored on a password-protected computer during the study and after research publication. All files will be destroyed after 5 years per IRB protocol.

Limitations and Delimitations

Limitations are a study's features that could negatively affect the results (Creswell, 2013). Most research approaches include the possibility of limitations beyond

researcher control (Simon, 2011). This mixed methods study has limitations, and their means of control involved acknowledging them to the reader (Bloomberg, 2023). As of 2022, the Atlantic Hurricane Database Re-Analysis Project, an effort to extend and revise the NHC HURDAT back to 1851, has provided revised hurricane data for 1851–1970. Future revisions could include updated versions of the data used for this study. Also, the data collection instrument of a new interview guide is a limitation of this study. Participants may find interview questions that are not carefully created to be biased, leading, imbalanced, exclusive, invasive, annoying, and offensive, resulting in limited and compromised data (Creswell, 2018). This study occurred with vigilance to avoid compromise, limitations, or the contamination of data collection, analysis, interpretation, and reporting, with measures taken for participant protection and study integrity.

The literature review is an important part of a study because it indicates the scope of work in the research area (Pyrczac & Tcherni-Buzzeo, 2020). The literature review for RQ2 lacked volume and depth because the question focused on a government organization with limited scholarship. There has been limited research on doctrine, technical manuals, after-action reports, think tank studies, and other government publications.

Delimitations are also part of every research project. Study delimitations are the research boundaries set to establish the scope of the study due to time, funds, or data access (Creswell, 2013). A delimitation of this study was restricting the research to the North Atlantic Basin because only about 12% of the world's TCs occur in the North Atlantic. This delimitation was necessary due to a lack of consistent, reliable, and historical data for other regions. Qualitative data collection for RQ2 was a delimitation,

although the data provided useful information for answering the research question. A quantitative survey could have produced additional data on the participants' opinions and the study topic.

Another delimitation was to limit the sample to 30 participants, although, per the study's definition, there are over 4,000 DSCA experts. The ideal size of a qualitative sample is a heavily debated issue. Most authors suggest sample sizes of five to 50 in qualitative research, with 25 to 30 participants as the minimum for saturation (Dworkin, 2012). The 30 participants in this study were a heterogeneous sample based on their experience with DSCA operations at various echelons. The last delimitation was restricting the study to hurricanes despite the DSCA addressing a range of disasters, including hurricanes, floods, earthquakes, tornadoes, landslides, tsunamis, volcanic eruptions, severe winter storms, droughts, extreme heat, coastal erosions, thunderstorms, hailstorms, and snow avalanches. The delimitation of focusing on hurricanes was a means of limiting the study scope due to limited resources and time to complete the research.

Summary

Chapter 3 commenced with the purpose of the study, methodology, research questions, hypotheses, and research design. This chapter also presented the population; sample; and the instruments for collecting, managing, and analyzing the data. There were discussions of validity, reliability, ethical considerations, limitations, and delimitations for the research.

RQ1 centered on the trend of hurricane activity in the North Atlantic Basin, and RQ2 focused on DSCA practitioners' perceptions of DoD readiness posture. Time series analysis was a means to analyze secondary data from NOAA's NHC. NVivo was the

software used to analyze the data from the 10-question semistructured interviews for themes. The population for RQ1 included TCs, and the sample consisted of 171 years (1851–2021) of hurricane activity in the North Atlantic Basin. The population for RQ2 consisted of 30 DSCA service members, civilians, and contractors with varied DSCA experience. A field test with six DSCA SMEs contributed to the study's validity and reliability.

IBM SPSS Advanced Statistics was the software used for advanced statistical analysis of the data from RQ1; analyzing RQ2 occurred using NVivo. The research aligned with the key principles of the Belmont Report (i.e., respect, justice, and beneficence) in the study design, sampling, theoretical framework, research problem, and questions. The study received St. John's University IRB approval before data collection. Chapter 4 will present the results of the quantitative and qualitative analyses, followed by a summary of the results, conclusions, future implications, and further research areas in Chapter 5.

CHAPTER 4: DATA ANALYSIS AND RESULTS

Introduction

Chapter 4 includes the data analysis and results from RQ1 and RQ2. The chapter commences with a review of the RQ1, the dataset for Part I, and the descriptive statistics. Next, the chapter presents sequence charts, correlations, and time series analysis of data trends. ARIMA models showed the data trends used to predict hurricane frequency and intensity. There were no statistically significant increases or decreases in U.S. hurricanes between 1851 and 2021. Between 1991 and 2020, there was a statistically significant increase in named storms, but no statistically significant increase or decrease in hurricanes, major hurricanes, ACE, or U.S. hurricanes.

Part II commences with a review of RQ2, descriptive statistics, data analysis, and the findings. The study included a sample of 30 participants from a population of more than 4,000 DSCA experts. Voluntary disclosures showed the participants had between 5 and 37 years of experience, with the majority having between 13 and 17 years' experience with DSCA training and hurricane response. Nine themes emerged from the data regarding the participants' perceptions of DoD hurricane response readiness in the United States. The participants perceived the DoD as ready for a single hurricane landfall response. However, the participants acknowledged inefficiencies and dangers from multiple simultaneous or successive landfalls.

Part I: RQ1: Quantitative Results of Hurricane Trends

Part I of this study involved investigating whether there is increasing hurricane frequency in the North Atlantic Basin. HURDAT data underwent analysis to answer the following research question and hypotheses:

RQ1: What is the trend of hurricane activity in the North Atlantic Basin?

$H1_0$: The frequency of hurricanes continues to increase in recent years.

$H1_a$: The frequency of hurricanes has not increased in recent years.

Descriptive Statistics of Hurricane Data

The dataset included data on the number of named storms, hurricanes, major hurricanes, ACE, and U.S. hurricanes per year from 1851 to 2021. The analysis also included the revised figures for each variable. Analyzing the dataset for the 30-year period of 1991–2020 occurred separately. The study focused on the 30-year period from 1991–2020 because there were varying observation techniques, instrumentation, and undersampling issues before the early 1970s, particularly before the hurricane reconnaissance era in the mid-1940s.

Tables 6 and 7 present the descriptive statistics for 1851–2021 and 1991–2020, respectively. Between 1851 and 2021, the average number of named storms per year was 9.99 (*SD* = 4.58), and the average number of hurricanes per year was 5.53 (*SD* = 2.61). The average number of major hurricanes per year was 1.91 (*SD* = 1.64). The yearly average ACE was 89.25 (*SD* = 53.03). The average number of U.S. hurricanes per year was 1.77 (*SD* = 1.45).

Between 1991 and 2020, the average number of named storms per year was 14.40 (*SD* = 5.53). The average number of hurricanes per year was 7.20 (*SD* = 3.33). The average number of major hurricanes per year was 3.23 (*SD* = 2.00). The yearly average ACE was 122.40 (*SD* = 65.33). The average number of U.S. hurricanes per year was 1.73 (*SD* = 1.76).

Table 6

Descriptive Statistics for Hurricane Data 1851–2021

Variable	Mean	Median	Mode	*SD*	Min.	Max.
Named storms	9.99	9	6	4.58	1	30
Hurricanes	5.53	5	4	2.61	0	15
Major hurricanes	1.91	2	1	1.64	0	7
ACE	89.25	76	36	53.03	3	259
U.S. hurricanes	1.77	2	1	1.45	0	7

Table 7

Descriptive Statistics for Hurricane Data 1991–2020

Variable	Mean	Median	Mode	*SD*	Min.	Max.
Named storms	14.40	15	15	5.53	7	30
Hurricanes	7.20	7	4	3.33	2	15
Major hurricanes	3.23	3	2	2.00	0	7
ACE	122.40	127.5	36	65.33	32	250
U.S. hurricanes	1.73	1	0	1.76	0	6

Trends in Hurricane Data Indicate Mixed Results

Sequence charts graphically show the trends in the data for each variable for 1851–2021 and 1991–2020. Mann–Kendall correlation was the means of testing for statistically significant increasing or decreasing trends in the data. Figure 2 shows the number of named storms by year from 1851 to 2021. A significant Mann–Kendall correlation ($\tau = .40$, $p < .001$) indicates a statistically significant increasing trend in named storms during this period.

Figure 2

Named Storms by Year 1851–2021

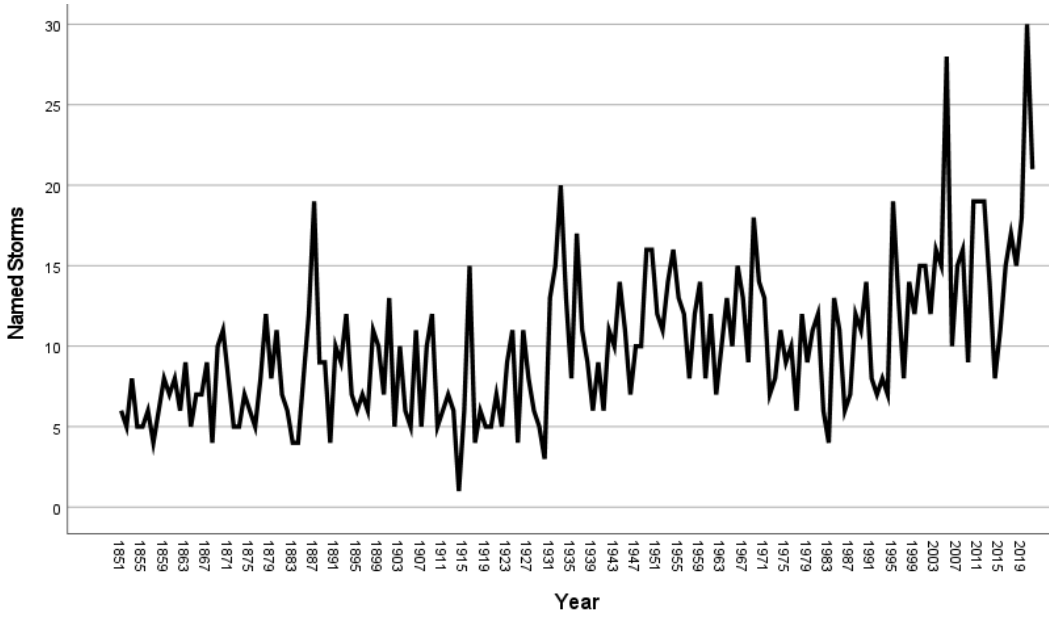


Figure 3 shows the number of hurricanes by year from 1851 to 2021. A significant Mann–Kendall correlation ($\tau = .19$, $p < .001$) indicates a statistically significant increasing trend in hurricanes during this period.

Figure 3

Hurricanes by Year 1851–2021

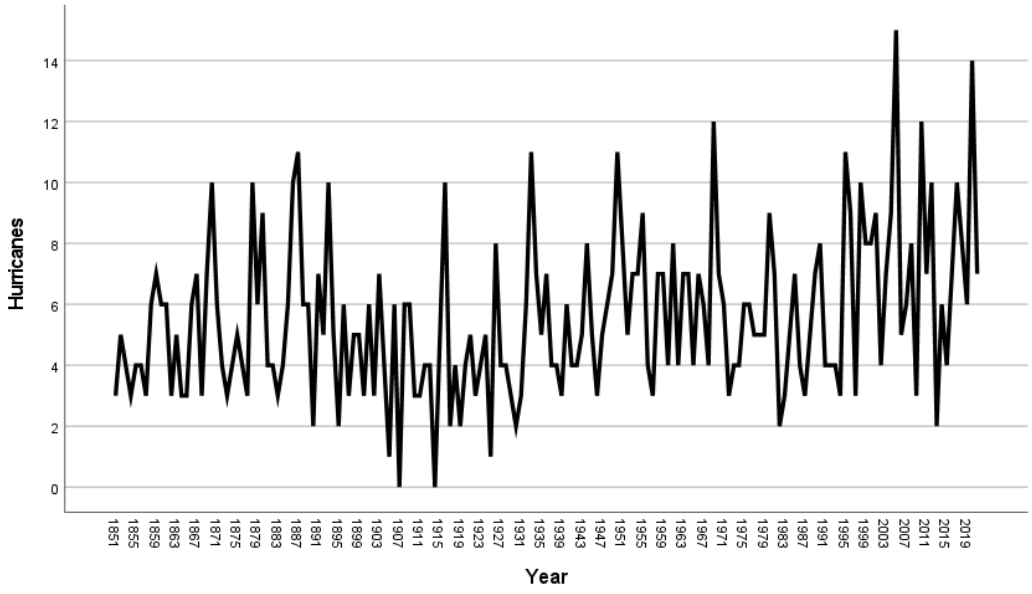


Figure 4 shows the number of major hurricanes by year from 1851 to 2021. A significant Mann–Kendall correlation ($\tau = .32$, $p < .001$) indicates a statistically significant increasing trend in major hurricanes during this period.

Figure 4

Major Hurricanes by Year 1851–2021

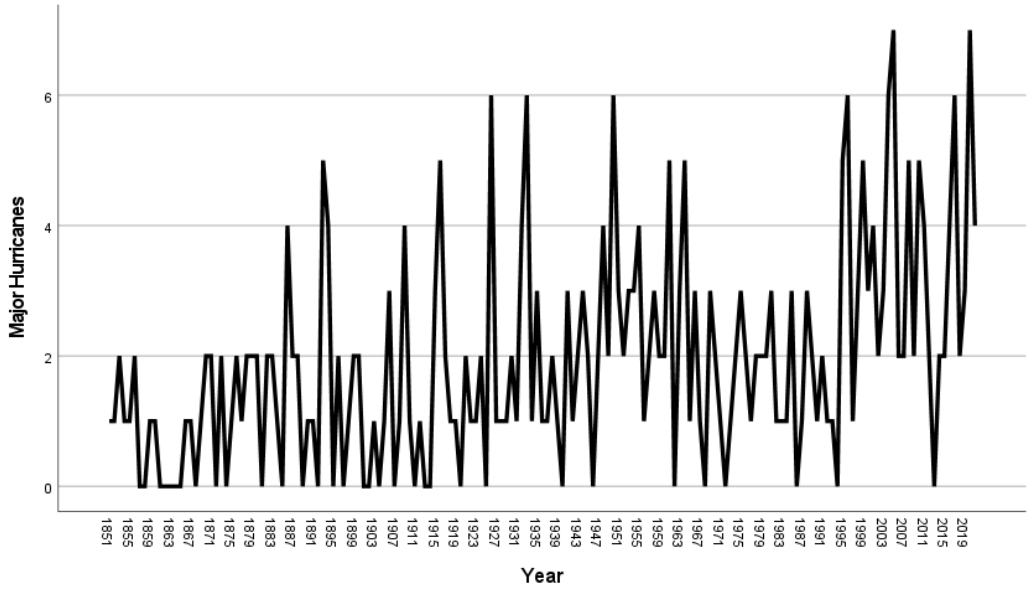


Figure 5 shows the ACE by year from 1851 to 2021. A significant Mann–Kendall correlation ($\tau = .20$, $p < .001$) indicates a statistically significant increasing trend in ACE during this period.

Figure 5

ACE by Year 1851–2021

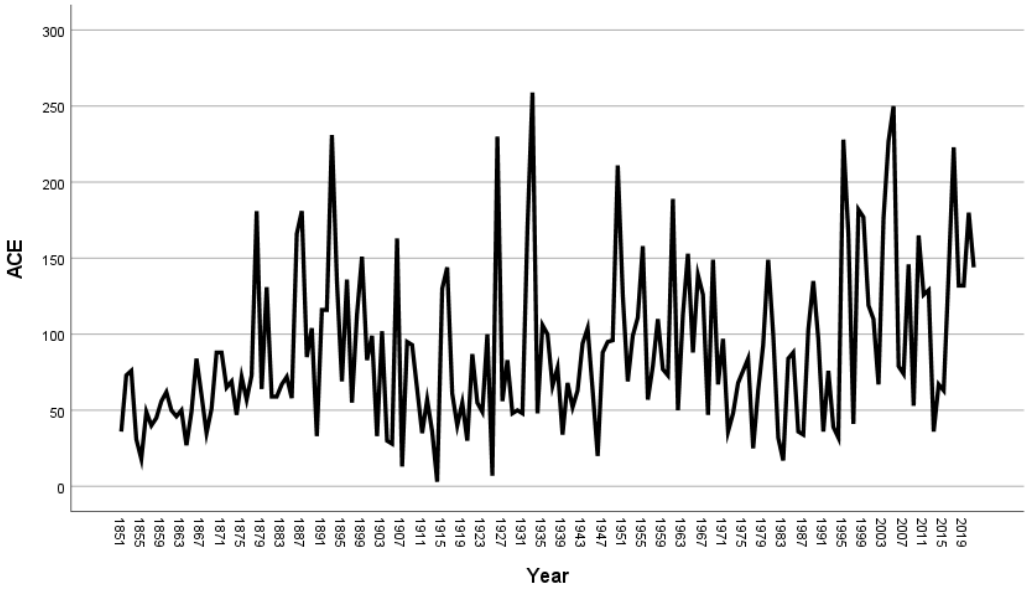


Figure 6 shows the number of U.S. hurricanes by year from 1851 to 2021. There was no significant Mann–Kendall correlation (τ = -.08, p = .148), indicating no statistically significant trend in U.S. hurricanes during this period.

Figure 6

U.S. Hurricanes by Year 1851–2021

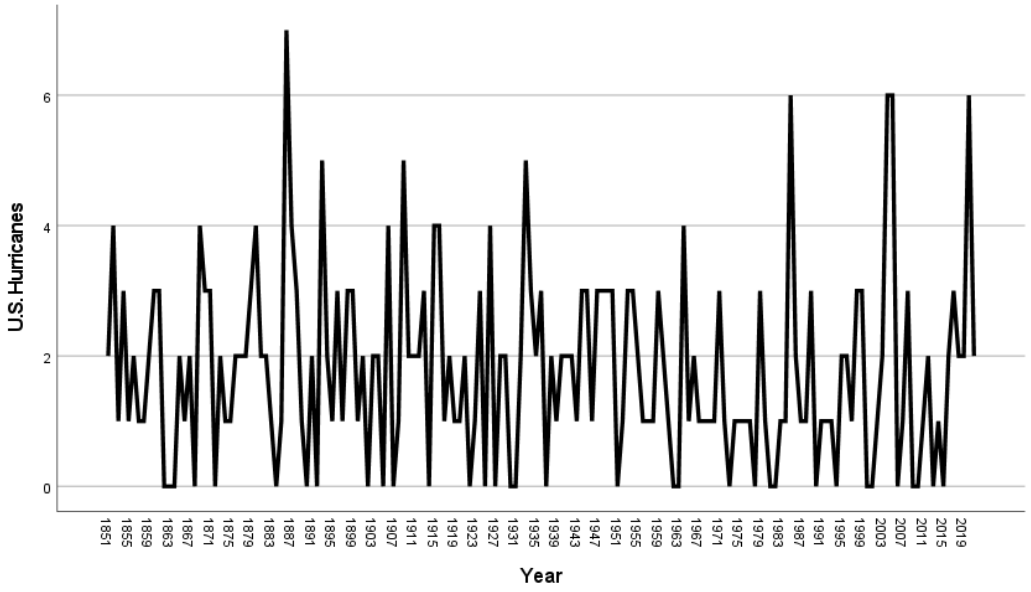


Figure 7 shows the number of named storms by year from 1991 to 2020. A significant Mann–Kendall correlation ($\tau = .39$, $p = .004$) indicates a statistically significant increasing trend in named storms during this period.

Figure 7

Named Storms by Year 1991–2020

Figure 8 shows the number of hurricanes by year from 1991 to 2020. There was no significant Mann–Kendall correlation ($\tau = .12$, $p = .379$), indicating no statistically significant trend in hurricanes during this period.

Figure 8

Hurricanes by Year 1991–2020

Figure 9 shows the number of major hurricanes by year from 1991 to 2020. There was no significant Mann–Kendall correlation ($\tau = .15$, $p = .283$), indicating no statistically significant trend in major hurricanes during this period.

Figure 9

Major Hurricanes by Year 1991–2020

Figure 10 shows the ACE by year from 1991 to 2020. There was no significant Mann–Kendall correlation ($\tau = .12$, $p = .363$), indicating no statistically significant trend in ACE during this period.

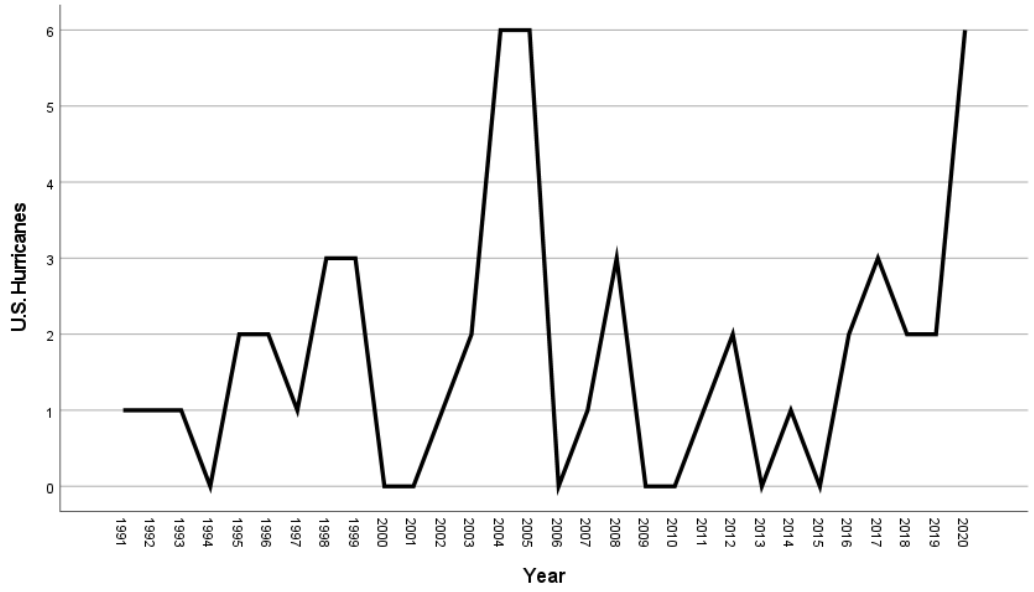
Figure 10

ACE by Year 1991–2020

Figure 11 shows the number of U.S. hurricanes by year from 1991 to 2020. There was no significant Mann–Kendall correlation ($\tau = .13$, $p = .377$), indicating no statistically significant trend in U.S. hurricanes during this period.

Figure 11

U.S. Hurricanes by Year 1991–2020



Time Series Models of Tropical Storm Data

ARIMA models showed the data trends. The study included separate models for each variable for each period of interest (1851–2021 and 1991–2020). Developing each model involved visualizing and testing the data for stationarity with sequence charts and Mann–Kendall correlations. There was differencing applied to the model for nonstationary data based on the assessments. To determine the order of the ARIMA model, examination of plots of the autocorrelation function (ACF) and partial autocorrelation function (PACF) occurred per Tabachnick and Fidell (2013). The ACF showed the correlations of the time series observations with previous lagged values (i.e., the correlations between activity in any given year and activity in previous years). While

controlling for prior lags, the PACF showed the correlations of the time series observations with previous lagged values. ACF and PACF patterns indicated the most appropriate autoregressive (AR) and moving average (MA) components for the model. Peaks in the functions suggest potential lag values for the AR and MA components, and gradually decaying functions suggest a lack of significant AR or MA components. A comparison of the model fits occurred with Akaike's information criterion (AIC). Finally, plots of model residual ACF and PACF underwent examination to ensure no significant autocorrelation in the selected model's residuals.

Analysis of Named Storms, 1851–2021

The sequence chart of named storms (see Figure 2) and the corresponding Mann–Kendall correlation showed nonstationary data. Lag 1 differencing occurred to make the data stationary. ACF and PACF plots underwent examination to determine the most AR and MA model components. Figure 12 shows a peak at Lag 1 in the ACF. Figure 13 shows a gradually decaying PACF. The results suggest an AR component of 0 and an MA component of 1. Therefore, testing of an ARIMA (0,1,1) model occurred. The AIC of the ARIMA (0,1,1) model was 936.36, a better fit than the differencing-only ARIMA (0,1,0) model with an AIC of 1005.39.

Figure 12

Autocorrelation Function for Named Storms 1851–2021

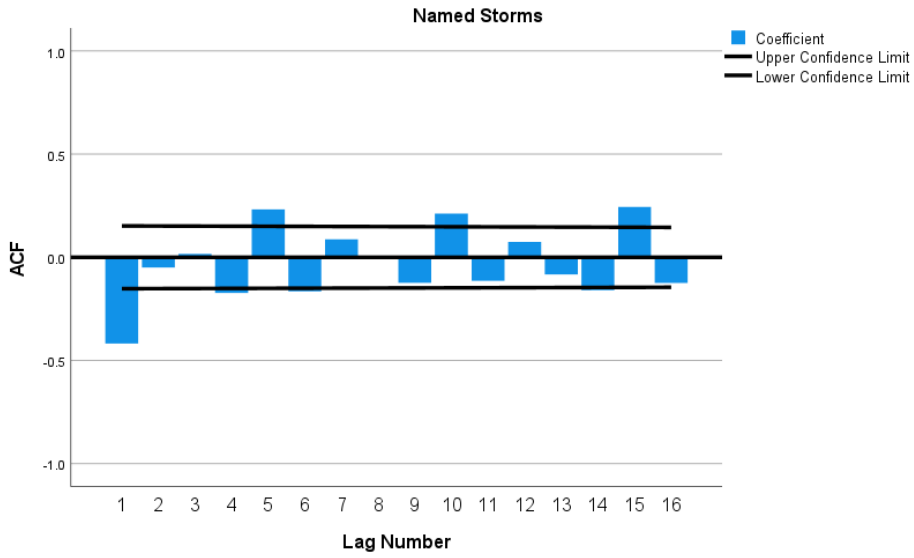
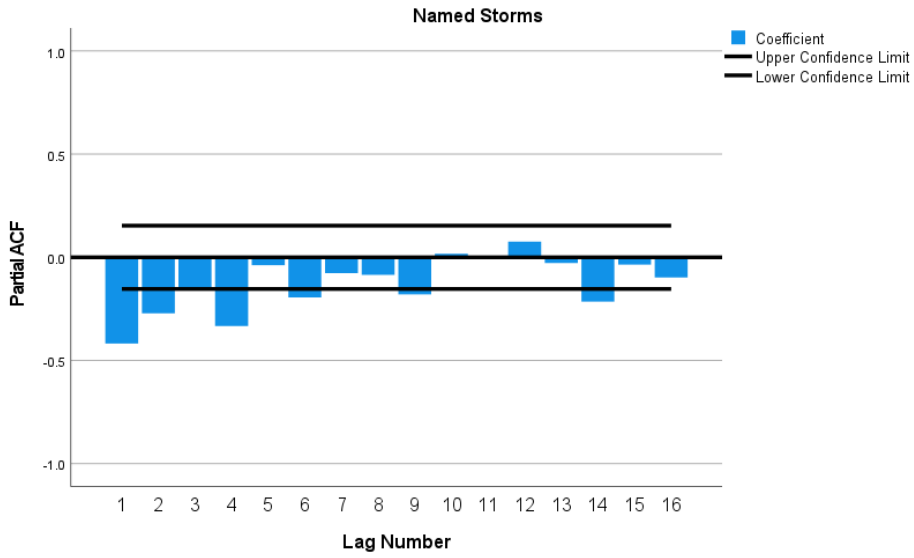


Figure 13

Partial Autocorrelation Function for Named Storms 1851–2021



ACF and PACF plots of the ARIMA (0,1,1) model residuals underwent examination to determine the need for model respecification. Figures 14 and 15 show ACF and PACF results approximately random and within the lower and upper 95% confidence limits. Therefore, there were no further changes to the model specification.

Figure 14

Autocorrelation Function for Named Storms Residuals 1851–2021

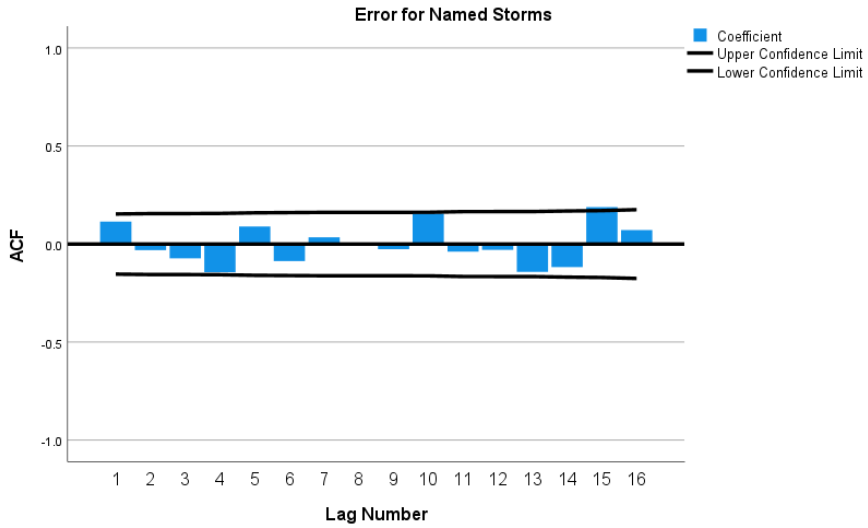


Figure 15

Partial Autocorrelation Function for Named Storms Residuals 1851–2021

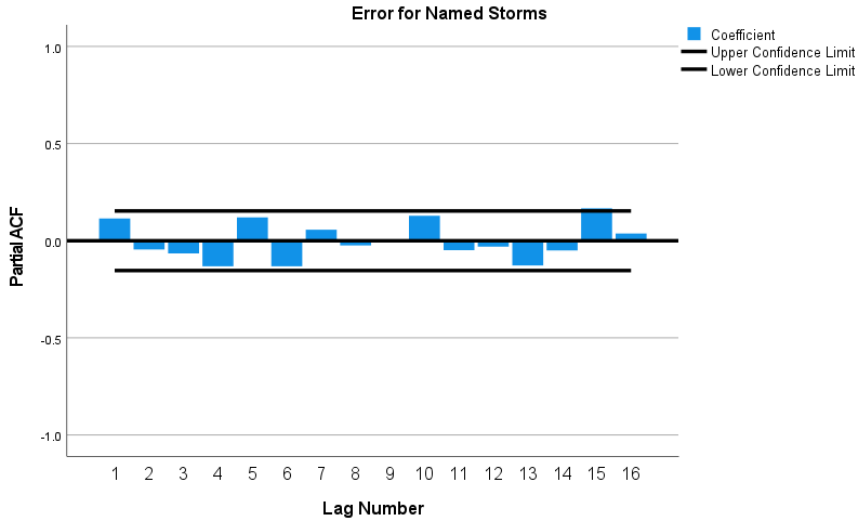


Table 8 presents the final model's parameters. The results showed a significant MA component ($B = 0.86$, $p < .001$). Therefore, the MA component significantly contributed to the named storm prediction.

Table 8

ARIMA (0,1,1) Model Parameters for Named Storms 1851–2021

Parameter	Estimate	*SE*	*t*	Sig.
Constant	0.07	0.04	1.68	.095
Difference	1.00			
MA (Lag 1)	0.86	0.04	19.50	< .001

Table 9 shows the forecasted number of named storms indicated by the model 30 years after the data.

Table 9

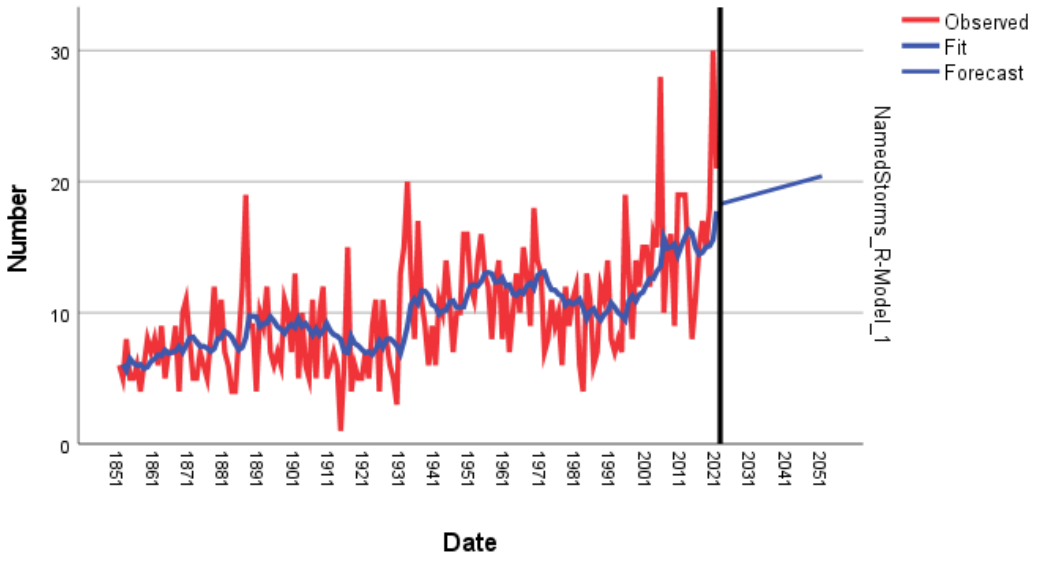
ARIMA (0,1,1) Model Forecast for Named Storms 1851–2021

Year	Forecast	95% CI Upper	95% CI Lower
2022	18	26	11
2023	18	26	11
2024	18	26	11
2025	19	26	11
2026	19	26	11
2027	19	26	11
2028	19	27	11
2029	19	27	11
2030	19	27	11
2031	19	27	11
2032	19	27	11
2033	19	27	11
2034	19	27	11
2035	19	28	11
2036	19	28	11
2037	19	28	11
2038	19	28	11
2039	20	28	11
2040	20	28	11
2041	20	28	11
2042	20	29	11
2043	20	29	11
2044	20	29	11
2045	20	29	11
2046	20	29	11
2047	20	29	11
2048	20	29	11
2049	20	30	11
2050	20	30	11
2051	20	30	11

Figure 16 shows the model plotted against the observed data.

Figure 16

ARIMA (0,1,1) Model for Named Storms Plotted Against Observed Data 1851–2021



Analysis of Named Storms, 1991–2020

The sequence chart of named storms (see Figure 7) and the corresponding Mann–Kendall correlation showed nonstationary data. Lag 1 differencing occurred to make the data stationary. ACF and PACF plots underwent examination for the most appropriate AR and MA model components. Figure 17 shows a random pattern of alternating peaks in the ACF. Figure 18 shows a peak at Lag 1 in the PACF, resulting in unclear definitions for the AR and MA components. Testing of several ARIMA models occurred, including ARIMA (1,1,0), ARIMA (0,1,1) and ARIMA (1,1,1). Only the ARIMA (1,1,0) model produced a significant AR parameter. Additionally, ARIMA (0,1,1) and ARIMA (1,1,1) models near the bounds of invertibility could have resulted in unreliable standard errors. Therefore, the analysis included the ARIMA (1,1,0) model. The AIC of the ARIMA (1,1,0) model was 188.12, a better fit than the differencing-only ARIMA (0,1,0) model with an AIC of 191.82.

Figure 17

Autocorrelation Function for Named Storms 1991–2020

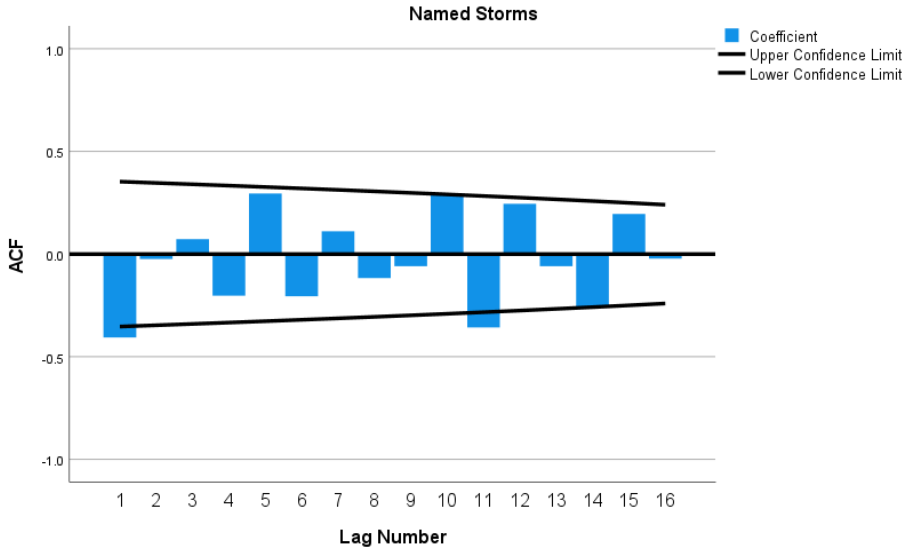
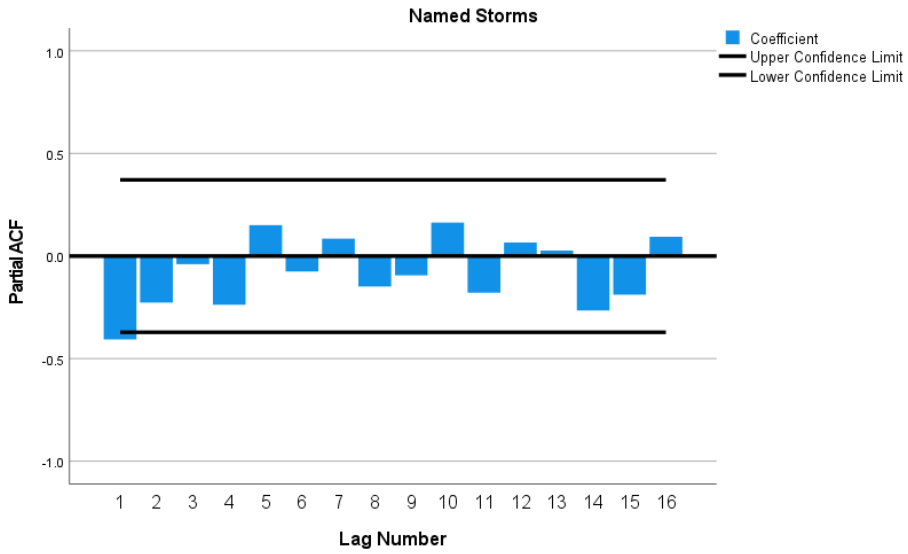


Figure 18

Partial Autocorrelation Function for Named Storms 1991–2020



ACF and PACF plots of the ARIMA (1,1,0) model residuals underwent examination to determine the need for model respecification. Figures 19 and 20 show ACF and PACF results approximately random and within the lower and upper 95%

confidence limits. Therefore, there were no further changes made to the model specification.

Figure 19

Autocorrelation Function for Named Storms Residuals 1991–2020

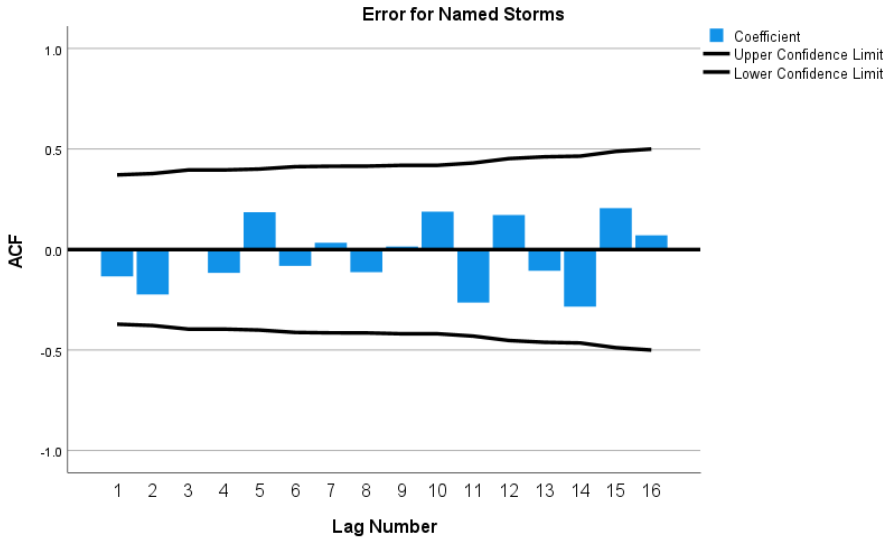


Figure 20

Partial Autocorrelation Function for Named Storms Residuals 1991–2020

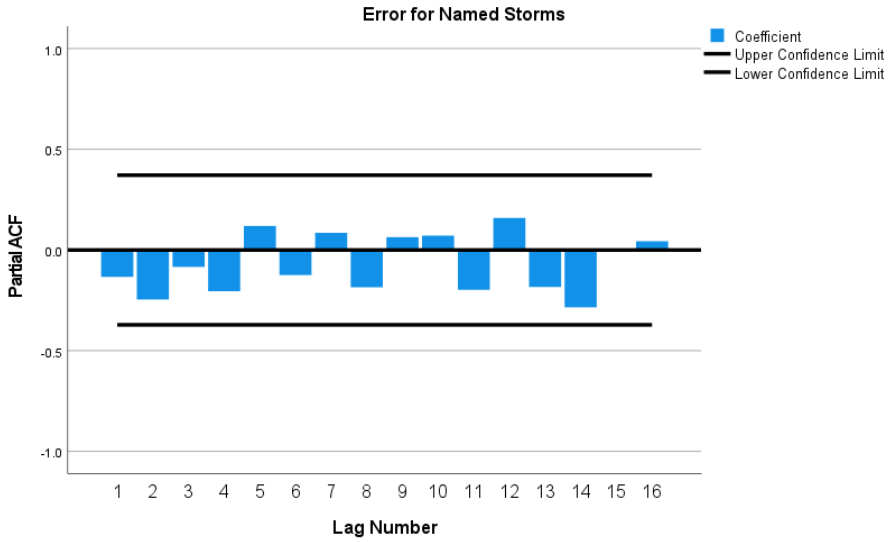


Table 10 presents the parameters of the final model. A significant AR component (B = -0.44, p = .024) indicates the AR component significantly contributes to named storm prediction.

Table 10

ARIMA (1,1,0) Model Parameters for Named Storms 1991–2020

Parameter	Estimate	*SE*	*t*	Sig.
Constant	0.66	0.78	0.84	.407
AR (Lag 1)	-0.44	0.18	-2.39	.024
Difference	1.00			

Table 11 shows the number of forecasted named storms indicated by the model 30 years after the data.

Table 11

ARIMA (1,1,0) Model Forecast for Named Storms 1991–2020

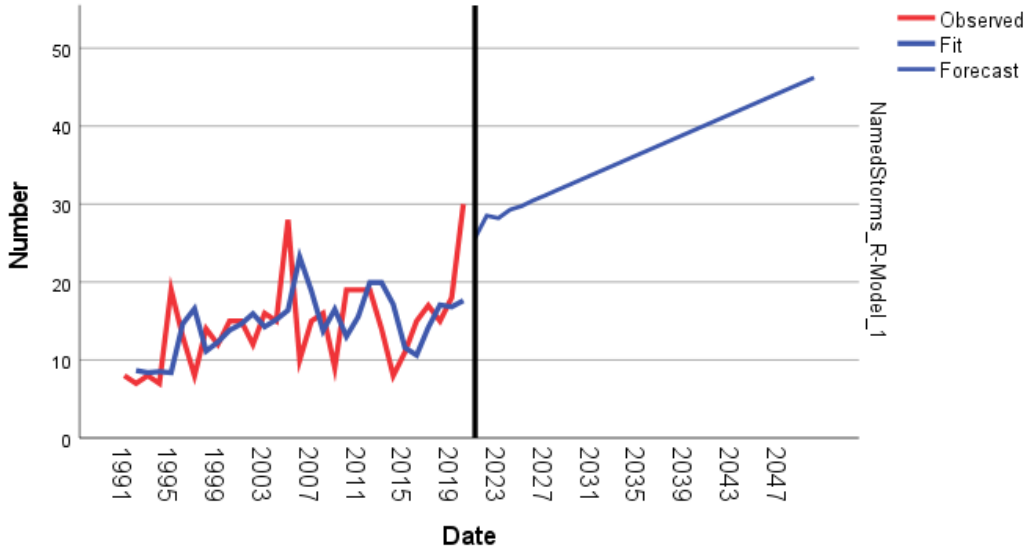
Year	Forecast	95% CI upper	95% CI lower
2021	26	38	13
2022	29	43	14
2023	28	45	11
2024	29	48	11
2025	30	50	9
2026	30	53	8
2027	31	55	7
2028	32	57	6
2029	32	59	6
2030	33	61	5
2031	34	63	4
2032	34	65	4
2033	35	67	3
2034	36	68	3
2035	36	70	3
2036	37	72	2
2037	38	74	2
2038	38	75	1
2039	39	77	1
2040	40	78	1
2041	40	80	1
2042	41	82	0

Year	Forecast	95% CI upper	95% CI lower
2043	42	83	0
2044	42	85	0
2045	43	86	0
2046	44	88	0
2047	44	89	0
2048	45	91	0
2049	46	92	0
2050	46	93	0

Figure 21 shows the model plotted against the observed data.

Figure 21

ARIMA (1,1,0) Model for Named Storms Plotted Against Observed Data 1991–2020



Analysis for Hurricanes, 1851–2021

The sequence chart of hurricanes (see Figure 3) and the corresponding Mann–Kendall correlation showed nonstationary data. Lag 1 differencing occurred to make the data stationary. ACF and PACF plots underwent examination for the most appropriate AR and MA model components. Figure 22 shows a peak at Lag 1 in the ACF. Figure 23 shows a gradually decaying PACF. The results suggest an AR component of 0 and an MA component of 1. Therefore, there was an ARIMA (0,1,1) model tested. The AIC of

the ARIMA (0,1,1) model was 801.38, a better fit than the differencing-only ARIMA (0,1,0) model with an AIC of 899.20.

Figure 22

Autocorrelation Function for Hurricanes 1851–2021

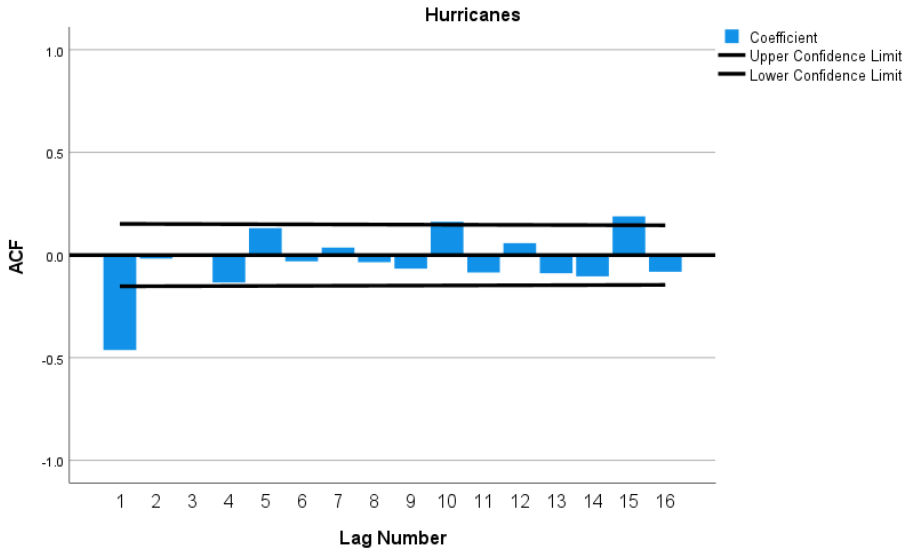
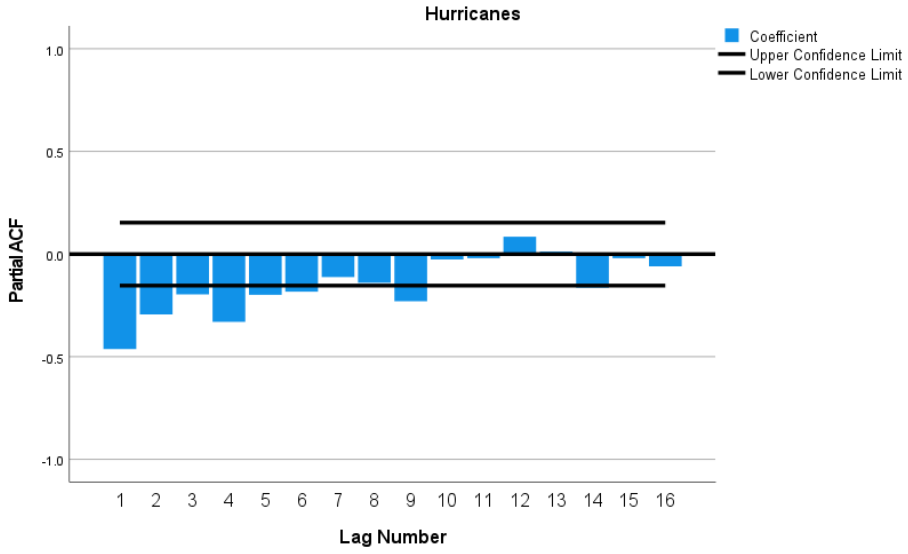


Figure 23

Partial Autocorrelation Function for Hurricanes 1851–2021



ACF and PACF plots of the ARIMA (0,1,1) model residuals underwent examination to determine the need for model respecification. Figures 24 and 25 show ACF and PACF results approximately random and within the lower and upper 95% confidence limits. Therefore, there were no further changes made to the model specification.

Figure 24

Autocorrelation Function for Hurricanes Residuals 1851–2021

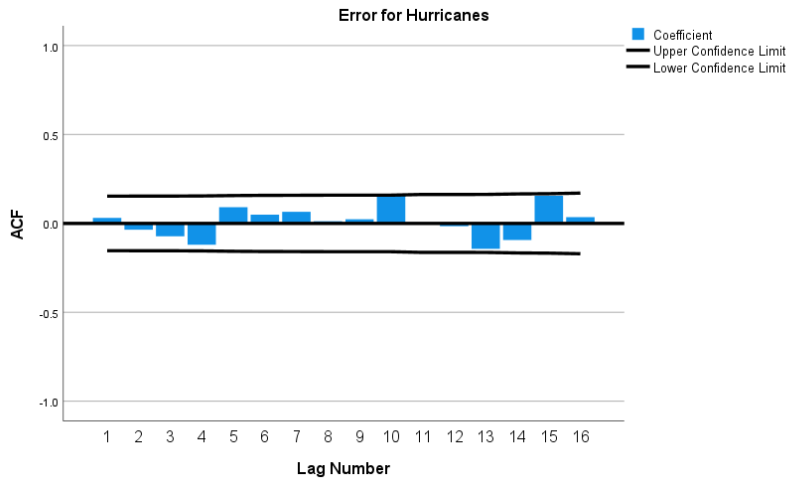


Figure 25

Partial Autocorrelation Function for Hurricanes Residuals 1851–2021

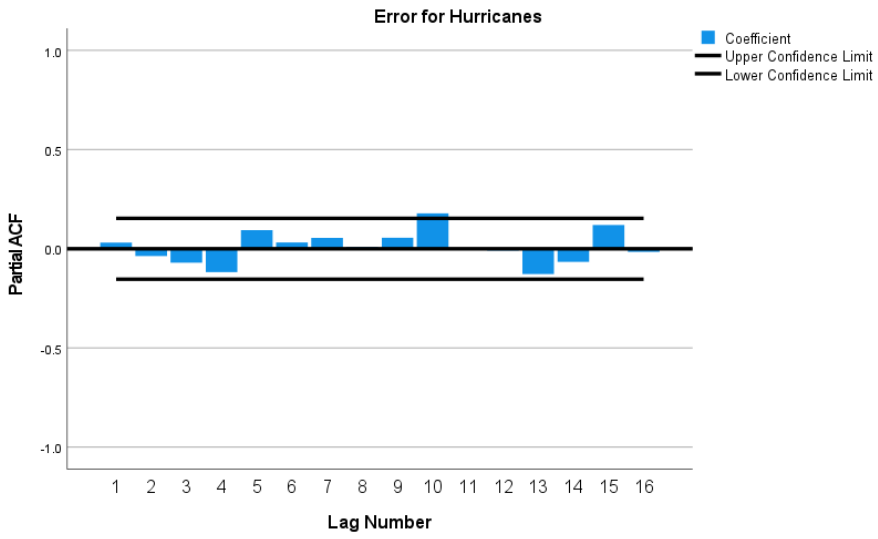


Table 12 shows the parameters of the final model. A significant MA component ($B = 0.94$, $p < .001$) indicates the MA component significantly contributes to hurricane prediction.

Table 12

ARIMA (0,1,1) Model Parameters for Hurricanes 1851–2021

Parameter	Estimate	*SE*	*t*	Sig.
Constant	0.02	0.01	1.32	.189
Difference	1.00			
MA (Lag 1)	0.94	0.03	31.16	< .001

Table 13 shows the forecasted number of hurricanes indicated by the model 30 years beyond the data.

Table 13

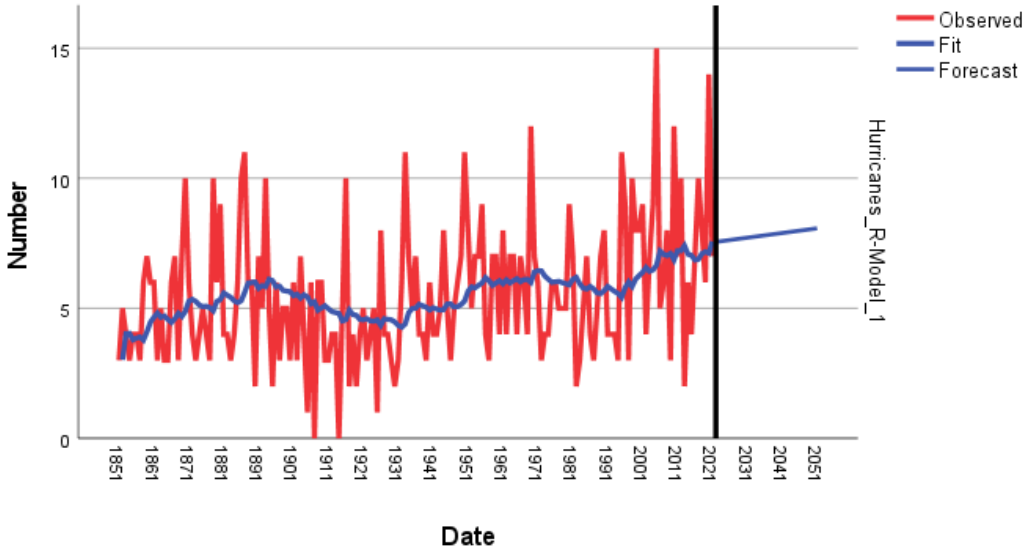
ARIMA (0,1,1) Model Forecast for Hurricanes 1851–2021

Year	Forecast	95% CI upper	95% CI lower
2022	8	13	3
2023	8	13	3
2024	8	13	3
2025	8	13	3
2026	8	13	3
2027	8	13	3
2028	8	13	3
2029	8	13	3
2030	8	13	3
2031	8	13	3
2032	8	13	3
2033	8	13	3
2034	8	13	3
2035	8	13	3
2036	8	13	3
2037	8	13	3
2038	8	13	3
2039	8	13	3
2040	8	13	3
2041	8	13	3
2042	8	13	3
2043	8	13	3
2044	8	13	3
2045	8	13	3
2046	8	13	3
2047	8	13	3
2048	8	13	3
2049	8	13	3
2050	8	13	3
2051	8	13	3

Figure 26 shows the model plotted against the observed data.

Figure 26

ARIMA (0,1,1) Model for Hurricanes Plotted Against Observed Data 1851–2021



Analysis for Hurricanes, 1991–2020

The sequence chart of hurricanes (see Figure 8) and the corresponding Mann–Kendall correlation showed nonstationary data. ACF and PACF plots underwent examination to determine the most appropriate AR and MA model components. Figures 27 and 28 show mostly random patterns with possible peaks at Lags 8 and 11 in the ACF and PCAF. These results suggest possible AR components of 8 and 11. The ARIMA (8,0,0) model had an AIC of 170.33. The ARIMA (11,0,0) model had an AIC of 169.12. Therefore, there was an ARIMA (11,0,0) model tested. The AIC of the intercept-only ARIMA (0,0,0) model was 158.24.

Figure 27

Autocorrelation Function for Hurricanes 1991–2020

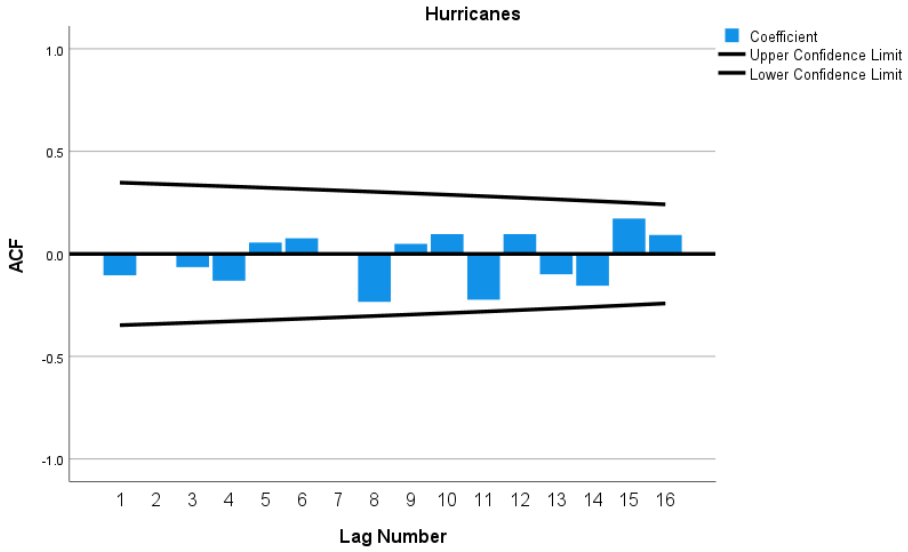
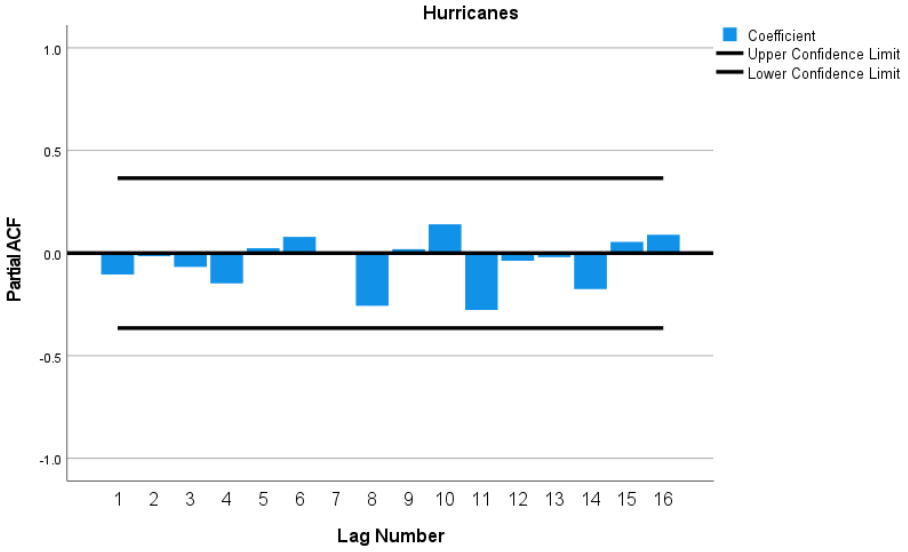


Figure 28

Partial Autocorrelation Function for Hurricanes 1991–2020



ACF and PACF plots of the ARIMA (11,0,0) model residuals underwent examination to determine the need for model respecification. Figures 29 and 30 show ACF and PACF results approximately random and within the lower and upper 95% confidence limits. Therefore, there were no further changes to the model specification.

Figure 29

Autocorrelation Function for Hurricanes Residuals 1991–2020

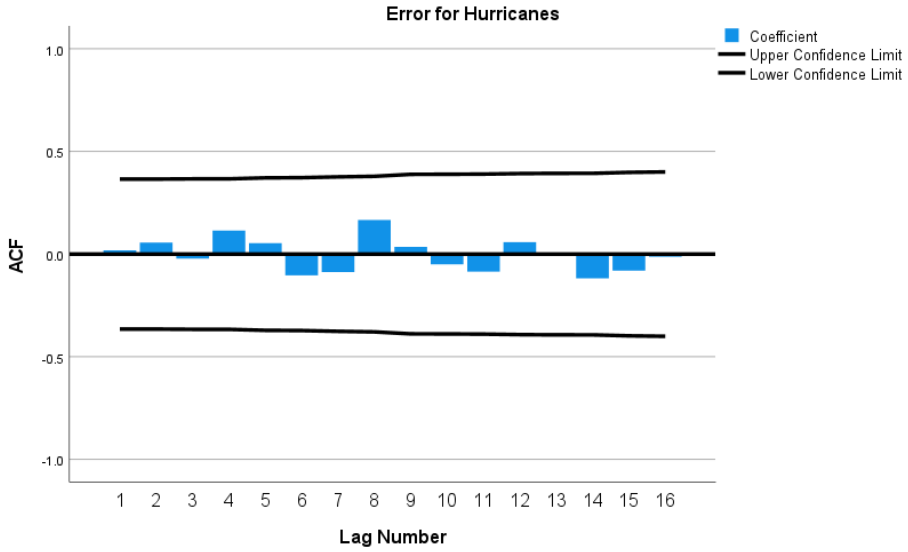


Figure 30

Partial Autocorrelation Function for Hurricanes Residuals 1991–2020

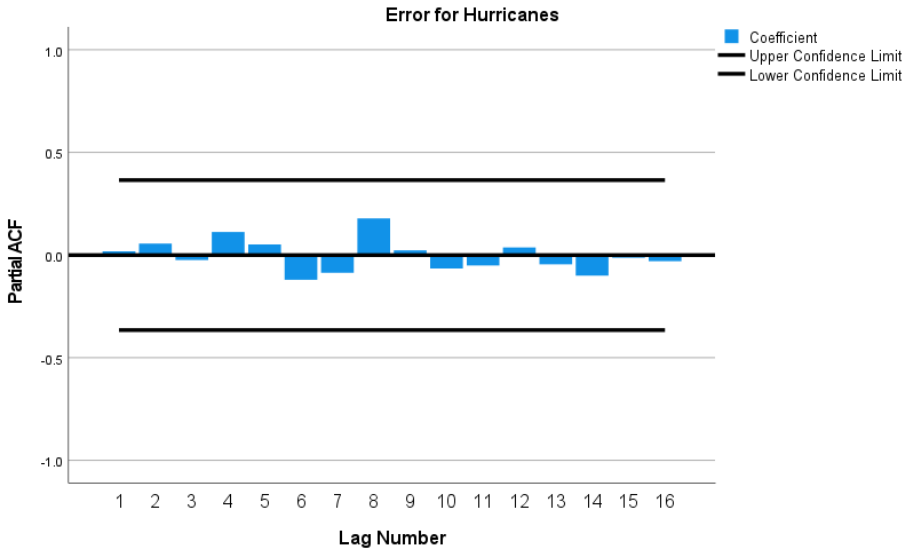


Table 14 presents the parameters of the final model. A significant AR Lag 8 component (B = -0.46, p = .039) indicates the AR Lag 8 component significantly contributes to hurricane prediction.

Table 14

ARIMA (11,0,0) Model Parameters for Hurricanes 1991–2020

Parameter	Estimate	*SE*	*t*	Sig.
Constant	7.33	0.28	26.63	< .001
AR (Lag 1)	-0.06	0.23	-0.27	.794
AR (Lag 2)	0.12	0.22	0.54	.596
AR (Lag 3)	-0.35	0.24	-1.49	.154
AR (Lag 4)	-0.31	0.24	-1.29	.212
AR (Lag 5)	0.00	0.24	-0.02	.987
AR (Lag 6)	0.13	0.24	0.55	.591
AR (Lag 7)	-0.22	0.24	-0.92	.369
AR (Lag 8)	-0.46	0.21	-2.23	.039
AR (Lag 9)	0.06	0.23	0.27	.793
AR (Lag 10)	0.16	0.24	0.66	.516
AR (Lag 11)	-0.52	0.27	-1.96	.066

Table 15 shows the forecasted number of hurricanes indicated by the model 30 years beyond the data.

Table 15

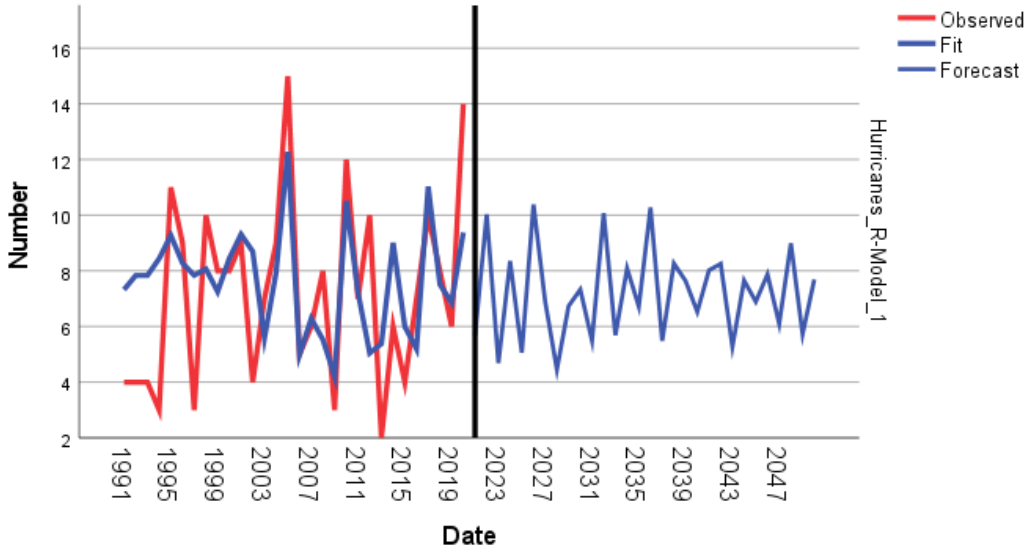
ARIMA (11,0,0) Model Forecast for Hurricanes 1991–2020

Year	Forecast	95% CI upper	95% CI lower
2021	6	12	0
2022	10	17	3
2023	5	11	0
2024	8	15	1
2025	5	12	0
2026	10	18	3
2027	7	14	0
2028	4	12	0
2029	7	14	0
2030	7	15	0
2031	5	13	0
2032	10	18	2
2033	6	14	0
2034	8	16	0
2035	7	15	0
2036	10	18	2
2037	5	14	0
2038	8	17	0
2039	8	16	0
2040	7	15	0
2041	8	16	0
2042	8	17	0
2043	5	14	0
2044	8	16	0
2045	7	16	0
2046	8	17	0
2047	6	15	0
2048	9	18	0
2049	6	14	0
2050	8	16	0

Figure 31 shows the model plotted against the observed data.

Figure 31

ARIMA (11,0,0) Model for Hurricanes Plotted Against Observed Data 1991–2020



Analysis for Major Hurricanes, 1851–2021

The sequence chart of major hurricanes (see Figure 4) and the corresponding Mann–Kendall correlation showed nonstationary data. The data were made stationary by applying Lag 1 differencing occurred to make the data stationary. ACF and PACF plots underwent examination to determine the most appropriate AR and MA model components. Figure 32 shows a peak at Lag 1 in the ACF. Figure 33 shows a gradually decaying PACF. The results suggest an AR component of 0 and an MA component of 1. Therefore, there was an ARIMA (0,1,1) model tested. The results showed an ARIMA (0,1,1) model near the bounds of invertibility, potentially resulting in unreliable standard errors. Thus, the testing of different model specifications occurred to alleviate the problem. ARIMA (0,1,3) model produced additional significant MA parameters and

addressed the invertibility problem. The AIC of the ARIMA (0,1,3) model was 625.44, a better fit than the differencing-only ARIMA (0,1,0) model with an AIC of 722.33.

Figure 32

Autocorrelation Function for Major Hurricanes 1851–2021

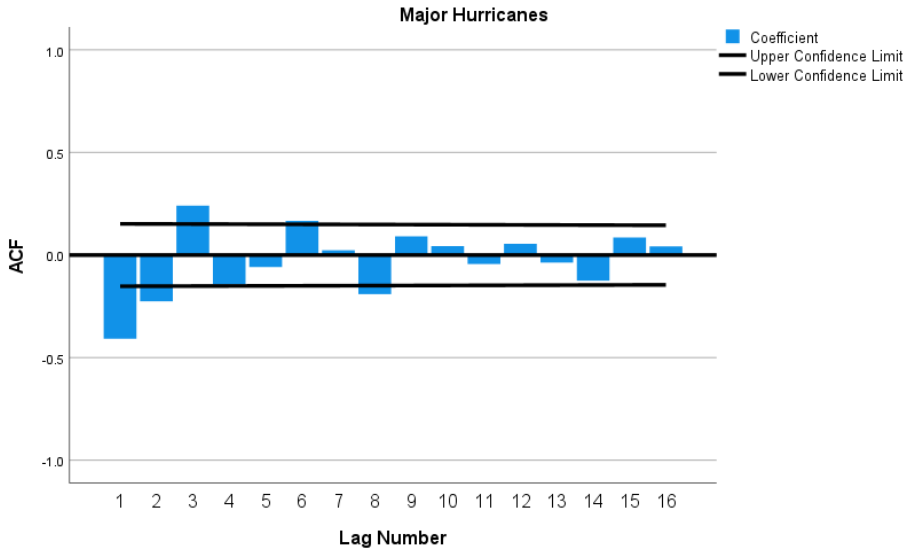
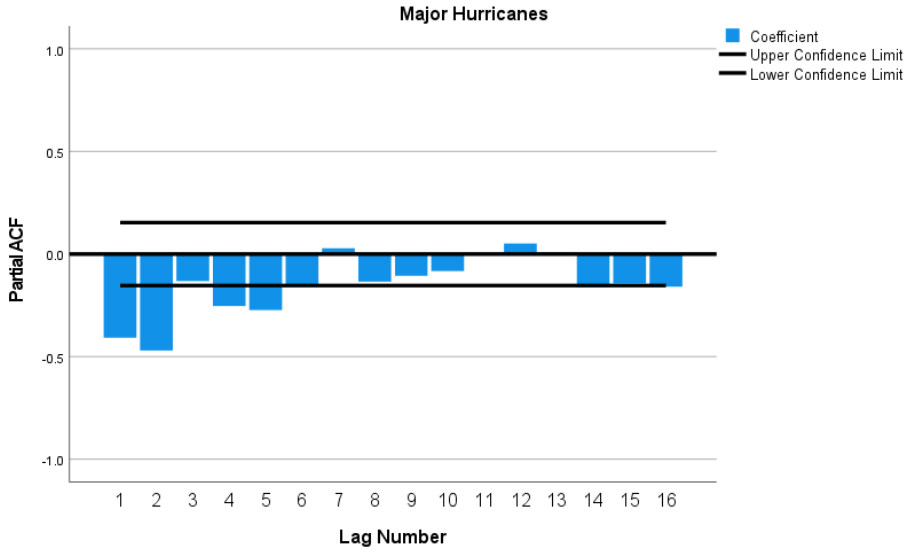


Figure 33

Partial Autocorrelation Function for Major Hurricanes 1851–2021



ACF and PACF plots of the ARIMA (0,1,3) model residuals underwent examination to determine the need for model respecification. Figures 34 and 35 show ACF and PACF results approximately random and within the lower and upper 95% confidence limits. Therefore, there were no further changes to the model specification.

Figure 34

Autocorrelation Function for Major Hurricanes Residuals 1851–2021

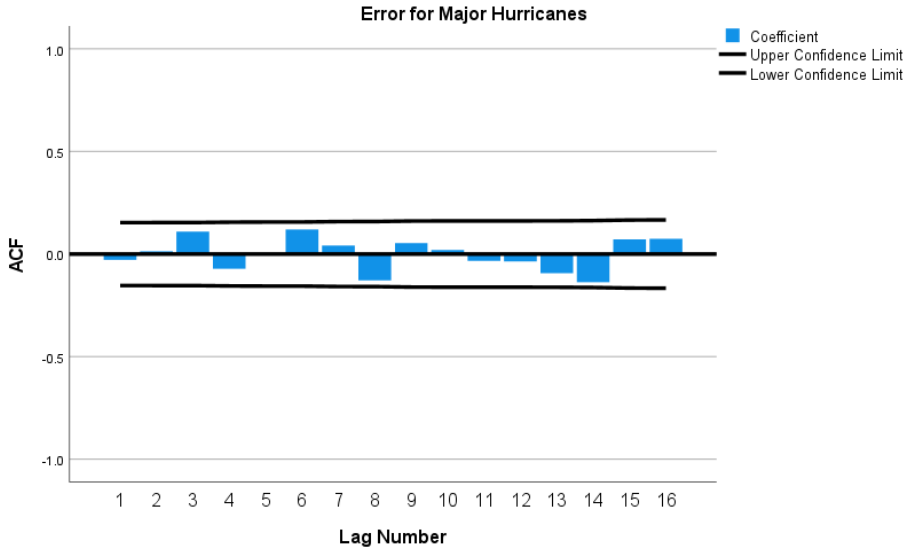


Figure 35

Partial Autocorrelation Function for Major Hurricanes Residuals 1851–2021

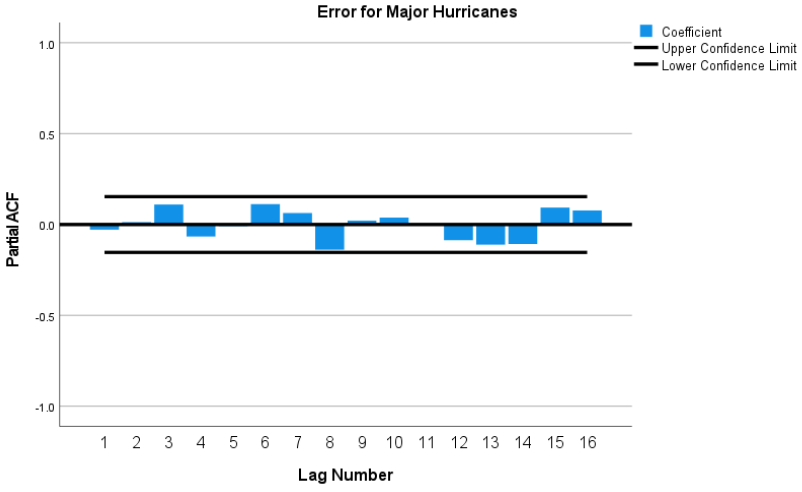


Table 16 presents the parameters of the final model. A significant MA component for Lag 1 ($B = 0.83$, $p < .001$), lag 2 ($B = 0.28$, $p = .005$) and Lag 3 ($B = -0.18$, $p = .020$), indicate the MA components significantly contributes to major hurricane predictions.

Table 16

ARIMA (0,1,3) Model Parameters for Major Hurricanes 1851–2021

Parameter	Estimate	*SE*	*t*	Sig.
Constant	0.02	0.01	1.76	.081
Difference	1.00			
MA (Lag 1)	0.83	0.08	10.80	< .001
MA (Lag 2)	0.28	0.10	2.87	.005
MA (Lag 3)	-0.18	0.08	-2.35	.020

Table 17 shows the forecasted number of major hurricanes indicated by the model 30 years beyond the data.

Table 17

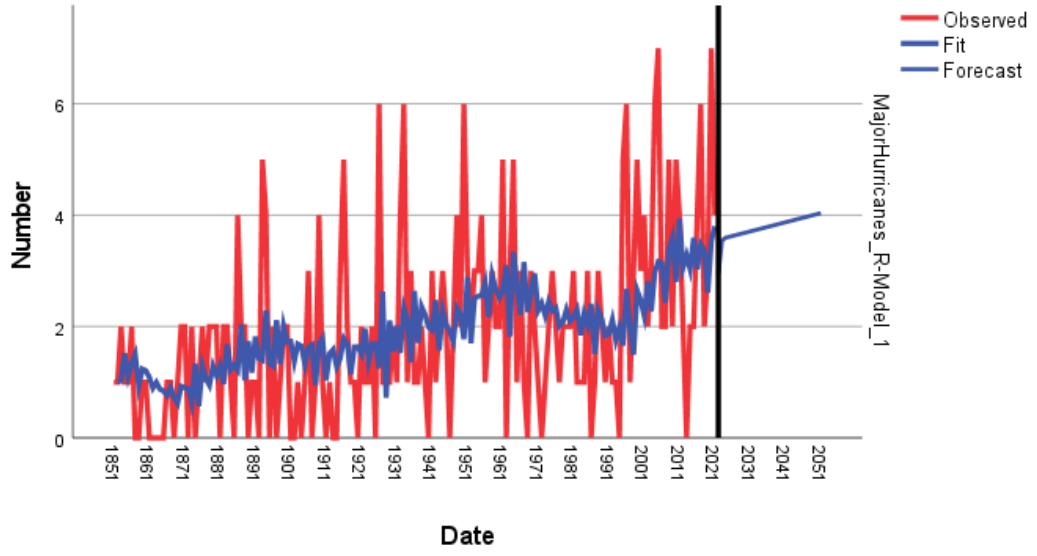
ARIMA (0,1,3) Model Forecast for Major Hurricanes 1851–2021

Year	Forecast	95% CI Upper	95% CI Lower
2022	3	6	0
2023	4	7	1
2024	4	7	1
2025	4	7	1
2026	4	7	1
2027	4	7	1
2028	4	7	1
2029	4	7	1
2030	4	7	1
2031	4	7	1
2032	4	7	1
2033	4	7	1
2034	4	7	1
2035	4	7	1
2036	4	7	1
2037	4	7	1
2038	4	7	1
2039	4	7	1
2040	4	7	1
2041	4	7	1
2042	4	7	1
2043	4	7	1
2044	4	7	1
2045	4	7	1
2046	4	7	1
2047	4	7	1
2048	4	7	1
2049	4	7	1
2050	4	7	1
2051	4	7	1

Figure 36 shows the model plotted against the observed data.

Figure 36

ARIMA (0,1,3) Model for Major Hurricanes Plotted Against Observed Data 1851–2021



Analysis for Major Hurricanes, 1991–2020

The sequence chart of major hurricanes (see Figure 9) and the corresponding Mann–Kendall correlation showed stationary data. ACF and PACF plots underwent examination to determine the most appropriate AR and MA model components. Figures 37 and 38 show mostly random patterns with alternating peaks in the ACF and PACF, resulting in unclear definitions for AR and MA components. Therefore, there were several ARIMA models tested. ARIMA (1,0,1) model produced significant AR and MA components and an AIC of 127.15, a better fit than an ARIMA (1,0,0) model with an AIC of 129.11 and an ARIMA (0,0,1) model with an AIC of 127.91. Therefore, the ARIMA (1,0,1) model underwent further examination. The AIC of the intercept-only ARIMA (0,0,0) model was 127.56.

Figure 37

Autocorrelation Function for Major Hurricanes 1991–2020

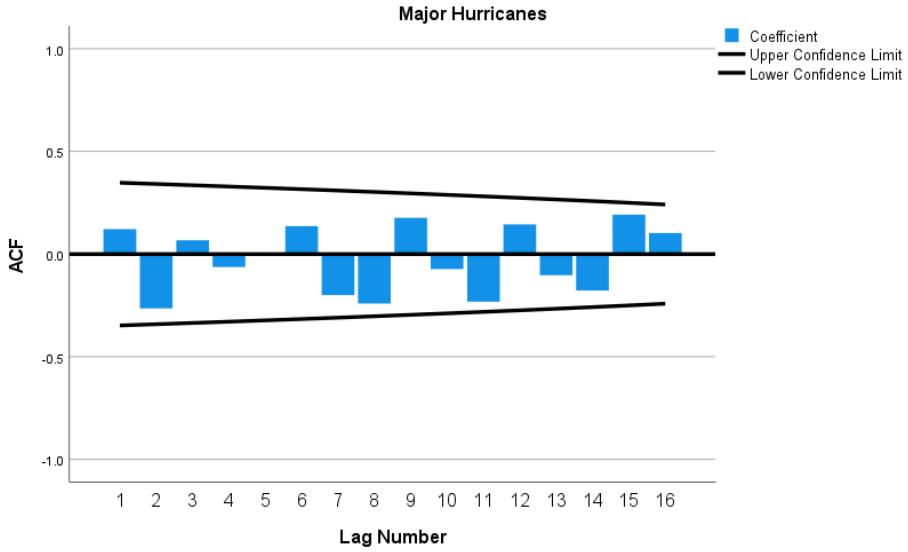
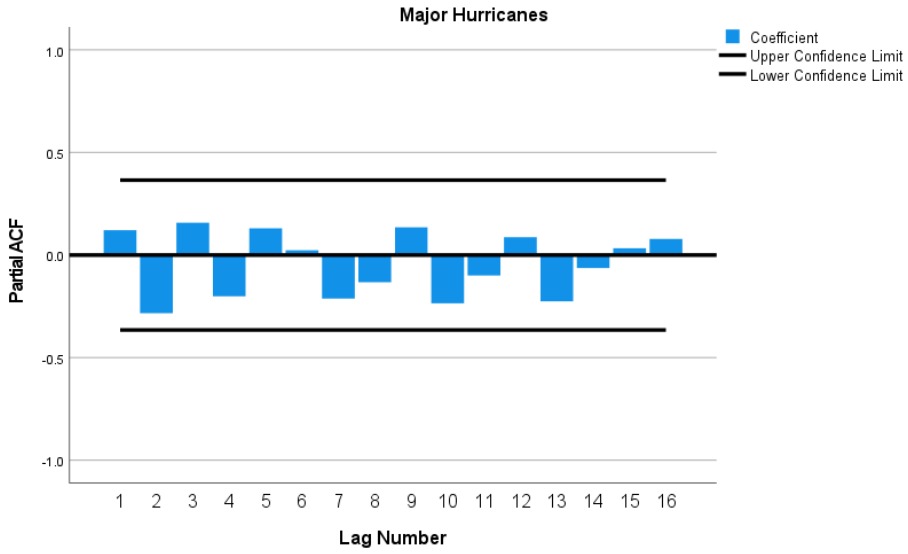


Figure 38

Partial Autocorrelation Function for Major Hurricanes 1991–2020



ACF and PACF plots of the ARIMA (1,0,1) model residuals underwent examination to determine the need for model respecification. Figures 39 and 40 show

ACF and PACF results approximately random and within the lower and upper 95% confidence limits. Therefore, there were no further changes to the model specification.

Figure 39

Autocorrelation Function for Major Hurricanes Residuals 1991–2020

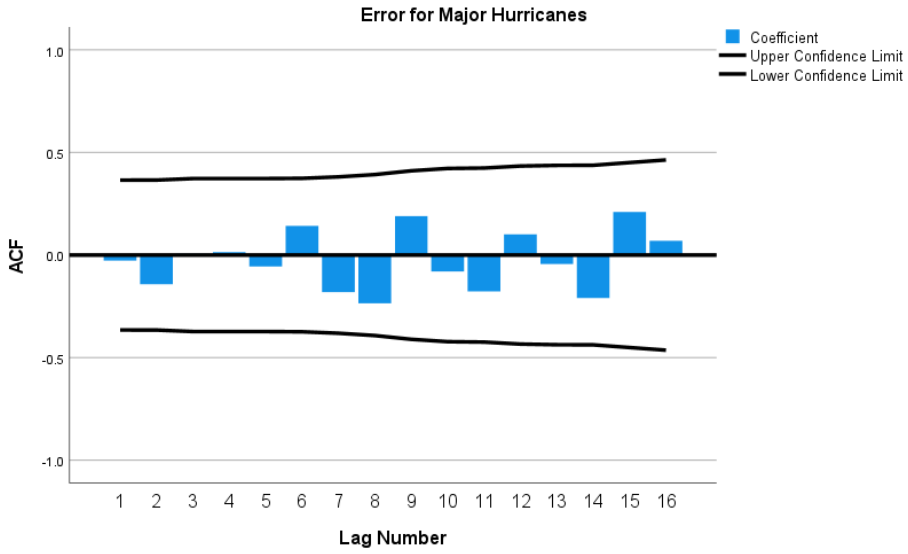


Figure 40

Partial Autocorrelation Function for Major Hurricanes Residuals 1991–2020

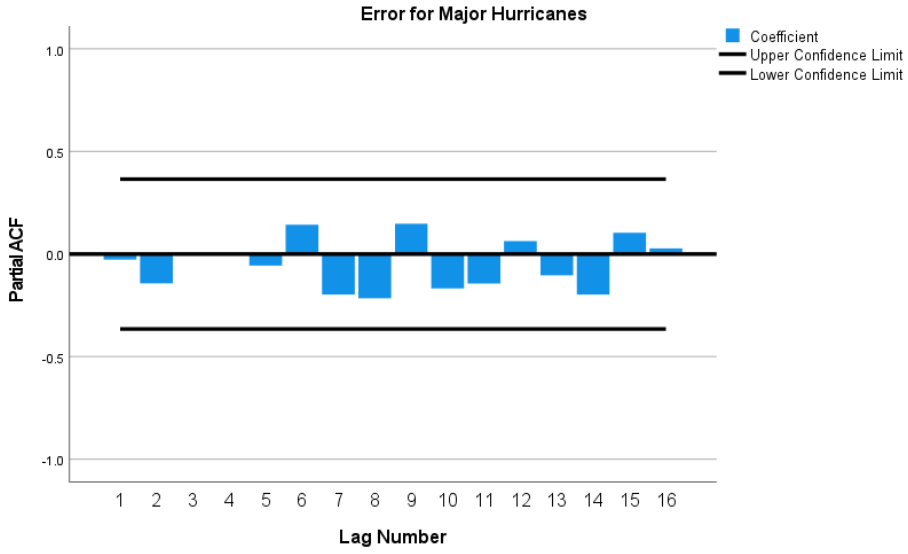


Table 18 shows the parameters of the final model. A significant AR component (B = -0.56, p = .039) and MA component (B = -0.94, p < .001) indicate the AR and MA components significantly contribute to major hurricane prediction.

Table 18

ARIMA (1,0,1) Model Parameters for Major Hurricanes 1991–2020

Parameter	Estimate	*SE*	*t*	Sig.
Constant	3.27	0.43	7.66	< .001
AR (Lag 1)	-0.56	0.26	-2.17	.039
MA (Lag 1)	-0.94	0.23	-4.01	< .001

Table 19 shows the forecasted number of major hurricanes indicated by the model 30 years after the data.

Table 19

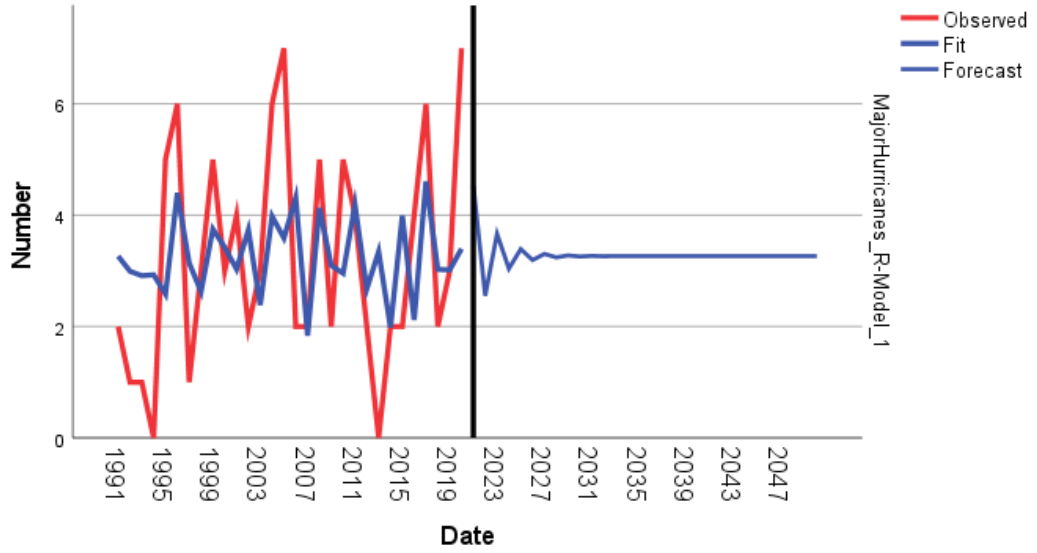
ARIMA (1,0,1) Model Forecast for Major Hurricanes 1991–2020

Year	Forecast	95% CI upper	95% CI lower
2021	5	8	1
2022	3	7	0
2023	4	8	0
2024	3	7	0
2025	3	8	0
2026	3	7	0
2027	3	8	0
2028	3	7	0
2029	3	8	0
2030	3	8	0
2031	3	8	0
2032	3	8	0
2033	3	8	0
2034	3	8	0
2035	3	8	0
2036	3	8	0
2037	3	8	0
2038	3	8	0
2039	3	8	0
2040	3	8	0
2041	3	8	0
2042	3	8	0
2043	3	8	0
2044	3	8	0
2045	3	8	0
2046	3	8	0
2047	3	8	0
2048	3	8	0
2049	3	8	0
2050	3	8	0

Figure 41 shows the model plotted against the observed data.

Figure 41

ARIMA (1,0,1) Model for Major Hurricanes Plotted Against Observed Data 1991–2020



Analysis for ACE, 1851–2021

The sequence chart of ACE (see Figure 5) and the corresponding Mann–Kendall correlation showed nonstationary data. Lag 1 differencing occurred to make the data stationary. ACF and PACF plots underwent examination to determine the most appropriate AR and MA model components. Figure 42 shows a peak at Lag 1 in the ACF. Figure 43 shows a gradually decaying PACF. The results suggest an AR component of 0 and an MA component of 1. Therefore, there was an ARIMA (0,1,1) model tested. The AIC of the ARIMA (0,1,1) model was 1824.21, a better fit than the differencing-only ARIMA (0,1,0) model with an AIC of 1909.10.

Figure 42

Autocorrelation Function for ACE 1851–2021

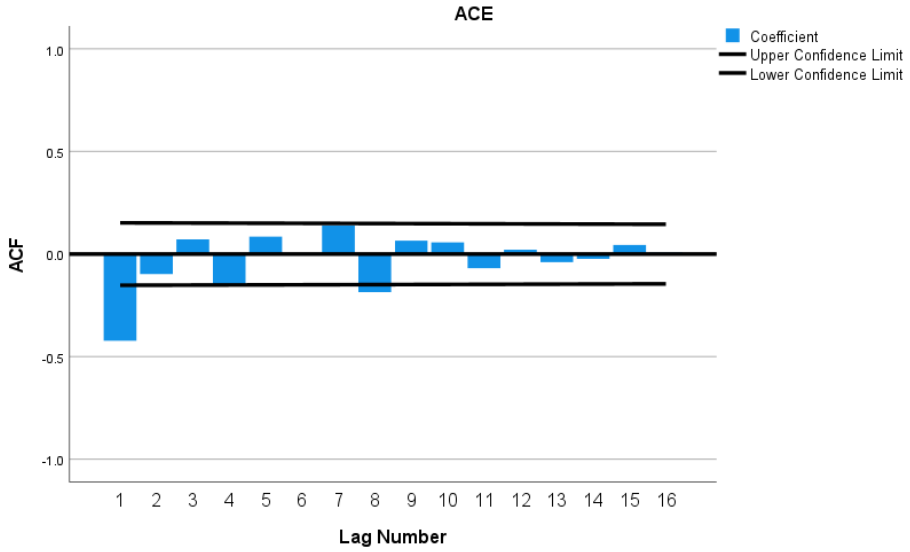
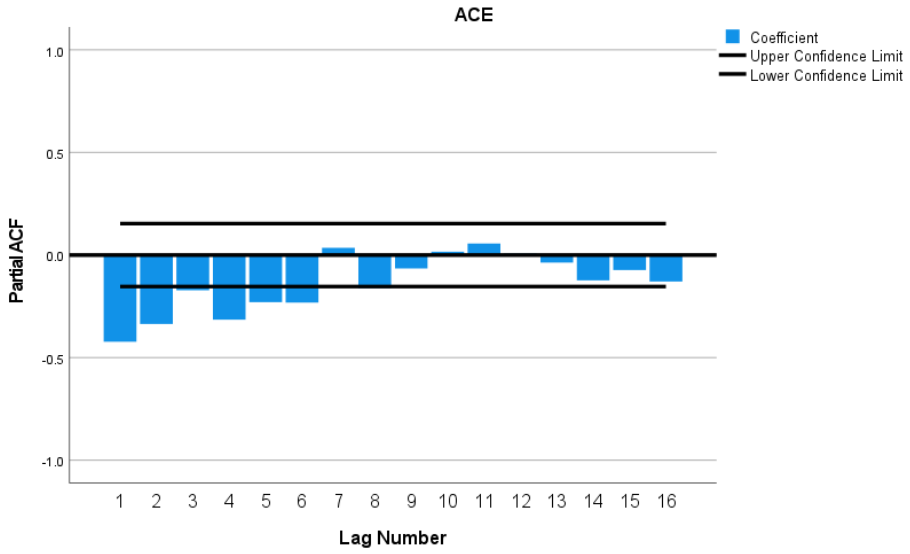


Figure 43

Partial Autocorrelation Function for ACE 1851–2021



ACF and PACF plots of the ARIMA (0,1,1) model residuals underwent examination to determine the need for model respecification. Figures 44 and 45 show

ACF and PACF results approximately random and within the lower and upper 95% confidence limits. Therefore, there were no further changes to the model specification.

Figure 44

Autocorrelation Function for ACE Residuals 1851–2021

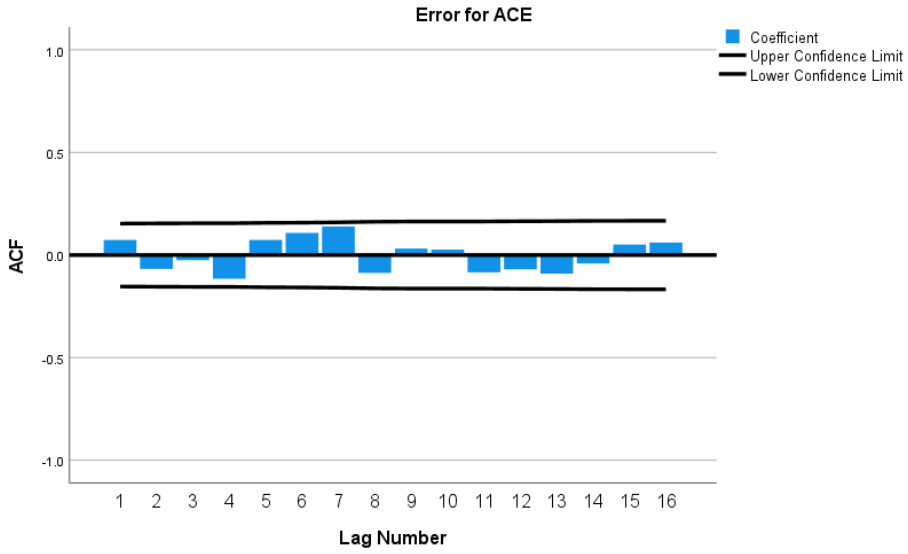


Figure 45

Partial Autocorrelation Function for ACE Residuals 1851–2021

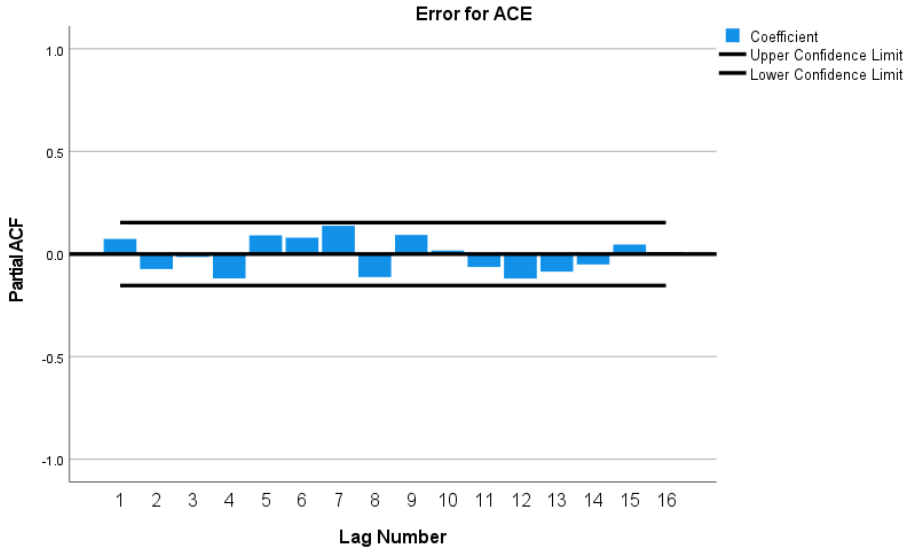


Table 20 presents the parameters of the final model. A significant MA component ($B = 0.90$, $p < .001$) indicates the MA component significantly contributes to ACE prediction.

Table 20

ARIMA (0,1,1) Model Parameters for ACE 1851–2021

Parameter	Estimate	*SE*	*t*	Sig.
Constant	0.50	0.41	1.23	.221
Difference	1.00			
MA (Lag 1)	0.90	0.04	25.98	< .001

Table 21 shows the forecasted ACE indicated by the model 30 years after the data.

Table 21

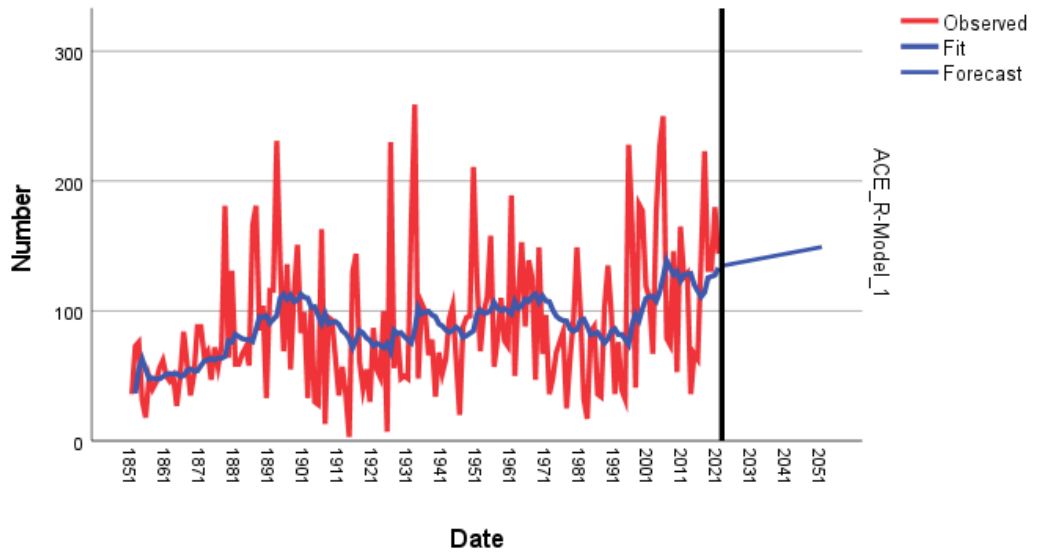
ARIMA (0,1,1) Model Forecast for ACE 1851–2021

Year	Forecast	95% CI upper	95% CI lower
2022	135	236	34
2023	135	237	34
2024	136	238	34
2025	136	239	34
2026	137	240	34
2027	137	241	34
2028	138	242	34
2029	138	243	34
2030	139	244	34
2031	139	245	34
2032	140	246	34
2033	140	247	34
2034	141	247	34
2035	141	248	34
2036	142	249	34
2037	142	250	34
2038	143	251	34
2039	143	252	34
2040	144	253	34
2041	144	254	34
2042	145	255	35
2043	145	256	35
2044	146	257	35
2045	146	258	35
2046	147	259	35
2047	147	260	35
2048	148	261	35
2049	148	262	35
2050	149	263	35
2051	149	263	35

Figure 46 shows the model plotted against the observed data.

Figure 46

ARIMA (0,1,1) Model for ACE Plotted Against Observed Data 1851–2021



Analysis for ACE, 1991–2020

The sequence chart of ACE (see Figure 10) and the corresponding Mann–Kendall correlation showed stationary data. ACF and PACF plots underwent examination to determine the most appropriate AR and MA model components. Figures 47 and 48 show mostly random ACF and PACF patterns, with a peak at Lag 11 in the ACF. The results did not provide clear definitions for the AR and MA components. Therefore, there were several ARIMA models tested. An ARIMA (1,0,1) model produced significant AR and MA components and had an AIC of 337.49, a similar fit compared to an ARIMA (1,0,0) model, which had an AIC of 337.87, and an ARIMA (0,0,1) model, which had an AIC of 337.15. The results showed significant AR and MA components in the ARIMA (1,0,1) model. Therefore, the model underwent further examination. The AIC of the intercept-only ARIMA (0,0,0) model was 336.91.

Figure 47

Autocorrelation Function for ACE 1991–2020

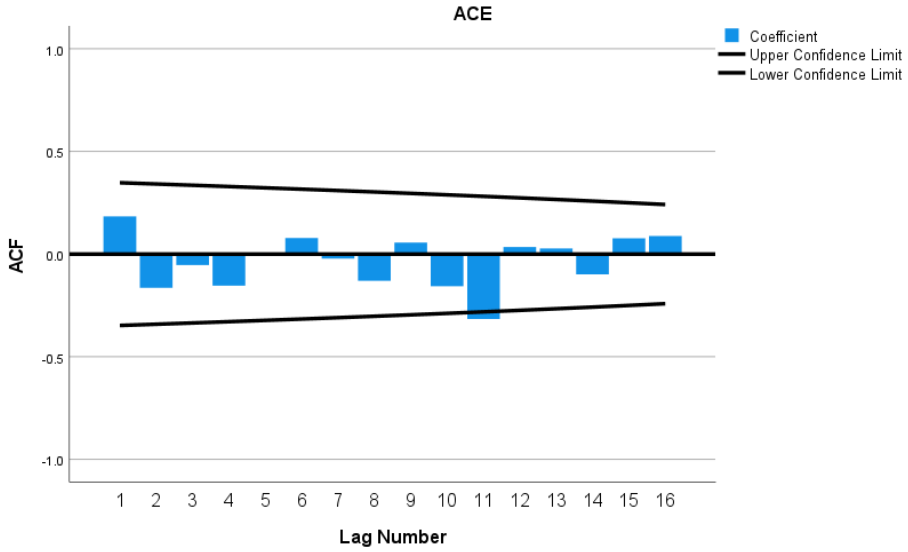
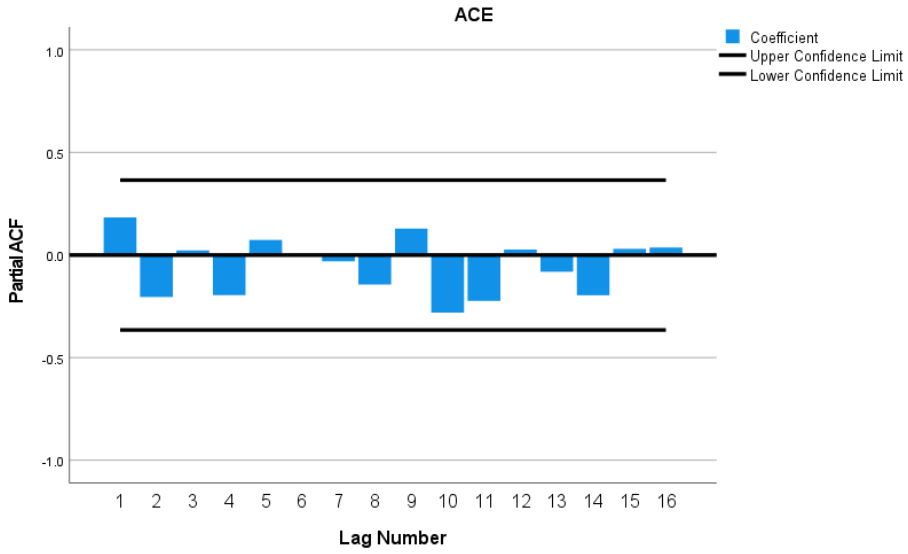


Figure 48

Partial Autocorrelation Function for ACE 1991–2020



ACF and PACF plots of the ARIMA (1,0,1) model residuals underwent examination to determine the need for model respecification. Figures 49 and 50 show ACF and PACF results approximately random and within the lower and upper 95%

confidence limits, with possible peaks at Lag 11. However, testing of models with AR and MA components at Lag 11 did not produce significant parameters. Therefore, there were no further changes to the model specification.

Figure 49

Autocorrelation Function for ACE Residuals 1991–2020

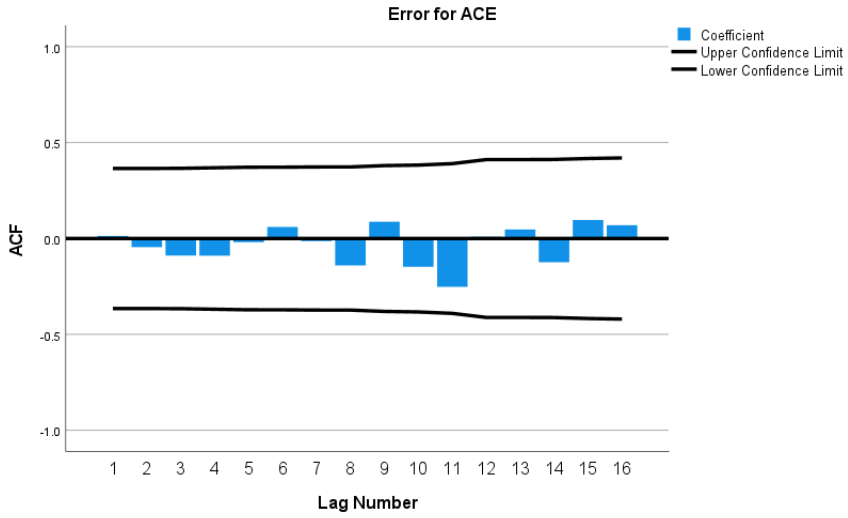


Figure 50

Partial Autocorrelation Function for ACE Residuals 1991–2020

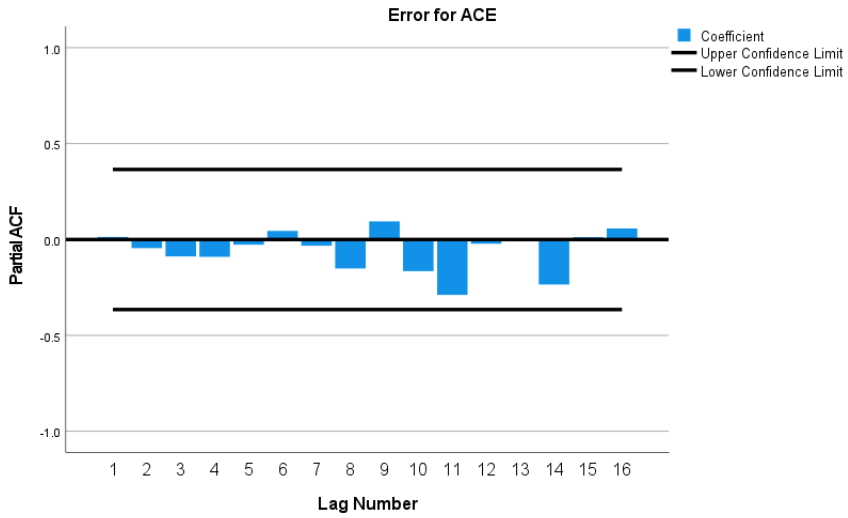


Table 22 presents the parameters of the final model. A significant AR component (B = -0.56, p = .039) and MA component (B = -0.94, p < .001) indicate the AR and MA components significantly contribute to ACE prediction.

Table 22

ARIMA (1,0,1) Model Parameters for ACE 1991–2020

Parameter	Estimate	*SE*	*t*	Sig.
Constant	122.57	13.66	8.98	< .001
AR (Lag 1)	-0.61	0.29	-2.08	.047
MA (Lag 1)	-0.90	0.22	-4.05	< .001

Table 23 shows the forecasted ACE indicated by the model 30 years beyond the data.

Table 23

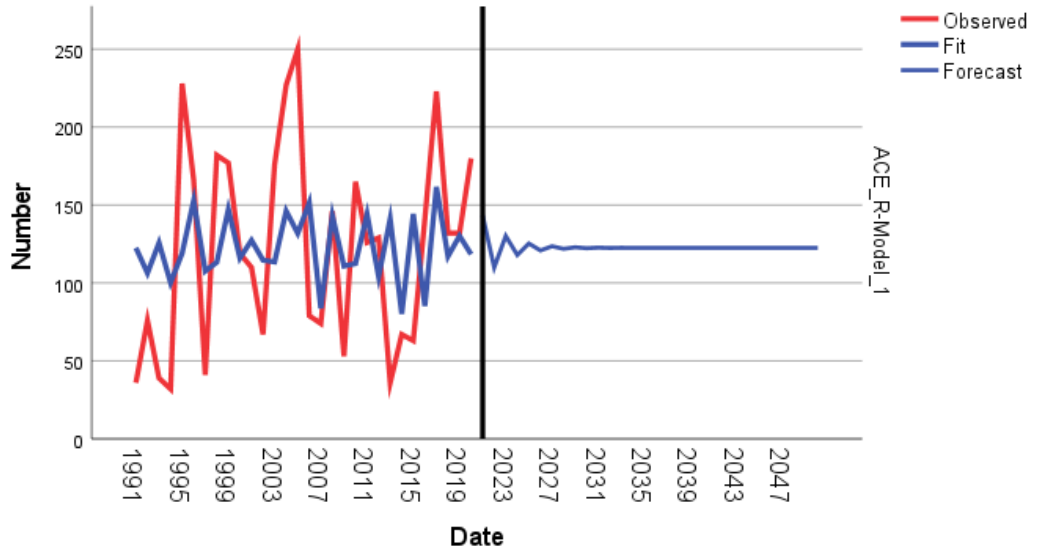
ARIMA (1,0,1) Model Forecast for ACE 1991–2020

Year	Forecast	95% CI upper	95% CI lower
2021	143	273	14
2022	110	245	0
2023	130	268	0
2024	118	256	0
2025	125	264	0
2026	121	259	0
2027	124	262	0
2028	122	261	0
2029	123	262	0
2030	122	261	0
2031	123	261	0
2032	122	261	0
2033	123	261	0
2034	123	261	0
2035	123	261	0
2036	123	261	0
2037	123	261	0
2038	123	261	0
2039	123	261	0
2040	123	261	0
2041	123	261	0
2042	123	261	0
2043	123	261	0
2044	123	261	0
2045	123	261	0
2046	123	261	0
2047	123	261	0
2048	123	261	0
2049	123	261	0
2050	123	261	0

Figure 51 shows the model plotted against the observed data.

Figure 51

ARIMA (1,0,1) Model for ACE Plotted Against Observed Data 1991–2020



Analysis for U.S. Hurricanes, 1851–2021

The sequence chart of U.S. hurricanes (see Figure 6) and the corresponding Mann–Kendall correlation showed stationary data. ACF and PACF plots underwent examination to determine the most appropriate AR and MA model components. Figures 52 and 53 show mostly random ACF and PACF patterns, with possible peaks at Lags 4 and 14. The results did not provide clear definitions for the AR and MA components. Therefore, there were several ARIMA models tested. An ARIMA (0,0,4) model had an AIC of 616.54, and an ARIMA (0,0,14) model had an AIC of 627.12. However, the ARIMA (0,0,4) model did not produce significant parameters. The ARIMA (0,0,14) model produced a significant MA component. Therefore, testing of an ARIMA (0,0,14) model occurred. The AIC of the intercept-only ARIMA (0,0,0) model was 613.68.

Figure 52

Autocorrelation Function for U.S. Hurricanes 1851–2021

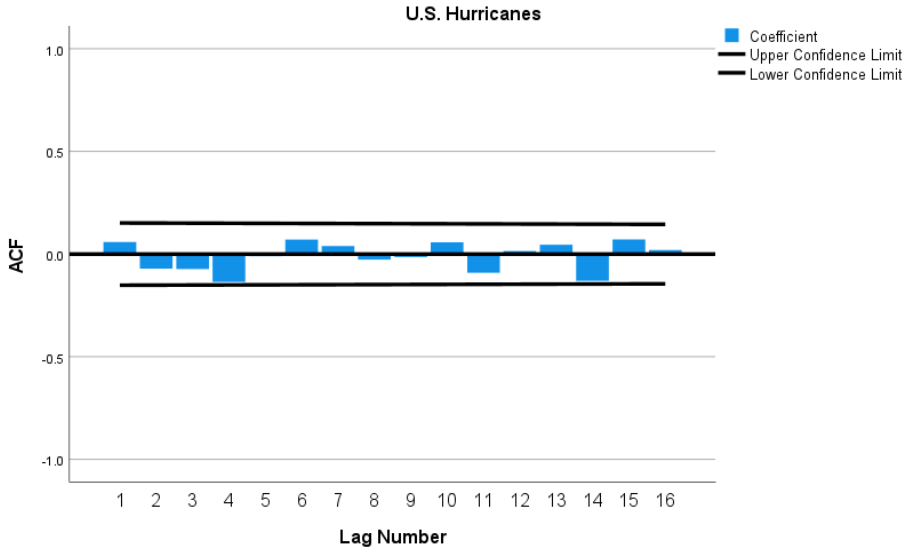
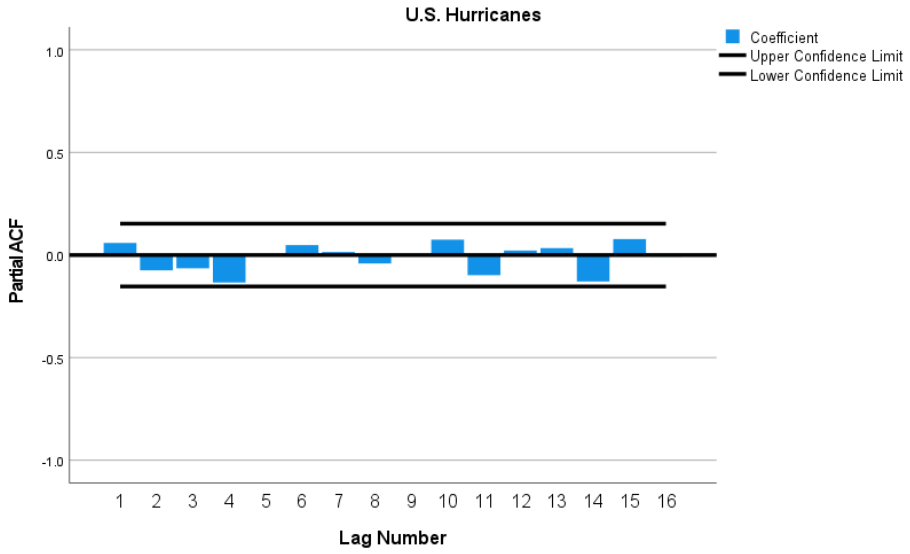


Figure 53

Partial Autocorrelation Function for U.S. Hurricanes 1851–2021



ACF and PACF plots of the ARIMA (0,0,14) model residuals underwent examination to determine the need for model respecification. Figures 54 and 55 show

there were no marked autocorrelations in the ACF and PACF. Therefore, there were no further changes to the model specification.

Figure 54

Autocorrelation Function for U.S. Hurricanes Residuals 1851–2021

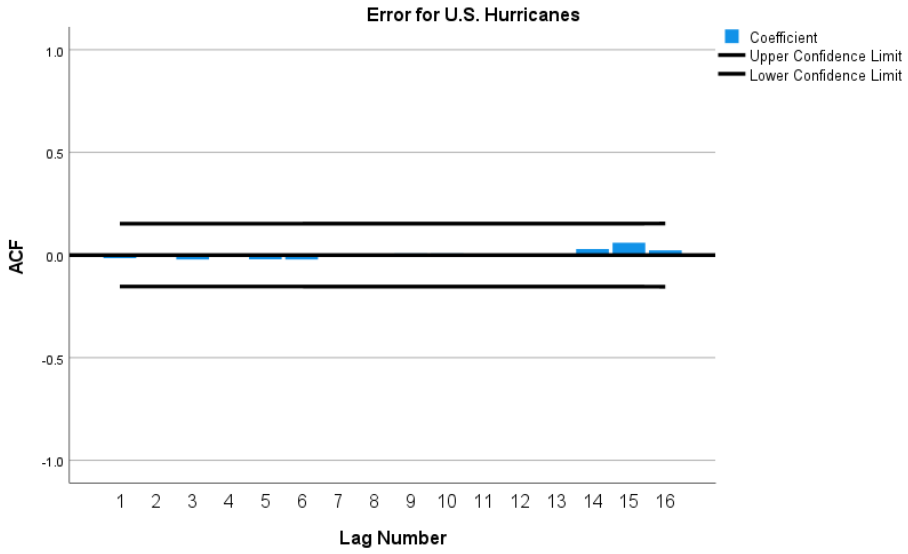


Figure 55

Partial Autocorrelation Function for U.S. Hurricanes Residuals 1851–2021

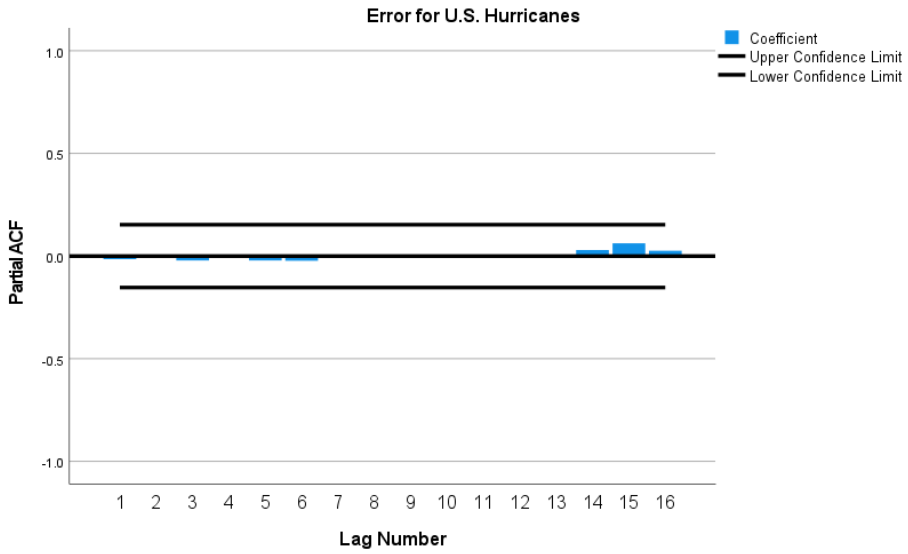


Table 24 shows the parameters of the final model. A significant MA component for Lag 14 ($B = 0.24$, $p = .005$) indicates the MA component significantly contributes to U.S. hurricane prediction.

Table 24

ARIMA (0,0,14) Model Parameters for U.S. Hurricanes 1851–2021

Parameter	Estimate	*SE*	*t*	Sig.
Constant	1.77	0.09	20.12	< .001
MA (Lag 1)	-0.11	0.08	-1.34	.182
MA (Lag 2)	0.05	0.08	0.60	.547
MA (Lag 3)	0.04	0.08	0.53	.596
MA (Lag 4)	0.12	0.08	1.50	.137
MA (Lag 5)	-0.04	0.08	-0.44	.663
MA (Lag 6)	-0.14	0.08	-1.74	.084
MA (Lag 7)	-0.04	0.08	-0.44	.664
MA (Lag 8)	0.01	0.08	0.14	.890
MA (Lag 9)	0.02	0.08	0.21	.837
MA (Lag 10)	-0.01	0.08	-0.14	.893
MA (Lag 11)	0.13	0.08	1.62	.107
MA (Lag 12)	0.01	0.08	0.07	.944
MA (Lag 13)	-0.06	0.08	-0.73	.468
MA (Lag 14)	0.24	0.08	2.85	.005

Table 25 shows the forecasted number of U.S. hurricanes indicated by the model 30 years after the data.

Table 25

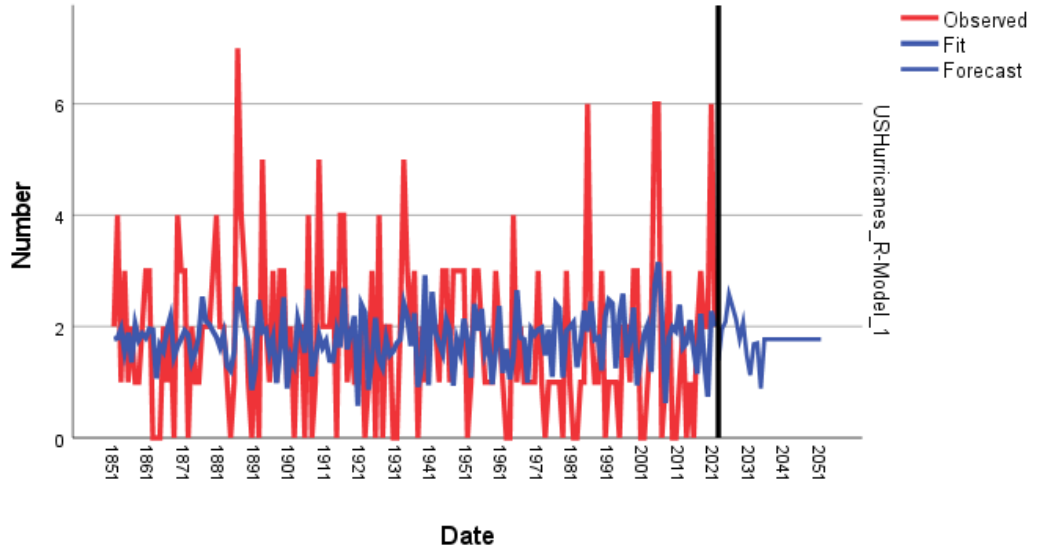
ARIMA (0,0,14) Model Forecast for U.S. Hurricanes 1851–2021

Year	Forecast	95% CI upper	95% CI lower
2022	1	4	0
2023	2	5	0
2024	2	5	0
2025	3	5	0
2026	2	5	0
2027	2	5	0
2028	2	5	0
2029	2	5	0
2030	1	4	0
2031	1	4	0
2032	2	5	0
2033	2	5	0
2034	1	4	0
2035	2	5	0
2036	2	5	0
2037	2	5	0
2038	2	5	0
2039	2	5	0
2040	2	5	0
2041	2	5	0
2042	2	5	0
2043	2	5	0
2044	2	5	0
2045	2	5	0
2046	2	5	0
2047	2	5	0
2048	2	5	0
2049	2	5	0
2050	2	5	0
2051	2	5	0

Figure 56 shows the model plotted against the observed data.

Figure 56

ARIMA (0,0,14) Model for U.S. Hurricanes Plotted Against Observed Data 1851–2021



Analysis for U.S. Hurricanes, 1991–2020

The sequence chart of U.S. hurricanes (see Figure 11) and the corresponding Mann–Kendall correlation showed stationary data. ACF and PACF plots underwent examination to determine the most appropriate AR and MA model components. Figures 57 and 58 show mostly random patterns with a peak at Lag 11 in the ACF. The results did not provide clear definitions for the AR and MA components. Therefore, there were several ARIMA models tested. An ARIMA (0,0,1) model produced a significant MA component and had an AIC of 116.58, a better fit than an ARIMA (1,0,0) model with an AIC of 119.84 and an ARIMA (1,0,1) model with an AIC of 118.43. Therefore, the ARIMA (0,0,1) model underwent further examination. The AIC of the intercept-only ARIMA (0,0,0) model was 120.07.

Figure 57

Autocorrelation Function for U.S. Hurricanes 1991–2020

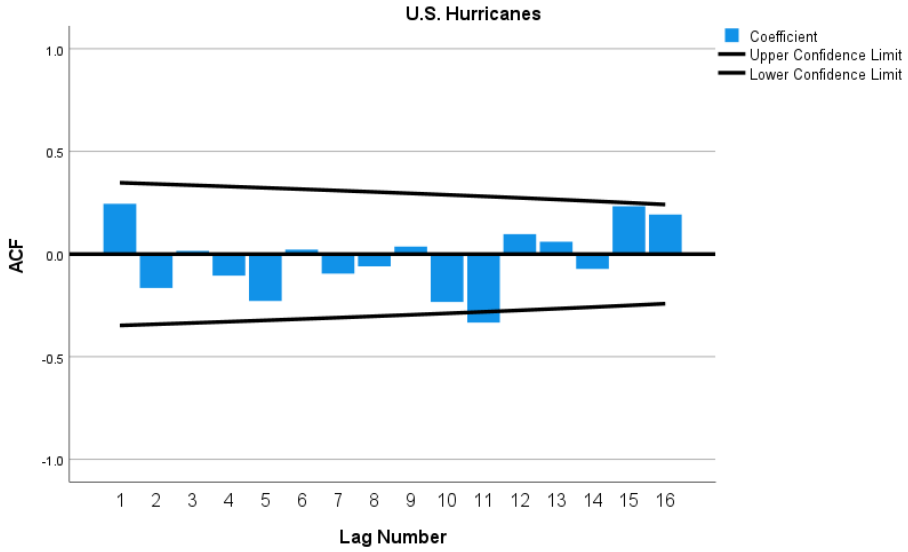
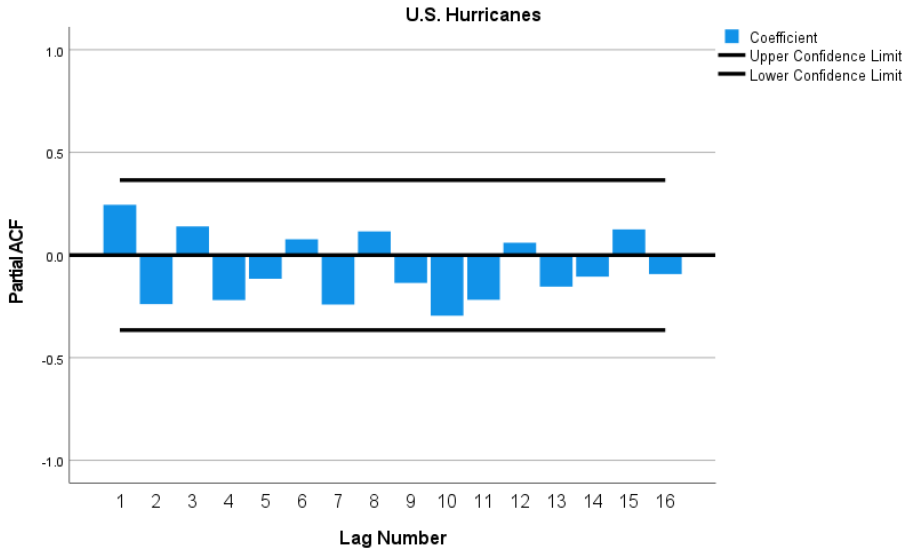


Figure 58

Partial Autocorrelation Function for U.S. Hurricanes 1991–2020



ACF and PACF plots of the ARIMA (0,0,1) model residuals underwent examination to determine the need for model respecification. Figures 59 and 60 show ACF and PACF results approximately random and within the lower and upper 95%

confidence limits, with possible peaks at Lag 11. However, testing of the models with AR and MA components at Lag 11 did not produce significant parameters. Therefore, there were no further changes to the model specification.

Figure 59

Autocorrelation Function for U.S. Hurricanes Residuals 1991–2020

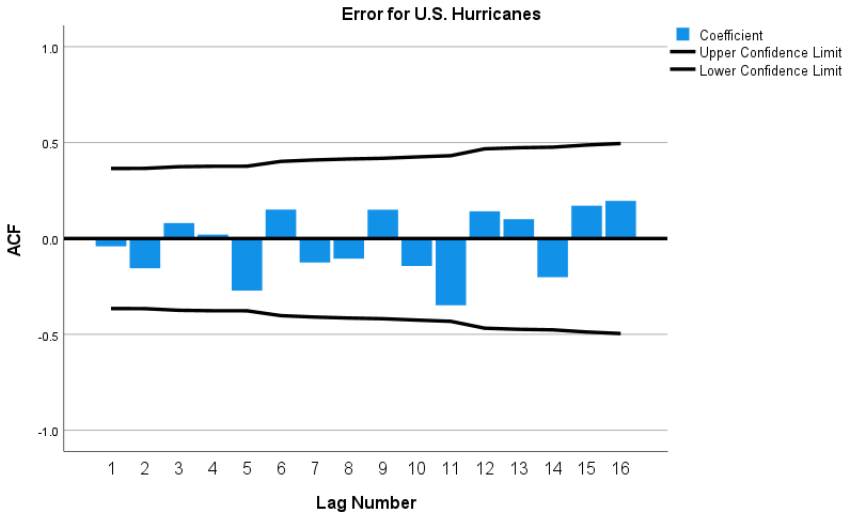


Figure 60

Partial Autocorrelation Function for U.S. Hurricanes Residuals 1991–2020

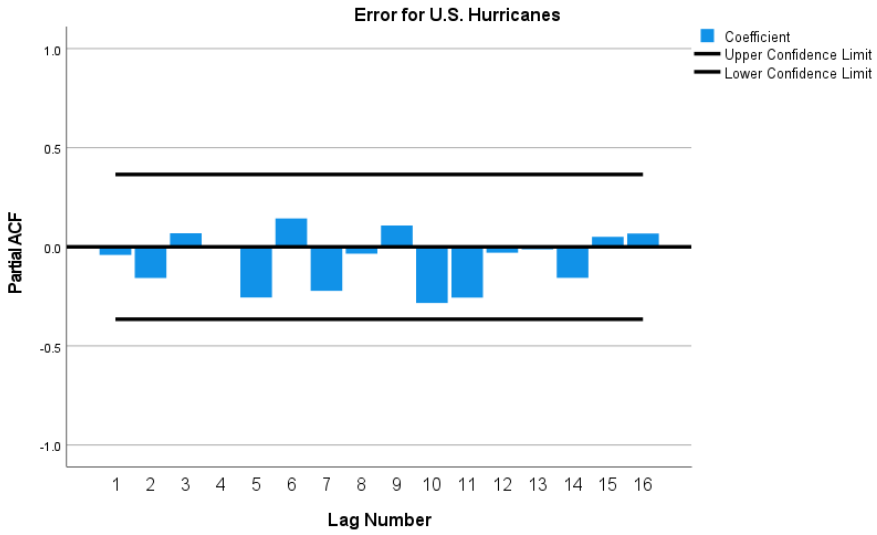


Table 26 shows the parameters of the final model. A significant MA component (B = -0.59, p = .003) indicates the MA component significantly contributes to U.S. hurricane prediction.

Table 26

ARIMA (0,0,1) Model Parameters for U.S. Hurricanes 1991–2020

Parameter	Estimate	*SE*	*t*	Sig.
Constant	1.81	0.47	3.88	< .001
MA (Lag 1)	-0.59	0.18	-3.25	.003

Table 27 shows the forecasted number of U.S. hurricanes indicated by the model 30 years after the data.

Table 27

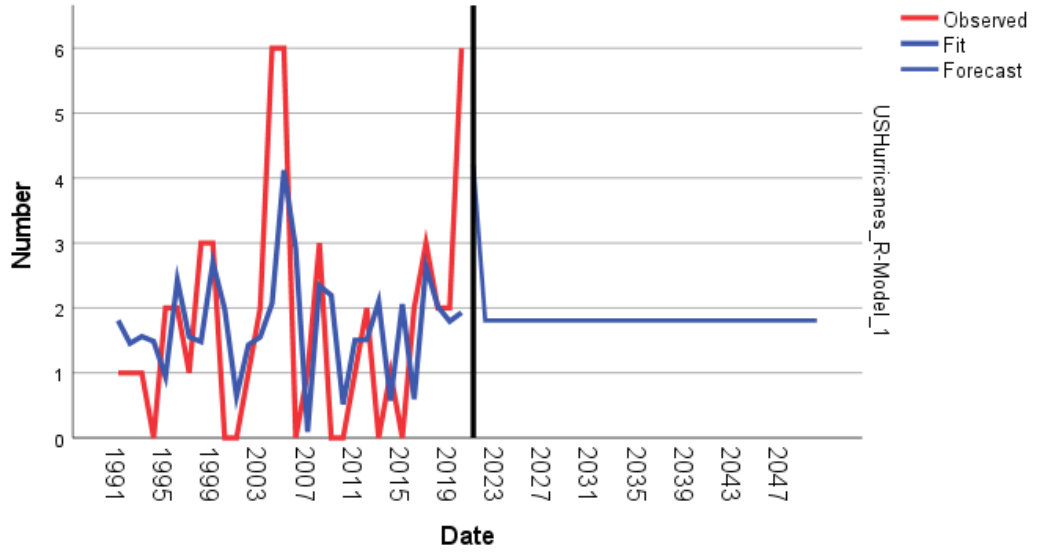
ARIMA (0,0,1) Model Forecast for U.S. Hurricanes 1991–2020

Year	Forecast	95% CI upper	95% CI lower
2021	4	8	1
2022	2	6	0
2023	2	6	0
2024	2	6	0
2025	2	6	0
2026	2	6	0
2027	2	6	0
2028	2	6	0
2029	2	6	0
2030	2	6	0
2031	2	6	0
2032	2	6	0
2033	2	6	0
2034	2	6	0
2035	2	6	0
2036	2	6	0
2037	2	6	0
2038	2	6	0
2039	2	6	0
2040	2	6	0
2041	2	6	0
2042	2	6	0
2043	2	6	0
2044	2	6	0
2045	2	6	0
2046	2	6	0
2047	2	6	0
2048	2	6	0
2049	2	6	0
2050	2	6	0

Figure 61 shows the model plotted against the observed data.

Figure 61

ARIMA (0,0,1) Model for U.S. Hurricanes Plotted Against Observed Data 1991–2020



Part II: RQ2 Qualitative Results: Perceptions of DoD Hurricane Readiness

The DoD is a last resort upon NRF activation. However, the DoD plays a major role with unique and tremendous capability to support FEMA during hurricane response. Thus, the goal of RQ2 was to determine DoD hurricane readiness posture.

R2. How prepared is the DoD to support the next major hurricane that makes landfall in the United States?

Descriptive Statistics: Characteristics of DSCA Experts

For RQ2, the study included a sample of 30 participants from a population of over 4,000 DSCA service members, civilians, and contractors who had worked at the strategic, operational, and tactical levels for various organizations in different regions for different incidents. Voluntary disclosures showed the participants had around 37 years of total experience, averaging between 13 and 17 years with DSCA training and hurricane

response. Most participants had responded to between two and eight hurricanes, with one participating in over 20 disaster responses, including tornadoes and typhoons. The participants' experience included DSCA positions such as federal coordinating officers, retired Army generals, DCOs, EPLOs, SEPLOs, a National Security Attorney, and ARNORTH employees. Various participants worked in DSCA planning, training, and operations, including the medical, veterinarian, legal, and military intelligence fields. All the participants had completed DSCA training, and nearly all indicated some experience with hurricane response, including Hurricanes Katrina, Sandy, and Maria. Table 28 presents the participants; their major DSCA experience; interview dates, times, and duration; transcript length; interview consent; and acceptance of the $15 monetary incentive.

Table 28

DSCA Experts' Characteristics

PID	Experience	Date	Time	Length	Pages	IC form	Comp
001	Federal Coordinating Officer	2-Jun	1000	26:18	7	Yes	Declined
002	NG JTF HQ	2-Jun	1100	18:54	4	Yes	Declined
003	Ph.D., Information Technology	2-Jun	1300	28:36	7	Yes	Yes
004	Defense Coordinating Officer	2-Jun	1400	13:56	4	Yes	Declined
005	Hurricane Sandy Experience	3-Jun	1000	33:56	7	Yes	Yes
006	TF Operations	2-Jun	1600	23:07	7	Yes	Declined
007	JFHQ Provost Marshall	5-Jun	1000	31:00	6	Yes	Yes
008	Ph.D., Safety and Occupational Health	2-Jun	1700	08:59	4	Yes	Declined
009	Senior National Security Attorney	7-Jun	1545	39:15	8	Yes	Declined
010	Chief of DSCA Training	9-Jun	1000	47:49	9	Yes	Declined
011	Military Intelligence	5-Jun	1200	22:28	7	Yes	Declined
012	DSCA Experience	5-Jun	1300	29:17	7	Yes	Yes
013	DSCA Experience	5-Jun	1400	24:24	7	Yes	Declined
014	DSCA Experience	8-Jun	1000	28:11	7	Yes	Yes
015	DSCA Health Services Admin	4-Jun	1500	18:58	5	Yes	Declined

PID	Experience	Date	Time	Length	Pages	IC form	Comp
016	Federal Coordinating Officer	7-Jun	0930	15:48	5	Yes	Declined
017	NG DSCA Experience	7-Jun	1300	17:36	5	Yes	Yes
018	USSOUTHCOM Officer	7-Jun	1030	12:51	5	Yes	Declined
019	Preventive Medicine	8-Jun	1830	33:04	7	Yes	Declined
020	DSCA Planner	9-Jun	1100	29:18	9	Yes	Declined
021	Civil Support Training Activity	15-Jun	1100	17:13	6	Yes	Yes
022	HD Civil Support Office, MSCoE	13-Jun	1400	24:52	6	Yes	Declined
023	USAR Homeland Defense Office	10-Jun	0800	29:45	7	Yes	Yes
024	TF Operations	9-Jun	1300	28:42	7	Yes	Yes
025	Retired General Officer, TF 76, EPLO	14-Jun	1100	32:19	8	Yes	Declined
026	Retired General Officer, ARNORTH	12-Jun	1500	29:03	7	Yes	Declined
027	Federal Coordinating Officer	15-Jun	1600	37:28	8	Yes	Declined
028	Ph.D., Veterinary Public Health	17-Jun	2130	48:02	11	Yes	Yes
029	Deputy DCO	13-Jun	1150	20:16	6	Yes	Yes
030	SEPLO	13-Jun	1800	16:27	5	Yes	Yes

Overview of Data Analysis: Process and Procedures

Thematic analysis began after collecting, transcribing, and uploading Cisco Webex data into NVivo to identify patterns and themes. Thematic analysis has six steps: familiarizing with the data, initial coding, searching for themes, reviewing themes, defining and naming themes, and producing the report.

The first step was data familiarization, which involved reading each transcript three times, noting initial ideas, and generating a list of potential codes. The first step occurred to identify key patterns for themes. The second step was generating a list of initial codes by identifying and labeling meaningful data segments, such as phrases, sentences, or paragraphs. The descriptive codes were the means of capturing the essence of the data. Initial code generation occurred through an inductive approach from the data itself. The initial round of coding produced 183 codes. The next step was removing 51

codes better suited to descriptive statistics than thematic analysis. Coding also involved grouping five codes related to specific military installations into a single code of specific installations suited for storm response. The final count was 127 codes.

After generating the initial code list, the third step entailed searching for and refining themes and patterns of meaning through the data by grouping similar codes. The goal was to establish themes coherent and relevant to the research question and capture the essence of the data. The fourth step was grouping and comparing codes for similarities and differences. Initially, 10 themes emerged from the data, but upon further review, the demarcation between Themes 3 and 4 appeared artificial based on the content and responses. The fifth step was grouping the nine themes that emerged from coding. Drafting the report occurred in the sixth step.

Findings: Nine Emergent Themes Detailing DSCA Readiness

Nine themes emerged from the participants' perceptions of DoD response readiness for hurricane landfalls in the United States. The themes reflected the participants' experiences with policy, training, organization, deployment, and overall readiness. This section includes reflective excerpts from participants for each subtheme to provide a description of each theme.

Theme 1: Joint Doctrine Provides Well-Rounded Guidance, but with Limitations

The participants perceived the joint and service doctrine as providing well-rounded and descriptive guidance. However, the participants also perceived several limitations of the doctrine, focusing on missing information and a disconnect between training and implementation.

The first emergent theme reflected the participants' perceptions regarding joint and service doctrine and whether it provided well-rounded and descriptive guidance. The participants described the doctrine as well-rounded but noted several limitations. The limitations fell into two categories: missing information in the doctrine and a divergence between training and implementation. This theme consisted of three subthemes.

Subtheme 1a: The Joint and Service Doctrine Is Well-Rounded and Descriptive. The first subtheme included the participants' positive perceptions of the joint and service doctrine. The participants perceived the doctrine as providing comprehensive guidance they considered descriptive but not prescriptive, describing it as the essence of operational foundations. Participant 002 presented the doctrine as "well-rounded and gives our left and right limits" and said,

> We spent a lot of time on service component capabilities and how we can integrate those into the civilian sector. With the FEMA classes, a lot of our FEMA instructors were prior military, so they were able to bridge that gap, take those words and change them or modify them into military language.

Similarly, Participant 003 said,

> I would say the relationships described in the joint publication are really well spelled out. I think [the joint publication] gives really good guidance and clears up the left and right limits of what each organization involved in an operation can and cannot do and how escalation works.

Participant 010 considered the doctrine adequate but described it as a more descriptive than an authoritative prescription for responding to situations, saying, "I see doctrine as more of a guide that lays out fundamental principles. I see it more as

descriptive in nature than prescriptive. Current doctrine, to me, is adequate in providing the sufficient framework for DSCA response missions."

Participant 020 said, "I think the doctrine is decent. It has improved over time, and I think it will continue to. I think it is good enough to get the game started; it is not too prescriptive." Participant 001 summarized the participants' overall perception regarding the joint and service doctrine:

> In my review of the joint and the service doctrine, [I think] they do a good job of capturing the foundations of how we conduct operations in the United States under the NRF. I think where they are lacking is [that] they do not get into how we execute; they talk about a lot of foundational things.

Many participants reported the joint and service doctrine as providing well-rounded information regarding operational foundations. However, they also considered the doctrine limited and flawed regarding DSCA execution.

Subtheme 1b: The Joint and Service Doctrine Is Missing Certain Details. The second subtheme reflected the participant's perspectives on the details they would find helpful in the joint and service doctrine. Participant 011 said, "I think the doctrine is spotty. I think when it comes to moving material support, [the doctrine] is robust. [However], when it comes to enabling personnel support, it is very challenging." This participant felt the doctrine had both positives and negatives.

Participant 001 said the doctrine lacked details on shifting the mindset that could indicate how to execute smoother operations:

> The doctrine does not explain how we actually employ a federal resource. Whether it is the DoD or another agency, that resource is actually working for that

local responder. When FEMA responds, and even when the state responds to a disaster, we are in very few circumstances actually doing something on our own. We are typically resource providers for that local responder. When FEMA brings in an urban search and rescue team or an EPA assessment team or something like that, we will launch that team down to a local responder. They will be working for a fire captain or a police sergeant or whoever is the incident commander for that particular piece of the incident. They are working under their direction. The work assignment is based on what that the incident commander at that local level needs them to do.

If you read the doctrine and have no experience in actually executing [it], you will think, "Oh, okay, well the Feds just come in, [and] start doing their thing because the locals are incapable," for lack of a better description. You get this mindset that, "Oh, okay, it is just like going to Afghanistan. I come in, I have a piece of terrain, and I start doing my thing on that piece of terrain and just report to my higher headquarters."

Well, there is a lot of lateral coordination that takes place during a disaster operation. We have to pull those DoD commanders aside and say, "Hey, look, you may be a senior colonel, but you are working for this 28-year-old fire engineer down here. You need to do what they say. They are the ones who are driving the boat in this particular situation."

For Participant 001, the missing details related to shifting personnel mindset from being in a military operation with a commander in charge to being a support player for a

civilian operation. Participant 001 also discussed a key area that many participants identified as lacking details in the doctrine: execution. The participant said,

> [The doctrine] really does not get into the execution piece of it. What I mean by that is [the doctrine] talks about why and how the federal government gets involved, and then, to an extent, how DoD comes in as part of the federal government. However, the [doctrine does] gloss over the fact that disasters and emergencies are a state and local responsibility.

Similarly, Participant 004 stated,

> [The doctrine] does not anticipate all the different disasters or emergencies we have to respond to. It is incumbent on the component lead for the DoD, which is USNORTHCOM, and the service lead, ARNORTH, to conduct planning, preparation, and exercises to close the gap."

Although all the participants praised the joint and service doctrine, they perceived it as missing details key to improving hurricane response.

Subtheme 1c: There Is a Disconnect Between Training and Implementation in the Joint and Service Doctrine. The third subtheme focused on the perceived disconnect between training and implementation. Participant 015 said,

> I just do not think that the average captain and sergeant have read the doctrine. If those on the ground responding are not trained and are not required to be familiar with the doctrine, then they cannot aid in responding to disasters such as hurricanes.

Participant 007 described the disconnect by saying,

> I believe there is a little bit of a disconnect as to how we train for and respond to large domestic operations-type events. Predominantly in the U.S., while USNORTHCOM has the onus for Title 10 active-duty response to any catastrophic event, it is mainly up to the states to respond first and then coordinate with other states to do their response through the EMACs. If [states] get overwhelmed, then the Title 10 active-duty forces will come in at the request of the governor of that state or those states. [Also], if it is a multistate event, they respond. When you talk to active duty, specifically ARNORTH or USNORTHCOM, they have to train in addition to their wartime mission. They have to train for these domestic operations and DSCA-level responses. Just as most unit commanders would do, if [active-duty personnel] have to train on that test, they think they own it.
>
> There is a little bit of disconnect when we talk about joint response. Who has the authority, and who is in charge? Ultimately, [control] is at the state level until such a time the state says they cannot handle it. When those active-duty forces come in, they are [there to] support the state forces and the DSC who has been stood up in that state to conduct those operations. They leave once they are done. I do not know if the joint doctrine explains that in those terms or as well as it should.

Participant 012 perceived the text of the doctrine as sufficient but lacking standardized training for those in command on the ground:

> Obviously at the beginning of their assignment, a DCO is unfamiliar with a lot of that information. Hence, the reason for a certification exercise is for the DCO to

> familiarize himself or herself with all [their] counterparts in that region. The idea is to have one within 90 days of taking office in a region. However, that is aspirational. It may not always happen, and the DoD accepts that risk. I say that the language [in the doctrine] is correct. It is just that the level of readiness varies when that DCO arrives and [based on] what events are happening inside and simultaneously.

In addition to missing details, some participants described the disconnect between training and response needs as a joint and service doctrine flaw.

Theme 2: DoD is Properly Organized for DSCA; However, Issues Remain

Although some participants perceived DoD organization as having no negative impacts on response ability, many perceived communication and reporting, the uncertainty of hurricanes, troop qualifications, and structural issues as having negative impacts. The second emergent theme reflected the participants' perceptions of the potential impediments to the DoD's organization and hurricane response ability. The theme had four subthemes based on the participants' experiences. The first subtheme included perceptions that the DoD's organization had no negative impacts; the other three addressed categories of perceived negative impact: communication, uncertainty, and structure.

Subtheme 2a: No Negative Impacts. Most participants indicated that the DoD's organization did not negatively impact its response ability. Participant 015 said,

> The military is organized around a plug-and-play framework. If you need an asset [or] a capability, the military probably has that capability. The military's ability to pick and choose elements from different units to create a task force tailored to a

specific scenario is unparalleled within the government and arguably within the civilian sector.

Similarly, Participant 019 stated,

> The different elements that compose the armed forces are designed to compete effectively to respond effectively and comprehensively to different hurricane response scenarios. The DoD, whether it is Title 10 or 32, has what FEMA designed to respond to different scenarios, including hurricanes. FEMA has emergency support functions, the different areas they bring to bear to respond to different situations, and the armed forces are built with all those functions. In other words, you find, on the DoD side, parallel functions to FEMA. I believe this gives DoD the ability and capacity to effectively and comprehensively respond to a hurricane or any other emergency situation.

The participants indicated that due to the organizational structure, the DoD was the ideal entity to provide aid and relief during response to hurricane-impacted zones. However, Participant 010 felt that the organization of the DoD remained disconnected from the ability to respond. Participant 010 said,

> I do not think the unit organization construct has anything to do with the DoD's ability to respond in a timely manner. DoD is not the LFA when it comes to disaster response. In this case, it would be FEMA once they articulate and register requirements. After all my experience, DoD is well organized to do it. It is not so much organization; it is about expediting processes to get capabilities out there.

Participant 010 did not think the DoD's organization was a significant factor in hurricane responses. The participant's response addressed one of the shortcomings in the second subtheme: speed of response across the chain of command.

Subtheme 2b: Communication and Reporting Impacts. Several participants felt that communication and reporting issues negatively impacted the DoD's hurricane response. Communicating and reporting issues included organizational politics, the perceived lack of speed in which troops received orders from the chain of command, and miscommunication. Participant 001 described higher headquarters' focus on reports as cumbersome:

> There is a larger reporting chain with daily requirements to report to. This is where it gets a little cumbersome. I am aware that these military organizations have a very long reporting chain that follows them into deployment. It seems like it takes a lot of their time to keep the higher headquarters informed of what is going on.
>
> I can appreciate that the higher headquarters are interested in knowing that their personnel are safe and their equipment is operational, but it seems to take on its own life in some instances, where instead of focusing on doing what we need that element to do, they are focused on packaging their reports and briefings [instead of] letting the DCO be the point of observation of what is going on and letting that DCO and their staff package [that] information and push it up to their higher headquarters so they can keep that unit involved or informed. When we need that element for DSCA operation, we do not typically need the entire battalion; we just need that one specialty platoon or maybe even a company to

> carry out a particular task in a particular area of operations. We do not need the whole logistics train to come with them to carry out that operation.

Participant 001 discussed how the "focus on reports" and the "packaging" resulted in a slower response that required a more efficient, streamlined reporting process. For other interviewees, such as Participant 002, politics negatively impacted response speed, especially for the National Guard:

> It seems that politics plays a role in how quickly we are flowing forces to disasters. Sometimes, the EMAC is a reeducation where we have to go back and explain to the requesting party that the support may not be for free and why some of the capabilities are not available to them.

In addition to politics and reporting requirements impacting response times, Participant 003 described miscommunication as an issue:

> I have firsthand experience with the relationship between active Army soldiers and National Guard garrison units supporting us. There was a lot of miscommunication. I would say that structurally and in practice, especially for hurricane response, it could get really messy so far as knowing when the state has used up all of its resources [and] now the National Guard is expended, [so] now we bring [in] the Reserve.

Some participants indicated that communication and reporting issues, whether related to headquarters requirements, politics, or miscommunication, were obstacles to response.

Subtheme 2c: Uncertainty Surrounding Hurricanes and Qualifications of Available Troops. Another concern with DoD organization among the participants was

uncertainty regarding hurricanes and the ability to accurately ascertain the qualifications of available troops with timeliness. Participant 007 described the impact of uncertainty and hurricane severity and devastation on readiness:

> It depends on the level of the devastation, it depends on the type of incident, the type of event, and it depends on the state's capabilities and what they are able to do if it is a disaster. I think that most states are accustomed to the usual disasters that typically occur in their state. Alabama is good at planning for and responding to hurricanes. If a Magnitude 7 earthquake hits, the state would not have the capability or have planned for the capability to respond to it. They would jump to a Title 10 response quicker than if it were a hurricane or a winter weather storm.

Participant 007 suggested that the uncertainty of disaster impact and the capabilities of those closest and able to respond first could affect the organization's readiness posture. The participant indicated that a lack of knowledge of who can and has the ability to respond and the disaster's potential impact could affect the implementation of a timely response.

Other participants discussed the uncertainty of the availability of qualified active-duty troops. Participant 013 described the uncertainty as a "pickup game" where those available were the ones who responded:

> [The response is] not as effective as it could be because USNORTHCOM and ARNORTH do not own the units that are assigned to the organization. It is like a pickup game once an event occurs. Thankfully, with hurricanes, you usually have more lead time. It is not like an earthquake, where you just have to show up.

> There is a little bit more time to review the standing EXORD and start activating some of the units [before a hurricane].

Participant 009 indicated that although there may be qualified troops, they might lack immediate availability. Regarding the decision to call the National Guard, the participant said,

> There may be a capability that FEMA is asking for, but the DoD may not have a force that is on active duty that is readily available. This is when the SECDEF will ask to borrow that capability from a governor who has the same within his or her National Guard.

The uncertainty of needing specific capabilities and their availability was an impediment that resulted in a request from another branch of service. Similarly, the lack of swift communication in the DoD described by the other participants could present challenges with disaster response.

Subtheme 2d: Structural and Organizational Issues. The final subtheme was perceived structural and organizational issues with the DoD. The most mentioned structural issue was the deployment of troops with optimized training for combat, which required a shift of mindset during the hurricane response. Participant 004 said,

> I think one of the challenges is the DoD is optimized for combat. We [at the DoD] are optimized to deploy and fight, and we build combat-ready units. Usually, in DSCA operations, what FEMA wants from us are trucks and drivers, water purification, communications, and individual capabilities. [FEMA does] not want units, [but] we provide units. A good example was in the U.S.VI, [where] I ended up getting a Marine battalion landing team of infantry, but then what we wanted

> to do was parcel them out. We wanted some to open roads, some to hand out supplies, some to drive trucks, and some to conduct search and rescue. You almost have to reorganize your forces to meet the mission assignments that FEMA has for you.

Other participants also mentioned the structural issues of reorganizing troops for a dramatically different function than their training. Some participants discussed the structural and organizational issues they perceived as negatively impacting disaster response. Participant 011 identified the NRF rather than the DoD as having a problematic structure:

> The NRF is not optimized to take advantage of the experience that the DoD can potentially bring to the table. I think what happens is that the local state leaders do not understand the capabilities that are brought to bear uniformly.

Participant 003 stated that structural issues resulted in unclear boundaries for reporting and command:

> You are jumping into an invisible wall between the National Guard, the Reserve, and, as a final escalation, active-duty forces. It can get messy despite the fact we say we are all one army, one fight. It is a great slogan; however, when you bring all three of those major components of the Army together and try to work toward a single hurricane response operation, the blurring of those boundaries can get really messy, especially when funds are concerned.

Participant 008 mentioned problems with the placement of key stockpiles by the DoD in locations impacted or near hurricanes:

> Some of our key stockpile locations are potentially in the path of a hurricane. In addition, the location of some of our key personnel is also an issue. Proximity is not always the worst thing, but it is left to probability a great deal because we often do not have teams [with] more than one or two people deep in a lot of locations.

Participant 008 noted the benefits of having resources close at hand but indicated that their likely availability was an issue.

Theme 3: DSCA Training Is Effective With Some Limitations

While the participants praised the DSCA training for quality, they perceived it had numerous limitations regarding uniformity and complete training verification. The third emergent theme reflected the participants' perceptions of DSCA training, and four subthemes emerged. The participants described the training's high quality and efficacy but also its limitations.

Subtheme 3a: DSCA Training Is Effective. Some participants perceived the DSCA training as effective and robust. Participant 015 described the training phases as "effective as an orientation," saying,

> I think the exercises do a very good job of opening the eyes of commanders at the tactical, operational, and strategic levels to the complexities of dealing with the interagency across the full spectrum of the U.S. government, as well as the civilian components of the DSCA enterprise.

Participant 003 described the DSCA Phase II as robust and well-done:

> DSCA Phase II was by far one of the best courses I have ever participated in because [it had] a lot of good representation from the different components,

> [including] FEMA and DHS. The insights from each of those organizations get you thinking about how each of those components views their role during disaster response.

Participant 005 said the training provided a valuable understanding for those with little hurricane response experience:

> DSCA Phase II opens up your eyes if you do not have much experience. There are many other DSCA courses. Most of them are online, but there are some in-person ones. With the in-person ones, I can see people's minds open up during discussions of how the scenarios actually apply to real-world events.

Subtheme 3b: Difficult to Assess Uniformity and Verification of Training Completion. The second subtheme addressed the participants' perceptions of the difficulties of assessing training uniformity and completion verification among troops. Participant 018 said,

> It has been a while since I did DSCA training. I assume they are getting completed when they are supposed to. I know units tasked with missions pertaining to DSCA must go through and complete the training, and there are checks and balances to ensure training happens.

Although Participant 018 noted structures for ensuring training completion, the verb "assume" suggests an uncertainty regarding whether the training occurring as intended.

Participant 006 said training uniformity was an issue, as training could vary by location:

> I have seen that [training] varies wildly. The units seem to focus on what they think is much more of an immediate problem. [For example], if you are in the

> middle of the country, they will consider tornadoes or earthquakes or flooding. If you are on the coastlines, they are very sharp about hurricane response.

Participant 007 expressed concerns about training uniformity across units:

> I think it depends on the type of unit you are in. When you get down to the company level, they do not receive that much training. When you get up to the battalion and higher units assigned to be a standing task force or joint task force, there is a little bit of training that goes on. Any training we do for responding to domestic operations has to be done in relation to that unit's wartime mission.

Participant 007 indicated a concern over shifting the mindset from wartime to peacetime functionality and nonuniform training across units.

Subtheme 3c: Shortcomings of the Current Training. The third subtheme addressed the perceived shortcomings in the training program, including implementation. One shortcoming was that Phase II was not a universal requirement. Participant 006 said, "It was a requirement that everyone in Task Force Operations was DSCA Phase I qualified."

However, Participant 021 described DSCA Phase II as a more limited offering, saying, "ARNORTH runs DSCA Phase II at Joint Base Sam Houston or through a mobile training team that goes out to different organizations. The slots are limited and generally reserved for majors and above or master sergeants and above."

Participant 017 also described the shortcoming of limited training:

> In my opinion, too few people get that training, and it tends to be a small number of senior leaders. Unfortunately, the masses are short of some information and knowledge that might help them contribute to the overall DSCA operation.

Similarly, Participant 006 described the senior officers as having certification, whereas "the younger soldiers just had practical experience."

Subtheme 3d: Limitations of the Current Training. The final subtheme focused on the limitations of the current training, such as the lack of allocated resources for the training and the need for revision. Participant 021 presented the lack of available instructors for DSCA Phase II as problematic, saying, "It is a commander's issue, and there are only so many people that can go teach DSCA Phase II; realize that it is a throughput issue."

Participant 012 described the lack of resources as a "lack of bandwidth." A lack of resources allocated for DSCA instruction was another perceived limitation of the training.

Participant 010 suggested streamlining the training for efficiency:

> Across the board, our whole training and preparation is pretty robust, for lack of a better term. We are reviewing where we can consolidate some of the training and exercises to get after what we need so we do not have 72 events on a calendar, all toward the same goal. At every one of these rock drills, it is the collective group still in attendance, so you are almost hearing the same information three different times.

Participant 004 advised revising the playbooks due to the size of the United States and the variety of response situations:

> The problem is, in a big country like the United States, there are more scenarios than you can train for. The DCO is generally training for a major exercise in a playbook every year, and it is like a 3-year cycle to plan for it. It is good, but you

are constantly revisiting it as military people rotate out, so you can probably never keep up with it.

Participant 008 identified the need for follow-up training as a limitation, stating, "There should be quarterly follow-ups to review exceptions to policies, new capabilities, and build partnerships within the network of personnel who respond to these types of events." Thus, due to the country's size and varying disasters, the participants suggested continuously updating training materials. The participants also indicated the need to address the limitations related to a lack of resources to train additional personnel.

Theme 4: Generally Accurate Reporting of Equipment Readiness

The participants reported that the DoD systems and materials were available, in working condition, and accurate. However, perceived shortcomings of the systems and materials included the difficulty of confirming readiness and general issues regarding equipment and its care.

The fourth emergent theme included the participants' perceptions of the DoD systems for confirming material availability and condition when deployed. Theme 4 had three subthemes: accuracy, readiness confirmation problems, and equipment and deployment problems.

Subtheme 4a: DoD Systems Were Perceived as Generally Accurate. The first subtheme includes the participants' perceptions of DoD systems for confirming the availability and reliability of materials as accurate. Participant 006 described this accuracy as "probably about 85% accurate at any given time based on materiel shortages, personnel shortages, or competing missions."

Participant 001 said,

> From my perspective, [the system] has been fairly accurate. The DCO tries to get that information for us when we know the DoD elements coming in. We will know what the OR [operational readiness] rate is. We all understand it is difficult to maintain 100% OR; we just want to make sure we have a really good, accurate picture.

Similarly, Participant 005 stated, "From experience, the systems in place are very good because we actually know where everything is, and, for the most part, it is updated. If our system is showing these vehicles are down, they are probably down." Participant 009 also mentioned system accuracy: "Service members are doing nothing different during disaster relief than they normally do according to their MOS. During hurricane response, we are basically asking military personnel to do what they would do ordinarily."

Subtheme 4b: The DoD Systems Have Perceived Shortcomings Regarding Confirming Readiness. Theme 4's second subtheme addressed the perceived shortcomings regarding the ability to confirm readiness in the DoD systems. Participant 013 said,

> In my opinion, it is hard to confirm that the materiel is actually available. A lot of the rolling stock is not designed specifically for DSCA; it is designed for and maintained as wartime materiel. For example, rotary wing aircrafts are doing their wartime mission, and the units that are tagged to support will conduct maintenance. In terms of medical supplies, we do not have a lot of it. The Health and Human Services provides support with an ambulance contract.

Other participants described the systems as only as good as the information entered into them. Participant 003 mentioned that issues occurred from human error and fallibility, saying, “Speaking from the perspective of the IT professional, those systems are only as good as the frequency by which they are updated.”

Participant 008 also discussed accuracy:

> Unit Status Reports are not accurate simply because humans input the information. We need to work on the interoperability of systems, not just the DoD specific where you must have a common access card or a[n] email address. It needs to be more robust or user-friendly to make our communication more seamless.

Participant 020 reported, “[System accuracy] varies by unit OR. If the unit is sitting at 70% OR, then they are not going to have it. I think in a lot of ways, the soldiers make it work.” The participants perceived the systems as generally accurate, but several discussed issues related to the ability to accurately confirm the readiness of materials.

Subtheme 4c: The DoD System Had Perceived Shortcomings Regarding the Equipment, Its Care, and Its Deployment. Theme 4’s final subtheme addressed the participants’ perceptions regarding shortcomings in the DoD equipment systems and their care and deployment. Participant 015 said, “I know the systems do exist. I do not think they are used effectively, and there are countless variables as to why that problem exists that probably go way beyond the scope of this discussion.”

Participant 012 described the issues with the emergency stockpiles:

> The Army Materiel Command has regional storages that coincide with FEMA’s National Strategic Stockpiles. The materials in there are out of date; they are

> designed to be encased and only utilized during an emergency. Because they do not rotate, some materials do expire. This became apparent from the spoilage that occurred during the COVID-19 pandemic.

Participant 007 spoke of unit-level maintenance issues from transitioning away from the War on Terror mindset:

> I think there is a lack of unit-level maintenance to keep the vehicles in order. The lull is a result of transitioning from 20 years of global war on terrorism to steady-state operations in the armories and Reserve centers.

Although the participants perceived the DoD systems for confirming resource availability as accurate, they described several issues related to materiel deployment, maintenance, and condition.

Theme 5: Perceived Deficiencies and Lack of Awareness

Whereas a few participants perceived the leadership and education programs as effective, many perceived deficiencies in the training, a lack of awareness, and limited program provision. The fifth emergent theme included the participants' perceptions of leadership and education programs for service members. Some participants described the program as effective; many others perceived flaws and deficiencies. The three subthemes were positive perceptions, a lack of awareness of the training, and a lack of offerings within the program.

Subtheme 5a: Education and Training Were Perceived as Effective by a Few.

A few participants perceived the offered education and training as effective. Participant 003 said,

> Speaking [about] just those standard military schools [and] professional military education channels, I think they prepare individuals for leadership in general. When you use the lexicon of setting up an operation, the system of the orders process, and managing troops and units at every echelon from battalion to divisions, I think they do a really good job from that perspective.

Participant 003 also felt the DSCA training increased leader efficacy and said, "When we go into DSCA, I would say with a caveat that if we did not have the DSCA-specific education, I think those leaders would not be as effective."

> Participant 010 recalled positive experiences in a War College for DSCA training: As far as DSCA is concerned, I think it is fine because we have this robust education program at the individual and collective levels that occurs regularly within USNORTHCOM. If we know we are getting capabilities to support us, we are going to ensure they understand the job.

Therefore, some participants considered the DSCA education effective and impactful.

Subtheme 5b: Perceived Deficiencies in the Education Program. Although some participants had positive impressions of DSCA education and training, many noted shortcomings. The second subtheme addressed the numerous perceived deficiencies in the education and training program. Participant 008 offered several suggestions for improvements, saying, "The education is inadequate. There needs to be quarterly and more tiered professional training. Completing DSCA Phase II helps you work in the environment; however, the professionalization needs to be more readily available with something more like a recertification."

Participant 019 described the DSCA education and training program as limited due to a lack of allocated resources to offer training, saying,

> [Training] is not widely available for the general military population. Most units undergo that training only when they have been identified for a mission. I would think if both the courses and the exercises were more widely available, it would increase the pool of responders if needed. Soldiers may be assigned to a particular unit for a few years, but then they move. A broader availability of training would increase that capacity.

Participant 005 suggested customizing the education and training program for each state:

> Maybe they customize the program by each state. I think the schoolhouse is doing a good job of just explaining DSCA in the overarching concept; however, each state has its own rules and laws, and a lot of us go to different states to provide support.

Participant 002 discussed the need to improve younger leaders' access to the education and training program for the DoD:

> I think there is a great opportunity to improve in this area. I did Joint Professional Military Education when I was a junior lieutenant colonel, and that was my first experience learning about DSCA operations. We need to hone in on that earlier, maybe at the E-5, O-2 level, [which] is boots on the ground advising the civilian counterparts instead of waiting for it to come to lieutenant colonel or E-9 level, where we are at home monitoring from afar. I think we need to do a better job of getting our younger leaders involved, informed, and educated.

Many participants described the DSCA education and training program as having limitations and deficiencies. Participant 002 suggested doing "a better job getting our young leaders involved, informed, and educated" in the military. The final subtheme included further program limitations.

Subtheme 5c: Perceived Lack of Awareness of, Interest in, and Access to Training. Theme 5's final subtheme was the perceived lack of awareness, interest, and access to the DSCA education for service members. Participant 012 discussed the overall lack of awareness regarding the training, saying, "Existing courses sufficiently cover [DSCA], but I just do not believe that there is enough awareness of these courses for more people to take them." Many participants also perceived a lack of interest, differing priorities, and a lack of access as problems. Participant 004 identified soldiers' lack of interest in training for disaster relief as a major issue. The participant said,

> I never did anything in DSCA until I became the DCO in my 26th year of military service. I know that besides DSCA Phase I and II, you can take an elective course at the command and general staff college. You can also take a course at the senior service colleges, but, generally the services do not spend much time training for DSCA because we are focused on readiness for combat; DSCA is not readiness for combat. Unless you have a particular interest in it, most services are not very interested in or preparing for DSCA training.

Participant 011 discussed the differing priorities among members of the armed forces:

> The question is priorities, right? Being a military officer is shockingly hard because there are so many things you have to be good at. DSCA is so niche,

> potentially career-ending. I think we must remind officers frequently that, "Hey, you live in the United States, and you might have to execute an immediate response. And, oh, by the way, if you are nearby but not in the affected area, you might get called in, depending on your specialty."

The participants' quotes suggest that service members with priorities based on their MOS or branch may lack an interest in disaster relief training. Other participants stated that although there is often education and training at higher levels, there is limited training for the personnel responding on the ground. Participant 016 said, "You do not want to take away from the combat missions, which is their priority, but I think having a familiarity with DSCA, even at the junior leadership levels, is helpful."

The above quote also indicates that service members have differing priorities; therefore, even junior leadership may lack DSCA familiarity, and personnel on the ground may lack training. Participant 017 said,

> I know, generally, those at higher headquarters and certainly at USNORTHCOM have had enough training. However, downtrace units that get mobilized could probably use more DSCA training [to] help them communicate effectively using the right kind of language when they are in a partnered activity supporting local communities.

Participant 021 noted how the focus for officers at the senior service colleges did not always extend to the subordinates:

> We did not really talk about it in the basic officer course or the captain career course. In the CBRNE realm, where we are focused on DSCA, I think the officers do a better job now, and maybe the Sergeant Major Academy does too. DSCA is

> an elective you can take at the command and staff colleges. I think it ought to be prioritized at those centers because when folks go and complete their joint time at around the senior major time, they will be involved with DSCA.
>
> I know the young soldiers and young leaders do not get it. Quite honestly, you see that when you go out to these training events. I am not 100% sure the soldiers know why they are there. They know they are here doing, let's say, a response to help civilians, but they do not know why.

Many participants reported the following issues: soldiers' lack of interest in the DSCA education and training program, limited program awareness, and a lack of training access for nonofficers.

Theme 6: Confirmation of Training is Somewhat Effective

The participants perceived the process for confirming personnel as qualified as effective. However, the participants noted challenges and shortcomings regarding team structuring and command, troop training and availability, and confirmation certainty.

The sixth emergent theme included the participants' perceptions of the efficacy of confirming personnel qualified to respond to hurricanes. Most participants perceived the confirmation methods as effective. However, participants noted challenges in three main areas: team structuring and command, troop training and availability, and confirmation certainty. This theme had four subthemes.

Subtheme 6a: Confirming Personnel Are Qualified Is Perceived as Effective. The first subtheme included the participants' perceptions of the means of confirming qualifications as effective. Participant 001 said,

I am confident the DoD does a great job of keeping the folks qualified in whatever their particular skill set is. In fact, I tell people that DoD probably does a better job than any organization of dedicating resources to make sure their personnel are not only qualified but are being developed for the next level. Similarly, Participant 003 stated, "I think we do a great job as far as hurricane response operations and training goes. We bring in those competent professionals based on their MOS and along those lines."

Participant 006 described the efficacy of checking qualifications as "good enough," saying,

> I believe we are training the forces that are already on a potential assignment to USNORTHCOM. They have enough repetitions on the exercise to be fully qualified. I think we get to, for want of a better term, good enough qualified.

Similarly, Participant 010 said, "I think the processes are effective. With the repetition we have in responding, those processes get better and better with more repetition."

Participant 021 stated,

> I think the [command post exercises] and FTXs do a good job of stressing, testing, and ensuring they know what they are doing. Leadership at all levels needs to ensure their folks have the right training. Emphasize or stress for personnel to take the independent FEMA courses, which are not particularly time-consuming. Leaders could allot time for personnel to complete courses and have some professional development sessions to discuss what they learned. From what I have seen, the soldiers and the leaders do show up with what they need.

The participants perceived the processes of confirming training qualifications as effective.

Subtheme 6b: Challenges and Shortcomings Regarding Team Structuring and Command. The second subtheme included the perceived shortcomings regarding response team structuring and command. Participant 003 said the challenge was not confirming their qualifications but putting together a composite team: "The challenge is structuring those forces to composite teams you can bring forward into a hurricane. The most imperative is to have the right kinds and variety of expertise you need to run a successful operation."

Participant 017 emphasized the importance of ascertaining leader credentials over those of individual soldiers:

> The essentials are driver's license qualifications and things that are going to impact safety. We can grab someone who is lacking the DSCA training and still ask them to move something with a forklift. [For example], an engineer might move some earth, and any soldier can help with sandbagging. We do not want to lose lives in the process of conducting DSCA, so safety is important.

Some participants perceived that a personnel challenge was structuring composite teams with adequate and varied training to respond to the situation.

Subtheme 6c: Challenges and Shortcomings Regarding Troop Training and Availability. The third subtheme included the perceived challenges and shortcomings regarding troop training and abilities. The participants described recognizing shortcomings as essential for improving readiness. For example, Participant 013 said that troops can only effectively work if they receive effective training:

> For those who take it, it is really effective because they know how to interact. The EPLOs and [defense coordinating element] personnel are familiar because their day-to-day operations involve dealing with their civilian counterparts. I have heard senior leaders say incorrect things in front of others. It is easy to tell they have not had the training, but once they take the course, they realize, "Oh wait, I did not know I am not supposed to be the hard-charging leader during DSCA. I am supposed to be in support."

Most participants described challenges with training confirmation related to duties, training, and mindset. Participant 007 said,

> Some of the duties and responsibilities we ask our personnel to do fall outside of their normal military occupational skill. As a hurricane state, we have high water evacuation teams [with] large vehicles that can travel in high water to conduct evacuation and rescue victims in non-swift water situations due to coastal flooding after a hurricane. The soldiers who perform this operation must be trained in a skillset not taught to the military. We have to partner with other entities to conduct this type of rescue and teach those types of skills with nonstandard equipment. Most service members do not know how to throw a ring at someone who is in the water. We have to figure out ways to train without using Army dollars since it is not a mission-essential task.

Some participants said the troops need more than training; they need updated training. Participant 005 emphasized updating training regularly for increased effectiveness:

> I would say that although the independent studies and the DSCA courses are great, the MOS specific is probably the one that is the biggest challenge. You want to make sure you have the right capability. You could have someone MOS qualified, but if they have not done that job for 5–10 years, they may not be able to function in the capacity they need. I would say most of our missions are kind of general concept missions. [Sometimes] you need bodies to move stuff, and sometimes you need bodies to just stand there.

The participants suggested updating and making education and training accessible to all service members or at least a wider range of personnel. Participant 019 said,

> Sometimes, it is not so much that they are the most DSCA trained or whether they have gone through exercises like that. [Rather, it is] when all the other factors are pulled together, are they available, are they ready, do they have equipment?

The participants indicated that although there was sometimes an issue with confirming there were trained personnel, the larger concern was ensuring the availability of trained personnel as a resource when needed.

Subtheme 6d: Uncertainty Regarding Confirmation. The issues with training resulted in the final subtheme of uncertainty regarding confirmation that personnel have undergone disaster response training. Some participants indicated a potential inability to confirm whether personnel had received training in the DoD. Participant 018 discussed uncertainty regarding the ability to confirm whether deployed personnel had training for hurricane support and relief efforts: "I do not specifically know about the training for search and rescue right now. As far as active-duty units, when they are tagged to do a DSCA mission, they go through the training prior to the mission."

In addition to uncertainty regarding trained personnel, the participants identified specific problems with the confirmation process. Participant 013 perceived a lack of set guidelines for confirmation, with the members of each unit "making up their own thing." The participant stated,

> There is a lack of guidance on the necessary qualifications for different levels. Each unit makes up its own thing. I have heard some people who were requesting seats in the course mention that our SOP says we must have it. Well, someone else's SOP does not.

A lack of consistent guidance on the necessary qualifications contributed to the participants' uncertainty regarding certification and training. In addition to the lack of guidance, some participants discussed issues with confirmability for response teams with multiple branches. Participant 002 said,

> At the JTF, I accepted soldiers and airmen for a disaster mission. Because there is no joint system where I can see all personnel, I would have to pull in an Air Force expert with access and get into their systems to see if those airmen were qualified. My warrant officer and I could see the Army data just because we had Army access.

Some participants perceived the lack of consistent, set guidance on required training a problem. Other participants identified an inability to easily and quickly certify the training of other branches challenging.

Theme 7: No Shortage of Facilities for Hurricane Support

Participants perceived the DoD had many facilities to designate as support bases and identified key considerations for selection. The seventh emergent theme focused on

participant perceptions of the DoD facilities that could be designated BSIs or ISBs during hurricane relief operations and the key considerations for selection. Theme 7 contained two subthemes: (a) a generalized description of the DoD facilities that could be BSIs or ISBs and (b) the considerations the participants identified as key for such designations.

Subtheme 7a: Potential DoD Facilities. The first subtheme focused on the potential DoD facilities that could be designated support bases. Many participants with direct hurricane experience listed specific bases, but most shared more generalized suggestions based on function. The most common response was that most DoD facilities could be designated support bases. Participant 005 said, "Every federal installation could be called on to serve as a BSI or an ISB."

Participant 010 shared a similar statement:

> All of the [facilities could be bases]. It depends on the location, impact, and track of a hurricane. We could use federal terrain, Reserve centers, National Guard armories, and Title 10 bases. We look at these things as a hurricane approaches. We study where impact is likely for landfall and what is going to be in harm's way. The services have a responsibility for mission assurance and taking care of their own people.

Participant 020 identified a specific installation but added, "You name them," implying any facility could be a designated base:

> You name them: Camp, Fort, Base, Reserve center, or National Guard armory, and the Feds own a ton of land. The National Guard and Reserve are spread all over. If one installation is affected, another installation is not that far away that can help respond not only to them but to the public.

The general consensus among participants was that any DoD facility could be a support base. Some participants provided a more nuanced response of specific bases, particularly ISB and BSI bases in states neighboring or near to the landfall location. Participant 005 stated,

> If you are in Florida or Louisiana and get hit by a hurricane, most of those soldiers and personnel may not even be able to help support it because they are the ones in the impacted area. I would look at the ISBs and BSIs located in the surrounding states that may have lower damage assessment impacts. That would be where I would consider staging them for the hurricane. I would work with those states in the affected area region and review what can be done now.

After describing the criteria for ISB and BSI designation and their capabilities, Participant 007 said, ISBs have a lot fewer criteria they have to meet, but they also go through the assessment process. As long as the sustainment command for USNORTHCOM and ARNORTH are still doing those assessments, it is safe to say those BSIs are in the right locations and meet all the required criteria.

Thus, the participants indicated that although any DoD facility could be a designated support base, the ISBs and BSIs in states neighboring the hurricane-impacted zone would likely be the ones tapped.

Subtheme 7b: Key Considerations for Selection. The second subtheme addressed the key considerations identified by the participants as criteria for selection. Location was the most common criterion described. Many participants said designation often occurred based on the storm and region. Participant 008 said, “[Designation] is a multitiered question based on your region.” Participant 015 said, “[Selection] depends on where the

hurricane strikes, how strong the hurricane is, what kind of damage is done between the hurricane making landfall, and where the BSI is located." Similarly, Participant 018 said, *"*We do have the resources. At the same time, we want them located just on the outskirts of the disaster zone so they are not impeded by the hurricane."

Many participants indicated that selecting a facility as a support base occurred based on disaster location and severity (in this case, the hurricane). Leaders at the DoD wanted a response base outside the impacted area but near enough to provide meaningful support. DoD leaders often survey bases and installations for readiness. Participant 006 said surveying should continue annually:

> I think what we need is to continue assessing annually, state by state, and along the affected coastlines. Fort Johnson, Louisiana, was in a great location to help eastern Texas and Louisiana, probably most of the way into Alabama on the coastline.

Participant 007 described the surveying process in more detail while expressing uncertainty as to its continuance:

> They have a BSI handbook they review to identify and assess all of the federal locations throughout the country. Do they have the correct life support? Do they have bulk fuel? Do they have base operations that can coordinate with units who are coming in to conduct [a joint reception staging onward movement and integration]? There is a checklist they go through to accomplish this.

Continuous DoD surveys could be an effective means of identifying and confirming facility readiness.

Theme 8: Lack of Familiarity With Policies Surrounding DSCA

Although the general perception was that policies supported readiness, the participants perceived limitations within and resulting from the policies and a lack of familiarity with the policies. The eighth emergent theme reflected the participants' perceptions regarding how policies supported readiness. Most participants considered the policy supportive of readiness; however, they identified key limitations. As a result, three subthemes emerged: the generalized voiced support of policy, limitations from the policies in place, and limitations from a lack of familiarity with policies.

Subtheme 8a: Policies Support Readiness. The first subtheme included the participants' perceptions of policies as supportive of readiness. Participant 001 discussed policies contributing to readiness and said,

> We are overwhelmed with legal support at every level of every federal organization. Everything we put down on paper goes through a team of lawyers before it gets published. I think we are more than adequately supported with policies. In a major disaster such as [Hurricanes] Maria, Irma, and Harvey, policies start getting waived right and left. Typically, that is what we look for whenever we are told we cannot do something. We want to know: is it a law, a regulation, or a policy? If it is a policy, we are going to get it waived. If it is a law or regulation, we are stuck with what it says.
>
> Oftentimes, you have to look at the intent of that policy. In some cases, it is to create efficiency, prevent misutilization, or something like that. In a major disaster operation, you do not really have time to work that out. You really need to get the resource moving now and get it to execute what you need to do now. I

think the policies do a really great job of defining the right and left limits of what we can and cannot do.

Similarly, Participant 012 said, "I believe the current policies and decrees are appropriate and sufficient for implementing DoD support to civil authority." Participant 015 stated,

> I think the policies are very effective. Having participated in some of the very low-level staff planning on some of those policies at USNORTHCOM, I do know those policies are reviewed on a regular basis from a variety of perspectives.

Participant 021 stated, "USNORTHCOM has done a good job with their CONPLANS and units assigned or allocated to USNORTHCOM. I think the CONPLANS are written well. It shows the left and right limits of what a military commander can or cannot do."

The general consensus among the study's participants was that the DoD policies supported readiness efforts. There was one caveat noted by a few respondents: policies did not support readiness unless implemented. As Participant 015 said, "In summary, yes, the policies do work. It is the implementation of those policies at the tactical level that may not always go according to plan." Although implementation did not always occur as planned, Participant 011 said, "I think that when we use them, the Economy Act and the Stafford Act work properly."

Some participants did not find the policies problematic but rather the lack of implementation by troops on the ground. Participant 020 said, "I think [the policy] is good. Whether it is read or not is a good question." The participants generally perceived

DoD policies as supporting readiness. However, the participants acknowledged that the policies only supported readiness when implemented, something not always done.

Subtheme 8b: Challenges and Limitations as a Result of Policies. The second subtheme included the perceived challenges and limitations of policy content. This subtheme addressed the lack of clarity and limitations on action regarding policies. Participant 005 described the policies as clear and helpful overall but noted one area requiring elaboration and clarification, saying, "The only [policy aspect] that tends to be an issue is the role of the DSC. What is the true trigger to activate a DSC? At what time do you activate one to support a disaster?"

Participant 008 stated that the primary issue with the policy was a lack of guidance in getting mission assignments to the proper resource provider:

> They are currently structured down to the detail. The problem is getting those exceptions and getting the mission assignments to the right resource providers. I think if we could work on that portion from overall vendor to end user, we could probably improve those documents a lot.

Although the participants found the policies supportive, they reported the lack of clarity on some points as troubling. Other participants found that the policies limited their actions. For example, Participant 004 identified the Stafford Act as limiting:

> I think most military people do not realize how limiting the Stafford Act is to DoD operations. Most military leaders want to take charge and lead things. I know in the U.S.VI, I reported up a military chain, but day to day, I sat next to the [federal coordinating officer], who sat next to the governor. There were times

when they both looked at me because they knew I had all the capabilities. If you are the governor of the territory of the USVI, you do not have a lot of capability.

Participant 011 described issues with the enforcing order:

> The PCA is tough because you cannot enforce the law on civilians, but you can enforce it on your soldiers. When soldiers are isolated in remote environments, that becomes a thing. Now, usually, it takes some time for them to settle down to the point where they can start thinking about shenanigans. This can happen if you are on a long contingency. You must consider law enforcement functions within your formation, not necessarily outside your formation, and I do not believe people think about that much.

Although the participants generally perceived the policies as providing positive support for readiness, they noted some limitations of the policy.

Subtheme 8c: Challenges Resulting From Lack of Familiarity With Policies. The last subtheme focused on the challenges resulting from a lack of familiarity with policy. Participant 012 said, "The challenge becomes education and awareness and the willingness of the services and commanders to comply and act with a sense of purpose and understanding versus hesitancy."

Similarly, Participant 007 said,

> Most of the lower-level units are aware of the PCA and what it means, and they get those JAG briefings when they conduct [joint reception staging onward movement and integration]. They understand the different statuses of Title 32 state active duty and Title 10 response. Where I think we get a little off course is when we say Stafford Act to some folks in leadership. They know the Stafford

Act is something different between active duty and National Guard, but they do not understand exactly what enacting the Stafford Act means.

When you start talking about PPD 8 and those types of presidential directives at a level that is higher up, there is confluence between DoD and FEMA that most do not necessarily understand. Sometimes, they just need to know, "Okay, I've been given a directive. The governor has told me to do this. We have a DSC now, and my piece of the puzzle is over here." I think it is a rarity to find senior leaders who understand all of the policies.

Participant 007 also believed that senior leaders should familiarize themselves with the policies so they can translate policies to lower-level troops on the ground.

Participant 013 stated,

The policies are effective, but they are not widely read. Very few people are aware of the limitations of the IRA and the PCA. The policies out there are good, but taken all together, I think they still confuse people. One person might know the DoD instruction or the Joint Pub 3-28 and understand the EXORD, but they won't understand the Economy Act. [They may think], "Hey, why can't we just show up? Oh, it's the Stafford Act. If we are doing this, why do we have to worry about getting reimbursed?" Well, this is the guidance that is out there. I think the policies are good, but many are not familiar with all these policies and how they interact together.

Thus, the participants found policies supportive when implemented by troops familiar with them.

Theme 9: DoD Can Support Adequately, but not Efficiently

The participants perceived the DoD's overall readiness as adequate but inefficient for responding to a single hurricane and acknowledged the strain of multiple and simultaneous landfalls on resources. The final emergent theme reflected the participants' perceptions of the DoD's overall readiness for hurricane response. Most participants perceived the DoD as ready to address a single hurricane landfall. However, the participants acknowledged the inefficiencies and dangers of multiple simultaneous or successive landfalls. Theme 9 had three subthemes.

Subtheme 9a: The DoD Is Adequately Ready to Respond to a Single Hurricane. The first subtheme included the general perception that the DoD appeared ready for hurricane response in the United States. Participant 001 said, "From my perspective, I think [the DoD] are adequately prepared to [respond]."

Participant 021 stated,

> We can definitely respond effectively; we have shown it in the past. Take a look at the CBRNE response enterprise with 18,000 personnel. It was designed to respond to one catastrophic event or three near-simultaneous events; therefore, you could use part of that.

Participant 018 described the DoD's readiness:

> On a scale of 1 to 10, I would say we are definitely a 9. Perhaps I am just being overconfident, but I believe we do have the ability to respond as required and provide the necessary support, especially since in a disaster, you do not know what is needed until the requirement is there. DoD is able to support the

> requirements as they come up because we are always thinking of new ways or better ways to make the mission happen.

Participant 12 perceived the DoD as a ready and good resource provider for civilian efforts, saying, "The DoD is 100% capable of responding to activities such as transportation, damage assessments, evacuation planning, communication, debris removal, support of sheltering, military installation, fuel distribution, medical assistance, and coordination."

Most participants considered the DoD ready for hurricane response. One participant considered the DoD ready with ample resources for a single-event response. Participant 006 described the event chain of Hurricane Katrina and Hurricane Rita:

> The current array of forces is stretched because we still have forces in the Middle East, NATO deployments in Europe, and rotational forces in the Pacific. We can respond, but hopefully, it is limited in scope. I think if we had a situation like Hurricane Katrina followed by Hurricane Rita again, we would have a hard time adequately responding to both. I think what we would end up seeing is forces coming all the way down from the Dakotas to help.

Despite perceived DoD readiness for a hurricane, the participants indicated multiple successive strikes in the same state could be an issue.

Subtheme 9b: Inefficiencies and Uncertainties Regarding Response. The second subtheme addressed the perceived inefficiencies and uncertainties regarding the DoD's response to hurricanes. Participant 011 discussed inefficiencies and said, "I think the DoD is good at [disaster response]. Now, will we do it efficiently? Probably not. Will we do it effectively? Probably."

Participant 015 alluded to the inefficiency of the necessary path of gaining approvals to respond:

> I think history will repeat itself this hurricane season and every other hurricane season. Our ability to respond is limited only by time. It depends on the governor of the state or states that are impacted. The good thing is that USNORTHCOM already has a prepackaged [strategy]. USNORTHCOM and FEMA both have standing agreements for the pre-scripted mission assignments. It is just a matter of pulling the playbook off the shelf, getting the signatures from the right people, [such as] the SECDEF and the president amongst others.

Several participants considered the DoD ready for a single hurricane but expressed concerns about response efficiency and speed. Other participants mentioned uncertainties regarding DoD response. For example, Participant 007 expressed uncertainty regarding the personnel sent and their capabilities during a disaster response, saying, "We have a lot of capability in the DoD as a whole with Title 10, National Guard, and the Reserve. Which one do you bring to the fight, and what capability do you put against the disaster?"

Similarly, Participant 004, a retired staff member, shared uncertainty about current capabilities and readiness:

> I think if you asked me, in 2018 or 2019, I would say [readiness] was very high after the experiences of [Hurricanes] Irma and Maria. The United States had suffered several major hurricane strikes, and the DoD was heavily involved in all three. But now it has been 6 years, and probably all the military people who

served have rotated out. Now, you are relying on that cadre of civilians to keep the continuity of all those lessons learned.

There are 15 national planning scenarios, and you do one every year; one of the [scenarios] is a major hurricane. Because I retired from the military, I do not know what their exercise schedule looks like. One of the exercises was the New Madrid earthquake, which was the fault up the Mississippi. They had one for a power outage and one for a nuke in Times Square. I do not know where they are in the exercise schedule for hurricanes, but you probably need to do one every year.

Thus, some participants appeared uncertain about readiness.

Subtheme 9c: Impact of Multiple and/or Simultaneous Landfalls. The final subtheme included the participants' perceptions of how multiple concurrent or successive landfalls might impact readiness. Three participants suggested that multiple landfalls would have minimal impact on readiness. For example, Participant 018 said,

I do not think multiple hurricanes would have a negative impact. It would [have an] impact and be a challenge; however, with the number of units that we have within the United States, while one unit is handling a disaster that may have happened 2 months ago, another unit can take on the next one as required.

Most participants believed that the DoD would have a less-than-ideal response during multiple landfalls. For many participants, the biggest negative impact was the draining of resources. Participant 001 stated,

It is going to water down no matter what organization you are talking about. There is a finite level of resources, and there is really nothing out above the Feds

> once you exhaust EMAC and everything else. With multiple landfalls, we typically are spaced apart. The resources you need during the initial response are not required 1 week into the response.

Similarly, Participant 003 said,

> Just like anything else in the military, you have an operation where you are splitting your available troops on two or multiple fronts. Of course, the amount of power or amount of capability you will be able to apply to each one is going to be divided.

Participant 006 indicated that successive landfalls could impact response unless there was a geographical separation, saying, "I think the second will be a much more limited response. God forbid we had a third. I think we are in trouble unless they are widely geographically separated." Other participants believed that the impact of multiple hurricanes could impact war efforts elsewhere. Participant 004 described the impact of multiple hurricanes combined with troops in a warzone overseas:

> The year 2017 was unique, where you had Hurricane Harvey in August, Hurricane Irma right after Labor Day weekend, and then, about the 21st of September, you had Hurricane Maria. You had three major hurricane strikes in a row, all of which required significant DoD support. We also had units deployed to Afghanistan, so it was a real challenge. Additionally, the Navy's ships are not just sitting at port; they are constantly sailing around the world. The Navy had the capability to support about one, maybe two disasters. When you have three, suddenly, there are more requirements than you have the assets available to support.

Similarly, Participant 011 said, “What ends up happening is we start exhausting C2 very quickly, and we start taking risk with other capabilities, which, as we move into a more tense relationship with adversaries, puts us at even more risk.”

Participant 002 also mentioned the impact of burnout on multiple concurrent landfalls:

> The DoD would have to get smarter about responding to multiple, either simultaneous or multiple in a sequence. The burnout is high. Not only do we have these disasters, but you also have the regular tempo and the regular warfighting efforts.

Many participants identified the most impactful detriment to DoD readiness as the possibility of multiple hurricanes resulting in depleted or strained resources. A similar experience occurred in recent years. In 2017, there was a rare combination of high disaster frequency, disaster cost, and diversity of weather and climate extreme events. Billion-dollar disasters occurred in six of the seven disaster event categories in 2017; a winter storm with billion-dollar impacts was the only missing event type during 2017 (NCEI, 2023).

Summary

Chapter 4 presented the quantitative results for RQ1 and qualitative results for RQ2. RQ1 included archival data for 1851–2021 and 1991–2020 for trends in Atlantic hurricane activity. Sequence charts and corresponding Mann–Kendall correlations showed statistically significant increases in named storms, hurricanes, major hurricanes, and ACE between 1851 and 2021. There was no statistically significant increase or decrease in U.S. hurricanes between 1851 and 2021. Between 1991 and 2020, there was a

statistically significant increase in named storms but no statistically significant increase or decrease in trends in hurricanes, major hurricanes, ACE, or U.S. hurricanes during this period. The analysis involved fitting ARIMA models to the data to show the trends and predictions of future hurricane activity based on the data from 1851 to 2021 and 1991 to 2020.

For RQ2, the research focused on a sample of 30 participants drawn from a population of over 4,000 DSCA experts. Voluntary disclosures showed the participants had between 5 and 37 years of experience, with the majority having between 13 and 17 years of experience with DSCA training and hurricane responses. Nine themes emerged from the data and reflected the participants' perceptions of DoD readiness for hurricane landfall response in the United States. Chapter 5 presents the summary, study strengths and limitations, and result significance. The chapter concludes with the study's implications and recommendations for future research and practice.

CHAPTER 5: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction and Summary of Study

This final chapter presents conclusions and recommendations based on the study results and two research questions.

1. What is the trend of hurricane activity in the North Atlantic Basin?
2. How prepared is the DoD to support the next hurricane that makes landfall in the United States?

Quantitative data from NHC's HURDAT provided insights into TC trends, and qualitative data from 30 face-to-face interviews with DSCA experts gave insight into DoD hurricane readiness posture. Chapter 5 commences with an overview of the purpose of the study and the research questions. The quantitative analysis results of RQ1 showed a mixed trend of hurricane activities. For RQ2, qualitative analysis indicated in nine major themes and 29 subthemes explicated from the respondents' textural descriptions. The combined results provided the basis for a summary of the findings. Chapter 5 concludes with the study's implications and recommendations for future research.

Summary of Findings and Conclusion

TC losses account for the greatest distribution of damage from U.S. billion-dollar disaster events from 1980 to 2023. TCs are responsible for the highest number of deaths (6,895), followed by drought/heatwave events (4,502) and severe storms (2,094; NCEI, 2023). TCs have caused the most damage ($1,379.9 billion) and have the highest average event cost ($22.6 billion per event). Hurricane Katrina was a Category 3 hurricane that caused over 1,833 deaths and $196.3 billion in damages. Hurricane Sandy, a Category 1

hurricane, caused 159 deaths and $86.5 billion in damages. Hurricane Maria, a Category 4, caused 3,000 deaths and $112.5 billion in damages (NCEI, 2023).

The DoD is a last resort upon NRF activation, with a unique and tremendous capability to support FEMA during hurricane response. Military personnel, usually in support of FEMA, execute DSCA missions through DCOs co-located at the 10 FEMA regional headquarters. DCOs are FEMA's single point of contact for military support. In addition, DCOs liaise between FEMA and USNORTHCOM to assist with the flow of relief to the most affected areas. U.S. military leaders worked progressively to improve disaster response after Hurricane Katrina in 2005, Hurricane Sandy in 2012, and Hurricane Maria in 2017.

Throughout FEMA's 44-year history, seven significant disasters caused massive changes in legislation and the national response. Five of the seven disasters were hurricanes: Hurricane Hugo (1989); Hurricane Andrew (1992); the California Northridge earthquake (1994); Hurricane Katrina (2005); Hurricane Sandy (2012); the California wildfires (2017); and Hurricanes Irma, Maria, and Harvey (2017; FEMA Historic Disasters, 2023). The U.S. Military had a vital role and was a reliable partner during the response to these disasters. DoD leaders worked to improve after the organization's disastrous response to Hurricane Katrina. Lessons learned resulted in a more effective response during Hurricane Sandy. DoD leaders further optimized operations in response to the record-setting 2017 hurricane season.

Hurricane frequency scholars have had three general conclusions. Scholars have found positive and negative trends or cautioned against defining trends due to varying observation techniques, undercount bias, and instrumentation improvements. DoD

leaders may consider these conclusions when allocating resources between warfighting and DSCA operations. The literature review also showed that the DoD is a transparent and learning organization with leaders who accept external and internal feedback to improve DSCA operations. In addition, the literature review showed the sensitivity of DSCA operations due to the U.S. public's leeriness of DoD operations on U.S. soil.

The goal of this study was to better understand hurricane trends and the DoD's hurricane response posture. The mixed methods approach was an appropriate method for gaining a more complete picture of hurricanes and DoD DSCA readiness. Quantitative or qualitative data alone would not have sufficiently addressed the two research questions. Research with the two methods was an effective means of placing the findings in context and adding richer detail to the conclusions for more credible results.

The study involved analyzing 171 years of TC data (1851–2021) from NOAA, more than 788 minutes of interviews with 30 DSCA experts, and 198 interview transcript pages. HURDAT data underwent analysis to answer RQ1:

1. What is the trend of hurricane activity in the North Atlantic Basin?

    $H1_0$: There is no trend in the series.

    $H1_a$: There is a positive trend in the series.

HURDAT included data for the number of Atlantic named storms, hurricanes, major hurricanes, ACE, and U.S. hurricanes each year from 1851 to 2021. The analysis included revised figures for each variable. The study focused on the 30 years from 1991 to 2020 due to varying observation techniques, improvements in instrumentation, and undersampling concerns before the early 1970s. Significant undersampling was an issue before the hurricane reconnaissance era in the mid-1940s.

The findings from the TC data analysis between 1851 and 2021 were as follows:

- The average number of named storms per year was 9.99 (*SD* = 4.58).
- The average number of hurricanes per year was 5.53 (*SD* = 2.61).
- The average number of major hurricanes per year was 1.91 (*SD* = 1.64).
- The yearly average ACE was 89.25 (*SD* = 53.03).
- The average number of U.S. hurricanes per year was 1.77 (*SD* = 1.45).

Mann–Kendall correlations occurred to test for statistically significant increases or decreases in trends and showed the following results:

- A significant Mann–Kendall correlation ($\tau = .40$, $p < .001$) indicated a statistically significant increasing trend in named storms.
- A significant Mann–Kendall correlation ($\tau = .19$, $p < .001$) indicated a statistically significant increasing trend in hurricanes.
- A significant Mann–Kendall correlation ($\tau = .32$, $p < .001$) indicated a statistically significant increasing trend in major hurricanes.
- A significant Mann–Kendall correlation ($\tau = .20$, $p < .001$) indicated a statistically significant increasing trend in ACE.
- A nonsignificant Mann–Kendall correlation ($\tau = -.08$, $p = .148$) indicated no statistically significant trend in U.S. hurricanes.

The TC data analysis between 1991 and 2021 produced the following findings:

- The average number of named storms per year was 14.40 (*SD* = 5.53).
- The average number of hurricanes per year was 7.20 (*SD* = 3.33).
- The average number of major hurricanes per year was 3.23 (*SD* = 2.00).
- The yearly average ACE was 122.40 (*SD* = 65.33).

- The average number of U.S. hurricanes per year was 1.73 (*SD* = 1.76).

Mann–Kendall correlations occurred to test for the presence of statistically significant increasing or decreasing trends and resulted in the following:

- A significant Mann–Kendall correlation ($\tau = .39$, $p = .004$) indicated a statistically significant increasing trend in named storms.
- A nonsignificant Mann–Kendall correlation ($\tau = .12$, $p = .379$) indicated no statistically significant trend in hurricanes.
- A nonsignificant Mann–Kendall correlation ($\tau = .15$, $p = .283$) indicated no statistically significant trend in major hurricanes.
- A nonsignificant Mann–Kendall correlation ($\tau = .12$, $p = .363$) indicated no statistically significant trend in ACE.
- A nonsignificant Mann–Kendall correlation ($\tau = .13$, $p = .377$) indicated no statistically significant trend in U.S. hurricanes.

The results of this study showed statistically significant increases in named storms, hurricanes, major hurricanes, and ACE between 1851 and 2021. There was no statistically significant increase or decrease in U.S. hurricanes between 1851 and 2021. Between 1991 and 2020, there was a statistically significant increase in named storms but no statistically significant increase or decrease in trends in hurricanes, major hurricanes, ACE, or U.S. hurricanes. The results suggest no increase in the frequency of hurricanes that make landfall in the United States.

Separate ARIMA models for each variable for each period of interest (1851-2021 and 1991–2020) showed data trends. The development of each model involved visualizing and testing the data for stationarity with the sequence charts and Mann–

Kendall correlations. There was differencing applied to the model for nonstationary data. Next, determining the order of the ARIMA model involved examining ACF and PACF plots. ACF and PACF patterns indicated the most appropriate AR and MA. Model fits underwent comparison with AIC. Finally, model residual ACF and PACF plots underwent examination to ensure no significant autocorrelation in selected model residuals.

The trends for the most recent 30 years (1991–2020) did not match the entire record (1851–2021), with no trends since 1990 compared to the large trends at the beginning of the database in 1851. The results aligned with the lack of technology in the 1800s and 1900s that resulted in undersampling and artificial trends. The recent and entire database showed no significant trends regarding U.S. hurricane numbers. The records contain more complete data near the beginning of the database and less likelihood of undercounting. The data showed no long-term trends regarding hurricane frequency on the U.S. coastline, the most important metric for decision-makers.

A significant Mann–Kendall correlation for the data between 1991 and 2021 (τ = .39, p = .004) indicates a statistically significant increasing trend in named storms; however, the rest of the recent 30 years showed no statistical significance. Technological improvements could have affected the named storm metric, even in recent years, due to an increased ability to detect and warn the public about weak, short-lived tropical storms. A few scholars have concluded that the dramatic increase in shorties since 2000 does not correlate with geophysical features, including manmade climate change.

The results provided insight into hurricane disaster science not typically considered by DoD planners and responders. DoD leaders operate in a resource-

constrained environment and should attempt to understand the basic science of planning to respond to hurricanes or other disasters. Many DoD personnel believe hurricane frequency will continue to increase (2030 Homeland Theatre Strategy, 2022). However, this study found no increases in hurricane frequency. The results aligned with scholars who have cautioned that changed observation practices, reporting, and presatellite era records could have led to inaccurate TC counts.

The study results also aligned with researchers who have countered the argument for a positive TC trend due to regional inconsistencies, timelines, and study types. This study suggested that mixed hurricane trends do not mean DoD leaders should ignore the importance of preparing for and responding to hurricanes. One major hurricane occurrence, such as Hurricane Katrina, Sandy, or Maria, can have a devasting impact on hurricane-prone regions, impacting lives and causing suffering.

2. How prepared is the DoD to support the next hurricane that makes landfall in the United States?

The goal of RQ2 was to investigate the DoD's hurricane readiness posture. For RQ2, the research focused on a sample of 30 participants from a population of over 4,000 DSCA service members, civilians, and contractors who had worked at the strategic, operational, and tactical levels for various organizations in different regions for different incidents. Voluntary disclosures showed the participants had around 37 years of total experience, averaging between 13 and 17 years of experience with DSCA training and hurricane response. Most participants had responded to between two and eight hurricanes, with one participating in over 20 disaster responses, including tornadoes and typhoons. The participants' experience included DSCA positions such as federal

coordinating officers, retired Army generals, DCOs, EPLOs, SEPLOs, national security attorneys, and ARNORTH employees. Various participants worked in DSCA planning, training, and operations, including in the medical, veterinarian, legal, and military intelligence fields. The participants had completed DSCA training, and nearly all reported some experience with hurricane response, including Hurricanes Katrina, Sandy, and Maria, and other disaster relief operations.

Cisco Webex was the platform for conducting interviews with 10 open-ended questions on DoD hurricane readiness. Rev was the transcription service used to transcribe the 30 Webex recordings. NVivo was the collaborative qualitative analysis software used to analyze the data and develop codes, themes, and content. The analysis included cleaning the data of information unrelated to the study, such as interruptions from an outside person or source, unrelated comments to the study topic, and noises unrelated to the study.

The study showed trustworthiness by aligning with Yin (2009), who suggested "conduct[ing] research as if someone were looking over your shoulder" (p. 49). The research aligned with the key principles of the Belmont Report (i.e., respect, justice, and beneficence) in the study design, sampling procedures, theoretical framework, research problem, and questions. The study did not include special populations such as children, people who are incarcerated, individuals with disabilities, and older adults. Therefore, there were no ethical concerns regarding the population.

Military personnel sometimes use the DOTMLPF-P for capability-based assessments under the Joint Capabilities Integration and Development System. The framework provided a better understanding of the literature on overall DoD readiness and

DSCA preparedness. Thus, the DOTMLPF-P was a useful template for developing the interview guide. Nine themes and 29 subthemes emerged from the RQ2 data. The nine themes reflected the participants' perceptions of DoD response readiness for hurricane landfalls in the United States.

- The first emergent theme reflected the participants' perceptions regarding whether the joint and service doctrine provided well-rounded and descriptive guidance. The participants perceived the doctrine as providing well-rounded and descriptive guidance. However, the doctrine has several limitations, such as missing information and a disconnect between training and implementation.
- The second theme emerged from the participants' perceptions regarding potential impediments to the DoD's organization and their impact on the ability for hurricane response. The theme had four emergent subthemes that reflected the participants' experiences. Some participants perceived the DoD's organization as having no negative impacts on response ability. However, many participants perceived communication and reporting, hurricane uncertainty, available troop qualifications, and structural issues as negatively impacting the ability to respond.
- The third emergent theme included the participants' perceptions of DSCA training. The participants praised the DSCA training for its quality but also discussed limitations regarding uniformity and the verification of completed training. Four subthemes emerged related to the training's perceived quality, efficacy, and limitations.

- The fourth emergent theme contained the participants' perceptions of the DoD systems for confirming materiel availability and condition when deployed. The participants considered the DoD systems for confirming material available and in working conditions accurate. The participants also acknowledged the system shortcomings, focusing on the difficulty of confirming readiness and general issues regarding the equipment and its care and its deployment.
- The fifth emergent theme related to the participants' perceptions of service member education and training. A few participants perceived the leadership and education programs as effective. However, many participants noted deficiencies in the training, a lack of awareness, and limited program offering.
- The sixth emergent theme addressed the participants' perceptions of the efficacy of confirming personnel qualifications to respond to hurricanes. The participants considered the confirmation methods effective. However, the participants noted challenges in three areas: team structuring and command, troop training and availability, and confirmation certainty.
- The seventh emergent theme focused on participant perceptions of DoD facilities designated as BSIs or ISBs during hurricane relief operations and key considerations for selection. The participants described the DoD as having many facilities that could be designated support bases and identified key considerations for selection. Theme 7 contained two subthemes: a generalized description of DoD facilities eligible for such designation and the key considerations for making such selections.

- The eighth emergent theme included the participants' perceptions regarding how well policy supports readiness. Although the participants perceived the policy as supportive of readiness, they also identified limitations within and as a result of the policies and a lack of policy familiarity.
- The ninth emergent theme addressed the participants' perceptions of overall DoD hurricane response readiness. Many participants considered the DoD adequately ready for response to a single hurricane landfall. However, the participants also expected inefficiencies and dangers from multiple simultaneous or successive landfalls. The three subthemes included the DoD's readiness for a single hurricane response, inefficiencies and uncertainties regarding response, and the negative impact of multiple or simultaneous landfall hurricanes.

The findings aligned with the theoretical proposition that the DoD is a learning organization with improved responses after each major hurricane. The findings further indicate the DoD's willingness and capability to support FEMA during the next major hurricane. The study found the DoD has a proper readiness posture; however, Theme 9 showed that the participants expressed concerns regarding inefficiencies and dangers resulting from multiple simultaneous or successive landfall hurricanes. Thus, DoD leaders should address concerns about multiple-hurricane response.

Implications

Theoretical Implications

Theories are means of satisfying human curiosity by providing a way to understand phenomena such as disasters. Academics and practitioners may use theories to

solve problems and advance their fields. The theoretical framework and literature reviewed in Chapter 2 aligned with this study's results. Individuals in the community of interest could use the results to help save lives and mitigate suffering during hurricane response. This study focused on hurricane activities and civil and military relationships and included significant verbal and nonverbal communication between the researcher and participants. The four theories of disaster, two civil-military relations theories, and two communication theories were the lenses used to expand the knowledge of DSCA, hurricane trends, and DoD readiness posture.

The four theories of disaster could have significant implications for the DoD and stakeholders at the federal and SLTT levels. DoD and government leaders should familiarize themselves with each theory because they may encounter survivors who subscribe to any of the four theories during disaster response. Disaster science suggests that disasters such as hurricanes occur due to a combination of human actions, nature, and social constructs, which aligns with three of the four theories. Hurricanes do not occur because a deity wants to punish a person or community. Hurricanes are predictable phenomena that will continue to occur in the North Atlantic Basin. Stakeholders could manage risk by relocating from hurricane-prone areas, building resilient structures, or preparing to evacuate for the next approaching TC. Perceptions could affect action among individuals or communities impacted by a hurricane. The following reactions that could contribute to the action or inaction of individuals encountering hurricanes:

- Acts of fate/acts of God: Do nothing.
- Acts of nature: Use technology, engineering, or money to control hurricane frequency or do nothing.

- Interactive effects of nature and society: Develop society to adjust through careful zoning and awareness of flood plains, seismic areas, wildfire zones, and other land use management.
- Social construction: Review the basic reasons and causes of injustice, human vulnerability, and hazards in society.

The civil-military relations theories provided an understanding of interactions between civilians in the federal and SLTT governments and the DoD, which has a long history of supporting civil authorities during disaster response. The debate between the schools of Huntington and Janowitz focuses on whether more efficient civil control over the military occurs via strict separation or full integration of civilian and military decision-making processes. Huntington indicated that the military is a unique entity; it does not belong to the civilian world and should remain separate. However, Janowitz claimed that the military and society should remain an organic whole.

In the modern security environment, the DoD should focus on unity of effort with partners rather than the unity of command preferred by all military leaders. DoD personnel train with FEMA and other federal agencies, SLTT personnel, and the private sector to strengthen and improve relationships before disaster strikes. Successful DSCA operations may require DoD leaders to consider the political implications of every action and mission with significant political expertise and practice.

Practical and Future Implications

This study provided insight into how DSCA practitioners viewed the DoD and its DSCA mission. The results could provide DoD leaders and stakeholders with renewed confidence that the DoD is a reliable partner for DSCA operations. The findings and

conclusions contributed to the literature on DSCA readiness. Further, the findings provided a knowledge baseline and a potential model for the DoD. In a broader context, the study provided an introspective look and a decision support tool for DoD personnel and other stakeholders to improve hurricane planning and response activities. Finally, the study's results contributed to the knowledge of DSCA operations and DoD readiness regarding doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policies. The study could present the DoD with valuable operational insight and knowledge for improved decision-making during each hurricane response.

The data indicated a mixed hurricane frequency, with the last 30 years showing no positive trends in U.S. landfall hurricanes. The results could have implications. DoD personnel could use available data and collaborate with meteorologists to prepare for and allocate efficient resources to hurricane response to balance other DoD priorities. The study may also have implications for DSCA doctrine and policies. DoD leaders should ensure personnel read and understand DSCA doctrine and policies. The findings showed that many staff do not understand policies such as the PCA, Stafford Act, and IRA, which could hinder disaster response, sometimes causing a delayed DoD arrival. Time is a precious resource during disaster response. Therefore, unnecessary delays can cost American lives.

The results could also have implications for the current organization of DSCA forces. One participant said, "Supporting DSCA seems like a pick-up game." The lack of a dedicated force could result in divided priorities and loyalties between warfighting and DSCA. The junior military personnel who support DSCA may execute missions as they learned during their training for war. However, personnel should understand the task and

purpose of every mission to acquire the urgency and empathy needed during DSCA operations.

The DoD provided and will continue to provide vital support to FEMA during hurricane response. However, the DoD also has infrastructure and valuable assets such as aircraft and vessels that personnel must move to safe locations before a hurricane landfall. If this becomes the norm, DoD decision-makers could use this study to inform future military base construction, realignments, and closures. The mixed trend of hurricane frequency indicates the need for continuous monitoring and assessment of the DoD's hurricane readiness posture. Hurricanes and their ensuring damages may continue to impact the military negatively. Therefore, future researchers could replicate this study and further the results on DSCA and DoD hurricane readiness posture.

Strengths and Weaknesses of the Study

All research, including this study, has strengths and weaknesses. The following are two noteworthy strengths and three limitations that provide opportunities for future research:

- This innovative study could be the basis for future repeated hurricane or other disaster studies.
- The study's methodology (mixed methods) and design (convergent parallel) provided a richer meaning and a better understanding of hurricanes and DoD readiness.
- Ongoing reanalysis of the Atlantic Basin hurricane database could result in updates to actual TC counts in the future.

- There are no long-term data for other regions in the world as for the North Atlantic Basin; therefore, the results have limited use for global comparison.
- The Army is the major proponent of the DSCA response enterprise. However, the study did not include participants from the Air Force, Navy, Marines, Coast Guard, or Space Force.

Recommendations

Recommendations for Future Research

This mixed methods study involved analyzing 171 years of TC data from NOAA and semistructured interviews with 30 DSCA experts. This section presents recommendations for further research based on the data, methodology, and study limitations. The intent is not to criticize, diminish, or tarnish the DoD's or any other stakeholder's image. Instead, the goal is to provide valuable insight into improving readiness and furthering research.

Due to ongoing reanalysis of the Atlantic Basin hurricane database, there will likely be updates to actual TC counts. Even in the 1970s, scientists missed TCs due to limited satellite imagery, instrumentation to interpret the imagery, and policy changes. Future research should occur upon the completion of the reanalysis project because there may be TCs missing in the data before the mid-20th century. This study focused on the North Atlantic Basin, where only about 12% of the world's TCs occur. Therefore, future research could focus on other hurricane basins for global comparison. As major hurricanes continue to make landfall in the United States, future researchers should continue to examine the DoD's hurricane readiness posture.

The study's research design provided a framework for future research on hurricanes and many other disasters requiring DoD support. For instance, a future scholar could analyze the actual trend of wildfires and research the DoD's readiness to support an LFA during the next wildfire. Scholars could replicate this study for floods, earthquakes, tornadoes, landslides, tsunamis, volcanic eruptions, severe winter storms, droughts, extreme heat, coastal erosions, thunderstorms, hailstorms, and snow avalanches. Other researchers could dissect the DoD and its subcomponents to investigate the preparedness of the Navy, Air Force, Marine Corps, Coast Guard, and Space Force to support a major hurricane or other disasters in the United States.

Recommendations for Future Practice

Despite mixed hurricane frequency, hurricane landfalls in the United States can have disastrous effects each year. The DoD's priority is warfighting and homeland defense. However, the organization is also a valuable and reputable partner with an integral role in disaster response. For example, Hurricane Ian made landfall on September 28, 2022, near Cayo Costa, Florida, as a Category 4 hurricane. Before landfall, the U.S. Coast Guard and approximately 10,000 National Guard personnel deployed to conduct DSCA, including search and rescue operations. Federal support included 26 aircraft, 10 rotary wing aircraft, 40 shallow-water boats, and 1,234 high-water vehicles (FEMA Factsheet, 2023). Hurricane Ian in 2022 was the third costliest cyclone to impact the United States after Hurricanes Katrina and Harvey, causing an estimated $116.3 billion in damage (NCEI, 2023). In the United States, Hurricane Ian resulted in at least 156 fatalities, 66 of which were deaths directly caused by the storm. All direct deaths in the United States occurred in Florida (Bucci et al., 2022).

Hurricane response requires a collaborative effort. DoD and FEMA leaders and stakeholders could use the study results to improve hurricane readiness and response. Along with state and local responders, the DoD almost always supports FEMA during a hurricane response. Some examples of support from the DoD (Vergun, 2021) are as follows:

- Coast Guards assist with search and rescue efforts at sea and on inland waterways, sometimes with assistance from the Navy.
- The Army Corps of Engineers monitors dams and levees for possible failure and takes preventive action when necessary. In the aftermath of a hurricane, the corps members shore up damaged storm defenses. The Corps also has temporary emergency power and handles route-clearing heavy equipment and communications capabilities for impacted communities.
- The Defense Logistics Agency may provide trailers filled with meals, cots, generators, fuel, and medical equipment.
- National Guard personnel use helicopters, swift-water boats, and high-water rescue vehicles for search and rescue missions and to distribute aid. Active-duty service members also assist when necessary.

The following are recommendations for practice based on this research. Despite consensus that the DoD has adequate readiness for a response to the next major hurricane, DoD strategists should consider addressing the dilemma of responding to simultaneous or successive hurricanes. The study's 29 subthemes could indicate where to make improvements beneficial to the DoD. Although DSCA operations differ from operations away from the homeland, they require the same planning, support, resources,

and enthusiasm as other military operations. DSCA operations should be a DoD priority because hurricanes in the homeland affect Americans. The mission of the DoD is to fight and win the nation's wars. However, the welfare of Americans should always have precedence and importance. A word search for "disaster" in the latest National Security Strategy, National Defense Strategy, and National Military Strategy found two occurrences in the first two strategic documents and no occurrence in the last, indicating that DSCA operations are somewhat of an afterthought for the DoD.

Issues caused by China in the Indo-Pacific region and Russia in Europe are serious problems. However, there is also the need for a response force postured to support Americans at home during disasters such as wildfires and major landfall hurricanes. DSCA planning and operations should never be an afterthought or a competition for already limited resources. Therefore, this study suggests that DoD leaders consider creating a dedicated DSCA force similar to the Space Force. The proposed DSCA force could undergo training and receive resources only for missions that pertain to disasters in the homeland so the remainder of the DoD can focus on homeland defense and warfighting away from the homeland.

APPENDIX A

ST. JOHN'S UNIVERSITY IRB APPROVAL (INITIAL)

Federal Wide Assurance: FWA00009066

Dec 19, 2022 12:44:41 PM EST

PI: Ralph Scott
CO-PI: Jie Xu
Dept: College of Prof Studies

Re: Initial - IRB-FY2023-149 A quantitative analysis of tropical cyclone trends and experts perception of future military hurricane readiness

Dear Ralph Scott:

The St John's University Institutional Review Board Institutional Review Board has rendered the decision below for A quantitative analysis of tropical cyclone trends and experts perception of future military hurricane readiness.

Decision: This is not human subjects research.

Sincerely,

Raymond DiGiuseppe, PhD, ABPP
Chair, Institutional Review Board
Professor of Psychology

APPENDIX B

ST. JOHN'S UNIVERSITY IRB APPROVAL (MODIFIED)

Federal Wide Assurance: FWA00009066

Mar 2, 2023 1:25:41 PM EST

PI: Ralph Scott
Dept: College of Prof Studies

Re: Modification - IRB-FY2023-149 *A quantitative analysis of tropical cyclone trends and experts perception of future military hurricane readiness*

Dear Ralph Scott:

The St John's University Institutional Review Board has rendered the decision below for *A quantitative analysis of tropical cyclone trends and experts perception of future military hurricane readiness*.

Decision: Approved

Sincerely,

Raymond DiGiuseppe, PhD, ABPP
Chair, Institutional Review Board

APPENDIX C

INFORMED CONSENT

Informed Consent

Title of Research: A MIX-METHODS ANALYSIS OF TROPICAL CYCLONE TRENDS AND EXPERTS' PERCEPTION OF FUTURE MILITARY HURRICANE READINESS

Principle Investigator: Ralph E. Scott
Affiliation: St. John's University, Collins College of Professional Studies
Contact Information: 585.314.3793 scottr2@stjohns.edu

Institutional Contact: Institutional Review Board
St. John's University
718.990.1440 irb@stjohns.edu

1. Introduction and Purpose of the Study
You are invited to participate in a research study under the direction of Dr. Xie Xu of the Division of Criminal Justice and Homeland Security, Lesley H. and William L. Collins College of Professional Studies at St. John's University in Queens New York. This study will investigate whether hurricanes in the North Atlantic Basin are increasing in frequency and intensity, and whether DSCA practitioners perceive the DoD is prepared to assist FEMA or other Lead Federal Agencies when the next major hurricane strikes.

2. Description of the Research
You will be asked to participate in one 10-15 minute online video interview via *Cisco WebEx* where the researcher will use 10 open-ended questions to ask about your perception of DOD's hurricane readiness in the areas of DSCA doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTMLPF-P).

3. Subject Participation
We estimate that 10-12 participants who are members of the DSCA Phase III online group will enroll in this study. Participants must be currently assigned or have supported DSCA operations in any one of the below positions within the last 10 years:

FCO	DSCA Civilians	Task Force Ops	Hurricane Maria
DCO	DSCA Contractors	Task Force Med.	DSCA CDR/CSM/1SG
DCE	EPLO	Task Force Avn.	DSCA S3/XO
DSC	SEPLO	Task Force Sust.	DSCA Trainer
AD, USAR, NG	C2CRE A	Hurricane Katrina	DSCA Instructor
DSCA Planner	C2CRE B	Hurricane Sandy	Other

4. Potential Risks and Discomforts
Participating in this study poses no known risks or discomfort.

5. Potential Benefits
People who participate in this study will help with preparedness and response, and arm decision and policy makers in the federal and at the state, local, tribal, and territorial governments with critical information to make sound decisions before, during, and after the next major hurricane.

6. Confidentiality
All information taken from the study will be coded to protect the subject's name. No names or other identifying information will be used when discussing or reporting data which will be aggregated using *NVivo* collaborative qualitative analysis software. *Rev* transcription services will transcribe the *WebEx* recording which will be encrypted and stored for five years on a password protected computer during and after the publication of this research, after which, all files will be destroyed.

7. Compensation
Each participant will receive $15.00 paid via *Zelle* or *Venmo* at the conclusion of the interview.

8. Voluntary Participation and Authorization
Your decision to participate in this study is completely voluntary. By signing this form, you authorize the use and disclosure of the records, observations, and findings found during the course of this study for education, publication and/or presentation.

9. Withdrawal from the Study and/or Withdrawal of Authorization
If you decide to participate in this study, you may withdraw from your participation at any time without penalty.

10. Cost/Reimbursements
There is no incurred cost for participating in this study.

Do you voluntarily agree to participate in this research study? ☐ **Yes** ☐ **No**

I understand that I will be given a copy of this signed Consent Form.

Name of Participant (print):	
Signature:	Date:
Person Obtaining Consent:	
Signature:	Date:

APPENDIX D

APPROVAL FROM THE ARNORTH TRAINING MANAGEMENT

ST. JOHN'S UNIVERSITY

Date: 16 December, 2022

To: Philip J. Halliburton

CC: Joseph K. Miller & Glenn M. McRill,

Attachment: Survey Instrument

Scott, Ralph, E.
Doctoral Candidate
Collins College of Professional Studies
St. Augustine Hall
(585) 314.3793
scottr2@stjohns.edu

Subject: Agreement to Upload Survey on the MilSuite and DSCA Phase III Facebook Page

Good day:

My name is Ralph E. Scott and I am a doctoral candidate at the Division of Criminal Justice and Homeland Security of the Lesley H. and William L. Collins College of Professional Studies at St. John's University in Queens New York. I am also a career military officer in the United States Army Reserve. I am requesting your permission to upload a survey to the 4000+ members of the Homeland Defense & Civil Support Operations Forum on MilSuite.com with potential overlap membership in the Defense Support of Civil Authorities (Phase III) private group page on Facebook.

My dissertation will investigate whether hurricanes in the North Atlantic Basin are increasing in frequency and intensity, and whether Defense Support of Civil Authorities (DSCA) practitioners perceive the Department of Defense (DoD) is prepared to assist FEMA or other Lead Federal Agencies when the next major hurricane strikes. This study will help with preparedness and response, and arm decision and policy makers in the federal and at the state, local, tribal, and territorial governments with critical information to make sound decisions before, during, and after the next major hurricane.

The survey consists of 15 questions regarding perceived readiness in the areas of DSCA doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTMLPF-P). The data collected for this dissertation will be used only for the purpose of the research phase of the dissertation, which may culminate in publications and or presentations. The data will be collected anonymously and analyzed in the aggregate.

This study is not being conducted or sponsored by the DoD or any other government agency. The resulting opinions and views expressed in the survey will be interpreted as personal opinions only and not as official DoD or US Army North policy. The goal is to survey approximately 400 of the members. You bare no responsibility if the 400 number is not achieved since the survey is voluntarily. I simply ask that you allow me to post the link to the survey on the MilSuite and Facebook pages.

I hope that the information gained from this research will help all stakeholders achieve their mission to help save lives and mitigate suffering. I thank you in advance for considering this request and hope you agree to help with this research project. Please reach out to me at 585.314.3793 or at scottr2@stjohns.edu with questions or concerns with the study or with your participation. You may also contact the following with questions, concerns, your rights as a participant, or to verify this research: Committee Chair, Dr. Jie Xu at or718.990.3221 or xuj@stjohns.edu; Chair, St. John's University's Institutional Review Board (IRB), Dr. Raymond DiGiuseppe at 718.990.1955 or digiuser@stjohns.edu; St. John's University IRB Coordinator, Marie Nitopi at 718.990.1440 or nitopim@stjohns.edu.

Ralph E. Scott

Philip J. Halliburton

APPENDIX E

RESEARCHER-CREATED INSTRUMENT

Hurricane Readiness Interview Guide

Q1: Please describe your experience with DSCA operations.
Probes: years served, positions, organizations, echelons, disasters, exercises

Q2: Please provide your perspective regarding how well the joint and service *doctrine* guides DOD forces and organizations to respond to a major hurricane.
Probes: Joint Publication (JP) 3-28 Defense Support of Civil Authorities, 29 October 2018, Service doctrine
Doctrine definition: *Authoritative guidance and will be followed except when, in the judgment of the commander, exceptional circumstances dictate otherwise.*

Q3: How might the *organization* of DOD units interfere with its ability to respond quickly and effectively to a major U.S. landfall hurricane?
Probes: USNORTHCOM, ARNORTH, NG, USAR, Active Duty
Organization definition: *A joint unit or element with varied functions enabled by a structure through which individuals cooperate systematically to accomplish a common mission and directly provide or support joint warfighting capabilities*

Q4: Please provide your perspective regarding the quality, content, and outcomes associated with the current *training* intended to prepare personnel conducting hurricane response.
Probes: DSCA Phase I and II, DSCA Exercises, Does the training get completed? Who confirms?
Training definition: *Mission rehearsals of individuals, units, and staffs using joint doctrine or joint tactics, techniques, and procedures to prepare joint forces or joint staffs to respond to strategic, operational, or tactical requirements considered necessary by the higher echelon to execute their assigned or anticipated missions capabilities*

Q5: What is your opinion regarding the effectiveness of the DOD systems that confirm *materiel* such as rolling-stock, and all of the other equipment for hurricane response remains available and in working condition?
Materiel definition: *Items (including ships, tanks, self-propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities) necessary to equip, operate, maintain, and support joint military activities without distinction as to its application for administrative or combat purposes*

Q6: What is your perspective regarding the current professional development education and training to maintain a talent pool of DSCA *leaders* at various levels?
Probes: OES, NCOES, JPME
Leadership & Education definition: *Professional development of the joint leader and is the product of a learning continuum that comprises training, experience, education, and self-improvement*

Q7: What is your opinion regarding the effectiveness of the DOD processes to confirm that the *personnel* it allocates to a major hurricane response have the necessary qualifications?
Probes: FEMA Independent Study, DSCA Course, MOS/Branch specific Courses
Personnel definition: *Qualification to support DSCA requirements*

Q8: Which DOD *facility* or infrastructure do you believe might be designated as a Base Support Installation (BSI) or an Incident Support Base (ISB) to support the next major hurricane response in the United States?
Probes: Is the facility suitable, feasible, and acceptable?
Facility definition: *All real property consisting of one or more of the following: buildings, structures, utility systems, associated roads and other pavements, and underlying land*

Q9: Please provide your assessment as to whether the *policies* surrounding DSCA operations clearly define the rules, regulations, and limits of hurricane operations in the homeland.
Probes: HSPDs, PPD, Stafford Act, Economy Act, Posse Comitatus, IRAs, DODD, DODI, CONPLANs, EXORDs
Policy definition: *DoD, interagency, or international policy issues that may prevent effective implementation of changes in the other seven DOTMLPF-P elemental areas*

Q10: What is your assessment of the DOD's overall readiness to effectively respond to the next major U.S. landfall hurricane?
Probe: How do multiple hurricanes impact the overall readiness?

APPENDIX F

LIST OF ACRONYMS AND TERMS

This study utilizes several publications, regulations, reports, and findings to explore and evaluate the military's role in disaster response. These acronyms and abbreviations developed the research landscape, including an in-depth analysis during the literature review.

AFNORTH	Air Force Northern Command
AFSC	Air Force Specialty Code
ALCOM	Alaska Command
BSI	Base Support Installation: a Department of Defense Service or agency installation within the United States and its territories tasked to serve as a base for military forces engaged in either homeland defense or conducting defense support of civil authorities
C2CRE	Command/Control CBRN Response Element
Catastrophic Event	Any natural or man-made incident, including terrorism, that results in extraordinary levels of mass casualties, damage, or disruption severely affecting the population, infrastructure, environment, economy, national morale, and/or government functions
CARRLL	Cost, Appropriateness, Risk, Readiness, Legality, Lethality
CJFLCC	Combined Joint Forces Land Component Command
CONPLAN	Concept Plan
CONUS	Continental United States
DCE	Defense Coordinating Element
DCO	Defense Coordinating Officer: Department of Defense single point of contact for domestic emergencies who is assigned to a joint field office to process requirements for military support; forward mission assignments through proper channels to the appropriate military organizations; and assign military liaisons, as appropriate, to activated emergency support functions
DCO/E	Defense Coordinating Officer/Element
DoD	Department of Defense
DoDD	Department of Defense Directive (document)
DoDI	Department of Defense Instruction (document)
DoDM	Department of Defense Manual (document)
DSC	Dual-Status Commander
DSCA	Defense Support of Civil Authorities (DoD)
EMAC	Emergency Management Assistance Compact
EPLO	Emergency Preparedness Liaison Officer; A senior reserve officer who represents their Service at the appropriate joint field office conducting planning and coordination responsibilities in support of civil authorities

ESF	Emergency Support Functions; government and certain private-sector capabilities grouped into an organizational structure to provide the support, resources, program implementation, and services that are most likely to be needed to save lives, protect property and the environment, restore essential services and critical infrastructure, and help victims and communities return to normal, when feasible, following domestic incidents (JP 3-28, 2018).
ESF #1	Emergency Support Function - Transportation
ESF #2	Emergency Support Function - Communications
ESF #3	Emergency Support Function - Public Works and Engineering
ESF #4	Emergency Support Function - Firefighting
ESF #5	Emergency Support Function - Emergency Management
ESF #6	Emergency Support Function - Mass Care, Emergency Assistance, Housing, and Human Services
ESF #7	Emergency Support Function - Logistics Management and Resource Support
ESF #8	Emergency Support Function - Public Health and Medical Services
ESF #9	Emergency Support Function - Search and Rescue
ESF #10	Emergency Support Function - Oil and Hazardous Materials Response
ESF #11	Emergency Support Function - Agriculture and Natural Resources
ESF #12	Emergency Support Function - Energy
ESF #13	Emergency Support Function - Public Safety and Security
ESF #14	Emergency Support Function - Long-Term Community Recovery
ESF #15	Emergency Support Function - External Affairs
EXORD	Execute Order
FMFLANT	U.S. Marine Forces Command/Marine Forces Atlantic
HSPD	Homeland Security Presidential Directive
IRA	Immediate Response Authority: any form of immediate action taken in the United States and territories to save lives, prevent human suffering, or mitigate great property damage in response to a request for assistance from a civil authority, under imminently serious conditions when time does not permit approval from a higher authority.
JFHQ-NCR	Joint Forces Headquarters-National Capital Region
JFLCC	Joint Forces Land Component Command
JFO	Joint Field Office
JP	Joint Publication
JPME	Joint Professional Military Education
JRSOI	Joint Reception Staging Onward movement and Integration
LNO	Liaison officer
MA	Mission Assignment (FEMA work order)
MATO	Mission Assignment Task Order (Modifications to original MA)
MOA	Memorandum of Agreement
MOS	Military Occupation Specialty

MOU	Memorandum of Understanding
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NRF	National Response Framework
NWS	National Weather Service
OSD	Office of the Secretary of Defense
PCA	Posse Comitatus Act
PDD	Presidential Disaster Declaration
PME	Professional Military Education
POD	Point of Distribution
PPD	Presidential Policy Directive
RFA	Request for Assistance; a request based on mission requirements and expressed in terms of desired outcome formally asking the Department of Defense to provide assistance within the United States or United States territories to a local, state, tribal, or other federal agency.
RFF	Request for Forces
SAD	State Active Duty (NG)
SECDEF	Secretary of Defense
SEPLO	State Emergency Preparedness Liaison Officer
SLTT	State, Local, Tribal, Territorial
SRUF	Standing Rules for the Use of Force; preapproved directives to guide United States forces on the use of force during various operations
Title 10	Title 10 (U.S. Code of Federal Regulations) (governs military duty status)
Title 32	Title 32 (U.S. Code of Federal Regulations) (National Guard performing DOD mission or training)
USACE	U.S. Army Corps of Engineers
USAFNORTH	U.S. Air Force North (also AFNORTH)
USARNORTH	U.S. Army North (5th Army) (also ARNORTH)
USFFC	U.S. Fleet Forces Command (also NAVNORTH)
USINDOPACOM	U.S. Indian Ocean Pacific Command
USNORTHCOM	U.S. Northern Command (also NORTHCOM)
USVI	Virgin Islands (also VI)

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Vita

Name	*Ralph E. Scott*
Baccalaureate Degree	*Bachelor of Arts* *Thomas Edison State University* *Trenton, NJ* *Major: Social Science*
Date Graduated	*December 2009*
Other Degrees and Certificates	*Master of Military Studies* *U.S. Marine Corps University* *Quantico, VA* *Major: Military Studies*
Date Graduated	*June 2019*
	Master of Science *Webster University* *St. Louis, MO* *Major: Environmental Management*
Date Graduated	*August 2010*