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PLANNING FOR CLIMATE CHANGE:

WHAT SHOULD THE AIR FORCE DO?

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by

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Table of Contents

Disclaimer i

Table of Contents ii

List of Figures iv

Preface v

Abstract vi

INTRODUCTION 1

- The Nature of the Problem 1
- Purpose of the Study 2
- Research Question 3
- Research Methodology 3

OVERVIEW OF GLOBAL CLIMATE CHANGE 4

- Global Climate Change Science 5
- National Security Implications 7

DEPARTMENT OF DEFENSE CLIMATE CHANGE POLICIES 10

- Executive Order 13514 11
- 2010 Quadrennial Defense Review 11
- 2010 National Security Strategy 12
- Evolution and Impacts of Policies 13

FUTURE CLIMATE CHANGE SCENARIOS 14

- Determining Factor #1 – Magnitude of Future Climate Change 15
- Determining Factor #2 – Level of Air Force Preparation 17
- Conceptual Spectrum of Future Climate Change Scenarios 18

COUNTERARGUMENTS TO ADDRESSING GLOBAL CLIMATE CHANGE 22

ANALYSIS OF US NAVY CLIMATE CHANGE EFFORTS 24

- US Navy Climate Change Program History 25
- US Navy Climate Change Roadmap 25

ANALYSIS OF US AIR FORCE CLIMATE CHANGE EFFORTS 30

- US Air Force Energy Program 30
- Comparison to the US Navy Climate Change Program 32

Digital Collections

CONCLUSIONS AND RECOMMENDATIONS 33

Create a Climate Change Senior Focus Group 33
Develop a Formal Climate Change Strategy 34
Assess Installations for Climate Change Impacts 35
Establish a Climate Change Office 36
Reach Out and Invest in Further Climate Research 37
Summary 38

Endnotes 40

Bibliography 44

Appendix A. Changes in Temperature, Sea Level and Snow Cover 47

Appendix B. Global Anthropogenic GHG Emissions 48

Appendix C. Global Temperature Change 49

Appendix D. GHG Emission Scenarios 50

Appendix E. Navy Climate Change Roadmap Desired Effects, Objectives and Action Items 51

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List of Figures

Figure 1. Matrix of possible future US Air Force climate change scenarios 19

Figure 2. Navy *Climate Change Roadmap* framework 26

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Preface

A few years ago I purchased a baseball cap that contains a patch depicting the world with a melting ice cube and the words “Global Warming - It’s Not Cool” embroidered on it. As I have worn this hat around over the years, I have found that the people I encounter are not quite sure how to interpret its message. The seemingly silly message on my hat highlights the divisive nature that the global climate change debates have taken over the past few decades. Over the past decade I have listened to and read many different, and often passionate, points of view on global climate change. The purpose of this research is not to convince the reader of how horrible the consequences of future climate change might be, but rather to convince the reader that we should prepare appropriately. Our level of preparation for future global climate should be based on sound assessment and predictions that enable continuous feedback. In the end, our goal should be to plan effectively when it comes to future climate change and to neither do too little nor too much to prepare.

I wish to thank my wonderful wife, not only for taking care of the children while I labored on my research, but also for all of her encouragement and support over the past thirteen years. I also wish to thank Dr. John Ackerman for his assistance with the selection of this research topic and my research advisor, Dr. Robert Niesiobedzki, for his assistance in the development of this research paper.

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Abstract

The Air Force does not currently have a formal climate change program or strategy and this presents a serious limitation to effectively planning for future climate change. The purpose of this research is to present possible future climate change scenarios and provide recommendations that would enable the Air Force to effectively and appropriately plan for future climate change. This research seeks to answer one primary question concerning global climate change and its potential future impacts on the Air Force: *How can the Air Force effectively assess and prepare for the potential future implications of global climate change?* A hybrid combination of the problem/solution and scenario planning methodologies is used in this research to examine how the Air Force can effectively assess and prepare for the potential future implications of global climate change. Analysis of driving forces and current practices are used to generate proposed solutions in the form of recommendations. This research concludes that the US Navy has implemented an effective climate change program which provides a replicable role model and great starting point for the development of an Air Force climate change program. It is recommended that the Air Force take steps to establish a formal climate change program including creating a Climate Change Senior Focus Group, developing a climate change strategy, assessing installations for climate change impacts, establishing a climate change office, and investing in further climate change research.

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INTRODUCTION

> *In national security planning, it generally can take about 30 years to design a weapons system and bring it to the battlefield, so it is important to anticipate future threat environments and to begin preparations now. The same is true of climate change.*
>
> Campbell et al., 2007[1]

Similar to designing a weapon system to counter a future threat, the Air Force must begin now to assess and prepare for the climate change threats of the coming decades. Imagine a possible future environment in which global unrest due to mass migration caused by both rising sea levels in certain regions of the world and drought and famine in other regions severely impedes the operational ability of the Air Force. Such is the immense nature of the potential challenges that future global climate change presents, yet detailed evaluation and planning by the Air Force for such possible future contingencies has not yet occurred.

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The Nature of the Problem

Global climate change has been heavily studied and discussed in the scientific and political communities ever since the creation of the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) in 1988.[2] In 2007, the IPCC published its *Fourth Assessment Report* (AR4) on climate change, which unequivocally concluded that the Earth's climate system is warming.[3] The AR4 also stated that future warming of the climate is expected to have mostly adverse effects and that some of the future impacts could be abrupt or irreversible.[4] The potential problems posed by future climate change are of particular importance and relevance to the military. Global climate change in the future decades has the potential to significantly affect the national security of the United States. In its role to support national security, the military will likely play an important role in dealing with the future geo-strategic impacts of global climate

change. Although the potential future effects of global climate change on the military are understood in a very general sense, the specific impacts on the military, especially the Air Force, are not well understood. Recent policy documents such as the 2010 *Quadrennial Defense Review* (QDR) and the 2010 *National Security Strategy* (NSS) mandate that the Department of Defense (DoD) address climate change in its future strategic planning.

Purpose of the Study

The purpose of this research is to present possible future climate change scenarios and provide recommendations that would enable the Air Force to effectively and appropriately plan for future climate change. The Air Force does not currently have a formal climate change program or strategy and this presents a serious limitation to effectively planning for future climate change. This research paper maintains that the Air Force can use the US Navy's climate change strategy as a good role model and starting point in preparing for global climate change. A 2010 report by the Center for a New American Security found that the DoD services "individually prioritize the short- and long-term implications of climate change" and that "understanding of how climate change may affect the strategic environment, missions and capabilities varies across the services."[5] The report also concluded that the US Navy's climate change preparations provide a "highly replicable model" that the Air Force could benefit from.[6]

An effective climate change program is one that ensures that the Air Force does neither too little nor too much to prepare for this potential future threat. Just as the Air Force would plan for any other potential future threat, the threat posed by climate change must be carefully balanced against other potential threats and resources must be allocated accordingly. Using an Air Force analogy, preparing for future climate change can be compared to preparing for an aircraft combat mission. The recent DoD guidance on climate change provides the orders to

complete a mission, but the enemy is not well understood. If the Air Force is to successfully complete its climate change mission, it must better comprehend the threats posed by climate change. As its understanding of the climate change threat expands and evolves, the Air Force must develop appropriate flight plans and ensure the missiles and bombs loaded on the aircraft are suitable for the target. The key to success in planning for climate change is understanding the threat and adjusting accordingly as new intelligence is received from the field.

Research Question

This research will seek to answer one primary question concerning global climate change and its potential future impacts on the Air Force: *How can the Air Force effectively assess and prepare for the potential future implications of global climate change?* To assist in understanding the potential implications of global climate change on the Air Force, a conceptual spectrum of future scenarios will be presented. In order to answer the primary question of this research, the current efforts of the Air Force and the Navy will be compared and analyzed. The thesis of this research is that a lack of adequate preparation in the near term for global climate change could have significant adverse impacts in the future on the Air Force's ability to complete its mission.

Research Methodology

This research uses a hybrid combination of the problem/solution and scenario planning methodologies to explore the research question and thesis. Analysis of driving forces and current practices will be used to generate proposed solutions in the form of recommendations. The next section provides a short overview of global climate change science and describes the potential national security implications associated with future climate change. Subsequent

sections discuss DoD climate change policies, future climate change scenarios and counterarguments to addressing climate change. Finally, this research analyzes the current state of implementation within the US Navy and US Air Force, and makes recommendations for how the Air Force can effectively prepare for global climate change.

OVERVIEW OF GLOBAL CLIMATE CHANGE

Despite over twenty years of global study, research and discussion on the matter, the DoD as a whole has been relatively slow in turning its attention to the topic. Advancements in the science behind climate change projections are still needed and debates over the likely impacts of climate change will inevitably continue in the years to come. However, the existing research and data are sufficient to warrant taking action and the time has come for "moving beyond the arguments of cause and effect."[7] As former US Army Chief of Staff General Gordon Sullivan so bluntly stated:

> *We seem to be standing by and, frankly, asking for perfectness in science. People are saying they want to be convinced, perfectly. They want to know the climate science projections with 100 percent certainty. Well, we know a great deal, and even with that, there is still uncertainty. But the trend line is very clear.*
>
> *We never have 100 percent certainty. We never have it. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield. That's something we know. You have to act with incomplete information. You have to act based on the trend line. You have to act on your intuition sometimes.*[8]

The remainder of this section provides a short summary of the current state of global climate change science and outlines some of the potential national security implications of global climate change.

Global Climate Change Science

The purpose of this research is not to provide a detailed examination of the scientific research and concepts behind global climate change. However, an overview of the causes of global climate change and current climate change projections will greatly benefit the reader in understanding the potential magnitude and significance of the matter. The terms 'global climate change' and 'climate change' will be used synonymously in this research paper and it is important to distinguish between these terms and the often used term 'global warming.' In a strict sense, global warming is defined as "an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns."[9] Climate change is defined more broadly and is not limited to temperature increases. For the discussion in this research paper, climate change is defined as "any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer)."[10] In common usage and popular discussion the terms 'global warming' and 'global climate change' are often used interchangeably. The descriptor 'global' can also be misleading since the effects of climate change will often vary significantly across the different geographies of the diverse regions of the earth.[11]

The *Fourth Assessment Report* of the Intergovernmental Panel on Climate Change presents a comprehensive summary of the current state of climate change science and provides the basis for this section. The IPCC consists of hundreds of highly qualified experts from throughout the world who review published scientific literature with the goal of providing "rigorous and balanced scientific information to decision makers."[12] A major assumption of this research is that the IPCC's literature research and peer review process is adequate to provide scientifically defensible observations and projections concerning global climate change.

Although proper scientific review and constructive debate should continue as more research and data become available, the current consensus is that climate change is occurring and will have certain adverse effects. The IPCC's extensive review process is adequate to scrutinize climate change research and until the claims of AR4 are repudiated by wide-ranging data and research to the contrary, the cynics of climate change should be considered statistical outliers. The following are 10 select summary findings from the IPCC's AR4:

1) Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.[13] See Appendix A for graphs of global temperatures, global average sea level and Northern Hemisphere snow cover.

2) Global greenhouse gas (GHG) emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.[14] See Appendix B for charts of global anthropogenic (i.e., human-caused) GHG emissions.

3) Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations. It is likely that there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica).[15] See Appendix C for graphs of global and continental temperature change.

4) There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.[16]

5) Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century.[17] See Appendix D for graphs of GHG emissions scenarios and surface temperature projections.

6) Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems.[18]

7) Anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if GHG concentrations were to be stabilized.[19]

8) Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change.[20]

9) A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change. There are barriers, limits and costs, which are not fully understood.[21]

10) Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity and attitudes to risk.[22]

It is important to note that the above findings represent the most current understanding of climate change based on research compiled at the time of the report. The IPCC is currently working on its *Fifth Assessment Report* (AR5), which is scheduled for completion in 2015.[23] As each future assessment report is published, the findings should be carefully examined for changes in observations and projections. Given the findings of AR4 that climate change is occurring and may have significant future impacts, it is important for military planners and policymakers to understand the implications such changes may have on the future national security of the United States.

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National Security Implications

When compared to other national security threats, "Global climate change presents a new and very different type of national security challenge."[24] Climate change is considered one in "a series of powerful cross-cutting trends" that will muddy future international relations and have substantial geopolitical impacts.[25] Climate change, in the absence of other factors, does not necessarily cause conflict, but it "may act as an accelerant of instability or conflict, placing a burden to respond on civilian institutions and militaries around the world."[26] A 2007 report by the Center for Strategic & International Studies and the Center for a New American Security,

titled *The Age of Consequences*, examined the national security implications in the next 30 years resulting from three future climate change scenarios: *expected*, *severe*, and *catastrophic*.[27] While the magnitude of the national security challenges vary significantly within each of the three future scenarios, the report established the following 10 "highly consequential implications of climate change" that were common to all scenarios:[28]

1) Soft power and North-South tensions will increase.
2) Migration and immigration will rise, producing a strong backlash.
3) Public health problems will grow.
4) Resource conflicts and vulnerabilities will intensify.
5) Nuclear activity will increase, with attendant risks.
6) Challenges to global governance will multiply.
7) Domestic political repercussions and state failure will occur.
8) The balance of power will shift in unpredictable ways.
9) China's role will be critical.
10) The United States must come to terms with climate change.

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Two broad categories exist for the potential effects of climate change on the military and those categories are geo-strategic implications and direct impacts to military equipment, facilities and operations.[29] The geo-strategic implications of climate change include reduced access to fresh water, impaired food production, health catastrophes, and displacement of major populations from sea level rise and flooding.[30] Direct impacts on the military from climate change include bases threatened by rising sea levels, severe weather effects on military operations, and increased maintenance on weapons systems and platforms.[31] Another

consideration in the discussion of national security implications is the potential link between climate change and terrorism.[32] Future effects of climate change such as resource scarcity and migration could lead the affected communities to turn to terrorist groups that "can provide for their basic needs better than existing economic and political institutions."[33]

In 2007 a Military Advisory Board composed of eleven retired three and four-star admirals and generals issued a report titled *National Security and the Threat of Climate Change.* The report was unique in that, according to Military Advisory Board member retired General Anthony C. Zinni, United States Marine Corps, it was "the first real look" at the security threats of climate change from a US military perspective.[34] The report contained the following four main findings:[35]

1) Projected climate change poses a serious threat to America's national security.

2) Climate change acts as a threat multiplier for instability in some of the most volatile regions of the world.

3) Projected climate change will add to tensions even in stable regions of the world.

4) Climate change, national security, and energy dependence are a related set of global challenges.

In addition to examining the national security threats of climate change, the Military Advisory Board also made five recommendations; one of which was that the "national security consequences of climate change should be fully integrated into national security and national defense strategies."[36] As is shown in the next section, the DoD has made significant progress on this recommendation since it was issued in 2007.

DEPARTMENT OF DEFENSE CLIMATE CHANGE POLICIES

Now that scientific consensus has established that global climate change is occurring and could entail significant consequences, the DoD is obligated to "determine the potential impacts of climate change on its ability to execute its mission in support of national security objectives."[37] The DoD's formal interest in climate change began with the passage of the 2008 National Defense Authorization Act (NDAA).[38] The 2008 NDAA required the DoD for the first time to:[39]

1) Assess the risks of projected climate change to current and future missions of the armed forces;

2) To update defense plans based on these assessments, including working with allies and partners to incorporate climate mitigation strategies, capacity building, and relevant research and development; and,

3) To develop the capabilities needed to reduce future impacts.

The above climate change language within the 2008 NDAA served as a catalyst for the establishment of several recent U.S. policy documents on climate change. Coupled with additional direction and mandates from the Executive branch, the DoD now has formal strategic-level guidance on climate change. The remainder of this section provides an overview of the current state of DoD climate change policies by summarizing in chronological order three significant policies that have been issued since the 2008 NDAA was enacted: (1) Executive Order 13514, (2) the 2010 Quadrennial Defense Review, and (3) the 2010 National Security Strategy.

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Executive Order 13514

Since assuming office, President Obama has been engaged on the matter of climate change and has taken several steps to establish climate change as a key issue for the Federal Government in general and the DoD in particular. In October 2009 President Obama issued *Executive Order (EO) 13514: Federal Leadership in Environmental, Energy and Economic Performance*. The object of EO 13514 is "to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas emissions a priority for Federal agencies."[40] Executive Order 13514 is significant since it mandates that the DoD and other Federal agencies establish Fiscal Year 2020 percentage reduction targets for GHG emissions.[41] In response to EO 13514, the DoD announced that it will cut non-combat GHG emissions 34% by 2020.[42] The 34% reduction target exempts "tactical vehicles such as aircraft, ships and armored vehicles that directly support the war fighter."[43] However, the DoD stated that energy reductions for combat activities are a "major focus of the department's energy security strategy."[44]

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2010 Quadrennial Defense Review

The 2010 QDR represents a major component in transforming how the DoD is addressing global climate change. Although the topic of climate change was totally absent in previous versions, the 2010 QDR sends a clear message that climate change should be a major consideration in future national security planning. Reforming the way the DoD does business is one of the two primary objectives established in the 2010 QDR.[45] The 2010 QDR further identifies climate change as a specific issue "where reform is imperative."[46] From the 2010 QDR:[47]

> *Climate change and energy will play significant roles in the future security environment. The Department is developing policies and plans to manage the effects of climate change on its operating environment, missions, and facilities. The Department already performs environmental stewardship at hundreds of DoD installations throughout the United States, working to meet resource efficiency and sustainability goals. We must continue incorporating geostrategic and operational energy considerations into force planning, requirements development, and acquisition processes.*

The 2010 QDR specifically addresses a Military Advisory Board recommendation by stating that the DoD "must complete a comprehensive assessment of all installations to assess the potential impacts of climate change on its missions and adapt as required."[48] Overall, the policies set forth in the 2010 QDR lay the foundation for addressing all three of the Military Advisory Board recommendations directed at the DoD.[49] As the science behind climate change advances, the 2010 QDR also commits to regular revaluation of risks and policies.[50]

2010 National Security Strategy

In May 2010, President Obama issued his first *National Security Strategy* and it boldly states, "The danger from climate change is real, urgent, and severe."[51] The 2010 NSS also repeatedly emphasizes the intertwined nature of climate change and many other national security concerns. Within the 2010 NSS, the phrase "climate change" appears 23 times in concert with security issues such as energy dependence, pandemic disease, resource scarcity, job creation, nuclear energy, drought, famine, and refugees. The discussion on climate change in the 2010 NSS is divided into two categories: 1) efforts within the United States, and 2) efforts abroad. Regarding climate change within the United States, the 2010 NSS states:[52]

> *Our effort begins with the steps that we are taking at home. We will stimulate our energy economy at home, reinvigorate the U.S. domestic nuclear industry, increase our efficiency standards, invest in renewable energy, and provide the incentives that make clean energy the profitable kind of energy. This will allow us to make deep cuts in emissions—in the range of 17 percent by 2020 and more*

> *than 80 percent by 2050. This will depend in part upon comprehensive legislation and its effective implementation.*

After discussing efforts within the United States, the 2010 NSS then addresses climate change abroad as follows:[53]

> *Regionally, we will build on efforts in Asia, the Americas, and Africa to forge new clean energy partnerships. Globally, we will seek to implement and build on the Copenhagen Accord, and ensure a response to climate change that draws upon decisive action by all nations. Our goal is an effective, international effort in which all major economies commit to ambitious national action to reduce their emissions, nations meet their commitments in a transparent manner, and the necessary financing is mobilized so that developing countries can adapt to climate change, mitigate its impacts, conserve forests, and invest in clean energy technologies. We will pursue this global cooperation through multiple avenues, with a focus on advancing cooperation that works. We accept the principle of common but differentiated responses and respective capabilities, but will insist that any approach draws upon each nation taking responsibility for its own actions.*

The 2010 NSS represents the latest forward step in a DoD climate-change-acknowledgement continuum. As is demonstrated in the following section, the policies enacted in recent years are already beginning to realize positive results and cultural changes within the DoD.

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Evolution and Impacts of Policies

Within a timeframe of less than three years, the DoD has gone from essentially having no official guidance on climate change to having multiple national-level strategic guidance documents that recognize the potential significance of future climate change and mandate that the DoD act accordingly to alleviate and prepare for this threat. There is still much work to be done by the DoD in order to fully incorporate the new climate change guidance, but the impacts of its recent climate change efforts have already been noted. In April 2010, the Pew Charitable Trusts released a report titled *Reenergizing America's Defense: How the Armed Forces Are*

Stepping Forward to Combat Climate Change and Improve the U.S. Energy Posture. The report finds that, "the military has clearly recognized and is responding to the twin threats of energy dependence and climate change."[54] Overall, the tone of the 2010 Pew report is optimistic and it concludes that, "While work remains to be done, the military continues to build on its successful record in managing resources and investing in long-term innovations. DoD is well-positioned to help manage the threats caused by climate change."[55]

It is a relatively easy matter to recognize a problem. However, fixing a problem is an entirely different and often more complicated matter. The DoD has clearly recognized the climate change threat, but the real work will be in preparing appropriately. In an effort to assist the Air Force in planning effectively, the next section provides a conceptual overview of potential future Air Force climate change scenarios.

FUTURE CLIMATE CHANGE SCENARIOS

> *In times of change, learners inherit the earth, while the learned find themselves equipped to deal with a world that no longer exists.*
>
> Eric Hoffer[56]

To avoid equipping itself for a "world that no longer exists" the Air Force must consider what ranges of possible futures might arise as a result of climate change.[57] Understanding and recognizing potential future scenarios will assist the Air Force in effective planning and preparation. The IPCC defines a scenario as "a coherent, internally consistent and plausible description of a possible future state of the world. Scenarios are not predictions or forecasts but are alternative images without ascribed likelihoods of how the future might unfold."[58] There are many variables that will determine the future impacts that climate change has upon the Air

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Force, but these can be reduced down to two primary factors; 1) the magnitude of future climate change and 2) the level of preparation undertaken by the Air Force.

Determining Factor #1 – Magnitude of Future Climate Change

As climate change science has developed over the past decades, a major focus has been developing projections and models to better understand and predict the future magnitude of climate change. A major complicating factor is that the various future climate scenarios are highly dependent upon several interrelated driving forces that are of a global scale. Some of the major driving forces behind climate change scenarios include population growth, socio-economic development and technological development.[59] Each of the major driving forces of climate change directly influences greenhouse gas sources and sinks and will alter the natural climate system.[60] Given that there is a high degree of uncertainty regarding the future magnitude of each of the major driving forces behind climate change, it is important to consider a wide range for the overall potential future magnitude of climate change.

As previously mentioned in the climate change overview section, *The Age of Consequences* report examined the national security implications resulting from three future climate change scenarios: *expected*, *severe*, and *catastrophic*.[61] The purpose of the research report was to use existing data and climate models to develop three different, yet plausible, scenarios for the effects of climate change in the coming decades. In the *expected* scenario an average global temperature increase of 1.3 degrees Celsius and a sea level rise of 0.23 meters by 2040 is assumed.[62] Under the *expected* scenario, the impacts would include "heightened internal and cross-border tensions caused by large-scale migrations; conflict sparked by resource scarcity, particularly in the weak and failing states of Africa; increased disease proliferation, which will have economic consequences; and some geopolitical reordering as nations adjust to shifts in

resources and prevalence of disease."[63] The authors of the report argue that their *expected* scenario "can reasonably be taken as a basis for national planning" and they also state that, "it is not alarmist to say that this scenario may be the best we can hope for. It is certainly the least we ought to prepare for."[64]

Under the *severe* scenario of the *The Age of Consequences* report, an average global temperature increase of 2.6 degrees Celsius and a sea level rise of 0.52 meters by 2040 is assumed.[65] A premise of the severe scenario is that "massive nonlinear events in the global environment give rise to massive nonlinear societal events."[66] In the *severe* scenario the magnitude of changes and the destructive challenges would overwhelm the nations of the world.[67] Significant increases in migration, changes in agriculture, and shortages of freshwater would occur around the world as a result of coastal flooding.[68] The severe scenario also concludes that "armed conflict between nations over resources, such as the Nile and its tributaries is likely" and that the "social consequences range from increased religious fervor to outright chaos."[69]

As the name implies, the *catastrophic* scenario presented in the *The Age of Consequences* report presents a rather sobering and gloomy future world. The *catastrophic* scenario assumes an average global temperature increase of 5.6 degrees Celsius and a sea level rise of 2.0 meters over the next 100 years.[70] Since it poses almost unconceivable difficulties to society, the *catastrophic* scenario challenges the imagination and is very difficult to visualize.[71] The major finding of the *catastrophic* scenario is a strong link between global climate change and international extremist terrorism.[72] The authors contend that the *catastrophic* scenario should be considered plausible because of "the possibility that some positive feedback loops could radically accelerate climate change well beyond what the climate models currently predict" and

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because of "the prospect of accelerated emissions of carbon dioxide in the near future due to substantial economic and population growth, particularly in developing countries such as China."[73] The future impact of climate change on the Air Force is highly dependent on the magnitude of change, but as will be shown in the next section, the level of Air Force planning and preparation will also play a role.

Determining Factor #2 – Level of Air Force Preparation

The extent to which the Air Force's level of planning and preparation will affect its ability to complete its future missions in the face of climate change challenges provides the thesis of this reserach. The author contends that a lack of adequate preparation in the near term for global climate change could have significant adverse impacts in the future on the Air Force's ability to complete its mission. It should come as no surprise that the correlation between the level of Air Force preparation and the effect this will have on future Air Force mission readiness is difficult to quantify. Just as with predicting the future magnitude of climate change, there are several interrelated driving forces, such as political systems and policies, resource allocation, and competing priorities, which will determine the Air Force's future level of planning and preparation for climate change. There exists a very high degree of uncertainty as to what impact the driving forces will have on the Air Force's ability to plan and prepare for climate change. Because of the very high uncertainty, the plausible ranges of Air Force preparation for climate change could range from doing nothing to entirely changing the way the Air Force conducts its current missions.

As an entity of the Federal government that is subject to the will of the American citizens as expressed through their elected politicians, the Air Force will be subjected to future political changes in regards to climate change. Just as the recent lawmakers have served as the genesis

for Federal and DoD guidance on climate change, changes in policy will inevitably occur under future administrations and Congresses. In addition to politics, resource allocation and competing priorities will serve as significant driving forces of Air Force preparation for climate change. Although strategic planning for climate change is a time-intensive matter, the planning costs are relatively inexpensive when compared to the potentially massive funding allocations that might be required to make operational, weapon system and facility modifications to counter future climate change.

Air Force preparations for climate change can be considered either proactive such as actions aimed at reducing greenhouse gas emissions or reactive such as mitigation actions. Due to its large size and its ability to drive industry changes through innovative technology, the Air Force will have a direct impact on the future magnitude of climate change. A significant component of Air Force proactive preparations for climate change will be the extent to which it reduces its future total greenhouse gas emissions. Reactive preparations for climate change could include facility and weapon system modifications in response climate change impacts such as rising sea levels or increased severe weather events. Many of the proactive and reactive preparations for climate change would have lead times on the order of decades and would require significant funding. High uncertainties in driving forces behind climate change make a wide variance in possible future scenarios for the impact of climate on the Air Force. The next section provides a conceptual spectrum that highlights four future climate change scenarios.

Conceptual Spectrum of Future Climate Change Scenarios

Based on the two determining factors discussed in the previous section, high and low extremes of each factor are assumed in order to present four future scenarios for the impacts of climate change on the Air Force. A matrix of the four possible future scenarios is provided in

Figure 1. The scenarios presented characterize a broad continuum of possible future outcomes and provide a conceptual look at how the Air Force might effectively prepare for climate change in the future decades, particularly in the year 2040.

HIGH Level of Air Force Preparation

3 - Who Cried Wolf? We are ready, but wish we had not invested so much time and money getting there.	**4 - Bring it On!** Climate change is a big deal and we are glad that we planned ahead.
1- Lucky Gambler. Good thing we did not bother with climate change and spent our time and money elsewhere.	**2- Noah's Ark.** Maybe we should have listened to that flood insurance salesman.

SMALL Magnitude of Future Climate Change

LARGE Magnitude of Future Climate Change

LOW Level of Air Force Preparation

Figure 1. Matrix of possible future US Air Force climate change scenarios

Under Scenario 1, Lucky Gambler, it is the year 2040 and the Air Force has not made any significant modifications to its practices of thirty years earlier in regards to countering climate change. The Air Force is primarily fueled by conventional petroleum sources and its greenhouse gas emissions have increased steadily over the past few decades. Due to other immediate needs, funding was not dedicated for research and projects to reduce Air Force greenhouse gas emissions. Projections made thirty years earlier of a warming climate with adverse impacts have not occurred and the earth's climate system has somehow continued to function relatively normally despite decades of worldwide increases in greenhouse gas emissions. Air Force

leadership is glad that they have lucked out when their predecessors decided decades ago not to tackle any global climate change initiatives.

Scenario 2, Noah's Ark, present a stark contrast to the future presented in Lucky Gambler. For the past thirty years, the projections made by climate change scientists have proven to be conservative and the earth's climate system has warmed at a rate much more significant than forecasted decades earlier. As a result of major sea level rise and severe regional droughts, mass migration of displaced populations has wreaked havoc upon the relatively peaceful geo-political system that existed thirty years prior. On a global level, terrorism runs rampant as immigrants turn to extremist organizations in hopes that they can provide them a better future than the once great nations they belonged to. Neighboring nations that were once allies are now enemies due to policies enacted to close borders in an attempt to prevent immigration. Despite all of the warning signs of the previous decades, the Air Force seems to have responded too late to all of the climate change problems and has desperately been trying to get in front of the problems. The Air Force has been severely strained as it struggles to support multiple simultaneous operations throughout the world that have emerged as a result of displaced populations. Pressure is mounting on the American home front to have the Air Force completely withdraw from its foreign operations in order to assist displaced Americans and defend its own borders against mass migration. Global disruptions in the petroleum distribution system have resulted in reduced availability, soaring oil prices, and have been significantly detrimental to the Air Force's ability to provide the fuel-intensive air support necessary to assist other DoD services. Air Force leadership does not foresee any solution to the current problems and is left wondering how it could have better prepared for the contingencies it is now facing.

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Welcome to Scenario 3, Who Cried Wolf? It is the year 2040 and the Air Force has been diligently planning and preparing for global climate change ever since the 2010 NSS and QDR identified the issue as a major DoD priority. Over the past thirty years considerable changes have been made in the way the Air Force does business and greenhouse gas emissions have been steadily and significantly reduced. Innovative, yet costly, alternative energy technologies have been developed and the Air Force is primarily fueled by alternative energy sources. Due to the immense cost of implementing alternative energy technologies, other strategic priorities and programs were indefinitely put on hold. The projections made decades earlier of the adverse impacts of a warming climate have not panned out. Air Force leadership is pleased that their predecessors chose to proactively respond to climate change concerns, but they cannot help wondering if at least some of their predecessors' time and money could have better been dedicated to other priorities and initiatives.

The year is 2040 and Scenario 4, Bring it On!, presents a world in which climate change has entailed significant adverse impacts on the nations of the world, but the Air Force has prepared effectively to confront these challenges. Beginning with publication of the 2010 NSS and QDR, the Air Force implemented changes to include reducing greenhouse gas emissions, implementing alternative energy technologies, and modifying weapon systems and facilities to withstand climate change impacts. The Air Force is primarily fueled by alternative energy sources and has invested in the infrastructure necessary to ensure that it is not dependent upon foreign nations to produce the fuel needed to accomplish its mission. The cost of implementing changes was initially enormous, but the dividends of these investments have yielded increased readiness to respond to the global issues associated with mass migration from sea level rise and severe regional droughts. The geo-political system is in turmoil, extremist terrorism is on the

rise and the Air Force is being called upon to assist throughout the world. The Air Force has done all it can in the previous decades to prepare and stands ready to accomplish its assigned missions in support of problems arising from climate change. Air Force leadership is troubled by current challenges but is grateful that their predecessors laid the groundwork and implemented the changes necessary to ensure their current state of mission readiness.

Because the four future climate change scenarios presented above are based on extremes, it is not likely that any one scenario will come to fruition. The actual future of the Air Force and its relationship to climate change is part of a continuum and will likely fall somewhere within the four extreme scenarios discussed. The author proposes that the key to preparing effectively for any future scenario is to better understand the driving forces behind climate change and incorporate feedback. Only through an enhanced comprehension of climate change observations and projections can the Air Force make informed future decisions regarding resource allocation and comparing climate change to other competing priorities.

COUNTERARGUMENTS TO ADDRESSING GLOBAL CLIMATE CHANGE

Despite the consensus of the IPCC, there are those who contest the science behind climate change. Perhaps the most outspoken US public critic of climate change is Senator James Inhofe, the ranking member of the US Senate Environment and Public Works Committee. Senator Inhofe has repeatedly stated on the floor of the US senate that he believes global warming to be "the greatest hoax ever perpetrated on the American people."[74] Unfortunately, climate change is a topic rife with "political and ideological divisiveness" and this tends to "undermine the development of trusting relationships" between the scientific community and policymakers.[75] Another contributing factor in the promulgation of controversial climate change

claims is the inability of scientific institutions to respond effectively and in a timely manner to criticism.[76]

A major assumption of this research is that the IPCC's literature research and peer review process are adequate to provide scientifically defensible observations and projections concerning global climate change. Although there are many differing opinions on climate change, the focus of this section is not to delve into any political or ideological debates over climate change. Given the assumption that the IPCC's findings are and will continue to be scientifically defensible and given that the DoD already recognizes climate change through its recent policies and guidance documents, the focus of this section is to present competing considerations for dedicating time and resources to preparing for global climate change.

Despite the sometimes dire projections associated with future climate change, it must be recognized that funding limitations exist and there are many other competing national security priorities for these limited resources. In *The Age of Consequences* report on the national security implications of global climate change, the authors present the following list of competing concerns:[77]

> *In the coming decade the United States faces an ominous set of challenges for this and the next generation of foreign policy and national security practitioners. These include reversing the decline in America's global standing, rebuilding the nation's armed forces, finding a responsible way out from Iraq while maintaining American influence in the wider region, persevering in Afghanistan, working toward greater energy security, re-conceptualizing the struggle against violent extremists, restoring public trust in all manner of government functions, preparing to cope with either naturally occurring or manmade pathogens, and quelling the fear that threatens to cripple our foreign policy—just to name a few. Regrettably, to this already daunting list we absolutely must add dealing responsibly with global climate change.*

It is an important question to consider where global climate change ranks on the list of national security concerns. There are those who question dedicating resources towards climate

change in the face of other immediate security issues. In 2007, Brett D. Schaefer, a Fellow in International Regulatory Affairs, and Ben Lieberman, a Senior Policy Analyst in Energy and the Environment, argued for delaying climate change action in favor of other issues since climate change "will not result in a tangible threat to international peace and security for decades."[78] Schaefer and Lieberman claim that addressing climate change within the UN Security Council "is an affront to the millions currently suffering from the depredations of dictatorial regimes around the world and those facing the near-term threats posed by proliferation of weapons of mass destruction, transnational terrorism, and conflict."[79]

The author recognizes that there are opposing points of view as to the importance of climate change in relationship to other priorities. The amount of effort expended by the Air Force to prepare for climate change should be relative to the risk it poses in relation to other strategic concerns. Competing priorities must be given full consideration when deciding what resources to dedicate towards countering climate change. The counterarguments for addressing global climate change can only be correctly evaluated if the threat of climate change is understood. An improved understanding of the potential effects of climate change on the Air Force will assist in making better risk-based comparisons to other competing priorities.

ANALYSIS OF US NAVY CLIMATE CHANGE EFFORTS

Each service within DoD places a different emphasis on climate change and the US Navy "has been most proactive in addressing the related challenges of climate change and energy security."[80] Because of its inherent connection to the sea and coastlines, the Navy is more attuned to many of the effects of climate change such as rising sea level, melting ice caps and extreme weather events. Awareness of the potential impacts of climate change on the Navy has

driven it "to explore more deeply than many other government departments how climate change will affect them."[81]

US Navy Climate Change Program History

In 2009, the Chief of Naval Operations established Task Force Climate Change and Task Force Energy in order to provide Navy leadership with recommended actions and investments in response to the challenges of climate change and energy security.[82,83] The task forces coordinate closely with one another and ensure that the two interconnected issues of climate change and energy security are considered together.[84] The Navy identified the Arctic as its most pressing climate change challenge and the first priority of the Navy's Task Force Climate Change was to establish a specific roadmap for the Arctic.[85] The Arctic "is warming twice as fast as the rest of the globe" and this has major Navy implications if the warming continues and leads to ice-free summers and increased resource development.[86] The Navy distributed its *Artic Roadmap* in November 2009 and it contains actions items, objectives, and desired effects in regards to the Arctic for the years 2010 to 2014.[87] Developing a roadmap for climate change in general was the task force's second priority and this document is discussed in the following section.[88]

US Navy Climate Change Roadmap

The Navy released its *Climate Change Roadmap* (CCR) in May 2010 to address climate change in regions other than the Arctic. [89] The CCR is similar the *Arctic Roadmap* in that it contains Fiscal Year 2010-2014 actions items, objectives, and desired effects in regards to the non-Arctic regions.[90] See Appendix E for a detailed listing of the desired effects, objectives and action items from the Navy's *Climate Change Roadmap*. Every four years, the Navy will update the roadmap reflect current QDR guidance and also extend it into coming fiscal years.[91] The

Navy's CCR consists of a framework of four pillars anchored on a foundation of assessment and prediction, as depicted in Figure 2. As an indication of the intertwined nature of the dual challenges of energy and climate change, the Navy chose to address climate change mitigation efforts under the Navy's *Energy Strategy*, which will be developed by its energy task force.[92] The analysis in the remainder of this section will center around the pillars and foundation presented in the Navy's climate change strategy.

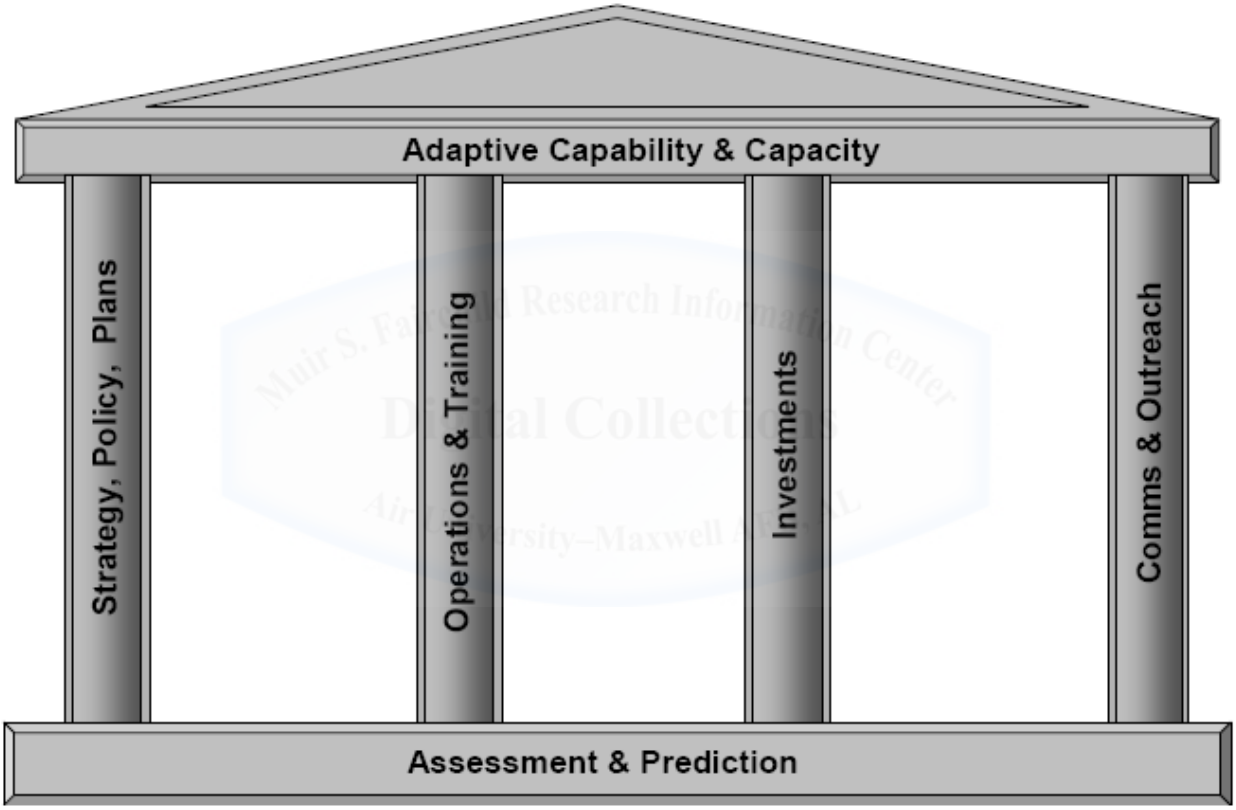

Figure 2. Navy Climate Change Roadmap framework. (Reprinted from United States Navy, "U.S. Navy Climate Change Roadmap," May 21, 2010.)

Strategy, Policy, and Plans. The Navy wants to ensure that its strategies, policies, and plans are "informed by scientifically-based climate change assessments and predictions."[93] The process for accomplishing this will involve generation of a *Global Climate Change Strategic Assessment* that will use existing reports and data to assess the impact of climate change on the current and future geo-strategic environment. Another strategic document, titled *Mission Analysis in View of the Changing Climate,* will be based on the results of the strategic assessment and will specify how the Navy "may need to adjust force structure and infrastructure and real estate to ensure resiliency and capability through a changing climate."[94]

The Navy's roadmap is very proactive in that it calls for the Navy to reach out to approximately twenty different organizations from science, policy and academia and suggest to those organizations climate change areas of interest for the Navy that require further research or study.[95] The Navy has also chosen a very proactive approach to forging and strengthening cooperative agreements with various government and non-government organizations both within and outside of the United States. [96] Climate change discussions and agreements with other DoD services are also specified as a component of the Navy's roadmap.[97]

Operations and Training. An important objective of the Navy is to remain fully mission-capable in the face of future climatic conditions. The Navy will ensure continued mission capability by conducting training and exercises that consider the future tactical, operational, and strategic impacts of climate change.[98] Fleet training programs will be adjusted based on the results of its strategic assessments and mission analysis of future climate change.[99] The Navy is also taking another anticipatory step by including "courses, seminars, symposia, and study/research topic assignments that address climate science and strategic considerations" into their formal training and education.[100] Climate change education will be incorporated into the

curricula offered at the Naval War College, Naval Postgraduate School and United States Naval Academy.[101]

Investments. The Naval investments necessary to counter the future effects of climate change could be significant and its finite resources must be wisely invested. The investments section of the Navy's roadmap recognizes that the Navy needs better information on the "current and required capability of infrastructure to adapt to climate change."[102] Consequently, a *Navy Climate Change Adaptation Capabilities Based Assessment* will identify potential infrastructure impacts and will also outline potential DoD, international, and interagency investment partners.[103] Also, the Office of Naval Research will identify and maintain a list of *Climate Change Science and Technology Needs*. The Navy's list of climate change science and technology needs will inform the scientific and academic communities on how they may "improve the Navy's capability for assisting, predicting, and adapting to climate change."[104] It is critical that climate change needs reflected in strategic guidance documents are also reflected in budget requirements. The Navy's roadmap mandates that the Navy, beginning with its Fiscal Year 2014 budget, identify any funding needed to address climate change science and technology needs as well as research and development requirements.[105]

Strategic Communication and Outreach. As an issue that is "laden with complex perspectives representing a wide range of worldviews", climate change is not readily understood by many policy makers and members of the American public.[106] Furthermore, the topic of climate change has been heavily undermined in the United States by political and ideological disagreement and this has led to both confusion and strong emotions on the topic.[107] A 2008 National Academy of Sciences report also notes that "In general, scientists and engineers have done a poor job of communicating scientific information clearly and effectively to policy makers

and the public."[108] The strategic outreach and communication portion of the Navy's roadmap attempts to counter the climate change misinformation by defining "target audiences, communication channels and venues, and milestones for communicating Navy action with regard to climate change."[109] The roadmap also calls for an annual Climate and Energy Forum to "communicate, discuss, advance and adjust the Navy's energy and climate change initiatives."[110]

Environmental Assessment and Prediction. A 2010 report by the Center for a New American Security titled *Lost in Translation* stated, "national security leaders do not yet have the scientific information they need to make the best possible policy decisions about climate change – policy decisions that will entail large financial commitments to address a range of national security risks."[111] The Navy recognizes this dilemma and their roadmap presents assessment and prediction as the foundation upon which the roadmap is built.[112] Without a solid foundation in environmental assessment and prediction, the Navy's climate change pillars (i.e., strategies, policies, and plans, operations and training, investments, and communications and outreach) will crumble. Components of the Navy's assessment and prediction action items are found throughout many of the other roadmap objectives. Just as with investments, the roadmap also contains mechanisms to ensure that environmental assessment and prediction requirements are identified and addressed within the Navy's budgets beginning in Fiscal Year 2014.[113]

The result of the *Climate Change Roadmap* is that the Navy has a "clearer vision than the other services and federal departments of how climate change is likely to affect their work, instilling a high level of confidence that they will be able to adapt."[114] The creation of Task Force Climate Change and the *Climate Change Roadmap* are a reflection of the importance that top Navy leadership has placed on understanding and preparing for climate change. A major key

to the success of the Navy's climate change program has undoubtedly been the vigor with which its senior leaders have taken on the climate change issue.

ANALYSIS OF US AIR FORCE CLIMATE CHANGE EFFORTS

Similar to the Navy, climate change also has the potential, in the mid to long term, to change the Air Force's operating and strategic environments.[115] However, the ways in which climate change may affect the Air Force are likely different from the Navy because of their differing missions. The Navy's connection to the sea brings the importance of climate change to the forefront, but the Air Force, with its connection to the sky, land and global security, must also consider the potential implications of global climate change. Although the Navy and Air Force are guided by the same DoD policies, their approaches to addressing climate change differ significantly.

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US Air Force Energy Program

To date, Air Force involvement in climate change has revolved almost exclusively around its energy security policy. The primary focus of Air Force energy reduction has been "ensuring access to fuel for mission effectiveness purposes" and there has been much less of a focus on "how reducing GHG emissions will affect its operating environment or capabilities."[116] As part of the general national security discussion, it is known that climate change could affect installations and equipment and it may create destabilizing conditions internationally, but researchers have not yet examined how climate change could affect the Air Force specifically.[117]

The Air Force has been very proactive in its energy security strategy and has developed an *Air Force Energy Plan 2010* with a vision to "Make Energy a Consideration In All We Do."[118] The *Air Force Energy Plan 2010* is based on three pillars of energy management: reduce

demand, increase the supply of renewable and alternative fuels, and culture change.[119] In regards to climate change, the *Air Force Energy Plan 2010* states the following:[120]

> *The Air Force recognizes the importance of addressing climate change, and supports all DoD and Administration objectives in tackling this global problem. Carbon dioxide emissions, the primary contributor to human-induced climate change, are largely a result of fossil fuel combustion. As the largest consumer of fossil fuels in the federal government, the Air Force recognizes that any efforts to reduce its consumption of fossil fuels will also reduce the Air Force's carbon footprint. The projected impacts of climate change are varied, but it is known that unstable regions of the world are most vulnerable to social and political unrest as a result of climate change. The national security consequences of climate change should be fully integrated into national defense strategies to ensure Air Force operational capabilities are aligned with the potential challenges ahead. Additionally, an assessment of the impact of rising sea levels, extreme weather events, and other climate change-related impacts on Air Force installations and MAJCOMs should be conducted. The Air Force should enhance its operational capabilities by accelerating the adoption of improved business processes and innovative technologies that result in improved U.S. combat power and energy efficiency. The Air Force must be an active participant in climate change mitigation efforts by the military and should pursue global partnerships to address the global security implications of climate change.*

While the efforts by the Air Force to reduce energy consumption and increase the use of alternative fuel are commendable, these efforts should also be linked to climate change considerations. Without careful planning and a clear link between energy security and climate change, it is possible to further one cause while damaging the other. For example, the 2010 QDR states, "By 2016, the Air Force will be postured to cost-competitively acquire 50 percent of its domestic aviation fuel via an alternative fuel blend that is *greener* than conventional petroleum fuel." (emphasis added)[121] By reading in the 2010 QDR of a "greener" alternative fuel blend, the reader might automatically assume that this is referring to lower GHG emissions. However, the US Environmental Protection Agency (EPA) has determined that "many, although not all, of these fuels can provide reductions in greenhouse gas emissions."[122] As of August 2010, the Air Force had certified 85% of its aircraft to run on Fischer-Tropsch alternative fuels

that use either coal or natural gas as the feedstock.[123] According to the US EPA, the production of Fischer-Tropsch fuels results in a 118% increase in lifecycle GHG emissions when compared to petroleum fuel.[124] Although the use of Fischer-Tropsch fuels will help the Air Force achieve its 2016 goal of 50 percent diversion to alternative fuels, the switch could result in a significant increase in GHG emissions.

The Air Force is also testing the performance of hydro-treated renewable jet (HRJ) fuels, which would result in reduced GHG emissions when compared to conventional jet fuel.[125] In March 2010, an Air Force A-10 Thunderbolt II flew on a 50/50 blend of HRJ and conventional jet fuel.[126] Continuing its alternative fuels certification testing, the Air Force successfully flew a C-17 Globemaster III in August 2010 using a mixture of 25 percent HRJ, 25 percent Fischer-Tropsch fuel, and 50 percent conventional jet fuel.[127] The Air Force alternative fuels program has the potential to reduce dependence on conventional petroleum-based fuels, but the Air Force may "have a difficult time translating how these efforts contribute to national climate change goals."[128]

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Comparison to the US Navy Climate Change Program

A comparison of the Air Force and Navy approaches to climate change is well-summarized by the following statement: "The Air Force is prioritizing assured access to fuel supplies and has not as strongly or directly linked its efforts to achieve energy security with the goal of climate change mitigation. Moreover, due to other pressing institutional challenges, the Air Force has simply devoted less attention to the issue of climate change to date."[129] In contrast to the Navy, the Air Force has not produced a formal guidance document, strategy or roadmap for assessing and adapting to the potential future effects of climate change. Even when climate change is mentioned in the *Air Force Energy Plan 2010*, support is expressed for climate change

initiatives, but it is not clarified when they will be addressed or who within the Air Force will be responsible for such efforts. Rather than clarifying what the Air Force *will* do to prepare for climate change, the *Air Force Energy Plan 2010* simply acknowledges a few things the Air Force *should* do. The *Air Force Energy Plan 2010* recognizes climate change as a concern but does not take on accountability or ownership for climate change planning. Air Force efforts to address climate change pale in comparison to the well-supported, well-documented, and well-coordinated strategy that the Navy has developed.

CONCLUSIONS AND RECOMMENDATIONS

The overarching conclusion of this research is that there is much that the Air Force should do to prepare for climate change in the coming decades. The US Navy has implemented an effective climate change program which provides a replicable role model and great starting point for the development of an Air Force climate change program. A significant challenge facing the Air Force in the coming years as it grapples to prepare for climate change will be striking "a delicate balance between spending money too soon and potentially wasting resources by placing bad bets and investing too late and risking failure or preventable complications in future missions."[130] In order to avoid placing bad bets, the Air Force needs to develop a sound climate change program and invest in further climate science. In support of the conclusions of this research, the following sections contain five specific recommendations that would assist the Air Force to effectively plan for future climate change.

Create a Climate Change Senior Focus Group

If the Air Force is to have a successful climate change program it must originate from and be adequately supported by top senior leadership. Similar to Task Force Climate Change created by the Navy, it is recommended that the Air Force create a Climate Change Senior Focus Group

(SFG). The Climate Change SFG could be modeled after the Air Force's Energy SFG and should be charged with oversight of the development of a formal climate change program and strategy for the Air Force.[131] It is important that the Climate Change SFG be composed of senior Air Force leaders. Senior leaders must be interested and involved in order for climate change issues to receive adequate exposure and in order to drive the cultural change that may be necessary for implementing climate change projects and initiatives. Another major key to success would be to ensure synergy and coordination between the Climate Change SFG and Energy SFG.

Develop a Formal Climate Change Strategy

It is recommended that the Air Force develop and publish a climate change strategy signed by the Secretary of the Air Force. The logic and reasoning behind the Navy's *Climate Change Roadmap* provide a great starting point for how the Air Force could establish a formal climate change strategy. In particular, the Navy's foundation of environmental assessment and prediction and four climate change pillars of: 1) strategies, policies, and plans, 2) operations and training, 3) investments, and 4) communications and outreach, provide an excellent framework for an Air Force climate change strategy. However, a direct duplication of the Navy's climate change strategy would not be appropriate for the Air Force. When developing an Air Force climate change strategy, a careful analysis of the efforts of the Navy and other services must be performed in order to avoid duplication of efforts and capitalize on lessons learned. As its formulates its climate change strategy the Air Force should identify which aspects of climate change are unique to the Air Force and which aspects are common to the other DoD services. Special consideration and attention must be given to any aspects of climate change identified as exclusively Air Force climate change issues. For those climate change challenges which are

faced by other DoD services, close coordination and partnering with other services should occur to ensure that proposed Air Force efforts are part of a broader and collective DoD response. Similar to the Navy's *Climate Change Roadmap*, mechanisms for regular feedback and assessment should also be incorporated into an Air Force climate change strategy. Once the Navy's Task Force Energy publishes its energy roadmap, the Air Force should also exam this document to evaluate the potential Air Force applicability of the Navy's climate change mitigation procedures.

The Air Force currently funds and sustains an extensive energy program. The issue of fully integrating the Air Force's energy and climate change programs should also be addressed in an Air Force climate change strategy. If properly synchronized, "the Air Force's most successful efforts to reduce GHG emissions and mitigate climate change are likely to come from the same measures that boost its mission effectiveness: reducing demand for energy through conservation and efficiency efforts."[132] Combining climate change and energy security will ensure that the Air Force is meeting the intent of the 2010 QDR, 2010 NSS and the President's federal climate and energy goals.

Assess Installations for Climate Change Impacts

The recommendation to individually assess military installations for the potential future impacts of climate change is contained in many documents. The Military Advisory Board report recommended that the DoD **"**conduct an assessment of the impact on US military installations worldwide of rising sea levels, extreme weather events, and other possible climate change impacts over the next 30 to 40 years."[133] In the 2010 QDR the need to still complete such an assessment at all installations was reiterated.[134] The well-documented need for the DoD to conduct installation climate change assessments still needs to be translated into action by the Air

Force. The execution plan for installation climate change assessment should be outlined in the formal Air Force climate change strategy discussed under the previous recommendation. The Air Force climate change strategy should address this requirement by first dictating the development of a framework to evaluate and rank potential impacts. After an acceptable impact evaluation framework is developed, the climate change strategy should then establish timelines for the accomplishment of base-by-base climate change assessments.

Establish a Climate Change Office

It is also recommended that the Air Force establish and fully fund an office with the purpose of monitoring the implementation and effectiveness of the Air Force climate change program. An Air Force Climate Change Program Management Office should be established at the Headquarters Air Force level. In order to achieve synergy and success, the office should be founded at the same organizational level as the already existing Energy Program Management Office (EPMO). It is recommended that, just as with the energy program, the Assistant Secretary of the Air Force for Installations, Environment and Logistics (SAF/IE) serve as the Director of the Climate Change Program Management Office and also the Office of Primary Responsibility (OPR) for the document outlining the Air Force's formal climate change strategy.[135]

A major role of the climate change office should be translating for policy makers the climate change information from science and academia. The scientific and academic communities and the Air Force policy makers are "intellectually, linguistically and culturally distinct" from one another.[136] In order for the climate change information to be correctly communicated to policy makers, trained personnel who understand both sides will need to act as mediators. To assist with the important task of translating scientific information for policy makers it is suggested that the Air Force climate change office rely upon the Air Force Center for

Engineering and the Environment (AFCEE). Part of the AFCEE mission is to provide "technical services that optimize Air Force and Joint capabilities through sustainable installations."[137] The Technical Support Division at AFCEE currently employs subject matter experts in various environmental program areas to provide technical expertise to Air Force personnel.[138] Borrowing from this existing organizational model, AFCEE should hire subject matter experts in climate change to provide technical advice and assistance to the Air Force Climate Change Program Management Office. Subject matter experts could also assist the Air Force climate change office in its initiatives to reach out to academia and scientific communities for assistance in climate change research.

Reach Out and Invest in Further Climate Research

Just as the Navy did in its climate change strategy, the Air Force needs to establish environmental assessment and prediction as the foundation of its climate change program.[139] The Air Force must carefully identify what specific climate change questions and needs it has and which organizations in the scientific and academic communities it will reach out to for help. The Air Force will need much research and study performed so that they can "fully conceptualize the effects that climate change may have on its strategic and operating environment."[140] It will also be important that the Air Force allocate funding to support its climate change research needs.

One example of an area requiring further research is the calculation of the total GHG emissions of alternative jet fuels when compared to conventional jet fuels. As previously discussed, certain alternative jet fuels that the Air Force is currently testing may lead to increased GHG emissions. The Air Force should invest in research that produces sound evaluation frameworks and further evaluates the total lifecycle GHG emissions for all fuels that are either

currently being tested or are being considered for its alternative jet fuels program. To avoid developing conflicting methodologies for calculating the lifecycle GHG emissions of alternative jet fuels, it would be wise for the Air Force to coordinate with private industry and involve the US Environmental Protection Agency in the development and review of the research. As better research results become available on the lifecycle GHG emissions of alternative fuels, the Air Force could use the information to align its alternative fuels program with Federal GHG emission reduction targets.

With technology in place such as climate satellites and computer modeling, there is much climate information available today, and there will undoubtedly be much more available in the future. However, it is unknown whether the resolution and type of information currently collected is valuable for the unique needs of the Air Force.[141] In order to know whether the available climate information is valuable for the specific needs of the Air Force, it must first define the specific climate change questions that need to be answered. Only through the careful and insightful consideration and input of Air Force leaders and climate experts will the Air Force be able to define the most important and relevant climate change questions. The Air Force policy makers require "actionable" data "that can be used to generate requirements, plans, strategies, training and materiel."[142]

Summary

Warming of the earth's climate is occurring and may have potentially significant adverse effects upon the geo-political strategic environment of the coming decades. President Obama and the DoD have now identified climate change as a significant factor in the future national security of the United States. Given the significant national security implications, the Air Force can, and should, do more in the near term to prepare for the future impacts of global climate

change. The Navy's efforts to prepare for global climate change provide a replicable role model for the Air Force and a great starting point for the development of its own climate change program.

The terrorist attacks of 9/11 caught the United States off guard. There were warning signs that terrorist networks were a significant threat, but "few correctly interpreted the signals."[143] When it comes to climate change, the importance of heeding the warning signs is emphasized in the following comparison:[144]

> *Warning signs of the need to deal with the very different kind of threat posed by climate change are now also troubling, and more Americans are beginning to grasp them. But as with the case of pre-9/11 assessments about mass-damage terrorism, it comes down to a matter of judgment. The difference is that if we wait for absolute certainty of the threat—for a climatological 9/11—we may then be past a tipping point from which there is no recovery.*

The consequences of ignoring the warning signs and failing to prepare for global climate change are potentially devastating to the future national security of the United States. An InterAcademy Council report co-chaired by Nobel Prize winner, and now Secretary of Energy, Dr. Steven Chu concludes: "What the world does in the coming decade will have enormous consequences that will last for centuries. It is imperative that we begin without further delay."[145]

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Endnotes

[1] Campbell et al., *Age of Consequences*, 105.
[2] United Nations General Assembly, *Resolution 43/53*.
[3] IPCC, *Summary for Policymakers*, 2.
[4] Ibid., 12-13.
[5] Carmen et al., *Broadening Horizons*, 11.
[6] Ibid.
[7] The CNA Corporation, *National Security Climate Change*, 1.
[8] Ibid., 10.
[9] USEPA, *Glossary of Climate Change*.
[10] Ibid.
[11] Campbell et al., *Age of Consequences*, 8.
[12] IPCC, *Organization*.
[13] IPCC, *Summary for Policymakers*, 2.
[14] Ibid., 5
[15] Ibid.
[16] Ibid., 7.
[17] Ibid.
[18] Ibid., 12.
[19] Ibid.
[20] Ibid., 13.
[21] Ibid., 14.
[22] Ibid., 22.
[23] IPCC, *Home*.
[24] The CNA Corporation, *National Security Climate Change*, 1.
[25] DoD, *Quadrennial Defense Review Report*, 30.
[26] Ibid., 85.
[27] Campbell et al., *Age of Consequences*, 6.
[28] Ibid., 106-108.
[29] The CNA Corporation, *National Security Climate Change*, 9.
[30] Ibid., 13-16.
[31] Ibid., 37-39.
[32] Campbell et al., *Age of Consequences*, 17-18.
[33] Ibid., 18.
[34] NPR, *Climate Change Worries Military*.
[35] The CNA Corporation, *National Security Climate Change*, 44-45.
[36] Ibid., 46.
[37] Ibid., 1.
[38] US House, *NDAA for FY2008*, 495-497.
[39] Ibid., 496.
[40] Obama, *Executive Order 13514*, 1.
[41] Ibid., 1-2.
[42] DoD, *Greenhouse Gas Targets Announcement*.
[43] Ibid.
[44] Ibid.
[45] DoD, *Quadrennial Defense Review Report*, 1.
[46] Ibid., 73.

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[47] Ibid., 20.
[48] Ibid., 85.
[49] The CNA Corporation, *National Security Climate Change*, 46-48.
[50] DoD, *Quadrennial Defense Review Report*, 86.
[51] Obama, *National Security Strategy*, 47.
[52] Ibid.
[53] Ibid.
[54] The Pew Charitable Trusts, *Reenergizing America's Defense*, 20.
[55] Ibid.
[56] AWC, *Quotes*.
[57] Ibid.
[58] IPCC, *New Assessment Methods*, 145.
[59] State of California, *Climate Change Glossary*.
[60] Ibid.
[61] Campbell et al., *Age of Consequences*, 6.
[62] Ibid., 55.
[63] Ibid., 6.
[64] Ibid., 6,55.
[65] Ibid., 71.
[66] Ibid., 7.
[67] Ibid.
[68] Ibid.
[69] Ibid.
[70] Ibid., 81.
[71] Ibid., 7.
[72] Ibid.
[73] Ibid., 81.
[74] Inhofe, *Climate Change Update*.
[75] Rogers et al., *Lost in Translation*, 35.
[76] Ibid., 22.
[77] Campbell et al., *Age of Consequences*, 10.
[78] Schaeffer et al., *Discussing Global Warming*, 4.
[79] Ibid.
[80] Carmen et al., *Broadening Horizons*, 11.
[81] Ibid., 25.
[82] Ibid., 11.
[83] USN, *Climate Change Roadmap*, 5.
[84] Carmen et al., *Broadening Horizons*, 26.
[85] USN, *Navy Arctic Roadmap*, 5.
[86] Ibid., 6.
[87] Ibid., 3.
[88] Ibid., 5.
[89] USN, *Climate Change Roadmap*, 3.
[90] Ibid.
[91] Ibid., 4.
[92] Ibid., 3.
[93] Ibid., 7.

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[94] Ibid., 9.
[95] Ibid., 10.
[96] Ibid., 11.
[97] Ibid.
[98] Ibid., 12.
[99] Ibid.
[100] Ibid.
[101] Ibid., 13.
[102] Ibid.
[103] Ibid.
[104] Ibid., 14.
[105] Ibid.
[106] Rogers et al., *Lost in Translation*, 36.
[107] Ibid.
[108] Olson, *State Science Policy Advice*, x.
[109] USN, *Climate Change Roadmap*, 15.
[110] Ibid.
[111] Rogers et al., *Lost in Translation*, 13.
[112] USN, *Climate Change Roadmap*, 8.
[113] Ibid., 18.
[114] Carmen et al., *Broadening Horizons*, 26-27.
[115] Ibid., 37.
[116] Ibid.
[117] Ibid.
[118] USAF, *Air Force Energy Plan*, 1.
[119] Ibid.
[120] Ibid., 25.
[121] DoD, *Quadrennial Defense Review Report*, 87.
[122] USEPA, *Greenhouse Gas Impacts*, 1.
[123] USAF, *C-17 Conducts Flight Test*.
[124] EPA, *Greenhouse Gas Impacts*, 2.
[125] Ibid.
[126] USAF, *Step Toward Cleaner Fuel*.
[127] USAF, *C-17 Conducts Flight Test*.
[128] Carmen et al., *Broadening Horizons*, 39.
[129] Ibid., 41.
[130] Ibid., 31.
[131] USAF, *Air Force Energy Plan*, 1.
[132] Carmen et al., *Broadening Horizons*, 42.
[133] The CNA Corporation, *National Security Climate Change*, 46-48.
[134] DoD, *Quadrennial Defense Review Report*, 85.
[135] USAF, *Air Force Energy Plan*, foreword.
[136] Rogers et al., *Lost in Translation*, 34.
[137] AFCEE, *MissionVision*.
[138] AFCEE, *AFCEE Organization*.
[139] USN, *Climate Change Roadmap*, 8.
[140] Carmen et al., *Broadening Horizons*, 47.

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[141] Rogers et al., *Lost in Translation*, 23.
[142] Ibid.
[143] Campbell et al., *Age of Consequences*, 91.
[144] Ibid..
[145] IAC, Lighting the Way, xi.

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Digital Collections
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Bibliography

Air Force Center for Engineering and the Environment (AFCEE). "AFCEE Organization." *AF Center for Engineering and the Environment.* 2011. http://www.afcee.af.mil/about/organization/index.asp (accessed April 25, 2011).

—. "MissionVision." *AF Center for Engineering and the Environment.* 2010. http://www.afcee.af.mil/about/missionvision/index.asp (accessed October 7, 2010).

Air War College. "Quotes." *Future Studies & Future Conflict Studies.* 2010. http://www.au.af.mil/au/awc/awcgate/awc-futr.htm#quotes (accessed December 22, 2010).

Campbell, Kurt M., et al. *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change.* Washington, DC: Center for Strategic & International Studies (CSIS) & Center for a New American Security (CNAS), November 2007.

Carmen, Herbert E., Christine Parthemore, and Will Rogers. *Broadening Horizons: Climate Change and the U.S. Armed Forces.* Washington, DC: Center for a New American Security (CNAS), April 2010.

Department of Defense (DoD). "Greenhouse Gas Targets Announcement for DOD." *U.S. Department of Defense.* January 29, 2010. http://www.defense.gov/releases/release.aspx?releaseid=13276 (accessed September 30, 2010).

—. "Quadrennial Defense Review Report." *United States Department of Defense.* February 12, 2010. http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf (accessed September 17, 2010).

Inhofe, U.S. Sen. James M. "Climate Change Update, Senate Floor Statement." *James M. Inhofe U.S. Senator - Oklahoma.* January 4, 2005. http://inhofe.senate.gov/pressreleases/climateupdate.htm (accessed September 26, 2010).

InterAcademy Council (IAC). *Lighting the Way toward a Sustainable Energy Future.* Amsterdam: IAC Secretariat, October 2007.

Intergovernmental Panel on Climate Change (IPCC). "New Assessment Methods and Characterisation of Future Conditions." In *Climate Change 2007: Impacts, Adaptation and Vulnerability*, 133-171. Cambridge, UK: Cambridge University Press, 2007.

—. *Organization.* 2010. http://www.ipcc.ch/organization/organization.htm (accessed September 30, 2010).

—. "Scope, Content and Process for the Preparation of the Synthesis Report (SYR) of the IPCC Fifth Assessment Report (AR5)." *Home.* 2010. http://www.ipcc.ch/meetings/session32/syr_final_scoping_document.pdf (accessed December 21, 2010).

—. "Summary for Policymakers." In *Climate Change 2007: Synthesis Report*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007.

National Public Radio (NPR). *Climate Change Worries Military Advisers.* April 16, 2007. http://ww.npr.org/templates/transcript/transcript.php?storyId=9580815 (accessed September 30, 2010).

Obama, U.S. President Barack H. "Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance." *The White House.* October 5, 2009. http://www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf (accessed September 28, 2010).

—. "National Security Strategy." *The White House.* May 27, 2010. http://www.whitehouse.gov/sites/default/files/rss_viewer/national_security_strategy.pdf (accessed September 30, 2010).

Olson, Steve. *State Science and Technology Policy Advice: Issues, Opportunities, and Challenges.* Edited by Jay B. Labov. Washington, DC: The National Academies Press, 2008.

Rogers, Will, and Jay Gulledge. *Lost in Translation: Closing the Gap Between Climate Science and National Security Policy.* Washington, DC: Center for a New American Security (CNAS), April 2010.

Schaeffer, Brett D. and Ben Lieberman. "Discussing Global Warming in the Security Council: Premature and a Distraction from More Pressing Crises ." *The Heritage Foundation WebMemo No. 1425.* April 16, 2007. http://www.policyarchive.org/handle/10207/bitstreams/12227.pdf (accessed October 1, 2010).

State of California. "California Climate Change Glossary." *California Climate Change Portal.* April 28, 2008. http://www.climatechange.ca.gov/glossary/letter_d.html (accessed December 28, 2010).

Fairchild Research Information Center
Digital Collections

The CNA Corporation. *National Security and the Threat of Climate Change.* Alexandria, VA: The CNA Corporation, April 2007.

The Pew Charitable Trusts. "Reenergizing America's Defense." *The Pew Project on National Security, Energy and Climate.* April 20, 2010. http://www.pewclimatesecurity.org/reenergizing-americas-defense/ (accessed December 28, 2010).

United Nations General Assembly. *Resolution 43/53.* December 6, 1988. http://www.un.org/documents/ga/res/43/a43r053.htm (accessed September 29, 2010).

United States Air Force (USAF). "Air Force Energy Plan 2010." *Installations, Environment, and Logistics.* December 8, 2009. http://www.safie.hq.af.mil/shared/media/document/AFD-091208-027.pdf (accessed October 5, 2010).

—. "Air Force officials take step toward cleaner fuel, energy independence." *Air Force Materiel Command.* March 26, 2010. http://www.afmc.af.mil/news/story.asp?id=123196918 (accessed October 5, 2010).

—. "C-17 conducts flight test with biofuel." *The official web site of the U.S. Air Force* . September 3, 2010. http://www.af.mil/news/story.asp?id=123220651 (accessed October 4, 2010).

United States Environmental Protection Agency (EPA). "Glossary of Climate Change Terms." *Climate Change.* September 9, 2009. http://www.epa.gov/climatechange/glossary.html (accessed December 30, 2010).

—. "Greenhouse Gas Impacts of Expanded Renewable and Alternative Fuels Use." *Fuels and Fuel Additives.* April 2007. http://www.epa.gov/oms/renewablefuels/420f07035.pdf (accessed October 5, 2010).

United States Navy (USN). "U.S. Navy Arctic Roadmap." *Official Website of the United States Navy.* November 10, 2009. http://www.navy.mil/navydata/documents/USN_artic_roadmap.pdf (accessed October 3, 2010).

—. "U.S. Navy Climate Change Roadmap." *Official Website of the United States Navy.* May 21, 2010. http://www.navy.mil/navydata/documents/CCR.pdf (accessed October 3, 2010).

US House. *National Defense Authorization Act (NDAA) for Fiscal Year 2008.* 110th Cong., 1st sess., H.R. 1585, Section 951, 2007.

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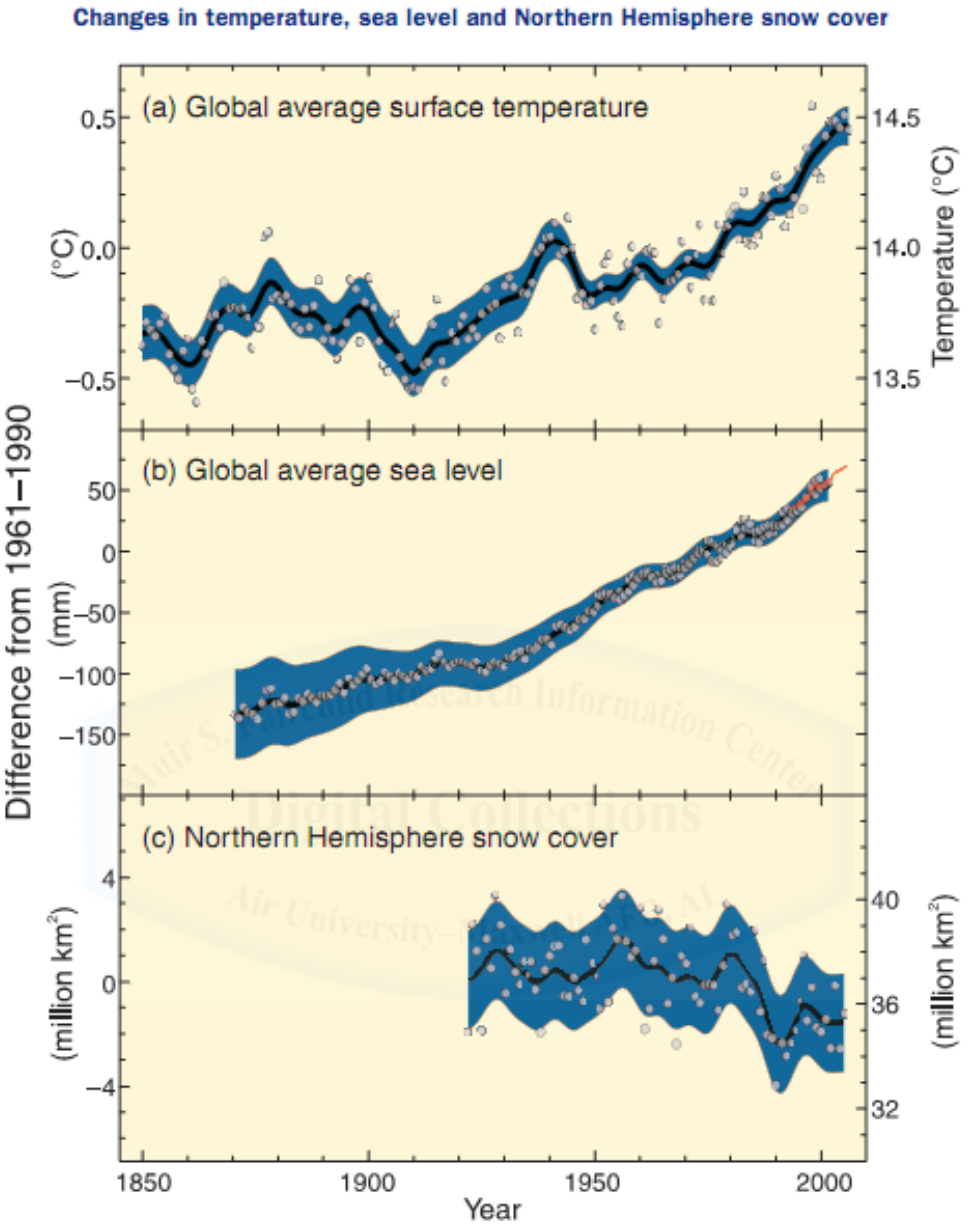
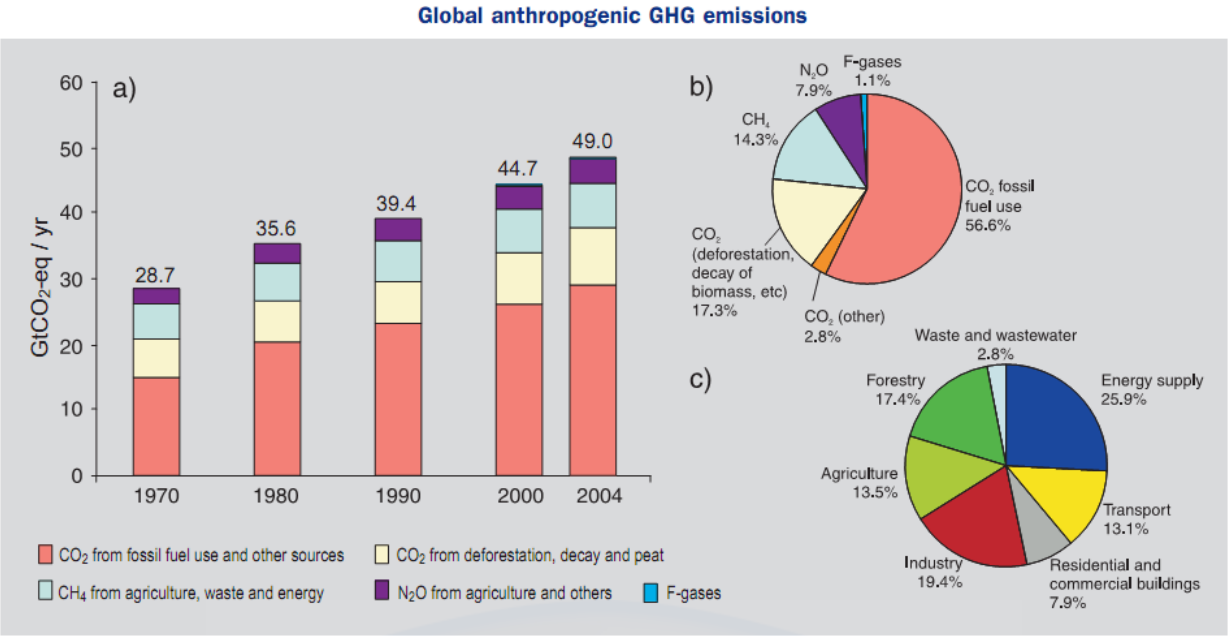
Appendix A. Changes in Temperature, Sea Level and Snow Cover



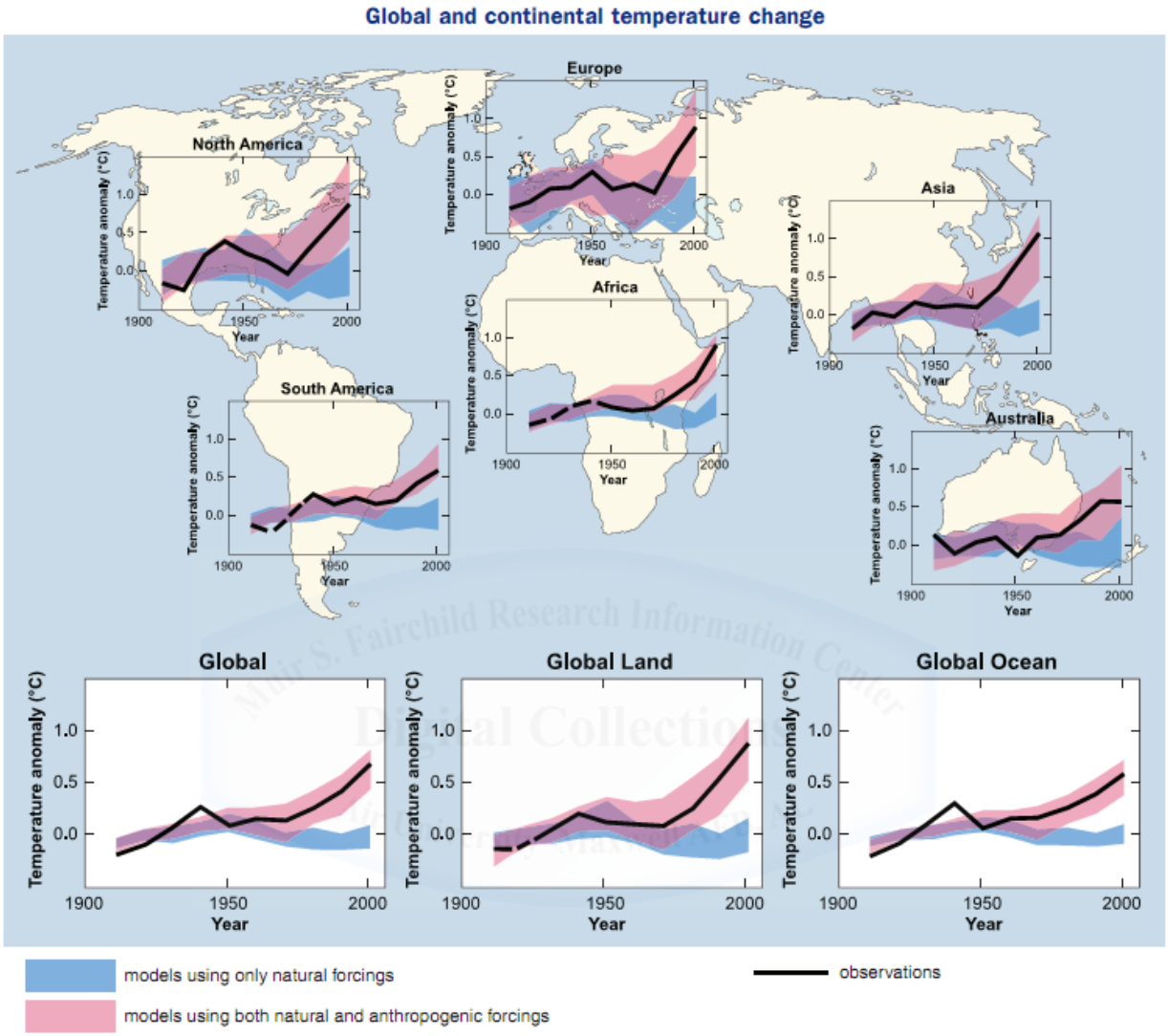
Observed changes in (a) global average surface temperature; (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All differences are relative to corresponding averages for the period 1961-1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). (Reprinted from Intergovermental Panel on Climate Change (IPCC). "Summary for Policymakers." In *Climate Change 2007: Synthesis Report*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007: 3).

Appendix B. Global Anthropogenic GHG Emissions



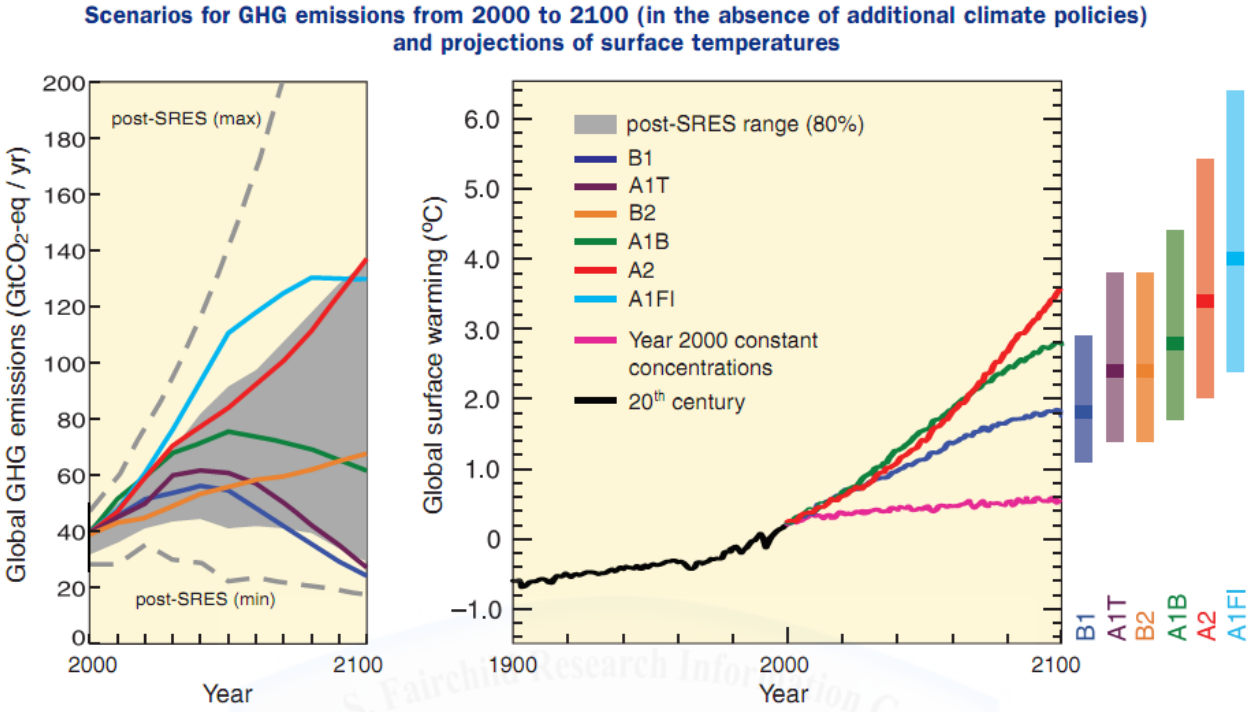
(a) Global annual emissions of anthropogenic GHGs from 1970 to 2004. (b) Share of different anthropogenic GHGs in total emissions in 2004 in terms of carbon dioxide equivalents (CO2-eq). (c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO2-eq. (Forestry includes deforestation.) (Reprinted from Intergovermental Panel on Climate Change (IPCC). "Summary for Policymakers." In *Climate Change 2007: Synthesis Report*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007: 5).

Appendix C. Global Temperature Change



Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using either natural or both natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906-2005 (black line) plotted against the center of the decade and relative to the corresponding average for the period 1901-1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5 to 95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5 to 95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. (Reprinted from Intergovermental Panel on Climate Change (IPCC). "Summary for Policymakers." In *Climate Change 2007: Synthesis Report*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007: 6).

Appendix D. GHG Emission Scenarios



Left Panel: Global GHG emissions (in GtCO2-eq) in the absence of climate policies: six illustrative SRES marker scenarios (colored lines) and the 80th percentile range of recent scenarios published since SRES (post-SRES) (gray shaded area). Dashed lines show the full range of post-SRES scenarios. The emissions include CO2, CH4, N2O and F-gases.

Right Panel: Solid lines are multi-model global averages of surface warming for scenarios A2, A1B and B1, shown as continuations of the 20th-century simulations. These projections also take into account emissions of short-lived GHGs and aerosols. The pink line is not a scenario, but is for Atmosphere-Ocean General Circulation Model (AOGCM) simulations where atmospheric concentrations are held constant at year 2000 values. The bars at the right of the figure indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios at 2090-2099. All temperatures are relative to the period 1980-1999.

(Reprinted from Intergovermental Panel on Climate Change (IPCC). "Summary for Policymakers." In *Climate Change 2007: Synthesis Report*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007: 7).

Appendix E. Navy Climate Change Roadmap Desired Effects, Objectives and Action Items

Strategy, Policy, and Plans

US Navy Desired Effect: The Navy is recognized as a valuable joint, interagency, and international partner in responding to climate change.

US Navy Roadmap Objective: To ensure the national security impacts of climate change are effectively addressed in the Navy's strategy, policy, and plans, and implement these through cooperative partnerships.

US Navy Roadmap Action Items:

1) Develop a *Global Climate Change Strategic Assessment*.

2) Conduct a *Mission Analysis in View of the Changing Climate*.

3) Propose additional studies and research regarding the national security implications of climate change on Naval missions, force structure, and infrastructure.

4) Inform strategic-level guidance documents, especially the development of potential future scenarios.

5) Form new and expand existing cooperative agreements with joint, interagency, international, scientific and academic, and non-governmental organization partners to consider climate change assessment, prediction, and adaptation.

Operations and Training

US Navy Desired Effect: The Navy is fully mission-capable through changing climatic conditions while actively contributing to national requirements for addressing climate change.

US Navy Roadmap Objective: Maintain competency in all missions under all climatic conditions.

US Navy Roadmap Action Items:

1) Conduct wargames, table-top exercises, and/or limited objective experiments that include projected climate change impacts.

2) Include climate change considerations in Fleet training and planning.

3) Include climate change science and strategic considerations in formal Naval training and education.

Investments

US Navy Desired Effect: Naval force structure and infrastructure are capable of meeting combatant commander requirements in all probable climatic conditions over the next 30 years.

US Navy Roadmap Objective: Provide the capability and capacity for Naval weapons, platforms, sensors, command, control, communications, computers, intelligence, surveillance, and reconnaissance, installations, and facilities to operate effectively in all potential climatic conditions.

US Navy Roadmap Action Items:

1) Initiate a *Navy Climate Change Adaptation Capabilities Based Assessment*.

2) Identify *Climate Change Science and Technology Needs*.

3) Beginning with Navy's *Program Objective Memorandum* for Fiscal Year 2014 and biennially each year thereafter, assess guidance in the *Navy Strategic Plan*, if any, relating to climate change assessment, prediction, and adaptation, and address these requirements in *Sponsor Program Proposals*.

Strategic Communication and Outreach

US Navy Desired Effect: The media, public, government, Joint, interagency, and international community understand how and why the Navy is effectively addressing climate change.

US Navy Roadmap Objective: To inform the media, public, government, Defense, inter-agency, international audiences and other interested stakeholders regarding the Navy's policy, strategy, investments, intentions, and actions in response to climate change.

US Navy Roadmap Action Items:

1) Develop a *Navy Climate Change Strategic Communication Plan* for Fiscal Years 2010-2014.

2) Annually host the Navy Energy and Climate Forum jointly with Task Force Energy.

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Environmental Assessment and Prediction

US Navy Desired Effect: The Navy understands the timing, severity, and impact of current and projected changes in the global environment.

US Navy Roadmap Objective: To provide Navy leadership and decision makers a science-based, comprehensive understanding of the timing, severity, and impact of current and predicted global environmental change on tactical, operational, and strategic (climatic) scales.

US Navy Roadmap Action Items:

1) Begin monitoring, accounting, tracking, and reporting Navy GHG emissions in accordance with EO 13514.

2) Leverage the results of the environmental observing, mapping, and prediction *Capabilities Based Assessment* in the Navy Arctic Roadmap to identify required capabilities for assessing and predicting global environmental change.

3) Identify *Science and Technology Needs for Environmental Assessment and Prediction*.

4) Leverage the *Next Generation Numerical Environmental Prediction* interagency partnership initiated in the Navy Arctic Roadmap to develop the capability for a global and regional coupled environmental model.

5) Beginning in Fiscal Year 2010 for the *Program Objective Memorandum* for Fiscal Year 2014 and biennially each year thereafter, produce a *Global Climate Change Assessment and Outlook Report* to inform Navy policy, strategy, and investment decisions.

6) Beginning with Navy's *Program Objective Memorandum* for Fiscal Year 2014 and biennially each year thereafter, assess the requirements in the *Navy Strategic Plan*, if any, relating to Navy environmental observation and prediction capability and address these requirements in recommendations to *Sponsor Program Proposals*.