

OUR CHANGING PLANET

THE U.S. GLOBAL CHANGE RESEARCH PROGRAM FOR FISCAL YEAR 2013

A Supplement to the President's Budget for Fiscal Year 2013



A Report by the U.S. Global Change Research Program and the Subcommittee on Global Change Research



OUR CHANGING PLANET



THE U.S. GLOBAL CHANGE RESEARCH PROGRAM FOR FISCAL YEAR 2013



United States
Global Change
Research Program

U.S. Global Change Research Program, Suite 250, 1717 Pennsylvania Ave NW, Washington D.C. 20006
Tel: +1 202 223 6262 | Fax: +1 202 223 3065

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EXECUTIVE OFFICE OF THE PRESIDENT
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February, 2013

Members of Congress:

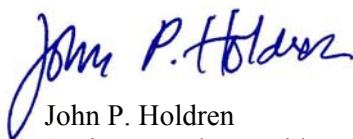
On behalf of the National Science and Technology Council, I am pleased to transmit *Our Changing Planet: The U.S. Global Change Research Program for Fiscal Year (FY) 2013*. The U.S. Global Change Research Program (USGCRP) coordinates scientific research across 13 Federal departments and agencies whose missions include understanding changes in the global environment and their implications for society. In accordance with the Global Change Research Act of 1990 (GCRA) the enclosed report summarizes USGCRP's recent achievements, current status, future priorities, and FY 2013 budget information.

Notably, in April 2012, USGCRP released the *National Global Change Research Plan 2012 – 2021: A Strategic Plan for the U.S. Global Change Research Program*. The Plan sets four strategic goals for USGCRP to achieve over the next decade: (1) advance science; (2) inform decisions; (3) conduct sustained assessments; and (4) communicate and educate. It also reinforces the importance of partnerships that leverage Federal investments and foster broad use of Program results.

Implementation of this Plan will build upon USGCRP's strengths in integrated observation, modeling, information services, and science to serve societal needs. It will also fully address the GCRA mandate to “*understand, assess, predict, and respond to human-induced and natural processes of global change.*”

This *Our Changing Planet* report summarizes USGCRP's significant progress toward achieving its strategic goals and building a knowledge base that effectively informs human responses to global change. I appreciate the close cooperation of the participating agencies and look forward to continuing to work with members of the Congress on advancing this essential National program.

Sincerely,



John P. Holdren
Assistant to the President for Science and Technology
Director, Office of Science and Technology Policy

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For further information, please email: ocp@usgcrp.gov

PHOTOGRAPHY CREDITS

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1. INTRODUCTION

“We’re aiming to ensure that any response to global change is a response informed by sound science.”

— Thomas R. Armstrong, Executive Director of the U.S. Global Change Research Program, April 2012

Global change is happening now. Increases in population, industrialization, and human activities have altered the world’s climate, oceans, land, ice cover, and ecosystems. In the United States, climate change has already resulted in more frequent heat waves, extreme precipitation, wildfires, and water scarcity.

These are serious challenges that directly affect American families, communities, and jobs. The only way to respond effectively is with a sound understanding of the changes underway, the threats and opportunities they present, and how they will change over time. The United States Congress recognized this urgent need in 1990 by mandating a Federal interagency program to *“assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”*

The U.S. Global Change Research Program (USGCRP) is designed to fulfill that mandate by coordinating the Federal Government’s \$2.6 billion annual investment in global change research—the largest such investment in the world (Figure 1).

Figure 1. USGCRP’s Vision and Mission.

Vision – *A nation, globally engaged and guided by science, meeting the challenges of climate and global change*

Mission – *To build a knowledge base that informs human responses to climate and global change through coordinated and integrated Federal programs of research, education, communication, and decision support*

OUR CHANGING PLANET

The science portfolio managed by USGCRP spans systems and scales from atoms, to ecosystems, to the entire planet, and includes changes being wrought by human behaviors as well as by larger forces. It incorporates nearly all forms of scientific work, including laboratory experiments, field research, computer modeling, scientific assessment, and observations of Earth from land, air, sea, and space. This vast body of work is carried out by 13 Federal agencies, each with its own mission and areas of expertise (Figure 2).

USGCRP provides both a skeletal framework for and connective tissue between these member agencies so that, together, they produce effective, efficient, and holistic results. This is accomplished in a variety of ways—by developing joint research priorities, enabling knowledge and capacity transfer

between agencies, minimizing redundancy across projects, and leveraging distributed Federal resources—an especially important task during austere budget times.

Science activities enabled by USGCRP include:

- Observations of the Earth, including satellite observations that allow scientists to monitor global change and understand climate processes;
- Development, testing, and application of sophisticated models—the principal tools scientists use to predict future climate;
- Assessments of the current climate and climate change impacts in the United States by synthesizing available scientific information from peer-reviewed literature and other credible sources;
- Sharing of information to support specific adaptation and response needs, in part through increased engagement between those researching global change and those affected by it; and
- Communication of scientific findings to diverse audiences, including the public, members of the Congress, and the global research community.

Figure 2. USGCRP Member Agencies and Departments.



For more than two decades, USGCRP has supported the Federal global change research enterprise to create a high-performance science portfolio that today provides taxpayers substantial returns on their investment—including major advances in our knowledge of Earth’s past and present climate, improved climate change projections for the future, and a better understanding of our vulnerabilities to the impacts of global change. These benefits extend far beyond pure science into domains that are directly relevant to the day-to-day lives of Americans and others around the world. They support weather forecasting, water and land resource management, agricultural crop production, and many other functions that impact lives, livelihoods, and communities.

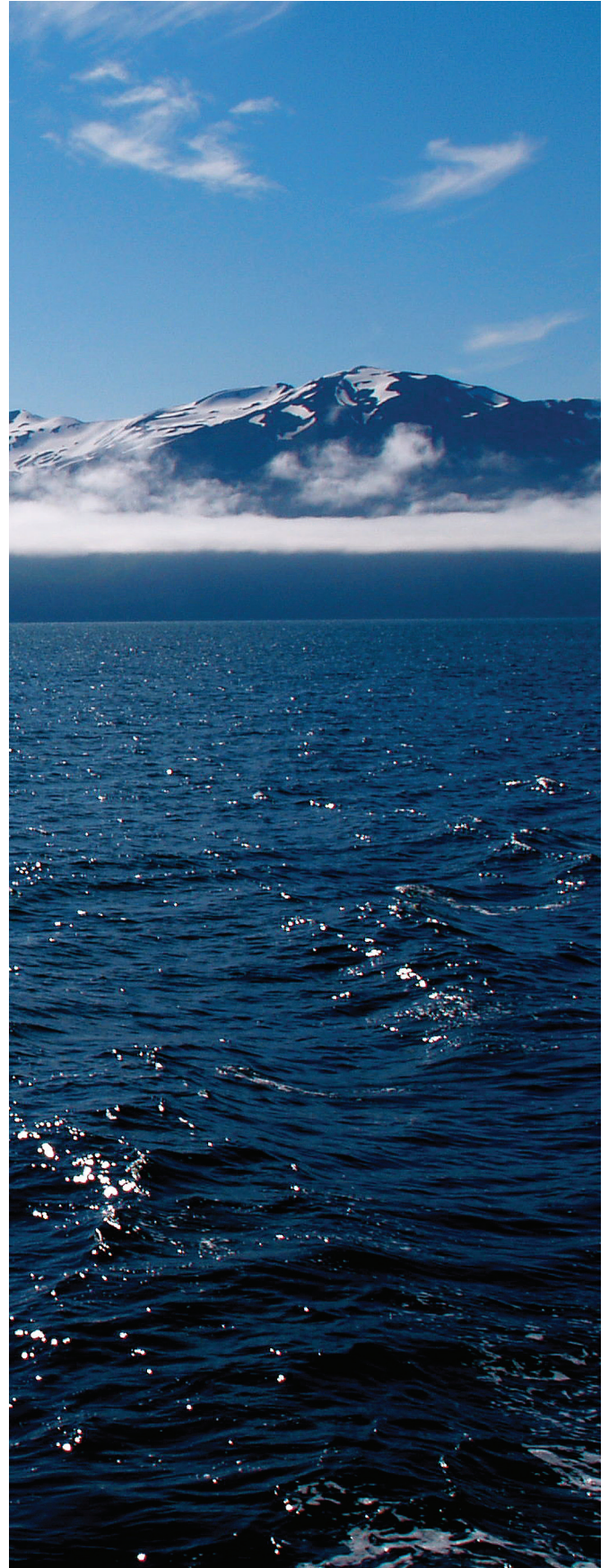
Today, USGCRP continues to advance fundamental scientific understanding of global change. But recognizing that global change and its consequences are happening already, it is also focusing more than ever on a new priority: ensuring that its science is as immediately decision-relevant as possible.

A new Research Plan for 2012-2021 lays out clear goals and objectives to achieve this ambitious new emphasis, including the expansion of stakeholder participation in all stages of the scientific process, and dissemination of results and information to broad audiences, including the public.

A substantial amount of work is underway at USGCRP to achieve this vision—with many notable successes already achieved. Highlights of this recent work and its benefits to the Nation are presented to members of the Congress and the public in this *Our Changing Planet* report.

“What we’re doing—at a fundamental level—is working to prepare the Nation and the world for the future.”

— Thomas Karl, Chair of the National Science and Technology Committee’s Subcommittee on Global Change Research, April 2012







2. FY 2012 & RECENT ACCOMPLISHMENTS

2.1 NEW DECADEAL RESEARCH PLAN

Today's rate of global change far exceeds anything documented in human history. Decision makers at every level of government, across every geographic region, and in every economic sector are demanding clear information about global change in order to plan, prepare, adapt, and respond. Because of USGCRP's legacy of major contributions to climate change science, the breadth of expertise encompassed by its member agencies, and its broad, ongoing engagement with decision makers, the Program is highly qualified to address this growing demand for information.

In April 2012, USGCRP released a new research plan that describes in detail how the Program will fulfill this role and its Congressional mandate over the next decade (Figure 3). The Plan, entitled *The National Global Change Research Plan 2012-2021: A Strategic Plan for the U.S. Global Change Research Program*, lays out specific goals and objectives to generate and disseminate scientific knowledge that is readily available and directly useful to decision makers and citizens (Figure 4).

Figure 3. Cover image of the National Global Change Research Plan 2012–2021.



Figure 4. New Decadal National Global Change Research Plan Goals and Objectives.

<p>GOAL 1. ADVANCE SCIENCE: Advance scientific knowledge of the integrated natural and human components of the Earth system.</p>
<p>Objective 1.1. Earth System Understanding: Advance fundamental understanding of the physical, chemical, biological, and human components of the Earth system, and the interactions among them, to improve knowledge of the causes and consequences of global change.</p> <p>Objective 1.2. Science for Adaptation and Mitigation: Advance understanding of the vulnerability and resilience of integrated human-natural systems and enhance the usability of scientific knowledge in supporting responses to global change.</p> <p>Objective 1.3. Integrated Observations: Advance capabilities to observe the physical, chemical, biological, and human components of the Earth system over multiple space and time scales to gain fundamental scientific understanding and monitor important variations and trends.</p> <p>Objective 1.4. Integrated Modeling: Improve and develop advanced models that integrate across the physical, chemical, biological, and human components of the Earth system, including the feedbacks among them, to represent more comprehensively and predict more realistically global change processes.</p> <p>Objective 1.5. Information Management and Sharing: Advance the capability to collect, store, access, visualize, and share data and information about the integrated Earth system, the vulnerabilities of integrated human-natural systems to global change, and the responses to these vulnerabilities.</p>
<p>GOAL 2. INFORM DECISIONS: Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation.</p>
<p>Objective 2.1. Inform Adaptation Decisions: Improve the deployment and accessibility of science to inform adaptation decisions.</p> <p>Objective 2.2. Inform Mitigation Decisions: Improve the deployment and accessibility of science to inform decisions on mitigation and the mitigation-adaptation interface.</p> <p>Objective 2.3. Enhance Global Change Information: Develop the tools and scientific basis to enable an integrated system of global change information, informed by sustained, relevant, and timely data to support decision making.</p>
<p>GOAL 3. CONDUCT SUSTAINED ASSESSMENTS: Build sustained assessment capacity that improves the Nation’s ability to understand, anticipate, and respond to global change impacts and vulnerabilities.</p>
<p>Objective 3.1. Scientific Integration: Integrate emerging scientific understanding of the integrated Earth system into assessments and identify critical gaps and limitations in scientific understanding.</p> <p>Objective 3.2. Ongoing Capacity: Strengthen and evolve ongoing capacity to conduct assessments with accessible, transparent, and consistent processes and broad participation of stakeholders across regions and sectors.</p> <p>Objective 3.3. Inform Responses: Inform responses to global change with accurate, authoritative, and timely information that is accessible to multiple audiences in multiple formats.</p> <p>Objective 3.4. Evaluate Progress: Ensure ongoing evaluation of assessment processes and products, and incorporate the findings into an adaptive response for systemic improvement.</p>
<p>GOAL 4. COMMUNICATE AND EDUCATE: Advance communications and education to broaden public understanding of global change and develop the scientific workforce of the future.</p>
<p>Objective 4.1. Strengthen Communication and Education Research: Strengthen the effectiveness of global change communication and education research to enhance practices.</p> <p>Objective 4.2. Reach Diverse Audiences: Enhance existing and employ emerging tools and resources to inform and educate effectively, providing for information flow in multiple directions.</p> <p>Objective 4.3. Increase Engagement: Establish effective and sustained engagement to enable a responsive and wholly integrated Program.</p> <p>Objective 4.4. Cultivate Scientific Workforce: Cultivate a capable, diverse scientific workforce that is knowledgeable about global change.</p>

USGCRP's new strategic goals are:

- (1) Advance Science;**
- (2) Inform Decisions;**
- (3) Conduct Sustained Assessments;** and
- (4) Communicate and Educate.**

To achieve these goals, USGCRP must leverage the strengths of its member agencies; improve coordination across the breadth of Federal activities; foster more effective collaboration among researchers in the natural and social sciences; and conduct more robust dialogues with decision makers and diverse audiences. It is estimated that full implementation of these objectives will take 10 years.

In FY 2012, in addition to setting a practical new course for research into the future, USGCRP also made significant progress in science, assessment, decision support, and communication to serve the Nation. These accomplishments are presented in the following sections and categorized according to their alignment with USGCRP's new strategic goals and other crosscutting priorities.

2.2 ADVANCE SCIENCE

Goal 1—Advance Science: *Advance scientific knowledge of the integrated natural and human components of the Earth system.*

Improving scientific understanding of the Earth system and its interactions with human society will remain at the core of USGCRP programs and activities. USGCRP will continue to *advance science* in the areas of *integrated Earth observation, multidisciplinary scientific understanding of Earth systems, and integrated Earth system modeling*, among others.

INTEGRATED EARTH OBSERVATIONS: Observations across all of Earth's domains – atmospheric, oceanic, and terrestrial – improve understanding of how Earth systems operate and how they respond to human activities. Satellite observations of changes to the Greenland ice sheet, for example, help scientists document the effects of human-induced global change on the high-latitude environment.

By definition, observations expose processes and impacts that have already occurred, or are ongoing. But they also underpin our ability to predict future behavior. For example, observations are used to test and evaluate models that predict future long-term global change, and to inform short-term weather forecasts, among other critical tasks.

No single technology can provide all of the observations needed to perform these functions. That is why complementary instruments are used in concert on the ground, at sea, in aircraft, and on satellites to obtain observational data. The United States has capabilities across all of these domains and produces both domestic observations and contributions to international observation efforts on an ongoing basis.

But despite their vast utility, our Nation's observational capabilities are at serious risk of decline. As has been widely documented, more than half of all United States and international satellite sensors are past their intended operational life spans. A large number of other United States observation instruments suffer the same status. Loss of aging instruments and inability to fully incorporate successor instruments into missions planned for the future have left the Nation at considerable risk for gaps in continuous observations of Earth from space. Such gaps are not only problematic in real time; they also make it challenging (or even impossible) to connect data streams from successive instruments—leaving the observations we *do* obtain vulnerable to greater uncertainty. Similar declines in ground-based monitoring networks are also hampering the Nation's ability to assess global change trends and prepare for the future.

As demand for reliable information grows, the Nation will be faced with increasing pressure to maintain existing capabilities and develop new observation systems that are better integrated and incorporate additional variables such as socioeconomic behavior. Building such integrated observational capacity is essential to advancing science, enhancing the Nation's resilience, and remaining globally competitive.

MULTIDISCIPLINARY SCIENTIFIC UNDERSTANDING OF EARTH SYSTEMS: Just as no single observational instrument can capture all information about a changing Earth system, no single scientific discipline or research method can address the full range of questions related to global change. Physical, geological, chemical, biological, ecological, social, behavioral, and economic processes interact with each other in various ways—with changes to one system inevitably affecting many others. Understanding the full picture of complex interactions requires diverse expertise, capabilities, and scientific approaches—ranging from controlled laboratory experimentation and field research campaigns, to modeling of complex multivariate systems and analyzing data trends across vast scales of time and space.

It is the job of scientists to stitch together insights that emerge from these various lines of inquiry, identify gaps or weaknesses in collective understanding, and seek new ways to address them. This iterative process is what ultimately leads to discovery and progress.

INTEGRATED EARTH SYSTEM MODELING: Models help scientists understand the behavior of Earth systems that sometimes interact in surprising ways. Models also allow scientists to predict the future behavior of systems, including how they will respond to human influences over time.

The earliest climate models incorporated atmosphere and land-surface components. Over time, additional components that we now know are critical pieces of the climate system—such as oceans and sea ice—began to be incorporated. More recently, climate models have been expanded to include detailed representations of ice sheets, atmospheric chemistry, biogeochemical cycles, and more. Scientists are continuously testing, evaluating, and improving these components so that models simulate Earth systems as accurately as possible.

Despite these major advances, challenges remain. More work is needed to improve the spatial resolution of models, improve representation of climate and weather extremes in models, quantify uncertainty in model results, and incorporate new socioeconomic components.

RECENT HIGHLIGHTS: ADVANCE SCIENCE

The following section highlights USGCRP interagency activities and research results in key areas of study including extreme weather, oceans, the cryosphere, climate modeling, and many others. While not comprehensive, these results demonstrate the breadth, depth, and national significance of USGCRP-enabled work—which has resulted in important scientific advances, new discoveries, and enhanced research capabilities.

In the United States, Weather Extremes Surge, Agencies Study Possible Links to Climate Change

In 2011 and 2012, the United States experienced an unusual number of extreme weather and climate events. A major national need for authoritative scientific information about extreme events continues to be filled by the National Oceanic and Atmospheric Administration (NOAA), the United States Department of Agriculture (USDA), and other USGCRP agencies. Much of what is known about these events—including their present character and historical context—derives from data collected and reported by USGCRP agencies. Examples include:

- In 2011, the United States experienced a record-breaking 14 weather disasters producing insured losses of more than \$1B each. The previous record was nine, set in 2008.¹
- The average temperature for the contiguous United States during July 2012 was the hottest for any month on record (since 1895).²
- In the United States, the 12-month period ending July 31, 2012 was the warmest since recordkeeping began in 1895³ and NOAA announced in December 2012 that 2012 was poised to go down in the record books as the hottest since 1895.
- During July 2012, 2.01 million acres were burned by wildfires in the United States—the 4th largest extent on record. In the same month, 9,869 fires burned—the 5th highest number on record for July over the past dozen years.⁴

¹ Billion Dollar Weather/Climate Disasters. National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC). <http://www.ncdc.noaa.gov/billions/>

² State of the Climate: July 2012. National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC). <http://www.ncdc.noaa.gov/sotc/2012/7>

³ State of the Climate: July 2012. National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC). <http://www.ncdc.noaa.gov/sotc/2012/7>

⁴ State of the Climate: July 2012. National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC). <http://www.ncdc.noaa.gov/sotc/2012/7>

- 62.9 percent of the contiguous United States experienced moderate to exceptional drought at the end of July 2012. The maximum value of 63.9 percent reached on July 24 set a record for the 13-year history of the United States Drought Monitor—which is maintained by NOAA, USDA, and other partners.⁵

In addition to tracking, analyzing, and reporting extreme weather as it occurs, USGCRP agencies have also begun to study extreme weather trends and possible links to climate change. A 2012 statistical analysis by NASA scientists, for example, showed that some recent extreme summer heat waves, including the intense heat that afflicted the U.S. Midwest in the summer of 2012, were almost certainly the consequence of global warming.⁶

At NOAA, scientists contributed to a report on the state of available science for connecting specific recent weather events to broader climate processes. They concluded that while much work remains to be done to improve this “attribution science”—including improving climate models and collecting better observational data—there is already some existing potential to make such connections and, with more targeted scientific research, this ability will likely improve over time.⁷

At High Latitudes, Climate Change Unlocks Hidden Carbon Stores

High latitude ecosystems are among the most vulnerable to global change, and impacts on these ecosystems can have global consequences. Research shows, for example, that changes in fire intensity in high latitude ecosystems have resulted in large releases of carbon previously locked up in tundra soils. Other research has shown that melting permafrost at high latitudes is causing both gradual and abrupt releases of carbon dioxide (CO₂) and methane—two greenhouse gases (GHG) that contribute significantly to global warming.⁸

USGCRP research is providing novel insights about the stores of carbon locked up in these high-latitude ecosystems. For



Figure 5. The Anaktuvuk River fire on the north slope of Alaska in 2007. Climate change has increased fire frequency and intensity in the arctic tundra, resulting in a fundamental change in the carbon balance in high latitude ecosystems. Photo credit: Alaska Fire Service

example, a *recent study* by scientists at the Department of Interior’s (DOI) United States Geological Survey (USGS) and university researchers shows that a substantial amount of organic carbon on Alaskan glaciers comes from atmospheric deposition of particles associated with fossil fuel burning. Prior research suggested that the primary source was ancient soil, plants, and other organic materials from forests and peat lands that were overrun by glaciers thousands of years ago. The finding suggests that a large portion of organic carbon – which can speed the melting of ice and snow by absorbing rather than reflecting solar radiation – found on glaciers can be traced to human activity.

In another USGS-led effort, scientists conducted a *landmark airborne survey* of permafrost in the Yukon Flats of Alaska that yielded some of the most detailed, data-rich maps of permafrost ever generated. Though permafrost—frozen ground that remains at or below water’s freezing point for at least two years—accounts for only 0.022 percent of all water on Earth, it covers more than 20 percent of exposed land at Earth’s northern high latitudes and is likely to play an important role in climate dynamics.

For example, as temperatures rise, permafrost thaws, making the massive stores of carbon locked up in permafrost increasingly available for release into the atmosphere, where they contribute to further warming. Changes in permafrost can also impact ground stability, affecting infrastructure such as roads, home foundations, water treatment facilities, and industrial sites.

USGCRP continues to coordinate a wide range of other high-latitude ecosystem research efforts across the Federal government, including: work supported by the National Science

⁴ State of the Climate: July 2012. National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC). <http://www.ncdc.noaa.gov/sotc/2012/7>

⁵ U.S. Drought Monitor: July 2012. National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Agriculture, et al. <http://droughtmonitor.unl.edu/monitor.html>

⁶ Hansen et al. 2012: Perception of Climate Change. Proceedings of the National Academy of Sciences. 10.1073/pnas.1205276109

⁷ Peterson et al. 2012: Explaining Extreme Events of 2012 from a Climate Perspective. American Meteorological Society

⁸ Schuur, E.A.G., B. Abbott, and the Permafrost Carbon Network. 2011: High risk of permafrost thaw: Northern soils will release huge amounts of carbon in a warmer world. *Nature* 480: 32-33.

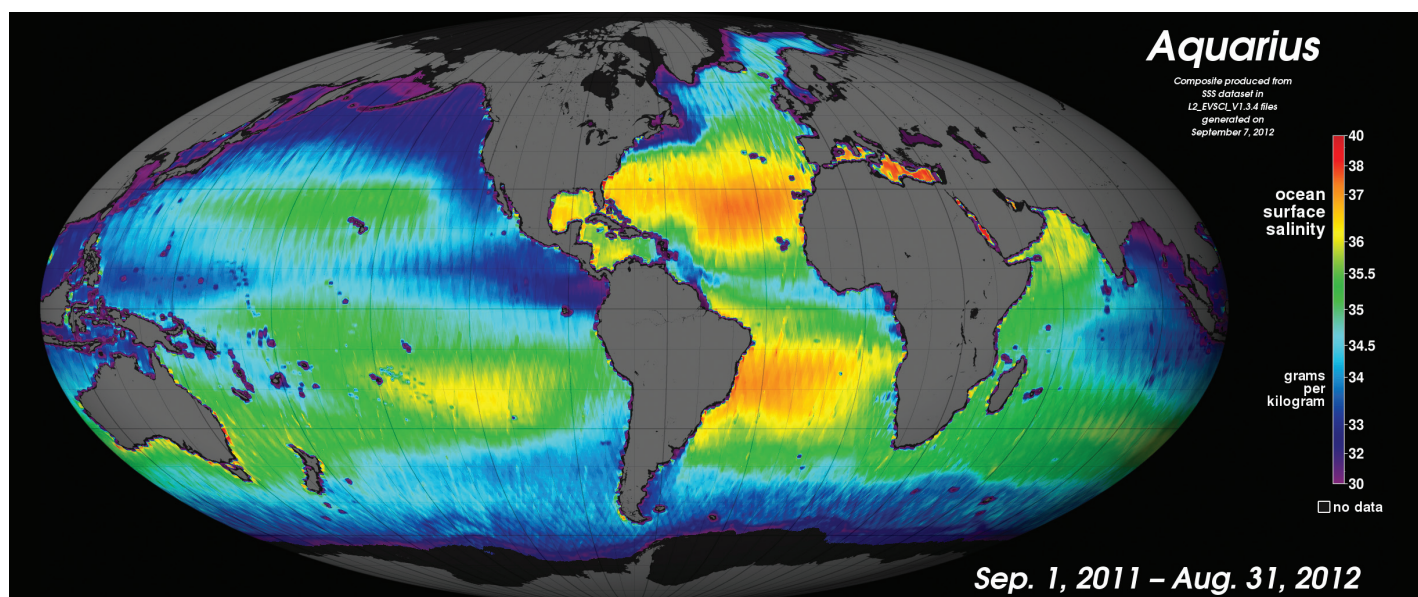


Figure 6. Aquarius-derived Sea Surface Salinity (SSS) Map. Source: NASA

Foundation (NSF) to study long-term patterns of change in organic carbon and CO₂ in Alaska; airborne campaigns by the National Aeronautics and Space Administration's (NASA) to collect detailed measurements of greenhouse gases in the Alaskan Arctic; and the Department of Energy's (DOE) development of a new high-resolution model of changing Arctic ecosystems.

Unprecedented Ocean Observations from Sea and Space

For more than a century, information about sea surface salinity has been collected from ship-based observations, surface buoys, and, more recently, profiling floats. Two new NASA efforts—the Aquarius mission and the Salinity Processes in the Upper Ocean Regional Study (SPURS) field campaign— will complement this sometimes-sparse data record by providing new observations of the complex interactions between evaporation, precipitation, and ocean circulation worldwide.

These observations are important because regional variations in ocean salinity can influence the ocean's ability to absorb, transport, and store heat, freshwater, and CO₂, and, therefore, drive further changes in atmospheric circulation and the hydrologic cycle.

NASA's Aquarius mission was launched in 2011 in partnership with the Space Agency of Argentina – Comisión Nacional de Actividades Espaciales – and is the first satellite mission specifically focused on producing global observations of sea surface salinity. It will deliver monthly salinity maps

with an estimated accuracy of 0.2 practical salinity units (psu) – equivalent to detecting a single “pinch” of salt (1/8th of a teaspoon) in one gallon of water.

The SPURS field campaign will closely monitor the saltiest region of the Earth's oceans – the subtropical North Atlantic gyre – to provide a 3D view of processes that drive changes in salinity distribution. Beginning in September 2012, NASA, NSF, NOAA, and European partner agencies have been deploying instruments on floats, ships, moored buoys, underwater gliders, and an autonomous underwater vehicle to capture this detailed view of ocean processes (Figure 7).

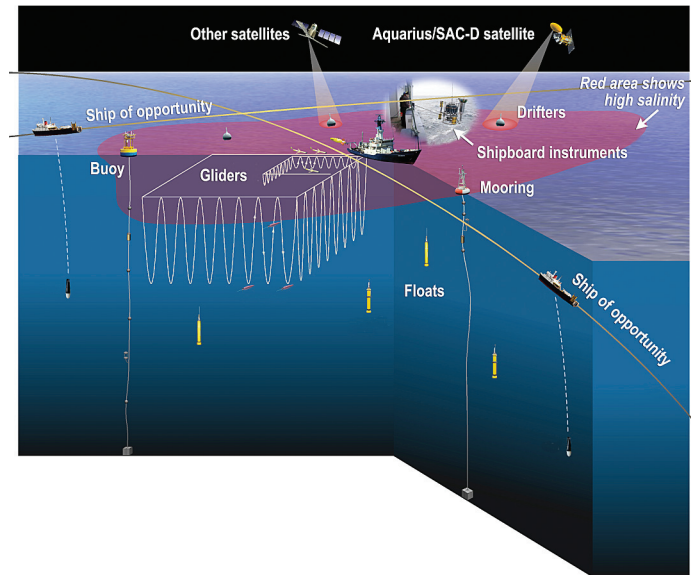
Particle Pollution Linked to Clouds and Climate

USGCRP scientists are studying airborne particles and their interactions with climate systems to support global change-related decision making in urban environments and elsewhere.

A recent DOE-funded study by the Massachusetts Institute of Technology (MIT) Joint Program on the Science and Policy of Global Change has delivered a novel global-scale air quality model. The new model includes, for the first time, the air pollution contributions of urban-scale aerosols—airborne suspensions of tiny particles or droplets, such as dusts, mist, or fumes.⁹ Historically, aerosol processes have not been included in

⁹ Cohen, J.B., Prinn, R.G., and C. Wang. 2011. The impact of detailed urban-scale processing on the composition, distribution, and radiative forcing of anthropogenic aerosols. *Geophysical Research Letters* 38, L10808.

Figure 7. Schematic of the SPURS observational strategy. A combination of instrumentation generates high-resolution measurements of the upper ocean.



global models because of the very high computation demands required to do so. The new system has already begun to be used by modelers to simulate the effects of cities on global aerosol chemistry and physics.

In 2010, USGCRP agencies led a field study in cooperation with the California Air Resources Board (CARB) and other partners to investigate emissions and atmospheric processes over California and the eastern Pacific coastal region. The study, called CalNex, examined the opportunities and trade-offs faced by decision makers at the nexus of air quality and climate change. Results show that California's clean-fuel regulations and voluntary actions taken by shipping companies have substantially reduced air pollution caused by near-shore ships. Research results show that these voluntary actions reduce emissions of sulfur dioxide, soot, and other pollutants that impact both human health and climate by as much as 90 percent.¹⁰ The results suggest that California's new regulations are working as intended—information that may help other regions to decide whether to adopt similar strategies.

DOE-funded scientists used measurements from a 2008 field campaign in conjunction with a weather research

¹⁰ Lack, D.A., C.D. Cappa, J. Langridge, R. Bahreini, G. Buffaloe, C. Brock, K. Cerully, D. Coffman, K. Hayden, J. Holloway, B. Lerner, P. Massoli, S.-M. Li, R. McLaren, A.M. Middlebrook, R. Moore, A. Nenes, I. Nuaaman, T.B. Onasch, J. Peischl, A. Perring, P.K. Quinn, T. Ryerson, J.P. Schwarz, R. Spackman, S.C. Wofsy, D. Worsnop, B. Xiang, and E. Williams. 2011. Impact of fuel quality regulation and speed reductions on shipping emissions: Implications for climate and air quality. *Environmental Science and Technology* 45, 9052–9060.

and forecasting model to examine the indirect effects of aerosols on two cloud regimes in Southeast China.¹¹ The scientists sought to better understand the effect of aerosols on cloud formation and precipitation—one of the least understood aspects of our climate system. They found that changes in the concentration of nuclei around which clouds form (i.e., aerosols) can significantly change the timing of storms, the rate and distribution of precipitation, and the height of deep convective clouds—and are thus important variables to include in regional and global climate simulations.

New Climate Models are Better Performing, Higher-Resolution

Modeling centers affiliated with USGCRP agencies continue to lead in developing, evaluating, and applying climate models, as well increasing the accessibility of model output to diverse user communities.

USGCRP agencies are playing key roles in Phase 5 of the Coupled Model Intercomparison Project (CMIP5)—a major international effort to evaluate and improve climate models. CMIP5 builds on the success of earlier phases of the project, which revolutionized the fields of model evaluation, uncertainty quantification, and societal impacts studies by allowing universal access to results of the world's major climate models. In that effort, USGCRP agencies were primarily responsible for developing Earth System Grid software that allows users to download model output from multiple locations without needing to know where the datasets physically reside—giving them faster, easier access to climate data.

The new CMIP models achieve finer spatial resolution and better representation of certain climate processes than older-generation models. These improvements are based upon careful comparison of model output to real-world observations—an area in which USGCRP agencies have particular expertise. For example, scientists funded by DOE and NASA worked with partners to create a diagnostic tool known as the Cloud Feedback Model Intercomparison Project Observation Simulator Package (COSIP), which enables comparison of model outputs with observations from satellite instruments. COSIP is used by most major climate and weather prediction models worldwide and will play an important role in the evaluation of models slated for review in the next Intergovernmental Panel on Climate Change (IPCC) report.

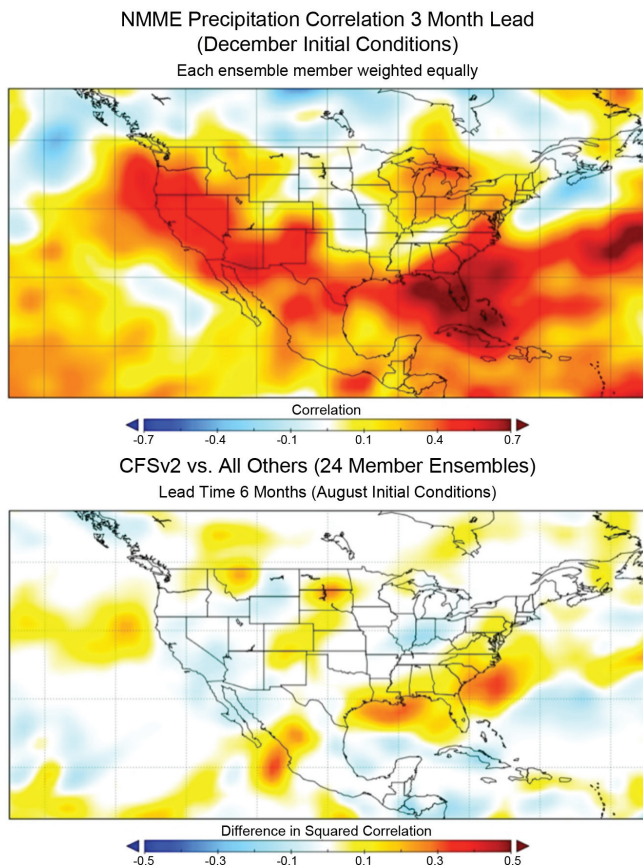
¹¹ Fan, J., L.R. Leung, Z. Li, H. Morrison, H. Chen, Y. Zhou, Y. Qian, and Y. Wang. 2012. "Aerosol Impacts on Clouds and Precipitation in Southeast China – Results From Bin and Bulk Microphysics." *J. Geophys. Res.*, 117, D00K36, DOI:10.1029/2011JD016537.

Finally, individual models often display strong predictive “skill” (ability to forecast future conditions) in particular regions or for particular variables. Overall skill can often be enhanced by combining models with unique strengths. DOE, NSF, NASA, and academic partners are investigating how such model combinations could potentially improve climate forecasts through the National Multi-Model Ensemble system (NMME) (Figure 8). NOAA’s Climate Prediction Center has already begun using the NMME system to inform its monthly climate briefings. A second phase of the project commenced in Fall 2012.

High-Tech Satellite Systems Observe Earth with Record Accuracy

USGCRP scientists and engineers continually seek new and innovative ways to observe the Earth. In October 2011, NASA, NOAA, and DoD launched the Suomi National Polar-orbiting Partnership (NPP) satellite with a mission to acquire a wide range of land, ocean, and atmospheric measurements. The project, formerly known as the National

Figure 8. (Top) Areas where the NMME system provides high degrees of skill in predicting precipitation patterns two months in advance are indicated by warm colors. (Bottom) Warm colors indicate regions where value was added by using a multi-model approach. Image courtesy of Ben Kirtman.



Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project, carries five scientific instruments that collect data for climate monitoring, operational weather forecasting, and global change science.

The NPP mission is a bridge between NASA’s Earth Observing System (EOS) satellites and the forthcoming series of Joint Polar Satellite System (JPSS) satellites, and will provide a wide range of data, including atmospheric and sea surface temperatures, land and ocean biological productivity measurements, cloud and aerosol property information, ozone measurements, and information about fluxes in Earth’s radiation budget.

In addition, six microsatellites that were launched jointly by the United States and Taiwan in 2006 have significantly improved weather forecasts. The system, called the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), continues to provide meteorological, climate, and space-weather data with unprecedented accuracy.

COSMIC uses instrumentation designed by NASA, is managed domestically by NSF, and receives co-funding from NOAA, NASA, the Air Force, and the Navy. The system’s capacity for collecting high-resolution global information has already been shown to reduce lower-stratosphere temperature measurement errors by up to 11 percent and improve forecasts of tropical cyclone tracks, among other important advances.

Polar Change Sets All-Time Records

The National Snow and Ice Data Center—an interagency center funded jointly by NASA, NOAA, and NSF—recently reported that Arctic sea ice reached its lowest-ever measured extent in September 2012.

The rapid reduction in Arctic sea ice extent (defined as horizontal area with at least 85 percent ice cover) and changes in sea ice thickness are being studied closely by USGCRP agency scientists. A recent NASA *analysis* showed, for example, that the average thickness of sea ice in the Arctic is on the decline.¹² In fact, the oldest and thickest Arctic sea ice is disappearing faster than younger, thinner ice that surrounds it—creating an overall thinning effect and more areas of open, ice-free water during the summer months.

Other USGCRP research, on the cryosphere (solid-state water, including ice, snow, and permafrost), is assessing trends in ice sheet and glacial melt—major potential contributors to sea level rise.

¹² Comiso, J.C. (2012). Large Decadal Decline of the Arctic Multiyear Ice Cover, *Journal of Climate*, 25, 1176–1193 10.1175/JCLI-D-11-00113.1

NASA satellites recently detected that 97% of Greenland's surface was covered by meltwater—more than has been observed in 30 years of satellite monitoring. And, a recent study supported by DOE and others estimated that because of climate change, Greenland's Mittivakkat Gletscher glacier would eventually lose at least 70 percent of its current area and 80 percent of its volume—even in the absence of further climate change.¹³ In 2011, on the other icy end of the globe, NASA flew 24 science flights during a six-week campaign called Operation IceBridge to collect data on the thickness and depth of Antarctic ice sheets as well as glacial movement (Figure 9). During one of the flights, researchers discovered a large crack across the Pine Island Glacier ice shelf—a precursor to the anticipated separation of an estimated 310-square-mile iceberg into the ocean (Figure 10).

Tropical Forest Carbon Mapped with Unprecedented Precision

Tropical forests store massive quantities of carbon in the wood and roots of their trees. When trees are cut down, burned, or naturally decompose, these stores of carbon are released into the atmosphere. The IPCC estimated that in the 1990's, net carbon emissions from land-use change constituted about 20 percent of human greenhouse gas emissions. That estimate was based largely upon self-reporting by countries to the United Nations Food and Agriculture Organization.

A new study using satellite measurements found that gross carbon emissions (emissions from forest loss, not including carbon absorption from forest regrowth) from tropical regions between 2000 and 2005 were only 25 to 50 percent of previous estimates—a large discrepancy with potential implications for policy and decision making.¹⁴

The new estimate was made possible by the first-ever global inventory of tropical forest carbon, created in 2011 using a variety of NASA satellite data. The inventory effort resulted in the most precise map ever produced depicting the amount and location of carbon stored in Earth's tropical forests.

These and similar studies are important for countries planning to participate in the Reducing Emissions from Deforestation and Degradation (REDD+) program—an international effort to set a financial value for the carbon stored in forests. The

Program offers incentives to preserve forestland in the interest of reducing carbon emissions and investing in low-carbon paths toward development.

Figure 9. Map of flight lines from NASA's Antarctic IceBridge mission in 2011. Image Credit: NASA.

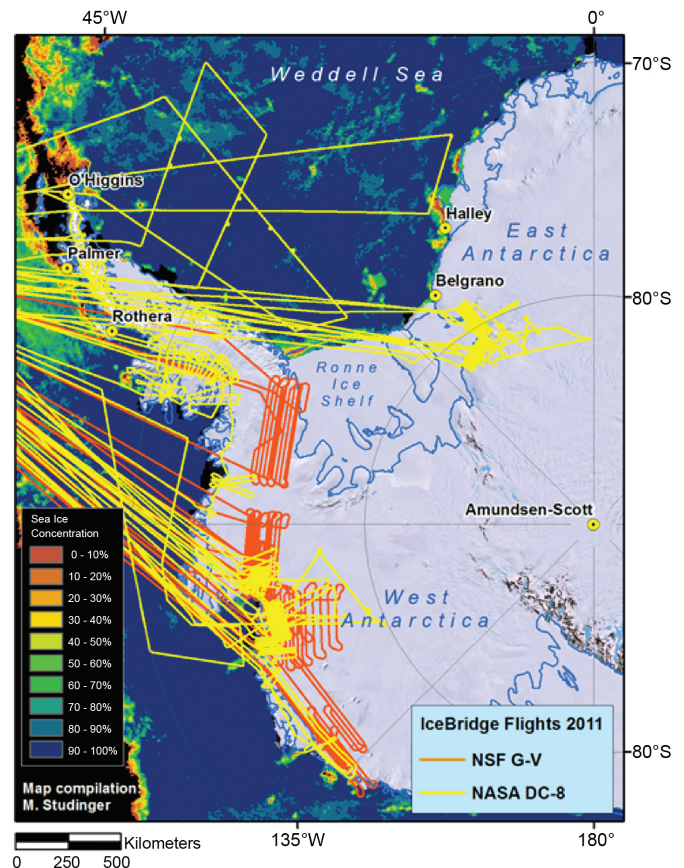
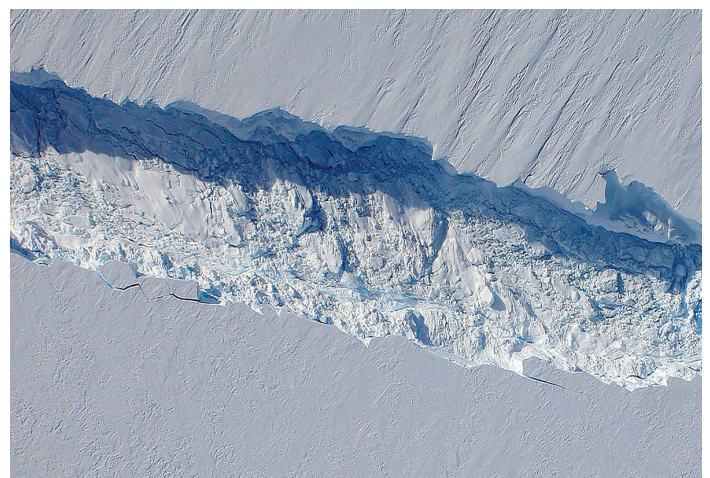


Figure 10. A close-up image of the crack spreading across the ice shelf of Pine Island Glacier that NASA's DC-8 flew over in October 2011.



¹³ Mernild, S. H., N. T. Knudsen, W. H. Lipscomb, J. C. Yde, J. K. Malmros, B. Hasholt, and B. H. Jakobsen, Increasing mass loss from Greenland's Mittivakkat Gletscher, *The Cryosphere*, 5, 341-348, 2011.

¹⁴ Harris, Nancy L., Sandra Brown, Stephen C. Hagen, Sassan S. Saatchi, Silvia Petrova, William Salas, Matthew C. Hansen, Peter V. Potapov, and Alexander Lotsch. 2012. *Science* (336): 6088: 1573-1576

2.3 INFORM DECISIONS

Goal 2—Inform Decisions: Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation.

People, businesses, communities, and entire nations are making decisions to minimize (mitigate) and prepare for (adapt to) global change. USGCRP's *Inform Decisions* goal is designed to support those decisions by translating research results into information that is relevant, usable, and accessible as well as by facilitating meaningful engagements between scientists and decision makers. Specifically, USGCRP is focused on advancing *adaptation science* and providing *global change information* in ways that are useful to those who need it.

ADAPTATION SCIENCE: More extreme precipitation events, longer wildfire seasons, reduced snowpack, increased extreme heat events, warming ocean temperatures, and rising sea levels are already beginning to affect our Nation's critical infrastructure, ecosystems, food production, energy supply, national security, human health, and cultural heritage.¹⁵ As changes in our climate continue, these impacts are expected to intensify and new impacts may emerge. Preparing for and adapting to these changes is a common sense approach to ensuring a safer, more prosperous future.

USGCRP agencies are already working to increase dialogue between climate researchers and decision makers to ensure there is mutual understanding of the most pressing adaptation science needs. They are also leveraging internal expertise to prepare for the impacts of climate change. For example, NASA is sponsoring research on potential adaptation approaches to climate change in the regions where its facilities reside. Other agencies are collaborating with State and local officials to co-produce specific information products relevant to managing climate variability and future change.

Despite the tremendous value of these steps, major challenges remain. Many methodologies used to inform adaptation decisions are nascent and not rigorously tested, and many existing climate models cannot provide reliable local-scale information. There is also a need to identify critical knowledge gaps, optimize allocation of limited resources, and ensure that there is sustained engagement between scientists and decision makers on the ground.

GLOBAL CHANGE INFORMATION: Informed decisions require credible information and data. Decision makers need global change information that is centrally accessible, clearly described, authoritative, and relevant. Meeting this need efficiently—when both the demand for reliable data and the diversity of available data are ballooning rapidly—is a sizable challenge.

In direct response to this challenge and to feedback from the National Academy of Sciences (NAS), USGCRP is developing a new, systematic approach to global change information provision. The approach confronts the reality that while many credible, topic-specific data delivery services exist across the Federal government, there is no single point of access for authoritative information on interrelated, multidisciplinary global change issues such as the coastal impacts of sea level rise, the health costs associated with temperature extremes, and others. Absent a central and intuitively structured access point, it can be difficult for users to find the data they need.

The main component of USGCRP's information provision plan is development of a Global Change Information System (GCIS)—a comprehensive web-based data integration platform that will efficiently deploy the broad range of global change information to diverse user communities. When fully developed, the GCIS will be a central access point for authoritative global change data from across the Federal agencies and beyond (including fundamental observational and modeling data, and derivative communication products and services). As a first but significant step, the GCIS will provide data related to the forthcoming National Climate Assessment (NCA), scheduled for release in 2013.

This effort will require multiple Federal agency partnerships; comprehensive access to *in situ* and space-based observing assets across the government; access to and translation of modeled data; significant data management capabilities; and consideration of diverse audience needs to create appropriate user-experiences.

RECENT HIGHLIGHTS: INFORM DECISIONS

New Plant Zone Map Informs Gardeners and Growers

In early 2012, USDA released a new Plant Hardiness Zone Map—a tool widely used by growers and gardeners across the United States to understand which plants are most likely to thrive in a given location. The last such map was released in 1990.

¹⁵ USGCRP. (2009). Global Climate Change Impacts in the United States. www.globalchange.gov/publications/reports and National Research Council. (2011). *America's Climate Choices*. The National Academies Press. Washington, DC. www.nap.edu/catalog.php?record_id=12781

Notably, two new zones (that fall only in Hawaii and Puerto Rico) have been added that represent particularly warm regions—where average coldest temperatures are above 50 and 60 degrees F. In addition, the new map is generally one half-zone warmer than previous maps.

Because the 2012 map was created with more precise techniques and additional data from new weather-reporting stations, these zone differences—as stand-alone observations—are not sufficient evidence to confirm whether there has been global warming in a particular location. However, the zone differences overall *do* reflect broader climate change trends observed by scientists through systematic evaluation of data from much longer time periods.

The map is an example of the many important uses of temperature data that reach beyond the walls of science labs, into the daily lives of Americans. Growers and gardeners across the country rely on this type of information to make day-to-day decisions about which species to plant and how to care for them that can affect the success of their home gardens, community gardens, and businesses.

New Climate Adaptation Strategies Strengthen National Resilience

In FY2012, USGCRP collaborated closely with the Interagency Climate Change Adaptation Task Force (ICCATF) to inform three major National adaptation strategies: (1) *National Action Plan for Managing Freshwater Resources in a Changing Climate*¹⁶; (2) *National Ocean Policy: Implementation Plan*¹⁷; and (3) *National Fish, Wildlife and Plants Climate Adaptation Strategy* (Figure 11).¹⁸

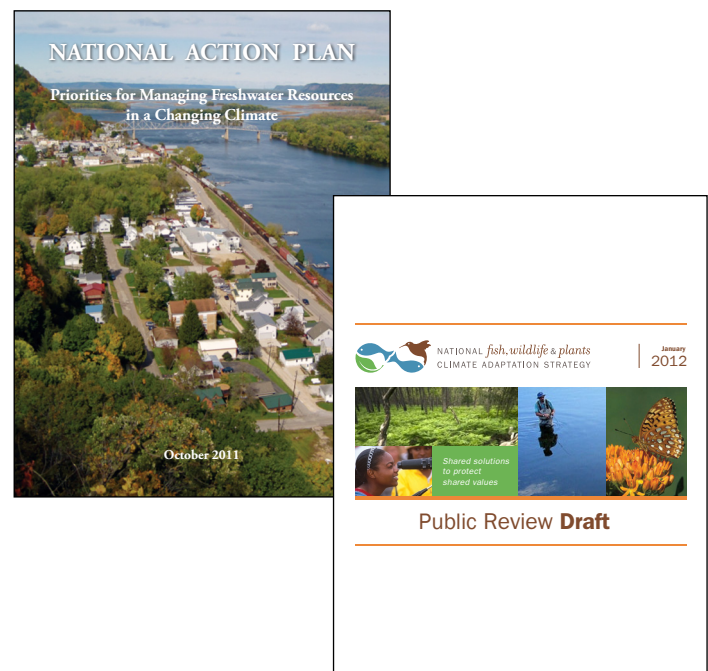
These strategies will help Federal agencies incorporate climate change adaptation considerations into their decisions and actions related to our Nation's freshwater, ocean, fish, wildlife, and plant resources.

USGCRP is also supporting efforts by individual Federal agencies to plan for climate change impacts on their own operations. In response to Executive Order (E.O.) 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, Agencies developed individual Adaptation Plans to evaluate and manage the risks, vulnerabilities, and impacts of climate change.

With scientific support from USGCRP, Federal agencies submitted full draft Adaptation Plans to the Council on Environmental Quality (CEQ) and the Office of Management and Budget (OMB) in June 2012 and continue to make progress. For example:

- USDA issued a new Departmental Regulation (D.R. 1070-001) to develop and implement adaptation actions to help the Nation's agricultural enterprise prosper in the face of a changing climate.
- The United States Army Corps of Engineers (USACE) is leading multi-agency and international teams to produce guidance on how to incorporate considerations of sea level change into Army Corps coastal projects.
- NASA's Climate Adaptation Science Investigators (CASI) Workgroup is currently developing climate projections for each NASA Center, an inventory of climate-relevant data and projects within NASA, and a set of recommendations for future research initiatives, among other activities.
- New regional maps developed by NOAA allowed the General Services Administration (GSA) to complete an initial high-level assessment of its vulnerabilities to climate change across the country.

Figure 11. *National Adaptation Strategies. Images of the 2011 National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate and the Public Review Draft of the National Fish, Wildlife, and Plants Climate Adaptation Strategy.*



¹⁶ National Action Plan for Managing Freshwater Resources in a Changing Climate: http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf

¹⁷ National Ocean Policy: Implementation Plan: http://www.whitehouse.gov/sites/default/files/microsites/ceq/national_ocean_policy_draft_implementation_plan_01-12-12.pdf

¹⁸ National Fish, Wildlife and Plants Climate Adaptation Strategy: <http://www.wildlifeadaptationstrategy.gov/>

Best Practices and Lessons Learned Parse Menu of Adaptation Options

Increasingly, decision makers are adopting an array of climate adaptation policies, plans, and actions. Moving forward, it will be critical to evaluate what works, what fails, and where more scientific support is needed. USGCRP is working to meet this need by monitoring and evaluating adaptation actions taking place on the ground. This will help decision makers determine whether their adaptation actions are successful and how they can be enhanced.

In March 2012, USGCRP's Adaptation Science Workgroup developed a bibliography of best practices (expected to be published and referenced in the next NCA in 2013) for monitoring and evaluating adaptation actions. The bibliography is the first step of an ongoing project that will:

- Mine literature for examples of strategic planning, indicators, performance measures, and evaluation of climate adaptation actions;
- Capture the knowledge of practitioners who are engaged in implementing and evaluating climate adaptation activities through interviews; and
- Provide a suite of products such as performance measures, best management practices, and lessons learned to help practitioners better evaluate their adaptation efforts.

Agencies Collaborate to Help U.S. National Parks Adapt

USGCRP agencies including DOI's USGS and National Park Service (NPS), USDA's Forest Service, in collaboration with other partners have jointly analyzed the vulnerability of six United States National Parks to climate change impacts. Analysis of 13 additional Parks is currently underway.

The analyses examine the three components of vulnerability (exposure, sensitivity, and adaptive capacity), across species, ecosystems, cultural resources, and infrastructure in each Park. Analysis results are now being used to identify particularly vulnerable areas and potential areas of refuge, develop adaptation measures, and prioritize areas for adaptation action. As a result of this effort, peer-reviewed scientific articles or government technical reports have been published on the following topics:

- Coastal ecosystems in 22 national parks, desert southwest species in Bryce Canyon National Park, Cedar Breaks National Monument, and Zion National Park;
- Forest ecosystems in Olympic National Forest and Olympic National Park;

- Joshua trees in Joshua Tree National Park;
- Pacific coast ecosystems in Point Reyes National Seashore; and
- Tropical ecosystems in Hawaii national parks.

Analyses in progress examine a range of ecosystems in Sequoia, Kings Canyon, Yosemite, and Badlands National Parks as well as Sequoia National Forest and other locations (Figure 12).

New Adaptation Tools for Water Resource Managers

USGCRP is supporting natural resource managers and region-based decision makers with tools, applications, and case studies to inform adaptation strategies.

Through its Carolinas Integrated Sciences and Assessments (CISA) program based at the University of South Carolina, NOAA and partners are working with regional stakeholders to incorporate climate information into water and coastal

Figure 12. Analyses by NPS, USGS, USDA Forest Service, and the University of California provide data to Sequoia, Kings Canyon, and Yosemite National Parks and Sequoia National Forest to adapt fire management under climate change (Photo by Patrick Gonzalez).



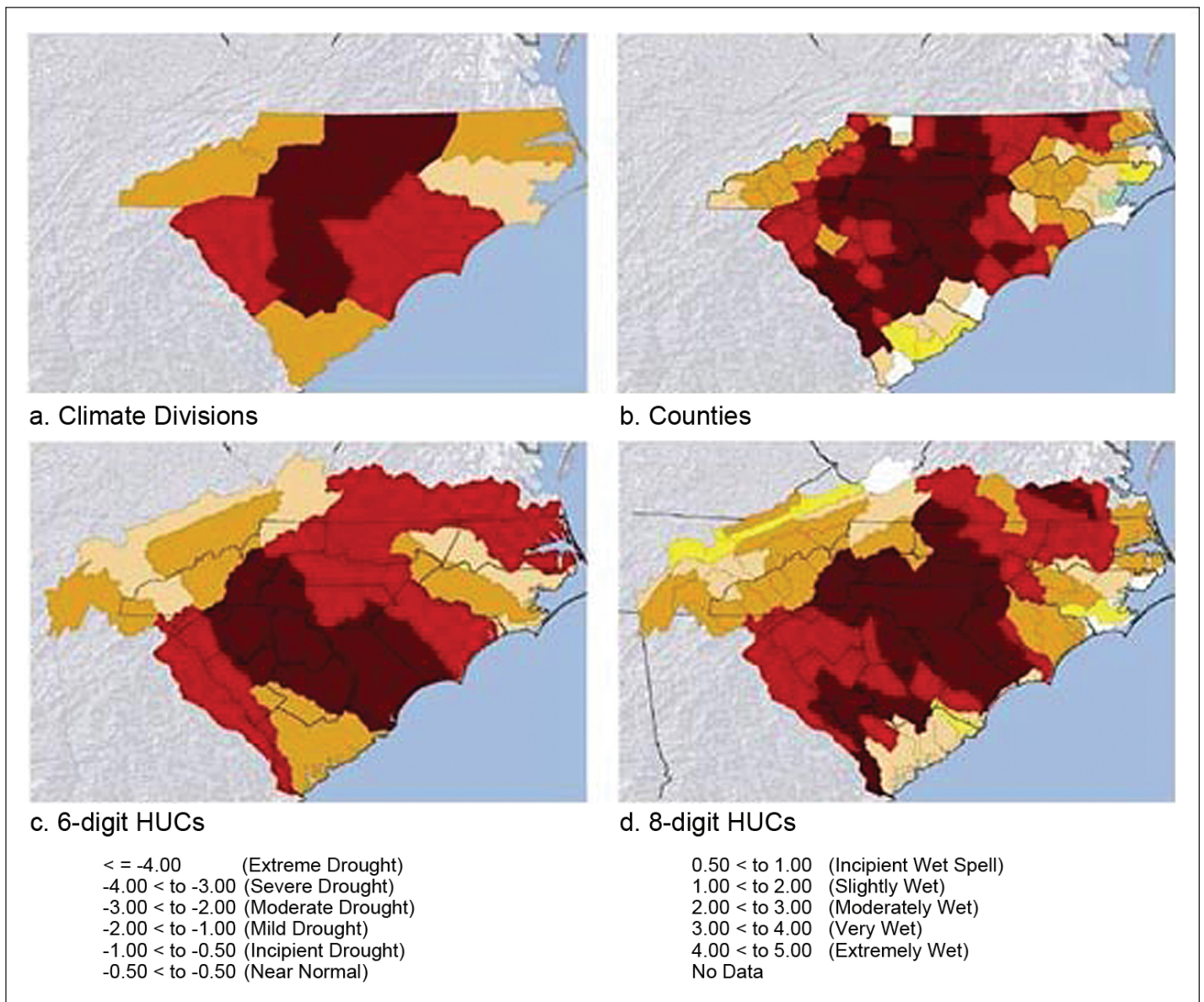
management decisions. CISA has already developed the Carolinas Dynamic Drought Index Tool to display multiple drought indices over different time scales and across user-specified regions (Figure 13). The tool is currently being refined and transferred for use by NOAA's regional climate centers.

The Environmental Protection Agency (EPA) has developed two additional assessment tools, the BASINS Climate Assessment Tool (BASINS CAT) and the Water Erosion Prediction Project Climate Assessment Tool (WEPPCAT), to foster the use of existing water simulation models to understand the

effects of climate change on water resources. A series of six case studies has been conducted to illustrate the capabilities of these tools for real world problem solving (see Figure 14).

EPA also reported on the activities of four domestic water utilities to evaluate their potential vulnerability to climate change. These additional case studies illustrate a range of issues being faced by U.S. water utilities and approaches being taken to assess vulnerabilities to climate risks. The case studies will be shared with water sector stakeholders, who will help identify additional scientific and technical needs to support such vulnerability assessments.

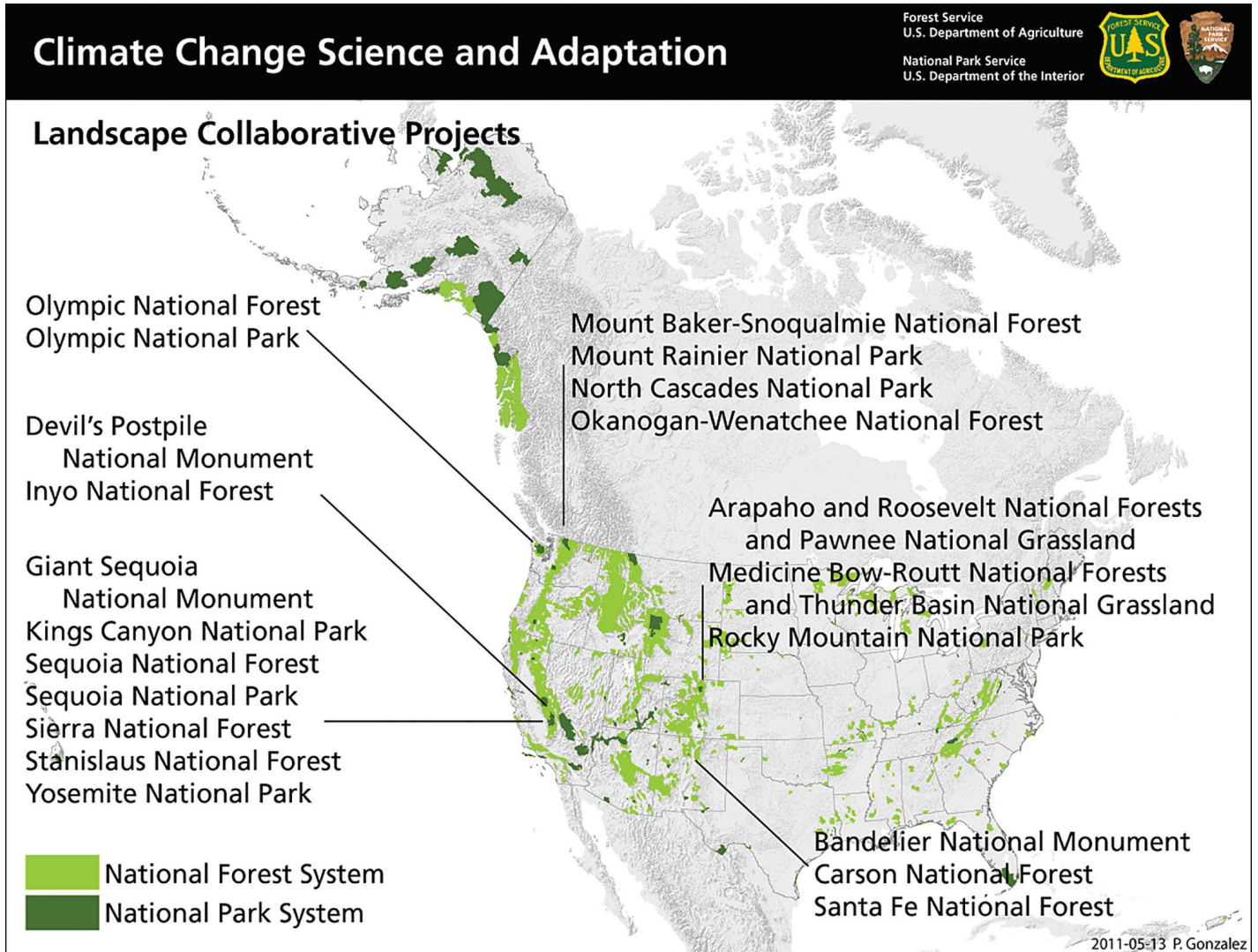
Figure 13. July 2002 Monthly Palmer Drought Severity Index (PDSI) maps. Source: <http://www.cisa.sc.edu/>



Other valuable adaptation tools have been developed by USDA's U.S. Forest Service (USFS) and DOI's NPS for vulnerability, including: *Scanning the Conservation Horizon*, a guide to climate change vulnerability assessment; *A System for Assessing Vulnerability of Species (SAVS) to Climate*

Change, a system that quantifies the relative impacts of expected climate change effects for terrestrial vertebrate species; and *Responding to Climate Change in National Forests*, a guidebook for developing adaptation options.

Figure 14. Joint vulnerability assessments by the USDA's Forest Service and DOI's National Park Service. Image: Patrick Gonzalez, NPS.



2.4 CONDUCT SUSTAINED ASSESSMENTS

Goal 3—Conduct Sustained Assessments: *Build sustained assessment capacity that improves the Nation’s ability to understand, anticipate, and respond to global change impacts and vulnerabilities.*

The Global Change Research Act of 1990 requires USGCRP to conduct a National Climate Assessment (NCA) every four years. USGCRP also coordinates Federal participation in international assessment efforts such as those led by the IPCC.

Here, “assessment” refers to the syntheses of peer-reviewed and other credible literature that summarize current scientific understanding of global change. Some, such as USGCRP’s NCA, are focused on specific geographical regions, while others are focused on specific aspects or impacts of global change. The best-known international assessments—IPCC Assessment Reports—cover the field very broadly. The effort required to produce such assessments is immense, but yields highly valuable sources of credible information for use by scientists and decision makers worldwide. Assessments are also important sources of information for members of the media and public who are seeking up-to-date information about the state of global change and projections for the future.

A major new goal for USGCRP is to strengthen and advance the Program’s capacity to conduct assessments on an iterative and sustained basis, rather than at widely spaced multi-year intervals. The Program is building upon its demonstrated ability to produce periodic assessments by developing a process that will ultimately enable continuous and transparent participation of scientists and stakeholders across regions and sectors.

THE NATIONAL CONTEXT: USGCRP’s National Climate Assessment (NCA) is widely recognized as one of the most robust, authoritative sources of information about the current status of the United States climate, climate changes, climate change impacts, and anticipated trends. Local and state governments, tribes, businesses, and the public regularly use Assessment findings to plan and strategize for the future.

The NCA integrates scientific information from a wide range of credible sources to highlight key findings of significance and important knowledge gaps. It also establishes consistent methods for evaluating climate vulnerabilities, impacts, and response strategies.

USGCRP has begun to approach its NCAs as an ongoing, or “sustained,” effort, rather than periodic report-writing activity. For example, the Program is focusing considerable

attention on building long-term partnerships with public and private sector organizations, and on establishing a strong stakeholder engagement process to support the development and release of future NCA products.

THE INTERNATIONAL CONTEXT: The long-term strength of global change research depends on intimate engagement with international efforts, including international climate assessments.

USGCRP-supported researchers continue to play important roles in the development of several major international assessments, including the forthcoming IPCC 5th Assessment Report. They are lead authors, reviewers, and working group co-chairs. They also provide technical support and scientific expertise as reviewers to IPCC assessments and other international projects.

USGCRP also ensures that U.S. interests are represented internationally, where appropriate. For example, the Program coordinates and supports U.S. participation in and review of the IPCC’s global assessment of the climate, the Arctic Climate Impact Assessment, and the Scientific Assessment of Ozone Depletion.

Finally, USGCRP collaborates with neighboring nations to achieve common goals related to water resources, shifting habitats, transportation, and other sectors impacted by global change. The United States benefits from such scientific diplomacy because it creates new opportunities for leveraging of resources, knowledge sharing, and efficiency.

RECENT HIGHLIGHTS: CONDUCT SUSTAINED ASSESSMENTS

Development of the 2013 National Climate Assessment Continues

In early 2012, The National Climate Assessment’s Federal Advisory Committee selected more than 240 authors from academic institutions, non-governmental organizations (NGO), and the public and private sectors to write the 2013 Assessment report. These authors completed first draft chapters in June 2012 and have continued to conduct revisions prior to the release of the final report in early 2014. In addition, 30 review editors will be selected to ensure that comments and edits identified through the National Research Council, USGCRP agencies, and general public review are adequately addressed in the spring of 2013.

In an important new step, authors of the 2013 National Climate Assessment will be delivering the report in a Web-based format (an e-book). Though this has placed significant new demands on Assessment authors, tremendous benefits are expected as a result, including significantly greater traceability and accessibility of assessment data.

Dozens of Technical Reports to Inform 2013 National Climate Assessment

USGCRP agencies have coordinated development of more than 25 technical reports that provided important foundational input to the 2013 National Climate Assessment, including:

- *Ecosystems, Biodiversity, and Ecosystems Services*: This report, developed by USGS, other USGCRP agencies, and external partners, explains current and projected future impacts of global change on biodiversity, ecosystem processes, and ecosystem services.
- *Urban Infrastructure and Vulnerability*: Two reports, by DOE and NOAA respectively, tackled the challenge of assessing and predicting climate change impacts on the Nation's cities and urban areas—which are home to more than 80 percent of the U.S. population.
- *Energy-Water-Land*: An interdisciplinary team led by DOE developed a report describing potential impacts of climate change on the Nation's competing needs for water, energy, and land-use sectors.
- *Coastal Zone, Development, and Ecosystems*: NOAA and USGS supported development of a report that summarizes recent information on the effects of climate change on coastal resources.
- *Northeast Region*: NOAA and NASA convened a workshop of Federal, state, and other stakeholders to develop a technical report on climate variability and change, impacts, and adaptation efforts in the region spanning from Maine to West Virginia.

New Global Change Scenarios to Inform Projections for the Next Century

The Global Change Research Act of 1990 requires that National Climate Assessments include projections of global change for the next 25 to 100 years. To meet this requirement for the 2013 Assessment, USGCRP developed a scenarios strategy that was implemented in FY 2012. Scenarios provide a consistent framework for projecting future conditions. The strategy designates two well-established IPCC scenarios for greenhouse gas emissions (SRES B1 and A2) as the minimum set for author teams to consider when preparing the 2013

Assessment. USGCRP's strategy also led to the development of new scenarios tailored for use by the NCA in key areas, including:

- **Climate** – NOAA led the development of a set of plausible representations of future climate conditions, based on the greenhouse gas emissions scenarios mentioned above, for each of the eight NCA regions as well as the Nation as a whole.
- **Sea Level** – Multiple agencies and external partners developed new sea level change scenarios, including estimates of future global average sea level from processes such as melting of ice sheets, and descriptions of anomalies along United States coastlines resulting from land subsidence.
- **Land Cover, Land Use, and Socioeconomic Factors** – EPA's Integrated Climate and Land Use Scenarios project and USGS' National Land Cover Database informed projections of socioeconomic change (e.g., urbanization) and the extent and distribution of land use categories resulting from climate change and other factors.

2013 NCA Receives Unprecedented Input from Stakeholders and Public

A broad engagement process was launched in FY 2010 to solicit stakeholder input to the 2013 National Climate Assessment report and has succeeded in attracting input from many diverse groups. For example, in response to an FY 2011 public "Request for Information," more than 130 teams submitted more than 500 discrete technical input products for consideration in development of the 2013 report.

During FY 2011 and FY 2012, USGCRP coordination staff, agency representatives, and partners convened more than 70 workshops, listening sessions, and discussions to invite input from a broad range of groups. Also in FY 2012 USGCRP launched, "NCAnet," a network of partners that connects the National Climate Assessment process to interested professional societies, and members of the public, private, academic, and non-profit sectors.

2009 NCA, Global Climate Change Impacts in the United States Report, Redeployed Online

In 2011, the 2009 NCA – *Global Climate Change Impacts in the United States* – was redeployed on the *web* (Figure 15).¹⁹ This activity allowed USGCRP to test new methods of searchability, transparency, and data access for the NCA, and

¹⁹ USGCRP, 2009: Global Climate Change Impacts in the United States, online website: <http://nca2009.globalchange.gov>.

2.5 COMMUNICATE & EDUCATE

Goal 4—Communicate and Educate: Advance communications and education to broaden public understanding of global change and develop the scientific workforce of the future.

USGCRP's new decadal research plan identifies *Communicate and Educate* as one of four key strategic goals. This is an explicit recognition of the importance of keeping the public informed about societally-relevant global change science, of showing taxpayers and members of Congress the results and value of their research investments, and of cultivating a national workforce with the skills and knowledge to address the challenges and opportunities posed by global change.

A rapidly growing body of social science, education research, and public surveys show that communicating research results in plain English and tailoring communications to the interests and needs of specific audiences are important components of broadening public understanding of science. Global change education is also essential for producing the next generation of scientists, researchers, and technical professionals who will ultimately be responsible for confronting the challenges of global change. Because of their direct societal relevance and focus on multidisciplinary science issues, global change education programs may also help draw students into science, technology, engineering, and mathematics (STEM) fields generally—a major benefit to the Nation's global competitiveness.

USGCRP has a long history of producing highly relevant and authoritative science products. Now the Program is working to improve communication of those products to the broadest possible set of users, including the public. Better coordination across Federal agencies will ensure that global change communication activities use the highest quality science information, are consistent and efficiently deployed, and reach diverse audiences.



Figure 15. Redeployment of the 2009 *Global Climate Change Impacts in the United States Report*. This online access allows for stakeholders to navigate the report in a more interactive manner.

to receive feedback from key groups. While this redeployment was a trial effort, initial feedback has been positive and will help inform the development of forthcoming 2013 NCA products and the larger Global Change Information System (GCIS) effort.

United States Provides Key Support to IPCC Fifth Assessment Report (AR5)

Intergovernmental Panel on Climate Change (IPCC) assessments are the most comprehensive, scientifically credible products that review current knowledge of climate change, its impacts, and associated adaptation and mitigation options. Unlike USGCRP's National Climate Assessment, which focuses on the United States, IPCC Assessment Reports are global in scope, and include discussions of mitigation options.

USGCRP contributes to the IPCC through agency scientists who act as authors, reviewers, and editors for Assessment Reports and Special Reports.

In addition, the USGCRP hosts a support unit for the IPCC that is responsible for managing the funds that enable participation of U.S. authors and contributors to IPCC's Fifth Assessment Report. USGCRP, the Department of State (DOS), and others are also responsible for hosting U.S. author nominations and government and expert reviews of IPCC special reports, including *Renewable Energy Sources and Climate Change (SRREN)* and *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)*.

RECENT HIGHLIGHTS: COMMUNICATE AND EDUCATE

Agencies Communicate Record-Breaking Extreme Weather to Americans

Recent surveys show that American views on climate change are shaped, in large part, by personal observations of temperature and weather phenomena.²⁰ Other studies show that a large majority of Americans report personally experiencing at least one extreme weather or natural disaster in the year preceding March 2012 and that more than one-third of Americans report having been personally affected by one or more such events.²¹

USGCRP is responsible for communicating scientific information about global change to American citizens in meaningful ways, in the context of topics that matter to them. That's why USGCRP agencies are engaged in several activities to communicate information on the recent surge in extreme weather events clearly, accurately, and to the broadest possible set of audiences. For example:

- NOAA hosts monthly public climate webinars featuring expert scientists who summarize climate and weather observations from the preceding month, and provide a three-month climate outlook in plain English.
- NASA releases near-real-time satellite images of severe and extreme weather, such as “Tropical Storm Isaac by Night”—a captivating image of Hurricane Isaac over the Gulf Coast of the United States captured by the Suomi NPP satellite that quickly went viral on the Internet (Figure 16).
- USDA releases regular Agricultural Weather and Drought updates on its widely viewed blog, which feature the latest maps of drought-affected areas of the United States and clear accompanying explanations of observed trends for lay audiences.

Federal Web-Based Climate Communications More Effective than Ever

In 2012, USGS' online Climate Connections video series won a Blue Pencil and Gold Screen Award in the category of “Public Affairs Program” from the National Association of Government Communicators (NAGC). The series features scientists answering questions gathered from people across the Nation and highlights what people want to know, from locations they recognize. Thus far, USGS has published episodes of the Climate Connections series from North Carolina, South Carolina, Puerto Rico, Glacier National Park, and Washington, D.C.

Also in 2012, USGCRP launched a revamped online Resource Library for easier, more intuitive access to Federal global change resources, including publications, reports, educational materials, and fact sheets. The revamped Resource Library provides free and easy access to more than 100 products containing data and information on climate change, many of which are used by schools, colleges, nonprofit organizations and other institutions seeking reliable global change information sources at little to no cost.

Finally, the NASA climate website (climate.nasa.gov) won the “Best Science Site” Webby Award in 2011. The main NASA portal (www.nasa.gov), which won two Webby Awards in 2012, also highlights climate and Earth system science on a routine basis. These sites are a powerful tool that USGCRP harnesses to communicate climate science to the public.

New Science Centers to Offer Week-long Climate “Boot Camp” for Students

DOI is currently establishing eight Climate Science Centers across the Nation to provide scientific support for those who manage natural and cultural resources and need to plan for a changing climate. When fully established, the Climate Science Centers will support more than 50 graduate students and post-doctoral candidates per year to work on issues directly related to climate change management challenges. To complement coursework and research activities, the Centers are also developing innovative education approaches such as a week-long “Climate Boot Camp” for students and managers at the Northwest Climate Science Center, and a two-week intensive short course on climate downscaling at the Alaska Climate Science Center. Both will combine classroom learning with real-world experience and interactions with managers on the ground.

²⁰ Borick, C. and Rabe, B. 2011. “Fall 2011 National Survey of American Public Opinion on Climate Change.” Brookings Institution. *Issues in Governance Studies* (44).

²¹ Leiserowitz, A., Maibach, E., Roser-Renouf, C., & Hmielowski, J. D. (2012) *Extreme Weather, Climate & Preparedness in the American Mind*. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication.

Growing Network of Citizen Scientists Provides Data on Nature's Changing Calendar

Scientists are increasingly turning to members of the public for help conducting phenology research—the study of plant and animal life cycles, or “nature’s calendar.” These “citizen scientists” are mobilizing to record and report climate-relevant observations that scientists can’t track as comprehensively on their own, including the shifting timing of flower blooms, leaf fall, animal reproduction, species migration, crop maturation, and insect emergence.

An effort to incorporate the work of citizen scientists into the phenology research community is being coordinated through the USA National Phenology Network (USA-NPN) in close collaboration with USGS, other USGCRP agencies, and external partners. This effort greatly expands the Nation’s capacity to collect phenological observations across the full range of geographic and time scales.

Approximately 4,000 people have registered to track the activity of nearly 16,000 plants and animal species across the Nation—and the number is growing. The NPN provides scientists, resource managers and decision makers with a more comprehensive view of the pace and patterns of phenological change. This information is particularly valuable to farmers and gardeners who must decide when to harvest crops, managers who must anticipate drought and wildfire risks, and public health officials who must track the onset of allergy seasons.

Agency Funds Support Climate Literacy among Midwestern Farmers

In 2011 USDA made a 5-year, \$20 million grant to Iowa State University to integrate research, extension, and education on climate change adaptation and mitigation for farmers across eight Midwestern states. As part of this project, extension and education programs will work with

Figure 16. Tropical Storm Isaac by Night. Exceptionally crisp nighttime images of Hurricane Isaac as it made landfall in August 2012 were made possible by the Suomi National Polar-orbiting Partnership satellite (NPP). Photo Credit: NASA Observatory.

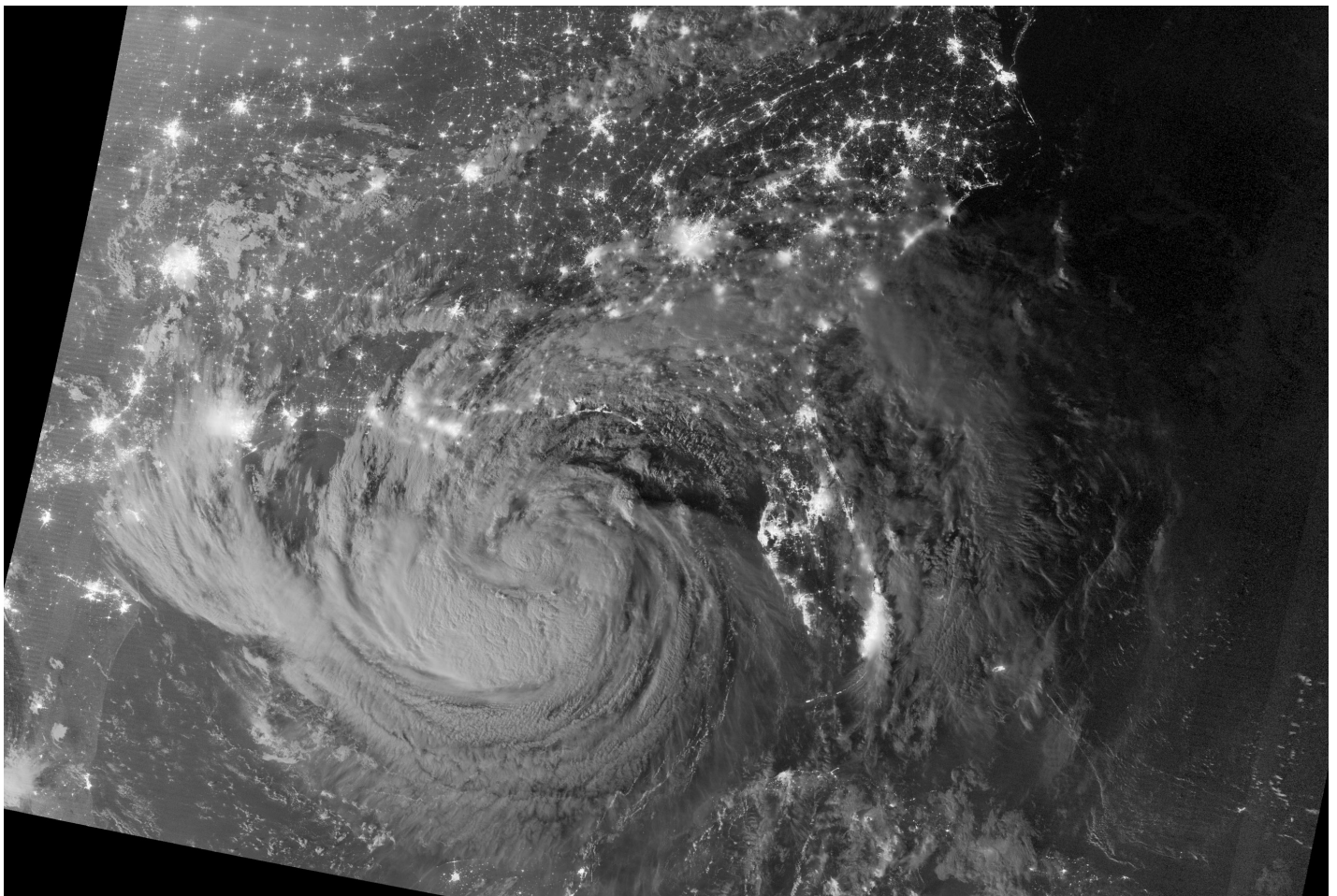




Figure 17. A small dam, terraces, buffer strips, and grass plantings are part of a conservation project to improve the quality of water entering Union Grove Lake in Tama County, Iowa. Photo credit: USDA-NRCS.

farmers, teachers, and students to promote climate literacy and collaborative learning.

An Iowa Agricultural Educators survey²² of middle- and high-school teachers showed that nearly 70 percent of respondents think climate change is caused primarily or in large part by human activities. Nearly 92 percent said they are interested in educational curricula and other materials that focus specifically on climate change and agriculture in Iowa.

2.6 INTERNATIONAL RESEARCH & COOPERATION

USGCRP coordinates international activities related to global change occurring across Federal agencies, with the following goals:

- Increase cooperation between U.S. scientists, institutions, and agencies and their international counterparts on topics related to global change;
- Empower scientists and institutions in less developed countries to improve understanding of and responses to global change;
- Promote international efforts to develop standards for data quality and accessibility at low cost;
- Sustain and improve observations of the Earth system globally; and
- Support international negotiations and overseas development assistance.

The landscape of international research and cooperation is evolving rapidly. Organizations and governments at home and abroad are recognizing the growing need for scientific knowledge to better inform policy and decision making. USGCRP is playing an integral role in providing such scientific knowledge and stands to significantly benefit from the knowledge and experience of partners around the world.

RECENT HIGHLIGHTS: INTERNATIONAL RESEARCH AND COOPERATION

Agencies Support Research and Tools to Reduce Agricultural Greenhouse Gas Emissions

In 2009, USDA led Federal efforts to formally establish the Global Research Alliance (GRA) on Agricultural Greenhouse Gases, an international research collaboration to manage climate change. As of June 2011, 30 countries have signed onto the Alliance. In cooperation with United States Agency for International Development (USAID), USDA supports researchers in developing countries that participate in the Alliance by providing fellowship opportunities to work side-by-side with USDA scientists on climate change mitigation research.

USDA also developed and released a Web-based book, *Greenhouse Gas Reduction through Agricultural Carbon Enhancement network (GRACEnet) Soil Carbon Sampling Protocols*, to establish soil carbon sampling protocols across

²² Arbuckle, J. Gordon Jr., Daren S. Mueller, and Adam Sisson. 2011. Climate Change in the Classroom: A Survey of Iowa Agricultural Educators. CSCAP2011-1. Ames, IA: Iowa State University Extension Sociology. (2 pp.)

many locations and within different agro-ecosystems. The 30 countries currently participating in the Alliance are now considering adopting these protocols to enable comparison of soil carbon across space and time.

USGCRP Showcases National Activities on International Stage

USGCRP continues to participate in *Planet Under Pressure*, an international conference organized by leaders in the worldwide global change research community. The 2012 conference focused on improving connections between natural sciences, social sciences, economics, decision making, and development to support responses to global change.

USGCRP agencies contributed to sessions, provided speakers, and exhibited at the conference. For example, NASA displayed its “Hyperwall” to demonstrate the global change communications power of compelling visualizations (Figure 18).

USGCRP agencies also showcased their work at the United Nations Framework Convention on Climate Change’s 17th Convention of the Parties (COP-17) in South Africa. USAID, USGS, USDA, NASA, and NOAA, for example, jointly showcased their Famine Early Warning System (FEWS), which provides climate information needed to prevent food insecurity. USDA also helped showcase the Presidential Feed the Future (FTF) Initiative, a \$3.5 billion program designed to help countries fight hunger by investing in agricultural developments such as climate-resilient cereals and increased grain and legume productivity.

Figure 18. NASA Hyperwall. At the Planet Under Pressure 2012 Conference, NASA’s hyperwall was showcased to demonstrate global change results visually. Photo Credit: NASA.



2.7 CLIMATE CHANGE & HUMAN HEALTH

Climate change poses potentially serious challenges to human health, including increased heat stress mortality, increases in diarrheal disease, degraded air and water quality, changes in vector-borne disease patterns, more severe pollen seasons, and danger from more frequent extreme weather events. In addition to threatening human well-being, these challenges can also contribute to increased healthcare costs.

In 2009, the National Research Council recommended that USGCRP strengthen its focus on integrating areas of high interest to decision makers, including climate change and human health. In direct response to this recommendation and in alignment with the Program’s own strategic vision, USGCRP launched a cross-cutting initiative to better understand the impacts of climate change on human health both today and in the future.

RECENT HIGHLIGHTS: CLIMATE CHANGE AND HUMAN HEALTH

With Climate Change, Longer Stronger Pollen Seasons

Carbon dioxide (CO₂) in the atmosphere directly affects plants by supplying the carbon they need for photosynthesis. In some cases, elevated CO₂ levels can help plants grow faster—a potential boon when that plant is an agriculturally important species, but CO₂ does not discriminate between desirable and undesirable plants. That means that while there may be benefits to more rapid growth in species like forest trees, for example, there can be serious negative consequences when these growth spurts occur in other plants, like ragweed—a plant to which at least ten percent of the United States population is sensitive.

A previous *field study* by USDA scientists and partners found that both higher atmospheric CO₂ levels and warmer temperatures—two key aspects of climate change—“significantly influence” pollen production in common ragweed and can increase pollen concentrations in the atmosphere.²³

²³ Ziska, L. et al. 2003. “Cities as harbingers of climate change: Common ragweed, urbanization, and public health.” *Journal of Allergy and Clinical Immunology*. 11, 2.

²⁴ Ziska, L. et al. 2011. “Recent warming by latitude associated with increased length of ragweed pollen season in central North America.” *Proceedings of the National Academy of Sciences*. DOI: 10.1073/pnas.1014107108.

In a more recent *study*, USDA researchers and collaborators found that in parts of North America, the ragweed pollen season is up to three weeks longer than it was in the mid-1990's because of climate change.²⁴

Today, allergic disorders, including asthma, comprise the 6th leading cause of chronic illness in the Nation. They affect more than 50 million Americans per year and cost the United States nearly \$20 billion annually.

Workshops Bridge Health, Climate, and Adaptation Communities

Several recent outreach events convened diverse stakeholders to share knowledge, promote dialogue, and bridge gaps between health professionals, climate scientists, and decision makers on critical issues related to climate and health.

In October 2011, USGCRP collaborated with the White House Office of Science & Technology Policy to convene climate adaptation planners from across the Federal government to identify linkages between climate change adaptation strategies, public health issues, and relevant resources.

Also in October 2011, USGCRP participated in the Annual Meeting of the American Public Health Association, the oldest and largest annual gathering of public health professionals, which attracted more than 13,000 national and international public health specialists. USGCRP's Climate Change and Human Health working group hosted a listening session and a skills-development workshop as part of the conference's Learning Institute for professional development. Participants in the skills development workshop, *Effectively Communicating the Human Health Impacts of Climate Change*, indicated anecdotally that the course increased their understanding of climate change communications and provided relevant resources for future use.

Finally, in 2012, USGCRP convened regional climate change and human health workshops in collaboration with NOAA, the Centers for Disease Control and Prevention (CDC), and the National Institutes of Health (NIH) in Charleston and Seattle. Each workshop convened 50 – 60 people to develop nuanced representations of regional climate change impacts on human health. The workshops were important venues for dialogue and yielded synthesis reports that will inform the 2013 National Climate Assessment.

USGCRP Develops New Climate-and-Health Data Tool

In 2012, USGCRP began development of the Metadata Access Tool for Climate and Health (MATCH), an interactive clearinghouse of datasets and tools related to the human health impacts of global climate change. The MATCH project is a pilot data-integration effort that will inform development of a broader Global Change Information System (GCIS). It presents a publically accessible user search interface for Federal datasets and allows for automated deposition of metadata into Data.gov and other existing Federal portals.

A fully operational MATCH portal—expected over the next few years and in collaboration with GCIS—will allow Federal agencies, universities, researchers, and stakeholders to:

- Analyze and integrate local, state, and national climate and human health data assets
- Facilitate the integration of other datasets related to climate and human health; and
- Integrate and link United States efforts to address climate change and human health concerns with international efforts such as GEO.







3. FY 2013 PRIORITIES

3.1 OVERVIEW

USGCRP's FY 2013 priorities are based on recommendations from stakeholders and the scientific community, including multiple National Academy reports on global change science and related human dimensions, the 2009 Global Climate Change Impacts in the United States report, a Pew Center report on the drivers of a coordinated Federal global change research program,²⁵ the National Adaptation Summit²⁶ report, and the National Academy of Sciences (NAS) *America's Climate Choices* reports,²⁷ among others.

This suite of reports shared a common recommendation: that the Federal climate and global change research enterprise should focus sharply on acquiring information for more effective and more iterative risk management in the face of global and climate change and place stronger emphasis on building resilience within the human component of the Earth system.

In response to this input and in support of the Program's new strategic goals, USGCRP has identified five priority areas of focus for FY 2013:

- Integrated Observations, Research and Modeling for Earth and Social Systems;
- Adaptation Research;
- Sustained Assessments;
- Interagency Global Change Information System; and
- Communications, Education, and Engagement.

USGCRP has also recognized that climate and global change impacts may be most evident when thresholds and tipping points are reached (e.g., outbreak of disease, collapse of ecological systems, proliferation of invasive species, ice-sheet collapse) and extreme events occur (e.g., tornadoes, droughts, floods, hurricanes). Therefore, thresholds, tipping points, and extremes have been selected as a unifying theme that cuts across all priority areas for FY 2013.

²⁵ Center for Climate and Energy Solutions (formerly Pew Center for Global Climate Change), 2010. *Adapting to Climate Change: A Call for Federal Leadership*. <http://www.c2es.org/publications/report/adapting-to-climate-change-call-for-federal-leadership>

²⁶ National Climate Adaptation Summit, 2010. <http://www.joss.ucar.edu/events/2010/ncas/>

²⁷ *America's Climate Choices*. <http://nas-sites.org/americasclimatechoices/>

3.2 FY 2013 PRIORITY AREAS

Integrated Research, Observations, and Modeling for Earth and Social Systems

USGCRP's FY 2013 priority targets in the area of Observations, Research, and Modeling include:

- Support the continued availability and new development of key satellite and *in situ* observation data that are required to improve scientific understanding and climate modeling;
- Conduct research to enhance understanding of predictability and better characterize highly uncertain processes, feedbacks, and environmental parameters (e.g., carbon cycling, biosphere interactions, atmospheric aerosols, clouds, ice sheet mass balance, and ocean circulation);
- Develop more comprehensive, highly-integrated models at spatially-relevant scales to increase understanding Earth systems and climate-related phenomena, and to inform adaptation and mitigation of climate impacts; and
- Develop mechanisms to incorporate human-system processes into models in order to improve scientific understanding, and enhance adaptation and mitigation capacities.

Adaptation Research

USGCRP's adaptation research in FY 2013 will emphasize anticipation and planning for thresholds, tipping points, and climate extremes, including research to:

- Advance understanding of social and ecological tipping points and thresholds to help define options and limits to adaptation;
- Integrate social, behavioural, and economic sciences (e.g. decision making under uncertainty, assessing adaptation trade-offs, costs of action vs. inaction) to improve understanding of human responses to rapid changes and extreme events; and
- Determine the effects of multiple cross-sectoral interacting stressors on human and natural systems that affect resilience to tipping points, extremes and thresholds.

USGCRP will also conduct fundamental work to support adaptation decision making by: (a) identifying flexible criteria for evaluating the effectiveness of near- and long-term adaptation options; (b) developing effective science translation strategies (e.g., methods to explain scientific jargon into laymen's terms) to expand translation capacity; and (c) mapping Federal science and decision support assets.

Establish and Sustain Assessments

The highest priority efforts related to the National Climate Assessment (NCA) in FY 2013 include:

- Writing, reviewing, and revising the draft 2013 NCA report in response to comments by USGCRP agencies, National Research Council, and the public in the spring of 2013. The final release of the NCA report will occur in early FY 2014. Concurrently, as part of the ongoing assessment process, the NCA staff will begin developing targeted special reports and other products for release between major quadrennial Assessment efforts and for web-based deployment. Partners in the NCA Network ("NCAnet") will help distribute key assessment findings to their stakeholders;
- Advancing development of the first national system of physical, ecological, and societal indicators that communicate key aspects of the physical climate, climate impacts, vulnerabilities, and preparedness to inform decision makers. Specific goals of this effort are to 1) provide meaningful, authoritative climate-relevant measures about the status, rates, and trends of key physical, ecological, and societal variables to inform decisions at multiple scales; 2) identify climate-related conditions and impacts to help develop effective mitigation and adaptation measures; and 3) provide analytical tools for users to derive indicators for particular purposes. This effort will build on or leverage existing data, observations, model output, as well as extant indicator networks and systems. Stakeholder engagement in the development of the indicators will be a strong focus in FY 2013; and
- Strengthening integration of land use and land cover scenarios, socioeconomic scenarios, and participatory scenario planning into future NCA processes and products; continually updating climate and sea level change scenarios as new scientific information becomes available; and incorporating global scenarios and related data from the IPCC's upcoming fifth assessment report into regional and sectoral assessments.

Interagency Global Change Information System (GCIS)

To meet growing public demand for timely, accessible, authoritative scientific information about global change and its impacts, USGCRP will work toward establishing a GCIS in FY2013.

In its initial phase, the GCIS will provide enhanced accessibility, transparency, and utility of data related to the 2013 National Climate Assessment report, including documentation and traceability of all relevant data sources. These steps will also directly respond to a recommendation by

the Interagency Climate Change Adaptation Task Force to *ensure scientific information about the impacts of climate change is easily accessible.*

Moving forward, the GCIS will evolve to incorporate broader sets of data, information, applications, tools, and services and disseminate that information more rapidly and to broader set of audiences.

Communication, Education, and Engagement

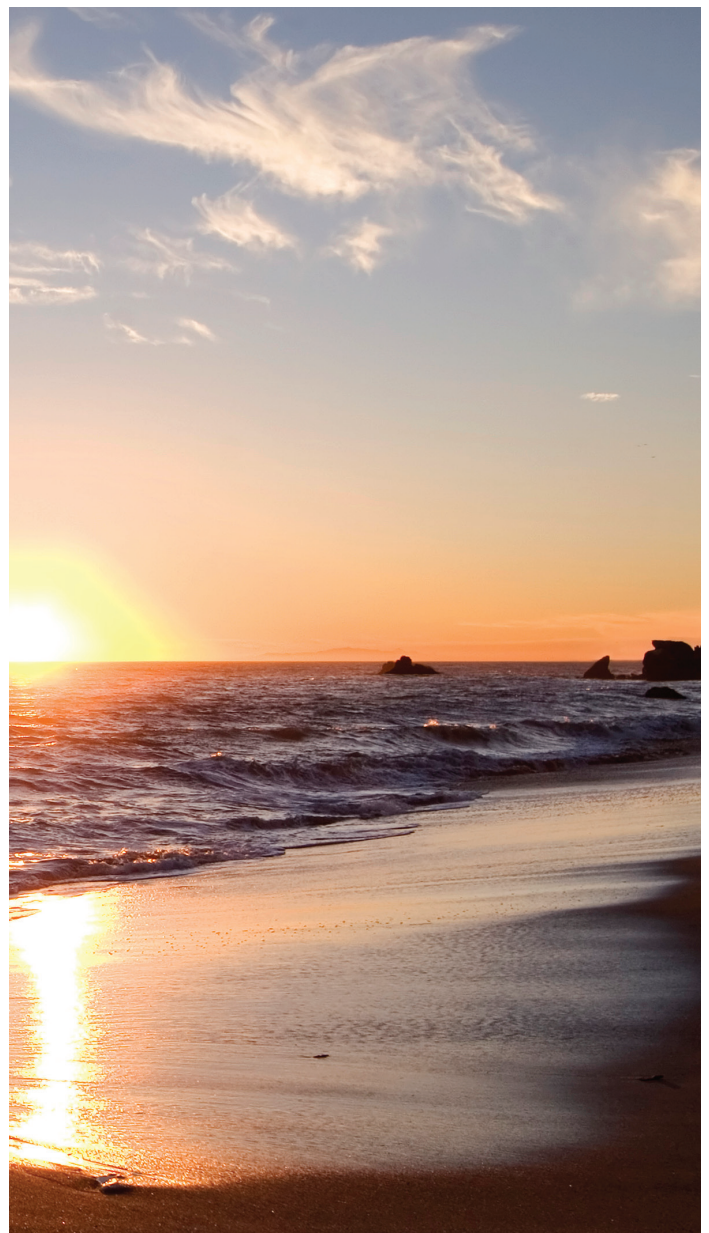
In April 2012, USGCRP launched a new Interagency Communications & Education Team (ICE-t) to advance the Program's goal to *Communicate & Educate*. The Team's working vision is to: *build and cultivate an attentive, conversant public who understand the reality, causes, and costs of climate and global change as well as the options for effective response.*

Priority communication, education, and engagement activities for USGCRP in FY2013 include:

- Strengthen the application of social science research to Federal global change science communications and education. Through the ICE-t, USGCRP has launched a new expert engagement series called "*Outside-In*," to increase exposure of Federal communicators to emerging social science research related to climate change communications and education. USGCRP has already hosted three *Outside-In* events featuring social science experts from George Mason University, Yale University, and Stanford University;
- Strengthen communications about the relationship between climate change and extreme weather events. Through the ICE-t, USGCRP is developing plans to create communications materials about connections between various extreme weather events and the larger climate system with the goal of being ready to deploy those materials during or soon after an extreme weather event occurs;
- Support communication, education, and outreach related to the 2013 National Climate Assessment. USGCRP will prioritize the development of communications materials, outreach events, and engagement opportunities to deploy scientific information contained in the new NCA to broad and diverse audiences. Specifically, the ICE-t will provide strategic communications guidance and input to support dissemination of the 2013 Assessment;
- Apply communication and education expertise to development of a Global Change Information System (GCIS). USGCRP will make it a priority in FY2013 to develop the GCIS as not only an information system but also a communications tool. This will include engaging communications and education specialists in the design

and implementation of the GCIS, including its visible user interfaces and the narrative and visual content it will disseminate; and

- Strengthen USGCRP's web presence. *Globalchange.gov* and the web generally are key communications interfaces for USGCRP. In FY2013, the Program will prioritize activities to make *globalchange.gov* a more intuitive, engaging, and informative website by increasing the frequency with which new content is posted, improving the design of the homepage, and testing new web-based communication platforms (i.e., social media) for dissemination of scientific information to diverse audiences.







4. BUDGET HIGHLIGHTS

The FY 2013 budget request for USGCRP programs is \$2.7 billion—an increase of approximately 7 percent over the 2012 enacted level. This increase reflects the needs discussed formerly and represents a commitment by the Administration to ensure that the USGCRP can fulfill its responsibilities under the law.

It is important to remember that the budget crosscut table represents those funds self-identified by the USGCRP agencies as their contributions to the USGCRP. The budget crosscut does not include the costs of many agency investments that are directly relevant, and indeed necessary, to the ability of the USGCRP to address national objectives related to climate and global change (e.g., many of the observing networks and satellite systems so critical to documenting trends were originally carried out by their sponsoring agencies for current operational purposes, and those are not typically included in the budget crosscut).

4.1 BUDGET BY AGENCY

Table 1: FY 2011-2013 U.S. Global Change Research Program Budget by Agency

Agency	FY 2011 Budget Enacted (\$M)	FY 2012 Budget Enacted (\$M)	FY 2013 Budget Requested (\$M)
Department of Agriculture (USDA)	85.9	115.0	122.6
Department of Commerce (DOC)	341.9	326.5	363.9
Department of Energy (DOE)	186.5	211.5	230.5
Department of Health and Human Services (HHS)	6.0	6.0	6.0
Department of the Interior (DOI)	64.3	58.9	67.7
Department of Transportation (DOT)	0.7	1.4	1.5
Environmental Protection Agency (EPA)	20.5	18.3	20.3
National Aeronautics and Space Administration (NASA)	1431.0	1422.0	1522.0
National Science Foundation (NSF)	321.3	333.4	332.9
Smithsonian Institution (SI)	7.0	8.0	8.0
[U.S. Agency for International Development (USAID)]	25.0	10.0	10.0
TOTALS	2490.2	2511.0	2685.5

4.2 BUDGET BY GOAL & PROGRAM ELEMENT

Table 2: FY 2011-2013 U.S. Global Change Research Program Budget by Goal and Program Element

Program Element	Description	Budgets (\$M)			Agency(ies)
		FY 2011 Budget Enacted	FY 2012 Budget Enacted	FY 2013 Budget Requested	
GOAL 1: ADVANCE SCIENCE – Advance scientific knowledge of the integrated natural and human components of the Earth system.		2073.7	2094.6	2243.3	USDA, DOC, DOE, HHS, DOI, DOT, EPA, NASA, NSF, SI
<i>Integrated Earth Observations</i>	Funds capabilities to observe the physical, chemical, biological, and human components of the Earth system over multiple space and time scales to gain fundamental scientific understanding and monitor important variations and trends	1252.3	1221.5	1348.4	USDA, DOC, DOE, HHS, EPA, NASA, NSF, SI
<i>Multidisciplinary Scientific Understanding of Earth Systems</i>	Funds research that contributes to advancing the fundamental understanding of the physical, chemical, biological, and human components of the Earth system, and the interactions among them, to improve knowledge of the causes and consequences of global change	667.3	719.7	729.8	USDA, DOC, DOE, HHS, DOI, DOT, EPA, NASA, NSF, SI
<i>Integrated Earth System Modeling</i>	Funds activities that contribute to improving and developing advanced models that integrate across the physical, chemical, biological, and human components of the Earth system, including the feedbacks among them, to represent more comprehensively and predict more realistically global change processes	154.1	153.4	165.1	USDA, DOC, DOE, NSF
GOAL 2: INFORM DECISIONS – Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation.		371.4	375.1	397.7	USDA, DOC, HHS, DOI, DOT, EPA, NASA, NSF
<i>Adaptation Science</i>	Funds activities that contribute to improving the research, application, and deployment of science that is specifically designed to inform adaptation decisions	126.3	113.5	134.6	USDA, DOC, HHS, DOI, DOT, EPA, NSF, USAID
<i>Global Change Information</i>	Funds activities that contribute to the advancement of capability to store, access, visualize, and share data and information about the integrated Earth-Human systems as well as fund the development of tools and scientific basis to support an integrated system of global change information to support decision making. This leverages much greater investments in collecting observational data.	245.1	261.6	263.1	USDA, DOC, HHS, DOT, NASA
GOAL 3: CONDUCT SUSTAINED ASSESSMENTS – Build sustained assessment capacity that improves the Nation’s ability to understand, anticipate, and respond to global change impacts and vulnerabilities.		34.0	29.7	34.7	USDA, DOC, HHS, DOI, EPA
<i>Conduct Sustained Assessments</i>	Funds activities that contribute to building a sustained assessment capacity that improves the nation’s ability to understand, anticipate, and respond to global change impacts and vulnerabilities	34.0	29.7	34.7	USDA, DOC, HHS, DOI, EPA
GOAL 4: COMMUNICATE AND EDUCATE – Advance communication and education to broaden public understanding of global change and develop the scientific workforce of the future.		11.0	11.6	9.8	USDA, DOC, DOE, HHS, NSF, SI
<i>Communicate and Educate</i>	Funds activities that contribute to advancing communications and education to broaden public understanding of global change, and develop the scientific workforce of the future	11.0	11.6	9.8	USDA, DOC, DOE, HHS, NSF, SI
USGCRP BUDGET CROSSCUT TOTAL		2490.2	2511.0	2685.5	USDA, DOC, DOE, HHS, DOI, DOT, EPA, NASA, NSF, SI, USAID

4.3 BUDGET BY AGENCY & PROGRAM ELEMENT

Table 3: FY 2011-2013 U.S. Global Change Research Program Budget by Agency and Program Element

FY 2011 Budget Enacted	Goal & Program Element							
Agency Name	GOAL 1			GOAL 2		GOAL 3	GOAL 4	TOTALS
	Integrated Earth Observations	Multidisciplinary Scientific Understanding of Earth Systems	Integrated Earth System Modeling	Adaptation Science	Global Change Information	Conduct Sustained Assessments	Communicate and Educate	
USDA	2.2	35.4	3.26	27.7	1.8	12.4	3.2	85.9
DOC	121.6	85.6	31.2	31.4	62.4	7.0	2.7	341.9
DOE	50.0	57	79.3	0.0	0.0	0.0	0.2	186.5
HHS	0.7	3.2	0.0	0.5	0.9	0.4	0.3	6.0
DOI	0.0	28.5	0.0	25.9	0.0	10.0	0.0	64.3
DOT	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.6
EPA	1.5	8.9	0.0	5.8	0.0	4.2	0.0	20.5
NASA	995.0	256.0	0.0	0.0	180.0	0.0	0.0	1431.0
NSF	81.0	185.5	40.3	10.0	0.0	0.0	4.5	321.3
SI	0.3	6.5	0.0	0.0	0.0	0.0	0.2	7.0
USAID	0.0	0.0	0.0	25.0	0.0	0.0	0.0	25.0
PROGRAM ELEMENT TOTALS	1252.3	667.3	154.1	126.3	245.1	34.0	11.1	2490.2
GOAL TOTALS	2073.7			371.4		34.0	11.1	
FY 2012 Budget Enacted	Goal & Program Element							
Agency Name	GOAL 1			GOAL 2		GOAL 3	GOAL 4	TOTALS
	Integrated Earth Observations	Multidisciplinary Scientific Understanding of Earth Systems	Integrated Earth System Modeling	Adaptation Science	Global Change Information	Conduct Sustained Assessments	Communicate and Educate	
USDA	2.4	46.7	9.3	42.4	1.2	9.0	4.1	115.0
DOC	135.9	69.6	30.5	19.6	63.5	5.1	2.3	326.5
DOE	71.0	66.0	74.3	0.0	0.0	0.0	0.2	211.5
HHS	0.7	3.2	0.0	0.5	0.9	0.4	0.3	6.0
DOI	0.0	22.0	0.0	27.9	0.0	9.0	0.0	58.9
DOT	0.0	1.4	0.0	0.0	0.0	0.0	0.0	1.4
EPA	1.5	7.5	0.0	3.1	0.0	6.2	0.0	18.3
NASA	928.0	298.0	0.0	0.0	196.0	0.0	0.0	1422.0
NSF	81.4	198.2	39.3	10.0	0.0	0.0	4.5	333.4
SI	0.7	7.1	0.0	0.0	0.0	0.0	0.2	8.0
USAID	0.0	0.0	0.0	10.0	0.0	0.0	0.0	10.0
PROGRAM ELEMENT TOTALS	1221.6	719.7	153.4	113.5	261.6	29.7	11.6	2511.0
GOAL TOTALS	2094.7			375.1		29.7	11.6	

Table 3 (continued)

FY 2013 Budget Requested	Goal & Program Element							
	GOAL 1			GOAL 2		GOAL 3	GOAL 4	TOTALS
Agency Name	Integrated Earth Observations	Multidisciplinary Scientific Understanding of Earth Systems	Integrated Earth System Modeling	Adaptation Science	Global Change Information	Conduct Sustained Assessments	Communicate and Educate	
USDA	2.2	48.0	9.0	46.1	0.9	11.6	4.8	122.56
DOC	146.0	76.8	39.0	24.3	67.3	7.7	2.8	363.9
DOE	74.0	78.0	78.3	0.0	0.0	0.0	0.2	230.53
HHS	0.7	3.2	0.0	0.5	0.9	0.4	0.3	6.05
DOI	0.0	23.2	0.0	35.1	0.0	9.4	0.0	67.741
DOT	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.52
EPA	1.8	9.1	0.0	3.9	0.0	5.6	0.0	20.27
NASA	1040.0	288.0	0.0	0.0	194.0	0.0	0.0	1522
NSF	83.0	194.9	38.8	14.8	0.0	0.0	1.5	332.91
SI	0.7	7.1	0.0	0.0	0.0	0.0	0.2	8.0
USAID	0.0	0.0	0.0	10.0	0.0	0.0	0.0	10.0
PROGRAM ELEMENT TOTALS	1348.4	729.8	165.1	134.7	263.1	34.7	9.8	2685.5
GOAL TOTALS	2243.3			397.8		34.7	9.8	



OUR CHANGING PLANET





APPENDIX A: OVERVIEW OF USGCRP

USGCRP was established by Presidential initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 in order to “assist the nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”²⁸

USGCRP operates as a unified Federal program that integrates the global change research capacities of thirteen Federal agencies and departments (Figure 1). The Program promotes close interagency coordination and streamlined development, translation, and deployment of scientific information related to global change.

Over several decades, USGCRP research has substantially improved our understanding of global environmental changes and their effects on society. The Program continues to expand this fundamental understanding and supply scientific information to inform the Nation’s response to global change.

A.1 VISION & MISSION

Vision – *A nation, globally engaged and guided by science, meeting the challenges of climate and global change*

Mission – *To build a knowledge base that informs human responses to climate and global change through coordinated and integrated Federal programs of research, education, communication, and decision support*

²⁸ See <http://library.globalchange.gov/>.

A.2 PROGRAM GOVERNANCE & MANAGEMENT

USGCRP is steered by the Subcommittee on Global Change Research (SGCR) of the National Science and Technology Council’s Committee on Environment, Natural Resources and Sustainability and overseen by the White House Office of Science and Technology Policy (Figure 19).

In consultation with White House officials and the SGCR, USGCRP’s Executive Director ensures that USGCRP meets all mandated requirements (Table A.1).

USGCRP works closely with the SGCR and White House offices to establish research priorities in alignment with national priorities, budgetary planning, and GCRA requirements. The Program also coordinates with other Federal interagency bodies such as the National Ocean Council (NOC), the Interagency Climate Change Adaptation Task Force (ICCATF), and other Subcommittees of the CENRS to ensure that USGCRP’s work can be leveraged by other Federal groups working to prepare for or minimize the impacts of global change.

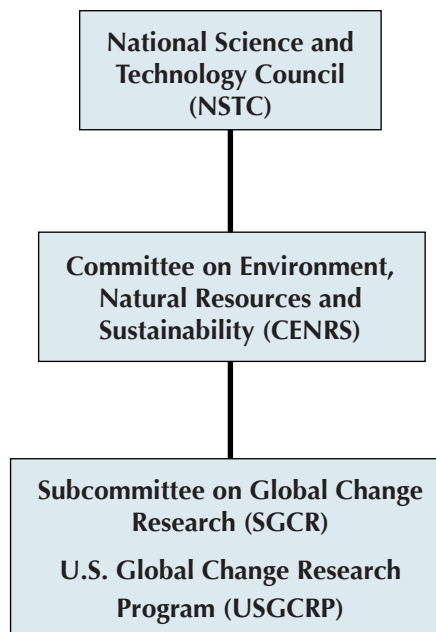


Figure 19: USGCRP Governance Structure

Table A.1: Global Change Research Act (GCRA) of 1990 Requirements

Requirement	Global Change Research Act of 1990 Requirement Description
Program Governance	Serve as the forum for developing the National Global Change Research Plan and for overseeing its implementation.
Global Change Research Coordination	Improve cooperation among Federal agencies and departments with respect to global change research activities.
Budget Coordination	Provide budgetary guidance and advice as specified in section 105 of the GCRA.
Programmatic Review	Work with academic, State, industry, and other groups conducting global change research, to provide for periodic public and peer review of the Program.
International Research and Cooperation	Cooperate with the Secretary of State in: (i) providing representation at international meetings and conferences on global change research in which the U.S. participates; and (ii) coordinating the Federal activities of the U.S. with programs of other nations and with international global change research activities.
Inform Response to Global Change	Consult 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.
Annual Report	Report at least annually to the President and the Congress, through the OSTP Director, on Federal global change research priorities, policies, and programs.
National Global Change Research Plan	The Plan shall contain recommendations for national global change research...and establish the goals and priorities for Federal global change research. A revised Plan shall be submitted at least once every three years.
Quadrennial Assessment	Prepare and submit to the President and the Congress an assessment which (1) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings; (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

A.3 PLANNING & PRIORITIZATION

USGCRP is currently developing a three-year implementation roadmap that describes near- and medium-term priorities as well as steps needed to accomplish longer-term goals. The roadmap will be updated periodically and will be used to inform development of a Revised Research Plan (RRP) for public comment and publication every three years. These triennial updates, which are mandated by the Global Change Research Act, will be based upon self-evaluation and external evaluation and will reflect changing conditions and new information. The Program will continue to consult the National Research Council (NRC) for independent scientific perspectives and report progress to Congress and the public annually in *Our Changing Planet*.

The Global Change Research Act (section 105) sets requirements for USGCRP to develop interagency priorities that are linked to annual budget development. Each year, the SGCRC develops a set of global change research funding priorities by identifying Program activities that fill critical scientific gaps or address evolving societal needs. These priorities are

communicated in a memo that is used by USGCRP agencies as guidance in their individual budgetary and prioritization processes. The memo also provides a framework for effective communication between the SGCRC and the White House Office of Management and Budget (OMB) on the topic of global change research. Detailed information about annual prioritization criteria is provided in the new 10-year Research Plan.²⁹

A.4 ORGANIZATION

The Global Change Research Act mandates the development of a 10-year *National Global Change Research Plan* for USGCRP. The previous such Plan was published in 2003. The Plan for 2012–2021 identifies seven new programmatic and budgetary categories, or “Program Elements,” that are described in Table A.2.

²⁹ USGCRP, 2012. National Global Change Research Plan 2012–2021: A Strategic Plan for the U.S. Global Change Research Program <http://library.globalchange.gov/u-s-global-change-research-program-strategic-plan-2012-2021>

Table A.2: Description of Program Elements

2012 Strategic Plan Program Elements	Budgetary Definition
Program Element 1: Integrated Observations	Funds capabilities to observe the physical, chemical, biological, and human components of the Earth system over multiple space and time scales to gain fundamental scientific understanding and monitor important variations and trends.
Program Element 2: Multidisciplinary Earth and Human System Understanding	Funds research that contributes to advancing the fundamental understanding of the physical, chemical, biological, and human components of the Earth system, and the interactions among them, to improve knowledge of the causes and consequences of global change.
Program Element 3: Integrated Modeling	Funds activities that contribute to improving and developing advanced models that integrate across the physical, chemical, biological, and human components of the Earth system, including the feedbacks among them, to represent more comprehensively and predict more realistically global change processes.
Program Element 4: Science of Adaptation and Science to Inform Adaptation Decisions	Funds activities that contribute to improving the research, application, and deployment of science that is specifically designed to inform adaptation decisions.
Program Element 5: Global Change Information	Funds activities that contribute to the advancement of capability to store, access, visualize, and share data and information about the integrated Earth-Human systems, as well as fund the development of tools and scientific basis to support an integrated system of global change information, informed by sustained, relevant, and timely data and information to support decision making.
Program Element 6: Assessments	Funds activities that contribute to building a sustained assessment capacity that improves the nation's ability to understand, anticipate, and respond to global change impacts and vulnerabilities.
Program Element 7: Communication and Education	Funds activities that contribute to advancing communications and education to broaden public understanding of global change, and develop the scientific workforce of the future.

Table A.3 illustrates USGCRP’s budget crosscut areas for FY 2010–2013 and their alignment with the strategic goals described in USGCRP’s new *National Global Change Research Plan* for 2012–2021. This alignment is critical to ensuring continuity of progress, ongoing support for priority efforts, and overall endurance of the Program.

A.5 OPERATIONS

USGCRP’s primary mechanism for interagency coordination is a set of interagency working groups made up of individuals from USGCRP’s 13 member agencies and staff from the Program’s National Coordination Office. USGCRP

has recently developed a revised portfolio of interagency working groups to align with the new Research Plan for 2012–2021, and is increasing the involvement of interagency working groups in priority setting activities. The revised portfolio will be evaluated periodically and modified as interim goals and objectives are accomplished. Table A.4 lists the current portfolio of interagency working groups and their corresponding activity areas.

A.6 PURPOSE OF THIS REPORT

Since 1989, USGCRP has submitted annual reports to Congress called *Our Changing Planet*. The reports describe

Table A.3: Budget Crosscut Areas for FY 2010, FY2011, & FY2013

FY 2010 Budget Crosscut Areas (based on 2003 Strategic Plan Goals)	FY 2011 Budget Crosscut Areas (based on Transitional Focus Areas)	FY 2013 Budget Crosscut Areas (based on 2012 Strategic Plan Program Elements)	2012–2021 New Strategic Goals
Goal 1: Improve knowledge of the Earth’s past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and changes	Focus Area 1: Improving our knowledge of Earth’s past and present climate variability and change	Program Element 1: Integrated Observations	Goal 1 - Advance Science: Advance scientific knowledge of the integrated natural and human components of the Earth system
Goal 2: Improve quantification of the forces bringing about changes in the Earth’s climate and related systems	Focus Area 2: Improving our understanding of natural and human forces of climate change	Program Element 2: Multidisciplinary Earth and Human System Understanding	
Goal 3: Reduce uncertainty in projections of how the Earth’s climate and related systems may change in the future	Focus Area 3: Improving our capability to model and predict future conditions and impacts	Program Element 3: Integrated Modeling	
Goal 5: Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change	Focus Area 5: Providing climate information and decision support tools	Program Element 4: Science of Adaptation and Science to Inform Adaptation Decisions	Goal 2 - Inform Decisions: Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation
		Program Element 5: Global Change Information	
Goal 4: Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes	Focus Area 4: Assessing the nation’s vulnerability to current and anticipated impacts of climate change	Program Element 6: Assessments	Goal 3 - Conduct Sustained Assessments: Build sustained assessment capacity that improves the nation’s ability to understand, anticipate, and respond to global change impacts and vulnerabilities
N/A	Focus Area 6: Climate Change Communication and Education	Program Element 7: Communication and Education	Goal 4 - Communicate and Educate: Advance communications and education to broaden public understanding of global change, and develop the scientific workforce of the future

the status of USGCRP research activities, provide progress updates, and document recent accomplishments. This FY 2013 edition of *Our Changing Planet* provides a summary of programmatic achievements, recent progress, future priorities, and budgetary information. It thereby meets the requirements set forth in the U.S. Global Change Research Act of 1990 (GCRA; Section 102, P. L. 101-606) to provide an annual report on “*Federal global change research priorities, policies, and programs.*”

Table A.4: USGCRP Interagency Working Groups (IWGs)

2012 Strategic Plan Program Elements, International, and Crosscutting Initiatives	USGCRP Interagency Working Group
Program Element 1: Integrated Observations	Integrated Observations IWG
Program Element 2: Multidisciplinary Earth and Human System Understanding	Process Research IWG Carbon Cycle Interagency Working Group (CCIWG)
Program Element 3: Integrated Modeling	Interagency Group on Integrated Modeling (IGIM)
Program Element 4: Science of Adaptation and Science to Inform Adaptation Decisions	Adaptation Science Workgroup
Program Element 5: Global Change Information	Global Change Information System (GCIS)
Program Element 6: Assessments	Interagency National Climate Assessment (INCA) IWG
Program Element 7: Communication and Education	Interagency Communications and Education Team (ICE-t)
International Research and Cooperation	International Research and Cooperation IWG
USGCRP Crosscutting Initiative	Climate Change and Human Health Group (CCHHG)

Full descriptions of each working group are provided in Appendix B: USGCRP Interagency Working Groups.

APPENDIX B: USGCRP INTERAGENCY WORKING GROUPS (IWGS)

B.1 ADVANCE SCIENCE

Integrated Observations Interagency Working Group

A new Integrated Observations IWG Scoping Team is coordinating agency activities to sustain essential Earth observations capabilities and achieve more comprehensive, integrated Earth observations in the future.

The first activity for this Team is to coordinate, along with the U.S. Group on Earth Observations, is to support National Earth Observations (NEO) Task Force activities by assessing critical observations of “Climate and Related Global Change.” This will require coordinate evaluation of the importance and performance of current observational capabilities and assets in the context of strategic Earth observations objectives.

Process Research Interagency Working Group

USGCRP’s Process Research IWG helps identify and prioritize scientific issues that require an integrated, coordinated response and fosters linkages with other IWG’s to ensure that the Program’s Advance Science portfolio is as integrated as possible. Specifically, the Process Research IWG is coordinating the following activities:

- Develop a research framework for Objectives 1.1 and 1.2 of USGCRP’s new decadal Research Plan and explore pathways for implementing such a framework;
- Plan a workshop to refine this research framework and organize an initial set of work teams to begin implementation;
- Define a set of high-priority activities and key near-term deliverables; and
- Ensure sustained flexibility to evolve as needed and deliver on new priorities as they emerge.

Interagency Group on Integrated Modeling

USGCRP’s Interagency Group on Integrated Modeling (IGIM) is charged with coordinating global-change related modeling activities across the Federal government and providing guidance to USGCRP on modeling priorities. The 10 Federal Agencies that participate in the IGIM engage on range of relevant topics, including physical models of the Earth system, socioeconomic models of human systems and their interactions with the Earth system, as well as impacts models.

Carbon Cycle Interagency Working Group

USGCRP’s Carbon Cycle Interagency Working Group (CCIWG) coordinates carbon cycle research funded by USGCRP member agencies. Because the carbon cycle and changes to the carbon cycle are associated with a wide range of global change research needs, the CCIWG works closely with other interagency working groups and engages with international partners. CCIWG works to establish priorities for carbon cycle science and evaluate needs emerging from new findings and observations. Currently, CCIWG coordinates work to advance the following priorities:

- Explain past and current variations in observed atmospheric concentrations of the major carbon-containing greenhouse gases (CO₂ and methane);
- Understand and quantify socioeconomic drivers of carbon emissions;
- Develop transparent methods to monitor and verify both natural and anthropogenic carbon emissions;
- Assess and evaluate the vulnerability of carbon fluxes and stocks under future conditions of global change and human activities;
- Predict the effects of different CO₂ and climate change scenarios on biodiversity, ecosystems, and natural resources, including potential positive feedbacks to the climate system;
- Assess the effectiveness and potential for unintended consequences of carbon management options that may be undertaken to mitigate GHG emissions and climate change; and
- Address needs of decision makers of all levels for useable data, information, models, projections, and decision support tools.

B.2 INFORM DECISIONS

Adaptation Science Workgroup

In 2009, the Obama Administration convened an Interagency Climate Change Adaptation Task Force (ICCATF), including participation from more than 20 Federal agencies. Shortly thereafter, President Obama signed Executive order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” directing the ICCATF to recommend ways the Federal government can strengthen the Nation’s ability to adapt to the impacts of climate change.

USGCRP’s Adaptation Science Workgroup works to ensure that Federal science effectively informs adaptation decisions at a range of scales, in diverse sectors. It also provides scientific support to agencies in the adaptation planning process. Specifically, USGCRP’s Adaptation Science Workgroup is leading the following efforts:

- Identification of existing capabilities and critical gaps in science for informing adaptation decisions and policies;
- Improvement of the application and translation of science to meet the needs of decision makers;
- Advancement of the social, behavioral, and economic sciences needed to visualize, analyze, and understand adaptation options; and
- Guidance for evaluating the effectiveness of adaptive actions.

Global Change Information System Interagency Working Group

The Global Change Information System IWG provides support, advice, and strategic guidance for developing and implementing an interagency Global Change Information System (GCIS). The GCIS itself is being developed as a federated data structure that bridges multiple data sources and formats from across USGCRP agencies and departments. It is intended to become a single web-based Global Change Web Portal that delivers authoritative, accessible, usable, and timely information for climate and global change for use by diverse audiences.

The GCIS IWG is a forum for agencies to discuss and agree upon metadata and interoperability standards for the GCIS as well as to share information and ensure that any related efforts are complementary. The key first task for the GCIS IWG is to inform implementation of a data system specifically focused on the 2013 National Climate Assessment—which will serve as a pilot for the larger GCIS.

B.3 CONDUCT SUSTAINED ASSESSMENTS

Interagency National Climate Assessment Working Group

The USGCRP’s Interagency National Climate Assessment (INCA) Working Group plays a vital role in coordinating, supporting, and implementing the Federal components of the assessment, including deploying essential research and infrastructure for a sustained assessment process and products. The INCA Working Group is responsible for coordinating, developing, and implementing an interagency operational plan for the NCA, providing critical input to identify and support future NCA products, and developing interagency assessment capacity at the national and regional scales. The INCA Working Group plans, coordinates, and implements the development of numerous technical products necessary for the assessment process, many of which have generated cutting-edge, interagency research on climate change science, impacts, and vulnerabilities. Under INCA leadership, the USGCRP agencies have hosted a wide range of expert and stakeholder workshops over the years in numerous regions and sectors to support the development of these technical products, advance assessment methodologies, and identify research needs.

B.4 COMMUNICATE & EDUCATE

Interagency Communication and Education Team

In April 2012, USGCRP launched a new Interagency Communications and Education Team (ICE-t). The ICE-t is made up of more than 100 self-selected volunteers from 12 Federal agencies who actually *do* climate communications—including press officers, writers, educators, park rangers, website designers, legislative affairs specialists, graphic designers, and other experts.

The ICE-t is organized as “community of practice” that is inherently *inclusive* (anyone in any agency can participate), *adaptive* (tasks, members, and leaders are able to evolve as needed), and *action-oriented* (there is a focus on near term, concrete, achievable tasks). An initial set of tentatively planned activities includes:

- Develop tools and strategies to link climate information on USGCRP agency websites;
- Increase use of social media to disseminate global change information to broad audiences;
- Develop communications material on relationships between extreme weather, climate events, and human-caused climate change for rapid deployment when an extreme weather event occurs;

- Support engagement activities related to the 2013 National Climate Assessment;
- Increase the application of social science research to Federal climate communications by inviting leading experts to engage with Federal communicators; and
- Apply communications expertise to the design of a Global Change Information System (GCIS).

B.5 INTERNATIONAL RESEARCH & COOPERATION

International Research and Cooperation Interagency Working Group

The International Research and Cooperation IWG advises and assists the Subcommittee on Global Change Research on advancing USGCRP's strategic goals through strategic international relationships, partnerships, and funding. The group is developing a portfolio of activities, priorities, and goals for USGCRP's international activities. Once the portfolio is established, the group will gradually transition into a working-level implementation and coordination.

B.6 CLIMATE CHANGE & HUMAN HEALTH

Climate Change and Human Health Group

The Interagency Crosscutting Group on Climate Change and Human Health (CCHHG) is charged with planning, coordinating, implementing, evaluating, and reporting on Federal research related to the human health impacts of global change. The ultimate goal is to ensure that communities are healthy and resilient to the impacts of climate change.

The CCHHG supports all four of USGCRP's new strategic goals and works to address key gaps in understanding of the human health-related impacts of global change. Specific activity areas include:

- **Adaptation**—including ongoing support for the Interagency Climate Change Adaptation Task Force;
- **Assessment**—including technical input and stakeholder engagement support for the development of the NCA reports;
- **Communication, Education, and Engagement**—including coordination with USGCRP's Interagency Communication & Education Team (ICE-t);

- **Data Integration**—including development of an interactive metadata clearinghouse (MATCH) of data sets, early warning systems, and monitoring tools related to the human health impacts of global climate change;
- **Joint Research and Funding Planning**—including development of a human health and climate change research framework, gap analysis, prioritization of research needs, and coordination of joint funding opportunities; and
- **International**—including review of International human health adaptation plans and assessments to capture lessons learned and engagement with the global health community on climate change and human health.

APPENDIX C: USGCRP MEMBER AGENCIES

This section summarizes the principal areas of focus related to global change research for each USGCRP member agency.

Department of Agriculture (USDA)

USDA's global change research program empowers land managers, policy makers, and Federal agencies with science-based knowledge to manage the risks and opportunities posed by climate change; reduce GHG emissions; and enhance carbon sequestration. USDA's global change research program includes contributions from the Agricultural Research Service (ARS), the National Institute of Food and Agriculture (NIFA), the Forest Service, Natural Resources Conservation Service (NRCS), National Agricultural Statistics Service (NASS), and Economic Research Service. This work is important to ensuring sustained food security for the nation and the world; maintaining and enhancing forest and natural resource health; and identifying risks to agricultural production from temperature and precipitation changes, pests, invasive species, and disease.

Specifically, USDA conducts assessments and projections of climate change impacts on agricultural and natural systems, and develops GHG inventories. USDA also develops cultivars, cropping systems, and management practices to improve drought tolerance and build resilience to climate variability. USDA promotes integration of USGCRP research findings into farm and natural resource management, and helps build resiliency to climate change by developing and deploying decision support. USDA maintains critical long-term data collection and observation networks, including the Snowpack Telemetry (SNOTEL) network, the Soil Climate Analysis Network (SCAN), the National Resources Inventory (NRI), and the Forest Inventory and Assessment (FIA). Finally, USDA also engages in communication, outreach, and education through multiple forums, including its vast network of agricultural extension services.

Department of Commerce (DOC)

NOAA and NIST comprise the DOC contribution to USGCRP.

NOAA's strategic climate goal is "an informed society anticipating and responding to climate and its impacts." NOAA's overall objective is to provide decision makers with a predictive understanding of the climate and to communicate climate information so that people can make more informed decisions in their lives, businesses, and communities. These outcomes are pursued by implementing a global observing system, conducting research to understand climate

processes, developing improved modeling capabilities, and developing and deploying climate educational programs and information services. NOAA aims to achieve its climate goal through the following strategic objectives:

- Improved scientific understanding of the changing climate system and its impacts;
- Assessments of current and future states of the climate system that identify potential impacts and inform science, service, and stewardship decisions;
- Mitigation and adaptation efforts supported by sustained, reliable, and timely climate services; and
- A climate-literate public that understands its vulnerabilities to a changing climate and makes informed decisions.

NIST works with other Federal agencies to develop or extend internationally accepted traceable measurement standards, methodologies, and technologies that enhance measurement capabilities for science-based GHG emission inventories and measurements critical to advancing climate science research. NIST provides measurements and standards that support accurate, comparable, and reliable climate observations and provides calibrations and special tests to improve the accuracy of a wide range of instruments and techniques used in climate research and monitoring. In FY 2009, NIST was included as a discrete element of USGCRP's budget crosscut to provide specific measurements and standards of direct relevance to the program.

Department of Defense (DoD)

DoD—while not supporting a formal mission dedicated to global change research—is developing policies and plans to manage and respond to the effects of climate change on DoD missions, assets, and the operational environment. Various research agencies within the DoD sponsor and undertake basic research activities that concurrently satisfy both national security requirements as well as the strategic goals of USGCRP. These include the Office of Naval Research (ONR), the Air Force Office of Scientific Research (AFOSR), the Army Research Office (ARO), and the Defense Advanced Research Projects Agency (DARPA). When applicable, the research activities of these agencies are coordinated with other Federally-sponsored research via USGCRP and other entities.

Because the performance of DoD systems and platforms are influenced by environmental conditions, understanding the variability of the Earth's environment and the potential for

change is of great interest to the Department. The DoD is responsible for the environmental stewardship of hundreds of installations throughout the U.S., and must continue incorporating geostrategic and operational energy considerations into force planning, requirements development, and acquisition processes. The DoD relies on the Strategic Environmental Research and Development Program (SERDP), a joint effort among DoD, DOE, and EPA, to develop climate change assessment tools and to identify the environmental variables that must be forecast with sufficient lead time to facilitate appropriate adaptive responses. Each service agency within the DoD incorporates the potential impact of global change into their long-range strategic plans. For example, the Navy's Task Force Climate Change (TFCC) assists in the development of science-based recommendations, plans, and actions to adapt to climate change. The USACE Engineer Research and Development Center (ERDC) Cold Regions Research and Engineering Laboratory (CRREL) also actively investigates the impacts of climate trends for USACE, Army, DoD and other agencies. The CRREL research program responds to the needs of the military, but much of the research also benefits the civilian sector and is funded by non-military customers such as NSF, NOAA, NASA, DOE, and state governments.

Department of Energy (DOE)

DOE's Office of Science supports fundamental research to understand the energy-environment-climate connection and its implications for energy production, use, sustainability, and security—with particular emphasis on the potential impact of increased anthropogenic emissions. The ultimate goal is to advance a robust predictive understanding of Earth's climate and environmental systems and to inform the development of sustainable solutions to the Nation's energy and environmental challenges.

Two DOE research areas focus on areas of uncertainty in Earth systems models: Atmospheric System Research (science of aerosols, clouds, and radiative transfer); and Terrestrial Ecosystem Science (role of terrestrial ecosystems and carbon cycle observations). DOE also collaborates with NSF to develop the widely used Community Earth System Model, supports methods to obtain regional climate information, integrates analysis of climate change impacts, and analyzes and distributes large climate datasets through the Program for Climate Model Diagnosis and Intercomparison and the Earth System Grid. The Department also supports the ARM Climate Research Facility, a scientific user facility that provides the research community with unmatched measurements permitting the most detailed high-resolution, three-dimensional documentation of evolving cloud, aerosol and precipitation characteristics in climate sensitive sites around the world.

Finally, DOE also conducts applied climate-related research through the CCTP, which is centered in DOE's Office of Policy and International Affairs. CCTP develops and utilizes energy-economic models, including integrated assessment models, to evaluate policies and programs that enable cost-effective GHG reductions and accelerate the development and deployment of clean energy technologies. As part of this mission CCTP supports work to characterize climate change impacts for use in policy analysis, vulnerability and adaptation assessment and agency rulemakings. DOE also conducts assessments of climate change on electric grid stability, water availability for energy production, and site selection of the next generation of renewable energy infrastructure.

Department of Health and Human Services (HHS)

The U.S. Department of Health and Human Services (HHS) supports a broad portfolio of research and decision support initiatives related to environmental health and the health effects of global climate change, primarily through the National Institutes of Health (NIH) and the Centers for Disease Control (CDC). Research focuses on the need to better understand the vulnerabilities of individuals and communities to climate-related changes in health risks such as heat-related morbidity and mortality, respiratory effects of altered air contaminants, changes in transmission of infectious diseases, and impacts in the aftermath of severe weather events, among many others. Research efforts also seek to assess the effectiveness of various public health adaptation strategies to reduce climate vulnerability, as well as the potential health effects of interventions to reduce GHG emissions.

Specifically, HHS supports USGCRP by conducting fundamental and applied research on linkages between climate change and health, translating scientific advances into decision support tools for public health professionals, conducting ongoing monitoring and surveillance of climate-related health outcomes, and engaging the public health community in two-way communication about climate change.

Department of the Interior (DOI)

USGS conducts global change research for DOI and comprises DOI's contribution to USGCRP.

USGS scientists work with other agencies to provide policy makers and resource managers with scientifically valid information and predictive understanding of global change and its effects with the ultimate goal of helping the Nation understand, adapt to, and mitigate global change.

Specifically, the USGS Climate and Land Use Change Research and Development Program supports research to understand processes controlling Earth system responses to global change and model impacts of climate and land-cover change on natural resources. USGS geographic analyses and land remote-sensing programs (such as the Landsat satellite mission and the National Land Cover Database) provide data that is used assess changes in land use, land cover, ecosystems, and water resources resulting from the interactions between human activities and natural systems. The science products and data sets from these programs are essential for conducting quantitative studies of carbon storage and GHG flux in the Nation's ecosystems.

USGS is also leading the establishment of regional Climate Science Centers that will provide science and technical support to region-based partners dealing with the impacts of climate change on fish, wildlife, and ecological processes.

Department of State (DOS)

Through DOS annual funding, the U.S. is the world's leading financial contributor to the United Nations Framework Convention on Climate Change (UNFCCC) and to the IPCC—the principal international organization for the assessment of scientific, technical, and socioeconomic information relevant to the understanding of climate change, its potential impacts, and options for adaptation and mitigation. Recent DOS contributions to these organizations provide substantial support for global climate observation and assessment activities in developing countries. DOS also works with other agencies in promoting international cooperation in a range of bilateral and multilateral climate change initiatives and partnerships.

Department of Transportation (DOT)

The Department of Transportation (DOT) conducts research to examine potential climate change impacts on transportation, methods for increasing transportation efficiency, and methods for reducing emissions that contribute to climate change. The U.S. DOT's Center for Climate Change and Environmental Forecasting coordinates transportation and climate change research, policies, and actions within DOT and promotes comprehensive approaches to reduce emissions, address climate change impacts, and develop adaptation strategies. DOT also contributes directly to USGCRP's National Climate Assessment through focused research such as the Center's Gulf Coast Studies.

The Federal Highway Administration, the Federal Transit Administration (FTA) and other DOT agencies are also undertaking climate impact and adaptation studies (including

vulnerability and risk assessments), working with science agencies to develop regional climate data and projections, methodological research, supporting pilot programs, and providing assistance to transportation stakeholders including State and local agencies. The Federal Aviation Administration (FAA), for example, conducts research to support USGCRP by working with NASA, NOAA, and EPA in the Aviation Climate Change Research Initiative (ACCRI) to identify and address key scientific gaps regarding aviation climate impacts and inform mitigation.

Other DOT initiatives address climate change and improve the sustainability of the U.S. transportation sector including: The FAA and NASA manage the Continuous Lower Energy, Emissions, and Noise (CLEEN) program as a government industry consortium to develop technologies for energy efficiency, noise and emissions reduction, and alternative fuels; and FAA participates in the Commercial Aviation Alternative Fuels Initiative (CAAIFI), a public-private coalition to encourage the development of alternative jet fuels.

Environmental Protection Agency (EPA)

The core purpose of EPA's Global Change Research Program is to develop scientific information that supports stakeholders, policy makers, and society at large as they respond to climate change and associated impacts on human health, ecosystems, and socioeconomic systems. EPA's research is driven by the Agency's mission and statutory requirements, and includes: (1) improving scientific understanding of global change effects on air quality, water quality, ecosystems, and human health in the context of other stressors; (2) assessing and developing adaptation options to effectively respond to global change risks, increase resilience of human and natural systems, and promote their sustainability; and (3) developing an understanding of the potential environmental impacts and benefits of GHG emission reduction strategies to support sustainable mitigation solutions. This research is leveraged by EPA Program Offices and Regions to support mitigation and adaptation, decisions and to promote communication with external stakeholders and the public.

EPA relies on USGCRP to develop high-quality scientific data and understanding about physical, chemical, and biological changes to the global environment and their relation to drivers of global change. EPA's Global Change Research Program connects these results to specific human and ecosystem health endpoints in ways that enable local, regional, and national decision makers to develop and implement strategies to protect human health and the environment. In turn, EPA's research provides USGCRP agencies with information about the connections between global change and local impacts and how local actions influence global changes.

Research activities include efforts to connect continental-scale temperature and precipitation changes to regional and local air quality and hydrology models to better understand the impacts of climate change on air quality and water quality, and to examine how watersheds will respond to large-scale climate and other global changes to inform decisions about management of aquatic ecosystems and expand understanding of the impacts of global change. Satellite and other observational efforts conducted by USGCRP are crucial to supporting EPA's efforts to understand how land use change, climate change, and other global changes are affecting watersheds and ecosystems, and the services they provide.

National Aeronautics and Space Administration (NASA)

As stated in the 2010 National Space Policy, NASA plays a crucial role in conducting global change research, ensuring sustained monitoring capabilities, and advancing scientific knowledge of the global integrated Earth system through satellite observations and satellite system development. As such, NASA fully supports USGCRP's new *National Global Change Research Plan* to advance science, inform decisions, conduct sustain assessments, and communicate and educate. NASA actively contributes to USGCRP's National Climate Assessment and provides roughly half of the funding for USGCRP as a whole.

NASA's global change activities have four integrated foci: satellite observations; technology development; research and analysis; and applications. Satellites provide critical global atmosphere, ocean, land, sea ice, and ecosystem measurements. NASA's sixteen on-orbit satellites measure numerous variables required to enhance understanding of Earth interactions. In February 2013, NASA launched the Landsat Data Continuity Mission (LDCM) satellite to measure land cover and evapotranspiration and is developing other satellites for launch in 2014 and beyond.

NASA's technology development efforts lead to new and enhanced space-based instruments and information technologies. Science research and analysis of satellite observations and model results improve predictability and knowledge of the global integrated Earth system. Airborne systems provide high resolution observations of variables relevant global change research—including polar seas and ice sheets; atmospheric composition; carbon storage and flux in the Arctic; hurricanes in the Atlantic Ocean; and root-zone soil moisture at different locales in North America.

National Science Foundation (NSF)

NSF addresses global change issues through investments that advance frontiers of knowledge, provide state-of-the-art instrumentation and facilities, develop new analytical methods, and enable cross-disciplinary collaborations while also cultivating a diverse, highly trained, workforce and developing resources for public education. In particular, NSF global change programs support the research and related activities to advance fundamental understanding of physical, chemical, biological, and human systems and the interactions among them. The programs encourage interdisciplinary approaches to studying Earth system processes and the consequences of change, including how humans respond to changing environments and the impacts on ecosystems and the essential services they provide. NSF programs promote the development and enhancement of models to improve understanding of integrated Earth system processes and to advance predictive capability. NSF also supports fundamental research on the processes used by organizations and decision makers to identify and evaluate policies for mitigation, adaptation, and other responses to the challenge of a changing and variable environment. Long-term, continuous and consistent observational records are essential for testing hypotheses quantitatively and are thus a cornerstone of global change research. NSF supports a variety of research observing networks that complement, and are dependent on, the climate monitoring systems maintained by its sister agencies.

NSF regularly collaborates with other USGCRP agencies to provide support for a range of multi-disciplinary research projects and is actively engaged in a number of international partnerships.

Smithsonian Institution (SI)

Within the Smithsonian Institution (SI), global change research is primarily conducted at the National Air and Space Museum, the National Museum of Natural History, the National Zoological Park, the Smithsonian Astrophysical Observatory, the Smithsonian Environmental Research Center, and the Smithsonian Tropical Research Institute. Research is organized around themes of atmospheric processes, ecosystem dynamics, observing natural and anthropogenic environmental change on multiple time scales, and defining longer term climate proxies present in the historical artifacts and records of the museums as well as in the geologic record. Most of these units participate in the Smithsonian Institution Group on Earth Observations (SIGEO) examining the dynamics of forests over decadal time frames.

The Smithsonian Grand Challenge Consortium for Understanding and Sustaining a Biodiverse Planet brings together researchers from around the Institution to focus on joint programs ranging from estimating volcanic emissions to ocean acidification measurement. Smithsonian paleontological research documents and interprets the history of terrestrial and marine ecosystems from 400 million years ago to the present. Other scientists study the impacts of historical environmental change on the ecology and evolution of organisms, including humans. Archaeobiologists examine the impact of early humans resulting from their domestication of plants and animals, creating the initial human impacts on planetary ecosystems.

These activities are joined by related efforts in the areas of history and art, such as the Center for Folklife and Cultural History, the National Museum of the American Indian, and the Cooper Hewitt Museum of Design to examine human responses to global change, within communities, reflected in art and culture, food and music. Finally, Smithsonian outreach and education expands our scientific and social understanding of processes of change and represents them in exhibits and programs, including at the history and art museums of the Smithsonian. USGCRP funding enables the Smithsonian to leverage private funds for additional research and education programs on these topics.

U.S. Agency for International Development (USAID)

The USAID supports programs that enable decision makers to apply high-quality climate information to decision making. USAID's climate change and development strategy calls for enabling countries to accelerate their transition to climate resilient, low emission sustainable economic development through direct programming and integrating climate change adaptation and mitigation objectives across the Agency's development portfolio. USAID is the lead contributor to bilateral assistance, with a focus on capacity building, civil society building, and governance programming, and creating the legal and regulatory environments needed to address climate change. USAID leverages scientific and technical resources from across the government (e.g., NASA, NOAA, USDA, USGS) as it applies its significant technical expertise to provide leadership in development and implementation of low-emissions development strategies, creating policy frameworks for market-based approaches to emission reduction and energy sector reform, promoting sustainable management of agriculture lands and forests, and mainstreaming adaptation into development activities in countries most at risk. USAID has long-standing relationships with host country governments that enable it to work together to develop shared priorities and implementation plans. USAID's engagement and expertise in agriculture,

biodiversity, infrastructure, and other critical climate sensitive sectors provide an opportunity to implement innovative cross-sectoral climate change programs. Finally, USAID bilateral programs work in key political and governance areas where multilateral agencies cannot.

APPENDIX D: GLOSSARY & ACRONYMS

D.1 DEFINITION OF KEY TERMS

Adaptation: Adjustment in natural or *human systems* to a new or changing environment that exploits beneficial opportunities and moderates negative impacts.

Adaptation Science: Integrated scientific research that directly contributes to enabling adjustments in natural or human systems to a new or changing environment and that exploits beneficial opportunities or helps moderate negative effects.

Adaptive management: Operational decisions, principally for managing entities that are influenced by *climate variability* and change. These decisions can apply to the management of infrastructure (e.g., a wastewater treatment plant), the integrated management of a natural resource (e.g., a watershed), or the operation of societal response mechanisms (e.g., human health alerts, water restrictions). *Adaptive management* operates within existing policy frameworks or uses existing infrastructure, and the decisions usually occur on time scales of a year or less.

Aerosols: Fine solid or liquid particles suspended in a gas. *Aerosols* may be of either natural or *anthropogenic* origin.

Anthropogenic: Resulting from or produced by human beings.

Assessments: Processes that involve analyzing and evaluating the state of scientific knowledge (and the associated degree of scientific certainty) and, in interaction with users, developing information applicable to a particular set of issues or decisions.

Atmosphere: The gaseous envelope surrounding Earth.

Belmont Forum: A collaborative mechanism among international organizations, such as the International Council for Science (ICSU), and national funding agencies to identify GCR priorities that might benefit from better cooperation and how best to address these.

Biodiversity: The total diversity of all organisms and ecosystems at various spatial scales.

Biomass: The total mass of living organisms in a given area or volume.

Biosphere: The part of the Earth system comprising all ecosystems and living organisms, in the *atmosphere*, on land or in the ocean, including derived dead organic matter, such as litter, soil organic matter, and oceanic detritus.

Carbon cycle: The term used to describe the flow of carbon (in various forms, e.g., as carbon dioxide, calcium carbonate) through the *atmosphere*, ocean, terrestrial *biosphere*, and *lithosphere*.

Carbon sequestration: The process of increasing the carbon content of a carbon reservoir other than the atmosphere.

Climate: The mean and variability of relevant measures of the *atmosphere*-ocean system over periods ranging from weeks to thousands or millions of years.

Climate change: A statistically significant variation in either the mean state of the climate or in its *variability*, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or to external forcing, including changes in solar radiation and volcanic eruptions, or to persistent human-induced changes in atmospheric composition or in land use. See also *climate variability*.

Climate model: A numerical representation of the *climate system* based on the mathematical equations governing the physical, chemical and biological properties of its components and including treatment of key physical processes and interactions, cast in a form suitable for numerical approximation making use of computers.

Climate prediction: A *climate* prediction or climate forecast is the result of an attempt to produce an estimate of the actual evolution of the climate – including weather variations – in the future, for example, at seasonal, interannual, or long-term timescales.

Climate projection: A projection of the response of the climate system to emission or concentration scenarios of *greenhouse gases* or *aerosols*, or *radiative forcing scenarios*, often based upon simulations by *climate models*. Climate projections are distinguished from *climate predictions* in order to emphasize that climate projections depend upon the *emission/concentration/radiative forcing* scenario used, which are based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized and are therefore subject to substantial uncertainty.

Climate scenario: A plausible and often simplified representation of the future *climate*, based on an internally consistent set of climatological relationships, that has been constructed for explicit use in investigating the potential consequences of *anthropogenic climate change*, often serving as input to impact models.

Climate system: The highly complex system consisting of five major components: the *atmosphere*, the hydrosphere, the cryosphere, the land surface, and the *biosphere*, and the interactions among them.

Climate variability: Variations in the mean state and other statistics (such as the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual *weather* events. These variations are often due to internal processes within the *climate system* (internal variability), or to variations in natural or *anthropogenic* external forcing (external variability).

Committee on Environment, Natural Resources, and Sustainability (CENRS): A subcommittee of the *National Science and Technology Council* (NSTC) established to assist the NSTC in increasing the overall productivity and application of Federal research and development efforts in the areas of environment, natural resources, and sustainability, and to provide a formal mechanism for interagency coordination in these areas. CENRS encompasses the *Subcommittee on Global Change Research*, the steering committee of the *U.S. Global Change Research Program*.

Decision support: The provision of timely and useful information that addresses specific questions.

Downscaling: A method that derives local- to regional-scale (10 to 100 km) information from larger-scale (100 to 1000 km) models or data analyses.

Earth system: The unified set of physical, chemical, biological, and social components, processes and interactions that together determine the state and dynamics of planet Earth.

Earth System Modeling Framework: Open-source software for building and coupling weather, climate, and related models.

Ecosystem: A system of living organisms interacting with each other and their physical environment as an ecological unit.

Ecosystem services: The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. Examples include provision of clean water, maintenance of liveable climates, pollination of crops and native vegetation, and fulfillment of people's cultural, spiritual, intellectual needs.

Emissions: In the *climate change* context, emissions refer to the release of radiatively or chemically active substances (e.g., *greenhouse gases* and/or their precursors, *aerosols*) into the atmosphere over a specified area and period of time.

End-to-end: The nature of research needed to address the *climate* and *global change* issue, from understanding causes and processes to supporting actions needed to cope with the impending societal problems of climate and global change.

Extreme weather event: An event that is rare at a particular place and time of year. Definitions of "rare" vary, but an extreme *weather* event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density of weather events.

Feedback: An interaction mechanism between processes such that the result of an initial process triggers changes in a second process and that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it.

Fiscal Year (FY): A period used for calculating annual ("yearly") financial statements in the Federal government.

General Circulation (GCM) or Atmosphere/Ocean Global Climate Model: A numerical representation of the *climate system* based on the physical and chemical properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties.

Geo-engineering: Deliberate large-scale manipulation of the planetary environment as a strategy to counteract *anthropogenic* climate change.

Global change: Changes in the global environment (including alterations in *climate*, land productivity, oceans or other water resources, atmospheric composition and/or chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life.

Global change information system: An information system that establishes data interfaces and interoperable repositories of *climate* and *global change* data which can be easily and efficiently accessed, integrated with other data sets, maintained over time and expanded as needed into the future.

Global change research: Study, monitoring, assessment, prediction, and information management activities to describe and understand the interactive physical, chemical, and biological processes that regulate the total *Earth system*; the unique environment that the Earth provides for life; changes that are occurring in the *Earth system*; and the manner in which such system, environment, and changes are influenced by human actions.

Global Change Research Act (GCRA; Section 102, P. L. 101-606): A 1990 act establishing the *U.S. Global Change Research Program*, an interagency program aimed at understanding and responding to global change, including the cumulative effects of human activities and natural processes on the environment, to promote discussions toward international protocols in global change research, and for other purposes.

Global Earth Observing System of Systems (GEOSS): A "system of systems" linking together existing and planned *observing systems* around the world and promoting common technical standards so that data from thousands of different instruments can be combined into coherent data sets.

Global Framework for Climate Services: An outcome of the World Climate Conference (WCC-3) of the United Nations World Meteorological Organization, with the goal of the development and provision of relevant science-based climate information and prediction for climate risk management and adaptation to climate variability and change, throughout the world.

Greenhouse effect: Trapping and build-up of infrared radiation (heat) in the *atmosphere* (troposphere) near the Earth's surface. Some of the heat flowing back toward space from Earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward Earth's surface. If the atmospheric concentrations of these *greenhouse gases* rise, the average temperature of the lower atmosphere will gradually increase.

Greenhouse gas (GHG): Any gas that absorbs infrared radiation (heat) in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, hydrochlorofluorocarbons, ozone, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

Human system: Any system in which human organizations play a major role. Often, but not always, the term is synonymous with 'society' or 'social system' e.g., agricultural system, political system, technological system, or economic system.

Human-natural system: Integrated systems in which human and natural components interact, such as the interaction between socioeconomic and biophysical processes in urban ecosystems.

In situ: Measurements obtained through instruments that are in direct contact with the subject (e.g., a soil thermometer), as opposed to those collected by remote instruments (e.g., a radar altimeter).

Integrated Assessment Models: A method of analysis that combines results and models from the physical, biological, economic, and social sciences, and the interactions between these components, in a consistent framework, to evaluate the status and consequences of environmental change and the policy responses to it.

Intergovernmental Panel on Climate Change (IPCC): An international scientific body for the assessment of *climate change*, established by the United Nations Environmental Programme and the United Nations World Meteorological Organization.

IPCC AR4: The fourth in a series of assessment reports by the *Intergovernmental Panel on Climate Change*, intended to assess the most recent scientific, technical, and socioeconomic information produced worldwide concerning *climate change*, its potential effects, and options for *adaptation* and *mitigation*.

IPCC AR5: The fifth in a series of assessment reports by the *Intergovernmental Panel on Climate Change*, intended to assess the socioeconomic aspects of climate change and implications for sustainable development, risk management, and the framing of a response through both *adaptation* and *mitigation*.

Land cover: The land surface covering, including areas of vegetation (forests, shrub lands, crops, deserts, lawns), bare soil, developed surfaces (paved land, buildings), and wet areas and bodies of water (watercourses, wetlands).

Landsat Program: The Landsat Program is a series of Earth-observing satellite missions jointly managed by NASA and the U.S. Geological Survey.

Land use: The total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation).

Land use and land cover change: A change in the use or management of land by humans that may lead to a change in land cover.

Metadata: Information about meteorological and climatological data concerning how and when they were measured, their quality, known problems, and other characteristics.

Mitigation (climate change): An intervention to reduce the sources or enhance the sinks of *greenhouse gases* and other climate forcing agents. This intervention could include approaches devised to reduce *emissions of greenhouse gases* to the *atmosphere*; to enhance their removal from the atmosphere through storage in geological formations, soils, biomass, or the ocean.

Monitoring: A scientifically designed system of continuing standardized measurements and observations and the evaluation thereof. Monitoring is specifically intended to continue over long time periods.

National Academy of Sciences (NAS): An honorific society of distinguished scholars engaged in scientific and engineering research established by an Act of Congress in 1863, which calls upon the NAS to “investigate, examine, experiment, and report upon any subject of science or art” whenever called upon to do so by any department of the government.

National Climate Assessment (NCA): An assessment conducted under the auspices of the Global Change Research Act of 1990, which requires a report to the President and the Congress every four years that evaluates, integrates and interprets the findings of the *U.S. Global Change Research Program*.

National Research Council (NRC): An arm of the *National Academy of Sciences* that forms committees to enlist the nation’s top scientists, engineers, and other experts to provide independent advice to the government on matters of science, technology, and medicine.

National Science and Technology Council (NSTC): A Cabinet-level Council established by Executive Order 12881 that is the principal means within the executive branch to coordinate science and technology policy across the diverse entities that make up the Federal research and development enterprise.

Observations: Measurements (either continuing or episodic) of variables in *climate* and related systems.

Observing system: A coordinated series of instruments for long-term observations of the land surface, *biosphere*, solid Earth, *atmosphere*, and/or oceans to improve understanding of Earth as an integrated system.

Ocean acidification: The phenomenon in which the pH of the ocean becomes more acidic due to increased levels of carbon dioxide in the atmosphere from human activities, which, in turn, increase the amount of dissolved carbon dioxide in seawater. Ocean acidification may lead to reduced calcification rates of calcifying organisms such as corals, mollusks, algae and crustacea.

Office of Science and Technology Policy (OSTP): A division of the Executive Office of the President (EOP) established by Congress in 1976 with a broad mandate to advise the President and others within the EOP on the effects of science and technology on domestic and international affairs. The 1976 Act also authorizes OSTP to lead interagency efforts to develop and implement sound science and technology policies and budgets, and to work with the private sector, state and local governments, the science and higher education communities, and other nations toward this end.

Ozone: A very active colorless gas consisting of three atoms of oxygen, readily reacting with many other substances.

Permafrost: Ground (soil or rock and including water, ice, and organic material) that remains at or below freezing for at least two consecutive years.

Prediction: A probabilistic description or forecast of a future *climate* outcome based on *observations* of past and current climatological conditions and quantitative models of climate processes (e.g., a prediction of an El Niño event).

Projection: A description of the response of the *climate system* to an assumed level of future *radiative forcing*. Climate “projections” are distinguished from climate “predictions” in order to emphasize that climate projections depend on *scenarios* of future socioeconomic, technological, and policy developments that may or may not be realized.

Practical Salinity Units (PSU): Used to describe the concentration of dissolved salts in water, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Practical Salinity Scale of 1978 (PSS78) defines salinity in terms of a conductivity ratio, so it is dimensionless. Salinity was formerly expressed in terms of parts per thousand (ppt) or by weight (parts per thousand or 0/00). That is, a salinity of 35 ppt meant 35 pounds of salt per 1,000 pounds of seawater. Open ocean salinity is generally in the range from 32 to 37.

Radiative forcing: A process that directly changes the average energy balance of the Earth-atmosphere system by affecting the balance between incoming solar radiation and outgoing radiation. A positive forcing warms the surface of the Earth and a negative forcing cools the surface.

Remote sensing: The technique of obtaining information about objects through the analysis of data collected by instruments that are not in physical contact with the object of investigation. In the climate context, remote sensing is commonly performed from satellites or aircraft.

Scenario: A coherent description of a potential future situation that serves as input to more detailed analyses or modeling. Scenarios are tools that explore, “if..., then....” statements, and are not predictions of or prescriptions for the future.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by *climate*-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).

Sink: Any process, activity, or mechanism that removes a *greenhouse gas*, an *aerosol*, or a precursor of a *greenhouse gas* or aerosol from the atmosphere. Sinks may be of natural or human origin.

Stakeholders: Individuals or groups whose interests (financial, cultural, value-based, or other) are affected by *climate variability*, *climate change*, or options for *adapting* to or *mitigating* these phenomena. Stakeholders are important partners with the research community for development of decision support resources.

Storm surge: The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds).

Subcommittee on Global Change Research (SGCR): The steering committee of the *U.S. Global Change Research Program* (USGCRP) under the *Committee on Environment, Natural Resources, and Sustainability*, overseen by the Executive Office of the President. SGCR is composed of representatives from each of the member agencies of the USGCRP.

Sustainability: Balancing the needs of present and future generations while substantially reducing poverty and conserving the planet’s life support systems.

Sustainable development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

System: Integration of interrelated, interacting, or interdependent components into a complex whole.

Technology: An approach, including both the experimental technique and the instrumental and scientific infrastructure needed to implement it.

Tipping point: A critical *threshold* at which a tiny perturbation can qualitatively alter the state or development of a system.

Threshold: A point in a system after which any change that is described as *abrupt* is one where the change in the response is much larger than the change in the *forcing*. The changes at the threshold are therefore abrupt relative to the changes that occur before or after the threshold and can lead to a transition to a new state.

Uncertainty: An expression of the degree to which a value (e.g., the future state of the *climate system*) is unknown. Uncertainty in future climate arises from imperfect scientific understanding of the behavior of physical systems, and from inability to predict human behavior.

United Nations Framework Convention on Climate Change (UNFCCC): The United Nations Framework Convention on Climate Change is an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED) intended to stabilize *greenhouse gas* concentrations in the atmosphere at a level that would prevent dangerous *anthropogenic* interference with the *climate system*.

U.S. Global Change Research Program (USGCRP): An interagency program that coordinates and integrates Federal research on changes in the global environment and their implications for society. USGCRP began as a presidential initiative in 1989 and was mandated by Congress in the Global Change Research Act of 1990 (P.L. 101-606). Thirteen departments and agencies participate in the USGCRP. The program is steered by the *Subcommittee on Global Change Research* under the *Committee on Environment and Natural Resources*, overseen by the Executive Office of the President, and facilitated by a National Coordination Office (NCO).

U.S. Group on Earth Observations (USGEO): An interagency group established in 2005 under the White House *Office of Science and Technology Policy’s Committee on Environment, Natural Resources, and Sustainability* to lead Federal efforts to achieve a national Integrated Earth Observation System. Through USGEO, the U.S. further supports cooperative, international efforts to build the *Global Earth Observation System of Systems* (GEOSS).

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of *climate* and *global change*, including *climate variability and extremes*, as well as climate change in conjunction with other stressors.

Weather: The specific condition of the atmosphere at a particular place and time. It is measured in terms of parameters such as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation.

D.2 ABBREVIATIONS & ACRONYMS

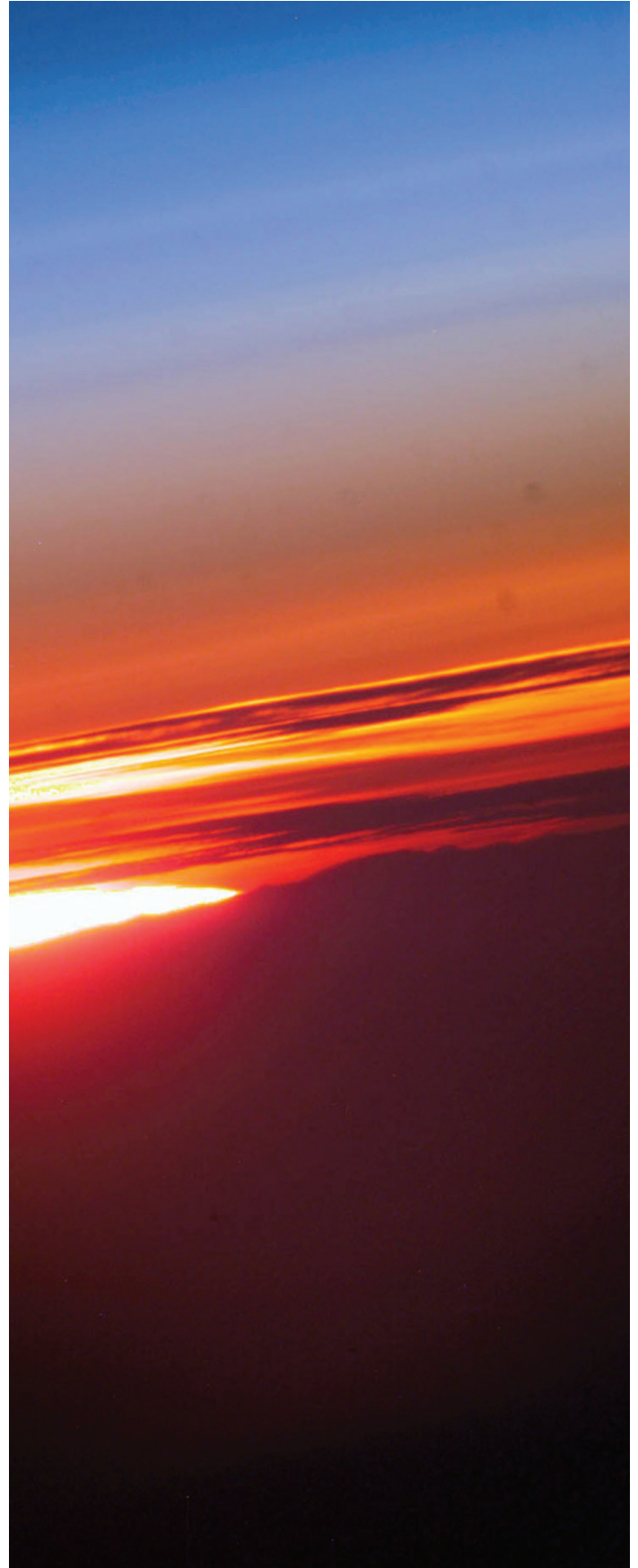
ABoVE – Arctic-Boreal Vulnerability Experiment	CLIC – Climate and the Cryosphere
ACCRI – Aviation Climate Change Research Initiative	CLIVAR – Climate Variability and Prediction
ACIS – Applied Climate Information System	CLM – Community Land Model
ACRIMSAT – Activity Cavity Radiometer Irradiance Monitor SATellite	CloudSat – Cloud Satellite
AFOSR – Air Force Office of Scientific Research	CMIP5 – Fifth-phase Coupled Model Intercomparison Project
AFRI – Agriculture and Food Research Initiative	CNH – Coupled National and Human systems
AgMIP – Agricultural Model Intercomparison and Improvement Project	CO₂ – Carbon Dioxide
AMF – Atmospheric Radiation Measurement Mobile Facility	COP – Conference of Parties
AMOC – Atlantic Meridional Overturning Circulation	COSMIC – Constellation Observing System for Meteorology, Ionosphere, and Climate
AR4 – IPCC Fourth Assessment Report	COSP – Cloud Feedback Model Intercomparison Project Observation Simulator Package
AR5 – IPCC Fifth Assessment Report	CRREL – Cold Regions Research and Engineering Laboratory
ARL – Air Resources Laboratory	CSC – Climate Science Centers
AMR – Atmospheric Radiation Measurement	DARPA – Defense Advanced Research Projects Agency
ARO – Army Research Office	DDIT – Dynamic Drought Index Tool
ARS – Agricultural Research Service	DHS – Department of Homeland Security
BASINS CAT – BASINS Climate Assessment Tool	DMS – Digital Mapping System
BIO – NSF Directorate for Biological Science	DMUU – Decision Making Under Uncertainty
BDR – Budget Data Request	DoD – Department of Defense
CAAFI – Commercial Aviation Alternative Fuels Initiative	DOE – Department of Energy
CALIPSO – Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation	DOI – Department of the Interior
CARB – California Air Resources Board	DOS – Department of State
CARVE – Carbon in Arctic Reservoirs Vulnerability Experiment	DOT – Department of Transportation
CASI – Climate Adaptation Science Investigators	DR – Departmental Regulation
CATs – Climate Assessment Tools	DRMS – Decision, Risk, and Management Sciences
CCHHG – Climate Change and Human Health Group	EaSM – Earth System Models
CCIWG – Carbon Cycle Interagency Working Group	EID – Ecology of Infectious Diseases
CDC – Centers for Disease Control and Prevention	ENSO – El Niño-Southern Oscillation
CCSP – Climate Change Science Program	EO – Earth Observer
CENRS – Committee on Environment, Natural Resources, and Sustainability	EPA – Environmental Protection Agency
CEQ – Council on Environmental Quality	EPPA – Emissions Prediction and Policy Analysis
CFMIP – Cloud Feedback Model Intercomparison Project	ERDC – Engineer Research and Development Center
CH₄ – Methane	ERS – Economic Research Center
CISA – Carolinas Integrated Sciences and Assessments	ESM – Earth System Modeling
CLEEN – Continuous Lower Energy, Emissions, and Noise	ESMF – Earth System Modeling Framework
	ESSI – Earth System Sustainability Initiative

ESSP – Earth System Science Partnership	IGFA – International Group of Funding Agencies for Global Change Research
EV – Earth Venture	IGIM – Interagency Group on Integrated Modeling
FAA – Federal Aviation Administration	IHDP – International Human Dimensions Program
FACA – Federal Advisory Committee Act	INCA – Interagency National Climate Assessment Working Group
FEWS – Famine Early Warning Systems	INFLUX – Indianapolis Flux Experiment
FIA – Forest Inventory Analysis	IOSS – Integrated Ocean Observing System
FTF – Feed the Future Initiative	IPCC – Intergovernmental Panel on Climate Change
FY – Fiscal Year	ISSC – International Social Science Council
GCIS – Global Change Information System	IT – Information Technology
GCOS – Global Climate Observing System	IWG – Interagency Working Group
GCRA – Global Change Research Act	JPSS – Joint Polar Satellite System
GCRIO – Global Change Research Information Office	LBA – Large Scale Biosphere-Atmosphere
GDP – Gross Domestic Product	LDCM – Landsat Data Continuity Mission
GEO – Group on Earth Observations	LTER – Long-Term Ecological Research
GEOS – Global Earth Observation System of Systems	LTREB – Long-Term Research in Environmental Biology
GEWEX – Global Energy and Water Cycle Experiment	LULC – Land Use/Land Cover
GHG – Greenhouse Gas	MARKAL – MARKet ALlocation
GLOBE – Global Learning and Observations to Benefit the Environment	MATCH – Metadata Access Tool for Climate and Health
GOOS – Global Ocean Observation System	MC3E – Midlatitude Continental Convective Cloud Experiment
GPS – Global Positioning System	MERRA – Modern Era Retrospective Analysis for Research and Applications
GRA – Global Research Alliance	MIT – Massachusetts Institute of Technology
GRACE – Gravity Recovery and Climate Experiment	MODIS – Moderate Resolution Imaging Spectroradiometer
GRACEnet – Greenhouse Gas Reduction through Agricultural Carbon Enhancement network	MPS – Division of Mathematical and Physical Sciences
GSA – General Services Administration	NAS – National Academy of Sciences
GVP – Global Volcanism Program	NSAS – National Aeronautics and Space Administration
HHS – U.S. Department of Health and Human Services	NASS – National Agricultural Statistics Service
HPC – High Performance Computing	NCA – National Climate Assessment
HUC – Hydrological Unit Code	NCADAC – National Climate Assessment and Development Advisory Committee
IAM – Integrated Assessment Models	NCAR – National Center for Atmospheric Research
ICCATF – Interagency Climate Change Adaptation Task Force	NCCWCS – National Climate Change and Wildlife Science Center
ICESat – Ice, Cloud, and land Elevation Satellite	NCDC – National Climatic Data Center
ICE-t – Interagency Communications and Education Team	NCEP – National Center for Environmental Prediction
ICLUS – Integrated Climate and Land Use Scenarios	NCO – National Coordination Office
ICSU – International Council of Science	NDVI – Normalized Difference Vegetation Index
IEHS – Chinese National Institute of Environmental Health and Related Product Safety	NEO – National Earth Observations
IGBP – International Geosphere-Biosphere Program	

OUR CHANGING PLANET

- NEON** – National Ecological Observatory Network
- NESDIS** – National Environmental Satellite, Data, and Information Service
- NGDC** – National Geophysical Data Center
- NGEE** – Next Generation Ecosystem Experiment
- NGO** – Non-governmental Organizations
- NHTSA** – National Highway Traffic Safety Administration
- NIEHS** – National Institute of Environmental Health Sciences
- NIFA** – National Institute of Food and Agriculture
- NIH** – National Institutes of Health
- NMME** – National Multi-Model Ensemble
- NMNH** – National Museum of Natural History
- NOAA** – National Oceanic and Atmospheric Administration
- NOC** – National Ocean Council
- NODC** – National Oceanographic Data Center
- NO_x** – Nitrogen Oxide
- NPOESS** – National Polar-orbiting Operational Environmental Satellite System
- NPP** – NPOESS Preparatory Project
- NPS** – National Park Service
- NRC** – National Research Council
- NRCS** – Natural Resources Conservation Service
- NRI** – National Resources Inventory
- NSF** – National Science Foundation
- NSTC** – National Science and Technology Council
- NWS** – National Weather Service
- NZP** – National Zoological Park
- OAR** – Oceanic and Atmospheric Research
- Obs4MIPs** – Observation for Model Intercomparison Projects
- OCO** – Orbiting Carbon Observatory
- OMB** – Office of Management and Budget
- ONR** – Office of Naval Research
- OPP** – Office of Polar Programs
- ORD** – Office of Research and Development
- OSTM** – Ocean Surface Topography Mission
- OSTP** – Office of Science and Technology Policy
- PAR** – Photosynthetically Active Radiation
- PARTNER** – Partnership for Air Transportation Noise and Emissions Reduction
- PDSI** – Palmer Drought Severity Index
- ppm** – parts per million
- PSU** – practical salinity units
- QDR** – Quadrennial Defense Review
- QuikSCAT** – Quick Scatterometer
- RAMA** – Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction
- RCC** – Regional Climate Centers
- RCP** – Representative Concentration Pathways
- RDD** – Research and Development Division
- REDD+** – Reducing Emissions from Deforestation and Degradation
- RISA** – Regional Integrated Sciences and Assessments
- RO** – Radio Occultation
- RRED** – Resource and Rural Economics Division
- RRP** – Revised Research Plan
- SAGE** – Stratospheric Aerosol and Gas Experiment
- SBA** – Societal Benefit Area
- SBE** – Directorate for Social, Behavioral and Economic Sciences
- SCAN** – Soil Climate Analysis Network
- SEES** – Science, Engineering, and Education for Sustainability
- SERDP** – Strategic Environmental Research and Development Program
- SGCR** – Subcommittee for Global Change Research
- SIGEO** – Smithsonian Institution Group on Earth Observations
- SNOTEL** – Snowpack Telemetry
- SO₂** – Sulfur Oxides
- SORCE** – Solar Radiation and Climate Experiment
- SPARC** – Stratospheric Processes and their Role in Climate
- SPURS** – Salinity Processes in the Upper Ocean Regional Study
- SREX** – Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
- SSREN** – Special Report on Renewable Energy Sources and Climate Change Mitigation
- SSS** – Sea Surface Salinity
- SST** – Sea Surface Temperature
- STEM** – Science, Technology, Engineering, and Mathematics
- STRI** – Smithsonian Tropical Research Institute
- Suomi-NPP** – Suomi National Polar-orbiting Partnership
- TFCC** – Task Force Climate Change

TRMM – Tropical Rainfall Measuring Mission
TSU – Technical Support Unit
UCAE – University Corporation for Atmospheric Research
ULTRA – Urban Long-Term Research Area
UN – United Nations
UNEP – United Nations Environment Programme
UNESCO – United Nations Educational, Scientific, and Cultural Organization
UNFCCC – United Nations Framework Convention on Climate Change
USACE – U.S. Army Corps of Engineers
USAID – U.S. Agency for International Development
USA-NPN – USA National Phenology Network
USDA – U.S. Department of Agriculture
USGCRP – U.S. Global Change Research Program
USGEO – U.S. Group on Earth Observation
USGS – U.S. Geological Society
WCRP – World Climate Research Programme
WEPPCAT – Water Erosion Prediction Project Climate Assessment Tool
WGII – Working Group II
WGISS – CEOS Working Group on Information Systems and Science
WMO – World Meteorological Organization
WOA – World Ocean Assessment
WRAP – Water Resource Adaptation Program
WWRP – World Weather Research Program





The U.S. Global Change Research Program
1717 Pennsylvania Avenue NW • Suite 250 • Washington, D.C. 20006 USA
+1.202.223.6262 (voice) • +1.202.223.3065 (fax)