Lost in Translation:
Closing the Gap Between Climate Science and National Security Policy

APRIL
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By Will Rogers and Jay Gulledge

Center for a New American Security

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Cover Image

On March 22, 2009, Chief of U.S. Naval Operations Admiral Gary Roughead toured the Applied Physics Lab Ice Station in the Arctic Ocean where researchers from the University of Washington and the Navy Arctic Submarine Laboratory participated in Ice Exercise 2009. (MC1 TIFFINI M. JONES/U.S. Navy)

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Glossary of Terms

AAAS	American Association for the Advancement of Science
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
FFRDC	Federally Funded Research and Development Center
GAO	Government Accountability Office
IPCC	Intergovernmental Panel on Climate Change
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCS	National Climate Service
NEPA	National Environmental Policy Act
NIC	National Intelligence Council
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NRC	National Research Council
NSF	National Science Foundation
OES	Oceans and International Environmental and Scientific Affairs, State Department
ONR	Office of Naval Research
ORNL	Oak Ridge National Laboratory
OSTP	Office of Science and Technology Policy, The White House
QDR	Quadrennial Defense Review
SES	Senior Executive Service
USAID	U.S. Agency for International Development
UCAR	University Corporation for Atmospheric Research
USDA	Department of Agriculture
USGCRP	U.S. Global Change Research Program

EXECUTIVE SUMMARY

Lost in Translation:
Closing the Gap Between Climate Science and National Security Policy

EXECUTIVE SUMMARY

National security leaders now recognize that global climate change is a matter of national security and may even be a defining security challenge of the 21st century. Nonetheless, some national security professionals have yet to fully conceptualize how climate change could impact their areas of responsibility, or whether they need to analyze potential implications at all. What is more, they currently lack the "actionable" data necessary to generate requirements, plans, strategies, training and materiel to prepare for future challenges. Though the scope and quality of available scientific information has improved in recent years, this information does not always reach – or is not presented in a form that is useful to – the decision makers who need it. Closing this gap between national security policy makers who *consume* information and the scientists who *produce* it is essential for the nation to effectively deal with the national security implications of climate change.

Today, a thin thread of climate information links producer and consumer communities, but different needs, priorities, processes and cultures separate them – in addition to a divisive political debate surrounding the validity of climate science. As new public policies, regulations and laws come into effect and the consequences of climate change become more obvious, the demand for information is likely to surge.

Multiple barriers impede improved communication. The producer community tends to be stovepiped, even though consumers often need interdisciplinary science and analysis. Consumers, who may also be stovepiped in various agencies or subject areas, may lack familiarity with or access to these separate communities, as well as the tools or time to navigate scientific information and disciplines. Indeed, the immediate needs of consumers do not align well with the longer timelines involved in scientific inquiry, and consumer communities have not signaled the kinds of actionable data they require in order

to make decisions. Broadly speaking, scientists do not commonly serve public policy goals, at least not directly. And the academic community does not necessarily value communication with non-scientific constituencies. To make matters worse, there is a clear shortage of "translators" who can interpret climate science into actionable information for policy makers. Finally, a two-way conversation about such information requires trusting relationships, which, for a variety of reasons, may not always exist between the scientific and national security policy communities.

Scientists and national security professionals can bridge this gap. Consumers of information can signal the kinds of information they need by commissioning studies and collaborating or contracting with scientific organizations. Producers of climate information can rise to the occasion, accept that their work is critical to good governance and invest time and resources into better communication. For this approach to work, however, both producer and consumer institutions will need to change their incentive structures.

In short, policy makers and scientists need to build new bridges in order to address climate change. Some degree of separation is healthy for the sake of setting policy priorities and maintaining scientific integrity. But regardless, decision makers at all levels of government have already moved from merely *studying* climate change to *responding* to it – both to mitigate the damage from greenhouse gases and to adapt to potentially unavoidable changes over the next 20-30 years. For the nation, and the national security community specifically, to deal with national and international challenges associated with climate change, these two communities will need to work more closely together.

KEY POLICY RECOMMENDATIONS

Integrate Climate Science into National Security Policy

The president should form an interagency working group on climate change and national security with all relevant interagency partners (e.g., Executive Office of the President, DOD, Departments of Energy and Agriculture, U.S. Agency for International Development, Environmental Protection Agency, U.S. Global Change Research Program) to determine how other actors in the national security community are responding to climate change in order to prevent a duplication of efforts or agencies working at cross-purposes.

The Department of Defense should direct the Under Secretary of Defense for Acquisitions, Technology and Logistics to establish a Permanent Advisory Group on Climate Change and National Security under the Defense Science Board to provide independent advice to the Under Secretary of Defense for Policy and establish a permanent demand for the Defense Department's climate science needs.

- Establish a senior executive professional science fellowship akin to the Secretary of Defense Corporate Fellows Program to integrate military officers into scientific institutions.
- Appoint a climate science executive to be responsible for meeting the Defense Department's information needs related to climate change and national security.
- Select the most appropriate military commands to provide the Department of Defense with climate change analysis.

The Department of State should appoint climate science advisors to serve within the regional bureaus and on the policy and planning staff to develop actionable policies to address the effects of climate change, including foreign aid assistance.

The academic and scientific communities should create incentives for biophysical scientists to partner with social and political scientists to conduct research and publish peer-reviewed articles on how climate change could affect national security. Incentives could include research funding, prestigious awards from professional societies that explicitly recognize service to public policy or public recognition from government agencies. Most important, research grants and peer-reviewed publications in interdisciplinary or policy-oriented journals should receive full recognition and credit in the tenure and promotion process in academic institutions.

Develop National Security Research Support

Congress should fund research programs on the international effects of climate change, especially where those effects will be most acute. These programs should reflect specific institutional needs (e.g., Department of Defense) and non-traditional security priorities (e.g., international aid and development), and how to best disseminate information within the national security community.

The Department of Defense should establish research funding programs to encourage Federally Funded Research and Development Centers to provide actionable scientific recommendations to the Defense Department and to ensure that these organizations include climate change and national security in their research agenda.

Invest in a Community of Climate-Security Translators

Congress should invest in building a community of climate-security translators by amending Title VI of the National Defense Education Act to encourage the development of multidisciplinary educational programs on the national security implications of climate change.

The Departments of Defense and Education, the Office of the Director of National Intelligence and the National Science Foundation should reduce stovepiping between natural and social scientists by developing programs that reward research partnerships and training a new generation of interdisciplinary climate change risk thinkers, assessors and managers.

The Department of Defense should encourage Senior Executive Service (SES)-level decision makers to participate in science policy certification workshops and include science and technology policy as a core educational curriculum component of the SES Federal Candidate Development Program.

LOST IN TRANSLATION:
CLOSING THE GAP BETWEEN CLIMATE SCIENCE AND NATIONAL SECURITY POLICY

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Climate change and energy will play significant roles in the future security environment. The Department is developing policies and plans to manage the effects of climate change on its operating environment, missions, and facilities.

— Department of Defense, Quadrennial Defense Review, February 2010

I. INTRODUCTION

Many national security leaders now recognize that global climate change is a national security challenge, perhaps even a defining security challenge of the 21st century. Climate change could dramatically reshape the future security environment by driving migration, undermining community development and weakening state governance. America's political leaders are just beginning to grapple with the implications of climate change for U.S. policy, including how the nation can best reduce or mitigate future greenhouse gas emissions and prepare for or adapt to climate changes that unfold in the United States and abroad.

Despite this recognition, national security leaders do not yet have the scientific information they need to make the best possible policy decisions about climate change – policy decisions that will entail large financial commitments to address a range of potential national security risks. "From an intelligence perspective, the present level of scientific understanding of future climate change lacks the resolution and specificity we would like for detailed analysis at the [country] level," said Dr. Thomas Fingar, former Chairman of the National Intelligence Council (NIC).[1]

Though there has been a significant improvement in the scope and quality of scientific information available in recent years, a gap persists between available scientific information and decision makers' needs. It is unclear, however, to what degree this gap is caused by a true lack of usable information (i.e., data that policy makers can understand and base decisions on) or to what degree it is caused by a lack of communication and understanding between climate change analysts and decision makers. Regardless, closing the gap between the policy makers who need information and the scientists who produce it is essential for the nation to deal effectively with the challenges of global climate change.

As a think tank dedicated to developing balanced and innovative solutions to 21st century national security challenges, the Center for a New American Security (CNAS) has worked from its inception to assess the implications of energy insecurity and climate change for U.S. interests and the global security environment. This study was inspired in part by the experience of CNAS researchers in various projects, particularly during the designing of a climate change scenario planning exercise, or "war game," which simulated climatic impacts through 2015.[2]

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In constructing future scenarios for the July 2008 exercise, CNAS found that while there had been a wealth of data on projected climate effects around the world, the data were not of the right type or fidelity to support concrete plans for how to respond to the impact of climate change on human societies. For example, it was unclear how specific manifestations of climate change (e.g., changes in precipitation patterns, temperature fluctuations and extreme weather events) would affect existing societal trends such as migration, civil conflict and governance. CNAS analysts collaborated with a consortium of groups, including several with a range of scientific expertise, to try to understand and mine the available data. At times, the scientific and security researchers found each other mutually unintelligible. Ultimately, the researchers were able to find common ground and develop plausible climate change projections for East Asia, South Asia, Europe and the United States. Nonetheless, this experience and others led CNAS researchers to conclude that the gap between scientists and national security professionals was not an aberration, but rather a significant gap that must be bridged to support sound public policy decision making, especially on national security matters.

Beginning in July 2009, CNAS began to study this gap between climate change science and national security decision makers. The goal was to understand the nature of the divide and explore ways to bridge it. CNAS initiated a dialogue between the climate information "producer" and "consumer" communities and conducted formal interviews and ongoing informal conversations with scientists and decision makers. In developing this paper, researchers spoke with scientists from the national labs, nonprofit institutions, state agencies and academia, as well as decision makers from local, state and federal governments. This report draws on insights from these discussions, as well as from supporting research. Although we hope our observations will benefit a broad range of policy communities, the primary audience is the U.S. national security community, including the military, homeland security, foreign policy and national intelligence establishments.

II. CLIMATE CHANGE AND NATIONAL SECURITY

The national security community is just beginning to integrate climate change into its analyses and strategies. In June 2008, the NIC produced the first classified assessment of the national security implications of climate change, *The National Intelligence Assessment on the National Security Implications of Global Climate Change to 2030*. In February 2010, the Department of Defense (DOD) responded to a 2008 Congressional requirement to consider "the effect of climate change on Department facilities, capabilities, and mission" by incorporating climate change into the 2010 Quadrennial Defense Review (QDR). Likewise, the U.S. Agency for International Development (USAID) has begun to integrate climate adaptation into its development practices abroad.[3] The Department of Homeland Security explicitly stated in its inaugural Quadrennial Homeland Security Review that climate change is a trend that is likely to shape the current and future security environments. As climate science continues to advance and more departments and agencies begin to incorporate climate change into their strategic planning, there will be a growing need for sustained interaction with the climate science community in order to make informed national security policy.

Developing more informed national security policies, however, will require clearer lines of communication between climate scientists and national security decision makers to ensure that the national security community has the necessary information to prepare for future challenges.

Improved communication between these two groups of professionals will also broaden the community of individuals concerned with and engaging on the implications of climate change for national security.

Indeed, despite a better understanding of the link between national security and climate change, some national security professionals have yet to fully conceptualize how climate change could impact the areas where they have responsibility, or whether they need to conceptualize potential implications at all. To give a few concrete examples, Yemen, Pakistan and the Arctic are areas where the implications of climate change may not be fully developed or understood.

Yemen

Yemen has recently risen to the top of the national security agenda, with military, foreign policy and intelligence officers concerned about the strong presence of al Qaeda and the country's increasing instability. In the coming decades, Yemen's stability will hinge increasingly on its management of natural resources, in particular oil and water. To date the Yemeni government has been able to use its oil wealth, which accounts for approximately 85 percent of its revenue, to assuage an acute water crisis by subsidizing diesel fuel for pumps that extract water out of deep aquifers.[4] But dwindling oil production will make water extraction increasingly expensive, and inadequate access to water could ultimately undermine the government's power and legitimacy. By affecting precipitation patterns and drought conditions, climate change could exacerbate this acute water crisis and potentially create a situation of absolute water scarcity to which the government is unable to adapt. A better understanding of how climate change may affect these trends by officials at U.S. Central Command, the U.S. embassy in Yemen and the relevant bureau and country desks at the State Department could assist these decision makers in developing strategies to help prevent Yemen from becoming a failed state on par with Somalia, prevent a humanitarian crisis or otherwise minimize the negative ramifications of water scarcity.

Pakistan

Pakistan's stability has direct consequences for U.S. national security. Achieving U.S. and NATO objectives in the war in Afghanistan will continue to rely on the Pakistani government's ability to exert control over ungoverned spaces in its Federally Administered Tribal Areas along the Afghan border, where al Qaeda and Taliban militia continually evade capture. However, inadequate access to water and food undermines government legitimacy in the local population and could hamper its ability to win public support against al Qaeda and the Taliban. Pakistan relies heavily on water from its many rivers replenished by glacial melt from the Himalayas, but current scientific observations suggest that the Himalayan glaciers are retreating – which could have serious consequences for Pakistan's water supply and society. Indeed, water scarcity and drought-induced food shortages have sparked violence in the recent past. Understanding how, when and where climate change is expected to affect Pakistan's water supply will be essential to national security planners in the coming decades.

The Arctic

Change in the Arctic will present significant challenges for the national security community, as summer ice coverage shrinks and increases access to and navigation of the High North. Competition for resources and commercial shipping are two potential challenges, with particular consequences for DOD. In particular, the Department is assessing how to manage the Arctic; three combatant commands – U.S. European, Pacific, and Northern Commands – currently have responsibility for the area. Meanwhile, access to potential mineral and energy resources will increase international activity in the Arctic and will likely require monitoring by and coordination among interagency actors such as the Environmental Protection Agency (EPA), the Departments of Defense, Energy, Homeland Security, Interior, State and the national intelligence community. The question of when the Arctic will become ice-free is a significant uncertainty that makes it difficult to plan platforms, force structure and major expenditures. The national security community needs a more robust understanding of climate changes in the region in order to develop environmental assessments that will inform near- and long-term planning in the Arctic.

Climate change will likely exacerbate trends such as food insecurity, water scarcity and extreme weather events in the United States and around the world, with significant implications for national and global security. These changes could increase the need for humanitarian and disaster relief, as well as threats to security emanating from already weak or failing states. DOD is currently studying locations where climate change could worsen trends such as drought and increased frequency and intensity of storms. DOD recognizes the need to better understand where these trends will be most acute in order to prepare for possible U.S. military deployments to provide humanitarian and disaster assistance, as well as to prepare the military for possible climate-induced flashpoints.[5]

National security professionals, and the military in particular, have a vested interest in understanding how climate change could affect the operating environment in regions where they have personnel, infrastructure and equipment. For instance, changes in the operating environment have the potential to interfere with or incapacitate military installations and equipment vital to mission effectiveness (i.e., the military's ability to complete its missions), including training ranges, forward operating bases and military aircraft, vehicles and personnel.

While understanding climate science is and will continue to be essential to the national security

The U.S. Coast Guard Cutter *Healy* took part in a multi-year, multi-agency Arctic survey in the Arctic Ocean in September 2009 that is intended to help define the Arctic continental shelf. The U.S. Coast Guard and U.S. Navy are increasingly active in the High North. (PETTY OFFICER PATRICK KELLEY/U.S. Coast Guard)

community, the implications of not integrating climate science into regular decision making processes should not be overstated. The U.S. government, and in particular the national security community, is resilient and capable of operating under uncertainty and adapting to change. But adapting in response to, rather than in advance of, projected climatic changes would likely be less effective and more costly in both economic and human terms. The military, development and diplomatic communities may require long lead times to develop new capabilities, strategies and trained personnel – and position them appropriately – for the future security environment. If these communities do not integrate climate science into their decision making today, they may find themselves less well prepared to meet future challenges.

III. THE GAP BETWEEN PRODUCERS AND CONSUMERS OF CLIMATE SCIENCE

Producers and consumers of climate information span many communities of expertise, in all sectors of the U.S. economy. They may be tightly linked together or not directly engaged with each other at all. In this report, "producers" of climate information are defined as public and private sector researchers who work across a broad range of natural and social science disciplines involving specialized, technical and scientific training. While "consumers" of climate information are comprised of a broad range of individuals who make public policy or business decisions – either directly about climate change or decisions that are affected by climate change – this report is focused on national security decision makers. These

decision makers may include facilities managers, weapons systems designers, information technology developers, strategists, intelligence analysts, force planners, budget experts, diplomats, military leaders, international aid managers and lawmakers. Where appropriate, the paper draws insights from the relevant experience and observations of other public policy professionals, such as local or state government officials.

The producer and consumer communities are linked by a thin thread of climate information that is relevant to their respective endeavors, but they are separated by different needs, priorities, processes and cultures. The general characteristics of producers and consumers that create a natural gap between these two communities are discussed in more detail below.

Producers of Climate Information

Today, many producers of climate information generally do not provide the type of information that national security professionals need to make day-to-day or long-term decisions. As discussed below, this situation may stem primarily from the lack of an effective demand signal from the relevant consumer community. However, the way the producer community is organized and accustomed to operating also impedes the sharing of information that the security policy community could use.

The vast majority of producers, whether they work in the private sector, in academe or in government, are engaged in the scientific enterprise – the search for new knowledge about the characteristics and functioning of natural and social systems through systematic observation and experimentation. It is largely an organic, curiosity-driven process in which the answer to one question leads logically to the next, rather than being prescribed externally. Except for a relatively small number in government and in boundary organizations, most scientists are not in the profession to inform policy, nor do their peers and institutions generally encourage it or reward them for it.[6] Although it is appropriate that most scientists should continue to operate in this manner, there is an urgent need for more bridges between climate science and public policy.

Moreover, to the surprise and chagrin of some consumers, scientists are not always concerned with achieving greater certainty regarding the probability of their projections, which is something policy makers value. Indeed, some scientists have characterized progress as increasing the level of uncertainty, since the process of asking new questions generally turns up yet more questions.[7] As Dr. Anthony Janetos, Director of the Joint Global Change Research Institute at the University of Maryland and the Pacific Northwest National Laboratory, explained at a July 20, 2009, CNAS event:

> The scientific community has not done the right thing in that we've all been caught up in this mantra that we must reduce uncertainty. But in fact what we do as scientists is ask more questions and in many cases that **increases** uncertainty.[8] (emphasis added)

This pattern does not mean scientists are oblivious to uncertainty. On the contrary, metrics of uncertainty are built into the scientific process to ensure confidence about basic conclusions, but not necessarily to secure all of the details. To illustrate this point, consider the evolution of the conclusions of the Intergovernmental Panel on Climate Change (IPCC) regarding the existence and cause of contemporary climate change:

First IPCC Assessment Report (1990)

"The unequivocal detection of the enhanced greenhouse effect from observations is ***not likely*** for a decade or more."[9]

Second IPCC Assessment Report (1995)

"The balance of evidence ***suggests*** a discernable human influence on the global climate."[10]

Third IPCC Assessment Report (2001)

"Most of the observed warming over the last 50 years is ***likely [2:3 odds]*** to have been due to the increase in greenhouse gas concentrations."[11]

Fourth IPCC Assessment Report (2007)

"Warming of the climate system is unequivocal," and "Most of the observed increase in globally averaged temperatures since the mid-20th century is ***very likely [9:10 odds]*** due to the observed increase in anthropogenic greenhouse gas concentrations."[12] (emphasis added)

This remarkable series of ever more precise conclusions evolved over the span of two decades, illustrating a deliberate approach to resolving uncertainty about an important, policy-relevant question: is the Earth warming and, if so, are human activities the main cause? Nonetheless, there is little emphasis in these statements on precisely what proportion of the recent climate change is human induced. For the past 20 years, scientists have been content to ask simply whether ***most*** of the observed warming was caused by human activities. But is the percentage closer to 51 percent or to 99 percent? This question has not generated a great deal of discussion within the scientific community, perhaps because it is not critical to further progress in understanding the climate system. In the policy arena, however, this question is asked often and largely goes unanswered.

National Security Professionals as Consumers of Climate Information

The national security community confronts both long-term challenges and crises of the day. As such, national security professionals need information tailored to help them respond to a range of imperatives (including statutory responsibilities) on a broad range of timelines. Long-term planning may require information about large-scale, decadal trends, whereas near-term decisions may require details about current conditions and their causes in a particular location. For example, the Force Structure, Resources and Assessment Directorate (or J8) of the Joint Staff, the strategy, plans, and force development offices in the Office of the Secretary of Defense, and the Joint Forces Command all analyze future national security needs and challenges. This analysis may include major infrastructure needs and the future threat environment, for example. As such, these consumers may require long-term projections or other forward-looking research to inform immediate decisions. Tracking down the best available science to inform these decisions can be a challenge – all the more so if there is not an informed producer community anticipating consumers' needs.

Other offices tend to focus on current operations or day-to-day events and are often driven by urgent concerns. This is particularly true of offices dealing with pressing national priorities such as violent conflicts in regions of vital interest to the United States. According to Eileen Claussen, former Special Assistant to the President and Senior Director for Global Environmental Affairs at the National Security Council:

> Being a Senior Director in the National Security Council didn't always mean that I had easy access to the National Security Advisor, not because he [Anthony Lake] didn't support what I was doing, but because the [National Security] Council was dealing with Bosnia, Somalia, or another crisis every day.[13]

Decision makers who require a quick response may find it difficult to establish relationships with information producers who operate at a different pace, as may be the case in the academic environments where many climate information producers reside.

Beyond those agencies specifically charged with marrying science and public policy, such as the Office of Science and Technology Policy

In a world where the past is no longer prologue, decision makers need new methods and analytical support to accommodate uncertainty about how climate change could affect the future security environment.

(OSTP) in the Executive Office of the President and the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce, science-related capabilities are likely to focus on highly targeted needs. The U.S. Air Force and U.S. Navy, for example, do have meteorologists, aerographers and oceanographers in their ranks, but they largely focus on weather and ocean conditions that affect day-to-day military operations. The State Department has a Science and Technology Advisor and a Bureau of Oceans, Environment and Science, though the former is a small operation that is not always well integrated into policy making and the latter is focused largely on international negotiations, bilateral relations and other diplomatic needs. Consequently, it may be difficult for influential government officials in national security agencies to acquire concise, comprehensible and relevant information on complex, emerging scientific issues in time to support policy decisions.

According to Commander Esther J. McClure, USN, who helped lead the effort to integrate climate change into the 2010 QDR:

> If your principal needs to address some climate-change-related issues in a bilateral ministerial discussion in two weeks, you have just that much time to extract something actionable from the producer community, digest it, and put it in context for the meeting. This is a huge challenge, and great source of mutual frustration.[14]

Operating Under Conditions of Uncertainty

In a world where the past is no longer prologue, decision makers need new methods and analytical support to accommodate uncertainty about how climate changes could affect the future security environment. Such innovations will require intensive and sustained interactions between those who produce climate information and those who use it to make decisions.

When making decisions requiring large investments, consumers may require higher quality, more specific scientific information. "We can't make multibillion-dollar decisions based on the hypothetical," Rohit Aggarwala, New York City's director of long-term planning and sustainability, told the *Wall Street Journal*.[15] If policy makers are not convinced that scientific information is useful to them, they may be less likely to factor it into their decision making or they may base decisions on more familiar criteria or sources of information, even if they are less germane to the problem or omit important considerations. For example, in the absence of confident climate projections for sea level rise, coastal facilities planners or naval facility managers might base new flood defense requirements on existing standards, even though those standards may not take rising sea levels into account. Indeed, there may be financial incentives to do so, since factoring in sea level rise would likely raise costs. Therefore, failing to consider climate projections could mean designing 100-year coastal walls that could be inundated in a matter of decades.

Nonetheless, making policy in the face of uncertainty is possible. For instance, city planners and other consumers are accustomed to making decisions under conditions of uncertainty. According to Dr. Jack Fellows, Vice President and Community Programs Director for the University Corporation for Atmospheric Research (UCAR) and former Branch Chief in the White House Office of Science and Technology Policy:

> Despite the uncertainties, many cities are making decisions with the best available climate information. They are looking at the broad trends of temperature and precipitation anticipated for their regions and combining that with a lot of other non-scientific information to move forward with planning.[16]

The national security community is particularly adept at making decisions under conditions of uncertainty. Some analysts are therefore left to wonder why national security decision makers often seem to require a higher standard of certainty for climate-related decisions than for other types of decisions. Margaret Purdy, former Canadian Associate Deputy Minister of National Defence, commented:

> I am puzzled by the recurring comments from security officials about the lack of resolution and specificity in climate science. These same officials are accustomed to making decisions on incomplete and uncertain information about future geopolitical alliances, about international terrorism, about the next moves of insurgents, about the next turn in cyber attacks, and so on.[17]

Making climate-related decisions under conditions of uncertainty can have long-term, costly implications. The national security community will find it increasingly difficult to prepare for long-term challenges in a changing security environment when it is unclear where those challenges will be most acute and will deserve the most resources. For example, as Larry Brilliant, former director of Google.org and head of the Skoll Global Threat Fund, wrote for *Forbes Magazine*:

> It seems true, if inconvenient, that X millions of acres of seashore, Y hundreds of millions of climate refugees, and Z billions of malaria mosquitoes will result if we don't act. But scientists won't tell you the actual numbers for X, Y or Z. They will tell you they are "90 percent confident that there will be between 100 million and 1 billion climate refugees." Those wide ranges, coupled with the long delay time, the intangible nature of the risks, and the complexity, make this global threat a hard sell.[18]

Indeed, for the national security community, there is a significant difference between 1 billion refugees and 100 million refugees. The difference could mean the difference between the national security community needing to dedicate increasingly constrained and finite resources – such as military, medical and development personnel and assets – to a particular state or region, and not needing to change their plans at all. The national security community has a vested interest in knowing where it needs to engage to help prevent such shocks to the global system, especially in countries of strategic importance to the United States.

Eliminating uncertainty from the scientific discipline is impractical and, at times, counterproductive. Therefore, the producer community may need to disabuse the consumer community of the notion that projecting climate change and its impacts will ever provide precise predictions. Producers will need to partner with consumers to develop approaches that can accommodate uncertainty in decision making.

A Thorn in the Relationship: Controversial Claims in Climate Science

Recent controversies surrounding climate science, even if largely unfounded, undermine serious efforts to bring the scientific and decision making communities closer together. In late 2009 and early 2010, stolen emails and revelations about inaccuracies in the 3,000-page Fourth Assessment Report of the IPCC – the gold standard of climate science reporting for the policy community – damaged the credibility of climate science among some consumers.[19] Climate scientists have articulated compelling defenses against accusations of scientific misconduct, convincingly reaffirmed the scientific case for human-induced climate change, and demonstrated that most of the accusations of errors in the IPCC report are incorrect.[20]

But the IPCC and other authoritative scientific institutions, such as the national academies of the world, have been slow to respond to these controversies. To this day, no authoritative or official review had been conducted of the IPCC report, although, the IPCC announced that it would establish an independent panel to conduct a review of its methodology in an effort to eliminate scientific bias or errors from future reports.[21] The slow response from scientific institutions and the IPCC independent panel's plan to not review previous findings reveals a lack of appreciation for the difficult position that decision makers are now in as a result of the public controversy surrounding the IPCC, even if it is scientifically unfounded. Scientific institutions need to react to real or perceived errors quickly: "We need to acknowledge the errors and help turn attention from what's happening in the blogosphere to what's happening in the atmosphere," Peter C. Frumhoff, director of science and policy at the Union of Concerned Scientists told *The New York Times*.[22]

Yet, it is crucial for the consumer community to recognize that the producer community is generally poorly equipped to navigate political debates and understandably reluctant to try. Every controversial issue will have politically motivated detractors and it is incumbent on the policy community to develop mechanisms to withstand unfounded political buffeting. Since climate change is a national security concern, trusted members of the security policy community, especially the military, can act to tilt policy discussions toward evidence-based conclusions. Enhanced climate science expertise within the producer community and trusting relationships between the consumer and producer communities can provide a foundation to bolster consumer confidence and stabilize policy debates.

What Consumers Need and What Producers Produce

Public controversies notwithstanding, much credible and useful information is available from government and nongovernment entities that provide details on global change and plausible projections of the future. In recent decades, the science community has made significant improvements in the collection, analysis and interpretation of basic climate data and the impact that carbon emissions and environmental change are having on the world and human societies. For example, the National Aeronautics and Space Administration (NASA) Ames Research Center in California is using a new "cube-based" approach to modeling the climate system that improves the resolution and accuracy of ocean circulation models. This method helps to create a more accurate simulation near the Earth's poles, where the fate of huge ice sheets – which hold the potential for catastrophic sea level rise – will be determined.[23] The Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL) and the National Center for Atmospheric Research (NCAR) have recently incorporated the nitrogen cycle into climate simulations, generating a more realistic picture of the carbon cycle and its influence on the pace of climate change.[24]

The intelligence community continues to declassify one-meter resolution images taken from its satellite systems, giving climate scientists access to images 15 to 30 times sharper than the next-best systems controlled by NASA and commercial entities such as Google.[25] These and a plethora of other advancements have produced a greater understanding of the Earth's climate system as well as the affects of human activities (or anthropogenic influences) on the climate system.

The amount of observational data and output from climate models is growing quickly. For example, there are terabytes of highly credible climate change projections now available from the IPCC's Fourth Assessment Report that have never been examined in detail – particularly with regard to local and near-term projections, by decade, to the end of the century and beyond. The sheer volume of available but unanalyzed data creates the potential for many policy-relevant questions to be answered today, if only decision makers were aware of the data, knew how to access it and could make sense of it – and if more scientists understood the needs of decision makers and were motivated to provide it to them in a more useful form. In the future, as even more data become available, new efforts are emerging to handle the onslaught of information. NOAA is leading one public sector effort, the National Polar-orbiting Operational Environmental Satellite System (NPOESS), which will orbit the Earth every 100 minutes, "providing global coverage, monitoring environmental conditions, collecting, disseminating and processing data about the Earth's weather, atmosphere, oceans, land and near-space environment."[26] The private sector has started to contribute to the flow of new information as well. For example, there are new public-private partnerships to advance climate science data collection and analysis with new satellite systems.[27] Meanwhile, other private companies are embarking on similar solo endeavors, in part, in recognition of the likelihood that there will be a surge in the demand for collection and analysis of climate information.

The slow response from scientific institutions and the IPCC independent panel's plan to not review previous findings reveals a lack of appreciation for the difficult position that decision makers are now in as a result of the public controversy surrounding the IPCC, even if it is scientifically unfounded.

Given the proliferation of new tools (e.g., climate satellites and advanced computer models) and data acquisition systems, there will be no shortage of climate information (especially data related to present conditions and short-term trends). The question for the national security community is whether its unique needs will be met. Since the community has not traditionally based decisions on climate change projections or assessments, there are few processes in place to ensure that the necessary information will be available when it is needed and in a form that is useful.

In particular, many national security decision makers require "actionable" data, or data that can be used to generate requirements, plans, strategies, training and materiel. They need to know where to dedicate resources. Actionable

climate-related data requires marrying physical and social science data to forecast the national security implications of climate change. While many national security decision makers will find biophysical data useful in order to hedge against specific impacts of climate change (e.g., sea level rise at naval installations), others will need more targeted information about how biophysical changes will influence existing social trends, such as ethnic tensions, economic prosperity and political dissension. DOD noted in the 2010 QDR that, "While climate change alone does not cause conflict, it may act as an accelerant of instability or conflict, placing a burden to respond on civilian institutions and militaries around the world."[28] For example, an important question for operational planners to consider could be how climate change could exacerbate water scarcity in Yemen, and how this might contribute to political unrest, a fractured civil society, al Qaeda recruitment and state weakness or failure. Current biophysical climate data lack the level of detail, fidelity or appropriate spatial and temporal scaling with social science data necessary to answer many of the types of questions that national security professionals need to ask.

While there are efforts within the military services to better understand how climate science can inform their assessment of the impact of climate change at the operational level (e.g., the U.S. Navy's Task Force Climate Change[29]), these effects are still not well understood. What is more, most of the climate science capabilities in the U.S. government reside in civilian agencies, many with a primarily domestic focus, such as NOAA, DOE and EPA, or research agencies that lack policy authority, such as the National Science Foundation (NSF) and NASA. While much of the information these agencies generate may be useful to the national security community, the quality and specificity of data about the forecasted impact of climate change on particular world regions, and supporting analysis of the implications, is relatively limited.

Until recently, climate change was largely isolated within science-focused agencies and a small contingent within the State Department, with little interest expressed in other quarters of the U.S. government. But with increasing action from states and local governments, recent executive orders from governors and the president, and major climate and energy legislation making its way through the U.S. Congress and state legislatures, public policy on climate change is increasingly in the hands of more operational agencies (e.g., public works offices, first responders and military professionals). Indeed, like many national security professionals, these decision makers need actionable information that has traditionally been unavailable in the past.

THE MARYLAND CLIMATE CHANGE COMMISSION

In April 2007, Governor Martin O'Malley issued an executive order creating the Maryland Climate Change Commission to prepare a climate change action plan for the state.[30] The action plan included draft legislation, a statewide climate change impact assessment, a greenhouse gas footprint reduction strategy and a strategy to reduce the state's vulnerability to climate change. To carry out the impact assessment, a Scientific and Technical Working Group was established, comprised of 22 experts from five universities, two state agencies, one federal agency and two nongovernmental organizations. Even though the assessment process relied solely on existing information, it took more than a year to complete. Other components of the action plan also required the participation of a wide variety of experts from multiple sectors and institutions. These multidisciplinary assessments will have to be repeated over time as climate science evolves and as the outcomes of new climate policies start to become apparent.

Laboratories of Change: Experiments in State and Local Government

In the absence of national leadership from the White House or congress, states have been very active in developing climate change mitigation and adaptation policies. One of the primary reasons for this proactive policy making is that state policy makers are keenly aware that their decisions can have an impact on guiding federal policy, which could be why most states have placed significant priority on mitigation policy, even though their individual actions are small relative to global greenhouse gas emissions. The National Conference of State Legislatures and the National Association of Governors have strong policy positions on energy security that integrate carbon reductions and renewable energy technology. A list compiled by the Pew Center on Global Climate Change names 33 states that have or are currently drafting climate action plans that focus specifically on climate change mitigation.[31]

States that are already experiencing climatic impacts (or will in the near future) have been first to implement adaptation strategies. California recently became the first state to release a comprehensive draft of its climate change adaptation strategy. Perhaps it comes as no surprise that California is moving on adaptation policy, because severe drought and wildfires that could be exacerbated by climate change are already persistent issues.[32] The strategy prioritizes six sectors that will likely be most impacted by climate change: public health; biodiversity and habitat; ocean and coastal resources; water management; agriculture; forestry; transportation and energy infrastructure.[33]

California Governor Arnold Schwarzenegger addressed the U.N. General Assembly before a special session on climate change in September 2007. Governor Schwarzenegger signed Executive Order S-13-2009 in November 2008 directing the California Natural Resources Agency to explore adaptation strategies to a changing climate.
(MARCO CASTRO/United Nations)

A recent report from the Environmental Protection Agency and the U.S. Global Change Research Program indicated that the U.S. eastern seaboard would be inundated by rising sea levels.[34] Every coastal state has started to implement or is drafting an adaptation strategy due to concerns over rising sea levels, saltwater intrusion and fisheries. States that are not experiencing direct effects have been reluctant to put forth adaptation strategies – though it is worth mentioning that states that have been reluctant to make decisions about adaptation may be failing to connect trends they are experiencing with climate change.

Recognizing the void of actionable information on climate change, local governments have started to establish special task forces and committees on climate adaptation. A major focus for local policy makers has become where to allocate money for adaptation measures. Meanwhile, local governments that are large enough to have a measurable impact, or can demonstrate leadership with a mitigation policy, do focus on reducing carbon emissions and improving energy efficiency as well. These types of local governments tend to be large metropolitan cities, such as New York, Los Angeles, San Francisco and Chicago; smaller towns have focused less on mitigation.

A few local governments – notably New York City – have been at the forefront of adaptation planning.

As the recent report from the EPA and the U.S. Global Change Research Program indicated, New York is particularly vulnerable due to its location along the eastern seaboard.[35] New York City planners had previously convened their own panel - The New York City Panel on Climate Change (NPCC) – tasked with producing climate change projections specific to the greater New York metropolitan area. According to Adam Freed, Deputy Director of Long-Term Planning and Sustainability for New York City:

> The challenge in preparing for climate change is either having too much information to digest or no information about local impacts. When we began this [NPCC] process, there were a number of national and regional climate projections available. We had to come up with a way to filter the existing data and generate information on local impacts. To do this, the City partnered with the Rockefeller Foundation to convene the New York City Panel on Climate Change – a group of leading climate change scientists, academics, and economists as well as insurance, risk management, and legal experts – to develop New York City-specific climate change projections and advise the City on our approach to climate resilience.[36]

New York Mayor Michael Bloomberg launched the Climate Change Adaptation Task Force and the New York City Panel on Climate Change on August 12, 2008 to develop strategies to secure the city's infrastructure from the effects of climate change. (City of New York)

The resulting Climate Risk Information, released in February 2009, will help policy makers working on PlaNYC, Mayor Michael Bloomberg's comprehensive sustainability plan that includes initiatives for mitigating and adapting to climate change. The projections also serve as the basis for the work of the New York City Climate Change Adaptation Task Force, which consists of 40 city, state and federal agencies and public authorities as well as private sector companies that operate, regulate or maintain critical infrastructure in New York City. The Task Force, which is an initiative of PlaNYC, is conducting an assessment of the impacts of climate change on the city's infrastructure and developing strategies to increase the city's climate resilience.[37]

Despite these efforts, many policy makers are uncertain what role they should play in working across the various levels of the policy community, and are sometimes unaware of what actors in the other tiers of government are doing. For example, federal decision makers are keenly aware that climate change adaptation is ramping up at the local level. However, a senior Obama administration official who spoke on the condition of anonymity said that the administration is grappling with what role, if any, the federal government should play in local adaptation efforts (e.g., funding new designs for irrigation canals without a complete understanding of how climate change will affect local water resources).[38]

IV. THE PRODUCTS AND PRODUCERS OF CLIMATE SCIENCE

If the consumer community, particularly consumers who require actionable information, has not yet generated a clear demand signal for the scientific information that they need, it is important to understand what sorts of information are currently available and how these might be accessed, enhanced or augmented.

Journal Articles

The most basic deliverable of scientific research – an individual peer-reviewed article published in an academic journal – is targeted to a specialized scientific audience and is rarely intended to guide policy decisions. Because of how scientific knowledge evolves, it is almost always unwise to base a policy decision on one or a few academic papers, regardless of provenance. The goal of individual papers is rarely to evaluate real-world policy options and the peer review process for individual papers is not intended to ensure that the conclusions of the study are correct. Peer review is simply to ensure that the work offers new data, meets minimum quality standards for the field and does not defy reason. Since scientific knowledge progresses through the proliferation of competing ideas, followed by the gradual rejection of incorrect ones as new evidence permits, many incorrect interpretations necessarily find their way into the peer-reviewed literature. The substantive debate over a new hypothesis or interpretation then occurs after publication, when peers attempt to replicate, refine or refute previous work. This process is essential to the scientific method and underpins the folly of using individual peer-reviewed papers as a basis for decisions.

Reports and Assessments

Much better suited to decision making are assessment reports produced by independent panels of experts charged with vetting a body of peer-reviewed literature on a topic of interest to decision makers. Key examples for climate change include the periodic assessment reports of the IPCC, the "synthesis and assessment products" of the interagency U.S. Global Change Research Program (USGCRP) and reports produced by the National Research Council (NRC) under the auspices of the National Academies. These sorts of assessments have emerged as the most reliable and authoritative mechanism through which decision makers extract current information from the scientific community in a form that is packaged specifically for a policy audience. A recent example is *Indicators for Understanding Global Climate Change*, an NRC study commissioned by the NIC. The project seeks to develop a coordinated "climate observing strategy" for decision makers and stakeholders in the Intelligence Community.[39] Many such studies are available to the public and can be used by local, state and federal policy makers. Studies by respected scientific bodies, such as the IPCC and the National Academies, are authoritative and technically reliable. By design, however, they usually stop short of issuing policy recommendations and decision makers often complain that reports from the expert community fail to offer actionable information. "We need to make research investments more relevant to decision making and the scientific community needs to be a partner in that," says Dr. Philip DeCola, Senior Policy Analyst in the White House Office of Science and Technology Policy. "Reports from the National Academies are full of great science recommendations but they don't suggest how we can govern based on them."[40]

Government, Nongovernment and Professional Research Offices

Other sources of scientific information for decision makers are reports from third-party aggregators, including government research offices (e.g., DOE's Energy Information Administration, the Congressional Budget Office, the Congressional Research Service and the Government

Accountability Office), international boundary organizations (e.g., the World Meteorological Organization and the International Energy Agency), private think tanks/nongovernmental organizations (e.g., the World Resources Institute and the Pew Center on Global Climate Change), and professional consultancies (e.g., ICF and Science Applications International Corporation). Information from such institutions is often reliable and can be very useful because it is usually aimed specifically at offering actionable advice or identifying key issues that remain to be resolved. However, many organizations occupy this category and their credentials, objectivity and the quality of their advice vary.

Federally Funded Research and Development Centers

Federally Funded Research and Development Centers (FFRDCs) produce high-grade climate information at the request of consumers. In addition to having worked with CNAS in the past to produce its climate change war game scenarios, ORNL recently worked with the Office of the Secretary of Defense to provide climate change projections to help DOD meet its statutory requirement to integrate the implications of climate change on its capabilities, facilities and missions into the 2010 QDR. Many federally funded labs and agencies offer information resources that are useful at the state and local levels as well. The DOE labs, for instance, "thrive within their local communities and have an intimate interest [in those communities]," says Lynn Peters, a former Director of Pacific Northwest National Laboratory.[41] Similarly, NOAA's Regional Integrated Sciences and Assessments program "supports research that addresses complex climate sensitive issues of concern to decision-makers and policy planners at a regional level."[42] Other FFRDCs specialize in providing policy analysis. For example, CNA, an FFRDC funded in part by the Pentagon, has been very influential in bringing climate change to the attention of national security decision makers.

Academic Institutions and Outlets

Academic institutions are a valued source for innovative climate science research. A large number of climate research projects are executed by individuals and research teams housed in academic departments within colleges and universities. One unique academic institution, the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, performs a large share of U.S. climate research. NCAR is a federally chartered and funded nongovernmental research laboratory managed by a nonprofit consortium of 75 universities called the University Corporation for Atmospheric Research. According to its website, NCAR "provides the university science and teaching community with the tools, facilities, and support required to perform innovative research."[43] Other academic institutions, such as the Scripps Institute of Oceanography at the University of California San Diego, are dedicated entirely to basic and applied research in ocean, atmospheric and Earth sciences. Stanford University's Global Climate and Energy Project conducts "research on technologies that will permit the development of global energy systems with significantly lower greenhouse gas emissions."[44] The information produced by such basic research organizations is generally available to decision makers at all levels of government, but most academic research is not tailored to decision makers' needs.

Government-Funded Academic Programs

Programs that fund targeted university research are more tailored to the social science needs of the national security community, specifically DOD. Indeed, these programs are a result, in part, of DOD and other interagency actors recognizing a vacuum in their research portfolios. One particular example of this program is the Minerva Initiative – a DOD-sponsored, university-based social science research initiative. Its primary objectives are:

1. To develop the Department's social science intellectual capital in order to enhance its ability to address future challenges;

2. To improve the Department's relationship with the social science community; and

3. To support and develop basic research and expertise within the social sciences community in subject areas that may provide insight to current and future challenges.[45]

The Initiative is aimed at generating interdisciplinary collaboration, and may provide an opportunity for climate scientists and other social scientists to engage each other to help DOD answer questions related to the socio-political consequences of climate change (e.g., potential migration of coastal communities in developing countries where climatic impacts are most acute). Indeed, the Minerva Initiative funds research in "New Approaches to National Security, Conflict and Cooperation," including projects related to climate change and state stability that could be potentially useful to DOD.[46] However, the Initiative is not without its critics, who argue that it unnecessarily militarizes academic research and compromises academic integrity – concerns that will need to be addressed to further these exchanges, scale up programmatic funding and promote healthy relationships between the two communities.

Professional Scientific Organizations

Professional scientific organizations – such as the National Academies, the American Association for the Advancement of Science (AAAS), the American Geophysical Union and the American Meteorological Society – issue position statements that broadly reflect the consensus views of their members.[47] Such statements help policy makers sort out the conflicting claims of various stakeholders about widely accepted scientific conclusions, but they are brief and rarely offer information specific enough to inform individual decisions. More coordination among scholarly societies and greater attention to their role as mediators of political debates surrounding science and scholarship could be useful to the consumer community.

Science Advisors

Science advisors can also be a reliable source of scientific information for decision makers, but are sometimes an underutilized resource, depending on the capacity in which they serve. As one former State Department official observed, the State Department's science advisor is typically underutilized during climate negotiations. However, this experience points to the different goals of scientists and diplomats. Diplomatic negotiations around climate change may rely less on the fidelity of scientific underpinnings and more on leveraging the science to make political gains.

Task Forces and Committees

Ad hoc task forces and committees on climate change are a common way for climate scientists and policy makers to build partnerships and for decision makers to get specific information that is tailored to their needs. Washington State's King County established an Executive Action Group on Climate Change that has been partnering with the Climate Impacts Group at the University of Washington, the Washington State Department of Ecology and the Washington Sea Grant to produce an annual climate report for King County.[48] Similar task forces have been created across the country at the municipal and state levels. Large networks like ICLEI-Local Governments for Sustainability offer decision makers access to a variety of technical tools and climate science data, and publish local success stories about implementing mitigation and adaptation policies for other decision makers to emulate.

V. BARRIERS TO CLOSING THE GAP

Ideally, there should be a synergy between consumers and producers of climate information: more information is needed than ever before and more information is available. And yet, solid scientific information is not reliably or consistently getting into the right hands, while some of the information that translates across the gap is not, or is not perceived as, useful. Why not? In the course of this study, climate scientists and decision makers with deep experience working across the producer-consumer gap repeatedly emphasized several barriers to effective communication and collaboration.

A Weak Demand Signal

Busy decision makers, especially in the national security field, often have their hands full with the problems of the day. As such, there may be little bandwidth to think about future information needs. Moreover, the national security community has not generally viewed environmental information as critical to decision making. In effect, this means demand signals may be lacking for research on emerging issues such as the security implications of climate change. However, the ***consumers*** of climate information must convey to the producer community the nature of the information they need and provide incentives for producers to generate that information in an actionable form in order to strengthen the link between science and policy on climate change.

While communication of needs is important, any effective demand signal must be supported by funding. As Dr. Mary-Elena Carr, Associate Director of Columbia University's Climate Center, pointed out:

> The science community will make an effort to work with other disciplines if funding is available. Prior to the 1990s, the Navy wanted to be able to track submarines: ONR [the Office of Naval Research] funded a lot of open-ocean oceanography. However, then mines on beaches were a concern, and ONR funded coastal oceanography instead. Nevertheless, if there is money, the community will be incentivized to work, even in an interdisciplinary way.[49]

But even with funding behind them, demand signals may be buried in budgets or legislation, several steps removed from and not effectively translated to the relevant producers. In the FY10 budget, for example, research and related activities (R&RA) created a significant demand signal by directing the NSF to commit federal dollars to climate science programs:

> Funding within the broad and flexible R&RA portfolio underscores the President's priorities for science and innovation with a focus on high-risk, potentially transformative research; new faculty and young investigator support; graduate research fellowships; and support for research priorities in global climate change.[50]

Climate change-related programs – including the Geosciences Directorate, the Office of Polar Programs and U.S. Arctic Research Commissions – received significant budget increases over FY08-FY09, largely aligning with the president's priorities. Indeed, the new FY11 budget requests increases in these research programs as well. It is not clear, however, whether these increases will encourage the type of climate science data most useful to national security professionals and others in the operational community. Appropriations for social sciences and integrated programs are relatively small, due in part to the lack of demand for such information. Although the research conducted under this diffuse demand signal may feed into future information needs, there is no apparent mechanism to ensure that future national security planning needs will be met.

The climate-related research and information needs of the security community will continue to be broad and varied. A variety of demand signals organized around specific needs may therefore require new funding mechanisms. For traditional physical climate research, several existing funding sources, such as the Office of Naval Research and DOE, will require little adjustment. For less traditional information needs, such as the implications of climate impacts on the stability of developing countries, existing mechanisms may lack the purview or expertise to design the necessary programs and generate an effective demand signal. Moving forward, the security community will likely need to study its information needs and develop strategies and programs to ensure that the producer community will recognize those needs and be motivated to meet to them.

Stovepiped Communities

As information flows along the chain from producers to consumers, some of it may become fragmented, misinterpreted or lost at each step. For instance, weather and climate are geophysical phenomena that interact strongly with biological and social systems. Earth and atmospheric scientists study the underlying physical systems and biological and social scientists study the impacts on and responses of natural and social systems. It is the planning and management implications of these system responses that concern decision makers, but integrated assessment of the fragmented biophysical and sociopolitical information is lacking, especially where national security policy is concerned.

One aspect of the stovepiping problem is the traditional lack of integration between the natural and social sciences. Dr. Geoffrey Dabelko, Director of the Environmental Change and Security Program at the Woodrow Wilson International Center for Scholars, explained:

> Security risks can't be analyzed without integrating social science data with physical climate information, yet social scientists often feel like an afterthought in designing and executing climate assessments. Physical scientists and social scientists need to break down the barriers between them – attend each others' meetings, learn each others' languages, collaborate from the start of research projects.[51]

This schism between producers and consumers has long endured calls for greater integration. Dr. Antonio Busalacchi, Director of the Earth System Science Interdisciplinary Center at the University of Maryland, says that natural and social scientists cannot solve this problem by simply talking

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to each other. He feels that new, interdisciplinary training programs are required:

> In the 1980s a new breed of climate scientist was trained – part oceanographer, part meteorologist. In the 1990s the same happened across the hydrology and meteorology disciplines. While there is a clear need to integrate social sciences into the assessment process, experience has shown that this will not occur organically, but rather we will need to train a new class of scientist comfortable in both the natural and social sciences.[52]

UCAR, the consortium of 75 American universities that manages NCAR, has recognized this need in recent years. Dr. Jack Fellows, UCAR's Director of Community Programs, says that one of the consortium's objectives "is to produce the next generation of environmental leaders and workforce. This will be a critical but challenging effort to marry law, ethics, economics, policy, and science so we have a workforce that can really tackle complex environment-society issues."[53]

The stovepiped nature of substantive expertise within the national security and foreign policy community itself is a challenge because of the wide spectrum of intersecting policy areas this community must integrate. For example, a decision maker may confront a crisis situation that involves natural resources, climate, economics, poverty and politics. The relevant expertise in each of these areas may be distributed throughout several government agencies, adding yet another level of information transfer, translation and potential information infidelity. As Eileen Claussen, former Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs (OES) observed:

> OES was functional, not substantive; we negotiated agreements . . . If there was anyone looking at specific environmental threats, like drought in Africa, it was in the Africa bureau, which had no particular environmental or scientific expertise.[54]

Uncertainty About Where to Find Information

Although there is much useful information available today, decision makers are not always sure where to find it, and in fact may not have access to it once they find what they are looking for. "For decision makers, there is a lack of access and navigation aids when it comes to the climate information they need," said Maria Blair, Deputy Associate Director for Climate Change Adaptation in the White House Council on Environmental Quality. "More importantly, there is not enough time to dig through and find the right information."[55]

One reason is that the sources are disaggregated. All levels of government solicit assessment reports for issues that concern them. Similar reports produced under a variety of jurisdictions provide a wealth of information relevant to other jurisdictions, but finding the information requires time, patience and some idea of where to look.

Moreover, there are few standardized institutional channels or resources to point would-be consumers to relevant scientific information. Staff responsible for providing information to decision makers are left to their own devices to find the scientific information they need, yet they may lack scientific training. Furthermore, a certain amount of staff turnover is normal, particularly in politically appointed positions; once a staffer leaves, the individualized process for collecting scientific information may be lost to the office or institution.

Redundant or discredited information may also crowd the field and make it difficult for decision makers to decide on which information to use.

Decision makers at different levels of government also may not be aware they are working on similar issues and fail to leverage the work that others have already done.

In addition to difficulties in locating the right information, some products may have restricted access. According to a 2007 Government Accountability Office (GAO) report, for some climate change research "the scientific community acknowledges that there are certain legally binding limitations to the goal of openness." The GAO concluded that "there are statutory and other legal limits on data sharing designed to protect intellectual property, privacy, and national security" that may prohibit specific scientific studies and their findings from being distributed.[56]

Inadequate Communication

A 2008 report by the National Academy of Sciences (NAS), *State Science and Technology Policy Advice: Issues, Opportunities, and Challenges: Summary of a National Convocation*, notes that "In general, scientists and engineers have done a poor job of communicating scientific information clearly and effectively to policy makers and the public."[57] This observation has two root causes: first, scientists do not necessarily see it as their job to communicate with the public, and second, they may lack the training and skills to do so.

Many scientists do not believe they are responsible for communicating with the public or helping decision makers mediate among competing scientific interpretations to decide which ones they should act on. According to Deborah Sliter, Vice President for Programs at the National Environmental Education Foundation:

> At the World Climate Broadcasters Forum, a WMO official said that the IPCC's only responsibility was to provide the scientific findings and they relied on others to interpret and disseminate the data. I believe that the lack of an effective communications strategy for the IPCC's excellent scientific findings is an obstacle for policy makers.[58]

Indeed, this paradigm may apply to government scientists, as well. Researchers at national labs and U.S. Department of Agriculture (USDA) Agricultural Research Stations, for example, function essentially as academics and are expected to spend their time conducting experiments, publishing peer-reviewed papers and raising external funding to support their research. "Nobody asks me, 'how many policy decisions did your work inform?' Instead they ask, 'How many papers did you publish and how much grant money did you raise for the institute?'" said Dr. Anthony Janetos, who directs a government research center.[59]

For many scientists, this view is technically correct in that it is neither in their job descriptions, nor how their institutions expect them to use their professional time. Of course, many scientists volunteer their time and effort to help decision makers, but this behavior is exceptional; in many cases, the rewards are mostly longer work hours and expectations to maintain output.

The challenge is, if communicating actionable climate science information to decision makers is nobody's job, how are decision makers to get effective decision support for climate change? There is a long-standing recognition that the dominant reward system in the scientific community is not designed to motivate scientists to provide decision support to policy makers. One NRC report concluded that "Scientific priorities and practices need to change so that the scientific community can provide better support to decision makers in managing emerging climate risks."[60]

A further complication is that scientists typically are not trained or practiced in communicating with policy makers. Although communicating

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their work to peers is a key metric of success in academe, communicating outside of the peer community usually is not. However, as the findings of another NRC report confirm, "Clear science communications is especially important given that only a small fraction of the citizen law-makers who are elected to state legislatures and the people who advise governors or regulatory agencies have a background in science or technology."[61] Decision makers, especially elected officials, need information that they can understand and translate back to the public. Moreover, what is obvious to climate scientists may not be obvious to decision makers. If these decision makers cannot articulate the scientific foundations for decisions, then they cannot justify their decisions to their superiors or constituents.

Technical jargon is one obvious problem, but scientists are fairly adept at overcoming this issue after gaining some experience interacting with decision makers. A more fundamental impediment is the way that scientists organize their thinking around a problem. Consider the old adage, "Ask two scientists the same question and you will get six opinions." Often, scientists think less in terms of "the right answer" and more in terms of any and all potential answers that are more or less consistent with all of the currently available evidence. Over time, the goal is to discard potential answers one at a time as new evidence gradually invalidates them. In essence, scientists ask which of the potential answers can be discarded based on its inconsistency with the evidence, rather than ask which of the potential answers is best. This way of approaching problems is respected and cherished within the scientific community because it sharpens the understanding of complex systems over time as new evidence comes to light, while guarding against jumping to incorrect conclusions. Clearly, though, this approach is not optimized for making practical or quick decisions and can put the scientific mindset at odds with decision makers' needs.

A Lack of Translators

Since climate information producers and consumers are intellectually, linguistically and culturally distinct, they may require mediators who understand consumer needs and priorities as well as producer information and solutions. As Dr. Philip DeCola, Senior Policy Analyst in the White House OSTP aptly described:

> A colleague of mine was fond of saying, "We need to breed more amphibians," scientists who can work with policy makers. "Publish or perish" for young scientists at universities doesn't help. Young investigators are not rewarded for helping in the decision-making process.[62]

Today there are too few individuals dedicated to translating information between the climate science and national security communities. Indeed, it is clear that the rapidly rising demand for technical information to support climate-related decisions may be difficult to satisfy in the near future due to a paucity of skilled mediators. Though there are a few existing programs such as the AAAS Science and Technology Policy and Jefferson fellowships at the State Department, which attempt to train such translators and inject science into policy making,

the number of trainees is not large and few of them have backgrounds in climate change per se.

An Issue of Time

Many of the national security community's decisions that are affected by climate change involve long-term processes such as facilities planning, future threat assessment and personnel training requirements. Such planning typically begins years in advance of final decisions, a time frame that meshes well with the deliberate pace of science, which typically operates on timescales of months to years. On the other hand, decision makers who manage day-to-day operations – such as emergency responders, military commanders, negotiators and logisticians – often must make decisions within hours, days or weeks. While it is not known whether such operators will need to develop a climate information capability, it is prudent for them make a deliberate determination rather than ignore the question and learn later that they should have developed the capability.

The scientific community already has a vast archive of raw climate data that decision makers could use to help guide their decisions. However, if the data are not in a form that is useful for decision makers, scientists require time to refine the data. Returning to CNAS's own climate change war game experience, scientists from ORNL provided CNAS analysts with excellent models and regional maps in order to design plausible security scenarios. However, these maps were rendered using technically challenging metrics (e.g., precipitation minus evaporation) that were unintelligible to the CNAS staff who needed the environmental projections to generate the war game material. While CNAS analysts were fortunate to have months to talk through these issues with ORNL scientists, few national security decision makers likely have the time or inclination to clarify their exact information needs, let alone the opportunity to communicate those needs to scientists.

Today there are too few individuals dedicated to translating information between the climate science and national security communities.

For data that do not already exist, the issue of time becomes even more challenging since new scientific results typically require months or years to generate. For example, an individual run of a global climate model can take months. Processing and analyzing the output takes additional time; new data become available on the time scale of a year or more. Instead of waiting for new information, decision makers may have to rely on existing information that is available to them, including "second-best" data that may be inadequate and leave them ill informed.

A Matter of Trust

Decision makers need to "be able to trust the advice and information they receive."[63] They are asked to justify the commitment of significant funds and other resources to preventing and preparing for climate change, but the general lack of scientific expertise among would-be consumers places decision makers who must rely on scientists for the information they need in a vulnerable position. Building sustained, trusting relationships is therefore an important step in bridging the gap between producers and consumers. Scientific stumbles – real or perceived – can threaten the credibility of information and may force decision makers to disregard the data and make poorly informed decisions, or forego decisions altogether. A recent example

Climate change is not an issue with which most decision makers are well acquainted; it is laden with complex perspectives representing a wide range of worldviews.

is when faulty satellite sensors automatically published inaccurate data on climate science websites like the National Snow and Ice Data Center. Although these errors were detected within weeks and corrected, the momentary glitch provided an excuse for some political operatives to call the quality of the most basic climate data into question. Decision makers who lack the expertise to evaluate such claims might be persuaded that the data are too unreliable to inform weighty decisions. "Part of that challenge is actually setting up networks so that there's a consistent and trusted exchange of information. There have to be mechanisms by which people in policy advising or decision-making positions feel that they have trusted access to the scientific community," Dr. Anthony Janetos told an audience at a September 30, 2009 CNAS event.[64]

When CNAS analysts worked with ORNL to produce scenarios for its 2008 climate change war game, the process of working closely together over several months forged a trusting relationship between the groups. If the time frame of the project had been weeks rather than months, the security analysts would not have been able to access the scientific information they sought and would likely have defaulted to a "plan B" that used less tailored and less suitable information already available from other sources. A failed interaction with the scientists might have undermined the development of a sustained relationship. The development of trusted relationships also requires sustained funding – if it is cut off during the early stages of interaction, then the process of building trust may have to be restarted. What is more, the trust of the producer community may be undermined by a volatile demand signal.

Climate change is not an issue with which most decision makers are well acquainted; it is laden with complex perspectives representing a wide range of worldviews. Rather than embracing scientific information and analysis on climate change that might benefit the policy community, some decision makers might actively distance themselves from it for a variety of reasons, some of them fringe (e.g., that climate change is a hoax, an effort by liberals to increase taxes, an effort by the UN to exert greater control over American sovereignty, etc.). Indeed, political and ideological divisiveness associated with climate change continues to undermine the development of trusting relationships between the producer and consumer communities.

By the same token, climate scientists are sometimes wary of working too closely with decision makers, especially those working within the political process. Decision makers may try to find scientific data to support a political position, even when no consensus exists within the scientific community. In these cases decision makers may "cherry pick" their preferred data and seek support from within the scientific community. Moreover, decision makers have been known to disregard and even suppress science for purely political reasons. A December 2007 report released by the House Committee on Oversight and Government Reform concluded that the Bush administration routinely ignored climate science, and "censor[ed] climate scientists by controlling

their access to the press and editing testimony to Congress . . . editing EPA legal opinions and op-eds on climate change."[65] And politically motivated disregard for science is not a partisan practice. Regarding one of his health policy priorities as Surgeon General in the Clinton administration, Dr. David Satcher testified to Congress, "…the White House had decided not to support Federal funding for needle exchange programs, despite the science, because of a political environment in Washington that would not support it."[66] Consequently, many scientists are suspicious of any marriage prospects between science and policy. Building trust will require sustained, good-faith interaction between climate science and policy communities.

VI. BRIDGING THE GAP

Some aspects (though not all) of each of the issues listed above can be addressed though institutionalized efforts to share climate-related research and information with a security component across government agencies. Other changes are needed within the science community, including academia. While many of these changes can and should occur within their respective communities, Congressional action is necessary to incentivize change. Despite the best intentions from producers and consumers, new or realigned incentive structures are essential to promote more effective, interdisciplinary analysis and information sharing.

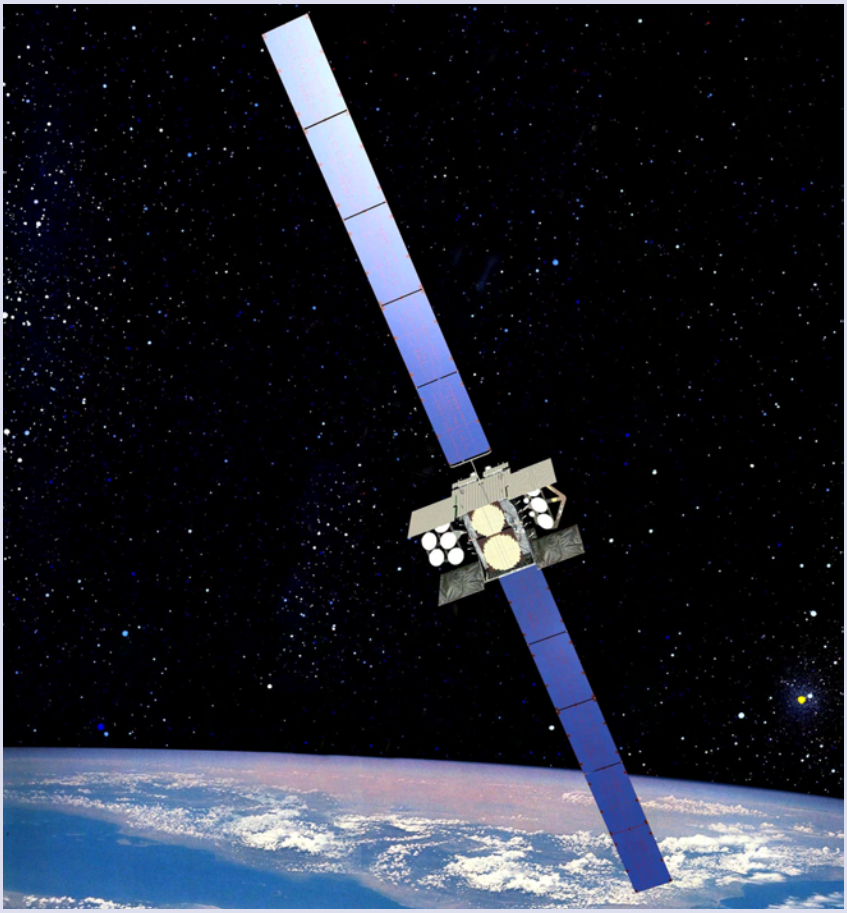
Incentivizing Research

Congress should legislate changes to existing incentive structures to encourage research that reflects the priorities of the national security community. As noted earlier, there is a tendency to limit government research funding to domestic concerns. However, since much of the security risk from climate change falls on developing countries that lack well-developed research and assessment capabilities, there is a serious void of information to support assessments of international effects from climate change. The national security community needs access to reliable analysis about the impact of climate change on these vulnerable countries in order to adequately prepare for potential threats to U.S. national security.

Congress is currently developing sweeping new programs to mitigate and manage climate change. The House recently passed the American Clean Energy and Security Act of 2009 (H.R. 2454), and the Senate is currently engaged in bipartisan discussions to develop similar legislation. H.R. 2454 provides for federally funded, forward-looking research agendas and programs for climate impacts and adaptation.

Laboratories of Change: Climate Science and the Intelligence Community

Creating the proper demand signal for climate information is tricky, but one civilian-intelligence community program offers some lessons for signaling the kinds of information national security professionals need and is a vivid example of the benefits of sustained engagement between the climate science and national security communities.



(U.S. Airforce)

In 1994, Vice President Al Gore requested that the U.S. intelligence community assess the links between key environmental factors and "state failure," prompting the Central Intelligence Agency (CIA) to establish an Environment Center that would map potential "environmental flashpoints."[67] In addition, the CIA stood up what became known as the MEDEA program (Measurements for Earth Data for Environmental Assessment), which provided a small, select group of scientists with access to classified satellite photos taken from U.S. spy satellites to help with their research.

Under the MEDEA program, scientists were given early access to time stamped photos that were collected and classified by the intelligence community (IC). [68] While the ultimate goal of the MEDEA program was to declassify images for scientific research after a certain amount of time had passed, early access to these powerful, classified images allowed scientists to make great strides in their understanding of changes in the Arctic and drought conditions in northern Africa.

In addition to the strides made from using classified data, declassified photos have also contributed immensely to climate science research. According to the National Academies of Science, since 1999 "Several hundred [Literal Imagery Derived Products (LIDPs)] with a nominal resolution of 1 meter have been produced from the images collected at the six Arctic sites" monitored by MEDEA satellites; these images offer a photo set with a resolution 15 to 30 times sharper than images captured from the next-best satellite systems controlled by NASA, Google and other commercial enterprises.[69]

Although the MEDEA program was discontinued under the Bush administration, scientists are still seeking declassified material generated under the program. The recent National Academies Report, *Scientific Value of Arctic Sea Ice Imagery Derived Products*, recommended that the intelligence community release all of its MEDEA Arctic sea images as soon as possible.[70] According to the report, "All of the Arctic sea ice LIDPs contain information that will be extremely valuable to scientific research."[71] The release of these data has the potential to help scientists better

understand key scientific properties of the Arctic, including certain sea ice physical processes, snow distribution, lateral ablation (which can help scientists understand the loss of multiyear ice), ice topography and thickness, shear and crack patterns and melt pond recurrence.[72] "The [forecasting] models do well at capturing the overall sea ice cover in the Arctic. But there are certain processes that we cannot adequately model yet, mainly . . . because we don't have enough data," said Thorsten Markus of NASA's Goddard Space Flight Center. In August 2009, the intelligence community released thousands of declassified Arctic images with one-meter resolution in part as a response to the National Academy of Science's recommendation.[73] With more declassified images made available, many scientists are optimistic that they will be able to fill the holes in their understanding of Arctic change.

While scientists have reaped significant benefits from access to intelligence imagery, the IC has also been able to make progress in understanding the link between environmental trends and national security. Traditionally, the IC has used classified information to assess or estimate national security risks. Climate change presents new challenges in this regard, since the IC generally lacks depth in the Earth and environmental sciences.

In 2008, the National Intelligence Council (NIC) produced its first classified assessment of the security implications of climate change in *National Intelligence Assessment on the National Security Implications of Global Climate Change to 2030*. According to Dr. Thomas Fingar, then-Chairman of the NIC, the Council's "overall strategy consisted of developing a good understanding of climate science, and supplementing this with state specific information on water scarcity, overall vulnerability to climate change, and populations at risk of sea level rise."[74] According to Fingar, "Since the Intelligence Community does not conduct climate research, [the NIC] began its effort by looking for other U.S. government entities that were experts in this area," and leveraged research from climate scientists and climate programs at universities as well. However, when the NIC completed its assessment it concluded that it did not have access to all the data that it could have found useful. For the next iteration, NIC analysts created a "wish list" of data related to water systems, agricultural development, extreme weather events, geoengineering and models on global tipping points – which, combined with lessons learned from the MEDEA program, could help create a demand signal for cliamte scientists about the type of information being sought by the national security community.

In another step to further understand the national secruity implications of climate change, in September 2009, the CIA announced the launch of The Center for Climate Change and National Security. "Decision makers need information and analysis on the effects climate change can have on security," said Director Leon Panetta in a press release. "The CIA is well positioned to deliver that intelligence."[75] According to Senator Dianne Feinstein, the Center will aid policy makers by helping "assess the plans and intentions of other countries, and . . . help the administration design verification regimes for any climate change treaties so policy makers can negotiate from a position of strength..." as well as "assess the national security implications of climate change."[76] Nonetheless, the CIA will likely rely primarily on existing, open-source data to conduct its assessments and would benefit from sustained engagement with the civilian science community. Indeed, a sustained engagement could become a focal point for developing and funding a forward-looking research agenda and for generating a demand signal for better integration of physical and social sciences into climate impact assessments.

In particular, strong research provisions are included for water resources, natural resources conservation, and the human health implications of climate change. However, each of these programs are limited to domestic impacts and adaptation. Although the bill supports programs aimed at protecting American interests abroad from the destabilizing effects of climate change, these programs simply provide aid and do not necessarily establish forward-looking research programs.

The research needs of the national security community are unique, span all sectors and increasingly emphasize the social sciences. Research programs tailored individually to water, natural resources and health are unlikely to meet some of the security community's specific information needs, especially if these programs are limited to domestic concerns. Further integration of social science data are needed in order to assess the potential for social instability, human migration and potential conflict. The latter factors are not traditional concerns for domestic research programs, so simple extrapolation of domestic programs to international situations will not likely be sufficient.

As noted earlier, the National Defense Authorization Act of 2008 required DOD to consider the "effect of climate change on department facilities, capabilities, and missions." The Secretary is directed to conduct regular assessments informed by "the mid-range projections of the fourth assessment report of the Intergovernmental Panel on Climate Change; subsequent mid-range consensus climate projections . . . and findings of appropriate and available estimations or studies of the anticipated strategic, social, political, and economic effects of global climate change." In other words, DOD is to rely solely on existing assessments performed under the auspices and for the purposes of civilian agencies and organizations. Undoubtedly, such resources will provide relevant information, but they have not been geared toward the specialized needs of the national security community. In his 2008 Congressional testimony, Dr. Fingar said, "We require improved and better validated regional and local models (accounting for regional and local processes)." Non-tailored research may lack regional specificity and may not include the regions of primary concern for the security community – or be tailored to operating conditions of concern for military platforms and forces. They may also fail to integrate social science information that is important to security assessments, such as the impact of climate change on a particular population group.

Since the legislative agenda for climate change is still under development in Congress, the opportunity remains to provide a funded, forward-looking research program tailored to the needs of the national security and foreign policy community. Potential opportunities may exist with FFRDCs, with existing programs organized around providing support to a range of actors in the national security community, including the Departments of Defense and State and the NIC.

Generating an Effective Demand Signal

The weak demand signal from consumers of climate science information is a significant barrier to the production of actionable and accessible climate science information. As discussed previously, this situation is changing rapidly because new policies have recently been implemented or are under consideration that will require many more decision makers to grapple with climate change. As a consequence, the demand signal is slowly strengthening. For example, in response to the 2008 Congressional requirement for DOD to incorporate the implications of climate change into its strategy documents, the Office of the Secretary of Defense, the Joint Staff and the military services designated officials to study climate change and incorporate their findings into the QDR. Drafters of the QDR climate change language in the Office

of the Secretary of Defense engaged scientists at ORNL and other professional scientific institutions to better understand the implications of climate change on the U.S. military. This process effectively created a new intellectual infrastructure of civil servants and military officers who are well informed about the security implications of climate change.[77] This new intellectual infrastructure signals DOD's intent to continue engaging with the climate science community; the QDR states that DOD should remain engaged with the climate science community: "As climate science advances, the Department will regularly reevaluate climate change risks and opportunities in order to develop policies and plans to manage its effects on the Department's operating environment, missions, and facilities."[78]

However, a demand signal that does not align effectively with the institutional incentives of the producer community is likely to under-produce. To be effective, there must be incentives that reward and recognize both individuals and institutions for producing the types of scholarship necessary to anticipate future needs. Though professional schools and government offices have a strong tradition of supporting practitioners, academic science institutions – including most government research laboratories – traditionally discourage non-scholarly activity. Producer institutions could aid in this process by adapting their incentive systems to take advantage of opportunities afforded by the consumer community. To do so, however, the producer community will need to learn new skills for understanding decision makers' needs, for generating information in forms useful to decision makers and for effective communication across the producer-consumer gap.

It is important for both consumers and producers to recognize that the demand for actionable climate science information is likely to explode over the next few years and beyond. Consumers and producers alike may be surprised by the inadequacy of current data, institutions and decision processes for meeting the emerging needs of decision makers. The potential exists for great frustration to overwhelm incipient relationships as interactions between producers and consumers increase. Patience, combined with a spirit of service and innovation, will be needed to get through this initial period of change – and producer institutions will need to reward their employees for engaging in this unpredictable process.

It is important for both consumers and producers to recognize that the demand for actionable climate science information is likely to explode over the next few years and beyond.

Scientists Rising to the Cause

As one NRC report observes, "Scientific priorities and practices need to change so that the scientific community can provide better support to decision makers in managing emerging climate risks."[79] Indeed, a culture shift may already be underway within the producer community. As Dr. Jack Fellows notes, "I think the UCAR community is making progress at a cultural shift regarding our responsibility to be a useful partner in supporting policy decisions." But he acknowledges that the current academic incentive structure does is not conducive to this shift:

> One of the biggest hurdles is that it has been largely pro bono and not always a solid career move. I think being useful to society should be rewarded in the tenure process.[80]

As another example of this burgeoning cultural shift in science, the leaders of 18 American scientific organizations – representing hundreds of thousands of professional members – issued an open letter to the U.S. Senate in October 2009 "to state the consensus scientific view" regarding human-induced climate change and its risks.[81] This event was remarkable: as one of the authors of this paper wrote, "In my two decades as a practicing scientist, I've never seen [so many] scientific organizations speak with one voice about a politically controversial issue."[82]

In the past few decades, a new breed of academic program has begun to produce capable science-policy translators. Stanford University's Aldo Leopold Leadership Program at the Woods Institute for the Environment recognizes that "traditional scientific education does not adequately prepare them to communicate about their work with stakeholders outside academe." The program aims to equip "academic research scientists with the skills and connections they need to be effective leaders and communicators.[83] Degree granting programs that train students to operate at the boundaries of science, engineering and public policy have gained traction as well. The Energy and Resources Group at the University of California Berkeley offers Master's and Doctorate degrees aiming "to develop, transmit and apply critical knowledge to enable a future in which human material needs and a healthy environment are mutually and sustainably satisfied."[84] The Earth Institute at Columbia University offers more than 20 undergraduate and graduate degree programs in a variety of majors, including an M.A. in "Climate and Society," an M.P.A in "Environmental Science and Policy," and a Ph.D. in "Sustainable Development." Other U.S. colleges and universities have developed programs that explicitly aim to build bridges between traditional academic programs and public policy. Such programs may offer partnership opportunities for the security policy community.

In collaboration with approximately 30 science and engineering organizations, the AAAS began placing scientists and engineers in Congressional offices in the early 1970s under the Science & Technology Policy Fellows program. Perhaps reflecting the level of support for such activities in the scientific community at the time, the inaugural class fielded only seven fellows. According to Michael Telson, one of the original seven, Congressional members did not know how to use the science fellows at first: "[They] looked at us and said, 'Well, I guess we can use you to help in offices,' meaning the mail and answering the phones. It was really a meeting of two different cultures."[85] But the daily cross-cultural experience changed that situation quickly, Telson says, as lawmakers discovered that many of the issues they were working on would benefit from the scientists' input. Rear Admiral Jay Cohen (USN, Ret.), Undersecretary of Homeland Security for Science and Technology, told AAAS that the fellows "are our future. At an early stage in their careers they are able to understand the confluence of science, technology and policy making that will then influence lawmakers, decision-makers and policy-makers."[86]

There is an urgent need for scientifically trained thinkers who also understand the highly textured nature of decision making for public policy. Many variables are taken into account in reaching policy decisions and science may not be the most important variable in any given decision. According to Dr. John Holdren, the Science Advisor to the President, "the relevant facts from science and engineering are never the only inputs to policy decisions, but they are often essential."[87] Similarly, scientific information may enrich a policy debate, but other factors must be considered as well. The common inability for producers to appreciate the valid

need for decision makers to consider criteria other than those presented by them is a frequent barrier to deeper cooperation between producers and consumers and may, at times, serve to diminish the influence of scientific analysis on decision making. For example, according to one House professional staffer who worked closely on the American Clean Energy and Security Act of 2009, the bill should have been unanimously adopted on the merits of the science alone.[88] However, for some decision makers, other considerations, such as concerns over economic impacts, outweighed the scientific findings.

Because the environmental sciences community seems to be taking stock of its potential to enhance decision making for public policy, there may be a strategic moment of opportunity for leaders and institutions in the producer and consumer communities to shape the future decision environment for climate security. Creating a sustained demand signal that aligns effectively with the incentive structures of the producer community and that encourages institutions to reward practice and service in addition to scholarship should help to focus the producer community's time and attention on policy applications.

Institutionalized Support for Decision Making

Meeting the climate information needs of the national security community will require a new type of institutional effort. As Major General Richard Engel (USAF, Ret.), Director of the Climate Change and State Stability program at the NIC, has observed:

> [Scientific projections] help us understand phenomena of real importance, but they are not done and repeated for the purposes of providing clear trends or sensing operationally relevant changes. . . [I]f we're going to depend on them from an intelligence point of view – which would require us to routinely go back and look for changes – we need to do that through institutionalized processes or permanent measurement systems that will be there all the time.[89]

Policy communities that traditionally rely on science to inform decisions (e.g., public health, environmental quality and natural resources management) have developed formal processes to ensure the ongoing availability of required information and to provide analyses directed specifically at the kinds of decisions made by these communities. As mentioned previously, this formalized process is often referred to as **decision support**, which an NRC report defines as "organized efforts to produce, disseminate and facilitate the use of data and information in order to improve the quality and efficacy of climate-related decisions."[90] The NRC report makes an observation that aptly applies to the national security and foreign policy community:

> For many of the agencies that need to be involved, decision support research or services are not part of their current missions, and they lack offices and personnel with the responsibilities and expertise needed to manage the research.[91]

The national security community needs institutionalized decision support for climate security. Although the details of how to design an effective decision support process are beyond the scope of this study, the national security and foreign policy community will likely have to engage in two non-traditional activities in order to meet its decision support needs. First, it will need to advocate for a government research program on the impact of international climate change and how to adapt to it. According to Dr. Philip DeCola, "One problem is that our policy makers are heavily focused on domestic impacts of climate change. We need an international research component to assess global adaptation needs."[92] The second non-traditional activity necessary to

ensure effective decision support is engagement of a wider range of government agencies and offices with a need to understand the linkages between climate change and security. Eileen Claussen led the interagency process on environmental affairs at the assistant secretary level for four years during the Clinton administration. She observed that:

> DOD attended [interagency] meetings but they tended to relate narrowly to particular issues, like fisheries – we were in a dispute with Canada over access to Alaska fishing grounds at the time – and NEPA [National Environmental Policy Act].[93] But they were not at the table on broad environmental issues.[94]

According to the 2010 QDR, however, "Managing the national security effects of climate change will require DoD to work collaboratively, through a whole-of-government approach, with both traditional allies and new partners."[95] Applying this "whole-of-government" approach requires effective coordination among DOD, State and USAID, and other agencies as needed (the Department of Agriculture, for example, has been actively involved in recovery efforts in Iraq and Afghanistan). Although this coordination has improved in recent years, for example in connection with military operations in Afghanistan and Iraq or in the reorganization of U.S. Southern Command, there is not yet a consistent or formalized interagency process for environmental policy in general and climate change in particular. Engaging consistently and routinely in the interagency process will help the security community ensure that information generated elsewhere in the government can meet its needs.

More recently, an interagency effort to launch a major space-based climate observing system – the NPOESS program mentioned previously – "experienced escalating costs, schedule delays, and technical difficulties."[96] Even though this observing system "is considered critical to the United States' ability to maintain the continuity of data required for weather forecasting (including severe weather events such as hurricanes) and global climate monitoring," the three agencies responsible for it – NOAA, NASA and DOD – have been unable to keep the program on track.[97] Because of the delays, it now appears impossible to achieve the baseline schedule required to avoid data gaps, unless an existing satellite continues to operate beyond its expected life.[98] Among the program's problems, it appears that the interagency process has been undermined by the DOD Executive Committee member. The GAO found that "the DOD Executive Committee member with acquisition authority does not attend Committee meetings – and sometimes contradicts the Committee's decisions."[99] DOD and other security officials might do well to take lessons from the tri-agency NPOESS process into future interagency efforts aimed at ensuring national and international climate security.

There are existing and proposed government mechanisms for providing climate-related decision support, but it is unclear if any will be successful. Several proposed bills in Congress would establish a National Climate Service (NCS). Although details vary, all such proposals include an interagency process to ensure that NCS resources meet the needs of decision makers throughout government. It is unclear how the NCS would be resourced, or even if it will be established.

In anticipation of an NCS, on February 8, 2010, NOAA announced that it would reorganize its climate services in an effort to provide decision makers with a centralized portal for their climate information needs. The website, www.climate.gov, was created to be the "'go-to' source for NOAA's climate data, products, and services for all users."[100] While the website is still

in early development, NOAA's plan to actively engage decision makers – in order to make the web portal truly user friendly while it continues to evolve – offers a promising opportunity for sustained engagement between the two communities. Standing up an NCS, however, will require more resources and extensive coordination across a variety of agencies. Whether and how this might be done remains to be seen.

An existing interagency program, the USGCRP, should also be harnessed and enhanced to meet the information and decision support needs of the national security community. Thirteen agencies, including DOD, State and USAID, already participate in this program. Known as the Climate Change Science Program during the George W. Bush administration, Congress established USGCRP in 1990 to provide decision support for climate change. The USGCRP was "aimed at understanding and responding to global change, including the cumulative effects of human activities and natural processes on the environment, to promote discussions towards international protocols in global change research, and for other purposes."[101] The law required the USGCRP to produce comprehensive assessments of climate change effects on the United States every four years, but only two national assessments have been released during the program's 20 years, the second of which was compelled by a federal court order.[102] As a result, the USGCRP has yet to provide decision support at the level that Congress intended.[103] Indeed, the Program has been weakened by the lack of a dedicated research budget and weak participation by many of the member agencies. What is more, the USGCRP was never intended to provide direct support to the national security community (in fact, the word "security" never appears in the law at all). While the legal functions of the program include consulting "with actual and potential users of the results of the Program to ensure that such results are useful in developing national and international policy responses to global change," there is no explicit language directing the program to support the national security community.[104] Two recent NRC reports suggest ways to strengthen the USGCRP to improve decision support across the government.[105] A number of bills have also been introduced in Congress to enhance the decision support role of USGCRP,[106] but none have become law and it is not yet clear if or when such steps will be taken.

VII. POLICY RECOMMENDATIONS

No policy recommendation will succeed without incentives that effectively reward the recommendations we make below. Thus climate science and policy making communities should develop incentive structures that promote collaboration between the two communities. As noted earlier, each year scientists are awarded public policy fellowship, some of which allow scientists to work within the national security community (e.g., AAAS science fellows and Jefferson Science Fellows at the Department of State, and DOD Science and Engineering fellows). To get more climate scientists involved in the policy community, master and doctoral programs that include the field of public policy (e.g. Environment Science and Policy; Climate Change and Society) should include requirements for internships in the policy-making community. At the same time, policy, public and government organizations should establish postdoctoral fellowships in public policy for climate change scientists, and universities should do more to prepare candidates for careers at the nexus of science and policy and help them transition into postdoctoral programs in policy by building relationships and career pathways with policy organizations. Academic institutions, scholarly societies and the U.S. National Academies should work together to reassess and restructure the scientific and academic incentive and rewards system to allow a greater emphasis on professional service to the policy community. Adopting new incentive systems may also open avenues to new funding streams, such as operational contracts from non-traditional government sources.

The U.S. government should seek opportunities to integrate climate change into national security research, analysis and planning. DOD's efforts to meet the Congressional requirement to include climate change in the 2010 QDR and other strategy documents show how this approach can integrate climate change into existing business practices and operations. Developing the proper incentives would be incumbent on the leadership of both government and non-government institutions.

Developing proper incentives will require care and resources, but if both communities seek increased collaboration, it will be an important step toward better national security policies. However, despite the best of intentions from the producer and consumer communities, new policies will be needed to encourage professionals in the producer and consumer communities to close this gap.

Integrate Climate Science into National Security Policy

The president should:

Form an interagency working group on climate change and national security with relevant interagency partners (e.g., Executive Office of the President, DOD, DOE, USAID, USDA, EPA, USGCRP).

This working group should meet quarterly to determine how other actors in the national security community are responding to climate change in order to prevent a duplication of efforts or agencies working at cross-purposes. For example, DOD may have an interest in understanding how the Department of State is approaching negotiations on an international climate change regime in order to understand how it might impact the U.S. military (e.g., stricter emissions targets, mandates on greener fuels, restrictions on specific operations in international waters, etc.). If the working group proves useful, the president should create a permanent interagency task force.

DOD should:

Direct the Under Secretary of Defense for Acquisitions, Technology and Logistics to establish a Permanent Advisory Group on Climate Change and National Security under the Defense Science Board (DSB).

This advisory group should provide study support, referee and evaluate independent climate change assessments and provide independent advice to the Under Secretary of Defense for Policy. The 2010 QDR states that DOD will "regularly reevaluate climate change risks and opportunities in order to develop policies and plans to manage its effects on the Department's operating environment, missions, and facilities." Establishing a permanent advisory group will help to institutionalize this process while establishing a permanent demand signal for the Department's climate science needs. In addition, DOD should also appoint a climate science expert to the DSB to advise the new Permanent Advisory Group on Climate Change. This expert should have a very broad, interdisciplinary grasp of climate change, as well as familiarity with national security policy issues.

Establish a senior executive professional science fellowship akin to the Secretary of Defense Corporate Fellows Program.

Through this new initiative, DOD would select two or more officers from each military service each year to receive their military senior service college credit by training with sponsoring institutions, such as professional science organizations (e.g., AAAS), national labs (e.g., ORNL), or commercial enterprises (e.g., Honeywell, Johnson Controls, Siemens, etc.), that have a history of providing climate science and climate change solutions to the policy community.

Appoint a climate science executive to serve as the lead officer responsible for meeting the Department's information needs related to climate change and national security.

Appointing a single person to serve as the executive agent (EA) would help DOD's senior leadership navigate competing claims and information regarding climate change and national security and establish a clear line of communication between the scientists and decision makers. Furthermore, an EA could help reinforce the credibility of climate science institutionalizing this position with a senior military officer or career civil servant with an expertise related to climate science (e.g., oceanography, atmospheric science, meteorology, ecology, etc.). The EA could potentially be housed in the Office of the Secretary of Defense for Policy.

Conduct a study to determine which of its military commands with expertise in climate change could provide analysis tailored to the Department's climate science needs more broadly.

The Commander Naval Meteorology and Oceanography Command at the Stennis Space Center in Mississippi, for example, provides "critical environmental knowledge to the warfighting disciplines" of the U.S. Navy through its environmental data collection and analysis services that could be leveraged to better serve DOD's climate science information and analysis needs.[107] The U.S. Naval Observatory in Washington, D.C.; the Naval Maritime Forecast Centers at Pearl Harbor, HI and Norfolk, VA; and the Air Force Weather Agency at Offutt Air Force Base, NE are other examples of military commands with similar capabilities that could be put into service to address the Department's climate science needs.

The Department of State should:

Appoint climate science advisors to serve within the regional bureaus and on the policy and planning staff.

These appointments would help the Department of State develop expertise and actionable policy recommendations to address the implications of climate change on different regions of the world – and help translate the impact assessments into actionable policy tools that the State Department can use to address those effects, including foreign aid assistance.

The academic and scientific community should:

Create incentives for climate scientists to conduct applied and interdisplinary research on how climate change could affect national security and publish their findings in prominent national security journals. Such incentives could include financial benefits, access to advanced research tools and databases, or recognition for public service.

Doing so would not only educate national security professionals but also encourage scientists to increase the policy relevance of their research and publications. Published articles could also be circulated in DOD's Early Bird, the Department's daily round-up of key national security-related news articles, to expose a broader audience to new climate security concepts, policy implications and recommendations.

Develop National Security Research Support

Congress should:

Fund research programs that focus on the international impact of climate change, especially where that impact will be most acute. These programs should consider:

Institutional needs: Research programs targeted to the needs of DOD, State and the Office of the DNI should demonstrate the value of this research to the national security community and develop clearer incentives for those agencies to increase funding for internal and external research initiatives.[108] For example, DOD has signaled its interest in understanding not only where climate changes will be most acute, but also how these effects are likely to impact military operational effectiveness.[109]

Non-traditional security: These research programs should also consider the needs of professionals in non-traditional security fields. In particular, the international development and aid community must have a strong hand in prioritizing and administering these programs to ensure they include conflict-prone areas of the developing world.

Information dissemination: Programs should be designed with an interagency focus and reporting requirement to ensure that all relevant stakeholders in the national security community have access to information that would be useful to their decision making.

DOD should:

Establish programs and grants to encourage Federally Funded Research and Development Centers to provide actionable scientific recommendations to the Department and to ensure that these organizations include climate change and national security in their research agenda.

Invest in a Community of Climate-Security Translators

Congress should:

Invest in building a community of climate-security translators by amending Title VI of the National Defense Education Act to encourage the development of multidisciplinary educational programs on the national security implications of climate change.

Title VI programs develop social science competencies in American higher education in support of broad national security interests. These programs provide support for foreign language, area and international studies at U.S. colleges and universities in order to ensure a steady supply of graduates with expertise in less commonly taught foreign languages, world areas and transnational issues of importance to the United States. A new priority area should develop undergraduate and graduate students' expertise on the national security implications of climate change. The program should be multidisciplinary, focusing not only on the military and national security implications, but on science and technology trends and economic development as well.

The Departments of Defense and Education, the Office of the Director of National Intelligence and the NSF should:

In the short term, reduce barriers between natural and social scientists by encouraging them to partner on joint research and training a new generation of interdisciplinary climate change risk thinkers, assessors and managers.

These programs should be interdisciplinary and require collaboration between academic departments focused on atmospheric sciences, environmental management, economics and political science. An excellent model is the NSF's Integrative Graduate Education and Research Traineeship program, which was developed to educate a wide-range of interdisciplinary, technical, and professional Ph.D. scientists, engineers, and educators to "become in their own careers the leaders and creative agents for change."[110]

DOD should:

Encourage Senior Executive Service (SES)-level decision makers to participate in science policy certification workshops and include science and technology policy as a core educational curriculum component of the SES Federal Candidate Development Program.

The SES Federal Candidate Development Program aims to "help Federal agencies meet their succession planning goals and contribute to the Government's effort to create a high-quality SES leadership corps."[111] As climate change and climate science could become core competencies for many throughout the U.S. government, it would be helpful to familiarize government professionals with the type of science and information that might be needed for future decision making.

VIII. CONCLUSION: BUILDING BRIDGES ACROSS THE GAP

There is a clear gap between climate science and national security policy. Distinct barriers prevent climate scientists and decision makers from facilitating a more coherent dialogue that would help promote timely, effective and informed decision making on how to mitigate greenhouse gas emissions and adapt to climate change.

At the same time, there are good reasons to maintain a firewall between scientific enterprise and decision making. Whether founded or unfounded, recent accusations that the Chairman of the IPCC, Dr. R.K. Pachauri, ignored conflicts of interest by accepting institutional funding in exchange for his policy advice illustrates the need for guidelines and institutional procedures to guard against conflicts of interest.

It is not desirable for policy (or politics) to drive science. An effective demand signal from the consumer community could pique the interest of the producer community and ensure that gaps are filled, without interfering with the intellectual development and transparency of science. But these protections should not – and need not – inhibit improved communication across the consumer-producer gap.

The biomedical sciences have a strong tradition of supporting public policy, yet have not suffered greatly from political influence. In fact, biomedical research has a very large government lab component (e.g., National Institute of Health and Veterans Affairs hospitals) where basic and applied research is conducted. This field also has vast experience in managing conflicts of interest. The biomedical sciences might therefore offer a successful model for how to encourage public policy decision support while maintaining scientific independence.

Decision makers, especially those in the national security community, need science to make good policies. Filling this need will require building bridges across the communication gap. Indeed, decision makers at all levels of government have already started the shift from merely studying climate change to responding to it – both to mitigate the damage from GHG emissions and to adapt to locked-in climate changes over the next 20-30 years. As a result, climate scientists are likely to be asked for more actionable climate information that can translate the physical impacts of climate change into predictions about their societal consequences. Promisingly, the security community has started to request the type of data it will need to integrate climate change into their decision making.

Bridging the gap between policy makers and scientists will require change on all sides. The national security community generally – and DOD in particular – will have to develop new ways to cross the gap in order to continue meeting requirements to integrate climate change into its future strategy documents. Producers of climate information will have to accept that they work in a policy-relevant, inherently political field and will be asked to invest more time and resources into communicating science and listening to the needs of consumers. Consumers, in turn, will have to make a conscious effort to generate a demand signal for the information they need and build mechanisms for cultivating and incorporating sound scientific advice. Existing bridges will not prove sufficient, and there will be a role for new public and private sector institutions to translate science to policy makers and policy needs to scientists. If the nation is to prepare for, prevent and respond to global climate change, climate science and national security professionals will have to find a new way of doing business or risk having valuable science lost in translation.

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About the CNAS Natural Security Program

The Center for a New American Security (CNAS), a non-profit, non-partisan national security research organization based in Washington, D.C., launched the Natural Security program in June of 2009. CNAS initiated the program in order to study the near-term national security implications of natural resources supply and demand patterns, as well as the security consequences of high consumption rates. The program focuses on energy, minerals, water, land, climate change, and biodiversity, as well as the links among these resource challenges. The ultimate goal of the program is to offer practical solutions and strategies to anticipate, shape, and respond to the ways in which natural resources will shape the 21st century strategic environment.

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