Critical Thinking, Army Design Methodology, and the Climate Change Policy Debate

A Monograph

by

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Military practitioners must be creative and critical thinkers while confronting today's broad range of traditional and nontraditional national security issues. An analysis of the current climate change policy debate demonstrates the value of considering nontraditional problem sets in an effort to enhance creative and critical thinking. When approaching complex problems such as climate change and other national security threats, policy makers should consider all available tools. One such tool is the Army Design Methodology (ADM). A team using ADM has the potential to change the direction of the current climate change policy debate in order to foster consensus-based action. An analysis of the current climate change policy debate will highlight some of the major friction points in the debate where ADM could help policy makers. In doing so, this will provide military practitioners training in identifying potential bottlenecks and applying critical thinking in other complex problem systems. Policy makers are not generating consensus-based action on climate change. Creative and critical thinking and ADM can help policy makers and by extension, military practitioners on future problems.

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Abstract

Critical Thinking, Army Design Methodology, and the Climate Change Policy Debate, by Lieutenant Colonel Derek B. Heifner, USAF, 56 pages.

Military practitioners must be creative and critical thinkers while confronting today's broad range of traditional and nontraditional national security issues. An analysis of the current climate change policy debate demonstrates the value of considering nontraditional problem sets in an effort to enhance creative and critical thinking. When approaching complex problems such as climate change and other national security threats, policy makers should consider all available tools. One such tool is the Army Design Methodology (ADM). A team using ADM has the potential to change the direction of the current climate change policy debate in order to foster consensus-based action. An analysis of the current climate change policy debate will highlight some of the major friction points in the debate where ADM could help policy makers. In doing so, this will provide military practitioners training in identifying potential bottlenecks and applying critical thinking in other complex problem systems. Policy makers are not generating consensus-based action on climate change. Creative and critical thinking and ADM can help policy makers and by extension, military practitioners on future problems.

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Acronyms

ADM	Army Design Methodology
ADRP	Army Doctrine Reference Publication
ATP	Army Techniques Publication
CARL	Combined Arms Research Library
CGSC	US Army Command and General Staff College
CMIP	Coupled Model Intercomparison Project
CO_2	Carbon Dioxide
IPCC	Intergovernmental Panel on Climate Change
ISIS	Islamic State of Iraq and Syria
MDMP	Military Decision Making Process
NIPCC	Nongovernmental International Panel on Climate Change
SAMS	School of Advanced Military Studies
UN	United Nations
UNEP	United Nations Environment Program
WCRP	World Climate Research Programme
WMO	World Meteorological Organization

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Introduction

In November 2015, a former Central Intelligence Deputy Director, Michael Morell, gave an interview in which he asserted the current United States strategy to defeat the Islamic State of Iraq and Syria (ISIS) was not working.[1] He argued a new approach was needed, possibly even an approach many would consider nontraditional. Using other words, he was advocating for the US government to consider breaking from its current strategy to pursue a more creative one. This approach would require critical and creative thinking to assess the current situation, articulate a desired future state (of continued US advantage), and design a strategy and course of action to realize national objectives.[2]

Military practitioners must be agile critical thinkers in order to aid in the process of creative problem solving. The current portfolio of global instability, including the fight against ISIS, demands the military practitioner engage fully in the formulation and execution of strategy. Military practitioners must be critical thinkers. Army doctrine says of critical thinking, "leaders apply creative thinking to gain new insights, novel approaches, fresh perspectives, and new ways of understanding and conceiving things."[3] In a message to joint warfighters, US Army Major General Frederick Rudesheim, then Deputy Director (J-7) for Joint and Coalition Warfare remarked, "The complex nature of current and projected challenges requires that critical thinking, creativity, foresight, and adaptability—rather than strict reliance on methodical steps—must become routine."[4] General Rudesheim's message was an introduction to the *Planner's Handbook*

[1] Bradford Richardson, "Former CIA Deputy Director: ISIS Strategy Not Working," The Hill, November 15, 2015, accessed January 22, 2016, http://thehill.com/policy/national-security/260211-former-cia-deputy-director-isis-strategy-not-working.

[2] Everett Dolman, *Pure Strategy* (New York, NY: Taylor & Francis, 2005), 4, 6.

[3] Army Techniques Publication (ATP) 5-0.1, *Army Design Methodology* (Washington, DC: Government Printing Office, 2015), 1-6.

[4] Joint Staff J-7, *Planner's Handbook for Operational Design* (Washington DC:

for Operational Design. That guide went on to provide the following four definitions useful in this context.[5] The third definition, provided by Diane F. Halpern, is especially succinct and relevant. It defines the kind of thinking military practitioners need to combat a range of new and emerging threats around the globe.

> (1) Critical thinking is a deliberate process of thought whose purpose is to discern truth in situations where direct observation is insufficient, impossible, or impractical.[6]
>
> (2) Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness.[7]
>
> (3) Critical thinking is the use of those cognitive skills or strategies that increase the probability of a desired outcome. It is used to describe thinking that is purposeful, reasoned, and goal directed.[8]
>
> (4) Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness. Critical thinking—in being responsive to variable subject matter, issues, and purposes—is incorporated in a family of interwoven modes of thinking, among them: scientific thinking, mathematical thinking, historical thinking, anthropological thinking, economic thinking, moral thinking, and philosophical thinking.

Government Printing Office, 2011), 2.

[5] Joint Staff J-7, *Planner's Handbook for Operational Design* (Washington DC: Government Printing Office, 2011), II-2, II-3.

[6] Field Manual (FM) 5-0, *The Operations Process* (Washington DC: Government Printing Office, 2010), 3-1.

[7] Michael Scriven and Richard Paul, "Defining Critical Thinking," (presented at the 8th Annual International Conference on Critical Thinking and Education Reform, The Critical Thinking Community, 1987), accessed 2 April, 2016, http://www.criticalthinking.org/pages/defining-critical-thinking/766.

[8] Diane F. Halpern, *Thought and Knowledge: An Introduction to Critical Thinking* (New York, NY: Taylor & Francis, 2014), 8.

Critical thinking is an acquired skill requiring practice and rigorous exercise, not unlike core combat skills and physical fitness. Military practitioners must think more critically and creatively to combat adaptable enemies who are operating in ways and in environments unfamiliar to many practicing the profession of arms. Improving critical and creative thinking will help the US military maintain and enhance its asymmetric advantages. This monograph offers an exercise is critical thinking using a nontraditional topic in order to reinforce the military practitioner's critical thinking skills.

On December 12, 2015, representatives of 195 states met in Paris to establish a new agreement on limiting greenhouse gas emissions. Earth's primary greenhouse gases include water vapor, carbon dioxide, nitrous oxide, methane and ozone.[9] The effort was the culmination of nearly a decade of behind the scenes negotiations meant to bring all countries to the table and seek agreement on climate change policy. The current US administration holds climate change as a key component of its political agenda and several administration officials have voiced their satisfaction with the progress made in Paris. Nearly all participating states committed to reducing emissions. More well-off states committed to subsidizing less well-off states so as to equally distribute the burden of effort around the globe. The importance of these commitments is illustrated by Sir Nicholas Stern's conclusion reached in 2006, "if a wider range of risks and impacts is taken into account, the estimates of damage [from taking no action against climate change] could rise to 20 percent [annually] of [global] gross domestic product (GDP) or more."[10]

[9] Intergovernmental Panel on Climate Change, *Climate Change 2013: The Physical Science Basis* (New York, NY: Cambridge University Press, 2013), 1,455.

[10] Nicholas Stern, *The Economics of Climate Change: The Stern Review* (Cambridge, UK: Cambridge University Press, 2006), xv.

In 2014, the global GDP was approximately $78 trillion.[11] Of the global GDP, 20 percent represents approximately $16 trillion. That amounts to about the entire annual US GDP.

Other US policy makers remain unconvinced of the necessity or urgency for action. Senator Mitch McConnell, US Senate Majority Leader remarked, "Before his [the US President's] international partners pop the champagne, they should remember that this is an unattainable deal based on a domestic energy plan that is likely illegal, that half the states have sued to halt, and that Congress has already voted to reject."[12] In February 2009, the Supreme Court agreed, to an extent, and sided with twenty-nine US states suing to suspend landmark regulations established to bring US energy production emissions in line with the Paris agreement.[13] One account of sentiment within the larger body of the US Congress reveals many US Representatives may have diverging thoughts on the issue of climate change and associated policy. The Think Progress organization noted, "Climate change is happening, humans are the cause, and a shocking number of congressional Republicans — over 56 percent — deny or question the science."[14]

The US population appears to be somewhere in the middle of the debate on the urgency, validity of the science, scientific consensus, and need for action concerning climate change. In 2013, a Yale University survey found that only "47 percent of Americans believe global warming

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[11] The World Bank, "World Bank GDP 2014," accessed 30 November, 2015, http://databank.worldbank.org/data/download/GDP.pdf.

[12] Corl Davenport, "Nations Approve Landmark Climate Accord in Paris," *New York Times*, December 12, 2015, accessed December 12, 2015, http://www.nytimes.com/2015/12/13/world/europe/climate-change-accord-paris.html?_r=0

[13] Adam Liptak and Coral Davenport, "Supreme Court Deals Blow to Obama's Efforts to Regulate Coal Emissions," *New York Times*, February 9, 2016, accessed February 9, 2016, http://www.nytimes.com/2016/02/10/us/politics/supreme-court-blocks-obama-epa-coal-emissions-regulations.html.

[14] Tiffany Germain, Thinkprogress.org, "The Anti-Science Climate Denier Caucus," accessed 27 December, 2015, http://thinkprogress.org/climate-denier-caucus-114th-congress/.

— if it is happening — is caused mostly by human activities. At the same time 37 percent of Americans believe that global warming is due mostly to natural changes in the environment."[15] Some policy makers believe climate change is urgent and requires immediate action. Other policy makers believe differently. Some Americans believe climate change is mankind's fault. Some believe differently. Clearly, there is a disconnect between the various parties involved in the climate change policy debate yielding beliefs that span a wide spectrum of positions. The climate change policy debate is not producing consensus-based action because of the nature of the climate change problem. Policy makers need a new approach. Applying the Army Design Method (ADM) to the climate change policy debate problem might permit policy makers to make more consensus-based progress.

Before ADM or a similar technique can be applied, certain preliminary analysis of the policy debate is necessary. This monograph is a pre-ADM analysis of the climate change policy debate problem. This monograph does not offer a climate change solution using ADM. To attempt such an endeavor would violate several of the core principles of ADM, not the least of which would be a complete lack of diversity in thought by way of a single author.[16] Instead, this monograph argues that the climate change problem is a good candidate for ADM. This will become clearer after orientating to the essential components of ADM, building a basis of understanding of the history of climate science, and finally examining the friction points within the current climate change policy debate. In the spirit of neutrality during problem analysis, no attempt is made to justify or validate one side or another of the debate. Rather, this monograph

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[15] A. Leiserowitz, E. Maibach, C. Roder-Renouf, G. Feinberg, S. Rosenthal, and J. Marlon, *Climate Change in the American Mind: America's Global Warming Beliefs and Attitudes in November, 2013* Yale University and George Mason University (New Haven, CT: Yale Project on Climate Change Communication, 2013), 5.

[16] Army Doctrine Reference Publication (ADRP) 5-0, *The Operations Process* (Washington, DC: Government Printing Office, 2012), 1-10.

attempts to render a survey of debate positions to gain additional understanding of the debate, consistent with doctrine. Additionally, this monograph does not prescribe application of the ADM methodology to specific elements of the climate change debate. Instead, a survey and brief analysis is offered along with an introduction to core ADM concepts in order to create an atmosphere for the application of critical thinking and analysis.

Section I: Joint and Army Doctrine on Operational Design/ADM

This section offers an introduction to ADM methodology. Each of the ADM components serve to better illustrate the problem at hand and generate productive conversation toward consensus action. Introducing all of the ADM components will demonstrate the appropriateness of ADM to the climate change policy debate problem. As a pre-ADM effort, this monograph emphasizes the critical and creative thinking component of ADM. This element, along with the other ADM components are outlined below.

To be most effective, leaders must understand, visualize, describe, direct, lead, and assess action in order to effectively achieve objectives. In the Army, this is known as the Army Operational Process. The components of this system are dynamic and flexible in order to meet changing environments.[17] This process is not unlike any other decision making process except by which doctrine defines phases of the process in order to train and communicate a common approach across a large force. Civilian agencies and individuals use similar constructs to execute complex tasks, probably using a slightly different vocabulary. This monograph is scoped to focus on the need to better understand and visualize the climate change problem which is where ADM is designed to have maximum value.

[17] ADRP 5-0, 1-3.

Army Doctrine Reference Publication (ADRP) 5-0 defines ADM as "a methodology for applying critical and creative thinking to understand, visualize, and describe problems and approaches to solving them."[18] Army Commanders use ADM to creatively and effectively visualize the environment to inform his or her Military Decision Making Process (MDMP). They also run other planning and decision informing processes in parallel to take effective action toward solving a derived problem. While MDMP is a formalized approach to making command decisions in a complex military environment, its exact mechanism is not specifically pertinent to this monograph. It is important however, to point out that MDMP can be substituted by any rational decision making process and that ADM can provide the essential problem visualization step in any decision making system. ADM is not a checklist of performance actions, but rather a living construct of information exchange during the engagement and attempted influence of any complex system. There are several ADM key considerations applicable to this discussion.

First, there is critical and creative thinking. Army doctrine states, "critical thinking is purposeful and reflective judgment about what to believe or what to do in response to observations, experience, verbal or written expressions, or arguments."[19] This principle is important throughout the planning and decision making process, but it is especially important during the ADM phase where decision makers and their staff examine the problem from as many different angles as possible.[20] This reduces the likelihood actors will invest energy or resource in an improperly crafted or underdeveloped conceptualization of the current state, end state, and method to bridge the gap and ultimately take successful action. With climate change, actors must be willing to turn the current argument on its head, even at the risk of negating investment or

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[18] ADRP 5-0, Glossary-2.

[19] ADRP 5-0, 1-10.

[20] ATP 5-0.1, 1-6.

policy decisions to date. Decision makers must move past any notion of sunk cost and focus on making better, or more complete, decisions from this point forward.

Perhaps the most critical and relevant failure in the current climate change policy debate has been the community's inability to effectively collaborate, create consensus, and strengthen the merit of consolidated analysis and recommendations across the full range of equity owners.[21] Collaboration and dialog are central to any effective problem solving process. Discussing organizational theory, Mary Jo Hatch revealed, "the more knowledge you have of multiple perspectives, concepts, and theories, the greater will be your capacity to choose a useful approach to dealing with the situations you face in your organization."[22] As a result of ineffective collaboration, stakeholders have divided into several prominent groups including those who believe anthropogenic contributions are causing climate change and those who believe anthropogenic contributions are important, but not the principal driver of observed changes over the past hundred years or so. When performed properly, collaboration yields a better product. Multidisciplinary specialists can create a more comprehensive product, better balanced and more credible across a wider range of information consumers. Proper collaboration and dialog establishes an open discussion between relevant parties and creates an environment where problems and solutions can be checked for progress and where new knowledge can be incorporated into the planning and decision making process. This collaborative environment serves as the foundation for follow-on steps.

Systems thinking asserts that systems contain many components. These components interrelate, interact and sometimes act independently within the system.[23] Systems have purpose.

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[21] ATP 5-0.1, 1-7.

[22] Mary Jo Hatch and Ann Cunliffe, *Organizational Theory* (New York, NY: Oxford University Press, 2006), 11.

[23] ATP 5-0.1, 1-7.

Components are designed or they come to form in order to achieve specific objectives. Understanding system components is important. Even more important is understanding the relationships between the components and how they collectively interact in order to operate as a whole or complete system. Systems thinking is an acquired skill where an observer begins to understand how parts of a system work and how they influence other parts and the whole. Understanding these relationships allows a user to begin influencing a system in a way to meet desired outcomes.

While applying systems thinking, policy makers and the planning team must view the climate change policy debate as a system. This includes climate science as well as all of the competing equities that exist outside of climate science, but within the broader climate debate. An internal logic may emerge that would help inform the debate environment. Planners would also need to assess how moving the climate debate in a certain direction might influence other complex systems. These systems might include, a political election, other environmental concerns, budgetary constraints, popular sentiment, etc. This allows policy makers to understand the multi-dimensional environment and how any action in a complex system will have second and third order effects. Some of these effects will be desirable, some will not.

Framing provides decision makers and other actors perspective from which problem understanding grows informing the ability to take effective action on a problem.[24] ADRP 5-0 states, "framing involves selecting, organizing, interpreting, and making sense of an operational environment and a problem by establishing context."[25] Related specifically to climate change, rising global average temperatures are important, but to best identify and address the problem, the context must be understood.[26] What do higher temperatures mean and what is the impact? Are

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[24] ADRP 5-0, 2-5.

[25] ADRP 5-0, 2-5.

[26] ATP 5-0.1, 1-8.

higher temperatures undesired for all people around the world or do some people benefit? Does anyone suffer disproportionately? Knowing the context begins to expose the depth of the current state and begins to inform the visualization of connection between a current and future desired state critical for deriving an effective approach to problem solving. Framing opens the aperture during the visualization process which can be overwhelming for actors. Creating a visual model and forming a narrative weave the framing considerations into a more consumable product ready for process advancement.

Complex problems are difficult to conceptualize. Visual modeling is a means to help some who might benefit from a graphical depiction of the relationships between complex system elements.[27] For example, how would a reduction in CO_2 emissions impact other elements of the complex climate system? A visualization would pictorially represent CO_2 levels as they relate to other elements of the system like temperature, farming capacity, drought levels, precipitation levels, impact on wildlife, smog, homelessness coping abilities, etc. Often, both the exercise of deriving a product and the visual product itself help actors unearth additional considerations never before seen. This enhances the understanding and visualization of the environment before committing expensive resources to problem solving.

Finally, the narrative creates a story participants and observers can more easily understand.[28] Doctrine states, "in a broad sense, a narrative is a story constructed to give meaning to things and events."[29] This is not an effort to manipulate the problem solving process. Rather, it is both an exercise to increase understanding as well as an effort to produce a product. The narrative ties elements of the current state together including inputs to the situation, equity members and their interests, along with relevant historical events and significant social concerns.

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[27] ATP 5-0.1, 1-9.

[28] ATP 5-0.1, 1-9.

[29] ADRP 5-0, 2-5.

With climate change, there are a number of equity owners attempting to influence action. Energy companies, environmental organizations, government agencies, citizens, etc. all have different interests. Decision makers can better understand these varied interests through the use of the narrative.

ADM can be a powerful tool for decision makers, especially when used to address very complex problems, like climate change. It is multi-disciplinary, examines a problem from multiple views, and forces participants to explore, merge, and strengthen ideas. This dialog then informs a multi-faceted approach to problem solving and consensus action. Policy makers have a tremendous task at hand. They must merge the current disparate thinking into viable courses of action. ADM, while not the only tool available, offers an organized approach to problem solving policy makers would be wise to consider, else risk further discourse, inaction, or improper action.

Section II: The Current Climate Change Policy Debate

This is not the first time policy makers have had to debate weather issues and potential impacts to national security. During the 1980s, scientists produced studies arguing for and against the legitimacy of the nuclear winter concept.[30] This concept asserted that a cloud of dust and debris would envelop the Earth after a nuclear war causing the planet to cool significantly. Especially interesting is the course reversal many adamant scientists made in the 1990s when they learned they may have overestimated the severity of such an event. As this monograph will show, a new potentially catastrophic weather scenario may be at hand and policy makers, once again, will have to rely on weather experts and other scientists for knowledge and information to make effective policy decisions.

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[30] Malcolm W. Browne, "Nuclear Winter Theorists Pull Back," *New York Times*, January 23, 1990, accessed March 16, 2016, http://www.nytimes.com/1990/01/23/science/nuclear-winter-theorists-pull-back.html.

Before examination of the climate change policy debate is possible, it is important to organize the current debate into a conceptual framework. This framework permits analysis from a common starting point. There are many contributors to the climate change policy debate, including authors, climate researchers, statisticians, politicians, and ordinary citizens, to name only a few. Most of the actors can be grouped in order to facilitate analysis. One possible method of grouping is to organize actors into three broad categories: anthropogenic followers, middle grounders, and alternative theorists. No doubt, arguments could be made supporting different classification systems. For the purpose of this monograph, these groups shall suffice.

Researchers can group most climate change policy debate participants into three broad categories. Anthropogenic followers believe mankind is the principal driving force behind climate change, especially since the start of the industrial revolution in the early 1800s. Anthropogenic follows believe carbon dioxide (CO_2) released into the atmosphere from the burning of fossil fuels is modifying the Earth's natural greenhouse effect. This modification is causing a global warming and alteration of natural weather and climate patterns. Anthropogenic followers largely reject any notion of non-anthropogenic related climate change. They have adopted fully the theory put forth and endorsed by the Intergovernmental Panel on Climate Change (IPCC), established in 1988. More details on the IPCC are included later. The IPCC presents several types of research including work focused on computer climate model forecasting in accordance with the anthropogenic theory. The IPCC published its first major report on the effects of anthropogenic climate change in 1990 and issues an updated report about every five years. A large number of world government agencies echo the IPCC's assertions and have started incorporating IPCC recommendations into policymaking. The anthropogenic theory is the predominant theory endorsed by the United Nations and its signatory nations and has been advertised widely to the public as the best explanation for recent climate changes. This group includes media organizations, politicians, climatologists, scientists, and researchers from other

Earth science related fields. This group is occasionally identified as “alarmists” because they predict severe consequences for life on Earth without cessation of harmful activities. This group is frequently differentiated from alternative-theorists as being more “main-stream” while alternative theorists are characterized as “climate deniers” or “climate skeptics.” Anthropogenic followers believe that climate science unequivocally explains climate change. Above all else, the adherence to the validity of climate science is the single most significant attribute of this following.

Middle grounders believe in a center position between the anthropogenic followers and the alternative theorists. For the most part, they assert the Earth’s climate is always in fluctuation driven by a multitude of complex interactions. Contributors include the sun, atmospheric chemistry, biological processes, the Earth’s tilt, greenhouse components such as CO_2 and water vapor, cloud cover, etc. Middle grounders emphasize the enormity and complexity of the Earth’s natural processes. They also advocate for more responsible behavior from mankind in the form of cost-effective reductions in greenhouse gas emissions. The balanced approach perspective is unique to middle grounders in that they believe mankind is influencing climate change, but is not the principal driver. This group includes some politicians and many Earth science specialists like geologists, biologists, and others.

Lastly, alternative theorists reject the claim that mankind is the principal driver of climate change. Instead, they assert natural causes are the main contributor. They dispute the notion that the Earth has warmed any appreciable amount since the industrial revolution. More importantly, they contend that even if there has been a recent climb in global average temperatures, the cause is largely from natural cycles rather than anthropogenic inputs. They assert that the Earth’s climate is vast and complex. They also believe that the relationships between all of the climate’s components are more important than understanding any one particular component, for example, the rate of CO_2 change measured in the atmosphere. Above all else, the alternative theorists want better information before acting. They are very hesitant to support policy changes that could misallocate scarce resources in an effort to combat the anthropogenic theory of climate change. This group has climatologists, Earth scientists, industry leaders, researchers from other fields, and politicians in it.

This monograph references two major contributors of climate change information. They are outlined below for two reasons. First, understanding their makeup and background is important to appreciating the basis of their contributions. Second, their existence supports the notion that each camp has credible data upon which to draw conclusions. This contributes to the friction in the climate change policy debate and complicates the situation for policy makers.

The World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) established the Intergovernmental Panel on Climate Change in 1988. The WMO Executive Council and the UNEP Governing Council control policy for the IPCC. These governing bodies set forth the principals of IPCC work that same year. In part, "the role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation."[31] From its beginning, the IPCC was chartered by a governmental agency to focus on human-induced climate change rather than studying the entire climate system.

Since 1990, the IPCC has published at least forty-two reports in eighteen languages including five major reports on climate change, one each in 1990, 1995, 2001, 2011, and 2014. Each of the major reports have at least three sub-reports several thousand pages in length. The IPCC does not produce independent research. Instead it "reviews and assesses the most recent

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[31] IPCC website, Principals Governing IPCC Work, (IPCC, 1998), accessed 30 November, 2015, http://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles.pdf.

scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change."[32] Integral to the IPCC reports, especially its forecasts, are computer models produced as part of the Coupled Model Intercomparison Project (CMIP). The WMO also controls policy for the World Climate Research Programme (WCRP) which controls policy for CMIP. The CMIP objectives are "to determine the predictability of climate and to determine the effect of human activities on climate."[33] As chartered, the CMIP is focused on the anthropogenic theory.

Kirstin Peters, a geologist whose views on climate change are discussed later stated, "the IPCC is not a strictly scientific organization. It's a hybrid of scientists and representatives from government around the world, working under the auspices of the United Nations (UN)."[34] The IPCC has 195 member countries. Together with information from the CMIP, the IPCC provided the following conclusion in its most recent report:

> Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800 thousand years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-twentieth century.[35]

195 countries, each endorsing the findings of the IPCC, agree anthropogenic causes are the dominant causes of observed global warming since the mid-twentieth century. It is also reasonable to conclude government agencies within each of these 195 countries would echo the

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[32] IPCC website, Organization, accessed 30 November, 2015, http://www.ipcc.ch/organization/organization.shtml.

[33] WCRP website, The WCRP Mission, accessed 23 December, 2015, http://www.wcrp-climate.org/about-wcrp/about-mission.

[34] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 225.

[35] IPCC, *Climate Change 2014: Synthesis Report* (Geneva, Switzerland: IPCC, 2014), 4.

anthropogenic theory. This also means the IPCC publishes products "with at least some political as well as scientific sensibilities."[36] This point is important in-so-much as it differentiates climate science from purely scientific endeavors or those endeavors free from political influence and control.

There is no organized counterbalance to the IPCC. This distorts the debate environment by making it appear that the anthropogenic theory, the IPCC's theory, is the only credible argument available. This also allows an unfair advantage to a portion of the community. Despite the short-circuiting of the paradigm forming process (discussed later), the field continues to exhibit signs of a pre-paradigm phase with active community discourse. Instead of a healthy discussion needed to form the paradigm for climate science, the community instead struggles with the tension generated by the artificial paradigm established through the IPCC. The friction emanates from the two largest camps in the debate. The anthropogenic camp accepts the government designed paradigm while researchers supporting alternative theories reject the paradigm. Alternative theory supporters are not the outliers left over from the pre-paradigm phase as Thomas Kuhn describes them.[37] Rather, they are active participants in the debate frequently overshadowed by the IPCC's relative weight and ability to broadcast its message. This does not diminish alternative theory supporters. It does, however, present the appearance that alternative theory supporters are less organized and effective because of the value and credibility of their argument. Instead, the perceived weakness of alternative theories is a function of the mechanism that created the artificial paradigm and the IPCC. The tension in the community is a result of an unnatural evolution of the science. This tension will continue and presents a serious complication

[36] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 225.

[37] Thomas Kuhn, *The Structure of Scientific Revolutions* 4th ed. (Chicago, IL: The University of Chicago Press, 2012), 19. Kuhn's thoughts on paradigms are covered in Section III.

for policy makers as they strive to validate IPCC recommendations or search for credible alternatives. While there is no formal governmental organization supporting alternative theories, there are several smaller privately funded groups working to provide alternative theory research. One such organization is the NIPCC.

The Nongovernmental International Panel on Climate Change (NIPCC) traces its origin to a meeting in Milan organized by the Science and Environmental Policy Project, a not-for-profit group based out of Arlington, VA. Its goal was to provide an alternative scientific opinion to balance the IPCC major report of 2007. The group has since changed its name to NIPCC.[38] The group has issued five reports since 2007. In essence, the NIPCC falls into the alternative theory camp by concluding, "the forecasts in the [IPCC] Fourth Assessment Report were not the outcome of validated scientific procedures. In effect, they are the opinions of scientists transformed by mathematics and obscured by complex writing. The IPCC's claim that it is making "projections" rather than "forecasts" is not a plausible defense."[39]

Filtering through the vast quantity of opinion, information, and conclusions (from all sides of the debate) is an exhaustive and unending chore. This, in and of itself, contributes to the confusion inherent in the climate change policy debate. There is simply too much information available for policy makers to reasonably consume and translate into good governance. Amazon.com alone returns 128,348 hits for the topic "climate change." Google.com offers about 139 million related returns. Neither queries account for the myriad of search term permutations related to the climate debate or energy production.

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[38] NIPCC website, About the NIPCC, accessed 23 December, 2015, http://www.nipccreport.org/about/about.html.

[39] Craig Idso and S. Fred Singer, *Climate Change Reconsidered* (Chicago, IL: The Heartland Institute, 2009), 2.

This section outlines the positions of two representative authors in order to reveal several important historical markers in the climate change policy debate timeline. There are many other authors offering insight into the debate, however, these two provide laymen accounts of the scientific history leading into the modern climate change policy debate. This background is important during the creation of an ADP environmental frame. Fred Pearce published his book, *With Speed and Violence* in 2007. He is a believer in the anthropogenic theory. Kirsten Peters published her book, *The Whole Story of Climate,* in 2012. She is a middle grounder. Recently, John Sutter, a Cable News Network author, assembled a popular list of books emphasizing the anthropogenic view.[40] Alternative theory publications are less numerous and not as well organized as anthropogenic theory sources. Joe Weisenthal wrote an article in *Business Insider* listing some of the more prominent alternative theorists.[41] For the purpose of exposing readers to the major historical events underpinning the climate change policy debate, Pearce and Peters offer concise outlines.

Fred Pearce argued climate change is real and mankind is accountable. From an environmental journalist's point-of-view, he takes readers through time to examine a number of natural events during and since the recent ice ages all the way up to modern time. Pearce's conclusion is that while mankind can attribute some of the current climate change to natural causes, a majority of the current state is better explained by the impact from mankind's use and burning of fossil fuels. Pearce holds that most of the manmade impact is due to the consumption

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[40] John D. Sutter, "12 must-reads on climate change -- as submitted by you," Cable News Network, May 20, 2015, accessed January 22, 2016, http://www.cnn.com/2015/05/19/opinions/sutter-2-degrees-book-club.

[41] Joe Weisenthal, "The 10 Most-Respected Global Warming Skeptics," Business Insider, July 30, 2009, accessed January 22, 2016, http://www.businessinsider.com/the-ten-most-important-climate-change-skeptics-2009-7?op=1.

of fossil fuels since the start of the industrial revolution. Pearce's argument is fairly representative of those who suggest mankind is the principal cause of climate change.

Kirsten Peters, a geologist, also maps many of the major climate science discoveries over time. She attempts to describe climate change contributors, both manmade and natural, in a more balanced fashion. Her position appears to lean more toward mankind being a component of climate change rather than the principal cause of it. She is quick to point out the historical evidence showing climate change as a normal state rather than an abnormal one. For example, she notes, "the ice-core data make it clear as crystal that temperature on Earth is never static, that change is the rule, not the exception. The cores also demonstrated that the broad ups and downs in temperature correlate in a general way to major changes in concentrations of greenhouse gases."[42] She is also careful to leave room for the possibility that mankind is changing the climate in harmful ways. She advocated for action if evidence supports the notion mankind is causing damage. She also appears to support action when the alternative cost is low. That is, if the action is relatively inexpensive and there is no significant trade-off, she would support action even without overwhelming data underwriting the claim.

Since the mid-nineteenth century, scientists having been making gradual contributions to mankind's understanding of the climate. As the following paragraphs demonstrate, each major discovery along the way contributed to a shift in thinking concerning the Earth's climate, including its history, complexity, and diversity. In this way, climate science progressed much the same way as other scientific disciplines have, up to about the 1980s.

Perhaps the first scientist to make a major contribution to the field of climate science, Jean Louis Rodolphe Agassiz hypothesized during the early 1800s that giant sheets of ice once

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[42] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 215.

covered large portions of the Earth.[43] This was a new and unusual theory, especially since most people at the time did not have any exposure to harshly cold climates like Greenland and Antarctica. Popular perception of the world, at the time, was largely limited to the relatively warm areas people had inhabited during their lives. Agassiz explored areas in Switzerland. He observed geologic features and then deduced their formations as having been related to the forming and retreating of giant ice sheets. He later visited areas in the United Kingdom and was able to identify similar evidence supporting his conclusions. Agassiz is credited with significantly shifting the thinking about climate change during his day. His was a geologic discovery. Other researchers made discoveries in other areas that when added together, form the basis of thinking for the three major debate camps.

Later in the 1800s, James Croll theorized that the amount of energy from the sun reaching the Earth was driving the Earth's climate.[44] This may seem intuitive given the changes in weather on Earth as a result of the shifting seasons. Croll's work went further though identifying minute differences in the Earth's rotation that translated into larger climate impacts as "small differences in sunlight can make for big differences in temperature."[45] In the 1900s, Milutin Milankovitch took up Croll's work and reinforced it.[46] He was able to corroborate some of the major historical

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[43] David C. Smith and Harold W. Borns, Jr., "Louis Agassiz, the Great Deluge, and Early Maine Geology," *Northeastern Naturalist*, 7, 2 (2000): 1, accessed December 1, 2015, https://www.jstor.org/stable/3858648.

[44] James Roger Fleming, "James Croll in Context: The Encounter between Climate Dynamics and Geology in the Second Half of the Nineteenth Century" (paper presented as part of the Colby College Science, Technology, and Society Program, Waterville, ME, 2006), 51, accessed December 1, 2015, http://www.meteohistory.org/2006historyofmeteorology3/3fleming_croll.pdf.

[45] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 142.

[46] "Astronomical Theory of Climate Change," National Climatic Data Center, National Oceanic and Atmospheric Administration, last modified April 6, 2009, accessed December 1, 2015, http://www.ncdc.noaa.gov/paleo/milankovitch.html.

climate shifts to changes in the Earth's axis. He concluded that "every twenty-three thousand years the Earth goes through a full cycle in which the seasons occur at different points along the Earth's elliptical path around the sun."[47] Mikankovitch's theory and data established that without any other contributions, like increased anthropogenic CO_2, the Earth's climate changed. These climate changes were the result of the Earth's orbital changes as it shifted its orientation to the sun. While the scientists thus far mentioned focused on geology and physics, other fields have contributed to climate science as well.

During the 1800s, John Tyndall was working on the basic science of energy and started experimenting with infrared heat. Tyndall's work was in a non-geologic field, though his discoveries tie very much into the logic of the anthropogenic theory. He discovered that gases are not transparent to infrared radiation. Rather, different gases absorb different levels of heat from infrared radiation instead of simply passing the energy through. He noted that nitrogen and oxygen, the principal components of Earth's atmosphere, do not retain heat. He also noted that CO_2 and water vapor, on the other hand, were strong infrared absorbers.[48] This discovery was particularly important as a key component of the anthropogenic theory, but needed to be tied to atmospheric phenomenon to realize its full potential.

Near the turn of the twentieth century, Svante Arrheniu was working on some geology questions using chemistry.[49] He theorized a greenhouse effect had contributed to the Earth's transition out of the last ice age. Along with his colleague, Arvid Hogbom, the two determined

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[47] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 143.

[48] Spencer R. Weart, *The Discovery of Global Warming* (United States: Spencer Weart, 2008), "The Carbon Dioxide Greenhouse Effect," accessed December 1, 2015, https://www.aip.org/history/climate/co2.htm.

[49] Spencer R. Weart, *The Discovery of Global Warming* (United States: Spencer Weart, 2008), "The Carbon Dioxide Greenhouse Effect," accessed December 1, 2015, https://www.aip.org/history/climate/co2.htm.

that since CO_2 is a greenhouse gas (discovered by Tyndall), and mankind was emitting CO_2, mankind must be contributing to greenhouse warming. Interestingly at this time, these two scientists saw mankind's contribution as positive in that additional CO_2 would warm the atmosphere and would keep another ice age at bay. At this point, the consensus opinion was that mankind was creating a greenhouse gas (CO_2) and as a result, preventing the Earth from slipping back into another ice age which would have been the planet's natural tendency.

Guy Callendar advanced Arrheniu's research and hypothesized that CO_2 levels had risen significantly since the 1800s.[50] This was a significant assertion to add on to what previous scientists had already proved. Specifically, that mankind was not only making additional greenhouse gases, but that industrialization would accelerate this contribution. While his data was mostly estimations rather than actual measurements, his work inspired others to continue down the anthropogenic theory trail.

Roger Revelle and Hans Suess wrote an article in 1957 that argued the world's oceans, while capable of offsetting some of the increased CO_2 emissions, would do so at a slow rate.[51] This meant that even though some natural balancing efforts may occur, the overall amount of CO_2 in the atmosphere would increase as a result of mankind's activities. Revelle and Suess were two of the earliest theorists to suggest mankind's contributions to global warming would go beyond any beneficial effect of staving off another ice age. Instead, this additional greenhouse heat would warm the Earth to an uncomfortable level. Despite their conclusions, most scientists at this time did not feel a sense of urgency with regard to the potential damaging effects from global

[50] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 208.

[51] Roger Revelle and Hans E. Suess, "Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO_2 during the Past Decades," *Tellus*, 9, 1 (1957): 26, accessed December 1, 2015, http://onlinelibrary.wiley.com/doi/10.1111/j.2153-3490.1957.tb01849.x/epdf.

warming because they believed it would not occur for hundreds of years. This was due, in part, to the underestimation of the upcoming growth in the Earth's population and industrial capacity. Additionally, as Callendar had, scientists continued to struggle with proving actual atmospheric levels of CO_2. That was soon to change.

Charles Keeling, a chemist, began measuring atmospheric carbon dioxide levels atop Mauna Loa in Hawaii during the mid-1950s. Keeling's CO_2 measurements took Callendar's work to the next level since Keeling was able to collect reliable data to support his thinking.[52] Keeling's work demonstrated a predictable or seasonal pattern of increases and decreases of carbon dioxide levels. Levels go down when plants consume CO_2 in the spring and summer and then go up when dying plants return this CO_2 to the atmosphere in the fall. Additionally, independent of this natural variation, Keeling was able to show a gradual increase of CO_2 from 315 parts per million (ppm) in 1958 to 380 ppm in 2005. Keeling's curve, as the graph is known, helped reorient climatologists. Pearce noted "climatologists, many of whom had predicted in the 1960s that natural cycles were on the verge of plunging the world into a new ice age, began instead to warn of imminent manmade global warming."[53] At this point, climate science needed a more precise historical record in order to test the prevailing theories.

In 1988, Paul Mayewski drilled ice core samples on the Greenland ice sheet.[54] His data showed evidence of climate changes occurring over the past several thousand years. Information showed that the Earth's temperature has never been static. Also, he found that temperature and CO_2 levels were closely related. Each went up and down using similar patterns during similar

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[52] Justin Gillis, "A Scientist, His Work and a Climate Reckoning," *New York Times*, December 21, 2015, accessed January 5, 2016, http://www.nytimes.com/2010/12/22/science/earth/22carbon.html.

[53] Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change* (Boston, MA: Beacon Press, 2007), 8.

[54] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 211-15.

times. Unfortunately, the specificity of the data did not clarify which typically changed first. This data was not able to settle the discussion on whether CO_2 rises and temperatures follow or vice versa. Understanding the exact relationship between temperature and CO_2 changes would allow scientists to make better predictions about future climate change. Despite this shortcoming, Mayewski's work was important to climate researchers and excited the community.

Gerard Bond advanced Mayewski's ice core work by focusing on samples from the Atlantic seabed. He corroborated Mayewski's work with ice core samples by overlapping the results with samples from Bond's research on the seabed.[55] He was able to show that the skies and seas were connected and changed behavior at similar historical times. His samples matched up neatly with the information gleaned from the ice core samples. At this point in climate science's development, scientists have a pretty good idea about the history of the Earth's climate and a basic understanding of some of the relationships within the climate system. The focus was slowly turning to understanding the climate of the future.

David Meeker, a mathematician, and Paul Mayewski (the ice core scientist) collaborated to identify patterns in the ice core samples.[56] These patterns could be translated into statistical representations and models. Though the ice core patterns had some inconsistent periods, the modeling provided a way to show historical patterns assuming certain entering arguments. These arguments could be manipulated to better represent the observed conditions from the ice cores. The 1980s showed a continued unification between data production and analysis in the form of modeling. The invention of and rapid development of computers aided this process. The images

[55] CBS News, "Why Climate Change Skeptics Remain Skeptical," Livescience.com, November 22, 2011, accessed December 1, 2015, http://www.cbsnews.com/news/why-climate-change-skeptics-remain-skeptical/.

[56] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 222.

of past historic trends began to give researchers a glimpse of recent climate trends and reinforced the belief that mankind's consumption of fossil fuels was, and is, contributing to climate change.

At this point, scientists were working hard to understand the relationships of components within the climate system and how their contributions impacted the climate system as a whole. They also had a pretty good record of temperature and CO_2 levels from ice core and ocean debris fields spanning several thousands of years into the past. They understood that the Earth's greenhouse effect is especially important to understanding the Earth's climate and that mankind's contribution of additional CO_2 is likely having an impact. By most respects, the accumulation of scientific knowledge to this point had been similar to other scientific fields. Section III discusses the break from normal progression and how that break is contributing to the climate change policy debate confusion. As a lead-in to that discussion, the following paragraphs are an introduction to some of the debate confusion.

Mankind is likely a contributor to the forcing factors that drive climate change, but not the only contributor and possibly not even the biggest contributor. If there is no natural fossil fuel CO_2 contributor to the atmosphere (fossil fuel derived CO_2 leaves a unique detectable fingerprint in the atmosphere), a measurement of CO_2 indicating the presence of fossil fuel CO_2 suggests mankind's consumption of fossil fuels is likely adding CO_2 to the atmosphere.[57] In 1908, Arrhenius theorized that captured greenhouse gases trapped in the lower atmosphere changed the Earth's radiation balance and thus altered temperatures.[58] CO_2 is a greenhouse gas as John Tyndall discovered during the 1800s. Greenhouse gases are a major component of the Earth's warming mechanism that traps energy from the sun and warms the lower atmosphere of the

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[57] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 125, 220.

[58] Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change* (Boston, MA: Beacon Press, 2007), 3.

planet. If there is more CO_2 in the atmosphere, it logically follows that the greenhouse effect should be amplified and the Earth should be warming. Alas, this effect is not completely understood since historical warming and cooling periods using similar parameters do not always yield the same results researchers are seeing today. Additionally, there are inconsistencies in modern observed data showing stable or cooling temperatures when, given the increase in greenhouse gases, researchers would normally expect to see climbing average temperatures.[59] Thus, mankind might be adding additional CO_2 to the atmosphere, but there is not universal agreement on the impact from this action.

Additionally, some evidence supports a "chicken and egg" circular argument on whether an increase in CO_2 causes a temperature change or the other way around. Greenhouse gases might not even be a primary cause of climate change on Earth, but rather other major or interrelated factors.[60] There is even discussion that if researchers insert today's greenhouse gas levels into historical climate examples, global average temperatures would be closer to ten or fifteen degrees warmer than recent measurements rather than the one or so degree researchers have been able to measure. The inability of researchers to show consistently the relationship between all of Earth's climatological forcing factors does not indicate ineptitude. It does however, demonstrate the currently unknown dynamics and interrelatedness of climate forcing factors. This questions the assumption that mankind's fossil fuel emissions are a major contributing factor to climate change. It is not because of the fact that mankind is burning fossil fuels and depositing additional CO_2 into the atmosphere, rather, because researchers do not understand the real impact of this action and whether it is actually a problem at all. Pearce makes

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[59] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 201.

[60] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 219-20.

this observation early in his book. If researchers accept that climate change is underway, as researchers on both sides of the debate do, the more important question is, how will the Earth respond?[61] It appears researchers do not have broad agreement on this point making policy changes difficult or potentially costly without better a better understanding of the climate system. When designing an ADP operational approach to move a complex system from its current state to a desired state, researchers must know how specific inputs will affect the system.

The relative size and expense of climate science projects has changed the dynamic on climate research.[62] Typically, governments are the only organizations able to support these large endeavors. As such, the climate research community has organized in such a way to seek and acquire funding. This dynamic has influenced and potentially biased the research community into a tautological cycle of government funded, peer reviewed work. Since the community is relatively small, research has the potential to take on political aspects that could shift the natural direction of climate science epistemology. Since the IPCC is run *de facto* by the governments of the world and governments are funding research projects, it because difficult to develop effective counter proposals to those adopted by governments for political reasons.

CO2 is not the only contributor to climate change, anthropogenic or otherwise. Solar radiation, other greenhouse gas emissions, carbon sinks, glaciers, ice sheets, and other factors also contribute to climate change. Both Pearce and Peters introduce a number of alternative sources for climate change including the sun, the Earth's minor orientation variations (axis wobble), CO_2 sinks, and thawing methane patches. They explain each that of these sources might have contributed to climate change. Pearce asserts mankind remains a bigger contributor. Peters

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[61] Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change* (Boston, MA: Beacon Press, 2007), 15.

[62] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 223.

suggests a balanced scenario. Peters agrees with the notion that climate change is complex and driven by many different factors of varying impact across time. Pearce, instead asserts mankind is likely the main contributor and cites Ockham's razor as proof, "Changes in greenhouse gases are the simple, least convoluted explanation for climate change. And those changes are predominantly man-made."[63] Not only does this assessment disagree with the complexity Pearce discusses in other areas of his book, but does an injustice to the vastness of the problem so many people are struggling to understand.

While the anthropogenic view is the dominant theory, there are at least six other climate change theories under review. Alternative theory researchers are investigating these theories while the IPCC continues to investigate the anthropogenic theory.[64] As previously stated, there is no alternative theory agency with the same power and influence of the IPCC. Instead, small groups of scientists or other private industry backed organizations publish lesser known studies or summaries in hope of balancing the climate change policy debate. Because the IPCC is the sole government sponsored organization investigating climate change, the alternative theory groups are normally discredited for not having the same level of legitimate backing, here defined as a government charter. Regardless, this monograph has identified the friction in the debate and pointed out why it will be difficult to make progress on this issue. The exact nature of each of the alternative exceeds the scope of this monograph, however, their existence is germane.

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[63] Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change* (Boston, MA: Beacon Press, 2007), 15. Ockham's razor is an assertion popularized by William of Ockham holding that the answer with the fewest assumptions is usually the correct answer.

[64] Joseph L. Bast, *Seven Theories of Climate Change* (Chicago, IL: Heartland Institute, 2010), 5. Joseph Blast of the Heartland Institute summarized the seven theories (including the anthropogenic theory). The six other theories are bio-thermostat, cloud formation and albedo, human forcings besides greenhouse gases, ocean currents, planetary motion, and solar variability.

Pearce briefly discusses one of the main points alternative theory scientists use. The sun has an enormous effect on the Earth's climate as a result of variations in the amount of energy released by the sun. Knud Lassen, a Danish scientist, was able to show the correlation between sun spots and the temperature changes on Earth since 1850.[65] Pearce noted that "Climate scientists who once put all global warming since 1850 down to the greenhouse effect now concede that up to 40 percent was probably due to the sun."[66] Here again, the introduction of previously unknown data significantly reshaped thinking on the relationships between climate change components.

There is some confusion surrounding temperature observations researchers use to make comparisons and draw conclusions on climate change. First, researchers have been able to reliably measure temperatures around the Earth only for about the last 150 years, or roughly since 1866.[67] Any claim to know temperatures prior to this date are only as reliable as the proxy method used to calculate the measurement. There are various techniques in use for this purpose and this data is a reference across the entire climate debate. While there are some minor differences in the exactness of these methods, these measurements are generally accepted by researchers across the debate spectrum.

Second, as with most technology, the quality, reliability, and accuracy of temperature measuring devices has improved over time. Today's thermometers are vastly better than those from the 1800s. Thus, it is reasonable to assume the accuracy of temperature readings is better

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[65] Paul E. Damon and Peter Laut, "Pattern of Strange Errors Plagues Solar Activity and Terrestrial Climate Data," *EOS Space and Earth Science News*, 85, 39 (2004): 370, accessed December 1, 2015, http://onlinelibrary.wiley.com/doi/10.1029/2004EO390005/pdf.

[66] Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change* (Boston, MA: Beacon Press, 2007), 14.

[67] Jordan R. Raney, "Taking the Earth's Temperature," *New Atlantis*, 21 (Summer 2008): 117, accessed December 1, 2015, http://www.thenewatlantis.com/docLib/20080813_TNA21Raney.pdf.

today than yesteryear. Further, two modern thermometers might reveal minor variations in temperature. Researchers have not used identical measuring instruments for all observations across time. This lack of control mechanism makes it difficult to accept the minute temperature differences over time, especially when the difference is reported to be about one degree of warming across several decades.

Third, in order to truly know the Earth's average temperature across time, researchers would need the same reliable thermometer measuring every square inch of the plant. This is not a reasonable expectation which is why scientists make generalizations about regional temperatures and then combine these measurements to form a global temperature conclusion. This is a reasonable technique. However, it introduces potential error and becomes problematic when measurement changes are so minute.

Section II introduced the normal progression and accumulation of knowledge in climate science. There has been a gradual accumulation of scientific achievement contributing to mankind's current understanding of climate change. Scientists made discoveries about CO_2, greenhouse gases, the sun's impact on temperatures, and the Earth's axis wobble. Other scientists discovered different contributors to climate change. The anthropogenic theory follows a logical chain of thought concerning cause and effect. Scientists understand that mankind is producing CO_2 from fossil fuel consumption and much of this CO_2 is mixing into the Earth's atmosphere. Scientists also understand the Earth's greenhouse effect and how additional CO_2 in the atmosphere should impact the Earth's greenhouse effect. Some researchers believe they have identified a recent warming trend across the planet. Thus, mankind's burning of fossil fuels is adding CO_2 which is warming the planet unnaturally and undesirably. Today's researchers have more reliable means of measuring climate data points including atmospheric CO_2 levels and temperatures all across the Earth. This should permit researchers to collect better data and fine tune their hypothesis with regard to the causes of climate change.

Each camp, more or less, accepts the history of climate discerned by scientists to date. Specifically, each camp acknowledges that "geologists carefully mapped evidence not just of repeated glaciations and intermittent warm spells, but also of global sea-level shifts, vast inland lakes, and catastrophic flooding."[68] This means that without any input from mankind, the Earth's climate would be changing. That anthropogenic followers fail to incorporate historical climate research is a point of contention with the alternative theory camp. For the alternative theorists, considering anthropogenic inputs absent the greater context of historical understanding is incomplete and misleading.

The culmination of these discoveries along with contributions from other Earth sciences forms the basis of climate science. Climate science forms the basis of the climate change policy debate. This section introduced some of the history of climate change and started to reveal some of the foundational problems with the debate.

Section III: Climate Science Complexity and Epistemology

This section examines how climate science's complexity is working against policy makers who want to take action, the lack of clarity on exactly what climate science entails, and some of the confusion contrasting climate science to empirically-based sciences. Despite claims to the contrary, the climate system is complex. This becomes relatively easy to accept by observing weather across a much smaller timescale, perhaps a seven-day forecast. Try as they may, forecasters have difficulty predicting near term weather events. A forecast for rain may yield sunshine. A forecast for sunshine may frustrate someone caught in the rain without an umbrella. The WMO states, "Climate in a narrow sense is usually defined as the average

[68] Kirsten Peters, *The Whole Story of Climate: What Science Reveals About the Nature of Endless Change* (Amherst, NY: Prometheus Books, 2012), 64.

weather."[69] Accepting the average of weather (climate) then, simply means accepting the amalgamation of smaller difficulties of understanding short-term weather. James Ladyman provides a definition, "a complex system is literally one in which there are multiple interactions between many different components."[70] The IPCC provides another one:

> The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere, and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations and anthropogenic forcings such as the changing composition of the atmosphere and land use change.[71]

Thus, according to the IPCC, the climate system is complex. Researchers and forecasters may have knowledge on the climate's raw materials (temperature, jet stream, etc.) but they rarely understand the exact relationships between the climate system components, at least well enough to provide accurate predictions. Because of its complexity, the climate system is difficult to understand and predict, just like short-term weather. With the climate system falling squarely into the definition of complex, it becomes important to understand the impact from such an assertion.

The climate's nature makes analysis difficult because of incomplete data, complexity, and time factors. Valerio Lucarini notes that "due to the complexity of the system, climate dynamics is chaotic and is characterized by a large natural variability on different temporal scales that would cause non-trivial difficulties in detecting trends in statistically relevant terms, even if

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69 World Meteorological Organization/United Nations Environment Programme, Climate Change 2013: *The Physical Science Basis* (Intergovernmental Panel on Climate Change 2013), 1,450.

70 James Ladyman, James Lambert, and Karoline Wiesner, "What is a complex system," University of Pittsburg Digital Publishing Program, preprint edition (2011): 3, accessed November 25, 2015, http://philsci-archive.pitt.edu/9044.

71 World Meteorological Organization/United Nations Environment Programme, Climate Change 2013: *The Physical Science Basis* (Intergovernmental Panel on Climate Change 2013), 1,451.

the observational data were absolutely precise."[72] Basically, even with perfect data extending infinitely into the past, it would be difficult to recognize climate patterns in concrete ways because of the climate's complexity. Of course, researchers do not have data from the start of time. Nor do they have consistent data during the relatively short observation period on record. Lucarini adds, "the actual situation is much more problematic because even for the atmosphere, which is the observationally best-known component of the climate system, the database of observations having global extension, good reliance, and good temporal frequency go back in time no more than 4-5 decades."[73] This makes arguing for or against anthropogenic climate change very difficult. Researchers cannot say exactly what the climate has been, what it will be, or even the exact relationships between climate components. As a result, it becomes very difficult to understand the interrelatedness of climate system components. Even if researchers are able to isolate a portion or component of the climate system, that effort may not contribute to understanding the entire system. More importantly, understanding specific components may not yield additional information about the relationships of components within the system.

Understanding the relationships within a complex system might provide incremental system understanding, despite not understanding the complete system. There are several important characteristics of a complex system that help explain why it is difficult to fully comprehend a complex system. Each of these characteristics apply to the climate system and will help explain how and why the climate system is a complex system. Accepting this premise is key to understanding why the current debate is so difficult.

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[72] Valerio Lucarini, "Towards a Definition of Climate Science," *International Journal of Environment and Pollution*, 18, 5: 3, accessed November 25, 2015, http://www.inderscienceonline.com/doi/abs/10.1504/IJEP.2002.002336.

[73] Valerio Lucarini, "Towards a Definition of Climate Science," International Journal of Environment and Pollution, vol. 18, no. 5: 3, accessed November 25, 2015, http://www.inderscienceonline.com/doi/abs/10.1504/IJEP.2002.002336.

In the journal *Science* in 1999, editors offered a working definition of a complex system or "one whose properties are not fully explained by an understanding of its component parts."[74] More specific to the climate change discussion, "The climate that we experience results from both ordered forcing and chaotic behavior; the result is a system with characteristics of each. In forecasting prospective climate changes for the next century, the focus has been on the ordered system response to anthropogenic forcing. The chaotic component may be much harder to predict, but at this point it is not known how important it will be."[75] If the climate is a complex system, a host of complex system science attributes become relevant. The IPCC makes special note with regard to its effort to reduce unpredictable system behaviors by the use of scenarios. The WMO states that, "scenarios help in the assessment of future developments in complex systems that are either inherently unpredictable, or that have high scientific uncertainties."[76]

Accepting the IPCC's assessment, the climate system is a complex system which also means "the shortfalls in reductionism are increasingly apparent."[77] Put another way, all attempts to dissect or reduce a complex system in order to build a body of knowledge concerning the entire system runs the risk of being incomplete or inaccurate. Jamshid Gharajedaghi holds, "we are less likely to be able to explain the behavior of a complex whole by studying the behavior of the parts;

[74] Roger Lewin, *Complexity: Life at the Edge of Chaos* (Chicago, IL: The University of Chicago Press, 1999), x.

[75] D. Rind, "Complexity and Climate," *Science*, 284, 5411 (1999): 105-7, accessed December 1, 2015, http://science.sciencemag.org/content/284/5411/105.

[76] World Meteorological Organization/United Nations Environment Programme, *Climate Change 2013: The Physical Science Basis* (Intergovernmental Panel on Climate Change 2013), 138.

[77] Roger Lewin, *Complexity: Life at the Edge of Chaos* (Chicago, IL: The University of Chicago Press, 1999), x.

contrarily, we are more likely to be able to explain the behavior of the parts by studying the behavior of the whole."[78]

This does not necessarily mean all reduction efforts are fruitless, but that conclusions drawn from reduction must be further analyzed and considered once reintroduced to the system and should not be considered conclusive in independent form. Researchers use models to reintroduce climate components back into the system in order to assess the validity of component manipulation. For example, a model could increase CO_2 emissions across time while holding other variables constant in order to assess the impact on other component parts, perhaps, precipitation levels and temperature. The IPCC describes a climate model as "A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties."[79] Basically, in an attempt to better understand the knowledge of a component part, the IPCC puts it in a computer model attempting to bolster this knowledge by predicting an outcome and then comparing that outcome to an observed condition. In this example, in order to compare to an observed condition, historical data is used and simulations are essentially run backwards in time. If the prediction and observation match, the component part may increase the knowledge of the system and thus better the understanding of how component changes will affect future climate systems given certain variables. However, while this technique may produce information, it may not be focused on the proper question. Researchers are still looking for other ways to provide clarity on future climate predictions by using climate science.

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[78] Jamshid Gharajedaghi, *Systems Thinking: Managing Chaos and Complexit*y (Boston, MA: Elsevier, 2006), 51.

[79] World Meteorological Organization/United Nations Environment Programme, *Climate Change 2013: The Physical Science Basis* (Intergovernmental Panel on Climate Change 2013), 1,450.

Curiously, there is no clear definition of climate science. Valerio Lucarini in his article, "Towards a Definition of Climate Science" attempts to reduce the ambiguity of climate science as a field of study. Unfortunately, the IPCC does not offer a concise definition of climate science. The IPCC does define approximately 357 other climate related terms in its 1,535-page long report "Climate Change 2013" published that same year. It is unclear why the IPCC does not provide a definition for climate science. The lack of a clearly defined foundational science for the climate change policy debate inhibits a policy maker's ability to sort through data or make confident decisions.

Different from other sciences, climate science, according to Lucarini, does not fit the typical concept of classic science.[80] It does not comply with the classic testable structure since climate science experiment "answers cannot be singular and deterministic; they must be plural and stated in probabilistic terms." Further, Lucarini notes that, "in terms of societal impacts of scientific knowledge, it is necessary to accept that any political choice in a matter involving complex systems is made under unavoidable conditions of uncertainty." Lastly, he concludes, "there are several evidences that in the recent and distant past the climate of our planet experienced sudden changes, and it is clear that the rapid and violent forcing due to greenhouse gas emissions enhances the chances of the manifestation of bad climatic surprises." It appears then, the divide between the anthropogenic and alternative theory camps may be complicated by the willingness of public servants to accept political risk using an underpinning science uncertain by its very nature. Before turning to the theoretical basis behind scientific discovery, it is worthwhile to explore the non-deterministic nature of climate science a little more.

[80] Valerio Lucarini, "Towards a Definition of Climate Science," *International Journal of Environment and Pollution*, 18, 5: 2, 10, accessed November 25, 2015, http://www.inderscienceonline.com/doi/abs/10.1504/IJEP.2002.002336.

The term climate introduces an enduring and foundational inconsistency which muddles the climate change discussion from its start.[81] Climate refers to patterns of weather, or averaged pattern components, broken into reference time periods. There is no *a priori* for a climate time period rather it is defined by a research team in accordance with the purpose of that particular study. There then exists a large number of climate definitions based on an equally large number of predefined time periods. This confusion extends as much into the past as it does into the future. Even at present, the baseline of understanding climate and climate change is at the mercy of the researcher's selection of reference. One such reference is commonly referred to as the "base years" and helps illustrate why the term climate contributes to debate confusion.[82]

Researchers establish "base years" in order to provide a reference against which to compare a dataset. For example, the average temperature for a month for a certain spot on the Earth between 1930 and 1960 is sixty-six degrees. The "base years" are 1930 to 1960 and the reference temperature is sixty-six degrees for that location in that month. An observed temperature of sixty-eight degrees in 1990 during that same reference month at that same location on Earth can be said to be two degrees warmer than "normal." Given the vast amount of time involved during climate studies, it becomes practical to scope a study to a specific timeframe to facilitate understanding. Unfortunately, this scaling effort simultaneously confuses analysis by creating potential for inductive logic failure. That is, scoping to a specific timeframe allows a researcher to draw conclusions that may not actually apply universally to the entirety of climate across time. Continuing with the example above, drawing the conclusion that 1990 was two

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[81] Valerio Lucarini, "Towards a Definition of Climate Science," *International Journal of Environment and Pollution*, 18, 5: 2, accessed November 25, 2015, http://www.inderscienceonline.com/doi/abs/10.1504/IJEP.2002.002336.

[82] Bob Tisdale, *Climate Models Fail: The IPCC's Climate Models Show No Skill at Simulating Surface Temperatures, Precipitation and Sea Ice Area* (Bob Tisdale, 2013), loc. 1405, Kindle.

degrees warmer than “normal” may be inaccurate. The conclusion is correct using the current “base years,” but what if the researcher instead chose to reference 1900 to 1930 which had a notional value of sixty-nine degrees? In this case, 1990 was actually cooler than “normal.”

When a researcher makes a claim that temperature or any other climate measurement is more or less than it should be, the first question should be, “Compared to what?” In the case of “base years,” researchers may err in their conclusions simply by selecting an outlying reference period. The potential for induction error should not deter researchers from performing analysis in this way. Rather, it is important to acknowledge the potential for error in the context of attempting to make universal claims based on data subsets which are clearly vulnerable to error.

This potential for induction error is only one component of the larger problem with climate science. Consistent analysis requires a consistent “base years” for comparison. Similarly, and applied more broadly, if climate scientists assess the climate is moving toward an undesirable end state, they must have in mind a desired end state or ideal end state toward which the Earth should instead be moving. Additionally, as previously discussed, attempting to utilize the entire temperature dataset as a “base years” would not eliminate the potential error since the dataset itself is incomplete. That is, the dataset does not include all measurements of all places on Earth using the same measuring instrument for the entirety of the Earth’s history.

Lucarini’s point appears valid. Climate science, especially climate modeling, is by nature uncertain. Policy makers must determine the relative worth of climate science in the context of a cost and benefit analysis. If climate science is not certain in the way policy makers expect, as with more empirically based sciences like physics, climate science might have a different epistemology. If true, it would be misleading for anyone to lean on the social value assigned to traditional empirically based scientific research. To do so would serve to further confuse the debate.

Related to the definition of climate science, there is another foundational problem with the climate science debate environment. The IPCC spends a great deal of time attempting to model the future state of the climate. When attempting to identify a problem, it becomes very important to properly describe the desired current and future states of the environment. To agree on a solution to a problem, it would help if there was agreement between the debate camps on what exactly the current state is. Equally important would be agreement on a desired future state. That is, how do researchers and policy makers want the climate and weather of the future to behave? There must also be agreement on how a future climate will behave in the event policy makers elect to take no action at all. Lastly, there needs to be agreement on how the climate will develop under certain scenarios where mankind attempts to adjust atmospheric variables in order to achieve a desired future climate state. There is little agreement on these important concepts. Figure 1 is a picture of a notional current state and future state from ATP 5-0.1. Figure 2 goes one step further by showing a climate change specific environmental frame. The point here is that the climate change policy debate suffers from a lack of consensus on these essential elements. ADM, especially through the collaboration and dialog phase, could make progress in this area. Without a common understanding on current state, end state, and tendency of the system to move under influence, policy makers will struggle to make debate progress. Nor can they reach a productive consensus on the problem or opportunities for solution. In essence, without agreed upon beginning and end states, policy makers are working to solve different problems. There are several reasons contributing to why policy makers will continue to have difficulty agreeing on these states.

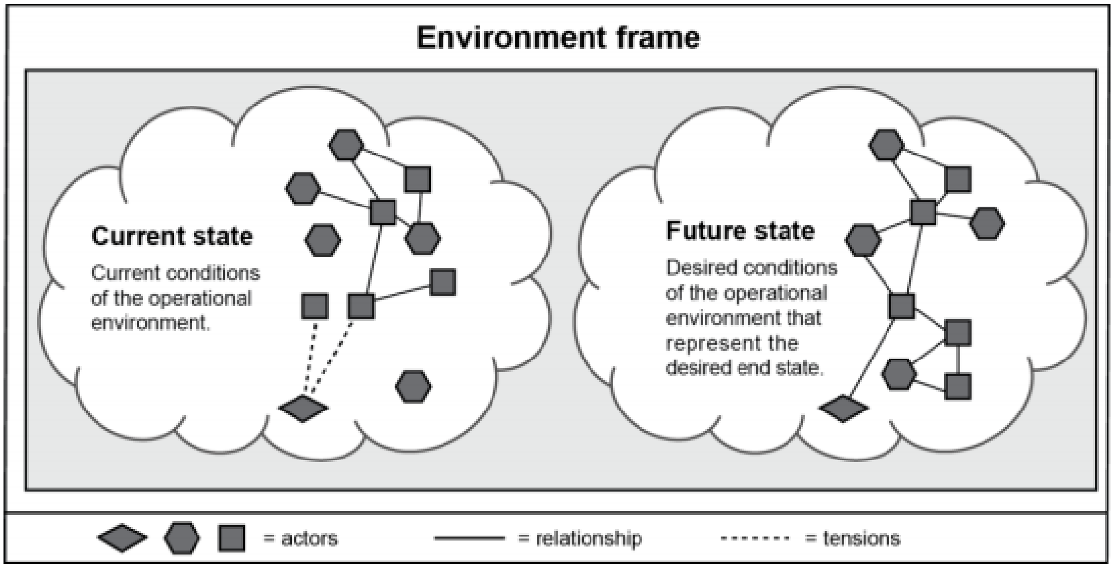

Figure 1 Framing and Operational Environment.

Source: Army Techniques Publication (ATP) 5-0.1, *Army Design Methodology* (Washington, DC: Government Printing Office, 2015), 3-2.

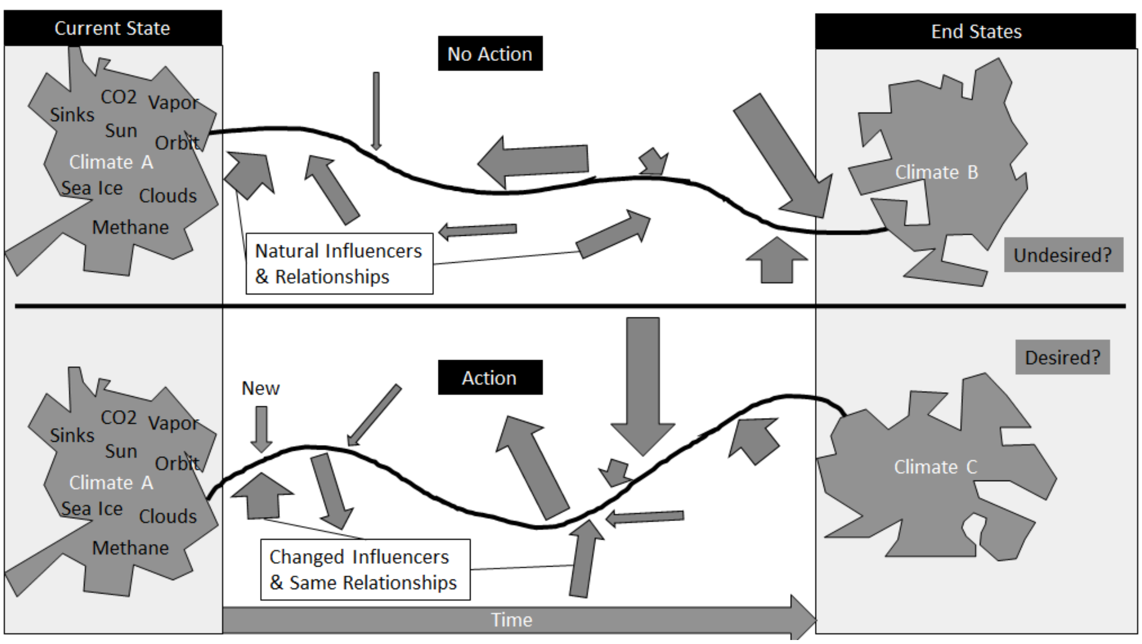

Figure 2. Climate Change Current and End States

Source: Created by author.

The IPCC's theory of anthropogenic change and its support for policy action is heavily dependent on two concepts. These concepts underwrite the argument for the predominant climate change theory – the anthropogenic theory. The two concepts are the idea of scientific community consensus and the authoritative nature of climate science. The IPCC advertises broad based agreement amongst climate scientists amounting to a consensus belief in the anthropogenic theory. Science, in its classic Galilean form is typically accepted by the scientific community, politicians, and the public alike. As the following pages will show, both the consensus view and the dependency on climate science do not necessarily support the anthropogenic camp as strongly as many claim. This is accomplished by examining the epistemology and methodology of climate science.

This section examines some of the epistemology of modern climate science. The underpinnings of the "science" in the climate change policy debate are contributing to debate confusion. Two authors are especially important here. Karl Popper wrote extensively on scientific discovery during the early 1900's.[83] Thomas Kuhn wrote on the same topic a little later. Both authors have extensive credibility in their fields.[84]

Popper asserts there are two major characteristics of science separating it from metaphysical or non-science. He examines these characteristics under the umbrella of the problem of demarcation, or the separation of science from non-science. To Popper, demarcation is the most fundamental issue and the "source of nearly all the other problems of the theory of knowledge."[85] For Popper, the only real science is that which is derived using empirical methods. Empirical science then, becomes synonymous with science as they are both the same. Any non-

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[83] Stephen Thornton, "Karl Popper," The Stanford Encyclopedia of Philosophy, 2015, accessed April 2, 2016, http://plato.stanford.edu/archives/win2015/entries/popper/.

[84] Alexander Bird, "Thomas Kuhn," The Stanford Encyclopedia of Philosophy, 2015, accessed April 2, 2016, http://plato.stanford.edu/archives/win2015/entries/thomas-kuhn/.

[85] Karl Popper, *The Logic of Scientific Discovery* (New York, NY: Routledge, 2002), 11.

empirical pursuit falls into the metaphysical realm and is not credited with scientific backing. Popper holds that scientific method eligibility and "falsifiability" are the two attributes setting science apart from non-science.

The notion of being subject to the scientific method is relatively easy to understand. For science to be science, researchers must empirically derive it. It must be tested and it must pass these tests.[86] Falsifiability, on the other hand, is occasionally misunderstood. Popper holds that in order for something to pass the empirical test, it must be structured in such a way as to be testable, or falsifiable. This is easier to understand when considering a hypothesis. In order to be useful, Popper wrote that researchers must craft a hypothesis so it can be tested. To do otherwise would protect a hypothesis from deductive reasoning, which Popper holds as the only real method of increasing knowledge. The opportunity for confusion surrounds the difference between falsifiability and verifiability. Testing may not verify a particular hypothesis. Instead, a successful test where a hypothesis survives experimentation is said to have not been disproven. The important point is that a hypothesis must be testable (falsifiable) in order to produce empirical data through observation. This then sets the parameters for the problem of demarcation in climate science.

Climate science does not appear to be a strictly empirically based science. It does not utilize the scientific method in a traditional way. This reduces climate science's credibility, according to Popper's writings. That is not to say the widely accepted subcomponents of climate science are under attack, such as the basics of chemistry and biological processes. These traditionally empirically based sciences have well established paradigms. At issue here is the amalgamation of these basic sciences and their relationships in climate change. The long time-periods across which researchers must test climate predictions make it very difficult to assess

[86] Karl Popper, *The Logic of Scientific Discovery* (New York, NY: Routledge, 2002), 9, 17, 18.

results. The complexity of the climate system makes testing complicated since most experiments, as people have come to understand them, necessitate reducing system complexity into testable components. Scientists do this in order to maximize the credibility of experiment findings and prove results are valid and not attributable to other influences. This moves the results of an experiment closer to knowledge and strengthens a hypothesis as it evolves into a theory. Reducing the climate system into testable elements is problematic. Understanding the relationships between all of the complex system components illuminates the true nature of the system. This presents a quandary as people struggle to reconcile their instinctive reluctance to accept the validity of the science professed to be inherent in climate change. Without the ability to strengthen the validity of climate science through appropriate experimentation, citing the science behind climate change policy will have diminished persuasive value. Using Popper's analysis, emphasis on deductive logic, and his test of demarcation, climate science appears to not meet the classic standards for scientific credibility. A significant portion of the validity of the anthropogenic climate change camp rests on the value of climate science. If climate science does not have the same credibility as the larger body of generic scientific work, policy makers are left with only metaphysical assertions.

Kuhn builds on Popper's ideas by exploring how scientific knowledge accumulates. This includes its methodology. Kuhn believed layers of knowledge are grafted upon earlier broadly accepted premises thereby gradually building the quantity and quality of knowledge on a particular subject. He called this "normal science."[87] Especially important, is the idea of paradigms or accepted principles of "theory, application, and instrumentation together-provide

[87] Thomas Kuhn, *The Structure of Scientific Revolutions* 4th ed. (Chicago, IL: The University of Chicago Press, 2012), 10.

models from which spring particular coherent traditions of scientific research."[88] Paradigms serve as the foundation for substantive progress in a given field. Paradigms establish a set of accepted rules by which researchers test both the existing paradigm and new ideas.

Paradigms take time to form. A scientific community will debate extensively before finally settling on a consensus view of the science at hand. This consensus denotes a maturation in the field and moves the particular science into the "normal science" phase.[89] Establishing a paradigm in a particular field is important if researchers want to move passed the most basic formative elements in their field.[90] For Kuhn, this is the typical order of the scientific process. Many major fields of science went through long formation periods before reaching the normal science phase. The laws of physics, for example, did not form in a mere decade or two. Rather, it took several hundred years to establish a paradigm.

Climate science has not yet formed its paradigm and has not moved into the normal science phase, as Kuhn defined it. Consensus is required for paradigm. The oft repeated quote, "97 percent of climate scientists agree with climate change," presents a large number of validity questions surrounding survey styles, population size, etc. Most important here is the notion that in order to have a paradigm, a community must reach consensus. This quote is rooted in an article published by *EOS* based on work by Peter Doran and Maggie Kendall Zimmerman. These authors conducted a survey in 2008 to assess the consensus in the scientific community with regard to climate change. Surveys were sent to "10,257 Earth scientists"[91] of which 3,146

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[88] Thomas Kuhn, *The Structure of Scientific Revolutions* 4th ed. (Chicago, IL: The University of Chicago Press, 2012), 11.

[89] Thomas Kuhn, *The Structure of Scientific Revolutions* 4th ed. (Chicago, IL: The University of Chicago Press, 2012), 12.

[90] Thomas Kuhn, *The Structure of Scientific Revolutions* 4th ed. (Chicago, IL: The University of Chicago Press, 2012), 20.

[91] Peter T. Doran and Maggie Kendall Zimmerman, "Examining the Scientific Consensus

responded. Seventy-nine indicated they were climate scientists with the balance of the others being from other disciplines. The survey contained two questions. The first asked if global temperatures have fallen, stayed the same, or risen since before the 1800s. The second asked if "human activity is a significant contributing factor in changing mean global temperatures."[92] Of the seventy-nine climate scientists, 96.2% reported they believed temperatures are on the rise and 97.4% believed human activity is to blame. The entire survey population (all scientists, not just climate scientists) percentages were 90% and 82% for the same questions. Conversely, more than thirty thousand scientists have signed a petition encouraging the US government to revisit the notion that climate change is largely due to anthropogenic causes. The lack of consensus indicates climate science is in a pre-paradigm phase which, as Kuhn holds, is healthy for the advancement of knowledge, but emblematic of the current debate discourse and struggle.[93]

Without a paradigm as defined by Kuhn, the state of climate science is insufficient to justify the basis of climate change. It is the science that informs the IPCC models predicting dire consequences without immediate modifications to the consumption of fossil fuels. This is a major contributor to the problem facing policy makers. Without a reliable information source to inform decisions, policy makers will have a hard time making effective cost-to-benefit analyses with regard to climate change policy decisions. On the surface, it appeared this conundrum was solved in 1990 with the establishment of the IPCC. Unfortunately, the creation of the IPCC made the problem worse.

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on Climate Change," *EOS Space and Earth Science News*, 90, 3 (2009): 22, accessed December 20, 2015, http://onlinelibrary.wiley.com/doi/10.1029/eost2009EO03/epdf.

[92] Peter T. Doran and Maggie Kendall Zimmerman, "Examining the Scientific Consensus on Climate Change," *EOS Space and Earth Science News*, 90, 3: 22, accessed December 20, 2015, http://onlinelibrary.wiley.com/doi/10.1029/eost2009EO03/epdf.

[93] Thomas Kuhn, *The Structure of Scientific Revolutions* 4th ed. (Chicago, IL: The University of Chicago Press, 2012), 13.

The creation of the IPCC was a government induced delivery of a climate science paradigm. The IPCC's charter is to study the effects of mankind on the changing climate. With the establishment of the IPCC, governments bypassed the normal science timeline by selecting a theory and administratively dismissing other climate change theories. The anthropogenic climate change theory did not endure nor survive the rigors of a pre-paradigm phase. Rather, it was adopted prematurely by a policy decision instead of developing as a Kuhn defined paradigm. This violates Kuhn's premise since "paradigms gain their status because they are more successful than their competitors in solving a few problems that the group of practitioners has come to recognize as acute."[94]

There are several significant contributors to the problem contained within the climate change policy debate. The different camps cannot agree on current and end states which makes it cumbersome to agree on a course of action. The climate is a complex system making its analysis very difficult. Proponents from all camps look to the foundation science, climate science, for definitive answers to clarify the debate. Each camp values the relative worth of climate science differently. Finally, climate science may not be as universally credited with having the necessary answers to advance the debate in a positive direction.

Conclusion

Climate change is one of the biggest challenges facing policy makers today. Military practitioners are facing equally complex, if not more so, problems across the entire national security spectrum. Expanding a critical thinker's horizon is key to exercising and improving the military practitioner's ability to creatively design and execute strategy. Considering and analyzing

[94] Thomas Kuhn, *The Structure of Scientific Revolutions* 4th ed. (Chicago, IL: The University of Chicago Press, 2012), 24.

nontraditional topics can assist in this process. The climate change policy debate is just such a topic.

The current climate change policy debate is not producing consensus-based action. Policy makers do not agree on the current course of action namely, the reduction of carbon emissions in order to potentially curb the estimated impacts from climate change. The recent Yale survey shows the split in American public opinion. This is due largely to the way climate science matured and the involvement of government and scientific communities.

The climate system is a complex system making the climate change policy debate complex by extension. While climate science experienced a normal maturation process up until the creation of the IPCC, the establishment of the IPCC short-circuited the normal science process creating an unnatural debate environment. Empirically based science would ordinarily be able to help researchers and policy makers navigate this complex environment, but climate change debate participants have varying levels of appreciation for the validity of climate science. Critically, climate science might not be an empirically based science at all. Or, it is a different kind of science moving throughout the debate environment lending misplaced credibility to some, confusion to others. These problems are vast and it becomes clearer why policy makers are struggling to build consensus action. They need a new approach to identify the unifying themes between camps in order to move past the current discord. ADM provides one such tool. ADM is not a panacea for climate change. It is, however, a method to reduce ambiguity in complex problems and provide decision makers with options for consensus-based productive action. Policy makers would be wise to consider the benefits of applying ADM, or a similar technique, to the climate policy debate. Given the complexity of the climate system and the interrelatedness of all climate change policy debate components, consensus action becomes the best option to make policy without complete surety of the value and legitimacy of climate science.

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