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Comprehensive Analysis of Climate Change Effects on Military Bases

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Effects on Military Bases

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by

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ABSTRACT OF THE THESIS

Comprehensive Analysis of Climate Change

Effects on Military Bases

by

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Master of Arts in Geography

University of California, Los Angeles, 2019

Professor Adam D. Moore, Chair

Within the past 25 years, climate change has been a constant and often polarized topic of discussion within the scientific, academic, and political communities. This thesis provides a holistic review of the effects of climate change as it pertains to U.S. military installations and the ability of the military to project force abroad. Recent climatic events and assessments conducted by the Department of Defense have pegged climate change as a persistent threat to the structural integrity and operational capacity of military bases at home and abroad. Politically, there is a disconnect between this reality and an administration that wants to prioritize global force projection while ignoring climate change, one of the most salient threats to its military.

The thesis of Norman Dela Fuente is approved.

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2019

Thank you Lord for bringing me here and pulling me through. Dad and Tita Che, thank you for letting me study in my room when Neiman and Nico had to do dishes and take-out trash.

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Introduction

On June 2017, the United States withdrew from the Paris Climate Accord. Later that year climate change was removed from the U.S. National Security Strategy (NSS). These decisions were in line with President Donald Trump's climate change denialism. It sent a clear message that climate change will not be a determinant of political decisions under the Trump administration and it provided a prime example of how the politics of climate change can trump both scientific proof and subject matter expert suggestions.

This thesis conducts an assessment of the observed and potential fallout from the denial of climate change and the unwillingness to recognize and act on its effects. The focus is on the effects of climate change on military installations and how these effects impact national security and military force projection. By analyzing the destructive potential that climate change can have on military installations, I argue that: a) Climate change is a salient concern for the military since its damaging effects on military installations are already being observed and the threats they pose are directly linked to climate-driven factors, and b) Climate change denialism is detrimental for the United States since disruption in vital installations can lead to degraded national security and weakened global force projection.

The following sections of the paper review the academic literature and DoD-led research on climate change and security as it pertains to a) exacerbating violent conflict, b) disrupting military operations, and c) degrading military installations. Then, case studies are presented to highlight the damage that climate change can have on military installations and on the crucial national security functions that they perform. To conclude, current Trump Administration policies are collectively assessed to highlight the disconnect that exists between an apolitical military force's needs and the heavily politicized imperatives that dictate its actions.

Climate Change and Security: Literature Review

This section of the thesis conducts a literature review on three aspects of climate security research that are pertinent to my thesis: a) academic literature that explores how a rapidly changing climate can exacerbate violent conflict, b) military assessments on how climate change adaptation behaviours have the potential to compromise national security and alter the nature, extent, or frequency of global military operations, and c) assessments of how climate change can disrupt national security and U.S. force projection through its damaging effects on U.S. military installations.

I. Violent Conflict

Research examining the link between climate change and conflict began in 1987 when a report released by the World Commission on Environment and Development (WCED) warned that resource scarcity and stagnated economic development brought about by environmental degradation can result in widespread violent conflict (Brundtland et al. 1987; Barnett 2003). Following the red flags raised by the WCED report, environmental matters began to make their way into the global political agenda and the conventional understanding of stability was reevaluated to include environmental issues as a salient factor (Dalby 1992).

By the 1990s, the relationship between climate change and violent conflict began to gain momentum both as a cause of concern for international relations and as a valid field of academic study. Initial studies investigated the correlation between rapid and increasingly variable climatic change and its potential to cause or influence acute conflicts (Homer-Dixon 1991). The studies found that environmental degradation was a factor in violent conflict but isolating and quantifying the degree that environmental factors influence conflict was inherently difficult due to the myriad political, social, and spatio-temporal factors that are simultaneously at play in most acute conflicts and since most affected areas already had a pre-existing history of abuse and instability caused by socioeconomic and political factors (Baechler 1998; Homer-Dixon 1999, 1991).

Recent studies on climate change driven violent conflict have taken a more comprehensive approach by factoring in second-order effects of climate variabilities. Research methods and questions shifted focus towards climate change's "adverse knock-on consequences for agricultural productivity, economic activity, and food security" as a more comprehensive method of establishing connections between climate change, instability, and conflict (McDonald 2013; Buhaug 2016). For example, reduced rainfall and increased temperatures adversely reduce agricultural production which in turn drives resource scarcity and increased food prices resulting in widespread poverty, public unrest, and increased potential for conflict (Barnett and Adger 2007; Hendrix and Haggard 2012).

Quantitative research has also been conducted to analyze connections between extreme climate variabilities and violent conflict. Hsiang, Burke, and Miguel (2013) evaluated 60 primary studies and 45 distinct conflict datasets to infer a causal relationship between climate variability and violent conflict. Their research indicated that deviations from normal temperature and precipitation levels systematically led to increased incidence of conflict. Each 1 standard deviation change towards warmer climate or towards more extreme rainfall levels resulted in increased frequency of interpersonal violence by 4% and intergroup conflict by 14% (median estimates). The meta-analysis did not claim that climate change is the sole or even primary cause of conflict but it did show that extreme climate variations have a substantial influence on the frequency of violent conflict (Hsiang, Burke, and Miguel 2013).

The role of climate change as a secondary factor for violent conflict is widely supported by academic research and looking at the climate change and violent conflict nexus holistically shows that factors that increase the risk of violent armed conflicts are heavily impacted by the effects of climate change (Adger et al. 2014). However, academic studies have not isolated a robust and direct causal relationship between climate change and violent conflict (Koubi 2019). The general consensus remains that politically weak, economically unstable, and agriculture dependent regions are the most vulnerable to the conflict-inducing effects of climate change since they are not capable of absorbing disruptions to the social, political, and economic norms (Reuveny 2007; Koubi 2019). Therefore, political geographers like Halvard Buhaug have begun to reframe the analysis by investigating threats to economic security and societal stability instead of focusing on discussions of "climate wars" (Buhaug 2016). Since the most probable causal link between climate change and violent conflict is with regards to its effect in exacerbating conflict in unstable regions, a growing number of academic studies are contending that improving economic and political resilience might be the best way to prevent the violent conflict inducing effects of climate change (Buhaug 2016).

II. Climate Security Implications for U.S. Military Operations:

The United States military has also been conducting studies on climate security, however, by nature of their organizational purpose they intentionally focus on effects of climate change that have the potential to compromise national security or alter the nature, extent, or frequency of global military operations. A landmark 2007 publication by the Center for Naval Analysis classified climate change as a "threat multiplier" for US national security and global military operations (CNA 2007), the 2010 U.S. Army War College Key Strategic Issues List called to "assess potential impact of global climate change on U.S. national security" (U.S. Army War College 2010), and the 2010 Quadrennial Defense Review and 2010 NSS both identified "climate change as likely to trigger outcomes that will threaten U.S. security" (Department of Defense 2010; Office of the President 2010; McElroy and Baker 2012). The increasing gravity of climate change as a military concern is echoed in Former US Secretary of Defense James

Matthis' confirmation statement where he alluded to how "climate change is impacting stability in areas of the world where [U.S.] troops are operating [in]" (Doherty 2017).

A 2012 Central Intelligence Agency (CIA) funded Harvard study warned that "the national security context will change" in response to climate-driven water, energy, and food insecurities around the world and that the U.S. needs to be vigilant about "the behavior of nations in their attempts to mitigate or adapt to the effects of changing [climate] extremes, and [its] impacts on social, economic, and political well-being" (McElroy and Baker 2012; Lippert 2016). The Harvard study contextualizes climate change as a valid challenge for U.S. national security because of its influence on the decisions made by nations and individuals coping with scarcities and unpredictabilities produced by a rapidly changing climate.

A report by the German think tank Adelphi found that climate change "creates an environment where terrorism can thrive" through more legitimized influence and through increased recruiting capabilities (Lukas and Rüttinger 2016). Non-State Armed Groups (NSAGs) utilize situations created by climate change to bolster their legitimacy by gaining control of supply and creating demand for increasingly scarce natural resources such as water or arable land. These groups can then gain favor from the local populace by offering alternative, more seemingly stable livelihoods and economic incentives and/or by responding to unheard socio-economic and political grievances (Lukas and Rüttinger 2016).

Limited access to resources and livelihood can also "diminish the opportunity costs of conflict participation, increase costs of non-participation, and heighten anti-state grievances" within regions that heavily rely on climate and weather consistency for agricultural production (Reuveny 2007; Devlin and Hendrix 2014; Eastin 2018). This results in increased NSAG recruitment since they offer economic incentives to a predominantly young male population with otherwise limited alternatives for sustainable livelihood (Lukas and Rüttinger 2016). Climate change exacerbates this dynamic by further reducing the availability of vital resources and, as documented in the Adelphi study, “the scarcer resources become, the more power is given to those who control them” (Lukas and Rüttinger 2016).

The threat of declining resources can also extend beyond NSAG actions and into the realm of interstate conflict wherein the threat of militarized action is present among multiple legitimate governing bodies due to precipitation variability resulting in uncertain levels of shared water resources. To a degree, this presents a more complex problem since there are no clear enemies and mediating peace means attempting to manufacture an irreplaceable natural resource such as water or land. According to The U.S. National Intelligence Council “serious water shortages will, over the medium term, destabilize already tense bilateral relationships” (U.S. National Intelligence Council 2012; Devlin and Hendrix 2014).

Though a majority of studies only identify climate change as a peripheral influencer, its ability to exacerbate factors that are commonly associated with increased terrorist activities and resource-driven interstate conflict is sufficient reason for the U.S. military to take notice of climate change as a potential threat to regional stability. The U.S. military is a pre-emptive entity so it views the prevention of conflict as a vital component for continued U.S. economic prosperity and international political cooperation. As stated in a 2012 National Intelligence Council report, “[during] the next 10 years, many countries important to the United States will experience water problems — shortages, poor water quality, or floods — that will risk instability and state failure, increase regional tensions, and distract them from working with the United States on important US policy objectives” (U.S. National Intelligence Council 2012).

Climate change has broad overreaching effects and as stated by Chairman of the Joint Chiefs of Staff General Dunford, one of the main facets of climate change concern is “the category of sources of conflict around the world and things [the military] have to respond to”

(Department of Defense 2019). In addition to increased likelihood of terrorism and armed conflict, the Senate Select Committee on Intelligence also warns that "global environmental and ecological degradation, as well as climate change, are likely to fuel competition for resources, economic distress, and social discontent through 2019 and beyond" (Senate Select Committee on Intelligence 2019). For military operations, this means that a shift can happen from primarily dealing with armed conflicts to having the additional burden of simultaneously responding to peacekeeping and humanitarian missions. Increased extreme weather catastrophes across the globe will demand more immediate and continuous support over a more dispersed area of operations. Displacement and mass migrations will divert the military's attention from external overseas operations into internal border security engagements (Smith 2007). These anticipated climate change effects can overwhelm current military capabilities by forcing it to continuously respond to simultaneous events over geographically dispersed regions (Department of Defense 2014).

III. Climate Change Effects on Military Infrastructure and Operations

The effects of climate change on violent conflict and global military operations are well-explored and well-documented areas of environmental security discourse. However, the impacts of climate change on violent conflict is supplemental at best and its direct effects on military missions are primarily speculative. That being said, I argue that the impacts of climate change on military installations pose a greater threat to military operations since damaging effects directly linked to climate change are already being observed. This section conducts a historical review of how climate change came to be seen as a threat to military installations as well as the steps that the DoD has taken to adapt to or mitigate those disruptive effects.

In 1990, a U.S. Naval War College paper warned against the potential negative effects of sea level rise and oceanic warming on the Navy's fixed land structures. The paper speculated that

Naval bases in coastal regions and in low lying areas are susceptible to flooding and infrastructure damage due to rising sea levels and extreme weather events (Kelley 1990). This was an insightful and informative paper for civil engineers and base planners but the relative uncertainty surrounding climate change and the lack of concrete evidence did not warrant any substantial response at the time.

Nearly two decades later, towards the end of President George W. Bush's second term, the military's climate change concerns began to expand more seriously and with more political backing into the operational readiness and warfighting capabilities at the installation level. In 2008, the DoD Strategic Environmental Research and Development Program (SERDP) was "green-lighted to move into the area of climate change-related research as it affected DoD [installation level] interests" (Hall 2015). Since that administrative mandate was established, the Department of Defense, Congress, Senate, and political think-tanks have all initiated studies and established guidelines to assess, mitigate, and/or adapt to harmful effects of a changing climate on military built infrastructures, training tempo, and operational capabilities both in foreign and domestic training sites.

In 2010, Climate Change was added into the National Security Strategy as a salient concern for continued global stability and national security. This has prompted the military to take a more serious stance on national security issues that can arise from a rapidly changing climate. The Navy created its own Climate Change Roadmap where it recognized effects of climate change on military installation resilience, water resource management, and sea level rise ("U.S. Navy Climate Change Roadmap" 2010). The Army War College also called for the assessment of "potential impact of global climate change on U.S. national security" in its Key Strategic Issues List (U.S. Army War College 2010) and the DoD established a Climate Change Adaptation Workgroup tasked with developing a DoD-wide climate change adaptation strategy.

The increased military and political imperative to address the harmful effects of climate change on military bases resulted in comprehensive analysis, concrete case studies, and readily actionable data. The DoD concluded that "[US military] coastal installations are vulnerable to rising sea levels and increased flooding, while droughts, wildfires, and more extreme temperatures could threaten many of [the military's] training activities" (Department of Defense 2014). More pronounced hot and cold temperatures can also place added strain on the energy infrastructure due to the increased heating and/or cooling demands of installation infrastructures (SERDP 2013). Sea level rise, desertification, and more frequent temperature extremes can reduce the availability of suitable specialized training sites. Training activities such as amphibious beach landing operations, prolonged outdoor combat simulations, and aviation maneuver exercises would have to be delayed, moved to more suitable locations, or postponed indefinitely (USACE Engineer Research Development Center 2013; The Center for Climate and Security 2016).

In a 2013 High Level Assessment conducted by the U.S. Army, they concluded that at the highest or intermediate levels of climate change impact, Army installations "may no longer be able to support current and future mission requirements" or they would "require adaptive actions to prevent, remediate, or repair impacts, which could carry high costs and require significant time for planning and implementation" (USACE Engineer Research Development Center 2013). A 2019, DoD-led *Report on Effects of a Changing Climate to the Department of Defense* surveyed 79 military and national security critical installations and they found that, two-thirds of the bases are "vulnerable to current or future recurrent flooding" and approximately half of the bases are "vulnerable to current and future" droughts and wildfires (Department of Defense 2019).

To further improve its scope and to develop diverse perspectives,the DoD also participated in climate change related scientific research by funding the United States Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA) to study topics and locations that can aid in preparation, adaptation, and mitigation of climate change effects (Council 2001; Storlazzi, Elias, and Berkowitz 2015; Storlazzi et al. 2018). The DoD was also an active participant in the advisory committee conducting the National Climate Assessment (NCA) (USACE Engineer Research Development Center 2013). The NCA is the principal report that analyzes present and future impacts of climate change on the United States. In addition to conducting assessments, the DoD also established sustainability measures to "advance the mission by ensuring the longevity of critical resources" while proactively reducing the military infrastructure's impact on the environment and reducing the DoD's reliance on non-renewable sources of energy (Department of Defense 2016).

Case Studies

The aforementioned assessments, guidelines, and studies show the degree of concern that the DoD has placed on climate change effects for military bases. This section highlights exactly why these are valid concerns through 6 case studies that show varying degrees of disruption that have resulted from sea-level rise, increased temperatures, and extreme weather events; all effects linked to climate change. I selected these case studies to serve as empirical backing for my argument due to their immediate effects on military infrastructures but more importantly because of the broader roles these facilities and operations play in preserving U.S. national security and strengthening U.S. global force projection.

I. Sea-level Rise:

Sea-level rise has been one of the most widely studied and frequently observed byproducts of climate change. Both private research groups and government-led panels have agreed that sea-level rise and the higher risk of storm surge that accompanies it are measurable and observable byproducts of a changing climate (Houghton, Jenkins, and Ephraums 1991; Gregory et al. 2007; Church et al. 2013; Change (IPCC) 2013; IPCC 2018). The DoD has also classified sea-level rise as a current and upcoming threat for both national and global military operations at coastal sites. In a 2019 government-mandated study, the DoD reported that two-thirds of the bases that it assessed were vulnerable to present and/or future flooding (Office of the Under Secretary of Defense for Acquisition and Sustainment 2019). The Strategic Environmental Research and Development Program (SERDP) which is the DoD's primary environmental science research program published a report stating "sea level rise to be a significant and pervasive threat multiplier to mission sustainability, significantly increasing loadings on built infrastructure, and dramatically increasing risks to system capabilities and service provisioning." (Burks-Copes et al. 2014). Rising sea levels and increasingly pervasive storm surges will cause degradation of coastal infrastructure which would reduce available training sites for littoral and shore training; damage vital ship docking, repair, and storage infrastructures; and impact logistical supply chains via shipping delays and cancellations (USACE Engineer Research Development Center 2013; GAO 2014; The Center for Climate and Security 2016; Kusnetz 2017).

These effects can have further second and third order byproducts. Docking and deployment time for submarines, ships, and aircraft carriers can be adversely affected by flooded or damaged piers and docking sites. Fiscal spending priorities will be shifted from force readiness and technological research & development into base repair, floodwall construction, and land reclamation operations. Flooded road networks can make vital parts of the base inaccessible to personnel for extended periods of time (SERDP 2013). Training events such as amphibious assault, coastal corridor maneuvers, and beach landing simulations, which require specific training environments, would need to be reassessed due to loss of available coastal training sites and degradation of simulated training environments (SERDP 2013).

The aforementioned effects of sea-level rise are widespread in both domestic and international military sites. However, there are specific sites that are affected more heavily than others and in which damage to operational capacity will be more detrimental to national security due to the strategic roles they play in maintaining American global military dominance. The following section will highlight two case studies: Naval Station Norfolk, the largest naval base in the world and the center of operations for the U.S. Navy Atlantic Fleet (Kusnetz 2017), and the Ronald Reagan Ballistic Missile Defense (RRBMD) site located on the Kwajalein Atoll in the Republic of the Marshall Islands, a primary missile testing asset and home to Asia-focused Intercontinental Ballistic Missile (ICBM) detectors (The Center for Climate and Security 2016).

A. Naval Station Norfolk, Virginia

Naval Station Norfolk is the center of operations for all Atlantic naval operations. However, it is also one of the most telling case studies on the effects of sea-level rise within coastal military installations. Over the past 100 years, the naval base has experienced a 1.5-foot sea-level rise (Kusnetz 2017) and the U.S. Army Corps of Engineers (USACE) has warned that an additional 1.5 feet of sea-level rise would represent a “tipping point” for the base (Burks-Copes et al. 2014). A 2013 state-commissioned report found that Norfolk Naval Station and its surrounding areas are predicted to experience that amount of sea-level rise within the next 20 to 50 years (Virginia Institute of Marine Science 2013). A NASA-led study also concluded that Norfolk Naval Base has “one of the highest rates of relative sea level rise” along the entire East Coast—about two inches every decade (Bekaert et al. 2017). In addition, the Union of Concerned Scientists conducted an independent analysis and found that an additional 1.4 feet of sea-level rise would result in low-lying areas flooding up to 20 times a year and spending 10 percent of the year fully submerged underwater (Spanger-Siegfried et al. 2016; Kusnetz 2017).

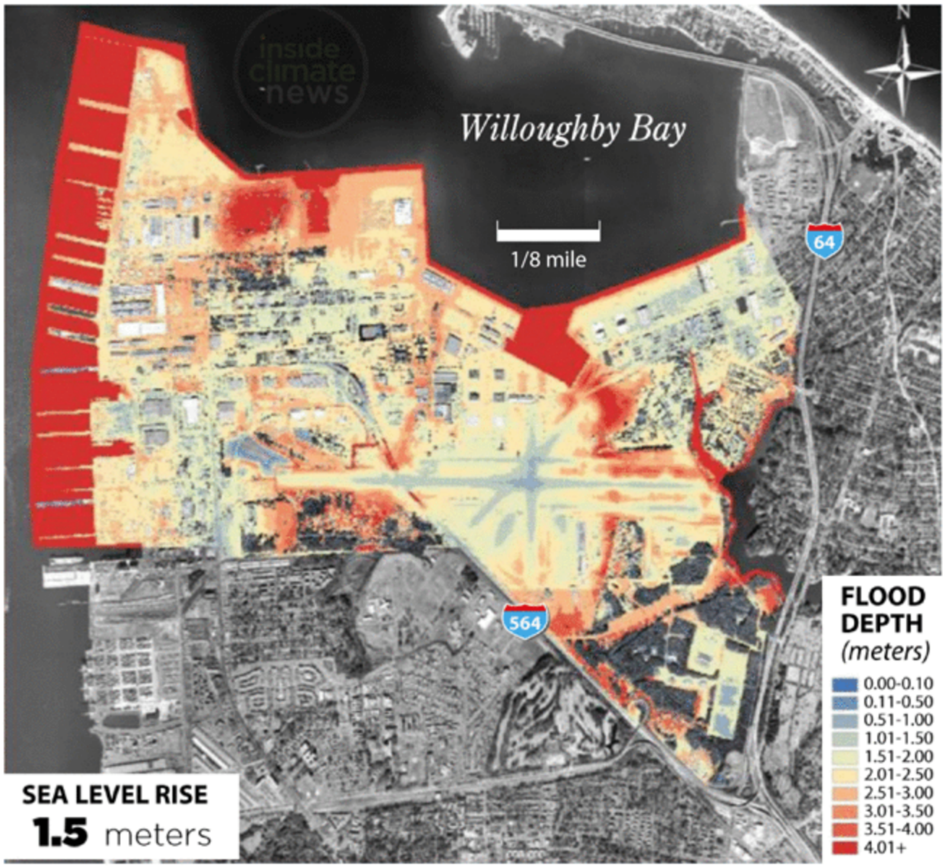

Figure 1: Anticipated flooding during storms in Norfolk Naval Base with a 1.5m sea-level rise. Source: U.S. Army Engineer Research and Development Center[1]

The current extent of sea-level rise already has observable effects on both mission-critical and routine base operations. One of the most pressing and costly issues in the base is the inability of piers to service naval ships during periods of high tides. The current high tide sea-levels have made it impossible to use the older single-deck piers since they are flooded with ocean water making them inaccessible to personnel. Electrical power is also shut off to these piers in order to prevent short-circuiting the electrical grid. Single deck piers have been replaced with higher

[1]https://insideclimatenews.org/news/10252017/military-norfolk-naval-base-flooding-climate-change-sea-level-global-warming-virginia

double deck piers in order to continue operations during high tides, however, due to budgetary and operational constraints the base has only been able to replace 4 of the 12 piers; that means that during high tides, the docking, repair, and resupply piers in the largest naval base in the world is only operating at 33% capacity. Replacement cost for these piers is valued at $150-$200 million each making it fiscally difficult to retrofit and update all piers (Kusnetz 2017). The Navy has drafted plans to spend $21 billion over 20 years to update its aging docks, however, it will be a challenge to simultaneously upgrade the docks and conduct routine operations (Eckstein 2018). The reduction in pier operating capacity has detrimental and overreaching consequences for naval power projection in the Atlantic since a majority of aircraft carriers, submarines, and warships are stationed, serviced, and resupplied at Naval Station Norfolk.

In addition to direct mission impacts, routine tasks needed to maintain and operate the base will also be heavily affected by sea-level rise. The probability and severity of flooding from precipitation events are projected to increase due to higher ocean levels blocking storm drain pipes and reducing their ability to efficiently redirect rainwater into the ocean. As a result, road networks and housing facilities of personnel stationed in Naval Station Norfolk will likely experience more severe and frequent flooding. The integrity of power and communications grids throughout the immediate vicinity of the base will also be affected by annual flooding events (Kusnetz 2017). All of these peripheral effects of sea-level rise, while not directly affecting military infrastructure and operations, will place an unnecessary mental and emotional burden on military service members.

B. Ronald Reagan Ballistic Missile Defense Test Site, Kwajalein Atoll

For more than a century, small chains of islands have been utilized by the United States military as a means of extending its influence by monitoring remote allies and enemies, lightening the logistical load of overseas operations, and utilizing remote locations for nuclear and ballistic missile testing and detection (Hecht 2011; Vine 2015; Bélanger and Arroyo 2016). Sea-level rise is an imminent threat for a majority of U.S. remote island installations but Ronald Reagan Ballistic Missile Defense (RRBMD) Test Site on Kwajalein Atoll warrants a closer look due to the severity of damage that sea level rise poses for the atoll and due to its importance in maintaining U.S. national security (The Center for Climate and Security 2016). It's geographical location at the heart of the Pacific and as a midway point between the United States mainland and countries with nuclear capabilities such as Russia, China, and North Korea make it a pivotal staging post for missile detection scanners and air-defense artillery. Future plans also include the addition of a $1 billion "Space Fence" radar system which would provide the U.S. Air Force with "detection, tracking, and accurate measurement of space objects" (Lockheed Martin n.d.; Kusnetz 2018). The addition of this infrastructure would add to Kwajalein Atoll's already technology-dense landscape and increase its importance as a strategic "territorial bulwark" (The Center for Climate and Security 2016).

A 2018 study conducted in Roi-Namur, a contingent of the RRBMD Test Site, found that wave-driven run-up, a phenomenon wherein incident waves cause a "vertical excursion of the instantaneous shoreline", will cause consistent sea-water intrusion of potable groundwater resources (Oberle, Swarzenski, and Storlazzi 2017; Buckley et al. 2018). If sea-level increases by 0.4 meters higher than present levels, storm surges can inundate the islands to a degree that groundwater will be non-potable year round (Storlazzi et al. 2017, 2018). Under the most severe ice sheet collapse scenarios (RCP8.5+), the 0.4-meter mark will be reached before 2035. At 1 meter higher than present sea-level, a majority of Kwajalein Atoll will be flooded at least once a year (Storlazzi et al. 2017, 2018). Although the studies were conducted specifically for Roi-Namur, other military assets located in atolls (i.e. Diego Garcia and Wake Island) and remote low-lying islands (i.e. Hawaii) are equally vulnerable to the same threats (see Fig. 2).

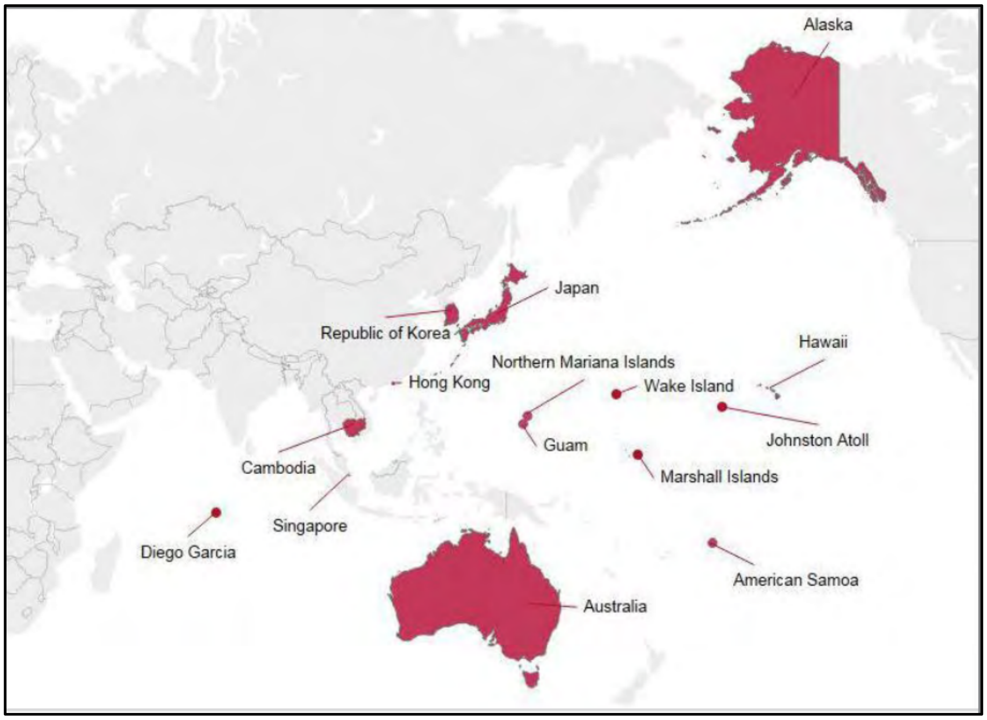

Figure 2: Location of military installations in the Pacific
(Kwajalein Atoll located within Republic of Marshall Islands)
Source: The Center for Climate and Security[2]

The impending inhabitability and lack of mobility within island installations is an issue for operational capacity and personnel safety. However, due to the location and type of these remote island bases, national security interests such as continued defense against hostile intercontinental ballistic missiles (ICBM) will also be challenged. Ground based missile defense systems rely on a complicated network of radars and satellites in order to successfully track and intercept hostile projectiles. This system operates on information that is continuously relayed through a series of sensors so a disruption in this chain can hugely reduce a defense missile's accuracy and effectiveness (Union of Concerned Scientists n.d.)(Figure 3). Early stage ICBM detection and interception is contingent upon continued operations of forward-located bases like

[2]https://climateandsecurity.files.wordpress.com/2016/09/center-for-climate-and-security_military-expert-panel-report2.pdf

RRBMD; therefore, a reduction in operational capacity in sites like RRBMD will heavily degrade U.S. capabilities to defend against ICBMS which are potentially the most damaging single-form threat that the U.S. is currently facing.

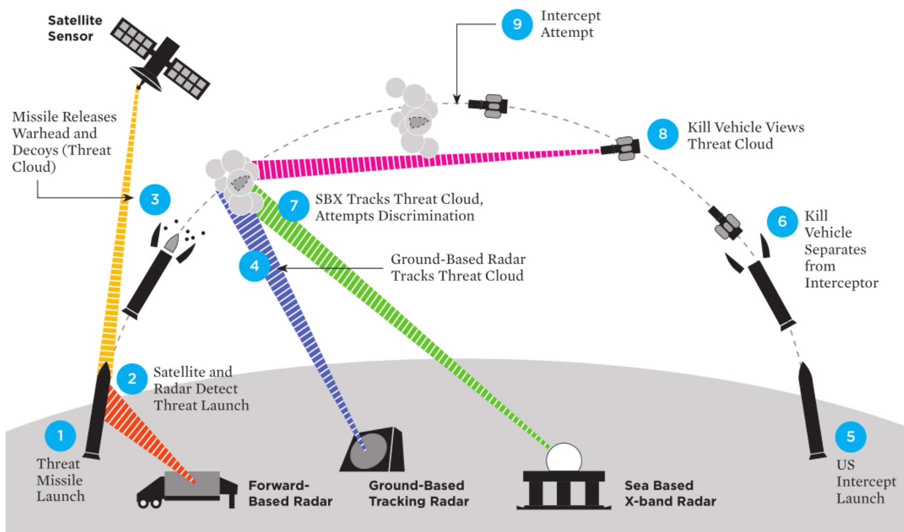

Figure 3: Process of detection and interception of hostile projectile
Source: Union of Concerned Scientists[3]

II. Increasing Temperatures

Increasing global temperatures have been one of the most steadily observed and well-documented effects of climate change (Oreskes 2004; Hansen et al. 2010; Blunden and Arndt 2016; IPCC 2018). Starting in 1975, the rate of global mean temperature increase has doubled from previous century estimates (see Fig. 4) (Blunden et al. 2018). This steady increase in temperature has brought a host of problems for military installations located in heavily impacted regions. This section of the analysis will be looking at loss of training capabilities from extreme heat and the degradation of vital military infrastructure in Alaska.

[3] https://www.ucsusa.org/nuclear-weapons/missile-defense/how-gmd-missile-defense-works

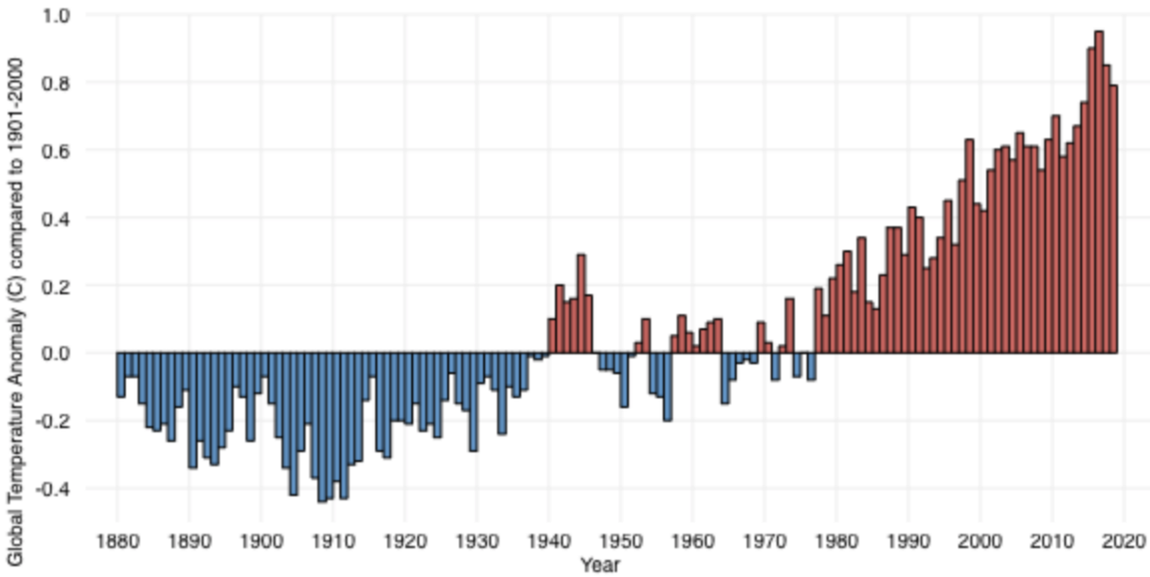

Figure 4: History of global surface temperature since 1880
Source: National Climatic Data Center[4]

A. Land-Based Training and Operations

United States focused research have projected annual average surface air temperature increases between 2.7° and 8.6°F through the year 2100 for multiple greenhouse-gas emission scenarios (Intergovernmental Panel on Climate Change 2014; Weatherly and Rosenbaum 2017). Increasing temperatures are a prime concern for the military since extreme heat will disrupt training events by altering its intensity, frequency, type, and location (USACE Engineer Research Development Center 2013; Department of Defense 2014; Office of the Under Secretary of Defense for Acquisition and Sustainment 2019).

In all branches of the U.S. military, a "black flag" or suspended outdoor training category is issued when the Wet-Bulb Globe Temperature (WBGT) exceeds 90°. Unlike direct temperature measurements, the WBGT index measures "air temperature, humidity, and solar

[4] https://www.ncdc.noaa.gov/cag/global/time-series

exposure" (Sawka et al. 2003; Weatherly and Rosenbaum 2017). The addition of humidity into the measurement creates an uneven forecast for WBGT change over the continental United States. Using the most severe greenhouse gas-emission scenarios (RCP 8.5+), regions in the humid southeast, where a majority of land and air-based military training and testing are conducted, will be susceptible to increased frequency of high WBGT days (USACE Engineer Research Development Center 2013; Weatherly and Rosenbaum 2017). Increases in WBGT can be extremely detrimental to productivity and outdoor training since current military guidelines propose that "all strenuous, non-essential outdoor activity is to be halted for everyone" when a *black flag* warning is issued (Sawka et al. 2003). In situations where work is necessary, *black flag* categories require 50 minutes of rest for every 10 minutes of work. This can be highly problematic for meeting outdoor training objectives since black flag days cause an 80% loss of productivity (Dunne, Stouffer, and John 2013; USACE Engineer Research Development Center 2013; Department of Defense 2014). In a time when geopolitical tensions are high and international relations are volatile, the military has repeatedly expressed that having fully-trained, deployment capable units is the top priority (Kimmons 2019). However, the projected increase in *black flag* days will adversely affect short and long term training targets resulting in delayed readiness timelines and reduced deployability of military personnel (Department of Defense 2014).

Aside from extensive training restrictions, increasing temperatures are also altering the physical training environment causing loss, degradation, or restriction of access to existing training lands and simulated environments (USACE Engineer Research Development Center 2013; Department of Defense 2014; Office of the Under Secretary of Defense for Acquisition and Sustainment 2019). Realistic training environments and weapons usage, which are vital to maintaining military readiness, will also be affected by byproducts of increasing temperatures. Drought and desertification have made training sites susceptible to wildfires making them unsuitable for use of military weaponry and combustive munitions such as tracer rounds, mortars, and artillery (USACE Engineer Research Development Center 2013; Office of the Under Secretary of Defense for Acquisition and Sustainment 2019). Training delays and restrictions are consistently experienced in areas where these simulations have sparked wildfires prompting personnel to relocate or postpone training.

Vital vehicle, weaponry, and infrastructure will also be affected by the effects of increasing temperatures. Low-level rotary aircraft will experience reduced lift capacity due to extremely high surface air temperatures affecting both simulated training operations and emergency medical evacuations in remote desert environments (USACE Engineer Research Development Center 2013). Electronic and mechanical weaponry systems will also need to be altered for extended exposure to extremely high temperatures (USACE Engineer Research Development Center 2013). Anticipated increase in demand for cooling within buildings will also result in financial costs from higher electricity consumption, retrofitting of existing buildings for better insulation and energy efficiency, and expansion of the electric grid to accommodate increased demands.

B. Alaska

Temperature increases are projected to occur at an even greater degree in higher latitudes such as Alaska due to *Arctic amplification,* a phenomenon primarily caused by melting sea ice resulting in lower albedo and higher heat absorption (Screen and Simmonds 2010; Cohen, Pfeiffer, and Francis 2018). This higher than normal rate of temperature rise, projected to be 2 to

3 times higher than the global average, will result in coastal erosion, intensified storm effects, sea ice retreat, and permafrost thawing in areas where key military bases are located (SERDP 2012).

Infrastructure built in Alaska were planned and created with stable and consistent permafrost levels in mind, however, rapidly increasing temperature levels have resulted in unprecedented permafrost thawing. Permafrost extent varies from sporadic & discontinuous, where small to medium concentrations of permafrost are found underground serving as a glue to hold together soil components, to continuous, where permafrost constitutes a majority of solid foundation that structures are built upon (see Fig. 5). When sporadic or discontinuous permafrost melts, the ground begins to soften and warp creating uneven, pliable landscapes out of formerly flat and solid ground. When continuous permafrost melts, the overlying ground can suddenly collapse severely damaging or completely destroying anything built on top of it (Alex 2018).

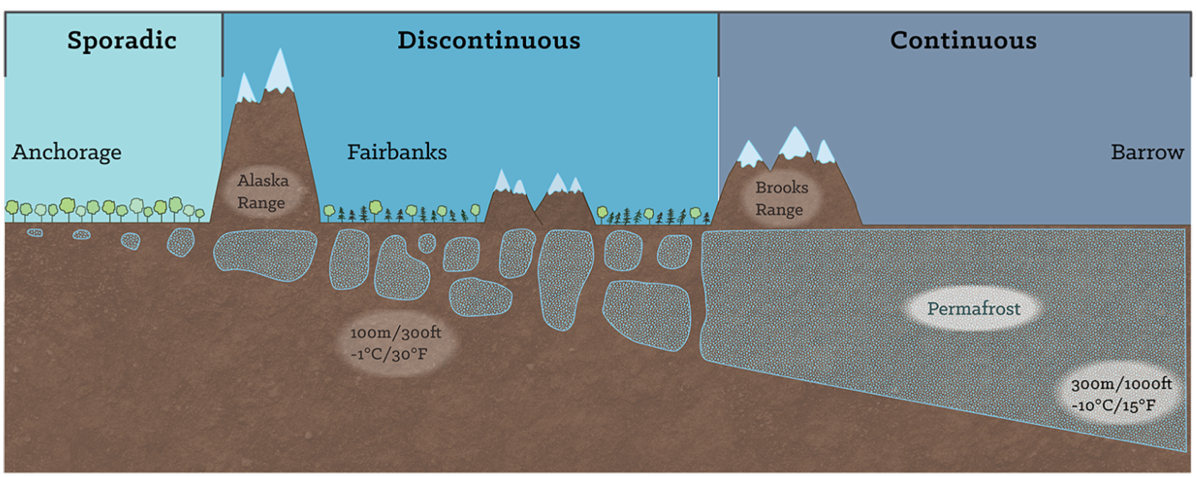

Figure 5: Varying degrees of permafrost extent
Source: Permafrost Tunnel[5]

This phenomenon is significant for military installations since the degradation of military infrastructure in Alaska poses a major threat to US Command, Control, Communications,

[5] http://permafrosttunnel.org/permafrost-in-alaska.html

Computers, Intelligence, Surveillance and Reconnaissance (C4ISR). Currently, a majority of mission critical radar and missile defense stations in Alaska rely on permafrost to stabilize its structure and provide access to personnel (see Fig. 6). In addition, 15% of the U.S. Army's training lands are situated in Alaska and the Department of Defense (DoD) has 5 major installations in Alaska with a majority of their built infrastructure relying heavily on permafrost as a foundation (SERDP 2012). This includes vital cantonment and testing buildings, roadways, runways, and other training sites which need continuous subzero temperatures to properly operate and maintain structural integrity (Douglas et al. 2016).

Figure 6: Alaskan radar systems locations and extents of permafrost
Source: Piquniq Management Corporation[6] & Permafrost Tunnel[7]

In a 2014 study of military installation resilience against climate change, the Government Accountability Office (GAO) found that "the combination of thawing permafrost, decreasing sea ice, and rising sea level on the Alaskan coast have led to an increase in coastal erosion at several Air Force radar early warning and communication installations...this erosion has damaged roads, utility infrastructure, seawalls, and runways...at one radar early warning installation, 40 feet of shoreline has been lost as a result of erosion and the erosion has damaged half of the runway"

[6] http://www.alaska.net/~pmc/experience/radar.html
[7] http://permafrosttunnel.org/permafrost-in-alaska.html

(GAO 2014). In 2007, continuously melting sea ice and coastal erosion caused the foundation of 3 NORAD (North American Aerospace Defense Command) radar stations in Alaska to significantly erode to a point where they were shut down for unstable foundations and budgetary restrictions. These radar stations positioned in Alaska were essential for maintaining air sovereignty in the Northern Hemisphere since they provide continued surveillance for a majority of the Arctic and the Bering Sea (Hughes 2019). Due to the existence of back-up radars proximate to the 3 NORAD sites, shutting them down did not have any major consequences on radar coverage. Though contingency plans set in place had prevented any significant effects on defense and surveillance operations, this was a telling example of how an increasingly warming climate in Alaska can directly impact regional military operations (Revkin 2007).

Maintaining the structural integrity of military installations in Alaska is also vital for defense against nuclear and ballistic threats. The geographical location of Alaska makes it unparalleled in its ability to monitor and intercept any hostile enemy projectiles coming from the Eastern hemisphere. The United States has 44 Ground Based Interceptors (GBI) missiles in its arsenal and 40 of them are staged at Fort Greely, Alaska (Holoday 2018). These GBI's are the United States' primary option for defending against ballistic projectiles and when launched from Alaska its trajectory would give it an optimal chance of intercepting Intercontinental Ballistic Missiles (ICBM) coming from locations such as Iran or North Korea (Curry 2013).

In response to the threat of thawing permafrost, planners and engineers have employed a holistic approach which recognizes the uncertainties that will be presented by increasing temperatures (SERDP 2012). The military has been proactive in ensuring the continued functionality and accessibility of vital Alaskan military infrastructures, a $47 million sea-wall project is currently in place to ensure continued access for a remote radar station located just 48 miles from the Russian mainland. Additionally, $254 million has already been budgeted by the DoD for maintenance and improvement projects in the Alaskan region for the next 5 years (Hughes 2019). However, with the the pace of permafrost thawing and coastal erosion, the fiscal allocation might not be enough since it cost 18.6% ($47 million) of the total budget to build a sea-wall for one runway in 1 of 15 Air Force-managed radar sites. Given that cost of repairs and maintenance are often shared with public agencies such as the The Federal Aviation Administration, which pays 41% of the costs to maintain the sites, fighting back thawing permafrost and coastal erosion is still a costly endeavor. Regardless of who pays for the costs, climate driven changes to the Alaskan topography are undeniably causing infrastructural, fiscal, and operational burdens for the military.

This shift towards recognizing climate change as a valid threat in Alaska is vital to the adaptability and resilience of future buildings, however, existing infrastructure might be in an irreconcilable state since military bases, including several locations in Alaska, are experiencing erosion levels that were not expected until 2040 (GAO 2014) and "80% of the infrastructure that will exist [in Alaska] in 2050 is already in place" (SERDP 2012). Despite the threats to Alaskan infrastructure, its importance in military operations have continually given Congress a reason to increase military investments in this remote region. In 2017, Congress approved the military's request for $200 million to field 20 more GBIs to Fort Greely. In the 2019 fiscal year, an additional $8 million was approved to add 2 more GBIs (Friedman 2018). The continued government investment in anti-missile interceptors is testament to the importance of Alaska's location as a military bulwark against the types of missile threats that the US is anticipated to face.

Alaska is also becoming an increasingly pivotal site for regional stability and U.S. influence within the adjacent Arctic region which has experienced warming rates approximately twice the global average over the past four decades. The anticipated Arctic thawing is projected to open up shipping routes between Asia, Europe, and the United States' East coast, a treasure trove containing precious metals & minerals, and up to 30% of the world's gas reserves (Stephenson, Smith, and Agnew 2011; Pezard et al. 2017). In anticipation of this, nations surrounding the Arctic region have begun to lay claim on their respective Exclusive Economic Zones (EEZ), however, these areas are often overlapping and the United Nations' Convention on the Law of the Sea, the guidebook for establishing EEZs, has no clear parameters regarding these issues (Stephenson et al. 2013; Forsyth 2018). As resources become more and more readily extractable the potential for conflict also rises with it. Competing Arctic and "near-Arctic" superpowers like Russia and China have expressed growing interest in establishing a controlling presence in the region (Bennett 2015). The events that will inevitably transpire within the Arctic region is being touted as a 'litmus test' to see how geopolitics and military actions will respond to an area of contention that is primarily being shaped by climate change (Huebert et al. 2012).

In the past 10 years, Russia has significantly ramped up their investments in the Arctic region by establishing new military bases and restarting previously dormant ones. These actions have resulted in a disproportionate Russian military presence in the Arctic region (see Fig. 7) (Forsyth 2018). By 2015, Russia was already deriving 20 percent of its Gross Domestic Product from economic activity originating in the Arctic so they have a huge incentive to preserve the current unofficial EEZs (Conley and Rohloff 2015). Russia has also begun acting on plans to moderate and dominate the projected Northeast Passage, a shipping route directly connecting

East Asia with Europe and Eastern U.S. (Stephenson et al. 2013). Since 2016, Russia has launched three nuclear icebreakers that are meant to patrol and increase mobility of its assets throughout the Arctic Region (Bershidsky 2019). Alaska, being the only US territory with direct access to the Arctic, will play a significant role as a counterbalance to Russia in order to ensure that EEZ's are assigned in accordance with internationally agreed upon regulations. That is why the degradation of structural integrity and operational capacity of Alaskan military bases will be a national security and global stability issue that warrants utmost attention.

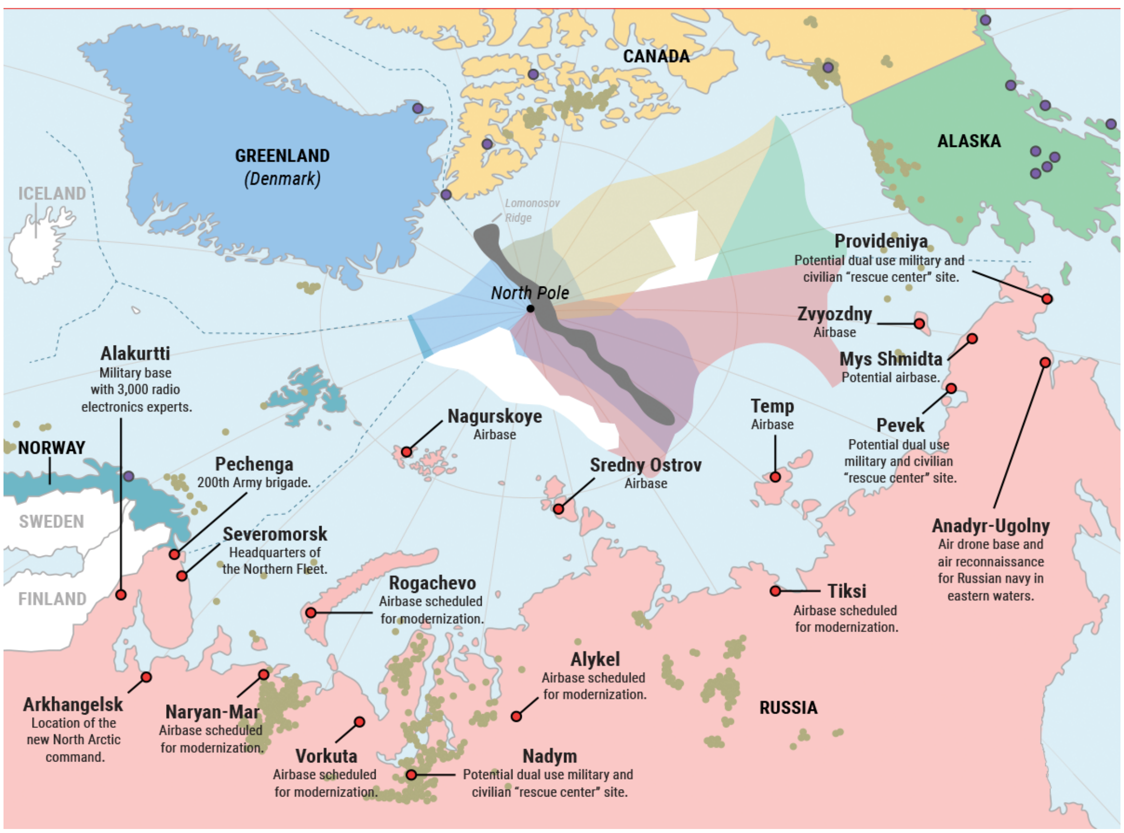

Figure 7: Military bases and EEZ claims in the Arctic Circle
Source: Malte Humpert from The Arctic Institute[8]

[8] https://www.thearcticinstitute.org/future-arctic-shipping/

III. Extreme Weather Events

Another issue at the intersection of climate change and military operations is the increased frequency and intensity of extreme weather events. There has been a scientific consensus that the increased overall intensity and faster intensification rates of hurricanes can be attributed to factors that stem from climate change. As “seas warm, the ocean has more energy to convert to tropical cyclone wind” resulting in more favorable conditions for the formation and intensification of hurricanes (Elsner, Kossin, and Jagger 2008; Knutson et al. 2010; Bhatia et al. 2018). Different modeling methods and selection of parameters have resulted in varied metrics for tracking and measuring hurricane intensification. Some studies predict increases of average intensity by 10% if continued warming persists (Knutson et al. 2010), some track superstorm occurrences stating that “superstorms with sustained winds over 190 mph are projected to have increased occurrence: nine of these storms in a simulation of the late 20th century climate...32 for the period from 2016 to 2035 and 72 for the period from 2081 to 2100” (Bhatia et al. 2018), while others focus on measurable temperature increases concluding that “since 1975 there has been a substantial and observable regional and global increase in the proportion of Category 4–5 hurricanes...per °C of anthropogenic global warming” (Holland and Bruyère 2014). Regardless of the metric used for quantifying hurricane intensity, there is a definitive consensus in the atmospheric sciences that a warmer climate will increase the intensity of hurricanes. The total number of hurricanes might remain stagnant or even decline but there will be an “increase in the proportion of intense hurricanes relative to all hurricanes”; a shift from smaller low intensity hurricanes to stronger, more destructive category 4 or 5 hurricanes (see Fig. 8) (Knutson et al. 2010, 2013; Holland and Bruyère 2014; Kang and Elsner 2015; Knutson 2019).

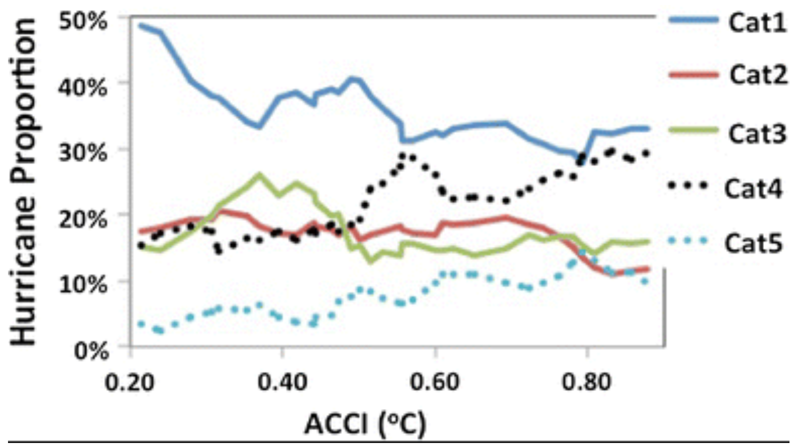

Figure 8: Increasing proportion of category 4 and 5 hurricanes
Source: (Holland and Bruyère 2014)

In combination with increased frequency and intensity, other climate-change driven effects have also been shown to increase the destructive potential of hurricanes. Sea-level rise has been shown to extend the range and strength of the storm surge inundating coastal areas (Knutson 2019). A warmer atmosphere is capable of holding more moisture which would cause hurricane rainfall rates to increase by approximately 20% and making them "up to 15% wetter for every 3.6 degrees Fahrenheit of warming" (Knutson et al. 2010, 2013; Knutson 2019). Higher precipitation rates during hurricanes increase the likelihood of flooding and infrastructural damage to water and electricity grids. Hurricanes can also linger over a specific location for a longer period of time since anthropogenic warming has been shown to reduce summer tropical circulation responsible for keeping hurricanes moving (Kossin 2018). Concentrating the harmful effects of hurricanes on a singular location can increase the chances that hurricane safety measures such as reinforced building infrastructures, seawalls, and levees will be overwhelmed.

A. Tyndall Air Force Base

Increased hurricane intensities and the destruction that come with them have brought a host of problems for critical military bases located in hurricane prone regions. One of the worst examples of hurricane-caused damage to a military base was caused by Hurricane Michael which made landfall at Tyndall Air Force Base on October 2018. The gravity of the hurricane's impact on mission critical capabilities and the extent of damage to physical infrastructures have highlighted the threat that extreme weather events pose for military operations. Hurricane Michael was extremely devastating for two reasons, its overall strength and the the rate in which it intensified from a mere tropical depression into a full-strength category-4 hurricane. Hurricane Michael, which came with sustained winds of up to 155 miles per hour, tore off hangar roofs and hurled debris across Tyndall AFB, resulting in infrastructure damage to 95% of the buildings on the base (see Fig. 9) (Spinelli 2018). The primary concern is with regards to the 55 F-22 Raptor fighter jets which were stationed on runways and hangars within the base. These jet, which cost approximately $150 million each, were a crucial part of the damage estimate since they are a vital component to sustaining American airspace dominance and they are nearly irreplaceable since their production run ended in 2012 (Sullivan 2009; "Lockheed Martin F-22 Raptor" 2019). 38 F-22 jets were safely flown outside of the base before the hurricane hit while 17 F-22 jets were non-mission capable (NMC) when the hurricane made landfall so they were forced to shelter in place during the hurricane (Pawlyk 2018). Due to security concerns Air Force officials have declined to disclose the exact extent of damage that the jets sustained (see Fig. 10) (Achenbach, Begos, and Lamothe 2018).

Figure 9: Aftermath of Hurricane Michael on Tyndall AFB
Source: Scott Olson/Getty Images[9]

Hurricane Michael caused extensive damage because it intensified at such an unprecedented pace that it gave personnel very limited time to evacuate the base and relocate aircraft. According to Air Force Chief of Staff Gen. David L. Goldfein, "Tyndall's command team had only 48 hours after Michael was upgraded from a tropical storm to a Category 4 hurricane to get 11,000 people out and evacuate aircraft" (Svan and Egnash 2018). The rapid intensification of Hurricane Michael was difficult to predict due to the complexity of factors that affect a hurricane's strength. A wind shear that was expected to slow down Hurricane Michael's rotation dissipated sooner than expected creating a "highly favorable environment" for continued

[9] https://www.npr.org/2019/02/12/693549647/tyndall-air-force-base-to-be-rebuilt-as-air-base-of-the-future

hurricane intensification, “a moist atmosphere and...the water of the Gulf of Mexico [being] two or three degrees higher than normal” also aided in the rapid intensification of Hurricane Michael (Fleshler 2018). It is difficult to establish direct causation between a warming climate and the confluence of events that caused the rapid formation and intensification of Hurricane Michael; however, the climate models and projections point to the increase of similar phenomena as the atmosphere and oceans continue to warm.

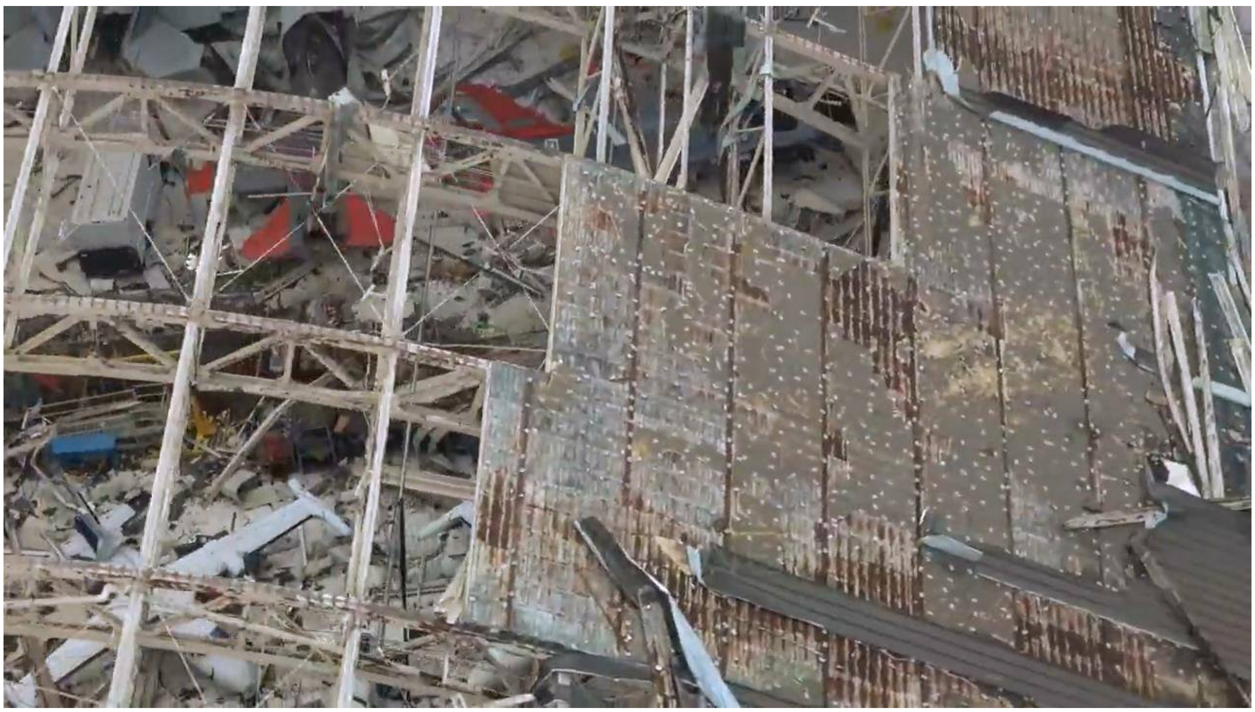

Figure 10: Roofless hangar at Tyndall AFB with rumored F-22 fighter jet in the rubble (upper left)
Source: (Rogoway 2018)

B. Offutt Air Force Base

Aside from direct hurricane damage, the military has also began to experience damaging effects from a combination of rare weather anomalies. In mid-March 2019, snowmelt runoff from the northern regions, thin layers of ice that made the ground & waterways less permeable than usual, and heavy precipitation created a “rare confluence of circumstances” that overwhelmed the natural flow capacity of the Missouri River and resulted in devastating widespread flooding across several Midwestern states (see Fig. 11) (Voiland 2019). The flooding was further heightened by the presence of an extremely rare ‘bomb cyclone’, a rapidly intensifying hurricane that produces “destructive winds, coastal flooding, erosion, and...very heavy precipitation” (NOAA 2018; Earl and Schallhorn 2019).

Figure 11: Satellite imagery of the Missouri River before (left) and after (right) the flooding event
Source: NASA Earth Observatory (Voiland 2019)

The formation and devastating effects of a ‘bomb cyclone’ can be attributed to factors symptomatic of climate change. As John Gyakum, one of the people responsible for coining the term states, “[a]s the waters warm, they can add more moisture to the air, allowing the storms to dump more precipitation...Climate change could also periodically cause cold air to spill farther south, and when the two meet, there’s an increased risk for these extreme storms.” (Sanders and

Gyakum 1980; Cappucci 2018). Only two U.S. storms were considered "bomb cyclones" in 2018, but Gyakum projects increased occurence in the future due to warmer ocean temperatures and rising sea levels (Cappucci 2018).

One of the most heavily damaged areas from the Missouri River flooding was Eastern Nebraska where Offutt Air Force Base is located. This air force base serves as the central headquarters for U.S. Strategic Command and docking point for several mission-critical Air Force aircrafts. This military installation received considerable attention due to its importance in maintaining national security and from the extensive flooding it experienced.

Offutt AFB is home to several expensive, mission-critical, and low-density aircraft including the entire Air Force arsenal of seventeen RC-135 reconnaissance planes and four E-4B “doomsday” airborne command post planes. There have been no exact reports on the condition of the aircraft but extensive flooding in approximately one-third of the base’s structures and 40% of its main runway would have grounded most if not all aircraft that were left in the base (see Fig. 12) (Fedschun 2019). Aside from crucial aircraft, Offutt AFB is also home to U.S. Strategic Command (STRATCOM) which controls America’s nuclear capabilities. The flooding of roads and buildings have made it difficult for personnel to maintain 100% operational capability within STRATCOM (USAF 2007; Rogaway 2019). The physical damage caused by the flooding to infrastructure and aircraft is detrimental to the Air Force’s operations; however, the unquantifiable damage and loss of productivity that resulted from halting almost all maintenance, training, and reconnaissance operations can prove to be a bigger threat if these events happened during critical times of war or conflict.


Figure 12: The main runway and parts of Offutt AFB during the flood
Source: Colonel Michael Manion Facebook post[10]

Conclusion: Disconnect Between Military and Politics

Military leadership is a decisive force when choosing the degree to which climate change mitigation efforts are implemented within installations and throughout military operations. However, administrative political will might be a better determinant of progress or stagnation of climate change adaptation measures. Since President Donald Trump took office in 2017, he has implemented measures that have stagnated or retracted climate change adaptation and mitigation measures within military bases. The Obama-era Executive Order (EO 13653) that called for the production of a Climate Change Adaptation Roadmap, a DoD-led climate change mitigation and adaptation strategy, has been rescinded by President Trump (EO 13783). The same Trump-issued Executive Order (EO 13783) also halted the production of the US Army Corp of Engineer's

[10] https://www.facebook.com/55.WG.Commander/?__tn__=HHH-R

(USACE) Climate Adaptation Plan and Report, an annual assessment of climate-driven risks to military installations and an updated list of actions to mitigate these risks (U.S. Army Corp of Engineers 2015). The primary sustainability imperative within military installations, DoD Strategic Sustainability Performance Plan, was also promptly halted in 2017 (Department of Defense 2016). These actions follow a trend of discontinuations in DoD and USACE studies aimed at mitigating and identifying current and future climate change driven effects on military installations (see Fig. 13).

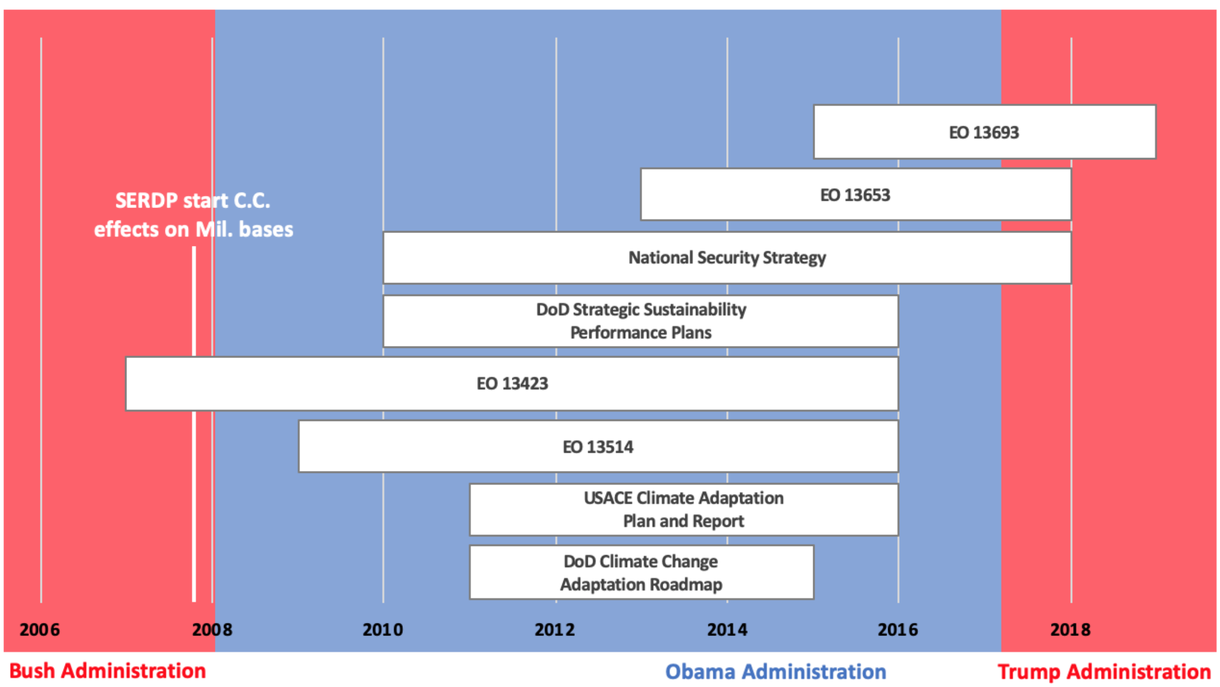

Figure 13: Trend of discontinuations in climate change related DoD studies

In addition to rescinding climate change mitigation focused Executive Orders, the Trump administration also dropped all mention of climate change from the most recent National Security Strategy (Office of the President 2017). The government's deprioritization of climate change associated risks have begun to significantly alter and potentially mislead military installation assessments that are supposed to be objective. The *Climate-Related Risk to DoD*

Infrastructure Initial Vulnerability Assessment Survey (SLVAS) Report's first draft, released in December 2016, had 23 instances where 'climate change' was mentioned but the final draft released in January 2018 had drastically cut down the mentions to just 1 and opted to use terms 'extreme weather' or simply 'climate' in some instances (Mooney and Ryan 2018). This shift in language is damaging because risks and effects are relegated to unpredictable, sporadic events instead of an observed climatic pattern influenced by human actions.

There is no established connection between the accuracy of reports and political predisposition. However, more recent DoD reports have been proven to be insufficient or inaccurate at predicting bases that are vulnerable to climate change related risks. For example, the 2019 *Report on Effects of a Changing Climate to the Department of Defense* failed to identify Offutt AFB within the top 10 most flood prone military bases.

This has prompted a movement from senior military and national security officials to denounce the President's actions towards deprioritization and undermining of the military and scientific community's findings on climate change. In response to a proposed move by the Trump Administration to establish a special committee to refute the general consensus on climate change, 58 former senior military and national security officials wrote a letter to President Trump urging him to acknowledge the national security implications of climate change and arguing that "imposing a political test on reports issued by the science agencies, and forcing a blind spot onto the national security assessments that depend on them, will erode our national security" (The Center for Climate & Security 2019).

The Administration's decision to ignore climate change threats has sent ripples across the international community and stalemated major climate focused reforms from being implemented. At the beginning of this month, a meeting of Arctic based nations aimed at preserving the region concluded without any collective declaration because the United States openly opposed any document that mentioned 'climate change'. U.S. Secretary of State Mike Pompeo acknowledged the changes happening in the Arctic as well as the potential dangers and opportunities that would present themselves; however, he strategically shied away from addressing climate change as the main determinant and accelerator of these changes (Spinelli 2019; Blank 2019).

The refusal to acknowledge present and future effects of climate change have also caused an alarming gap in Arctic power projection between Russia and the United States. Russian President Vladimir Putin has recognized the rapidly changing Arctic conditions and he has taken steps, such as increasing military presence and launching nuclear icebreakers, to prepare for what he believes is an inevitable Arctic future. The U.S. on the other hand has fallen behind in this arena since political mandate has oscillated from the Obama Administration recognizing and preparing for climate change to the Trump Administration ignoring the threat altogether. This politicization of climate change has proven to be detrimental to long-term strategic military planning since mitigation and adaptation become exponentially difficult when each subsequent administration uses their own political ideology to dictate the actions taken against an apolitical and ever-present threat.

Since political mandate dictates a majority of military actions, the effects of climate change on military installations are undeniable and political alignment should not be a hindrance to addressing evident problems. As John Conger, former Defense Department deputy comptroller, frankly stated, "[w]hen politics affects the debate of what you can and cannot pay attention to or everything we do in this space is somehow politicized, it throws a wrench into the pragmatic apolitical instincts of the military...The military's goal is to be pragmatic and apolitical" (Werrell and Femia 2017). Based on the evidence presented in this thesis and the current geopolitical climate, I contend that the Trump Administration's denial of climate change will hamper the military's ability to function at full operational capacity and endanger future operations by turning a blind eye to an unavoidable and potentially irreversible threat.

Bibliography

Achenbach, Joel, Kevin Begos, and Dan Lamothe. 2018. “Hurricane Michael: Tyndall Air Force Base Was in the Eye of the Storm, and Almost Every Structure Was Damaged.” *Washington Post*, October 2018. https://www.washingtonpost.com/national/hurricane-michael-tyndall-air-force-base-was-in-the-eye-of-the-storm-and-almost-every-structure-was-damaged/2018/10/23/26eca0b0-d6cb-11e8-aeb7-ddcad4a0a54e_story.html?noredirect=on&utm_term=.953225b2b9ff.

Adger, W. Neil, Juan M. Pulhin, Jon Barnett, Geoffrey D. Dabelko, Grete K. Hovelsrud, Marc Levy, Ursula Oswald Spring, and Coleen H. Vogel. 2014. “Human Security.” In . Cambridge University Press.

Alex, Bridget. 2018. “Artic Meltdown: We’re Already Feeling the Consequences of Thawing Permafrost | DiscoverMagazine.Com.” Discover Magazine. June 2018. http://discovermagazine.com/2018/jun/something-stirs.

Baechler, Günther. 1998. “Why Environmental Transformation Causes Violence: A Synthesis.” *Environmental Change and Security Project Report* 4 (1): 24–44.

Barnett, Jon. 2003. “Security and Climate Change.” *Global Environmental Change* 13 (1): 7–17.

Barnett, Jon, and W. Neil Adger. 2007. “Climate Change, Human Security and Violent Conflict.” *Political Geography* 26 (6): 639–55.

Bekaert, D. P. S., B. D. Hamlington, B. Buzzanga, and C. E. Jones. 2017. “Spaceborne Synthetic Aperture Radar Survey of Subsidence in Hampton Roads, Virginia (USA).” *Scientific Reports* 7 (1): 14752.

Bélanger, Pierre, and Alexander S. Arroyo. 2016. *Ecologies of Power: Countermapping the Logistical Landscapes & Military Geographies of the U.S. Department of Defense*. Cambridge, Massachusetts: The MIT Press.

Bennett, Mia M. 2015. “How China Sees the Arctic: Reading Between Extraregional and Intraregional Narratives.” *Geopolitics* 20 (3): 645–68. https://doi.org/10.1080/14650045.2015.1017757.

Bershidsky, Leonid. 2019. “Putin’s Arctic Plans Are a Climate Change Bet.” The Moscow Times. May 28, 2019. https://www.themoscowtimes.com/2019/05/28/putins-arctic-plans-are-a-climate-change-bet-a65780.

Bhatia, Kieran, Gabriel Vecchi, Hiroyuki Murakami, Seth Underwood, and James Kossin. 2018. “Projected Response of Tropical Cyclone Intensity and Intensification in a Global Climate Model.” *Journal of Climate* 31 (20): 8281–8303.

Blank, Stephen. 2019. “Russia Exploits Climate Change in the Arctic, Ignoring Threat to Infrastructure.” Text. TheHill. May 13, 2019. https://thehill.com/opinion/international/443402-russia-exploits-climate-change-in-the-arctic-ignoring-threat-to.

Blunden, Jessica, and Derek S. Arndt. 2016. “State of the Climate in 2016.” *Bulletin of the American Meteorological Society* 98 (8): Si-S280.

Blunden, Jessica, Derek S. Arndt, Gail Hartfield, Ahira Sánchez-Lugo, Ted A. Scambos, Carl J. Schreck III, Sharon Stammerjohn, Diane M. Stanitski, Kate M. Willett, and Peter Bissolli. 2018. “State of the Climate in 2017.” *Bulletin of the Amererican Meteorological Society* 99 (8).

Brundtland, Gro Harlem, M. Khalid, S. Agnelli, and S. Al-Athel. 1987. “Our Common Future.” *New York*.

Buckley, M. L., R. J. Lowe, J. E. Hansen, A. R. van Dongeren, and C. D. Storlazzi. 2018. “Mechanisms of Wave-Driven Water Level Variability on Reef-Fringed Coastlines.” *Journal of Geophysical Research: Oceans* 123 (5): 3811–31. https://doi.org/10.1029/2018JC013933.

Buhaug, Halvard. 2016. “Climate Change and Conflict: Taking Stock.” *Peace Economics, Peace Science and Public Policy* 22 (4): 331–38. https://doi.org/10.1515/peps-2016-0034.

Burks-Copes, Kelly A., Edmond J. Russo Jr, Scott Bourne, Mike Case, Austin Davis, Craig Fischenich, Mike Follum, Honghai Li, Lihwa Lin, and Steve Lofton. 2014. “Risk Quantification for Sustaining Coastal Military Installation Asset and Mission Capabilities (RC-1701).” ARMY CORPS OF ENGINEERS VICKSBURG MS ENGINEER RESEARCH AND DEVELOPMENT CENTER.

Cappucci, Matthew. 2018. “This Researcher Helped Coin the Term ‘Bomb Cyclone.’ He Did It to Keep People Safe.” *Washington Post*, January 2018. https://www.washingtonpost.com/news/capital-weather-gang/wp/2018/01/04/this-researcher-helped-coin-the-term-bomb-cyclone-he-did-it-to-keep-people-safe/?noredirect=on&utm_term=.ff6bd1f901cc.

Change (IPCC), Intergovernmental Panel on Climate. 2013. “Working Group I Contribution to the IPCC Fifth Assessment Report, Climate Change 2013: The Physical Science Basis.”

Church, John A., Peter U. Clark, Anny Cazenave, Jonathan M. Gregory, Svetlana Jevrejeva, Anders Levermann, Mark A. Merrifield, Glenn A. Milne, R. Steven Nerem, and Patrick D. Nunn. 2013. “Sea Level Change.” *Climate Change* 1975.

CNA. 2007. “National Security and the Threat of Climate Change.” Center for Naval Analysis. https://www.cna.org/cna_files/pdf/national%20security%20and%20the%20threat%20of%20climate%20change.pdf.

Cohen, Judah, Karl Pfeiffer, and Jennifer A. Francis. 2018. “Warm Arctic Episodes Linked with Increased Frequency of Extreme Winter Weather in the United States.” *Nature Communications* 9 (1): 869.

Conley, Heather A., and Caroline Rohloff. 2015. *The New Ice Curtain: Russia's Strategic Reach to the Arctic*. Rowman & Littlefield.

Council, National Research. 2001. *Climate Change Science: An Analysis of Some Key Questions*. https://doi.org/10.17226/10139.

Curry, Colleen. 2013. "If North Korea Nukes Are Fired, Alaska's Fort Greely Is Last Line of Defense." ABC News. April 4, 2013. https://abcnews.go.com/US/alaskas-fort-greely-line-defense-north-korea-nukes/story?id=18941174.

Dalby, Simon. 1992. "Ecopolitical Discourse:'environmental Security'and Political Geography." *Progress in Human Geography* 16 (4): 503–22.

Department of Defense. 2010. "Quadrennial Defense Review Report." https://archive.defense.gov/qdr/QDR%20as%20of%2029JAN10%201600.pdf.

. 2014. "2014 Climate Change Adaptation Roadmap." Department of Defense.

. 2016. "Department of Defense Strategic Sustainability Performance Plan." https://www.denix.osd.mil/sustainability/dod-sspp/unassigned/department-of-defense-strategic-sustainability-performance-plan-fy-2016/.

. 2019. "Report on Effects of a Changing Climate to the Department of Defense." Department of Defense. https://media.defense.gov/2019/Jan/29/2002084200/-1/-1/1/CLIMATE-CHANGE-REPORT-2019.PDF.

Devlin, Colleen, and Cullen S. Hendrix. 2014. "Trends and Triggers Redux: Climate Change, Rainfall, and Interstate Conflict." *Political Geography* 43 (November): 27–39. https://doi.org/10.1016/j.polgeo.2014.07.001.

Doherty, Ben. 2017. "Climate Change Will Fuel Terrorism Recruitment, Report for German Foreign Office Says." *The Guardian*, April 19, 2017, sec. Environment. https://www.theguardian.com/environment/2017/apr/20/climate-change-will-fuel-terrorism-recruitment-adelphi-report-says.

Douglas, Thomas A., M. T. Jorgenson, D. N. Brown, C. A. Hiemstra, A. K. Liljedahl, C. Downer, N. Pradhan, S. Marchenko, S. Campbell, and G. Senseman. 2016. "Addressing the Impacts of Climate Change on US Army Alaska with Decision Support Tools Developed Through Field Work and Modeling." US Army Cold Regions Research and Engineering Laboratory Fort Wainwright ….

Dunne, John P., Ronald J. Stouffer, and Jasmin G. John. 2013. "Reductions in Labour Capacity from Heat Stress under Climate Warming." *Nature Climate Change* 3 (February): 563.

Earl, Jennifer, and Kaitlyn Schallhorn. 2019. "What Is a 'Bomb Cyclone'?" *Fox News*, March 2019. https://www.foxnews.com/us/what-is-a-bomb-cyclone.

Eastin, Joshua. 2018. "Hell and High Water: Precipitation Shocks and Conflict Violence in the

Philippines." *Political Geography* 63 (March): 116–34. https://doi.org/10.1016/j.polgeo.2016.12.001.

Eckstein, Megan. 2018. "Navy Plans to Spend $21B Over 20 Years to Optimize, Modernize Public Shipyards - USNI News." US Naval Institute News. April 17, 2018. https://news.usni.org/2018/04/17/navy-plans-spend-21b-20-years-optimize-modernize-public-shipyards.

Elsner, James B., James P. Kossin, and Thomas H. Jagger. 2008. "The Increasing Intensity of the Strongest Tropical Cyclones." *Nature* 455 (7209): 92.

Fedschun, Travis. 2019. "Nebraska Floods Swamp Air Force Base, as Devastation from 'Bomb Cyclone' Seen in Satellite Photos." *Fox News*, March 2019. https://www.foxnews.com/us/nebraska-floods-swamp-air-force-base-as-devastation-from-bomb-cyclone-seen-in-satellite-photos.

Fleshler, David. 2018. "How Did Hurricane Michael Get so Powerful so Quickly? It 'defies Traditional Logic,' Experts Say. - Sun Sentinel," October 2018. https://www.sun-sentinel.com/news/weather/hurricane/fl-ne-hurricane-michael-intensification-20181011-story.html.

Forsyth, Michael. 2018. "Why Alaska and the Arctic Are Critical to the National Security of the United States." Army University Press. January 2018. https://www.armyupress.army.mil/Journals/Military-Review/English-Edition-Archives/January-February-2018/Why-Alaska-and-the-Arctic-are-Critical-to-the-National-Security-of-the-United-States/.

Friedman, Sam. 2018. "Funding in 2019 Budget Will Expand Greely Missile Interceptor Count to 62." Fairbanks Daily News-Miner. October 9, 2018. http://www.newsminer.com/news/local_news/funding-in-budget-will-expand-greely-missile-interceptor-count-to/article_34542c14-cb95-11e8-ac69-4fa378d52925.html.

GAO. 2014. "Climate Change Adaptation." Government Accountability Office. https://www.gao.gov/assets/670/663734.pdf.

Gregory, Jonathan, Ronald J. Stouffer, Mario Molina, Amnat Chidthaisong, Susan Solomon, Graciela Raga, Pierre Friedlingstein, Nathaniel L. Bindoff, Hervé Le Treut, and Matilde Rusticucci. 2007. "Climate Change 2007: The Physical Science Basis."

Hall, John A. 2015. "Assessing the Impacts of Climate Change on Coastal Military Installation: A Short History Fom the R&D Perspective." Natural Selections Newsletter.

Hansen, James, Reto Ruedy, Mki Sato, and Ken Lo. 2010. "Global Surface Temperature Change." *Reviews of Geophysics* 48 (4).

Hecht, Gabrielle, ed. 2011. *Entangled Geographies: Empire and Technopolitics in the Global Cold War*. Inside Technology. Cambridge, Mass: MIT Press.

Hendrix, Cullen, and Stephan Haggard. 2012. "International Food Prices, Regime Type, and Protest in the Developing World." *Under Journal Review*.

Holland, Greg, and Cindy L. Bruyère. 2014. "Recent Intense Hurricane Response to Global Climate Change." *Climate Dynamics* 42 (3): 617–27. https://doi.org/10.1007/s00382-013-1713-0.

Holoday, Tim. 2018. "A Look inside the Missile Defense Complex at Fort Greely." Delta Wind. May 3, 2018. https://www.deltawindonline.com/news/local/a-look-inside-the-missile-defense-complex-at-fort-greely/article_ae65f33c-4ed3-11e8-b2a1-0b6737596f22.html.

Homer-Dixon, Thomas F. 1991. "On the Threshold: Environmental Changes as Causes of Acute Conflict." *International Security* 16 (2): 76. https://doi.org/10.2307/2539061.

. 1999. *Environment, Scarcity, and Violence*. Princeton University Press. http://www.jstor.org/stable/j.ctt7pgg0.

Houghton, John Theodore, Geoffrey J. Jenkins, and Jim J. Ephraums. 1991. *Climate Change*.

Hsiang, Solomon M., Marshall Burke, and Edward Miguel. 2013. "Quantifying the Influence of Climate on Human Conflict." *Science* 341 (6151): 1235367.

Huebert, Robert Neil, Heather Exner-Pirot, Adam Lajeunesse, and Jay Gulledge. 2012. *Climate Change & International Security: The Arctic as a Bellweather*. Center for Climate and Energy Solutions Arlington, VA.

Hughes, Zachariah. 2019. "How Climate Change Is Affecting Alaska's Military Radar Stations." NPR.Org. February 2019. https://www.npr.org/2019/02/25/697615977/how-climate-change-is-affecting-alaskas-military-radar-stations.

Intergovernmental Panel on Climate Change, ed. 2014. *Climate Change 2013 - The Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781107415324.

IPCC. 2018. "2018: Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (Eds.)]." In Press.

Kang, Nam-Young, and James B. Elsner. 2015. "Trade-off between Intensity and Frequency of Global Tropical Cyclones." *Nature Climate Change* 5 (7): 661.

Kelley, Terry. 1990. "Global Climate Change Implications for the United States Navy." United States Naval War College.

Kimmons, Sean. 2019. "Army Gains in Readiness Are Just the Beginning, Chief of Staff Says." Www.Army.Mil. January 2019. https://www.army.mil/article/216184/army_gains_in_readiness_are_just_the_beginning_chief_of_staff_says.

Knutson, Thomas R. 2019. "Global Warming and Hurricanes." Text. February 2019. https://www.gfdl.noaa.gov/global-warming-and-hurricanes/.

Knutson, Thomas R., John L. McBride, Johnny Chan, Kerry Emanuel, Greg Holland, Chris Landsea, Isaac Held, James P. Kossin, A. K. Srivastava, and Masato Sugi. 2010. "Tropical Cyclones and Climate Change." *Nature Geoscience* 3 (3): 157.

Knutson, Thomas R., Joseph J. Sirutis, Gabriel A. Vecchi, Stephen Garner, Ming Zhao, Hyeong-Seog Kim, Morris Bender, Robert E. Tuleya, Isaac M. Held, and Gabriele Villarini. 2013. "Dynamical Downscaling Projections of Twenty-First-Century Atlantic Hurricane Activity: CMIP3 and CMIP5 Model-Based Scenarios." *Journal of Climate* 26 (17): 6591–6617. https://doi.org/10.1175/JCLI-D-12-00539.1.

Kossin, James P. 2018. "A Global Slowdown of Tropical-Cyclone Translation Speed." *Nature* 558 (7708): 104.

Koubi, Vally. 2019. "Climate Change and Conflict." *Annual Review of Political Science* 22 (1): 343–60. https://doi.org/10.1146/annurev-polisci-050317-070830.

Kusnetz, Nicholas. 2017. "Rising Seas Are Flooding Virginia's Naval Base, and There's No Plan to Fix It." InsideClimate News. October 25, 2017. https://insideclimatenews.org/news/10252017/military-norfolk-naval-base-flooding-climate-change-sea-level-global-warming-virginia.

. 2018. "Climate Change Will Leave Many Pacific Islands Uninhabitable by Mid-Century, Study Says." InsideClimate News. April 25, 2018. https://insideclimatenews.org/news/25042018/rising-sea-level-projections-pacific-islands-military-sites-kwajalein-atoll-usgs-climate-change-research.

Lippert, Tyler. 2016. "NATO, Climate Change, and International Security: A Risk Governance Approach." RAND.

Lockheed Martin. n.d. "Space Fence." Lockheed Martin. Accessed March 8, 2019. https://www.lockheedmartin.com/en-us/products/space-fence.html.

"Lockheed Martin F-22 Raptor." 2019. In *Wikipedia*. https://en.wikipedia.org/w/index.php?title=Lockheed_Martin_F-22_Raptor&oldid=890235745.

Lukas, Katharina, and Lukas Rüttinger. 2016. *Insurgency, Terrorism and Organised Crime in a Warming Climate: Analysing the Links Between Climate Change and Non-State Armed Groups*. adelphi.

McDonald, Matt. 2013. "Discourses of Climate Security." *Political Geography* 33 (March): 42–51. https://doi.org/10.1016/j.polgeo.2013.01.002.

McElroy, M., and D. J. Baker. 2012. *Climate Extremes: Recent Trends with Implications for National Security. Harvard University Center for the Environment*.

Mooney, Chris, and Missy Ryan. 2018. "Pentagon Revised Obama-Era Report to Remove Risks from Climate Change." *Washington Post*, May 10, 2018, sec. Climate and Environment. https://www.washingtonpost.com/news/energy-environment/wp/2018/05/10/pentagon-revised-obama-era-report-to-remove-risks-from-climate-change/.

NOAA. 2018. "What Is Bombogenesis?" *National Ocean Service Website*, June 2018. https://oceanservice.noaa.gov/facts/bombogenesis.html.

Oberle, Ferdinand, Peter Swarzenski, and Curt Storlazzi. 2017. "Atoll Groundwater Movement and Its Response to Climatic and Sea-Level Fluctuations." *Water* 9 (9): 650. https://doi.org/10.3390/w9090650.

Office of the President. 2010. "National Security Strategy." http://nssarchive.us/NSSR/2010.pdf.

. 2017. "National Security Strategy of the United States of America." http://nssarchive.us/wp-content/uploads/2017/12/2017.pdf.

Office of the Under Secretary of Defense for Acquisition and Sustainment. 2019. "Report on Effects of a Changing Climate to the Department of Defense." Office of the Under Secretary of Defense for Acquisition and Sustainment.

Oreskes, Naomi. 2004. "The Scientific Consensus on Climate Change." *Science* 306 (5702): 1686–1686.

Pawlyk, Oriana. 2018. "Senator to Air Force: Fix Hurricane-Damaged F-22s Fast." Military.Com. October 24, 2018. https://www.military.com/dodbuzz/2018/10/24/senator-air-force-fix-hurricane-damaged-f-22s-fast.html.

Pezard, Stephanie, Abbie Tingstad, Kristin Van Abel, and Scott Stephenson. 2017. *Maintaining Arctic Cooperation with Russia: Planning for Regional Change in the Far North*. Rand Corporation.

Reuveny, Rafael. 2007. "Climate Change-Induced Migration and Violent Conflict." *Political Geography* 26 (6): 656–73.

Revkin, Andrew C. 2007. "Radars Taken Out by Arctic Warming." *Dot Earth Blog* (blog). December 7, 2007. https://dotearth.blogs.nytimes.com/2007/12/07/cold-war-radar-taken-out-by-arctic-warming/.

Rogaway, Tyler. 2019. "Home Of Strategic Command And Some Of The USAF's Most Prized Aircraft Is Flooding." *Www.Thedrive.Com*, March 2019. https://www.thedrive.com/the-war-zone/26991/home-of-strategic-command-and-some-of-usafs-most-prized-aircraft-is-flooding.

Rogoway, Tyler. 2018. “Tyndall Air Force Base In Ruins After Michael, Fighter Jets Seen Inside Roofless Hangars.” The Drive. October 2018. http://www.thedrive.com/the-war-zone/24178/tyndall-air-force-base-in-ruins-after-michael-fighters-seen-inside-roofless-hangars.

Sanders, Frederick, and John R. Gyakum. 1980. “Synoptic-Dynamic Climatology of the ‘Bomb.’” *Monthly Weather Review* 108 (10): 1589–1606. https://doi.org/10.1175/1520-0493(1980)108<1589:SDCOT>2.0.CO;2.

Sawka, M. N., C. B. Wenger, S. J. Montain, M. A. Kolka, B. Bettencourt, S. Flinn, J. Gardner, W. T. Matthew, M. Lovell, and C. Scott. 2003. “Heat Stress Control and Heat Casualty Management.” ARMY RESEARCH INST OF ENVIRONMENTAL MEDICINE NATICK MA.

Screen, James A., and Ian Simmonds. 2010. “The Central Role of Diminishing Sea Ice in Recent Arctic Temperature Amplification.” *Nature* 464 (7293): 1334.

Senate Select Committee on Intelligence. 2019. “Worldwide Threat Assessment of the U.S. Intelligence Community.” https://www.dni.gov/files/ODNI/documents/2019-ATA-SFR---SSCI.pdf.

SERDP. 2012. “FY2014 Statement of Need (SON): Climate Change Impacts to Built Infrastructure in Alaska.” Strategic Environmental Research and Development Program. https://www.serdp-estcp.org/content/search?cqp=Standard&SearchText=permafrost+alaska&x=0&y=0.

. 2013. “Assessing Impacts of Climate Change on Coastal Military Installations: Policy Implications.” Strategic Environmental Research and Development Program.

Smith, Paul J. 2007. “Climate Change, Mass Migration and the Military Response.” *Orbis* 51 (4): 617–33. https://doi.org/10.1016/j.orbis.2007.08.006.

Spanger-Siegfried, Erika, Kristina Dahl, Astrid Caldas, and Shana Udvardy. 2016. *The US Military on the Front Lines of Rising Seas: Growing Exposure to Coastal Flooding at East and Gulf Coast Military Bases*. Union of Concerned Scientists.

Spinelli, Dan. 2018. “This Year’s Extreme Weather Showed That the Pentagon Is Not Ready for Climate Change.” *Mother Jones* (blog). December 2018. https://www.motherjones.com/environment/2018/12/this-years-extreme-weather-showed-that-the-pentagon-is-not-ready-for-climate-change/.

. 2019. “Mike Pompeo Admitted the Arctic Is Melting. He Just Didn’t Mention Why.” *Mother Jones* (blog). May 7, 2019. https://www.motherjones.com/environment/2019/05/mike-pompeo-admitted-the-arctic-is-melting-he-just-didnt-mention-why/.

Stephenson, Scott R., Laurence C. Smith, and John A. Agnew. 2011. "Divergent Long-Term Trajectories of Human Access to the Arctic." *Nature Climate Change* 1 (3): 156–60. https://doi.org/10.1038/nclimate1120.

Stephenson, Scott R., Laurence C. Smith, Lawson W. Brigham, and John A. Agnew. 2013. "Projected 21st-Century Changes to Arctic Marine Access." *Climatic Change* 118 (3): 885–99. https://doi.org/10.1007/s10584-012-0685-0.

Storlazzi, Curt D., Edwin P.L. Elias, and Paul Berkowitz. 2015. "Many Atolls May Be Uninhabitable Within Decades Due to Climate Change." *Scientific Reports* 5 (1). https://doi.org/10.1038/srep14546.

Storlazzi, Curt D., Stephen B. Gingerich, Ap van Dongeren, Olivia M. Cheriton, Peter W. Swarzenski, Ellen Quataert, Clifford I. Voss, et al. 2018. "Most Atolls Will Be Uninhabitable by the Mid-21st Century Because of Sea-Level Rise Exacerbating Wave-Driven Flooding." *Science Advances* 4 (4): eaap9741. https://doi.org/10.1126/sciadv.aap9741.

Storlazzi, Curt D., Stephen Gingerich, Peter Swarzenski, Olivia Cheriton, Clifford Voss, Ferdinand Oberle, Joshua Logan, Kurt Rosenberger, Theresa Fregoso, and Sara Rosa. 2017. "The Impact of Sea-Level Rise and Climate Change on Department of Defense Installations on Atolls in the Pacific Ocean (RC-2334)." GEOLOGICAL SURVEY RESTON VA RESTON United States.

Sullivan, Andy. 2009. "Senate Votes to Stop Production of F-22 Jet." *Reuters*, July 21, 2009. https://www.reuters.com/article/us-usa-congress-defense-idUSTRE56K4KN20090721.

Svan, Jennifer, and Martin Egnash. 2018. "Military Leaders Assess Tyndall AFB Damage as Congressmen Push for Rebuild." Stars and Stripes. October 2018. https://www.stripes.com/news/military-leaders-assess-tyndall-afb-damage-as-congressmen-push-for-rebuild-1.551961.

The Center for Climate & Security. 2019. "Letter to the President of the United States: 58 Senior Military and National Security Leaders Denounce NSC Climate Panel." *The Center for Climate & Security* (blog). March 2019. https://climateandsecurity.org/letter-to-the-president-of-the-united-states-nsc-climate-panel/.

The Center for Climate and Security. 2016. "Sea Level Rise and the U.S. Military's Mission." The Center for Climate and Security. https://climateandsecurity.files.wordpress.com/2016/09/center-for-climate-and-security_military-expert-panel-report2.pdf.

Union of Concerned Scientists. n.d. "How Does Missile Defense Work?" Union of Concerned Scientists. Accessed April 9, 2019. https://www.ucsusa.org/nuclear-weapons/missile-defense/how-gmd-missile-defense-works.

U.S. Army Corp of Engineers. 2015. "Climate Change Adaptation Plan." https://cdm16021.contentdm.oclc.org/utils/getfile/collection/p266001coll1/id/5265.

U.S. Army War College. 2010. "2010 Key Strategic Issues List." https://ssi.armywarcollege.edu/pubs/display.cfm?pubID=999.

U.S. National Intelligence Council. 2012. "Global Water Security." https://www.dni.gov/files/documents/Special%20Report_ICA%20Global%20Water%20Security.pdf.

"U.S. Navy Climate Change Roadmap." 2010. United States Navy.

USACE Engineer Research Development Center. 2013. "High-Level Climate Change Vulnerability Assessment." U.S. Army Corp of Engineers. https://www.asaie.army.mil/Public/ES/doc/ArmyHigh-LevelClimateChangeVulnerabilityAssessment2013final.pdf.

USAF. 2007. "Factsheets : E-4B." October 2007. https://web.archive.org/web/20110318185705/http://www.af.mil/information/factsheets/factsheet.asp?fsID=99.

Vine, David. 2015. *Base Nation: How U.S. Military Bases Abroad Harm America and the World*. First edition. New York: Metropolitan Books, Henry Holt and Company.

Virginia Institute of Marine Science. 2013. "Recurrent Flooding Study for Tidewater Virginia." 2013. https://rga.lis.virginia.gov/Published/2013/SD3.

Voiland, Adam. 2019. "Historic Floods Inundate Nebraska." *NASA Earth Observatory*, March 2019. https://earthobservatory.nasa.gov/images/144691/historic-floods-inundate-nebraska?fbclid=IwAR3hgIIxIuqDwQ0e-zPV133N981JmihHec8YNu5u91NM2glyVoPHtakfDOo.

Weatherly, John W., and Mattson A. Rosenbaum. 2017. "Future Projections of Heat and Fire-Risk Indices for the Contiguous United States." *Journal of Applied Meteorology and Climatology* 56 (4): 863–76. https://doi.org/10.1175/JAMC-D-16-0068.1.

Werrell, Caitlin, and Francesco Femia. 2017. "Defense Bill Passes with Climate Change and National Security Provision." Climateandsecurity.Org. November 2017. https://climateandsecurity.org/2017/11/22/defense-bill-passes-with-climate-change-and-national-security-provision/.