

Global Change Research: Strategic Planning, Knowledge Production and Barriers to Use

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Abstract
Concerns about global change resulting from global warming, ozone depletion and population pressures provided the motivation for the development of the United States Global Change Research Act (USGCRA) of 1990 (Roger A. Pielke 1995). The legislation was enacted to develop and coordinate a comprehensive, integrated research program with two primary goals: to advance scientific understanding of global change and provide "usable information" upon which to develop "effective policies to abate, mitigate, and cope with global change"(1990; Roger A. Pielke 1994; Roger A. Pielke 1995).

An analysis of the USGCRA and United States Global Change Research Program (USGCRP) was conducted based on an examination of planning and reporting documents and proxy measures. Results of the analysis indicate three areas in which improvements in the policy can be made. The three improvements are:

1. Better metrics for quantifying reduction in uncertainties and knowledge production must be developed and employed to better measure progress.
2. Strengthening interagency working relationships should improve Program continuity particularly during periods of transition. Reducing the frequency of strategic plan revisions from every three years to every five years would help conserve personnel resources and focus energies to enable the 10-year strategic planning timeline for deliverables to be met.
3. Congress should consider creating an independent governing structure for the USGCRP comprised of a combination of outside experts, lay public, agency scientists/officials and administration scientists/officials.

There is limited evidence that water resource managers are using climate change science. This paper lays the foundation for additional work examining research priority setting of the USGCRP as well as an investigation of user information needs and barriers to use.

Introduction

The federal government has a long history of supporting scientific research. Vannevar Bush's publication *Science the Endless Frontier* marked the beginning of post-war federally funded scientific research that yielded such advancements as: advances in medical sciences, manned space flight, and the internet. Federal funding for scientific research enjoyed much popular and political support after World War II through the cold war but that support has changed in recent years. The Congress has been under increasing pressure to balance the federal budget and to justify public funding for research. Ethical missteps by scientists coupled with the politicization of science have eroded the stature and credibility of the scientific enterprise. These issues have combined to change the nature of the research enterprise to be outcome driven, to require progress reporting and peer-reviewed assessment of research goals, to require stakeholder input, and to require competition for federal budget appropriations alongside all other federally funded programs. Though the nature and conduct of federal funding for scientific research has changed over time, the need for large-scale, federal funding of scientific research remains.

Concerns about global change resulting from global warming, ozone depletion and population pressures provided the motivation for the development of the United States Global Change Research Act (USGCRA) of 1990 (Roger A. Pielke 1995). The legislation was enacted to develop and coordinate a comprehensive, integrated research program "to understand, assess,

predict and respond to human-induced and natural processes of global change" and to promote discussions toward international protocols in global change research (1989; Heyman, French et al. 1995). The two primary goals of the policy are: to advance scientific understanding of global change[1] and provide "usable information" upon which to develop "effective policies to abate, mitigate, and cope with global change"(1990; Roger A. Pielke 1994; Roger A. Pielke 1995). The USGCRA is implemented through the United States Global Change Research Program (USGCRP), which is now incorporated within the Climate Change Science Program (CCSP).

A report released by the National Assessment Synthesis Team describes impacts to the United States resulting from climate change. These impacts include rising temperatures, biodiversity loss, loss of permafrost and glaciers, increased ecosystem stress, and threats to coastal areas and islands (USGCRP 2000). Climate change will also have important impacts on the hydrologic cycle, on water supplies and on water quality (Gleick, Jacobs et al. 2000). These impacts include: increased competition for water supplies, increased precipitation leading to flooding and diminished water quality in some areas, and increased temperatures leading to droughts, reduced streamflows and habitat loss in some areas (Gleick, Jacobs et al. 2000).

The federal government has invested 28 billion dollars over 16 years to fund the USGCRP (CCSP 2006). The program has advanced the state of the science of climate change and increased our ability to model change. However, while our understanding of climate change and our ability to predict change has improved, we continue to struggle to develop meaningful solutions to the climate change problem either at the global scale, at the national scale or at the local/regional scale. The focus of this paper is (1) to describe the evolution of the USGCRP, (2) to evaluate the USGCRP in terms of research foci, leadership and strategic planning, (3) to determine how the research enterprise itself may contribute to the lack of solution, and (4) to lay the foundation for future work on barriers to information use. Examination of research foci and other examples focus on water resources management.

Brief History of US Global Change Research and the USGCRA/P

The history of federally funded climate change research in the United States began with a National Research Council (NRC) report in 1975, *Understanding Climate Change: A Program for Action* (Fleagle 1992). That report spurred interest in climate change, increasing public awareness and concern and paving the way for Congressional action. In 1978 the U.S. Congress passed the National Climate Act authorizing the U.S. Climate Program; nine years later the Congress passed the Climate Protection Act of 1987.(Fleagle 1992)

The National Academy of Science (NAS)/NRC played a significant role in the development of global change policies early by working directly with Congressional Staff to help shape Congressional actions. The NAS/NRC influence waned however as other Federal agencies including NASA, NOAA, DOE, USDA, USGS, NSF, OMB, USEPA, and the Department of State played increasingly significant roles as participants in the Committee on Earth Sciences (CES) meetings and as future recipients of funding and coordinators of research programs (Fleagle 1992).

[1] Global changes are those that alter the Earth's atmosphere and/or oceans and are experienced worldwide including climate change, ozone depletion and changes in ultraviolet radiation rates [4].

The CES, established by William Graham, President Reagan's Science Advisor, and housed in the Executive Office of the President, developed the U.S. Climate Change Research Program in 1987 that later became the U.S. Global Change Research Program in 1989 (1989; Roger A. Pielke 1995; Brunner 1996). The framework for the USGCRP evolved through a series of meetings convened by the CES in 1987 and 1988 with input from NASA, NOAA, USGS, NSF, OMB, State and DOE. The U.S. Congress relied upon the framework developed by the CES in drafting the USGCRA of 1990 with some modifications (1989; 1989; 1989). Agency officials involved in the early CES meetings later lobbied Congress during the hearings process to make the program a scientific research program by arguing that "policy analysis compromises scientific research"(Cowen 1986; Brunner 1996). Scientists also argued that keeping science separate from policy ensured that science would not become politically driven (Roger A. Pielke 2000). But, Congress viewed more and better research as essential to building broad political consensus and for developing policy alternatives (Roger A. Pielke 2000). The tension was resolved through the political process with Congress crafting the Act to include a provision that research provide policy relevant scientific information ("usable information") upon which to base policy decisions (Roger A. Pielke 1995).

International attention to global change generally and climate change in particular increased with the passage of UN Resolution 43/53[2] and the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988. The World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) established the IPCC to evaluate the state of climate science as a basis for informed policy action (Rykiel 2001; Oreskes 2004).[3] Even with increased attention and calls for action, the George H. W. Bush (Bush I) Administration began to focus more and more on the scientific uncertainties of global climate change as reason to forestall action. This Administration's focus on uncertainty added to the debate of the science of climate change in the media during the late 1980's and early 1990's and fueled criticism by Members of Congress, agency and academic scientists, NGOs and think tanks that the Bush I Administration was not doing enough (Stevens 1989; Shabecoff 1990). The focus on resolving scientific uncertainties as a precursor to action to reduce GHG emissions also sharpened criticism from the international community which already had plans to take steps to reduce emissions (Weisskopf 1990). In 1990, President George H. W. Bush diffused some of the international criticism and criticism by members of Congress by signing the USGCRA into law (HCSST 1992; Roger A. Pielke 2000; Sarewitz, Roger A. Pielke et al. 2000).

Politics, Motivations and Interests that Shaped Implementation of the USGCRP

The Reagan Administration's emphasis on research over policy actions shaped the origins of the research program and influenced the Bush I Administration during development of the USGCRP (Peterson 1986; Shabecoff 1986). Many thought the Bush I Administration would move towards a research for policy action program based on his campaign promise to use the "White House effect" to reduce the "greenhouse effect" (Weisskopf 1990). President George H. W. Bush's

[2] A non-binding resolution aimed at protecting the "global climate for present and future generations of mankind."
[3] The IPCC draws upon scientists and experts from every country in the world [18] to make assessments based on peer-reviewed and published scientific literature, and to publish those assessments to provide scientific, technical and socio-economic advice to the world community [19].

stance on climate change equivocated between a proactive, leadership approach and a more measured, research only approach early in his presidency (Shabecoff 1989; Weisskopf 1990).

The IPCC completed the First Assessment Report (FAR) in 1990 (IPCC 1990). Among the reports conclusions were the following: (1) human activities are substantially increasing the atmospheric concentrations of greenhouse gases (GHGs); (2) the global mean temperature has increased a rate greater than that seen over the past 10,000 years; and, (3) the global mean surface air temperature has increased, but the observed increase could be due to natural variability (IPCC 1990). The publication of the IPCC FAR in 1990 influenced the Bush Administration's approach to implementation of the USGCRA as a research program focused on increasing scientific understanding of the climate, the Earth's systems and global change because (1) it was unclear whether or not human activities were to blame for global warming and (2) the economic risks were too great to justify action without clear, unequivocal evidence.

USGCRA Implementation

The USGCRA is implemented through the United States Global Change Research Program (USGCRP or Program). The Program integrates the research efforts of 18 departments and agencies under the direction of the executive offices of the President (Heyman, French et al. 1995). The Program was originally organized under the Committee on Earth and Environmental Sciences (CEES) but in 1994 the Program was restructured and a new committee was formed, the Committee on Environment and Natural Resources Research (CENR). The committee was housed within the newly formed National Science and Technology Council (NSTC) which operated within the Office of Science and Technology Policy (OSTP) (Heyman, French et al. 1995; Roger A. Pielke 1995; SGCR 1999). President Clinton established the NSTC by Executive Order on November 23, 1993 to coordinate science, space, and technology policies across the Federal Government (SGCR 1999).

The Program is articulated via 10-year strategic plans. Only two strategic plans have been published. The first was published shortly after George H. W. Bush (Bush I) took office in 1988. President Clinton was elected in 1992 but never published a strategic plan. President George W. Bush (Bush II) published the second strategic plan in 2003 two years after taking office (CES 1989). The strategic plans define the research foci for the 10-year period, summarize the state-of-the-science of global change, define priorities, provide a framework for development of decision tools, and describe communication between users and producers of scientific information.

Evolution in the state-of-the-science over the course of the sixteen years since inception of the program is evident in the language of the two published strategic plans and the Clinton draft strategic plan. The Bush I plan was aimed at increasing fundamental knowledge of the Earth system by: (1) monitoring the Earth system; (2) improving our understanding of the physical, chemical, and biological process that influence Earth system; and, (3) developing predictive earth system models (CES 1989). President Clinton took office after the passage of the United Nations Framework Convention on Climate Change in 1992. The state-of-the-science was advancing and for Clinton and Gore, the environment was very much on the agenda. Vice President Albert Gore (Gore) had a long-standing interest in climate change which motivated the quick release of the U.S. Climate Change Action Plan intended to usher in a new era wherein the

U.S. would endeavor to reduce emissions of greenhouse gases to 1990 levels by 2010 (HCSST 1994). But, the political climate was not conducive to mandatory emissions reductions and Congress took steps that signaled their reluctance to act.

The scientific basis for Clinton's draft strategic plan (1999) differed markedly from the previous Administration's plan in that it acknowledged "human-induced changes in atmospheric composition are already starting to change the climate"(USGCRP 2000). The Clinton plan incorporated all three of the Bush I plan goals and added two more: (1) to address uncertainties and gaps in scientific knowledge critical to policymaking and, (2) provide data inputs for improved decision making to "protect the environment, enhance socioeconomic development and ensure a sustainable future for the Nation"(SGCR 1999).

George W. Bush (Bush II) succeeded Clinton in the 2000 presidential election. Like Clinton, the new Bush administration wanted to put their mark on global change and climate change research. In 2001 Bush II created the Climate Change Research Initiative (CCRI) to "reduce significant uncertainties in climate science" with a short-term (2-4 year) focus (CCSP and SGCR 2003). The next year President Bush formed the Climate Change Science Program (CCSP) to coordinate the short-term focus of the CCRI with the long-term focus of the USGCRP (CCSP and SGCR 2003). The Bush II plan state-of-the-science differed markedly from the Clinton plan acknowledging the possibility and likelihood that human activities were having an impact but not ruling out other causes or explanations (CCSP and SGCR 2003).

Research Foci and Programmatic Flexibility

Early reports criticized the lack of ecosystem scale research, lack of human and economic impacts research and a lack of emphasis on research into adaptation and mitigation (Stevens 1989; Roger A. Pielke 1995). Ecosystem scale research and human impacts research have only recently become priorities. The Bush II strategic plan devotes entire chapters to ecosystem research and human contributions/responses to environmental change and just recently published a research priorities document focused on ecosystems and climate change (CCSP and SGCR 2003). Research on economic and social impacts as well as assessment of vulnerability and capacity for adaptation are discussed not as separate foci but as integrated foci within each research area.

The change in research foci over time is a strength of the USGCRA. The Act's flexibility is due to a number of Programmatic mechanisms: periodic revision of the Strategic Plan[4]; periodic public and peer review; and, consultation with end users to ensure results are useful for policy making. The Act incorporates these mechanisms assuming research generated through the Program will improve scientific understanding requiring the flexibility to reshape Programmatic foci to delve deeper in some areas, to begin investigation into new areas and to reduce effort in areas that have been extremely productive. These mechanisms strengthen the principle tenants of the Program, which are to (1) increase scientific understanding and (2) provide usable information by providing a means for the research foci to develop and change over time with improvements in scientific understanding.

[4] Revisions are to occur no less than every three years and development of a new Plan every 10-years. However, the strategic planning process hasn't been conducted as required per the Act. Strategic planning will be discussed in the planning section.

Usable Information and Policy Progress

The USGCRP focused research has produced substantial increases in understanding of numerous global change processes including stratospheric ozone depletion, the El Niño-Southern Oscillation, global climate change, and tropical deforestation (SGCR 1999). Volumes of scientific, peer-reviewed papers have been written over the sixteen years since the Program's inception. However, while scientific advancements engendered through the Program during the first ten years are significant, only some progress has made towards generating information to address policy relevant questions, assessing socioeconomic impacts, or generating other information relevant to the needs of public and private decision makers(SGCR 1999). One reason for the dearth of policy relevant information is that scientists and program administrators structured the program to advance the science of global change over and above policy concerns in spite of the Congressional mandate for "usable information"(1990; HCSST 1994; Roger A. Pielke 2000; Roger A. Pielke 2000). *Better metrics for quantifying reduction in uncertainties and knowledge production must be developed and employed to better measure progress.* While significant advancements in the state of the science of global change have occurred, little Federal legislation has been promulgated as a direct result of advancing knowledge.

Leadership

Where the USGCRP likely does falter is in managing transitions between successive administrations. Because the Program is housed within the Executive Branch, Program leadership undergoes fairly significant upheavals during Administration transitions. An examination of the Subcommittee on Global Change Research indicates significant loss of personnel between 1990 and 1994 as well as between 1998 and 2002 periods that mark the transition from Bush I to Clinton and from Clinton to Bush 2. Lower level agency personnel likely help bridge the gap and such interruption of the day-to-day conduct of research is likely not as pronounced as that of the upper level Program management. However, while day-to-day work may continue unimpeded, the disruption in management does have a deleterious effect on long-term, strategic planning. This is likely reflected in the use of the annual reporting mechanism as a pseudo-planning document and in the three-year delay in the release of the second USGCRP strategic plan, failure to issue some annual reports, and failure to issue national assessments. *Strengthening interagency working relationships should improve continuity particularly during periods of transition. And, reducing the frequency of strategic plan revisions from every three years to every five years would help conserve personnel resources and focus energies to enable the 10-year strategic planning timeline for deliverables to be met.*

Issues with Program leadership and strategic planning are significant concerns but even more important is control of the rhetoric of the debate. The Program is authorized by and accountable to the Congress, yet the White House governs coordination, strategic planning, integrative assessments, and articulation of Program findings. This fact ensures enormous control over the rhetoric of global change science research that may go beyond concerns about the state-of-the-science and therefore of scientific uncertainties (Guston 2001). Even though the science advances, tight control over the debate and over the research foci by whomever sits in the White House, factors heavily in the progress that is made by constraining policy and by affecting public awareness and perception which might provide political pressure in the absence of such constraint. *Congress should consider creating an independent governing structure for the*

USGCRP comprised of a combination of outside experts, lay public, agency scientists/officials and administration scientists/officials. The combination would ensure some continuity between successive administrations and would provide for more independent assessment and communication of the results of the Program. Because the USGCRP is mature, the political feasibility of creating a new, independent governing body is likely quite impractical.

Incorporating Climate Change Research into Water Resource Management Decisions

Significant research has been undertaken to understand the connections between water and climate change (Gleick, Jacobs et al. 2000). Research indicates climate change will likely influence "the amount, timing, and geographical distribution of rain, snowfall and runoff" leading to increased incidences of flooding in some areas and drought conditions in other areas. Lower streamflows will likely result in decreased water quality while increased intensity of precipitation will likely increase erosion and increase the amount of contaminants flushed into streambeds. Research also indicates that competition for water supplies will likely increase and that ecosystems will be vulnerable to climate change.

Some water resource managers in the United States and abroad are beginning to incorporate climate change into the decision making process. In Western Australia a long-term drought coupled with climate change modeling led water managers to incrementally derate the amount of expected supply from existing water resources, to institute water conservation efforts and to speed the acquisition of new water supplies (Power, Sadler et al. 2005). Climate forecasts are being used to manage irrigation in Georgia (Steinemann 2006). However, many institutions and much of the water infrastructure in the United States was built and continues to be operated with "the assumption that future conditions will be similar to the historically observed climate"(Gleick, Jacobs et al. 2000). The next section will explore barriers to information use.

Barriers to Information Use

There are a number of barriers to information use in the water sector including institutional, regulatory/legal, issues with information characteristics (understandability, trust, uncertainty and prediction), and cognitive reasons. Institutions charged with water resource management generally reflect the interests of existing water rights users and are generally inflexible and inefficient (Gleick, Jacobs et al. 2000). Water rights doctrines vary and are not conducive to efficient and flexible water resource management. Additionally, the regulatory environment does not adequately incorporate the interaction between water quality and quantity (Gleick, Jacobs et al. 2000).

Information that is highly uncertain, difficult to understand, untested, or that is not in a form that is easily incorporated into the decision making process tends to be a barrier for information use. Also, the magnitude of potential damages from climate change induced changes (i.e., sea level rise, island population losses, etc.) may be too threatening and difficult to contemplate. Cognitive illusions and psychological barriers can also affect information use. For example, the tendency to radically discount the future leads policy makers to decisions that address immediate needs that are detrimental to future needs (Hoffman and Bazerman 2005). Further, framing an issue (in terms of expected losses or gains) can have an effect on issue perception and decision-making (Nicholls 1999).

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