



# Executive Summary

The environment is changing rapidly. Increases in world population, accompanied by industrialization and other human activities, are altering the atmosphere, ocean, land, ice cover, ecosystems, and the distribution of species over the planet. Understanding these and other global changes, including climate change, is critical to our Nation's health and economic vitality. Scientific research is critical to gaining this understanding. Research, along with an array of increasingly sophisticated tools for collecting and analyzing data, can provide essential knowledge to governments, businesses, and communities as they plan for and respond to the myriad manifestations of global change, including sea-level rise and ocean acidification, heat waves and drought, and the severe storms, floods, and forest fires that pose an ever-growing risk to life, property, and agriculture.

To help fill this need, President Ronald Reagan created—and Congress in 1990 codified—the United States Global Change Research Program (USGCRP or Program), charged with providing a “comprehensive and integrated United States research program to assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”<sup>1</sup> The Program coordinates the work of 13 agencies that fund research on global change, maximizing efforts and taking advantage of synergies while facilitating communication not only among member agencies but also with partners in industry, academia, and state, local, and foreign governments. Since USGCRP's inception, Federal research programs have created and maintained a robust mix of atmospheric, oceanic, and land- and space-based observing systems; gained new theoretical understanding of Earth-system processes; developed sophisticated predictive models; supported advances in data management and sharing; and helped develop an expert scientific workforce.

These research accomplishments have had far-reaching and significant impacts on the advancement and application of global change knowledge. For example, seasonal climate forecasts are now significantly more accurate and have longer lead times, often giving farmers critical and timely information for crop management. In addition, mathematical models of the general circulation of the atmosphere and ocean now can reproduce major features of the global temperature record of the 20th century, providing confidence that climate projections accurately reflect the link between rising levels of greenhouse gases in the atmosphere and planetary warming. These abilities are on display in a series of USGCRP publications that, over the years, have provided practical information about global change trends—in some cases sorted by geographic region and economic sector—to assist city and regional planners and others as they make decisions about upcoming investments in, for example, infrastructure and projected energy needs.

Today, new technological capacities and growing demands from a range of stakeholders for practical insights about global change require that USGCRP strengthen its role as both a generator and distributor of reliable, evidence-based climate change information. This Strategic Plan aims to facilitate this timely programmatic advancement. While the Program's first two decades focused largely on observations, process research, and modeling of the physical climate system, it is now poised to more fully integrate important dimensions to our understanding of the Earth system by incorporating such complex and critical components as the roles of ecosystems and human communities.

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1. The Global Change Research Act of 1990 ( Public Law 101-606)

This ten-year Strategic Plan—which reflects recommendations from multiple reports of the National Academies, dozens of listening sessions with stakeholders around the country, public comments on a draft plan, and collaborative planning among the USGCRP agencies—charts a course that will advance the Program’s legislative mandate to deepen basic scientific understanding while providing information and tools to support the Nation’s preparation for and response to global change. In particular, the Program will coordinate Federal research efforts through the following four strategic goals:

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

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

**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.

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

These four goals and their related objectives (**Box 1**) recognize that to respond effectively to global change will require a deep understanding of the integrated Earth system—an understanding that incorporates physical, chemical, biological, and behavioral information. Looking forward, USGCRP will accomplish this by supporting the use of advanced computing science and analytic technologies capable of spanning traditional scientific disciplines and also integrating research findings from the ecological, social, and economic sciences, with ongoing coordinated emphases on observations and modeling.

In furtherance of its mission to inform decision makers with the best global change-related information available, USGCRP is also committed under its new Strategic Plan to improving its assessment—and ensuring its fulfillment—of stakeholder needs. Farmers, as previously noted, depend on USGCRP-generated information to manage planting decisions as growing zones, pest and weed ranges, and seasonal boundaries shift. Health care providers need predictive models to prepare for anticipated increases in severe weather events and outbreaks of diseases previously uncommon in their regions. Insurers must account for the increased likelihood of weather extremes as they assess future financial risk. Inhabitants of coastal cities need to understand the implications of sea-level rise, especially in the context of novel storm patterns and other pending changes. Water resources, energy, and infrastructure planners need to address accelerating changes in the availability of freshwater, demands for energy, and needs to divert stormwater runoff. By considering and responding to these societal needs, the Program will not only enhance its immediate value to the Nation but also improve its ability to make wise decisions about future research directions.

Providing decision makers with timely and relevant information requires regular evaluations and assessments. As part of its mandate to perform periodic assessments, USGCRP will implement a long-term, consistent, and ongoing process for evaluating global change risks and opportunities across diverse regions and sectors. Specifically, rather than conducting such assessments periodically, as was the case during the Program’s first decades, USGCRP will work to establish a sustained assessment capacity focused on evaluating the state of scientific knowledge related to impacts and trends, and on informing the Nation’s activities in adaptation and mitigation.

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But to be fully effective, USGCRP must communicate with more than just decision makers; engagement with the public is also essential. By integrating communication, education, and engagement into the Program's core research activities over the next decade, USGCRP and its member agencies will serve as an unprecedentedly important gateway to credible and authoritative global change scientific information. The Program's education efforts will also support the critical goal of developing a home-grown scientific workforce capable of bridging the physical, chemical, biological, and social sciences, and coordinating that integrated knowledge-base with the engineering skills that are needed to respond to global change challenges and cultivate future research advances.

This Strategic Plan acknowledges several looming challenges in global change research. Among them, the Nation is at risk of experiencing observational gaps that would affect the ability to monitor and understand natural and human-induced variability, due to developmental and launch delays of replacements for aging systems (e.g., Earth Observing System satellites). Also, to achieve the new heights of multimodal integration recommended in this Plan, scientists and engineers will have to overcome the technical challenges of integrating observing and data systems focused on the physical environment with the range of social and ecological observations collected by other means.

Finally, this Plan recognizes that global change is an international concern. Across the Nation and around the world, people are increasingly becoming aware of the need to mitigate effectively the impacts of global change and adapt to those changes that cannot be prevented. The global nature of today's economy—and the speed with which challenges faced in one part of the world can affect others—reinforce the need for a global response based upon the best available science. Social, economic, and political upheaval can result from such manifestations of global change as decreased availability of water, food, and other critical resources that can sweep across regional and national boundaries. Understanding global change and the options for minimizing and managing its risks is important for U.S. national security and for maintaining regional and global stability.

A worldwide issue such as global change also requires international research cooperation. Observations across the globe are crucial to develop the long-term data sets needed to leverage and build upon U.S. investments. Networks of satellite, ocean, atmosphere, and land-based observations are essential to producing the data necessary to test models and advance research that can ultimately protect livelihoods and the environment.

To summarize, looking forward, the USGCRP will work to integrate the physical, chemical, biological, and social sciences; interact with decision makers about research results relevant to their needs; advance communication and interdisciplinary education in global change research; and make effective use of assessment results to inform future research activities. Broadening Federal participation in the Program is also needed, as current agency participants may lack the direct links to and experience with stakeholder communities that are key to developing viable adaptation and mitigation options. The implementation strategy section of the Strategic Plan outlines a path forward to address these and other challenging aspects of the new strategic goals and objectives.

Taken together, the Program envisioned through this Strategic Plan will coordinate the work of Federal agencies more productively than ever, ensuring a more effective global change research effort for the benefit of the Nation.

### Box 1. USGCRP Strategic Goals and Objectives

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

- **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.
- **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.
- **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.
- **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.
- **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.

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

- **Objective 2.1. Inform Adaptation Decisions:** Improve the deployment and accessibility of science to inform adaptation decisions.
- **Objective 2.2. Inform Mitigation Decisions:** Improve the deployment and accessibility of science to inform decisions on mitigation and the mitigation-adaptation interface.
- **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.

**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.

- **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.
- **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.
- **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.
- **Objective 3.4. Evaluate Progress:** Ensure ongoing evaluation of assessment processes and products, and incorporate the findings into an adaptive response for systemic improvement.

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

- **Objective 4.1. Strengthen Communication and Education Research:** Strengthen the effectiveness of global change communication and education research to enhance practices.
- **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.
- **Objective 4.3. Increase Engagement:** Establish effective and sustained engagement to enable a responsive and wholly integrated Program.
- **Objective 4.4. Cultivate Scientific Workforce:** Cultivate a capable, diverse scientific workforce that is knowledgeable about global change.